APPENDIX 9
PRE 2001 VIBRACORE COMPOSITE DATA

COMPOSITE SUMMARY TABLE
OCEAN ISLE BEACH TERMINAL GROIN PROJECT

VIBRACORE I. D.	PHI MEDIAN	MEDIAN (mm)	MEAN (mm)	PHI MEAN	% SILT
SHI-6 COMPOSITE	0.65	0.14	0.00	0.00	1.1
SHI-7 COMPOSITE	1.25	0.11	0.00	0.00	1.45
SHI-8 COMPOSITE	0.88	0.08	0.00	0.00	1.5
SHI-12 COMPOSITE	0.51	0.34	0.00	0.00	1.5
SHI-13 COMPOSITE	0.46	0.29	0.00	0.00	0.9
SHI-14 COMPOSITE	1.63	0.11	0.00	0.00	1.6
SHALLOTTE INLET BA COMPOSITE	0.86	0.16	0.00	0.00	1.3

COMPOSITE DATA TABLE
OCEAN ISLE BEACH TERMINAL GROIN PROJECT

VIBRACORE I. D.	EFFECTIVE LENGTH (FT)	PHI MEDIAN	MEDIAN (mm)	MEAN (mm)	PHI MEAN	% SILT
SHI-6 COMPOSITE	9.0	0.65	0.14	0.00	0.00	1.1
SHI-7 COMPOSITE	7.2	1.2	0.1	0.0	0.0	1.5
SHI-8 COMPOSITE	11.0	0.88	0.08	0.00	0.00	1.5
SHI-12 COMPOSITE	5.5	0.51	0.34	0.00	0.00	1.5
SHI-13 COMPOSITE	4.9	0.46	0.29	0.00	0.00	0.9
SHI-14 COMPOSITE	3.6	1.63	0.11	0.00	0.00	1.6
SHALLOTTE INLET BA COMPOSITE	41.2	0.86	0.16	0.00	0.00	1.3

CUMULATIVE PERCENTS AND COMPUTED DISTRIBUTIONS
OCEAN ISLE BEACH TERMINAL GROIN PROJECT (1 OF 1)

SAMPLE I. D.	ELEVATION (MLW)	EFFECTIVE LENGTH (FT)	PHI MEDIAN	MEDIAN (mm)	MEAN (mm)	PHI MEAN	% SILT
SHI-6 #1	-4.0	3.8	1.55	0.34	N/A	N/A	0.8
SHI-6 #2	-9.0	5.2	N/A	N/A	N/A	N/A	1.3
Cut to -15.0' MLW							
% silt estimated from granularmetric curves based on the #200 sieve							
SHI-6 COMPOSITE		**9.0**	**0.65**	**0.14**	**0.00**	**0.00**	**1.1**
SHI-7 #1	-8.1	3.3	N/A	N/A	N/A	N/A	1.8
SHI-7 #2	-12.1	3.9	2.30	0.20	N/A	N/A	1.2
Cut to -15.0' MLW							
% silt estimated from granularmetric curves based on the #200 sieve							
SHI-7 COMPOSITE		**7.2**	**1.25**	**0.11**	**0.00**	**0.00**	**1.5**
SHI-8 #1	-0.8	4.3	2.25	0.21	N/A	N/A	0.9
SHI-8 #2	-6.8	6.7	N/A	N/A	N/A	N/A	1.9
Cut to -15.0' MLW							
% silt estimated from granularmetric curves based on the #200 sieve							
SHI-8 COMPOSITE		**11.0**	**0.88**	**0.08**	**0.00**	**0.00**	**1.5**
SHI-12 #1	-9.8	3.3	0.85	0.56	N/A	N/A	0.8
SHI-12 #2	-12.8	2.2	N/A	N/A	N/A	N/A	2.6
Cut to -15.0' MLW							
% silt estimated from granularmetric curves based on the #200 sieve							
SHI-12 COMPOSITE		**5.5**	**0.51**	**0.34**	**0.00**	**0.00**	**1.5**
SHI-13 #1	-9.2	2.3	N/A	N/A	N/A	N/A	1.0
SHI-13 #2	-11.2	2.6	0.86	0.55	N/A	N/A	0.8
Cut to -15.0' MLW							
% silt estimated from granularmetric curves based on the #200 sieve							
SHI-13 COMPOSITE		**4.9**	**0.46**	**0.29**	**0.00**	**0.00**	**0.9**
SHI-14 #1	-12.2	2.3	2.55	0.17	N/A	N/A	1.5
SHI-14 #2	-13.7	1.3	N/A	N/A	N/A	N/A	1.8
SHI-14 #3	-21.5	0.0	N/A	N/A	N/A	N/A	5.0
SHI-14 #4	-23.7	0.0	N/A	N/A	N/A	N/A	45.0
Cut to -15.0' MLW							
% silt estimated from granularmetric curves based on the #200 sieve							
SHI-14 COMPOSITE		**3.6**	**1.63**	**0.11**	**0.00**	**0.00**	**1.6**

CPE Sieve PHI	Sieve Phi	Sieve #	% Passing	% Retained
-4.25	-4.25	3/4"	100.00	0.00
-4.00				
-3.50				
-3.25	-3.25	3/8"	100.00	0.00
-3.00				
-2.50				
-2.25	**-2.25**	**#4**	**99.20**	**0.80**
-2.00				
-1.50	-1.50	#7	98.70	**1.30**
-1.00	-1.00	#10	98.20	**1.80**
-0.50	-0.50	#14	97.40	**2.60**
0.00	**0.00**	**#18**	**96.10**	**3.90**
0.50	0.50	#25	92.80	**7.20**
1.00	**1.00**	**#35**	**84.00**	**16.00**
1.50	1.50	#45	66.20	**33.80**
2.00	**2.00**	**#60**	**40.40**	**59.60**
2.50	**2.50**	**#80**	**16.20**	**83.80**
3.00	**3.00**	**#120**	**2.20**	**97.80**
3.50	3.50	#170	0.70	**99.30**
3.75	**3.75**	**#200**	**0.60**	**99.40**
4.00	**4.00**	**#230**	**0.50**	**99.50**

APPENDIX 10
2005 & 2009 USACE VIBRACORE LOGS, GRANULARMETRIC
REPORTS & GRAIN SIZE DISTRIBUTION CURVES

Hole No. OI-05-03

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

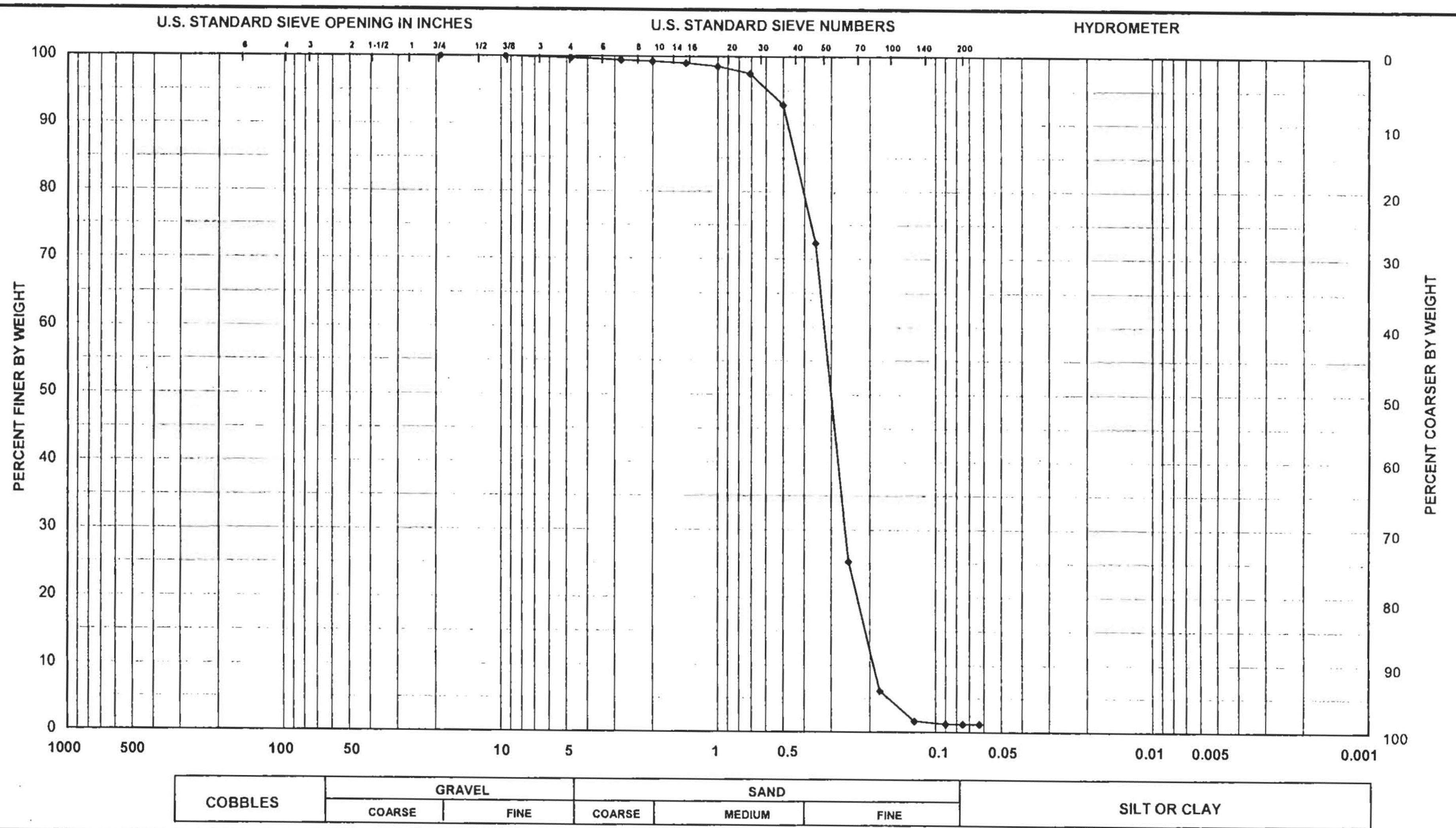
1. PROJECT: OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NC Coord. E 2188487.9 N 55049.4	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number): OI-05-03	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 3, UNDISTURBED 0
5. NAME OF DRILLER: LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: (X) VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. THICKNESS OF OVERBURDEN: N/A (7.7' of Water)	16. DATE HOLE: STARTED 4/20/05, COMPLETED 4/20/05
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0 MLLW
9. TOTAL DEPTH OF HOLE: 13.9'	18. TOTAL CORE RECOVERY FOR BORING: N/A %
	19. SIGNATURE OF INSPECTOR: KELLY KALTENBACH, GEOLOGIST TRAINEE

ELEVATION MLLW	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
0.0	0		0.0' TO 7.7' WATER			Time begin vibracoring: 1439 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	7.0					NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
-7.7	7.7		OCEAN BOTTOM @7.7'		7.7'	
	8.0		SP Tan-light gray, fine to coarse sand, clean, poorly graded, w/some fine to medium sand size shell material.		1	
					8.2'	VIBRACORE BORING From 7.7' to 13.7' Ran 6.2' Rec: 6.2' Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
	9.0					
			9.7' decreasing shell content, trace fine shells.			
	10.0					
					10.7'	
	11.0				2	LAB CLASSIFICATION
					11.2'	Jar Number 1: SP; 2: SP; 3: SP
	12.0					
	13.0				13.2'	NOTE Assumed vibracore refusal @ 13.9'
			SP-SM Gray to dark gray, fine medium silty sand, traces silt trace shell, few silt seams. trace coarse shell material.		3	
					13.7'	
-13.9	13.9		BOTTOM OF HOLE @13.9'			

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP

SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 1	7.7'- 8.2'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	22					

Project Ocean Isle Renourishment

Area

Boring No. OI-05-03

Date 8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
3047-4 St. Johns Bluff Road S.
Jacksonville, Florida 32246
(904) 997-1400 (Tel) · (904) 997-9150 (Fax)

VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

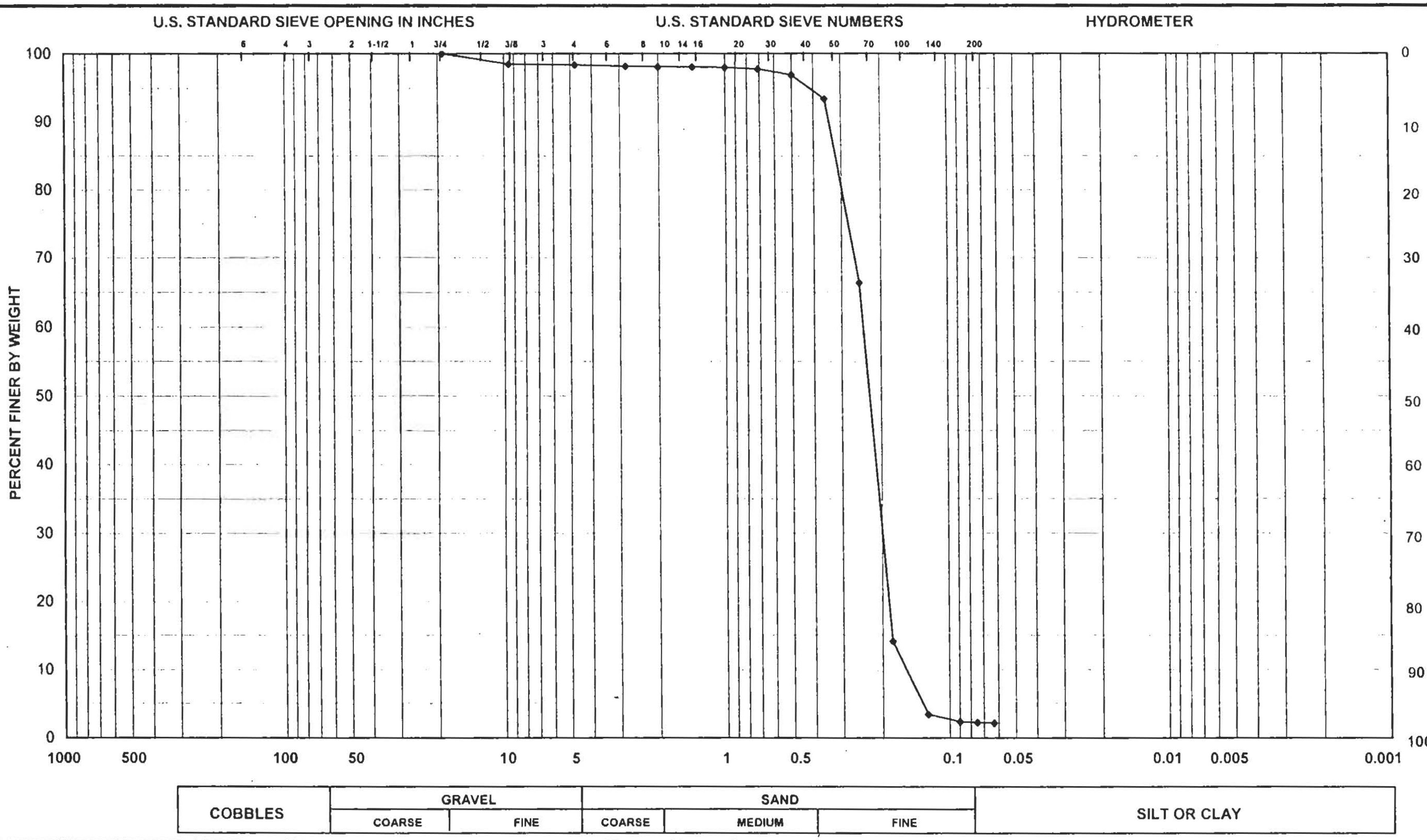
Project: Ocean Isle Renourishment
Depth: 7.7'- 8.2'
Project No.: 2216-01-60
Date: 8/1/2005
Boring No.: OI-05-3
Sample No.: 1
Description: SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)

Tare Weight, (g): 50.73
Dry Wt. Before Washing (g): 158.51 (with tare)
Dry Weight After Washing (g): 157.68 (with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.28	99.74	100	0.28
#7	2.800	0.34	99.42	100	0.34
#10	2.000	0.14	99.29	100	0.14
#14	1.400	0.29	99.03	100	0.29
#18	1.000	0.51	98.55	95	0.48
#25	0.710	1.14	97.49	90	1.03
#35	0.500	4.97	92.88	70	3.48
#45	0.355	22.16	72.32	50	11.08
#60	0.250	50.72	25.26	30	15.22
#80	0.180	20.66	6.10	10	2.07
#120	0.125	4.81	1.63	5	0.24
#170	0.090	0.45	1.22	1	0.00
#200	0.075	0.04	1.18	1	0.00
#230	0.063	0.01	1.17	1	0.00

Total Shell Content: 22 %

aw 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI		
• 2	10.7'- 11.2'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	24						Project	Ocean Isle Renourishment
									Area	
									Boring No.	OI-05-03
									Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

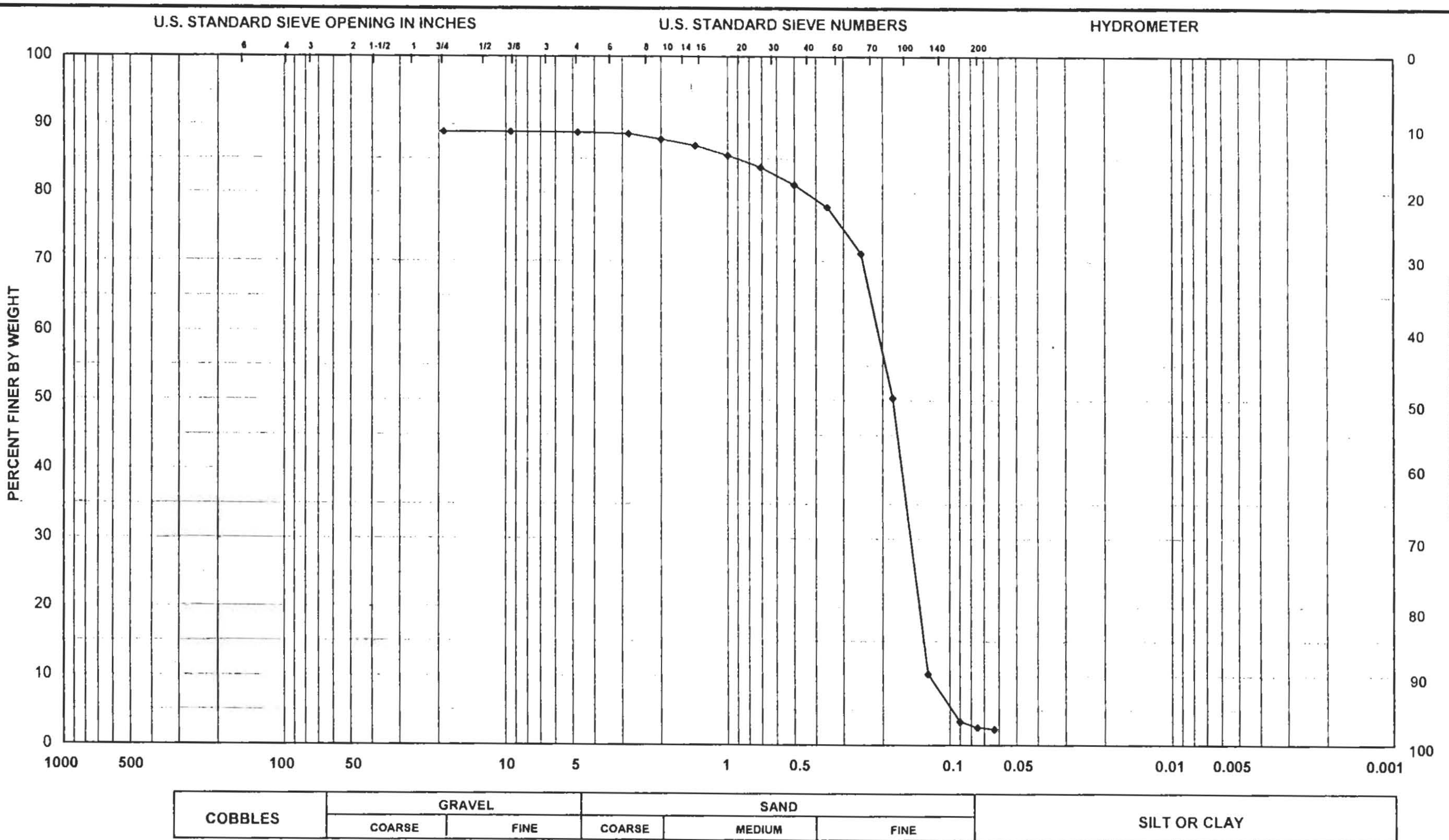
Project:	**Ocean Isle Renourishment**	**Depth:**	**10.7'- 11.2'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-3**		
Sample No.:	**2**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	49.82	
Dry Wt. Before Washing (g):	140.33	(with tare)
Dry Weight After Washing (g):	139.05	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	1.37	98.49	100	1.37
#4	4.750	0.09	98.39	100	0.09
#7	2.800	0.19	98.18	100	0.19
#10	2.000	0.06	98.11	100	0.06
#14	1.400	0.03	98.08	100	0.03
#18	1.000	0.07	98.00	100	0.07
#25	0.710	0.21	97.77	95	0.20
#35	0.500	0.75	96.94	80	0.60
#45	0.355	3.17	93.44	70	2.22
#60	0.250	24.51	66.36	50	12.26
#80	0.180	47.33	14.06	30	14.20
#120	0.125	9.67	3.38	20	1.93
#170	0.090	0.96	2.32	5	0.05
#200	0.075	0.09	2.22	1	0.00
#230	0.063	0.05	2.17	1	0.00

Total Shell Content: **24 %**

Cw 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 3	13.2'- 13.7'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	24					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-03
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**13.2'- 13.7'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-03**		
Sample No.:	**3**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.77	
Dry Wt. Before Washing (g):	166.68	(with tare)
Dry Weight After Washing (g):	164.16	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	12.89	88.88	100	12.89
3/8"	9.500	0.00	88.88	0	0.00
#4	4.750	0.09	88.80	100	0.09
#7	2.800	0.22	88.61	100	0.22
#10	2.000	0.98	87.77	100	0.98
#14	1.400	1.04	86.87	100	1.04
#18	1.000	1.65	85.45	100	1.65
#25	0.710	2.00	83.72	95	1.90
#35	0.500	3.01	81.12	80	2.41
#45	0.355	3.76	77.88	70	2.63
#60	0.250	7.84	71.12	50	3.92
#80	0.180	24.12	50.31	30	7.24
#120	0.125	46.37	10.30	10	4.64
#170	0.090	8.05	3.36	5	0.40
#200	0.075	0.95	2.54	1	0.01
#230	0.063	0.33	2.25	1	0.00

Total Shell Content: **24** **%**

8/2/05

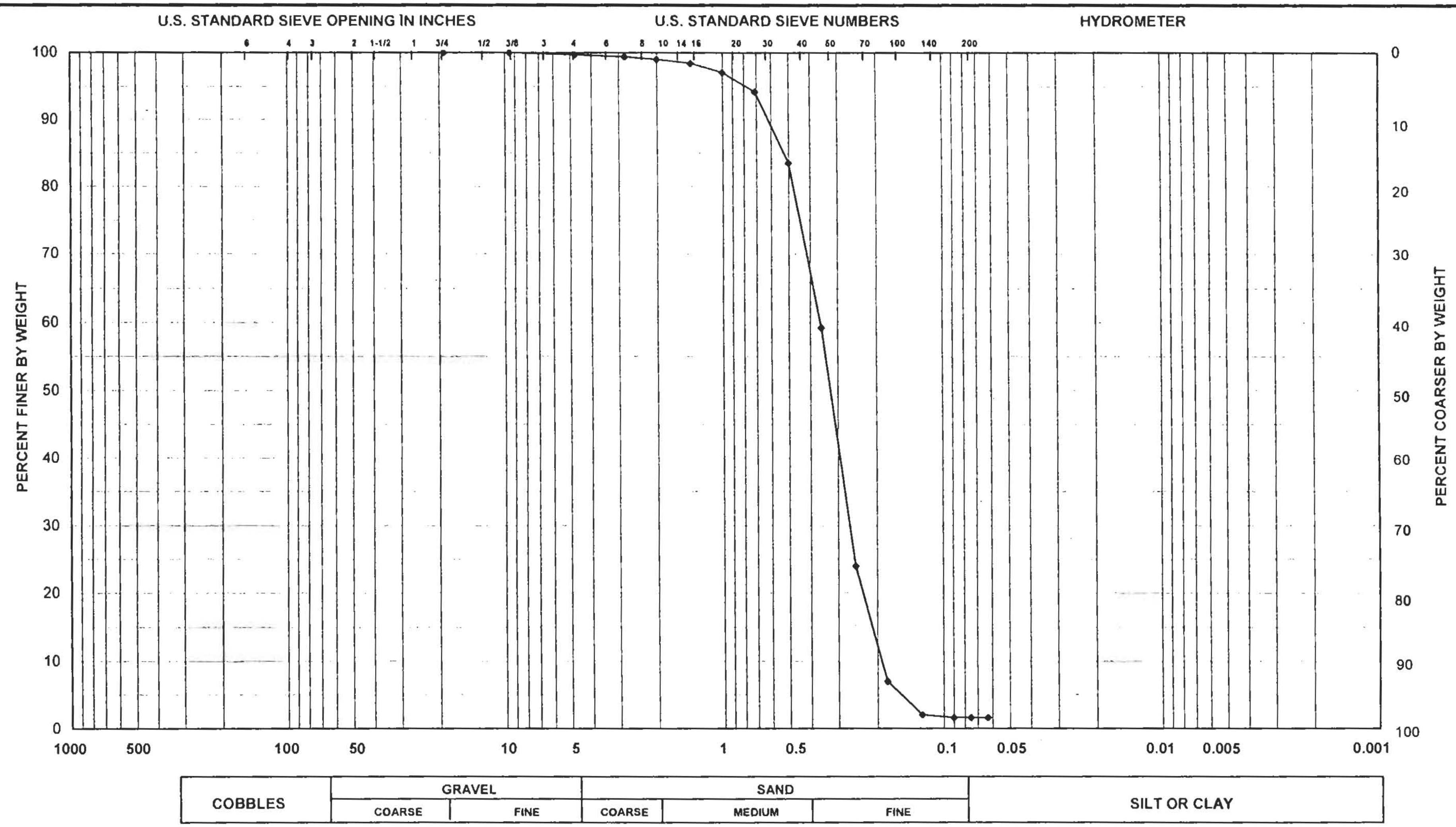
Hole No. OI-05-05

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NC Coord. E 2187652.9 N 56197.5	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number) : OI-05-05	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN DISTURBED : 3 UNDISTURBED : 0
5. NAME OF DRILLER LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
	16. DATE HOLE STARTED : 4/20/05 COMPLETED : 4/20/05
	17. ELEVATION TOP OF HOLE 0.0 MLLW
7. THICKNESS OF OVERBURDEN N/A (2.9' of Water)	18. TOTAL CORE RECOVERY FOR BORING N/A %
8. DEPTH DRILLED INTO ROCK 0.0'	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE 11.9'	KELLY KALTENBACH, GEOLOGIST TRAINEE

ELEVATION MLLW	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
0.0	0		0.0' TO 2.9' WATER			Time begin vibracoring: 1242 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	2.0					
-2.9	2.9		OCEAN BOTTOM @ 2.9'		2.9'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
			SP Tan to light gray, fine to coarse sand, clean poorly graded, little shell material (sand sized).		1	
					3.4'	
	4.0					VIBRACORE BORING From 2.9' to 11.9' Ran 9.3' Rec: 9.0'
	6.0					Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
					6.9'	
					2	
					7.4'	
	8.0					
	10.0					LAB CLASSIFICATION
			10.9'		10.9'	Jar Number / Classification
	11.0		coarse gravel size shell material.		3	1 SP; 2 SP; 3 SP
					11.4'	
-11.9	11.9		BOTTOM OF HOLE @11.9'			
						NOTE Assumed vibracore refusal @ 11.9'
			SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. MAR 71 | PROJECT OCEAN ISLE RENOURISHMENT | HOLE NO. OI-05 05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 1	2.9'- 3.4'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	27					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-05
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

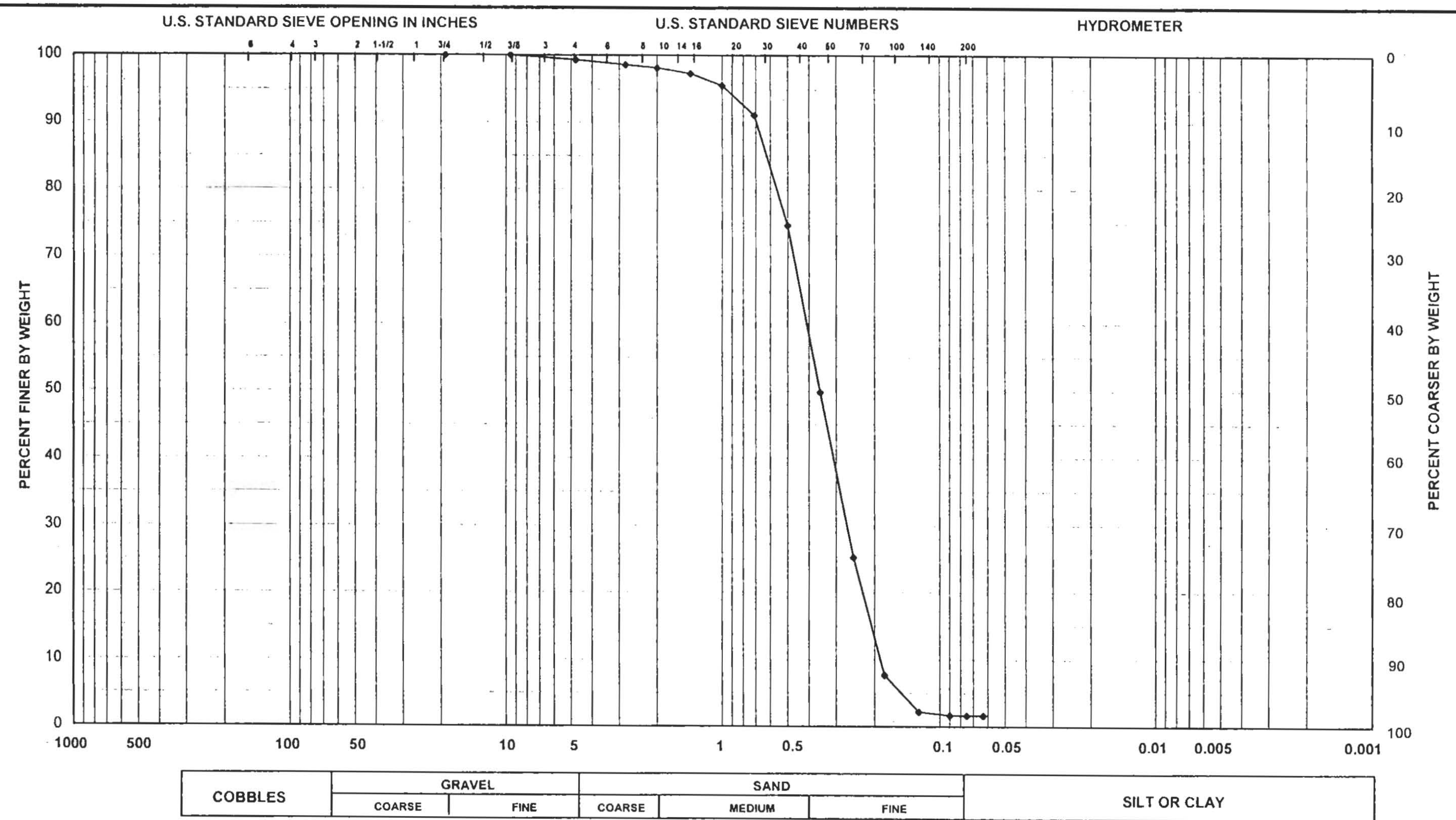
Project: Ocean Isle Renourishment
Depth: 2.9'- 3.4'
Project No.: 2216-01-60
Date: 8/1/2005
Boring No.: OI-05-05
Sample No.: 1
Description: SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)

Tare Weight, (g): 49.28
Dry Wt. Before Washing (g): 174.98 (with tare)
Dry Weight After Washing (g): 173.71 (with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.36	99.71	100	0.36
#7	2.800	0.41	99.39	100	0.41
#10	2.000	0.45	99.03	100	0.45
#14	1.400	0.72	98.46	100	0.72
#18	1.000	1.70	97.10	95	1.62
#25	0.710	3.68	94.18	80	2.94
#35	0.500	13.40	83.52	70	9.38
#45	0.355	30.51	59.24	50	15.26
#60	0.250	44.29	24.01	30	13.29
#80	0.180	21.34	7.03	10	2.13
#120	0.125	6.27	2.04	5	0.31
#170	0.090	0.53	1.62	1	0.01
#200	0.075	0.01	1.61	1	0.00
#230	0.063	0.01	1.61	1	0.00

Total Shell Content: 27 %

6 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 2	6.9'- 7.4'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	29					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-05
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**6.9'- 7.4'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-05**		
Sample No.:	**2**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.26	
Dry Wt. Before Washing (g):	166.39	(with tare)
Dry Weight After Washing (g):	165.12	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.79	99.32	100	0.79
#7	2.800	0.84	98.60	100	0.84
#10	2.000	0.53	98.14	100	0.53
#14	1.400	0.96	97.31	100	0.96
#18	1.000	2.00	95.59	95	1.90
#25	0.710	5.27	91.05	80	4.22
#35	0.500	19.06	74.64	70	13.34
#45	0.355	28.87	49.78	50	14.44
#60	0.250	28.47	25.26	30	8.54
#80	0.180	20.36	7.73	10	2.04
#120	0.125	6.43	2.20	5	0.32
#170	0.090	0.63	1.65	1	0.01
#200	0.075	0.03	1.63	1	0.00
#230	0.063	0.01	1.62	1	0.00

Total Shell Content: 29 %

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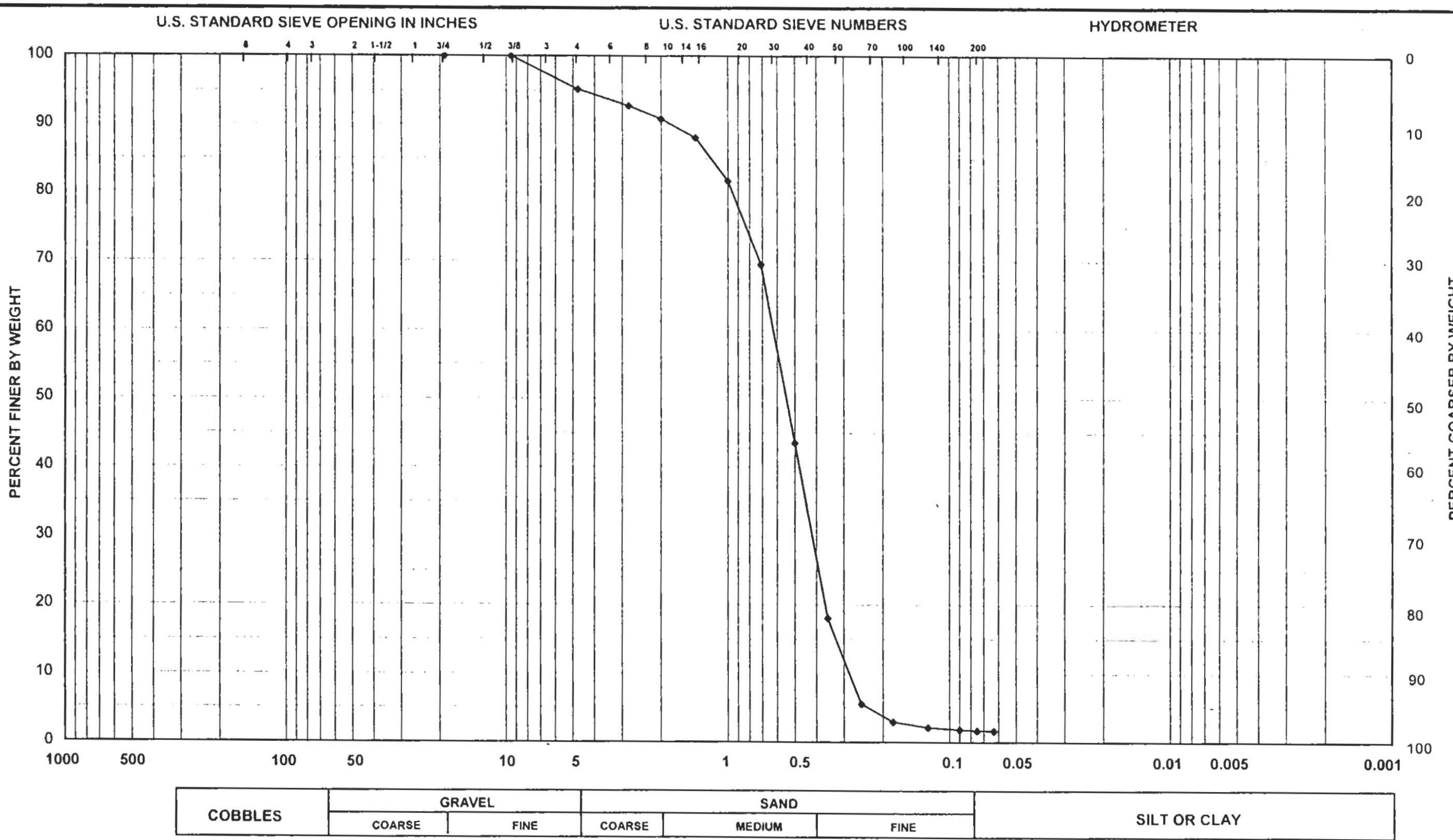

Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 3	10.9'- 11.4'	SAND, poorly-graded, mostly fine-grained quartz, some carbonate, trace silt, olive brown (SP)	44					

Project Ocean Isle Renourishment

Area

Boring No. OI-05-05

Date 8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

Hole No. OI-05-06

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NC Coord. E 2188206.5 N 56149.4	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number): OI-05-06	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 4; UNDISTURBED 0
5. NAME OF DRILLER: LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: (X) VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
	16. DATE HOLE: STARTED 4/20/05; COMPLETED 4/20/05
7. THICKNESS OF OVERBURDEN: N/A (10.6' of Water)	17. ELEVATION TOP OF HOLE: 0.0 MLLW
8. DEPTH DRILLED INTO ROCK: 0.0'	18. TOTAL CORE RECOVERY FOR BORING: N/A %
9. TOTAL DEPTH OF HOLE: 19.4'	19. SIGNATURE OF INSPECTOR: KELLY KALTENBACH, GEOLOGIST TRAINEE

ELEVATION MLLW	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
0.0	0		0.0' TO 10.6' WATER			Time begin vibracoring: 1046 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	10.0		OCEAN BOTTOM @ 10.6'		10.6'	
-10.6	10.6		SP Tan to light gray, fine to coarse sand, clean, poorly graded, some fine to coarse sand size shell material.		1	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
					11.1'	
	12.0					VIBRACORE BORING From 10.6' to 19.4' Ran 9.0' Rec: 8.8'
			13.6' few gravel size shell material.			
	14.0				14.6'	Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
					2	
			15.5'		15.1' 15.5'	
-15.5	15.5		SP-SM Tan, mottled, w/dark gray fine to medium sand, trace fine sand size shell material.		3	
	16.0				16.0'	
	18.0		18.3'		18.3'	LAB CLASSIFICATION
			SP Light tan, mottled tan, fine-medium sand, clean, poorly graded, trace shell. Wood fragments @18.9'.		4	
					18.8'	
-19.4	19.4		BOTTOM OF HOLE @19.4'			

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SP

SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM

NOTE Assumed vibracore refusal @ 19.4'

*wood fragments @18.9'

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. MAR 71

PROJECT OCEAN ISLE RENOURISHMENT | HOLE NO. OI-05 06

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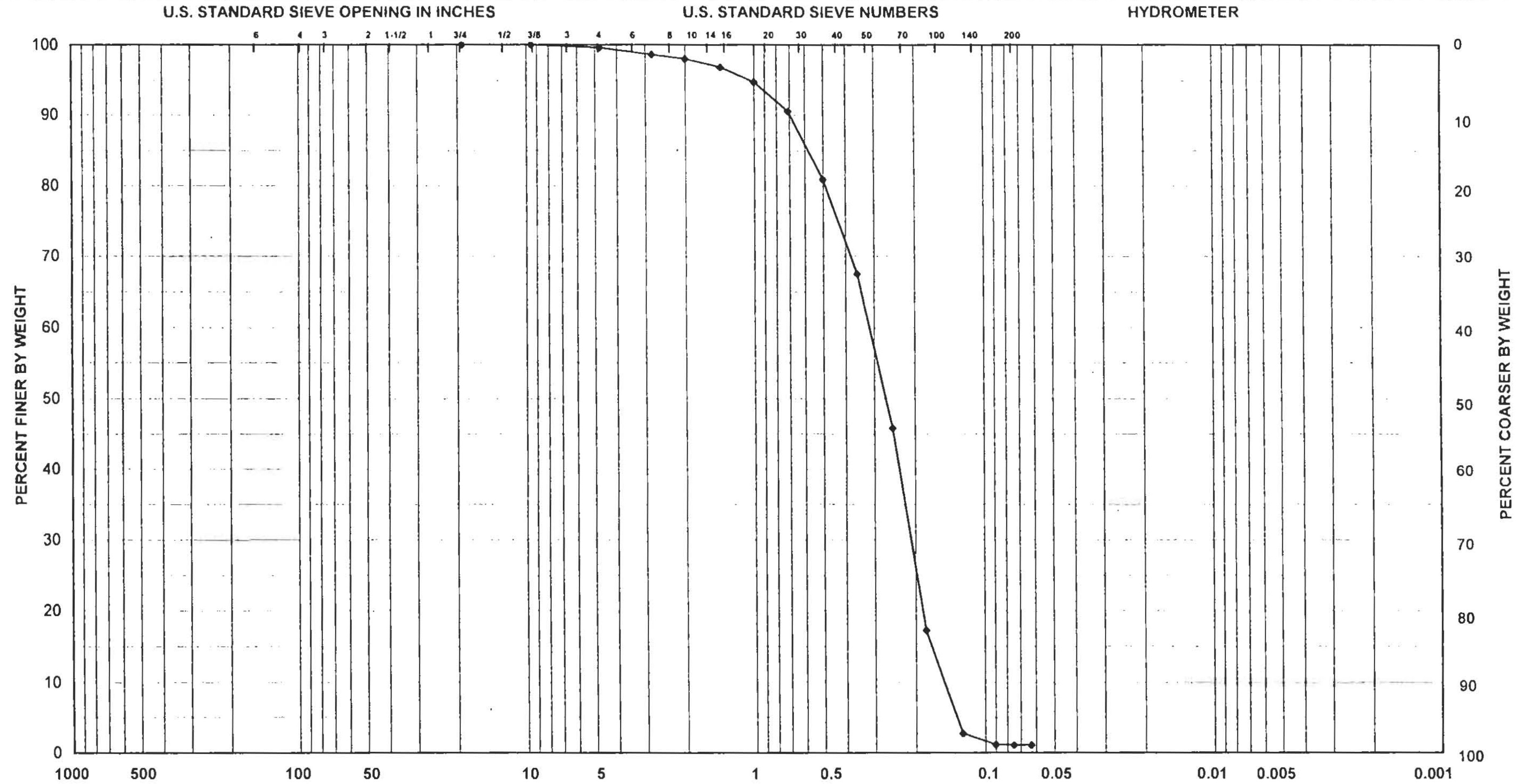


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 1	10.6'- 11.1'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	20					

Project Ocean Isle Renourishment

Area

Boring No. OI-05-06

Date 8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
3047-4 St. Johns Bluff Road S.
Jacksonville, Florida 32246
(904) 997-1400 (Tel) · (904) 997-9150 (Fax)

VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

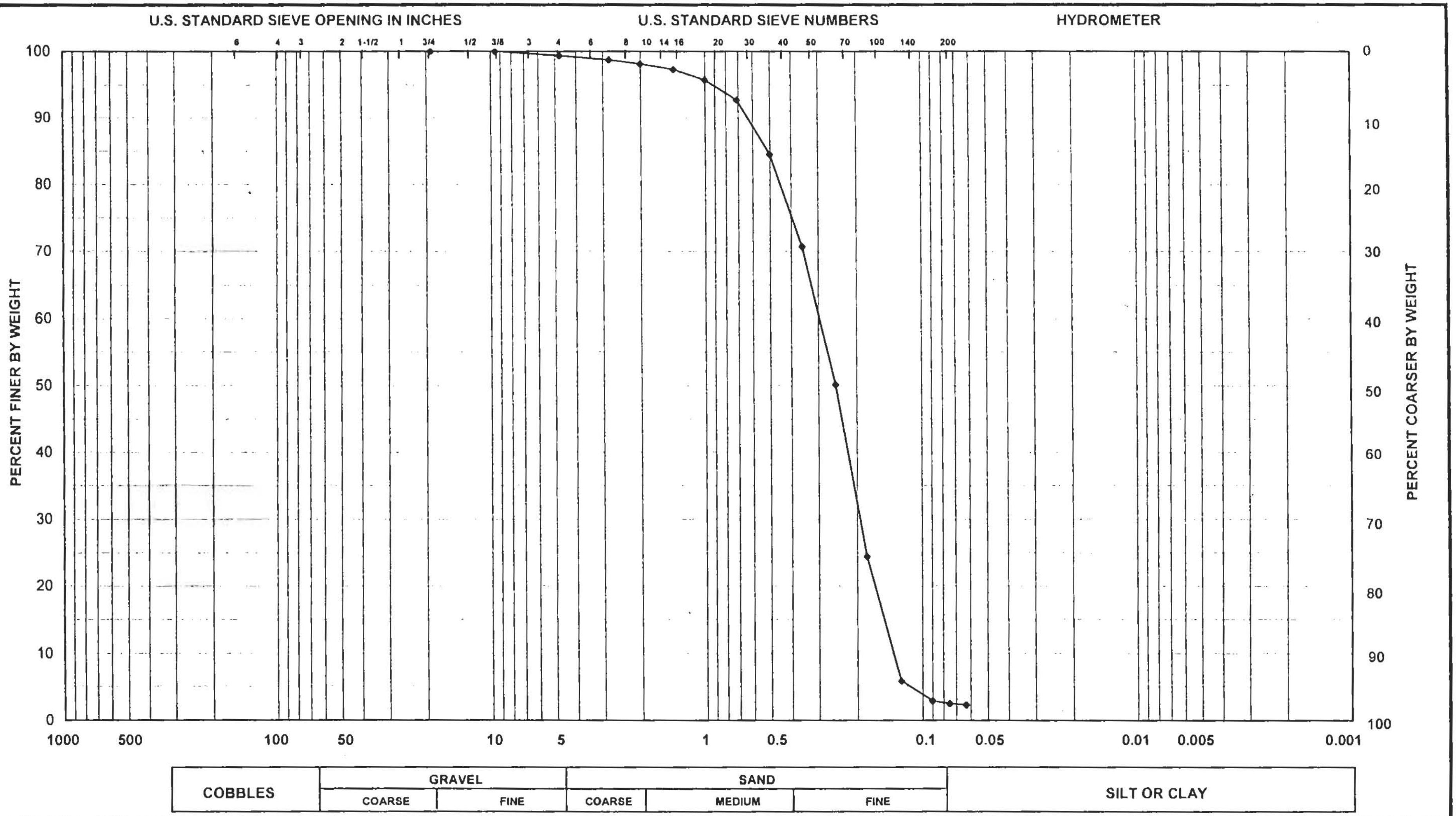
Project:	Ocean Isle Renourishment
Project No.:	2216-01-60
Boring No.:	OI-05-6
Sample No.:	1
Description:	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)
Depth:	10.6'- 11.1'
Date:	8/1/2005

Tare Weight, (g):	49.83	
Dry Wt. Before Washing (g):	144.88	(with tare)
Dry Weight After Washing (g):	143.92	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.39	99.59	100	0.39
#7	2.800	0.91	98.63	100	0.91
#10	2.000	0.56	98.04	100	0.56
#14	1.400	1.12	96.86	100	1.12
#18	1.000	1.97	94.79	100	1.97
#25	0.710	4.05	90.53	80	3.24
#35	0.500	9.14	80.92	50	4.57
#45	0.355	12.68	67.57	50	6.34
#60	0.250	20.68	45.82	30	6.20
#80	0.180	27.15	17.25	10	2.72
#120	0.125	13.83	2.70	5	0.69
#170	0.090	1.50	1.13	1	0.02
#200	0.075	0.06	1.06	1	0.00
#230	0.063	0.01	1.05	1	0.00

Total Shell Content: 20 %

a 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI		
◆ 2	14.6'- 15.1'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	23						Project	Ocean Isle Renourishment
									Area	
									Boring No.	OI-05-06
									Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
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Jacksonville, Florida 32246
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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

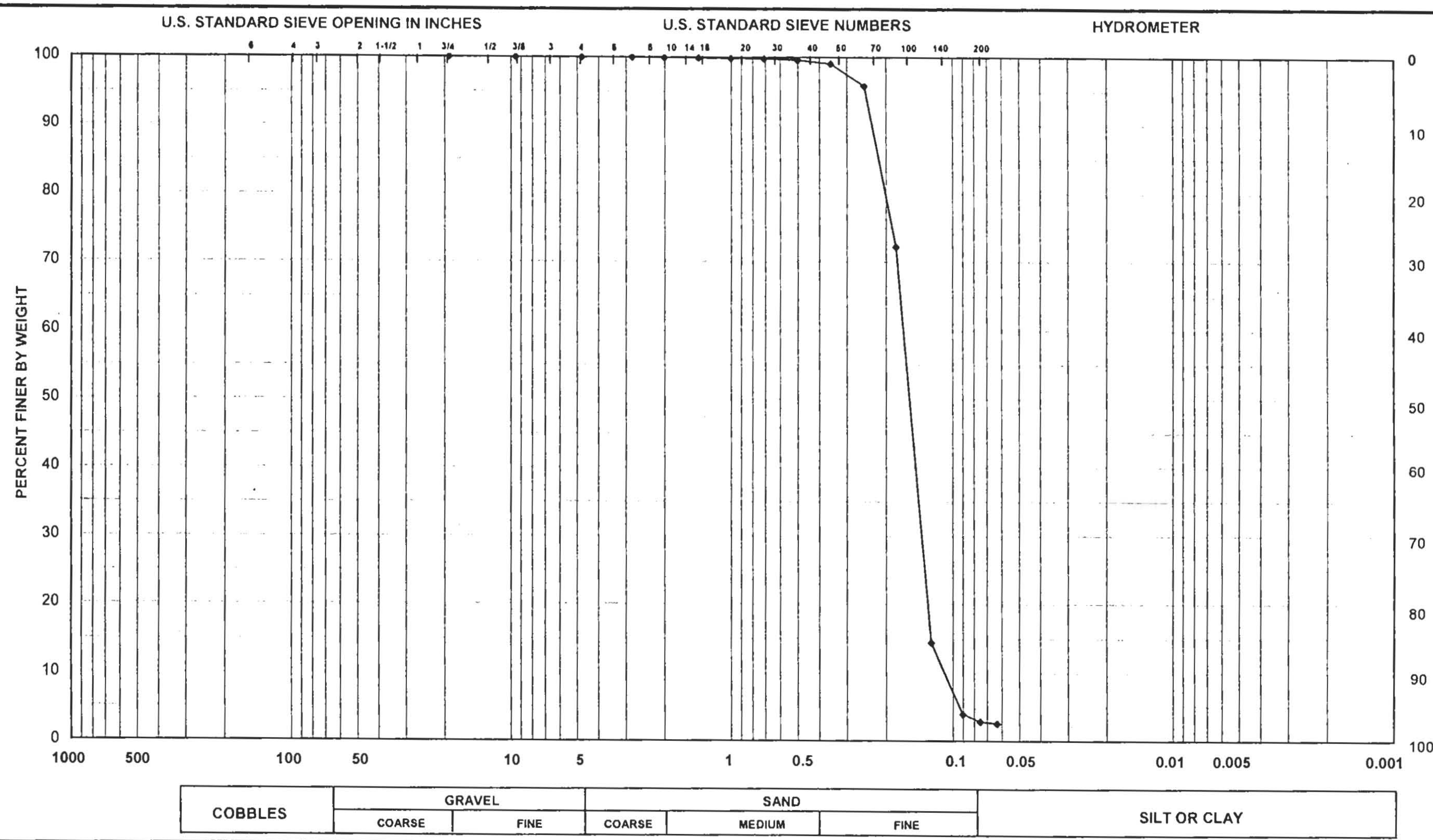
Project:	**Ocean Isle Renourishment**	**Depth:**	**14.6'- 15.1'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-6**		
Sample No.:	**2**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.29	
Dry Wt. Before Washing (g):	163.55	(with tare)
Dry Weight After Washing (g):	161.77	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.73	99.36	100	0.73
#7	2.800	0.70	98.74	100	0.70
#10	2.000	0.65	98.16	100	0.65
#14	1.400	0.94	97.33	100	0.94
#18	1.000	1.77	95.77	95	1.68
#25	0.710	3.42	92.75	80	2.74
#35	0.500	9.35	84.50	70	6.55
#45	0.355	15.65	70.68	50	7.83
#60	0.250	23.25	50.15	30	6.98
#80	0.180	29.13	24.43	20	5.83
#120	0.125	21.09	5.81	10	2.11
#170	0.090	3.35	2.85	5	0.17
#200	0.075	0.45	2.45	1	0.00
#230	0.063	0.23	2.25	1	0.00

Total Shell Content: 23 %

a 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 3	15.5'- 16.0'	SAND, poorly-graded, mostly fine-grained quartz, few carbonate, trace silt, light olive brown (SP)	11					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-06
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
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Jacksonville, Florida 32246
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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**15.5'- 16.0'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-6**		
Sample No.:	**3**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, few carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.53	
Dry Wt. Before Washing (g):	150.54	(with tare)
Dry Weight After Washing (g):	148.01	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.00	100.00	0	0.00
#7	2.800	0.00	100.00	0	0.00
#10	2.000	0.07	99.93	100	0.07
#14	1.400	0.06	99.87	100	0.06
#18	1.000	0.05	99.82	100	0.05
#25	0.710	0.03	99.79	100	0.03
#35	0.500	0.21	99.58	95	0.20
#45	0.355	0.54	99.04	80	0.43
#60	0.250	3.21	95.83	50	1.61
#80	0.180	23.63	72.20	30	7.09
#120	0.125	57.75	14.46	10	5.78
#170	0.090	10.56	3.90	5	0.53
#200	0.075	1.11	2.79	1	0.01
#230	0.063	0.25	2.54	1	0.00

Total Shell Content: 11 %

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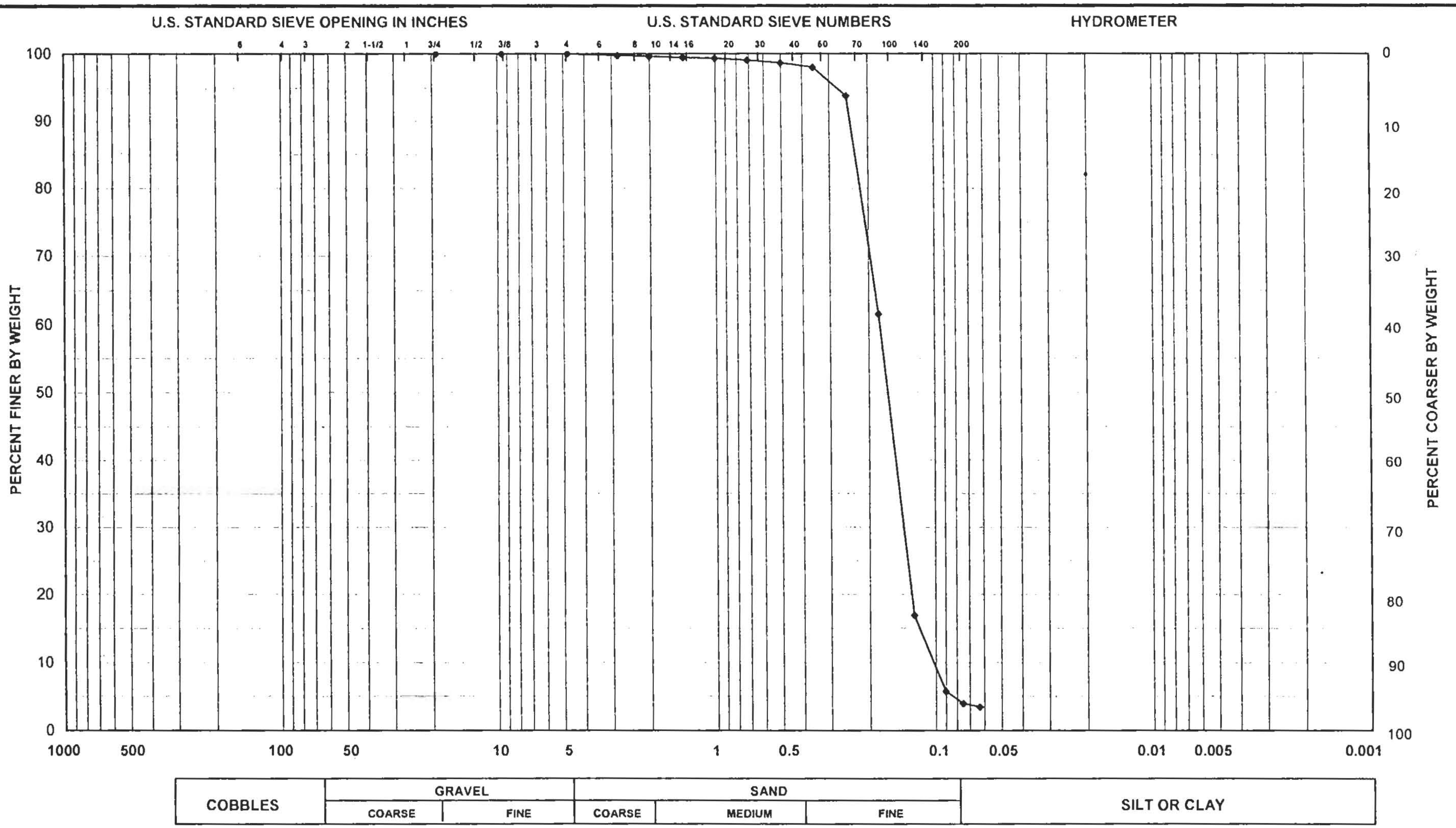

Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI	
◆ 4	18.3'- 18.8'	SAND, poorly-graded, mostly fine-grained quartz, few carbonate, trace silt, light olive brown (SP)	6						Project: Ocean Isle Renourishment
									Area
									Boring No. OI-05-06
									Date 8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
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Jacksonville, Florida 32246
(904) 997-1400 (Tel) · (904) 997-9150 (Fax)

VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**18.3'- 18.8'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-6**		
Sample No.:	**4**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, few carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.18	
Dry Wt. Before Washing (g):	161.3	(with tare)
Dry Weight After Washing (g):	157.92	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.00	100.00	0	0.00
#7	2.800	0.28	99.75	100	0.28
#10	2.000	0.16	99.60	100	0.16
#14	1.400	0.17	99.45	100	0.17
#18	1.000	0.16	99.31	100	0.16
#25	0.710	0.26	99.07	95	0.25
#35	0.500	0.42	98.70	90	0.38
#45	0.355	0.73	98.04	80	0.58
#60	0.250	4.70	93.81	40	1.88
#80	0.180	35.77	61.62	10	3.58
#120	0.125	49.69	16.90	5	2.48
#170	0.090	12.42	5.72	1	0.12
#200	0.075	2.00	3.92	1	0.02
#230	0.063	0.53	3.45	1	0.01

Total Shell Content: **6** **%**

8/2/05

Hole No. OI-05-07

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NC Coord. E 2186577.9 N 57340.5	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number) : OI-05-07	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN : DISTURBED 3 : UNDISTURBED 0
5. NAME OF DRILLER LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
	16. DATE HOLE : STARTED 4/20/05 : COMPLETED 4/20/05
7. THICKNESS OF OVERBURDEN N/A (3.8' of Water)	17. ELEVATION TOP OF HOLE 0.0 MLLW
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING N/A %
9. TOTAL DEPTH OF HOLE 7.4'	19. SIGNATURE OF INSPECTOR KELLY KALTENBACH, GEOLOGIST TRAINEE

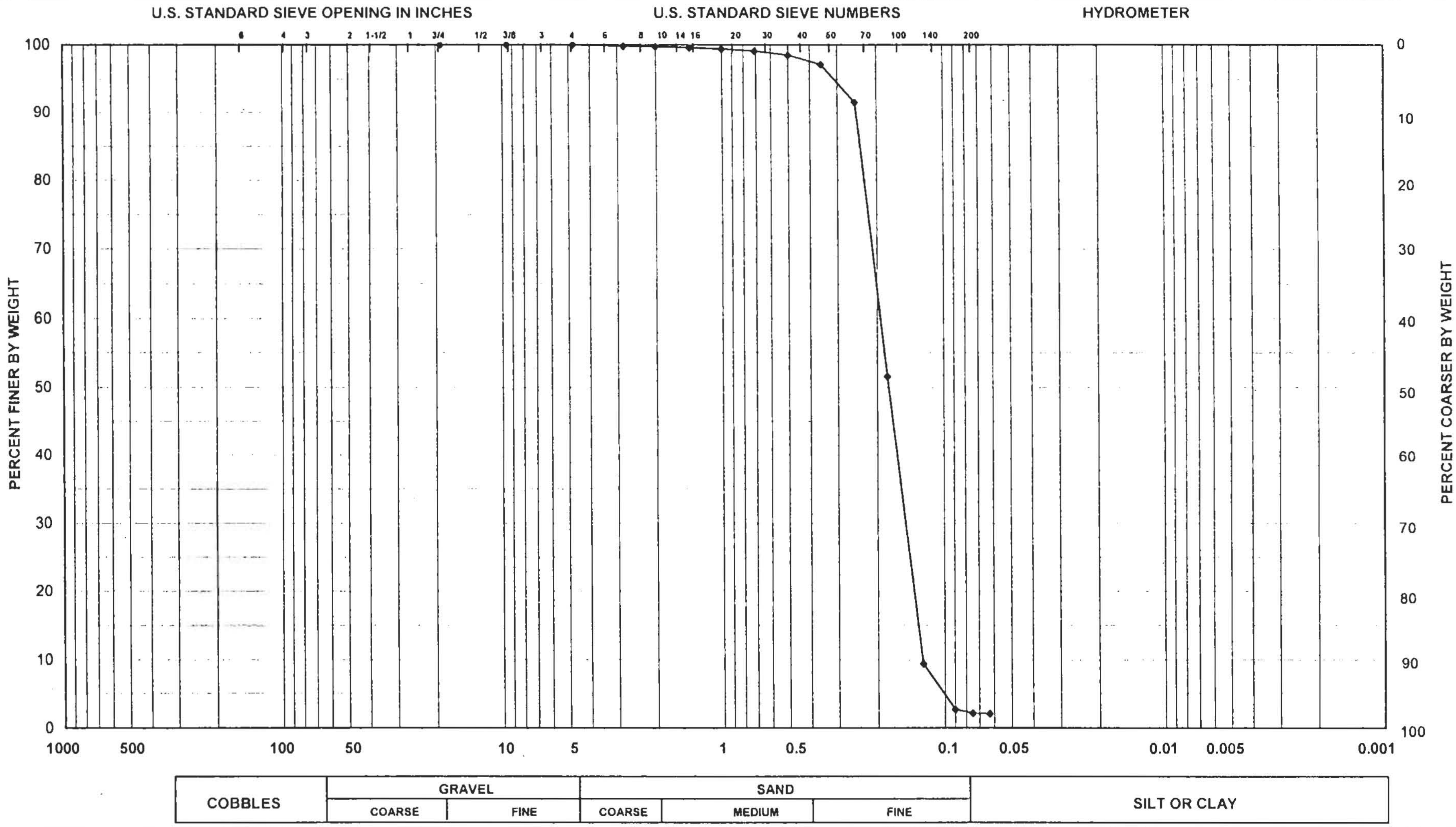
ELEVATION MLLW a	DEPTH feet b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc. if significant) g
0.0	0		0.0' TO 3.8' WATER			Time begin vibracoring: 0839 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	3.0					NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
-3.8	3.8		OCEAN BOTTOM @3.8'		3.8'	
	4.0		SP Gray, fine-medium sand, clean, poorly graded, trace fine sand size shell material.		1	
					4.3'	VIBRACORE BORING From 3.8' to 7.4' Run 5.8' Rec: 3.6'
	5.0					Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
					5.8'	
	6.0				2	
					6.3'	
-6.7	6.7		GP Gray, mottled brown, fine-coarse gravel & rock fragments, Some fine-coarse sand some inorganic silt, some to fine-coarse sand size shell material.		6.7'	
	7.0				3	
					7.2'	
-7.4	7.4		BOTTOM OF HOLE @7.4'			

SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SM

NOTE Assumed vibracore refusal @ 6.8'



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 1	3.8'- 4.3'	SAND, poorly-graded, mostly fine-grained quartz, few carbonate, trace silt, light olive brown (SP)	7					

Project: Ocean Isle Renourishment

Area:

Boring No.: OI-05-07

Date: 8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.

3047-4 St. Johns Bluff Road S.
Jacksonville, Florida 32246
(904) 997-1400 (Tel) · (904) 997-9150 (Fax)

VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

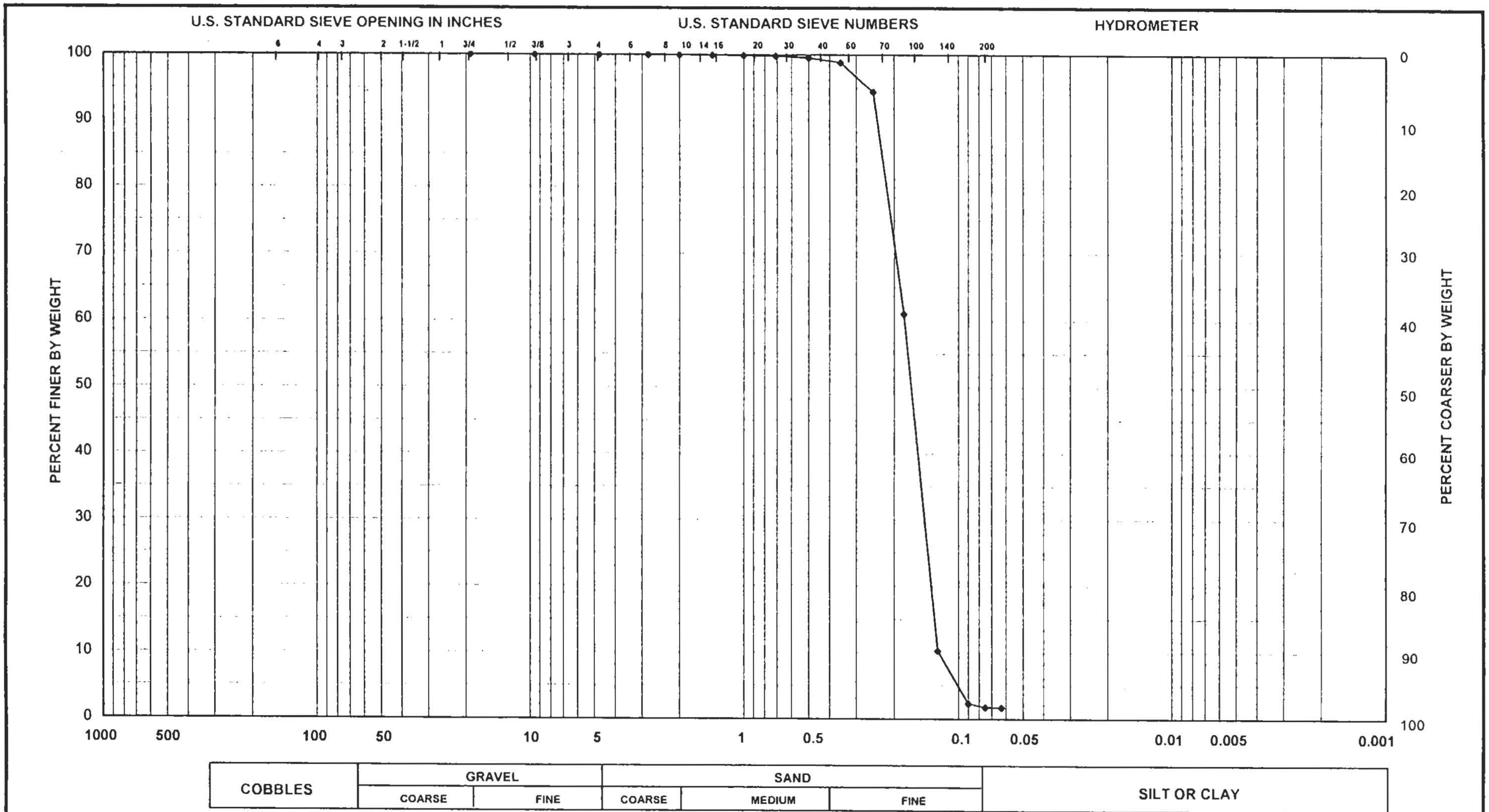
Project:	Ocean Isle Renourishment	Depth:	3.8'- 4.3'
Project No.:	2216-01-60	Date:	8/1/2005
Boring No.:	OI-05-7		
Sample No.:	1		
Description:	SAND, poorly-graded, mostly fine-grained quartz, few carbonate, trace silt, light olive brown (SP)		

Tare Weight, (g):	49.99	
Dry Wt. Before Washing (g):	178.29	(with tare)
Dry Weight After Washing (g):	175.86	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.00	100.00	0	0.00
#7	2.800	0.24	99.81	100	0.24
#10	2.000	0.08	99.75	100	0.08
#14	1.400	0.20	99.59	100	0.20
#18	1.000	0.25	99.40	100	0.25
#25	0.710	0.39	99.10	90	0.35
#35	0.500	0.79	98.48	70	0.55
#45	0.355	1.75	97.12	50	0.88
#60	0.250	7.17	91.53	30	2.15
#80	0.180	51.30	51.54	10	5.13
#120	0.125	54.07	9.40	5	2.70
#170	0.090	8.65	2.66	1	0.09
#200	0.075	0.68	2.13	1	0.01
#230	0.063	0.14	2.02	1	0.00

Total Shell Content: 7 %

8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 2	5.8'- 6.3'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	16					

Project Ocean Isle Renourishment

Area

Boring No. OI-05-07

Date 8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
3047-4 St. Johns Bluff Road S.
Jacksonville, Florida 32246
(904) 997-1400 (Tel) · (904) 997-9150 (Fax)

VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

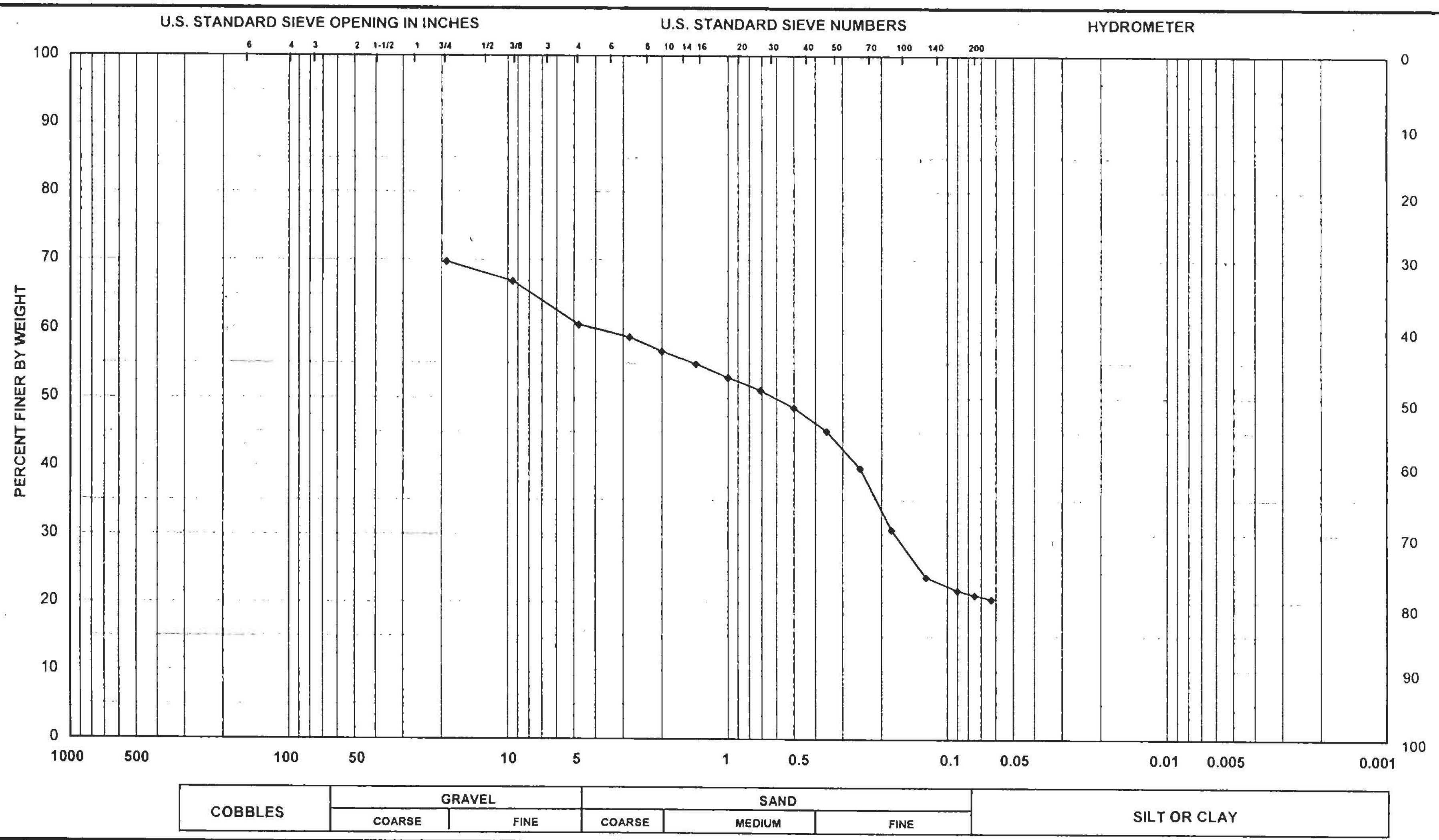
Project:	**Ocean Isle Renourishment**	**Depth:**	**5.8'- 6.3'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-7**		
Sample No.:	**2**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	49.90	
Dry Wt. Before Washing (g):	151.49	(with tare)
Dry Weight After Washing (g):	150.16	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.00	100.00	0	0.00
#7	2.800	0.00	100.00	0	0.00
#10	2.000	0.02	99.98	100	0.02
#14	1.400	0.05	99.93	100	0.05
#18	1.000	0.06	99.87	100	0.06
#25	0.710	0.05	99.82	100	0.05
#35	0.500	0.27	99.56	95	0.26
#45	0.355	0.72	98.85	80	0.58
#60	0.250	4.49	94.43	50	2.25
#80	0.180	33.93	61.03	30	10.18
#120	0.125	51.57	10.27	20	10.31
#170	0.090	8.09	2.30	5	0.40
#200	0.075	0.56	1.75	1	0.01
#230	0.063	0.05	1.70	1	0.00

Total Shell Content: **16** **%**

8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 3	6.7'- 7.2'	SAND, silty, mostly fine-grained quartz sand, little silt, few carbonate, little limestone fragments, olive brown (SM)	7					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-07
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
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Jacksonville, Florida 32246
(904) 997-1400 (Tel) · (904) 997-9150 (Fax)

VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**6.7'- 7.2'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-7**		
Sample No.:	**3**		
Description:	**SAND, silty, mostly fine-grained quartz sand, little silt, few carbonate, little limestone fragments, olive brown (SM)**		

Tare Weight, (g):	50.95	
Dry Wt. Before Washing (g):	145.75	(with tare)
Dry Weight After Washing (g):	127.2	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	28.72	69.70	0	0.00
3/8"	9.500	2.65	66.91	50	1.33
#4	4.750	5.93	60.65	30	1.78
#7	2.800	1.73	58.83	50	0.87
#10	2.000	2.02	56.70	50	1.01
#14	1.400	1.74	54.86	50	0.87
#18	1.000	1.89	52.87	30	0.57
#25	0.710	1.71	51.07	30	0.51
#35	0.500	2.38	48.55	30	0.71
#45	0.355	3.22	45.16	20	0.64
#60	0.250	5.24	39.63	10	0.52
#80	0.180	8.50	30.66	1	0.09
#120	0.125	6.56	23.74	1	0.07
#170	0.090	1.86	21.78	1	0.02
#200	0.075	0.65	21.10	1	0.01
#230	0.063	0.59	20.47	1	0.01

Total Shell Content: 7 %

d 8/2/05

Hole No. OI-05-08A

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

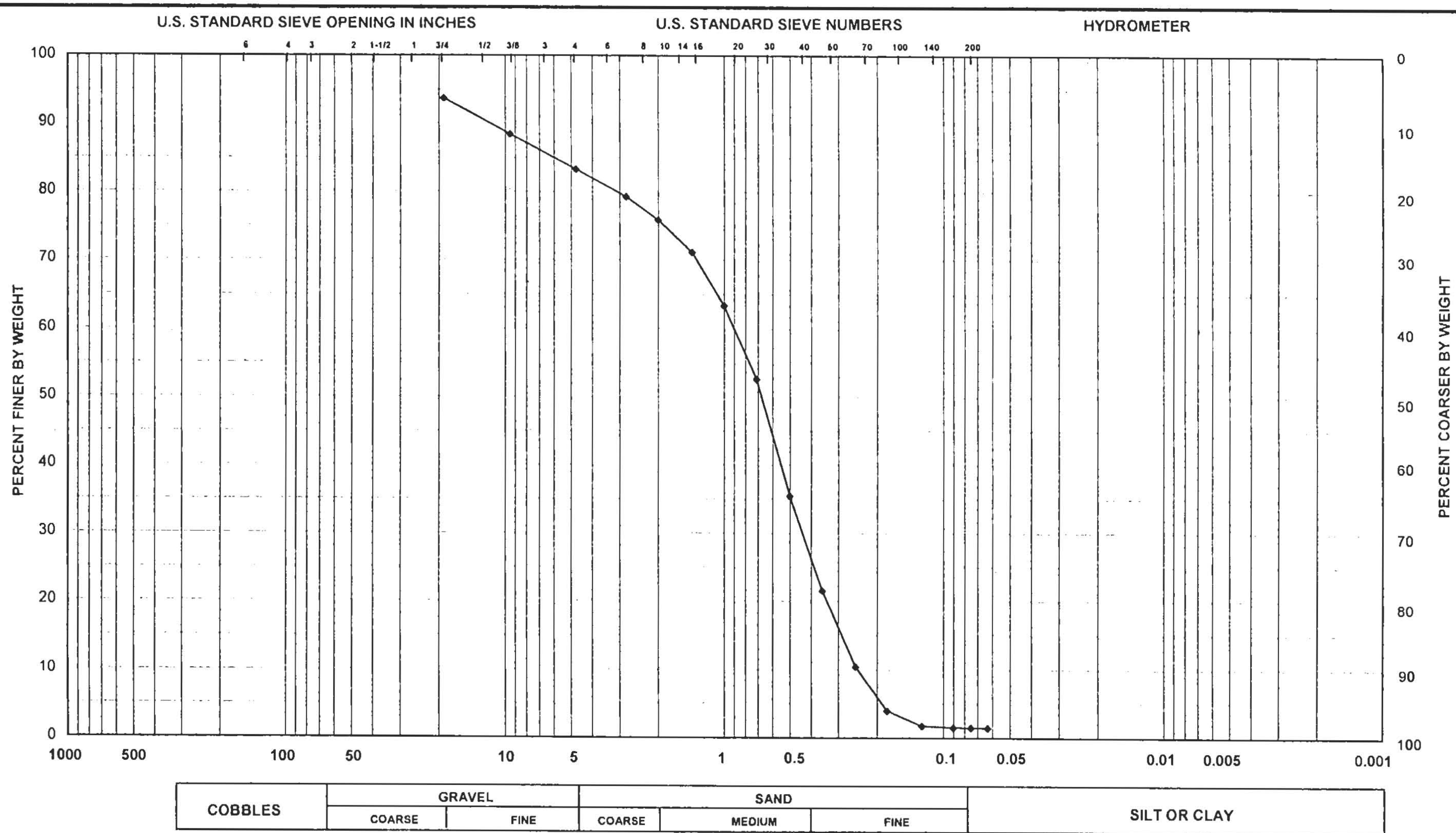
1. PROJECT OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NC Coord. E 2187137.9 N 57204.5	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number) : OI-05-08A	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN : DISTURBED : 4 : UNDISTURBED : 0
5. NAME OF DRILLER LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
	16. DATE HOLE : STARTED : 4/20/05 : COMPLETED : 4/20/05
7. THICKNESS OF OVERBURDEN N/A (3.4' of Water)	17. ELEVATION TOP OF HOLE 0.0 MLLW
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING N/A %
9. TOTAL DEPTH OF HOLE 11.1'	19. SIGNATURE OF INSPECTOR KELLY KALTENBACH, GEOLOGIST TRAINEE

ELEVATION MLLW	DEPTH feet	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
0.0	0		0.0' TO 3.4' WATER			Time begin vibracoring: 1300 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	3.0					
-3.4	3.4		OCEAN BOTTOM @3.4'		3.4'	
			SP Tan, mottled dark gray fine-coarse sand and fine-coarse sand size shell hash. Trace organic silt, organic . Poorly graded, little to some gravel size shell material.		1	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
	4.0				3.9'	VIBRACORE BORING From 3.4' to 11.1' Ran 8.1' Rec: 7.7' Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
	5.0					
	6.0				6.4'	
					2	
			6.9'			
	7.0		shell hash content increases.		6.9'	LAB CLASSIFICATION
			7.3'		7.3'	
			gray mottled, dark gray fine-medium sand little-trace fine-med . sand size shell material. trace organic material poorly graded.		3	
					7.8'	
	8.0					
	9.0					NOTE Assumed vibracore refusal @ 11.1'
			9.4'			
			fine-coarse sand shell content increases few gravel size shell material.		9.9'	
	10.0				4	
					10.4'	
	11.0					
-11.1	11.1		BOTTOM OF HOLE AT 11.1'			
			SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SP

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT OCEAN ISLE RENOURISHMENT | HOLE NO. OI-05 08A



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 1	3.4'- 3.9'	SAND, poorly graded, mostly fine-grained quartz, some carbonate, trace silt, olive brown (SP)	48					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-08A
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

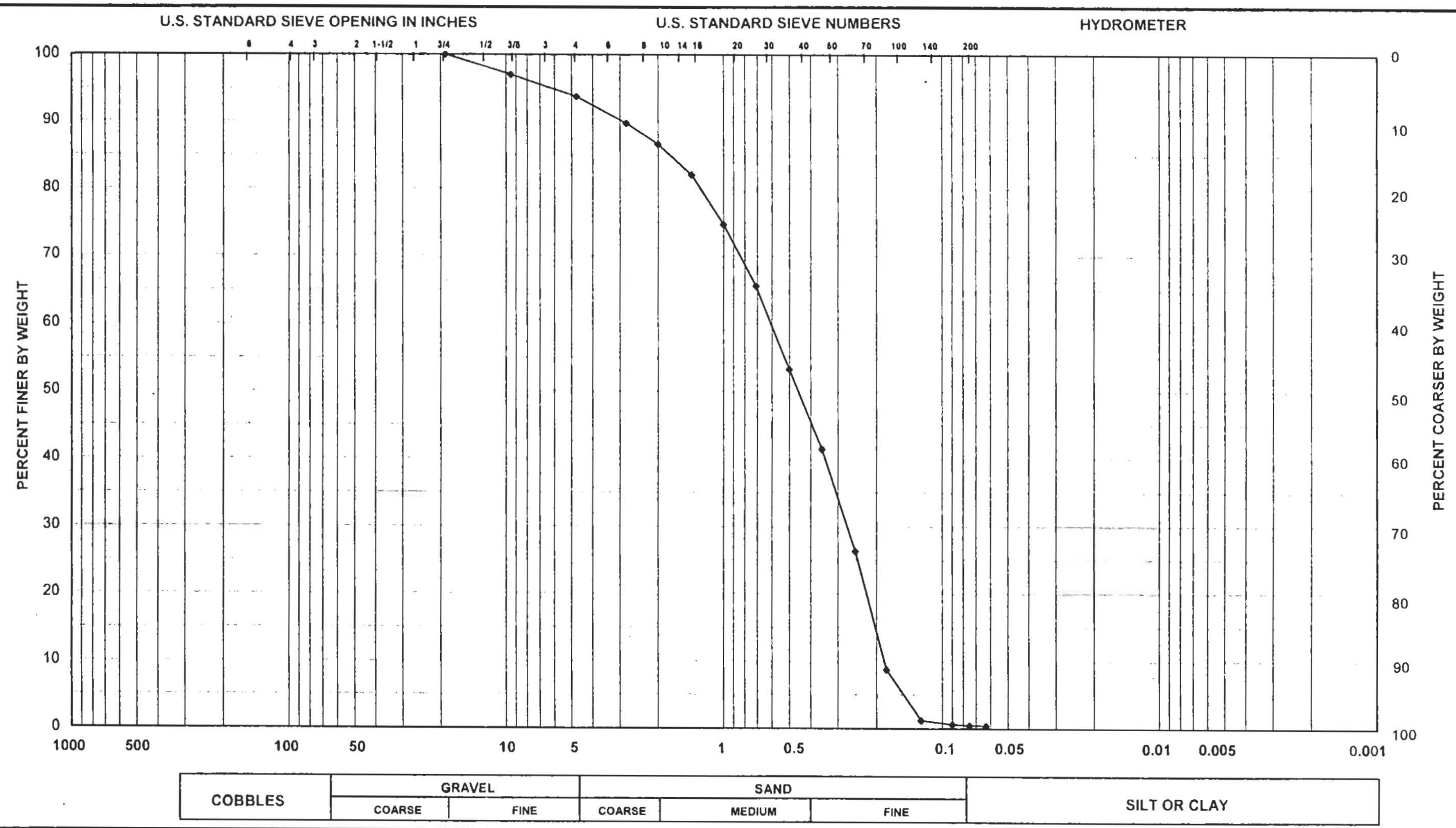
Project:	Ocean Isle Renourishment	Depth:	3.4'- 3.9'
Project No.:	2216-01-60	Date:	8/1/2005
Boring No.:	OI-05-8A		
Sample No.:	1		
Description:	SAND, poorly graded, mostly fine-grained quartz, some carbonate, trace silt, olive brown (SP)		

Tare Weight, (g):	49.48	
Dry Wt. Before Washing (g):	164.92	(with tare)
Dry Weight After Washing (g):	163.7	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	7.26	93.71	100	7.26
3/8"	9.500	6.16	88.37	100	6.16
#4	4.750	5.90	83.26	100	5.90
#7	2.800	4.57	79.31	100	4.57
#10	2.000	4.00	75.84	100	4.00
#14	1.400	5.52	71.06	100	5.52
#18	1.000	8.86	63.38	90	7.97
#25	0.710	12.48	52.57	80	9.98
#35	0.500	19.75	35.46	70	13.83
#45	0.355	16.17	21.46	50	8.09
#60	0.250	12.70	10.46	30	3.81
#80	0.180	7.52	3.94	10	0.75
#120	0.125	2.53	1.75	5	0.13
#170	0.090	0.27	1.52	1	0.00
#200	0.075	0.07	1.46	1	0.00
#230	0.063	0.02	1.44	1	0.00

Total Shell Content: 48 %

a 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 2	6.4'- 6.9'	SAND, poorly graded, mostly fine-grained quartz, some carbonate, trace silt, olive brown (SP)	29					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-08A
Date	8/1/2005

GRADATION CURVES

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**6.4'- 6.9'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-08A**		
Sample No.:	**2**		
Description:	**SAND, poorly graded, mostly fine-grained quartz, some carbonate, trace silt, olive brown (SP)**		

Tare Weight, (g):	49.72	
Dry Wt. Before Washing (g):	148.19	(with tare)
Dry Weight After Washing (g):	147.06	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	2.94	97.01	100	2.94
#4	4.750	3.23	93.73	100	3.23
#7	2.800	3.98	89.69	100	3.98
#10	2.000	3.08	86.56	100	3.08
#14	1.400	4.41	82.09	100	4.41
#18	1.000	7.30	74.67	90	6.57
#25	0.710	8.93	65.60	70	6.25
#35	0.500	12.16	53.25	50	6.08
#45	0.355	11.64	41.43	30	3.49
#60	0.250	14.88	26.32	10	1.49
#80	0.180	17.32	8.73	5	0.87
#120	0.125	7.42	1.20	1	0.07
#170	0.090	0.54	0.65	1	0.01
#200	0.075	0.15	0.50	1	0.00
#230	0.063	0.08	0.42	1	0.00

Total Shell Content: **29 %**

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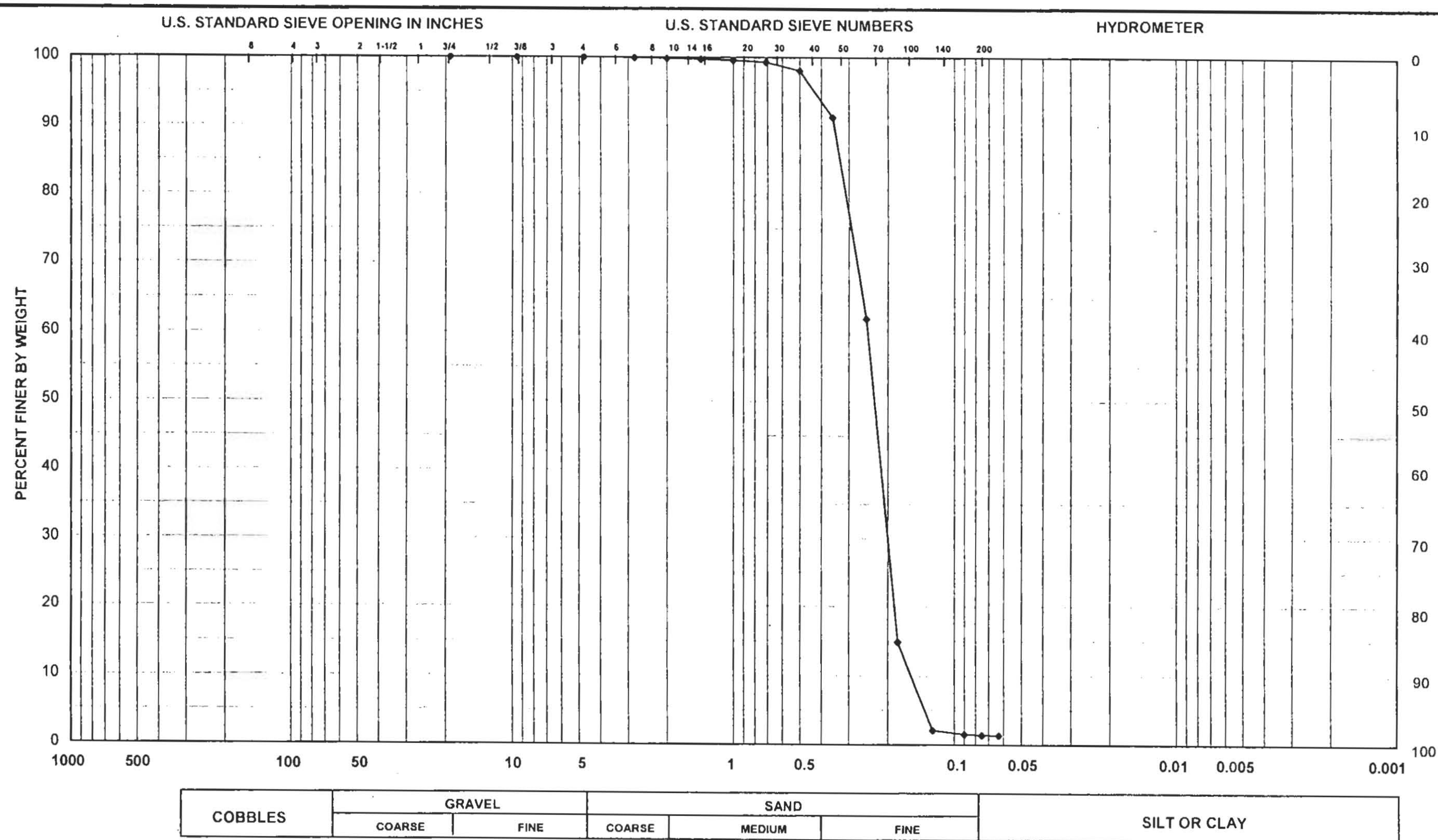

Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 3	7.3'- 7.8'	SAND, poorly graded, mostly fine-grained quartz, little carbonate, trace silt, greenish gray (SP)	26					

Project Ocean Isle Renourishment

Area

Boring No. OI-05-08A

Date 8/1/2005

GRADATION CURVES

ENG FORM 2087

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

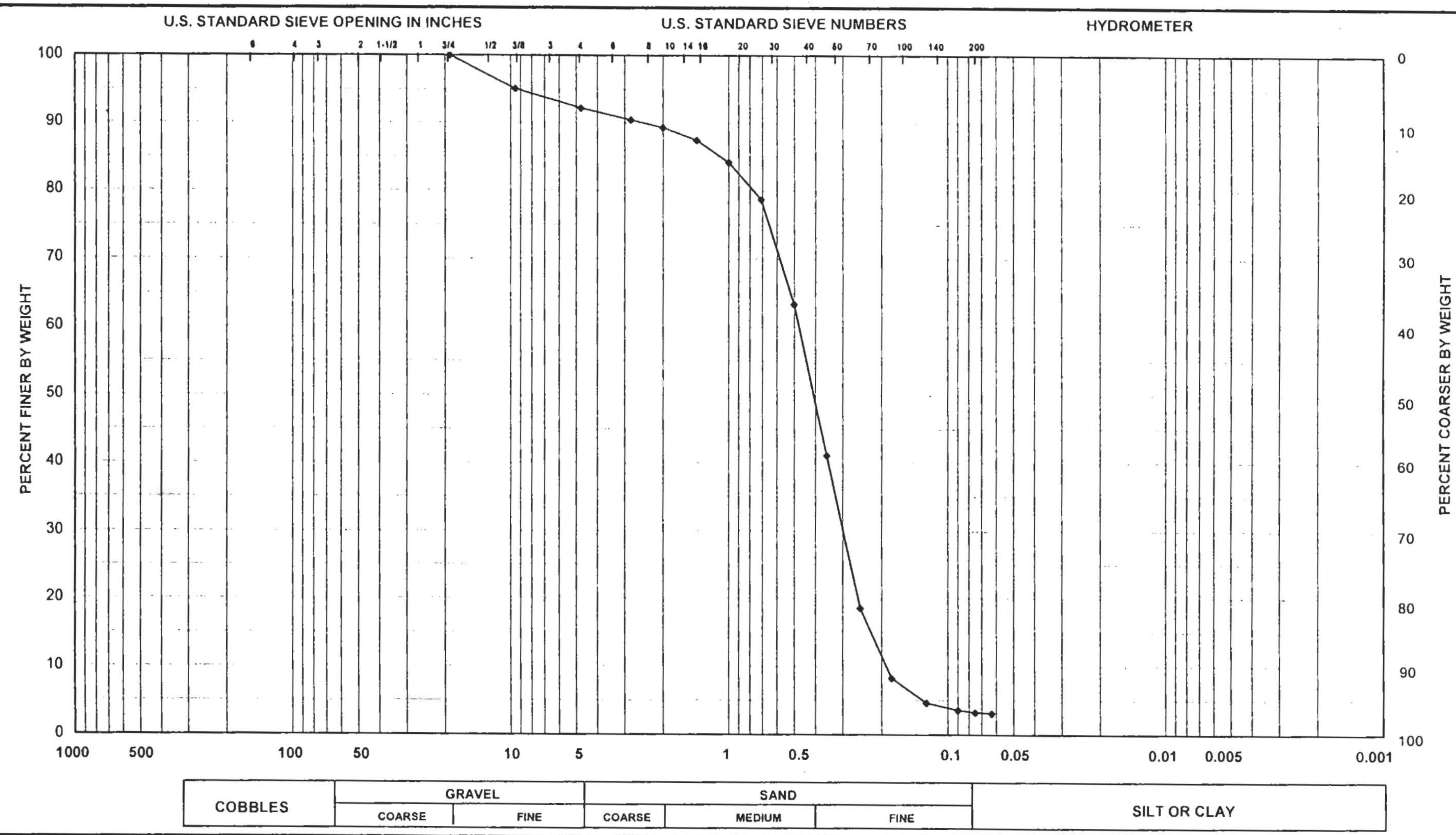
Project: Ocean Isle Renourishment
Depth: 7.3'- 7.8'
Project No.: 2216-01-60
Date: 8/1/2005
Boring No.: OI-05-08A
Sample No.: 3
Description: SAND, poorly graded, mostly fine-grained quartz, little carbonate, trace silt, greenish gray (SP)

Tare Weight, (g): 50.21
Dry Wt. Before Washing (g): 170.68 (with tare)
Dry Weight After Washing (g): 168.96 (with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.00	100.00	0	0.00
#7	2.800	0.08	99.93	100	0.08
#10	2.000	0.11	99.84	100	0.11
#14	1.400	0.11	99.75	100	0.11
#18	1.000	0.19	99.59	100	0.19
#25	0.710	0.32	99.33	100	0.32
#35	0.500	1.44	98.13	90	1.30
#45	0.355	8.34	91.21	70	5.84
#60	0.250	35.16	62.02	50	17.58
#80	0.180	56.81	14.87	30	17.04
#120	0.125	15.40	2.08	10	1.54
#170	0.090	0.68	1.52	1	0.01
#200	0.075	0.19	1.36	1	0.00
#230	0.063	0.07	1.30	1	0.00

Total Shell Content: 26 %

c 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 4	9.9'- 10.4'	SAND, poorly graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)	35					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-08A
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**9.9'- 10.4'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-8A**		
Sample No.:	**4**		
Description:	**SAND, poorly graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.03	
Dry Wt. Before Washing (g):	188.77	(with tare)
Dry Weight After Washing (g):	184.88	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	6.86	95.06	100	6.86
#4	4.750	4.00	92.17	100	4.00
#7	2.800	2.43	90.42	100	2.43
#10	2.000	1.65	89.23	100	1.65
#14	1.400	2.55	87.39	100	2.55
#18	1.000	4.47	84.17	90	4.02
#25	0.710	7.60	78.69	70	5.32
#35	0.500	21.21	63.41	50	10.61
#45	0.355	31.01	41.06	50	15.51
#60	0.250	31.21	18.56	30	9.36
#80	0.180	14.30	8.25	10	1.43
#120	0.125	5.03	4.63	5	0.25
#170	0.090	1.45	3.58	1	0.01
#200	0.075	0.45	3.26	1	0.00
#230	0.063	0.25	3.08	1	0.00

Total Shell Content: **35** %

a 8/2/05

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

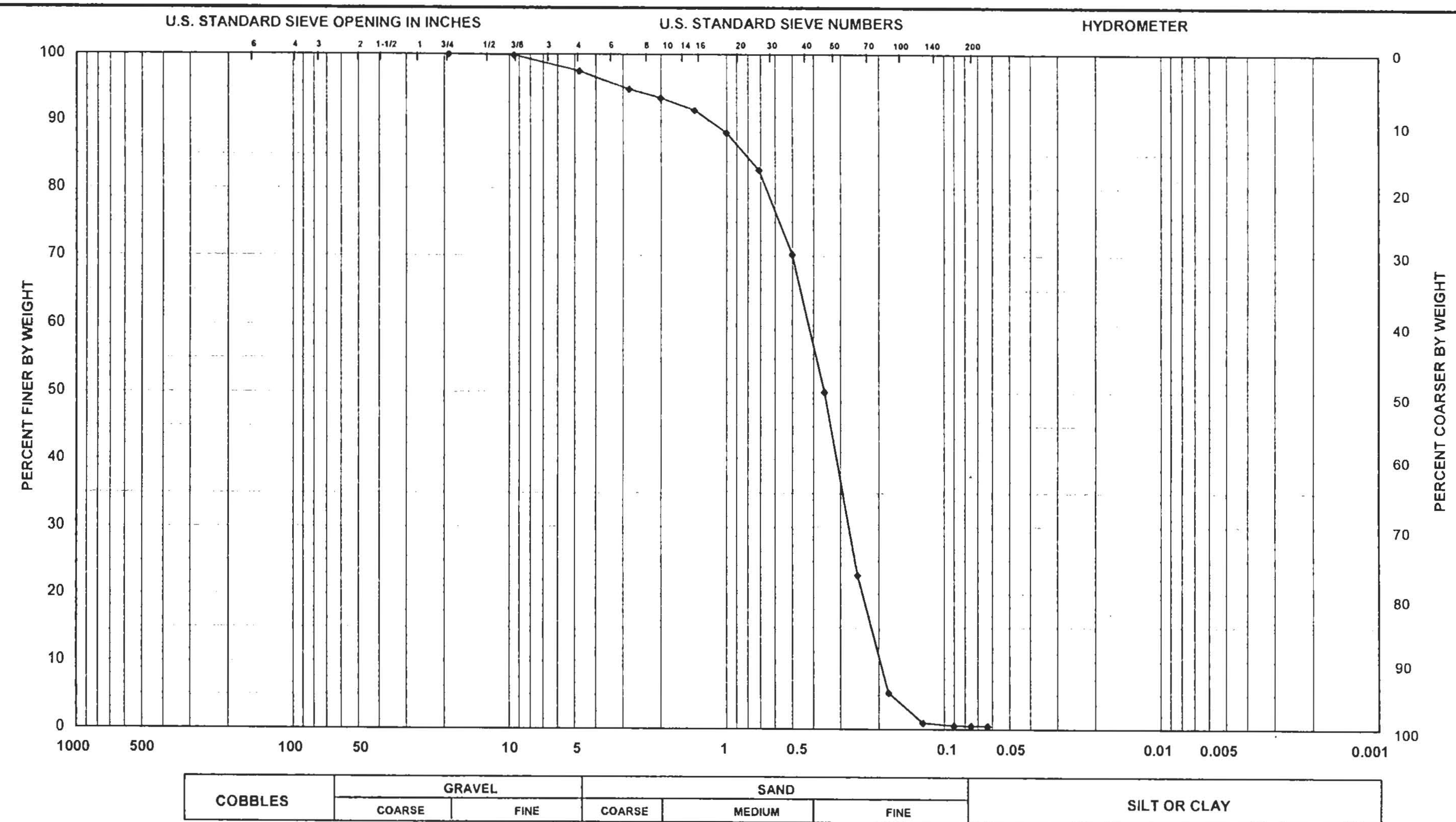
1. PROJECT OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NC Coord. E 2188487.9 N 57557.8	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number) OI-05-09	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2; UNDISTURBED 0
5. NAME OF DRILLER LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE (X) VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
	16. DATE HOLE: STARTED 4/20/05; COMPLETED 4/20/05
7. THICKNESS OF OVERBURDEN N/A (4.7' of Water)	17. ELEVATION TOP OF HOLE 0.0 MLLW
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING N/A %
9. TOTAL DEPTH OF HOLE 8.9'	19. SIGNATURE OF INSPECTOR KELLY KALTENBACH, GEOLOGIST TRAINEE

ELEVATION MLLW	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
0.0	0		0.0' TO 4.7' WATER			Time begin vibracoring: 1320 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	4.0					NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
-4.7	4.7		OCEAN BOTTOM @ 4.7'		4.7'	
	5.0		SP Gray-tan, fine-coarse sand, clean, poorly graded. Little fine-medium sand sized shell material.		1	
					5.2'	VIBRACORE BORING From 4.7' to 8.9' Ran 4.9' Rec: 4.2' Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
	6.0					
	7.0					
	8.0				8.2'	
					2	
					8.7'	
-8.9	8.9		BOTTOM OF HOLE @8.9'			
	9.0		SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE Assumed vibracore refusal @ 8.9'

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP

ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE. MAR 71



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 1	4.7'- 5.2'	SAND, poorly-graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)	33					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-09
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

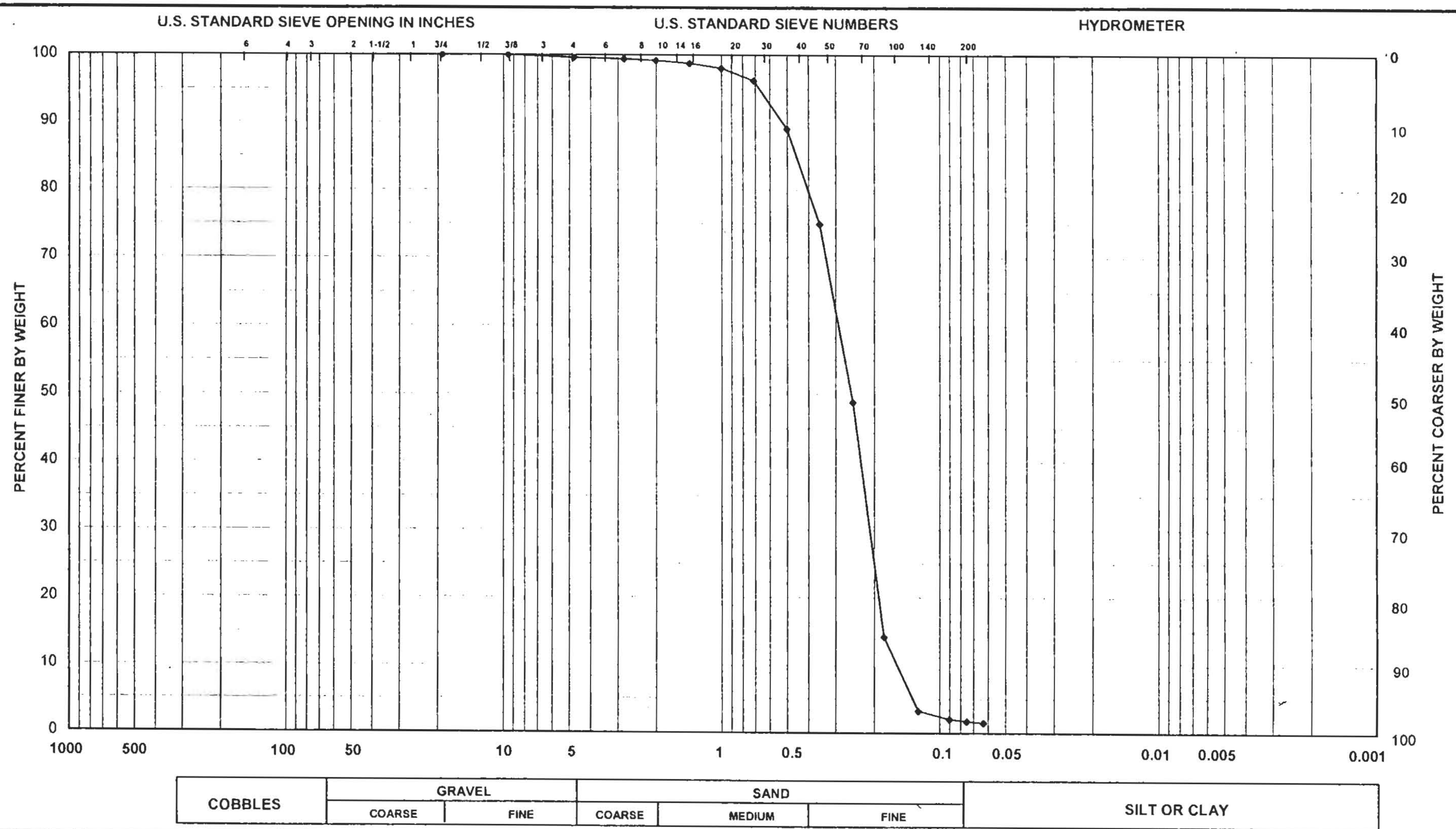
Project:	**Ocean Isle Renourishment**	**Depth:**	**4.7'- 5.2'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-9**		
Sample No.:	**1**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	49.90	
Dry Wt. Before Washing (g):	162.09	(with tare)
Dry Weight After Washing (g):	161.23	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.16	99.86	100	0.16
#4	4.750	2.66	97.49	100	2.66
#7	2.800	3.01	94.80	100	3.01
#10	2.000	1.49	93.48	100	1.49
#14	1.400	2.07	91.63	100	2.07
#18	1.000	3.80	88.24	95	3.61
#25	0.710	6.20	82.72	80	4.96
#35	0.500	14.01	70.23	70	9.81
#45	0.355	22.63	50.06	50	11.32
#60	0.250	30.58	22.80	30	9.17
#80	0.180	19.63	5.30	20	3.93
#120	0.125	4.91	0.93	5	0.25
#170	0.090	0.39	0.58	1	0.00
#200	0.075	0.06	0.53	1	0.00
#230	0.063	0.02	0.51	1	0.00

Total Shell Content: **33** %

a 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 2	8.2'- 8.7'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	19					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-09
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**8.2'- 8.7'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-9**		
Sample No.:	**2**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.32	
Dry Wt. Before Washing (g):	163.59	(with tare)
Dry Weight After Washing (g):	161.65	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.45	99.60	100	0.45
#7	2.800	0.24	99.39	100	0.24
#10	2.000	0.27	99.15	100	0.27
#14	1.400	0.44	98.76	100	0.44
#18	1.000	0.83	98.03	100	0.83
#25	0.710	2.02	96.25	90	1.82
#35	0.500	8.12	89.08	70	5.68
#45	0.355	16.05	74.91	50	8.03
#60	0.250	29.58	48.79	30	8.87
#80	0.180	39.10	14.28	10	3.91
#120	0.125	12.49	3.25	5	0.62
#170	0.090	1.37	2.04	1	0.01
#200	0.075	0.34	1.74	1	0.00
#230	0.063	0.24	1.53	1	0.00

Total Shell Content: **19 %**

ℓ 8/2/05

Hole No. OI-05-10

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

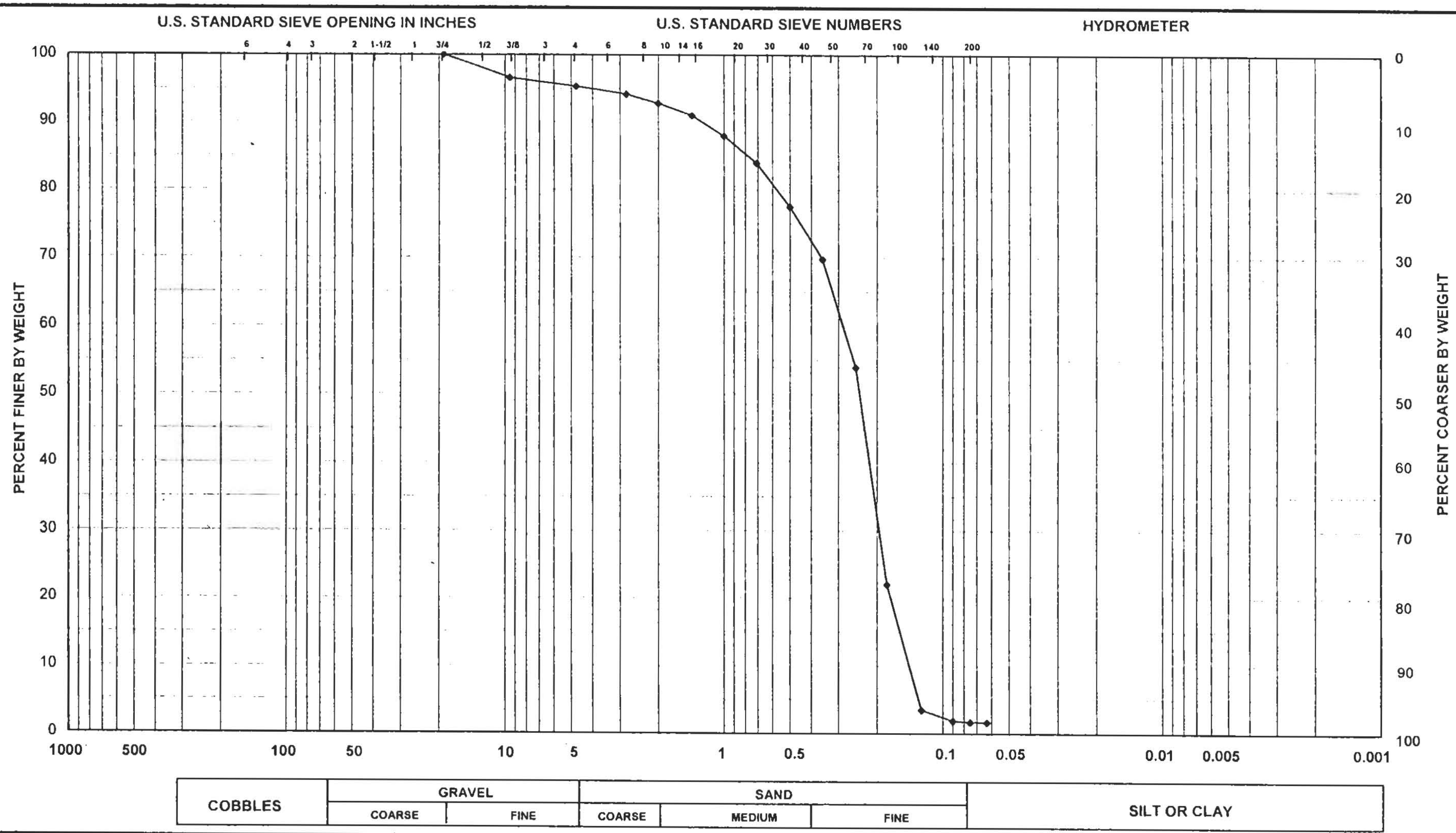
1. PROJECT: OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NC Coord. E 2187473.4 N 57045.6	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number): OI-05-10	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED: 4; UNDISTURBED: 0
5. NAME OF DRILLER: LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: (X) VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. THICKNESS OF OVERBURDEN: N/A (7.6' of Water)	16. DATE HOLE: STARTED 4/20/05; COMPLETED 4/20/05
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0 MLLW
9. TOTAL DEPTH OF HOLE: 17.9'	18. TOTAL CORE RECOVERY FOR BORING: N/A %
	19. SIGNATURE OF INSPECTOR: KELLY KALTENBACH, GEOLOGIST TRAINEE

ELEVATION MLLW	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
0.0	0		0.0' TO 7.6' WATER			Time begin vibracoring: 0931 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	7.0					
7.6	7.6		OCEAN BOTTOM @7.6'		7.6'	
			SP Tan-light gray, fine-coarse sand, some fine-coarse gravel size shell material. Contains gravel size rock fragments, poorly graded.		1 / 8.1'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
	9.0					VIBRACORE BORING: From 7.6' to 17.9' Ran 10.3' Rec: 10.3'
			10.7' fine to medium sand little to some fine to medium shell material no gravel size material.			
	11.0				11.6' / 2 / 12.1'	Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
-12.5	12.5		12.5' SP-SM Gray, mottled with tan fine-medium sand, poorly sorted, T/silty material trace to little fine shell material, contains thin lenses of organic material (worm burrows).		12.5' / 3 / 13.0'	
	13.0					
	15.0					LAB CLASSIFICATION
	17.0		17.2'		17.2'	
-17.2	17.2		SM Brown, fine to medium silty sand, little shell material.		4 / 17.7'	
-17.9	17.9		BOTTOM OF HOLE @ 17.9'			NOTE Assumed vibracore refusal @ 17.9'

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SM

SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 1	7.6'- 8.1'	SAND, poorly-graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)	31					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-10
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
3047-4 St. Johns Bluff Road S.
Jacksonville, Florida 32246
(904) 997-1400 (Tel) · (904) 997-9150 (Fax)

VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

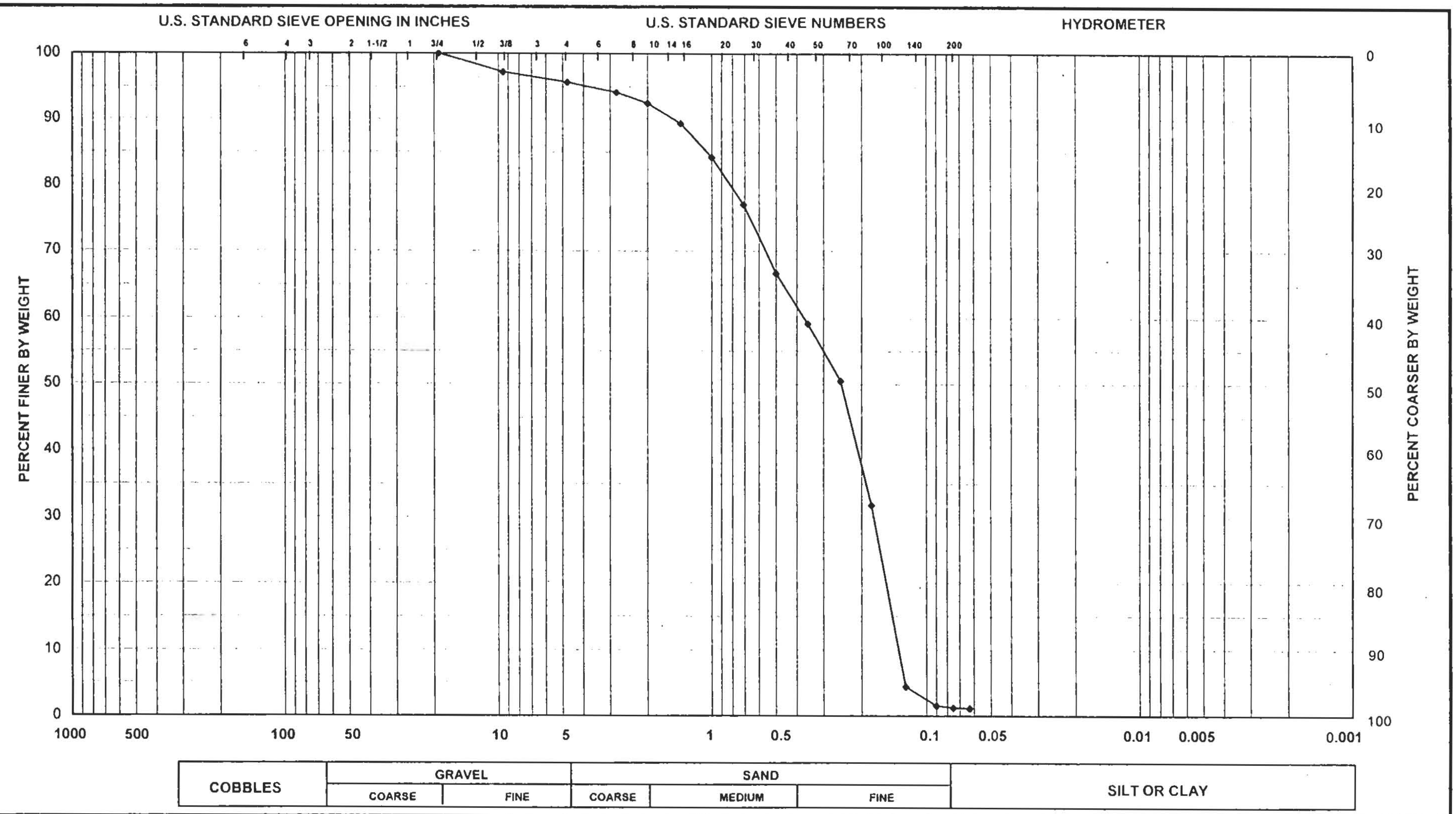
Project: Ocean Isle Renourishment
Depth: 7.6'- 8.1'
Project No.: 2216-01-60
Date: 8/1/2005
Boring No.: OI-05-10
Sample No.: 1
Description: SAND, poorly-graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)

Tare Weight, (g): 50.31
Dry Wt. Before Washing (g): 163.65 (with tare)
Dry Weight After Washing (g): 162.21 (with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	3.86	96.59	100	3.86
#4	4.750	1.45	95.31	100	1.45
#7	2.800	1.33	94.14	100	1.33
#10	2.000	1.52	92.80	100	1.52
#14	1.400	2.05	90.99	100	2.05
#18	1.000	3.49	87.91	95	3.32
#25	0.710	4.50	83.94	80	3.60
#35	0.500	7.28	77.52	70	5.10
#45	0.355	8.79	69.76	70	6.15
#60	0.250	17.94	53.94	50	8.97
#80	0.180	36.21	21.99	30	10.86
#120	0.125	21.03	3.43	10	2.10
#170	0.090	1.77	1.87	1	0.02
#200	0.075	0.21	1.69	1	0.00
#230	0.063	0.01	1.68	1	0.00

Total Shell Content: 31 %

8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 2	11.6'- 12.1'	SAND, poorly-graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)	31					

Project Ocean Isle Renourishment

Area

Boring No. OI-05-10

Date 8/1/2005

GRADATION CURVES

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

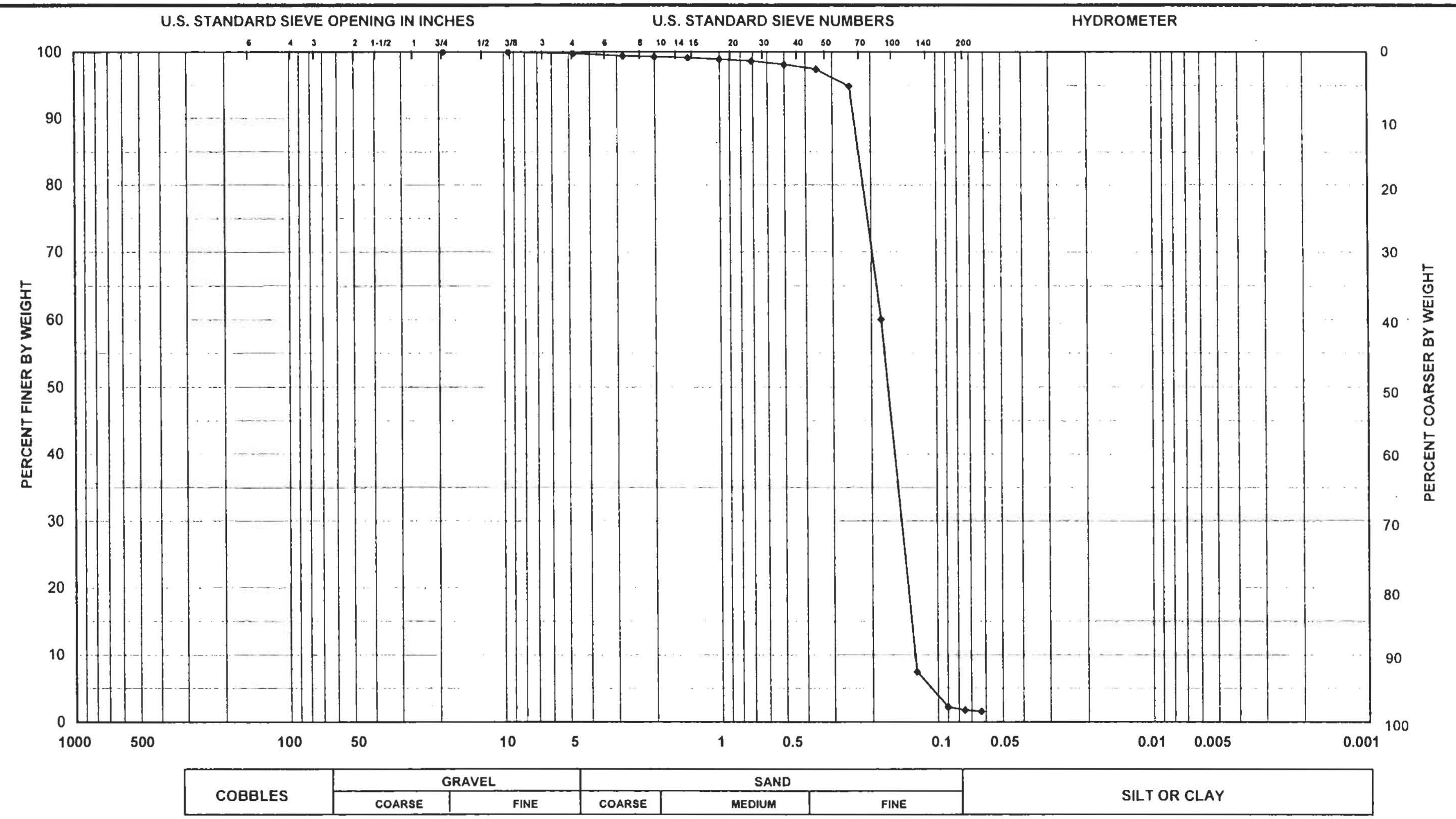
Project:	**Ocean Isle Renourishment**	**Depth:**	**11.6'- 12.1'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-10**		
Sample No.:	**2**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.13	
Dry Wt. Before Washing (g):	157.83	(with tare)
Dry Weight After Washing (g):	156.31	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	3.02	97.20	100	3.02
#4	4.750	1.66	95.65	100	1.66
#7	2.800	1.64	94.13	100	1.64
#10	2.000	1.82	92.44	100	1.82
#14	1.400	3.34	89.34	100	3.34
#18	1.000	5.55	84.19	95	5.27
#25	0.710	7.71	77.03	80	6.17
#35	0.500	11.10	66.72	70	7.77
#45	0.355	8.17	59.14	70	5.72
#60	0.250	9.32	50.48	50	4.66
#80	0.180	20.07	31.85	30	6.02
#120	0.125	29.60	4.36	5	1.48
#170	0.090	3.09	1.49	1	0.03
#200	0.075	0.30	1.22	1	0.00
#230	0.063	0.09	1.13	1	0.00

Total Shell Content: **31** %

d 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI		
• 3	12.5'- 13.0'	SAND, poorly-graded, mostly fine-grained quartz, few carbonate, trace silt, greenish gray (SP)	13						Project	Ocean Isle Renourishment
									Area	
									Boring No.	OI-05-10
									Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

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VISUAL SHELL CONTENT

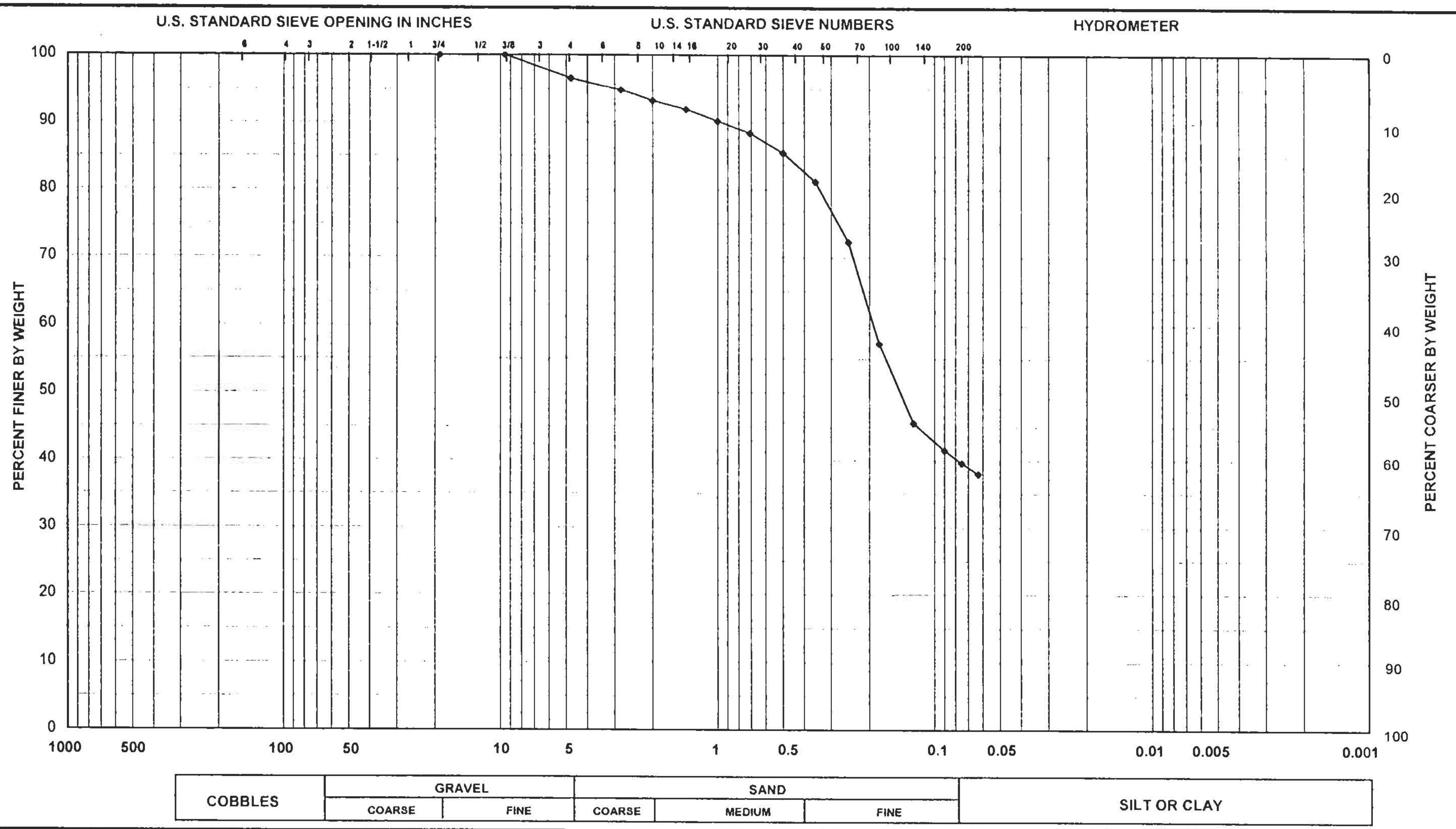
GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**12.5'- 13.0'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-10**		
Sample No.:	**3**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, few carbonate, trace silt, greenish gray (SP)**		

Tare Weight, (g):	50.09	
Dry Wt. Before Washing (g):	158.54	(with tare)
Dry Weight After Washing (g):	156.75	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.26	99.76	100	0.26
#7	2.800	0.39	99.40	100	0.39
#10	2.000	0.11	99.30	100	0.11
#14	1.400	0.19	99.12	100	0.19
#18	1.000	0.23	98.91	100	0.23
#25	0.710	0.31	98.63	100	0.31
#35	0.500	0.55	98.12	90	0.50
#45	0.355	0.73	97.45	70	0.51
#60	0.250	2.75	94.91	50	1.38
#80	0.180	37.82	60.04	30	11.35
#120	0.125	57.00	7.48	10	5.70
#170	0.090	5.68	2.24	1	0.06
#200	0.075	0.50	1.78	1	0.01
#230	0.063	0.21	1.59	1	0.00

Total Shell Content: **13 %**



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 4	17.2'- 17.7'	SAND, silty, mostly fine-grained quartz sand, some silt, few carbonate, trace limestone fragments, olive brown (SM)	8					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-10
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project: Ocean Isle Renourishment
Depth: 17.2'- 17.7'
Project No.: 2216-01-60
Date: 8/1/2005
Boring No.: OI-05-10
Sample No.: 4
Description: SAND, silty, mostly fine-grained quartz sand, some silt, few carbonate, trace limestone fragments, olive brown (SM)

Tare Weight, (g): 49.77
Dry Wt. Before Washing (g): 147.7 (with tare)
Dry Weight After Washing (g): 110.73 (with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	3.36	96.57	25	0.84
#7	2.800	1.70	94.83	50	0.85
#10	2.000	1.56	93.24	30	0.47
#14	1.400	1.29	91.92	20	0.26
#18	1.000	1.68	90.21	20	0.34
#25	0.710	1.80	88.37	20	0.36
#35	0.500	2.88	85.43	30	0.86
#45	0.355	4.17	81.17	30	1.25
#60	0.250	8.75	72.24	20	1.75
#80	0.180	14.66	57.27	10	1.47
#120	0.125	11.45	45.57	5	0.57
#170	0.090	4.00	41.49	1	0.04
#200	0.075	1.87	39.58	1	0.02
#230	0.063	1.60	37.95	1	0.02

Total Shell Content: 8 %

L 8/2/05

Hole No. OI-05-11

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NC Coord. E 2187039.7 N 56840.9	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number) : OI-05-11	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN : DISTURBED 3 : UNDISTURBED 0
5. NAME OF DRILLER LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE (X) VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
	16. DATE HOLE : STARTED 4/20/05 : COMPLETED 4/20/05
7. THICKNESS OF OVERBURDEN N/A (8.2' of Water)	17. ELEVATION TOP OF HOLE 0.0 MLLW
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING N/A %
9. TOTAL DEPTH OF HOLE 13.7'	19. SIGNATURE OF INSPECTOR KELLY KALTENBACH, GEOLOGIST TRAINEE

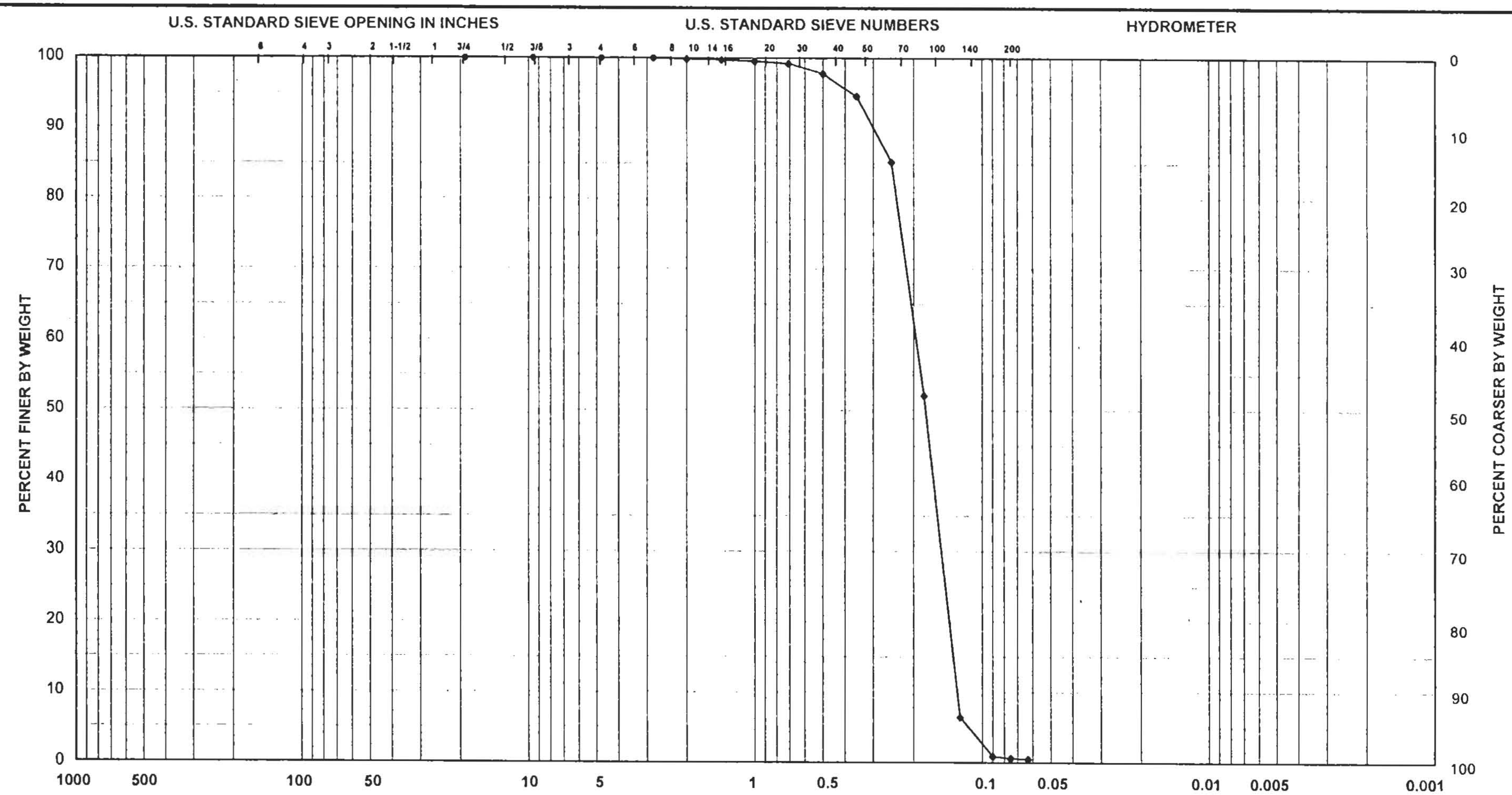
ELEVATION MLLW a	DEPTH feet b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
0.0	0		0.0' TO 8.2' WATER			Time begin vibracoring: 1013 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	8.0		OCEAN BOTTOM @8.2'		8.2'	
8.2	8.2		SP Tan-light gray, fine-medium sand, clean, poorly graded, trace fine-coarse sand size shell material. Contains a few black organic silty lenses 2mm in thickness.		1	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
					8.7'	
	9.0					VIBRACORE BORING From 8.2' to 13.7' Ran 8.2' Rec: 5.5' Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
	10.0					
	11.0				11.2'	
					2	
					11.7'	
	12.0		12.6' some coarse shelly material, little black organic silty sand.			LAB CLASSIFICATION
	13.0		13.0'		13.0'	
			MH Brown to dark gray sandy silt, little fine-medium sand. Little shell material, inorganic trace ore silt.		3	
					13.5'	
-13.7	13.7		BOTTOM OF HOLE @13.7'			
	14.0		SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE Assumed vibracore refusal@ 13.7'

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SM

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT OCEAN ISLE RENOURISHMENT | HOLE NO. OI-05 11



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 1	8.2'- 8.7'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, greenish gray (SP)	15					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-11
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
3047-4 St. Johns Bluff Road S.
Jacksonville, Florida 32246
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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

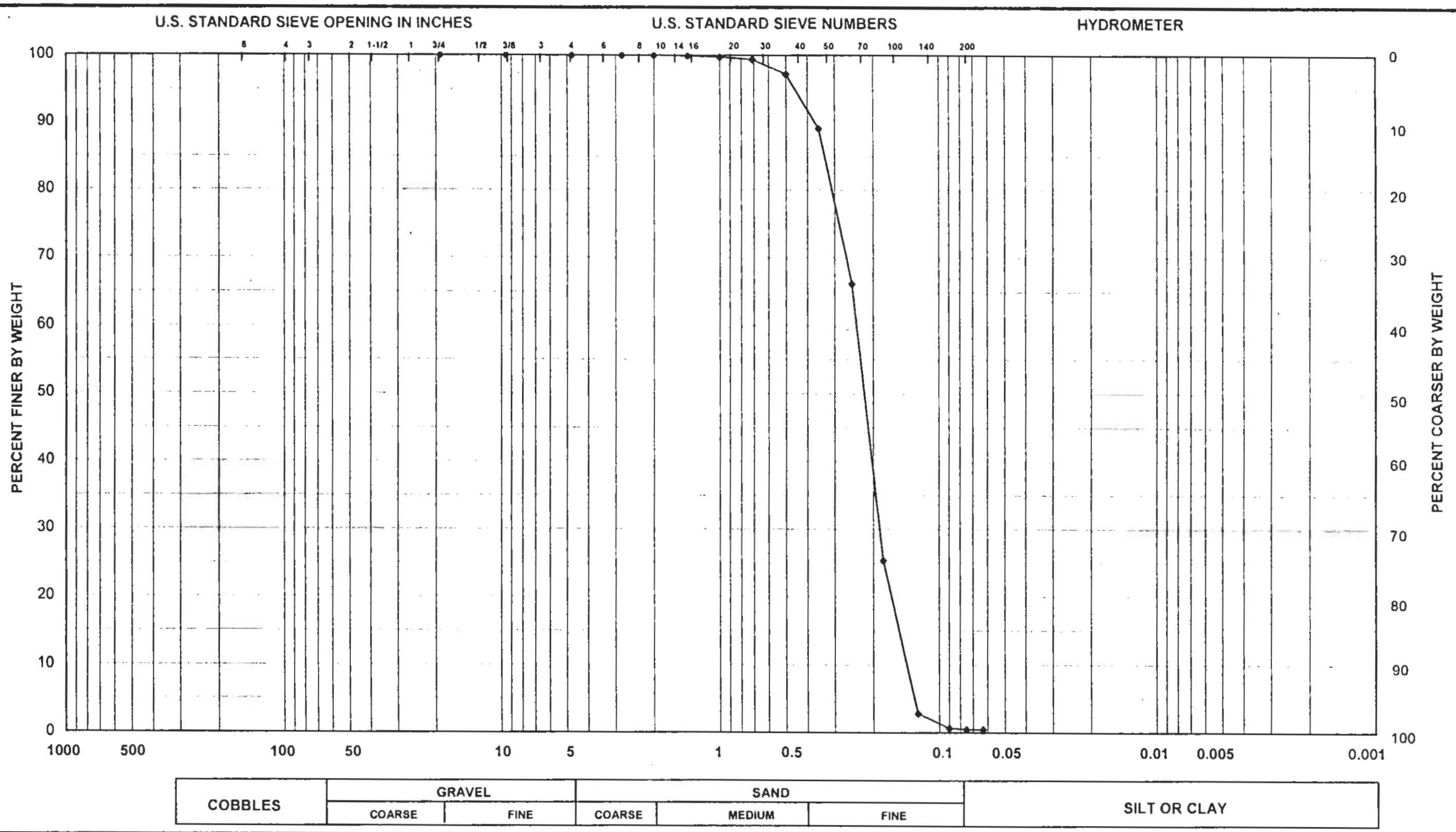
Project: Ocean Isle Renourishment
Depth: 8.2'- 8.7'
Project No.: 2216-01-60
Date: 8/1/2005
Boring No.: OI-05-11
Sample No.: 1
Description: SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, greenish gray (SP)

Tare Weight, (g): 50.18
Dry Wt. Before Washing (g): 138.64 (with tare)
Dry Weight After Washing (g): 137.71 (with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.00	100.00	0	0.00
#7	2.800	0.01	99.99	100	0.01
#10	2.000	0.12	99.85	100	0.12
#14	1.400	0.12	99.72	100	0.12
#18	1.000	0.15	99.55	100	0.15
#25	0.710	0.31	99.20	100	0.31
#35	0.500	1.21	97.83	60	0.73
#45	0.355	2.85	94.61	50	1.43
#60	0.250	8.32	85.20	50	4.16
#80	0.180	29.33	52.05	30	8.80
#120	0.125	40.36	6.42	10	4.04
#170	0.090	4.91	0.87	5	0.25
#200	0.075	0.24	0.60	1	0.00
#230	0.063	0.08	0.51	1	0.00

Total Shell Content: 15 %

8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 2	11.2'- 11.7'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, greenish gray (SP)	20					

Project Ocean Isle Renourishment

Area

Boring No. OI-05-11

Date 8/1/2005

GRADATION CURVES

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3047-4 St. Johns Bluff Road S.
Jacksonville, Florida 32246
(904) 997-1400 (Tel) · (904) 997-9150 (Fax)

VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

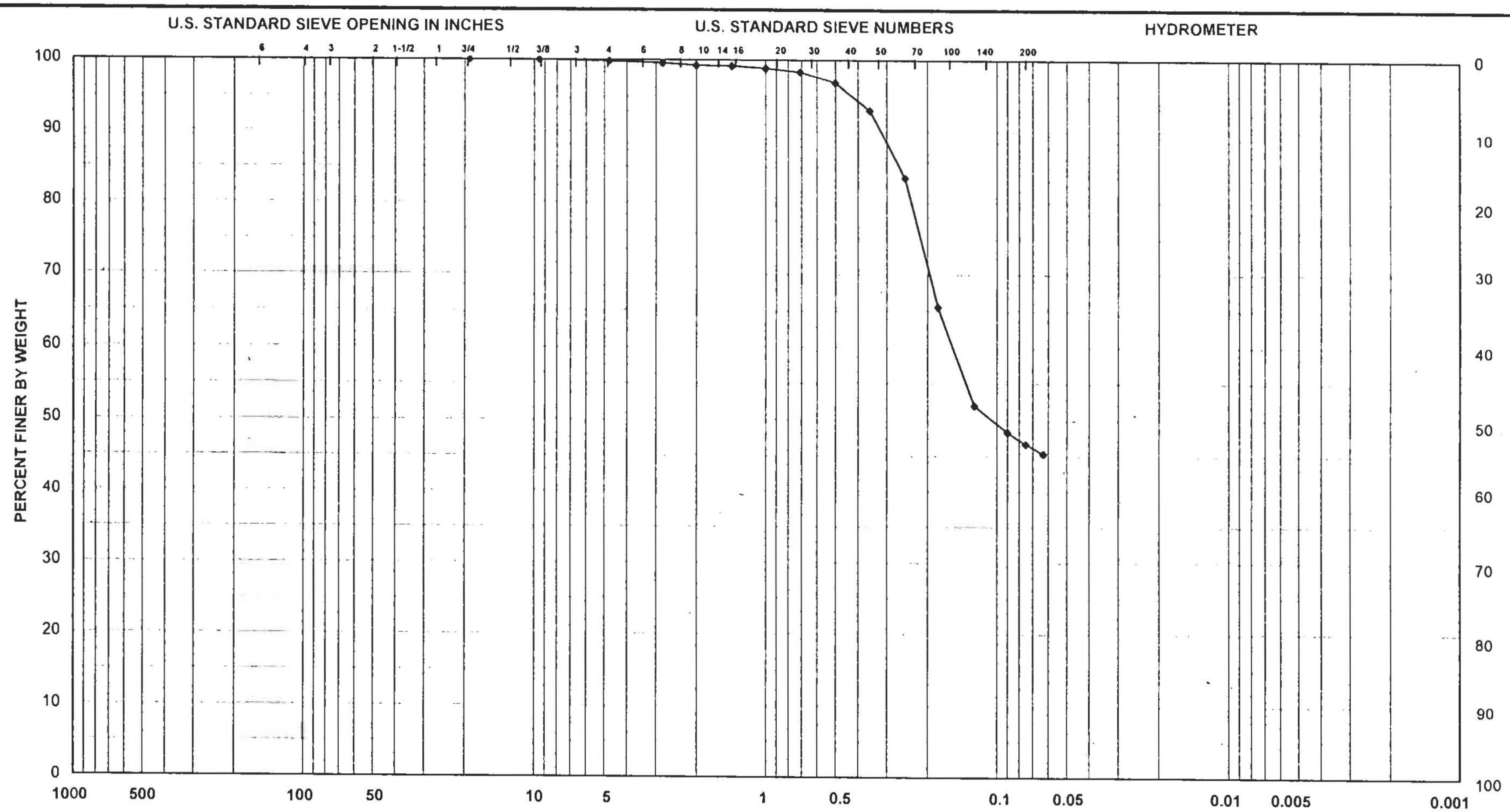
Project:	**Ocean Isle Renourishment**	**Depth:**	**11.2'- 11.7'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-11**		
Sample No.:	**2**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, greenish gray (SP)**		

Tare Weight, (g):	50.13	
Dry Wt. Before Washing (g):	145.19	(with tare)
Dry Weight After Washing (g):	144.43	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.02	99.98	100	0.02
#7	2.800	0.01	99.97	100	0.01
#10	2.000	0.02	99.95	100	0.02
#14	1.400	0.06	99.88	100	0.06
#18	1.000	0.15	99.73	100	0.15
#25	0.710	0.35	99.36	90	0.32
#35	0.500	2.01	97.24	70	1.41
#45	0.355	7.74	89.10	50	3.87
#60	0.250	21.82	66.15	40	8.73
#80	0.180	38.78	25.35	30	11.63
#120	0.125	21.50	2.74	10	2.15
#170	0.090	1.97	0.66	5	0.10
#200	0.075	0.17	0.48	1	0.00
#230	0.063	0.01	0.47	1	0.00

Total Shell Content: **20** **%**

ci 2/2/05



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 3	13'- 13.5'	SAND, silty, mostly fine-grained quartz sand, some silt, few carbonate, dark greenish gray (SM)	9					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-11
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

WOLF TECHNOLOGIES, INC.
3047-4 St. Johns Bluff Road S.
Jacksonville, Florida 32246
(904) 997-1400 (Tel) · (904) 997-9150 (Fax)

VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	Ocean Isle Renourishment	Depth:	13'- 13.5'
Project No.:	2216-01-60	Date:	8/1/2005
Boring No.:	OI-05-11		
Sample No.:	3		
Description:	SAND, silty, mostly fine-grained quartz sand, some silt, few carbonate, dark greenish gray (SM)		

Tare Weight, (g):	50.25	
Dry Wt. Before Washing (g):	129.39	(with tare)
Dry Weight After Washing (g):	93.2	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.14	99.82	100	0.14
#7	2.800	0.23	99.53	100	0.23
#10	2.000	0.22	99.25	100	0.22
#14	1.400	0.08	99.15	100	0.08
#18	1.000	0.24	98.85	90	0.22
#25	0.710	0.36	98.40	90	0.32
#35	0.500	1.22	96.85	80	0.98
#45	0.355	3.05	93.00	50	1.53
#60	0.250	7.52	83.50	30	2.26
#80	0.180	14.19	65.57	10	1.42
#120	0.125	10.75	51.98	5	0.54
#170	0.090	2.91	48.31	5	0.15
#200	0.075	1.30	46.66	1	0.01
#230	0.063	1.06	45.32	1	0.01

Total Shell Content: 9 %

8/2/05

Hole No. OI-05-12

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NC Coord. E 2187399.2 N 56483.8	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number) : OI-05-12	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN : DISTURBED 3 : UNDISTURBED 0
5. NAME OF DRILLER LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ______ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
	16. DATE HOLE : STARTED 4/20/05 : COMPLETED 4/20/05
	17. ELEVATION TOP OF HOLE 0.0 MLLW
7. THICKNESS OF OVERBURDEN N/A (1.3' of Water)	18. TOTAL CORE RECOVERY FOR BORING N/A %
8. DEPTH DRILLED INTO ROCK 0.0'	19. SIGNATURE OF INSPECTOR
9. TOTAL DEPTH OF HOLE 10.0'	KELLY KALTENBACH, GEOLOGIST TRAINEE

ELEVATION MLLW a	DEPTH feet b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
0.0	0		0.0' TO 1.3' WATER			Time begin vibracoring: 1155 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	1.0		OCEAN BOTTOM @1.3'		1.3'	
1.3	1.3		SP Tan, mottled light gray fine-coarse sand, clean, poorly graded. Little to trace fine shell.		1	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
					1.8'	
			2.9' some fine to coarse sand size shell material.			
	3.0				3.3'	VIBRACORE BORING From 1.3' to 10.0' Ran 9.8' Rec: 8.7'
					2	
					3.8'	
	5.0					Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
	7.0				7.3'	
			7.7' shell content increases cont gravel size shell material.		3	
					7.8'	
	9.0					
-10.0	10.0		BOTTOM OF HOLE @10.0'			

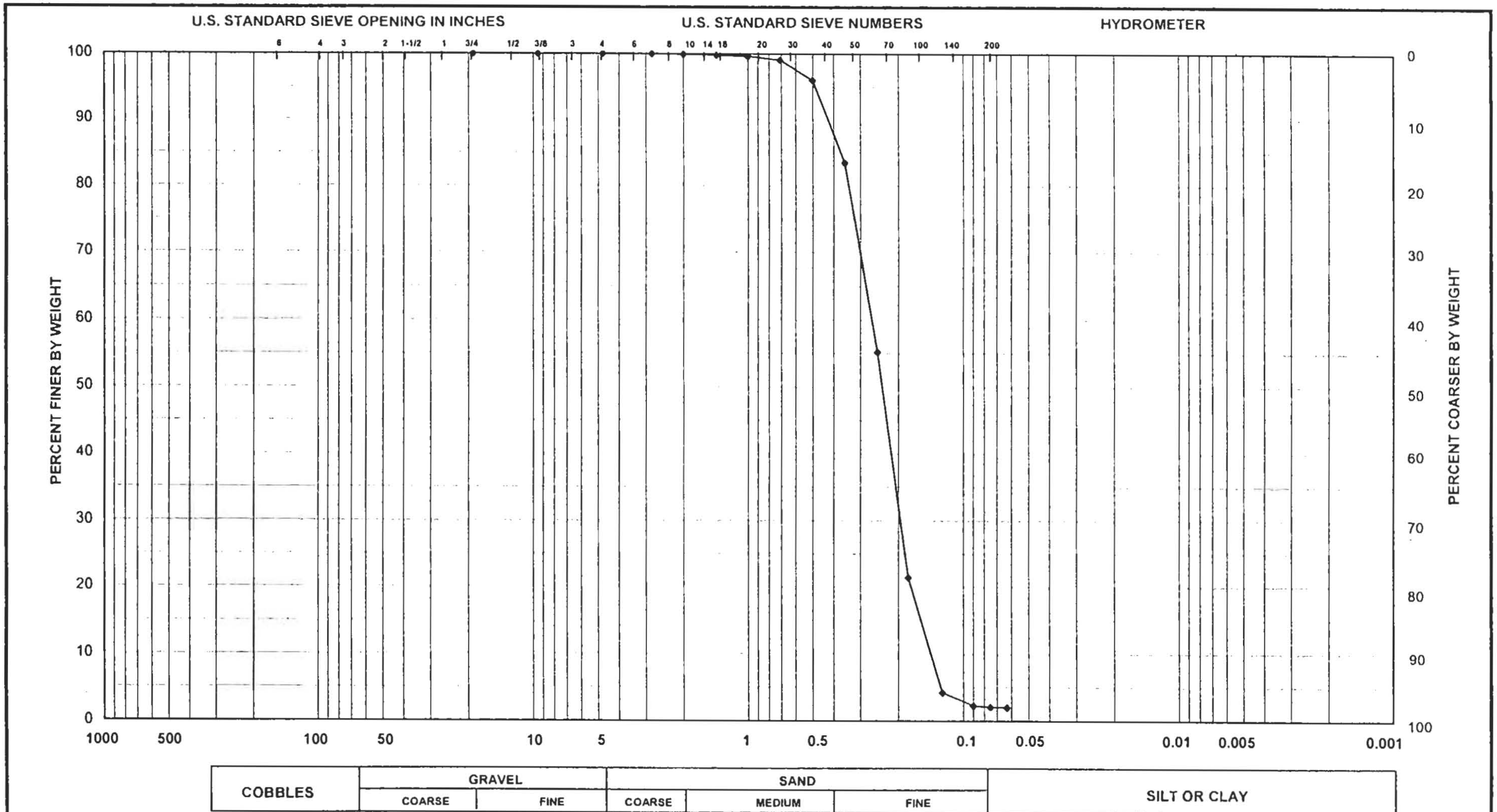
LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP

SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM

NOTE Assumed vibracore refusal @ 10.0'

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT OCEAN ISLE RENOURISHMENT | HOLE NO. OI-05 12



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 1	1.3'- 1.8'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, greenish brown (SP)	18					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-12
Date	8/1/2005

GRADATION CURVES

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

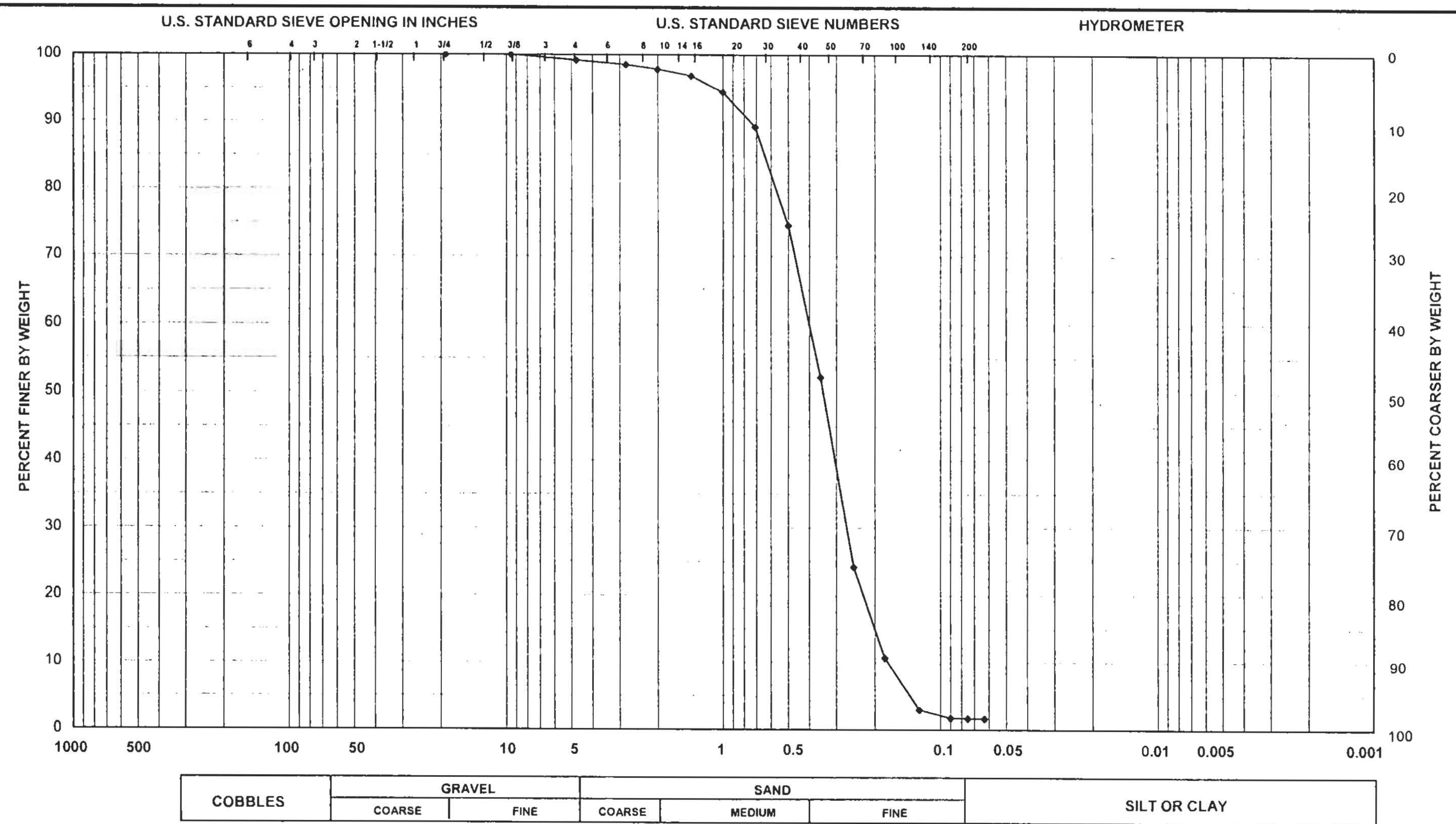
Project:	**Ocean Isle Renourishment**	**Depth:**	**1.3'- 1.8'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-12**		
Sample No.:	**1**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, greenish brown (SP)**		

Tare Weight, (g):	51.01	
Dry Wt. Before Washing (g):	158.11	(~~with~~ tare)
Dry Weight After Washing (g):	156.48	(~~with~~ tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.00	100.00	0	0.00
#7	2.800	0.02	99.98	100	0.02
#10	2.000	0.07	99.92	100	0.07
#14	1.400	0.10	99.82	100	0.10
#18	1.000	0.21	99.63	100	0.21
#25	0.710	0.63	99.04	95	0.60
#35	0.500	3.20	96.05	70	2.24
#45	0.355	13.50	83.45	50	6.75
#60	0.250	30.28	55.17	30	9.08
#80	0.180	36.19	21.38	20	7.24
#120	0.125	18.41	4.19	10	1.84
#170	0.090	2.08	2.25	5	0.10
#200	0.075	0.20	2.06	1	0.00
#230	0.063	0.06	2.01	1	0.00

Total Shell Content: 18 %

2 8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 2	3.3'- 3.8'	SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)	27					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-12
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

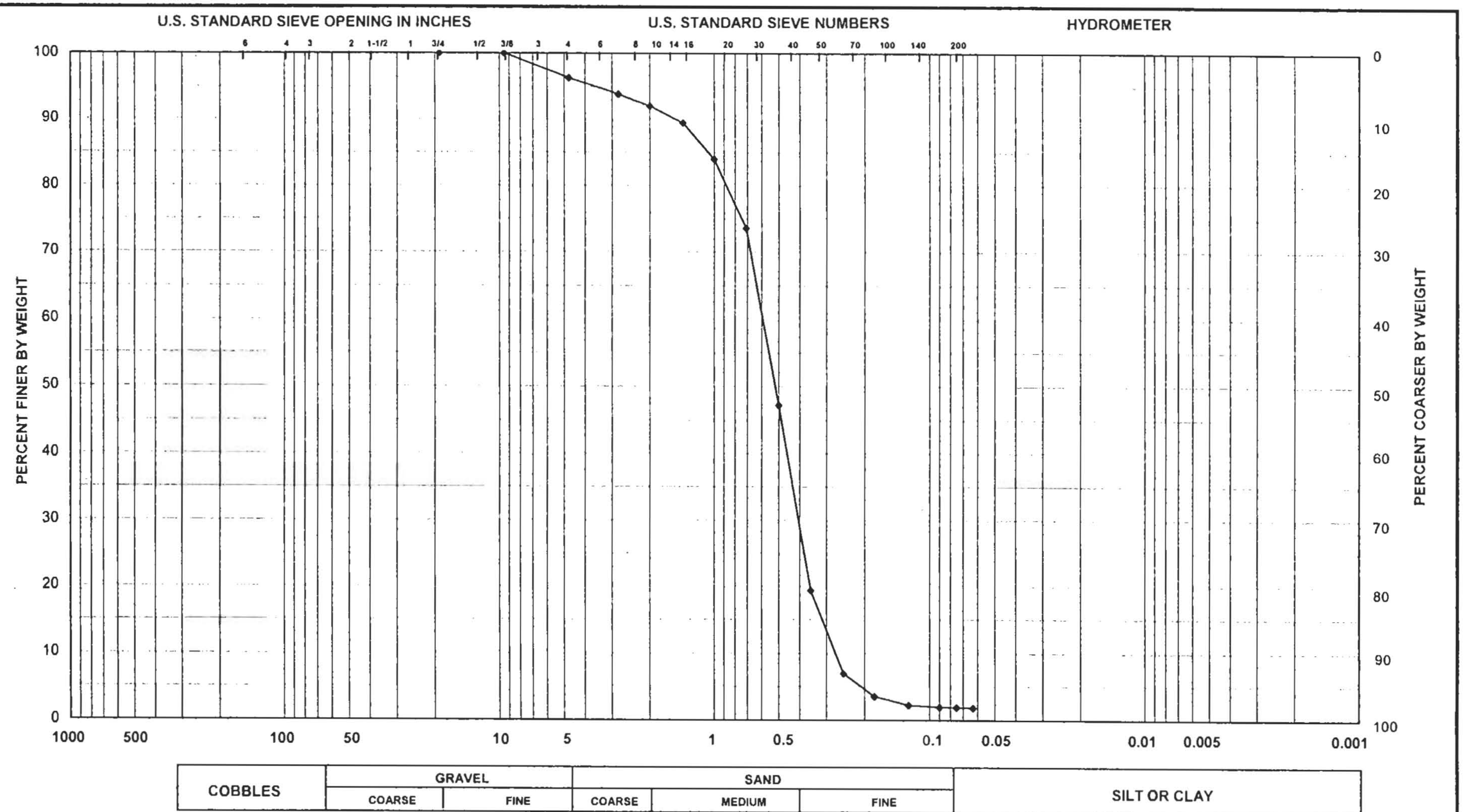
Project:	**Ocean Isle Renourishment**	**Depth:**	**3.3'- 3.8'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-12**		
Sample No.:	**2**		
Description:	**SAND, poorly-graded, mostly fine-grained quartz, little carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.04	
Dry Wt. Before Washing (g):	147.88	(with tare)
Dry Weight After Washing (g):	146.71	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	0.81	99.17	100	0.81
#7	2.800	0.64	98.52	100	0.64
#10	2.000	0.67	97.83	100	0.67
#14	1.400	0.94	96.87	100	0.94
#18	1.000	2.39	94.43	95	2.27
#25	0.710	5.09	89.23	80	4.07
#35	0.500	14.33	74.58	70	10.03
#45	0.355	21.90	52.20	50	10.95
#60	0.250	27.46	24.13	30	8.24
#80	0.180	13.21	10.63	10	1.32
#120	0.125	7.57	2.89	5	0.38
#170	0.090	1.14	1.73	1	0.01
#200	0.075	0.06	1.67	1	0.00
#230	0.063	0.04	1.63	1	0.00

Total Shell Content: **27** **%**

8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 3	7.3'- 7.8'	SAND, poorly-graded, mostly medium to fine-grained quartz, some carbonate, trace silt, light olive brown (SP)	40					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-12
Date	8/1/2005

GRADATION CURVES

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**
Project No.:	**2216-01-60**
Boring No.:	**OI-05-12**
Sample No.:	**3**
Description:	**SAND, poorly-graded, mostly medium to fine-grained quartz, some carbonate, trace silt, light olive brown (SP)**
Depth:	**7.3'- 7.8'**
Date:	**8/1/2005**

Tare Weight, (g):	50.16	
Dry Wt. Before Washing (g):	164.59	(with tare)
Dry Weight After Washing (g):	162.65	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	4.20	96.33	100	4.20
#7	2.800	2.84	93.85	100	2.84
#10	2.000	2.09	92.02	100	2.09
#14	1.400	2.96	89.43	100	2.96
#18	1.000	6.26	83.96	90	5.63
#25	0.710	11.88	73.58	70	8.32
#35	0.500	30.18	47.21	60	18.11
#45	0.355	31.89	19.34	50	15.95
#60	0.250	14.20	6.93	30	4.26
#80	0.180	3.91	3.51	10	0.39
#120	0.125	1.47	2.23	5	0.07
#170	0.090	0.31	1.96	1	0.00
#200	0.075	0.05	1.91	1	0.00
#230	0.063	0.08	1.84	1	0.00

Total Shell Content: **40 %**

Hole No. 01-05-13

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT OCEAN ISLE RENOURISHMENT	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NC Coord. E 2187968.5 N 55646.7	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL VIBRA CORE SNELL)
4. HOLE NO. (As shown on drawing title and file number) 01-05-13	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 4; UNDISTURBED 0
5. NAME OF DRILLER LESTER GAUGHF (Crane Operator)	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
	16. DATE HOLE: STARTED 4/20/05; COMPLETED 4/20/05
7. THICKNESS OF OVERBURDEN N/A (2.5' of Water)	17. ELEVATION TOP OF HOLE 0.0 MLLW
8. DEPTH DRILLED INTO ROCK 0.0'	18. TOTAL CORE RECOVERY FOR BORING N/A %
9. TOTAL DEPTH OF HOLE 12.6'	19. SIGNATURE OF INSPECTOR KELLY KALTENBACH, GEOLOGIST TRAINEE

ELEVATION MLLW	DEPTH feet	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
0.0	0		0.0' TO 2.5' WATER			Time begin vibracoring: 1110 hrs. Soils described by Kelley J. Kaltenbach, Geologist-Trainee.
	2.0					
-2.5	2.5		OCEAN BOTTOM @ 2.5'		2.5'	
			SP Tan-light gray, fine-coarse sand, clean, poorly graded, some fine-coarse sand size shell marterial. Little gravel size shell material. Trace organic material.		1	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of Hole is 0.0 EL MLLW.
					3.0'	
	4.0					VIBRACORE BORING From 2.5' to 12.6' Ran 8.3' Rec: 10.1'
					5.5'	
					2	
	6.0				6.0'	Top of vibracore soil sample is logged as beginning at Ocean Bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
	8.0					
					8.5'	
					3	
					9.0'	
	10.0					LAB CLASSIFICATION
					11.5'	
					4	
	12.0				12.0'	
-12.6	12.6		BOTTOM OF HOLE AT 12.6'			
			SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE Assumed vibracore refusal @ 12.6'

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SP

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. | PROJECT OCEAN ISLE RENOURISHMENT | HOLE NO. 01-05 13

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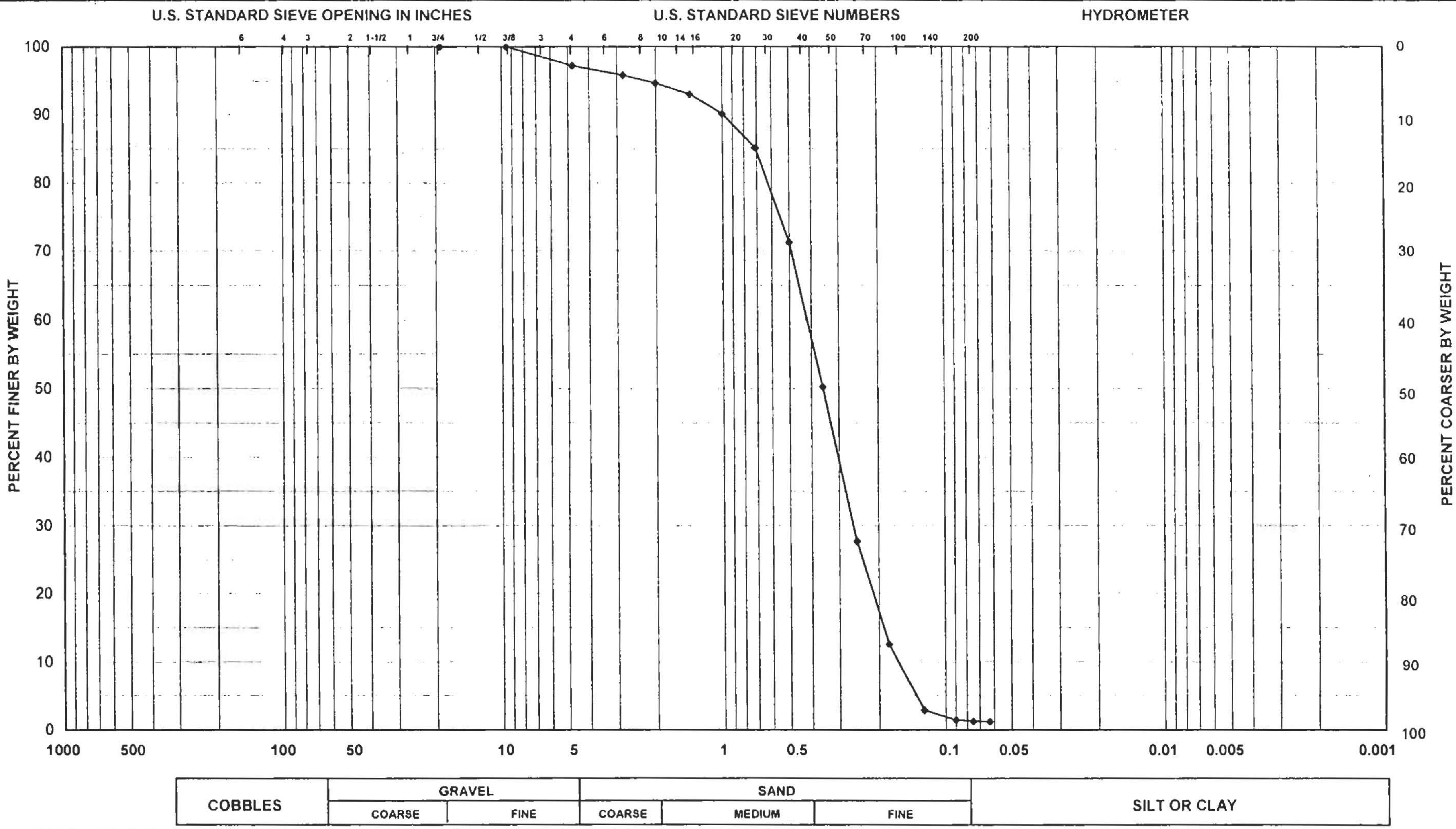

Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 1	2.5'- 3.0'	SAND, poorly graded, mostly medium to fine-grained quartz, little carbonate, trace silt, trace limestone fragments, light olive brown (SP)	27					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-13
Date	8/1/2005

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VISUAL SHELL CONTENT

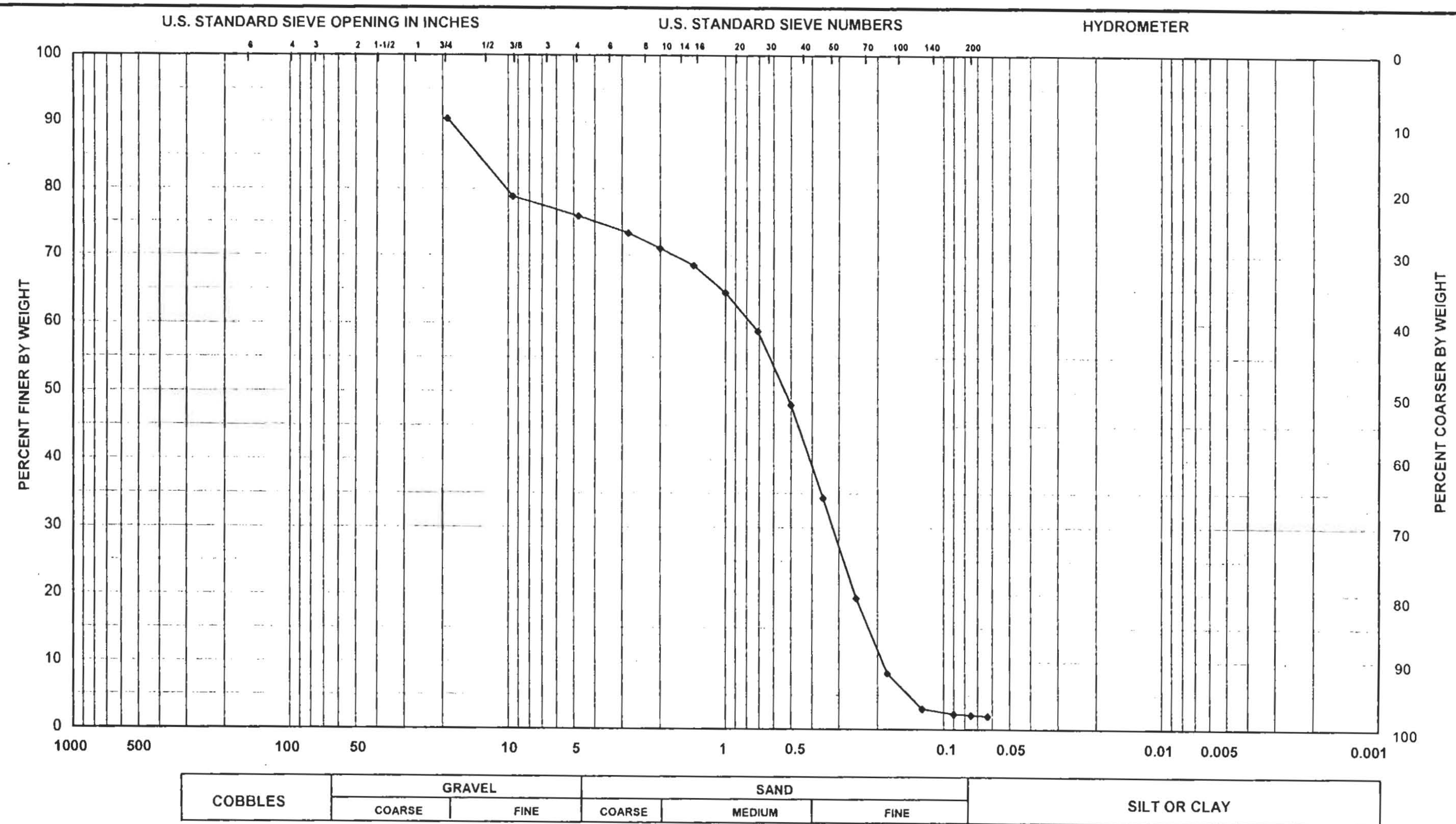
GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**2.5'- 3.0'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-13**		
Sample No.:	**1**		
Description:	**SAND, poorly graded, mostly medium to fine-grained quartz, little carbonate, trace silt, trace limestone fragments, light olive brown (SP)**		

Tare Weight, (g):	50.11	
Dry Wt. Before Washing (g):	185.79	(with tare)
Dry Weight After Washing (g):	183.92	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	3.75	97.24	80	3.00
#7	2.800	1.82	95.89	90	1.64
#10	2.000	1.64	94.69	100	1.64
#14	1.400	2.23	93.04	100	2.23
#18	1.000	3.95	90.13	95	3.75
#25	0.710	6.79	85.13	80	5.43
#35	0.500	18.86	71.23	50	9.43
#45	0.355	28.54	50.19	40	11.42
#60	0.250	30.56	27.67	30	9.17
#80	0.180	20.49	12.57	10	2.05
#120	0.125	13.18	2.85	5	0.66
#170	0.090	1.92	1.44	1	0.02
#200	0.075	0.27	1.24	1	0.00
#230	0.063	0.05	1.20	1	0.00

Total Shell Content: **27** **%**



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
• 2	5.5'- 6.0'	SAND, poorly graded, mostly medium to fine-grained quartz, some carbonate, trace silt, few limestone fragments, olive brown (SP)	35					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-13
Date	8/1/2005

GRADATION CURVES

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VISUAL SHELL CONTENT

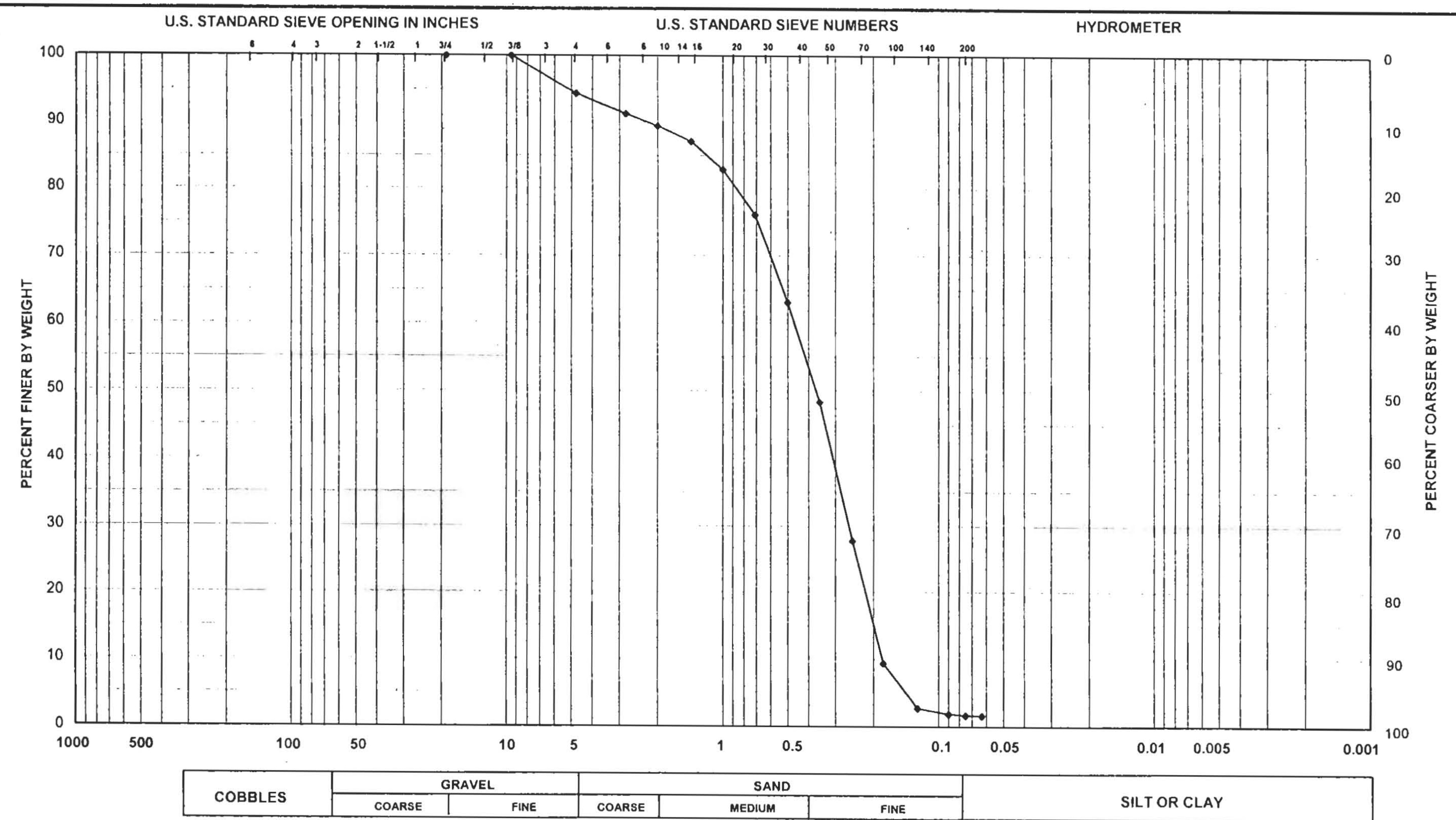
GRAIN SIZE AND VISUAL SHELL CONTENT

Project:	**Ocean Isle Renourishment**	**Depth:**	**5.5'- 6.0'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-13**		
Sample No.:	**2**		
Description:	**SAND, poorly graded, mostly medium to fine-grained quartz, some carbonate, trace silt, few limestone fragments, olive brown (SP)**		

Tare Weight, (g):	50.21	
Dry Wt. Before Washing (g):	169.68	(with tare)
Dry Weight After Washing (g):	167.96	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	11.44	90.42	0	0.00
3/8"	9.500	13.90	78.79	90	12.51
#4	4.750	3.48	75.88	95	3.31
#7	2.800	3.05	73.32	95	2.90
#10	2.000	2.73	71.04	100	2.73
#14	1.400	3.02	68.51	100	3.02
#18	1.000	4.77	64.52	90	4.29
#25	0.710	6.71	58.90	80	5.37
#35	0.500	12.93	48.08	70	9.05
#45	0.355	16.45	34.31	50	8.23
#60	0.250	17.80	19.41	30	5.34
#80	0.180	13.31	8.27	10	1.33
#120	0.125	6.30	3.00	5	0.32
#170	0.090	0.90	2.24	1	0.01
#200	0.075	0.22	2.06	1	0.00
#230	0.063	0.14	1.94	1	0.00

Total Shell Content: **35 %**



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 3	8.5'- 9.0'	SAND, poorly graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)	32					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-13
Date	8/1/2005

GRADATION CURVES

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VISUAL SHELL CONTENT

GRAIN SIZE AND VISUAL SHELL CONTENT

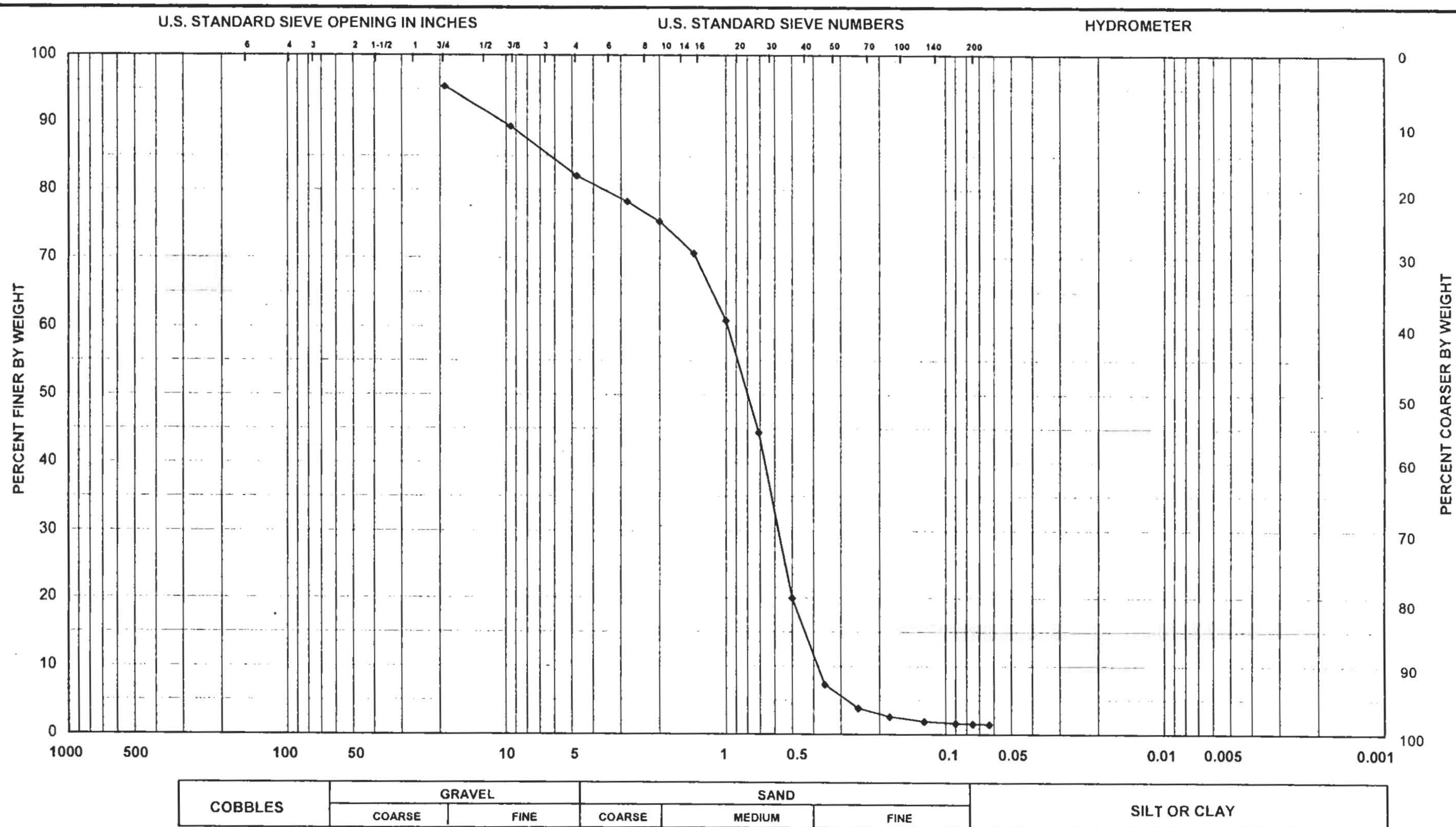
Project:	**Ocean Isle Renourishment**	**Depth:**	**8.5'- 9.0'**
Project No.:	**2216-01-60**	**Date:**	**8/1/2005**
Boring No.:	**OI-05-13**		
Sample No.:	**3**		
Description:	**SAND, poorly graded, mostly fine-grained quartz, some carbonate, trace silt, light olive brown (SP)**		

Tare Weight, (g):	50.62	
Dry Wt. Before Washing (g):	151.97	(with tare)
Dry Weight After Washing (g):	150.28	(with tare)

Sieve Size (Name)	Sieve Size (mm)	Weight Retained (g)	% Passing	Approx. Visual Shell %	Approx. Visual Shell Wt. (g)
3/4"	19.000	0.00	100.00	0	0.00
3/8"	9.500	0.00	100.00	0	0.00
#4	4.750	5.75	94.33	100	5.75
#7	2.800	3.11	91.26	100	3.11
#10	2.000	1.87	89.41	100	1.87
#14	1.400	2.35	87.09	100	2.35
#18	1.000	4.32	82.83	95	4.10
#25	0.710	6.84	76.08	80	5.47
#35	0.500	13.15	63.11	70	9.21
#45	0.355	14.93	48.38	50	7.47
#60	0.250	20.84	27.81	30	6.25
#80	0.180	18.73	9.33	10	1.87
#120	0.125	6.75	2.67	5	0.34
#170	0.090	0.82	1.86	1	0.01
#200	0.075	0.19	1.68	1	0.00
#230	0.063	0.11	1.57	1	0.00

Total Shell Content: **32 %**

8/2/05



Sample No.	Elev. Or Depth	Classification	% CO_3	G_s	Nat w%	LL	PL	PI
◆ 4	11.5'- 12.0'	SAND, poorly graded, mostly medium to fine-grained quartz, some carbonate, trace silt, light olive brown (SP)	47					

Project	Ocean Isle Renourishment
Area	
Boring No.	OI-05-13
Date	8/1/2005

GRADATION CURVES

ENG FORM 2087

MAY 63

2009 USACE VIBRACORE LOGS & GRANULARMETRIC DATA

Hole No. SHI-V-09-01

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 57,586 E 2,186,898	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number): SHI-V-09-01	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
	16. DATE HOLE: STARTED 2/19/2009; COMPLETED 2/19/2009
7. WATER DEPTH (BELOW MLW): 7.9'	17. ELEVATION TOP OF HOLE: 0.0' MLW
8. DEPTH DRILLED INTO ROCK: 0.0'	18. TOTAL CORE RECOVERY FOR BORING: 100%
9. TOTAL DEPTH OF HOLE: 27.9'	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 7.9' WATER			Time begin vibracoring: 09:57 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-7.9	7.9		SEDIMENT SURFACE (7.9')		7.9' / 1 / 8.4'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Light tan, coarse, poorly graded SAND w/trace shell fragments.		11.0' / 2 / 11.5'	VIBRACORE BORING: From 0.0' to 20' Run: 20' Rec: 20'. Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
					14.0' / 3 / 14.5'	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
-15.4	15.4		SC - Greenish tan, fine, Clayey SAND.		15.4' / 4 / 15.9'	
-17.9	17.9		CL - Greenish tan, lean CLAY with thin layers of ML zones to bottom.		17.9' / 5 / 18.4'	
					21.0' / 6 / 21.5'	
					24.0' / 7 / 24.5'	
-27.9	27.9		Bottom of Hole Terminated at Elev. -27.9 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SC
5	SC-CL
6	NOT TESTED
7	NOT TESTED

ENG FORM ... PROJECT ... HOLE NO.

DRILLING LOG

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 57,580 E 2,187,095	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number): SHI-V-09-02	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. WATER DEPTH (BELOW MLW): 12.3'	16. DATE HOLE: STARTED 2/19/2009; COMPLETED 2/19/2009
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0' MLW
9. TOTAL DEPTH OF HOLE: 32.3'	18. TOTAL CORE RECOVERY FOR BORING: 98%
	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 12.3' WATER			Time begin vibracoring: 09:57 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-12.3	12.3		SEDIMENT SURFACE (12.3')			NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
-13.3	13.3		SP - Tan, coarse, poorly graded SAND w/shell fragments	12.8'	12.3' / 1 / 13.3'	
-19.3	19.3		SC - Greenish gray, fine Clayey SAND		13.3' / 2 / 13.8'; 16.0' / 3 / 16.5'	
-32.0	32.0		CL - Greenish gray, lean CLAY with hard thin layers of ML		19.3' / 4 / 19.8'; 22.0' / 5 / 22.5'; 26.0' / 6 / 26.5'; 29.0' / 7 / 29.5'	
-32.3	32.3		ASSUMED NOT RECOVERED			
			Bottom of Hole Terminated at Elev. -32.3 ft			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.
			SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			

VIBRACORE BORING

From 0.0' to 20'
Run: 20' Rec: 19.6'

Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.

NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SM
3	SC
4	NOT TESTED
5	NOT TESTED
6	NOT TESTED
7	NOT TESTED

Hole No. SHI-V-09-03

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT SHALLOTTE INLET	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NCSP NAD 83 (USft) N 56,990 E 2,187,216	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number) SHI-V-09-03	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 0
5. NAME OF DRILLER ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
7. WATER DEPTH (BELOW MLW) 1.7'	16. DATE HOLE: STARTED 2/19/2009; COMPLETED 2/19/2009
8. DEPTH DRILLED INTO ROCK 0.0'	17. ELEVATION TOP OF HOLE 0.0' MLW
9. TOTAL DEPTH OF HOLE 21.7'	18. TOTAL CORE RECOVERY FOR BORING 60%
	19. SIGNATURE OF INSPECTOR LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 1.7' WATER			
-1.7	1.7		SEDIMENT SURFACE (1.7')		1.7' / 1 / 2.2'	Time begin vibracoring: 10:27 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech. NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded SAND w/trace shell fragments		5.0' / 2 / 5.5'; 8.0' / 3 / 8.5'	VIBRACORE BORING: From 0.0' to 20' Run: 20' Rec: 12'. Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
-9.2	9.2		With shell fragments		11.0' / 4 / 11.5'	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
-11.7	11.7		SC - Greenish gray, fine, Clayey SAND		11.7' / 5 / 12.2'	
-13.7	13.7		ASSUMED NOT RECOVERED			
-21.7	21.7		Bottom of Hole Terminated at Elev. -21.7 ft. SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SP
5	SM

ENG FORM | PROJECT | HOLE NO.

Hole No. SHI-V-09-04

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 56,549 E 2,187,502	11. DATUM FOR ELEVATION SHOWN (*TBM or MSL*): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (*As shown on drawing title and file number*): SHI-V-09-04	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. WATER DEPTH (BELOW MLW): 5.1'	16. DATE HOLE: STARTED 2/19/2009; COMPLETED 2/19/2009
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0' MLW
9. TOTAL DEPTH OF HOLE: 25.1'	18. TOTAL CORE RECOVERY FOR BORING: 88%
	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (*Drilling time, water loss, depth weathering, etc., if significant*) g
0.0	0.0		0.0' TO 5.1' WATER			Time begin vibracoring: 11:06 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-5.1	5.1		SEDIMENT SURFACE (5.1')		5.1' / 1 / 5.6'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded SAND with trace shell fragments		8.0' / 2 / 8.5'; 11.0' / 3 / 11.5'	VIBRACORE BORING From 0.0' to 20' Run: 20' Rec: 17.6' Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
-14.1	14.1		With shell fragments		14.0' / 4 / 14.5'	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
-15.0	15.0		SP - Tan, coarse, poorly graded SAND		16.5' / 5 / 17.0'	LAB CLASSIFICATION Jar Number / Classification 1 SP 2 SP 3 SP 4 SP 5 SP 6 NOT TESTED 7 NOT TESTED
-18.1	18.1		SM - Greenish gray, fine, Silty SAND		18.1' / 6 / 18.6'; 21.0' / 7 / 21.5'	
-22.7	22.7		ASSUMED NOT RECOVERED			
-25.1	25.1		Bottom of Hole Terminated at Elev. -25.1 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

Hole No. SHI-V-09-05

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 56,120 E 2,187,843	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number): SHI-V-09-05	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED — DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. WATER DEPTH (BELOW MLW): 3.7'	16. DATE HOLE: STARTED 2/20/2009; COMPLETED 2/20/2009
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0' MLW
9. TOTAL DEPTH OF HOLE: 23.7'	18. TOTAL CORE RECOVERY FOR BORING: 73%
	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 3.7' WATER			Time begin vibracoring: 11:06 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-3.7	3.7		SEDIMENT SURFACE (3.7')		3.7' / 1 / 4.2'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded SAND with trace shell fragments		7.0' / 2 / 7.5' 10.0' / 3 / 10.5'	VIBRACORE BORING From 0.0' to 20' Run: 20' Rec: 14.5' Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered. NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
-13.0	13.0		SP - Tan, coarse, poorly graded SAND with shell fragments		13.0' / 4 / 13.5'	LAB CLASSIFICATION Jar Number – Classification 1 – SP 2 – SP 3 – SP 4 – SP 5 – SM
-16.2	16.2		SM - Gray, fine Silty SAND		16.2' / 5 / 16.7'	
-18.2	18.2		ASSUMED NOT RECOVERED			
-23.7	23.7		Bottom of Hole Terminated at Elev. -23.7 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

Hole No. SHI-V-09-06

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 56,291 E 2,187,710	11. DATUM FOR ELEVATION SHOWN (*TBM or MSL*): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (*As shown on drawing title and file number*): SHI-V-09-06	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ---- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
	16. DATE HOLE: STARTED 2/20/2009; COMPLETED 2/20/2009
7. WATER DEPTH (BELOW MLW): 6.1'	17. ELEVATION TOP OF HOLE: 0.0' MLW
8. DEPTH DRILLED INTO ROCK: 0.0'	18. TOTAL CORE RECOVERY FOR BORING: 69%
9. TOTAL DEPTH OF HOLE: 26.1'	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (*Drilling time, water loss, depth weathering, etc., if significant*) g
0.0	0.0		0.0' TO 6.1' WATER			Time begin vibracoring: 10:53 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-6.1	6.1		SEDIMENT SURFACE (6.1')		6.1' / 1 / 6.6'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded SAND with shell fragments		9.0' / 2 / 9.5'	**VIBRACORE BORING** From 0.0' to 20' Run: 20' Rec: 13.8' Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
					12.0' / 3 / 12.5'	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
					15.0' / 4 / 15.5'	LAB CLASSIFICATION — Jar Number / Classification: 1 SP; 2 SP; 3 SP; 4 SP; 5 NOT TESTED
-18.6	18.6		SM - Gray, fine, Silty SAND		18.6' / 5 / 19.1'	
-19.9	19.9		ASSUMED NOT RECOVERED			
-26.1	26.1		Bottom of Hole Terminated at Elev. -26.1 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

Hole No. SHI-V-09-07

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 55,778 E 2,188,158	11. DATUM FOR ELEVATION SHOWN (*TBM or MSL*): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (*As shown on drawing title and file number*): SHI-V-09-07	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 6; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. WATER DEPTH (BELOW MLW): 5.3'	16. DATE HOLE: STARTED 2/20/2009; COMPLETED 2/20/2009
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0' MLW
9. TOTAL DEPTH OF HOLE: 23.3'	18. TOTAL CORE RECOVERY FOR BORING: 79%
	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (*Drilling time, water loss, depth weathering, etc., if significant*) g
0.0	0.0		0.0' TO 5.3' WATER			Time begin vibracoring: 11:13 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-5.3	5.3		SEDIMENT SURFACE (5.3')		5.3' / 1 / 5.8'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded SAND with shell fragments		8.0' / 2 / 8.5'	VIBRACORE BORING: From 0.0' to 18' Run: 18' Rec: 14.3'. Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
					11.0' / 3 / 11.5'	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
					13.0' / 4 / 13.5'	
-17.3	17.3				16.0' / 5 / 16.5'	
			SM - Dark gray, fine, Silty SAND		17.3' / 6 / 17.8'	
-19.6	19.6		ASSUMED NOT RECOVERED			
-23.3	23.3		Bottom of Hole Terminated at Elev. -23.3 ft			NOTE: Hole terminated at refusal depth at 18' below sediment surface.
			SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SP
5	SP
6	SM

ENG FORM ... PROJECT HOLE NO.

Hole No. SHI-V-09-08

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT SHALLOTTE INLET	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NCSP NAD 83 (USft) N 55,156 E 2,188,426	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number) SHI-V-09-08	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 6; UNDISTURBED 0
5. NAME OF DRILLER ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ---- DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
7. WATER DEPTH (BELOW MLW) 7.1'	16. DATE HOLE: STARTED 2/20/2009; COMPLETED 2/20/2009
8. DEPTH DRILLED INTO ROCK 0.0'	17. ELEVATION TOP OF HOLE 0.0' MLW
9. TOTAL DEPTH OF HOLE 27.1'	18. TOTAL CORE RECOVERY FOR BORING 70%
	19. SIGNATURE OF INSPECTOR LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 7.1' WATER			Time begin vibracoring: 11:32 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-7.1	7.1		SEDIMENT SURFACE (7.1')		7.1' / 1 / 7.6'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded SAND		9.5' / 2 / 10.0'	
-13.1	13.1		Trace shell fragments		13.0' / 3 / 13.5'	
					16.0' / 4 / 16.5'	
-17.0	17.0		SP - Tan, coarse, poorly graded SAND with shell fragments		18.0' / 5 / 18.5'	
-18.6	18.6		Trace shell fragments		20.6' / 6 / 21.1'	
-21.1	21.1		ASSUMED NOT RECOVERED			
-27.1	27.1		Bottom of Hole Terminated at Elev. -27.1 ft			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.
			SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			

VIBRACORE BORING

From 0.0' to 20'
Run: 20' Rec: 14'

Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.

NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SP
5	SP
6	NOT TESTED

Hole No. SHI-V-09-09

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT SHALLOTTE INLET	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NCSP NAD 83 (USft) N 57,263 E 2,187,186	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number) SHI-V-09-09	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 7; UNDISTURBED 0
5. NAME OF DRILLER ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ---- DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
7. WATER DEPTH (BELOW MLW) 20.7'	16. DATE HOLE: STARTED 3/4/2009; COMPLETED 3/4/2009
8. DEPTH DRILLED INTO ROCK 0.0'	17. ELEVATION TOP OF HOLE 0.0' MLW
9. TOTAL DEPTH OF HOLE 40.7'	18. TOTAL CORE RECOVERY FOR BORING 100%
	19. SIGNATURE OF INSPECTOR LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 20.7' WATER			Time begin vibracoring: 08:58 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-20.7	20.7		SEDIMENT SURFACE (20.7')		20.7' / 1 / 21.2'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SM - Greenish gray, fine Silty SAND		23.5' / 2 / 24.0'	VIBRACORE BORING: From 0.0' to 20' Run: 20' Rec: 20'. Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
-26.0	26.0		CL - Greenish gray, lean CLAY		26.0' / 3 / 26.5'	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
					29.0' / 4 / 29.5'	
					32.0' / 5 / 32.5'	
					35.0' / 6 / 35.5'	
					38.0' / 7 / 38.5'	
-40.7	40.7		Bottom of Hole Terminated at Elev. -40.7 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

LAB CLASSIFICATION

Jar Number	Classification
1	SM
2	NOT TESTED
3	NOT TESTED
4	NOT TESTED
5	NOT TESTED
6	NOT TESTED
7	NOT TESTED

ENG FORM 1836 PROJECT HOLE NO.

Hole No. SHI-V-09-10

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 57,465 E 2,187,333	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number): SHI-V-09-10	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 8; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. WATER DEPTH (BELOW MLW): 4.9'	16. DATE HOLE: STARTED 3/4/2009; COMPLETED 3/4/2009
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0' MLW
9. TOTAL DEPTH OF HOLE: 24.9'	18. TOTAL CORE RECOVERY FOR BORING: 94%
	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
0.0	0.0		0.0' TO 4.9' WATER		
-4.9	4.9		SEDIMENT SURFACE (4.9')		4.9'
-5.9	5.9		SM - Gray, fine Silty SAND		1 (4.9'–5.4')
-12.9	12.9		SP - Tan, coarse, poorly graded SAND with shell fragments		2 (5.9'–6.4'); 3 (9.0'–9.5')
-17.3	17.3		SM - Gray, fine Silty SAND		4 (12.9'–13.4'); 5 (15.0'–15.5')
-18.4	18.4		MH - Dark gray, elastic SILT		6 (17.3'–17.8')
-20.4	20.4		SP - White, coarse, poorly graded SAND with wood		7 (18.4'–18.9')
-23.7	23.7		SM - Gray, fine Silty SAND		8 (20.4'–20.9')
-24.9	24.9		ASSUMED NOT RECOVERED		
			Bottom of Hole Terminated at Elev. -24.9 ft		
			SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM		

REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g

Time begin vibracoring: 09:26 hrs.
Soils described by LARRY BENJAMIN, Civil Engr. Tech.

NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW

VIBRACORE BORING

From 0.0' to 20'
Run: 20' Rec: 18.8'

Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.

NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487

LAB CLASSIFICATION

Jar Number	Classification
1	SM
2	SP-SM
3	SP-SM
4	SM
5	SM
6	MH
7	NOT TESTED
8	NOT TESTED

NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 57,368 E 2,187,577	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number): SHI-V-09-11	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
	16. DATE HOLE: STARTED 3/4/2009; COMPLETED 3/4/2009
7. WATER DEPTH (BELOW MLW): 5.2'	17. ELEVATION TOP OF HOLE: 0.0' MLW
8. DEPTH DRILLED INTO ROCK: 0.0'	18. TOTAL CORE RECOVERY FOR BORING: 62%
9. TOTAL DEPTH OF HOLE: 25.2'	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 5.2' WATER			Time begin vibracoring: 10:40 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-5.2	5.2		SEDIMENT SURFACE (5.2')		5.2' / 1 / 5.7'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded SAND with shell fragments		8.0' / 2 / 8.5'	VIBRACORE BORING: From 0.0' to 20' Run: 20' Rec: 12.4'. Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
-9.4	9.4		Trace shell fragments		11.0' / 3 / 11.5'	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
					14.0' / 4 / 14.5'	
-15.0	15.0		SP - Tan, coarse, poorly graded SAND		17.1' / 5 / 17.6'	
-17.6	17.6		ASSUMED NOT RECOVERED			
-25.2	25.2		Bottom of Hole Terminated at Elev. -25.2 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SP
5	SM

Hole No. SHI-V-09-12

DRILLING LOG

DIVISION	SOUTH ATLANTIC
INSTALLATION	WILMINGTON DISTRICT
SHEET	1 OF 1 SHEETS
1. PROJECT	SHALLOTTE INLET
2. LOCATION (Coordinates or Station)	NCSP NAD 83 (USft) N 53,455 E 2,187,870
3. DRILLING AGENCY	WILMINGTON DISTRICT
4. HOLE NO. (*As shown on drawing title and file number*)	SHI-V-09-12
5. NAME OF DRILLER	ROBIE PAGE CRANE OPERATOR
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED ---- DEG. FROM VERT.
7. WATER DEPTH (BELOW MLW)	12.5'
8. DEPTH DRILLED INTO ROCK	0.0'
9. TOTAL DEPTH OF HOLE	32.5'
10. SIZE AND TYPE OF BIT	4" Dia. Vibracore
11. DATUM FOR ELEVATION SHOWN (*TBM or MSL*)	MLW
12. MANUFACTURER'S DESIGNATION OF DRILL	ALPINE VIBRACORE - SNELL
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED: 8 / UNDISTURBED: 0
14. TOTAL NUMBER CORE BOXES	N/A
15. ELEVATION GROUND WATER	N/A
16. DATE HOLE	STARTED: 3/4/2009 / COMPLETED: 3/4/2009
17. ELEVATION TOP OF HOLE	0.0' MLW
18. TOTAL CORE RECOVERY FOR BORING	87%
19. SIGNATURE OF INSPECTOR	LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f
0.0	0.0		0.0' TO 12.5' WATER		
-12.5	12.5		SEDIMENT SURFACE (12.5')		12.5'
			SP - Gray, coarse, poorly graded SAND with shell fragments		1 (12.5'–13.0')
					2 (15.5'–16.0')
					3 (18.0'–18.5')
-19.7	19.7		SP-SM - Gray, fine, poorly graded Silty SAND		4 (19.7'–20.2')
-21.0	21.0		SM - Gray, fine, Silty SAND with shell fragments		5 (21.0'–21.5')
-22.0	22.0		SM - Gray, fine, Silty SAND		
-22.7	22.7		With shell fragments		
-23.7	23.7		MH - Dark gray, elastic SILT		6 (23.7'–24.2')
-25.1	25.1		SM - Gray, fine, Silty SAND		7 (25.1'–26.6')
-26.0	26.0		CL - Dark gray, lean CLAY		8 (26.6'–26.5')
-29.8	29.8		ASSUMED NOT RECOVERED		
-32.5	32.5				
			Bottom of Hole Terminated at Elev. -32.5 ft		
			SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM		

REMARKS (*Drilling time, water loss, depth weathering, etc., if significant*) g

Time begin vibracoring: 11:44 hrs.
Soils described by LARRY BENJAMIN, Civil Engr. Tech.

NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW

VIBRACORE BORING

From 0.0' to 20'
Run: 20' Rec: 17.3'

Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.

NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	NOT TESTED
5	NOT TESTED
6	NOT TESTED
7	NOT TESTED
8	NOT TESTED

NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

Hole No. SHI-V-09-13

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 54,056 E 2,187,889	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number): SHI-V-09-13	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 6; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. WATER DEPTH (BELOW MLW): 3.6'	16. DATE HOLE: STARTED 3/4/2009; COMPLETED 3/4/2009
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0' MLW
9. TOTAL DEPTH OF HOLE: 23.6'	18. TOTAL CORE RECOVERY FOR BORING: 72%
	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 3.6' WATER			Time begin vibracoring: 11:57 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-3.6	3.6		SEDIMENT SURFACE (3.6')		3.5'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded, SAND		1 (3.5'–4.1'); 2 (6.0'–6.5')	VIBRACORE BORING From 0.0' to 20' Run: 20' Rec: 14.3' Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
-8.6	8.6		SP-SM - Grayish tan, fine to medium, poorly graded, Silty SAND		3 (8.6'–9.1')	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
-11.6	11.6		SP - Tan, coarse, poorly graded, SAND		4 (11.6'–12.1'); 5 (13.5'–14.0'); 6 (16.0'–16.5')	LAB CLASSIFICATION Jar Number / Classification 1 SP 2 SP 3 SP 4 SP 5 SP 6 SP
-17.9	17.9		ASSUMED NOT RECOVERED			
-23.6	23.6		Bottom of Hole Terminated at Elev. -23.6 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

Hole No. SHI-V-09-14

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT SHALLOTTE INLET	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NCSP NAD 83 (USft) N 53,891 E 2,187,642	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number) SHI-V-09-14	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN — DISTURBED 6; UNDISTURBED 0
5. NAME OF DRILLER ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
7. WATER DEPTH (BELOW MLW) 6.6'	16. DATE HOLE — STARTED 3/4/2009; COMPLETED 3/4/2009
8. DEPTH DRILLED INTO ROCK 0.0'	17. ELEVATION TOP OF HOLE 0.0' MLW
9. TOTAL DEPTH OF HOLE 26.6'	18. TOTAL CORE RECOVERY FOR BORING 64%
	19. SIGNATURE OF INSPECTOR LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 6.6' WATER			Time begin vibracoring: 12:17 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-6.6	6.6		SEDIMENT SURFACE (6.6')		6.6' / 1 / 7.1'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded, SAND with trace shell fragments		9.0' / 2 / 9.5' 11.0' / 3 / 11.5' 13.0' / 4 / 13.5' 15.0' / 5 / 15.5'	VIBRACORE BORING From 0.0' to 20' Run: 20' Rec: 12.8' Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered. NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
-16.0	16.0		SP - Tan, coarse, poorly graded SAND with shell fragments			LAB CLASSIFICATION Jar Number / Classification 1 SP 2 SP 3 SP-SM 4 SP 5 SP 6 SP-SM
-17.0	17.0		SM - Gray, fine, Silty SAND		17.0' / 6 / 17.5'	
-19.4	19.4		ASSUMED NOT RECOVERED			
-26.6	26.6		Bottom of Hole Terminated at Elev. -26.6 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT SHALLOTTE INLET	10. SIZE AND TYPE OF BIT 4" Dia. Vibracore
2. LOCATION (Coordinates or Station) NCSP NAD 83 (USft) N 53,978 E 2,188,075	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MLW
3. DRILLING AGENCY WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number) SHI-V-09-15	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 6; UNDISTURBED 0
5. NAME OF DRILLER ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES N/A
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER N/A
7. WATER DEPTH (BELOW MLW) 3.2'	16. DATE HOLE: STARTED 3/4/2009; COMPLETED 3/4/2009
8. DEPTH DRILLED INTO ROCK 0.0'	17. ELEVATION TOP OF HOLE 0.0' MLW
9. TOTAL DEPTH OF HOLE 23.2'	18. TOTAL CORE RECOVERY FOR BORING 73%
	19. SIGNATURE OF INSPECTOR LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 3.2' WATER			Time begin vibracoring: 12:49 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-3.2	3.2		SEDIMENT SURFACE (3.2')			NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded, SAND		3.2' / 1 / 3.7' 5.5' / 2 / 6.0' 8.0' / 3 / 8.5' 10.0' / 4 / 10.5' 12.0' / 5 / 12.5' 14.0' / 6 / 14.5'	**VIBRACORE BORING** From 0.0' to 20' Run: 20' Rec: 14.5' Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered. NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487 **LAB CLASSIFICATION** Jar Number / Classification 1 SP 2 SP 3 SP 4 SP 5 SP 6 SP
-17.7	17.7		ASSUMED NOT RECOVERED			
-23.2	23.2		Bottom of Hole Terminated at Elev. -23.2 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

Hole No. SHI-V-09-16

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 54,092 E 2,188,645	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number): SHI-V-09-16	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 6; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED --- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. WATER DEPTH (BELOW MLW): 3.8'	16. DATE HOLE: STARTED 3/4/2009; COMPLETED 3/4/2009
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0' MLW
9. TOTAL DEPTH OF HOLE: 23.8'	18. TOTAL CORE RECOVERY FOR BORING: 68%
	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 3.8' WATER			Time begin vibracoring: 13:18 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-3.8	3.8		SEDIMENT SURFACE (3.8')		3.8'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded, SAND		1 (3.8'–4.3')	
					2 (6.0'–6.5')	VIBRACORE BORING: From 0.0' to 20' Run: 20' Rec: 13.5'. Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
					3 (8.5'–9.0')	
					4 (11.0'–11.5')	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
-13.0	13.0		SP-SM - Tan, fine, poorly graded, Silty SAND		5 (13.0'–13.5')	
					6 (15.0'–15.5')	
-17.3	17.3		ASSUMED NOT RECOVERED			
-23.8	23.8		Bottom of Hole Terminated at Elev. -23.8 ft			NOTE: Hole terminated at predetermined depth at 20' below sediment surface.

SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM

LAB CLASSIFICATION

Jar Number	Classification
1	SP
2	SP
3	SP
4	SP
5	SP
6	SP-SM

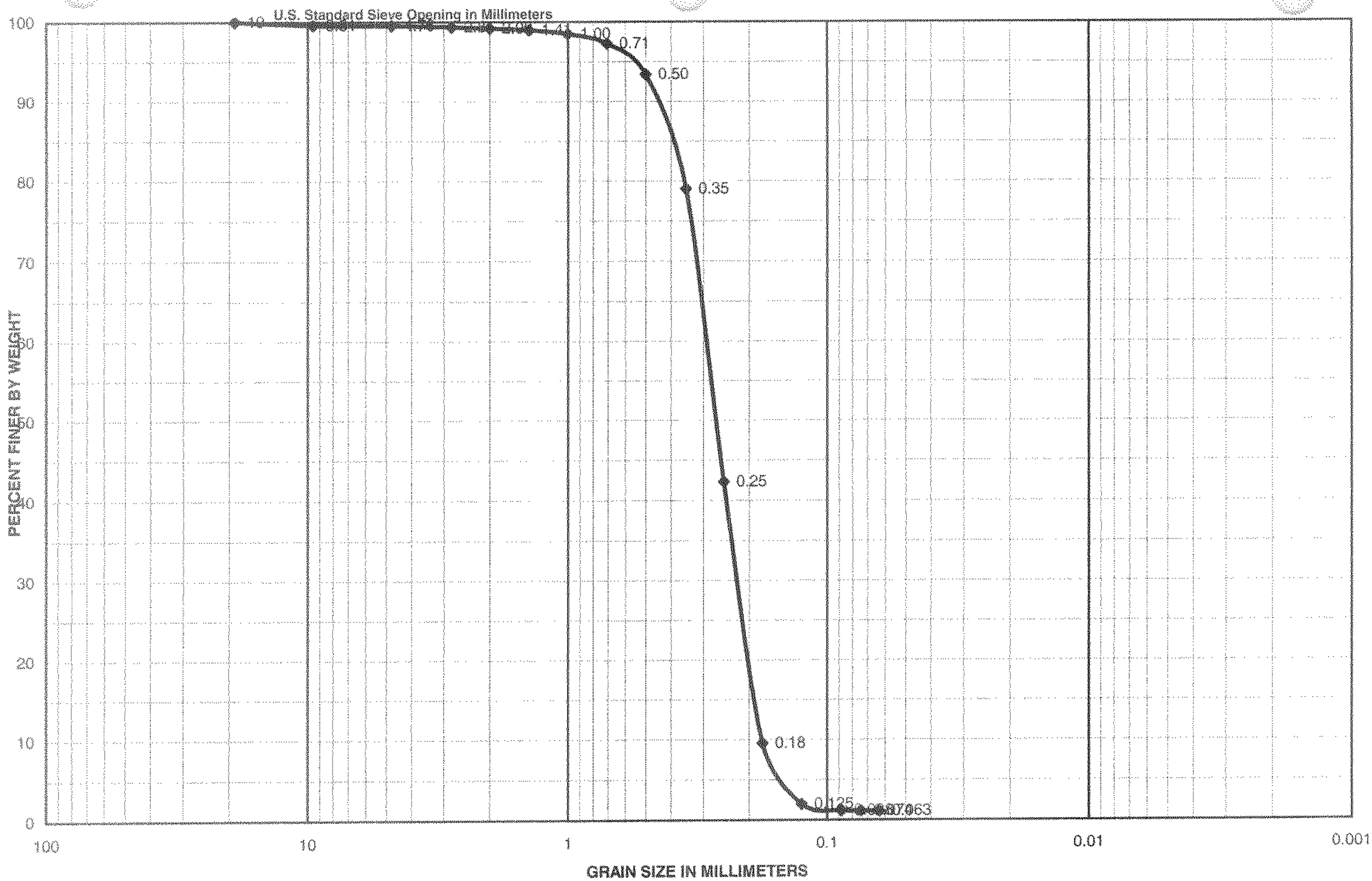
Hole No. SHI-V-09-17

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: WILMINGTON DISTRICT	SHEET 1 OF 1 SHEETS

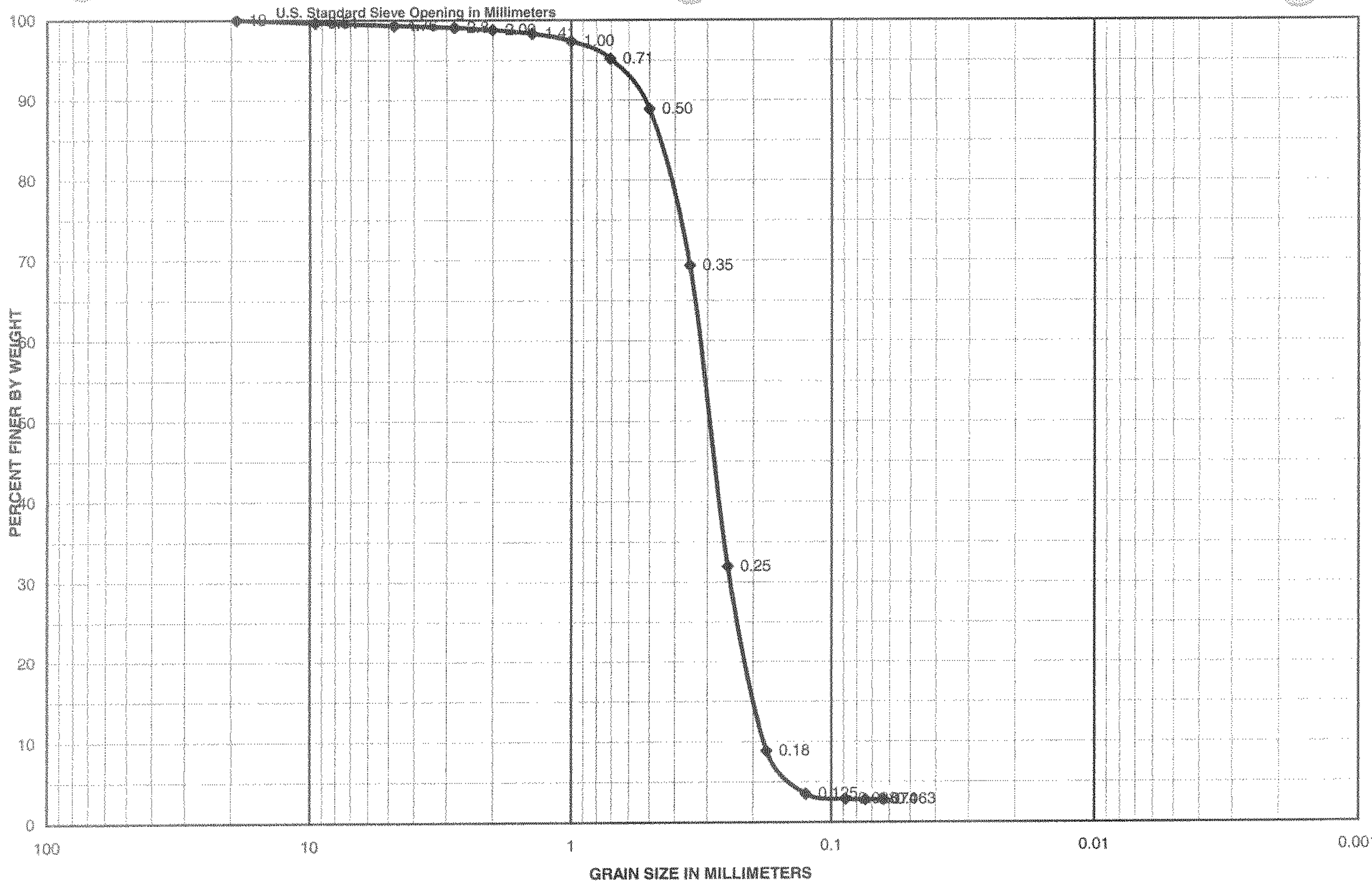
1. PROJECT: SHALLOTTE INLET	10. SIZE AND TYPE OF BIT: 4" Dia. Vibracore
2. LOCATION (Coordinates or Station): NCSP NAD 83 (USft) N 54,511 E 2,187,018	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
3. DRILLING AGENCY: WILMINGTON DISTRICT	12. MANUFACTURER'S DESIGNATION OF DRILL: ALPINE VIBRACORE - SNELL
4. HOLE NO. (As shown on drawing title and file number): SHI-V-09-17	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 5; UNDISTURBED 0
5. NAME OF DRILLER: ROBIE PAGE CRANE OPERATOR	14. TOTAL NUMBER CORE BOXES: N/A
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ---- DEG. FROM VERT.	15. ELEVATION GROUND WATER: N/A
7. WATER DEPTH (BELOW MLW): 5.7'	16. DATE HOLE: STARTED 3/4/2009; COMPLETED 3/4/2009
8. DEPTH DRILLED INTO ROCK: 0.0'	17. ELEVATION TOP OF HOLE: 0.0' MLW
9. TOTAL DEPTH OF HOLE: 20.7'	18. TOTAL CORE RECOVERY FOR BORING: 57%
	19. SIGNATURE OF INSPECTOR: LARRY BENJAMIN

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth weathering, etc., if significant) g
0.0	0.0		0.0' TO 5.7' WATER			Time begin vibracoring: 13:57 hrs. Soils described by LARRY BENJAMIN, Civil Engr. Tech.
-5.7	5.7		SEDIMENT SURFACE (5.7')		5.7' / 1 / 6.2'	NOTE: TOP OF HOLE is defined as surface of water and compensation is made for the tide such that top of hole is 0.0' MLW
			SP - Tan, coarse, poorly graded, SAND with trace shell fragments		8.0' / 2 / 8.5'	VIBRACORE BORING From 0.0' to 15' Run: 15' Rec: 8.6' Top of vibracore soil sample is logged as beginning at water bottom. When Run is greater than Recovery, the difference is depicted as Assumed Not Recovered.
					10.0' / 3 / 10.5'	
-12.7	12.7				12.7' / 4	NOTE: Soils Commercial Lab Classified in Accordance with ASTM-D2487
-13.2	13.2		MH - Dark gray, elastic SILT with shell fragments	13.2	5 / 13.7'	
-14.3	14.3		SP - Tan, coarse, poorly graded, SAND			
			ASSUMED NOT RECOVERED			LAB CLASSIFICATION Jar Number / Classification 1 SP 2 SP 3 SP 4 SM 5 SP-SM
-20.7	20.7					
			Bottom of Hole Terminated at Elev. -20.7 ft SOILS ARE FIELD VISUALLY CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM			NOTE: Hole terminated at refusal depth at 15' below sediment surface.

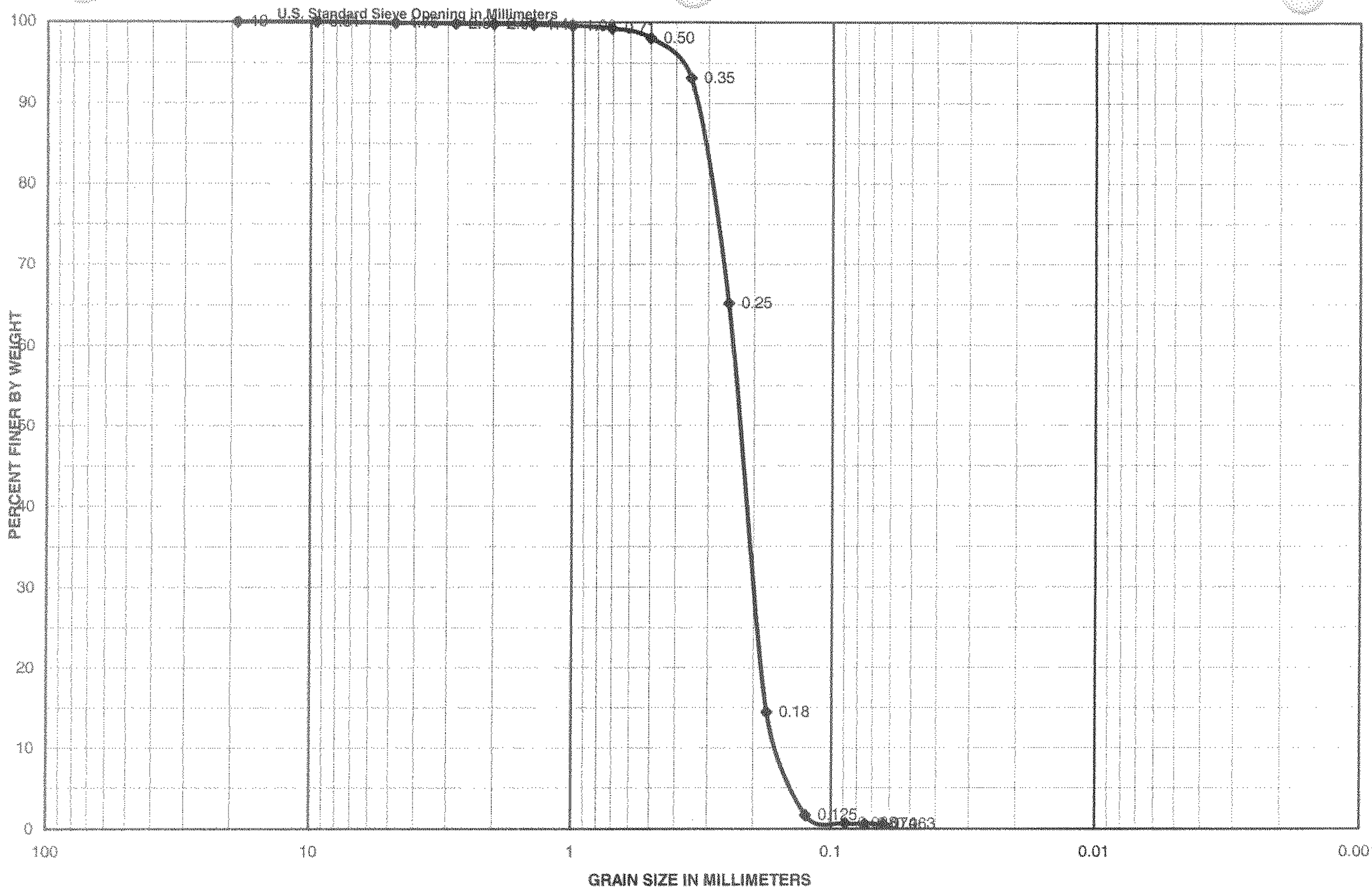
ENG FORM 1836 PREVIOUS EDITIONS ARE OBSOLETE | PROJECT | HOLE NO.



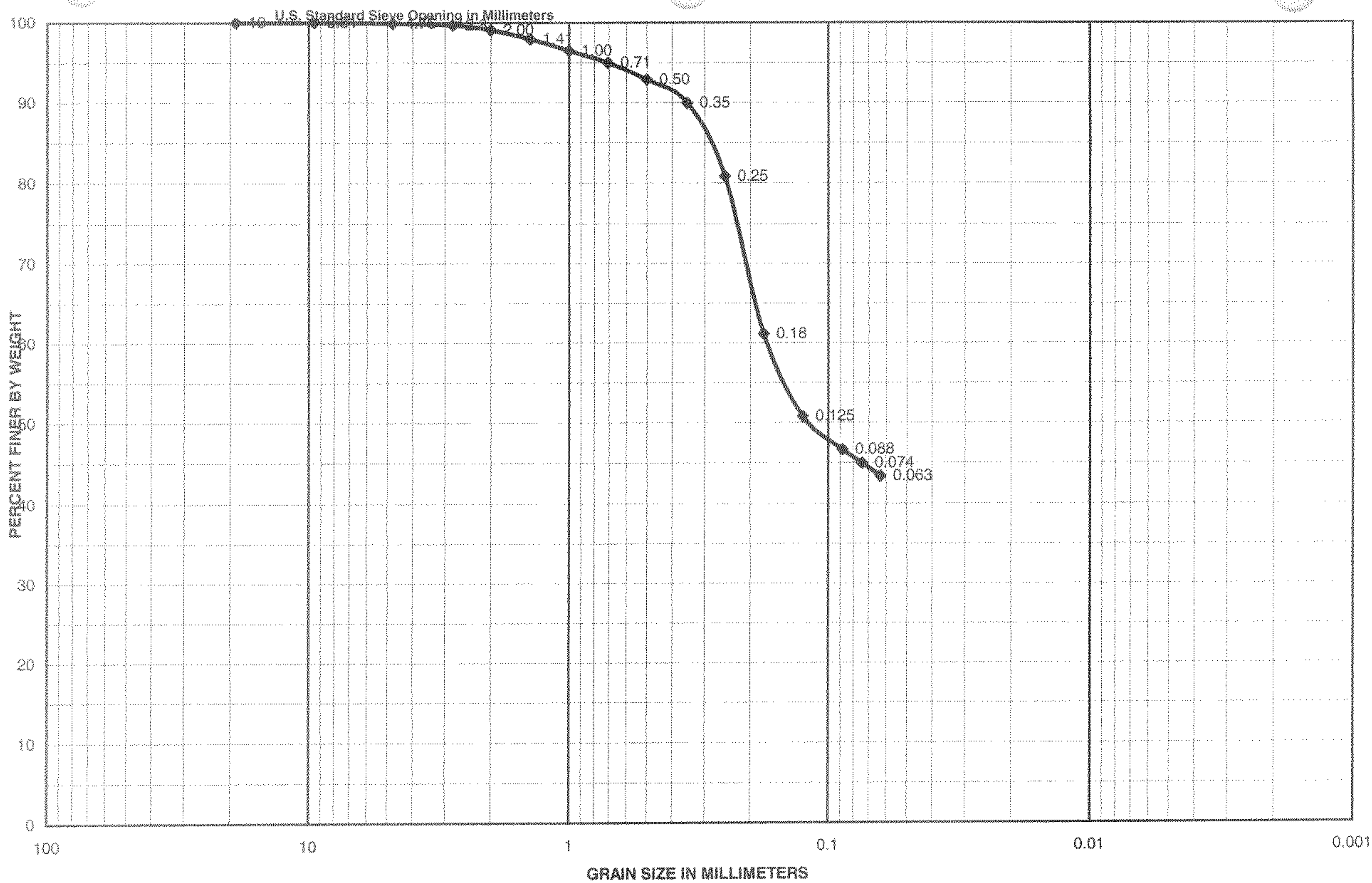
Sample No.	Depth	Classification	Area Shallotte Inlet
1	7.9-8.4	Olive gray poorly graded sand with few shells, SP	**CATLIN Geotechnical Laboratory**
		6.6% shells	Boring No. SHI-V-09-1
			Date 4/29/2009



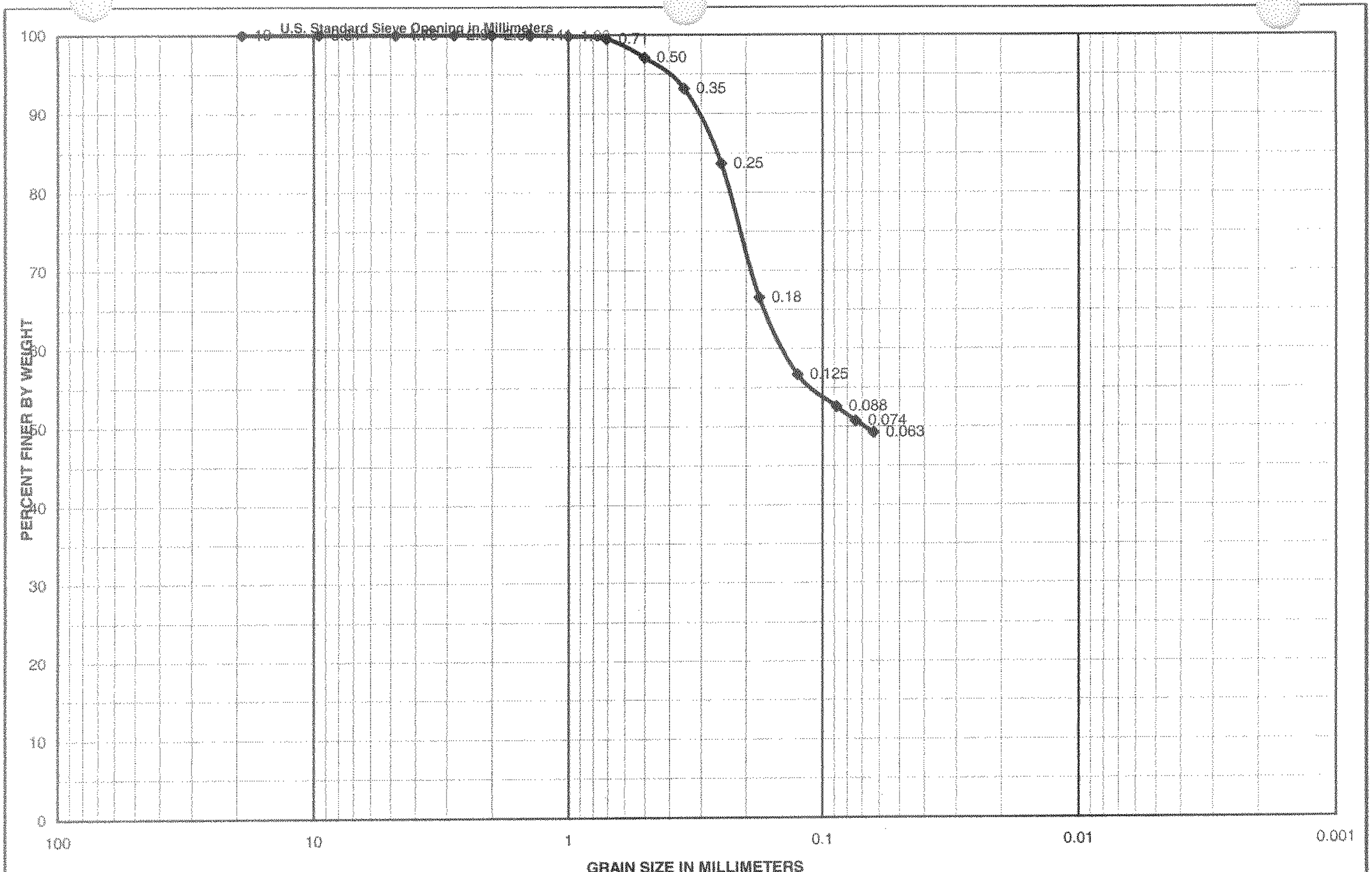
Sample No.	Depth	Classification	Area	Shallotte Inlet
2	11.0-11.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		4.8% shells	**Boring No.**	SHI-V-09-1
			Date	4/29/2009



Sample No.	Depth	Classification	Area	Shallotte Inlet
3	14.0-14.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		1.9% shells	**Boring No.**	SHI-V-09-1
			Date	4/29/2009

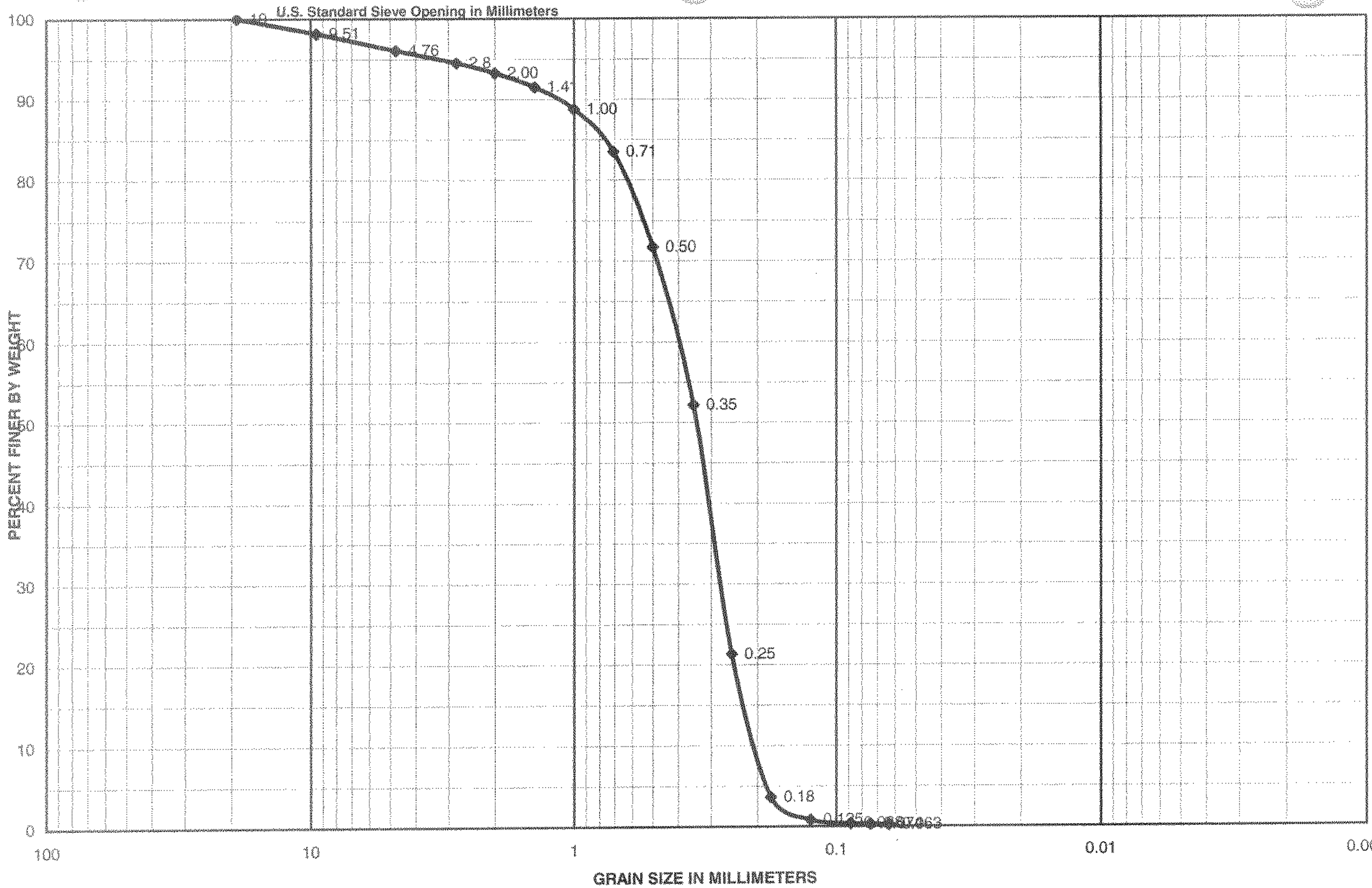


Sample No.	Depth	Classification	Area	Shallotte Inlet
4	15.4-15.9	Olive gray clayey sand with trace fine gravel, SC	**CATLIN Geotechnical Laboratory**	
			Boring No.	SHI-V-09-1
			Date	4/29/2009

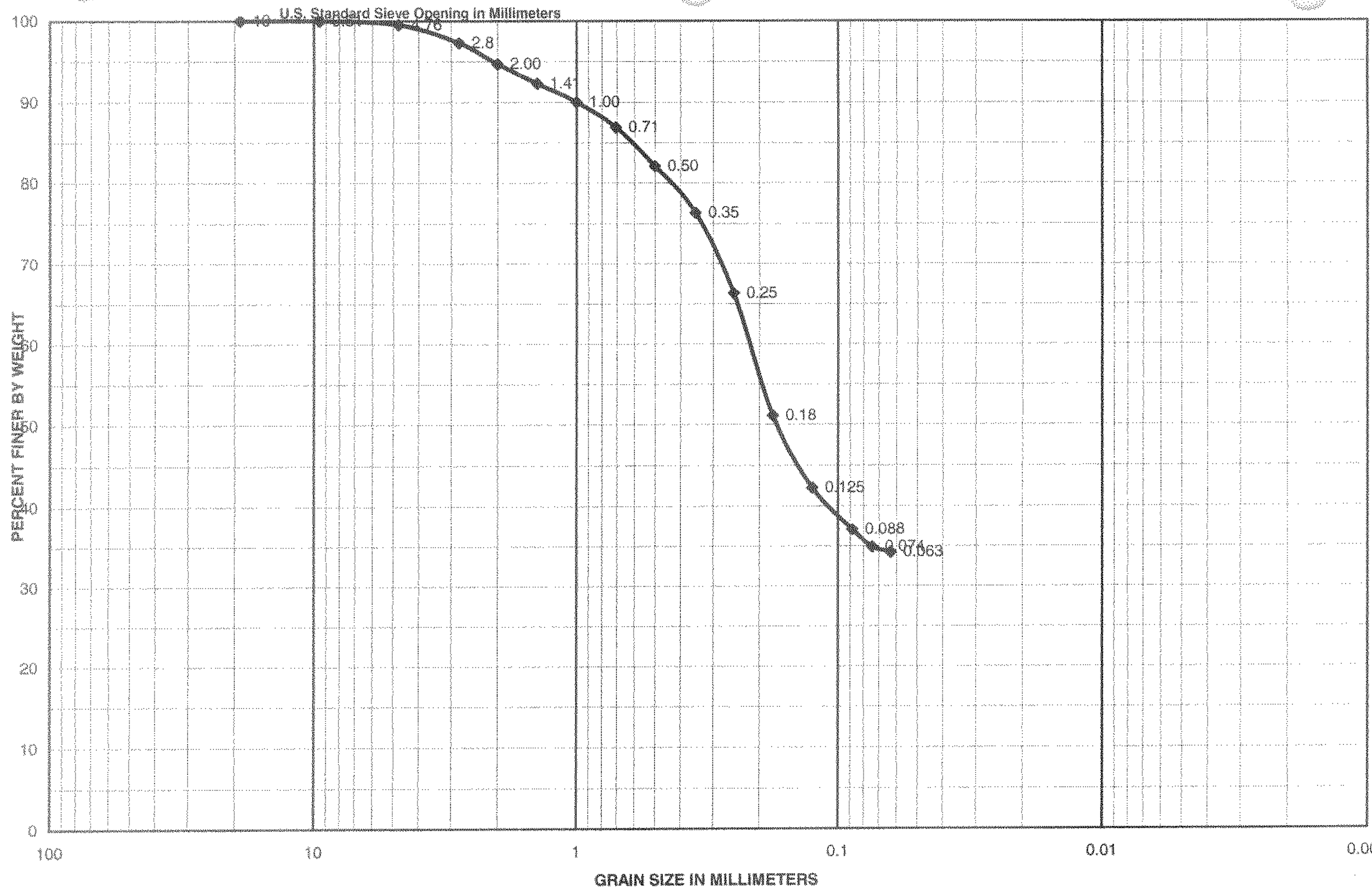


Sample No.	Depth	Classification
5	17.9-18.4	Olive gray ~~clayey sand to~~ sandy lean clay with trace fine gravel, SC/CL

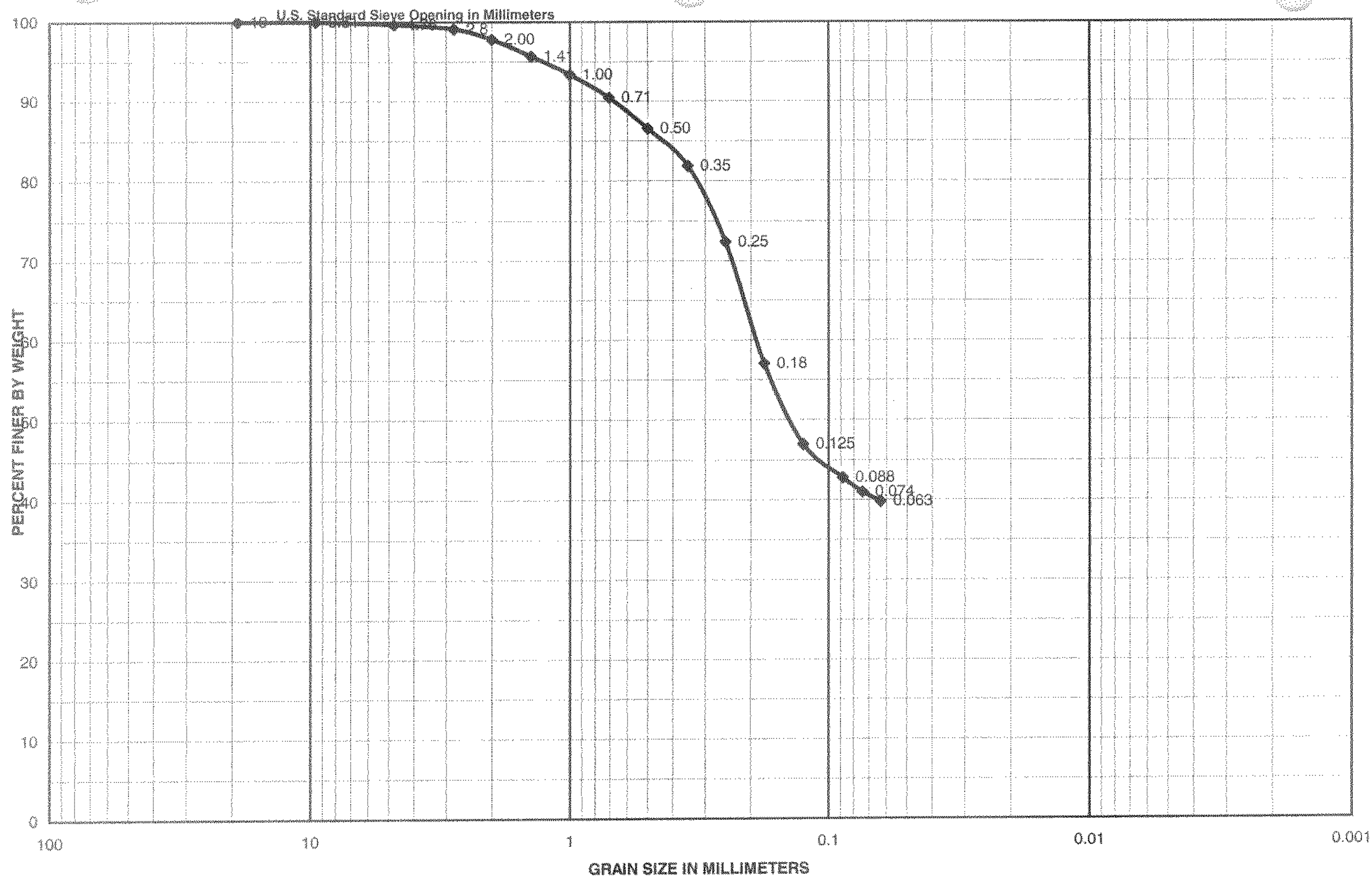
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-1
Date	4/29/2009



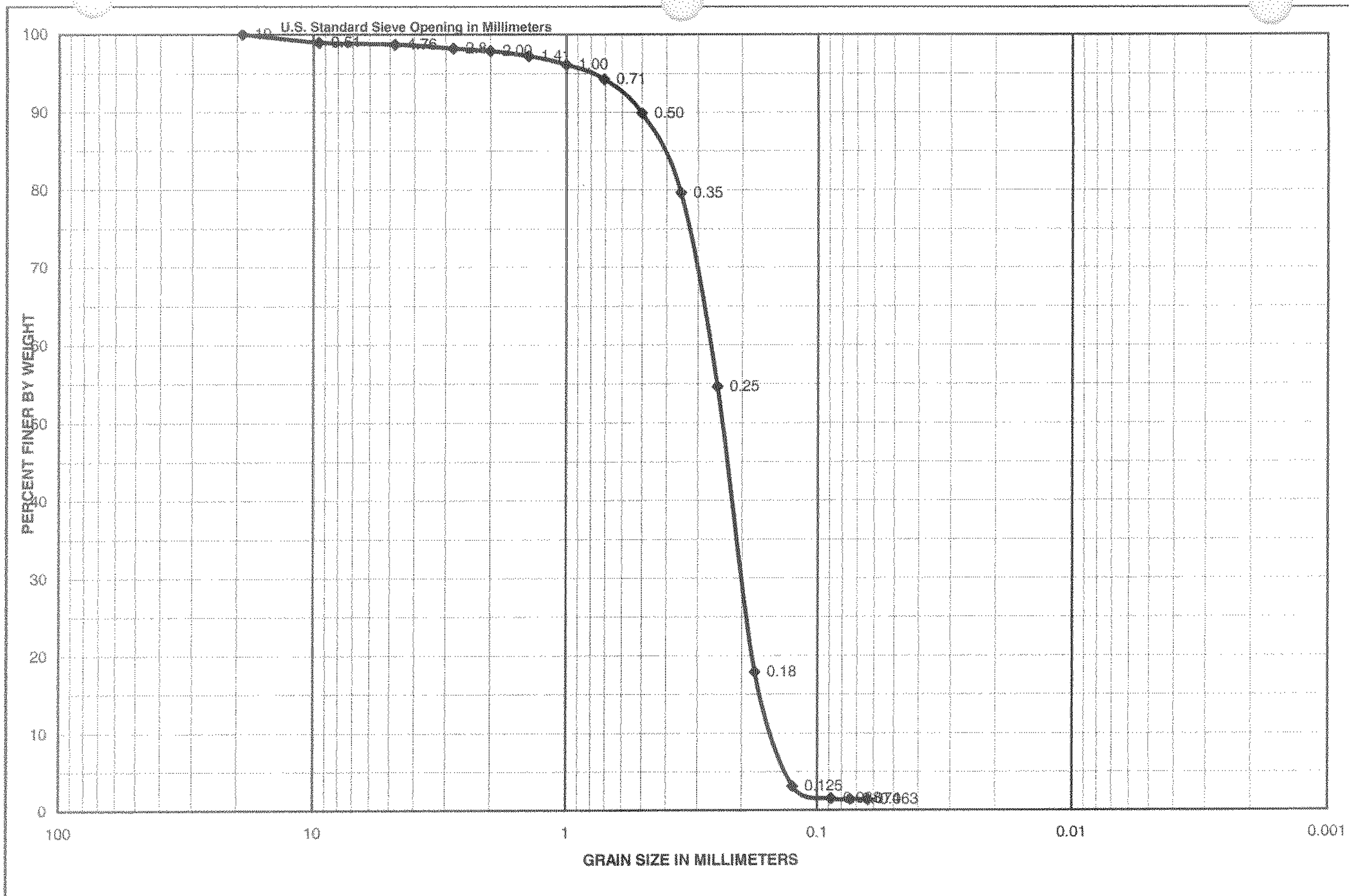
Sample No.	Depth	Classification	Area	Shallotte Inlet
1	12.3-12.8	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		16.5% shells	**Boring No.**	SHI-V-09-2
			Date	4/29/2009



Sample No.	Depth	Classification	Area	Shallotte Inlet
2	13.3-13.8	Olive gray silty sand with trace fine gravel, SM	**CATLIN Geotechnical Laboratory**	
			Boring No.	SHI-V-09-2
			Date	4/29/2009

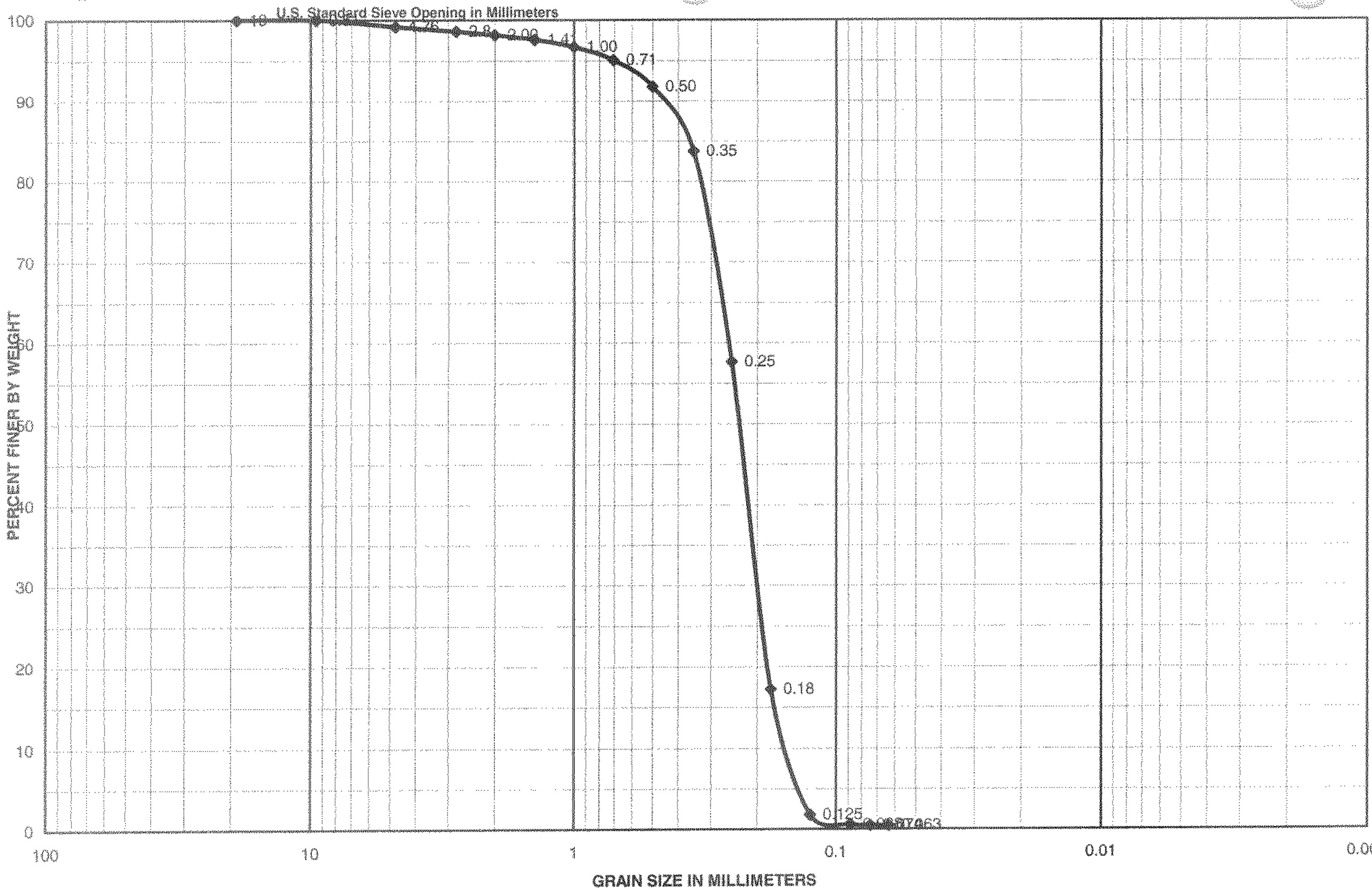


Sample No.	Depth	Classification	Area	Shallotte Inlet
3	16.0-16.5	Olive gray clayey sand with trace fine gravel, SC	**CATLIN Geotechnical Laboratory**	
			Boring No.	SHI-V-09-2
			Date	4/29/2009

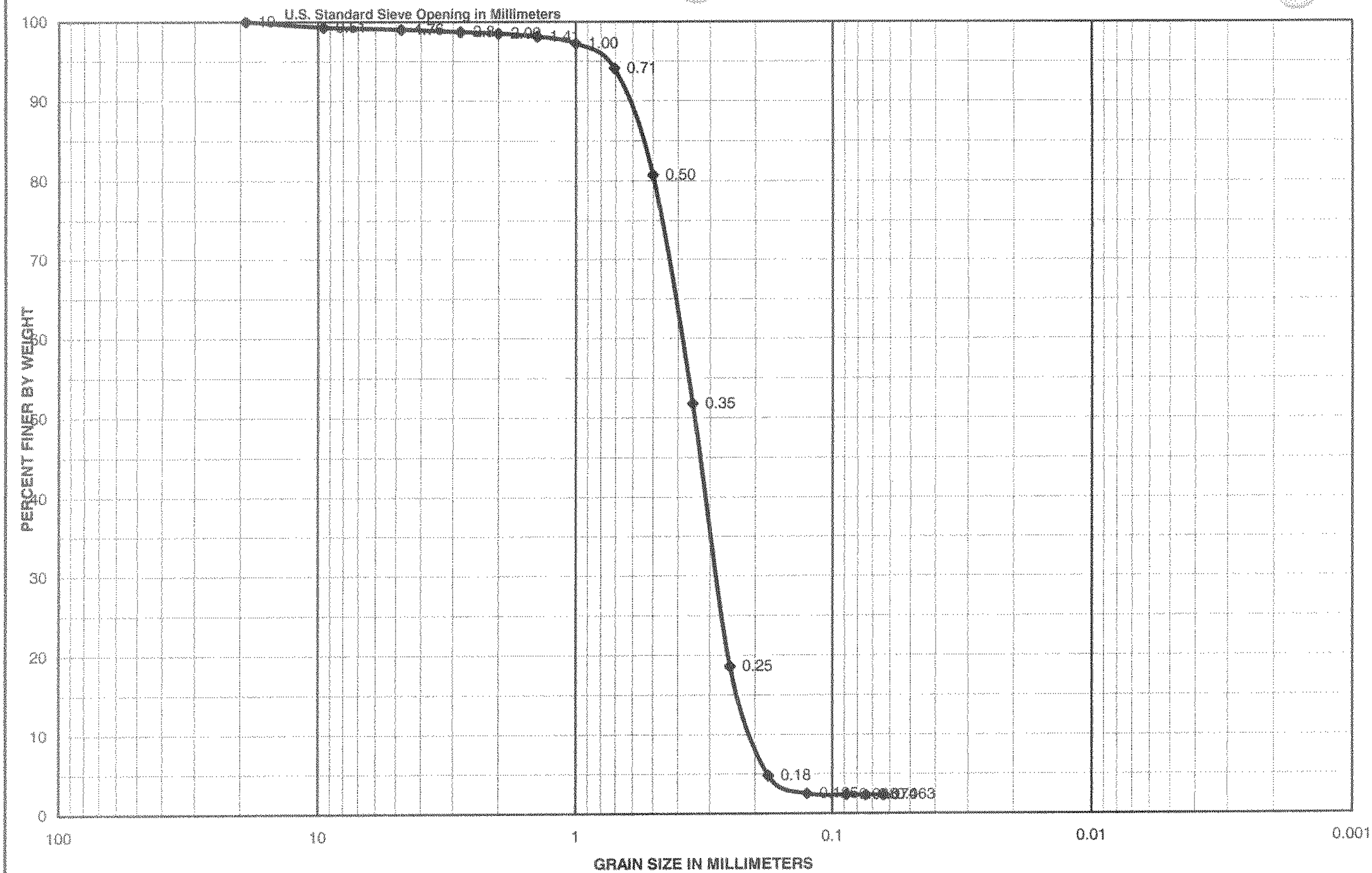


Sample No.	Depth	Classification
1	1.7-2.2	Olive gray poorly graded sand with trace shells, SP
		3.9% shells

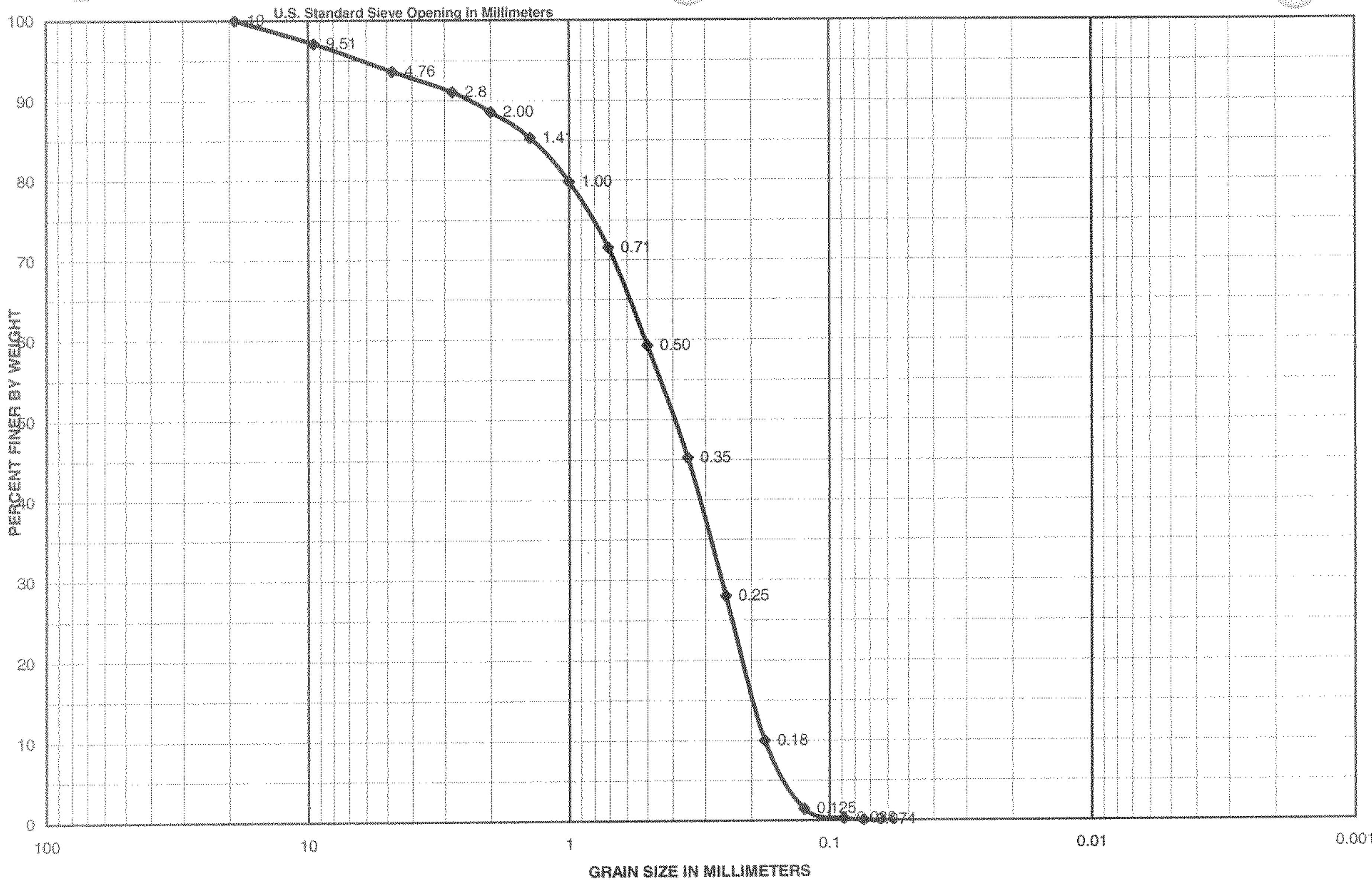
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-3
Date	4/29/2009



Sample No.	Depth	Classification	Area	Shallotte Inlet
2	5.0-5.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		3.3% shells	**Boring No.**	SHI-V-09-3
			Date	4/29/2009

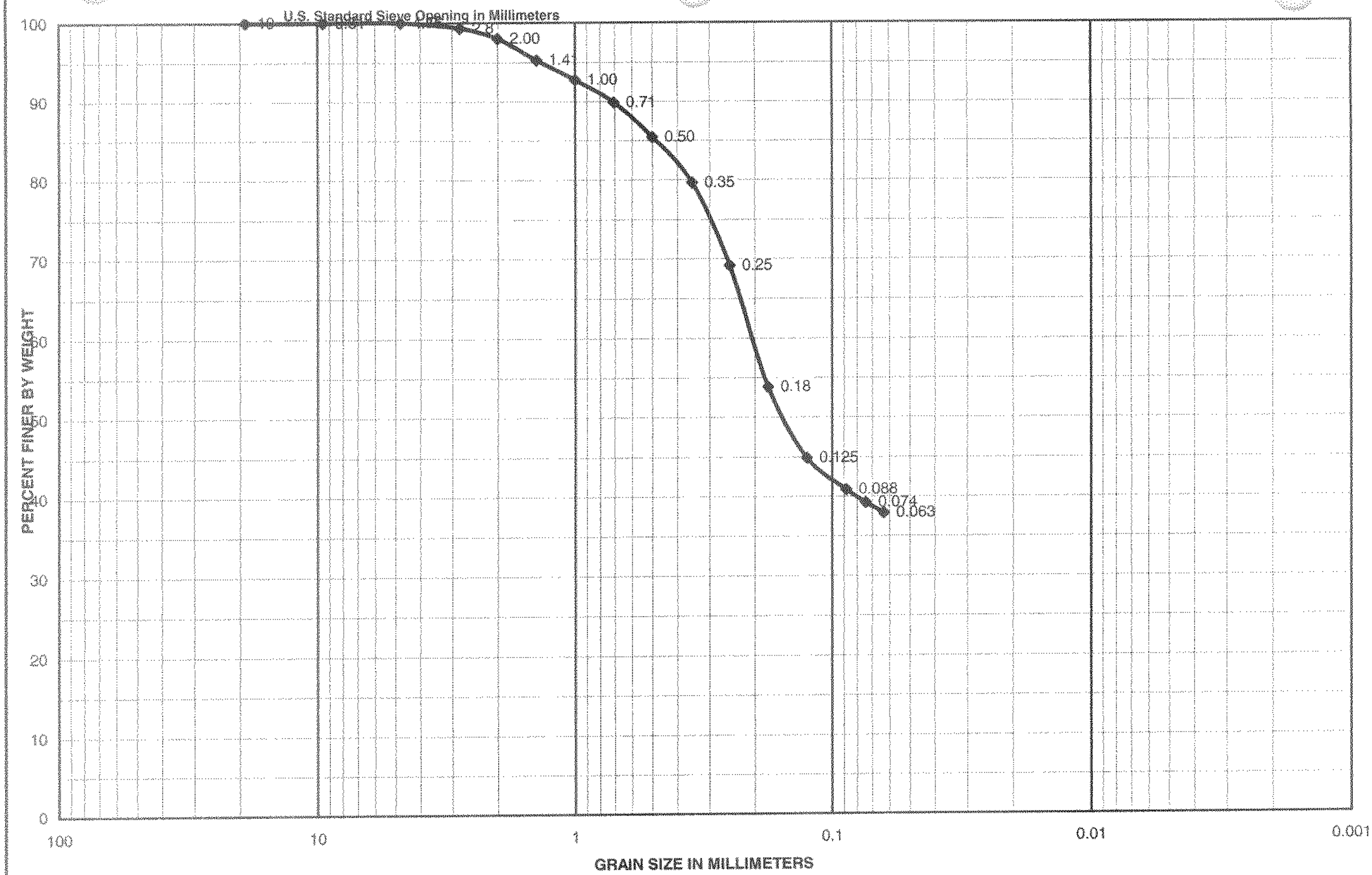


Sample No.	Depth	Classification	Area	Shallotte Inlet
3	8.0-8.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		5.9% shells	**Boring No.**	SHI-V-09-3
			Date	4/29/2009



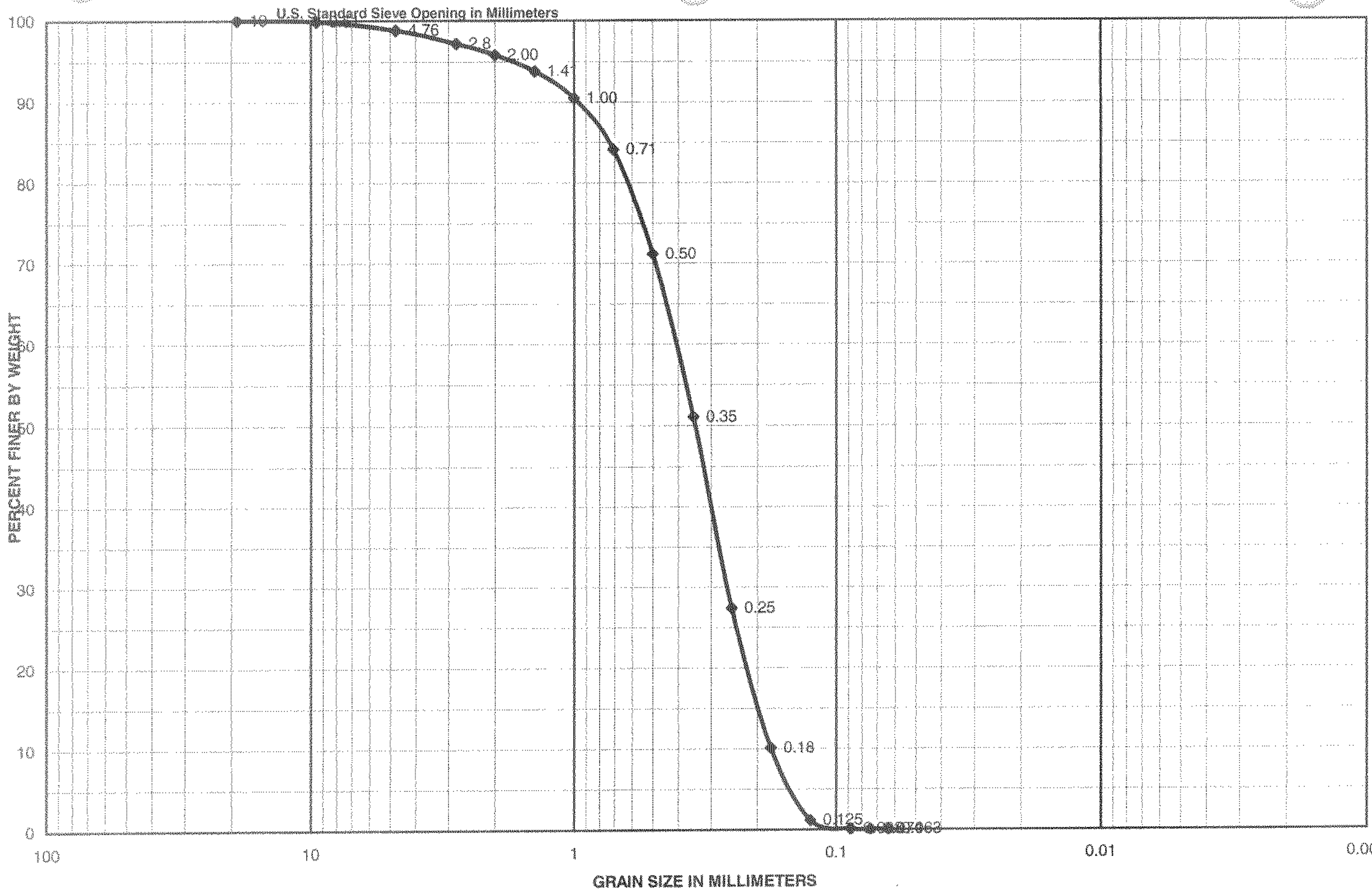
Sample No.	Depth	Classification
4	11.0-11.5	Olive gray poorly graded sand with little shells, SP
		20.2% shells

Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-3
Date	4/29/2009

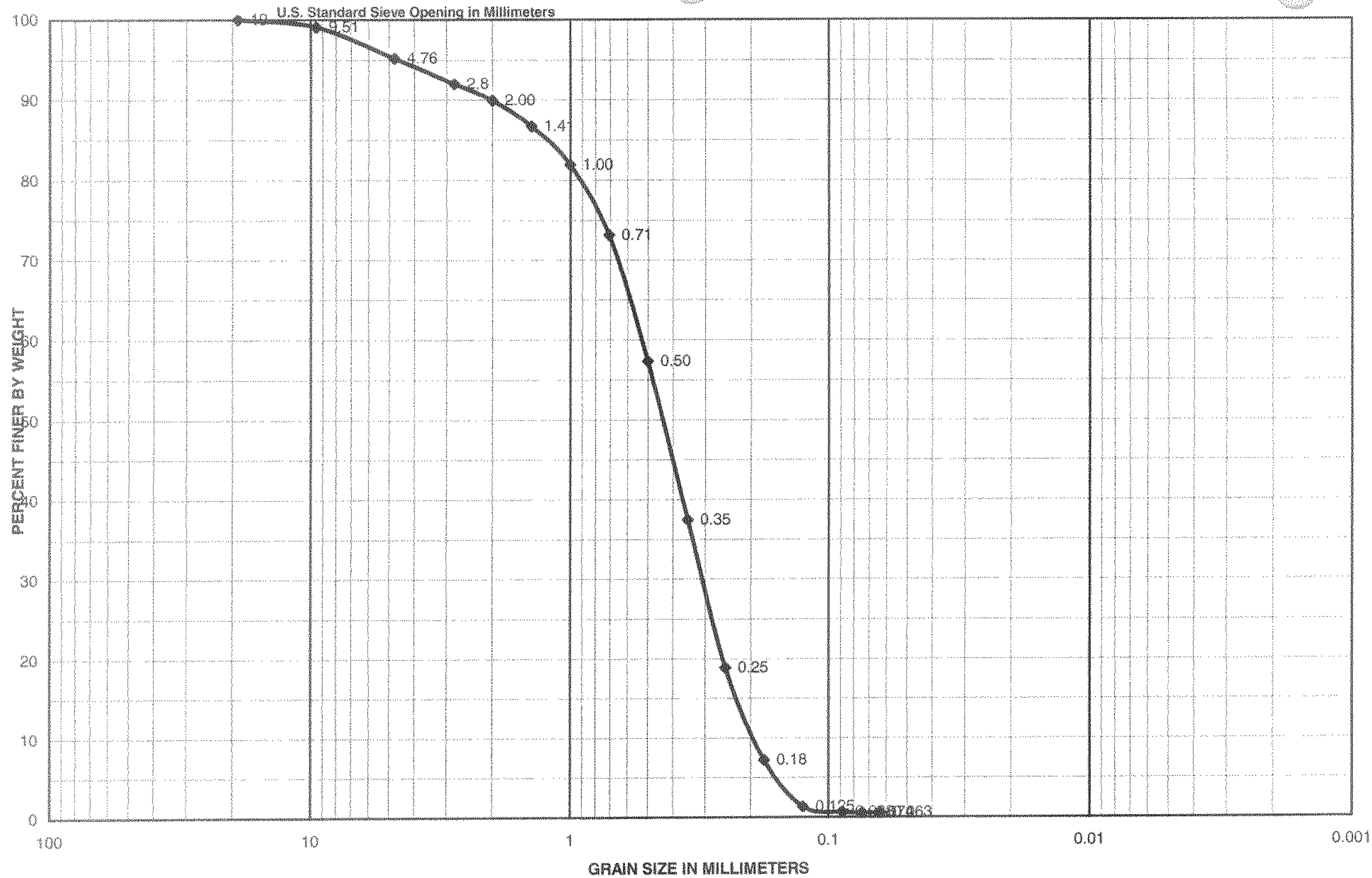


Sample No.	Depth	Classification
5	11.7-12.2	Olive gray silty sand with fine gravel, SM

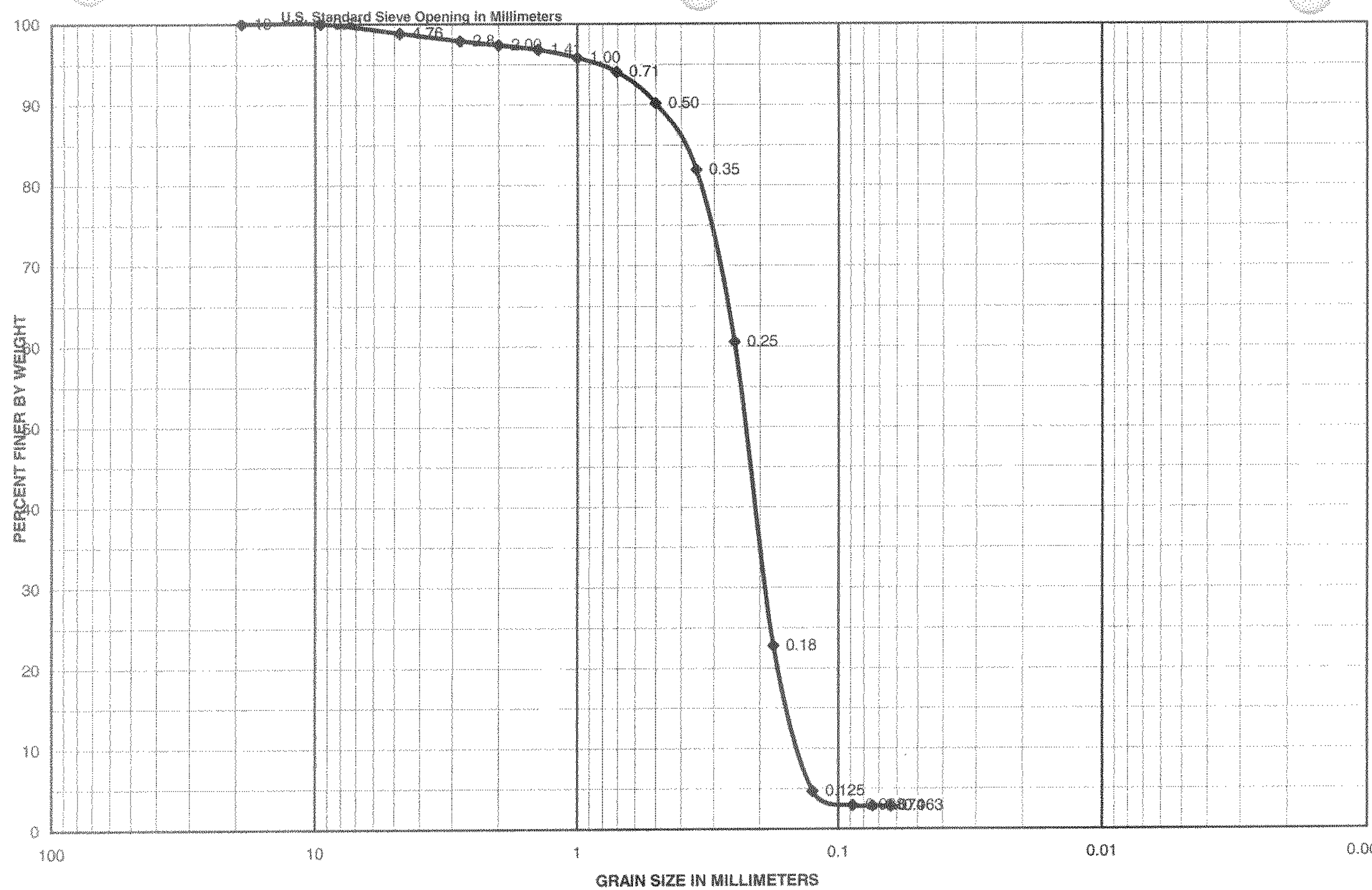
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-3
Date	4/29/2009



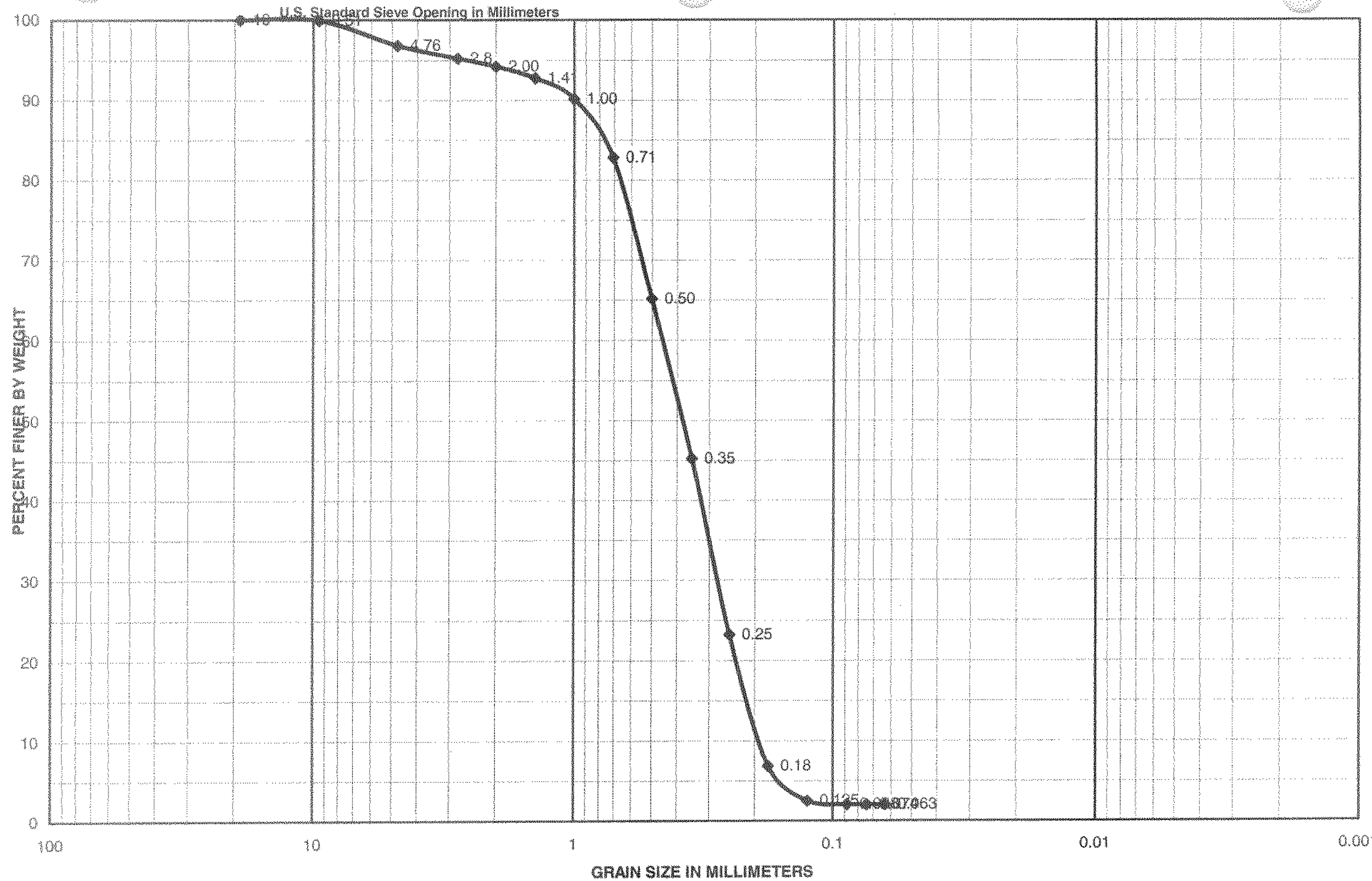
Sample No.	Depth	Classification	Area	Shallotte Inlet
1	5.1-5.6	Olive gray poorly graded sand with few shells, SP	**CATLIN Geotechnical Laboratory**	
		9.5% shells	**Boring No.**	SHI-V-09-4
			Date	4/29/2009



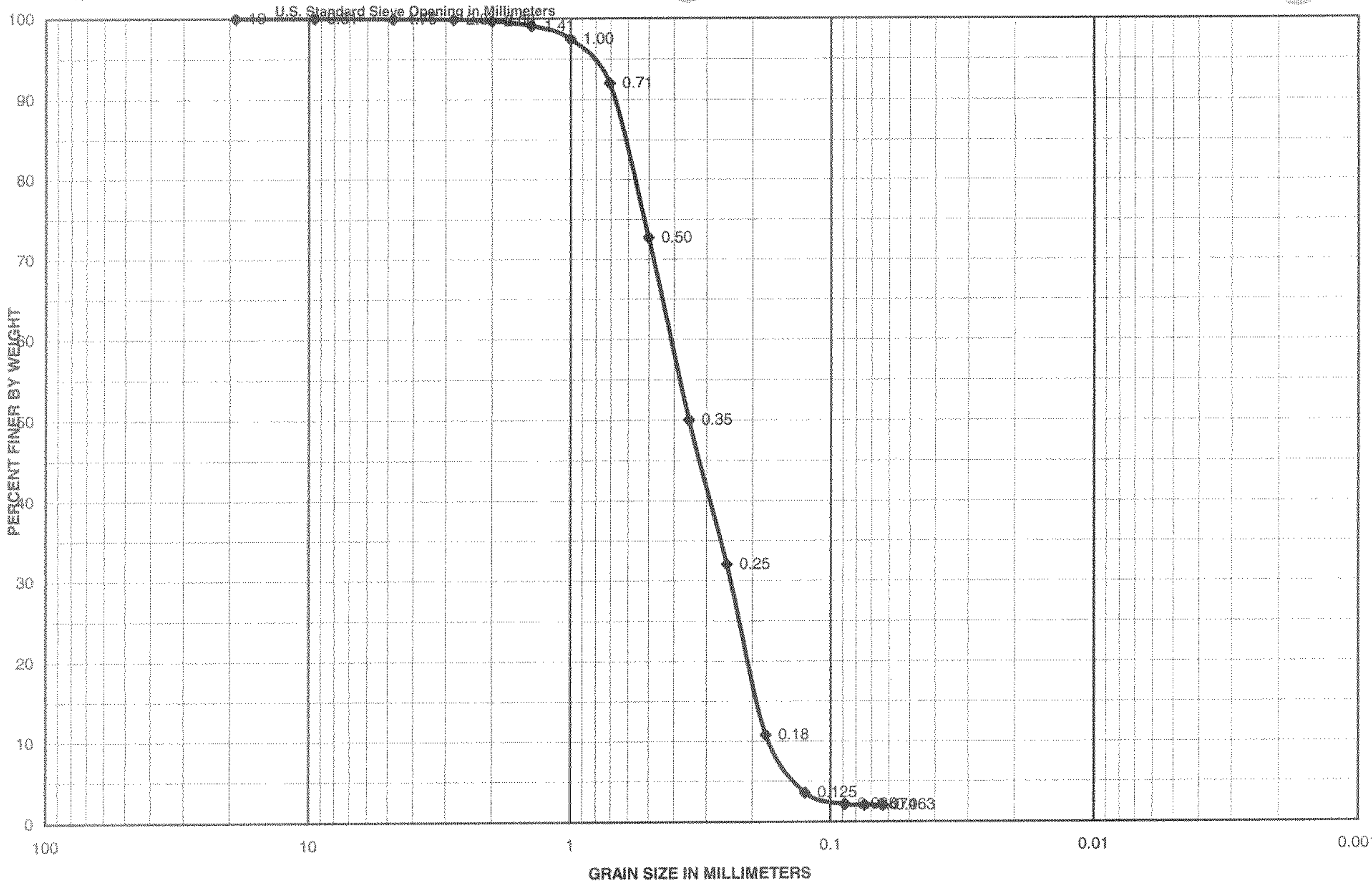
Sample No.	Depth	Classification	Area	Shallotte Inlet
2	8.0-8.5	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		18.1% shells	Boring No.	SHI-V-09-4
			Date	4/29/2009



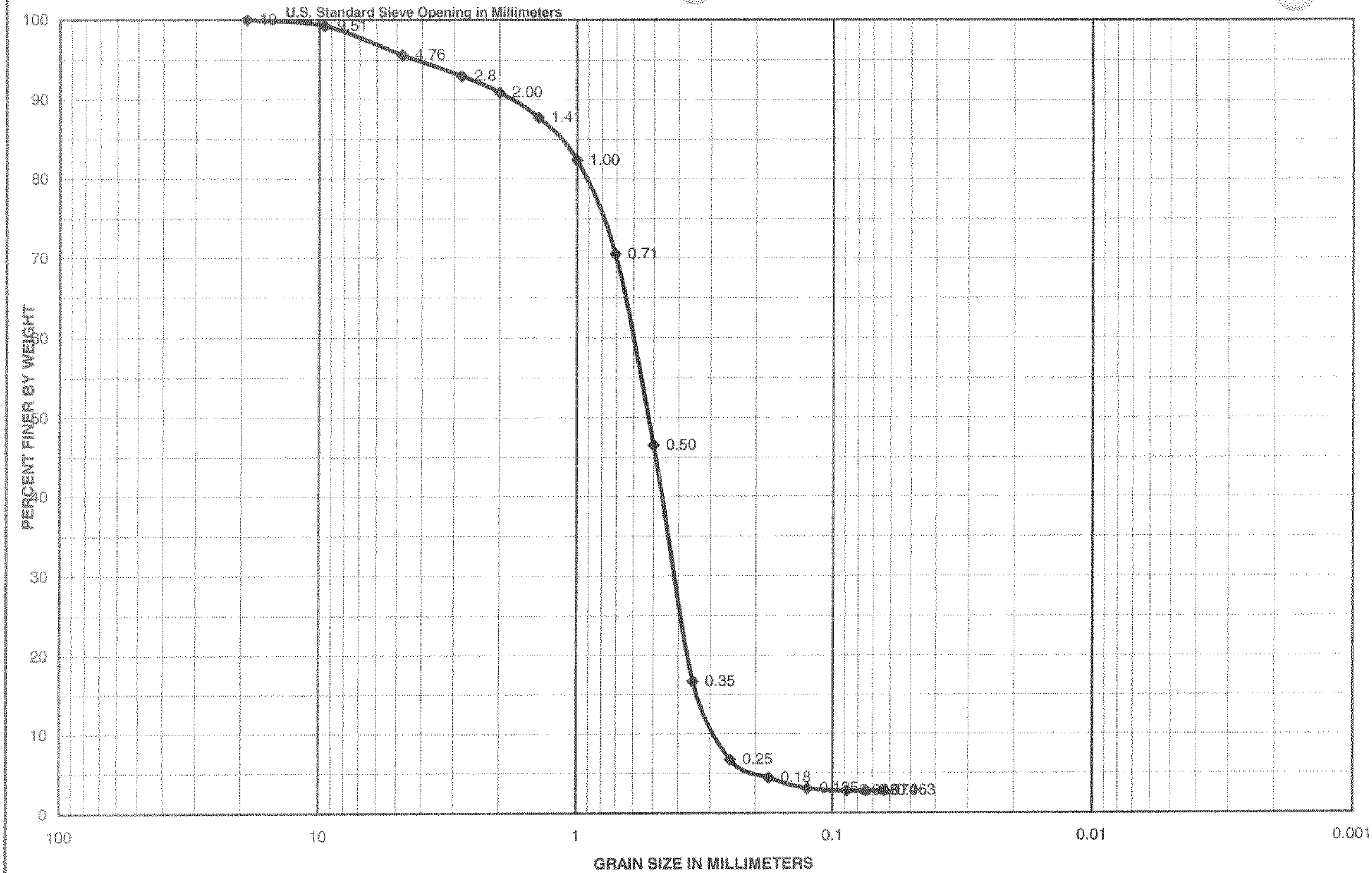
Sample No.	Depth	Classification	Area	Shallotte Inlet
3	11.0-11.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		4.2% shells	Boring No.	SHI-V-09-4
			Date	4/29/2009



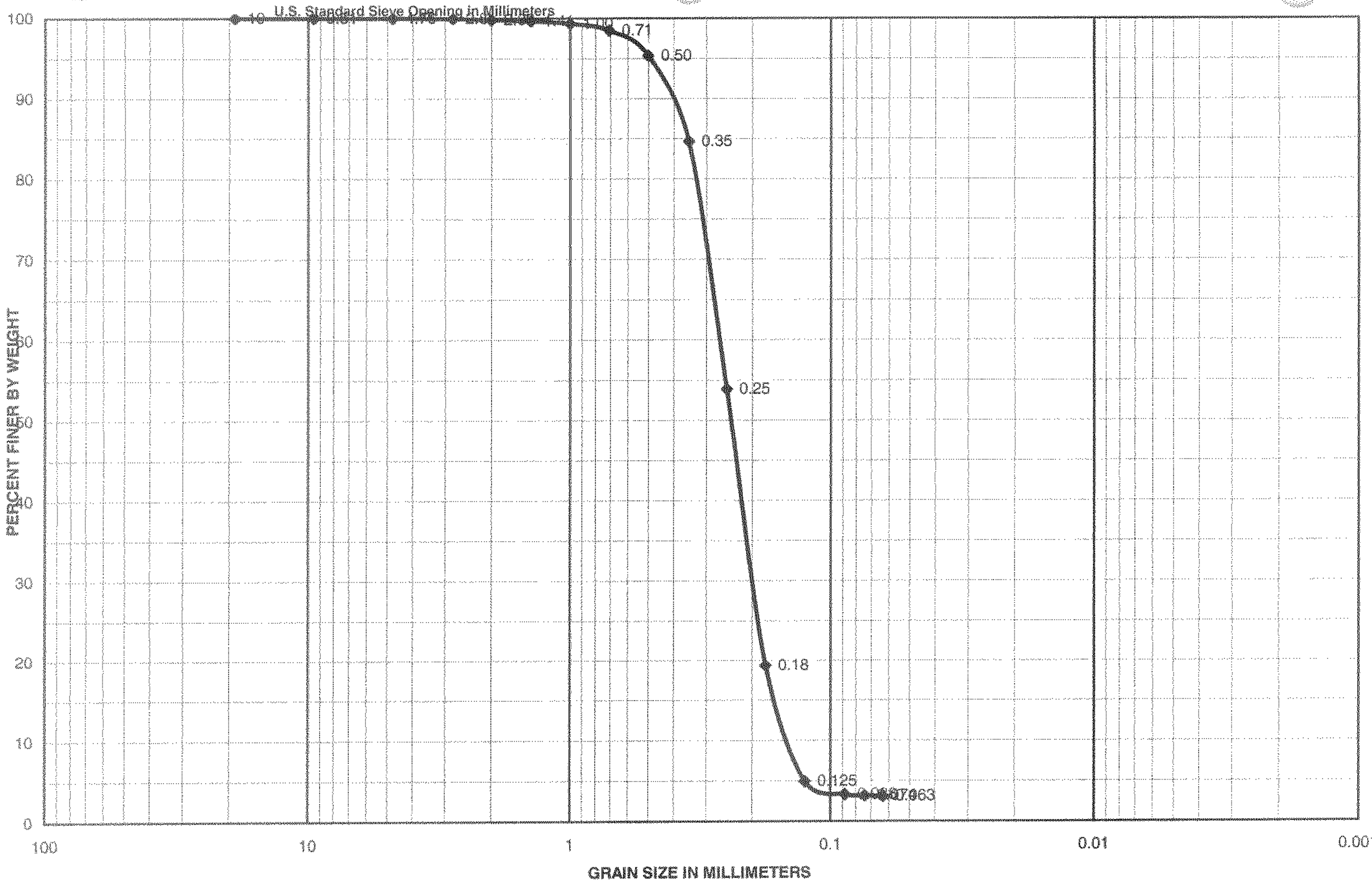
Sample No.	Depth	Classification	Area	Shallotte Inlet
4	14.0-14.5	Olive gray poorly graded sand with few shells, SP	**CATLIN Geotechnical Laboratory**	
		9.8% shells	**Boring No.**	SHI-V-09-4
			Date	4/29/2009



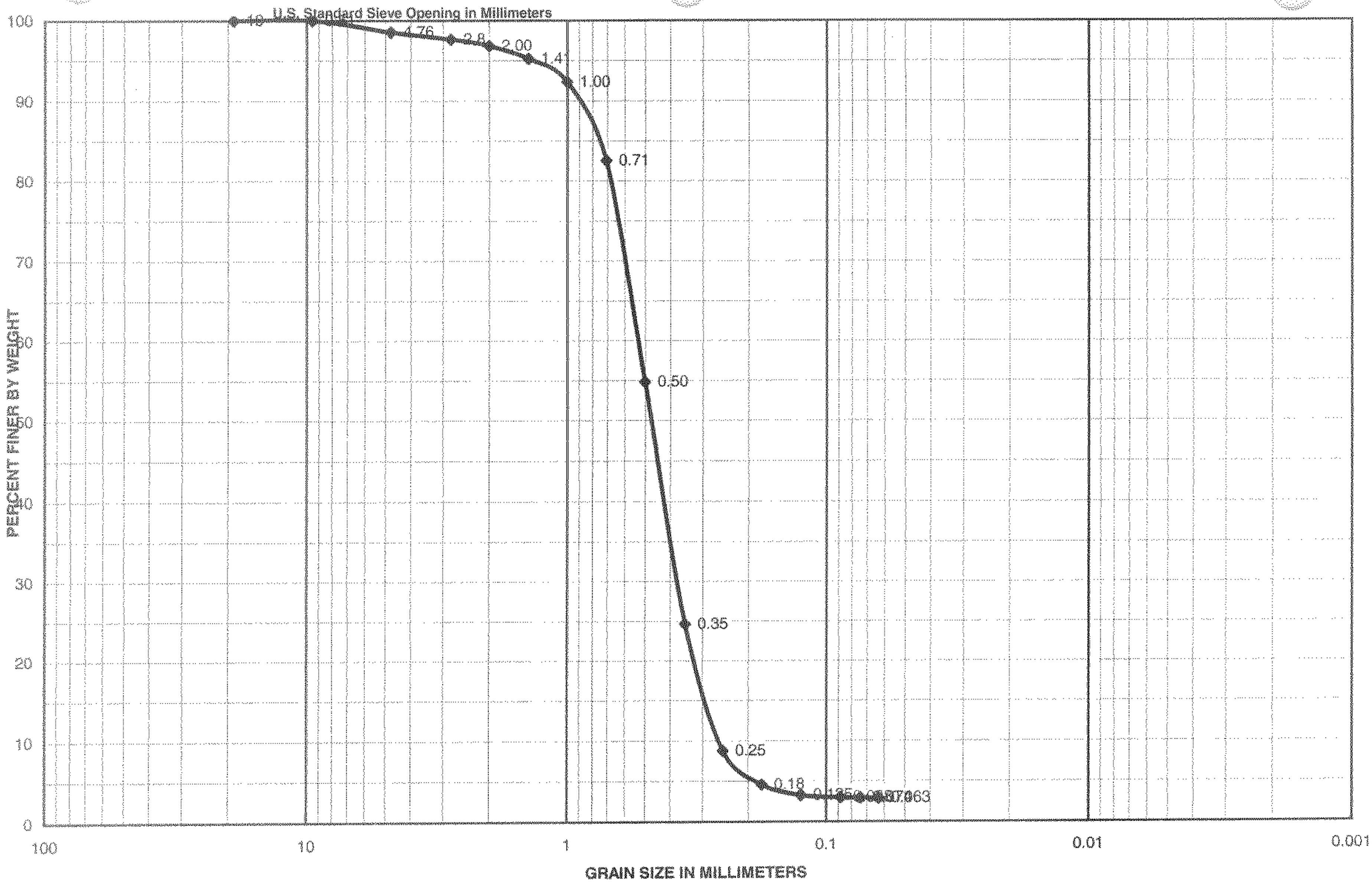
Sample No.	Depth	Classification	Area Shallotte Inlet
5	16.5-17.0	Olive gray poorly graded sand, SP	**CATLIN Geotechnical Laboratory**
			Boring No. SHI-V-09-4
			Date 4/29/2009



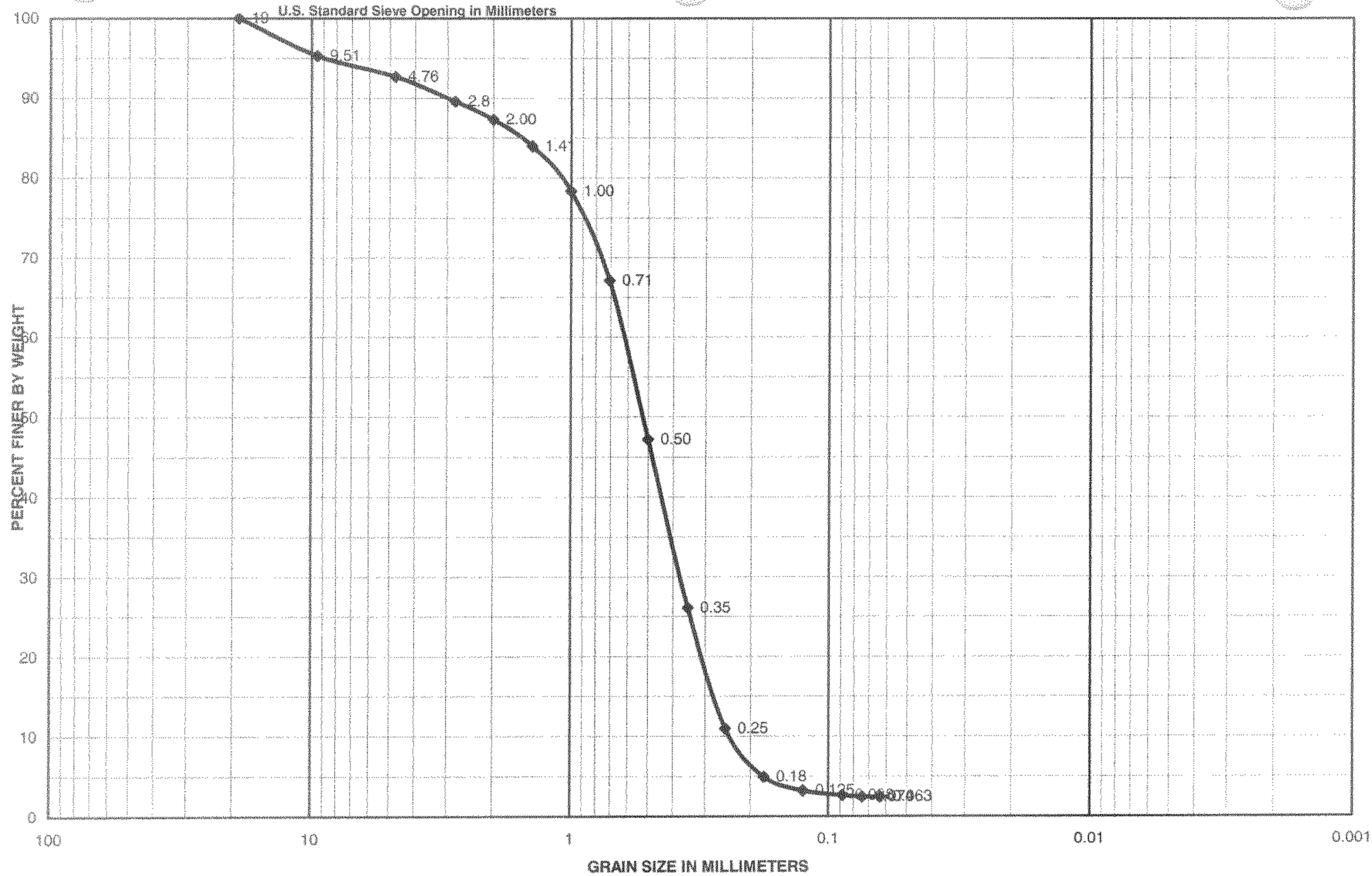
Sample No.	Depth	Classification	Area	Shallotte Inlet
1	3.7-4.2	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		17.6% shells	Boring No.	SHI-V-09-5
			Date	4/29/2009



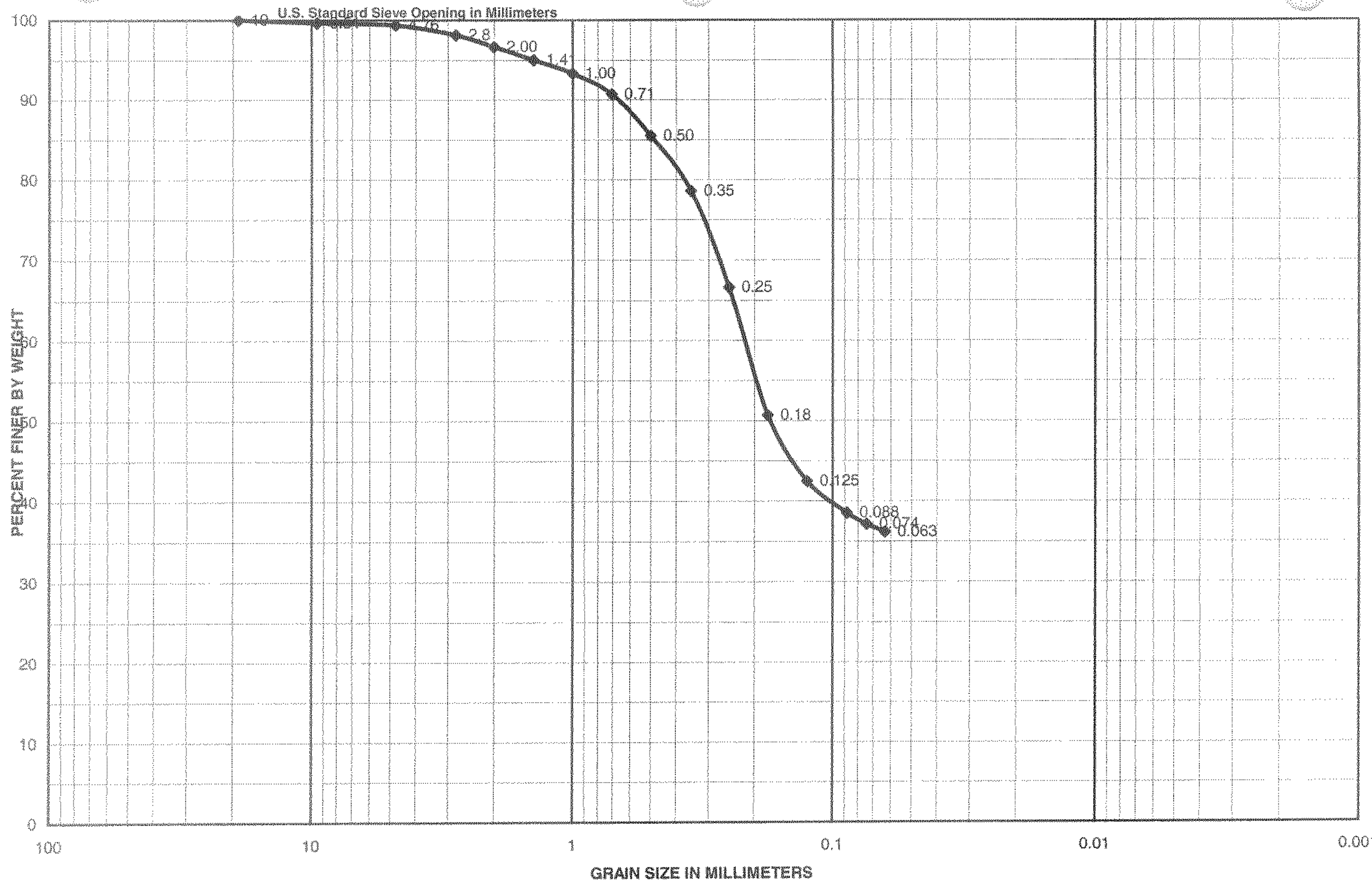
Sample No.	Depth	Classification	Area	Shallotte Inlet
2	7.0-7.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		1.5% shells	**Boring No.**	SHI-V-09-5
			Date	4/29/2009



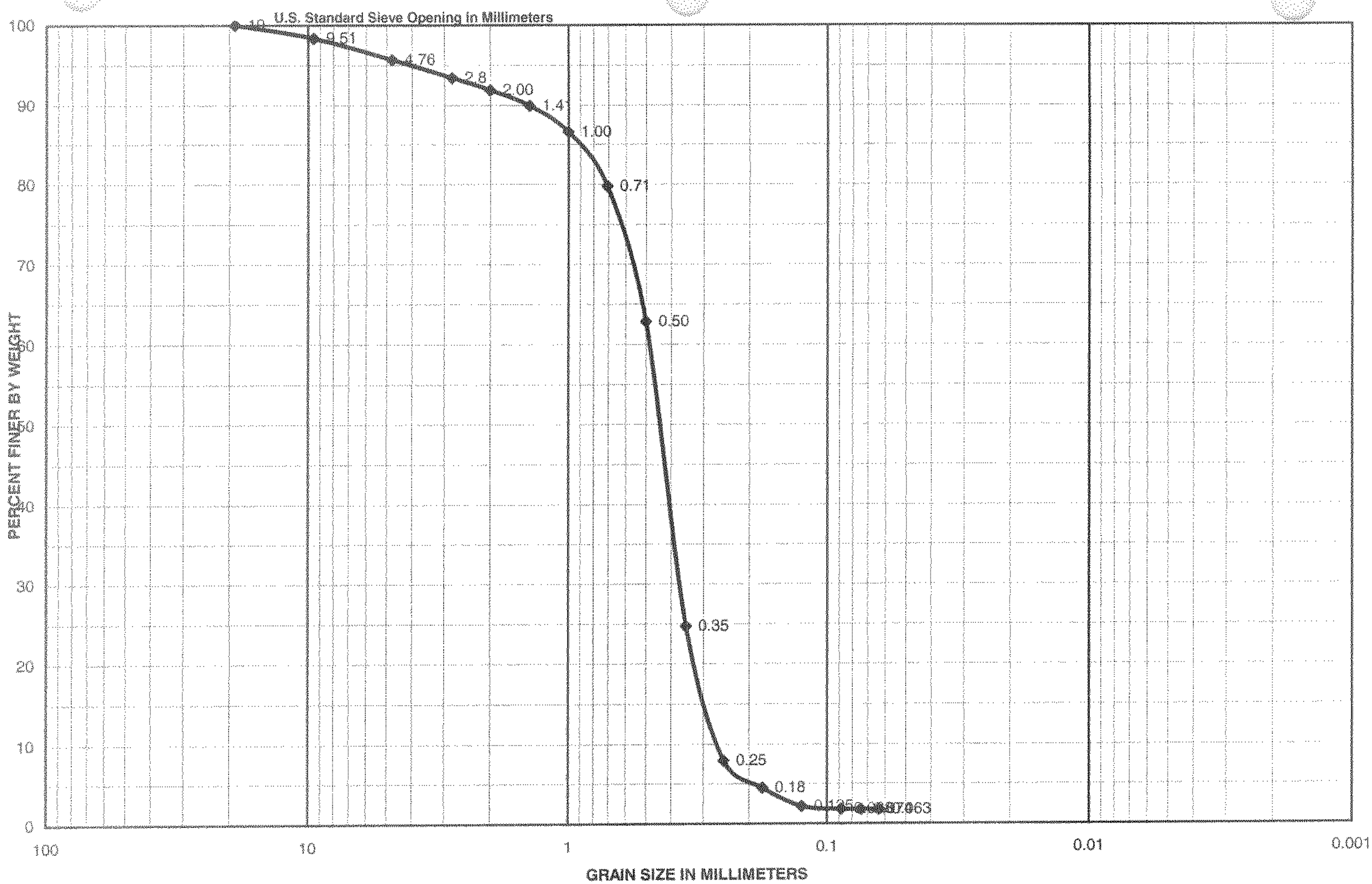
Sample No.	Depth	Classification	Area	Shallotte Inlet
3	10.0-10.5	Olive gray poorly graded sand with few shells, SP	**CATLIN Geotechnical Laboratory**	
		7.7% shells	**Boring No.**	SHI-V-09-5
			Date	4/29/2009



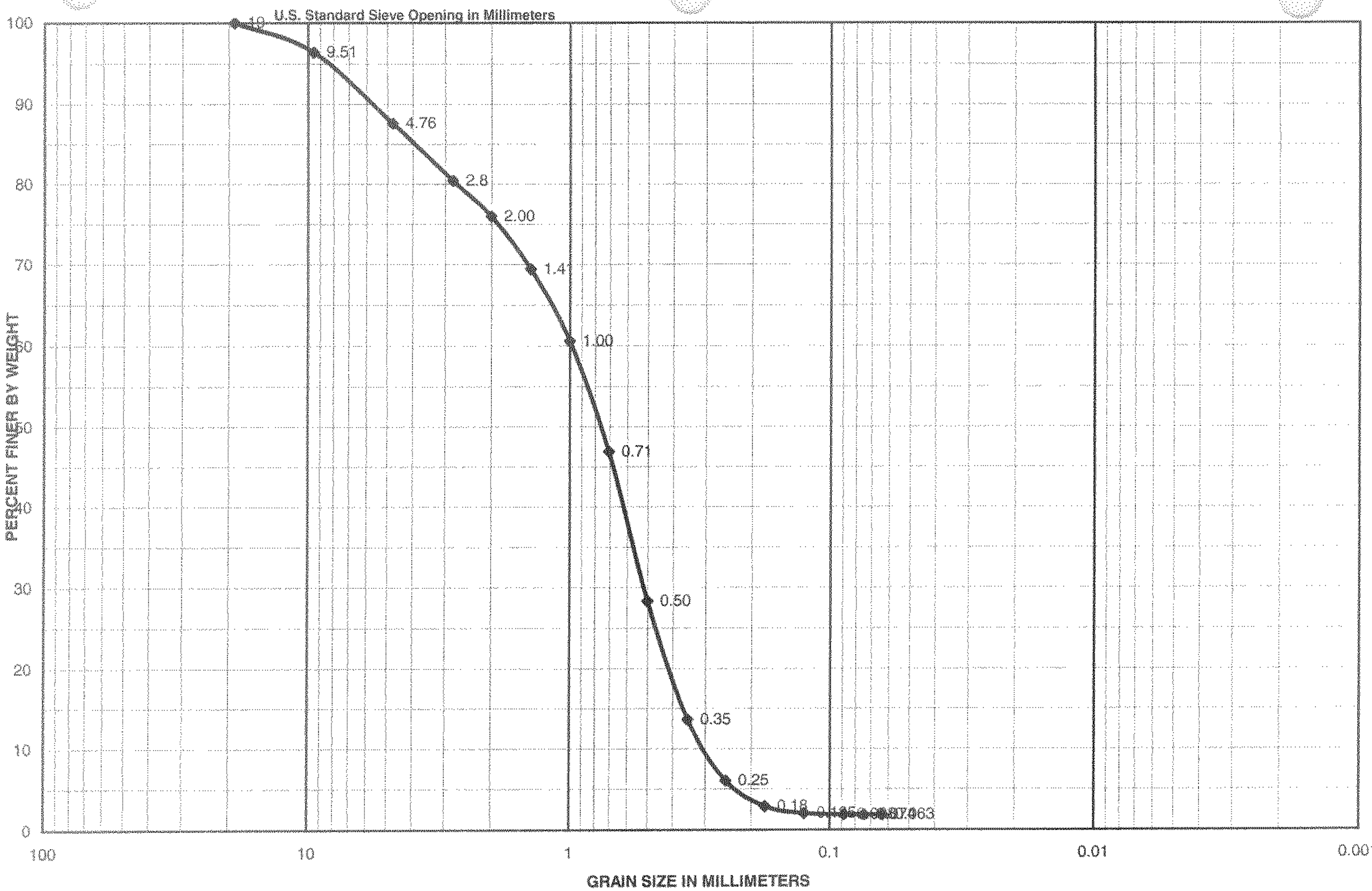
Sample No.	Depth	Classification	Area	Shallotte Inlet
4	13.0-13.5	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		21.6% shells	**Boring No.**	SHI-V-09-5
			Date	4/29/2009



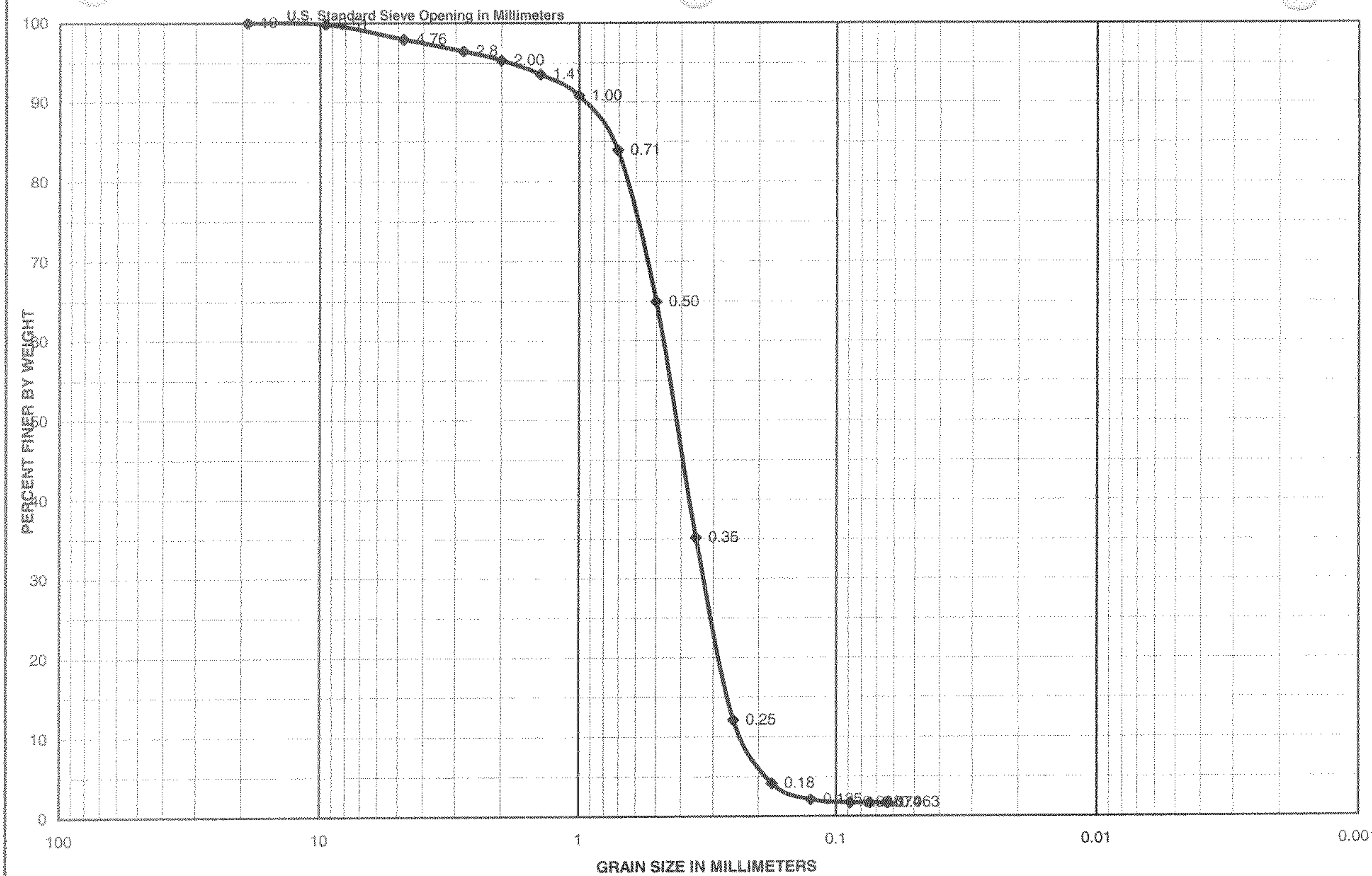
Sample No.	Depth	Classification	Area	Shallotte Inlet
5	16.2-16.7	Olive gray silty sand with trace shells and fine gravel, SM	**CATLIN Geotechnical Laboratory**	
		1.9% shells	**Boring No.**	SHI-V-09-5
			Date	4/29/2009



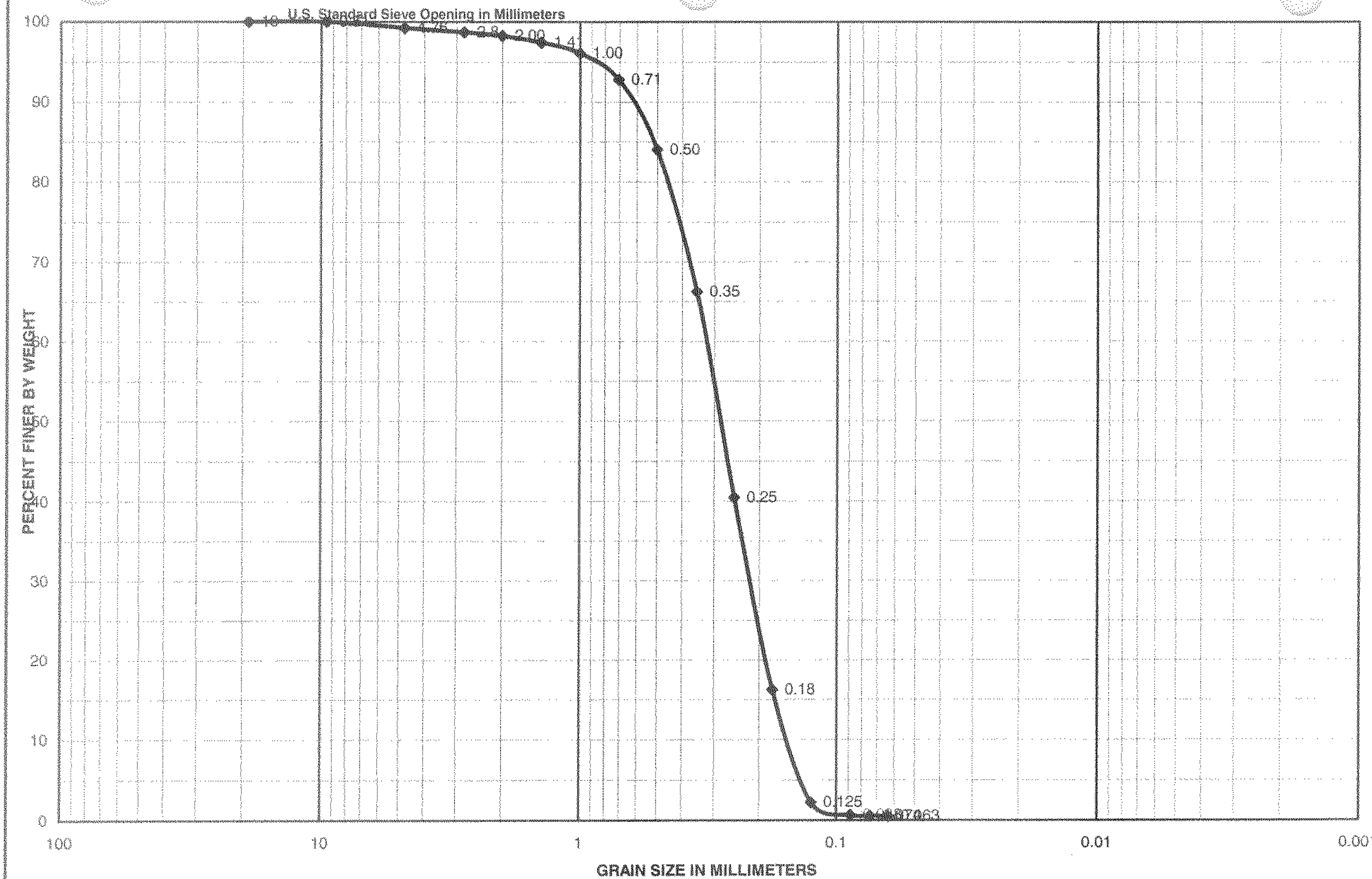
Sample No.	Depth	Classification	Area	Shallotte Inlet
1	6.1-6.6	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		20.2% shells	**Boring No.**	SHI-V-09-6
			Date	4/29/2009



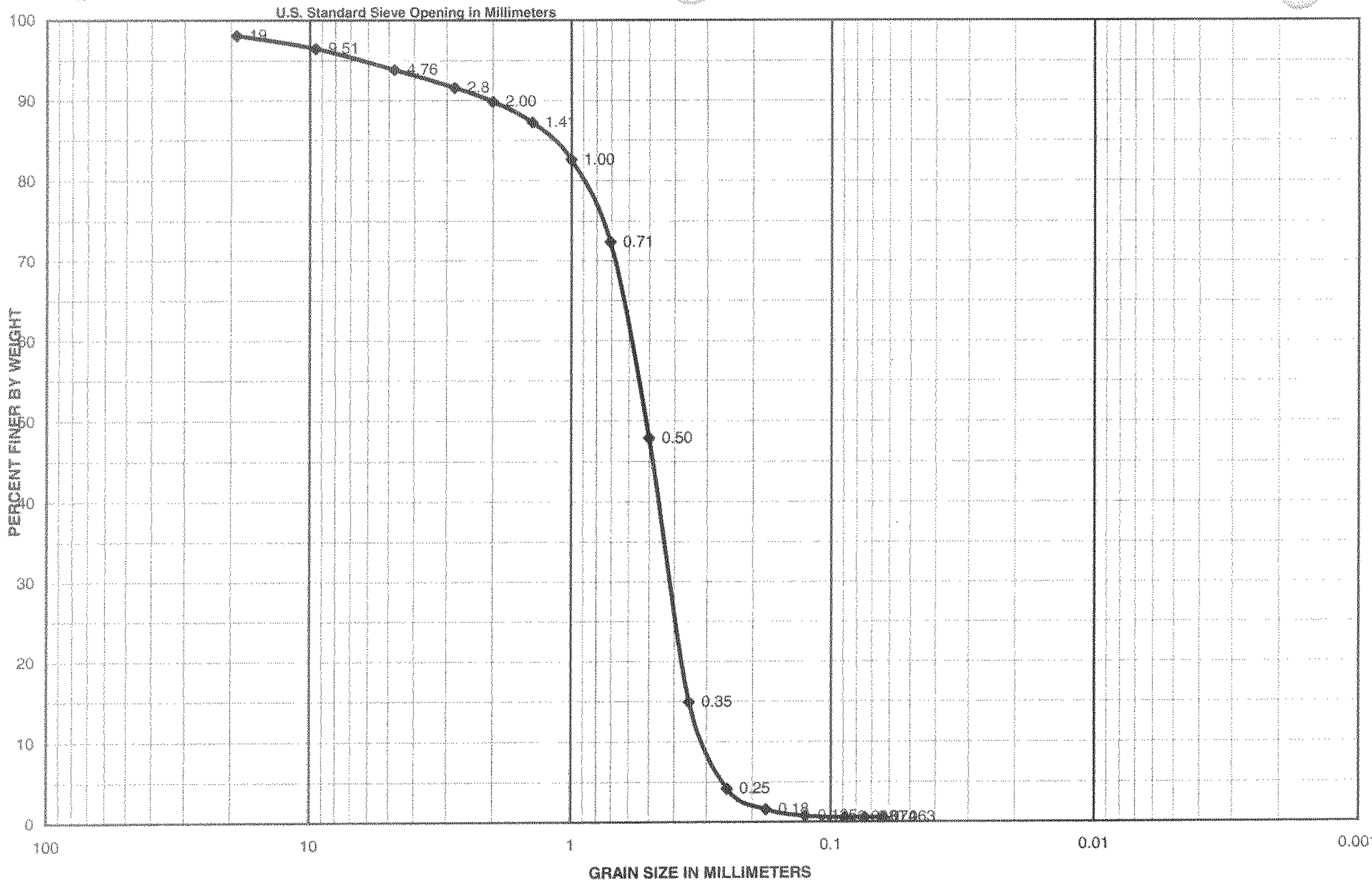
Sample No.	Depth	Classification	Area	Shallotte Inlet
2	9.0-9.5	Olive gray poorly graded sand with some shells, SP	**CATLIN Geotechnical Laboratory**	
		30.6% shells	**Boring No.**	SHI-V-09-6
			Date	4/29/2009



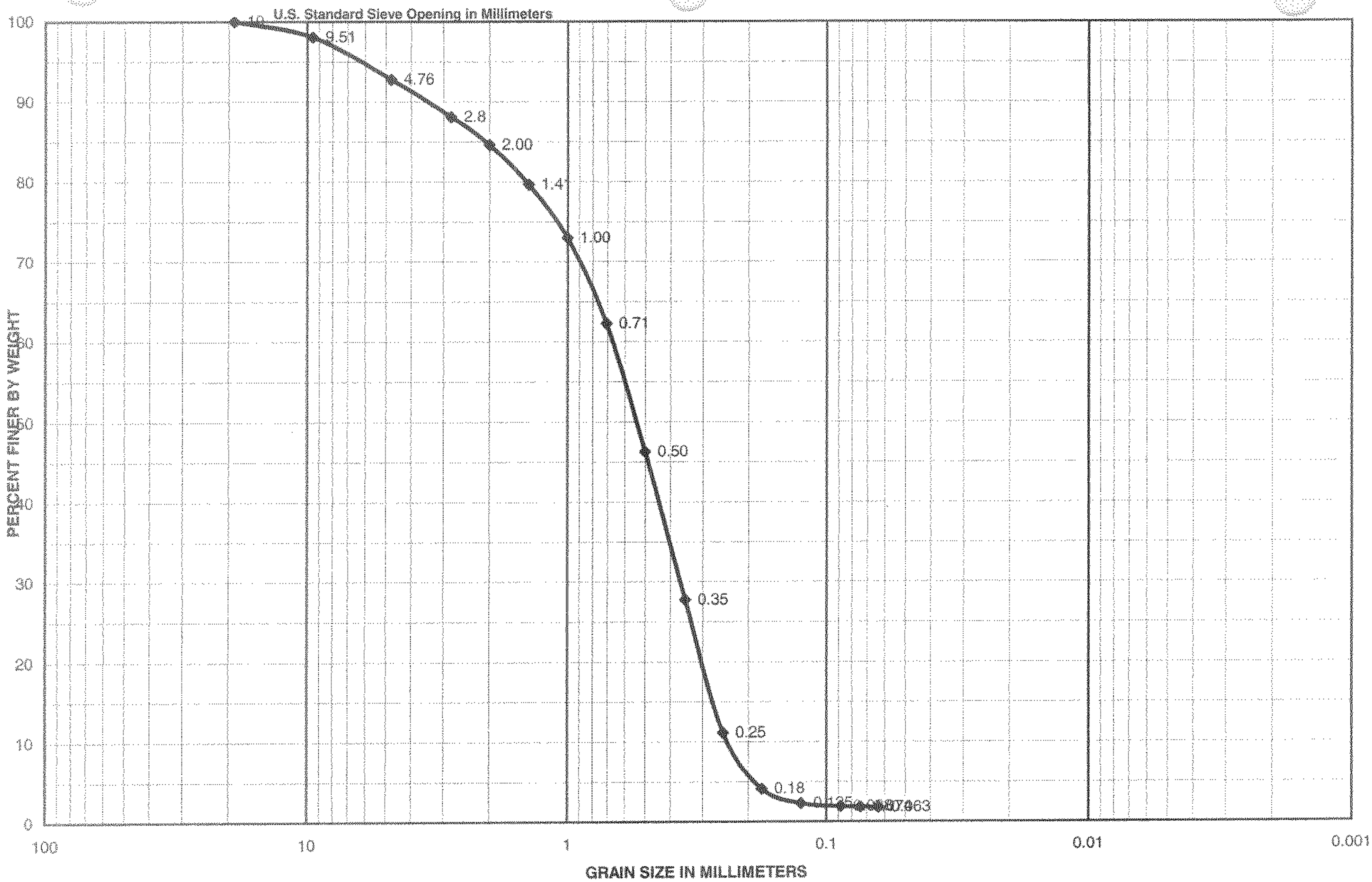
Sample No.	Depth	Classification	Area	Shallotte Inlet
3	12.0-12.5	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		16.1% shells	Boring No.	SHI-V-09-6
			Date	4/29/2009



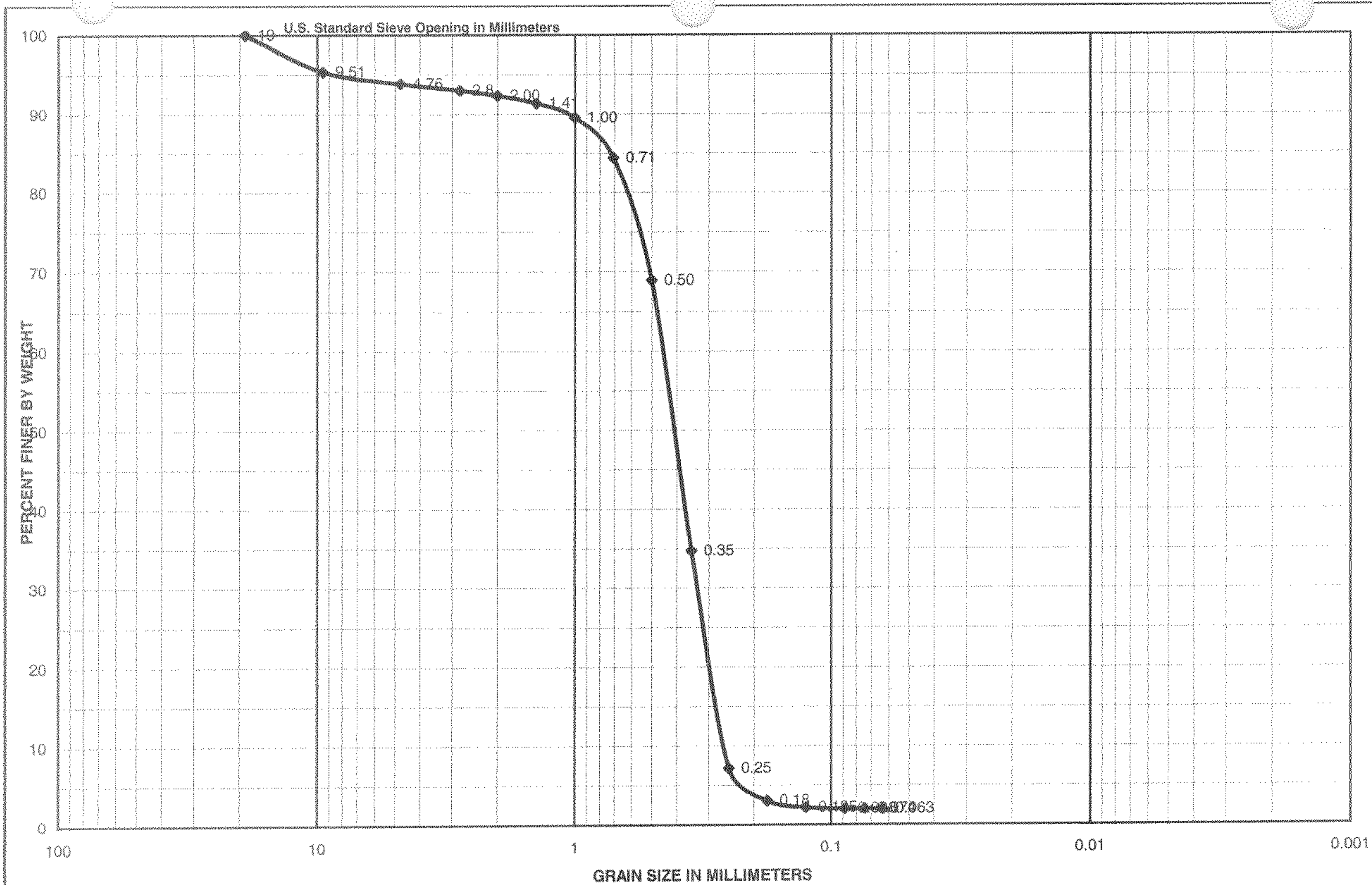
Sample No.	Depth	Classification	Area Shallotte Inlet
4	15.0-15.5	Olive gray poorly graded sand with few shells, SP	**CATLIN Geotechnical Laboratory**
		7.2% shells	**Boring No.** SHI-V-09-6
			Date 4/29/2009



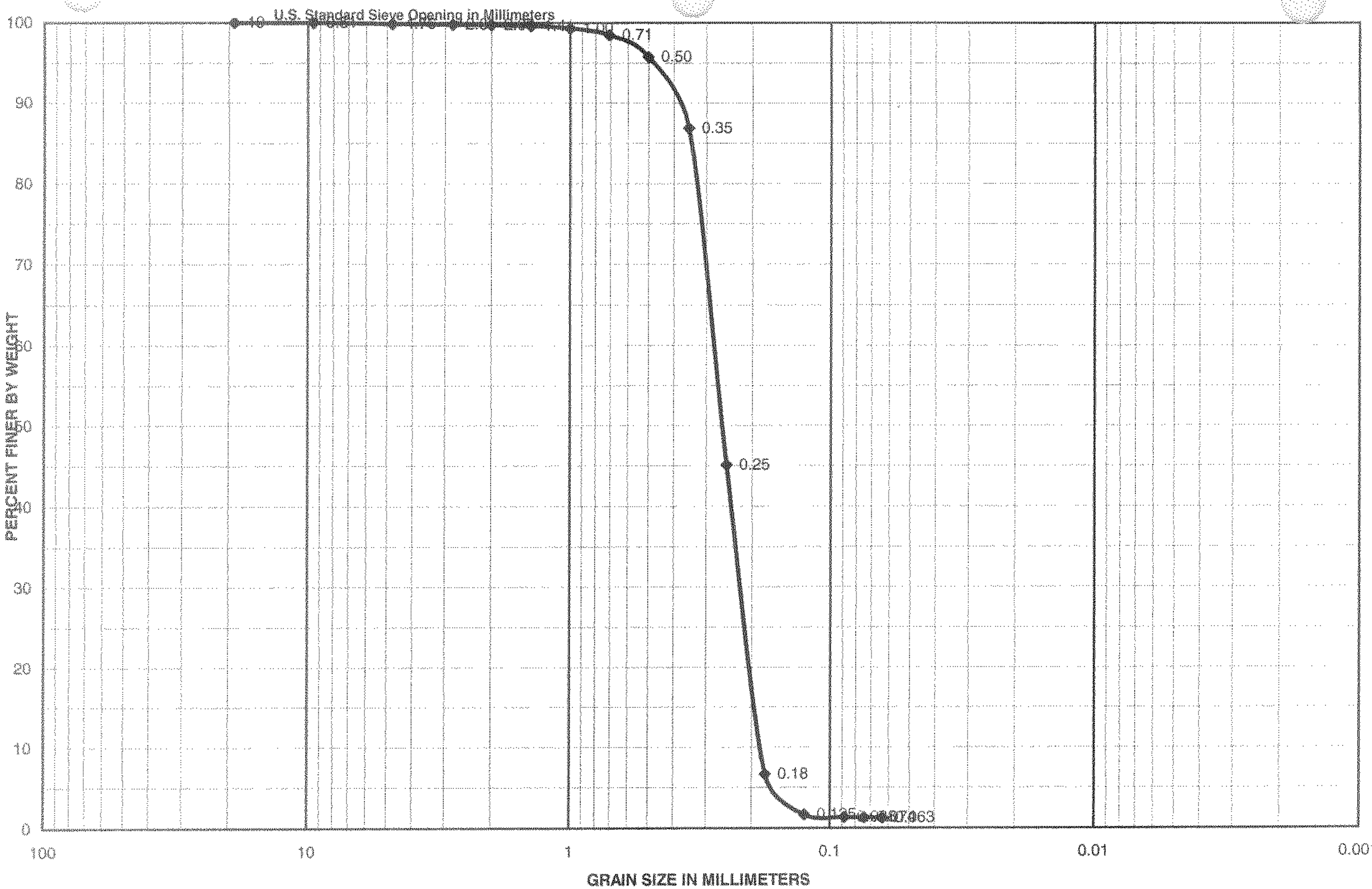
Sample No.	Depth	Classification	Area Shallotte Inlet
1	5.3-5.8	Olive gray poorly graded sand with some shells, SP	**CATLIN Geotechnical Laboratory**
		27.7% shells	**Boring No.** SHI-V-09-7
			Date 4/29/2009



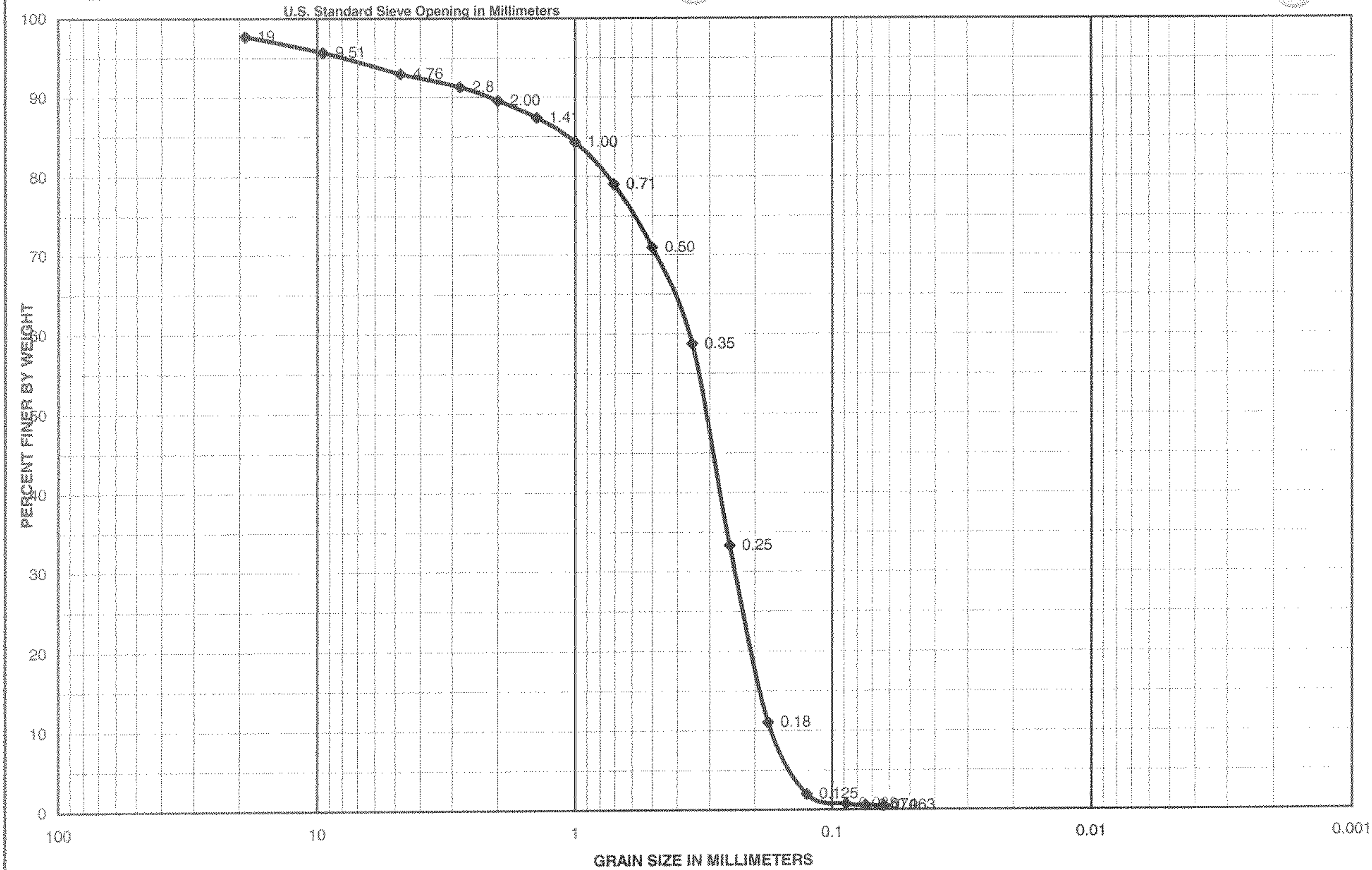
Sample No.	Depth	Classification	Area	Shallotte Inlet
2	8.0-8.5	Olive gray poorly graded sand with some shells, SP	**CATLIN Geotechnical Laboratory**	
		37.7% shells	**Boring No.**	SHI-V-09-7
			Date	4/29/2009



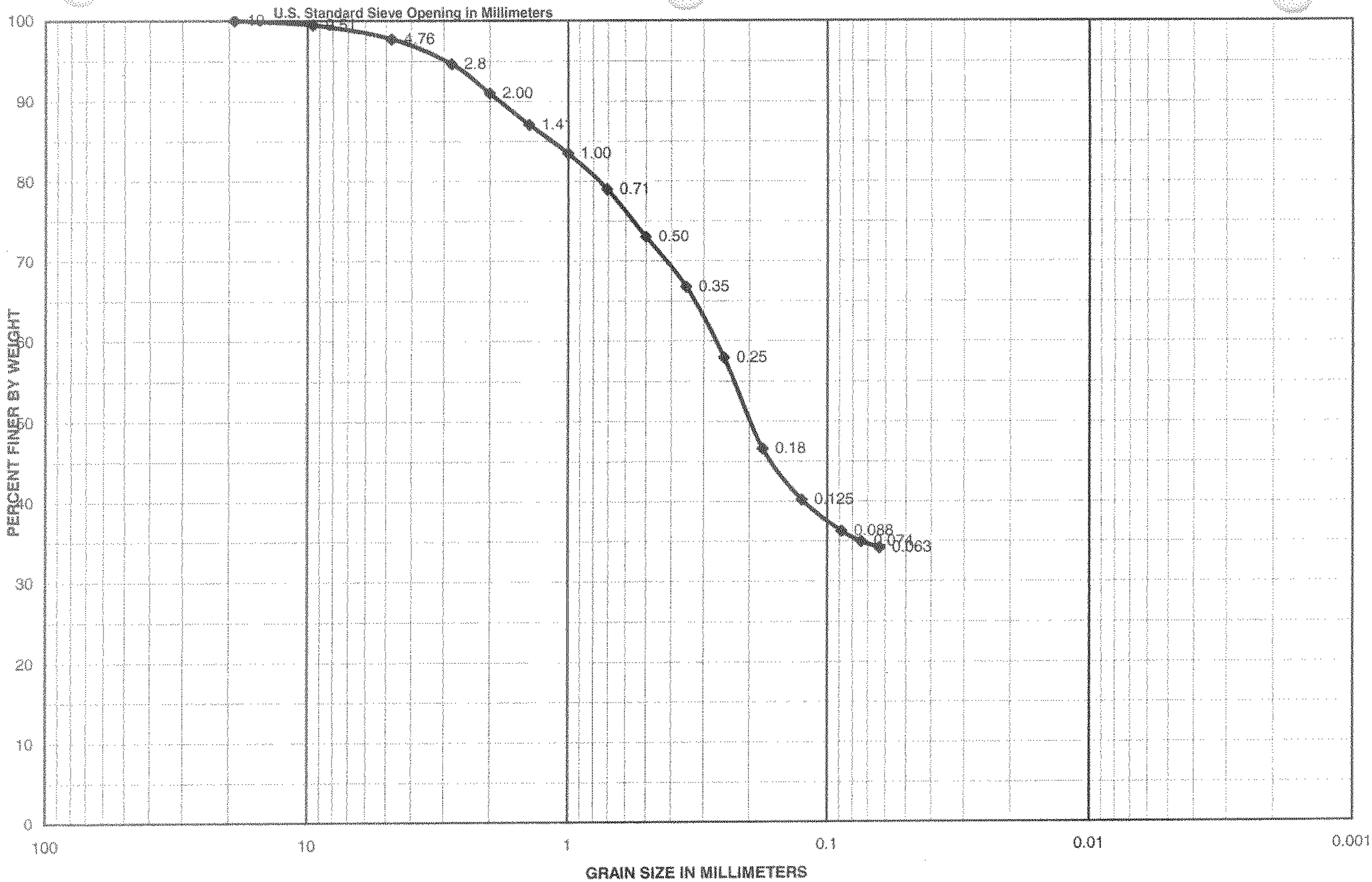
Sample No.	Depth	Classification	Area	Shallotte Inlet
3	11.0-11.5	Olive gray poorly graded sand with few shells, SP	CATLIN Geotechnical Laboratory	
		10.4% shells	Boring No.	SHI-V-09-7
			Date	4/30/2009



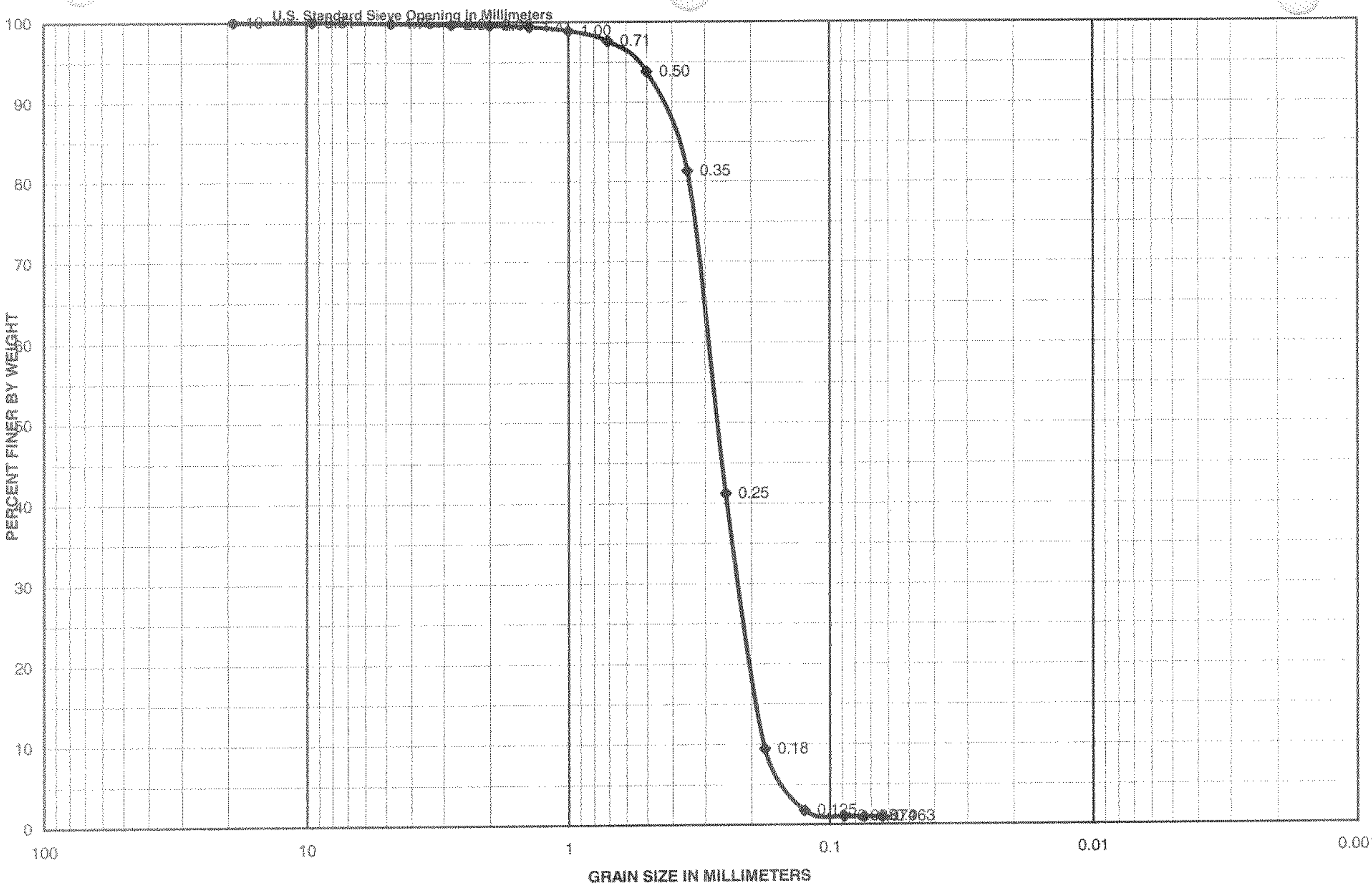
Sample No.	Depth	Classification	Area	Shallotte Inlet
4	13.0-13.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		0.7% shells	**Boring No.**	SHI-V-09-7
			Date	4/30/2009



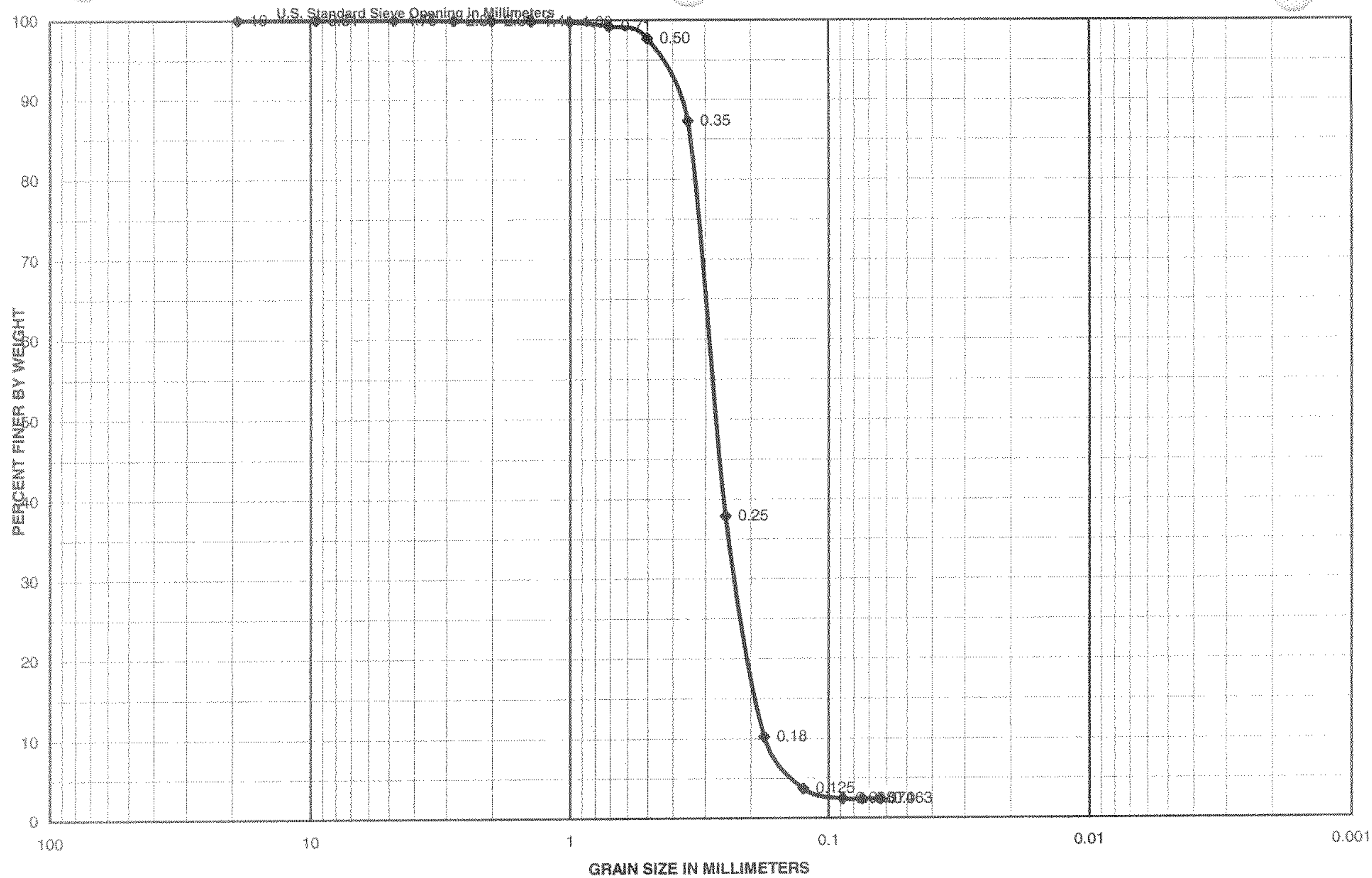
Sample No.	Depth	Classification	Area	Shallotte Inlet
5	16.0-16.5	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		15.7% shells	Boring No.	SHI-V-09-7
			Date	4/30/2009



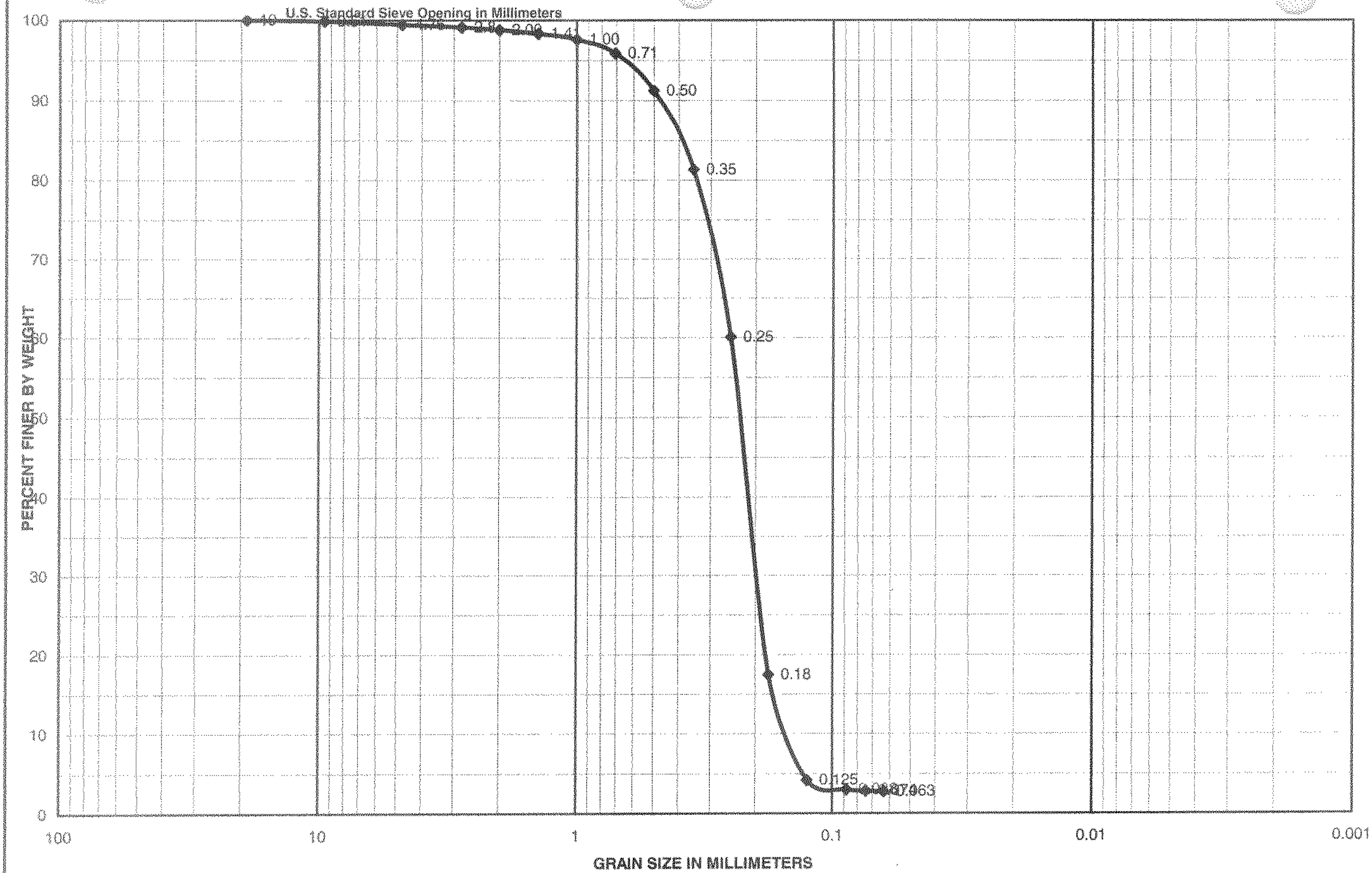
Sample No.	Depth	Classification	Area Shallotte Inlet
6	17.3-17.8	Olive gray silty sand with trace shells and fine gravel, SM	**CATLIN Geotechnical Laboratory**
		2.3% shells	**Boring No.** SHI-V-09-7
			Date 4/30/2009



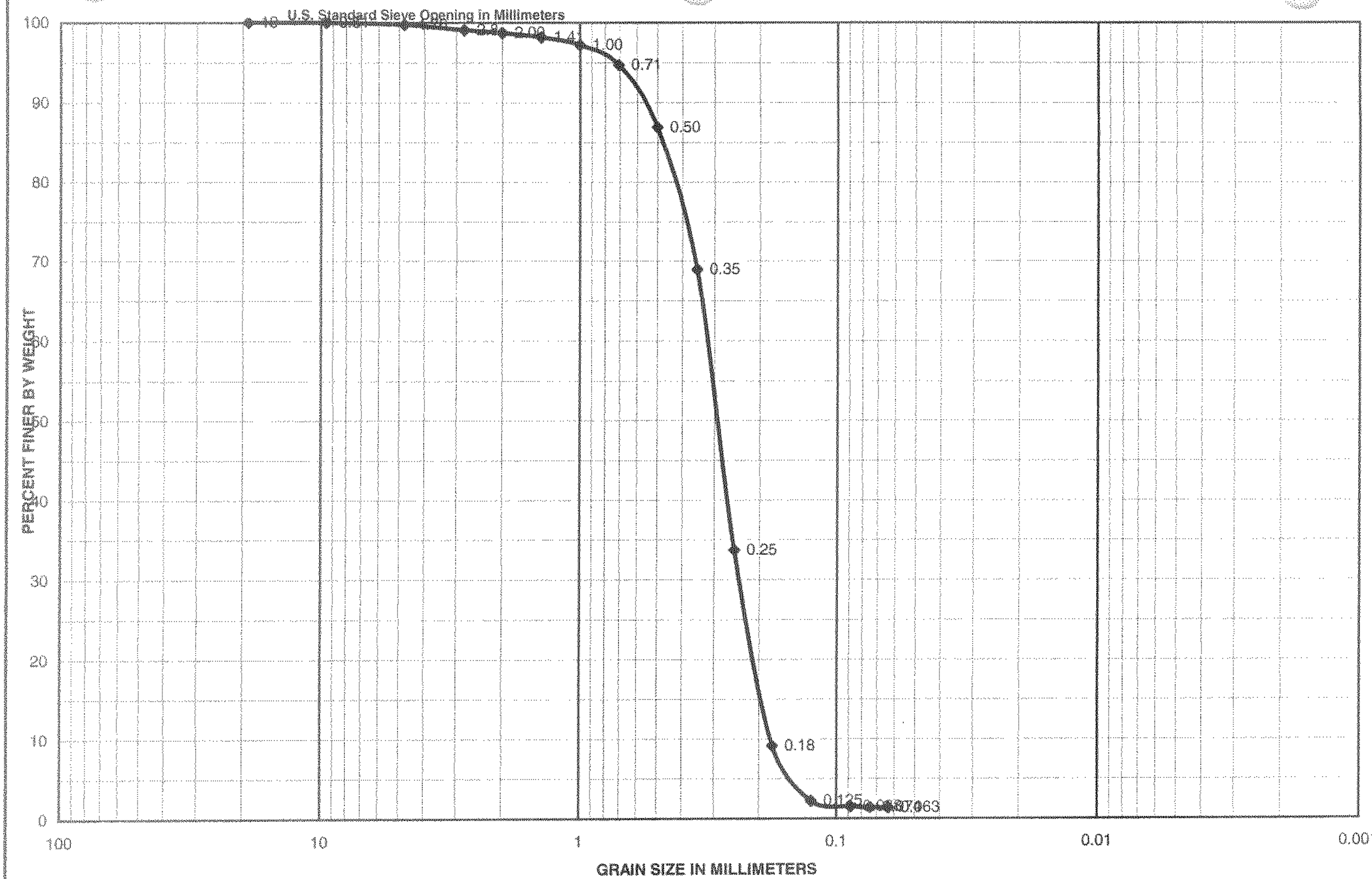
Sample No.	Depth	Classification	Area	Shallotte Inlet
1	7.1-7.6	Olive gray poorly graded sand with trace shells, SP	CATLIN Geotechnical Laboratory	
		1.1% shells	Boring No.	SHI-V-09-8
			Date	4/30/2009



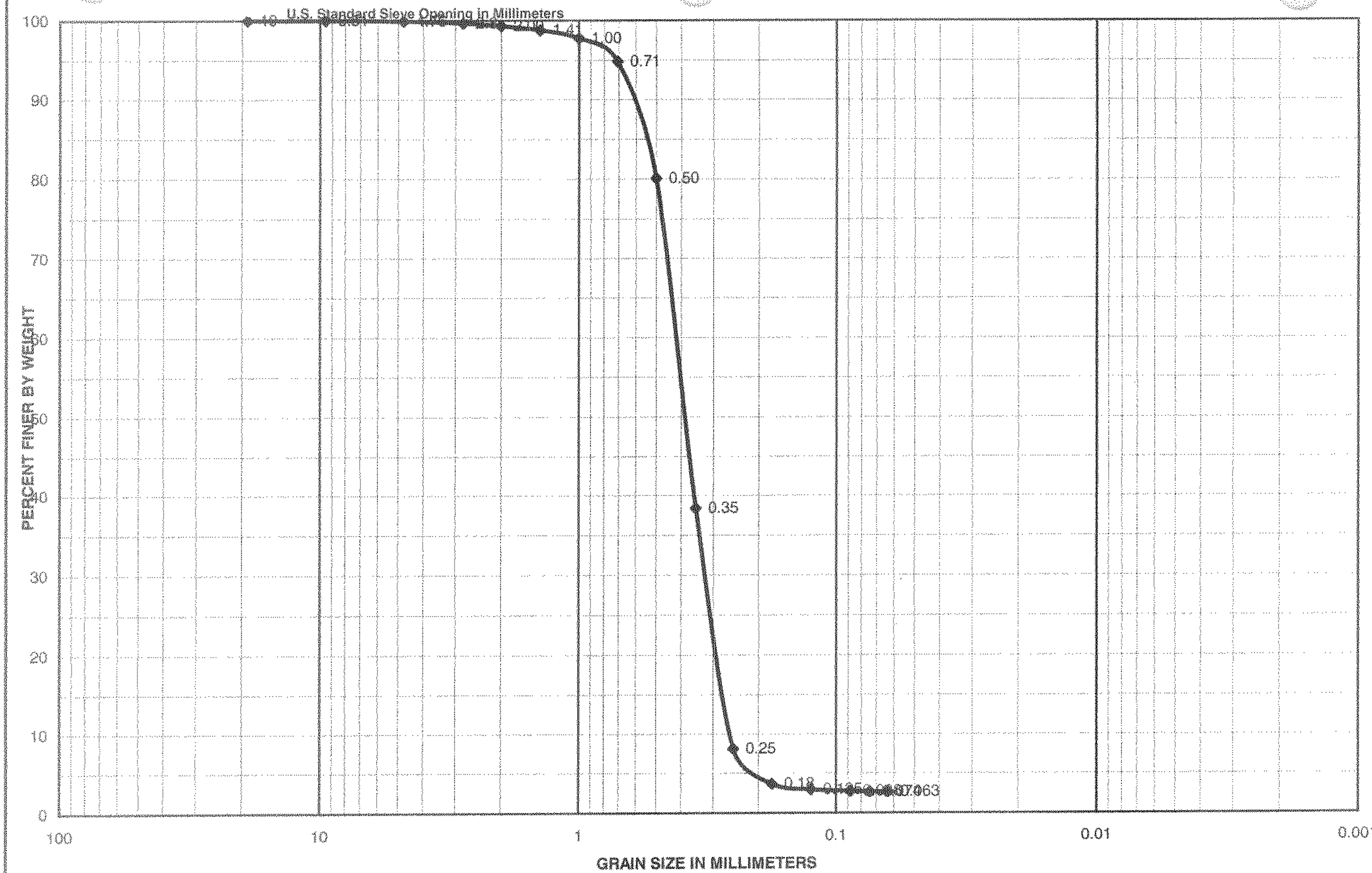
Sample No.	Depth	Classification	Area	Shallotte Inlet
2	9.5-10.0	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		0.8% shells	**Boring No.**	SHI-V-09-8
			Date	4/30/2009



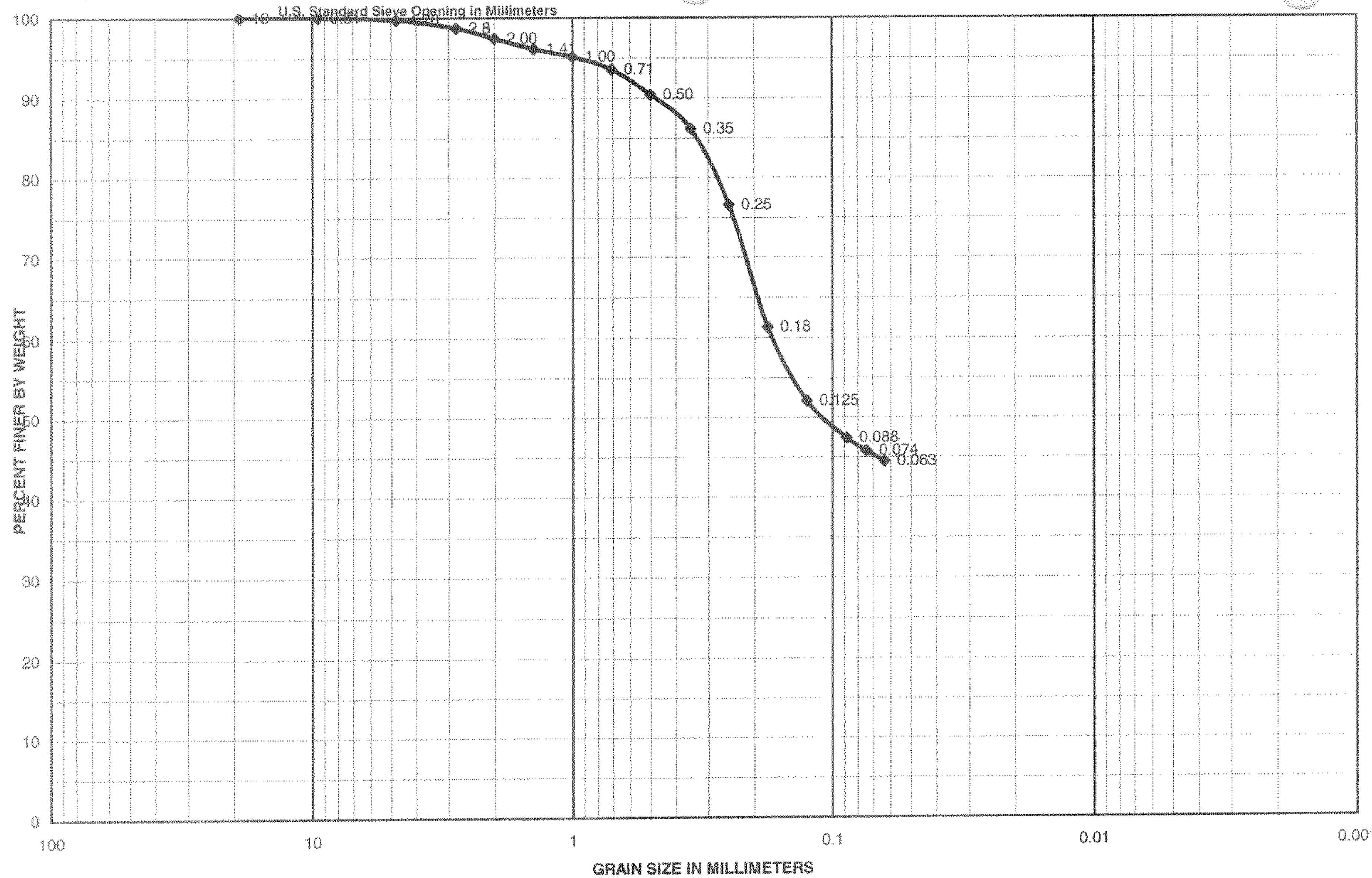
Sample No.	Depth	Classification	Area	Shallotte Inlet
3	13.0-13.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		2.4% shells	**Boring No.**	SHI-V-09-8
			Date	4/30/2009



Sample No.	Depth	Classification	Area	Shallotte Inlet
4	16.0-16.5	Light gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		2.8% shells	Boring No.	SHI-V-09-8
			Date	4/30/2009

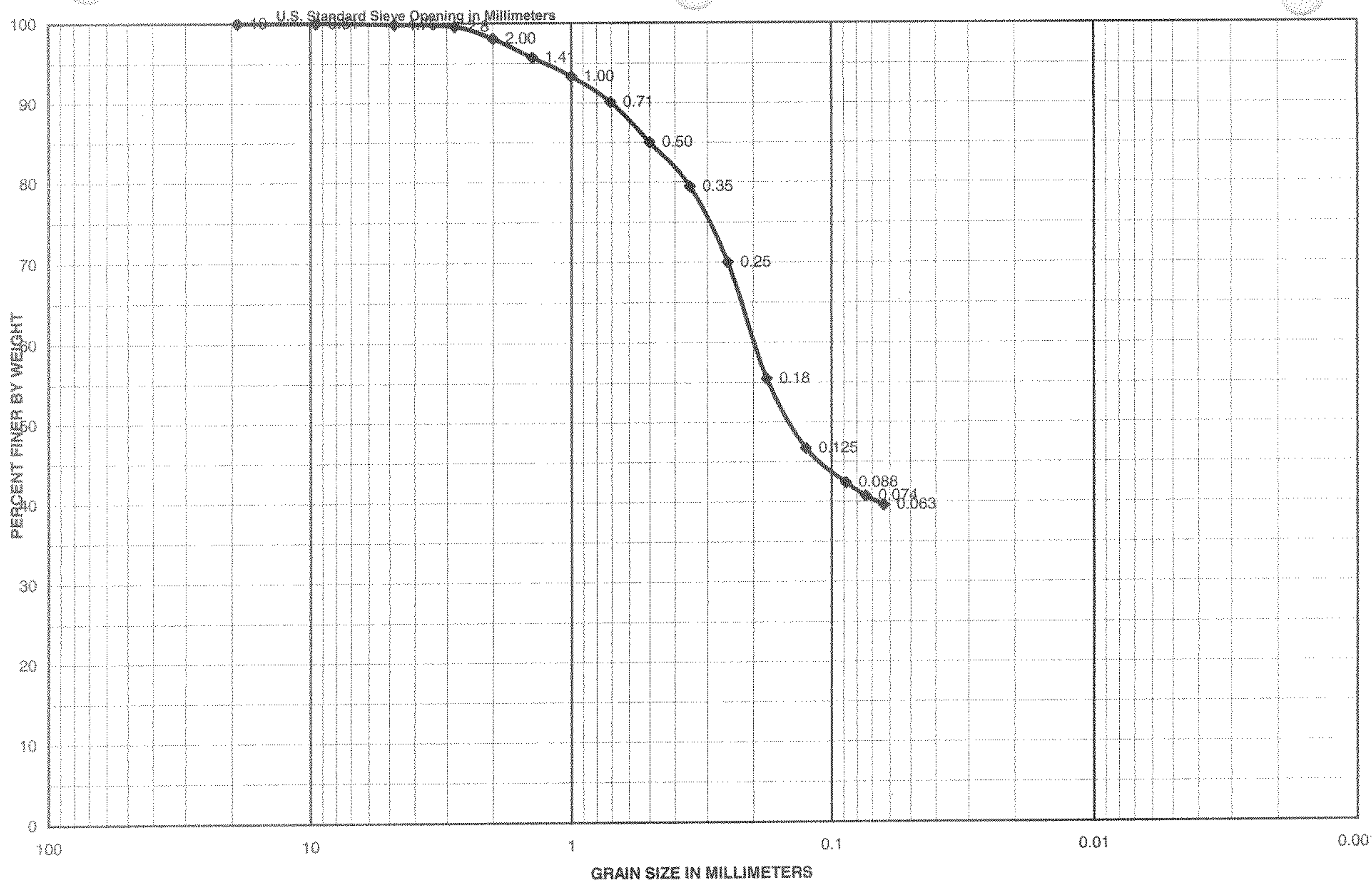


Sample No.	Depth	Classification	Area	Shallotte Inlet
5	18.0-18.5	Light brown poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		5.2% shells	Boring No.	SHI-V-09-8
			Date	4/30/2009



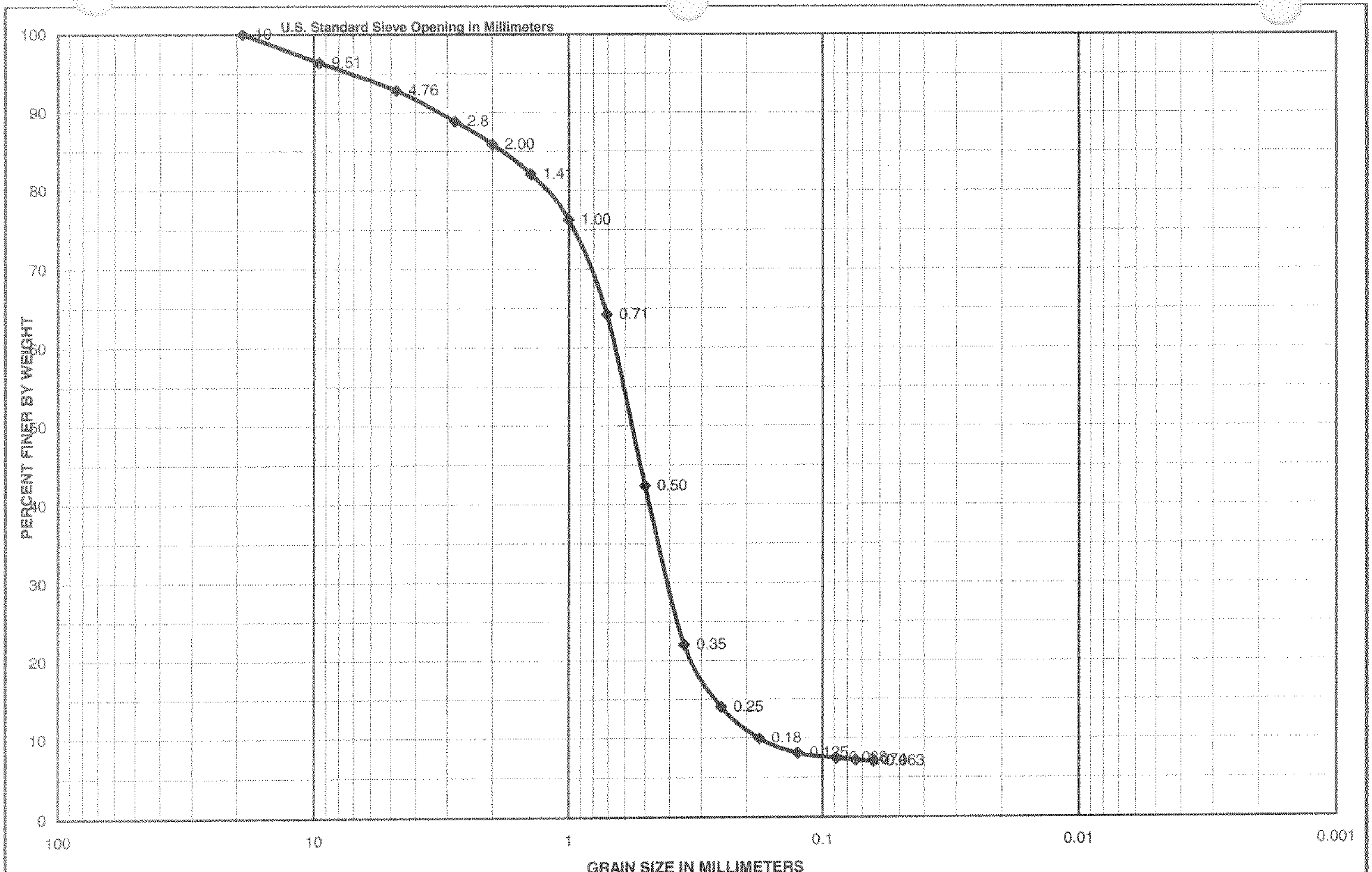
Sample No.	Depth	Classification
1	20.7-21.2	Olive gray silty sand with trace fine gravel, SM

Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-9
Date	4/30/2009

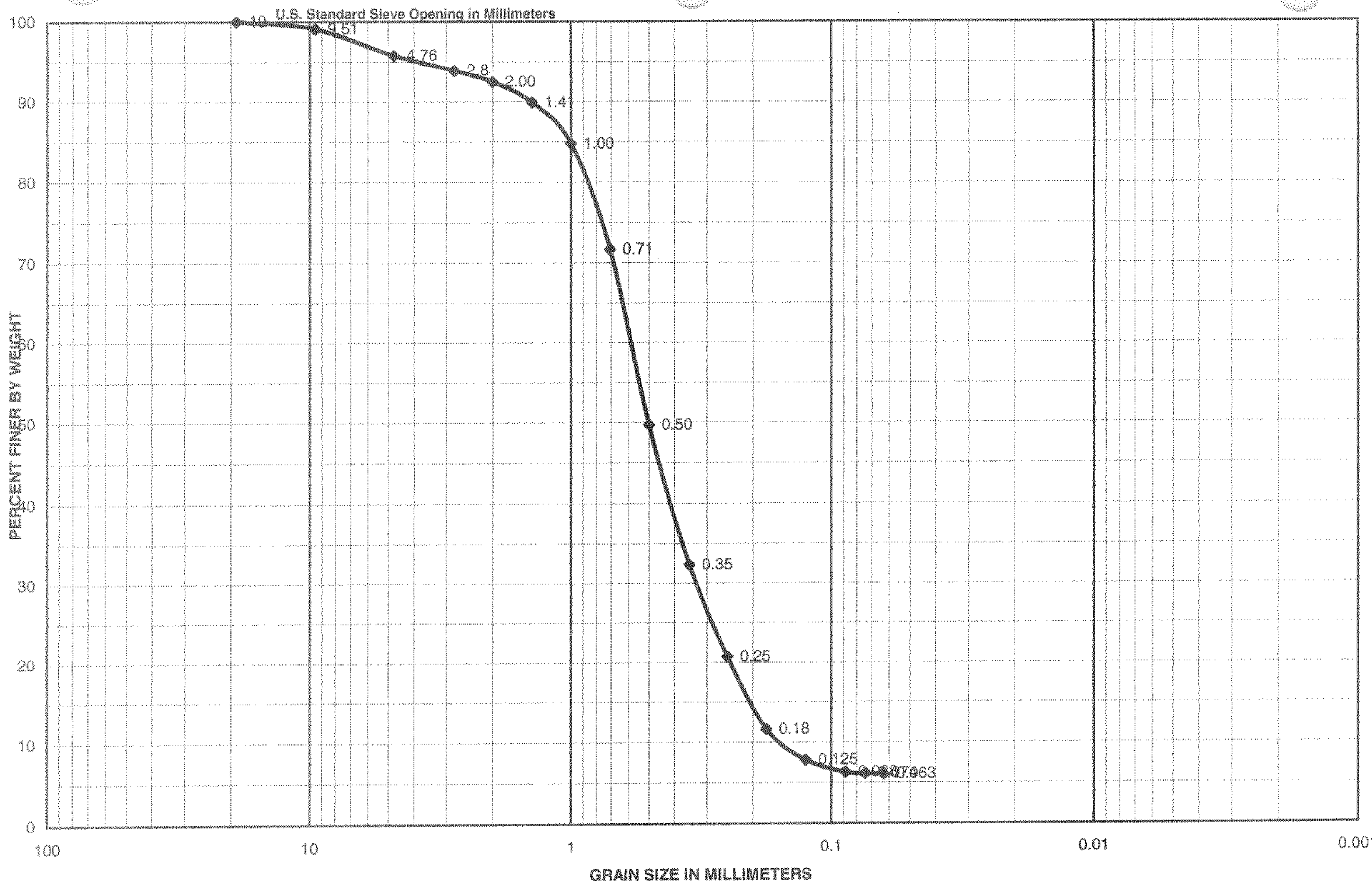


Sample No.	Depth	Classification
1	4.9-5.4	Olive gray silty sand with trace fine gravel, SM

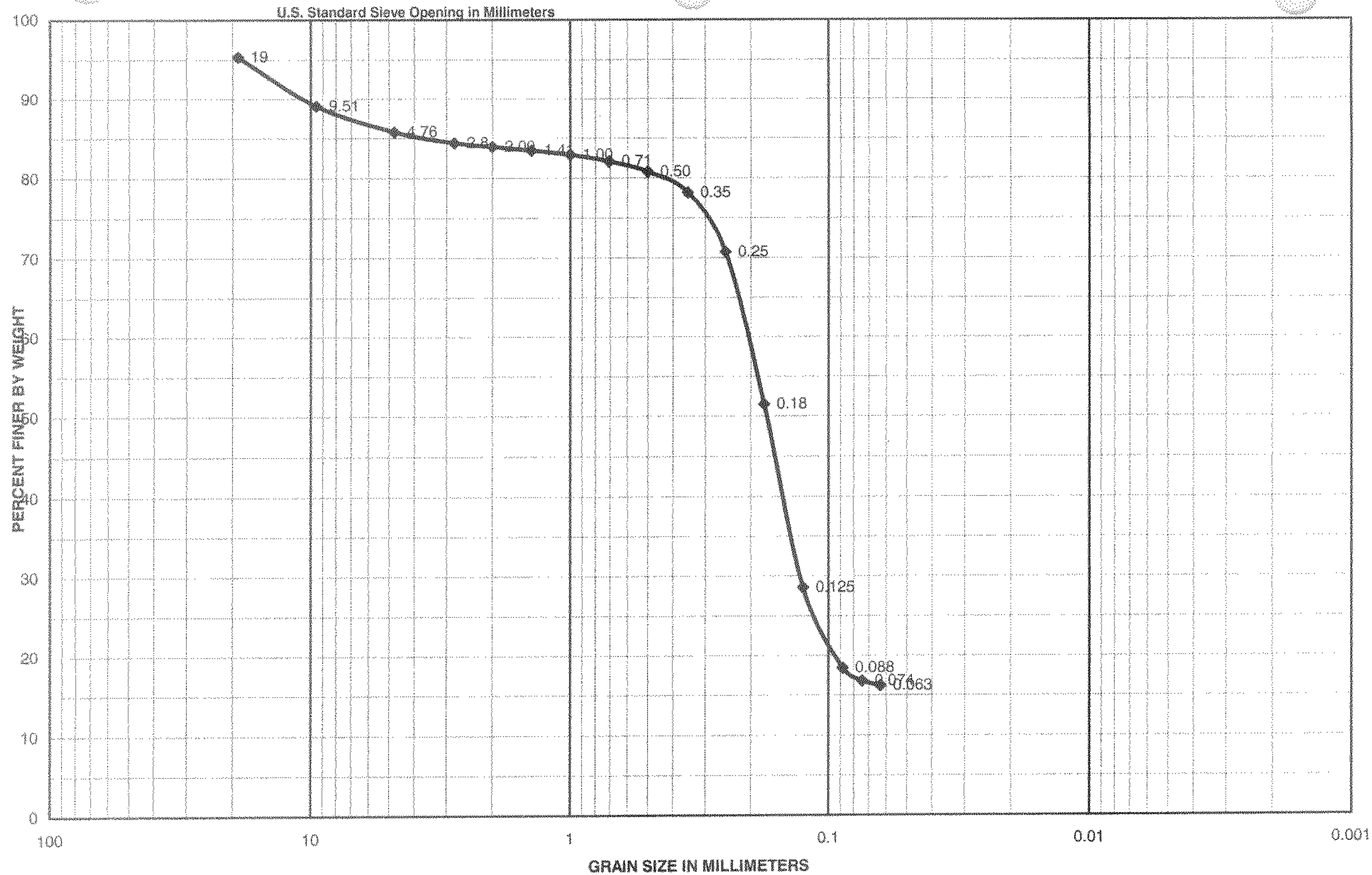
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-10
Date	4/30/2009



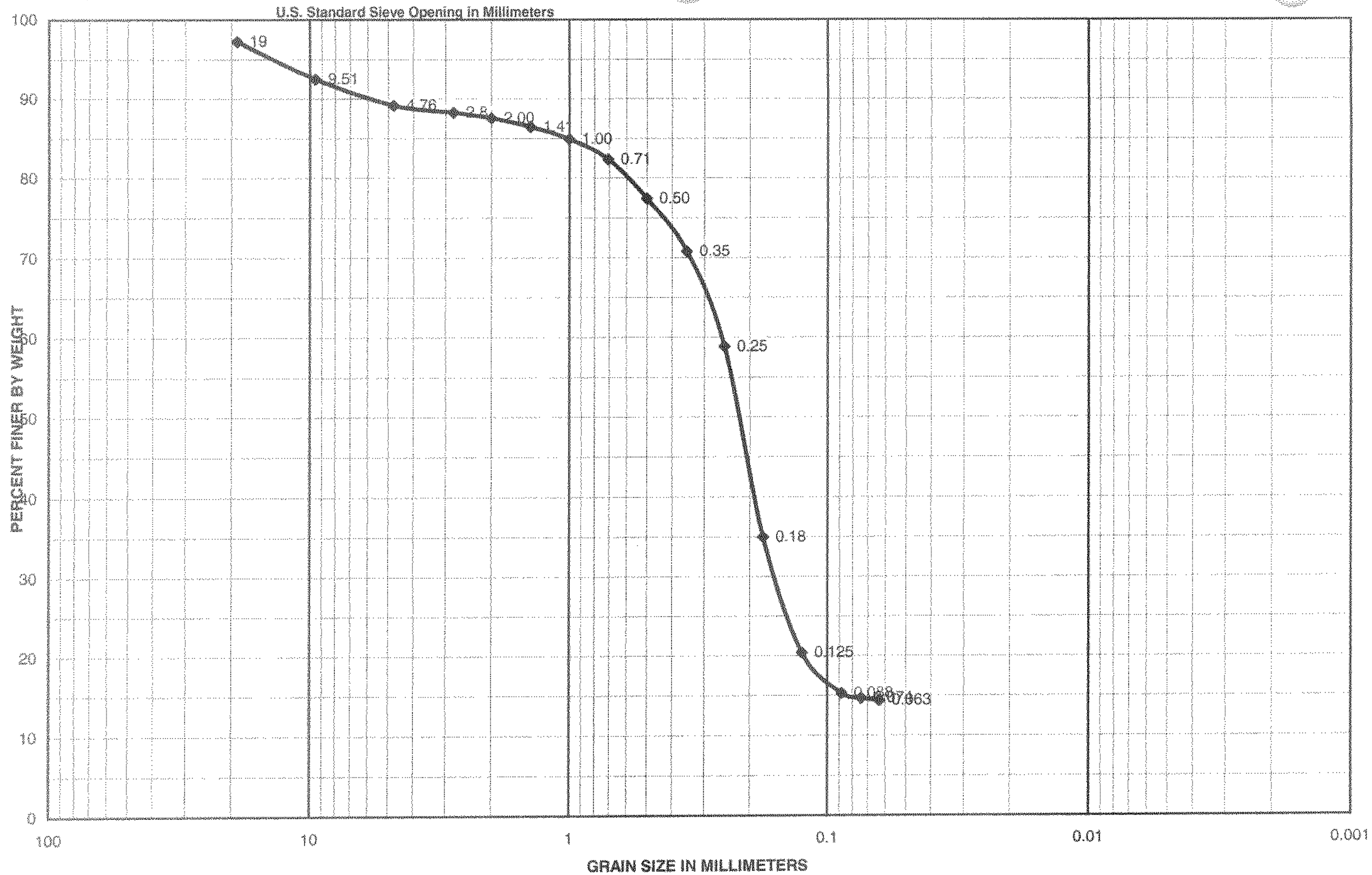
Sample No.	Depth	Classification	Area	Shallotte Inlet
2	5.9-6.4	Olive gray poorly graded sand with silt and little shells, SP-SM	**CATLIN Geotechnical Laboratory**	
		23.7% shells	Boring No.	SHI-V-09-10
			Date	4/30/2009



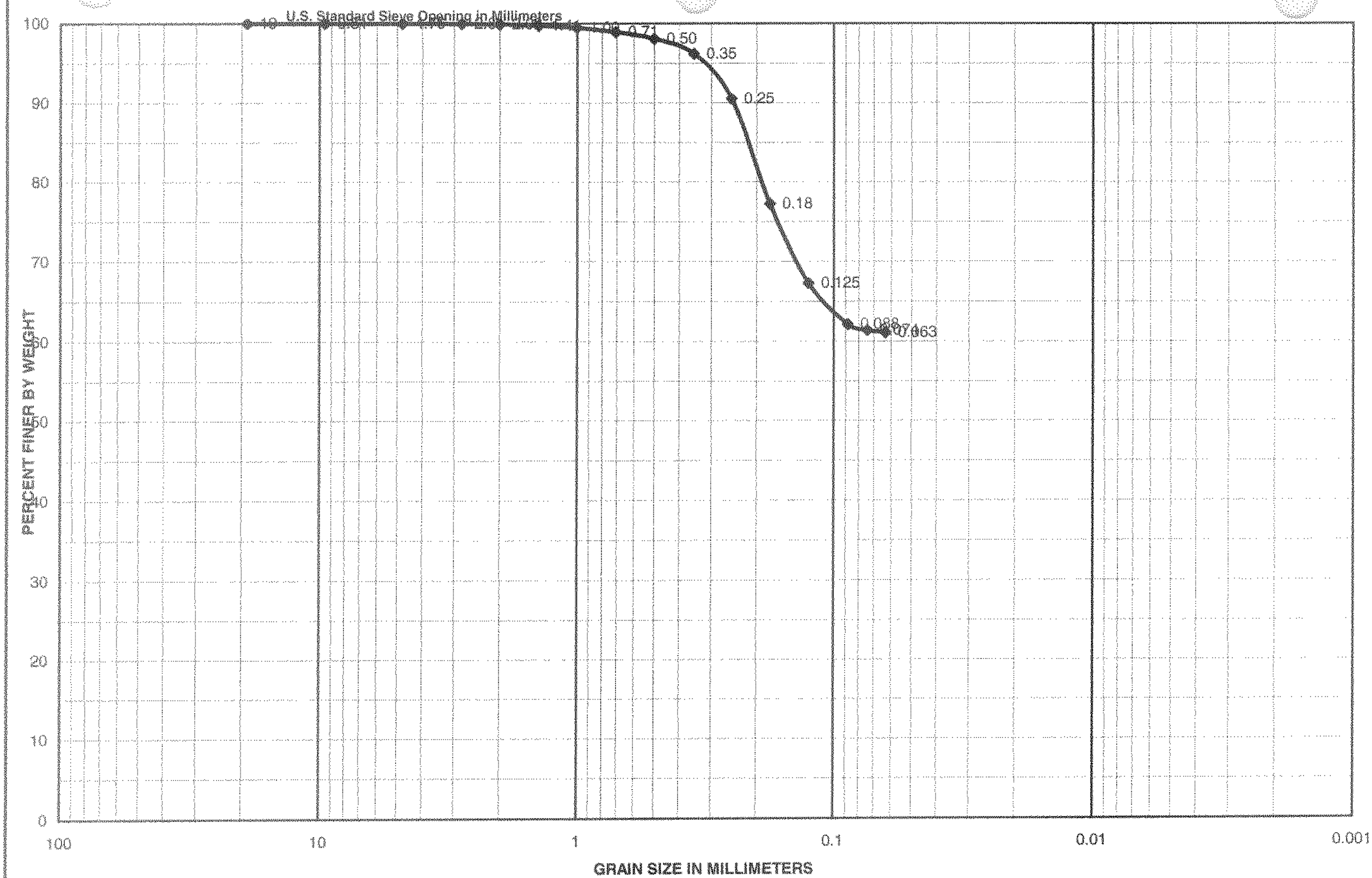
Sample No.	Depth	Classification	Area	Shallotte Inlet
3	9.0-9.5	Olive gray poorly graded sand with silt and little shells, SP-SM	**CATLIN Geotechnical Laboratory**	
		15.2% shells	**Boring No.**	SHI-V-09-10
			Date	4/30/2009



Sample No.	Depth	Classification	Area	Shallotte Inlet
4	12.9-13.4	Dark gray silty sand with little shells, SM	CATLIN Geotechnical Laboratory	
		17.9% shells	Boring No.	SHI-V-09-10
			Date	4/30/2009

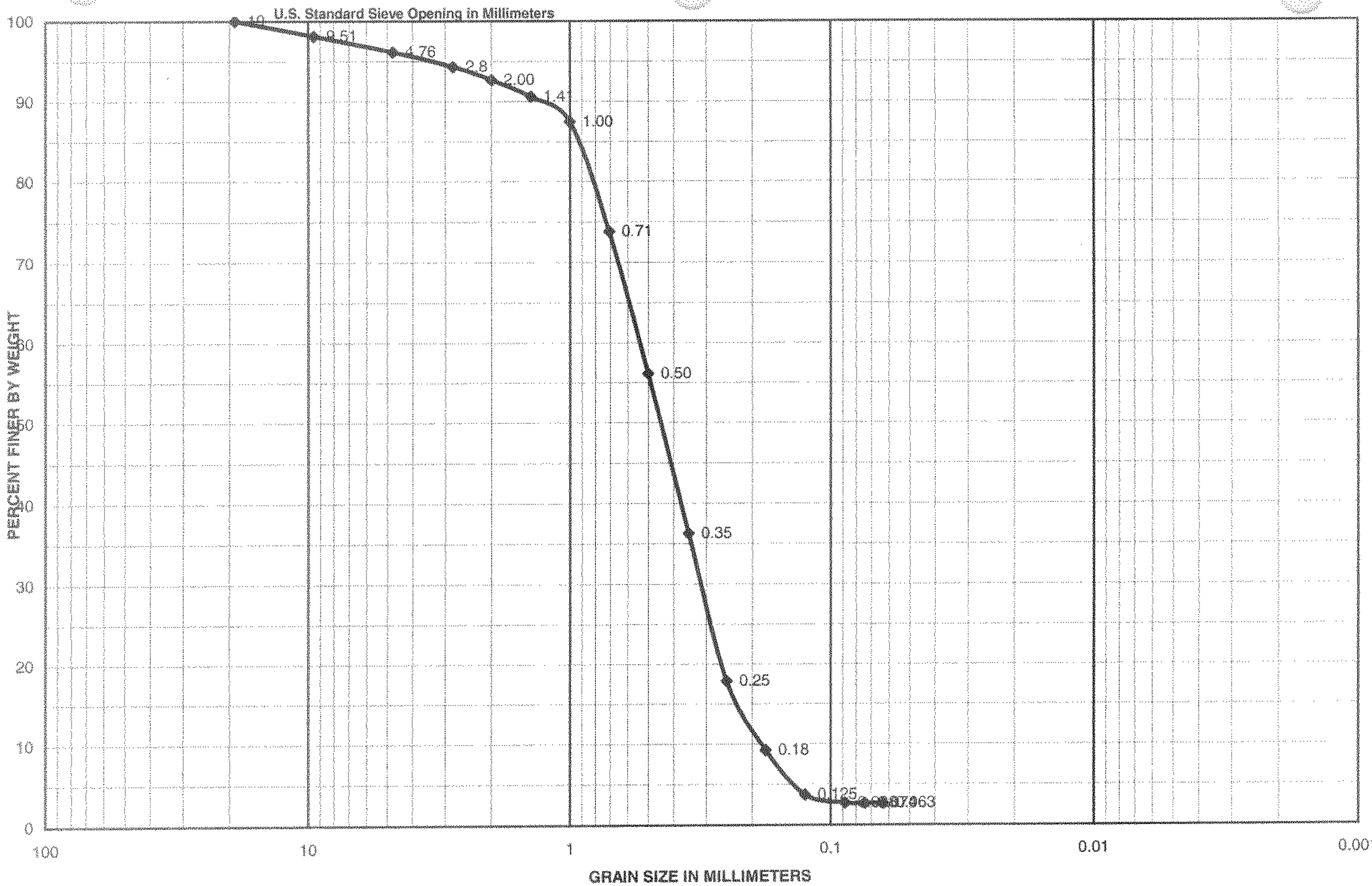


Sample No.	Depth	Classification	Area Shallotte Inlet
5	15.0-15.5	Dark gray silty sand with little shells, SM	**CATLIN Geotechnical Laboratory**
		15.1% shells	**Boring No.** SHI-V-09-10
			Date 4/30/2009

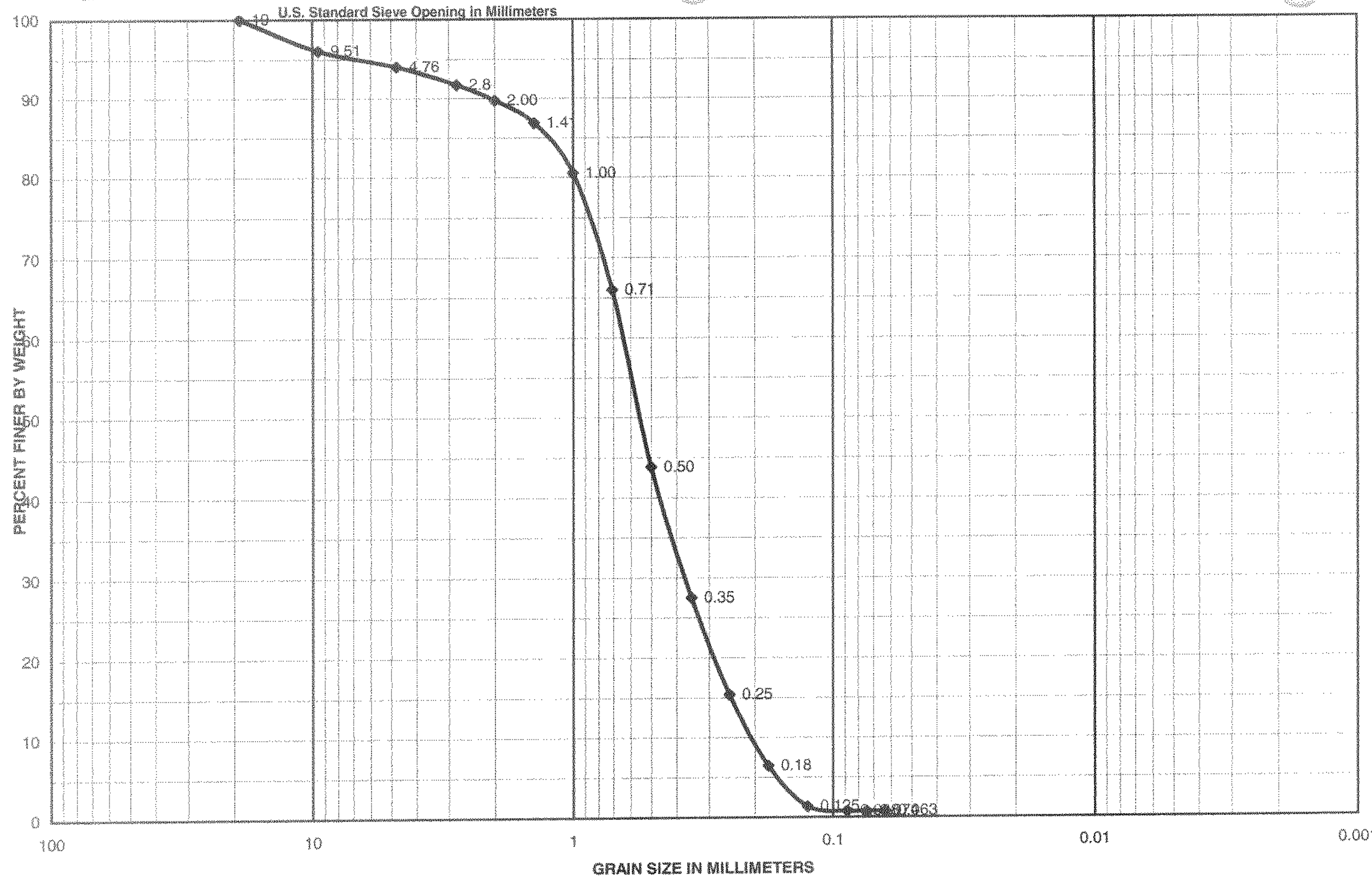


Sample No.	Depth	Classification
6	17.3-17.8	Dark gray sandy elastic silt with trace shells, MH
		0.5% shells

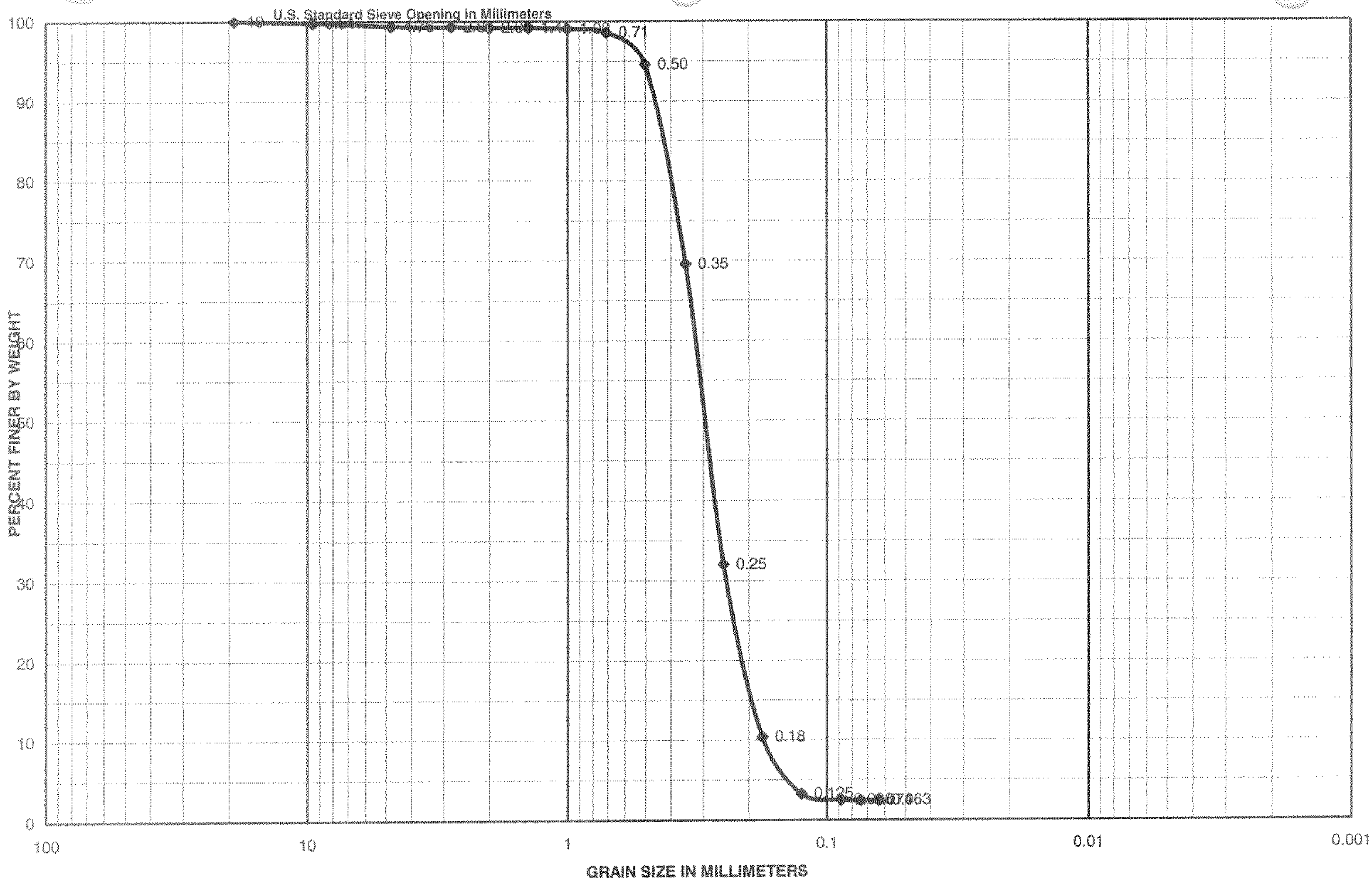
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-10
Date	4/30/2009



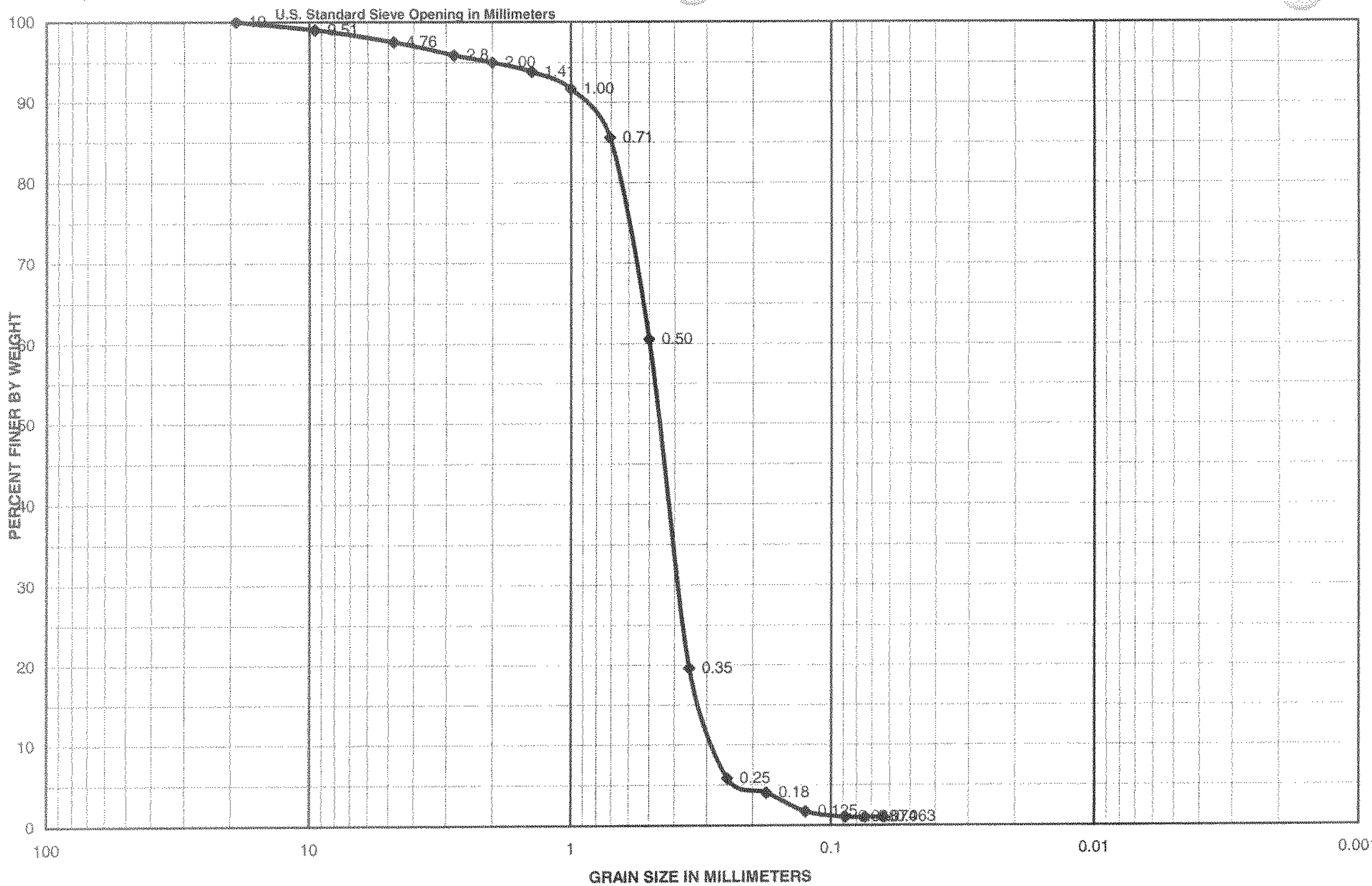
Sample No.	Depth	Classification	Area	Shallotte Inlet
1	5.2-5.7	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		12.6% shells	Boring No.	SHI-V-09-11
			Date	4/30/2009



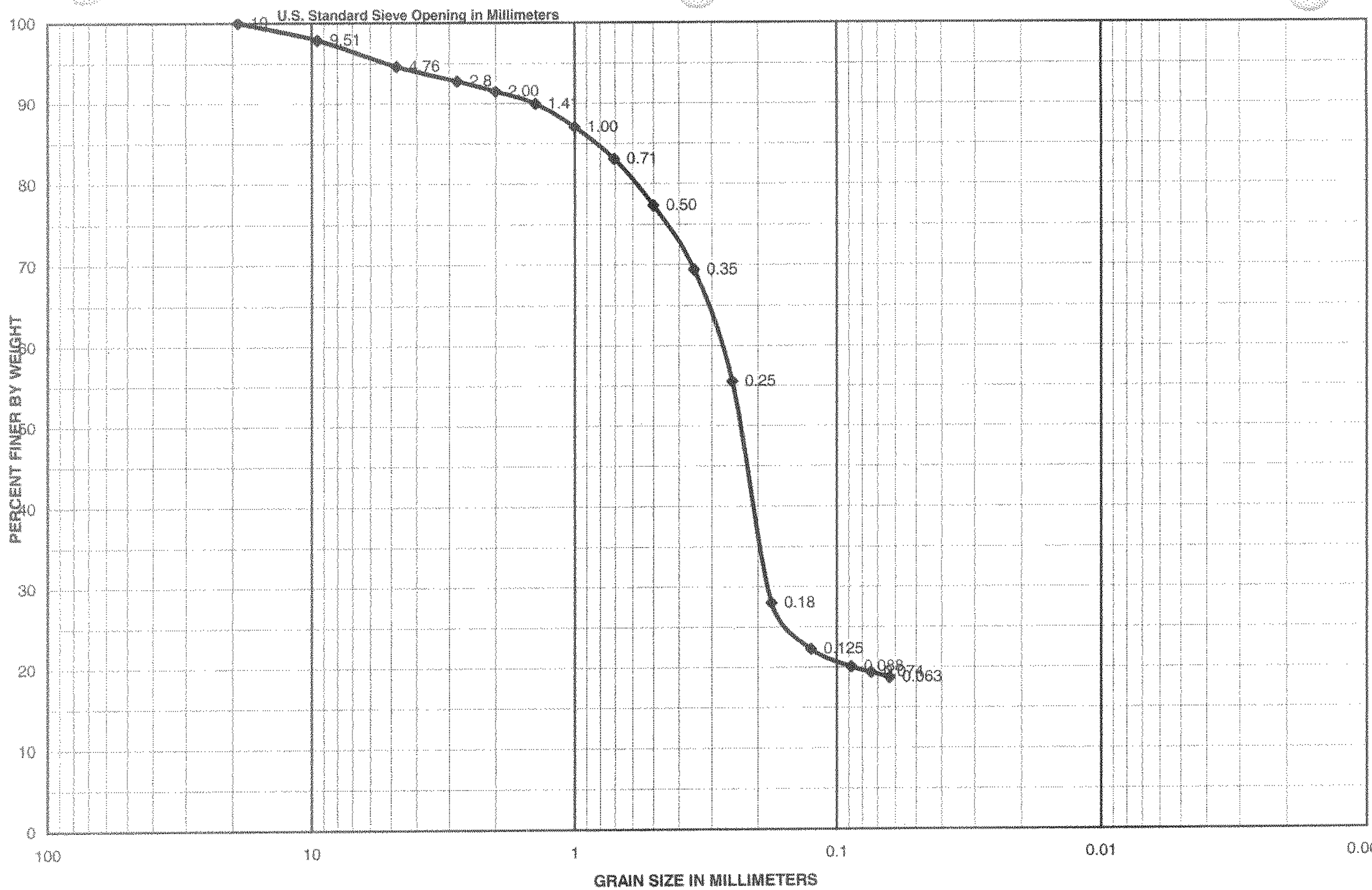
Sample No.	Depth	Classification	Area	Shallotte Inlet
2	8.0-8.5	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		19.5% shells	**Boring No.**	SHI-V-09-11
			Date	4/30/2009



Sample No.	Depth	Classification	
3	11.0-11.5	Olive gray poorly graded sand with trace shells, SP	**Area** Shallotte Inlet
		1.4% shells	**CATLIN Geotechnical Laboratory**
			Boring No. SHI-V-09-11
			Date 4/30/2009

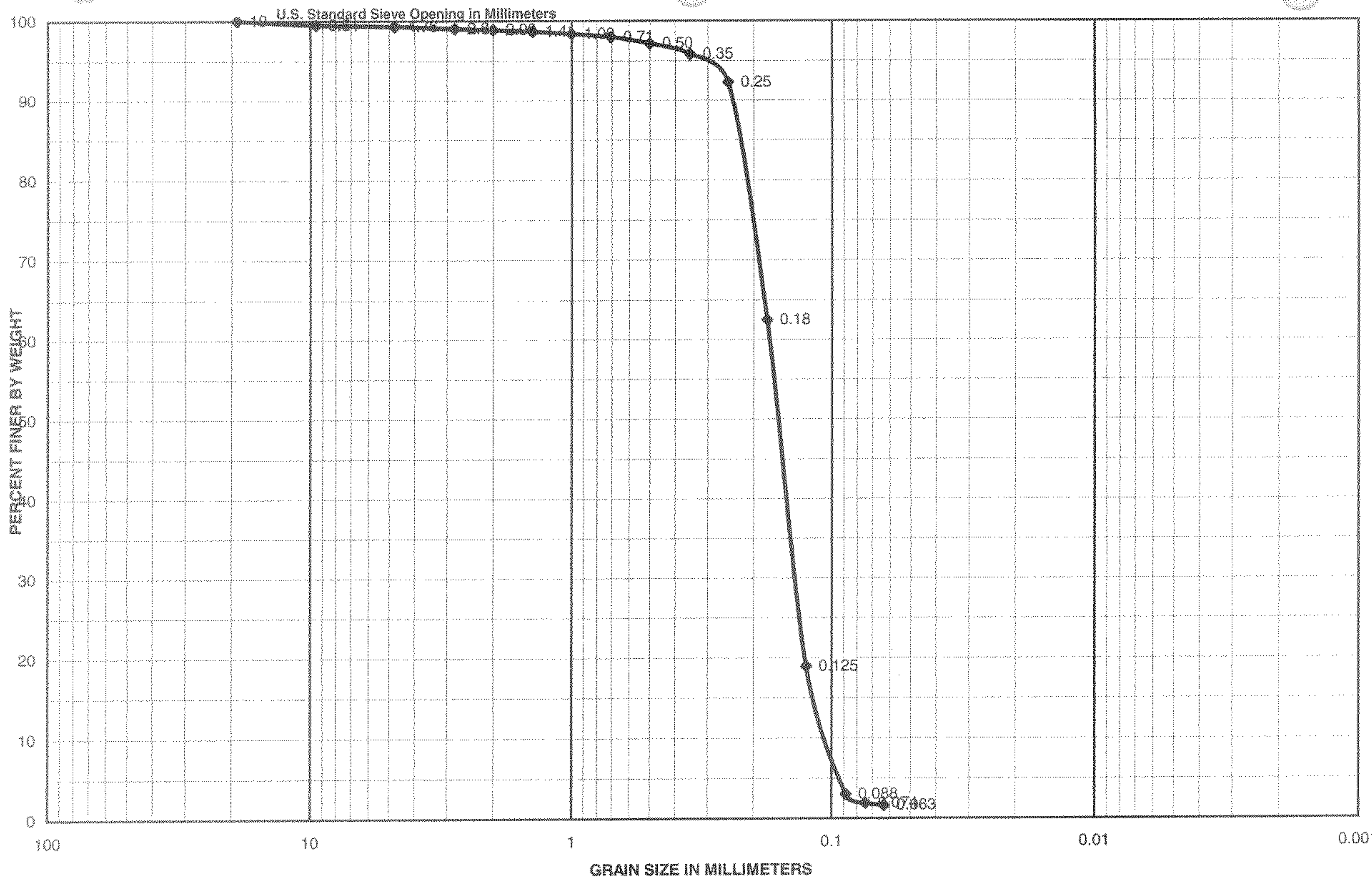


Sample No.	Depth	Classification	Area	Shallotte Inlet
4	14.0-14.5	Olive gray poorly graded sand with little shells, SP	**CATLIN Geotechnical Laboratory**	
		14.5% shells	**Boring No.**	SHI-V-09-11
			Date	4/30/2009



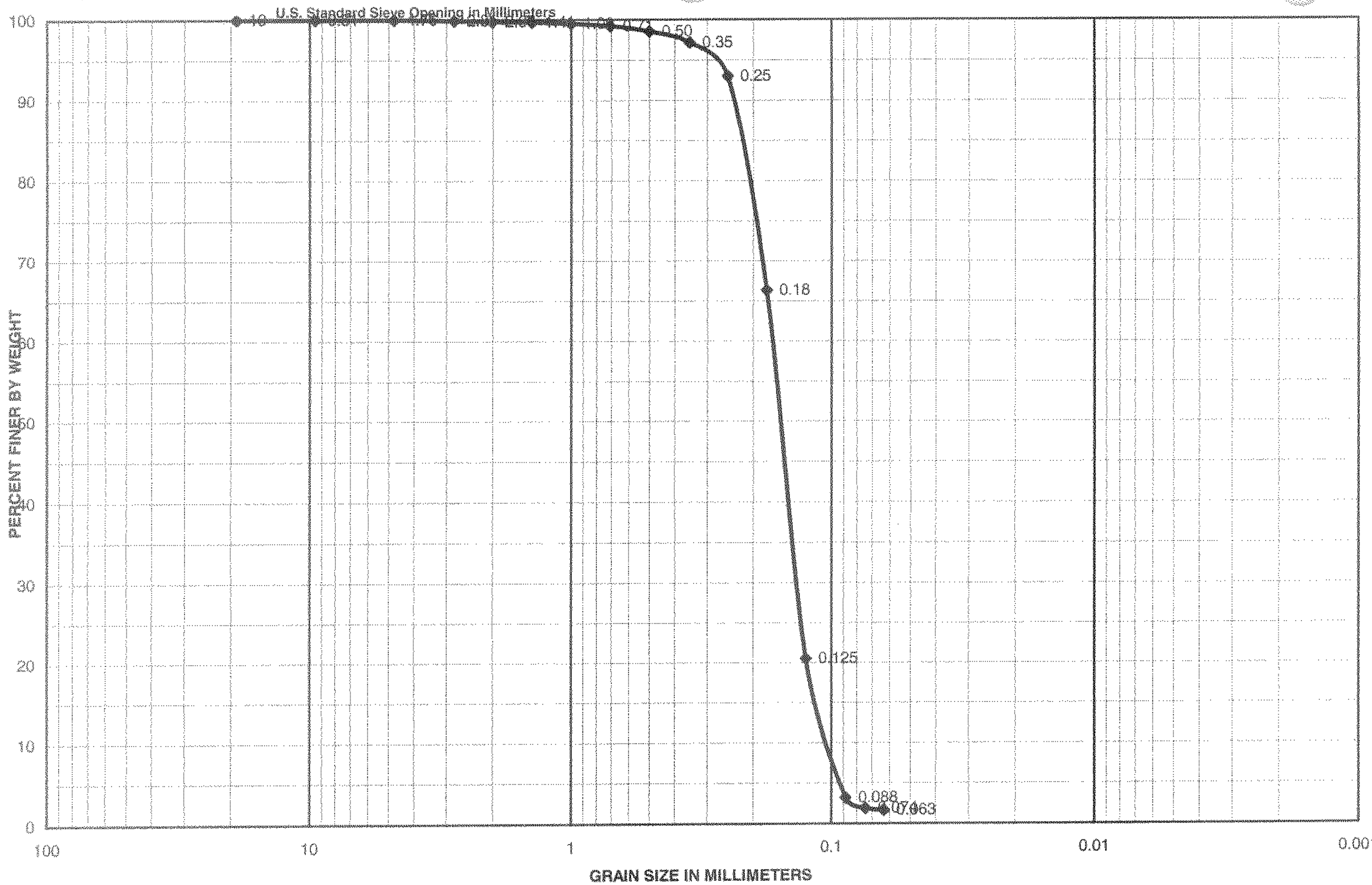
Sample No.	Depth	Classification
5	17.1-17.6	Olive gray silty sand with few shells, SM
		10.1% shells

Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-11
Date	4/30/2009

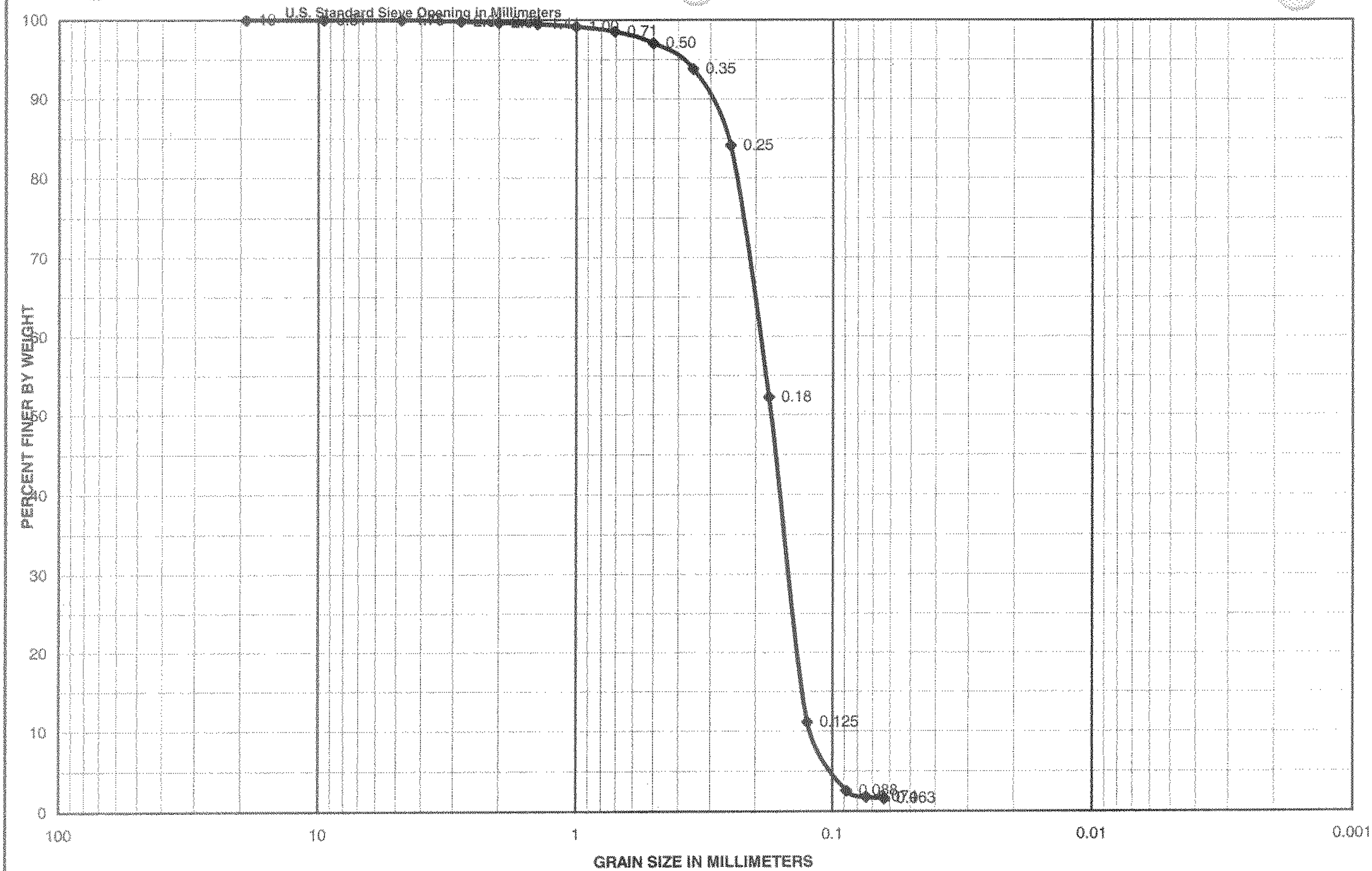


Sample No.	Depth	Classification
1	12.5-13.0	Olive gray poorly graded sand with trace shells, SP
		2.0% shells

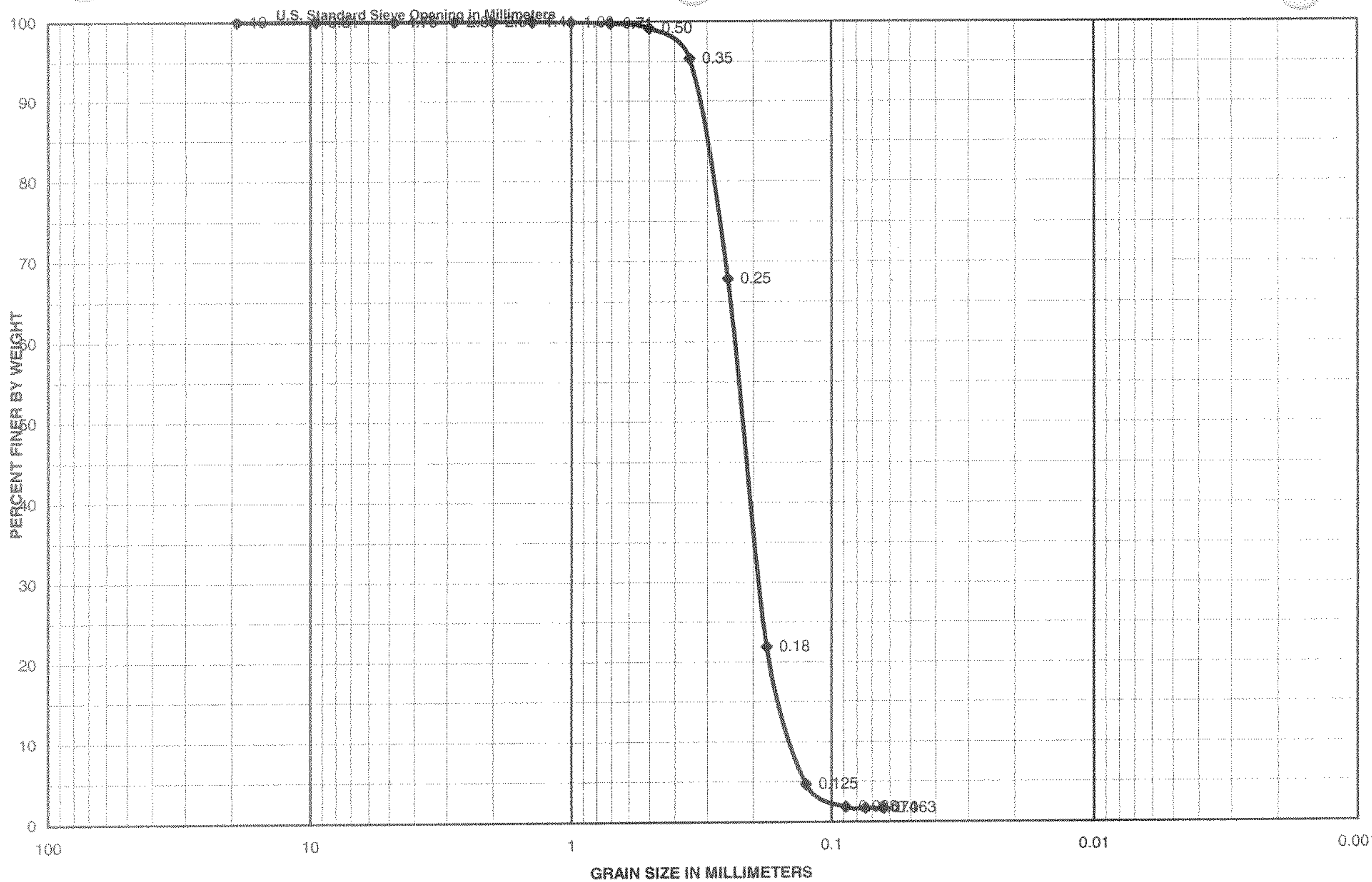
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-12
Date	4/30/2009



Sample No.	Depth	Classification	Area Shallotte Inlet
2	15.5-16.0	Olive gray poorly graded sand with trace shells, SP	CATLIN Geotechnical Laboratory
		0.8% shells	Boring No. SHI-V-09-12
			Date 5/1/2009

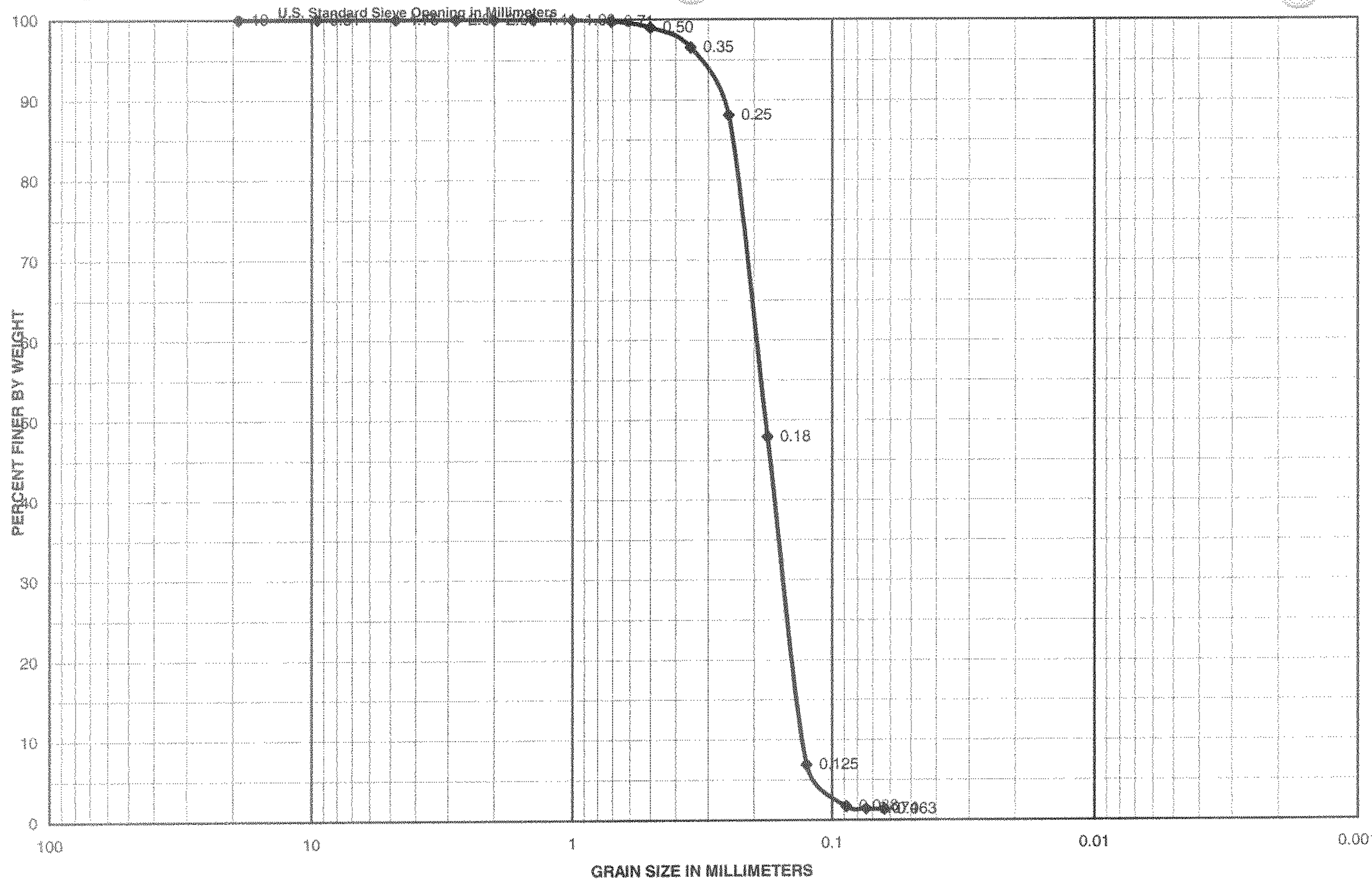


Sample No.	Depth	Classification	Area Shallotte Inlet
3	18.0-18.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**
		1.5% shells	**Boring No.** SHI-V-09-12
			Date 4/30/2009

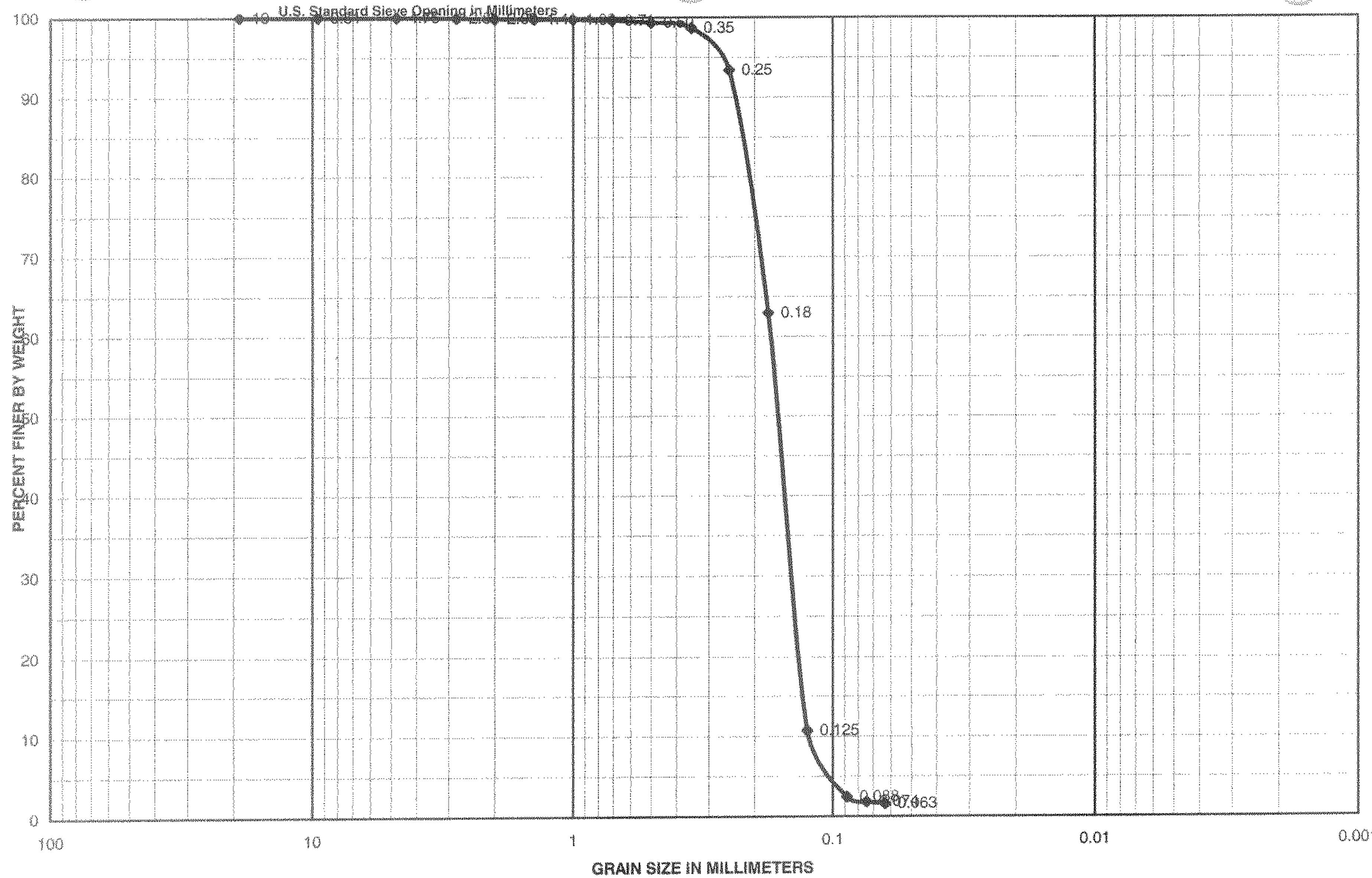


Sample No.	Depth	Classification
1	3.6-4.1	Olive gray poorly graded sand with trace shells, SP
		0.3% shells

Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-13
Date	4/30/2009

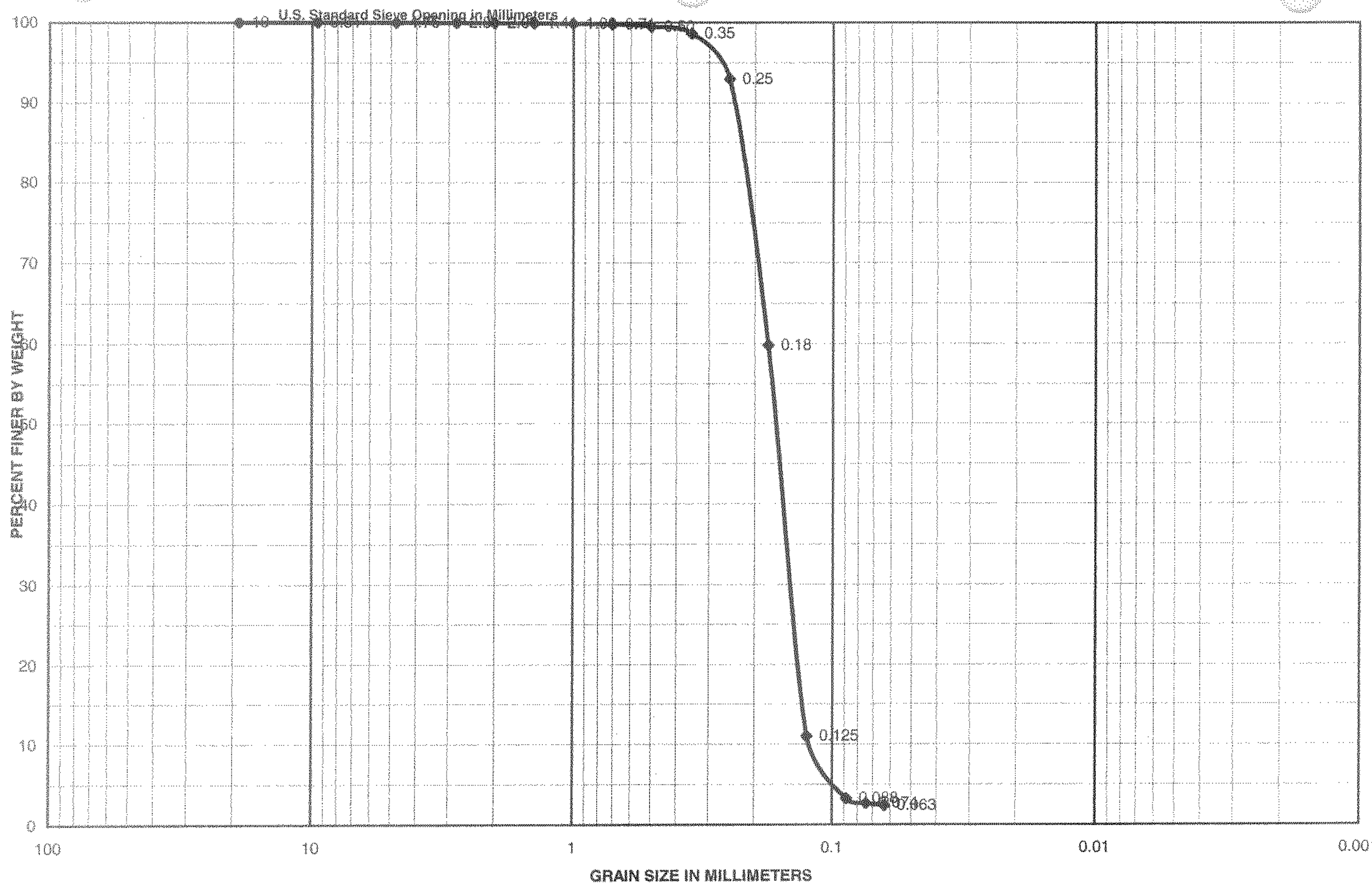


Sample No.	Depth	Classification	Area	Shallotte Inlet
2	6.0-6.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		0.2% shells	Boring No.	SHI-V-09-13
			Date	4/30/2009

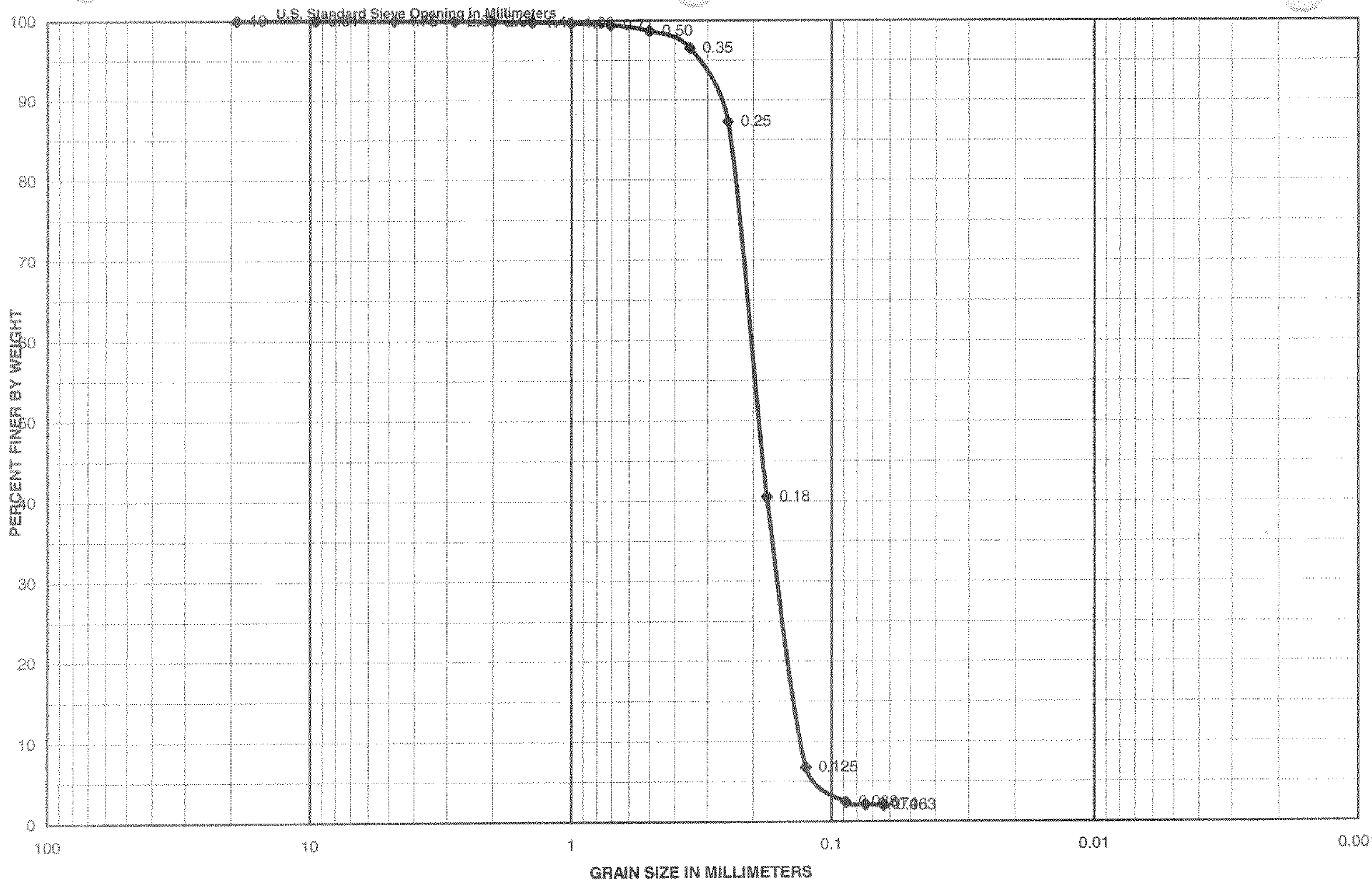


Sample No.	Depth	Classification
3	8.6-9.1	Olive gray poorly graded sand with trace shells, SP
		0.4% shells

Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-13
Date	5/1/2009

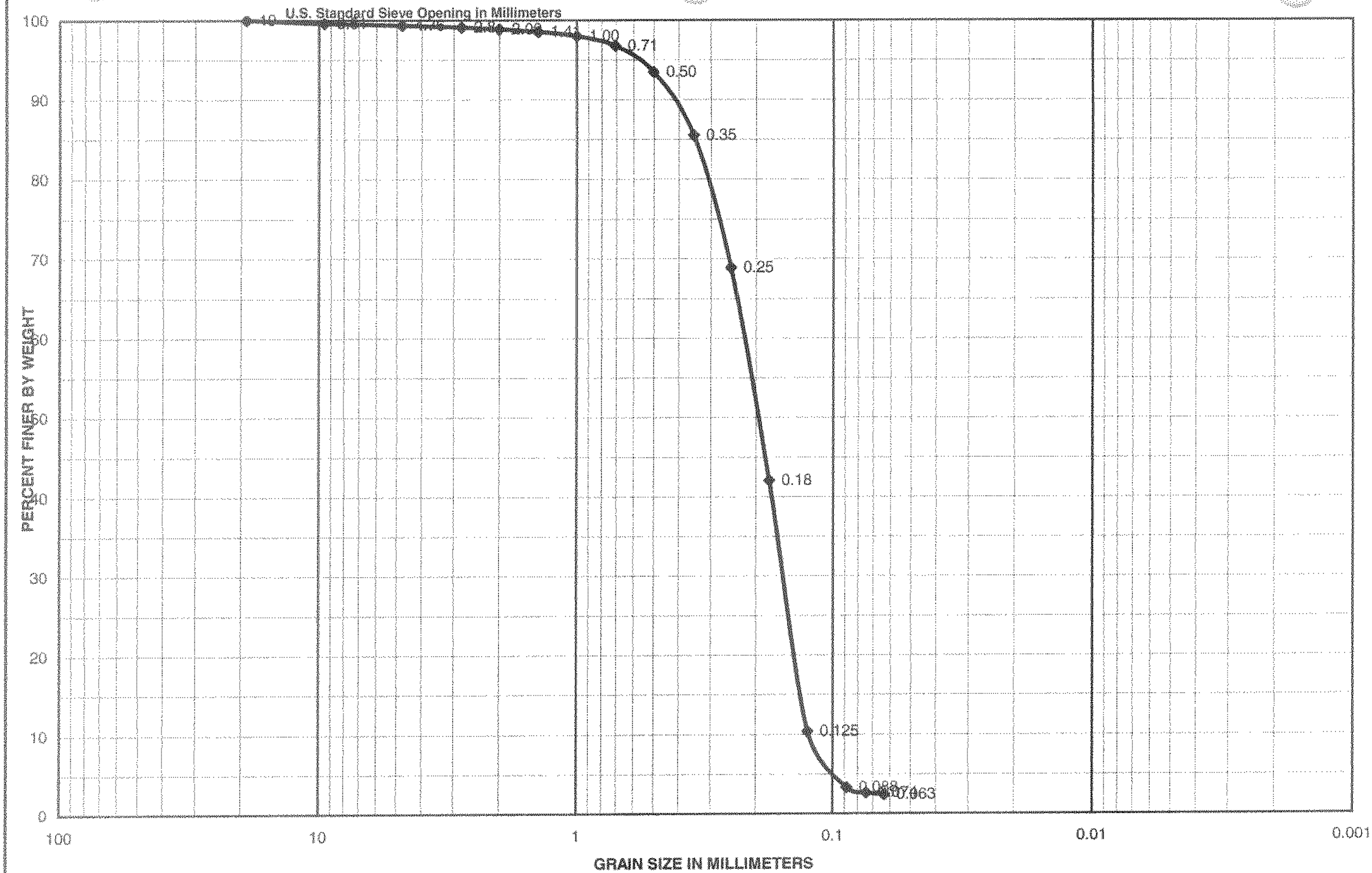


Sample No.	Depth	Classification	Area	Shallotte Inlet
4	11.6-12.1	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		0.2% shells	**Boring No.**	SHI-V-09-13
			Date	5/1/2009

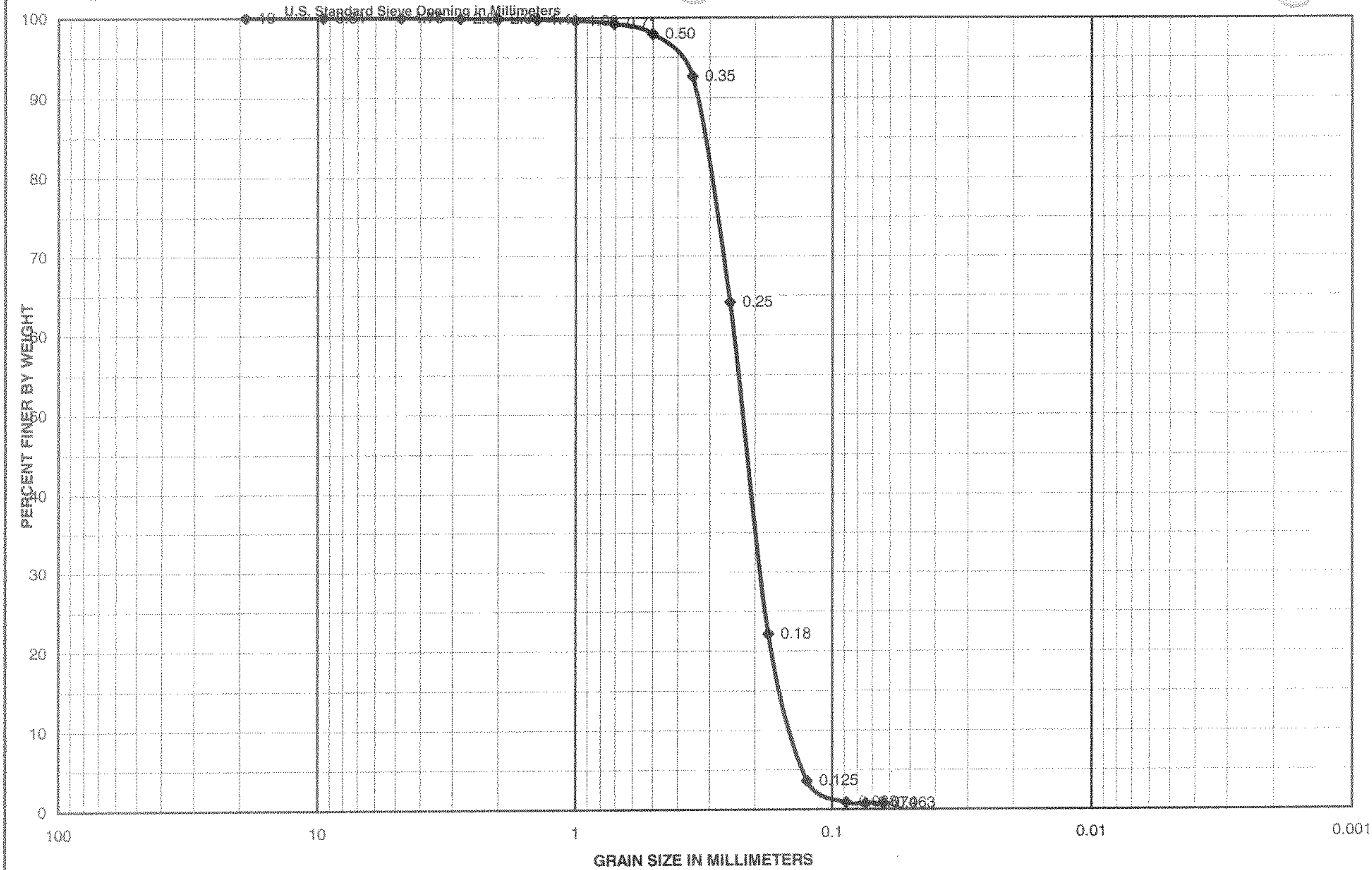


Sample No.	Depth	Classification
5	13.5-14.0	Olive gray poorly graded sand with trace shells, SP
		1.3% shells

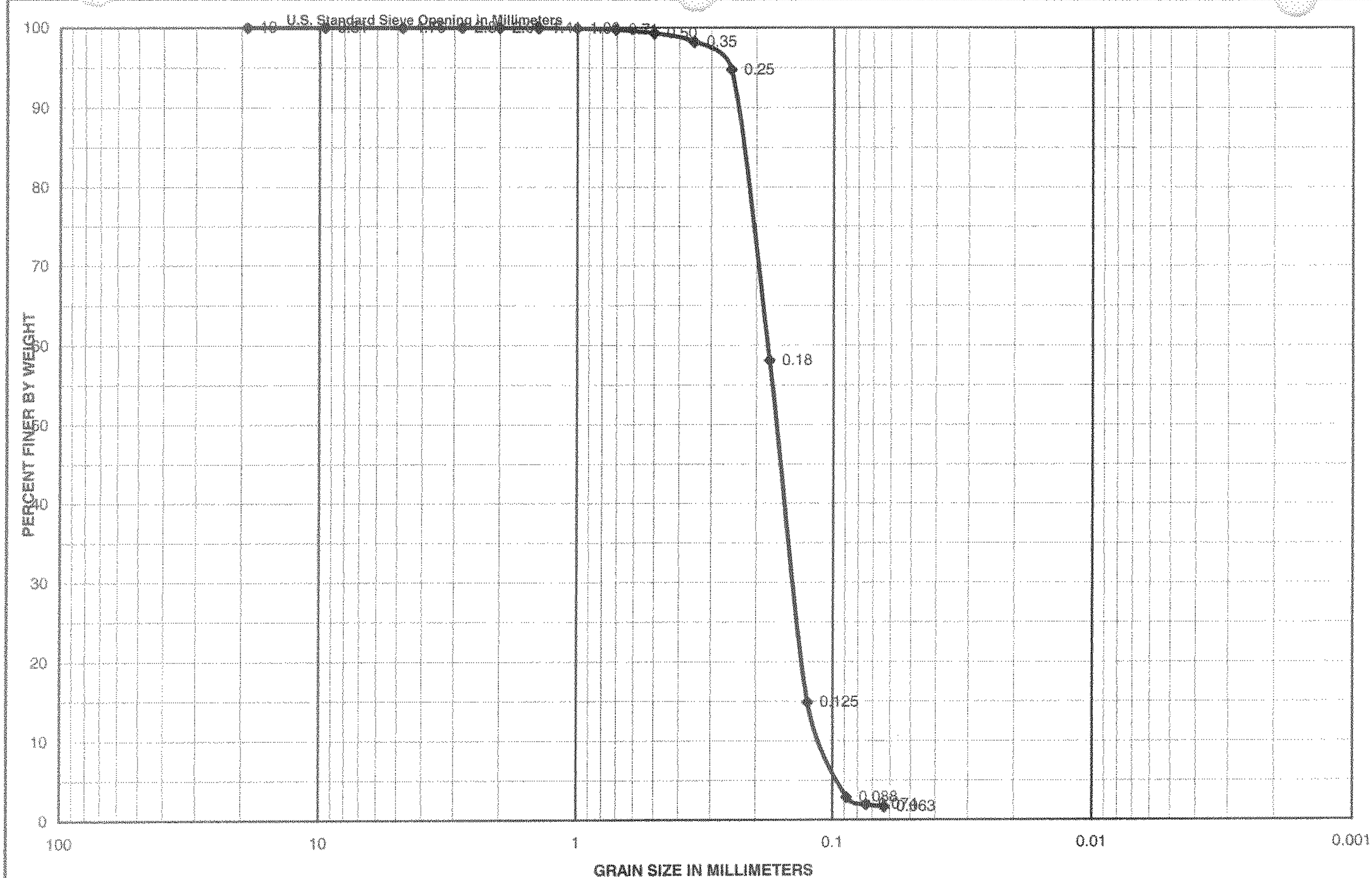
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-13
Date	5/1/2009



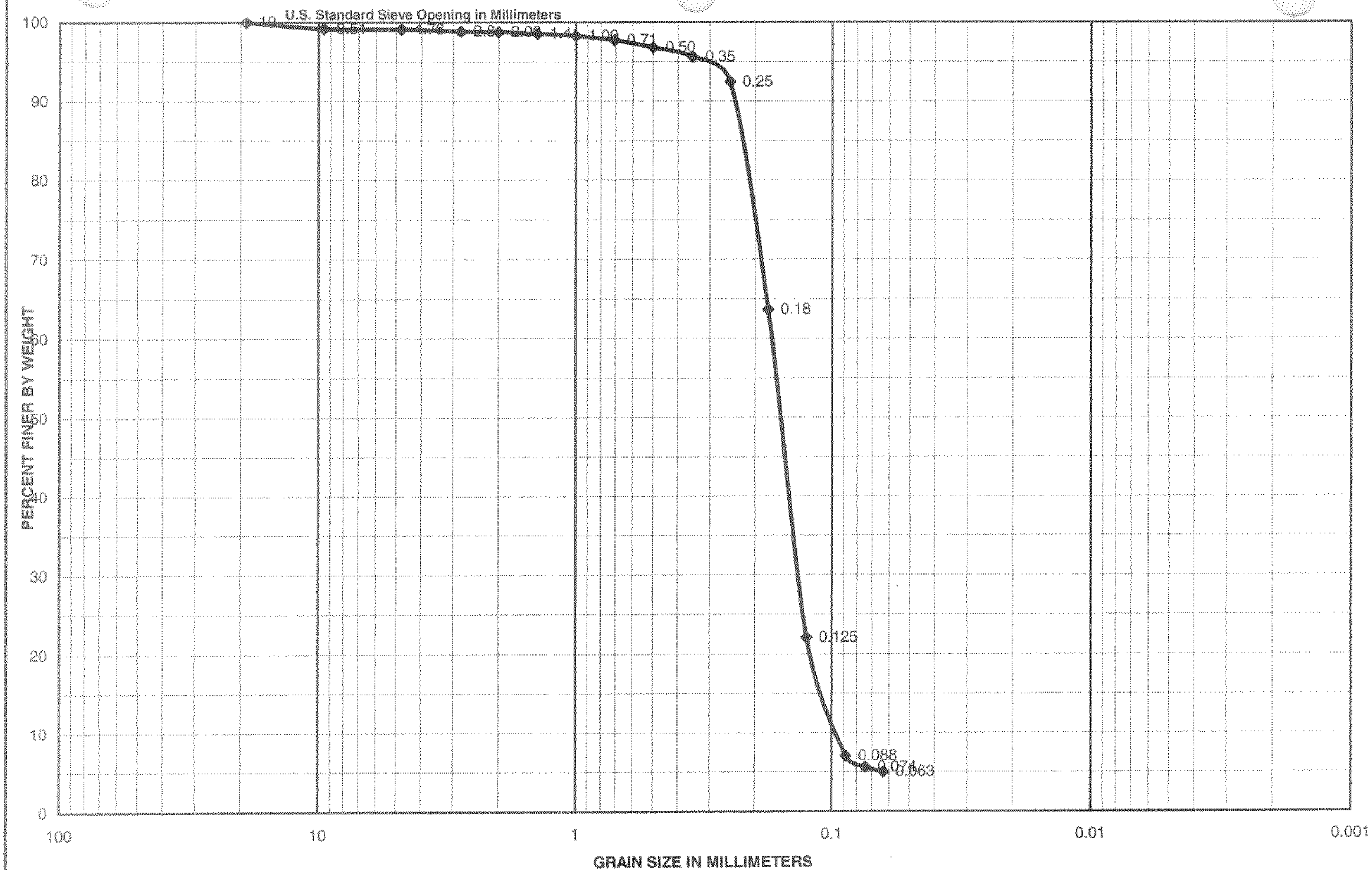
Sample No.	Depth	Classification	Area	Shallotte Inlet
6	16.0-16.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		3.2% shells	Boring No.	SHI-V-09-13
			Date	5/1/2009



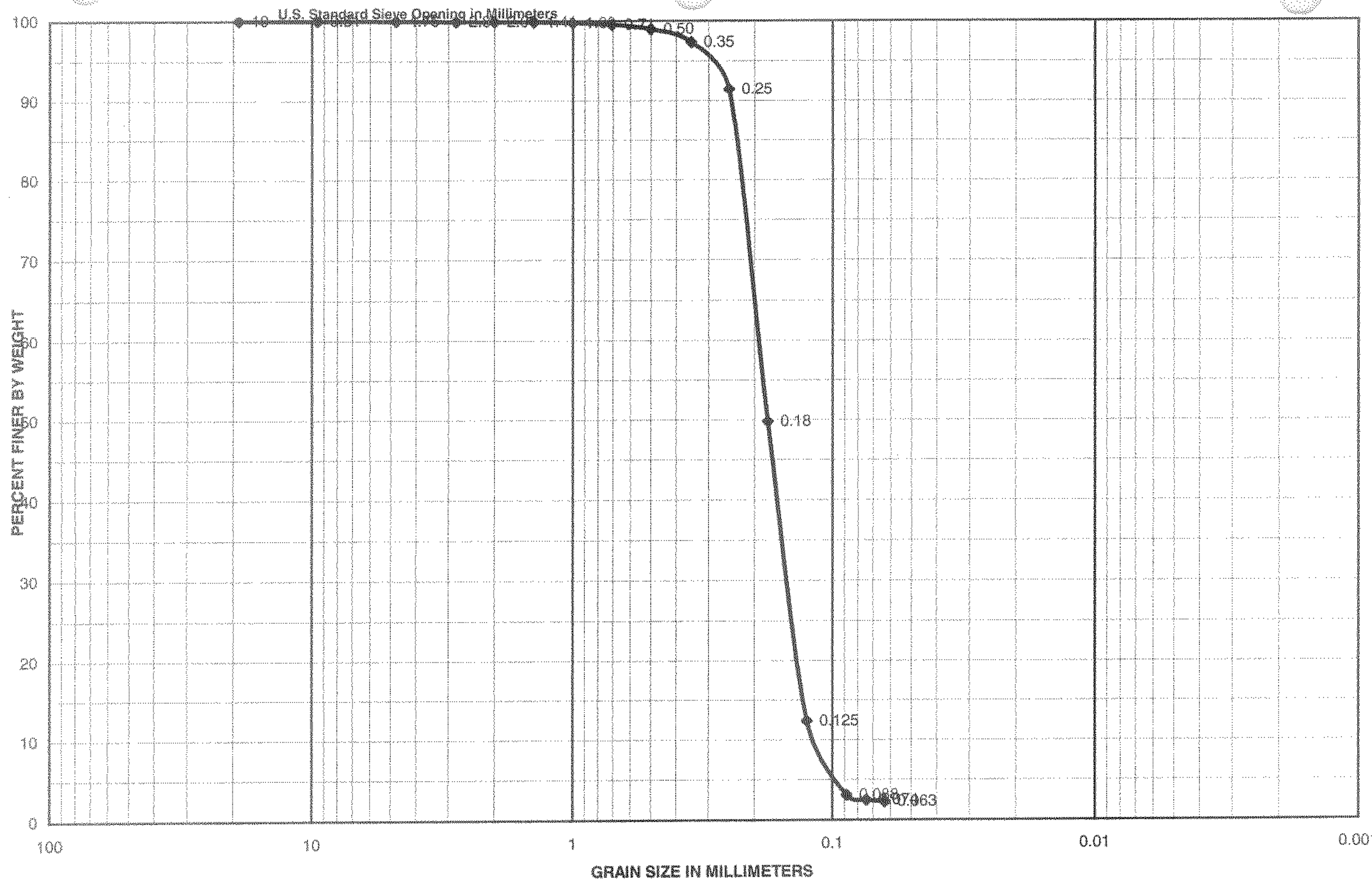
Sample No.	Depth	Classification	Area	Shallotte Inlet
1	6.6-7.1	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		0.8% shells	**Boring No.**	SHI-V-09-14
			Date	5/1/2009



Sample No.	Depth	Classification	Area Shallotte Inlet
2	9.0-9.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**
		0.3% shells	**Boring No.** SHI-V-09-14
			Date 4/30/2009

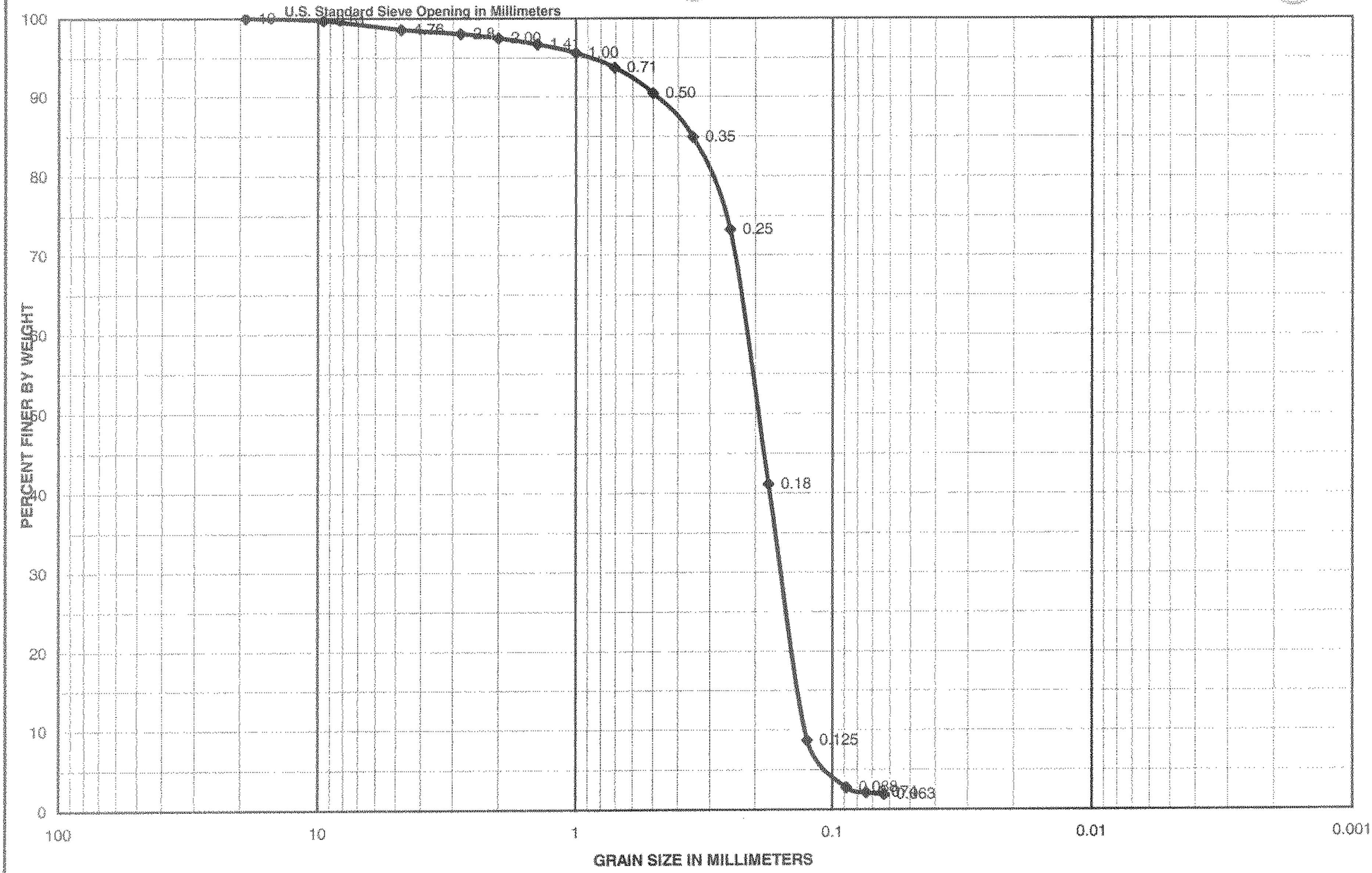


Sample No.	Depth	Classification		
			Area	Shallotte Inlet
3	11.0-11.5	Olive gray poorly graded sand with silt and trace shells, SP-SM	CATLIN Geotechnical Laboratory	
		2.3% shells	Boring No.	SHI-V-09-14
			Date	5/1/2009

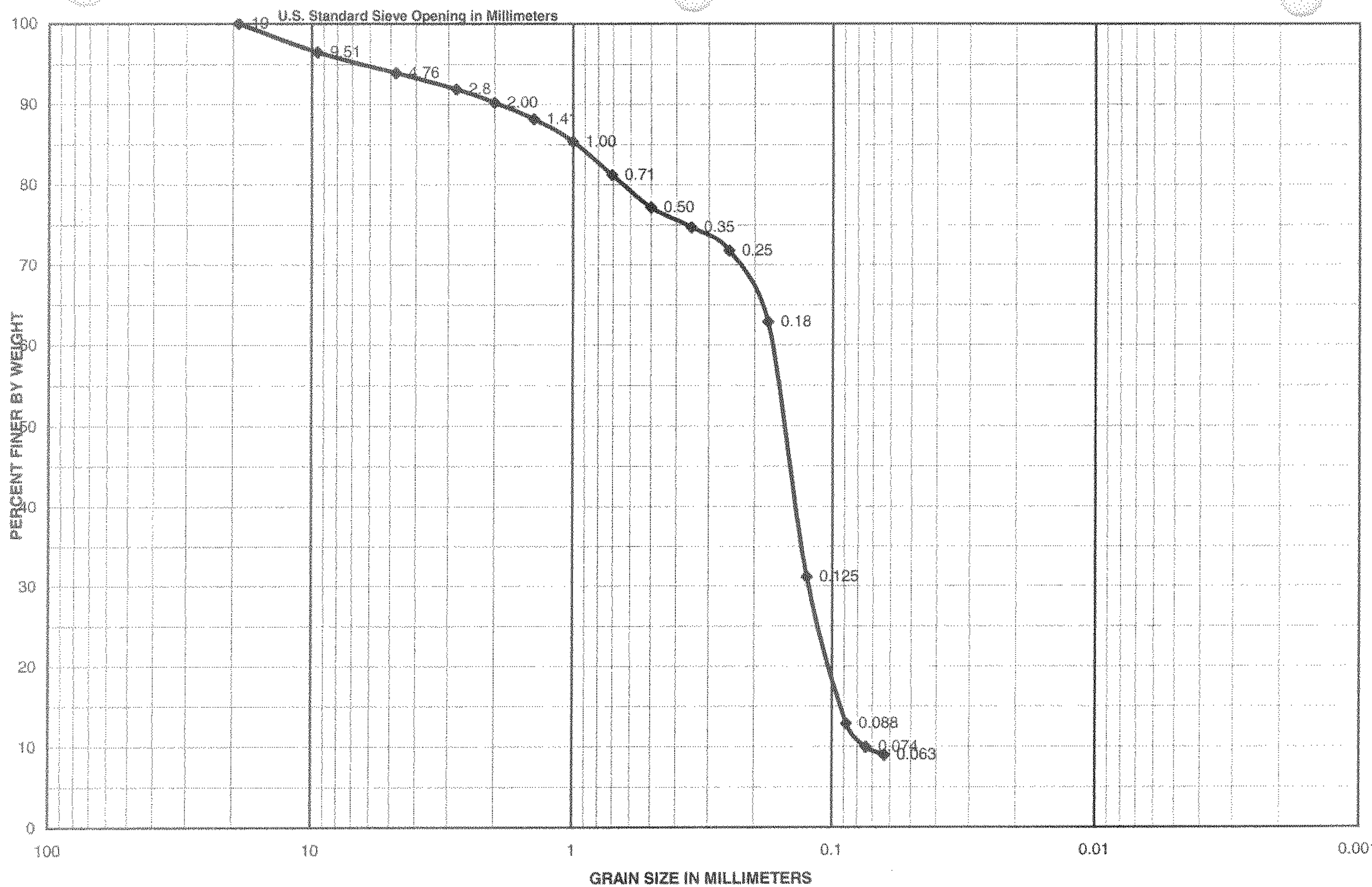


Sample No.	Depth	Classification
4	13.0-13.5	Olive gray poorly graded sand with trace shells, SP
		0.3% shells

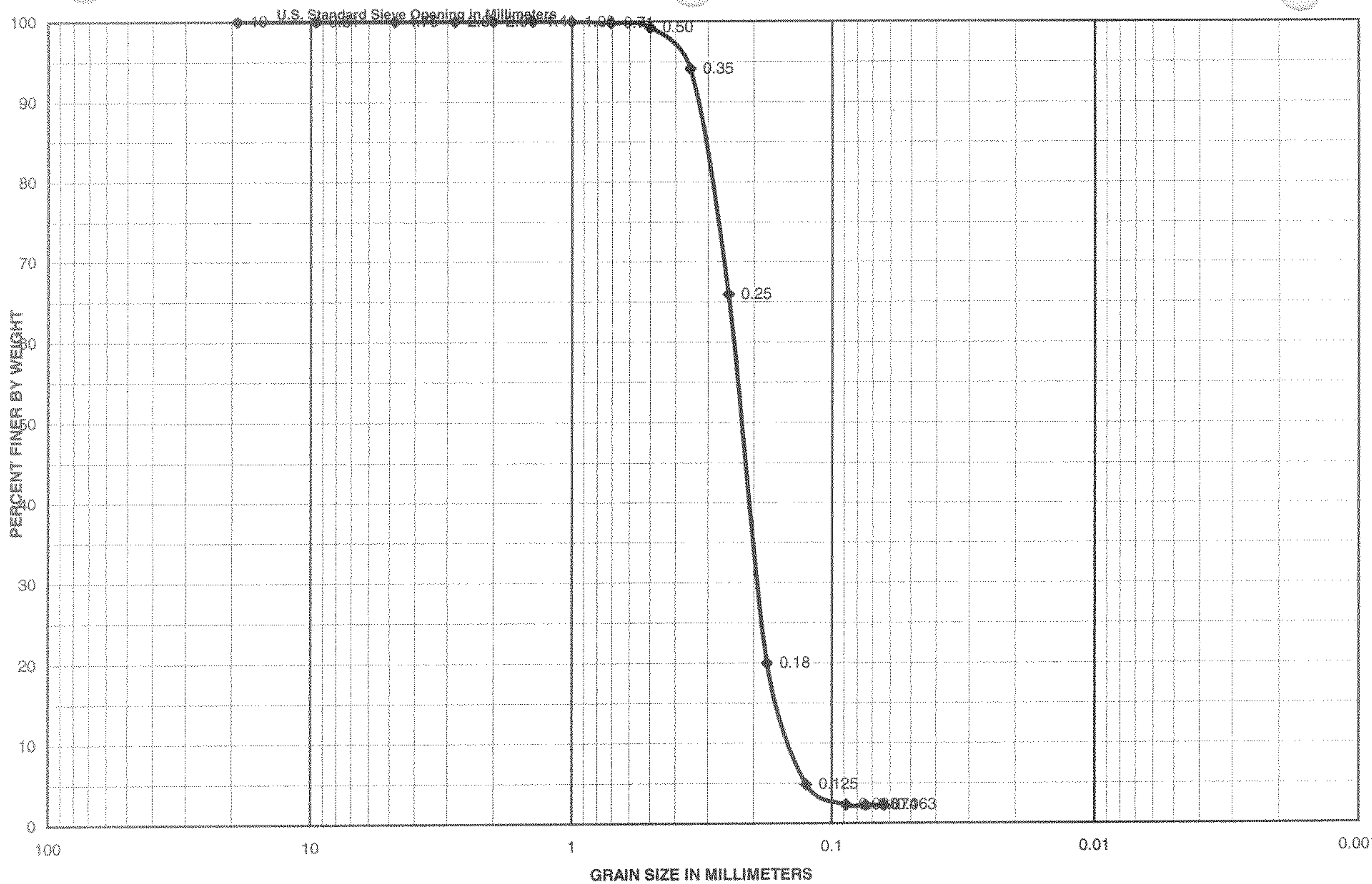
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-14
Date	5/1/2009



Sample No.	Depth	Classification	
			Area Shallotte Inlet
5	15.0-15.5	Olive gray poorly graded sand with few shells, SP	**CATLIN Geotechnical Laboratory**
		6.3% shells	**Boring No.** SHI-V-09-14
			Date 5/1/2009

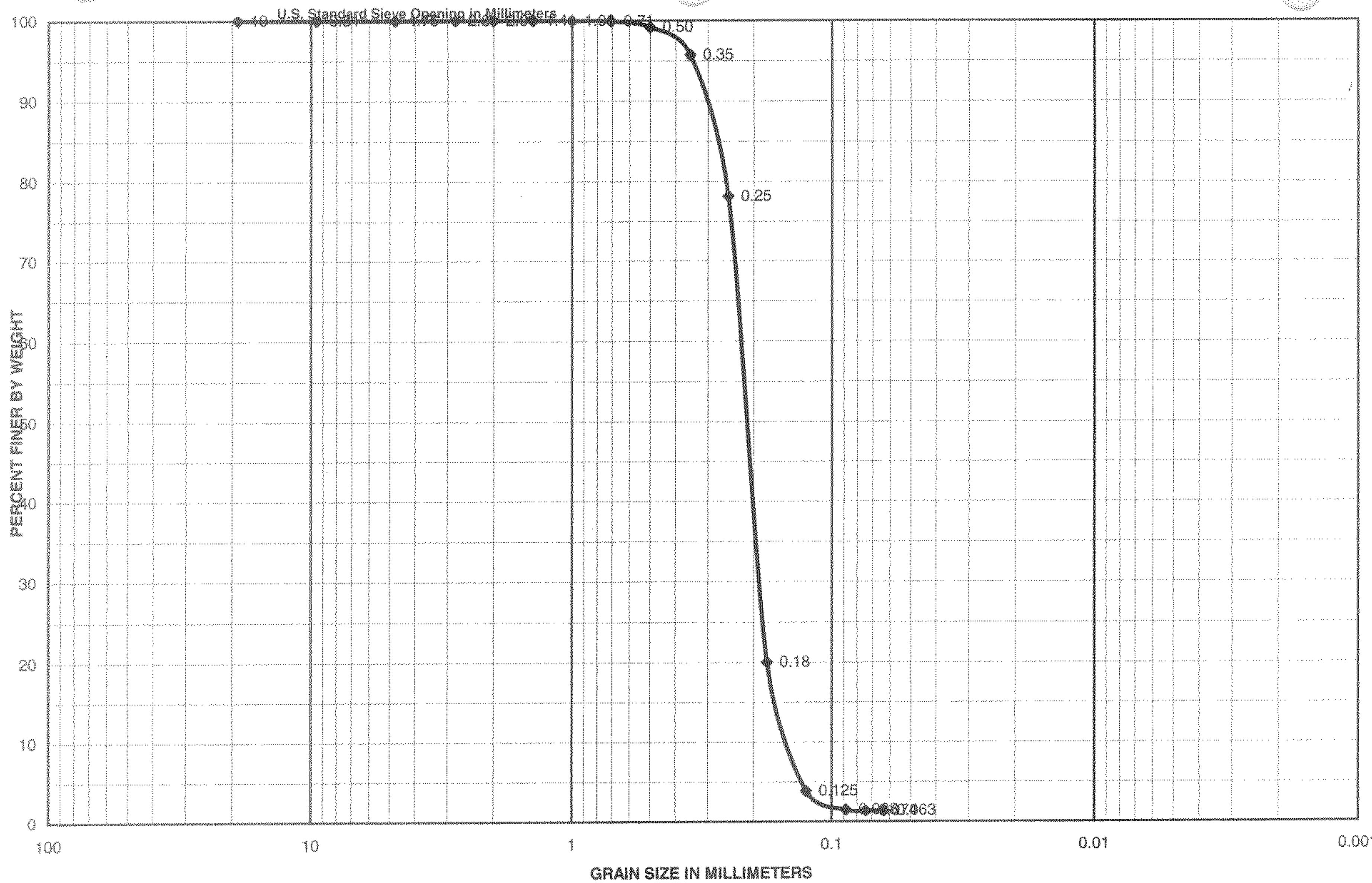


Sample No.	Depth	Classification	Area Shallotte Inlet
6	17.0-17.5	Dark gray poorly graded sand with silt and little shells, SP-SM	**CATLIN Geotechnical Laboratory**
		18.8% shells	**Boring No.** SHI-V-09-14
			Date 5/1/2009

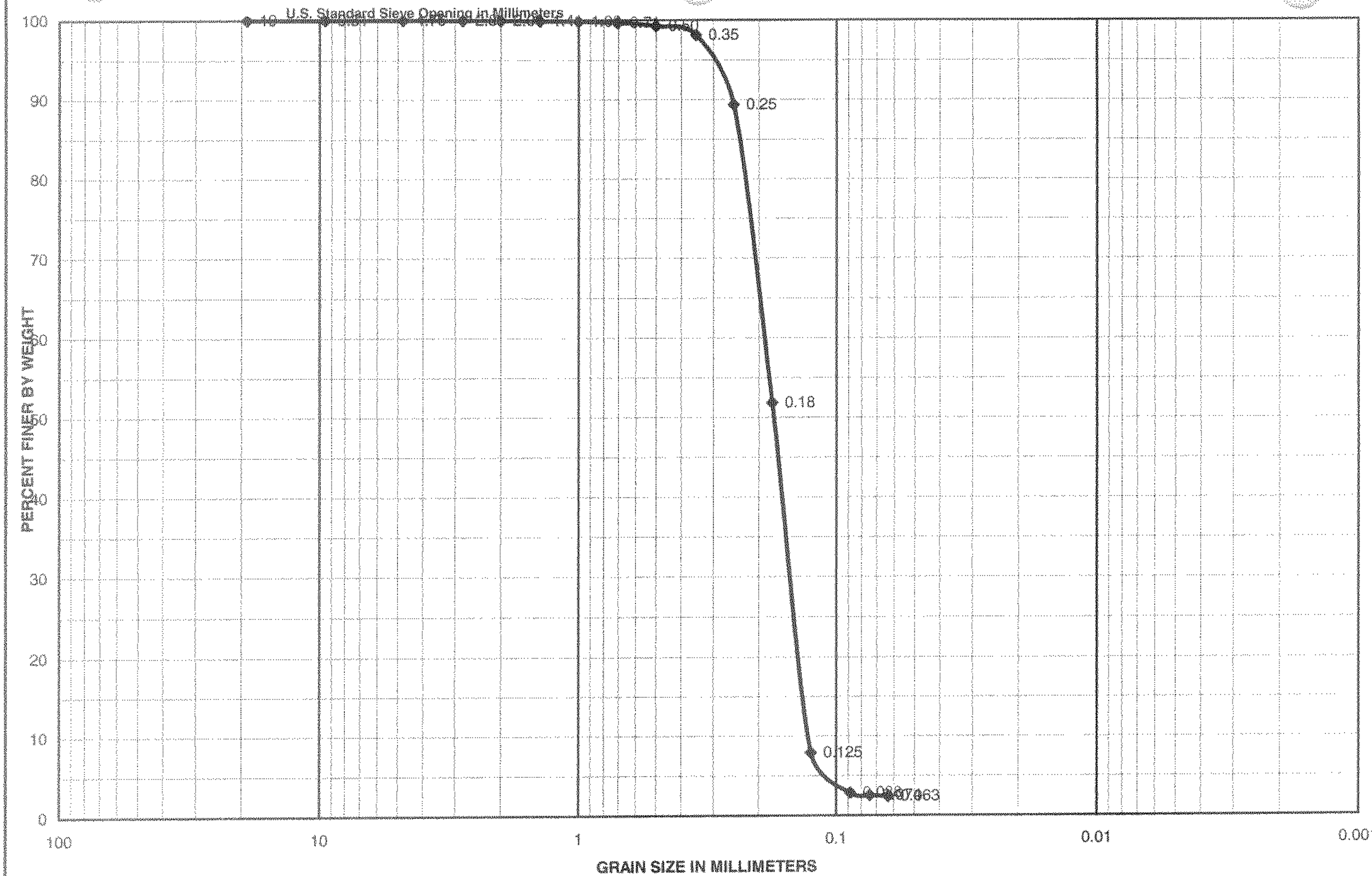


Sample No.	Depth	Classification
1	3.2-3.7	Olive gray poorly graded sand with trace shells, SP
		0.2% shells

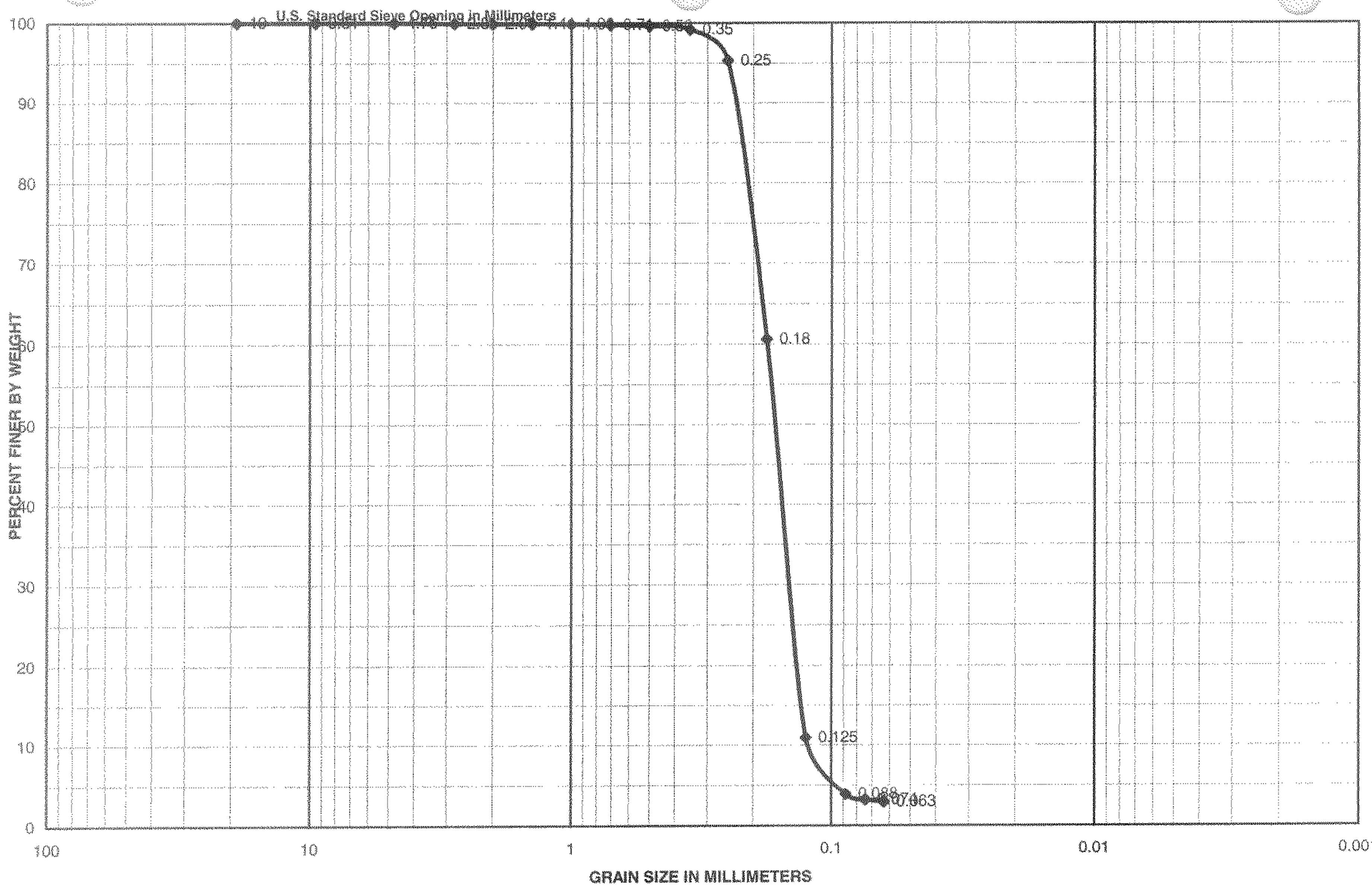
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-15
Date	5/1/2009



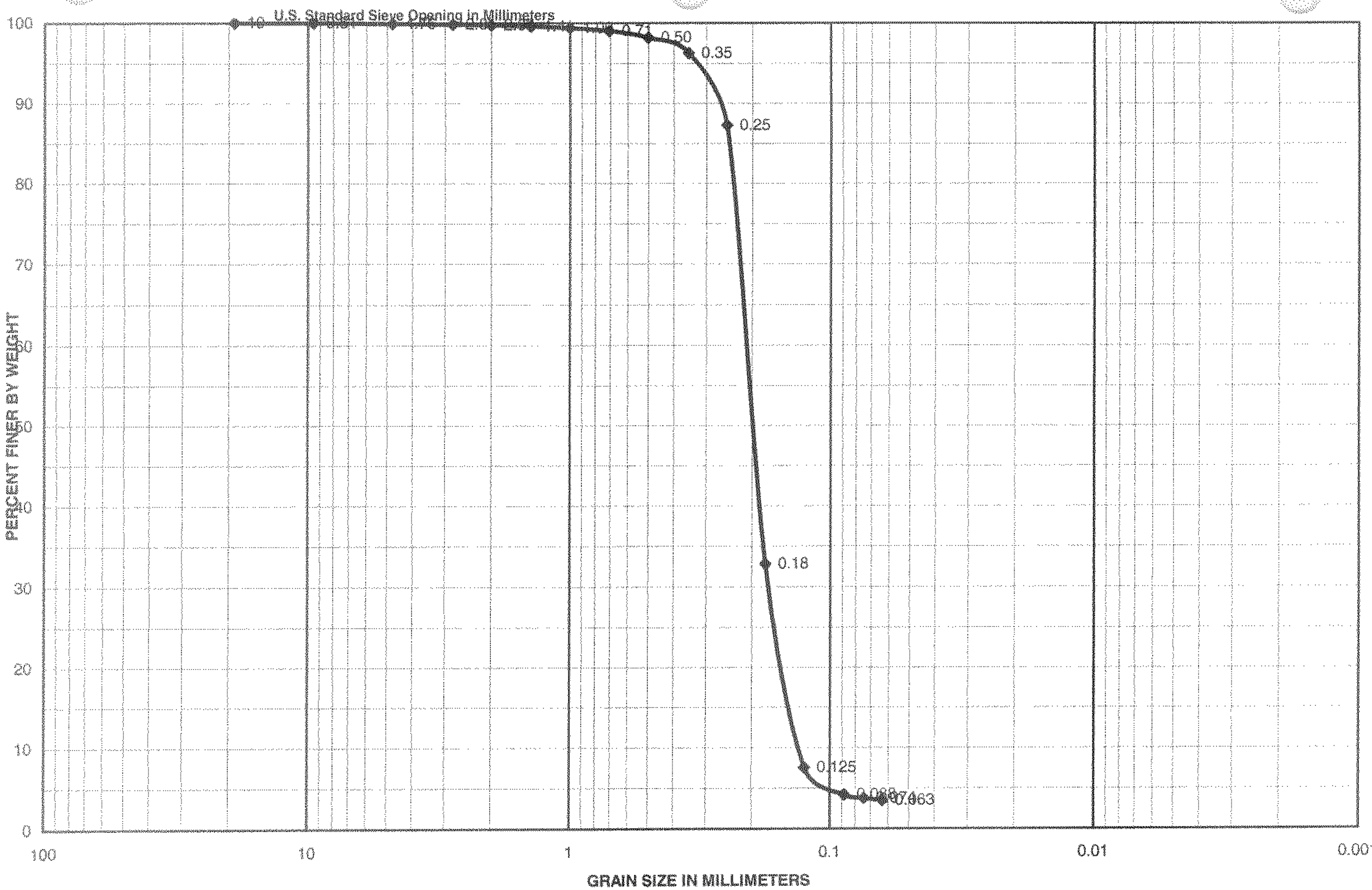
Sample No.	Depth	Classification	Area Shallotte Inlet
2	5.5-6.0	Olive gray poorly graded sand, SP	**CATLIN Geotechnical Laboratory**
			Boring No. SHI-V-09-15
			Date 5/1/2009



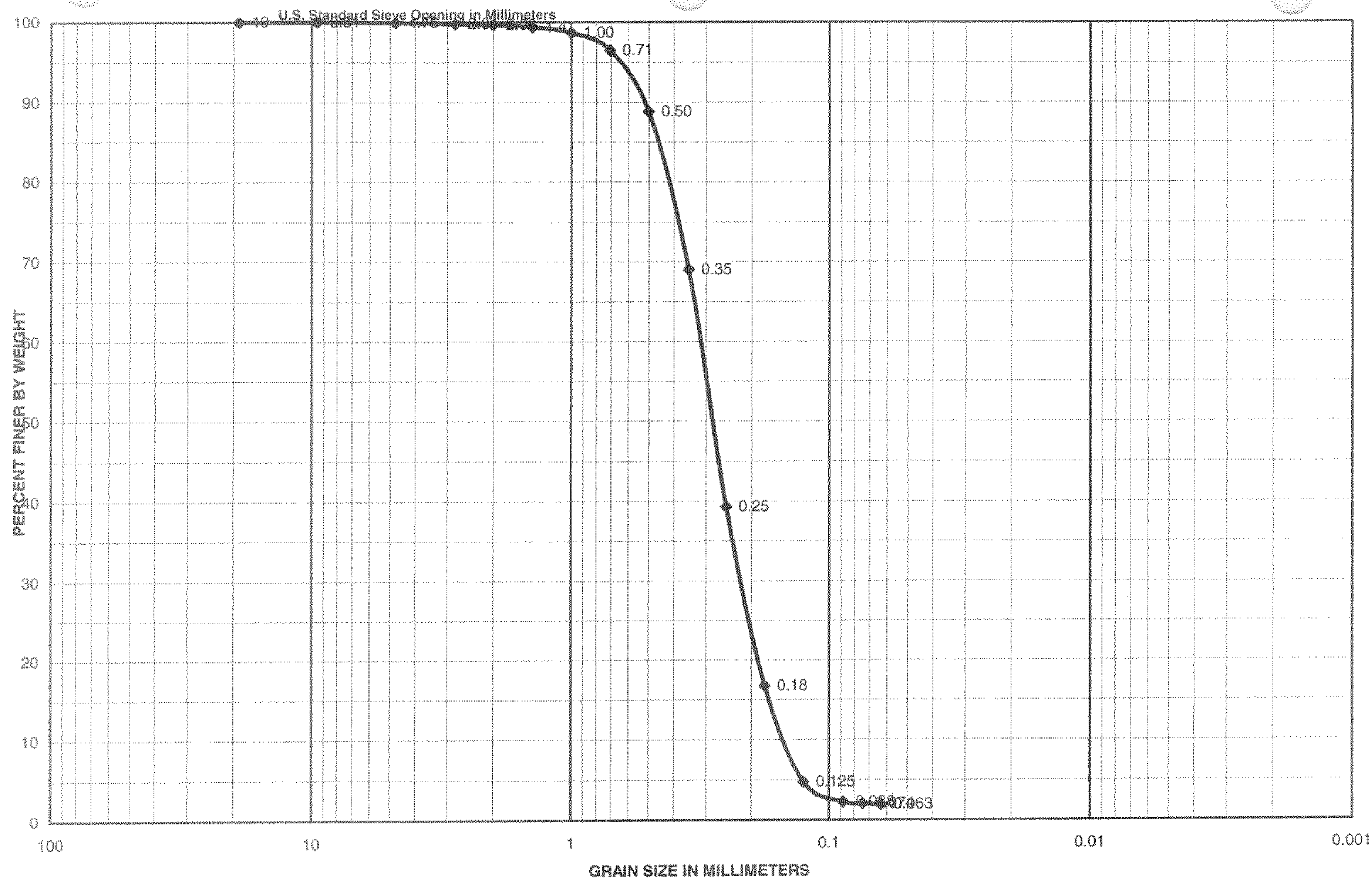
Sample No.	Depth	Classification	Area	Shallotte Inlet
3	8.0-8.5	Olive gray poorly graded sand with trace shells, SP	CATLIN Geotechnical Laboratory	
		0.4% shells	Boring No.	SHI-V-09-15
			Date	5/1/2009



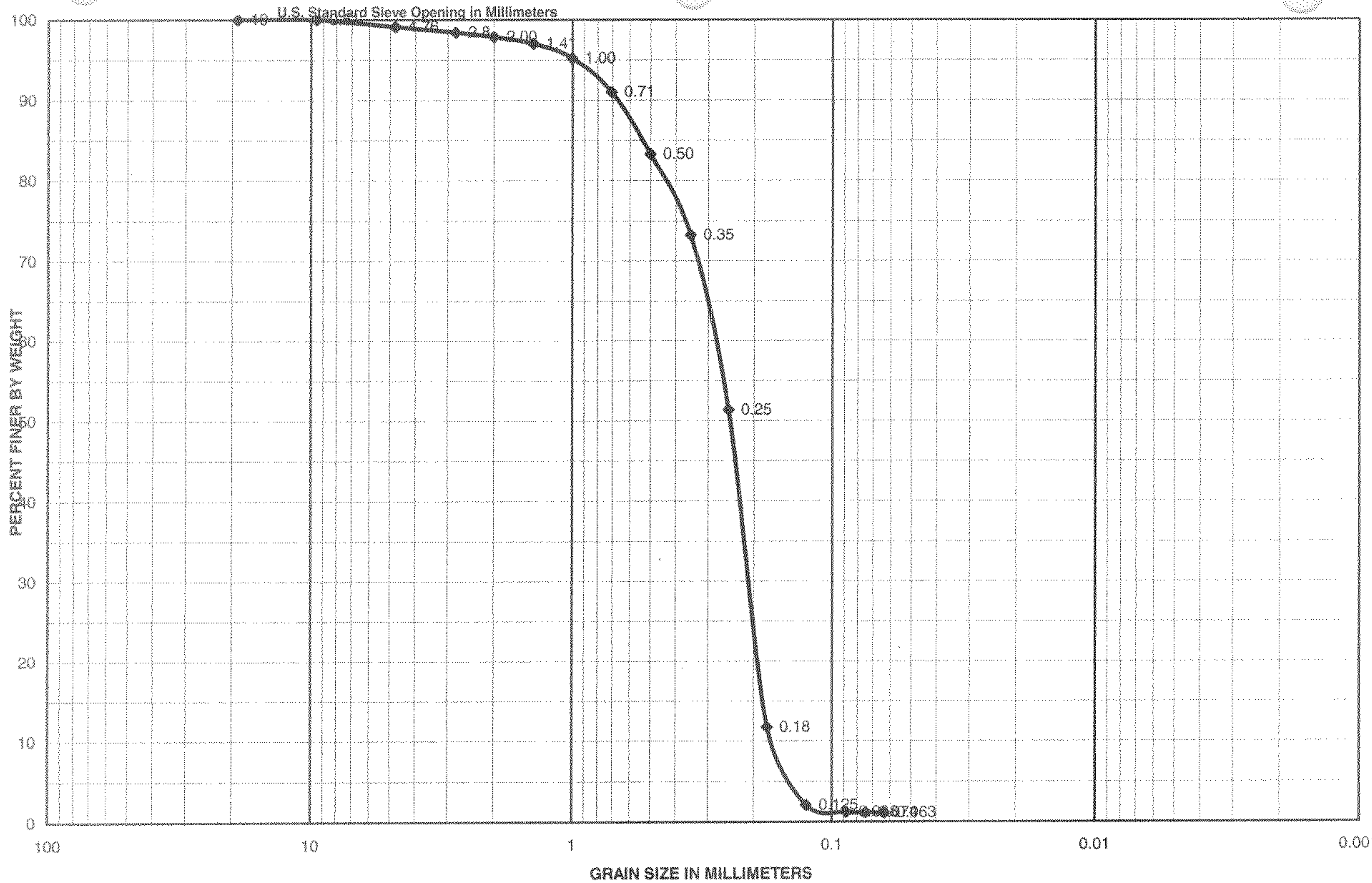
Sample No.	Depth	Classification	Area Shallotte Inlet
4	10.0-10.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**
		0.1% shells	**Boring No.** SHI-V-09-15
			Date 5/1/2009



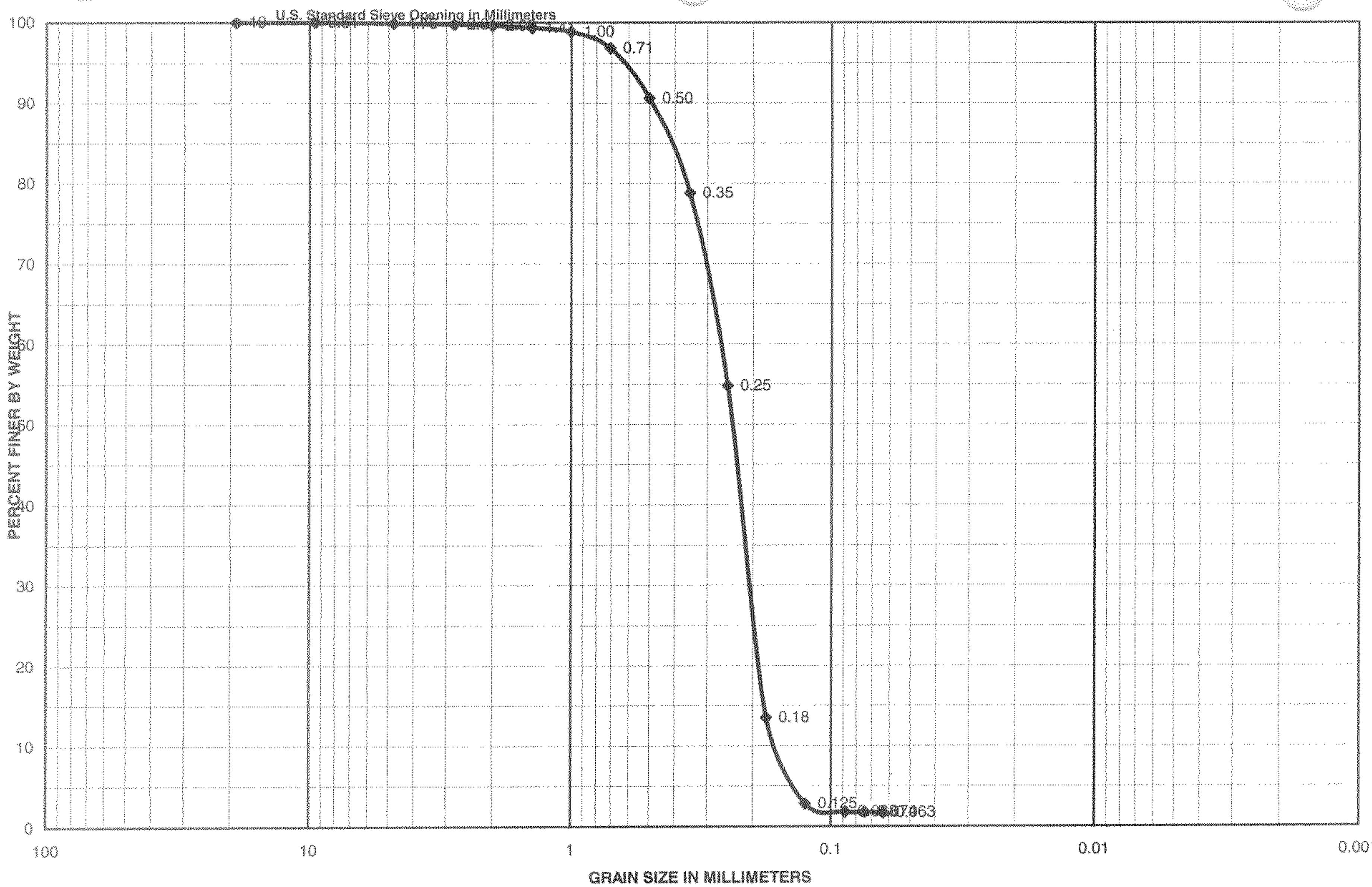
Sample No.	Depth	Classification	Area Shallotte Inlet
5	12.0-12.5	Olive gray poorly graded sand with trace shells, SP	CATLIN Geotechnical Laboratory
		1.0% shells	Boring No. SHI-V-09-15
			Date 5/1/2009



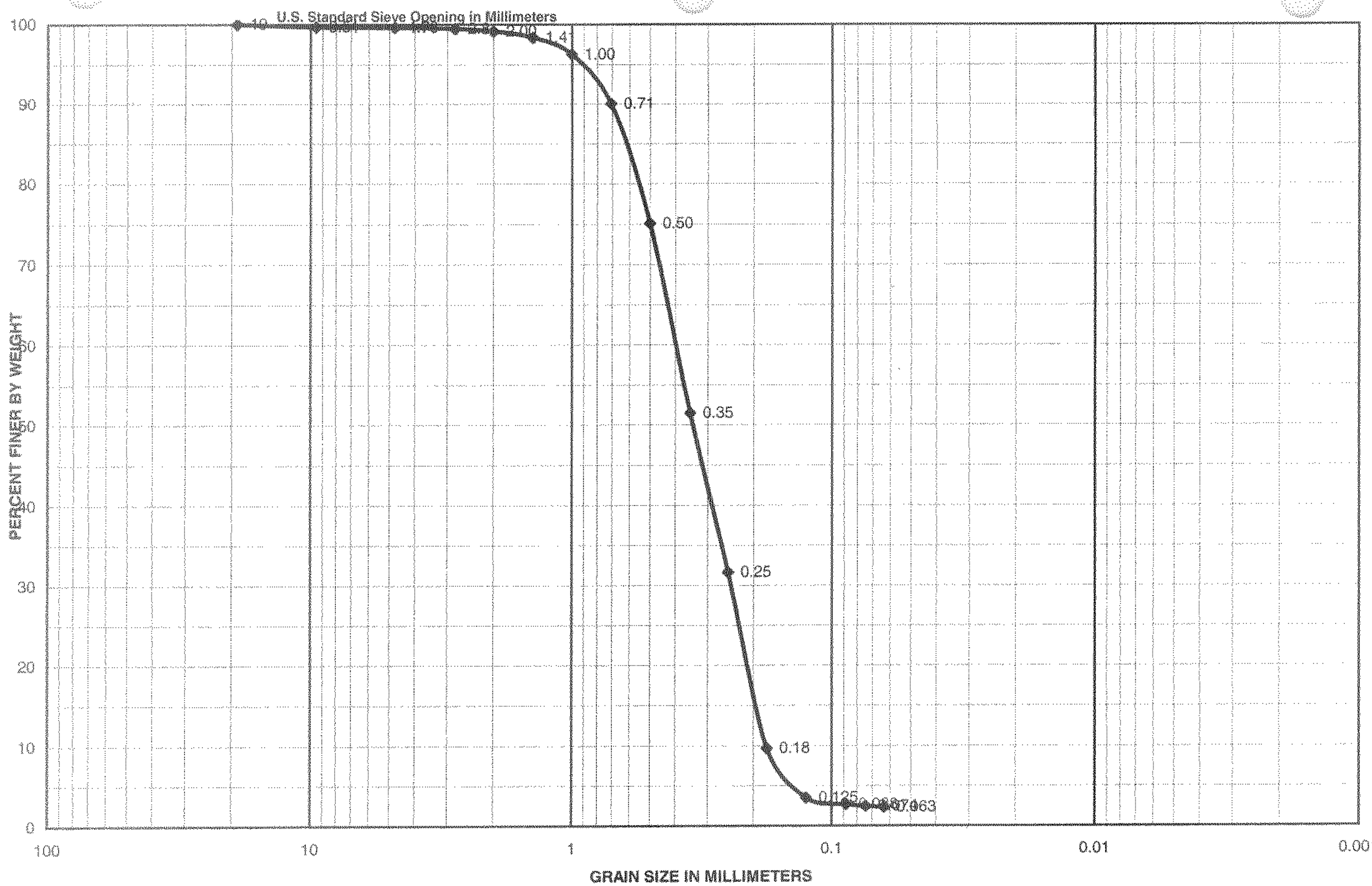
Sample No.	Depth	Classification	Area Shallotte Inlet
6	14.0-14.5	Olive gray poorly graded sand with trace shells, SP	CATLIN Geotechnical Laboratory
		3.5% shells	Boring No. SHI-V-09-15
			Date 5/1/2009



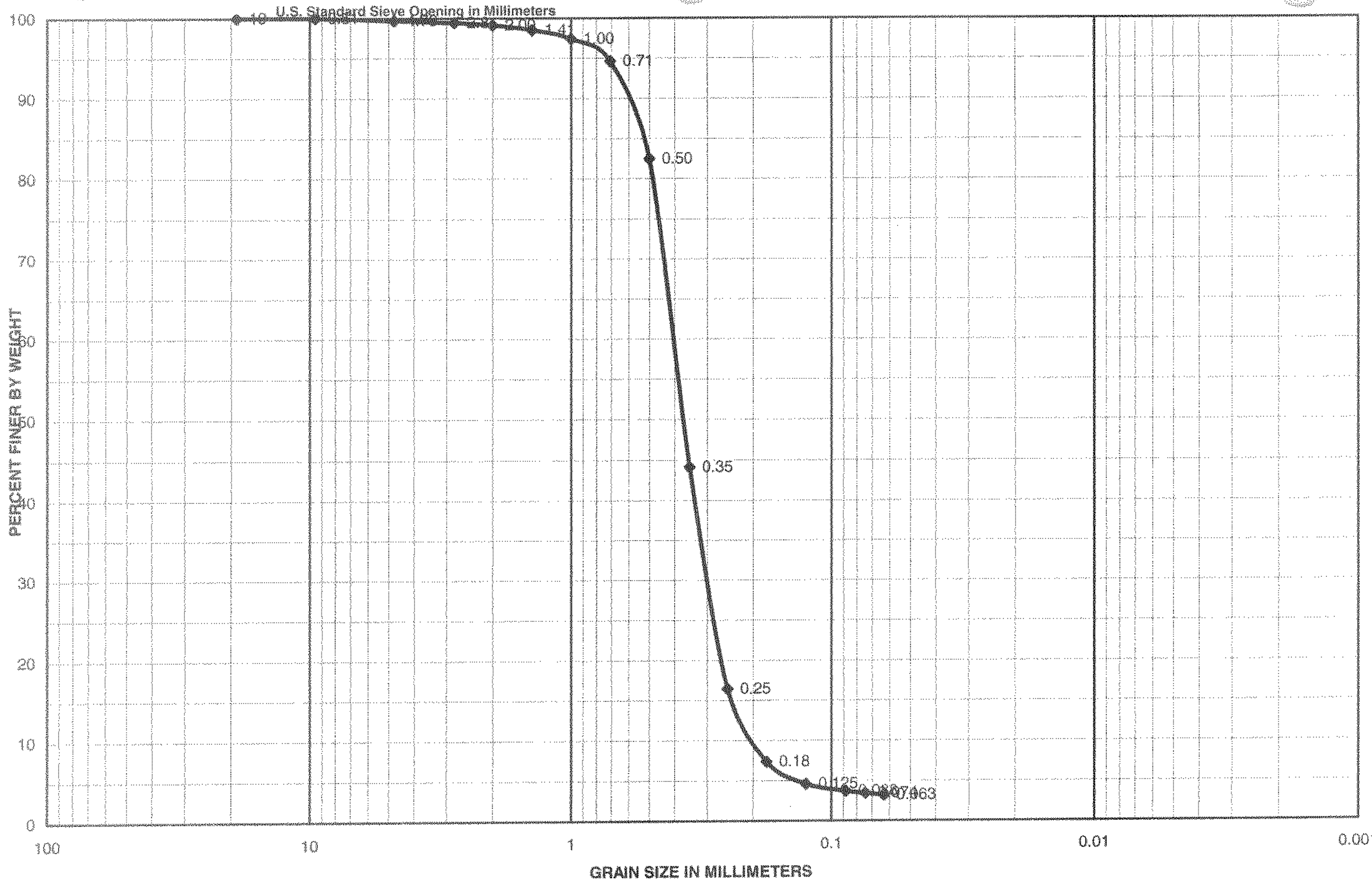
Sample No.	Depth	Classification	Area	Shallotte Inlet
1	3.8-4.3	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		4.8% shells	**Boring No.**	SHI-V-09-16
			Date	5/1/2009



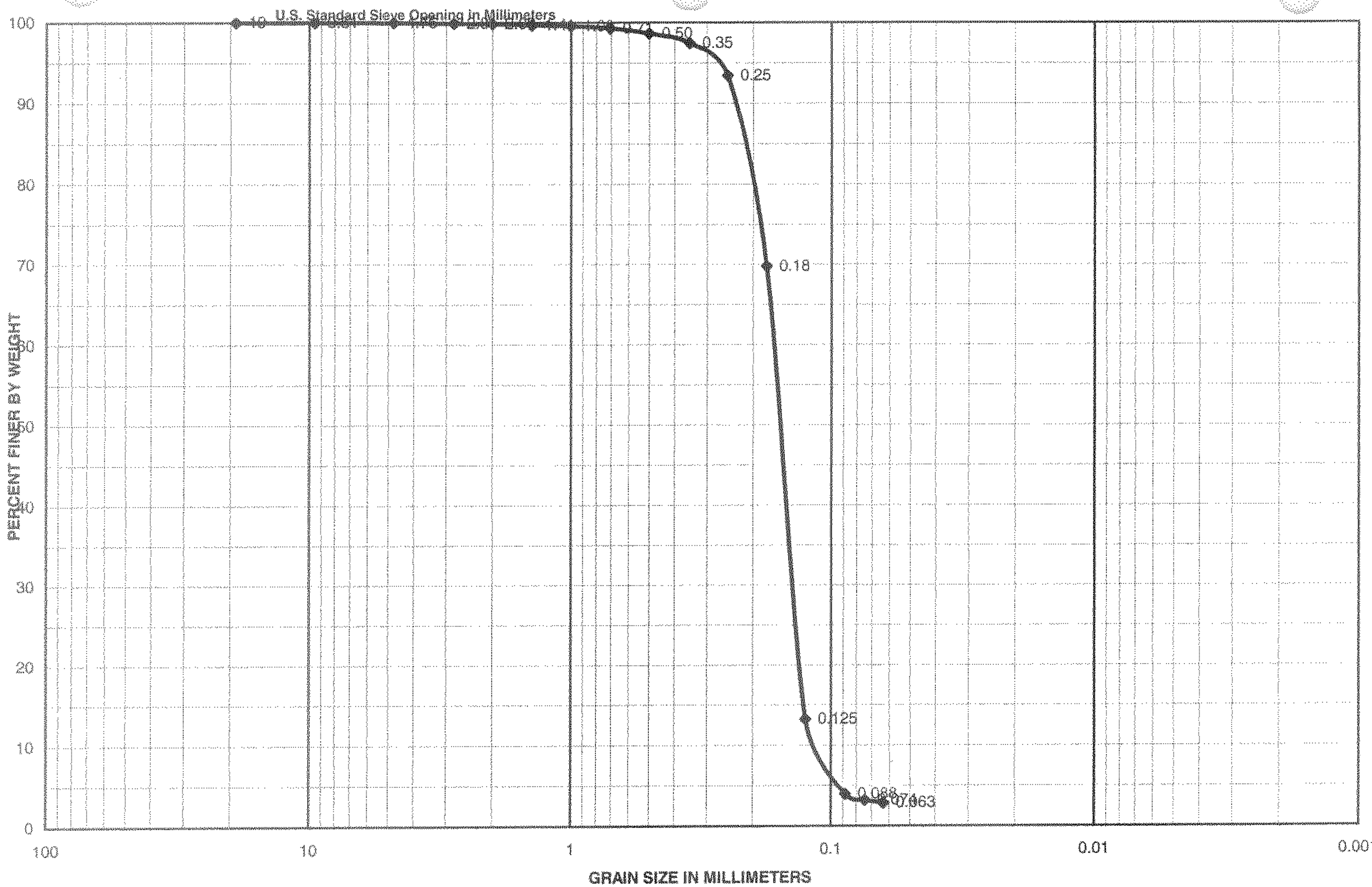
Sample No.	Depth	Classification	Area	Shallotte Inlet
2	6.0-6.5	Olive gray poorly graded sand with trace shells, SP	CATLIN Geotechnical Laboratory	
		3.2% shells	Boring No.	SHI-V-09-16
			Date	5/4/2009



Sample No.	Depth	Classification	Area	Shallotte Inlet
3	8.5-9.0	Olive gray poorly graded sand with trace shells, SP	CATLIN Geotechnical Laboratory	
		3.8% shells	Boring No.	SHI-V-09-16
			Date	5/4/2009

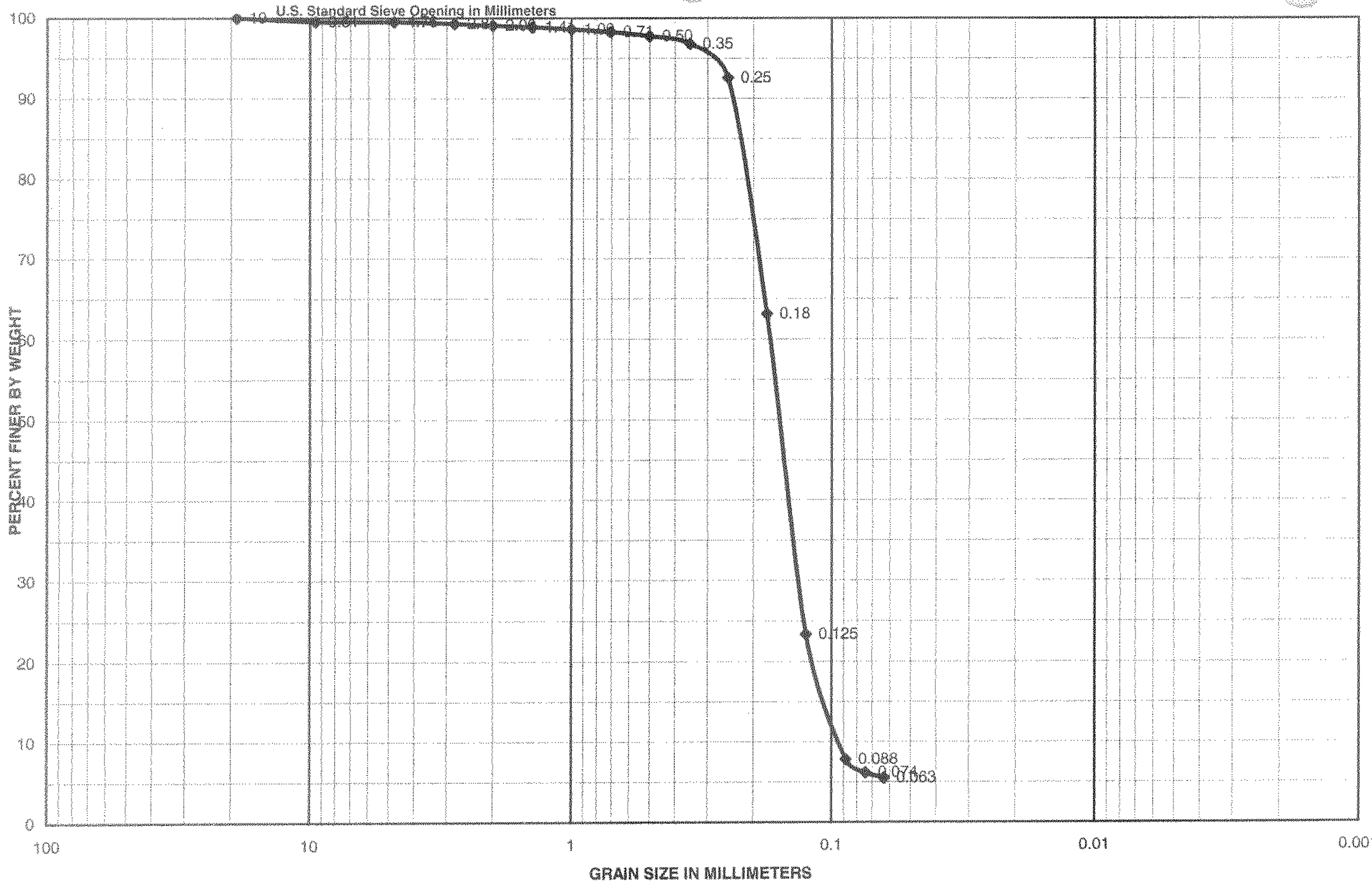


Sample No.	Depth	Classification	Area	Shallotte Inlet
4	11.0-11.5	Olive gray poorly graded sand with trace shells, SP	**CATLIN Geotechnical Laboratory**	
		5.4% shells	Boring No.	SHI-V-09-16
			Date	5/4/2009

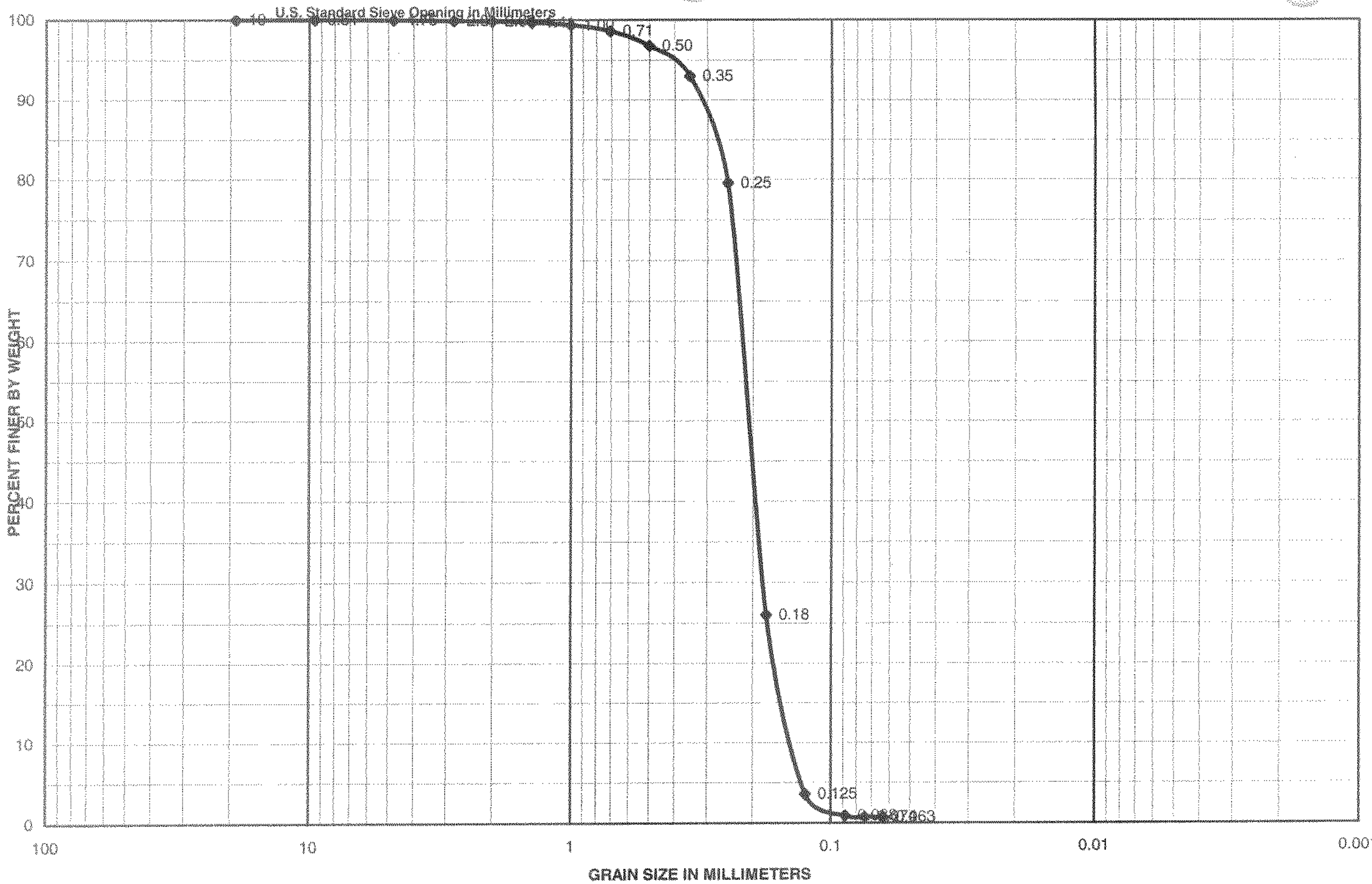


Sample No.	Depth	Classification
5	13.0-13.5	Olive gray poorly graded sand with trace shells, SP
		0.7% shells

Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-16
Date	5/4/2009

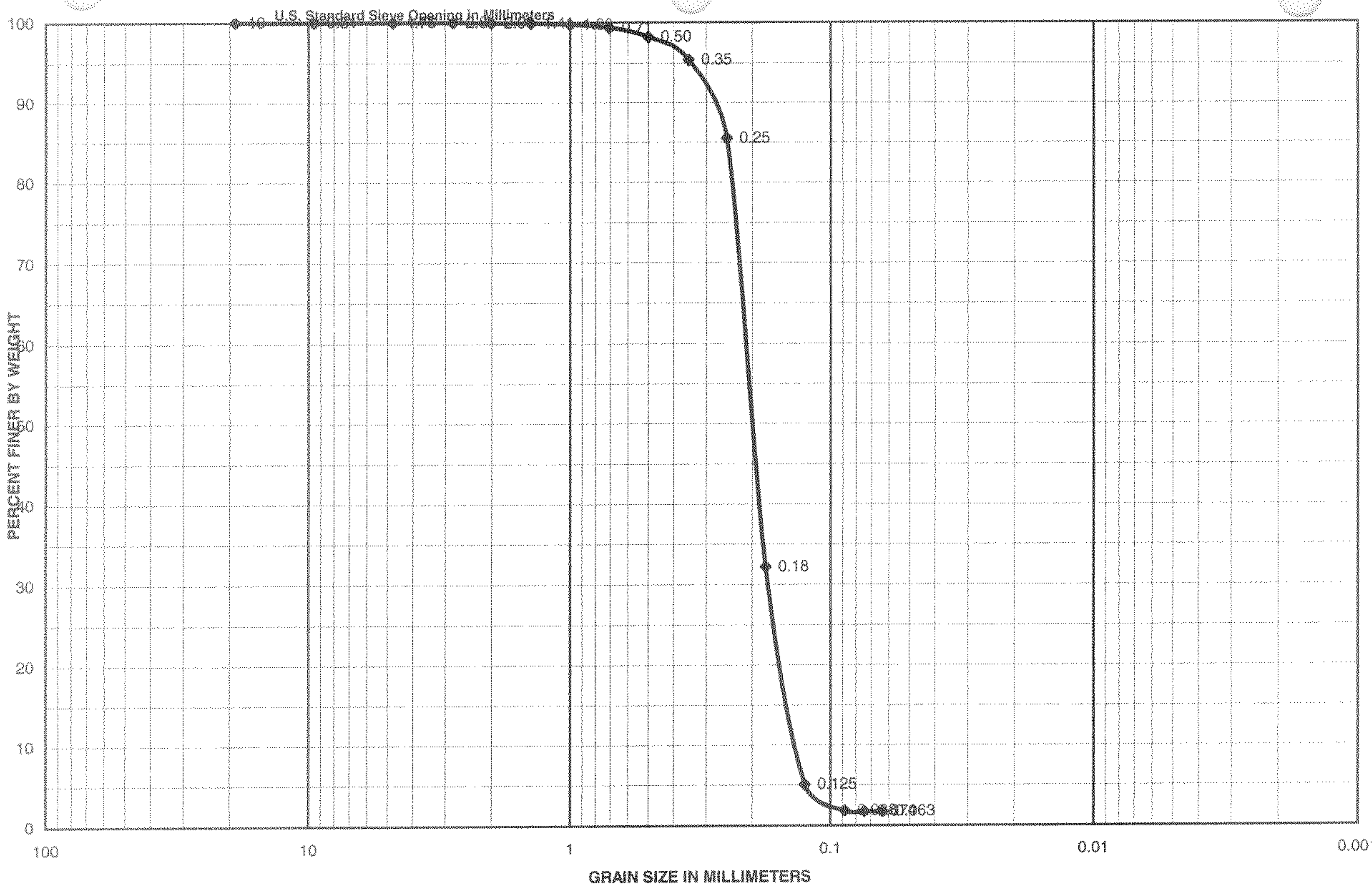


Sample No.	Depth	Classification	Area	Shallotte Inlet
6	15.0-15.5	Olive gray poorly graded sand with silt and trace shells, SP-SM	**CATLIN Geotechnical Laboratory**	
		1.8% shells	**Boring No.**	SHI-V-09-16
			Date	5/4/2009



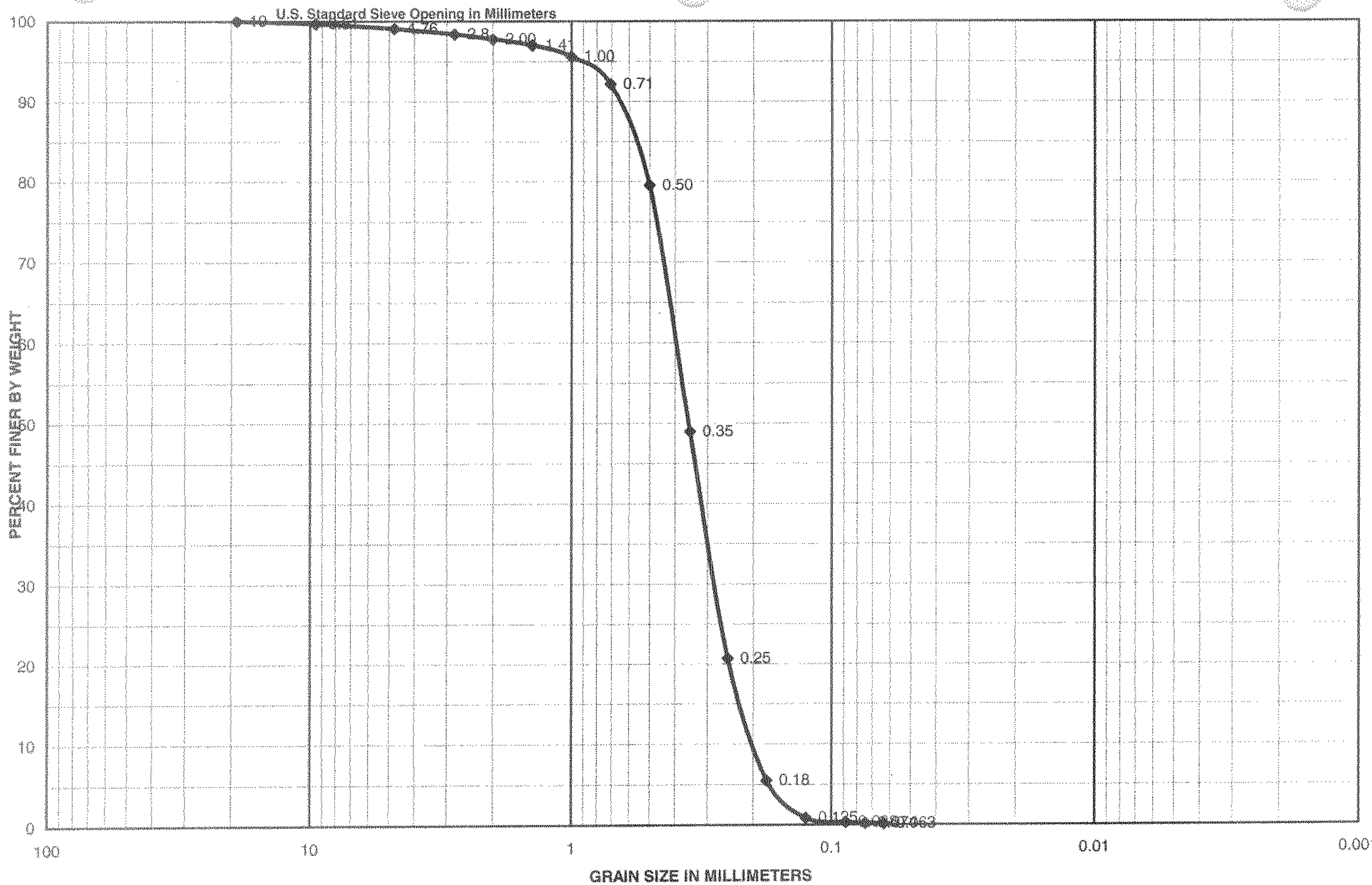
Sample No.	Depth	Classification
1	5.7-6.2	Olive gray poorly graded sand with trace shells, SP
		1.4% shells

Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-17
Date	5/4/2009

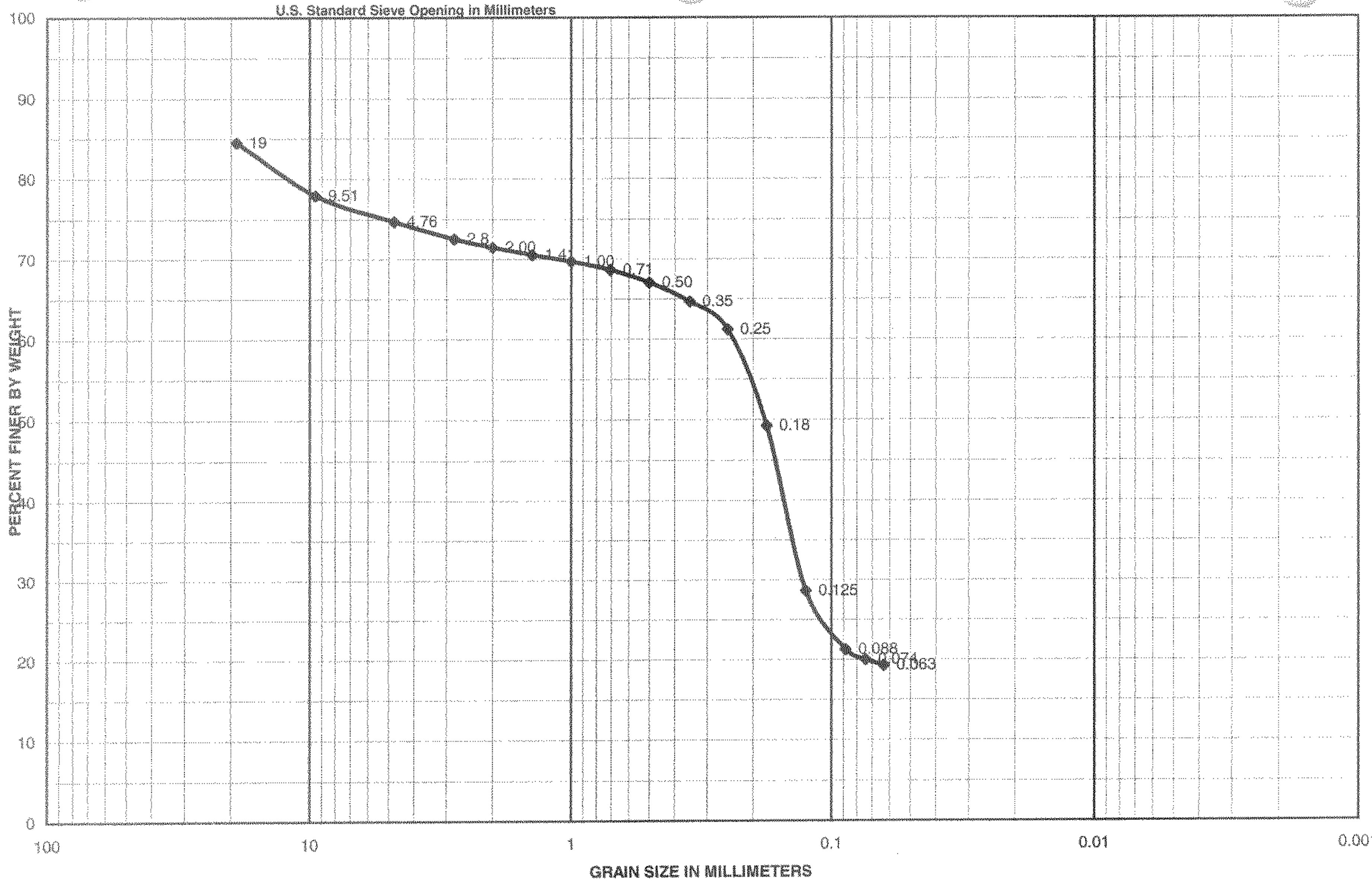


Sample No.	Depth	Classification
2	8.0-8.5	Olive gray poorly graded sand with trace shells, SP
		0.6% shells

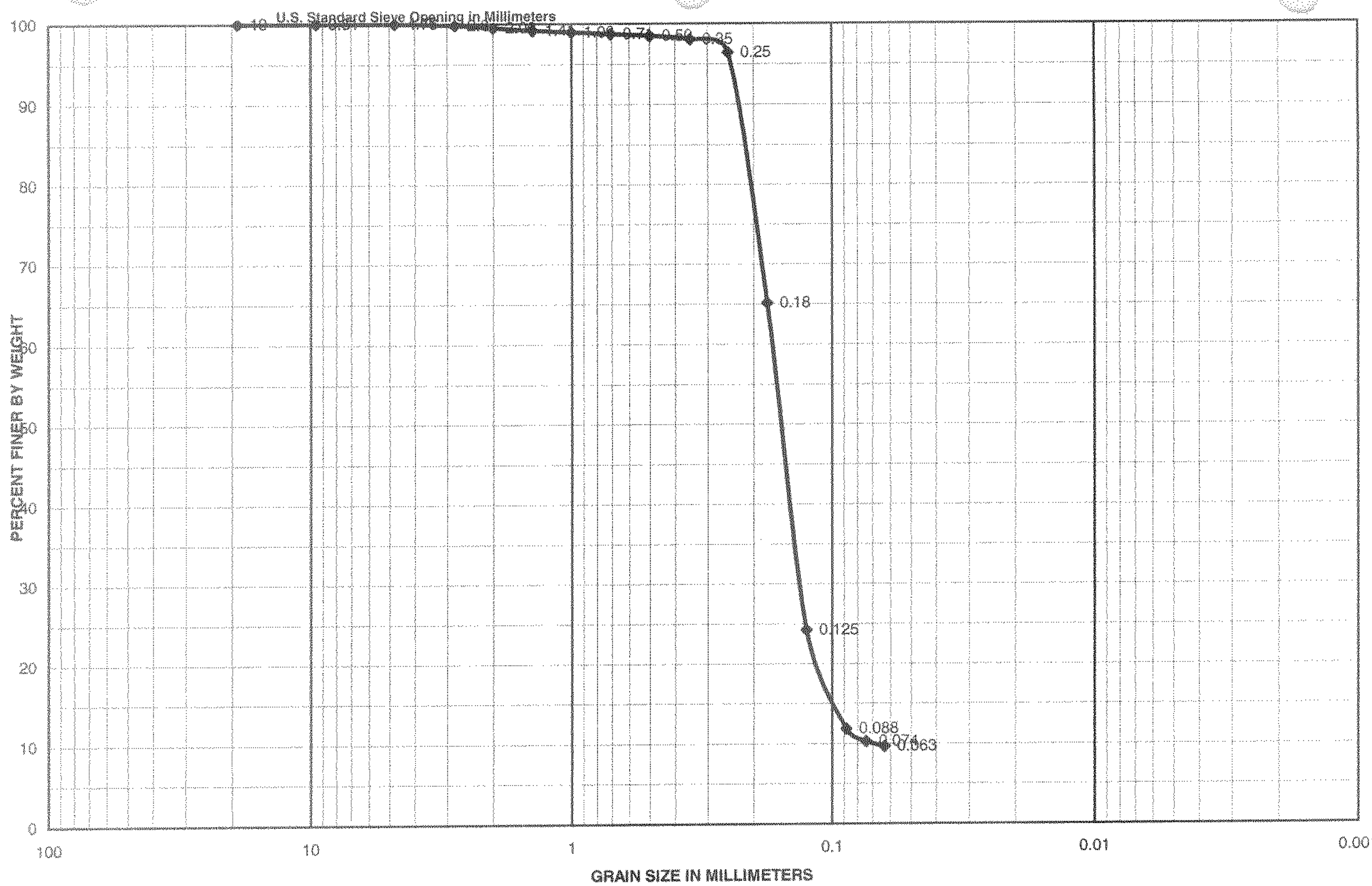
Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-17
Date	5/4/2009



Sample No.	Depth	Classification		
3	10.0-10.5	Olive gray poorly graded sand with few shells, SP	**Area**	Shallotte Inlet
		7.8% shells	**CATLIN Geotechnical Laboratory**	
			Boring No.	SHI-V-09-17
			Date	5/4/2009



Sample No.	Depth	Classification	Area	Shallotte Inlet
4	12.7-13.2	Dark gray silty sand with some shells, SM	**CATLIN Geotechnical Laboratory**	
		31.4% shells	**Boring No.**	SHI-V-09-17
			Date	5/4/2009



Sample No.	Depth	Classification
5	13.2-13.7	Light/olive gray poorly graded sand with silt and trace shells, SP-SM
		1.3% shells

Area	Shallotte Inlet
CATLIN Geotechnical Laboratory	
Boring No.	SHI-V-09-17
Date	5/4/2009

APPENDIX 11
POST 2001 VIBRACORE COMPOSITE DATA

COMPOSITE SUMMARY TABLE
OCEAN ISLE BEACH TERMINAL GROIN PROJECT

VIBRACORE I. D.	PHI MEDIAN	MEDIAN (mm)	MEAN (mm)	PHI MEAN	PHI SORTING	% SILT	% CARBONATE
SHI-V-09-04 COMPOSITE	1.62	0.33	0.40	1.34	1.23	1.45	10.5
SHI-V-09-05 COMPOSITE	1.28	0.41	0.48	1.07	1.23	2.78	11.7
SHI-V-09-06 COMPOSITE	1.05	0.48	0.63	0.67	1.35	1.74	21.7
SHI-V-09-07 COMPOSITE	1.36	0.39	0.49	1.02	1.31	1.47	18.6
SHI-V-09-12 COMPOSITE	2.65	0.16	0.17	2.56	0.73	1.60	1.7
SHI-V-09-13 COMPOSITE	2.49	0.18	0.18	2.44	0.47	1.81	0.5
SHI-V-09-14 COMPOSITE	2.49	0.18	0.19	2.42	0.68	2.43	1.4
SHI-V-09-15 COMPOSITE	2.32	0.20	0.21	2.27	0.55	2.37	0.8
OI-05-05 COMPOSITE	1.38	0.38	0.42	1.24	0.98	1.62	32.3
OI-05-06 COMPOSITE	1.95	0.26	0.30	1.74	0.96	1.60	21.4
OI-05-12 COMPOSITE	1.33	0.40	0.44	1.20	1.08	1.79	31.5
OI-05-13 COMPOSITE	1.01	0.50	0.73	0.46	1.68	1.58	35.4
SHALLOTTE INLET BA COMPOSITE	1.78	0.29	0.36	1.47	1.28	1.95	15.5

COMPOSITE DATA TABLE
OCEAN ISLE BEACH TERMINAL GROIN PROJECT

VIBRACORE I. D.	EFFECTIVE LENGTH (FT)	PHI MEDIAN	MEDIAN (mm)	MEAN (mm)	PHI MEAN	PHI SORTING	% SILT	% CARBONATE	-4.25	-4.0	-3.25	-3.50	-3.0	-2.50	-2.25	-2.0	PHI SIZES -1.5	-1.0	-0.5	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	3.75	4.0	PAN
SHI-V-09-04 COMPOSITE	9.9	1.62	0.33	0.40	1.34	1.23	1.45	10.5	0.00	0.10	0.20	0.30	1.10	1.90	2.70	3.62	4.53	5.78	7.59	10.48	16.38	28.47	44.84	65.96	87.61	97.42	98.48	98.54	98.54	100.00
SHI-V-09-05 COMPOSITE	11.3	1.28	0.41	0.48	1.07	1.23	2.78	11.7	0.00	0.49	0.98	1.47	2.05	2.64	3.22	4.02	4.82	6.08	8.12	11.47	19.60	37.68	59.91	78.58	91.32	96.32	97.07	97.18	97.22	100.00
SHI-V-09-06 COMPOSITE	8.9	1.05	0.48	0.63	0.67	1.35	1.74	21.7	0.00	0.53	1.06	1.59	3.03	4.46	5.90	7.64	9.37	11.68	15.08	19.89	28.99	47.45	73.96	90.68	96.16	97.91	98.21	98.25	98.25	100.00
SHI-V-09-07 COMPOSITE	9.7	1.36	0.39	0.49	1.02	1.31	1.47	18.6	0.33	1.00	1.68	2.35	3.15	3.95	4.75	5.76	6.77	8.26	10.43	13.74	20.18	33.82	56.26	81.65	95.90	98.20	98.44	98.50	98.54	100.00
SHI-V-09-12 COMPOSITE	2.5	2.65	0.16	0.17	2.56	0.73	1.60	1.7	0.00	0.12	0.24	0.36	0.41	0.46	0.50	0.63	0.75	0.85	1.02	1.29	1.66	2.41	3.81	7.27	36.44	80.65	96.94	98.10	98.40	100.00
SHI-V-09-13 COMPOSITE	11.4	2.49	0.18	0.18	2.44	0.47	1.81	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.06	0.11	0.19	0.34	0.86	2.68	12.34	50.59	91.55	97.64	98.05	98.20	100.00
SHI-V-09-14 COMPOSITE	8.4	2.49	0.18	0.19	2.42	0.68	2.43	1.4	0.00	0.07	0.14	0.22	0.25	0.29	0.33	0.41	0.49	0.56	0.74	0.96	1.41	2.38	4.74	13.86	50.39	86.52	96.45	97.28	97.57	100.00
SHI-V-09-15 COMPOSITE	11.8	2.32	0.20	0.21	2.27	0.55	2.37	0.8	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.06	0.08	0.14	0.19	0.37	0.83	2.40	7.21	22.47	65.46	93.34	97.18	97.50	97.64	100.00
OI-05-05 COMPOSITE	8.5	1.38	0.38	0.42	1.24	0.98	1.62	32.3	0.00	0.00	0.00	0.00	0.55	1.10	1.65	2.18	2.71	3.52	4.78	7.60	13.67	31.01	55.88	80.19	93.71	97.87	98.31	98.37	98.38	100.00
OI-05-06 COMPOSITE	4.2	1.95	0.26	0.30	1.74	0.96	1.60	21.4	0.00	0.00	0.00	0.00	0.17	0.34	0.51	0.92	1.32	1.91	2.93	4.77	8.47	17.46	31.02	52.22	79.50	95.89	98.09	98.31	98.41	100.00
OI-05-12 COMPOSITE	8.7	1.33	0.40	0.44	1.20	1.08	1.79	31.5	0.00	0.00	0.00	0.00	0.66	1.32	1.98	2.67	3.36	4.46	6.02	9.49	16.32	34.48	57.86	78.94	90.96	97.21	98.09	98.16	98.22	100.00
OI-05-13 COMPOSITE	10.1	1.01	0.50	0.73	0.46	1.68	1.58	35.4	3.90	5.51	7.12	8.73	10.30	11.87	13.43	14.82	16.20	18.32	21.12	26.30	34.62	49.74	64.83	80.18	91.41	97.38	98.16	98.32	98.41	100.00
SHALLOTTE INLET BA COMPOSITE	105.4	1.78	0.29	0.36	1.47	1.28	1.95	15.5	0.40	0.74	1.07	1.40	1.99	2.59	3.18	3.85	4.53	5.51	6.96	9.43	14.33	25.25	40.35	57.67	79.64	95.01	97.78	98.01	98.10	100.00

CUMULATIVE PERCENTS AND COMPUTED DISTRIBUTIONS
OCEAN ISLE BEACH TERMINAL GROIN PROJECT (1 OF 2)

SAMPLE I. D.	ELEVATION (MLW)	EFFECTIVE LENGTH (FT)	PHI MEDIAN	MEDIAN (mm)	MEAN (mm)	PHI MEAN	PHI SORTING	% SILT	% CARBONATE									PHI SIZES													
										-4.25	-4.0	-3.50	-3.25	-3.0	-2.50	-2.25	-2.0	-1.5	-1.0	-0.5	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	3.75	4.00	PAN
SHI-V-09-04 #1	-5.4	1.8	1.52	0.35	0.40	1.34	1.08	0.10	9.5	0.00	0.03	0.07	0.10	0.47	0.83	1.20	2.00	2.80	4.20	6.20	9.50	15.90	28.80	48.90	72.60	89.90	98.80	99.90	99.90	99.90	100.00
SHI-V-09-04 #2	-8.3	2.9	1.18	0.44	0.54	0.90	1.38	0.50	18.1	0.00	0.30	0.60	0.90	2.20	3.50	4.80	6.40	8.00	10.10	13.30	18.10	26.90	42.70	62.50	81.10	92.80	98.70	99.40	99.50	99.50	100.00
SHI-V-09-04 #3	-11.3	3.0	2.14	0.23	0.27	1.91	0.95	2.80	4.2	0.00	0.00	0.00	0.00	0.40	0.80	1.20	1.65	2.10	2.60	3.20	4.20	5.90	9.80	18.10	39.40	77.20	95.30	97.10	97.20	97.20	100.00
SHI-V-09-04 #4	-14.3	2.2	1.38	0.38	0.45	1.16	1.15	2.02	9.8	0.00	0.03	0.07	0.10	1.13	2.17	3.20	3.95	4.70	5.70	7.20	9.80	17.20	34.90	54.70	76.80	93.10	97.50	98.00	98.00	98.00	100.00
SHI-V-09-04 #5	-16.8	0.0	1.50	0.35	0.35	1.50	0.79	2.01	0.0	0.00	0.00	0.00	0.00	0.03	0.07	0.10	0.10	0.10	0.30	0.90	2.50	8.00	27.30	50.00	68.00	89.20	96.40	97.80	97.90	98.00	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
SHI-V-09-04 COMPOSITE		**9.9**	**1.62**	**0.33**	**0.4**	**1.34**	**1.23**	**1.45**	**10.5**	**0.00**	**0.10**	**0.20**	**0.30**	**1.10**	**1.90**	**2.70**	**3.62**	**4.53**	**5.78**	**7.59**	**10.48**	**16.38**	**28.47**	**44.84**	**65.96**	**87.61**	**97.42**	**98.48**	**98.54**	**98.54**	**100.00**
SHI-V-09-05 #1	-4.0	2.0	0.93	0.52	0.65	0.63	1.17	2.69	17.6	0.00	0.27	0.53	0.80	2.00	3.20	4.40	5.70	7.00	9.10	12.30	17.60	29.50	53.50	83.30	93.30	95.60	96.90	97.20	97.20	97.30	100.00
SHI-V-09-05 #2	-7.3	3.1	2.06	0.24	0.25	1.99	0.60	3.10	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.20	0.40	0.70	1.50	4.60	15.40	46.10	80.60	95.00	96.70	96.80	96.90	100.00
SHI-V-09-05 #3	-10.3	3.0	1.08	0.47	0.51	0.97	0.86	2.89	7.7	0.00	0.00	0.00	0.00	0.47	0.93	1.40	1.85	2.30	3.10	4.80	7.70	17.50	45.20	75.40	91.20	95.50	96.80	97.00	97.10	97.10	100.00
SHI-V-09-05 #4	-13.3	3.2	0.93	0.52	0.68	0.55	1.49	2.38	21.6	0.00	1.57	3.13	4.70	5.57	6.43	7.30	8.85	10.40	12.70	16.10	21.60	32.90	52.80	73.90	89.00	95.10	96.80	97.40	97.60	97.60	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
SHI-V-09-05 COMPOSITE		**11.3**	**1.28**	**0.41**	**0.48**	**1.07**	**1.23**	**2.78**	**11.7**	**0.00**	**0.49**	**0.98**	**1.47**	**2.05**	**2.64**	**3.22**	**4.02**	**4.82**	**6.08**	**8.12**	**11.47**	**19.60**	**37.68**	**59.91**	**78.58**	**91.32**	**96.32**	**97.07**	**97.18**	**97.22**	**100.00**
SHI-V-09-06 #1	-6.4	1.8	1.17	0.44	0.55	0.86	1.21	1.81	20.2	0.00	0.53	1.07	1.60	2.50	3.40	4.30	5.45	6.60	8.10	10.10	13.40	20.20	37.20	75.30	92.00	95.50	97.80	98.20	98.20	98.20	100.00
SHI-V-09-06 #2	-9.3	2.9	0.39	0.76	1.04	-0.05	1.56	1.81	30.6	0.00	1.20	2.40	3.60	6.53	9.47	12.40	16.00	19.60	24.00	30.60	39.40	53.10	71.70	86.40	93.90	97.10	98.00	98.10	98.20	98.20	100.00
SHI-V-09-06 #3	-12.3	4.2	1.25	0.42	0.47	1.08	1.01	1.70	16.1	0.00	0.07	0.13	0.20	0.83	1.47	2.10	2.80	3.50	4.70	6.50	9.20	16.10	35.10	64.80	87.90	95.80	97.90	98.30	98.30	98.30	100.00
SHI-V-09-06 #4	-15.3	0.0	1.81	0.29	0.31	1.70	0.91	0.49	7.2	0.00	0.00	0.00	0.00	0.27	0.53	0.80	1.05	1.30	1.80	2.60	3.90	7.20	16.00	33.80	59.60	83.80	97.80	99.30	99.40	99.50	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
SHI-V-09-06 COMPOSITE		**8.9**	**1.05**	**0.48**	**0.63**	**0.67**	**1.35**	**1.74**	**21.7**	**0.00**	**0.53**	**1.06**	**1.59**	**3.03**	**4.46**	**5.90**	**7.64**	**9.37**	**11.68**	**15.08**	**19.89**	**28.99**	**47.45**	**73.96**	**90.68**	**96.16**	**97.91**	**98.21**	**98.25**	**98.25**	**100.00**
SHI-V-09-07 #1	-5.6	1.7	0.96	0.51	0.66	0.59	1.15	0.50	27.7	1.90	2.43	2.97	3.50	4.37	5.23	6.10	7.25	8.40	10.10	12.80	17.50	27.70	52.10	85.10	95.80	98.40	99.30	99.40	99.40	99.50	100.00
SHI-V-09-07 #2	-8.3	2.8	0.88	0.54	0.71	0.50	1.48	1.80	37.7	0.00	0.63	1.27	1.90	3.67	5.43	7.20	9.55	11.90	15.40	20.30	27.00	37.70	53.70	72.30	88.90	95.90	97.70	98.10	98.20	98.20	100.00
SHI-V-09-07 #3	-11.3	2.5	1.28	0.41	0.52	0.93	1.33	2.01	10.4	0.00	1.53	3.07	4.60	5.10	5.60	6.10	6.55	7.00	7.60	8.60	10.40	15.60	31.10	65.30	92.80	96.90	97.80	97.90	98.00	98.00	100.00
SHI-V-09-07 #4	-13.3	2.7	1.94	0.26	0.27	1.90	0.52	1.21	0.7	0.00	0.00	0.00	0.00	0.03	0.07	0.10	0.15	0.20	0.30	0.40	0.70	1.50	4.20	13.10	54.90	93.40	98.40	98.70	98.70	98.80	100.00
SHI-V-09-07 #5	-16.3	0.0	1.67	0.31	0.45	1.15	1.42	0.49	15.7	2.30	2.97	3.63	4.30	5.20	6.10	7.00	7.85	8.70	10.40	12.60	15.70	21.00	29.10	41.30	66.70	89.00	98.00	99.30	99.40	99.50	100.00
SHI-V-09-07 #6	-17.6	0.0	2.35	0.20	0.47	1.08	1.65	34.19	2.3	0.00	0.17	0.33	0.50	1.10	1.70	2.30	3.80	5.30	9.00	13.00	16.50	21.00	27.00	33.20	42.00	53.40	59.80	63.70	65.10	65.80	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
SHI-V-09-07 COMPOSITE		**9.7**	**1.36**	**0.39**	**0.49**	**1.02**	**1.31**	**1.47**	**18.6**	**0.33**	**1.00**	**1.68**	**2.35**	**3.15**	**3.95**	**4.75**	**5.76**	**6.77**	**8.26**	**10.43**	**13.74**	**20.18**	**33.82**	**56.26**	**81.65**	**95.90**	**98.20**	**98.44**	**98.50**	**98.54**	**100.00**
SHI-V-09-12 #1	-12.8	1.8	2.64	0.16	0.17	2.53	0.79	1.58	2.0	0.00	0.17	0.33	0.50	0.57	0.63	0.70	0.85	1.00	1.10	1.30	1.60	2.00	2.80	4.20	7.37	37.50	81.10	97.00	98.10	98.40	100.00
SHI-V-09-12 #2	-15.8	0.7	2.68	0.16	0.16	2.61	0.54	1.60	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.20	0.30	0.50	0.80	1.40	2.80	7.00	33.70	79.50	96.80	98.10	98.40	100.00
SHI-V-09-12 #3	-18.3	0.0	2.53	0.17	0.19	2.42	0.62	1.60	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.30	0.50	0.80	1.50	2.90	6.20	15.90	47.80	88.90	97.50	98.20	98.40	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
SHI-V-09-12 COMPOSITE		**2.5**	**2.65**	**0.16**	**0.17**	**2.56**	**0.73**	**1.6**	**1.7**	**0.00**	**0.12**	**0.24**	**0.36**	**0.41**	**0.46**	**0.50**	**0.63**	**0.75**	**0.85**	**1.02**	**1.29**	**1.66**	**2.41**	**3.81**	**7.27**	**36.44**	**80.65**	**96.94**	**98.10**	**98.40**	**100.00**
SHI-V-09-13 #1	-3.9	1.5	2.19	0.22	0.22	2.17	0.45	1.70	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.30	0.90	4.70	32.20	78.10	95.30	98.20	98.30	98.30	100.00
SHI-V-09-13 #2	-6.3	2.5	2.47	0.18	0.19	2.43	0.46	1.30	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	1.00	3.50	11.90	52.10	93.10	98.30	98.60	98.70	100.00
SHI-V-09-13 #3	-8.9	2.8	2.62	0.16	0.17	2.56	0.45	1.60	0.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.10	0.20	0.30	0.40	0.70	1.40	6.60	37.10	89.20	97.60	98.20	98.40	100.00
SHI-V-09-13 #4	-11.9	2.5	2.60	0.16	0.17	2.54	0.43	2.40	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.10	0.20	0.50	1.40	7.00	40.20	89.00	96.70	97.30	97.60	100.00
SHI-V-09-13 #5	-13.8	2.1	2.40	0.19	0.19	2.38	0.48	2.00	1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.10	0.20	0.30	0.60	1.30	3.50	12.70	59.50	93.20	97.60	97.90	98.00	100.00
SHI-V-09-13 #6	-16.3	0.0	2.35	0.20	0.22	2.17	0.88	2.41	3.2	0.00	0.13	0.27	0.40	0.50	0.60	0.70	0.80	0.90	1.20	1.50	2.00	3.20	6.50	14.50	31.10	57.90	89.60	96.70	97.40	97.60	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
SHI-V-09-13 COMPOSITE		**11.4**	**2.49**	**0.18**	**0.18**	**2.44**	**0.47**	**1.81**	**0.5**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.02**	**0.04**	**0.06**	**0.11**	**0.19**	**0.34**	**0.86**	**2.68**	**12.34**	**50.59**	**91.55**	**97.64**	**98.05**	**98.20**	**100.00**
SHI-V-09-14 #1	-6.9	1.5	2.17	0.22	0.23	2.14	0.52	0.70	0.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.10	0.20	0.40	0.80	2.10	7.40	35.90	77.90	96.40	99.10	99.20	99.30	100.00
SHI-V-09-14 #2	-9.3	2.2	2.59	0.17	0.17	2.57	0.45	1.70	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.30	0.70	1.80	5.30	41.90	85.10	97.10	98.10	98.30	100.00
SHI-V-09-14 #3	-11.3	2.0	2.66	0.16	0.17	2.52	0.86	5.00	2.3	0.00	0.27	0.53	0.80	0.83	0.87	0.90	1.05	1.20	1.30	1.50	1.80	2.30	3.20	4.40	7.50	36.30	77.90	93.00	94.40	95.00	100.00
SHI-V-09-14 #4	-13.3	2.0	2.50	0.18	0.18	2.48	0.49	2.20	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.10	0.20	0.30	0.50	1.10	2.70	8.60	50.20	87.60	96.90	97.60	97.80	100.00
SHI-V-09-14 #5	-15.3	0.7	2.36	0.19	0.23	2.12	1.04	1.79	6.3	0.00	0.10	0.20	0.30	0.67	1.03	1.40	1.70	2.00	2.50	3.30	4.40	6.30	9.60	15.10	26.70	58.90	91.30	97.30	97.90	98.20	100.00
SHI-V-09-14 #6	-17.3	0.0	2.70	0.15	0.29	1.81	1.90	9.00	18.8	0.00	1.17	2.33	3.50	4.33	5.17	6.00	7.05	8.10	9.80	11.90	14.60	18.80	22.80	25.30	28.20	37.10	68.90	87.20	90.00	91.00	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
SHI-V-09-14 COMPOSITE		**8.4**	**2.49**	**0.18**	**0.19**	**2.42**	**0.68**	**2.43**	**1.4**	**0.00**	**0.07**	**0.14**	**0.22**	**0.25**	**0.29**	**0.33**	**0.41**	**0.49**	**0.56**	**0.74**	**0.96**	**1.41**	**2.38**	**4.74**	**13.86**	**50.39**	**86.52**	**96.45**	**97.28**	**97.57**	**100.00**
SHI-V-09-15 #1	-3.5	1.5	2.17	0.22	0.23	2.14	0.45	2.30	0.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.20	0.80	5.90	34.10	80.00	95.10	97.70	97.70	97.70	100.00
SHI-V-09-15 #2	-5.8	2.4	2.24	0.21	0.21	2.22	0.41	1.30	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.80	4.30	21.80	80.00	96.20	98.50	98.70	98.70	100.00
SHI-V-09-15 #3	-8.3	2.2	2.52	0.17	0.18	2.46	0.45	2.40	0.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.20	0.40	0.80	1.90	10.70	48.10	92.10	97.20	97.50	97.60	100.00
SHI-V-09-15 #4	-10.3	2.0	2.61	0.16	0.17	2.56	0.41	2.90	0.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.10	0.10	0.10	0.20	0.40	0.80	4.70	39.40	89.10	96.10	96.80	97.10	100.00
SHI-V-09-15 #5	-12.3	2.0	2.34	0.20	0.20	2.32	0.52	3.51	1.0	0.00	0.00	0.00	0.00	0.03	0.07	0.10	0.15	0.20	0.30	0.40	0.60	1.00	1.80	3.70	12.80	67.20	92.50	95.80	96.20	96.50	100.00
SHI-V-09-15 #6	-14.3	1.7	1.82	0.28	0.29	1.79	0.72	1.91	3.5	0.00	0.00	0.00	0.00	0.03	0.07	0.10	0.15	0.20	0.40	0.60	1.40	3.50	11.20	31.00	60.70	83.20	95.30	97.70	98.00	98.10	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
SHI-V-09-15 COMPOSITE		**11.8**	**2.32**	**0.2**	**0.21**	**2.27**	**0.55**	**2.37**	**0.8**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.02**	**0.03**	**0.06**	**0.08**	**0.14**	**0.19**	**0.37**	**0.83**	**2.40**	**7.21**	**22.47**	**65.46**	**93.34**	**97.18**	**97.50**	**97.64**	**100.00**

CUMULATIVE PERCENTS AND COMPUTED DISTRIBUTIONS
OCEAN ISLE BEACH TERMINAL GROIN PROJECT (2 OF 2)

SAMPLE I. D.	ELEVATION (MLW)	EFFECTIVE LENGTH (FT)	PHI MEDIAN	MEDIAN (mm)	MEAN (mm)	PHI MEAN	PHI SORTING	% SILT	% CARBONATE	-4.25	-4.0	-3.50	-3.25	-3.0	-2.50	-2.25	-2.0	PHI SIZES -1.5	-1.0	-0.5	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	3.75	4.00	PAN
OI-05-05 #1	-3.4	2.3	1.63	0.32	0.34	1.54	0.72	1.60	27.0	0.00	0.00	0.00	0.00	0.10	0.19	0.29	0.45	0.61	0.97	1.54	2.90	5.82	16.48	40.76	75.99	92.97	97.96	98.38	98.39	98.39	100.00
OI-05-05 #2	-7.4	4.0	1.50	0.35	0.38	1.41	0.86	1.61	29.0	0.00	0.00	0.00	0.00	0.23	0.45	0.68	1.04	1.40	1.86	2.69	4.41	8.95	25.36	50.22	74.74	92.27	97.80	98.35	98.37	98.38	100.00
OI-05-05 #3	-11.4	2.2	0.88	0.54	0.65	0.63	1.15	1.64	44.0	0.00	0.00	0.00	0.00	1.61	3.23	4.84	6.06	7.28	9.21	11.96	18.30	30.47	56.48	81.97	94.49	97.11	97.90	98.18	98.34	98.37	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
OI-05-05 COMPOSITE		**8.5**	**1.38**	**0.38**	**0.42**	**1.24**	**0.98**	**1.62**	**32.3**	**0.00**	**0.00**	**0.00**	**0.00**	**0.55**	**1.10**	**1.65**	**2.18**	**2.71**	**3.52**	**4.78**	**7.60**	**13.67**	**31.01**	**55.88**	**80.19**	**93.71**	**97.87**	**98.31**	**98.37**	**98.38**	**100.00**
OI-05-06 #1	-11.1	2.3	1.90	0.27	0.31	1.69	0.95	1.04	20.0	0.00	0.00	0.00	0.00	0.14	0.27	0.41	0.89	1.37	1.96	3.14	5.21	9.47	19.08	32.43	54.18	82.75	97.30	98.87	98.94	98.95	100.00
OI-05-06 #2	-15.1	1.9	2.00	0.25	0.29	1.80	0.96	2.26	23.0	0.00	0.00	0.00	0.00	0.21	0.43	0.64	0.95	1.26	1.84	2.67	4.23	7.25	15.50	29.32	49.85	75.57	94.19	97.15	97.55	97.75	100.00
OI-05-06 #3	-16.0	0.0	2.69	0.15	0.16	2.64	0.41	2.54	11.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.13	0.18	0.21	0.42	0.96	4.17	27.80	85.54	96.10	97.21	97.46	100.00
OI-05-06 #4	-18.8	0.0	2.63	0.16	0.17	2.57	0.55	3.46	6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.25	0.40	0.55	0.69	0.93	1.30	1.96	6.19	38.38	83.10	94.28	96.08	96.55	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
OI-05-06 COMPOSITE		**4.2**	**1.95**	**0.26**	**0.30**	**1.74**	**0.96**	**1.60**	**21.4**	**0.00**	**0.00**	**0.00**	**0.00**	**0.17**	**0.34**	**0.51**	**0.92**	**1.32**	**1.91**	**2.93**	**4.77**	**8.47**	**17.46**	**31.02**	**52.22**	**79.50**	**95.89**	**98.09**	**98.31**	**98.41**	**100.00**
OI-05-12 #1	-1.8	1.3	2.08	0.24	0.25	2.02	0.58	2.01	18.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.08	0.18	0.37	0.96	3.95	16.55	44.83	78.62	95.81	97.75	97.94	97.99	100.00
OI-05-12 #2	-3.8	3.5	1.54	0.34	0.37	1.42	0.92	1.63	27.0	0.00	0.00	0.00	0.00	0.28	0.55	0.83	1.16	1.48	2.17	3.13	5.57	10.77	25.42	47.80	75.87	89.37	97.11	98.27	98.33	98.37	100.00
OI-05-12 #3	-8.8	3.9	0.95	0.52	0.61	0.72	1.10	1.85	40.0	0.00	0.00	0.00	0.00	1.22	2.45	3.67	4.91	6.15	7.98	10.57	16.04	26.42	52.79	80.66	93.07	96.49	97.77	98.04	98.09	98.16	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
OI-05-12 COMPOSITE		**8.7**	**1.33**	**0.40**	**0.44**	**1.20**	**1.08**	**1.79**	**31.5**	**0.00**	**0.00**	**0.00**	**0.00**	**0.66**	**1.32**	**1.98**	**2.67**	**3.36**	**4.46**	**6.02**	**9.49**	**16.32**	**34.48**	**57.86**	**78.94**	**90.96**	**97.21**	**98.09**	**98.16**	**98.22**	**100.00**
OI-05-13 #1	-3.0	1.8	1.50	0.35	0.40	1.33	1.19	1.21	27.0	0.00	0.00	0.00	0.00	0.92	1.84	2.76	3.44	4.11	5.31	6.96	9.87	14.87	28.77	49.81	72.33	84.43	97.15	98.56	98.76	98.80	100.00
OI-05-13 #2	-6.0	3.0	0.91	0.53	1.06	-0.08	1.99	1.93	35.0	9.58	13.46	17.33	21.21	22.18	23.15	24.12	25.40	26.68	28.96	31.49	35.48	41.10	51.92	65.69	80.59	91.73	97.00	97.76	97.94	98.06	100.00
OI-05-13 #3	-9.0	3.0	1.45	0.37	0.49	1.04	1.43	1.58	32.0	0.00	0.00	0.00	0.00	1.89	3.78	5.67	7.21	8.74	10.59	12.91	17.17	23.92	36.89	51.62	72.19	90.67	97.33	98.14	98.32	98.43	100.00
OI-05-13 #4	-12.0	2.3	0.33	0.80	1.23	-0.30	1.52	1.46	47.0	4.61	6.63	8.65	10.67	13.11	15.54	17.98	19.85	21.72	24.70	29.37	39.11	55.58	80.05	92.70	96.19	97.42	98.12	98.39	98.47	98.53	100.00
Cut to -15.0' MLW																															
Values in RED indicate interpolated values.																															
OI-05-13 COMPOSITE		**10.1**	**1.01**	**0.50**	**0.73**	**0.46**	**1.68**	**1.58**	**35.4**	**3.90**	**5.51**	**7.12**	**8.73**	**10.30**	**11.87**	**13.43**	**14.82**	**16.20**	**18.32**	**21.12**	**26.30**	**34.62**	**49.74**	**64.83**	**80.18**	**91.41**	**97.38**	**98.16**	**98.32**	**98.41**	**100.00**

APPENDIX 12
2013 CPE-NC CARBONATE ANALYSIS RESULTS

Project Title: Ocean Isle Beach Terminal Groin Project

Carbonate Analysis

Sample ID	Dish Weight	Dish + Dry	Dish + End	Dry Weight	Post Reaction Weight	% Terrigenous	% Carbonate
OIB 0+00	154.27	240.58	235.86	86.31	81.59	95%	5%
OIB 10+00	168.44	255.76	251.08	87.32	82.64	95%	5%
OIB 25+00	166.79	250.39	244.82	83.60	78.03	93%	7%
Average Carbonate							6%

Appendix F- Cultural Resources Report

A Phase I Remote-Sensing Archaeological Survey Near the Location of a Proposed Groin at Ocean Isle Beach, Brunswick County, North Carolina

Submitted to:

Coastal Planning & Engineering of North Carolina
4038 Masonboro Loop Road
Wilmington, North Carolina 28409

Submitted by:

Gordon P. Watts, Jr.
Principal Investigator

Tidewater Atlantic Research, Inc.
P. O. Box 2494
Washington, North Carolina 27889

7 March 2015

Abstract

Coastal Planning and Engineering of North Carolina (CPE-NC) is the project engineer representing Ocean Isle Beach, North Carolina in its efforts to control erosion at the eastern end of Ocean Isle Beach immediately west of Shallotte Inlet. In order to determine the effects of proposed terminal groin construction activities on potentially significant submerged cultural resources, CPE-NC contracted with Tidewater Atlantic Research, Inc. of Washington, North Carolina to conduct a marine and terrestrial remote-sensing survey of the proposed construction area. Field research for the project was conducted on 12 through 14 December 2014. Analysis of the remote-sensing data generated during the Ocean Isle Beach survey identified a total of 22 magnetic anomalies in the offshore project environment and 4 anomalies in the terrestrial project environment. Sonar identified 16 targets in the marine environment. All of the anomalies and all of the sonar images are associated with previous groin structures or small objects that represent debris associated with those groins or perhaps residential material deposited by storms. None of the anomalies and sonar images appears to represent more complex signatures associated with historic vessel remains. No additional investigation is recommended in conjunction with the proposed groin construction.

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Introduction

Coastal Planning and Engineering of North Carolina (CPE-NC) is the project engineer representing Ocean Isle Beach, North Carolina in its efforts to control erosion at the eastern end of Ocean Isle Beach immediately west of Shallotte Inlet. In order to determine the effects of proposed terminal groin construction activities on potentially significant submerged cultural resources, CPE-NC contracted with Tidewater Atlantic Research, Inc. (TAR) of Washington, North Carolina to conduct a marine and terrestrial remote-sensing survey of the proposed construction area. As a consequence of that agreement, CPE-NC contracted with TAR to conduct a magnetometer and sidescan sonar survey of the offshore construction site and a magnetometer survey of the terrestrial construction area.

The marine and terrestrial remote-sensing investigations conducted by TAR archaeologists were designed to provide accurate and reliable identification, assessment and documentation of submerged cultural resources in the study area. The assessment methodology was developed to comply with the criteria of the National Historic Preservation Act of 1966 (Public Law 89-665), the National Environmental Policy Act of 1969 (Public Law 11-190), Executive Order 11593, the Advisory Council on Historic Preservation Procedures for the protection of historic and cultural properties (36 CFR Part 800) and the updated guidelines described in 36 CFR 64 and 36 CFR 66. The results of the investigation were designed to furnish CPE-NC with the archaeological data required to comply with submerged cultural resource legislation and regulations.

Field research for the project was conducted on 12 through 14 December 2014. Analysis of the remote-sensing data generated during the Ocean Isle Beach survey identified a total of 22 magnetic anomalies in the off shore project environment and 4 anomalies in the terrestrial project environment. Sonar identified 16 targets in the marine environment. All of the anomalies and all of the sonar images are associated with previous groin structures or small objects that represent debris associated with those groins or perhaps residential material deposited by storms. None of the anomalies and sonar images appears to represent more complex signatures associated with historic vessel remains. No additional investigation is recommended in conjunction with the proposed groin construction.

Project field personnel consisted of Gordon P. Watts, Jr., principal investigator and Ralph Wilbanks remote-sensing operator. John W. Morris from the Underwater Archaeology Branch (UAB) of North Carolina Department of Cultural Resources (NCDCR) was aboard the survey vessel for the marine investigation. Dr. Watts and Morgan V. Arnold conducted the terrestrial survey. Senior Historian Robin Arnold carried out the historical and literature research. Dr. Watts and Ms. Arnold prepared this report.

Project Location

The remote-sensing project area is situated at the east end of Ocean Isle Beach immediately west of Shallotte Inlet (Figure 1). The terrestrial survey area is rectangular in shape measuring 450 feet in width and 800 feet in length and equals 8.26 acres. The marine survey area is approximately square measuring 750 feet in length and 800 feet in width and equals 13.77 acres. Data was collected on 50-foot survey lines in the marine environment. That same line spacing was carried out as vegetation permitted in the terrestrial environment.

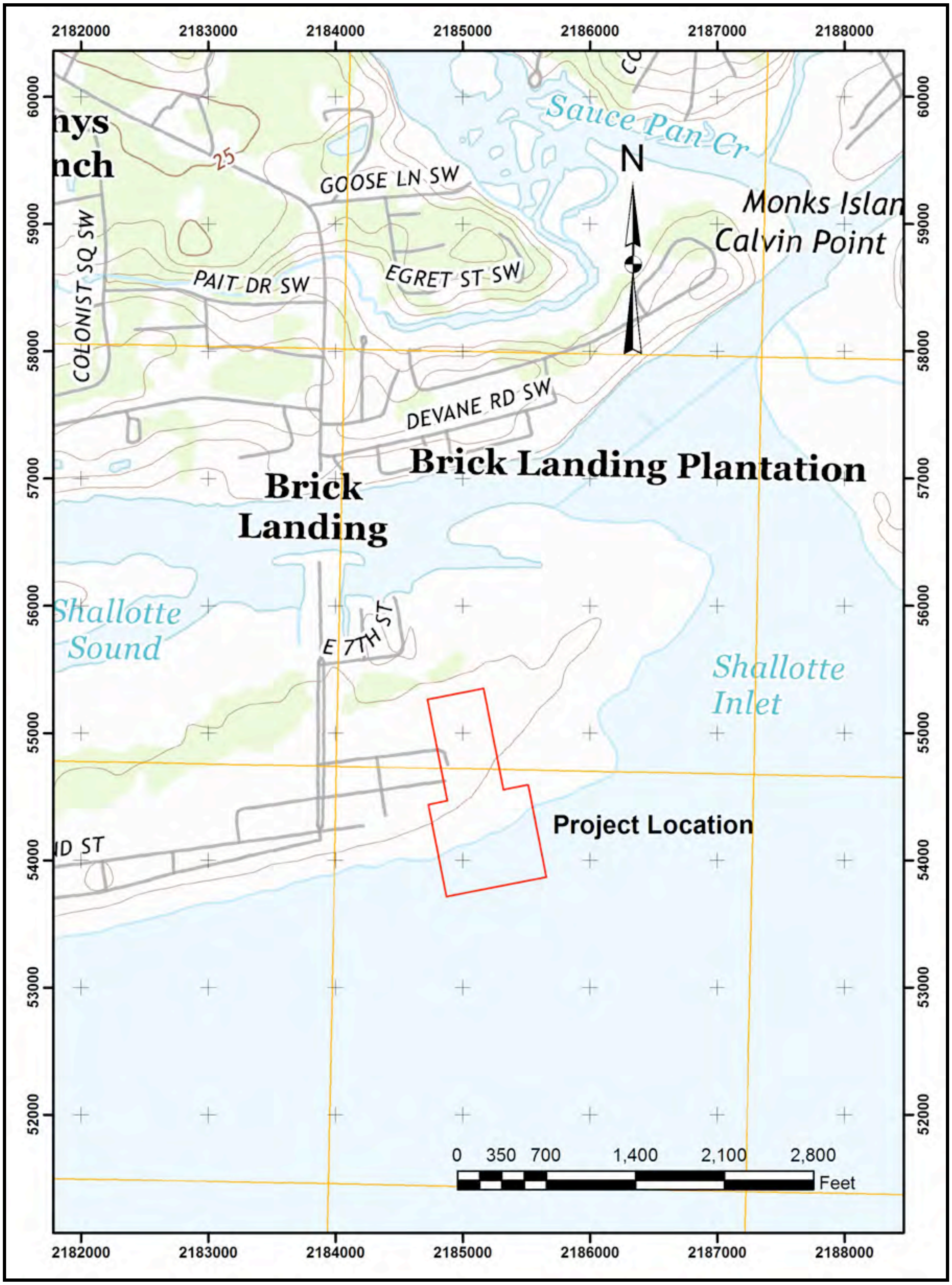

Figure 1. Project Location Map (USGS "Cape Fear, North Carolina" 1:24,000).

The survey boundaries (Figure 2) defined in North Carolina State Plane Coordinates, based on NAD 83, U.S. Survey Foot are shown in the following table.

Boundary Point	X Coordinate	Y Coordinate
A	2184722.77	55264.98
B	2185163.92	55351.69
C	2185320.69	54555.34
D	2185514.96	54593.62
E	2185657.76	53869.93
F	2184873.82	53714.72
G	2184729.89	54438.59
H	2184879.63	54468.28

Table 1. Survey boundaries defined in North Carolina State Plane coordinates, NAD 83, U.S. Survey Foot.

Research Methodology

Literature and Historical Research

TAR historians conducted a literature search of primary and secondary sources to assess the potential to find significant historic and/or cultural resources within the proposed dredge site. A general background history of Ocean Isle Beach and the lower Cape Fear region was prepared from source material in the TAR research library. Preliminary wreck-specific information was collected from published sources including: *Disasters to American Vessels, Sail and Steam, 1841-1846* (Lockhead 1954), *Encyclopedia of American Shipwrecks* (Berman 1972), *Shipwrecks of the Civil War* (Shomette 1973), *Merchant Steam Vessels of the United States 1790-1868* (Lytle and Holdcamper 1975), *Shipwrecks of the Americas* (Marx 1983), and *Official Records of the Union and Confederate Navies in the War of the Rebellion* (National Historical Society 1987). In addition, the National Register of Historic Places (NRHP) online database (National Park Service n.d.), and the Automated Wreck and Obstruction Information System (NOAA n.d.) were queried for wreck-specific information.

Personnel at the UAB of the North Carolina Office of State Archaeology (Fort Fisher) were contacted for shipwreck data associated with Ocean Isle Beach and coastal Brunswick County. TAR personnel also interviewed area archaeologists and other individuals knowledgeable in maritime history and shipwreck research to solicit their assistance to generate wreck data.

Remote-Sensing Survey

In order to reliably identify submerged cultural resources, TAR archaeologists conducted a systematic remote-sensing survey of the proposed dredge site. Underwater survey activities were conducted from the 24-foot survey vessel *Atlantic Surveyor*; and a pedestrian survey collected data on the beach during low tide and into the interior as vegetation permitted for approximately 800 feet. In order to fulfill the requirements for survey activities in North Carolina, magnetic and acoustic remote-sensing equipment were employed.

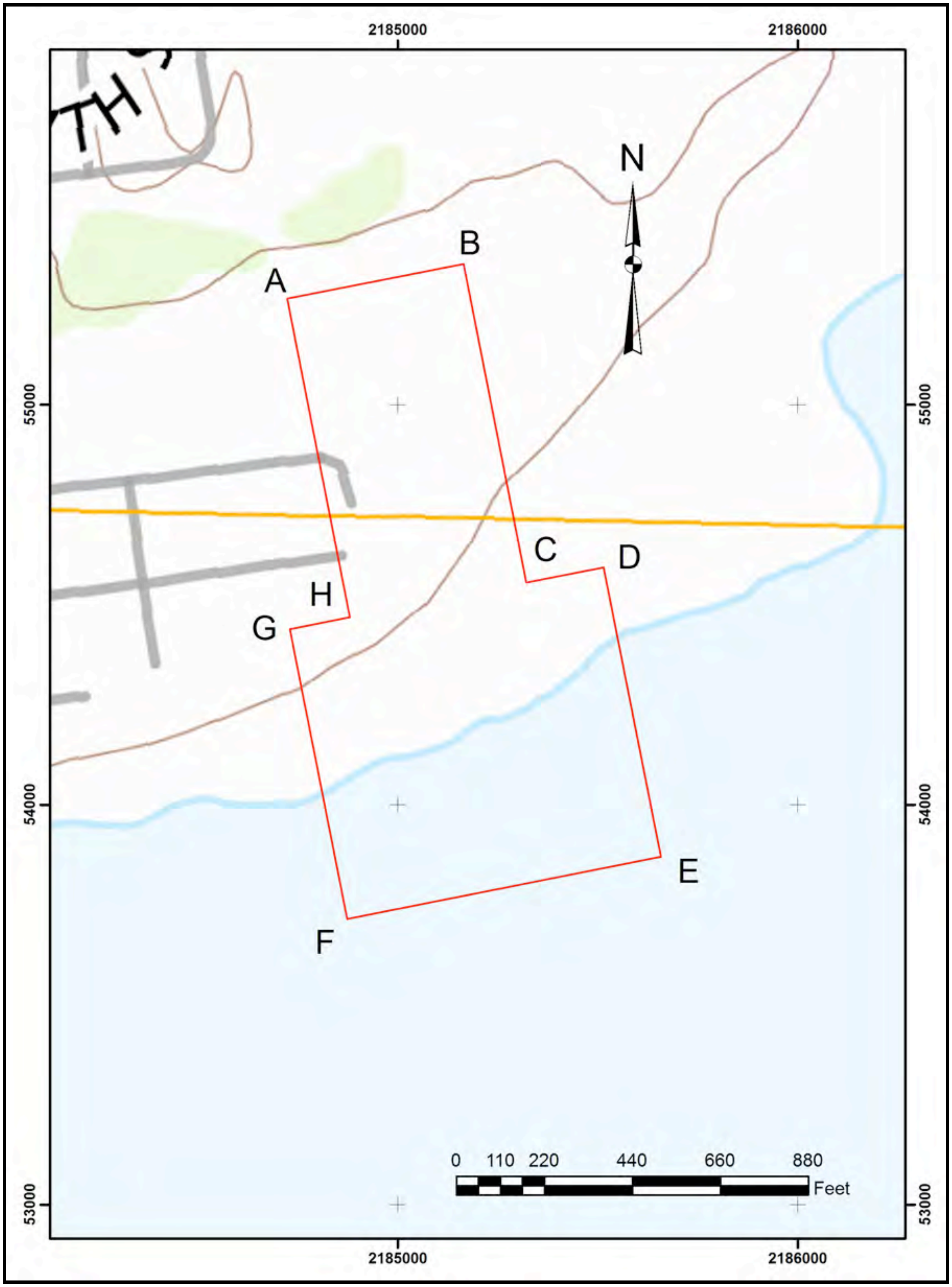

Figure 2. Survey map coordinate locations.

This combination of remote sensing represents the state of the art in submerged cultural resource location technology and offers the most reliable and cost-effective method to locate and identify potentially significant targets. Data collection was controlled using a differential global positioning system (DGPS). DGPS produces the highly accurate coordinates necessary to support a sophisticated navigation program and assures reliable target location. An EG&G Geometrics G-881 marine cesium magnetometer, capable of plus or minus 0.001 gamma resolution, was employed to collect magnetic data in the survey area (Figure 3).

To produce the most comprehensive magnetic record, data was collected at 10 samples per second. Due to shoal water within the project area, the magnetometer sensor was towed just below the water surface at a speed of approximately three to four knots. Magnetic data were recorded as a data file associated with the computer navigation system. Data from the survey were contour plotted using QuickSurf® computer software to facilitate anomaly location and definition of target signature characteristics. All magnetic data were correlated with the acoustic remote-sensing records.

Figure 3. The EG&G Geometrics G-881 cesium vapor magnetometer.

A 445/900 kHz Klein System 3900 digital sidescan sonar (interfaced with SonarPro Sonar Processing System) was employed to collect acoustic data in the survey area (Figure 4). Due to shoal water within the project area, the sidescan sonar transducer was deployed and maintained between 3 and 5 feet below the water surface. Acoustic data were collected using a range scale of 30 and 50 meters to provide a minimum of 200% coverage and high target signature definition. Acoustic data were recorded as a digital file with SonarPro and tied to the magnetic and positioning data by the computer navigation system.

Figure 4. The KLEIN SYSTEM 3900 digital sidescan sonar.

A TRIMBLE AgGPS was used to control navigation and data collection in the survey area. That system has an accuracy of plus or minus three feet, and can be used to generate highly accurate coordinates for the computer navigation system on the survey vessel. The DGPS was employed in conjunction with an onboard laptop loaded with HYPACK navigation and data collection software (Figure 5). Positioning data generated by the navigation system were tied to magnetometer records by regular annotations to facilitate target location and anomaly analysis. All data is related to the North Carolina State Plane Coordinate System, NAD 83.

Figure 5. Computer navigation system located on the research vessel helm.

A TRIMBLE GeoExplorer Series GeoXT handheld DGPS capable of +/-3 feet was employed to control positioning for the magnetic data within the survey area. The GeoXT utilizes WAAS satellites to provide differential corrections in the field. The beach survey area was investigated with a GEOMETRICS 856 cesium vapor magnetometer and a TRIMBLE GeoExplorer Series GeoXT handheld DGPS to identify buried ferromagnetic cultural material (Figure 6).

Figure 6. The Geometrics G-856 magnetometer and Trimble DGPS terrestrial survey.

Remote-Sensing Data Analysis

To ensure reliable target identification and assessment, analysis of the magnetic and acoustic data was carried out as it was generated. Using QUICKSURF® contouring software, magnetic data generated during the survey were contour plotted at 3-gamma intervals for analysis and accurate location of magnetic anomalies. The magnetic data was examined for anomalies, which were then isolated and analyzed in accordance with intensity, duration, areal extent and signature characteristics. Sonar records were analyzed to identify targets on the basis of configuration, areal extent, target intensity and contrast with background, elevation and shadow image, and were also reviewed for possible association with identified magnetic anomalies.

Data generated by the remote-sensing equipment were developed to support an assessment of each magnetic and acoustic signature. Analysis of each target signature included consideration of magnetic and sonar signature characteristics previously demonstrated to be reliable indicators of historically significant submerged cultural resources. Assessment of each target includes avoidance options and possible adjustments to avoid potential cultural resources. Where avoidance is not possible the assessment includes recommendations for additional investigation to determine the exact nature of the cultural material generating the signature and its potential NRHP significance. Historical evidence was developed into a background context and an inventory of shipwreck sites that identified possible correlations with magnetic targets (Appendix A). A magnetic contour map of the survey area was produced to aid in the analysis of each target.

Historical Background

Shallotte Inlet has served the community of Shallotte and southern Brunswick County since early colonization of coastal North Carolina. Prior to the establishment of paved roads and rail facilities in the early 20th century, the community of Shallotte was approachable only by water through Shallotte Inlet. The inlet is located in southwestern Brunswick County between Holden Beach and Ocean Isle Beach and provides access to the Shallotte River, Shallotte Creek, and Saucepan Creek.

Early settlement of the Shallotte River basin and the area surrounding Shallotte Inlet probably first occurred in the late seventeenth century, but permanent settlement seems to have begun during the second quarter of the eighteenth century (Angley, n.d.:1). A 1738 map of the area indicated a sparse settlement of three plantations on the eastern side of the lower portions of the Shallotte River. Two plantations were also shown on the sound to the west of the river's mouth. An Anglican missionary reported in 1762 that a group of dissenters had settled along the beach between Lockwood's Folly and Shallotte Inlet (Angley, n.d.:1). The name for the region was noted as early as 1801. The original correct name being "Charlotte", but through improper usage the name Shallotte developed. The modern name was fixed by 1837 (Lee, 1978:88).

The Shallotte River basin was included within the Port of Brunswick, and during the colonial period rice, lumber and naval stores probably made up the majority of the exports shipped through Shallotte Inlet to other ports. By the late eighteenth century two landings were in use in the area: Gause Landing and Brick Landing. According to traditional accounts, Brick Landing, located just across Saucepan Creek from present Shallotte Point, was used for an importation site of bricks from England. Large plantations and naval stores facilities remained in operation on both sides of the Shallotte River until the outbreak of the Civil War (Angley, n.d.:2).

The original location of Shallotte is unknown, although the name has been applied to where the main bridge or ferry crossed the Shallotte River. Around 1840 an unsuccessful attempt was made to establish a town near the mouth of the river. What is now called Shallotte was established at its present location by 1889 where the main road bridge crossed the river, and at the head of sloop navigation. Shallotte was incorporated in 1899 with a population of 149 (Lee, 1978:181).

On 19 April 1861 newly elected President Abraham Lincoln issued a proclamation establishing a blockade of Confederate ports in South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas. Eight days later, Lincoln extended the blockade to include ports in Virginia and North Carolina.

Within a few months of Lincoln's proclamation, the newly appointed secretary of the U.S. Navy, Gideon Wells, took proactive steps to implement an effective blockade off the South's coastline. In the interim, stationed aboard the U.S. gunboat *Penobscot* off Shallotte Inlet on 8 June 1862, Lieutenant Francis M. Bunce reported that:

> In obedience to your [J. M. B. Clitz] orders I left this vessel with the second cutter and gig, manned by volunteers. The gig was in charge of Acting Master J. W. Simmons, who was accompanied by Assistant Surgeon E. C. Ver Meulen, Acting Assistant Paymaster A. Pool, and Mr. John Clitz, captain's clerk. In the second cutter with me were Acting Master's Mates S. K. Luce and S. H. Damon

> and [Acting] Assistant Paymaster T. H. Haskell, of the State of Georgia. We entered Shallotte Inlet and boarded the schooner *Sereta*, of Nassau, New Providence, which we found deserted. Her cargo consisted of salt and fruit. She being aground, [sic] burned her. While returning we were fired upon once. I noticed that several houses in the distance displayed flags of truce (U.S. Navy Department [USND], ser. I, vol. 7, 1898:467).

Bunce's statement was forwarded to North Atlantic Blockading Squadron headquarters (Hampton Roads) as an enclosure in his superior's account of the *Sereta* affair, and in the latter's hand this interesting remark about his vessel's grounding at Shallote Inlet was made:

> Agreeable to Commander Armstrong's order of the 8th instant I [J. M. B. Clitz] proceeded to the westward in chase of a strange sail. When near Shallotte Inlet I saw the chase, a schooner, enter that inlet. In trying to obtain a good position for shelling the vessel I unfortunately grounded on a bank of sand outside the bar. This ship [USS gunboat Penobscot] was running slow in 4 fathoms water, heading offshore, when the depth suddenly changed to 2 fathoms. I immediately reversed the engine, but before we could stop her way she struck. Sounded about the ship, ran out a kedge and hawser astern and hove taut. The wind offshore from the northward and sea smooth, but the tide ebbing, and no prospect of soon getting off. Immediately dispatched a boat in charge of an officer to communicate with Commander Armstrong, senior officer off Cape Fear….That night, about 11 o'clock, the U.S.S. State of Georgia arrived and commenced preparations for getting the ship off. On the morning of the 9th, before that ship could be got into position, the tide ebbed, the wind changed to northeast, creating considerable swell. The kedge anchor coming home, the vessel forging ahead and thumping heavily, it was determined to lighten the ship, first, that we might get her off the more easily; and, secondly, in case of nonsuccess to prevent the Government property from falling into the hands of the enemy, by whom, from our close proximity to the land, we were surrounded. During the night of the 9th the wind and sea moderating, the ship laid easily without changing her position. The 10th being a fine calm day and a high tide, at about half past 4 p.m., with the assistance of the *State of Georgia*, the ship, I am happy to say, floated off. On examination I find the ship considerably damaged, but not so much so as to prevent her from attending to the duties of the blockaded for the present. I respectfully call your [L. M. Goldsborough] attention to the reports of Engineer Jones and Carpenter's Mates Murdock, of this ship, and Campbell, of the *Victoria*. I also enclose the report of Lieutenant Bunce in relation to the destruction of the above-named schooner, *Sereta*, and a log book found on board (USND, ser. I, vol. 7, 1898:466).

Another relevant report, this one filed by U.S. Navy Commander James Armstrong (USS *State of Georgia*) on 19 August 1862, related that:

> Three contrabands came off last night. They report the steamer *Carolina* (*Kate*), Lockwood, master, from Nassau, entered this port [Wilmington, North Carolina] some thirteen days since. She brought in liquors, clothing, and fruit; had been chased and compelled to throw over her arms to escape. The master stated the *Nashville* was at Nassau when he left, loading, and was coming to this place. The contrabands state a schooner loaded with salt entered Shallotte Inlet a few

> days since, and that a rebel regiment left Smithville for Kinston (USND, ser. I, vol. 7, 1898:659).

The aforementioned schooner that evaded Federal vessels after entering Shallotte Inlet became a subject of discussion during the Board of Inquiry held aboard the *State of Georgia* on 30 September 1862. Previously, at Norfolk aboard the U.S. flagship *Minnesot*a, Rear-Admiral L. M. Goldsborough dispatched this order to Commander Armstrong stationed off New Inlet:

> SIR: Yours of the 19th ultimo [August] reached me by the mail of today [1 September 1862], and I regret exceedingly to learn that two vessels, one a schooner and the other the steamer Carolina, had succeeded, a short time previously, in eluding the blockade and getting into port. This will never answer. More vigilance must be exercised. Why is it that the vessels stationed on the side the Carolina entered "have no knowledge of the fact?" Appoint a board of three impartial and suitable officers to investigate the subject of the entrance of the above vessels and report to me in writing the result of their enquiry; and if there be fault, let them state frankly with what officer or officers of the blockading squadron off Wilmington it lies….I wish the board to state also what vessels of the blockading force were off the entrances, respectively, by which the schooner and steamer managed to get in (USND, ser. I, vol. 7, 1898:660).

At the conclusion of the Federal investigation, U.S. Navy board members related that the unknown schooner that entered Shallotte Inlet in early August 1862 was "chased" by the *Mystic* (Master R. F. Coffin) unsuccessfully through "no want of vigilance" (USND, ser. I, vol. 7, 1898:662). Depositions also revealed that the *Monticello* and *Stars and Stripes* were also standing in at the location near Shallotte Inlet on Federal blockade duty (USND, ser. I, vol. 7, 1898:660-662).

Intelligence collected by the commander of the USS *Victoria* stationed off Wilmington in early autumn 1862 suggested that the schooner *James Buchanan* had entered Shallotte Inlet during late summer and was now loading cotton at that location. In other news, the Federals reported that 15 deaths had been attributed to the steamer *Kate*, which had recently entered the Cape Fear River from Nassau (USND, series I, vol. 8, 1899:82).

Meanwhile, U. S. Naval Commander G. H. Scott voiced his concern that the Wilmington blockade was insufficient, and reported that the enemy were "plainly seen erecting batteries on the beach near Fort Caswell (USND, series I, vol. 8, 1899:87). Scott added this remark about nearby Shallotte Inlet:

> The withdrawal of the *Octorara* and *Victoria* leaves the force here (six) in my opinion too small to blockade the two passes effectually; there should, I think, be at least eight here, three at each inlet. One is at all times absent for coal, and there should be, I think, one at Charlotte [Shallotte] Inlet, 20 miles west of this, where it is said vessels drawing 8 or 9 feet frequently enter, loaded with salt and other articles (USND, series I, vol. 8, 1899:87).

Due to "the constant trade" moving between Shallotte Inlet and Wilmington by early October 1862 Commander Scott was ordered to "send a vessel at once to blockade off Shallotte Inlet and keep watch over as much of the neighboring coasts as possible without interfering with the blockade of the inlet" (USND, series I, vol. 8, 1899:120, 126).

This decision proved prudent and immediately fruitful. At dawn on 22 October 1862, the master of the U.S. gunboat *Penobscot* overtook the "English full-rigged brig *Robert Bruce*" off Shallotte Inlet

(USND, series I, vol. 8, 1899:142). Before being sent to New York for adjudication, the cargo of the Federal prize was inventoried with these items:

> Thirty-seven bales and 14 cases woolens, 4 bales linens, 26 cases boots and shoes, 20 barrels drugs, 15 cases drugs, 400 bundles iron hoops, 225 pigs of iron, 8 hogsheads of ale, 30 casks (300 dozen) bottled porter, 5 puncheons of rum, 3 casks of table cutlery, 58 crates of earthenware, 186 crates of bottles, 3 crates and 1 hamper tinware [sic], 60 bags of glue, [and] 42 bags of corks (USND, series I, vol. 8, 1899:142).

At the time of its capture, the 200-ton brig's crew hoisted a British flag, and its master William Muir claimed to be bound for Halifax, Nova Scotia after setting sail from Hull, England some 53 days before. Muir claimed that he could enter Shallotte Inlet "at half tide or low water" and the vessel's log supported his statement that he had "fair winds from England" (USND, series I, vol. 8, 1899:142). Commander Clitz of the *Penobscot*, however, reported that when "boarded she was near Shallotte Inlet, a place much used to run cargo into for the rebels" and that this vessel was "recognized as the same one that ran the blockade out of Wilmington, N.C., in December, 1861" (USND, series I, vol. 8, 1899:142, 150).

Within a few weeks, the *Monticello* was assigned to the Shallotte Inlet station to relieve Commander Macomb of the *Genese*e. The former Federal vessel was at that time tasked to blockade duties off Cape Fear River under the command of D. L. Braine (USND, series I, vol. 8, 1899:209). On 18 November, the *Ariel* and *Ann Maria* were both intercepted by sailors assigned to the Federal blockader *Monticello* at Shallotte Inlet, and were subsequently destroyed. In both instances, the blockade-running schooners carried large cargoes of salt (Report of the Secretary of the Navy, 4 December 1865 in: U.S. Congress 1865:458). Specific details of the separate events off Shallotte Inlet, were described at the time of the captures to Rear-Admiral S. P. Lee, by Lieutenant Commander Braine as follows:

> Sir: I have the honor to inform you that this morning at early daylight we weighed anchor as usual, and, as soon as everything could be distinctly seen around, I stood to the westward along the coast. At 8 a.m. we discovered a schooner close inshore to the westward and gave chase. The parties on board of her ran her on shore. With a few shell we dispersed those unloading her. She proved to be the English schooner Ariel, of Halifax. We found no papers or colors on board. At this time another schooner was discovered to the westward down the coast. Leaving two boats endeavoring to get off the first schooner, I immediately started in pursuit of the second. She was also run on shore. I drove those employed in unloading her away from her with a few shell. On boarding, she proved to be the English schooner Ann Maria, of Nassau, New Providence. I found no papers or colors. Getting as close to her as possible with the steamer, I got a hawser to her and hauled her off. She was, however, bilged and sunk in 4 fathoms of water. I immediately returned to the first schooner and, finding her bilged, fired, but the fire was extinguished by the sea. The cargoes of these vessels were principally salt, a few kegs of lard, and a few barrels of flour and sugar. I destroyed everything I could lay my hands on. I obtained two compasses, some old charts, and a few other articles of slight value, such as brooms, etc., which I appropriated for ship's use. I enclose all the papers found on board. I think we must have destroyed upward of 2,000 bags of salt. The schooners were each about 80 tons, one English and one American built (USND, series I, vol. 8, 1899:218-219).

Blockaders continued their close scrutiny of the inlet, and on Christmas Day 1862, a "propeller steamer" was observed attempting to enter Shallotte Inlet but was "chased away from shore" by the blockader *Victoria* (USND, series I, vol. 8, 1899:401). Just three days later, Captain Hooker of the *Victoria* witnessed a "stranger [sic] steamer" as the latter "hauled up for the land" in the late morning (USND, series I, vol. 8, 1899:401). Hooker "gave chase till 2 p.m., when the steamer abandoned her intention and stood offshore, going very fast" (USND, series I, vol. 8, 1899:401). This blockade runner was "described as two-masted, very rakish, had the appearance of two smoke pipes, and dark-colored paint" and appeared to be a side-wheel steamer (USND, series I, vol. 8, 1899:401). Federal eyewitnesses stressed to their superiors that both "strangers" were "described as far superior in speed to the Victoria" USND, series I, vol. 8, 1899:401).

On 7 February 1863, Acting Ensigns James C. Gibney and George Smith commenced a nocturnal marine reconnaissance "up Shallotte Inlet" aboard "a well manned" launch belonging to the *Maratanza* (USND, series I, vol. 8, 1899:529; Neeser 1909:148-149). Gibney and Smith later informed their superior that they first [7:30PM] steered northeast by north and took soundings as they proceeded. The soundings were found:

> [T]o be very regular, the water shoaling gradually from 6 to 3 fathoms to within one-fourth of a mile of the bar, which runs parallel and nearly across the mouth of said inlet. After some delay in finding the entrance we discovered a break in the bar, which we supposed to be the channel. We immediately steered for it, and were right in our supposition, for it proved to be the entrance. In it we found 2 fathoms of water, it being then nearly high tide, and just within we found 3 fathoms, which soundings we kept until we arrived nearly across the inlet. We then steered E. about 2 miles, shoaling the water from 2 to 1 fathoms. We then found it necessary to cross to the south side of the inlet, as the channel tended in that direction. We proceeded up that shore about 3 miles farther without seeing anything of importance. Finding the tide to be ebbing very fast, and having a difficult channel to navigate, we started on our return. We followed the south side of the river back, where we found another channel, but more intricate than the one on the north side of said inlet. At 1 a.m. we passed out of the entrance to Shallotte Inlet on the bar, it being then low tide, 1 fathoms of water. At 2 a.m. [8 February 1863] we returned to the ship, having accomplished the object of our enterprise (USND, series I, vol. 8, 1899:529).

Lieutenant E. Hooker [volunteer] of the three-gun steamer *Victoria* captured the Canadian brig *Minna* as it attempted to enter Shallotte Inlet on 18 February 1863 and towed the vessel to the Cape Fear River rendezvousing with the USS *Dacotah* (USND, series I, vol. 8, 1899:535; Neeser 1909:382-383). The *Minna*, of and from Quebec, was loaded with salt, drugs and other items and was most recently outbound from Nassau. In this instance, the prize was condemned and was sailed to New York for adjudication along with its master, mate, two crewmen and some retiring sailors of the *Dacotah* (Neeser 1909:383).

Two days later, as the USS *Monticello* reconnoitered Little River Inlet, its commander observed two contrabands "making signals" (USND, series I, vol. 8, 1899:548). The men proved to be Sam Picket (22) and Henry Picket (17) from Shallotte, who informed the Federals that a schooner was waiting to run out of Shallotte Inlet after discharging its cargo of perhaps cotton and naval stores. Furthermore, the two young men related that there were 14 pickets at Shallotte. At this point, the Pickets were assigned to the steamer *Monticello* for the term of three years (USND, series I, vol. 8, 1899:548).

On 22 February 1863, the USS *Victoria* and *Matthew Vassar* encountered "a large two-masted steamer, painted lead color" running up along the beach to Shallotte Inlet (USND, series I, vol. 8, 1899:562). Despite being fired upon with guns and muskets, the blockade runner apparently turned to a seaward direction and escaped into the darkness (USND, series I, vol. 8, 1899:562). Two boats and their crews acting under the joint supervision of Master C. A. Pettit performed a survey of Shallotte Inlet in late winter 1865. On that date, the Federals "[s]urprised and routed a Confederate force, capturing six prisoners" (Neeser 1909:236-237).

On 4 December 1864, Secretary of the Navy Gideon Welles remarked that the "demands upon the naval service, which for four years had been exacting, were relaxed upon the fall of Fort Fisher" (Report of the Secretary of the Navy, 4 December 1865 in: U.S. Congress 1865:III). In his report to President Lincoln [and the U.S. Congress], Welles furthermore suggested that the possession of the Cape Fear River and Wilmington "put an end to illicit traffic with the States in insurrection, and extinguished the last remnants of that broken commerce which foreign adventurers had, notwithstanding constant and severe losses, persisted in carrying on by breach of blockade" (Report of the Secretary of the Navy, 4 December 1865 in: U.S. Congress 1865:III).

Following the Civil War and the end of the blockade, numerous vessels again passed through Shallotte Inlet and up river to the town of Shallotte. The town, located at the head of sloop navigation, had attained considerable importance as a center of trade (Angley n.d.:4). Vessels navigating Shallotte Inlet experienced local problems with sand deposits in the channel that limited the size of vessels that could safely pass over the bar. By 1889 "the channel depth at the ocean bar of Shallotte Inlet was found to be 3 1/2 feet at low tide and 7 feet at high tide.

From the bar to a point 2 miles above the mouth of the river, the depth was 5 feet at low tide, varying for the next 1 1/2 miles between 1-2 feet at low tide and 4-7 at high tide. From that point upstream to Shallotte, the water varied between 3 and 10 feet at low tide. Coasting schooners of 250 barrels, or 22 tons capacity, of 50 feet in length, 16 feet wide, and 4-5 feet draught, could and were entering through the inlet on a favorable tide and journeying upriver to Shallotte" (Angley, n.d.:4).

On 12 July 1878 the schooner *Flash*, under Captain Bryan Morse, experienced firsthand the dangers of trying to pass over the shallow bar at the inlet. While attempting to go out over the Shallotte Bar for Wilmington, the *Flash* got aground on what was called the West Breakers. On the following tide she bilged, floated off into the channel, and then filled with water and sank with her cargo of eighteen casks of spirits of turpentine and ninety-three barrels of rosin (*The Morning Star* [*TMS*] 16 July 1878). The *Flash*, which registered only about 15 tons, was the property of Captain Morse, and was valued at about $600 and uninsured (*TMS* 16 July 1878). Another wreck was recorded on the bar several years later. On 15 November 1894, the two-masted schooner *Ray*, owned by Captain Moore and Sheriff Rouark, of Brunswick County stranded on the Shallotte bar. The schooner was bound from Wilmington to Shallotte with a cargo of general merchandise when it was totally lost (*The Messenger*, 27 November 1894).

Commerce of the Shallotte River Basin during the late nineteenth century was small compared to the other North Carolina ports. Annual exports totaled about $50,000 in value, with principal exports being crude and manufactured turpentine, tar, wood and lumber, cotton, rice, corn, sweet potatoes, peas, fish, oysters, and diamond-backed terrapins. Imports consisting mainly of manufactured goods from Wilmington (Angley, n.d.:4). Shallotte River proved to be even more active than Lockwood Folly by serving a larger community. During the 1880s coastal schooners were carrying cargoes during high tides up to Wilmington (Lee, 1978:197).

In an effort to increase the amount of commerce for the area, improvements to the river and inlet were proposed. On 22 February 1899, a Wilmington newspaper reported that Captain W. H. Bixby, of the Corps of Engineers, stated in his report that the Shallotte River could be improved by straightening the channel and removal of the oyster rock shoals. The changes would increase the channel width to 60 feet wide and a depth of four feet at low water. The total estimated cost would be $30,000 (*TMS* 22 February 1899). Apparently, the recommendations of Captain Bixby were not acted upon for several years.

In January 1905, local residents petitioned their Congressional representative to obtain appropriations for improvements to the Shallotte River. The impractical operation of the newly-constructed steamer *Franklin Pierce*, for the Wilmington run and the loss of two schooners loaded with cargoes near Shallotte, probably spurred the region's businessmen to again call for channel and inlet improvements (*The Wilmington Star* [*TWS*] 14 January 1905). However, the pleas of the Shallotte residents were again ignored. Finally, in 1912 the engineer in charge of the Wilmington District stated in an official report that "the improvement of this river [Shallotte] by the general government to the extent of $20,500, is justified by the present and prospective commercial interest involved" (*TWS* 25 January 1912).

Acting upon the latest incentive Congressman Godwin went before the Congressional Rivers and Harbors Committee and asked that the recommendations by the United States Engineer be incorporated in the following rivers and harbors bill. On 4 March 1913, the bill was passed authorizing a channel 4 feet deep and 36 feet wide to White's Landing. The channel did not extend from the ocean, but from the deep water in the inlet gorge or the mouth of the river. Following improvements to the river, imports and exports for Shallotte in 1914 rose to 3,901 tons and were valued at $132,780.

The majority of the commerce during 1914 was carried by 8 small schooners with a net tonnage of only 97 tons (Angley, n.d.:5). In a subsequent act passed on 21 January 1927, the channel would be extended up the river to Shallotte, a total distance of nine miles. The work was performed the following summer for a total cost of $18,181 (*TWS* 25 January 1912; T*MS* 27 May 1928).

In October of 1913, the 322-ton schooner *Greenleaf Johnson* ran aground near the mouth of the Shallotte River. The *Johnson* was outward bound with a cargo of 381,000 feet of lumber went it went ashore during a gale. Most of the cargo and ship's riggings were salvaged and offered for sale at auction the following February. Efforts were made to float the schooner although unsuccessful. Several of the local mariners expressed "doubts that she will ever be floated again" (Angley, n.d.:5; *TWS* 20 February 1914; *TMS* 4 March 1914).

By 1930 commerce on the Shallotte River had decreased to only 225 tons, valued at $11,944 (*TWS* 31 March 1931). Water-borne commerce through Shallotte Inlet was greatly changed with the advent of more paved roads and the construction of the Inter-coastal Waterway (Angley, n.d.:5). Wilmington continued to dominate the volume of maritime traffic in the region at its deep-water port. The Shallotte River vicinity with its sparse population remained overshadowed. At the present time, the inlet mainly serves the commercial and sports fishermen of the region.

According to the contemporary website maintained by the Town of Ocean Isle Beach (n.d.):

> The island was incorporated as the Town of Ocean Isle Beach in 1959 and has a current year-round resident population of approximately 554, with a seasonal population of 25,000. Ocean Isle Beach offers seven miles of pristine beach and provides a family beach environment. The Town operates under a council-mayor

form of government and provides its citizens with a variety of municipal services, including police and fire protection, water, sewer and sanitation service as well as an oceanfront community center.

Description of Findings

The terrestrial remote-sensing survey of the Ocean Isle project area identified a total of 4 magnetic anomalies (Figure 7; Appendix B). All of those appear to be associated with buried modern debris. They are possibly associated with debris from previous (1993/2007) projects to pump dredge spoil on the beach in the project area (Figure 8), construction of the earlier groins and/or residential structure debris associated with storms.

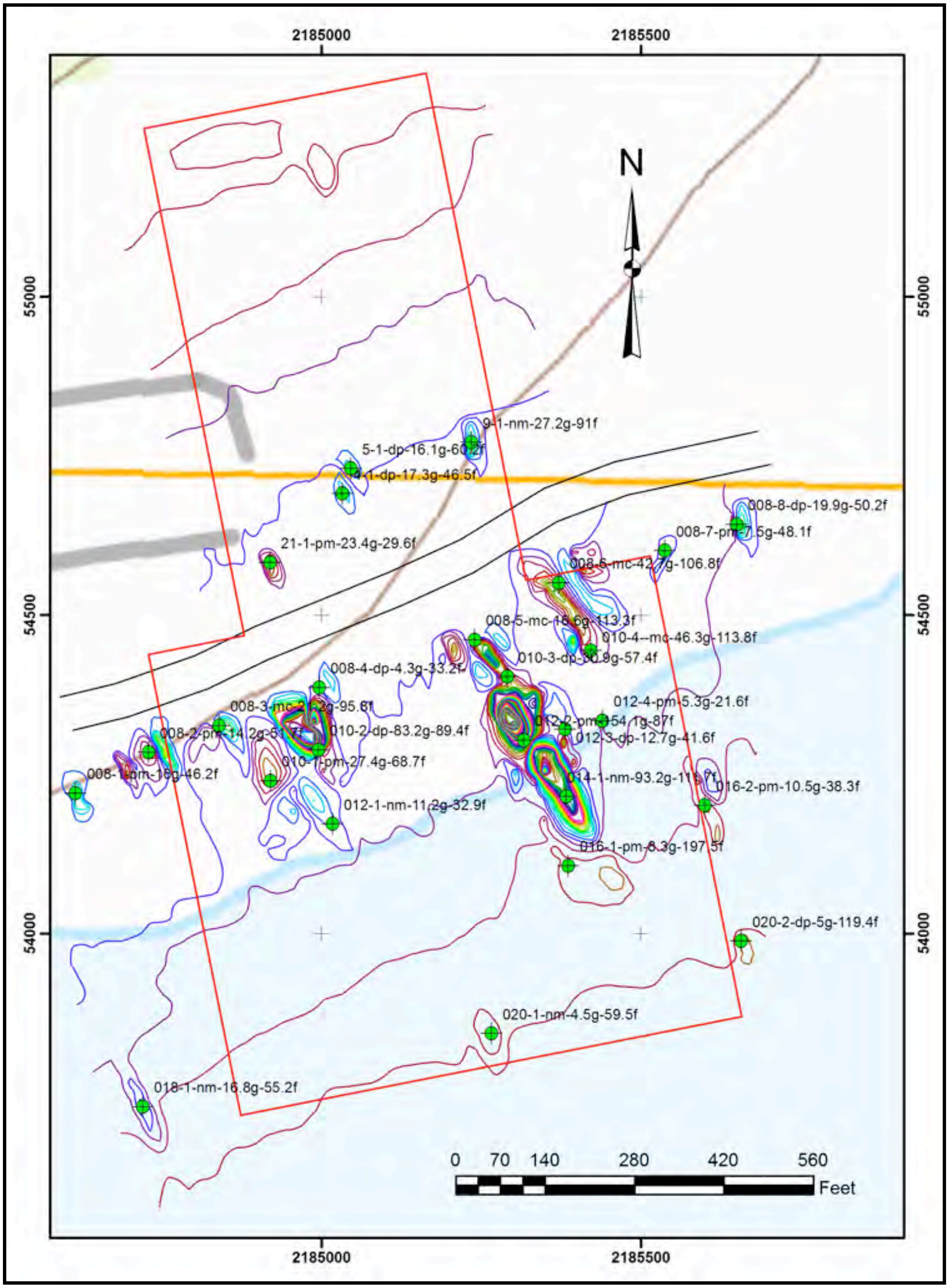

Figure 7. Magnetic anomalies and contoured magnetic data.

Figure 8. Previous groins and dredge spoil pumped on beach in project area ca. 1993.

The marine remote-sensing survey of the Ocean Isle project area identified a total of 22 magnetic anomalies (Figure 7; Appendix C). Seven of those are located outside the proposed project Area of Potential Effect (APE). Without exception, all of the magnetic anomalies were determined to have signature characteristics indicative of small single objects or modern debris. Most, if not all, appear to be reliably associated with previously constructed groins and associated debris or residential structural debris associated with storm damage. None of those anomalies have signature characteristics similar to those associated with historical vessel remains.

A total of 16 sonar targets were recorded in the remote-sensing survey (Figure 9; Appendix D). Many are duplicates of the same object or group of objects. One of the sonar targets lies outside the project APE. While there are no clear geographical associations with magnetic anomalies, many of the sonar images document the remains of previous groin structures and associated debris. Several identify small single objects on the bottom surface. None of the sonar images have signature characteristics similar to those associated with historical vessel remains (Appendix E).

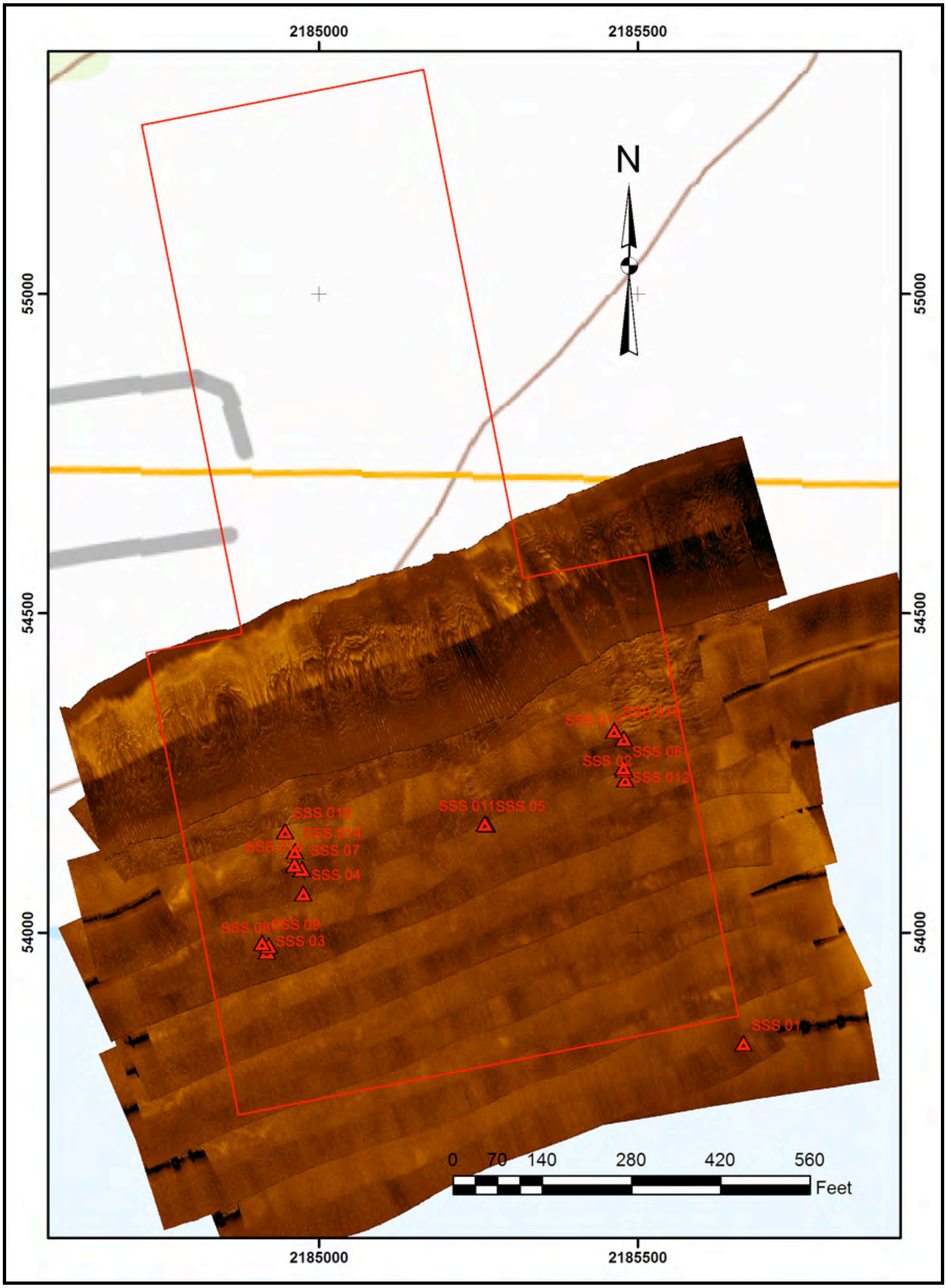

Figure 9. Sonar coverage mosaic with target locations.

Conclusions and Recommendations

A survey of historical and archaeological literature and background research confirmed evidence of sustained historic maritime activity associated with Shallotte Inlet. Although vessels have been passing over the shallow bar at Shallotte Inlet since the eighteenth century, the volume of traffic never reached that associated with nearby Wilmington. Several shipwrecks, however, have been recorded for the Shallotte Inlet vicinity (Appendix A). Five were lost during the period of the Civil War. Five other vessels have been documented lost near Shallotte Inlet during the late nineteenth century and early twentieth century. None of the ship losses have been directly associated with the project area.

Historical research confirmed that the Shallotte Inlet area has been closely tied to Brunswick County's maritime commerce since the early eighteenth century. Consequently the area's coastal and riverine waters must be considered high probability areas for shipwrecks and small coastal and riverine craft. In the vicinity of Shallotte Inlet documentation has confirmed the loss of at least nine vessels. None of the documented wrecks appear to have been located in or near the current project area. In spite of the area's high potential, analysis of the remote sensing data confirmed that there were no magnetic or acoustic targets at the proposed channel maintenance site. Consequently, no additional submerged cultural resource investigation is recommended in conjunction with the proposed project.

The terrestrial and marine magnetometer surveys identified 22 magnetic anomalies. The sidescan sonar identified 16 acoustic targets. Without exception, all of the magnetic anomalies were determined to have signature characteristics indicative of small single objects or modern debris. Most, if not all, appear to be reliably associated with previously constructed groins at the project site or storm related residential structural debris. Material generating 7 of the anomalies is located outside the proposed project APE. Because none of the anomalies have signature characteristics similar to those associated with historical vessel remains no additional investigation is recommended.

Many of the 16 sonar targets are duplicates of the same object or group of objects. One of the sonar targets lies outside the project APE. While there are no clear geographical associations with magnetic anomalies, many of the sonar images document the remains of previous groin structures, associated debris and/or residential structure debris. Several identify small single objects on the bottom surface. Because none of the sonar targets have signature characteristics similar to those associated with historical vessel remains no additional investigation is recommended.

Based on the remote-sensing data the proposed project will not impact any terrestrial or submerged cultural resources and no additional investigation is recommended. However, in the event that historical vessel remains or other archaeological sites are identified during the course of groin construction, the dredge operator should *immediately* notify the town of Ocean Isle Beach, CPE-NC point of contact, the Town of Ocean Isle Beach, the NCDCR and the UAB.

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1914 *The Morning Star* 4 March. Wilmington, NC.

1928 *The Morning Star* 27 May. Wilmington, NC.

The Wilmington Star (TWS)
1905 *The Wilmington Star* 14 January. Wilmington, NC.

1912 *The Wilmington Star* 25 January. Wilmington, NC.

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n.d. Ocean Isle Beach: Unchanged. Welcome To Ocean Isle Beach, NC. Ocean Isle Beach Government <http://www.oibgov.com/>, accessed 26 February 2015.

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1865 Report Of The Secretary Of The Navy. In: *Message Of The President Of The United States, And Accompanying Documents, To The Two Houses Of Congress, At The Commencement Of The First Session Of The Thirty-Ninth Congress*. Executive Document No. 1. U.S. House of Representatives, Washington, DC.

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Appendix A

Documented Shipwrecks In The Vicinity of Shallotte Inlet

Appendix A

Known Shipwrecks In The Vicinity of Shallotte Inlet

Vessel Name	Class	Nationality	Tonnage	Last Port	Loss Date	Location	Cargo	Comment
Unknown	Schooner				19 NOV 1862	"Off Shallotte Inlet"	"Turpentine and rosin"	"Captured and burned"
Unknown (2)	Schooners				1904	Near Shallotte Inlet		
Ann Maria	Schooner	British	80	Halifax	18 NOV 1862	Shallotte Inlet	Salt	"Destroyed" by D. L. Braine-U.S. steamer *Monticello*
Ariel	Schooner	British	80	Nassau	18 NOV 1862	Shallotte Inlet	Salt	"Driven ashore and destroyed" by D. L. Braine-U.S. steamer *Monticello*
Flash	Schooner				1878	Sank in channel		Small coastal craft
Greenleaf Johnson	Schooner				1914	Ashore at mouth of river		
Laura (Soleta)	Schooner				1862	Shallotte Inlet		Destroyed
Ray	Schooner				1894	Shallotte Bar		Ran aground. Total loss.
Sereta	Schooner				8 JUN 1862	Shallotte Inlet		"Burnt"

Appendix B

Terrestrial Magnetic Anomaly Table

Appendix B: Terrestrial Magnetic Anomaly Table

Anomaly	X Coordinate	Y Coordinate	Survey Line	Anomaly #	Signature	Intensity	Duration	Assessment
9-1-nm-27.2g-91f	2185235.93	54771.64	9	1	Negative Monopolar	27.2g	91f	Modern Debris
4-1-dp-17.3g-46.5f	2185033.74	54691.14	4	1	Dipolar	17.3g	46.5f	Modern Debris
5-1-dp-16.1g-60.2f	2185046.55	54730.73	5	1	Dipolar	16.1g	60.2f	Modern Debris
21-1-pm-23.4g-29.6f	2184920.11	54582.93	21	1	Positive Monopolar	23.4g	29.6f	Modern Debris

Appendix C

Marine Magnetic Anomaly Table

Appendix C: Marine Magnetic Anomaly Table

Anomaly	X Coordinate	Y Coordinate	Survey Line #	Target #	Signature	Intensity	Duration	Assessment
020-1-nm-4.5g-59.5f	2185267.1	53843.2	20	1	Negative Monopolar	4.5g	59.5f	Modern Debris
020-2-dp-5g-119.4f	2185657.9	53988.2	20	2	Dipolar	5g	119.4f	Modern Debris
018-1-nm-16.8g-55.2f	2184721	53728	18	1	Negative Monoipolar	16.8g	55.2f	Modern Debris
016-1-pm-8.3g-197.5f	2185387.4	54106.7	16	1	Positive Monoipolar	8.3g	197.5f	Modern Debris
016-2-pm-10.5g-38.3f	2185601.1	54201.4	16	2	Positive Monopolar	10.5g	38.3f	Modern Debris
014-1-nm-93.2g-111.7f	2185384.6	54215.3	14	1	Negative Monoipolar	93.2g	111.7f	Modern Debris
012-1-nm-11.2g-32.9f	2185018.3	54172.2	12	1	Negative Monoipolar	11.2g	32.9f	Modern Debris
012-2-pm-154.1g-87f	2185317.5	54303.8	12	2	Positive Monoipolar	154.1g	87f	Modern Debris
012-3-dp-12.7g-41.6f	2185382.1	54320.8	12	3	Dipolar	12.7g	41.6f	Modern Debris
012-4-pm-5.3g-21.6f	2185440.4	54334.5	12	4	Positive Monoipolar	5.3g	21.6f	Modern Debris
010-1-pm-27.4g-68.7f	2184920.9	54240	10	1	Positive Monoipolar	27.4g	68.7f	Modern Debris
010-2-dp-83.2g-89.4f	2184996.4	54288.4	10	2	Dipolar	83.2g	89.4f	Modern Debris
010-3-dp-30.9g-57.4f	2185291.8	54403.4	10	3	Dipolar	30.9g	57.4f	Modern Debris
010-4--mc-46.3g-113.8f	2185422.5	54444.6	10	4	Multicomponent	46.3g	113.8f	Modern Debris
008-1-pm-16g-46.2f	2184615.9	54220.4	8	1	Positive Monoipolar	16g	46.2f	Modern Debris
008-2-pm-14.2g-51.7f	2184730	54284.9	8	2	Positive Monoipolar	14.2g	51.7f	Modern Debris
008-3-mc-21.2g-95.8f	2184840.4	54326.7	8	3	Multicomponent	21.2g	95.8f	Modern Debris
008-4-dp-4.3g-33.2f-	2184997.4	54386.6	8	4	Dipolar	4.3g	33.2f	Modern Debris
008-5-mc-16.6g-113.3f	2185240.6	54461.4	8	5	Multicomponent	16.6g	113.3f	Modern Debris
008-6-mc-42.7g-106.8f	2185372.2	54550.9	8	6	Multicomponent	42.7g	106.8f	Modern Debris
008-7-pm-7.5g-48.1f	2185538.8	54601.5	8	7	Positive Monoipolar	7.5g	48.1f	Modern Debris
008-8-dp-19.9g-50.2f	2185651.3	54642.7	8	8	Dipolar	19.9g	50.2f	Modern Debris

Appendix D

Sonar Target Table

Appendix D: Sonar Target Table

Sonar Contact	X Coordinate	Y Coordinate	Assessment
SSS 01	2185666.251	53827.24946	Small Linear Object
SSS 02	2185481.192	54240.81425	Cluster of Small Objects
SSS 03	2184919.264	53971.19398	Small Single Object
SSS 04	2184975.9	54062.24744	Cluster of Small Objects
SSS 05	2185264.293	54169.89971	Small Linear Object
SSS 06	2185479.423	54255.72574	Linear Cluster of Objects. Possibly Groin Remains.
SSS 07	2184973.855	54100.44949	Linear Cluster of Objects. Possibly Groin Remains.
SSS 08	2184922.019	53979.98307	Small Linear Object
SSS 09	2184911.528	53984.44329	Small Linear Object
SSS 010	2184962.195	54106.88562	Linear Cluster of Objects. Possibly Groin Remains.
SSS 011	2185260.953	54170.78533	Small Single Object
SSS 012	2185477.922	54259.15512	Linear Cluster of Objects. Possibly Groin Remains.
SSS 013	2185478.782	54304.46977	Linear Cluster of Objects. Possibly Groin Remains.
SSS 014	2184963.141	54127.84472	Linear Cluster of Objects. Possibly Groin Remains.
SSS 015	2184947.304	54159.52638	Linear Cluster of Objects. Possibly Groin Remains.
SSS 016	2185463.729	54317.14988	Linear Cluster of Objects. Possibly Groin Remains.

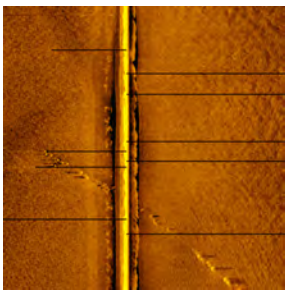
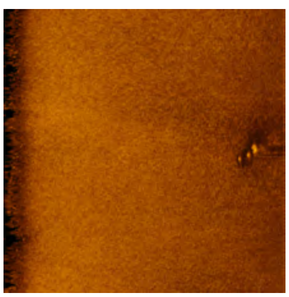
Appendix E

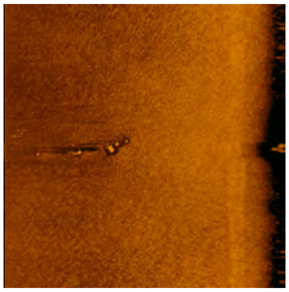
Sonar Target Report

Appendix E

Sonar Target Report

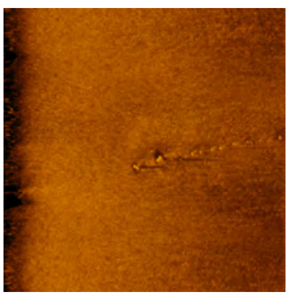
Shallotte Inlet Sonar Target Report

Target Image	Target Info	User Entered Info
	SSS001.1 • Sonar Time at Target: 12/12/2014 12:05:12 PM • Click Position 33.8983608285 -78.3882271184 (WGS84) 33.8981881521 -78.3885011399 (NAD27LL) 33.8983608285 -78.3882271184 (LocalLL) (X) 2185674.81 (Y) 54571.47 (Projected Coordinates) • Map Projection: NC83F • Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_09141212120300.xtf • Ping Number: 91142 • Range to target: 6.15 US ft • Fish Height: 0.00 US ft • Heading: 93.200 Degrees • Event Number: 0 • Line Name: OIL_09141212120300 • Water Depth: 0.00 US ft • Positioning System to Sensor: 2.3317	Dimensions and attributes • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft
	SSS002.1 • Sonar Time at Target: 12/12/2014 11:40:24 AM • Click Position 33.8974628007 -78.3888691332 (WGS84) 33.8972901177 -78.3891431293 (NAD27LL) 33.8974628007 -78.3888691332 (LocalLL) (X) 2185481.97 (Y) 54243.42 (Projected Coordinates) • Map Projection: NC83F • Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_16141212114000.xtf • Ping Number: 54869 • Range to target: 86.84 US ft • Fish Height: 8.74 US ft • Heading: 259.400 Degrees • Event Number: 0 • Line Name: OIL_16141212114000 • Water Depth: 0.00 US ft • Positioning System to Sensor: 0.5688	Dimensions and attributes • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft



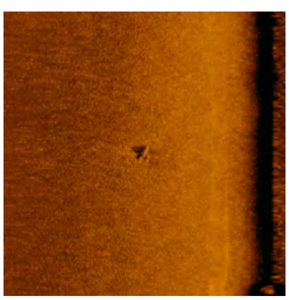
SSS002.2
- Sonar Time at Target: 12/12/2014 11:44:35 AM
- Click Position
  33.8975018205 -78.3888822011 (WGS84)
  33.8973291379 -78.3891561966 (NAD27LL)
  33.8975018205 -78.3888822011 (LocalLL)
  (X) 2185477.92 (Y) 54257.60 (Projected Coordinates)
- Map Projection: NC83F
- Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_15141212114200.xtf
- Ping Number: 60992
- Range to target: 69.17 US ft
- Fish Height: 5.64 US ft
- Heading: 83.900 Degrees
- Event Number: 0
- Line Name: OIL_15141212114200
- Water Depth: 0.00 US ft
- Positioning System to Sensor: 3.6224

Dimensions and attributes
- Target Width: 0.00 US ft
- Target Height: 0.00 US ft
- Target Length: 0.00 US ft
- Target Shadow: 0.00 US ft



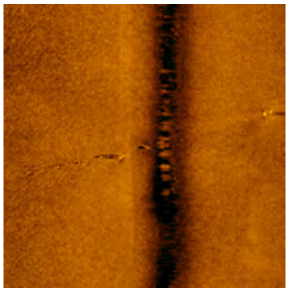
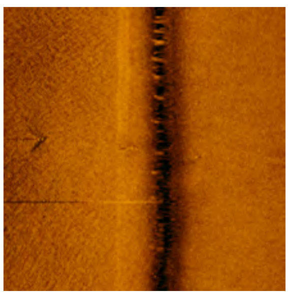
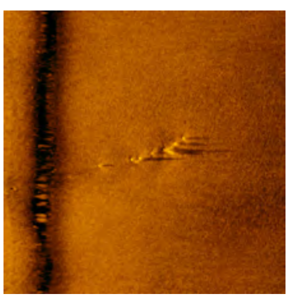
SSS003.1
- Sonar Time at Target: 12/12/2014 11:47:44 AM
- Click Position
  33.8970975937 -78.3905502792 (WGS84)
  33.8969249132 -78.3908242058 (NAD27LL)
  33.8970975937 -78.3905502792 (LocalLL)
  (X) 2184972.55 (Y) 54107.36 (Projected Coordinates)
- Map Projection: NC83F
- Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_14141212114600.xtf
- Ping Number: 65603
- Range to target: 57.29 US ft
- Fish Height: 8.09 US ft
- Heading: 252.100 Degrees
- Event Number: 0
- Line Name: OIL_14141212114600
- Water Depth: 0.00 US ft
- Positioning System to Sensor: 7.8299

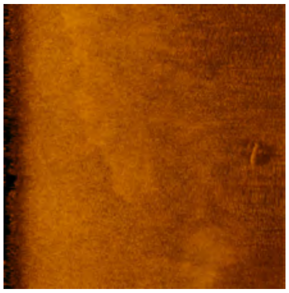
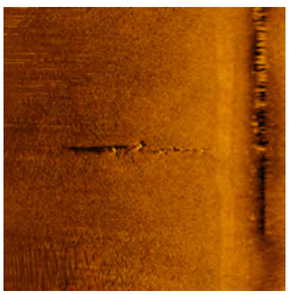
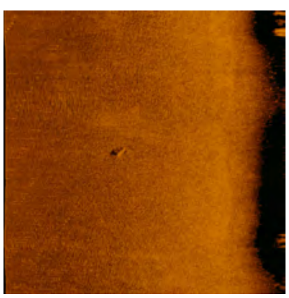
Dimensions and attributes
- Target Width: 0.00 US ft
- Target Height: 0.00 US ft
- Target Length: 0.00 US ft
- Target Shadow: 0.00 US ft

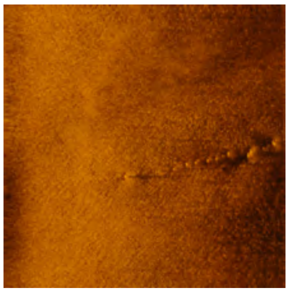


SSS004.1
- Sonar Time at Target: 12/12/2014 11:47:56 AM
- Click Position
  33.8967486995 -78.3907206768 (WGS84)
  33.8965760162 -78.3909945969 (NAD27LL)
  33.8967486995 -78.3907206768 (LocalLL)
  (X) 2184921.62 (Y) 53980.06 (Projected Coordinates)
- Map Projection: NC83F
- Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_14141212114600.xtf
- Ping Number: 65882
- Range to target: 44.89 US ft
- Fish Height: 8.82 US ft
- Heading: 260.500 Degrees
- Event Number: 0
- Line Name: OIL_14141212114600
- Water Depth: 0.00 US ft
- Positioning System to Sensor: 3.4860

Dimensions and attributes
- Target Width: 0.00 US ft
- Target Height: 0.00 US ft
- Target Length: 0.00 US ft
- Target Shadow: 0.00 US ft

	SSS003.2 • Sonar Time at Target: 12/12/2014 11:49:46 AM • Click Position 33.8970984123 -78.3905851588 (WGS84) 33.8969257319 -78.3908590840 (NAD27LL) 33.8970984123 -78.3905851588 (LocalLL) (X) 2184961.97 (Y) 54107.60 (Projected Coordinates) • Map Projection: NC83F • Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_13141212114900.xtf • Ping Number: 68555 • Range to target: 8.61 US ft • Fish Height: 6.78 US ft • Heading: 77.700 Degrees • Event Number: 0 • Line Name: OIL_13141212114900 • Water Depth: 0.00 US ft • Positioning System to Sensor: 1.2206	Dimensions and attributes • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft
	SSS005.1 • Sonar Time at Target: 12/12/2014 11:50:23 AM • Click Position 33.8973994693 -78.3896496161 (WGS84) 33.8972267885 -78.3899235798 (NAD27LL) 33.8973994693 -78.3896496161 (LocalLL) (X) 2185245.23 (Y) 54218.91 (Projected Coordinates) • Map Projection: NC83F • Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_13141212114900.xtf • Ping Number: 69458 • Range to target: 6.58 US ft • Fish Height: 7.27 US ft • Heading: 85.900 Degrees • Event Number: 0 • Line Name: OIL_13141212114900 • Water Depth: 0.00 US ft • Positioning System to Sensor: 6.1914	Dimensions and attributes • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft
	SSS002.3 • Sonar Time at Target: 12/12/2014 11:50:50 AM • Click Position 33.8975203438 -78.3888827692 (WGS84) 33.8973476614 -78.3891567647 (NAD27LL) 33.8975203438 -78.3888827692 (LocalLL) (X) 2185477.70 (Y) 54264.34 (Projected Coordinates) • Map Projection: NC83F • Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_13141212114900.xtf • Ping Number: 70128 • Range to target: 34.42 US ft • Fish Height: 7.27 US ft • Heading: 78.800 Degrees • Event Number: 0 • Line Name: OIL_13141212114900 • Water Depth: 0.00 US ft • Positioning System to Sensor: 4.6331	Dimensions and attributes • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft

	SSS004.2 • Sonar Time at Target: 12/12/2014 11:49:34 AM • Click Position 33.8967612776 -78.3907529650 (WGS84) 33.8965885945 -78.3910268837 (NAD27LL) 33.8967612776 -78.3907529650 (LocalLL) (X) 2184911.79 (Y) 53984.58 (Projected Coordinates) • Map Projection: NC83F • Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_13141212114900.xtf • Ping Number: 68286 • Range to target: 87.12 US ft • Fish Height: 7.74 US ft • Heading: 77.900 Degrees • Event Number: 0 • Line Name: OIL_13141212114900 • Water Depth: 0.00 US ft • Positioning System to Sensor: 5.7384	Dimensions and attributes • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft
	SSS003.3 • Sonar Time at Target: 12/12/2014 11:55:42 AM • Click Position 33.8971014338 -78.3905617793 (WGS84) 33.8969287533 -78.3908357054 (NAD27LL) 33.8971014338 -78.3905617793 (LocalLL) (X) 2184969.06 (Y) 54108.74 (Projected Coordinates) • Map Projection: NC83F • Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_12141212115400.xtf • Ping Number: 77252 • Range to target: 42.23 US ft • Fish Height: 6.14 US ft • Heading: 263.700 Degrees • Event Number: 0 • Line Name: OIL_12141212115400 • Water Depth: 0.00 US ft • Positioning System to Sensor: 7.1657	Dimensions and attributes • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft
	SSS006.1 • Sonar Time at Target: 12/12/2014 11:21:05 AM • Click Position 33.8963167608 -78.3882694241 (WGS84) 33.8961440641 -78.3885434468 (NAD27LL) 33.8963167608 -78.3882694241 (LocalLL) (X) 2185666.55 (Y) 53827.43 (Projected Coordinates) • Map Projection: NC83F • Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_22141212112000.xtf • Ping Number: 26600 • Range to target: 57.98 US ft • Fish Height: 11.04 US ft • Heading: 247.100 Degrees • Event Number: 0 • Line Name: OIL_22141212112000 • Water Depth: 0.00 US ft • Positioning System to Sensor: 7.0269	Dimensions and attributes • Target Width: 0.00 US ft • Target Height: 0.00 US ft • Target Length: 0.00 US ft • Target Shadow: 0.00 US ft



SSS003.4

- Sonar Time at Target: 12/12/2014 11:57:48 AM
- Click Position
  33.8971178681 -78.3906101412 (WGS84)
  33.8969451880 -78.3908840653 (NAD27LL)
  33.8971178681 -78.3906101412 (LocalLL)
  (X) 2184954.34 (Y) 54114.63 (Projected Coordinates)
- Map Projection: NC83F
- Acoustic Source File: F:\Ocean Isle Sonar Data 2014\OIL_11141212115700.xtf
- Ping Number: 80327
- Range to target: 87.86 US ft
- Fish Height: 5.69 US ft
- Heading: 81.700 Degrees
- Event Number: 0
- Line Name: OIL_11141212115700
- Water Depth: 0.00 US ft
- Positioning System to Sensor: 4.3362

Dimensions and attributes

- Target Width: 0.00 US ft
- Target Height: 0.00 US ft
- Target Length: 0.00 US ft
- Target Shadow: 0.00 US ft

Appendix G- Response to Comments

Ocean Isle Shoreline Management (Terminal Groin) Project
Summary of DEIS Comments and EIS Updates (2015)

Comment #	Nature of Comment	Agency/Entity	Category	Section Addressed	Notes/Comments
1	Terminal groins are not long term solutions to beach erosion issues, often causing erosion in adjacent areas. They are not a wise use of limited financial or human resources- we can not engineer our way around erosion problems.	David Hill	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1.
2	Citizen supporting the proposed project.	Carolyn Best	General	N/A	Noted.
3	Residents of Ocean Isle Beach in support of the proposed project	Dan and Frieda Souther	General	N/A	Noted.
4	Resident of Ocean Isle Beach in support of the proposed project	Angelo and Roberta Catucci	General	N/A	Noted.
5	Business in support of the proposed project	OIB Holdings, LLC	General	N/A	Noted.
6	Resident of Ocean Isle Beach in support of the proposed project	Thomas S. Blevins	General	N/A	Noted.
7	While this project may benefit a small number of property owners on the east end of Ocean Isle Beach, it will CAUSE erosion on other parts if the island, Sunset Beach and possibly Holden Beach.	Kelly Harris	Alternative #5	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1.
8	Please look out or the best interests of ALL property owners and tax payers in Brunswick County and DO NOT allow terminal groins at Ocean Isle Beach.	Kelly Harris	General	N/A	Noted.
9	Opposes the project based on the fact that the Applicant's Preferred Atlernative costing $46.5 million of tax payer money to protect 24 oceanfront properties worth $7.5 million	Chip Marchetti	Economics	Section 3.1	Noted. Table 3.10 shows that the total economic cost of constrcuting Alternative 5 is $1,567,000. The total cost over 30-years is $45,860,000 which significantly less than other project alternatives
10	Spending tax payer money on an experiment that is unlikely to protect a few homes on the East End of Ocean Isle Beach is neither cost effective nor environmentally sound.	David Morrison	Economics	N/A	Noted.
11	These types of structures will have unwanted consequences to other homeowners up or down the beach and will result in more problems than they will solve.	David Morrison	Alternative #5	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1.
12	Residents who state that they do not want an increase in taxes as a result of the proposed project.	Jennifer and Tim Keyes	Economics	N/A	Noted.
13	Oppsed to the hardening of North Carolina's shore and states that spending $46 million to protect property worth $7.5 million is not very smart	Thomas M. Dillon	Economics	Section 3.1	Noted. Table 3.10 shows that the total economic cost of constrcuting Alternative 5 is $1,567,000. The total cost over 30-years is $45,860,000 which significantly less than other porject alternatives
14	Terminal groins are detrimental to the environment and not worth the significant financial cost. Investing taxpayer money in such a project is foolish and wrong.	Jan Farmer	Economics	N/A	Noted.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

15	Terminal groins cause damage to beaches located south of the groin.	Jan Farmer	Downdrift effects	Section 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1.
16	The construction of a hardened structure on either side of the inlet will significantly change sediment transport and likely have a direct and indirect impact to these habitat areas.	NC WRC	Habitat Loss	Section 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1.
17	If constructed, biological and physical post-project monitoring should be conducted for a long enough period of time to determine the effect a terminal groin has on the surrounding areas. Monitoring reports should be provided to the appropraite resource agencies prior to ceasing any monitoring activity. If it is determined that the project has had a significant adverse impact or is not performing as intended, mitigation may have to be implemented.	NC WRC	Shorebirds	Chapter 6	Proposed biological and physical monitoring is outlined in Section 6.0 which includes the Inlet Management Plan. Also addressed in the BA and EFH Assessment. Agencies will dictate the final TC and CMs
18	Preconstrcution monitoring should be conducted for overwintering birds to better establish the use of the inlet area by these species.	NC WRC	Shorebirds	Chapter 6	A this time, the only bird monitoring efforts being proposed is a continuation of the existing efforts undertaken by NC WRC and it's partners. Existing data will serve as baseline data. Also addressed in the BA and EFH Assessment. Agencies will dictate the final Terms and Conditions and Conservation Measures.
19	The NCWRC is concerned that building a structure that is dependent upon regular nourishment events could potentially impact benthic invertebrate populations. Regular beach nourishment events, such as every five years, can reduce benthic populations when populations are not given appropriate time for recovery.	NC WRC	Benthic Invertebrates	Section 5, Alternative 5	Frequency and volume requirements for nourishment actions are expected to be less under the proposed action relative to those alternatives that consider nourishment as a component of a shoreline management strategy. A five-year renourishment interval should allow for the recovery of benthic invertebrates in between nourishment cycles.
20	The NCWRC is cocerned that the construction of a terminal groin may lead to a possible increase in requests to conduct emergency beach nourishment during ecologically sensitive times of the year, i.e. the nesting shorebird and nesting sea turtle moritoriums, due to potential increases in erosion rates around the groin structure.	NC WRC	Shorebirds/Sea Turtles	Chapter 5, Question 3.; Chapter 3.1	The implementation of the terminal groin would delay nourishment along OIB from a 3-year cycle to a 5-year cycle. The sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1.
21	The NCWRC is concerned about permanant, cumulative habitat loss and changes to the inlet complex. Mitigation would need to create or protect similar habitat type that would offset the loss of this inlet area. Please provide a discussion on the potential mitigation options that may be available to offset any unintended direct and indirect impacts from the proposed terminal groin.	NC WRC	Habitat Loss	Section 6	Additional detailed discussion of mitigation thresholds and actions are described in Section 6.0 and within the Inlet Management Plan. Conservation measures and terms and conditions to avoid and minimize potential adverse effects to listed species will be identified in the BO and EFH Conditions. Biotic Community habitat mapping has also been proposed to monitor any potential habitat loss.
22	If the terminal groin and/or beach nourishment project should be implemented, all work on the oceanfront shoreline, including mobilization and demobilization for all beach nourishment events and the construction of the terminal groin structure, should be conducted outside of the sea turtle nesting season which runs from May 1-Nov. 15, or until the last known sea turtle nest has hatched.	NC WRC	Sea Turtles	N/A	Noted. The environmental window for dredging will be maintained to maximum extent practicable for nourishment.
23	Nesting birds are sensitive to increased human activity and other disturbances around their nesting area. If the terminal groin and/or beach nourishment project should be implemented, all work on the oceanfront shoreline, including mobilization and demobilization for all beach nourishment events and the construction of the terminal groin structure, should be conducted outside of April 1-August 31.	NC WRC	Shorebirds	N/A	Noted. Nourishment will avoid nesting season to the maximum extent practicable.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

24	Individual inquiring about the liklihood that the proposed terminal groin will be built	Michael Lamson	General	N/A	It is not possible to predict the liklihood of any specific alternative being implemented at this time.
25	Resident of Sunset Beach does not want anyone to "screw around with mother nature".	Freddie Cole	General	N/A	Noted.
26	Resident of Sunset Beach expressing opposition to the proposed terminal groin as it is "wasteful from the standpoint of a taxpayer funds and unsound from a scientific perspective".	Gordon Bokelman	General	Table 3.10 and 3.11 in Chapter 3	All initial costs to pre-fill the accretion fillet and construct the terminal groin as well as any future maintenance of the terminal groin would be a non-Federal responsibility. Following construction of the terminal groin, all future beach nourishment would occur within the limits of the Federal storm damage reduction project and would be eligible for cost-sharing with the Federal government in the same 65%/35% Federal/non-Federal ratio as under the existing Project Cost Sharing Agreement. The resulting Federal and non-Federal cost responsibilities for the total 30-year project costs for the terminal groin options and the other project alternatives are provided in Tables 3.10 and 3.11 in Chapter 3 of the EIS.
27	Resident of Sunet Beach states that placement of a groin on the east end of Ocean Isle Beach will accelerate erosion on the middle of Ocean Isle Beach and will be harmful to the marine ecosystem on adjacent inlets.	Gordon Bokelman	Downdrift effects	Chapter 5, Question 3.; Chapter 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1.
28	The construction of the groin could have negative effects on fish, shellfish, and their habitats. Hardened structures can block and/or divert longshore larval transport which is especially important near inlets.	Shane Staples, NC DCM Fisheries Resource Specialist	Larval transport	Chapter 5, Section E, Larval Tranpsort	As stated in the DEIS, While concerns regarding larval transport into estuarine habitats through inlets due to interference by jetties may have merit, the proposed terminal groin on Ocean Isle Beach is not expected to substantially impact larval fish transport. As described in Chapter 3, the fillet of the terminal groin will be artificially filled with beach compatible material immediately following construction which will effectively extend the dry beach shoreline seaward approaching the end of the terminal groin. Therefore, unlike much longer jetties, the single terminal groin would not act as a direct impediment to longshore transport of larvae into the inlet. Once the beach protrudes to near the end of the structure, either by localized sediment transport (as described above) or through fillet nourishment/construction and maintenance, wave processes transport sand around and over the groins into the tidal inlet. The same sand by-passing action would also affect the movement of estuarine dependent larval forms thereby reducing any impacts to numerous species. As stated in thte 2010 Terminal Groin Report for the CRC, "In terms of larval transport, a terminal groin may reduce unrestricted access into inlet systems" (NCDENR, 2010). However, the report also states "As noted in the Physical Assessment Section, once a beach protrudes to near the end of the structure, either by natural longshore transport or through beach nourishment, wave processes transport sand around and over the groins into the tidal inlet. The same sand by-passing action would also affect the by-pass of estuarine dependent larval forms" (NCDENR, 2010).
29	Hardened structures can change the littoral flow of sediments, modify sediment grain size, narrow and steepen adjacent beaches, resulting in a reduction of intertidal habitat.	Shane Staples, NC DCM Fisheries Resource Specialist	Sediment transport	Chapter 3, Alternative 5.	As stated in Chapter 3 of the EIS, the purpose of a terminal groin on the east end of Ocean Isle Beach would be to create a permanent accretion fillet west of the structure. This would be accomplished by controlling tide induced or influenced sediment transport off the extreme east end of the island. The resulting position and alignment of the shoreline within the accretion fillet would mimic that of the shoreline immediately to the west. The elimination or reduction in tide induced sediment transport off the extreme east end of the island should improve the performance and longevity of beach fill placed east of Shallotte Boulevard as well as the performance of a portion of the federal storm damage reduction project that extends west of Shallotte Boulevard. Since wave induced sediment transport (i.e., littoral sand transport) would still be in play, erosion will continue to be a management issue for the shorelines lying outside the direct influence of the terminal groin. No information has supported the notion that the resulting adjacent beaches will be steeper than under natural conditions following the installation of the proposed terminal groin.
30	Were the project to move forward, the fisheries moratorium for dredging is April 1 - Sept. 20 in order to protect fish during a season critical to spawning success and larval/juvenile recruitment.	Shane Staples, NC DCM Fisheries Resource Specialist	Larval recruitment	N/A	Noted. The proposed construction timeframe included in the EIS is from Nov. 15 through April 30.
31	Data has been provided regarding records for rare species and conservation/managed area as well as natural heritage resources within the vicinity of the project area (Permit Area).	NC Natural Heritage Program	Threatened and endangered species	Chapter 4, Areas of Environmental Concern, and Table 4.3	A table listing the Federal and State listed species found or have the potential to be found within the Permit Area is included in Table 4.3 of the EIS and includes species recommented by NCNHP. Also, a description of the natural heritage area site, Brantley Island, has been included in Chapter 4.
32	Potenital to cause a localized increase in bacteria concentrations within the waters surrounding the project which could impact recreational swimmers should dredging continue past April 1.	NC Shellfish Sanitation	Water quality	N/A	Noted. The swimming season will be avoided to maximum extent practicable for nourishment. Water temperatures within the Permit Area are typically below 70 degrees in the month of April and, as such, recreational swimming will still be limited compared to the summer time.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

33	44 CFR 60.3.e prohibits man-made alteration of sand dunes and mangrove stands within Zones V1-30, VE, and V on the communities FIRM which would increase potential flood damage. Grading activity within one of these zones shall be accompanied by a hydraulic study to assure there will be no increase in flood damage potential.	NC Dept. of Public Safety, Division of Emergency Management Risk Management	Public safety	N/A	Aside from the construction of the sheetpile component of the proposed terminal groin, project alternatives do not include alteration of sand dunes or mangrove stands, which are not present in North Carolina. The sheetpile component of the terminal groin will temporarily impact the dunes within it's footprint, however, this area will be restored following construction. The project is not expected to increase the flood damage potential from what is currently authorized under the existing federal project. As stated in the EIS, "The rubble mound portion of the groin will have a maximum crest elevation of +4.9 feet NAVD. Considering that the beach fill associated with Alternative 5 will be constructed to +6 feet NAVD, thus much of the groin will be constructed below grade and, therefore, would not impose a public safety concern for individuals".
34	One of the conclusions of the NC CRC terminal groin study was that "under particular conditions, it may be possible to limit adverse effects with terminal structures without detrimental effects to the adjacent shorelines". This conclusion should send a message that a terminal groin is a very bad idea.	Richard Hilderman	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1.
35	Science has clearly demonstrated that terminal groins will temporarily stop erosion behind the groin but will trigger erosion on the other side of the groin. All one has to do is look at photos of the coasts of NJ and FL to see that once a single groin is put into place this will trigger cascade effect of additional groins.	Richard Hilderman	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	The referenced photos depict groin fields, not a terminal groin, and therefore do not offer a representative comparison to the proposed project in Alternative #5. Any potential downdrift effects would occur on the east side of the groin as the sediment transport in proximity to the inlet is from west to east. The engineering analysis does not support any substantial effects to adjacent shorelines in response to Alternative #5.
36	Termninal groins are a short term fix and the cost of ecological damage to the inlet and to fisherman can't be estimated at this time.	Richard Hilderman	Alternative #5	N/A	Noted.
37	The Service recommends that the proposed project not be authorized. The proposed project has the potential to adversely affect nesting female sea turtles, nests, and hatchlings on the beach, piping plovers, red knots, and seabeach amaranth within the proposed project area.	USFWS	Threatened and endangered species	N/A	Noted.
38	A groin built as proposed would not solve the erosion problem and may be detrimental to the west end of Ocean Isle Beach and Sunset Beach.	Susan Boeh	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1.
39	A North Carolina resident in support of the proposed terminal groin	John Rakoci	Alternative #5	N/A	Noted.
40	Resident of Sunset Beach in opposition of the proposed terminal groin as it would result in downstream erosion.	Gerald V. Otteni	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area.
41	Any harm resulting in the construction of the terminal groin should be paid for by the Town of Ocean Isle Beach	Gerald V. Otteni	Economics	Chapter 6	The Town of Ocean Isle Beach will be responsible for monitoring the perfomrance of the terminal groin and implementing mitigation measures deemed necessary to correct any documented negative impacts. Mitigation measures could include modification to the terminal groin to improve sedment movement past the structure, placement of beach fill along negatively impacted areas, or complete removal of the terminal groin should mitigation measures not adequately address the issue. The State CAMA permit requires financial assurances as well.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

42	Resident of Sunset Beach in opposition of the proposed terminal groin as it would result in downstream erosion.	Nina Marable	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area.
43	Sunset Beach must be included in the area to be monitored and must receive mitigation attention to minimize damage or erosion	Nina Marable	Monitoring	N/A	As stated in the DEIS, downdrift effects are not anticiapted on Sunset Beach and therefore monitoring along that shoreline would not be required.
44	Supports the construction of the proposed terminal groin	Arley Webb	Alternative #5	N/A	Noted.
45	Supports the construction of the proposed terminal groin	Robert C. Borden	Alternative #5	N/A	Noted.
46	The modeling does not accurately predict the results of the project downstream from Ocean Isle Beach.	Sam Swanson	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area.
47	The modeling fails to report results for the channel realignment option.	Sam Swanson	Alternative #4	Chapter 3, Alternative 3	The USACE incorporated a newly aligned channel in Shallotte Inlet as a feature of the federal storm damage reduction project, therefore, the model results obtained for the existing or no action alternative represented the channel realignment alternative (Alternative 4). Accordingly, model tests specifically for the channel realignment alternative would have been redundant. As explained in the Engineering Appendix of the DEIS, subsequent dredging of the Shallotte Inlet borrow area did not follow a designated channel corridor, rather, the USACE removed material from various locations within the borrow area needed to satisfy beach nourishment requirements. As a result, flow across the ebb tide delta was not concentrated along a preferred channel corridor. Alternative 4 would modify the periodic nourishment operation by requiring material be removed from a designated channel corridor located near the west boundary of the existing borrow area with an alignment parallel to the west boundary of the existing borrow area. Since the release of the DEIS, additional modeling has been conducted for Alternative 4 and suggeststs that the projected the fill along the east end would need to be re-nourished every 3 years following the initial 2 year adjustment period.
48	The aesthetics of placing the rock rubble structure on the sand is not discussed. Rocks will create a hazard to people using the beach.	Sam Swanson	Aesthetics	Chatper 5, E: impacts Associated with Alternative 5, section entitled "Aesthetics" and "Public Safety"	As stated in the DEIS impacts assoicated with Alternative 5 under the section entitled, "Public Safety", the top of the landward most portion of the shore anchorage section would be below the existing ground level and therefore would not pose a threat to public safety. Text has been amended to include, "The rubble mound portion of the groin will have a maximum crest elevation of +4.9 feet NAVD. Considering that the beach fill associated with Alternative 5 will be constructed to +6 feet NAVD, the much of the groin will be constructed below grade and, therefore, would not impose a public safety concern for individuals". It was also previously stated that in addition, a U.S. Coast Guard approved navigation aid consisting of a three-pile dolphin and light, may be installed at the seaward end of the terminal groin. This will reduce the chance of the structure becoming a navigational hazard to vessels. We have also inserted additional figures in Chapter 3 that depict the cross-sectional view of the terminal groin and the profile of the nourished beach.
49	This project offers a benefit to only a few people at a cost to many with no gaurantee the project will work.	Sam Swanson	Economics	N/A	Noted.
50	Stongly opposes the construction of the terminal groin based on several factors including their interpretation of the findings of the NC CRC report on terminal groins, photos of the NJ and FL coastline, and rising sea levels.	Jay and Mary Ann Klompmaker	Alternative #5	N/A	Noted.
51	Resident of Sunset Beach in opposition of the proposed terminal groin as it would result in downstream erosion.	Gregory and Ann Jensen	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area.

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52	Supports the construction of the proposed terminal groin	Delbert Bowen	Alternative #5	N/A	Noted.
53	Supports the construction of the proposed terminal groin	Roge and Valerie Brafford	Alternative #5	N/A	Noted.
54	Supports the construction of the proposed terminal groin	Linda and Steve Reinhalter	Alternative #5	N/A	Noted.
55	Supports the construction of the proposed terminal groin	Bill and Glenda Browning	Alternative #5	N/A	Noted.
56	The EIS does not address any potential impacts or mitigation on islands or properties immediately down-drift from this project, including the western end of Ocean Isle Beach, the island of Sunset Beach, and Bird Island.	David A. Eastburn	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Noted. Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area.
57	Supports the comments previously made by Sunset Beach and by Sunset Beach resident Jan Harris relating to the monitoring and mitigation aspects of this project.	David A. Eastburn	Monitoring	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Because terminal groin-induced impacts are not anticipated to occur on Sunset Beach, no monitoring or mitigation would be required along that barrier island.
58	Supports the commnets made previously by Jan Harris of Sunset Beach relating	David A. Eastburn	General	N/A	Noted.
59	The EIS made no consideration given to property ownership. It should be pointed out that the vast majority of property that stands to gain the most benefit from this project is controlled or owned by one family- the Odell Williamson Family, it's trusts and heirs.	David A. Eastburn	Property ownership	N/A	One of the stated purpose and needs of the proposed project is to preserve the Town's tax base. Satisfying this goal is not contrained by who may own a piece of property that would receive a direct or indirect benefit from the project. Any decision to implement a project to protect the east end of Ocean Isle Beach will be made by the Town Board of Commissioners after receiving imput from property owners on Ocean Isle Beach.
60	The erosion on the east end of Ocean Isle Beach is due to the very-well documented mining of sediments from the tidal delta to apptempt to protect the houses built at the very eastern tip of OIB especially during the passage of winter storms.	Len Pietrafesa	General	Chapter 3, Alternative 1: No Action	As stated in Chapter 3 of the EIS, "a Federal storm damage reduction project was constructed along 17,100 feet of the Town's shoreline west of Shallotte Boulevard between March 10 and May 7, 2001." This project does not serve to protect the homes east of the fill area. In fact, the high rate of erosion occurring east of Shallotte Boulevard during the time the project was being formulated was the primary reason the USACE did not inlcude the extreme east end of Ocean Isle Beach in the federal project as periodic nourishment requirments along this section of the beach would not meet the USACE standards for justifying federal protection of the area.
61	The advocates of the groin at OIB are real estate developers and owners and their town council representatives, especially the mayor.	Len Pietrafesa	Economics	N/A	Noted.
62	The implications of the groin is that following the damage due to the proposed groin there could be two more groins in the future- one at the pier and one at Tubbs Inlet.	Len Pietrafesa	General	Chapter 1- Introduction	As stated in the EIS, This proposed terminal groin is one of four such structures approved by the General Assembly to be constructed in North Carolina following passing of Senate Bill (SB) 110. As such, groins located neart the peir or any other location aside from the terminus of an island would be considered illegal. A terminal groin at Tubbs Inlet would be considered to be legal, however. At this time, the Town of Ocean Isle Beach has no plans for consideration of any type of additional hard erosion control structure for its shoreline. The area west of the federal project has been relatively stable, however, the Town is considering options for possible increased storm damage protection for the area through the implementation of a beach nourishment program that would extend the beach fill area west to Tubbs Inlet.
63	The recruitment of marsh and inshore nurservy dependent finfish could be greatly altered and reduced by the imposition of the groin.	Len Pietrafesa	Fish ingress	Chapter 4, Larval Transport, Chapter 5- Alternative 5: Water Column (Larval Transport)	It is stated in Chapter 4 that the mass of flowing water flowing in and out of the inlet during tidal exchange acts as a conduit for larvae found within the water column in proximity to the inlet. Settle et al. (2005) estimated that the larval fish concentrations in proximity to Bogue Inlet ranged throughout the water column between 0.5 and 5.0 larvae per cubic meter. Assuming that there is similar larval concentration in proximity to Shallotte Inlet, Shallotte Inlet would also serve as an important pathway for numerous species of zooplankton into the estuary. The impacts to larval transport into Shallotte Inlet in response to the constrcution of the terminal groin are discussed in Chapter 5: Alternative 5: Water Column (lLarval Transport). Specifically, it cites the CEC Terminal Groin Study which states "As noted in the Physical Assessment Section, once a beach protrudes to near the end of the structure, either by natural longshore transport or through beach nourishment, wave processes transport sand around and over the groins into the tidal inlet. The same sand by-passing action would also affect the by-pass of estuarine dependent larval forms" (NCDENR, 2010). Also cited is the Olsen Associate, Inc. numerical model study that investigated larval transport off Bald Head Island in response to thier proposed terminal groin which would result in minimal impacts associated with larval transport. This has also been addressed under the EFH and BA documents.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

64	Moving the 30 at risk homes to the northwest on the island would cost $5,000,000.	Len Pietrafesa	Economics	Appendix B, Table 4.2	An assessment of the economic impact of Alternatives 1 and 2, both of which included relocation and/or demolishion of threatened structures, is provided in Engineering Report (Appendix B) of the DEIS. For Alternative 1, which includes continuation of existing erosion response measures (sandbags), the economic costs over thirty years would be over $35.1 million. For Alternative 2, which would eliminate the use of temporary sandbags and simply move or demolish threatend homes, the total cost over 30 years would be about $29.6 million.
65	The cost of groin installation and ensuing downstream beach maintenance which has been shown to occur by groin induced beach destruction at Pea Island, Fort Macon, and other locations has cost at least $1.6M/year and will cost a total of $26M over the next 10 years.	Len Pietrafesa	Economics	N/A	Noted. The Fort Macon project was originally formualted to include beach nourishment. However, the need for periodic nourishment of the Fort Macon State Park shoreline was eliminated when material from maintenance of the federal navigation channels connecting to Morehead City Harbor began to be routinely deposited along the shoreline west of the Fort Macon terminal groin. Similarly, the material deposited on Pea Island following the construction of the terminal groin was a continuation of the agreement between the USACE and the US Fish & Wildlife Service which was implemented before construction of the terminal groin. In this agreement, the USACE would retun all of the Oregon Inlet channel maintenance material to the littoral zone along the north end of Pea Island. This has been done at no additional cost to the State of North Carolina which constructed the terminal groin. Channel maintenance material has been deposited on Pea Island using cutter-suction pipeline dredges which place material directly on the shoreline with the majority of the dredged material placed in the nearshore using split hull hopper dredges. After over 24 years since its completion, the monitoring of the Pea Island shoreline has only shown positive impacts along the shoreline south of the structure. Shallotte inlet is not a Federal Navigation Channel, as are the other two. The maintenance interval proposed is every 5 years under the Preferred alternative.
66	The applcant is urged to build an experimental "artifical oyster or alternative critter reef" on the east end of Ocean Isle Beach.	Len Pietrafesa	Alternative #5	N/A	Noted.
67	A letter written by NC State's Dr. Len Pietrafesa citing potential downdrift affects from the proposed terminal groin on Ocean Isle Beach isn not based on site specific modeling	Dean Walters	Downdrift effects	N/A	Noted.
68	A letter wrtten by Dr. Robert Borsten, registered PE and Prof. Emeritus at NC State, stated that "...after studying the EIS, the construction of a terminal groin will have substantial benefits to the Town and I largely support the proposed application".	Dean Walters	Alternative #5	N/A	Noted.
69	Based on the modeling in the EIS, the proposed terminal groin shows no different affect on Holden Beach, mid-island of Ocean Isle Beach, and Sunset Beach.	Dean Walters	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	As stated in Chapter 3 of the EIS, the purpose of a terminal groin on the east end of Ocean Isle Beach would be to create a permanent accretion fillet west of the structure. This would be accomplished by controlling tide induced or influenced sediment transport off the extreme east end of the island. The resulting position and alignment of the shoreline within the accretion fillet would mimic that of the shoreline immediately to the west. The elimination or reduction in tide induced sediment transport off the extreme east end of the island should improve the performance and longevity of beach fill placed east of Shallotte Boulevard as well as the performance of a portion of the federal storm damage reduction project that extends west of Shallotte Boulevard. Since wave induced sediment transport (i.e., littoral sand transport) would still be in play, erosion will continue to be a management issue for the shorelines lying outside the direct influence of the terminal groin. No information has supported the notion that the resulting adjacent beaches will be steeper than under natural conditions following the installation of the proposed terminal groin.
70	Science has proven that the terminal groin alternative is a viable tool in stabilizing our shoreline and asks for the approval of the required permits.	Dean Walters	General	N/A	Noted.
71	SB110 was amended by SB151 in 2013 and set out several requirements that must be met before a CAMA permit can be issued.	NC DCM	Terminal Groin Legislation	Chapter 1- Introduction	Text amended to include, "SB110 was amended by Senate Bill 151 (SB151) in 2013 and set forth additional stipulations that must be met prior to the issuance of State of North Carolina permits".
72	How will construction of a terminal groin, coupled with current beach management practices change the factors that currently affect chronic erosion (i.e. flood channels that have formed close to the OIB shoreline, ebb tide delta located further east, etc.) east of Shallotte Blvd.?	NC DCM	Alternative #5	Chatper 3, Alternative 5.	The factors that currently affect the chronic erosion will not change (i.e. the flood channels will still carry sediment into the inlet from the OIB shoreline and as long as the channel remains in it's current position, the ebb tide delta will not afford protection from wave attack on the east end of OIB. However, as stated in Chapter 3, elimination or reduction in tide induced sediment transport off the extreme east end of the island should improve the performance and longevity of beach fill placed east of Shallotte Boulevard as well as the performance of a portion of the federal storm damage reduction project that extends west of Shallotte Boulevard. Since wave induced sediment transport (i.e., littoral sand transport) would still be in play, erosion will continue to be a management issue for the shorelines lying outside the direct influence of the terminal groin.

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73	Please provide additional information on the overlapping of currently approved projects that authorize the placement of sand east and west of Shallotte Blvd. (USACE Navigartion Project, USACE placement template, USACE CSDR project, and CAMA Major Permit #91-05 issued to OIB). Inlcude the frequency of these events and volumes of materials associated with each project.	NC DCM	General	Chapter 3, Alternative 1.	The January 2007 OIB project that placed 155,000 cubic yards of fill between baseline stations -3+00 to 17+00 under CAMA permit #91-05 was a one-time operation. Due to the failure of the beach fill to provide any long-term shoreline protection, the Town of Ocean Isle Beach has opted not to attempt beach nourishment in this area as a stand alone project. The federal storm damage reduction project, which covers 17,100 feet of shoreline from Shallotte Boulevard (station 10+00) west to Dunside Dr. (station 18,100), was initially consructed in 2001 and has been nourished on three separate occassions, 2006-07, 2010, and 2013. In general, the three periodic nourishment operations have been limited to the shoreline from Shallotte Boulevard west to baseline station 120+00. The project west of 120+00 has not needed any nouishment to maintain the authorized beach fill design template. Thus, the only overlap of the Town's non-federal beach nourishment effort and that of the federal storm damage reduction project was the one-time occurrence when material from both efforts was placed between baseline stations 10+00 and 17+00. Inserted the following language under Alternative 1 in Chapter 3: "In addition to the construction of the sandbag revetment, the Town placed 155,000 cubic yards of material between stations -3+00 and 17+00 in 2007 under CAMA permit #91-05. The area between 10+00 and 17+00 overlaps with the Federal project. Due to the failure of this locally funded nourishment project to provide any long-term shoreline protection along the east end of the island, the Town has opted not to attempt beach nourishment as a stand-alone project within this area again."
74	It appears that not all alternatives were analyzed wth the same or simialr levels of detail. It is suggested that the DEIS be re-examined to ensure that similar information is provided for each alternative	NC DCM	Alternatives Analsysis	Various locations	All alternatives were evaluated using similar levels of detail. The model simulation used to evaluate Alternative 2 was also applicable to Alternative 1 since the only differences between the two alternatives in terms of man-made shoreline response measures was the use of sandbags or in the case of Alternative 2, the non use of sandbags, as a temporary erosion response measure. All other features of these two alternatives are the same, i.e., the federal storm damage reduction project would continue to be nourished using material from the Shallotte Inlet Borrow area. The performance of the beach fill under Alternative 3, the beach fill only alternatives, was also modeled to the same degree as Alternative 2. Alternative 4, which included realignment of the channel, was represented by the results for Alternative 2 which included the USACE borrow area through the middle of Shallotte Inlet. Additional modeling for Alt. 4 has been conducted and the results of the modeling are presented in detail in Chapter 5..... All of the terminal groin options evaluated for Alternative 5 were modeled under the same model input conditions as used for the other alternatives. With regard to economic impacts, the costs for all of the alternatives were computed over the 30-year planning period with equivalent average annual costs presented for each.
75	The document indicates that periodic nourishment was to occur approximately every three years following the initial storm damage reduction project in 2001, which would have triggered the nourishment event in 2004; however, it was decided that the “project performed so well” that nourishment would not be necessary until 6 years after the initial project (Ocean Isle Beach, NC Static Line Exception Progress Report, 2014). This information from the 2014 Static Line Exception Report is not mentioned in this section of the DEIS, which only notes the chronic erosion and that beach nourishment alone will not fix the problem. Additionally, the DEIS indicated that a portion of the project area did not receive sand in 2010, because of the “poor performance of the fill palced east of Station 10+00 in January 2007”. Please address why this portion of the project performed well after the 2001 event, and then very poorly after the 2007 project.	NC DCM	General	Chapter 3, Alternative 1.	The static line exception report was prepared by the Town of Ocean Isle Beach. While most portion of the federal project west of station 30+00 performed reasonably well following initial construction in 2001, project performance was not the only factor that postponed the first nourishment until 2006-2007 as there were also federal and state funding issues and a poor dredging climate due to the impacts of 2004 hurricanes in the State of Florida. The decision not to place sand east of station 10+00, which lies outside the authorized limits of the federal project, was a local decision and was based on the rapid loss of the fill placed in the are by the Town of Ocean Isle Beach in January 2007. With regard to the performance of the federal project following each periodic nourishment operation, Figures 3.5 to 3.7 in the Engineering Report (Appendix B) shows losses from the fill area east of station 30+00 ranged from approximately 25 cy/lf/yr to 45 cy/lf/yr after each operation. Comparison of these three figures does not indicate any impoved performace of the fill along the east end of the federal project. The reference to "poor performance" was only made with regard to the area east of Shallotte Boulevard that was nourished by the Town in 2007. The following language was inserted into Chapter 3, Alternative 1: "Since initial construction, Ocean Isle Beach has been nourished three times. Although the maintenance of this project was scheduled to be constructed on a 3-year cycle following the initial construction in 2001, the performance of the project was better than anticipated and allowed for a delay in the implementation of the first maintenance event (Ocean Isle Beach, NC Static Line Exception Progress Report, 2014)."
76	The DEIS states the total economic cost for Alternative 1, over a 30 year period, to be $101.49 million. Of this $101.48 million, it is stated the Federal government share of the Federal nourishment project is $43.19 million. Would this not make the total economic cost to the Town of Ocean Isle Beach $58.29 million?	NC DCM	Economics	Chapter 3, Alternative 1	The balance of the $101.55 million is supported by non-federal interests, including the Town of Ocean Isle Beach and the State of North Carolina
77	Please specify whether the $1.6 million loss in estimated appraised value since 2005 includes only the five (5) homes, or the homes plus a number of the 20-25 buildable parcels.	NC DCM	Economics	Chapter 3, Alternative 1	The estimated appraised value of the lost homes and parcels since 2005 totals approximately $1.6 million
78	Table 3.1: Please verify that the cost/loss for each item is counted only once; for example, “sandbags” and “public/beach accesses” are mentioned multiple times.	NC DCM	Economics	Chapter 3, Alternative 1	Table 3.1 is a list of damages/cost the Town of Ocean Isle Beach actually experienced since 2004. There are no duplications in the table. This table was provided for information purposes and was not used in determining future long-term damages.

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79	The statement that 45 houses and 238 parcels would be lost within the next 30 years assumes that sandbag revetments would fail completely and permanently after five years; that storm damage reduction projects would be ineffective for mitigating erosion; and that all of the houses and parcels would be completely and permanently lost or need to be relocated. What is the basis for stating none of these above mitigation measures will protect these parcels and homes? Additionally, a cursory review of available GIS data appears to show that a significant portion of the 238 parcels may in fact be currently either fully or partially submerged. The document should be revised to clearly separate highground parcels from submerged parcels that may now lie within public ownership. The various economic analysis's contained in the document should also be changed to reflect any changes in this information.	NC DCM	Economics	Appendix B, Table 4.2 and 4.5	Table 4.2 in Appendix B has been amended. The number of parcels having a value greater than $2,000 is 156. Parcels with a value less than $2000 are non-conforming parcels and will be excluded from the summary table and the EIS will be modified accordingly. The reference to 45 houses is correct. The assumption that sandbag revetments would only have an effective life of 5-years was based on the actual performance of sandbag revetments previously installed in the area. This is discussed in some detail in the Engineering Report and demonstrated on Figure 3.4 in the Engineering Report (Appendix B). The section of the area included in the analysis of future losses either is not included in the federal storm damage reduction project (i.e., its lies east of station 10+00) or lies in an area where the federal project has not performed well, essentially the area between station 15+00 and 10+00.
80	Based on the one-third relocation assumption, the average value of each of the fifteen (15) relocated homes would be $86,667. Please verify that this is an appropriate valuation.	NC DCM	Economics	N/A	The average value of the moved structures is correct. The average value of the 30 structures assumed to be demolished is $96,193.
81	The total economic cost for Alternative 2 includes the Federal portions of the project cost and should only include the total economic cost to the Town of Ocean Isle Beach.	NC DCM	Economics	N/A	When presenting the cost of the other alternatives that include continuation of the federal project, the total cost of the federal project is included in the total cost of that alternative. Therefore, the total cost of the federal project is the appropriate vlaue to use for Alternative 2.
82	The statement that the same homes and infrastructure damaged under Alternative 1 within 30 years would also be damaged under Alternative 2 repeats the assumption that sandbag revetments will be entirely ineffective over this period. What is the basis for this assertion?	NC DCM	Economics	N/A	Following the progression of the movement of the erosion scarp under Alternative 2 vs. Alternative 1, the only difference in the economic impact is when the structures would be lost. That is, with Alternative 1, there would be a 5 year delay in the ultimate demise of a structure but it would eventually be lost during the 30-year analysis period. The only difference in the average annual cost of Alternative 1 vs. Alternative 2 is in the equivalent average annual cost which is affected by the timing of when certain structures would be lost and the reduced cost for Alternative 2 associated with not using sandbags to delay the eventual loss of a structure.
83	According to the Delft3D model , the volumetric losses from a beach fill project (east of station 30+00) would be expected to erode a rate of 140,000 cubic yards/year as stated on Page 29. On pages 38-39, reference is made that there is very little difference between Alternative 1 and Alternative 5 in terms of impacting volume changes above -6' NAVD depth contour along the western end of Holden Beach, indicating that the results were within the accuracy of the model, thus suggesting no difference in the response on the west end of Holden Beach. Given that forces influencing sediment transport will remain in place, with or without a terminal groin structure, please explain how volume changes along the western end of Holden Beach remain relatively the same before and after construction of the project? Would it not be the case that the accretional side (west) of the structure would benefit, but the downdrift side (east) would lose material gained from littoral transport?	NC DCM	Downdrift effects	Chapter 5	The following text has been added to Chapter 5: The area west of the terminal groin (the accretion fillet) would be artificially filled which would be conducive to the continued movement of littoral sediment to the east past the structure. As a result of the artificial creation of the fillet and the movement of material to the east through, over, and around the terminal groin, the terminal groin should not have an impact on the west end of Holden Beach. Under existing conditions, the west end of Holden Beach is separated from the east end of Ocean Isle Beach by the borrow area in Shallotte Inlet which is dredged to a depth of 15 to 18 feet below NAVD. The sediment trap and the behavior of the inlet would have a much greater influence on the ability of littoral sediment to move from west to east across the inlet compared to the relatively minor changes in sediment transport patterns associated with the terminal groin.
84	In reference to the three terminal groin schematics generated by the Delft3D model used to assess the impacts of the proposed options (250, 500, and 750 ft.), the only visible difference is there is more material in the area of the terminal groin fillet (west side of structure, or updrift side), and the model does not predict any negative effects (erosion) east of the structure (downdrift side). On page 37 it is stated that "differences in the response of the model relative to Alternative 1 could be attributed to the structures and their accompanying beach fill." The model output images illustrate this, but how likely is it that there would not be a negative impact in some location?	NC DCM	Numerical Model	Chapter 6, Inlet Management Plan, Sand Spit section	The inlet management plan takes this uncertainty into account and establishes a threshold for the size of the sand spit east of the groin. Should the sand spit reduce in size to the threshold size, mitigative measures woud be take to increase the rate of sediment movement to the east past the structure. In addition to possibly modifying the structure to increase movement to the east past the structure, nourishment of the spit would be an option.
85	What is meant by, "The resulting position and alignment of the shoreline within the accretion fillet would mimic that of the shoreline immediately to the west"?	NC DCM	Alternative #5	Chapter 3, Alternative 5.	This statement is intended to suggest that the shoreline, once modified by the terminal groin and beach fill, would extend the existing shoreline seaward and follow the same tangent of the shoreline to the west of the fillet.
86	The statement "Since wave induced sediment transport (i.e., littoral sand transport) would still be in play, erosion will continue to be a management issue for the shorelines lying outside the direct influence of the terminal groin." implies that shorelines lying within the direct influence of the terminal groin will not be subject to erosion. Please clarify whether this is the intended claim.	NC DCM	Alternative #5	Chapter 3, Alternative 5.	Inserted the following language: The shoreline directly adjacent and in proximity to the proposed terminal groin would, however, be relatively stabilized due to the protection afforded by the structure.
87	Although it is stated in the preceding narrative, for ease of comparison it would be helpful to include nourishment requirements for Alternative 1 in Table 3.5.	NC DCM	Alternative #5	Chapter 3, Alternative 5.	It is important to keep in mind that Table 3.5 depicts the fill that incorporates the terminal groin fillet (from base station 0+00 to 30+00 AND the federal CSDR project that extends to Station 120+00 and, therefore, including the nourishment requirement for Alternative 1 would not be an accurate comparison. It should be noted, however, that it is stated two sentences below Table 3.5 that "Since the past, nourishment operations have placed an average of 408,000 cubic yards on Ocean Isle Beach every three years, the target volume for nourishment operation for the three (3) terminal groin options was set to be equal to or less than 408,000 cubic yards per operation."
88	In paragraph 3, when comparing the modeling for the different size terminal groins and the results indicating a relatively stable beach, please use the same measurement increments for comparison. In one instance the modeling results are expressed in feet, in the other, the modeling results are referenced against survey stations.	NC DCM	Alternative #5	Chapter 3, Alternative 5.	Inlcuded the use of survey station numbers where applicable.

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89	While the total volume of sediment required under the 500-foot and 750-foot terminal groin options are claimed to allow a less frequent nourishment interval, the stated volumes are cumulative over the entire beach strand from the terminal groin to station 120+00. It is also stated that nourishment requirements are only reduced from the terminal groin to station 30+00. No claims are made as to the potential impacts or feasibility of increasing the nourishment interval specifically between stations 30+00 and 120+00 which would see no reduced nourishment requirements from any of the terminal groin alternatives. Is it anticipated that there could be potential impacts or a feasibility of an increased nourishment interval between stations 30+00 and 120+00?	NC DCM	Alternative #5	Chapter 3, Alternative 5.	The increased nourishment interval as a result of constructing the terminal groin options would address the entire fill area (terminal groin to 120+00), not just the area between the terminal groin and 30+00. Text on page 39 has been ameneded to read "The reduction in periodic nourishment requirements, particularly for the 500-foot and 750-foot terminal groin options, provides an opportunity to increase the time interval between nourishment operations from the location of the proposed terminal groin to station 120+00."
90	The impacts of losing the ability to combine contracts with Wrightsville Beach, Masonboro Inlet, Carolina Beach and Kure Beach are not adequately addressed. The claim that "the potential cost savings for extending the nourishment interval would offset most of if not all of the cost impacts" is not substantiated. These impacts should be quantified with assumptions clearly stated. Potential nourishment schedules, showing the years in which combined contracts are possible, would be helpful.	NC DCM	Alternative #5	N/A	The combination of nourishment operations for Wrightsville Beach, Carolina Beach, Kure Beach, and Ocean Isle Beach along with the sand bypassing at Masonboro Inlet was done by the USACE in 2009 to encourage more dredging companies to bid on the projects. The combination of the projects into one contract did not necessarily result in any substantial cost savings for any individual project. For example, the total cost of mobilization and demobilization in the 2009-10 contract for all 5 projects was $6.5 million. Allocation of the mob-demob cost based on the fill volume for each project would suggest the mob-demob costs for Ocean Isle Beach would have been around $1.7 million. Inflating this cost to 2016 at a rate of 3%/year would result in a mob-demob cost of about $2.1 million. The cost estimates for mob-demob for Alternative 5 in the DEIS is $2.5 million. In this regard, all cost estimates for the alternatives assumed the project would be bid as stand-alone projects, i.e., the cost did not assume combining the Ocean Isle porject with any other project. The discussion of the impacts of not being able to combine the projects into one contract will be clarified in the EIS to reflect the real intent of combining the projects, i.e., to encourage a more dredge companies to bid on the total package.
91	The source of the maintenance cost estimates should be stated.	NC DCM	Economics	Chapter 3, Alternative 5.	The maintenance cost for the terminal groin options was based on the assumption an average of 1% of the armor stone would have to be replaced or repaired every year. However, as stated on page 41 of Chapter 3, these costs would not necessarily occur every year but that over the 30-year analysis period, the average annual equivalent cost for termimal groin repair would be associated with replacing or repariing 1% of the stone. The explanation of the 1% /year damage cost has been added to the EIS on page 41 of Chapter 3.
92	Please specify whether the stated periodic nourishment costs are based on combined contracts with other municipalities, and if not, provide the differential cost estimates	NC DCM	Economics	Chapter 3, Alternative 5.	The cost estimates in the DEIS were based on stand-alone projects not the combination of multiple projects as was done by the USACE in 2009-10. This has been clairified in Chapter 3 in the EIS
93	No claim is made as to how a terminal groin would perform relative to the 45 houses and 238 parcels that are would be lost within the next 30 years under the other alternatives.	NC DCM	Alternative #5	Chapter 3, Alternative 5.	The economic impact of the terminal groin alternative as well as the other alternatives involving beach fill is implied in Table 3.11 of Chapter 3 which indicates long-term erosion damage would be $0. None of the alternatives were evaluated for their ability to reduce storm damages.
94	No claim is made as to whether sandbag revetments would be required or anticipated in the project area following completion of the terminal groin.	NC DCM	Alternative #5	Chapter 3, Alternative 5.	Under Alternative 5, the applicant's preferred alternative, a 750 feet terminal groin with beach fill would be constructed 148 feet east of baseline station 0+00. This structure is intended to provide shoreline stabilization and would serve to reduce the erosion rate further west thereby reducing the nourishment interval of the Federal project from every 3 years to every 5 years and relieve the necessity of sandbag revetments within the project area.
95	Please provide information on existing sandbags within the project area.	NC DCM	Sandbags	Chapter 3, Alternative 1.	As stated in Chapter 3, "Additional erosion response measures undertaken by the Town on the east end include placement of a sandbag revetment along 1,400 feet of shoreline, beginning at a point west of Shallotte Boulevard and extending east to the end of development. This revetment was installed around 2005. The sandbag revetment has recently been extended 400 feet to the west or just past Charlotte Street. Some of the recent sandbag placement was accomplished by NCDOT in an attempt to protect the eastern end of 2nd Street."
96	Table 3.10 and 3.11 should be updated to remove any cost to be paid by the Federal government.	NC DCM	Economics	Chapter 3, Alternative 5.	A primary feature of Alternative 5 would be its impact of periodic nourishment of the federal project. Periodic nourishment of the federal project constitutes a real cost to both the local sponsor and the federal government. By implementing Alternative 5, the costs to both entities would be reduced whereas the other Alternatives involving beach fill and periodic nourishment do not have this same impact. Therefore in order to present the total economic impact of all of the alternatives considered, inclusion of both federal and not-federal costs over the 30-year planning period is imperative.
97	The DEIS states that the large armor stone will have spaces large enough to facilitate along-shore transport of both sediment and larval fish. It is requested that additional information be provided which explores potential impacts to larval fish movement through Shallotte Inlet.	NC DCM	Larval transport	Chapter 5, Alternative 5- Larval Transport	The impacts to larval transport into Shallotte Inlet in response to the construcution of the terminal groin are discussed in Chapter 5: Alternative 5: Water Column (lLarval Transport). Specifically, it cites the CEC Terminal Groin Study which states "As noted in the Physical Assessment Section, once a beach protrudes to near the end of the structure, either by natural longshore transport or through beach nourishment, wave processes transport sand around and over the groins into the tidal inlet. The same sand by-passing action would also affect the by-pass of estuarine dependent larval forms" (NCDENR, 2010). Also cited is the Olsen Associate, Inc. numerical model study that investigated larval transport off Bald Head Island in response to thier proposed terminal groin which would result in minimal impacts associated with larval transport.
98	Information is requested as to what will keep open spaces from filling with sediment which would no longer allow passage of sediment and/or fish larvae through the structure.	NC DCM	Larval transport	Chapter 5, Alternative 5- Larval Transport	Sediment and/or larvae would not be expected to pass through the structure; rather they may go over and around the structure. As stated on page 185, "Once the beach protrudes to near the end of the structure, either by natural longshore transport or through beach nourishment, wave processes transport sand around and over the groins into the tidal inlet. The same sand by-passing action would also affect the movement of estuarine dependent larval forms thereby reducing any impacts to numerous species."

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99	The DEIS refers to the environmental dredge window as November 15 – April 30. Please be aware that additional limitations necessary to protect fisheries resources may apply to dredging activities after March 31.	NC DCM	Environmental Dredge Windows	Chapter 5	Noted.
100	Senate Bill 151 (Session Law 2013-384) requires that the applicant for a terminal groin project address certain financial obligations for the project, including long-term maintenance. In order to ensure that the required financial information is provided in an acceptable fashion, the financial costs associated with the requirements of Senate Bill 151 (Session Law 2013-384) should be included in the DEIS in as detailed a manner as is possible at this stage in the project development process. The Division would therefore request more detailed cost information in the Final EIS.	NC DCM	Economics	Appendix	The Town of Ocean Isle Beach's financial assurance plan has been approved by the Secretary of the NC Department of Environment and Natural Resources. It has been included in an Appendix to the FEIS
101	With regards to verification of the final financial assurance package, 113A-115.1(e)(6) requires that a financial assurance plan be verified either by the Secretary of the Department of Environment and Natural Resources (DENR) or by the Coastal Resources Commission (CRC). DCM and the Department have taken the position that the choice of verification pathway (DENR Secretary or CRC) should fall to the discretion of the applicant. Therefore, as the financial assurance package becomes more detailed and refined, and the project moves closer to the permit application stage, the Division suggests a meeting between the Town and the Division to determine which of the two verification pathways are preferred by the Town.	NC DCM	Economics	N/A	Noted.
102	The Wildlife Resources Commission should be included in the list of agencies for which pipeline placement coordination should take place.	NC DCM	General	Chapter 6	Text has been amended to include: "In order to minimize impacts on wintering piping plover, the pipeline alignment will be designed to avoid potential piping plover wintering habitat. The alignment will be coordinated with, and approved by, the USACE, NCDCM, and the NC WRC."
103	In the paragraph labeled "escarpments", the second sentence should state, "18 inches or greater for 100 ft".	NC DCM	General	Chapter 6	Text has been ammended to include: "Visual surveys of escarpments will be made along the beach fill area immediately after completion of construction. Escarpments in the newly placed beach fill that exceed 18 inches or greater than for 100 ft shall be graded to match adjacent grades on the beach."
104	Senate Bill 151 states the permittee shall, "Define the baseline for assessing any adverse impacts and the thresholds for when adverse impacts must be mitigated." The DEIS states that no thresholds were established for the inlet due to the variable nature of the shoreline changes. DCM believes the Senate Bill 151 is explicit in stating a baseline and corresponding thresholds must be established. Please provide the baseline and thresholds to determine adverse impacts from the construction of the terminal groin at Stations 375-400 on Holden Beach and from the inlet to Station 5 on Ocean Isle Beach.	NC DCM	Monitoring	Chapter 6, Inlet Management Plan	The shoreline change threshold rates on the west end Holden Beach between stations 375 and 400 have been revised to reflect the same protocol used by the USACE to establish shoreline change thresholds for the other transects. This change results in positive or accretionary shoreline change thresholds for these stations. As for the east end of Ocean Isle Beach, as stated in the DEIS the sand spit did not exist until after the construction of the federal project in 2001. Therefore, the establishment of shoreline change thresholds based on the past history of the shoreline changes along the sand spit was not possible. As an alternative, the configuration of the sand spit as it existed in 2009 or prior to the initial construction of the federal project is being proposed as the threshold condition for the extreme east end of the island. Given the 2009 sand spit configuration, should the sand spit deminish in size to something less than what existed in 2009, mitigative measures would be evaluated. These measures would include possible nourishment of the sand spit or modification of the terminal groin to induce more sand movement to the east past the structure.
105	Potential effects to sea turtles include disorientation of hatchling turtles on beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of lighting or presence of the groin, and behavior modification of nesting females during the nesting season resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs due to escarpment formation or presence of the groin within the action area.... The presence of the groin may create a physical obstacle to nesting sea turtles, and the proposed groin is anticipated to result in decreased nesting and loss of nests that do get laid within the project area for all subsequent nesting seasons following the completion of the proposed project.	USFWS and USDOI	Sea Turtles	Chapter 5, Alternative 5- Oceanfront Dry Beach Direct Imapcts	Noted. Addressed in Chapter 5 and the Biological Assessment.
106	Potential effects to piping plover and red knots include degradation and loss of habitat, particularly down-drift of the structure. Groins can act as barriers to longshore sand transport and cause downdrift erosion (Hayes and Michel 2008), which prevents optimal habitat creation by limiting sediment deposition and accretion. The proposed action has the potential to adversely affect wintering and migrating red knots, wintering and migrating piping plovers and their habitat from all breeding populations, and breeding piping plovers from the Atlantic Coast. breeding population that may use the project area. Although the piping plover is not currently known to nest in the Action Area, the stabilization of the shoreline may also result in less suitable nesting habitat for all shorebirds, including the piping plover.	USFWS and USDOI	Shorebirds	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	Shoreline change thresholds on the west end of Holden Beach between 375 and 400 have been modify to conform with the same protocol used for the other transects. This results in positive shoreline change thresholds in this area.
107	Where hard stabilization is installed, the eventual loss of the beach and its associated habitats is virtually assured (Rice 2009), absent beach nourishment, which may also impact piping plover and red knots. Where they are maintained, hard structures are likely to significantly increase the amount of piping plover and red knot habitat lost as sea levels continue to rise.	USFWS and USDOI	Shorebirds	N/A	The erratic nature of the sand spit notwithstanding, the DEIS did establish a threshold for the sand spits.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

108	Potential impacts to seabeach amaranth include burying, trampling, or injuring plants as a result of construction operations and/or sediment disposal activities; burying seeds to a depth that would prevent future germination as a result of construction operations and/or sediment disposal activities; and, destruction of plants by trampling or breaking as a result of increased recreational activities. The Applicant proposes to place sand between November 15 and March 31 of any given year. However, given favorable weather, seabeach amaranth plants may persist until January. Therefore, there is still the potential for sand placement to adversely impact plants in the Action Area. Indirect impacts to seabeach amaranth include degradation of habitat from stabrhzaion of the shoreline.	USFWS and USDOI	Seabeach Amaranth	Chapter 5, Oceanfront Dry Beach Direct Impacts.	It is agreed that direct impacts to seabeach amaranth could occur due to the habitat reduction from construction of the terminal groin, as stated in Chapter 5 of the DEIS. However, the increased beach width and stability as a result of nourishment may compensate for this loss.
109	The Service has significant concerns for the estimation of costs of the five alternatives. In Chapters 2, 3 , 5, and 6, and Appendix A, the DEIS discusses 45 dwellings and 238 total parcels which are threatened by erosion for the next 30 years. The predicted loss or protection of these 238 parcels factors heavily in the estimated costs of each alternative. For example, on pages 27 and 28, in the discussion of the 30-year cost of Alternative 1 (No Additional Action) and Alternative 2 (Abandon/Retreat), the loss of the 238 parcels is estimated to cost $21.39 million. Conversely, the discussion of Alternative 5 (Terminal Groin with Beach Fill), the applicant's preferred alternative, makes no mention of the number of parcels that may be lost or protected by the proposed groin, and does not factor in the costs of parcel losses. However, there is no figure showing 238 parcels and very little description in the text. Page 25 states that there are "238 parcels east of station 15+00; 45 of which have homes". A quick count of the number of parcels shown in the DEIS as affected by erosion up to year 2045 (in Figure 3.1) indicates that there are approximately 88 parcels total. A review of the Town's zoning map indicated that most of the 150 parcels are likely waterward of the existing shoreline, within the footprint of the proposed project, or east of the proposed terminal groin location and are unbuildable. If this is the case, the terminal groin would not protect these parcels from erosion.	USFWS and USDOI	Economics	Appendix B, Chapter 3	Table 4.2 in Appendix B has been amended. The number of parcels in the EIS that would be impacted will be changed to 155 which will only include parcels with a stated tax value greater than $2000. Parcels with a value less than $2000 are non-conforming. The 45 homes that could be impacted is correct. While the DEIS did not state explicitly that Alternative 5 would prevent long-term erosion damage to the parcels and structures within the impact area, this was implied in Table 3.11 of Chapter 3 in which the long-term erosion damage under Alternative 5 is listed as $0. A statement will be added in the EIS to indicate Alternative 5 would eliminate all long-term erosion damages east of Shallotte Boulevard. A statement to that effect was included in the discussion of Alternative 3 but was inadvertently omitted from the discussion of Alternatives 4 and 5. The final EIS will include similar statements regarding the mitigation of long-term erosion impacts for all alternatives that include beach fill as a key component. The parcels that would be impacted by continued erosion are shown on Figure 3.1.
110	The DEIS should be revised to accurately reflect the situation of all ofthe parcels in the project area and the estimated losses for each alternative. Parcels that are mostly waterward of the current shoreline, within the footprint of the proposed groin, or east of the proposed groin should be considered a loss, and the costs of those losses should be added to the annual and 30-year costs of Alternative 5. The predicted loss of parcels due to Alternatives 3 and 4 should also be calculated and included in the estimated costs, as it is unlikely that many of the parcels east of station 0+00 will be protected or recovered from either of these alternatives. We note that including these costs will significantly increase the overall costs of the three build alternatives.	USFWS and USDOI	Economics	Appendix B	Based on the Brunswick County GIS, there are no developable parcels east of station 0+00. Table 4.2 in Appendix B has been amened.
111	On Page 4, the Table in Appendix D should be revised to provide a consistent comparison of costs between the five alternatives. Currently, the costs for Alternative 5 are shown as annual and 5-year costs, while the cost of other alternatives is shown for a 30-year period.	USFWS and USDOI	Economics	Appendix D	Amended text to read "Over the 30-year planning period, the total cost estimated for Alternative 4 is $62.13 million."
112	Table 3.10 on Page 44 lists Long-Term Erosion Damages and Response Costs for Alternatives 1 and 2, but shows these costs as $0 for Alternatives 3 and 5. However, the Service does not believe that there will be no erosion damages or response costs over 30 years in the project area, regardless of alternative chosen. Large winter storms, hurricanes and other named storms all have the potential to cause significant erosion and response costs.	USFWS and USDOI	Economics	N/A	Noted. The EIS only evaluated the potential reduction in damages due to long-term erosion. While any alternative that would widen the beach on the east end of the island would have some potential to reduce the risk of storm damage, the evaluation of the alternatives did not consider storm damage reduction.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

113	Page 116 in Chapter 5 states that the future impacts on development on the east end of Ocean Isle Beach were evaluated based on the continuation of erosion trends determined from surveys obtained between 1997 and 2010. There is no rationale provided for using this timespan as a baseline. Although there were several named storms that passed in the vicinity of Ocean Isle Beach during this time, only one passed over the island (with sustained winds of35 mph), none of them had winds over 70 mph, and at least half of them had winds of less than 40 mph. If a 30-year timespan had been used (from 1984 to 2014), erosion from a category 4 hurricane (Hurricane Hugo) could have been included in the analysis.	USFWS and USDOI	Numerical Model	Chapter 5, Alternative 1	The USACE intended the Shallotte Inlet borrow area to serve a dual purpose of providing sand for the federal project as well as relocation of the inlet channel to a preferred condition that would have a positive impact on the behavior of the shoreline on the east end of Ocean Isle Beach. The shoreline response created by the Shallotte Inlet Borrow area differed from shoreline changes observed in the past in that the extreme west end of Holden Beach experienced a considerable amount of accretion as portions of the ebb tide delta east of the inlet collapsed and welded on to the west end of the island. On the Ocean Isle Beach side of the inlet, a new sand spit grew and accreted eastward projecting into the throat of Shallotte Inlet. These changes associated with the borrow area and their impact on the behavior of the shorelines on either side of Shallotte Inlet were not represented in the long-term past history of shoreline in the area and therefore would not be representative of possible future shoreline changes under the influence of the Shallotte Inlet borrow area. Accordingly, the behavior of the shorelines adjacent to Shallotte Inlet were based on the a time period in which the effects of the Shallotte Inlet borrow are on shoreline behavior was included in the record. Also, the selected time period included the installation of sandbag revetments which had not been used in the past. While the sandbag revetments have not been effective in providing any long lasting erosion protection, the did impact short-term shoreline responses by delaying the movement of the shoreline. With regard to the possible impacts of storms such as Hurricane Hugo, the plan formulation for the east end of Ocean Isle Beach did not include any assessment of potential storm damage reduction with any of the alternatives. While some reduction in the risk of damage due to storms would be expected as a result of a wider beach provided that would be provided by Alternatives 3, 4 and 5, the level of storm damage reduction would be about the same for each of these alternatives. Therefore, including potential storm damage reduction would not change the relative cost difference for these alternatives. The EIS has been revised to include this rational on page 116 in Chapter 5..
114	It is likely that dwellings, particularly those on the oceanfront will be impacted by increases in sea leve rise over the next 30 years. Because sea level rise is not consistent through time and space, the impacts are often most first noticed when a storm-surge or spring tides occur. Over the 30-year proposed project life, it is more likely that named storms would cause erosion despite the precautions taken, and that costs would be incurred for beach bulldozing, additional emergency nourishment, or other response activities. Further, if the presence of the groin encourages development of currently undeveloped parcels that are on the oceanfront or waterward of current dwellings, erosion and response costs (beach bulldozing, emergency sand placement, infrastructure repair, demolition and solid waste costs) could be expected over the life of the project for Alternative 5 that would not be expected for the other 4 alternatives. The DEIS is silent on this issue.	USFWS and USDOI	Sea Level Rise	N/A	If Alternatives 3 and 4 were sucessful in prreventing damages due to long-term erosion, development of the undeveloped proprties on the east end of Ocean Isle Beach would be just as likely as under Alternative 5. Therefore, given the assumptions made in the comment, all the plans that inlcude beach nourishment would be subject to the same potential for damages caused by coastal storms and all could include the same erosion response measures, i.e., there would not be any difference in these economic costs for Alternative 5 versus Alternatives 3 and 4.
115	In Table 3.10 on Page 44, the Service recommends that the $21.39 million included for loss of parcels be revised to remove costs for parcels which are currently under water or within the footprint or east of the proposed terminal groin. Since most of these parcels are already unbuildable, and the terminal groin will not provide significant improvement in condition, the loss of them should not be counted for Alternatives 1 and 2 if they are not counted in the other alternatives.	USFWS and USDOI	Financial	Appendix B	The EIS has been revised to reflect that there are only 155 parcels in the project area that have a value greater than $2000 and are considered developable. Parcels east of the proposed terminal groin were not inlcuded in the values given in Table 3.10 of the DEIS. Based on the Brunswick County GIS, the parcels located east of the proposed terminal appear to be mostly below the mean high water line. Table 4.2 in Appendix B depicts the breakdown of costs.
116	On page 63 in Chapter 4, the reference to Figure 4.12 is in error. Please revise	USFWS and USDOI	Clerical	Chapter 4, F. Oceanfront Dry Beach and Dune Habitat	Revised.
117	On pages 74-76 in Chapter 4, please update the sea turtle nesting data for all species to include 2013 and 2014 data. A green sea turtle nested in Holden Beach in 2013	USFWS and USDOI	Sea Turtles	Chapter 4, A. Reptiles	Amended text and figures to include sea turle nesting data from 2013 and 2014.
118	On Page 97, Figure 4.14, the Service recommends that the written description ofthe piping plover critical habitat be used, rather than the old shape file.	USFWS and USDOI	Shorebirds	Chapter 4, F. Birds	The written description of the piping plover critical habitat is provided immediately above Figure 4.14
119	Please update Chapter 4 to include red knot records.	USFWS and USDOI	Shorebirds	Chapter 4, F. Birds	Noted.

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120	The DEIS does not adequately address accelerated erosion downdrift of the groin or the potential impacts from downdrift erosion and regular dredging (every five years to maintain the groin, every three years for the Corps CSDR project). Chapter 5 (page 175) and Appendix C change the topic from potential impacts of this groin on sand transport and intertidal habitats in Shallotte Inlet to a discussion of the impact of the Oregon Inlet jetties on Pea Island. Oregon Inlet and Shallotte Inlet are very different systems, and the DEIS does not explain how they are comparable. We note that there is no habitat above MLLW (including no intertidal habitat) downdrift of the Oregon Inlet jetty, and the stabilization of the shoreline within the sand fillet of the jetty has resulted in degradation or loss of intertidal habitats. The DEIS (page 176) states that the model shows the loss of approximately 1-2 acres of intertidal habitats in Shallotte Inlet due tothe project, but that habitat is expected to persist and recover within 2 years of dredging based on the rate of infill that currently occurs. However, the rate of infill that is referenced is not the rate that will occur after the groin is constructed, since the model shows that the rate of sediment transport will be reduced. There is no discussion in Chapter 5 or Appendix A of the expected passage rates of sand across the groin, or the expected infill rate after construction, and based on the information provided, it is not possible to determine impacts of the groin on the persistence or formation of intertidal shoals and flats in Shallotte Inlet.	USFWS and USDOI	Downdrift effects	N/A	Disagree. The DEIS adequately addresses potential shoreline changes on Ocean Isle Beach west of the proposed terminal groin. This discussion in provided in Chapter 3, Chapter 5, and in Appendix B. The major impact on shoreline behavior with the terminal groin is a reduction in the periodic nourishment cycle of the federal project from its present 3-year cycle to a 5-year cycle following implementation of the terminal groin. The area of the federal project that would be nourished every 5 years under Alternative 5 would also be reduced to the area generally between baseline station 25+00 west to station 120+00. Under existing condition, the federal project has been nourished about every three years with nourishment material placed between stations 10+00 and 120+00. With regard to Oregon Inlet, the terminal groin was constructed in open water and did result in the conversation of a higly dynamic inlet bottom to a subaerial sand fillet. Chapter 5 reports on the model results regarding the response of the Ocean Isle sand spit under for each alternative. For Alternative 5, the response of the sand spit 1,500 feet immediately east of the proposed groin would, based on the model results, experience some increase in the erosion rate, however, over the next two years of the simulation, erosion losses decreased and the area appeared to stablize in a new equilibrium position. The stabilization of the shoerline response after the first year of the simulation indicates sediment was moveing to the east past the terminal groin in sufficient quantities to maintain the integrity of the sand spit.
121	On Page 177, please change "nesting habitat for seabeach amaranth ..." to "habitat for seabeach amaranth ...."	USFWS and USDOI	Clerical	Chapter 4,	Text amended accordingly.
122	On Page 178, the DEIS should address the indirect impacts of stabilization of a dynamic system. The DEIS states that the "increase in stable dry beach as a result of the implementation of Alternative 5 is considered more advantageous to resident and migratory fauna." However, the resident and migratory fauna, particularly the shorebirds such as piping plover and red knot, rely on the dynamic coastal processes such as overwash, to provide optimal foraging, roosting, and nesting habitat. The presence of the groin and other hard structures prevents such processes. In addition, groins accelerate erosion on the downdrift side, thereby causing direct and indirect impacts to the dry beach and intertidal habitats.	USFWS and USDOI	Downdrift effects	Chapter 5- Alternative 5, Oceanfront Dry Beach and Dune Habitats.	Text has been modified to, "The increase in stable dry beach as a result of the implementation of Alternative 5 is considered more advantageous to resident and migratoryvarious fauna as well as flora. Certain migratory bird species such as piping plovers and red knots rely upon more dynamic environments such as the area to the east of the proposed structure." Negative effects associated with the down drift side causing direct and indirect effects have been incorporated in Chapter 5.
123	In Chapter 5 and Appendix A of the DEIS, the accretion and erosion patterns indicated by the Delft3D model are shown only for three years post-project. Given that this is a 30-year project, and the groin is proposed to be on a 5-year maintenance schedule, the DEIS should clarify why only three years of modeling is shown. In addition, no modeling runs are included to show the expected accretion or erosion patterns for Alternative 4. Information for Alternative 4 should be added to the DEIS.	USFWS and USDOI	Numerical Model	N/A	While Alternative 4 was not specifically modeled in the DEIS, the modeling of Alternative 2, which included a deep channel across the ocean bar of Shallotte Inlet as a result of the use of the inlet as a borrow source for the federal project, provided a proxy for interpreting changes that could be expected from a channel relocation project. Modeling specific to Alternative 4 has now been performed and the resutls and analysis are included within the FEIS. The three-year simulation adopted for evaluating all the alternatives was sufficient to develop relative differences in the response of the area to the various changes included in each alternative. The results of the three-year simulations were also sufficient to allow interpretation of possible changes that could affect the cost of the alternative beyond the three year results.
124	On Page 62 of Appendix A, the DEIS states that the model results for Alternative 1 underestimated the sediment retention rate of the borrow area, and that the modeled rate was approximately 80% of the measured rate. According to page 62 of the DEIS, the modelers assume that all of the other model runs also underestimated the sediment retention rate in the borrow area by the same amount, and adjusted the modeled rates for the terminal groin alternative without further justification. Alternatives 2, 3, and 4 were not considered in this exercise on page 2 or in Table 4.15, and only Alternatives 1 and 5 are used to compare model volume changes in the Shallotte Inlet complex. The Service recommends that information for Alternatives 2-4 be included in Table 4.15 of Appendix A.	USFWS and USDOI	Numerical Model	Appendix A	For modeling purposes, Alternaitve 2 was used to represent both Alternative 1 as well as Alternative 2. The only difference in these to alternatives is the assumed continued use of sandbags under Alternative 1 versus no sandbags under Alternative 2. The use of sandbags would not have a significant impact on the performance of the model as it relates to changes within the inlet complex or along the adjacent shorelines. Similarly, the model simulation of Alternative 2 was used as a proxy for Alternative 4 since both alternatives include a relocated channel across the ocean bar of Shallotte Inlet. With regard to Alternaitve 3, the primary difference in the volume accumulation in the inlet complex would have been due to high rates of sand transport to the east off the east end of the beach fill. This would only serve to increase sediment retention rates in the inlet. Since the volume accumulation rates under Alternative 2 were sufficient to maintain the beach fill only alternative represented by Alternative 3, there was no need to compute volume changes in Shallotte Inlet for this alternative.Model volume changes within the various cells in and around Shallotte Inlet were not computed for Alternatives 3 or 4 as the inlet would basically continue to function has is has since construction of the federal project in 2001. Volume changes for existing conditions are represented by Alternative 1 which also represent Alternative 2.
125	The DEIS provides estimates of future damage to structures and vacant lots. Out of 1,456 vacant lots on OIB, the DEIS indicates that 193 will be lost to erosion in the design year of 2045. This represents 13.2% of the total lots on OIB. Regarding structures, the DEIS estimates that 45 out of 3,247 will be lost to erosion in the design year or approximately 1.4%. Currently, there 238 parcels and 45 homes east of station 15+00 that are reported to be vulnerable to erosion damages and more than 1,800 feet of roads and associated utilities that could be damaged by 2045	EPA	Financial	Executive Summary	Noted.
126	EPA requests that the PRT members be updated to reflect the current EPA representative Mr. Dan Holliman.	EPA	General	Chapter 1, page 4, Table 1.2	Modified Table 1.1. to reflect this change.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

127	It is unclear from the discussion in the DEIS on how the preferred project compares to the other alternative projects for economic benefit. EPA recommends providing additional detail in the FEIS relating to the economic benefits of each alternative.	EPA	Financial	Chapter 1.	Disagree. The economic impact of the various alternatives is summarized in Table 3.10 and 3.11 in Chapter 3 with more detailed discussions provided in various sections of Chapter 5 as well as in the Engineering Report (Appendix B). While there is no specific discussion or direct comparison of the economics of one alternative versus another, this was done purposely so as not to appear to bias the information presented.
128	It appears that the orientation and position of the Shallotte Inlet is a significant source of the erosion issues at the East end of OIB. It is not clear how the current proposed project will fully address this issue. EPA recommends that the FEIS provide clarification on how the preferred alternative will address this issue.	EPA	Alternative 5	Chapter 3, Alternative 5; Chapter 1	As stated in Chapter 3, Alternative 5: "Under Alternative 5, the applicant's preferred alternative, a 750 feet terminal groin with beach fill would be constructed 148 feet east of baseline station 0+00. This structure is intended to provide shoreline stabilization and would serve to reduce the erosion rate further west thereby reducing the nourishment interval of the Federal project from every 3 years to every 5 years and relieve the necessity of sandbag revetments within the project area."
129	A table is provided that lists Category 3 and 4 Hurricanes Affecting the North Carolina Coast from 1933 to 1996. There is no reference in the text that describes the relevance of thisinformation to ' typical' erosion rates along OIB or what effect, if any, these storms had on the OIB shoreline and the proposed project. Were erosion rates accelerated during these events and why is there adequate sand along the western portion of OIB and not the eastern end?	EPA	General	Chapter 2	The intent of the table was to provide the reader context as to the relative frequency of large storms that also play a factor in shoreline erosion along with "typical" erosion rates along OIB. The table has been removed.
130	The DEIS does not discuss the history of shoreline erosion on OIB prior to March of 2001. There is no analytical discussion in the DEIS pertaining to why erosion rates have impacted the eastern end of the island and not the western end over the last several decades.	EPA	General	Chapter 2	With the implementation of the federal storm damage reduction project in 2001, past shoreline changes along the whole of Ocean Isle Beach were not germane to the formulation of an erosion response project specifically aimed at mitigating erosion on the extreme east end of the island. The construction of the federal project in 2001, which included the use of Shallotte Inlet as a source of beach fill material, materially changed the behavior of the shoreline on both sides of the inlet which rendered previous shoreline change histories irrelevant. Also, the high rate of erosion on the east end of the island has resulted in the installation of numerous privately funded sandbag revetments to protect upland development.
131	The DEIS states: "The material removed from the AIWW has eroded quickly and has been generally ineffective in slowing the rate of erosion in the area east of Shallotte Boulevard". The DEIS does not provide a rationale or causes as to why this Federal project was ineffective in slowing the rates of erosion along this section of OIB.	EPA	General	Chapter 1	As stated on page 8 in Chapter 1, "During the formulation of the Federal storm damage reduction project, the USACE attributed much of the chronic erosion on the eastern portion of Ocean Isle Beach to changes in the orientation and position of the main ebb channel through Shallotte Inlet. In this regard, when the ocean bar channel of Shallotte Inlet is oriented toward the west end of Holden Beach (as it had been since the mid 1970's up until the construction of the Federal project) the west side of the ebb tide delta of the inlet also migrates toward the east exposing the east end of Ocean Isle Beach to direct wave attack. In addition, with the main bar channel situated closer to Holden Beach, flood channels tend to form close to shore along the east end of Ocean Isle Beach. The presence of the flood channels combined with wave driven currents transport sediment off the east end of the island and into Shallotte Inlet at a faster rate than the supply of wave driven sand being transported toward the east off the main portion of the island."
132	The DEIS indicates that numerous beach nourishment efforts by the USACE and the Town have failed to protect against the chronic erosion and the damage caused by coastal storms. The DEIS docs not identify what type of damages occurred from coastal storms and why it was expected that Federal and local beach nourishment projects would prevent possible coastal storm damages.	EPA	General	N/A	The DEIS did not state that the federal storm damage reduction project has been ineffective; rather it states that local attempts to protect the areas east of Shallotte Boulevard with beach fill alone were ineffective. The DEIS was clear that the existing federal project has been sucessful in protecting the area included within the domain of the project.
133	The DEIS indicates that the 1,400' sandbag revetment has been repaired/replaced but continue to fail under the continued landward retreat of the shoreline. The DEIS does not identify the specific 'hydro-geological' reasons for the landward retreat. EPA recommends the FEIS provide the reader with a clear understanding of the causes of the landward retreat on the east end of OIB.	EPA	General	Appendix B and Chapter 1.	A discussion of the ongoing erosion issues was added to Appendix B and Chapter 1. In essence, the high rate of erosion has been a persistent feature since the mid 1960's following the reorientation of the ocean bar channel of Shallotte Inlet to the east or toward Holden Beach. The federal storm damage reduction project attempted to address this by using Shallotte Inlet as a borrow source for the federal project and in so doing, essentially repositioned the bar channel to a more central location between the two island. However, a more detailed discussion of the reason for the shoreline erosion on the east end of Ocean Isle Beach will be added to the final document in Chapter 1 as well as in the Engineering Report (Appendix B).
134	The Town has reported that it has spent $3.7 million responding to erosion on the east end ofthe island since 2005 and the State costs are approximately $1 million. The DEIS does not identify the past Federal costs from the 5 past beach nourishment projects conducted in 2001, 2006, 2006, 2010 and 2014 as identified in Table 2.1 of the DEIS. EPA recommends the total costs for all past shoreline protection projects (Federal, State, and local) be included in the FEIS.	EPA	Financial	Chapter 2	Added federal cost of $15.6 million in Chapter 2.
135	EPA notes that the Deft3D Model was the primary modeling package identified in the DEIS for evaluating the project. EPA appreciates the Corps providing the methodology, supporting data, and calibration of the model in Appendix C of the DEIS.	EPA	Modeling	Appendix C	Noted.
136	EPA recommends that any specific model or tool used to evaluate the alternatives in the context of Sea Level Rise (SLR) scenarios be included in Chapter 3 of the FEIS	EPA	Sea Level Rise	N/A	No specific model or tools were used to evaluate the alternatives in the context of sea level rise.
137	Under the Alternative 1 description several historical beach nourishments/stabilization projects are discussed yet erosion continues. There is no rationale provided that explains why these projects failed on the East end of the island and why erosion continues. The DEIS does not indicate why the western 6,000 feet of the Federal Project area continues to perform very well and has not required periodic renourishment since 200 l and the eastern portion of the island is eroding at a much increased rate. The DEIS does not indicate the coastal processes at work (since 2001) that has caused this significant difference from one end of the island to the other.	EPA	General	Chapter 1	As stated on page 8 in Chapter 1, "During the formulation of the Federal storm damage reduction project, the USACE attributed much of the chronic erosion on the eastern portion of Ocean Isle Beach to changes in the orientation and position of the main ebb channel through Shallotte Inlet. In this regard, when the ocean bar channel of Shallotte Inlet is oriented toward the west end of Holden Beach (as it had been since the mid 1970's up until the construction of the Federal project) the west side of the ebb tide delta of the inlet also migrates toward the east exposing the east end of Ocean Isle Beach to direct wave attack. In addition, with the main bar channel situated closer to Holden Beach, flood channels tend to form close to shore along the east end of Ocean Isle Beach. The presence of the flood channels combined with wave driven currents transport sediment off the east end of the island and into Shallotte Inlet at a faster rate than the supply of wave driven sand being transported toward the east off the main portion of the island."

*Agency comments have been summarized. Please refer to individual agency letters for full content.

138	It is stated in the DEIS that "238 parcels east of station 15+00 (location just west of Shallott e Boulevard); 45 of which have homes. All of the parcels and homes are vulnerable to erosion damage over the next 30 years should the past erosion trends continue." Figure 3.1 shows that the future predicted scarp line in 2045 will impact approx imately 45 structures, but it is unclear on how the 238 parcels estimate was generated. These parcels account for a significant amount of the financial losses predicted in the future scenarios. EPA recommends the FEIS clearly define where these parcels are located and how they will be impacted under future erosion scenarios.	EPA	Financial	Chapter 3; Appendix B	The number of parcels that could be impacted under the without project condition will be revised to only reflect parcels deemed to be developable. In this regard, parcels with a tax value of less than $2000 were deleted from the damage assessment resulting in a revised total of 155 parcels that could be impacted over the 30-year evaluation period.The affected parcels are shown on Figure 3.1. Reference to Figure 3.1 was inadvertently deleted or omitted but has been added to the text. A similar figure is provide in Appendix B as Figure 4.1. The figures show which parcels would be affected by continued erosion and no additional detail is needed. If the USACE wishes, a spreadsheet could be provided that identifies which parcels were included in the analysis.
139	It is unclear if Alternative 4 is a reasonable alternative since it involves the modification of an authorized USACE dredge project at Shallotte Inlet. The likelihood of Alternative 4 should be clearly described in the FEIS. It is also unclear if Alternative 4 would provide the same level of protection as the preferred Alternative 5 therefore we recommend this being more clearly discussed in the FEIS.	EPA	Alternative #4	Chapter 3, Alternative 4.	The following text has been added to Chapter 3: "Prior to the implementation of the prospective inlet relocation as described under Alternative 4, the USACE would be required to undergo consultation with their Civil Works section to ensure that the proposed inlet modification would not be injurious to the public interest and will not impair the usefulness of the Federal project, as stated in Section 14 of the Rivers and Harbors Act of 1899 and codified in 33 USC 408 (also known as a Section 408 review). The purpose of this policy is to improve consistency in processing requests both geographically and across Civil Works project types, outline a process that is scalable to be commensurate with the anticipated impacts of an alteration, and provide those seeking alteration a clear understanding of information required by them in seeking alteration to a USACE project. Should the outcome suggest that the proposed inlet modification associated with Alternative 4 be determined to jeopardize the functionality and performance of the Federal project, this alternative may be deemed to be impracticable."
140	Does the average annual cost of Alternative 5 take into account the potential need to reconstruct the terminal groin structure if damaged by a storm event? If not, why was this not considered in the analysis?	EPA	Financial	Chapter 3, Alternative 5.	Table 3.6 includes the average annual cost of repairs to the terminal groin which includes potential storm-related costs.
141	Because of the significant cost differences and estimated effects from the 3 different terminal groin lengths, the EPA is unclear on why the 3 options were not considered as separate alternatives in the DEIS evaluation. The FEIS should clarify the reasoning for including them as one alternative.	EPA	Alternative #5	N/A	One terminal groin alternative has been provided. The discussion regarding the other terminal groin lengths (250' and 500') were included in the EIS to demonstrate the formulation of the preferred alternative.The discussion regarding the other terminal groin lengths (250' and 500') were included in the EIS to demonstrate the formulation of the preferred alternative.
142	Figure 4.5 is unclear. EPA recommends providing a closer view of the project area for this figure to better identify hard bottom areas in relation to the project.	EPA	Hardbottom Resources	Chapter 4, Hardbottom Communities	Noted. The data from this figure was depicted at a regional scale in the CHPP and is intended to inform that reader that no hardbottom resources are located nearshore in proximity to the proposed project (nor within the permit area).
143	Figures 4.7-4.9 indicated that previous turtle nesting areas may fall in the project area. EPA suggests adding a project area boundary or active construction zone to these figures.	EPA	Sea Turtles	Chapter 4, Sea Turtles	Figures 4.7-4.12 have been modified to include the permit area.
144	EPA recommends provid ing a map in the FEIS of the RWQ sample stations near the project area	EPA	Water quality	Chapter 4, Water quality	Figure 4.17 has been updated to include these water quality monitoring stations.
145	EPA notes that there is a potential to impact historical ship wrecks in the Shallotte Inlet area. EPA is unclear on why surveys were not conducted and results not provided in the DEIS. This is an area of potential impact that should be disclosed therefore EPA recommends including survey results and an assessment of potential impact in the FEIS.	EPA	Cultural Resources	Chapter 4, Cultural Resources, Appendix F.	Text added to Chapter 4 includes: "In December 2014, TAR conducted a marine and terrestrial remote-sensing survey of the proposed terminal groin construction area. Analysis of the remote-sensing data generatedduring the Ocean Isle Beach survey identified a total of 22 magnetic anomalies in the offshore project environment and 4 anomalies in the terrestrial project environment. Sonar identified 16 targets in the marine environment. All of the anomalies and all of the sonar images are associated with previous groin structures or small objects that represent debris associated with those groins or perhaps residential material deposited by storms. None of the anomalies and sonar images appears to represent more complex signatures associated with historic vessel remains. AS concluded by the study, no additional investigation is recommended in conjunction with the proposed groin construction. See Appendix F for additional details regarding this study."
146	The FEIS should disclose consultation efforts and any conservation or mitigation project commitments required by natural resources agencies.	EPA	Mitigation	Chapter 6	Chapter 6 includes all proposed mitigation measures for this project. A finalized mitigation plan will be disclosed in the Record of Decision
147	EPA recommends the FEIS provide information on the potential for cumulative impacts to water quality taking into account other project activities in the area.	EPA	Water quality	Chapter 5, Alternative 1 Water Quality	The impacts of the federal project is already included in the impacts assessment. As stated for Alternative 1 (and other alternatives),"Dredging of the inlet every three years as part of the Federal project will be expected to result in increased turbidity, however, those dredging events will be limited to a finite duration of time spanning several months every three years. Under Alternative 1, erosion of the soundside shoreline would continue with minimal changes in turbidity levels as a result. Turbidity and TSS levels would be expected to increase during storm events. Therefore, naturally fluctuating turbidity and TSS levels would continue with or without beach nourishment and dredging efforts proposed under Alternative 1, therefore no adverse cumulative effects are anticipated."
148	Reference to Table 5.2- 3rd paragraph: most likely an editorial mistake, but it appears to EPA that the DEIS should be referencing Figure 5.2 and not the table.	EPA	Clerical	Chapter 5, Table 5.2	Changed text to read "Figure 5.2" from "Table 5.2".

*Agency comments have been summarized. Please refer to individual agency letters for full content.

149	Figures 5.1-5.3 show erosion and accretion areas and cover a three-year period. It is not clear why these analyses were not provided beyond 3 years. EPA recommends the FEIS provide reasoning for providing only three years of the Delft3D model simulation runs.	EPA	Numerical Model	Chapter 5, section entitlted "How were the environmental impacts analyzed?".	The following text has been added to Chapter 5 within the EIS: "Model simulations for all the alternatives were carried out over a three-year period. The use of the three-year period was based on the periodic nourishment interval for the federal storm damage reduction project. The formulation of each of the alternatives, particularly the alternatives involving beach nourishment, was based on the modeled performance of the beach fill over the three-year model simulation. In some instances, the modeled performance of the beach fill as well as criteria established to evaluate the alternatives suggested periodic nourishment intervals either shorter or longer than three years. However, since the model results were only used to obtain a relative comparison of the performance of each alternative, the three-year model simulation provided sufficient information on which to make engineering judgements with regard to determining long-term periodic nourishment requirements of each of the alternatives."
150	There are no figures provided in the DEIS that show model runs for Alternative 4 for project erosion/accretion patterns. EPA recommends either providin g the figures or an explanation on why they are not included in the FEIS.	EPA	Numerical Model	Appendix B, Chapter 3, Chapter 5	Numerical modeling results for Alternative 4 have been added to the FEIS in Appendix B, Chapter 3, and Chapter 5.
151	The text on page 125 indicates that after a three year period accretion will occur in the segment - 20+00 and -30+00 but Figure 5.5 appears to contradict this statement. The FEIS should clarify this information. Furthennore, the discu ssion in the FEIS should address how the accretion prediction west of station 01_020 compares between Alternatives 5 and 1.	EPA	Numerical Model	Chapter 5, Alternative 5; Appendix B.	Volumetric changes reported in the text only extend seaward to the -6.0 ft NAVD contour while the figures show changes for the entire area seaward to about the -30 foot depth contour.Table 4.14 in Appendix B provides a comparison of model volume changes for Alternative 1 versus all three of the terminal groin options for the entire area from station -30+00 on the shoulder of Shallotte Inlet west to Station 30+00 on Ocean Isle Beach. Also added text to page 40 of Appendix B, modified Table 4.7 in Appendix B, and added Table 4.10.
152	The cumulative impacts of other projects in the area are not described in detail in the DEIS and should be di sclosed in the FEIS. The DEIS does list others projects in the vicinity of OIB that may cumulatively affect the proposed project. However, the DEIS does not provide details regarding how , the potential timing, or what severity of effects which might take place with respect to these other projects (Maintenance of Wilmington Shipping Channel ; Maintenance of AIWW; Proposed Holden Beach Terminal Groin and Beach Nourishment; and Lockwoods Folly Inlet Maintenance with Oak Island Beach Nourishment).	EPA	Cumulative Impacts	Chapter 5, Question #4	Noted. The NEPA document cannot account for all impacts from all projects in the area. The document is specifically tailored to the direct, indirect, and cumulative effects of the project under review. R- Addressed on page 130.
153	The DEIS does not indicate if m onitoring for turbidity w ill be conducted during construction to ensure compliance with SWQS. The description of monitoring locations and the frequency should be provided in the FEIS. Detailed construction information provided in Chapter 5 (example Figure 5.7) appears to be more appropriate for Chapter 3 -description of the alternatives.	EPA	Water quality	Chapter 5, Question #5.	Added the following text to Chappter 5: "Elevated turbidity is anticipated only immediately adjacent to the dredge operation and would only persist while dredging and the subsequent beach filling occurs. As such, turbidity monitoring within specified areas (to be determined) will only be implemented should significant concerns arise from state or federal agencies."
154	I t is unclear if material deposited on the beach will be re-evaluated to ensure compliance with 15A NCAC 07H .0312. The discussion in this section focuses on historical sampling from borrow areas. There is a high probability that material in these areas may change over time, therefore , this material may not be compatible now. EPA recommends clarification in the FEIS.	EPA	Sediment compatibility	Chapter 5, General Environmental Consequences Related to Beach Fill	As stated in Chapter 5 of the DEIS, "Given the proposed borrow area is completely confined to the authorized dredge depth of a maintained sediment deposition basin within the inlet shoal system, compatibility as defined by (15A NCAC 07H.0312) is primarily defined in Section (2) (e) and (3) (a). Section (2) (e) allows an applicant to use previously collected data to establish sediment characteristics where both a pre-dredge and a post-dredge data set exist. Section (3) (a) states that compatibility for sediment completely confined to the permitted dredge depth of a sediment deposition basins within the inlet shoal system is defined as having an average percentage by weight of fine-grained (less than 0.0625 millimeters) sediment less than 10%. As stated above, the composite fine-grained sediment within the footprint of the area dredged in 2001 based on the data from six (6) vibracores collected in 1998 is 1.3%. The composite fine-grained sediment within the same footprint of the area dredged in 2001 based on data collected after the dredging event is 1.95%. The composite percent fine grained material for the existing beach sampled along the east end of Ocean Isle Beach is 1.34%. Therefore, sediment proposed for use under this action, which is confined to the footprint of the area dredged in 2001 in Shallotte Inlet, is compatible in accordance with 15A NCAC 07H.0312. See Appendix E (Geotechnical Report) for more information regarding the characteristics of the borrow material and the native beach". In addition, the following text has been included in Chapter 5: "Should incompatible material be encountered within the Shallotte Inlet borrow area, the contractor will immediately cease operation and reposition the drag arm to an alternate location within the borrow area."
155	The DEIS states that "impacts of historic rates of SLR are implicitly included in the historic shoreline change data used for OIB ". However, the DEIS does not provide for historic shoreline effects to OIB prior to 2001 when the first Federal nourishment project was performed. Prior to 2001, there did not appear to be excessive shoreline erosion problems identified in the DEIS.	EPA	Sea Level Rise	Chapter 5, Sea level rise Section	The EIS only addresses shoreline erosion issues on the east end of Ocean Isle Beach since the existing federal storm damage reduction project covers the area from Shallotte Boulevard west to Dunside Rd. (stations 10+00 to 181+00).
156	The USACE maintains that only a portion of the observed shoreline change rates are associated with SLR and that doubling the rate of SLR would not double the historic rate of shoreline change. There is no further explanation for this supposition.	EPA	Sea Level Rise	Chapter 5, Sea level rise Section	Shoreline change rates are affected by both sea level rise and other factors that affect the sediment budget of an area. Statewide, sea level changes probably contributes between 1 and 2 feet of shoreline recession per year. In areas that have recession rates in excess of this amount are probably being impacted by sediment retention in tidal inlets and other sediment sinks along the coast.
157	The DEIS fails to explain why the western portion of OIB is relatively stable with respect to prior beach renourishment efforts and the eastern end is eroding at an accelerated rate. If SLR is not the primary cause of observed shoreline erosion changes, the FEIS should clearly identify what is causing the erosion changes in the recent decade.	EPA	Sea Level Rise	Chapter 5, Sea level rise Section	The EIS clearly indicates the higher rates of shoreline change on the east end of Ocean Isle Beach is due to process associated with Shallotte Inlet.
158	The SLR section of the DEIS changes the units of measures back and forth between S.I. units (e.g., meters) and U.S. units (e.g., feet), without consistently providing the conversions. This should be corrected in the FEIS.	EPA	Clerical	Chaper 5, Sea level rise Secition.	All measurements have been edited to include both standard and metric conversions.

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159	Public beach areas impacted by the proposed project and potential safety issues associated with the landward anchored section of the groin and the seaward section's impact on boater traffic should be more clearly discussed in the FEIS. Mitigation measures should be clearly outlined when discussing these potential impacts.	EPA	Mitigation	Chapter 5, Alternative 5, Public Safety; Chapter 6, Terminal Groin Structure	The impacts to public safety with regards to Alternative 5 are documented in Chapter 5, Alternative 5, Public Safety. The following text has been added to Chapter 6 on page 188: "The navigational hazard of the low-profile terminal groin would be mitigated by the construction of a U.S. Coast Guard approved navigation aid possibly consisting of a three-pile dolphin and light, may be installed at the seaward end of the terminal groin. The determination for the need of such a structure will be made by the US Coast Guard."
160	It is stated on P. 191: "In order to avoid impacts associated with the transport of fill material to the disposal sites, the Town of Ocean Isle Beach will negotiate with the dredging contractor to monitor and assess the pipeline during construction." This statement is very unclear and provides no real details on what type of monitoring will be required during construction. EPA recommends clarification in the FEIS.	EPA	Mitigation	Chapter 6, Monitoring	The Record of Decision will include specific terms and conditions that specifiy what type of monitoring will be required during construction.
161	The USEPA requests that any reported exceedances to water quality standard s should also be reported to the NCDENR Water Quality Section and the USEPA and shown as a project commitment in the FEIS, Record of Decision and USACE Chi ef's Report.	EPA	Mitigation	Chapter 6, Monitoring	Text in Chapter 6 has been edited to read, "Turbidity monitoring during construction, if required, will be managed by the contractor. The contractor will be responsible for notifying the construction engineer in the event that turbidity levels exceed the State water quality standards. The contractor will be advised to report any exceedances of the turbidity standard to the NCDENR Division of Water Resources and the USEPA."
162	EPA i s unclear on how long beach monitoring will occur post project construction. A "confinn ation period " of 2 years is referenced in the document, but it remains unclear if this is the extent of the beach profile monitoring post construction. If so, EPA believes that the monitoring period is not long enough to determine the long-term impacts of the prop osed project. EPA recommends clarification in the FEIS.	EPA	Mitigation		Monitoring will occur over the full 30-year planning period and perhaps beyond. The 2-year confirmation period only refers to a time following the impacts of severe storms that may cause a major change in the shoreline position. The 2-year confirmation period is intended to allow natural recovery of the shoreline. If the shoreline does not recover after 2 years, miitiagation may be necessary. The following text has been added to Chapter 6: "The inlet and shoreline monitoring program as described in this EIS will occur over the full 30-year planning period."
163	It appears unlikely that the USACE can definitively determine if the terminal groin will impact beaches in the vicinity of the project , mainly because these systems are so dynamic. Can it be assumed that all significant changes to beach profiles in the vicinity of the project will be attributed to the project (with exception to storms)? EPA recommends clarification in the FEIS.	EPA	Mitigation	Chapter 6, Inlet Management Plan	Shoreline change thresholds have been established on both side of Shallotte Inlet. Should negative shoreline changes that exceed these thresholds after the terminal groin is installed, mitigation measures may be required.
164	Holden Beach supports the Ocean Isle's preferred alternative of constructing a terminal groin with beach replenishment.	Town of Holden Beach	General	N/A	Noted.
165	Although the DEIS indicates that the preferred alternative will have no shoreline impacts to the west end of Holden Beach, the numerical modeling results indicate that net longshore transport is from west to east and this area of Holden Beach will erode, contrary to past studies and monitoring data. Specifically, with respect to the west end of Holden Beach, the modeling results indicate volume changes above the -6-foot NAVD depth contour along the western 4,000 feet of the island were similar for Alternative 1 and the 750-foot terminal groin option. Despite the modeling results, the west end of Holden Beach has historically been stable to accretional as reflected in the Corps and Holden Beach monitoring data.	Town of Holden Beach	Downdrift effects	Chatper 6	Noted. The western end of Holden Beach is included in the beach monitoring program. Shorleine change thresholds have been developed that cover the entire 4,000 feet on the west end based on past shoreline behavior. Based on another comment provided by the Town of Holden Beach, the shoreline change thresholds between stations 375 and 400 on the west end of Holden Beach have been changed from 0 to actual positive, i.e., accretion, shoreline change rates.
166	The monitoring profiles should be extended beyond inlet radial profile 421 to include the Monk Island estuarine shoreline, the Shallotte River, and the AIWW, where modeling indicates that some significant changes may occur.	Town of Holden Beach	Inlet Management Plan	Chapter 6 Aerial Habitat Mapping and Inlet Management Plan	Monk Island and the estuarine shorelines up to the mouth of the Shallotte River will be monitored using aerial photographs as described in Chapter 6
167	Rather than arbitrarily assigning a shoreline change rate threshold of 0 feet/year for profiles in the area on the west end of Holden Beach between profiles 375 and 400, Holden Beach believes that the shoreline change rate threshold should be calculated based on the actual average shoreline change rate and the 95% confidence interval for each profile. Moreover, Holden Beach believes that shoreline change rate thresholds should be calculated for all profiles, including inlet radial profiles and estuarine profiles. Holden Beach, however, recognizes that inlet radial profiles vary dramatically and any potential thresholds or determinations whether mitigation is required need to take this into account.	Town of Holden Beach	Inlet Management Plan	Chatper 6, Table 6.1	Shoreline change thresholds between 375 and 400 on the west end of Holden Beach have been modified to inlcude the same protocol used by the USACE for the other profile stations within the project area. This change results in positive shoreline change rates for the west end of Holden Beach rather than 0 ft/yr adopted by the USACE.
168	Holden Beach also believes that the trigger to investigate whether any mitigation is required should not be based on shoreline change alone; volume changes should also be considered. Each profile should be evaluated from 7 feet NGVD to -17 feet NGVD to calculate profile-specific volume change thresholds.	Town of Holden Beach	Inlet Management Plan	N/A	There is not a sufficient historic record of profile changes on either side of Shallotte Inlet to establish reliable and/or statistically significant volume change thresholds for these areas.
169	Rather than applying a two-year confirmation period, Holden Beach requests that a Technical Advisory Committee (the "TAC") be formed if the shoreline or volume change threshold is exceeded at one or more designated survey locations. The TAC should be comprised of one North Carolina licensed coastal engineer from each of Ocean Isle, Holden Beach and the Corps (or similar agreed upon independent coastal engineer). If the shoreline or volume change threshold is exceeded at one or more profiles, the TAC would determine the potential cause(s) of the threshold exceedance and whether mitigation is appropriate.	Town of Holden Beach	Inlet Management Plan	N/A	The establishment of a TAC would defeat the purpose of the shoreline change thresholds. The purpose of pre-establishing shoreline change thresholds is to eliminate debate as to the cause of observed shoreline changes. If the observed post-construction shoreline changes exceed the thresholds, the question will be how to miitigate not if mitigation should be performed.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

170	Nothing in the DEIS addresses the downside risks known or unknown resulting from this project.	Town of Sunet Beach	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	As stated in Chapter 3 of the EIS, the purpose of a terminal groin on the east end of Ocean Isle Beach would be to create a permanent accretion fillet west of the structure. This would be accomplished by controlling tide induced or influenced sediment transport off the extreme east end of the island. The resulting position and alignment of the shoreline within the accretion fillet would mimic that of the shoreline immediately to the west. The elimination or reduction in tide induced sediment transport off the extreme east end of the island should improve the performance and longevity of beach fill placed east of Shallotte Boulevard as well as the performance of a portion of the federal storm damage reduction project that extends west of Shallotte Boulevard. Since wave induced sediment transport (i.e., littoral sand transport) would still be in play, erosion will continue to be a management issue for the shorelines lying outside the direct influence of the terminal groin. No information has supported the notion that the resulting adjacent beaches will be steeper than under natural conditions following the installation of the proposed terminal groin.
171	We question whether, if in fact property in Ocean Isle Beach further down from the terminal groin begins to erode, there is any requirement that the terminal groin be removed. Without this requirement, we fear that the process of installing additional groins will be instituted, thus continuing the damage farther down-drift from both the original groin and any additionally added groins.	Town of Sunet Beach	Inlet Management Plan	Chapter 6, Inlet Management Plan	The inlet management plan addresses the requirement to remove the terminal groin should it be determined that it is causing detrimental effects. At this time, only 4 terminal groins are allowed to be permitted in the State of North Carolina and no groins are allowed.
172	The USACE failed to "rigorously explore and objectively evaluate all reasonable alternatives" as the alternatives analysis focused on justifying construction of Ocean Isle Beach's preferred terminal groin alternative	Southern Environmental Law Center	General		Noted
173	The Engineering Report states that it was "Prepared For" the "Town of Ocean Isle Beach.". Appendix C makes clear that "[t]he objective of the Engineering Report (Appendix B) and this numerical study is to refine the terminal groin's design and develop a recommended plan which includes groin construction and strategic placement of beach fill."	Southern Environmental Law Center	General	Appendix B cover page, Appendix C,Introduction	The Engineering Report has been modified to reflect that it was prepared for the USACE. Appendix C has been modified to indicate that the objective of the Engineering Report was to evaluate potential shoreline protection measures and states that "the objective of the Engineering Report (Appendix B) is to disclose the methodology involved with developing all project alternatives. Tand this numerical study is to refine focuses on the applicant's preferred alternative and therefore serves to the terminal groin's design and develop a recommended plan which includes groin construction and strategic placement of beach fill."
174	Despite admitting that the Delft3D model is incapable of accurately predicting shoreline changes on Ocean Isle, the Corps has extensively relied on that model to evaluate future shoreline changes under each alternative.	Southern Environmental Law Center	Numerical Model	N/A	The Delf3D model is not intended or is claimed to be a predictor of the future. It is a numerical model that uses data input and then simulates changes based off those data. *TC Comment: Additionally, the Delt3D model is the best tool available to consistently and objectively evaluate all Alternatives using the same measuring stick.
175	Review of Appendix C demonstrates that the model cannot predict the direction of sand transport or past erosion rates accurately, much less provide any indication of future erosion rates or shoreline change.	Southern Environmental Law Center	Numerical Model	N/A	The Delf3D model is not intended or is claimed to be a predictor of the future. It is a numerical model that uses data input and then simulates changes based off those data..
176	The model did not accurately predict the direction of longshore sand transport. As described in Appendix C, "most sources have estimated the net sediment transport direction to be from east to west along the majority of Ocean Isle Beach." The model predicted the exact opposite; Appendix C states that "the net longshore transport based on the model results was from west to east, even along the midpoint ofOcean Isle Beach." At the most basic level of analysis—which direction sand moves—the model was wrong. CPE later adjusted the model, but even the final calibration predicted that net sand transport would move in the wrong direction for more than a mile on Ocean Isle Beach.	Southern Environmental Law Center	Numerical Model	Appendix B, Littoral Sediment Budget section	The following text has been added to The Littoral Sediment Budget Section within Appendix B: The direction of longshore transport produced by the model is a function of the wave data used as input to the model. In this regard, the model was calibrated for the April 2007-April 2010 time period using wave data measured by NOAA Buoy 41013 during this time period. The NOAA Buoy data was transferred to the Offshore ADCP location using the Hypercube method. The azimuth of the shoreline in the project area is approximately 73.5o; therefore, waves approaching the area with azimuths ranging from 16.5o to 163.5o would tend to produce sediment transport to the west while waves approaching the area along azimuths between 163.5o and 253.5o would tend to move sediment from west to east. Figures 32 and 33 in Sub-Appendix A of the Engineering Report show that for the April 2007-April 2010 time period, wave energy approaching the project area was predominantly from angles greater than 163.5o which would result in a predominant west to east direction of sand transport during the calibration period. Previous studies of the Brunswick County area have generally indicated predominant east to west transport along most of the islands, however, the earlier studies also found sediment transport predominance tended to change in areas near tidal inlets due to the influence of inlet ebb tide delta's and the interaction of waves with tidal currents. In the case of the model simulations for Ocean Isle Beach, the model results did indeed show a change in predominant sediment transport in the area just west of the fishing pier (approximate baseline station 145+00). The predominate movement of sediment from west to east for areas east of base line station 90+00 was also supported by the sediment budget developed for this same time period. An analysis of hindcast wave data reported for WIS Station 63313 (USACE Wave Information Study) for the time period from 1980 to 1999 indicated a slightly predominant westerly component with 50.7% of the longshore wave energy directed to the west and 49.3% to the east. WIS Station 63313 is situated in a water depth of 16 meters (52.5 feet) directly offshore of Ocean Isle Beach. In the feasibility report prepared by the USACE Wilmington District for the Ocean Isle Beach Storm Damage Reduction Project, the hindcast data for the 20-year period from 1956 to 1975 inclusive indicated westward transport predominated by a margin of 61.1% to 39.9%, however, 3 of the years in the 20 year record had eastward predominance while in 3 other years the westward predominance was close to a 55% to 45% split between west and east transport, respectively.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

177	The model failed to accurately predict whether Holden Beach would erode or accrete. Model Run 43A—the final calibration—predicted that Holden Beach would erode from HB300 to HB340; in reality the beach accreted at each monitoring location. The model predicted no change or slight erosion from HB340 to HB360; in reality, the beach accreted at each monitoring location. The model was so inaccurate on Holden Beach that it predicted a loss of approximately 70 cy/ft at HB400 when in reality the beach accreted approximately 80 cy/ft.	Southern Environmental Law Center	Numerical Model	Chapter 5 ; Appendix C, Model Calibration and Results section.	Numerical models such as Delft3D are used to develop relative differences in the response of a system to man-induced changes. In the case of Shallotte Inlet and the shorelines of Ocean Isle Beach and Holden Beach, the model did not exactly replicate changes that occurred during the April 2007-April 2010 calibration period but did show trends in the shoreline response that were similar to the observed. Granted the model indicated changes at anyone particular station did not agree with observed changes but, taken as a whole, the trends on both sides of the inlet obtained from Model Run 43A were judged to be sufficient to allow relative comparisons between the model results for each alternative. The following text has been added to Chapter 5 within the Section entitled "How were the environmental impacts analyzed?": "When the model was run to simulate a man-induced change such as the installation of a terminal groin on the east end of Ocean Isle Beach, it was run with the same forcing functions, i.e., waves, winds, and tides, used in the calibration process to represent without project conditions. If the model reacted differently from the results obtained during the calibration process, the indicated different response would have been entirely due to the man-induced change. The magnitude of the change was based on a relative comparison between the model results without the man-made change and the results with the change. These relative differences were then translated to the expected “real world” response by adjusting observed shoreline changes by the relative difference in the response of the model to the two conditions." Additional discussion of the use of the model to indicate "relative" changes between the response of the mode to various alternatives has been added to page 60 in Appendix C.
178	Appendix C states that “the model is able to reproduce the general erosion patterns along Ocean Isle Beach— high erosion rates from Shallotte Inlet to Profile OI_65 (Chadbourn Street) with stable beaches further to the west (see Figure 40).” What it does not say is that the erosion rate estimates approximated observed erosion rates. In the areas most critical to the EIS— between OI_15 and OI_45, modeled erosion rates were significantly different than observed rates. Using known data from past observations, the Delft3D failed to predict past shoreline changes and therefore cannot be considered to represent the operation of “the inlet system and adjacent beaches” under any set of conditions.	Southern Environmental Law Center	Numerical Model	Appendix C	See Response to Comment 177 above. Again, the model results were only used to determine relative differences in response to man-induced changes. The relative difference between the without project model simulation and the terminal groin simulation was used to adjust the observed shoreline response from the monitoring results. Therefore, if the model shoreline change on Ocean Isle Beach with the terminal groin reduced shoreline erosion in an area by 40% compared to the response in this same area under the "without project" condition, the expected shoreline response along that section of Ocean Isle Beach was take as equal to 40% of the observed response. Additiona discussion has been added Appendix c to clairfy how the model results were used to interpret potential impacts both positive and negative.
179	The DEIS and Appendix B refers to the “inherent accuracy” of the model. Notably lacking from either document is any discussion of the model’s error rate or confidence intervals that could be used to support the assertion that the model has any “inherent accuracy.” Without some clarification and definition, the term “inherent accuracy” as used to describe the model is misleading and must be removed.	Southern Environmental Law Center	Numerical Model	Chapter 3; Chapter 5; Appendix B .	Modeled elevation changes have an accuracy of ±0.2 foot. The margin of error for the modeled volume changes would depend on the size of the area being evaluated. For example, model volume changes in an area covering 10 acres would have an accuracy of ±3,226 cubic yards.
180	The DEIS describes the modeled shoreline changes for Alternatives 1 and 2. The document states that between stations 0+00 and 0+30, the focal point of the DEIS’s analysis, erosion is expected to be 24,000 cubic yards per year. The model results are succinctly and clearly depicted in a chart. No such chart is provided to describe model results for Alternatives 3 or 4. In the DEIS’s analysis of Alternative 3, the document refers to “a Delft3D model assessment of beach fill performance,” but does not include a description of model results. Appendix B similarly omits the model results for Alternative 3.26 Appendix C lacks any description of model results for individual alternatives.	Southern Environmental Law Center	Numerical Model	Appendix B, Table 4.	Table 4.8 in the Engineering Report (Appendix B of the DEIS) provides estimated volume losses for the beach fill area under Alternative 3 as deduced from the results of the Delft3D model simulation. A discussion of the model indicated performance of the beach fill under Alternative 3 is provided on page 39 of the Engineering Report. Table 4.10 has been added on Appendix B which includes modeled volume changes above the -6-foot NAVD contour for Alternatives 1 to 4. Similar volume changes for the three terminal groin options evaluated for Alternative 5 are provided in Table 4.14 and Table 4.15 . Both of these tables include the model results for Alternative 1 for comparison.
181	While the DEIS lacks model results for Alternative 3, it appears that Alternative 4 was not modeled at all. The DEIS states that the “models were employed to determine impacts for Alternatives 1, 2, 3, 4, and 5." The description of environmental consequences for Alternative 4 does not include any description of that modeling. Instead, it refers to modeling of Alternative 1, which differs significantly from Alternative 4	Southern Environmental Law Center	Numerical Model	Chapter 5; Appendix B.	The DEIS does include discussion of the model results for Alternative 3. These discussion are provided in Chapter 5 (page 121 of the DEIS) and in the Engineering Report (page 39 of Appendix B of the DEIS). The DEIS (Appendix B – Engineering Report) states the Delft3D model results for Alternative 1 are applicable to Alternative 2 since the only difference in the two alternatives is Alternative 2 would not use sandbags revetments for temporary erosion protection. Modeled results for Alternative 4 have been added to Appendix B and Chapter 3. The discussion regarding the Deflt3D model efforts for Alt. 4 have been added to Chapter 3 and Chapter 5 .
182	The descriptions of modeling results for the terminal groin alternatives fare little better. The DEIS states that “[t]he model results of volume changes above the -6-foot NAVD depth contour measured between the terminal groins and station 30+00 indicate the volumetric erosion rates and hence periodic nourishment requirements in this area would be reduced by 29.2% for the 250-foot terminal groin and by 75.0% and 95.8% for the 500-foot and 750-foot terminal groins respectively.” The only citation provided is a general citation to Section 4 of Appendix B. This citation is woefully inadequate and fails to provide the explanation necessary to comply with NEPA.	Southern Environmental Law Center	Numerical Model	Chapter 3, summary of model results for Alternative 5; Appendix B.	The commenter suggests that this statement is made on page 124 of the DEIS, however, this statement is not included within this chapter. Rather, it was made in Chapter 3 on page 39. The citiation has been modified to inlude reference to Table 4.13 in Appendix B with discussion in Chapter 3
183	On page 29, the DEIS assumes that erosion will continue at previous rates under Alternative 1 east of station 30+00, which are estimated to “average 91,000 cubic yards/year.” On page 117, the DEIS reports that the model for Alternative 1 predicts that the same stretch of beach will erode at a rate of 24,000 cy/yr.	Southern Environmental Law Center	Numerical Model	N/A	The 24,000 cubic yard/year rate refers to the model results of volume change above the -6-foot NAVD depth contour whereas the 91,000 cubic yards/year was the measured rate based on monitoring surveys. Model volume changes above the -6-foot NAVD depth contour were used as a basis of evaluating the relative difference in the modeled beach performance between the various alternatives. The model volume changes were adjusted to observed volume changes by prorating the model results to match observed rates.

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184	DEIS states that any modeled increase in erosion greater than 24,000 cy/yr will correspond to a proportional increase in the observed erosion rate. For example, a modeled erosion rate of approximately 37,000 cy/yr under Alternative 3 was assumed in the DEIS to mean that the observed erosion rate would increase by 54% to 140,000 cy/yr. Likewise, according to the analysis, any modeled decrease in erosion rate from 24,000 cy/yr would correspond to a proportional decrease in observed erosion rate. For example, a modeled decrease in erosion rate to 1,000 cy/yr with a 750-foot terminal groin was assumed to decrease observed erosion by 95.8%. Yet, the DEIS has not provided any analysis to support the assumption that modeled erosion rates under Alternative 1 are proportional to the observed erosion rates (and that therefore, changes in the erosion rate predicted by the model are proportional to changes in the,observed erosion rates).	Southern Environmental Law Center	Numerical Model	N/A	The model results used to evaluate shoreline response for the alternatives were based on model changes above the -6-foot NAVD depth contour. Since the model results were only used to determine relative differences in the response of the inlet and adjacent shoreline to man-induced changes, an assumption was made, based on engineering judgement, that corresponding changes in the “real world” would be proportionally the same as indicated by the model. Therefore, with the modeled results for Alternative 3 indicating a volume losses on the east end of Ocean Isle Beach would be 54% higher than volume losses indicated for Alternative 1, this relative difference in the shoreline response was appropriately applied to measured “real world” changes to obtain an estimate of volume losses that could be expected under Alternative 3.
185	The model was run for three years, a time period so short that it fails to account for the regular beach renourishment events that are part of each alternative. By doing so, the analysis presumes that after each three-year cycle, the shoreline will return to the shoreline assumed in year 0. That plainly is not so. By truncating the model at three years, the analysis entirely ignores a fundamental aspect of each alternative—regular renourishment—and unreasonably assumes that foreseeable effects of each alternative will be revealed in that short timeframe.	Southern Environmental Law Center	Numerical Model	N/A	Disagree with the assertion that a three year simulation is not sufficient to evaluate differences in the response of the system to man-induced changes. As previously stated, the model was calibrated for a three year period from April 2007 to April 2010 using input parameters (waves, tides, and winds) derived from known or observed conditions. The same “known” conditions were used in the simulation of the other alternatives with any difference in the response of the model clearly attributable to man-induced changes associated with the each alternatives. Running the model for an extended period of time using the same input parameters, while possible, would not be relevant since future sea and weather conditions would not be represented by the “known” input parameters applicable to the April 2007-April 2010 time period. Again, the Delft3D model is not used to “predict” future changes since predictions of climatic conditions far in to the future are not possible. As previously stated, the model results are only good for comparing relative differences in the response of the model a given set of induced man-made changes. The following text has been added to Chapter 3 and Chapter 5: "As stated in Appendix C, the model was calibrated for a three year period from April 2007 to April 2010 using input parameters (waves, tides, and winds) derived from known or observed conditions. The same “known” conditions were used in the simulation of the other alternatives with any difference in the response of the model clearly attributable to man-induced changes associated with the each alternatives."
186	The Corps must accept the Delft3D model in its entirety or reject it outright.	Southern Environmental Law Center	Numerical Model	N/A	Noted.
187	Although the DEIS states that “A complete description of the measured and modeled shoreline and volumetric changes is provided in Appendix C,” no such description is included in Appendix C. As discussed above, while Appendix B has some modeling information, it does not provide a “complete description of measured and modeled shoreline and volumetric changes.”	Southern Environmental Law Center	Numerical Model	Chapter 5, section entitled "What impacts would each alternative have on the shorelines of Ocean Isle Beach, Holden Beach, and Sunset Beach?"	The following text has been added to the EIS: "Appendix C provides details of the Delft3D model development and calibration while the results of the model simulations for Alternatives 1, 3, 4, and 5 are provided in Appendix B. The results of the model simulation for Alternative 1 are also applicable to Alternative 2, Abandon and Retreat, since the primary difference between these two alternatives is the use of temporary sandbag revetments under Alternative 1 to protect upland development while Alternative 2 does not involve the use of temporary sandbag structures. Measured shoreline changes and volume changes obtained from the ongoing beach monitoring program on Ocean Isle Beach and the west end of Holden Beach under the auspices of the federal storm damage reduction project are also provided in Appendix B ."
188	Appendix B, concludes that “[t]he average rates of movement of the scarp line during this period . . . appeared to provide a reasonable representation of recent changes on the east end of Ocean Isle Beach.” Impacts of Alternatives 1 and 2 were premised on continuation of these erosion rates for the next 30 years. It appears that this is based on a subset of LiDAR data that excludes relevant time periods with lower erosion rates. The DEIS does not offer any rationale as to why the erosion rates observed during the isolated 10-year period selected can be expected to occur “uniformly” for the next 30 years—particularly in light of modeling that predicts much lower erosion rates.	Southern Environmental Law Center	Numerical Model	Appendix B, Alternative 1 Introduction	The following text has been added to Appendix B: "While scarp movements were available from the LiDAR data beginning in September 1997, the September 1999 scarp position was selected as the start date for determining average rates of scarp movement since if preceded construction of the federal storm damage reduction project and provided a good representation of pre-federal project conditions". The time period selected determine movements of the erosion scarp on the east end of Ocean Isle Beach was done so in order to include recent man-induced changes that would have an impact on the movement of the scarp. The man-induced changes included; (1) the initial construction of the federal SDRP on Ocean Isle Beach in 2001, (2) subsequent nourishment of the federal project in 2006-07 and 2010, (3) the excavation of material from Shallotte Inlet for each of the beach fill operations, (4) the installation of sandbag revetments extending from just west of Shallotte Boulevard to the east end of the development, and (5) periodic disposal of navigation maintenance material along the east end of the island. Based on the available LiDAR data for the area, the 1999 shoreline was used to represent the condition prior to the implementation of the man-made changes listed above and the analysis extended to the April 2010 LiDAR survey to capture the impacts of the initial construction of the federal project and two subsequent periodic nourishment operations. None of the man-induced changes, except for occasional disposal of navigation maintenance material, occurred prior to 2001. With federal protection of Ocean Isle Beach authorized through 2051 (50 years after initiation of construction of the federal project), conditions that existed in the selected time period will likely continue for at least 30 years and possibly beyond.
189	When calculating erosion rates, however, CPE limited its analysis to LiDAR data from 1999 to 2010. The Feasibility Report does not provide any explanation for excluding the 1997 and 1998 LiDAR data. That analysis was carried forward in Appendix B and the DEIS, still without any explanation for the exclusion of the available data. The exclusion of this data must be explained.	Southern Environmental Law Center	Numerical Model	Appendix B. Alternative 1 Introduction	See response to Comment 188. The reason for selecting the 1999 to 2010 time period for determining the movement of the sand spit was done so in order to include recent man-induced changes that were not represented by earlier shoreline positions. These recent man-induced changes are listed in response to Comment 188 above. While the DEIS did not state this explicitly, it was implied in Section 3.1 of the Engineering Report (Appendix B). For clarity, a definitive statement to this effect will be added to the EIS.

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190	Even if the data from 1999 to 2010 accurately represented "recent changes on the east end of Ocean Isle Beach," the DEIS does not make any effort to support the assumption that those erosion rates can be expected to continue for the next 30 years. Inlets are dynamic systems and the USACE cannot simply assume that erosional forces at Shallotte Inlet will be static for the next 30 years.	Southern Environmental Law Center	General	N/A	Noted.
191	The assumed erosion rates based on LiDAR data from 1999 to 2010 conflict with modeled erosion rates. According to the Delft3D model, very little erosion will occur after three years under Alternative 1. Figure 5.3 of the DEIS, which is reproduced below, shows little erosion between station 0+00 and 30+00.Therefore, even if the 1999 to 2010 data could be considered representative of past erosion rates, the Delft3D model—which was designed based on those past erosion rates—predicts that erosion will stabilize at a much lower rate, allowing the beach to build up when combined with the beach nourishment from the federal storm damage reduction project.	Southern Environmental Law Center	Numerical Model	Appendix B; Chapter 5.	The Delft3D model results for Alternative 1 indicate continued erosion of the area between 0+00 and 30+00 throughout the 3 year simulation with no indication the rate of erosion was decreasing. The modeled erosion rates above the -6-foot NAVD depth contour between 0+00 and 30+00 were as follows: Year Model volume change above -6 feet NAVD (cy) 1 -35,600 2 -53,900 3 -73,300 While the rate of volume loss did decrease in each year, however, this was primarily due to erosion of the beach fill in the area. As reported in the DEIS, the loss of 73,300 cubic yards over the 3 year simulation period represented an annual rate of -24,000 cubic yards/year. This information was not included in the DEIS but will be added to the FEIS.
192	The conflict between the erosion rates relied on to develop the future scarp lines in Figure 3.1 of the DEIS and the modeled erosion rates and modeled shoreline changes cannot be overstated. The DEIS creates two Alternative 1 scenarios. Under the first, depicted in Figure 3.1, erosion continues uniformly and unabated for the next 30 years. Under the second, depicted in Figure 5.3, erosion stabilizes at a level that is more than replenished with beach nourishment. The DEIS relies on the first when evaluating economic impacts. The DEIS relies on the second when evaluating environmental impacts. Reliance on these dual forecasts could hardly be more arbitrary and capricious. Alternative 1 will result in one set of future erosion rates and a single shoreline. The USACE must choose one of the two scenarios offered by the DEIS and apply it consistently.	Southern Environmental Law Center	Numerical Model	N/A	Figure 3.1 in Chapter 3 shows the future positon of the erosion scarp if the scarp continued to move at the documented rates. Figure 5.3, which is in the Engineering Report (Appendix B), only shows modeled erosion/deposition patterns at the end of Year 2 of the simulation. Figure 5.3 does not show erosion stabilizing in the area so perhaps the comment referenced the wrong figure. The movement of the erosion scarp was selected to evaluate possible future damages due to continue long-term erosion since it was relatively unaffected by the intermittent disposal of navigation maintenance material on the east end of the island and over the long-term, not significantly impacted by the installation of sandbag revetments since the sandbags normally fail after only a relatively short period of time. While the disposal of material to nourish the federal project may have a limited impact on the area near Shallotte Boulevard, its impact farther east was not significant. As discussed in the DEIS, when the temporary sandbags fail, the scarp line makes an almost instantaneous correction and moves to a position it would have occupied had the sandbag revetment not been installed. Also, as discussed above, the model did not indicate any reduction in volume losses off the east end of Ocean Isle Beach under Alternative 1. Finally, the movement of the erosion scarp does not directly depend on changes in the nearshore bottom that occurs seaward of the mean high water line. Rather, the movement of the erosion scarp is more a function of elevated water levels associated with minor to moderate coastal storms. Consequently, the volume changes indicated by the model for Alternative 1 are not directly linked with observed movements of the erosion scarp. The use of the movement of the erosion scarp, which is a linear measure of shoreline change, was used to evaluate potential economic impacts of Alternatives 1 and 2 is appropriate since the movement of the scarp is not directly reflected in the volume changes that are occuring seaward of the scarp and existing sandbags. The erosion volume associated with Alternative 1 is directly related to the enviornmental impacts as it relates to the amount of dredging that would be needed to offset the volume losses.
193	Like Alternative 1, the DEIS uses the inflated observed erosion rate in its economic analysis—increasing beach nourishment costs substantially. As with Alternative 1, the DEIS uses the modeled erosion rates and the modeled shoreline to evaluate environmental impacts. As a result, the analysis of Alternative 3, on its face, is arbitrary and capricious—it predicts two fundamentally different outcomes.	Southern Environmental Law Center	Numerical Model	N/A	Disagree. The model results for Alternative 3, as discussed in Chapter 5 and in the Engineering Report (Appendix B) are totally comparable to the model results obtained for Alternative 1. Furthermore, the modeled results for Alternative 3, which indicate relatively high rates of erosion of a beach fill placed east of Shallotte Boulevard, is supported by the observed performance of the local beach fill placed in the area during the 2006-07 periodic nourishment operation. In that instance, the 155,000 cubic yards of fill placed between baseline stations -3+00 and 17+00 was completely lost in a matter of months.
194	The DEIS assumed loss of 140,000 cy/yr between station 0+00 and 0+30 is not supported by the DEIS. The inflated erosion rate is primarily based on observations of 2006-07 beach fill deposited on the east end of Ocean Isle Beach in addition to the federal storm damage reduction project. As reported in Appendix B, the additional fill of 155,000 cy eroded within approximately nine months. The overall erosion rate between 0+00 and 0+30 during that the three years following the fill, however, was approximately 88,000 cy/yr, indicating that while the additional fill eroded quicklly, the overall erosion rate did not increase.	Southern Environmental Law Center	Numerical Model	Appendix B, Alternative 3	The comment regarding the use of the performance of the local beach fill of 155,000 cubic yards placed on the east end of the island during the 2006-07 beach nourishment operation is not correct. As explained in the DEIS, the 140,000 cubic yard/year loss in the area between station 0+00 and 30+00 was based on the model results which indicated a 54% increase in volume losses compared to the model losses for Alternative 1. Under Alternative 1, documented volume losses based on monitoring surveys averaged 91,000 cubic yards/year following initial construction and two subsequent periodic nourishment operations. A 54% increase in this loss rate yields the 140,000 cubic yards/year loss rate applicable to Alternative 3.

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195	Appendix B explains that the modeled erosion rate was 54% higher than "existing conditions" or, more specifically, the modeled erosion rate under Alternative 1—24,000 cy/yr. A 54% increase would result in a modeled erosion rate of approximately 37,000 cy/yr, though neither Appendix B nor the DEIS reveal the modeled erosion rate. Therefore, the model predicted that over the three years assessed, the 450,000 cy initial fill would be reduced to 339,000 cy, a 25% reduction. That result is evident in Figure 5.4, which depicts substantial accretion.	Southern Environmental Law Center	Numerical Model	Appendix B, Alt. 3	The EIS has been revised to include the model results for Alternative 3 as well as the model results for Alternative 1 to demonstrate how the 54% increase in volume loss between stations 0+00 and 30+00 was derived. In this regard, the modeled rate of volume loss between 0+00 and 30+00 was 37,000 cubic yards/year. Applying the 54% increase in the rate of volume loss along the east end of Ocean Isle Beach to the observed rate of volume loss of 91,000 cubic yards/year results in the estimated loss rate for Alternative 3 of 140,000 cubic yards/year. The relative difference in the response of the other shoreline segments on Ocean Isle Beach to Alternative 3 relative to Alternative 1 west of station 30+00 will also be used in the final EIS to adjust expected average annual volume losses. This adjustment resulted in a lowering of the annual rate of volume loss between stations 30+00 and 60+00 and minor changes in the volume rates for the other two western segments. This adjustment resulted in a total annual volume loss of 192,000 cubic yards/year for Alternative 3. Given this rate of volume loss and the assumed limit of 408,000 cubic yards per nourishment operation, periodic nourishment under Alternative 3 would occur every 2 years. As a result of the two year nourishment interval, the initial fill volume along the east end of Ocean Isle Beach under Alternative 3 was reduced from 450,000 cubic yards to 387,000 cubic yards. At the end of the two-year cycle, the volume of fill remaining on the beach between stations -5+00 and 35+00 should be around 107,000 cubic yards. The referenced accretion shown on Figure 5.4 in Chapter 5 shows the remnants of the 450,000 cubic yard fill used in the simulation.
196	The DEIS refers to modeling of Alternative 1 in the discussion of Alternative 4, but Alternative 1 modeling cannot substitute for an analysis of Alternative 4 as is evident by the projection that Alternative 1 would require continued beach renourishment for 30 years as compared to the more specific dredging in Alternative 4 that CPE projects would eventually eliminate the need for beach nourishment between stations -5+00 and 30+00. Similarly, the DEIS refers to erosion rates under Alternative 3, but even if those erosion rates were reliable (they are not), they do not reflect the specific channel dredging included in Alternative 4.	Southern Environmental Law Center	Numerical Model	Appendix B and Chapter 3	The numerical model has been utilized to simulate conditions under Alternative 4 within the FEIS. Please see Appendix B and Chapter 3 for details regarding the model output.
197	The DEIS errs by assuming that the inlet relocation will take 20 years without explanation. A similar realignment at Emerald Isle achieved that modified sand transport after just 6 years. The historic shorelines mapped on Figure 4.13 of Appendix B do not support that assumption. The inlet position is not indicated in relation to the shorelines. Therefore it is not possible to draw any conclusions from the information included.	Southern Environmental Law Center	Numerical Model	N/A	The intent of Figure 4.13 of Appendix B was not to demonstrate past shoreline positions associated with historic channel conditions or Alternative 4. Rather Figure 4.13 was used to show that the shore anchorage section of the proposed terminal groin under Alternative 5 extended sufficiently far inland to prevent possible flanking of the landward end of the structure. Prediction for the time of recovery of the sand spit off the west end of Emerald Isle following the relocation of the bar channel of Bogue Inlet to a more central location and the predicted time of recovery of the north end of North Topsail Beach associated with moving the New River Inlet bar channel to a preferred position and alignment were both based on a reversal of historic trends that were observed at both inlets following the natural migration of the bar channel of the inlets toward the adjacent shorelines. In the case of Bogue Inlet, natural channel movement placed the channel juxtaposed to west end of Emerald Isle while the New River Inlet channel migrated north to an alignment toward Onslow Beach. Given the amount of time it took for negative impacts to manifest on both Emerald Isle and North Topsail Beach, in both instances an assumption was made that a reversal of these past trends would require comparable amounts of time following the artificial relocation of the channels. Assumptions regarding the eventual recovery of Shallotte Inlet and the shoreline along the east end of Ocean Isle Beach in response to the preferred channel position and alignment followed the same rational as used for both Bogue Inlet and New River Inlet. These assumptions are discussed on page 49 of the Engineering Report and basically indicate future changes were based on a reversal of the changes that were associated with the natural movement of the bar channel toward Holden Beach between 1965 and 1972. Since the erosion along the east end of Ocean Isle Beach took some time to occur following the channel movement, a comparable amount of time would be expected to be required before the east end of Ocean Isle Beach would be completely restored to a condition that existed prior to the natural channel movement toward Holden Beach. Added the following text to Chapter 3: "Under Alternative 4, the Federal project dredging scheme employed by the USACE would be modified to concentrate sediment removal for periodic nourishment from the same general footprint used by the USACE during initial construction of the federal storm damage reduction project in the Shallotte Inlet borrow area. The plan formulation for the Federal storm damage reduction project included an assessment of the impacts the orientation and position of the main channel crossing the ocean bar of Shallotte Inlet had on the east end of Ocean Isle Beach. The USACE concluded that when the channel was positioned approximately midway between the west end of Holden Beach and the east end of Ocean Isle Beach and oriented generally perpendicular to the adjacent shorelines, the east end of Ocean Isle Beach had a tendency to accrete. This condition was noted in historical aerial photographs of the inlet between 1954 and 1965 (Appendix B). "
198	The DEIS is decidedly one-sided, omitting any discussion of the disadvantages of terminal groins experienced elsewhere, only briefly addressing the groin at Oregon Inlet.	Southern Environmental Law Center	General	N/A	The purpose of the DEIS is to present the results of the evaluation of alternatives considered to provide erosion protection to the east end of Ocean Isle Beach. The assessment of each alternative was based on information applicable to Ocean Isle Beach. While the performance of terminal groin projects at other locations is of some interest, the conditions at other location would not match the conditions at Ocean Isle and Shallotte Inlet and are therefore the impacts of terminal groins installed at other locations is not directly transferable or applicable to the Ocean Isle Beach project. The DEIS did incorporate the evaluation of other terminal groins by referencing the NC study on terminal groins
199	The Corps' Coastal Engineering Manual describes groins as: "…probably the most misused and improperly designed of all coastal structures." It recognizes that "[o]ver the course of some time interval, accretion causes a positive increase in beach width updrift of the groin. Conservation of sand mass therefore produces erosion and a decrease in beach width on the downdrift side of the groin."	Southern Environmental Law Center	General	N/A	Noted. While this conclusion may be valid for groins in general, this conclusion does not stand true for terminal groins which are situated at the terminus of an island.

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200	CRC's terminal groin study found that, at Oregon Inlet, "[t]he six miles of [Pea Island] shoreline south of the terminal groin fillet that was monitored continues to erode at rates that range from slightly more to slightly less than the pre-terminal groin shoreline erosion rates, in spite of frequent dredging and beach nourishment efforts." With respect to Fort Macon, the report concluded that "[w]ithout constant beach nourishment, the terminal groin would no longer perform as observed historically and, potentially fail altogether." Similarly, the CRC's terminal groin study suggests that substantial beach nourishment is required even when terminal groins are constructed. The DEIS states that "[r]esults have shown that the project erosion rates are much less than historical rates in the first four miles of the study area." The CRC's study found that when the effect of beach nourishment was removed, the 1998-2004 erosion rate on Pea Island exceeded the 1949- 1980 erosion rate at intervals 1-2 miles from the inlet, 2-3 miles from the inlet, 4-5 miles from the inlet, and 5-6 miles from the inlet. On Bodie Island, the effect was more severe—erosion increased substantially at five of the six intervals evaluated.	Southern Environmental Law Center	Alternative #5	Chapter 5	The shoreline changes that have occurred along the north end of Pea Island following installation of the terminal groin show a definite improvement over the first three miles south of the groin. The Pea Island terminal groin project did not have a beach nourishment component, rather, the material placed on Pea Island following the construction of the terminal groin was associated with the disposal of navigation maintenance material removed from Oregon Inlet to maintain the federal navigation channels. Also, not all of the material removed from Oregon Inlet was placed directly on the beach. Based on USACE records, approximately 28% of the material removed from Oregon Inlet was deposited in the nearshore area off Pea Island in water depths of between 12 and 15 feet. The remaining 72% was placed directly on the beach. Regardless of the method of disposal, the end result of the combination of the terminal groin and navigation maintenance material disposal have combined to stabilize the north end of Pea Island. This has been well documented by shoreline monitoring studies conducted in the area by NC State University. Any direct comparison of the Pea Island terminal groin to the one proposed for the east end of Ocean Isle Beach would be inappropriate due the difference in scale of the physical characteristics of the two inlets and the littoral environment at both sites. In this regard, the littoral climate in the Oregon Inlet area produces gross sediment transport rates of the order of 2.5 million cubic yards/year compared to sediment transport rates of around 500,000 cubic yards/year for Ocean Isle. In terms of physical attributes, Oregon Inlet is about three times as wide as Shallotte Inlet and has a tidal prism that is an order of magnitude greater than the tidal prism of Shallotte Inlet. Given the positive shoreline response along the north end of Pea Island as the result of the terminal groin and periodic disposal of navigation maintenance material, a terminal groin project on the east end of Ocean Isle Beach which would include a periodic beach nourishment component as a feature of the overall plan, is expected to produce comparable positive shoreline responses on the east end of Ocean Isle Beach.
201	NEPA requires a robust analysis of environmental impacts. The Corps must not only consider direct impacts from each alternative, but must also take into account indirect and cumulative impacts. That analysis then forms the basis for the evaluation of the alternatives under the 404(b)(1) guidelines and the Endangered Species Act. The DEIS fails at the first step, defining the impacts, eliminating the document's utility.	Southern Environmental Law Center	Impact Analysis	N/A	Noted.
202	The direct effects were determined here "by identifying the footprints of project-related activities (i.e. proposed areas to be dredged, beach fill locations, staging area, etc.)." Because the footprint of each alternative depends on nourishment values derived from the inflated erosion rates based on the Delft3D model, the estimate of habitat directly affected by the alternatives is unreliable.	Southern Environmental Law Center	Impact Analysis	N/A	Noted.
203	In the DEIS, "[i]ndirect impacts were determined by the changes to the shoreline at Year 1 Post-construction as interpreted from the Delft3D modeling results." These impacts are based solely on the shoreline predicted by the Delft3D model. The DEIS itself says that such a use is improper.	Southern Environmental Law Center	Impact Analysis	Chapter 5, Question 2.	The text has been corrected to indicate that Indirect impacts were determined using Delf3d Model results at Year 3 for Alternatives 1 and 2, Year 2 for Alternatives 3 and 4, and Year 5 for Alternative 5. Knowing that the inlet and oceanfront shorelines are dynamic, the only basis to evaluate potential indirect impacts are throuh the utilizatoin of numerical models. As stated on page 113 of the DEIS, "Delft3D model results for Alternative 1 (No New Actions) obtained under a prescribed set of forcing conditions forms a basis for comparing relative changes in Shallotte Inlet and the adjacent shorelines that could be attributable to physical changes in the system associated with each alternative." Furthermore, the DEIS states "These results should be interpreted with caution as they are not intended to be a precise prediction of habitat change considering they are in part based on modeling simulations and are therefore only intended to provide insight on potential changes."
204	The analysis of indirect impacts was limited to one year following construction. There is no conceivable argument that indirect effects will cease one year post construction.	Southern Environmental Law Center	Impact Analysis	Chapter 5, Question 2.	The text has been corrected to state: For Alternatives 1 and 2, post-construction Year 3 model outputs were utilized for the analysis of indirect impacts due to the fact that beach nourishment is planned for every three years. Because the beach nourishment cycle for Alternatives 3 and 4 are proposed every two years at the beginning of the 30-Year project, Year 2 post-construction conditions were chosen for the indirect analysis. Finally, Alternative 5 involves a 5-year nourishment cycle, and hence, the Year-5 post-construction Deflt3D model output was utilized for the analysis of indirect impacts.
205	the DEIS's cumulative impacts analysis fails to meet basic requirements. A "[c]umulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions." 40 C.F.R. § 1508.7.	Southern Environmental Law Center	Impact Analysis	Chapter 5, Question 6.	Cumulative impacts are assessed throughout Chapter 5 for each resource within each project Alternative
206	The DEIS does not provide information required to satisfy the 404(b)(1) Guidelines.	Southern Environmental Law Center	General	N/A	Noted
207	Under the Clean Water Act, the Corps is only able to permit the least environmentally damaging practicable alternative ("LEDPA"). Practicable means "available and capable of being done after taking into consideration cost, existing technology, and logistics." 40 C.F.R. § 230.3(q). Although the Corps has not defined practicability in the DEIS—thereby unlawfully denying the opportunity for public comment on that essential element of the analysis—it is apparent that each alternative is practicable.	Southern Environmental Law Center	Impact Analysis	N/A	Noted.
208	No structures will be lost under any alternative and each alternative would provide protection to the imminently threatened properties with significantly reduced beach nourishment requirements. On that basis, each alternative is practicable and Alternative 4 appears to be the LEDPA. Therefore, it is the only alternative that can be permitted.	Southern Environmental Law Center	Impact Analysis	N/A	Noted.
209	Alternative 4 would have the least impact on substrate and benthic organisms because it would require decreasing dredging and nourishment.	Southern Environmental Law Center	Impact Analysis	Appendix B Beach fill design for Alt. 4; Chapter 3, beach fill design for Alt. 4.	Alternative 4 starts out with a 2-year nourishment cycle but increases every 4 years after year 14 and then to a 5-year nourishment cycle after year 18. Alternative 5 includes a 5-year nourishment cycle from the beginiing.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

210	Unlike any of the non-structural alternatives, however, the terminal groin alternatives will permanently alter the characteristics of the inlet.	Southern Environmental Law Center	Impact Analysis	Chapter 5, Alternative 5, Inlet Dunes and Dry Beaches	Indirect and cumulative impacts to the inlet area are disucssed in Chapter 5.
211	The USACE must evaluate "the nature and degree of effect that the proposed discharge will have individually and cumulatively on water, current patterns, circulation including downstream flows, and normal water fluctuation." 40 C.F.R. § 230.11(b).	Southern Environmental Law Center	Impact Analysis	Chapter 5- Hydrodynamics (each alternative	Alternative-related imapcts to the tidal prism are evaluated in Chapter 5.
212	As with impacts to substrate, Alternative 4 clearly has the least environmental impact on the aquatic communities and deposition of suspended particles. It would less adversely affect aquatic communities and would continue to allow deposition of suspended particles on the overwash areas at the eastern end of the island (as would the other non-structural alternatives). By comparison, the terminal groin alternatives would permanently displace aquatic communities at the eastern end of the island and eliminate overwash, cementing the accompanying adverse environmental impacts.	Southern Environmental Law Center	Impact Analysis	Appendix B Beach fill design for Alt. 4; Chapter 3, beach fill design for Alt. 4.	A comparison of impacts is not to be performed in the EIS, as part of the NEPA process. The Record of Decision will perform this analysis. It should be noted, however, that the nourishment interval for Alternative 4 is greater than Alternative 5 during the first 18 years.
213	The Corps' consideration of the fluctuation of normal water level must include consideration of "modifications [that] can alter or destroy communities and populations of aquatic animals and vegetation, . . . modify habitat, reduce food supply, restrict movement of aquatic fauna, destroy spawning areas, and change adjacent, upstream, and downstream areas." 40 C.F.R. § 230.24.	Southern Environmental Law Center	Impact Analysis	N/A	Noted.
214	The Corps must compare alternatives based on their potential impact on "nesting areas, protective cover, adequate and reliable food supply and resting areas for migratory species." 40 C.F.R. § 230.30(b)(2).	Southern Environmental Law Center	Impact Analysis	N/A	A comparison of impacts is not to be performed in the EIS, as part of the NEPA process. The Record of Decision will perform this analysis.
215	Construction of Alternative 5a, 5b, or 5c would eliminate habitat for all shorebirds that rely on relatively unvegetated back beach, wet beach, and intertidal habitats. Therefore, the adverse effects described above for piping plover are likely to be felt by red knots and other shorebirds.	Southern Environmental Law Center	Impact Analysis	Chapter 5, Alternative 5- Wet Beach and Intertidal sections	As stated in Chapter 5 within the discussion regarding intertidal habitat for Alternative 5, "Should the erosion continue along the inlet beaches on Ocean Isle Beach and Holden Beach, the overwintering critical habitat and nesting habitat for piping plovers and critical habitat for nesting sea turtles could be impacted". Under the Wet Beach discussion, the DEIS states, "The indirect impacts to the wet beach habitat within the Permit Area may affect shorebird, crustacean and fish foraging, and recreational fishing through a temporary reduction in prey during and immediately after construction."
216	Because this project "may affect" a number of listed species and designated critical habitat, the Corps must consult with the expert wildlife agencies – U.S. Fish and Wildlife and the National Marine Fisheries Service – to determine the effects of the project on these resources. 16 U.S.C. § 1536(a)(2). Production of such a "biological opinion" is required by the ESA and its implementing regulations unless the Corps determines, with the written concurrence of the expert wildlife agencies, "that the proposed action is not likely to adversely affect any listed species or critical habitat." 50 C.F.R.	Southern Environmental Law Center	Impact Analysis	N/A	A Biological Assessment has been sumbitted to the USFWS and consultation has been completed.
217	The FWS has previously made its view of this project known. In an email sent during the scoping process for this proposal, Pete Benjamin wrote as follows: The issues are clear. A project of this nature will destroy the ecological functioning of this inlet and the surrounding areas. The science is unequivocal. I see no unique issues or areas of significant uncertainty. We oppose this project. There is nothing more to discuss.	Southern Environmental Law Center	Impact Analysis	N/A	Noted.
218	Based on the well-known and intended effects of terminal groins, it is unavoidable that the terminal groin as proposed in Alternative 5 will destroy and adversely modify both habitats and inlet processes that constitute primary constituent elements of critical habitat and the Endangered Species Act ("ESA") prohibits issuance of a permit that would authorize these activities.	Southern Environmental Law Center	Impact Analysis	Chapter 5, Alternative 5-Intertidal section	As stated in Chapter 5 within the discussion regarding intertidal habitat for Alternative 5, "Should the erosion continue along the inlet beaches on Ocean Isle Beach and Holden Beach, the overwintering critical habitat and nesting habitat for piping plovers and critical habitat for nesting sea turtles could be impacted". In addition, a Biological Assessment will be sumbitted to the USFWS and consultation will be completed prior to the release of the Record of Decision.
219	Under current practice, the FWS "will find 'adverse modification' if the impacts of a proposed action on a species' designated critical habitat would appreciably diminish the value of the habitat for either the survival or the recovery of the species."	Southern Environmental Law Center	Impact Analysis	N/A	Noted.
220	Although it is not possible to reasonably predict the specific effects of the terminal groin alternatives based on the information provided in the DEIS, experience with terminal groins in other contexts makes clear that any of the terminal groin alternatives will result in the adverse modification of critical habitat. Primary constituent elements of critical habitat include intertidal flats, spits, sparsely vegetated flats above high tide, sparsely vegetated back beach, and inlet processes.	Southern Environmental Law Center	Impact Analysis	N/A	Noted.
221	Inlet stabilization with rock jetties and associated channel dredging for navigation alter the dynamics of longshore sediment transport and affect the location and movement rate of barrier islands (Camfield and Holmes 1995), typically causing downdrift erosion	Southern Environmental Law Center	Impact Analysis	N/A	It should be noted that the construction of a rock jetty is not a component of any proposed project alternative.
222	Because of these substantial environmental impacts, the terminal groin alternatives fail to meet the purpose and need. As described in the EIS, the purpose and need of this project is to "[b]alance the needs of the human environment with the protection of existing natural resources." The terminal groin alternatives will substantially and permanently degrade existing natural resources and cannot be permitted.	Southern Environmental Law Center	Impact Analysis	N/A	Noted.

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223	The DEIS's economic analysis is erroneous for several reasons. First, as modeled, each alternative will require significantly less dredging and beach nourishment than estimated in the economic analysis and no buildings or infrastructure will be lost. Second, even if buildings and infrastructure is lost, the DEIS substantially overestimates the "cost" to Ocean Isle Beach.	Southern Environmental Law Center	Financial		The basis of this comment is not clear. The economic costs for all alternatives involving beach nourishment as a component assumed damages due to a continuation of long-term erosion would be eliminated. The volume of material needed to initially construct and provide periodic nourishment to maintain the design fill were all based on the model results reported in the DEIS. With regard to periodic nourishment for Alternatives 1 and 2, the costs were based on a continuation of past periodic nourishment events which have placed an average of 408,000 cubic yards of material on Ocean Isle Beach every three years. The volume of periodic nourishment needed for Alternative 3 was derived from the model results which indicated maintenance of the beach fill only alternative would require 54% more material between stations 0+00 and 30+00 compared to the existing condition. The cost for Alternative 3 were based on a two year nourishment interval with 387,000 cubic yards of material being deposited within the project area. As for Alternative 4, periodic nourishment was assumed to decrease overtime in response to maintaining the Shallotte Inlet bar channel in a preferred position and alignment. Periodic nourishment for Alternative 4 varied from 436,000 cubic yards every two years during the initial four years following project implementation eventually decreasing to 390,000 cubic yards every 5 years by the end of the 30 year evaluation period The periodic nourishment requirements for Alternative 4 are provided in Table 4.8 of the Engineering Report (Appendix B of the DEIS). With regard to periodic nourishment for Alternative 5, it too was based on the results of the Delft3D numerical model evaluation.
224	The modeled erosion rates and modeled shorelines show dramatically reduced erosion without constructing a terminal groin. Under Alternative 1 and 2, the beach between 0+00 and 0+30 would grow larger each year. Under Alternative 3 the initial fill would last 12 years at the erosion rates predicted by the model. Because Alternative 4 more narrowly focuses the channel to reduce erosion, the initial beach fill should last even longer than that under Alternative 3. Therefore, the estimated dredging, beach nourishment, and property-loss related costs are over estimated for each of these alternatives and must be revised.	Southern Environmental Law Center	Financial	Appendix B, Table 4.4 and 4.7	Not sure what this comment is based on. The model results applicable to Alternatives 1 and 2 indicate continued erosion along the east end of Ocean Isle Beach. While the rate of erosion in each year of the simulation on the extreme east end of Ocean Isle Beach (Station 0+00 to 30+00) slowed after each year of the simulation, this reduction was due to the reduction in diffusion losses from the end of the fill as the planform of the beach fill approached the existing shoreline configuration. Cumulative volumetric changes above the -6-foot NAVD depth contour as determined by the Delft3D model along the segment of Ocean Isle Beach from Station 0+00 to 120+00 over the three year simulation period is provided in the table below. This table, Table 4.4 as shown below, has added to the FEIS in the discussion of the model results for Alternative 1. Table: Modeled cumulative volume changes for Alternative 1 above the -6-foot NAVD depth contour. Shoreline Segment / Volume Change above -6 feet NAVD after: Year 1, Year 2, Year 3 0+00 to 30+00: 35,600 / -53,900 / -73,300 30+00 to 60+00: -23,600 / -36,600 / -53,600 60+00 to 90+00: -34,200 / -33,200 / -42,300 90+00 to 120+00: -22,100 / -15,800 / -20,200 Comparable cumulative volumetric changes derived from the Delt3D model for Alternative 3 are provided in the table below and has been added to the FEIS as Table 4.7. As was the case for Alternative 1, volumetric losses from the segment between 0+00 and 30+00 were initially high during the first year of the simulation with the volume loss decreasing over the ensuing two years, but in no instance did the shoreline trend reverse. Table: Modeled volume changes for Alternative 3 above the -6-foot NAVD depth contour. Shoreline Segment / Volume Change above -6 feet NAVD after: Year 1, Year 2, Year 3 0+00 to 30+00: -71.000 / -88,700 / -110,000 30+00 to 60+00: -21,400 / -21,400 / -30,400 60+00 to 90+00: -35,600 / -33,700 / -37,900 90+00 to 120+00: -21,800 / -16,700 / -22,900 For Alternative 4, volumetric losses from the beach fill were assumed to reduce over time due the response of the shoreline to a quasi-permanent position and orientation of the Shallotte Inlet ocean bar channel.
225	Even if Alternatives 1 and 2 were to result in the loss of houses and infrastructure as projected in the DEIS, the "cost" to Ocean Isle Beach is dramatically overstated. Ocean Isle Beach does not own the properties at issue; its only loss is future profit from tax revenue. Given the current tax rate of 0.155/$100,96 the lost future revenue would be miniscule compared to the cost of the terminal groin. Moreover, the DEIS errs in the assessing the value of lost infrastructure at the "replacement cost". The infrastructure would not be replaced and, therefore, the cost would not be incurred.	Southern Environmental Law Center	Financial	N/A	The economic analysis of the impact of continued erosion on the east end of Ocean Isle Beach was not presented as a cost to the Town of Ocean Isle Beach per se, rather, the analysis presented the potential future loses as an overall economic impact should nothing be done to address the cause of the long-term erosion along the east end of Ocean Isle Beach. With regard to "replacement cost", the use of replacement cost to establish the value of things that cannot be replaced is an accepted economic tool. The loss of property is a Human Environment issue and the Corps realizes that the town of OIB is just a mechanism (as a governmental agency) to facilitate the protection of those stuctures and utilities.
226	40 CFR 1502.14 requires the DEIS to provide clear basis for choice among options: (a) "rigorously explore and objectively evaluate all reasonable alternatives…"; and (b) "devote substantial treatment to each alternative examined in detail including the proposed action so that reviews may evaluate their comparative merits." DEIS fails on both of these accounts.	North Carolina Coastal Federation	General	Appendix B and Chapter 3	Alternative 4 , which had not been specifically been modeled in the DEIS has been modeled in response to this comment to ensure that each alternative is objectively evaluated
227	Though the official purpose of the DEIS is stated at the beginning of the document, the information that follows is too narrow in scope, and essentially becomes an editorial simply supporting the terminal groin option. This is made very clear by the stated purpose of the engineering report and the numerical study that is attached to the DEIS. It states it has been done to, "refine the terminal groin's design and develop a recommended plan which includes groin construction and strategic placement of beach fill." Thus, this report that is used as the technical basis for the selection of the preferred alternative simply analyzes one alternative in detail and fails to rigorously explore other alternatives.	North Carolina Coastal Federation	General	Appendix B cover page, Appendix C,Introduction	The Engineering Report has been modified to reflect that it was prepared for the USACE. Appendix C has been modified to indicate that the objective of the Engineering Report was to evaluate potential shoreline protection measures and states that "the objective of the Engineering Report (Appendix B) is to disclose the methodology involved with developing all project alternatives. Tand this numerical study is to refine focusses on the applicant's preferred alternative and therefore serves tothe terminal groin's design and develop a recommended plan which includes groin construction and strategic placement of beach fill."

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228	The DEIS does not treat all alternatives in the same fashion. It is biased in favor of a terminal groin. The DEIS is relying on the modeling tool Delft3D to analyze the alternatives. However, modeling was only done for Alternative 1 and 5. Modeling results for Alternative 3 are omitted and modeling of Alternative 4 has not even been done. This prevents the reviewer from comparing the results across all alternatives.	North Carolina Coastal Federation	Numerical Model	Chapter 5; Appendix B.	See response to SELC comment #181
229	During a meeting on March 20, 2014 where CPE gave a presentation to the OIB commissioners, the commissioners voted to select the preferred alternative. However, CPE presented cost estimates only for alternatives 1, 2 and 5. They also showed only one modeling slide for both alternatives 3 and 4 regardless that the two alternatives refer to two very different actions. Thus, the town board voted for the preferred terminal groin alternative without seeing how alternatives 3 and 4 responded to the town's needs. This demonstrates that analyses of alternatives 3 and 4 were only later added to the DEIS. This is transparent in the obvious unequal treatment the DEIS gives to these two alternatives compared to alternatives 1,2 and especially 5.	North Carolina Coastal Federation	General	N/A	As shown in the presentation, each alternative was represented with a slide depicting modeling results. Alternative 5 inculdes 3 options: a 250', 500', and a 750' groin- all options were presented as well. The costs were only depicted for Alternatives 1, 2, and 5. This presentation was not intended to mirror all of the contents within the DEIS.
230	The DEIS compares all alternatives to modeled Alternative 1, also called "the current conditions." However, given the inaccuracy of the modeling tool as well as its inability to model existing and observed conditions, assuming Alternative 1 as a basis of comparison is inherently wrong and provides fundamentally flawed conclusions.	North Carolina Coastal Federation	Numerical Model	N/A	The model is used to compare the outcomes for the various project alternatives. While the model calibration did not fully mimic existing conditions, each alternative was run using the same model set-up and therefore the results for each alternative provide insight on how the shorelines would respond relative to each other.
231	The DEIS failed to devote substantial treatment to each alternative and to allow for comparable analysis among alternatives.	North Carolina Coastal Federation	Numerical Model	Appendix B and Chapter 3	Alternative 4 , which had not been specifically been modeled in the DEIS has been modeled in response to this comment to ensure that each alternative is objectively evaluated
232	The modeling tool failed to accurately indicate the observed erosion rates for Holden Beach. For example, the final calibration of the model predicted that the beach would erode between stations HB300 and HB340; the actual observation in reality was that the beach accreted at every station. The model also predicted no change or slight erosion from HB340 to HB360; in reality the beach accreted at each station. The model only correctly predicted that erosion would occur at six monitoring locations and at three of those sites the predicted erosion was less than half of the observed erosion. The model was so inaccurate on Holden Beach that it predicted a loss of approximately 70 cy/ft at HB400 when in reality the beach accreted approximately 80 cy/ft.	North Carolina Coastal Federation	Numerical Model		See response to SELC Comment #177 above
233	The model failed to predict erosion on Ocean Isle Beach accurately. Appendix C states that "the model is able to reproduce the general erosion patterns along Ocean Isle Beach [high erosion rates from Shallotte inlet to Profile OI_65 (Chadbourn Street) with stable beaches further to the west (see Figure 40)." What it does not say is that the erosion rate estimates approximated observed erosion rates. In the areas most critical to the EIS [between OI_15 and OI_45 [modeled erosion rates were significantly different than observed rates.	North Carolina Coastal Federation	Numerical Model		See response to SELC Comment #178 above
234	The model failed to indicate the observed direction of longshore sediment transportation. The DEIS states that "most sources have estimated the net sediment transport direction to be from east to west along the majority of Ocean Isle Beach" However, the model used in DEIS indicated the opposite "the net longshore transport based on the model results was from west to east, even along the midpoint of Ocean Isle Beach." Though the model was adjusted, the final calibration predicted that sand would still move in the wrong direction for more than a mile.	North Carolina Coastal Federation	Numerical Model	Appendix C, page 58 and 59	See response to SELC Comment #176 above
235	The DEIS is biased in overestimating negative economic effects of erosion and costs for non-groin alternatives and in underestimating costs related to groin alternative. Further, the economic analysis of alternatives is fundamentally flawed because it attributes to the town the costs borne by entities other than the applicant.	North Carolina Coastal Federation	Financial	N/A	Disagree. The economic assessment of all alternatives was evaluated to the same level of detail. The cost estimates for beach nourishment options were based on actual costs experienced for the Ocean Isle Beach federal storm damage reduction project while the cost of the terminal groin were determined based on current cost associated with similar projects. The economic impact of the various alternatives is not performed in a manner that attributes the economic cost to just one entity such as the town. Rather, the economic assessment is performed to evaluate the costs that affect entities across the board. The analysis of the economic consequences in the DEIS is no different than the economic considerations normally associated with the evaluation of federal storm damage reduction projects which also evaluate potential damages to both public and private development and infrastructure.
236	The shoreline was modeled only for 3 years whereas economic effects of erosion are estimated for 30 years. This incongruence renders the 30-year economic impacts as stated in the DEIS questionable. The DEIS defends this by saying that "the model results are by no means intended to represent predictions of what changes to expect in the future with certainty, as this would require an ability to predict future weather and oceanic conditions." However, the model cannot indicate known erosion rates and known direction of longshore sediment transport under the known weather conditions.	North Carolina Coastal Federation	Financial	N/A	See response to SELC Comment #185 above

*Agency comments have been summarized. Please refer to individual agency letters for full content.

237	The DEIS claims that that 238 parcels, 45 of which have homes situated "east of station 15+00 (located just west of the Shallotte Boulevard)" are vulnerable to erosion in the next 30 years. However, the DEIS does not provide clear identification of mentioned parcels. Consulting county GIS map reveals that there are no 238 parcels on dry land in the mentioned location, unless the DEIS is counting the submerged properties. By performing visual inspection of the map it stands that approximately 54 parcels are on dry land and about 184 are submerged. This is misleading because the submerged properties have already been under water for a number of years and thus are now a public trust resource.	North Carolina Coastal Federation	Financial		See response to Comments #79, #109, #110, and #185 above.
238	The economic impact under the Alternatives 1 is overestimated. The engineering report claims the total economic impact of Alternative 1 over 30 years to be $35,148,000. However, about 69 percent of this amount pertains to the value of lost parcels and lost structures. The applicant's reliance on the value of lost parcels and structures is misleading because the town's financial loss but the parcel and structure owners'.	North Carolina Coastal Federation	Financial	N/A	See response to SELC Comment #235 above
239	The total economic cost for Alternative 1 over the 30 year period of $101.49 million as stated in the DEIS is unsubstantiated because it includes the $66.44 million of the cost borne by the federal government as part of the federal storm reduction project.	North Carolina Coastal Federation	Financial	Appedix B, Alternative 1 30-Year Cost	The federal share of the $66.44 million for the storm damage reduction project is $43.19 million (see page 29 in Appendix B of the DEIS). Inclusion of the cost of continuing to nourish the federal project under Alternative 1 as well as Alternative 2 is appropriate since the economic costs of the federal project would be affected by implementation of the other alternatives. In some instances the other alternatives could increase periodic nourishment costs while others would actually reduce the nourishment costs.
240	The costs for Alternative 4 are grossly exaggerated. The DEIS estimates that the timeline for the positive effects of Alternative 4 on the island would be 20 years, thus bringing the initial periodic nourishment requirement to a biannual basis. The choice of a 20 year timeline for positive effects is blatantly unsupported. The DEIS mentions this is based on documentation of aerial photography, but these are not shown or discussed in the document. The DEIS mentions this is based on documentation of aerial photography, but these are not shown or discussed in the document.	North Carolina Coastal Federation	Financial	Appendix B Figures 4.9a-4.9e; Chapter 3, Table 3.3.	Figures 4.9 in Appendix B were added to depict aerial photography as requested. The intent of the DEIS was to incorporate the aerial photographs by reference to the USACE 1997 General Revaluation Report, however, the EIS will be revised to include aerial photographs of Shallotte Inlet taken between 1949 and 1989. These aerial photographs are included in the Inlet Atlas prepared by Dr. William Cleary with a grant provided by NOAA National Sea Grant College Program to the NC Sea Grant College (Publication UNC-SG-99-04). With regard to the basis of the 20-year recovery period associated with maintaining the bar channel in a preferred position and alignment, refer to the response provided for Comment #197.
241	The DEIS states that the 20 year timeframe for positive effects of Alternative 4 to manifest "was based on historic behavior of the inlet at the time that elapsed between the stable condition and the mid 1960's to the eroded condition that began to manifest in the early 1980's (Figure 4.9 in the Appendix B)". The reference to the historic behavior is not applicable because it refers to the opposite – the time it took for the end of the island to erode. In the case of Alternative 4 the island would experience accretion and not erosion. The mentioned figure 4.9 does not depict this historic behavior but rather a 2001 post-construction survey of Shallotte Inlet.	North Carolina Coastal Federation	Alternative #4	Appendix B Figures 4.9a-4.9e	Noted. The referenced timeframe demonstrates the time it takes for the ebb tide delta to reconfigure, which is relevant to the point at hand. The reference to Figure 4.9 in the document is correct as it only referrers to the condition of the inlet following initial construction of the federal storm damage reduction project. However, for clarity, aerial photographs of Shallotte Inlet take between 1949 and 1989 will be included in the FEIS (see response to Comment # 240). Figures 4.9 in Appendix B were added to depict aerial photography as requested.
242	The DEIS needs to provide a map that clearly delineates affected properties and shows the property tax that these contribute to the applicant.	North Carolina Coastal Federation	Financial		Figures showing properties that would be impacted by the continued movement of the scarp on the east end of Ocean Isle Beach are provided on Figure 3.1 in Chapter 3 and on Figure 4.1 in Appendix B. The tax value of the affected parcels, including the value of the land and structures, is included in the discussion of the potential impacts of Alternative 1 on page 29 in Chapter 3.
243	43 CFR § 46.235 describes scoping as, "a process that continues *throughout* the planning and early stages of preparation of an environmental impact statement." During the 3 year process of the DEIS development in the case of Ocean Isle Beach only one (1) scoping meeting was held. The Corps failed to involve the public in further development of the document. It also failed to inform the public about the status of the DEIS development until the DEIS was submitted for public comment on January 23, 2014.	North Carolina Coastal Federation	NEPA Compliance		Noted. Requirements have been satisfied
244	40 CFR §1502.8 requires the DEIS to be written in plain language and use appropriate and easily understandable graphics. However, the DEIS is purposefully confusing.	North Carolina Coastal Federation	NEPA Compliance	N/A	Noted.
245	40 CFR §1502.25 requires the lead agency to draft the EIS *concurrently* with analyses required under other laws such as Fish and Wildlife Coordination Act and the Endangered Species Act, among others. Further, 40 CFR 1501.6(1) states that the lead agency shall, "Request the participation of each cooperating agency in the NEPA process at *the earliest possible time* ." The Corps has failed to comply with these requirements and to request the Section 7 consultation with the required federal agencies. The DEIS provides neither information about whether the Section 7 process has occurred nor any findings pertaining to the Section 7 requirement.	North Carolina Coastal Federation	NEPA Compliance	N/A	NEPA does not require the consultations for EFH, ESA and 106 to be incorporated in the EIS document.
246	The monitoring and mitigation plan cannot be developed for this project until an official consultation process with USFWS is initiated and its biological opinion issued.	North Carolina Coastal Federation	NEPA Compliance	Chapter 6.	The monitoring mitigation plan as outlined in Chapter 6 are intended to reduce impacts to enivronmental concerns including T&E species which does not rely upon the initiation of the consultation process or issuance of the Biological Opinion.
247	The DEIS fails to properly evaluate direct, indirect and cumulative impacts to the environment. For its analysis of these impacts the DEIS relies on dubious Delft3D modeling results. This renders the analysis unreliable. The analysis is limited to only one year following the construction.	North Carolina Coastal Federation	Impact Analysis	Chapter 5, Question 2.	The text has been corrected to indicate that Indirect impacts were determined using Delf3d Model results at Year 3 for Alternatives 1 and 2, Year 2 for Alternatives 3 and 4, and Year 5 for Alternative 5. Knowing that the inlet and oceanfront shorelines are dynamic, the only basis to evaluate potential indirect impacts are throuh the utilizatoin of numerical models. As stated on page 113 of the DEIS, "Delft3D model results for Alternative 1 (No New Actions) obtained under a prescribed set of forcing conditions forms a basis for comparing relative changes in Shallotte Inlet and the adjacent shorelines that could be attributable to physical changes in the system associated with each alternative." Furthermore, the DEIS states "These results should be interpreted with caution as they are not intended to be a precise prediction of habitat change considering they are in part based on modeling simulations and are therefore only intended to provide insight on potential changes."

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248	The analysis of cumulative impacts fails to account for a number of already managed and hardened inlets along the coast of North Carolina, some of which are adjacent (i.e. Masonboro Inlet) to Shallotte Inlet.	North Carolina Coastal Federation	Impact Analysis		Noted. The NEPA document cannot account for all impacts from all projects in the area. The document is specifically tailored to the direct, indirect, and cumulative effects of the project under review. The following text has been added to Chapter 5: "Coastal structures found along the North Carolina coast, such as jetties and other terminal groins (both already constructed and those in the planning stages), are not located in proximity to the proposed project and therefore are not anticipated to have a significant effect on any resources found within the Permit Area. "
249	Under the Clean Water Act, the Corps is only able to permit the least environmentally damaging, practicable alternative (LEDPA). The proposed alternatives can be categorized into non[structural and structural. The effects of these vary in that those of structural alternatives have permanent effects, while those of non-structural vary. Among the non structural alternatives, Alternative 4 is the one that has the least negative effect on wet beach habitat, adjacent dry beach habitat and back beach habitat, as well as on aquatic communities.	North Carolina Coastal Federation	Impact Analysis	Appendix B Beach fill design for Alt. 4; Chapter 3, beach fill design for Alt. 4.	Noted. However, Alternative 4 starts out with a 2-year nourishment cycle but increases every 4 years after year 14 and then to a 5-year nourishment cycle after year 18. Alternative 5 includes a 5-year nourishment cycle from the beginiing.
250	The downdrift shoreline impacts of terminal groins are not appropriately addressed in assessing the impacts of the preferred alternative, Alternative 5. It is well documented that terminal groins cause erosion of the shoreline down-drift of the structure... The DEIS instead forecasts a lesser need for beach renourishment with the construction of a terminal groin, and does not address the real likelihood that the beach will simply narrow farther to the west and require additional and likely more frequent beach renourishment over the years.	Audubon North Carolina	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	The sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area.
251	At Fort Macon, NC, for example, three years after the completion of the terminal groin a beach renourishment project occurred because the groin itself was exacerbating erosion, and from 1973-2007, seven renourishment projects have occurred at Fort Macon at the cost of nearly $45 million (Pietrafesa 2012).	Audubon North Carolina	General	N/A	Noted. The nourishment at Fort Macon was in response to the disposal of material dredged following the maintenance of Beaufort Inlet and not a result of terminal groin-induced erosion.
252	The DEIS acknowledges that the decrease in erosion on Pea Island can be partially due to sediment placement projects, but it is clear that the construction of a terminal groin on the northern end of Pea Island and all associated efforts such as dredging, beach nourishment, and maintenance of highway 12 on Pea Island has not stopped erosion on the down-drift shoreline.	Audubon North Carolina	Downdrift effects	N/A	Noted.
253	The DEIS states that damages to roads and utilities would amount to $2.09 million over 30 years for Alternatives 1 and 2 (no action and abandon/retreat). The DEIS states the value of these damages were based on replacement costs, even though replacement is not an option in Alternatives 1 and 2, and therefore no actual expenditure is entailed. If replacement is not an option, the cost of replacement should not be listed in the 30-year cost for Alternative 1 or 2; this would make those options far less expensive than the other alternatives.	Audubon North Carolina	Financial	Chapter 3 Appendix B.	Replacement cost was used as a proxy to establish the value of the infrastructure that would be damaged. This was the same approach used recommended by UNCW economist Dr. Pete Schuhmann.
254	In Table 3.10, the DEIS states that there will be a $0 cost for Long-Term Erosion Damages & Response Cost for Alternatives 3, 4, and 5. As discussed, it is well established that hard structures cause erosion of the down-drift shoreline. A zero dollar amount in the Long-Term Erosion Damages & Response Cost and the discounting of renourishment costs for the 750-ft terminal groin alternative is misleading.	Audubon North Carolina	Downdrift effects	Chapter 5- Question 3.; Chapter 3.1; Appendix B Section 4.5	The sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach would not be impacted by the terminal groin. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. Text has been added to Chapter 3 accordingly. The sediment budget presented in Appendix B clearly shows there would be no direct or indirect impacts of the proposed terminal groin west of baseline statin 30+00. As for the shoreline east of the proposed terminal groin, the shoreline would be monitored using beach profile surveys as well as the analysis of aerial photographs. Should the shoreline move back to the position it occupied prior to the construction of the federal project in 2001, mitigation in the form of beach nourishment would be proposed. Since the eventually of having to provide mitigation fill can not be predicted with any degree or certainty or the volume of mitigation fill that could be involved, there is no basis for preparing an estimate of potential mitigation costs.
255	The DEIS often cites outdated literature (i.e. Overton et al. 1992), not the most relevant literature, and makes errors and omissions in its citations. At least six additional citations (Nelson 1985, Van Dolah et. al 1994, Levison and Van Dolah 1996, NCDENR 2010, Overton 2011, and Overton pers. comm.) are not listed in the literature cited section.	Audubon North Carolina	General	Literature Cited	These citations have been added to the Literature Cited Chapter.
256	The wealth of literature on the impacts of terminal groins is not discussed nor cited in the DEIS. A more complete review of the relevant literature would be helpful if fully evaluating all alternatives presented in the DEIS.	Audubon North Carolina	Impact Analysis	Chapter 5, Studies on the Impacts of Terminal Groins; Larval Transport for Alternative 5	The State's Terminal Groin study was cited in this EIS. The function of the study was to evaluate the impacts of terminal groins, and therefore by virtue of incorporating the findings of this study, the relevant literature has been incorporated.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

257	Though neither nests in the area of Shallotte Inlet, they are present during spring and fall migration, and Piping Plovers overwinter in the project area. Under Alternative 5, the DEIS predicts the loss of intertidal flats and shoals. These habitats are the primary foraging habitat for Piping Plovers while they are migrating and wintering through North Carolina. The intertidal flats and shoals as well as the ocean intertidal zone are the primary foraging habitat for Red Knots. The DEIS identifies these shoals as the borrow area for beach fill material and the placement of sand in the ocean intertidal zone will have a significant negative impact on the habitat available for these species.	Audubon North Carolina	Impact Analysis	N/A	Noted.
258	The known recovery time for macroinvertebrate and shorebird communities on nourished beaches is variable, largely due to the short duration of most monitoring studies; most studies ended before recovery to pre-project levels was established. In North Carolina, Emerita talpoida abundance recovered within months, but Donax spp. and amphipods did not recover within the time frame of the study (Peterson et al. 2006). Peterson et al. (2014) monitored the recovery of a sandy beach community for 3-4 years following nourishment and documented haustoriid amphipods and Donax spp. had reduced densities for 3-4 years following nourishment, E. talpoida had lower density for 1-2 years following nourishment, ghost crabs had lower abundances for 4 years and foraging shorebirds were less abundant for 2-4 years following nourishment. Additionally, infaunal organisms may be adapted to high-energy environments, but these organisms are not adapted to burial and/or the use of incompatible fill material. Repeated beach renourishment activities, combined with the recovery periods for these invertebrates will depress this food source for birds. Donax spp. and E. talpoida are important prey items for Red Knots as well as other migratory shorebird species.	Audubon North Carolina	Impact Analysis	Chapter 5	This information has been included within the section entitled "General Environmental Consequences Related to Beach Fill" in Chapter 5.
259	Bird species prefer to nest on overwash fans and unvegetated spits, and shorebirds forage in productive intertidal areas with abundant food resources. Stabilization of inlet areas that result following the construction of a terminal groin is not conducive to the creation of these types of habitats.	Audubon North Carolina	Impact Analysis		As stated in Chapter 5 under Alternative 5, "Should the erosion continue along the inlet beaches on Ocean Isle Beach and Holden Beach, the overwintering critical habitat and nesting habitat for piping plovers and state-listed bird species of special concern as well as critical habitat for nesting sea turtles could be impacted." This comment will be addressed in the ESA discussion in the BA and in the Terms and Conditions of the BO from USFWS
260	Misc.	Public Citizens	Varied	Multiple sections	Oral comments presented during the Public Hearing held on March 4, 2014 can be found in the Public Hearing Transcript which is available on the USACE Wilmington District's website (http://www.saw.usace.army.mil/Missions/RegulatoryPermitProgram/MajorProjects). All oral comments have been noted and/or addressed in the Final EIS.

*Agency comments have been summarized. Please refer to individual agency letters for full content.

Appendix H- National Marine Fisheries Service Letter of Concurrence and US Fish and Wildlife Service Biological Opinion

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701-5505
http://sero.nmfs.noaa.gov

F/SER31:KBD

MAR 0 3 2016

Scott C. McLendon
Chief, Regulatory Division
Wilmington District Corps of Engineers
Department of the Army
69 Darlington Avenue
Wilmington, North Carolina 28403-1343

Dear Mr. McLendon:

This letter responds to your request for consultation with us, the National Marine Fisheries Service (NMFS), pursuant to Section 7 of the Endangered Species Act (ESA) for the following action.

Permit Number	Applicant	SER Number	Project Type
SAW-2011-01241	Town of Ocean Isle Beach	SER-2015-16308	Terminal groin construction and beach nourishment

Consultation History
We received your letter requesting consultation on January 29, 2015. It was assigned to a Consultation Biologist on April 21, 2015. We initiated consultation on June 12, 2015, but due to a large workload, we were not able to proceed with completion of our letter until several months later.

Project Location

Address	Latitude/Longitude	Water body
Ocean Isle Beach, Brunswick County, North Carolina	33.898881°N, 78.389769°W (North American Datum 1983)	Shallotte Inlet, Atlantic Ocean

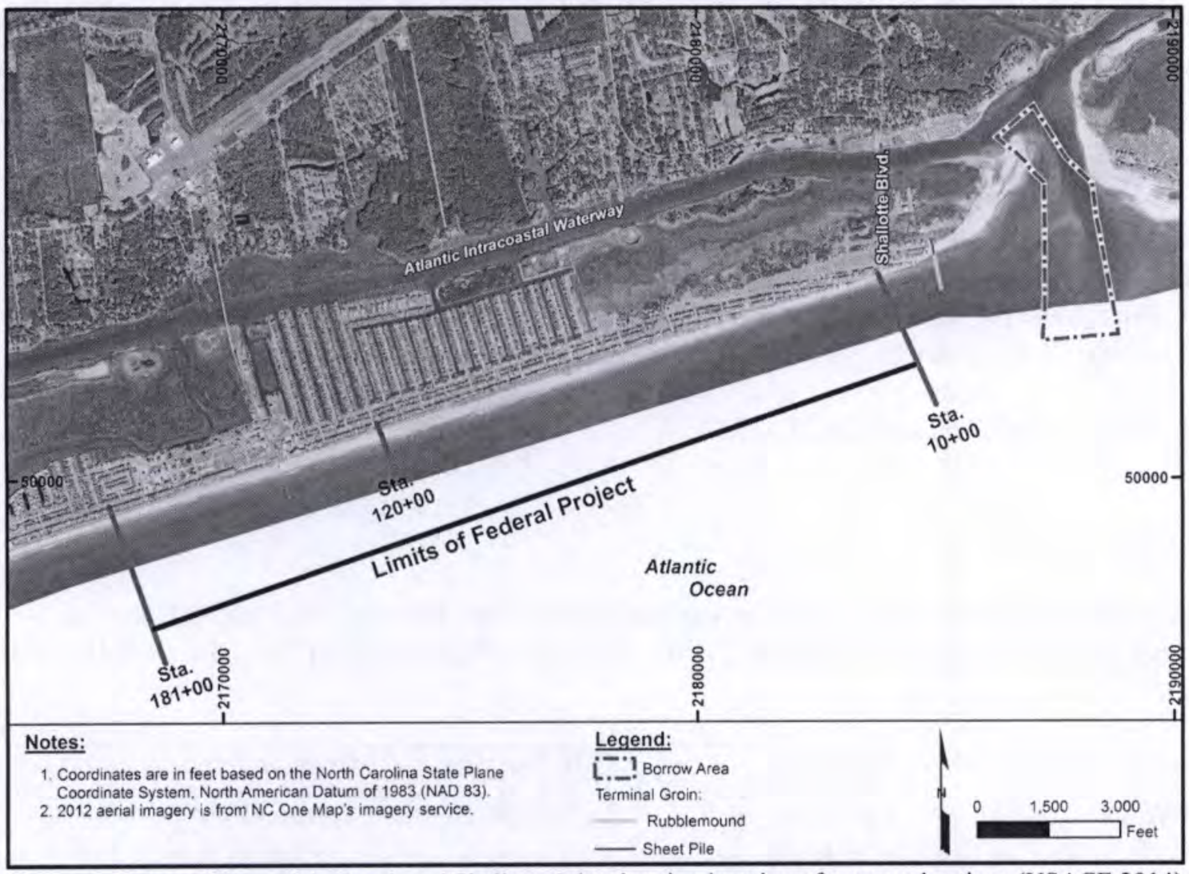


Figure 1. Town of Ocean Isle Beach and Shallotte Inlet showing location of proposed actions (USACE 2014)

Existing Site Conditions

The project area includes the beach at the Town of Ocean Isle Beach along Shallotte Boulevard and the borrow area within Shallotte Inlet located to the east. The purpose of the proposed project is to alleviate chronic erosion on the eastern portion of Ocean Isle Beach to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along the easternmost 3,500 feet (ft) of its oceanfront shoreline. Several beachfront properties and road infrastructures have been lost to erosion during the past few years. Many more properties and sections of road are in danger of being lost unless the beach can be restored soon. Sediments in the project area generally consist of sands, silts, and clays occurring in various mixtures. No seagrasses or corals are present.

Project Description

The project includes the construction of a terminal groin perpendicular to the shore of the east end of Ocean Isle Beach and placement of sand along 3,214 ft of shoreline adjacent to the Atlantic Ocean in Brunswick County, North Carolina. The nourishment sand would be excavated from maintenance of the existing borrow site in Shallotte Inlet that has previously been used for the federal storm damage reduction project. A cutterhead dredge will be used. The project is designed to control tidal current-induced shoreline changes immediately west of Shallotte Inlet. The terminal groin would include a 300-ft shore anchorage section extending landward from the 2007 mean high water (MHW) shoreline and a rubblemound section extending 750 ft seaward of the 2007 MHW. The shore anchorage section would be constructed with either steel or concrete sheet pile. The rubblemound portion of the terminal groin would be constructed with loosely placed armor stone on top of a foundation mat or mattress and would have a crest elevation of +4.9 ft NAVD. The armor stone would facilitate the movement of littoral material through the structure while the relative low crest elevation would allow some sediment to pass over the structure during periods of high tide. The terminal groin would slope 1H:3V from the structure crest down to the existing ocean floor. The rubblemound portion of the terminal groin would be constructed from a temporary trestle or pier installed parallel to the alignment of the terminal groin. The trestle would be removed upon completion of the construction of the terminal groin. Approximately 14,300 tons of stone would be required to construct the terminal groin. Materials for the nourishment and rock rubble for the groin construction will be transported by barge to a dock in the intracoastal waterway at the north end of Shallotte Boulevard. From there, the material would be off-loaded to trucks and transported to the beach construction site. Stone rubble would consist of 7.5 to 12-ton stones, approximately 5 ft in diameter. A 50 ft construction buffer will be in place around the construction zone. The proposed start date of the dredging of Shallotte Inlet and the beach nourishment is November 15 with the project to be completed by April 30. Groin construction and placement of sand is expected to take up to 4.5 months. Maintenance of the nourishment area is expected to occur on 5-year intervals and would take approximately 10 weeks to accomplish.

Effects Determinations for Species the USACE or NMFS Believes May Be Affected by the Proposed Action

Species	ESA Listing Status	Action Agency Effect Determination	NMFS Effect Determination
Sea Turtles			
Green	E/T[1]	NLAA	NLAA
Kemp's ridley	E	NLAA	NLAA
Leatherback	E	NLAA	NE
Loggerhead (Northwest Atlantic Ocean distinct population segment [DPS])	T	NLAA	NLAA
Hawksbill	E	NLAA	NE
Fish			
Shortnose sturgeon	E	NLAA	NLAA
Atlantic sturgeon (Carolina DPS)	E	NLAA	NLAA
Whales			
North Atlantic right	E	NLAA	NP
Humpback	E	NLAA	NP
Finback	E	NLAA	NP
Sei	E	NLAA	NP
Sperm	E	NLAA	NP

[1] Green turtles are listed as threatened except for the Florida and Pacific coast of Mexico breeding populations, which are listed as endangered.

Species	ESA Listing Status	Action Agency Effect Determination	NMFS Effect Determination
E = endangered; T = threatened; NLAA = may affect, not likely to adversely affect; NP = not present; NE = no effect			

We believe the project will have no effect on hawksbill and leatherback sea turtles, due to the species' very specific life history strategies, which are not supported at the project site. Leatherback sea turtles have pelagic, deepwater life history, where they forage primarily on jellyfish. Hawksbill sea turtles typically inhabit inshore reef and hard bottom areas where they forage primarily on encrusting sponges. There have been no reports of hawksbill or leatherback sea turtles nesting in the project area. We also do not believe that whales would be found in the nearshore project area where the terminal groin will be constructed or where the shallow inlet will be dredged. In addition, NMFS has previously determined that potential effects on North Atlantic right whales, and finback, sperm, sei, and humpback whales from dredging are discountable and will not be addressed further (Re: SER-2012-00948).

Critical Habitat
The project is located within the boundary of Northwest Atlantic loggerhead sea turtle distinct population segment (NWA DPS) LOGG-N-5.

Analysis of Potential Routes of Effects to Listed Species and Critical Habitat
Three species of sea turtles (loggerhead, green, and Kemp's ridley) and 2 species of sturgeon (shortnose and Atlantic) may be found in or near the action area and may be affected by the project. We have identified the following potential adverse effects to these listed species and concluded they are not likely to be adversely affected by the proposed action for the reasons described below.

<u>Sea Turtles</u>
Loggerhead, green, and Kemp's ridley sea turtles are known to nest on the beaches of North Carolina and have been sited near the project area, but only the loggerhead sea turtle has been reported nesting near the project site on Ocean Isle Beach. Sea turtles may be injured if they encounter the cutterhead dredging in the borrow area. However, we believe this adverse effect is discountable because these species are likely to move away from the dredging equipment and we expect them to exhibit avoidance behavior. NMFS has previously determined in existing biological opinions (i.e., the South Atlantic Regional Biological Opinion and the Gulf of Mexico Regional Biological Opinion) that non-hopper-type dredging activities, including hydraulic and mechanical-type dredges (including cutterhead and clamshell dredges), are not likely to adversely affect sea turtles, primarily because they are noisy and slow moving, enabling sea turtles to detect and avoid them, or affect only very small areas at one time. The implementation of the proposed dredging window and timing of the beach nourishment (November 15 to April 30) to avoid the presence of sea turtles will further reduce the risk of encounters and will not occur during nesting season, which begins May 1. In addition, operation of any mechanical construction equipment will cease immediately if a sea turtle is seen within a 50-ft radius of the equipment. Activities will not resume until the protected species has departed the project area of its own volition. Nourishment sand will be transported to the project site via trucks. Because

hopper dredges will not be used, the movements of the cutterhead dredge will be limited to the spatially constrained nearshore borrow area, a dredging window will be implemented, and sand placement on the beach will be via truck-hauled sand, we believe the potential for encounters with sea turtles is discountable or not likely to occur.

The construction of the terminal groin will occur concurrent with the nourishment activities and the act of placing material within open water may adversely affect sea turtles; however, construction will be spatially confined and temporary. We believe that sea turtles will be able to avoid the construction area around the terminal groin. In addition, the project area occurs within a segment of North Carolina's shoreline that is experiencing severe erosion with historically low numbers of nest sites relative to other areas with more stable beach areas. Since the existing condition of the project area is not conducive to sea turtles laying nests and the proposed action is restorative in nature, NMFS believes that the post-construction access to restored portions of the beach should benefit sea turtles, specifically in re-creating beach nesting habitat and therefore we believe that the likelihood of sea turtles being affected by the proposed groin construction is insignificant.

Critical Habitat for Loggerhead NWA DPS
The proposed dredging and groin construction will occur within critical nearshore reproductive habitat for the loggerhead sea turtle (LOGG-N-5), which extends one mile from MHW. Nearshore reproductive habitat includes habitat for the hatchling swim frenzy and for females during the internesting period from the shoreline (MHW seaward 1 mile). This nearshore zone is a vulnerable, pivotal transitional habitat area for hatchling transit to open waters, and for nesting females to transit back and forth between open waters and nesting beaches during their multiple nesting attempts throughout the nesting season. The habitat characteristics of this nearshore zone are important in female nest site selection and successful repeat nesting. In addition to nesting beach suitability and proximity to nearshore oceanic currents needed for hatchling transport, habitat suitable for transit between the beach and open waters by the adult female turtle is necessary. Nesting females typically favor beach approaches with few obstructions or physical impediments such as reefs or shallow water rocks, which may make the entrance to nearshore waters more difficult or even injure the female as she attempts to reach the surf zone.

The three physical and biological features essential to loggerhead conservation in this critical habitat unit and their current condition in the project area are described below. The first essential component to conservation is nearshore waters directly off the highest density nesting beaches as identified in 78 FR 18000 (March 25, 2013) to 1 mile offshore. The project area beach is currently severely eroded and has a history of being an erosional hot spot. It is also not located near the highest density nesting beaches, so this action would not affect the nearshore waters in that area; therefore there is no effect to the essential feature. The second essential feature to promote loggerhead survival is waters that are sufficiently free of obstructions or artificial lighting to allow transit through the surf zone and outward toward open water. The dredging would be taking place within Shallotte Inlet and not in the surf zone or in open water in front of nesting beaches, so there would be no obstructions to the open water from dredging. The terminal groin would be constructed perpendicular to the beach and would not present obstruction toward open waters. The third is waters with minimal manmade structures that could promote predators (i.e., nearshore predator concentration caused by submerged and emergent offshore structures), disrupt wave patterns necessary for orientation, and/or create excessive longshore currents. The construction of the terminal groin could impact sea turtle critical habitat. Yet, the proposed groin is designed as a low-crested, semi-permeable (i.e., "leaky") structure designed to permit seawater and animals to flow over the top and through the structure. It also will allow the longshore transport of sand to occur in a normal manner, so it should not disrupt wave patterns or create excessive longshore currents. It is possible that the groin could cause some predator concentration, but the majority of the rocks comprising the groin will be submerged too deep to accommodate resting seabirds that could prey on hatchlings. NMFS believes that the addition of the terminal groin will improve the condition of the nesting beach overall, and it will not cause a net increase in the likelihood of predator concentration, or cause wave patterns to be modified to the extent that it will disrupt orientation nor cause excessive longshore currents. Beach widening due to sand entrapment behind the terminal groin will result in increasing the amount of available turtle nesting habitat. Once the beach is stabilized and restored, we expect that nesting activity may increase in the project area. For these reasons, NMFS concludes that the effects of the proposed action on loggerhead sea turtle critical habitat are insignificant.

<u>Sturgeon</u>

Shortnose sturgeon were thought to be extirpated from North Carolina waters until an individual was captured in the Brunswick River in 1987. Subsequent gillnet studies (1989-1993) resulted in the capture of 5 shortnose sturgeon, confirming the presence of a small population in the lower Cape Fear River. Based on its restriction primarily to the portions of rivers above the freshwater-saltwater interface, its occurrence within the project area (i.e., Shallotte Inlet and within the Atlantic Ocean) is considered extremely unlikely; therefore, likely effects to this species are discountable or not likely to occur.

We believe that Atlantic sturgeon may be affected by the dredging in Shallotte Inlet. Atlantic sturgeon may be encountered as they pass through the Shallotte Inlet while leaving or returning to the nearshore ocean waters or while accessing upriver spawning and nursery areas from mid-winter to mid-spring. Adults spend the majority of their lives migrating up and down the coast in nearshore marine waters, only returning to their natal rivers to spawn. Atlantic sturgeon found in the project area are most likely a part of the Carolina DPS. The Carolina DPS includes all Atlantic sturgeon that are spawned in the watersheds (including all rivers and tributaries) from the Albemarle Sound southward along the southern Virginia, North Carolina, and South Carolina coastal areas to Charleston Harbor. Rivers known to have current spawning populations within the range of the Carolina DPS include the Roanoke, Tar-Pamlico, Cape Fear, Waccamaw, and Yadkin-Pee Dee River. Dredging can impact important habitat features of Atlantic sturgeon as they disturb benthic fauna and alter bottom habitat; however dredging will be conducted in an area that is highly dynamic and receives constant disturbance of bottom habitat from storm events and strong currents. Because the nearshore areas around Shallotte Inlet offers an abundance of habitat that will not be affected by the project and is probably more suitable for foraging or resting, we believe the dredging effects associated with the project will be insignificant. Although dredges have been known to impact sturgeon, the proposed dredging is to be performed with a slow-moving cutterhead dredge. NMFS believes that the impacts of this project are minimal given the mobility of the species and its ability to avoid encounters with the dredge. We have also identified the following potential route of effects from physical impacts from in-water construction of the terminal groin to sturgeon and concluded they are not likely to be adversely affected by the proposed action. Since sturgeon are highly mobile, they can avoid the area of disturbance. Furthermore, the construction equipment will be near-stationary as it will be a very slow process of adding rock materials to form the groin. Therefore, we have determined that the potential impacts associated with the proposed dredging and construction of the terminal groin will be insignificant.

Conclusion
Because all potential project effects to listed species and critical habitat were found to be discountable, insignificant, or beneficial we conclude that the proposed action is not likely to adversely affect listed species under NMFS's purview. This concludes your consultation responsibilities under the ESA for species under NMFS's purview. Consultation must be reinitiated if a take occurs or new information reveals effects of the action not previously considered, or if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat in a manner or to an extent not previously considered, or if a new species is listed or critical habitat designated that may be affected by the identified action. NMFS's findings on the project's potential effects are based on the project description in this response. Any changes to the proposed action may negate the findings of this consultation and may require reinitiation of consultation with NMFS.

We have enclosed additional relevant information for your review. We look forward to further cooperation with you on other projects to ensure the conservation of our threatened and endangered marine species and designated critical habitat. If you have any questions on this consultation, please contact Kay Davy, Consultation Biologist, at (727) 415-9271, or by e-mail at kay.davy@noaa.gov.

Sincerely,

Roy E. Crabtree, Ph.D.
for Regional Administrator

Enc.: 1. *Sea Turtle and Smalltooth Sawfish Construction Conditions* (Revised March 23, 2006)
2. *PCTS Access and Additional Considerations for ESA Section 7 Consultations* (Revised March 10, 2015)

File: 1514-22.F.1

SEA TURTLE AND SMALLTOOTH SAWFISH CONSTRUCTION CONDITIONS

The permittee shall comply with the following protected species construction conditions:

a. The permittee shall instruct all personnel associated with the project of the potential presence of these species and the need to avoid collisions with sea turtles and smalltooth sawfish. All construction personnel are responsible for observing water-related activities for the presence of these species.

b. The permittee shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing sea turtles or smalltooth sawfish, which are protected under the Endangered Species Act of 1973.

c. Siltation barriers shall be made of material in which a sea turtle or smalltooth sawfish cannot become entangled, be properly secured, and be regularly monitored to avoid protected species entrapment. Barriers may not block sea turtle or smalltooth sawfish entry to or exit from designated critical habitat without prior agreement from the National Marine Fisheries Service's Protected Resources Division, St. Petersburg, Florida.

d. All vessels associated with the construction project shall operate at "no wake/idle" speeds at all times while in the construction area and while in water depths where the draft of the vessel provides less than a four-foot clearance from the bottom. All vessels will preferentially follow deep-water routes (e.g., marked channels) whenever possible.

e. If a sea turtle or smalltooth sawfish is seen within 100 yards of the active daily construction/dredging operation or vessel movement, all appropriate precautions shall be implemented to ensure its protection. These precautions shall include cessation of operation of any moving equipment closer than 50 feet of a sea turtle or smalltooth sawfish. Operation of any mechanical construction equipment shall cease immediately if a sea turtle or smalltooth sawfish is seen within a 50-ft radius of the equipment. Activities may not resume until the protected species has departed the project area of its own volition.

f. Any collision with and/or injury to a sea turtle or smalltooth sawfish shall be reported immediately to the National Marine Fisheries Service's Protected Resources Division (727-824-5312) and the local authorized sea turtle stranding/rescue organization.

g. Any special construction conditions, required of your specific project, outside these general conditions, if applicable, will be addressed in the primary consultation.

Revised: March 23, 2006

PCTS Access and Additional Considerations for ESA Section 7 Consultations (Revised 03-10-2015)

Public Consultation Tracking System (PCTS) Guidance: PCTS is a Web-based query system at **https://pcts.nmfs.noaa.gov/** that allows all federal agencies (e.g., U.S. Army Corps of Engineers - USACE), project managers, permit applicants, consultants, and the general public to find the current status of NMFS's Endangered Species Act (ESA) and Essential Fish Habitat (EFH) consultations which are being conducted (or have been completed) pursuant to ESA Section 7 and the Magnuson-Stevens Fishery Conservation and Management Act's (MSA) Sections 305(b)2 and 305(b)(4). Basic information including access to documents is available to all.

The PCTS Home Page is shown below. For USACE-permitted projects, the easiest and quickest way to look up a project's status, or review completed ESA/EFH consultations, is to click on either the "Corps Permit Query" link (top left); or, below it, click the "Find the status of a consultation based on the Corps Permit number" link in the golden "I Want To…" window.

Then, from the "Corps District Office" list pick the appropriate USACE district. In the "Corps Permit #" box, type in the 9-digit USACE permit number identifier, with no hyphens or letters. Simply enter the year and the permit number, joined together, using preceding zeros if necessary after the year to obtain the necessary 9-digit (no more, no less) number. For example, the USACE Jacksonville District's issued permit number SAJ-2013-0235 (LP-CMW) must be typed in as 201300235 for PCTS to run a proper search and provide complete and accurate results. For querying permit applications submitted for ESA/EFH consultation by other USACE districts, the procedure is the same. For example, an inquiry on Mobile District's permit MVN201301412 is entered as 201301412 after selecting the Mobile District from the "Corps District Office" list. PCTS questions should be directed to Kelly Shotts at Kelly.Shotts@noaa.gov or (727) 551-5603.

EFH Recommendations: In addition to its protected species/critical habitat consultation requirements with NMFS' Protected Resources Division pursuant to Section 7 of the ESA, prior to proceeding with the proposed action the action agency must also consult with NMFS' Habitat Conservation Division (HCD) pursuant to the MSA requirements for EFH consultation (16 U.S.C. 1855 (b)(2) and 50 CFR 600.905-.930, subpart K). The action agency should also ensure that the applicant understands the ESA and EFH processes; that ESA and EFH consultations are separate, distinct, and guided by different statutes, goals, and time lines for responding to the action agency; and that the action agency will (and the applicant may) receive separate consultation correspondence on NMFS letterhead from HCD regarding their concerns and/or finalizing EFH consultation.

Marine Mammal Protection Act (MMPA) Recommendations: The ESA Section 7 process does not authorize incidental takes of listed or non-listed marine mammals. If such takes may occur an incidental take authorization under MMPA Section 101 (a)(5) is necessary. Please contact NMFS' Permits, Conservation, and Education Division at (301) 713-2322 for more information regarding MMPA permitting procedures.

BIOLOGICAL OPINION

Town of Ocean Isle Beach

Shoreline Management Project

August 6, 2015

Corps Action ID No. SAW-2011-01241

USFWS Log No. 04EN2000-2015-F-0201

Table of Contents

Acronyms

Act	**Endangered Species Act**
BA	**Biological Assessment**
BO	**Biological Opinion**
CAFF	**Council Conservation of Arctic Flora and Fauna**
CBRA	**Coastal Barrier Resources Act**
CFR	**Code of Federal Regulations**
CH	**Critical Habitat**
CITES	**Convention on International Trade in Endangered Species of Wild Fauna and Flora**
Corps	**U.S. Army Corps of Engineers**
COSEWIC	**Committee on the Status of Endangered Wildlife in Canada**
CSDR	**Coastal Storm Damage Reduction**
DOI	**U.S. Department of the Interior**
DTRU	**Dry Tortugas Recovery Unit**
F	**Fahrenheit**
FAC	**Florida Administrative Code**
FDEP	**Florida Department of Environmental Protection**
FEMA	**Federal Emergency Management Agency**
FR	**Federal Register**
GCRU	**Greater Caribbean Recovery Unit**
HCP	**Habitat Conservation Plan**
IPCC	**Intergovernmental Panel on Climate Change**
ITP	**Incidental Take Permit**
LF	**Linear Feet**
MHW	**Mean High Water**
MHWL	**Mean High Water Line**
MLLW	**Mean Low Low Water**
MLW	**Mean Low Water**
mtDNA	**Mitochondrial Deoxyribonucleic Acid**

NCWRC	**North Carolina Wildlife Resources Commission**
NGMRU	**Northern Gulf of Mexico Recovery Unit**
NMFS	**National Marine Fisheries Service**
NOAA	**National Oceanic and Atmospheric Administration**
NRU	**Northern Recovery Unit**
NWR	**National Wildlife Refuge**
PBF	**Physical and Biological Feature**
PCE	**Primary Constituent Element**
PFRU	**Peninsular Florida Recovery Unit**
SAJ	**South Atlantic Jacksonville**
SAM	**South Atlantic Mobile**
Service	**U.S. Fish and Wildlife Service**
SF	**Square Feet**
SNBS	**Statewide Nesting Beach Survey**
TED	**Turtle Excluder Device**
TEWG	**Turtle Expert Working Group**
U.S.C.	**United States Code**
U.S.	**United States**
USEPA	**United States Environmental Protection Agency**

CONSULTATION HISTORY

September 21, 2012 – The Corps issued a Notice of Intent (NOI) to prepare a Draft Environmental Impact Statement (DEIS) for the project. A Public Notice containing similar information was released by the Corps on the same date.

October 3, 2012 – A public scoping meeting was held for the project. The Service was unable to attend.

October 16, 2012 – The Service provided written scoping comments to the Corps.

March 5, 2013 – The Service attended a Project Review Team (PRT) meeting for the project.

January 21, 2015 – The Corps requested initiation of formal consultation for the project.

January 23, 2015 – The Corps issued a public notice and the DEIS for the project. The public notice comment period for the DEIS ended on March 16, 2015.

February 12, 2015 – The Service initiated formal consultation by letter to the Corps. The date for the biological opinion was set as June 10, 2015.

March 12, 2015 – The Service provided comments to the Corps on the DEIS.

April 21, 2015 – Due to the potential for new information to be provided by the applicant in response to comments on the DEIS, the Service emailed the Corps about the potential to extend the consultation period for 60 days.

April 27, 2015 – The Service requested a 60-day extension of the consultation period in accordance with 50 CFR §402.25(e) (to August 9, 2015).

July 10, 2015 – The Service provided the draft Reasonable and Prudent Measures and Terms and Conditions to the Corps.

July 16, 2015 – The Service discussed the draft Terms and Conditions with the Applicant’s consultant by phone.

July 17, 2015 – The Service discussed the duration of the project construction (in months) with the Applicant’s consultant by phone.

July 18, 2015 – By email, the Corps requested changes to the language of the Reasonable and Prudent Measures and Terms and Conditions.

July 20, 2015 – The applicant's consultant provided information by email concerning the duration of the initial project construction.

July 20, 2015 – By email, the Service provided revised language for the Reasonable and Prudent Measures and Terms and Conditions to the Corps.

July 21, 2015 – By email, the Corps agreed to the revised language for the Reasonable and Prudent Measures and Terms and Conditions.

BIOLOGICAL OPINION

I. INTRODUCTION

A biological opinion (BO) is the document that states the opinion of the U.S. Fish and Wildlife Service (Service) as to whether a federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat. This biological opinion addresses piping plover (*Charadrius melodus melodus*), red knot (*Calidris canutus rufa*), seabeach amaranth (*Amaranthus pumilus*), and the loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), and Kemp's ridley sea turtles (*Lepidochelys kempii*), and designated loggerhead critical habitat. The BO evaluates the effects of the proposed action, interrelated and interdependent actions, and cumulative effects relative to the status of the species and the status of the critical habitat to arrive at a Service opinion that the proposed action is or isn't likely to jeopardize species or adversely modify critical habitat. *Jeopardize the continued existence of* means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species. On May 9, 2014, the Service and the National Marine Fisheries Service (NMFS) proposed to define *destruction or adverse modification of designated critical habitat* as a direct or indirect alteration that appreciably diminishes the conservation value of critical habitat for listed species. Such alterations may include, but are not limited to, effects that preclude or significantly delay the development of the physical or biological features that support the life-history needs of the species for recovery. The Service plans to finalize the definition of *destruction or adverse modification of designated critical habitat* in the summer of 2015.

II. EXECUTIVE SUMMARY

The purpose of the proposed project is to alleviate chronic erosion on the eastern portion of Ocean Isle Beach to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along easternmost 3,500 feet of its oceanfront shoreline. The proposed project is the preferred alternative in the January 2015 Draft Environmental Impact Statement (DEIS) (Alternative 5). The project includes the construction of a single, 1,050 linear-foot (lf) terminal groin (300 lf landward, and 750 lf waterward of mean high water or MHW), placement of a concurrent 3,214 lf sand fillet, and the periodic placement of sand in the fillet from either scheduled federal disposal events and/or from locally-sponsored beach nourishment and disposal projects.

The Draft Environmental Impact Statement (DEIS) describes the Action Area to include the shorelines of Ocean Isle Beach and Holden Beach and the adjacent Atlantic Ocean and Shallotte

Inlet, Brunswick County, North Carolina. The Action Area includes 4,413 acres and approximately 24,500 lf of beach and inlet shoreline on Ocean Isle Beach and Holden Beach, from east of Concord Street on Ocean Isle Beach to an area near Sea Gull Street in Holden Beach. Federally-listed species under the purview of the Service occurring in the Action Area include the seabeach amaranth, piping plover, red knot, loggerhead sea turtle, green sea turtle, leatherback sea turtle, and Kemp's ridley sea turtle. The Action Area includes piping plover Critical Habitat Unit NC-17 (Shallotte Inlet – Brunswick County) and loggerhead terrestrial Critical Habitat Unit LOGG-T-NC-08 (Holden Beach).

The proposed action has the potential to adversely affect piping plover and piping plover critical habitat, red knot, seabeach amaranth, nesting female sea turtles, sea turtle nests, hatchlings, and loggerhead terrestrial critical habitat within the proposed Action Area.

The Service anticipates that directly and indirectly an unspecified amount of nesting female sea turtles, sea turtle nests, and sea turtle hatchlings along 24,500 lf of sea turtle nesting beach habitat could be taken as a result of this proposed action. Take is expected to be in the form of: (1) Destruction of all nests that may be constructed and eggs that may be deposited and missed by a nest survey and nest mark and avoidance program within the boundaries of the proposed project; (2) destruction of all nests deposited during the period when a nest survey and nest mark and avoidance program is not required to be in place within the boundaries of the proposed project; (3) harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities; (4) misdirection of nesting sea turtles or hatchling turtles on beaches within the boundaries of the proposed project or beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of increased sand accretion due to the presence of the groin or jetty; (5) behavior modification of nesting females due to escarpment formation, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs; (6) destruction of nests from escarpment leveling within a nesting season when such leveling has been approved by the Service; (7) behavior modification of nesting females or hatchlings due to the presence of the groin which may act as a barrier to movement or cause disorientation of turtles while on the nesting beach; (8) physical entrapment of hatchling sea turtles on the nesting beach due to the presence of the groin; behavior modification of nesting females if they dig above a buried portion of the structure, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas; and (9) obstructed or entrapped an unknown number of adult and hatchling sea turtles during ingress or egress at nesting sites.

The Service anticipates that directly and indirectly an unspecified amount of piping plovers and red knots along 24,500 lf of shoreline, all at some point, potentially usable by piping plovers and red knots, could be taken in the form of habitat loss as a result of this proposed action.

The construction of the groin and placement of sand in the Action Area could bury existing plants if work is conducted during the growing season. Sand placement at any time of year could also bury seeds to a depth that would prevent germination. Sand placement beaches could also have positive impacts on seabeach amaranth by creating additional habitat for the species.

After reviewing the current status of the nesting loggerhead sea turtle, green sea turtle, and leatherback sea turtle, the environmental baseline for the Action Area, the effects of the proposed dredging and sand placement activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that the groin construction and sand placement activities, as proposed, are not likely to jeopardize the continued existence of the piping plover, red knot, seabeach amaranth, green sea turtle, leatherback sea turtle, Kemp's ridley sea turtle and the Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle. It is the Service's biological opinion that the groin construction and sand placement activities, as proposed, are not likely to result in the destruction or adverse modification of designated critical habitat for the piping plover or nesting loggerhead sea turtles.

The Service believes the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize take of loggerhead sea turtles, green sea turtles, leatherback sea turtles, Kemp's ridley sea turtles, piping plovers, red knots, and seabeach amaranth. Unless specifically addressed below, these RPMs are applicable for the construction of the terminal groin and for any maintenance activities for the life of the permit. If the Applicant is unable to comply with the RPMs and Terms and Conditions, the Corps as the regulatory authority may inform the Service why the RPM or Term and Condition is not reasonable and prudent for the specific project or activity and request exception under the biological opinion.

<u>RPMs – All Species</u>

1. All derelict material or other debris must be removed from the beach prior to any construction.

2. Conservation Measures included in the permit application/project plans must be implemented in the proposed project. If a RPM and Term and Condition address the same requirement, the requirements of the RPM and Term and Condition take precedent over the Conservation Measure. This includes the timing of the proposed project to avoid the sea turtle nesting season, to reduce the possibility of sea turtle nest burial, crushing of eggs, or nest excavation.

3. Predator-proof trash receptacles must be installed and maintained at all beach access points used for the initial project construction and all maintenance events, to minimize

the potential for attracting predators of sea turtles, piping plovers, and red knots.

4. A meeting between representatives of the Applicant's contractor, Corps, Service, North Carolina Wildlife Resources Commission (NCWRC), the permitted sea turtle surveyor, bird and other species surveyors, as appropriate, must be held prior to the commencement of construction of the terminal groin.

5. In the event the terminal groin structure begins to disintegrate, all debris and structural material must be removed.

6. The Applicant or Corps must submit all reports produced pursuant to the Inlet Management Plan (referenced in the revisions to North Carolina General Statute 113A-115.1(e)(5)) to the Service's Raleigh Field Office, within 30 days of completion of each report.

7. The groin must be removed or modified if it is determined to not be effective as determined pursuant to the Inlet Management Plan listed above, or if it is determined to be causing a significant adverse impact to the beach and dune system.

8. During construction of the terminal groin, and for the life of the permit, all sand placement activities to maintain the sand fillet must be conducted within the winter work window (November 16 to April 30), unless necessitated by an emergency condition and allowed after consultation with the Service.

9. The pipeline placement must be coordinated with the Corps, the Raleigh Field Office, and the NCWRC.

<u>RPMs – Loggerhead, Green, Leatherback, and Kemp's Ridley Sea Turtle</u>

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of loggerhead, green, Kemp's ridley, and leatherback sea turtles:

1. Beach compatible sand suitable for sea turtle nesting, successful incubation, and hatchling emergence must be used on the project site for initial groin construction and all maintenance events.

2. No construction shall be conducted during the nesting season and hatching season from May 1 through November 15.

3. No permanent exterior lighting will be installed in association with this construction project, unless required by the U.S. Coast Guard. Temporary lighting will be allowed if safety lighting is required at any excavated trenches that must remain on the beach at night.

4. If the construction of the groin will be conducted during the period from April 15 to April 30, daily early morning surveys for early nesting sea turtles must be conducted. If the construction project will be conducted during the period from November 16 through November 30, surveys for late nesting sea turtles must be conducted. If nests are laid in the area of construction, the nests must be marked and avoided. Nesting surveys and nest marking must be initiated 65 days prior to construction activities or by April 15, whichever is later.

5. Visual surveys for escarpments along the Action Area must be made following completion of the terminal groin and any sand maintenance events, and also prior to May 1 for two subsequent years (after sand is placed on the beach). Escarpment formation must be monitored and leveling must be conducted if needed to reduce the likelihood of impacting nesting and hatchling sea turtles.

6. Staging areas for earth-moving equipment must be located off the beach during the early (April 15 through April 30) and late (November 16 through November 30) portions of the nesting season. Nighttime storage of earth-moving equipment not in use must be off the beach to minimize disturbance to sea turtle nesting and hatching activities. All excavations and temporary alteration of beach topography will be filled or leveled to the natural beach profile prior to 9:00 p.m. each day.

7. Sand compaction must be monitored in the area of sand placement immediately after completion of the project, after any future sand maintenance events, and also prior to May 1 for two subsequent years after sand is placed on the beach.

8. Daily sea turtle nesting surveys must be conducted by the Applicant or Corps for three nesting seasons following construction of the groin or sand maintenance events, if the groin remains on the beach. All nests from a point 3,200 feet west (updrift) of the groin (at approximately Highpoint Street) to a point 2,000 feet east (downdrift) of the groin must be marked for three (3) years post-construction. These nests must be monitored daily until the end of incubation to determine whether those nests are eroded and whether the groin is a potential barrier to hatchlings moving off the beach and through the surf zone. If the groin is found to be an obstruction, Corps will notify NCWRC and the Service immediately for remedial action.

9. A report describing the fate of the nests and hatchlings and any actions taken, must be submitted to the Service following completion of the proposed work for each year when an activity has occurred (such as sand placement).

10. A post-construction survey of all artificial lighting visible from the adjacent beach (1,000 lf on either side of the groin) must be completed by the Applicant or Corps to determine if sand accretion caused by the groin created an increased impact due to artificial lighting within the vicinity of the groin structures.

RPMs – Piping Plover and Red Knot

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of piping plovers and red knots:

1. All personnel involved in the construction or sand placement process along the beach shall be trained to recognize the presence of piping plovers and red knots prior to initiation of work on the beach. Before start of work each morning, a visual survey must be conducted along the ingress routes and in the area of work for that day, to determine if piping plovers or red knots are present.

2. A bird monitoring plan must be developed to monitor piping plover, red knot, waterbirds, colonial waterbirds and other shorebirds in the Shallotte Inlet area during and after construction. Monitoring must be conducted for a minimum of three (3) full years past the completion of groin construction, or until the end of the shorebird nesting season (August 31) of the third year, whichever is later.

RPM – Seabeach Amaranth

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of seabeach amaranth:

1. Seabeach amaranth surveys must be conducted in the Action Area for a minimum of three years after completion of construction.

Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which implement the RPMs described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

Unless addressed specifically below, the terms and conditions are applicable for the construction of the terminal groin and for any maintenance activities for the life of the permit.

<u>Terms and Conditions – All Species</u>

1. All derelict coastal armoring geotextile material and other debris must be removed from the beach prior to any sand placement or construction to the maximum extent possible.

2. Conservation Measures included in the permit application/project plans must be implemented in the proposed project. If a RPM and Term and Condition address the same requirement, the requirements of the RPM and Term and Condition take precedent over the Conservation Measure. This includes the timing of the proposed project to avoid the sea turtle nesting season, to reduce the possibility of sea turtle nest burial, crushing of eggs, or nest excavation.

3. Predator-proof trash receptacles must be installed and maintained during construction at all beach access points used for the project construction and sand maintenance events, to minimize the potential for attracting predators of sea turtles, piping plovers, and red knots. All contractors conducting the work must provide predator-proof trash receptacles for the construction workers. All contractors and their employees must be briefed on the importance of not littering and keeping the Action Area free of trash and debris. See **Appendix A** for examples of suitable receptacles.

4. A meeting between representatives of the contractor, the Service, NCWRC, the permitted sea turtle surveyor, bird and other species surveyors, as appropriate, must be held prior to the commencement of construction of the terminal groin. At least 10 business days advance notice must be provided prior to conducting this meeting. The meeting will provide an opportunity for explanation and/or clarification of the required measures in the BO, as well as follow-up meetings during construction.

5. In the event the structure begins to disintegrate, all debris and structural material must be removed from the nesting beach area and deposited off-site immediately upon coordination with the Service. If removal of the structure is required during the period from May 1 to November 15, no work will be initiated without prior coordination with the Corps and the Service.

6. The Applicant or Corps must submit all reports produced pursuant to the Inlet Management Plan (referenced in the revisions to North Carolina General Statute 113A-115.1(e)(5)) to the Service's Raleigh Field Office, within 30 days of completion of each report.

7. The groin must be removed or modified if it is determined to not be effective as determined by the Inlet Management Plan referred to above, or if it is determined to be causing a significant adverse impact to the beach and dune system.

8. During construction of the terminal groin, and for the life of the permit, all sand placement activities to maintain the sand fillet must be conducted within the winter work window (November 16 to April 30), unless necessitated by an emergency condition and allowed after consultation with the Service.

9. The pipeline placement must be coordinated with the Corps, the Raleigh Field Office, and the NCWRC.

<u>Terms and Conditions – Loggerhead, Green, Kemp's ridley, and Leatherback Sea Turtle</u>

1. Beach compatible fill must be placed on the beach or in any associated dune system. Beach compatible fill must be sand that is similar to a native beach in the vicinity of the site that has not been affected by prior sand placement activity. Beach compatible fill must be sand solely of natural sediment and shell material, containing no construction debris, toxic material, large amounts of rock, or other foreign matter. The beach compatible fill must be similar in both color and grain size distribution (sand grain frequency, mean and median grain size and sorting coefficient) to the native material in the Action Area. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. In general, fill material that meets the requirements of the North Carolina Technical Standards for Beach Fill (15A NCAC 07H .0312) is considered compatible.

2. During the nesting season (May 1 through November 15), no construction will be allowed on the beach, and no equipment may be placed and/or stored on the beach.

3. No permanent exterior lighting will be installed in association with this construction project, unless required by the U.S. Coast Guard. Temporary lighting will be allowed if safety lighting is required at any excavated trenches that must remain on the beach at night.

4. If the construction of the groin will be conducted during the period from April 15 to April 30, daily early morning surveys for early nesting sea turtles must be conducted. If the construction project will be conducted during the period from November 16 through November 30, surveys for late nesting sea turtles must be conducted. If nests are laid in the area of construction, the nests must be marked and avoided. Nesting surveys and nest marking must be initiated 65 days prior to construction activities or by April 15, whichever is later.

5. Visual surveys for escarpments along the Action Area must be made immediately after completion of construction, after sand maintenance events, and within 30 days prior to May 1 for two subsequent years after any construction or sand placement event. Escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet must be leveled and the beach profile must be reconfigured to minimize scarp formation by the dates listed above. Any escarpment removal must be reported by location. The Service must be contacted immediately if subsequent reformation of escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet occurs during the nesting and hatching season to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the Service or NCWRC will provide a brief written authorization within 30 days that describes methods to be used to reduce the likelihood of impacting existing nests. An annual summary of escarpment surveys and actions taken must be submitted to the Service's Raleigh Field Office.

6. Staging areas for earth-moving equipment must be located off the beach during the early (April 15 through April 30) and late (November 16 through November 30) portions of the nesting season. Nighttime storage of earth-moving equipment not in use must be off the beach to minimize disturbance to sea turtle nesting and hatching activities. All excavations and temporary alteration of beach topography will be filled or leveled to the natural beach profile prior to 9:00 p.m. each day. During any periods when excavated trenches must remain on the beach at night, nighttime sea turtle monitoring by the sea turtle permit holder will be required in the project area in order to further reduce possible impacts to nesting and hatchling sea turtles. Nighttime monitors will record data on false crawls, successful nesting, and any additional activities of nesting or hatchling sea turtles in the project area.

7. Sand compaction must be monitored in the area of sand placement immediately after completion of the construction, after any sand maintenance event, and also prior to May 1 for two subsequent years after any construction or sand placement event.

Out-year compaction monitoring and remediation are not required if the placed material no longer remains on the dry beach.

a. Within 7 days of completion of sand placement and prior to any tilling, a field meeting shall be held with the Service, NCWRC, and the Corps to inspect the Action Area for compaction, and determine whether tilling is needed.
b. If tilling is needed, the area must be tilled to a depth of 36 inches.
c. All tilling activity shall be completed prior to May 1.
d. Tilling must occur landward of the wrack line and avoid all vegetated areas that are 3square foot (sf) or greater, with a 3 sf buffer around the vegetated areas.
e. If tilling occurs during shorebird nesting season (after April 1), shorebird surveys are required prior to tilling per the Migratory Bird Treaty Act.
f. A report on the results of compaction monitoring will be submitted to the Raleigh Field Office and NCWRC prior to any tilling actions being taken. An annual summary of compaction assessments and the actions taken will be submitted to the Service, as required in REPORTING REQUIREMENTS, below.
g. This condition will be evaluated annually and may be modified if necessary to address sand compaction problems identified during the previous year.

8. Daily sea turtle nesting surveys must be conducted by the Applicant or Corps for three (3) full nesting seasons following construction if the groin structure remains in place. All nests from a point 3,200 feet west (updrift) of the groin (at approximately High Point Street) to a point 2,000 feet east (downdrift) of the groin must be marked for three (3) years post-construction. The survey area must be divided into three segments: Updrift Zone, Project Zone, and Downdrift Zone. The parameters listed in **Appendix B** shall be recorded for each crawl encountered on a daily survey. In addition, any obstructions (natural or man-made) encountered by the turtle and the turtle's response to that obstruction must be reported. These nests must be monitored daily till the end of hatching to determine whether those nests are eroded and whether the groin is a potential barrier to hatchlings moving off the beach and through the surf zone. This information will be provided to the Raleigh Field Office pursuant to the REPORTING REQUIREMENTS section, below, and will be used to periodically assess the cumulative effects of these projects on sea turtle nesting and hatchling production and monitor suitability for nesting. The Corps will notify the NCWRC and the Service immediately for remedial action.

9. A report describing the fate of sea turtle nests and hatchlings and any actions taken, must be submitted to the Raleigh Field Office following completion of the proposed work for each year when an activity has occurred (e.g. sand placement or groin construction). Please see REPORTING REQUIREMENTS below, for more information.

10. A post construction survey(s) of all artificial lighting visible from the adjacent beach (100 feet on either side of the groin must be completed by the Applicant or Corps. Two surveys must be conducted of all lighting visible from the construction area by the Applicant or the Corps, using standard techniques for such a survey (**Appendix C**), in the year following construction. The first survey must be conducted between May 1 and May 15 and a brief summary provided to the Raleigh Field Office. The second survey must be conducted between July 15 and August 1. A summary report of the surveys, (include the following information: methodology of the survey, a map showing the position of the lights visible from the beach, a description of each light source visible from the beach, recommendations for remediation, and any actions taken), must be submitted to the Raleigh Field Office within 3 months after the last survey is conducted. After the annual report is completed, a meeting must be set up with the Applicant, county or municipality, NCWRC, Corps, and the Service to discuss the survey report, as well as any documented sea turtle disorientations in or adjacent to the project area.

<u>Terms and Conditions – Piping Plover and Red Knot</u>

1. All personnel involved in the construction or sand placement process along the beach shall be trained to recognize the presence of piping plovers and red knots prior to initiation of work on the beach. Before start of work each morning, a visual survey must be conducted along the ingress route and in the area of work for that day, to determine if piping plovers or red knots are present. If plovers or red knots are present in the work area, careful movement of equipment in the early morning hours should allow those individuals to move out of the area. If piping plovers or red knots are observed, the observer shall make a note on the Quality Assurance form for that day, and submit the information to the Corps and the Service's Raleigh Field Office the following day.

2. A bird monitoring plan must be developed to monitor piping plover, red knot, waterbirds, colonial waterbirds and other shorebirds during and after construction. Monitoring must be conducted for a minimum of three (3) full years past the completion of groin construction, or until the end of the shorebird nesting season (August 31) of the third year after construction, whichever is later. Post-construction monitoring may only be ceased after the review of at least three years' worth of data and approval by the Corps, Service, NCDCM, and NCWRC.
    a. The bird monitoring plan, including methods and a figure showing the proposed locations and extent of monitoring, must be submitted for review and approval to the Corps, Service, NCDCM, and NCWRC, at least 60 days prior to the anticipated start of construction.

b. During construction, bird monitoring must be conducted weekly. For at least three years after construction is completed, bimonthly (twice-monthly) bird surveys shall be conducted in all intertidal and shoreline areas from a point 3,200 lf west (updrift) of the groin (at approximately Highpoint Street) to a point just west of Skimmer Court on Holden Beach. All intertidal and supratidal unvegetated areas of the oceanfront, inlet shoulders, and sandy shoreline along the AIWW (in the vicinity of Shallotte Inlet and piping plover critical habitat unit NC-17) must be included. Field observations must be conducted during daylight hours, and primarily during high tide.

c. Shorebird identification, especially when in non-breeding plumage, can be difficult. The person(s) conducting the survey must demonstrate the qualifications and ability to identify shorebird species and be able to provide the information listed below. The bird monitoring plan should include the collection and reporting of the following:
    i. Date, location, time of day, weather, and tide cycle when survey was conducted;
    ii. Latitude and longitude of observed piping plover and red knot locations (decimal degrees preferred);
    iii. Any color bands observed on piping plovers or red knots or other birds;
    iv. Behavior (e.g., foraging, roosting, preening, bathing, flying, aggression, walking, courtship, copulation);
    v. Landscape features(s) where birds are located (e.g., inlet spit, tidal creeks, shoals, lagoon shoreline);
    vi. Habitat features(s) used by birds when observed (e.g., intertidal, fresh wrack, old wrack, dune, mid-beach, vegetation);
    vii. Substrata used by birds (e.g., sand, mud/sand, mud, algal mat); and
    viii. The amount and type of recreational use (e.g., people, dogs on or off leash, vehicles, kite-boarders).

d. All monitoring information shall be provided in standardized form on an Excel spreadsheet. Monitoring results shall be submitted (datasheets, maps, database) on standard electronic media (e.g., CD, DVD) to the Raleigh Field Office. Please see REPORTING REQUIREMENTS below, for more information.

<u>Terms and Conditions – Seabeach Amaranth</u>

1. Seabeach amaranth surveys must be conducted updrift and downdrift of the terminal groin in the Action Area, from a point 3,200 lf west of the groin (at approximately Highpoint Street) along Ocean Isle Beach to a point 2,000 lf east of the groin, for a minimum of three years after completion of groin construction. Surveys should be

conducted in August of each year. Habitat known to support this species, including the upper edges of the beach, lower foredunes, and overwash flats must be visually surveyed for the plant. Annual reports should include numbers of plants, latitude/longitude, and habitat type. Please see REPORTING REQUIREMENTS, below, for more information.

Reporting Requirements

An annual report detailing the monitoring and survey data collected during the preceding year (required in the above Terms and Conditions) and summarizing all piping plover, red knot, shorebird, seabeach amaranth, and sea turtle data must be provided to the Raleigh Field Office by January 31 of each year for review and comment. In addition, any information or data related to a conservation measure or recommendation that is implemented should be included in the annual report. The contact for these reporting requirements is:

Pete Benjamin, Supervisor
Raleigh Field Office
U.S. Fish and Wildlife Service
Post Office Box 33726
Raleigh, North Carolina 27636-3726
(919) 856-4520

Upon locating a dead, injured, or sick individual of an endangered or threatened species, initial notification must be made to the Service Law Enforcement Office below. Additional notification must be made to the Service Ecological Services Field Office identified above and to the NCWRC at (252) 241-7367. Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible state for later analysis of cause of death or injury.

Tom Chisdock
U.S. Fish and Wildlife Service
160 Zillicoa St.
Asheville, NC 28801
828-258-2084

Reinitiation Notice

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion or the project has not been completed within five years of the issuance of this biological opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

For this biological opinion, the incidental take will be exceeded when the groin construction and nourishment of 24,500 lf of beach extends beyond the project's authorized boundaries. Incidental take of an undetermined number of young or eggs of sea turtles, piping plovers, red knots, and seabeach amaranth plants has been exempted from the prohibitions of section 9 by this opinion.

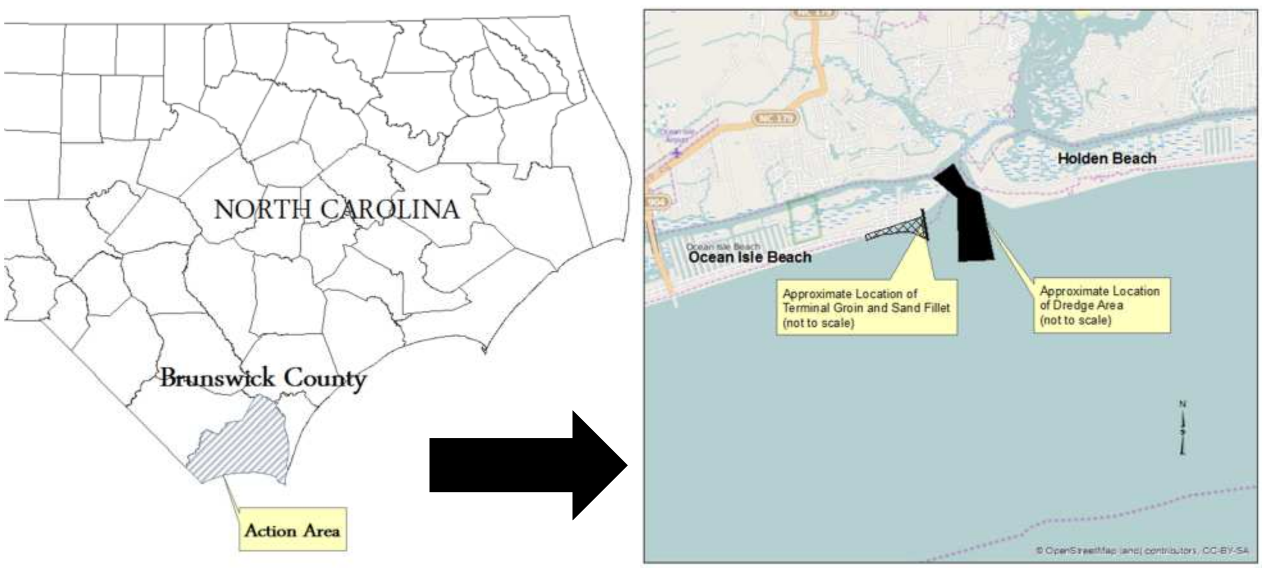
III. DESCRIPTION OF THE PROPOSED ACTION

A. Project Description

The purpose of the proposed project is to alleviate chronic erosion on the eastern portion of Ocean Isle Beach to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along easternmost 3,500 feet of its oceanfront shoreline. The proposed project is the preferred alternative in the January 2015 Draft Environmental Impact Statement (DEIS) (Alternative 5). The project includes the construction of a single, 1,050 lf terminal groin (300 lf landward, and 750 lf waterward of mean high water or MHW), placement of a concurrent 3,214 lf sand fillet, and the periodic placement of sand in the fillet from either scheduled federal disposal events and/or from locally-sponsored beach nourishment and disposal projects.

The DEIS describes the Action Area to include the shorelines of Ocean Isle Beach and Holden Beach and the adjacent Atlantic Ocean and Shallotte Inlet, Brunswick County, North Carolina (**Figure 1**). The Action Area includes 4,413 acres and approximately 24,500 lf of beach and inlet shoreline on Ocean Isle Beach and Holden Beach, from east of Concord Street on Ocean Isle Beach to an area near Sea Gull Street in Holden Beach. The Action Area for direct impacts includes those sections of Ocean Isle where terminal groin construction, sediment disposal, and earthen manipulation will occur – approximately 3,500 lf within the construction footprint and west of the groin (updrift). The Action Area for indirect impacts, however, is much larger. Because sea turtles and piping plovers are highly mobile species, animals influenced by direct project impacts may move great distances from the actual project site. The range of these movements produced by the project constitutes the Action Area for indirect impacts; for the purposes of this opinion it will be approximately 24,500 lf of beach and inlet shoreline on Ocean Isle Beach and Holden Beach for piping plovers, red knots, and sea turtles. The Action Area for seabeach amaranth is the area within the 3,500 lf proposed project footprint and the shoreline from the proposed groin to Shallotte Inlet (approximately 2,000 lf to the east or downdrift of the groin).

Figure 1. Action Area



Ocean Isle Beach was incorporated in 1959. Land ownership within the Action Area is both public and private, and land use encompasses recreational, commercial, and residential activities. Approximately 80% of uplands in Ocean Isle are developed, and the majority of the development is residential. The Action Area was relatively undeveloped until the 1970s and 1980's. Since then, it has become heavily developed with homes, shops, and recreational facilities. According to the Biological Assessment (BA), the permanent population of Ocean Isle is approximately 554, with a seasonal population of 25,000.

B. Project Design

The applicant proposes to construct a 750 lf terminal groin with a 300 lf shore anchorage system (1,050 lf total). The groin is proposed to be constructed of 7.5- to 12- ton stone rubble approximately 5 feet in diameter, while the anchorage system is proposed to be constructed using sheet piles. The rubblemound portion of the groin will cover approximately 52,500 square feet of area below MHW. The groin is proposed at a crest height of +4.9 feet NAVD, while the sheet piles are proposed to have a top elevation of +4.9 feet NAVD for a distance of about 130 feet between the landward end of the rubblemound section and the existing dune, and a top elevation of +4.5 feet NAVD for the remaining 170 feet. Excavation is needed for the landward 100 to 150 feet of the rubblemound portion of the structure in order to place the foundation stone or mattress at an elevation of -5.0 feet NAVD. From that point seaward, the foundation stone/mattress would be placed on grade.

Construction materials will be transported by barge to a facility on the north end of Shallotte Boulevard in the AIWW, off-loaded to trucks, and trucked from to the construction site. The rubble-mound portion of the groin would be constructed from a temporary trestle or pier installed parallel to the alignment of the terminal groin. The sheet piles will be driven into place with typical pile driving equipment. A 50-foot wide construction corridor is proposed for the shore anchorage section.

The groin will serve as a template for fill material placed westward thereof. The design goal is to reduce inlet-directed sand loss (both short-term and long-term) and to allow for a more stable condition. The project includes proposed maintenance of the sand fillet at 5-year intervals after the initial placement of sand and initiation of groin construction. 264,000 cubic yards (cy) of beach fill is anticipated to be placed along 3,214 lf of shoreline west of the terminal groin on a five-year nourishment interval. The proposed source of the sand for the initial construction and for maintenance of the sand fillet is the existing federal borrow area (approximately 83.1 acres) within Shallotte Inlet. Dredging is proposed with a cutterhead pipeline dredge.

According to the BA, the groin is designed as a leaky structure. The rubblemound portion of the groin would be constructed with loosely placed armor stone on top of a foundation mat or mattress. The loose nature of the armor stone was designed to facilitate the movement of littoral material through the structure while the relative low crest elevation would allow some sediment to pass over the structure during periods of high tide.

This BO addresses impacts to the piping plover (*Charadrius melodus*), red knot (*Calidris canutus rufa*), seabeach amaranth (*Amaranthus pumilus*), the leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles, and the Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle (*Caretta caretta*), all Federally-listed species under the purview of the Service occurring in the Action Area. This BO also addresses critical habitat for piping plover and terrestrial critical habitat for loggerhead sea turtles. Whales, sturgeon, and sea turtles in the water are the jurisdiction of

NMFS. The Service and NMFS share Federal jurisdiction for sea turtles under the Act. The Service has responsibility for sea turtles on the nesting beach. NMFS has jurisdiction for sea turtles in the marine environment. Activities proposed in this formal consultation would involve only impacts to sea turtles in the terrestrial environment, which includes the following life stages: nesting sea turtles, nests and eggs, and hatchlings as they emerge from the nest and crawl to the sea.

C. Project Timing and Duration

The dredging of Shallotte Inlet and the beach nourishment on Ocean Isle Beach is proposed to be conducted between November15 and April 30. The initial groin construction and placement of sand is expected to take up to 4 ½ months. On approximately 5-year intervals, maintenance of the 3,214 lf sand fillet is anticipated to take approximately 10 weeks.

D. Conservation Measures

To reduce the potential impacts of the proposed project on Federally-listed species, the Applicant has proposed the following Conservation Measures:

- Dredging and beach nourishment are scheduled to occur between November 16^{th} and April 30^{th}.

- A hydraulic cutterhead dredge will be used to dredge material from the borrow area. DREDGEPAK or similar navigation and positioning software will be used to accurately track the dredge location.

- The contractor will be required to abide by defined construction corridors, approved access locations and staging areas, and permitted construction timeframes.

- A construction corridor varying in width from 100 feet to 200 feet will be established around the footprint of the structure.

- Multiple daily observations of the pump-out location will be made of the material being placed on the beach. If incompatible material is placed on the beach, the Corps and appropriate resource agencies will be contacted immediately to determine appropriate actions.

- The Town of Ocean Isle Beach, the Engineer, or their duly authorized representative will collect a representative sub-surface grab sediment sample from each 100-foot long section of the constructed beach to visually assess grain size, wet Munsell color, granular, gravel, and silt content. If deemed necessary by the Engineer, or his duly authorized representative, quantitative assessments of the sand will be conducted for grain size, wet Munsell color, and content of gravel, granular, and silt.

- Visual surveys of escarpments will be made along the beach fill area immediately after completion of construction. Escarpments in the newly placed beach fill that exceed 18 inches for greater than 100 feet shall be graded to match adjacent grades on the beach. Removal of any escarpments during the sea turtle hatching season (May 1 through November 15) shall be coordinated with the NCWRC, Service, and the Corps.

- Turbidity monitoring during construction will be managed by the contractor. The contractor will be responsible for notifying the construction engineer in the event that the turbidity levels exceed the State water quality standards.

- In order to minimize adverse impact on wintering piping plover, the pipeline alignment will be designed to avoid potential piping plover wintering habitat. The alignment will be coordinated with and approved by the Corps.

- In order to avoid adverse impacts associated with the transport of fill material to the disposal sites, the Town of Ocean Isle Beach will negotiate with the dredge contractor to monitor and assess the pipeline during construction, to avoid leaking of sediment from the pipeline couplings and other equipment. The Town, along with its Engineer, will coordinate with the dredgers to have in place a mechanism to cease dredge and fill activities in the event that a substantial leak is detected.

- The construction crew will be advised of the restrictions established under Section 9 of the ESA prior to construction.

IV. LOGGERHEAD, GREEN, LEATHERBACK, AND KEMP'S RIDLEY SEA TURTLES

A. Status of the Species/Critical Habitat

1) Species/Critical Habitat Description

Species/Critical Habitat Description – Loggerhead Sea Turtle

The loggerhead sea turtle, which occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans, was federally listed worldwide as a threatened species on July 28, 1978 (43 Federal Register (FR) 32800). On September 22, 2011, the loggerhead sea turtle's listing under the Act was revised from a single threatened species to nine distinct population segments (DPS) listed as either threatened or endangered. The nine DPSs and their statuses are:

Northwest Atlantic Ocean DPS – threatened
Northeast Atlantic Ocean – endangered
Mediterranean Sea DPS – endangered
South Atlantic Ocean DPS – threatened
North Pacific Ocean DPS – endangered
South Pacific Ocean DPS – endangered
North Indian Ocean DPS – endangered
Southwest Indian Ocean – threatened
Southeast Indo-Pacific Ocean DPS – threatened

The loggerhead sea turtle grows to an average weight of about 200 pounds and is characterized by a large head with blunt jaws. Adults and subadults have a reddish-brown carapace. Scales on the top of the head and top of the flippers are also reddish-brown with yellow on the borders. Hatchlings are a dull brown color (National Marine Fisheries Service (NMFS) 2009a). The loggerhead feeds on mollusks, crustaceans, fish, and other marine animals.

The loggerhead may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and ship wrecks are often used as feeding areas. Within the Northwest Atlantic, the majority of nesting activity occurs from April through September, with a peak in June and July (Williams-Walls et al. 1983; Dodd 1988; Weishampel et al. 2006). Nesting occurs within the Northwest Atlantic along the coasts of North America, Central America, northern South America, the Antilles, Bahamas, and Bermuda, but is concentrated in the southeastern United

States and on the Yucatán Peninsula in Mexico on open beaches or along narrow bays having suitable sand (Sternberg 1981; Ehrhart 1989; Ehrhart et al. 2003; NMFS and Service 2008).

Designated critical habitat

On July 10, 2014, the Service designated portions North Carolina beaches as critical habitat for the Northwest Atlantic (NWA) population of loggerhead sea turtles. Holden Beach is located within Critical Habitat Unit LOGG-T-NC-08 (Oak Island, Brunswick County). From the Federal Register (FR) Notice (see http://www.regulations.gov/#!documentDetail;D=FWS-R4-ES-2012-0103-0001), this unit consists of 13.4 km (8.3 miles) of island shoreline along the Atlantic Ocean and extends from Lockwoods Folly Inlet to Shallotte Inlet. The island is separated from the mainland by the Atlantic Intracoastal Waterway, Elizabeth River, Montgomery Slough, Boone Channel, and salt marsh. The unit includes lands from the MHW line to the toe of the secondary dune or developed structures. Land in this unit is in private and other ownership (see Table 1). This unit was occupied at the time of listing and is currently occupied. This unit supports expansion of nesting from an adjacent unit (LOGG-T-NC-07) that has high-density nesting by loggerhead sea turtles in North Carolina.

In total, 1,189.9 kilometers (km) (739.3 miles) of loggerhead sea turtle nesting beaches are designated critical habitat in the States of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi. These beaches account for 48 percent of an estimated 2,464 km (1,531 miles) of coastal beach shoreline, and account for approximately 84 percent of the documented nesting (numbers of nests) within these six States. The designated critical habitat has been identified by the recovery unit in which they are located. Recovery units are management subunits of a listed entity that are geographically or otherwise identifiable and essential to the recovery of the listed entity. Within the United States, four terrestrial recovery units have been designated for the Northwest Atlantic population of the loggerhead sea turtle: the Northern Recovery Unit (NRU), Peninsular Florida Recovery Unit (PFRU), Dry Tortugas Recovery Unit (DTRU), and Northern Gulf of Mexico Recovery Unit (NGMRU). For the NRU, the Service has designated 393.7 km (244.7 miles) of Atlantic Ocean shoreline in North Carolina, South Carolina, and Georgia, encompassing approximately 86 percent of the documented nesting (numbers of nests) within the recovery unit.

Under the Act and its implementing regulations, the Service is required to identify the physical or biological features (PBFs) essential to the conservation of the loggerhead sea turtle in areas occupied at the time of listing, focusing on the features' primary constituent elements (PCEs). The Service determined that the following PBFs are essential for the loggerhead sea turtle:

(1) **PBF 1—**Sites For Breeding, Reproduction, or Rearing (or Development) of Offspring. To be successful, reproduction must occur when environmental conditions support adult activity (e.g., sufficient quality and quantity of food in the foraging area, suitable beach structure for digging, nearby inter-nesting habitat) (Georges et al. 1993). The environmental conditions of the nesting beach must favor embryonic development and survival (i.e., modest temperature fluctuation, low salinity, high humidity, well drained, well aerated) (Mortimer 1982; Mortimer 1990). Additionally, the hatchlings must emerge to onshore and offshore conditions that enhance their chances of survival (e.g., less than 100 percent depredation, appropriate offshore currents for dispersal) (Georges et al. 1993).

(2) **PBF 2** - Natural Coastal Processes or Activities That Mimic These Natural Processes. It is important that loggerhead nesting beaches are allowed to respond naturally to coastal dynamic processes of erosion and accretion or mimic these processes.

The Service considers PCEs to be those specific elements of the PBFs that provide for a species' life-history processes and are essential to the conservation of the species. Based on our current knowledge of the PBFs and habitat characteristics required to sustain the species' life-history processes, the terrestrial primary constituent elements specific to the Northwest Atlantic Ocean DPS of the loggerhead sea turtle are the extra-tidal or dry sandy beaches from the mean high-water line to the toe of the secondary dune, which are capable of supporting a high density of nests or serving as an expansion area for beaches with a high density of nests and that are well distributed within each State, or region within a State, and representative of total nesting, consisting of four components:

(1) **PCE 1—**Suitable nesting beach habitat that has (a) relatively unimpeded nearshore access from the ocean to the beach for nesting females and from the beach to the ocean for both post-nesting females and hatchlings and (b) is located above mean high water to avoid being inundated frequently by high tides.

(2) **PCE 2—**Sand that (a) allows for suitable nest construction, (b) is suitable for facilitating gas diffusion conducive to embryo development, and (c) is able to develop and maintain temperatures and a moisture content conducive to embryo development.

(3) **PCE 3—**Suitable nesting beach habitat with sufficient darkness to ensure nesting turtles are not deterred from emerging onto the beach and hatchlings and post-nesting females orient to the sea.

(4) **PCE 4—**Natural coastal processes or artificially created or maintained habitat mimicking natural conditions. This includes artificial habitat types that mimic the natural conditions

described in PCEs 1 to 3 above for beach access, nest site selection, nest construction, egg deposition and incubation, and hatchling emergence and movement to the sea.

This unit contains all of the PBFs and PCEs. The PBFs in this unit may require special management considerations or protections to ameliorate the threats of recreational use, predation, beach sand placement activities, in-water and shoreline alterations, climate change, beach erosion, artificial lighting, human-caused disasters, and response to disasters. The critical habitat in the project area has been relatively undisturbed since designation in 2014.

Species/Critical Habitat Description - Green Sea Turtle

The green sea turtle was federally listed on July 28, 1978 (43 FR 32800). Breeding populations of the green turtle in Florida and along the Pacific Coast of Mexico are listed as endangered; all other populations are listed as threatened. The green sea turtle has a worldwide distribution in tropical and subtropical waters.

The green sea turtle grows to a maximum size of about 4 feet and a weight of 440 pounds. It has a heart-shaped shell, small head, and single-clawed flippers. The carapace is smooth and colored gray, green, brown, and black. Hatchlings are black on top and white on the bottom (NMFS 2009b). Hatchling green turtles eat a variety of plants and animals, but adults feed almost exclusively on seagrasses and marine algae.

Major green turtle nesting colonies in the Atlantic occur on Ascension Island, Aves Island, Costa Rica, and Surinam. Within the U.S., green turtles nest in small numbers in the U.S. Virgin Islands and Puerto Rico, and in larger numbers along the east coast of Florida, particularly in Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties (NMFS and Service 1991). Nests have been documented, in smaller numbers, north of these Counties, from Volusia through Nassau Counties in Florida, as well as in Georgia, South Carolina, North Carolina, and as far north as Delaware in 2011. Nests have been documented in smaller numbers south of Broward County in Miami-Dade. Nesting also has been documented along the Gulf coast of Florida from Escambia County through Franklin County in northwest Florida and from Pinellas County through Monroe County in southwest Florida (FWC/FWRI 2010b).
Green sea turtles are generally found in fairly shallow waters (except when migrating) inside reefs, bays, and inlets. The green turtle is attracted to lagoons and shoals with an abundance of marine grass and algae. Open beaches with a sloping platform and minimal disturbance are required for nesting. Critical habitat for the green sea turtle has been designated for the waters surrounding Culebra Island, Puerto Rico, and its outlying keys. There is no designated critical habitat in North Carolina.

Species/Critical Habitat Description - Leatherback Sea Turtle

The leatherback sea turtle was federally listed as an endangered species on June 2, 1970 (35 FR 8491). Leatherbacks have the widest distribution of the sea turtles with nonbreeding animals recorded as far north as the British Isles and the Maritime Provinces of Canada and as far south as Argentina and the Cape of Good Hope (Pritchard 1992). Foraging leatherback excursions have been documented into higher-latitude subpolar waters. They have evolved physiological and anatomical adaptations (Frair et al. 1972; Greer et al. 1973) that allow them to exploit waters far colder than any other sea turtle species would be capable of surviving.

The adult leatherback can reach 4 to 8 feet in length and weigh 500 to 2,000 pounds. The carapace is distinguished by a rubber-like texture, about 1.6 inches thick, made primarily of tough, oil-saturated connective tissue. Hatchlings are dorsally mostly black and are covered with tiny scales; the flippers are edged in white, and rows of white scales appear as stripes along the length of the back (NMFS 2009c). Jellyfish are the main staple of its diet, but it is also known to feed on sea urchins, squid, crustaceans, tunicates, fish, blue-green algae, and floating seaweed. This is the largest, deepest diving of all sea turtle species.

Leatherback turtle nesting grounds are distributed worldwide in the Atlantic, Pacific, and Indian Oceans on beaches in the tropics and subtropics. The Pacific Coast of Mexico historically supported the world's largest known concentration of nesting leatherbacks. The leatherback turtle regularly nests in the U.S. Caribbean in Puerto Rico and the U.S. Virgin Islands. Along the U.S. Atlantic coast, most nesting occurs in Florida (NMFS and Service 1992). Nesting has also been reported in Georgia, South Carolina, and North Carolina (Rabon et al. 2003) and in Texas (Shaver 2008). Adult females require sandy nesting beaches backed with vegetation and sloped sufficiently so the distance to dry sand is limited. Their preferred beaches have proximity to deep water and generally rough seas.

Marine and terrestrial critical habitat for the leatherback sea turtle has been designated at Sandy Point on the western end of the island of St. Croix, U.S. Virgin Islands (50 Code of Federal Regulations (CFR) 17.95). There is no designated critical habitat in North Carolina.

Species/Critical Habitat Description – Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle was federally listed as endangered on December 2, 1970 (35 FR 18320). The Kemp's ridley, along with the flatback sea turtle (*Natator depressus*), has the most geographically restricted distribution of any sea turtle species. The range of the Kemp's ridley includes the Gulf coasts of Mexico and the U.S., and the Atlantic coast of North America as far north as Nova Scotia and Newfoundland.

Adult Kemp's ridleys and olive ridleys are the smallest sea turtles in the world. The weight of an adult Kemp's ridley is generally between 70 to 108 pounds with a carapace measuring approximately 24 to 26 inches in length (Heppell et al. 2005). The carapace is almost as wide as it is long. The species' coloration changes significantly during development from the grey-black dorsum and plastron of hatchlings, a grey-black dorsum with a yellowish-white plastron as post-pelagic juveniles and then to the lighter grey-olive carapace and cream-white or yellowish plastron of adults. Their diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks.

The Kemp's ridley has a restricted distribution. Nesting is essentially limited to the beaches of the western Gulf of Mexico, primarily in Tamaulipas, Mexico (NMFS et al. 2011). Nesting also occurs in Veracruz and a few historical records exist for Campeche, Mexico (Marquez-Millan 1994). Nesting also occurs regularly in Texas and infrequently in a few other U.S. states. However, historic nesting records in the U.S. are limited to south Texas (Carr 1961; Hildebrand 1963).

Most Kemp's ridley nests located in the U.S. have been found in south Texas, especially Padre Island (Shaver and Caillouet 1998; Shaver 2002, 2005). Nests have been recorded elsewhere in Texas (Shaver 2005; 2006a; 2006b; 2007; 2008), and in Florida (Johnson et al. 1999; Foote and Mueller 2002; Hegna et al. 2006; FWC/FWRI 2010b), Alabama (J. Phillips, Service, personal communication, 2007 cited in NMFS et al. 2011; J. Isaacs, Service, personal communication, 2008 cited in NMFS et al. 2011), Georgia (Williams et al. 2006), South Carolina (Anonymous 1992), and North Carolina (Marquez et al. 1996), but these events are less frequent. Kemp's ridleys inhabit the Gulf of Mexico and the Northwest Atlantic Ocean, as far north as the Grand Banks (Watson et al. 2004) and Nova Scotia (Bleakney 1955). They occur near the Azores and eastern north Atlantic (Deraniyagala 1938; Brongersma 1972; Fontaine et al. 1989; Bolten and Martins 1990) and Mediterranean (Pritchard and Marquez 1973, Brongersma and Carr 1983; Tomas and Raga 2007; Insacco and Spadola 2010).

Juvenile Kemp's ridleys spend on average 2 years in the oceanic zone (NMFS SEFSC unpublished preliminary analysis, July 2004, as cited in NMFS et al. 2011) where they likely live and feed among floating algal communities. They remain here until they reach about 7.9 inches in length (approximately 2 years of age), at which size they enter coastal shallow water habitats (Ogren 1989); however, the time spent in the oceanic zone may vary from 1 to 4 years or perhaps more (Turtle Expert Working Group (TEWG) 2000; Baker and Higgins 2003; Dodge et al. 2003).

No critical habitat has been designated for the Kemp's ridley sea turtle.

2) Life history

Life History – Loggerhead Sea Turtle

Loggerheads are long-lived, slow-growing animals that use multiple habitats across entire ocean basins throughout their life history. This complex life history encompasses terrestrial, nearshore, and open ocean habitats. The three basic ecosystems in which loggerheads live are the:

1. Terrestrial zone (supralittoral) - the nesting beach where both oviposition (egg laying) and embryonic development and hatching occur.

2. Neritic zone - the inshore marine environment (from the surface to the sea floor) where water depths do not exceed 656 feet. The neritic zone generally includes the continental shelf, but in areas where the continental shelf is very narrow or nonexistent, the neritic zone conventionally extends to areas where water depths are less than 656 feet.

3. Oceanic zone - the vast open ocean environment (from the surface to the sea floor) where water depths are greater than 656 feet.

Maximum intrinsic growth rates of sea turtles are limited by the extremely long duration of the juvenile stage and fecundity. Loggerheads require high survival rates in the juvenile and adult stages, common constraints critical to maintaining long-lived, slow-growing species, to achieve positive or stable long-term population growth (Congdon et al. 1993; Heppell 1998; Crouse 1999; Heppell et al. 1999; 2003; Musick 1999).

Numbers of nests and nesting females are often highly variable from year to year due to a number of factors including environmental stochasticity, periodicity in ocean conditions, anthropogenic effects, and density-dependent and density-independent factors affecting survival, somatic growth, and reproduction (Meylan 1982; Hays 2000; Chaloupka 2001; Solow et al. 2002). Despite these sources of variation, and because female turtles exhibit strong nest site fidelity, a nesting beach survey can provide a valuable assessment of changes in the adult female population, provided that the study is sufficiently long and effort and methods are standardized (Meylan 1982; Gerrodette and Brandon 2000; Reina et al. 2002). **Table 1** summarizes key life history characteristics for loggerheads nesting in the U.S.

Loggerheads nest on ocean beaches and occasionally on estuarine shorelines with suitable sand. Nests are typically laid between the high tide line and the dune front (Routa 1968; Witherington 1986; Hailman and Elowson 1992). Wood and Bjorndal (2000) evaluated four environmental factors (slope, temperature, moisture, and salinity) and found that slope had the greatest influence on loggerhead nest-site selection on a beach in Florida. Loggerheads appear to prefer relatively narrow, steeply sloped, coarse-grained beaches, although nearshore contours may also play a role in nesting beach site selection (Provancha and Ehrhart 1987).

The warmer the sand surrounding the egg chamber, the faster the embryos develop (Mrosovsky and Yntema 1980). Sand temperatures prevailing during the middle third of the incubation period also determine the sex of hatchling sea turtles (Mrosovsky and Yntema 1980). Incubation temperatures near the upper end of the tolerable range produce only female hatchlings while incubation temperatures near the lower end of the tolerable range produce only male hatchlings.

Table 1. Typical values of life history parameters for loggerheads nesting in the U.S. (NMFS and Service 2008).

Life History Trait	**Data**
Clutch size (mean)	100-126 eggs[1]
Incubation duration (varies depending on time of year and latitude)	Range = 42-75 days[2,3]
Pivotal temperature (incubation temperature that produces an equal number of males and females)	84˚F[5]
Nest productivity (emerged hatchlings/total eggs) x 100 (varies depending on site specific factors)	45-70 percent[2,6]
Clutch frequency (number of nests/female/season)	3-4 nests[7]
Internesting interval (number of days between successive nests within a season)	12-15 days[8]
Juvenile (<34 inches Curved Carapace Length) sex ratio	65-70 percent female[4]
Remigration interval (number of years between successive nesting migrations)	2.5-3.7 years[9]
Nesting season	late April-early September
Hatching season	late June-early November
Age at sexual maturity	32-35 years[10]
Life span	>57 years[11]

1 Dodd (1988).
2 Dodd and Mackinnon (1999, 2000, 2001, 2002, 2003, 2004).
3 Witherington (2006) (information based on nests monitored throughout Florida beaches in 2005, n = 865).
4 NMFS (2001); Foley (2005).
5 Mrosovsky (1988).
6 Witherington (2006) (information based on nests monitored throughout Florida beaches in 2005, n = 1,680).
7 Murphy and Hopkins (1984); Frazer and Richardson (1985); Hawkes et al. 2005; Scott 2006.
8 Caldwell (1962), Dodd (1988).
9 Richardson et al. (1978); Bjorndal et al. (1983).
10 Snover (2005).
11 Dahlen et al. (2000).

Loggerhead hatchlings pip and escape from their eggs over a 1- to 3-day interval and move upward and out of the nest over a 2- to 4-day interval (Christens 1990). The time from pipping to emergence ranges from 4 to 7 days with an average of 4.1 days (Godfrey and Mrosovsky 1997). Hatchlings emerge from their nests en masse almost exclusively at night, and presumably using decreasing sand temperature as a cue (Hendrickson 1958; Mrosovsky 1968; Witherington et al. 1990). Moran et al. (1999) concluded that a lowering of sand temperatures below a critical threshold, which most typically occurs after nightfall, is the most probable trigger for hatchling emergence from a nest. After an initial emergence, there may be secondary emergences on subsequent nights (Carr and Ogren 1960; Witherington 1986; Ernest and Martin 1993; Houghton and Hays 2001).

Hatchlings use a progression of orientation cues to guide their movement from the nest to the marine environments where they spend their early years (Lohmann and Lohmann 2003). Hatchlings first use light cues to find the ocean. On naturally lighted beaches without artificial lighting, ambient light from the open sky creates a relatively bright horizon compared to the dark silhouette of the dune and vegetation landward of the nest. This contrast guides the hatchlings to the ocean (Daniel and Smith 1947; Limpus 1971; Salmon et al. 1992; Witherington and Martin 1996; Witherington 1997; Stewart and Wyneken 2004).

Life History - Green Sea Turtle

Green sea turtles deposit from one to nine clutches within a nesting season, but the overall average is about 3.3 nests. The interval between nesting events within a season varies around a mean of about 13 days (Hirth 1997). Mean clutch size varies widely among populations. Clutch size varies from 75 to 200 eggs with incubation requiring 48 to 70 days, depending on incubation temperatures. Only occasionally do females produce clutches in successive years. Usually two or more years intervene between breeding seasons (NMFS and Service 1991). Age at sexual maturity is believed to be 20 to 50 years (Hirth 1997).

Life History – Leatherback Sea Turtle

Leatherbacks nest an average of five to seven times within a nesting season, with an observed maximum of 11 nests (NMFS and Service 1992). The interval between nesting events within a season is about 9 to 10 days. Clutch size averages 80 to 85 yolked eggs, with the addition of usually a few dozen smaller, yolkless eggs, mostly laid toward the end of the clutch (Pritchard 1992). Nesting migration intervals of 2 to 3 years were observed in leatherbacks nesting on the Sandy Point National Wildlife Refuge, St. Croix, U.S. Virgin Islands (McDonald and Dutton 1996). Leatherbacks are believed to reach sexual maturity in 13 to 16 years (Dutton et al. 2005; Jones et al. 2011).

Life History – Kemp's Ridley Sea Turtle

Nesting occurs primarily from April into July. Nesting often occurs in synchronized emergences, known as "arribadas" or "arribazones," which may be triggered by high wind speeds, especially north winds, and changes in barometric pressure (Jimenez et al. 2005). Nesting occurs primarily during daylight hours. Clutch size averages 100 eggs and eggs typically take 45 to 58 days to hatch depending on incubation conditions, especially temperatures (Marquez-Millan 1994; Rostal 2007).

Females lay an average of 2.5 clutches within a season (TEWG 1998) and inter-nesting interval generally ranges from 14 to 28 days (Miller 1997; Donna Shaver, Padre Island National Seashore, personal communication, 2007 as cited in NMFS et al. 2011). The mean remigration interval for adult females is 2 years, although intervals of 1 and 3 years are not uncommon (Marquez et al. 1982; TEWG 1998, 2000). Males may not be reproductively active on an annual basis (Wibbels et al. 1991). Age at sexual maturity is believed to be between 10 to 17 years (Snover et al. 2007).

3) Population Dynamics

Population Dynamics – Loggerhead Sea Turtle

The loggerhead occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans (Dodd 1988). However, the majority of loggerhead nesting is at the western rims of the Atlantic and Indian Oceans. The most recent reviews show that only two loggerhead nesting beaches have greater than 10,000 females nesting per year (Baldwin et al. 2003; Ehrhart et al. 2003; Kamezaki et al. 2003; Limpus and Limpus 2003; Margaritoulis et al. 2003): Peninsular Florida (U.S.) and Masirah (Oman). Those beaches with 1,000 to 9,999 females nesting each year are Georgia through North Carolina (U.S.), Quintana Roo and Yucatán (Mexico), Cape Verde Islands (Cape Verde, eastern Atlantic off Africa), and Western Australia (Australia).

The major nesting concentrations in the U.S. are found in South Florida. However, loggerheads nest from Texas to Virginia. Since 2000, the annual number of loggerhead nests in NC has fluctuated between 333 in 2004 to 1,260 in 2013 (Godfrey, unpublished data). Total estimated nesting in the U.S. has fluctuated between 49,000 and 90,000 nests per year from 1999-2010 (NMFS and Service 2008; FWC/FWRI 2010a). Adult loggerheads are known to make considerable migrations between foraging areas and nesting beaches (Schroeder et al. 2003; Foley et al. 2008). During non-nesting years, adult females from U.S. beaches are distributed in waters off the eastern U.S. and throughout the Gulf of Mexico, Bahamas, Greater Antilles, and Yucatán. From a global perspective, the U.S. nesting aggregation is of paramount importance to the survival of the species, as is the population that nests on islands in the Arabian Sea off Oman (Ross 1982; Ehrhart 1989; Baldwin et al. 2003).

Population Dynamics - Green Sea Turtle

There are an estimated 150,000 females that nest each year in 46 sites throughout the world (NMFS and Service 2007a). In the U.S. Atlantic, the majority of nesting occurs in Florida, where about 100 to 1,000 females are estimated to nest annually (FWC 2009c). In North Carolina, between 4 and 44 green sea turtle nests are laid annually (Godfrey, unpublished data). In the U.S. Pacific, over 90 percent of nesting throughout the Hawaiian archipelago occurs at the French Frigate Shoals, where about 200 to 700 females nest each year (NMFS and Service 1998a). Elsewhere in the U.S. Pacific, nesting takes place at scattered locations in the Commonwealth of the Northern Marianas, Guam, and American Samoa. In the western Pacific, the largest green turtle nesting aggregation in the world occurs on Raine Island, Australia, where thousands of females nest nightly in an average nesting season (Limpus et al. 1993). In the Indian Ocean, major nesting beaches occur in Oman where 30,000 females are reported to nest annually (Ross and Barwani 1995).

Population Dynamics – Leatherback Sea Turtle

A dramatic drop in nesting numbers has been recorded on major nesting beaches in the Pacific. Spotila et al. (2000) have highlighted the dramatic decline and possible extirpation of leatherbacks in the Pacific.

The East Pacific and Malaysia leatherback populations have collapsed. Spotila et al. (1996) estimated that only 34,500 females nested annually worldwide in 1995, which is a dramatic decline from the 115,000 estimated in 1980 (Pritchard 1982). In the eastern Pacific, the major nesting beaches occur in Costa Rica and Mexico. At Playa Grande, Costa Rica, considered the most important nesting beach in the eastern Pacific, numbers have dropped from 1,367 leatherbacks in 1988-1989 to an average of 188 females nesting between 2000-2001 and 2003-2004. In Pacific Mexico, 1982 aerial surveys of adult female leatherbacks indicated this area had become the most important leatherback nesting beach in the world. Tens of thousands of nests were laid on the beaches in 1980s, but during the 2003-2004 seasons a total of 120 nests were recorded. In the western Pacific, the major nesting beaches lie in Papua New Guinea, Papua, Indonesia, and the Solomon Islands. These are some of the last remaining significant nesting assemblages in the Pacific. Compiled nesting data estimated approximately 5,000 to 9,200 nests annually with 75 percent of the nests being laid in Papua, Indonesia.

However, the most recent population size estimate for the North Atlantic alone is a range of 34,000 to 94,000 adult leatherbacks (TEWG 2007). During recent years in Florida, the total number of leatherback nests counted as part of the SNBS program ranged from 540 to 1,797 from 2006-2010 (FWC/FWRI 2010a). Assuming a clutch frequency (number of nests/female/season) of 4.2 in Florida (Stewart 2007), these nests were produced by a range of 128 to 428 females in a given year.

Nesting in the Southern Caribbean occurs in the Guianas (Guyana, Suriname, and French Guiana), Trinidad, Dominica, and Venezuela. The largest nesting populations at present occur in the western Atlantic in French Guiana with nesting varying between a low of 5,029 nests in 1967 to a high of 63,294 nests in 2005, which represents a 92 percent increase since 1967 (TEWG 2007). Trinidad supports an estimated 6,000 leatherbacks nesting annually, which represents more than 80 percent of the nesting in the insular Caribbean Sea. Leatherback nesting along the Caribbean Central American coast takes place between Honduras and Colombia. In Atlantic Costa Rica, at Tortuguero, the number of nests laid annually between 1995 and 2006 was estimated to range from 199 to 1,623. Modeling of the Atlantic Costa Rica data indicated that the nesting population has decreased by 67.8 percent over this time period.

In Puerto Rico, the main nesting areas are at Fajardo (Northeast Ecological Corridor) and Maunabo on the main island of Puerto Rico and on the islands of Culebra and Vieques. Between 1993 and 2010, the number of nests in the Fajardo area ranged from 51 to 456. In the Maunabo area, the number of nests recorded between 2001 and 2010 ranged from a low of 53 in 2002 to a high of 260 in 2009 (Diez 2011). On the island of Culebra, the number of nests ranged from a low 41 in 1996 to a high of 395 in 1997 (Diez 2011). On beaches managed by the Commonwealth of Puerto Rico on the island of Vieques, the Puerto Rico Department of Natural and Environmental Resources recorded annually 14-61 leatherback nests between 1991 and 2000; 145 nests in 2002; 24 in 2003; and 37 in 2005 (Diez 2011). The number of leatherback sea turtle nests recorded on Vieques Island beaches managed by the Service ranged between 13 and 163 during 2001-2010. Using the numbers of nests recorded in Puerto Rico between 1984 and 2005, the Turtle Expert Working Group (2007) estimated a population growth of approximately 10 percent per year. Recorded leatherback nesting on the Sandy Point National Wildlife Refuge on the island of St. Croix, U.S. Virgin Islands, between 1982 and 2010, ranged from a low of 82 in 1986 to a high of 1,008 in 2001 (Garner and Garner 2010). Using the number of observed females at Sandy Point from 1986 to 2004, the Turtle Expert Working Group (2007) estimated a population growth of approximately 10 percent per year. In the British Virgin Islands, annual nest numbers have increased in Tortola from zero to six nests per year in the late 1980s to 35 to 65 nests per year in the 2000s (TEWG 2007).

The most important nesting beach for leatherbacks in the eastern Atlantic lies in Gabon, Africa. It was estimated there were 30,000 nests along 60 miles of Mayumba Beach in southern Gabon during the 1999-2000 nesting season (Billes et al. 2000). Some nesting has been reported in Mauritania, Senegal, the Bijagos Archipelago of Guinea-Bissau, Turtle Islands and Sherbro Island of Sierra Leone, Liberia, Togo, Benin, Nigeria, Cameroon, Sao Tome and Principe, continental Equatorial Guinea, Islands of Corisco in the Gulf of Guinea and the Democratic Republic of the Congo, and Angola. In addition, a large nesting population is found on the island of Bioko (Equatorial Guinea) (Fretey et al. 2007). In North Carolina between the year 2000 and 2013, as many as 9 nests were laid per year (Godfrey, unpublished data).

Population Dynamics – Kemp's Ridley Sea Turtle

Most Kemp's ridleys nest on the beaches of the western Gulf of Mexico, primarily in Tamaulipas, Mexico. Nesting also occurs in Veracruz and Campeche, Mexico, although a small number of Kemp's ridleys nest consistently along the Texas coast (NMFS et al. 2011). In addition, rare nesting events have been reported in Alabama, Florida, Georgia, South Carolina, and North Carolina. Historical information indicates that tens of thousands of ridleys nested near Rancho Nuevo, Mexico, during the late 1940s (Hildebrand 1963). The Kemp's ridley population experienced a devastating decline between the late 1940s and the mid-1980s. The total number of nests per nesting season at Rancho Nuevo remained below 1,000 throughout the 1980s, but gradually began to increase in the 1990s. In 2009, 16,273 nests were documented along the 18.6 miles of coastline patrolled at Rancho Nuevo, and the total number of nests documented for all the monitored beaches in Mexico was 21,144 (USFWS 2010b). In 2011, a total of 20,570 nests were documented in Mexico, 81 percent of these nests were documented in the Rancho Nuevo beach (Burchfield and Peña 2011). In addition, 153 and 199 nests were recorded during 2010 and 2011, respectively, in the United States, primarily in Texas.

4) Status And Distribution

Status and Distribution – All Sea Turtles

<u>Reason for Listing</u>: There are many threats to sea turtles, including nest destruction from natural events, such as tidal surges and hurricanes, or eggs lost to predation by raccoons, foxes, ghost-crabs, and other animals. However, human activity has significantly contributed to the decline of sea turtle populations along the Atlantic Coast and in the Gulf of Mexico (NRC 1990). These factors include the modification, degradation, or loss of nesting habitat by coastal development, artificial lighting, beach driving, and marine pollution and debris. Furthermore, the overharvest of eggs for food, intentional killing of adults and immature turtles for their shells and skin, and

accidental drowning in commercial fishing gear are primarily responsible for the worldwide decline in sea turtle populations.

Status and Distribution – Loggerhead Sea Turtle

Range-wide Trend: Five recovery units have been identified in the Northwest Atlantic based on genetic differences and a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries (NMFS and Service 2008). Recovery units are subunits of a listed species that are geographically or otherwise identifiable and essential to the recovery of the species. Recovery units are individually necessary to conserve genetic robustness, demographic robustness, important life history stages, or some other feature necessary for long-term sustainability of the species. The five recovery units identified in the Northwest Atlantic are:

1. Northern Recovery Unit (NRU) - defined as loggerheads originating from nesting beaches from the Florida-Georgia border through southern Virginia (the northern extent of the nesting range);

2. Peninsula Florida Recovery Unit (PFRU) - defined as loggerheads originating from nesting beaches from the Florida-Georgia border through Pinellas County on the west coast of Florida, excluding the islands west of Key West, Florida;

3. Dry Tortugas Recovery Unit (DTRU) - defined as loggerheads originating from nesting beaches throughout the islands located west of Key West, Florida;

4. Northern Gulf of Mexico Recovery Unit (NGMRU) - defined as loggerheads originating from nesting beaches from Franklin County on the northwest Gulf coast of Florida through Texas; and

5. Greater Caribbean Recovery Unit (GCRU) - composed of loggerheads originating from all other nesting assemblages within the Greater Caribbean (Mexico through French Guiana, The Bahamas, Lesser Antilles, and Greater Antilles).

The mtDNA analyses show that there is limited exchange of females among these recovery units (Ehrhart 1989; Foote et al. 2000; NMFS 2001; Hawkes et al. 2005). Male-mediated gene flow appears to be keeping the subpopulations genetically similar on a nuclear DNA level (Francisco-Pearce 2001).

Historically, the literature has suggested that the northern U.S. nesting beaches (NRU and NGMRU) produce a relatively high percentage of males and the more southern nesting beaches (PFRU, DTRU, and GCRU) a relatively high percentage of females (e.g., Hanson et al. 1998; NMFS 2001; Mrosovsky and Provancha 1989). The NRU and NGMRU were believed to play an important role in providing males to mate with females from the more female-dominated subpopulations to the south. However, in 2002 and 2003, researchers studied loggerhead sex ratios for two of the U.S. nesting subpopulations, the northern and southern subpopulations (NGU and PFRU, respectively) (Blair 2005; Wyneken et al. 2005). The study produced interesting results. In 2002, the northern beaches produced more females and the southern beaches produced more males than previously believed. However, the opposite was true in 2003 with the northern beaches producing more males and the southern beaches producing more females in keeping with prior literature. Wyneken et al. (2005) speculated that the 2002 result may have been anomalous; however, the study did point out the potential for males to be produced on the southern beaches. Although this study revealed that more males may be produced on southern recovery unit beaches than previously believed, the Service maintains that the NRU and NGMRU play an important role in the production of males to mate with females from the more southern recovery units.

The NRU is the second largest loggerhead recovery unit within the Northwest Atlantic Ocean DPS. Annual nest totals from northern beaches averaged 5446 nests from 2006 to 2011, a period of near-complete surveys of NRU nesting beaches, representing approximately 1,328 nesting females per year (4.1 nests per female, Murphy and Hopkins 1984) (NMFS and Service 2008). In 2008, nesting in Georgia reached what was a new record at that time (1,646 nests), with a downturn in 2009, followed by yet another record in 2011 (1,987 nests). South Carolina had the two highest years of nesting in the 2000s in 2009 (2,183 nests) and 2010 (3,141 nests). The previous high for that 11-year span was 1,433 nests in 2003. North Carolina had 947 nests in 2011, which is above the average of 765. The Georgia, South Carolina, and North Carolina nesting data come from the seaturtle.org Sea Turtle Nest Monitoring System, which is populated with data input by the State agencies. The loggerhead nesting trend from daily beach surveys was declining significantly at 1.3 percent annually from 1983 to 2007 (NMFS and USFWS, 2008). Overall, there is strong statistical data to suggest the NRU has experienced a long-term decline (NMFS and Service 2008). Currently, however, nesting for the NRU is showing possible signs of stabilizing (76 FR 58868, September 22, 2011).

<u>Recovery Criteria (only the Demographic Recovery Criteria are presented below; for the Listing Factor Recovery Criteria, see NMFS and Service 2008)</u>

1. Number of Nests and Number of Nesting Females
    a. Northern Recovery Unit

   i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is 2 percent or greater resulting in a total annual number of nests of 14,000 or greater for this recovery unit (approximate distribution of nests is North Carolina =14 percent [2,000 nests], South Carolina =66 percent [9,200 nests], and Georgia =20 percent [2,800 nests]); and
   ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

b. Peninsular Florida Recovery Unit
   i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is statistically detectable (one percent) resulting in a total annual number of nests of 106,100 or greater for this recovery unit; and
   ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

c. Dry Tortugas Recovery Unit
   i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 1,100 or greater for this recovery unit; and
   ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

d. Northern Gulf of Mexico Recovery Unit
   i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 4,000 or greater for this recovery unit (approximate distribution of nests (2002-2007) is Florida= 92 percent [3,700 nests] and Alabama =8 percent [300 nests]); and
   ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

e. Greater Caribbean Recovery Unit
    i. The total annual number of nests at a minimum of three nesting assemblages, averaging greater than 100 nests annually (e.g., Yucatán, Mexico; Cay Sal Bank, Bahamas) has increased over a generation time of 50 years; and
    ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

2. Trends in Abundance on Foraging Grounds
A network of in-water sites, both oceanic and neritic across the foraging range is established and monitoring is implemented to measure abundance. There is statistical confidence (95 percent) that a composite estimate of relative abundance from these sites is increasing for at least one generation.

3. Trends in Neritic Strandings Relative to In-water Abundance
Stranding trends are not increasing at a rate greater than the trends in in-water relative abundance for similar age classes for at least one generation.

Status and Distribution - Green Sea Turtle

Range-wide Trend: Annual nest totals documented as part of the Florida SNBS program from 1989-2010 have ranged from 435 nests laid in 1993 to 13,225 in 2010. Nesting occurs in 26 counties with a peak along the east coast, from Volusia through Broward Counties. Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, green turtle nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2010). Green sea turtle nesting in Florida is increasing based on 22 years (1989-2010) of INBS data from throughout the state ((FWC/FWRI 2010b). The increase in nesting in Florida is likely a result of several factors, including: (1) a Florida statute enacted in the early 1970s that prohibited the killing of green turtles in Florida; (2) the species listing under the Act afforded complete protection to eggs, juveniles, and adults in all U.S. waters; (3) the passage of Florida's constitutional net ban amendment in 1994 and its subsequent enactment, making it illegal to use any gillnets or other entangling nets in State waters; (4) the likelihood that the majority of Florida green turtles reside within Florida waters where they are fully protected; (5) the protections afforded Florida green turtles while they inhabit the waters of other nations that have enacted strong sea turtle conservation measures (e.g., Bermuda); and (6) the listing of the species on Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which stopped international trade and reduced incentives for illegal trade from the U.S (NMFS and Service 2007a).

Recovery Criteria

The U.S. Atlantic population of green sea turtles can be considered for delisting if, over a period of 25 years, the following conditions are met:

1. The level of nesting in Florida has increased to an average of 5,000 nests per year for at least six years. Nesting data must be based on standardized surveys;

2. At least 25 percent (65 miles) of all available nesting beaches (260 miles) is in public ownership and encompasses at least 50 percent of the nesting activity;

3. A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds; and

4. All priority one tasks identified in the recovery plan have been successfully implemented.

Status and Distribution - Leatherback Sea Turtle

Range-wide Trend: Pritchard (1982) estimated 115,000 nesting females worldwide, of which 60 percent nested along the Pacific coast of Mexico. Declines in leatherback nesting have occurred over the last two decades along the Pacific coasts of Mexico and Costa Rica. The Mexican leatherback nesting population, once considered to be the world's largest leatherback nesting population (historically estimated to be 65 percent of the worldwide population), is now less than 1 percent of its estimated size in 1980. Spotila et al. (1996) estimated the number of leatherback sea turtles nesting on 28 beaches throughout the world from the literature and from communications with investigators studying those beaches. The estimated worldwide population of leatherbacks in 1995 was about 34,500 females on these beaches with a lower limit of about 26,200, and an upper limit of about 42,900. This is less than one-third the 1980 estimate of 115,000. Leatherbacks are rare in the Indian Ocean and in very low numbers in the western Pacific Ocean. The most recent population size estimate for the North Atlantic is a range of 34,000 to 94,000 adult leatherbacks (TEWG 2007). The largest population is in the western Atlantic. Using an age-based demographic model, Spotila et al. (1996) determined that leatherback populations in the Indian Ocean and western Pacific Ocean cannot withstand even moderate levels of adult mortality and that the Atlantic populations are being exploited at a rate that cannot be sustained. They concluded that leatherbacks are on the road to extinction and further population declines can be expected unless action is taken to reduce adult mortality and increase survival of eggs and hatchlings.

In the western Atlantic, the U.S., nesting populations occur in Florida, Puerto Rico, and the U.S. Virgin Islands. In Florida, the SNBS program documented an increase in leatherback nesting numbers from 98 nests in 1989 to between 453 and 1,747 nests per season in the early 2000s (FWC 2009a; Stewart and Johnson 2006). Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, leatherback nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2010). Under the INBS program, approximately 30 percent of Florida's SNBS beach length is surveyed. The INBS nest counts represent approximately 34 percent of known leatherback nesting in Florida. An analysis of the INBS data has shown an exponential increase in leatherback sea turtle nesting in Florida since 1989. From 1989 through 2010, the annual number of leatherback sea turtle nests at the core set of index beaches ranged from 27 to 615 (FWC 2010b). Using the numbers of nests recorded from 1979 through 2009, Stewart et al. (2011) estimated a population growth of approximately 10.2 percent per year. In Puerto Rico, the main nesting areas are at Fajardo (Northeast Ecological Corridor) and Maunabo on the main island and on the islands of Culebra and Vieques. Nesting ranged from 51 to 456 nests between 2001 and 2010 (Diez 2011). In the U.S. Virgin Islands, leatherback nesting on Sandy Point National Wildlife Refuge on the island of St. Croix ranged from 143 to 1,008 nests between 1990 and 2005 (TEWG 2007; NMFS and Service 2007b).

Recovery Criteria

The U.S. Atlantic population of leatherbacks can be considered for delisting if the following conditions are met:

1. The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico, St. Croix, U.S. Virgin Islands, and along the east coast of Florida;
2. Nesting habitat encompassing at least 75 percent of nesting activity in U.S. Virgin Islands, Puerto Rico, and Florida is in public ownership; and
3. All priority one tasks identified in the recovery plan have been successfully implemented.

Status and Distribution – Kemp's Ridley Sea Turtle

Nesting aggregations of Kemp's ridleys at Rancho Nuevo were discovered in 1947, and the adult female population was estimated to be 40,000 or more individuals based on a film by Andres Herrera (Hildebrand 1963; Carr 1963). Within approximately 3 decades, the population had declined to 924 nests and reached the lowest recorded nest count of 702 nests in 1985. Since the mid-1980s, the number of nests observed at Rancho Nuevo and nearby beaches has increased 15 percent per year (Heppell et al. 2005), allowing cautious optimism that the population is on its way to recovery. This increase in nesting can be attributed to full protection of nesting females and their nests in Mexico resulting from a bi-national effort between Mexico and the U.S. to prevent the extinction of the Kemp's ridley, the requirement to use Turtle Excluder Devices (TEDs) in shrimp trawls both in the U.S. and Mexico, and decreased shrimping effort (NMFS et al. 2011; Heppell et al. 2005).

Recovery Criteria (only the Demographic Recovery Criteria are presented below; for the Listing Factor Recovery Criteria, see NMFS et al. 2011)

The recovery goal is to conserve and protect the Kemp's ridley sea turtle so that protections under the Act are no longer necessary and the species can be removed from the List of Endangered and Threatened Wildlife. Biological recovery criteria form the basis from which to gauge whether the species should be reclassified to threatened (i.e., downlisted) or delisted, whereas the listing factor criteria ensure that the threats affecting the species are controlled or eliminated.

Downlisting Criteria

1. A population of at least 10,000 nesting females in a season (as estimated by clutch frequency per female per season) distributed at the primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) in Mexico is attained. Methodology and capacity to implement and ensure accurate nesting female counts have been developed.

2. Recruitment of at least 300,000 hatchlings to the marine environment per season at the three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) in Mexico is attained to ensure a minimum level of known production through *in situ* incubation, incubation in corrals, or a combination of both.

Delisting Criteria

1. An average population of at least 40,000 nesting females per season (as measured by clutch frequency per female per season and annual nest counts) over a 6-year period distributed among nesting beaches in Mexico and the U.S. is attained. Methodology and capacity to ensure accurate nesting female counts have been developed and implemented.

2. Ensure average annual recruitment of hatchlings over a 6-year period from *in situ* nests and beach corrals is sufficient to maintain a population of at least 40,000 nesting females per nesting season distributed among nesting beaches in Mexico and the U.S into the future. This criterion may rely on massive synchronous nesting events (i.e., arribadas) that will swamp predators as well as rely on supplemental protection in corrals and facilities.

5) Analysis of the Species/Critical Habitat Likely to be Affected

The loggerhead sea turtle, the green sea turtle, the leatherback sea turtle, and the Kemp's ridley sea turtle are currently listed because of their reduced population sizes caused by overharvest and habitat loss with continuing anthropogenic threats from commercial fishing, disease, and degradation of remaining habitat.

Barrier islands and inlets are complex and dynamic coastal systems that are continually responding to sediment supply, waves, and fluctuations in sea level. The location and shape of the beaches of barrier islands perpetually adjusts to these physical forces. Waves that strike a barrier island at an angle, for instance, generate a longshore current that carries sediment along the shoreline. Cross-shore currents carry sediment perpendicular to the shoreline. Wind moves sediment across the dry beach, dunes and island interior. During storm events, overwash may breach the island at dune gaps or other weak spots, depositing sediments on the interior and back sides of islands, increasing island elevation and accreting the soundside shoreline.

Tidal inlets play a vital role in the dynamics and processes of barrier islands. Sediment is transferred across inlets from island to island via the tidal shoals or deltas. The longshore sediment transport often causes barrier spits to accrete, shifting inlets towards the neighboring island. Flood tidal shoals that are left behind by the migrating inlet are typically incorporated into the soundside shoreline and marshes of the island, widening it considerably. Many inlets have a cycle of inlet migration, breaching of the barrier spit during a storm, and closure of the old inlet with the new breach becoming the new inlet. Barrier spits tend to be low in elevation, sparse in vegetation, and repeatedly submerged by high and storm tides.

The Service and the NMFS share Federal jurisdiction for sea turtles under the Act. The Service has responsibility for sea turtles on the nesting beach. NMFS has jurisdiction for sea turtles in the marine environment. In accordance with the Act, the Service completes consultations with all Federal agencies for actions that may adversely affect sea turtles on the nesting beach. The Service's analysis only addresses activities that may impact nesting sea turtles, their nests and eggs, and hatchlings as they emerge from the nest and crawl to the sea. NMFS assesses and consults with Federal agencies concerning potential impacts to sea turtles in the marine environment, including updrift and downdrift nearshore areas affected by sand placement projects on the beach.

The proposed action has the potential to adversely affect nesting females, nests, and hatchlings on the beach within the proposed Action Area. Potential effects include destruction of nests deposited within the boundaries of the proposed project, harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities, disorientation of hatchling turtles on beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of project lighting or presence of the groin, and behavior modification of nesting females during the nesting season resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs due to escarpment formation or presence of the groin within the Action Area. The quality of the placed sand could affect the ability of female turtles to nest, the suitability of the nest incubation environment, and the ability of hatchlings to emerge from the nest. The presence of the groin could affect the movement of sand by altering the natural coastal processes and could affect the ability of female turtles to nest, the suitability of the nest incubation environment, and the ability of hatchlings to emerge from the nest and crawl to the ocean.

Some individuals in a population are more “valuable” than others in terms of the number of offspring they are expected to produce. An individual’s potential for contributing offspring to future generations is its reproductive value. Because of delayed sexual maturity, reproductive longevity, and low survivorship in early life stages, nesting females are of high value to a population. The loss of a nesting female in a small recovery unit would represent a significant loss to the recovery unit. The reproductive value for a nesting female has been estimated to be approximately 253 times greater than an egg or a hatchling (NMFS and Service 2008). However, the construction of a groin and sand placement action includes avoidance and minimization measures that reduce the possibility of mortality of a nesting female on the beach as a result of the project. Therefore, we do not anticipate the loss of any nesting females on the beach as a result of the project.

With regard to indirect loss of eggs and hatchlings, on most beaches, nesting success typically declines for the first year or two following sand placement, even though more nesting habitat is available for turtles (Trindell et al. 1998; Ernest and Martin 1999; Herren 1999). Reduced nesting success on constructed beaches has been attributed to increased sand compaction, escarpment formation, and changes in beach profile (Nelson et al. 1987; Crain et al. 1995; Lutcavage et al. 1997; Steinitz et al. 1998; Ernest and Martin 1999; Rumbold et al. 2001). In addition, even though constructed beaches are wider, nests deposited there may experience higher rates of wash out than those on relatively narrow, steeply sloped beaches (Ernest and

Martin 1999). This occurs because nests on constructed beaches are more broadly distributed than those on natural beaches, where they tend to be clustered near the base of the dune. Nests laid closest to the waterline on constructed beaches may be lost during the first year or two following construction as the beach undergoes an equilibration process during which seaward portions of the beach are lost to erosion. As a result, the project may be anticipated to result in decreased nesting and loss of nests that are laid within the Action Area for two subsequent nesting seasons following the completion of the proposed sand placement. However, it is unknown whether nests that would have been laid in an Action Area during the two subsequent nesting seasons had the project not occurred are actually lost from the population, or if nesting is simply displaced to adjacent beaches. Regardless, eggs and hatchlings have a low reproductive value; each egg or hatchling has been estimated to have only 0.004 percent of the value of a nesting female (NMFS and Service 2008). Thus, even if the majority of the eggs and hatchlings that would have been produced on the project beach are not realized for up to 2 years following project completion, the Service would not expect this loss to have a significant effect on the recovery and survival of the species, for the following reasons: 1) some nesting is likely just displaced to adjacent non-project beaches, 2) not all eggs will produce hatchlings, and 3) destruction and/or failure of nests will not always result from a sand placement project. A variety of natural and unknown factors negatively affect incubating egg clutches, including tidal inundation, storm events, and predation.

During project construction, direct mortality of the developing embryos in nests within the Action Area may occur for nests that are missed and not relocated or marked for avoidance. The exact number of these missed nests is not known. However, in two separate monitoring programs on the east coast of Florida where hand digging was performed to confirm the presence of nests and thus reduce the chance of missing nests through misinterpretation, trained observers still missed about 6 to 8 percent of the nests because of natural elements (Martin 1992; Ernest and Martin 1993). This must be considered a conservative number, because missed nests are not always accounted for. In another study, Schroeder (1994) found that even under the best of conditions, about 7 percent of nests can be misidentified as false crawls by highly experienced sea turtle nest surveyors. Missed nests are usually identified by signs of hatchling emergences or egg or hatchling predation in areas where no nest was previously documented. Signs of hatchling emergence are very easily obliterated by the same elements that interfere with detection of nests. Regardless, eggs and hatchlings have a low reproductive value; each egg or hatchling has been estimated to have only 0.004 percent of the value of a nesting female (NMFS and Service 2008). Thus, even if, for example, the number of missed nests approaches twice the rate mentioned above, the Service would not expect this loss to have a significant effect on the recovery and survival of the species, for the following reasons: 1) not all eggs in all unmarked nests will produce hatchlings, and 2) destruction and/or failure of a missed nest will not always result from a construction project. A variety of natural and unknown factors negatively affect incubating egg clutches, including tidal inundation, storm events, predation, accretion of sand, and erosional processes. The loss of all life stages of sea turtles including eggs are considered "take" and minimization measures are required to avoid and minimize all life stages. During project construction, predators of eggs and nestlings may be attracted to the Action Area due to food waste from the construction crew.

The presence of the groin may create a physical obstacle to nesting sea turtles. The impact of nesting females interacting with the groin in the marine environment will be analyzed by NMFS in their consultation. As a result, the groin is anticipated to result in decreased nesting and loss of nests that do get laid within the Action Area for all subsequent nesting seasons following the completion of the proposed project. However, it is unknown whether nests that would have been laid in the Action Area had the project not occurred are actually lost from the population, or if nesting is simply displaced to adjacent beaches. Regardless, eggs and hatchlings have a low reproductive value; each egg or hatchling has been estimated to have only 0.004 percent of the value of a nesting female (NMFS and Service 2008). The Service would not expect this loss to have a significant effect on the recovery and survival of the species, for the following reasons: 1) some nesting is likely just displaced to adjacent non-project beaches, 2) not all eggs will produce hatchlings, and 3) destruction and/or failure of nests will not always result from the construction project. A variety of natural and unknown factors negatively affect incubating egg clutches, including tidal inundation, storm events, and predation.

The DEIS states that the terminal groin was designed to include large voids between the stones to facilitate sediment movement though the structures. The interaction between the groin and the hydrodynamics of tide and current often results in the alteration of the beach profile seaward and in the immediate vicinity of the structure (Pilkey and Wright 1988; Terchunian 1988; Tait and Griggs 1990; Plant and Griggs 1992); including increased erosion seaward of structures, increased longshore currents that move sand away from the area, loss of interaction between the dune and ocean, and concentration of wave energy at the ends of an armoring structure (Schroeder and Mosier 1996). These changes or combination of changes can have various detrimental effects on sea turtles and their nesting habitat.

B. Environmental Baseline

1) Status of Sea Turtle Species within the Action Area

The loggerhead sea turtle nesting and hatching season for North Carolina beaches extends from May 1 through November 15. Incubation ranges from about 45 to 95 days. See **Table 2** for data on observed loggerhead sea turtle nests on Ocean Isle and Holden Beach. Data was provided in the January 2015 BA unless otherwise noted.

Table 2. Number of loggerhead nests observed between 1980 and 2012 on Ocean Isle and Holden Beach.

Year	**Number of Loggerhead Nests**	
	Ocean Isle Beach	Holden Beach
2009	25	23
2010	23	30
2011	22	30
2012	24	46
2013	36*	73*
2014	4*	19*

*data from www.seaturtle.org, accessed on July 17, 2015

Critical Habitat Unit LOGG-T-NC-08

For the Northern Recovery Unit, the Service designated 393.7 km (244.7 miles) of Atlantic Ocean shoreline in North Carolina, South Carolina, and Georgia, encompassing approximately 86 percent of the documented nesting (numbers of nests) within the recovery unit.

This critical habitat unit is one of 38 designated critical habitat units for the Northern Recovery Unit of the Northwest Atlantic DPS. In North Carolina, 96.1 shoreline miles (154.6 km) of critical habitat for nesting loggerhead sea turtles was designated. Some of this acreage has been affected recently by activities such as beach nourishment, sandbag revetment construction, and groin construction. However, with the exception of beach nourishment activities and recreational activities, most of the critical habitat units in North Carolina remain relatively unaffected by development.

The green sea turtle nesting and hatching season North Carolina beaches extends from May 15 through November 15. Incubation ranges from about 45 to 75 days. One green sea turtle nest was reported on Holden Beach in both 2010 and 2013 (data from NCWRC).

The leatherback sea turtle nesting and hatching season on North Carolina beaches extends from April 15 through November 15. Incubation ranges from about 55 to 75 days. There was one leatherback nest reported on Holden Beach in 2010.

The Kemp's ridley sea turtle nesting and hatchling season on North Carolina beaches appears to be similar to other species. Incubation ranges from 45 to 58 days. One Kemp's ridley nest was observed on Ocean Isle Beach in 2010.

2) Factors Affecting the Species Environment within the Action Area

A number of recent and on-going beach disturbance activities have altered the proposed Action Area and, to a greater extent, the North Carolina coastline, and many more are proposed along the coastline for the near future. **Table 3** lists the most recent projects, within the past 5 years.

Table 3. Actions that have occurred in the Action Area in the last five years.

Year	Species Impacted	Project Type	Anticipated Take
Regularly, most recently in 2014 and 2010.	Loggerhead, green, leatherback, and Kemp's ridley sea turtle, piping plover, red knot, seabeach amaranth	Ocean Isle Beach Coastal Storm Damage Reduction (CSDR) Project. Dredging of AIWW Inlet crossing and Shallotte Inlet, and associated beach nourishment	Up to 17,100 lf of beach shoreline and an unknown amount of inlet habitats
2014	Loggerhead, green, leatherback, and Kemp's ridley sea turtle, piping plover, red knot, seabeach amaranth	Beach bulldozing	Approximately 1,200 lf of beach shoreline
Various Years, beginning in approximately 2005	Loggerhead, green, Kemp's ridley, and leatherback sea turtle, piping plover, red knot, seabeach amaranth	Sandbag placement in front of several properties.	Approximately 1,400 lf of beach shoreline.

Nourishment activities widen beaches, change their sedimentology and stratigraphy, alter coastal processes and often plug dune gaps and remove overwash areas.

Inlet dredging activities alter the sediment dynamics on adjacent shorelines and stabilize these dynamic environments; beach disposal of dredge material further alters the natural habitat adjacent to inlets. Estuarine dredging of navigational channels can alter water circulation patterns and sediment transport pathways, as well as increase the frequency and magnitude of boat wakes; sound-side sand or mud flats may be impacted by increased erosion rates as a result. The Corps has regularly dredged Shallotte Inlet every few years since 2001 as part of the Ocean Isle Coastal Storm Damage Reduction (CSDR), and the sediment has been disposed on Ocean Isle.

Beach scraping or bulldozing can artificially steepen beaches, stabilize dune scarps, plug dune gaps, and redistribute sediment distribution patterns. Artificial dune building, often a product of beach scraping, removes low-lying overwash areas and dune gaps. As chronic erosion catches up to structures throughout the Action Area, artificial dune systems are constructed and maintained to protect beachfront structures either by sand fencing or fill placement. Beach scraping or bulldozing has been frequent on North Carolina beaches in recent years, in response to storms and the continuing retreat of the shoreline with rising sea level. These activities primarily occur during the winter months. Artificial dune or berm systems have been constructed and maintained in several areas. These dunes make the artificial dune ridge function like a seawall that blocks natural beach retreat, evolution, and overwash.

Sandbags and revetments are vertical structures built parallel to the beach in front of buildings, roads, and other facilities to protect them from erosion. However, these structures often accelerate erosion by causing scouring in front of and downdrift from the structure (Hayes and Michel 2008), which can eliminate sea turtle nesting habitat. Geotubes (long cylindrical bags made of high-strength permeable fabric and filled with sand) and sandbag revetments are softer alternatives, but act as barriers by preventing overwash. There are two existing rock revetments along the coast of North Carolina: one at Fort Fisher (approximately 3,040 lf), and another along Carolina Beach (approximately 2,050 lf). Sandbags and sandbag revetments have been placed along at least 1,400 lf of the Action Area on Ocean Isle Beach. A sandbag revetment at least 1,500 lf long was constructed in 2015 at the north end of North Topsail Beach.

Threats to Sea Turtles

Coastal Development

Loss of sea turtle nesting habitat related to coastal development has had the greatest impact on nesting sea turtles. Beachfront development not only causes the loss of suitable nesting habitat, but can result in the disruption of powerful coastal processes accelerating erosion and interrupting the natural shoreline migration (National Research Council 1990b). This may in turn cause the need to protect upland structures and infrastructure by armoring, groin placement, beach emergency berm construction and repair, and beach nourishment, all of which cause changes in, additional loss of, or impact to the remaining sea turtle habitat.

Hurricanes and Storms

Hurricanes and other large storms were probably responsible for maintaining coastal beach habitat upon which sea turtles depend through repeated cycles of destruction, alteration, and recovery of beach and dune habitat. Hurricanes and large storms generally produce damaging winds, storm tides and surges, and rain, which can result in severe erosion of the beach and dune systems. Overwash and blowouts are common on barrier islands.

Hurricanes and other storms can result in the direct loss of sea turtle nests, either by erosion or washing away of the nests by wave action and inundation or "drowning" of the eggs or pre-emergent hatchlings within the nest, or indirectly by causing the loss of nesting habitat. Depending on their frequency, storms can affect sea turtles on either a short-term basis (nests lost for one season and/or temporary loss of nesting habitat) or long term, if frequent (habitat unable to recover). The manner in which hurricanes affect sea turtle nesting also depends on their characteristics (winds, storm surge, rainfall), the time of year (within or outside of the nesting season), and where the northeast edge of the hurricane crosses land.

Because of the limited remaining nesting habitat in a natural state with no immediate development landward of the sandy beach, frequent or successive severe weather events could threaten the ability of certain sea turtle populations to survive and recover. Sea turtles evolved under natural coastal environmental events such as hurricanes. The extensive amount of predevelopment coastal beach and dune habitat allowed sea turtles to survive even the most severe hurricane events. It is only within the last 20 to 30 years that the combination of habitat loss to beachfront development and destruction of remaining habitat by hurricanes has increased the threat to sea turtle survival and recovery. On developed beaches, typically little space remains for sandy beaches to become reestablished after periodic storms. While the beach itself moves landward during such storms, reconstruction or persistence of structures at their pre-storm locations can result in a loss of nesting habitat.

Erosion

A critically eroded area is a segment of shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost. It is important to note that for an erosion problem area to be critical there must be an existing threat to or loss of one of four specific interests – upland development, recreation, wildlife habitat, or important cultural resources.

Beachfront Lighting

Artificial lights along a beach can deter females from coming ashore to nest or misdirect females trying to return to the surf after a nesting event. A significant reduction in sea turtle nesting activity has been documented on beaches illuminated with artificial lights (Witherington 1992). Artificial beachfront lighting may also cause disorientation (loss of bearings) and misorientation (incorrect orientation) of sea turtle hatchlings (Philibosian 1976; Mann 1977; Witherington and Martin 1996). Visual signs are the primary sea-finding mechanism for hatchlings (Mrosovsky and Carr 1967; Mrosovsky and Shettleworth 1968; Dickerson and Nelson 1989; Witherington and Bjorndal 1991) . The emergence from the nest and crawl to the sea is one of the most critical periods of a sea turtle's life. Hatchlings that do not make it to the sea quickly become food for ghost crabs, birds, and other predators, or become dehydrated and may never reach the sea. In addition, research has documented significant reduction in sea turtle nesting activity on beaches illuminated with artificial lights (Witherington 1992). During the 2010 sea turtle nesting season in Florida, over 47,000 turtle hatchlings were documented as being disoriented (FWC/FWRI 2011).

Predation

Predation of sea turtle eggs and hatchlings by native and introduced species occurs on almost all nesting beaches. Predation by a variety of predators can considerably decrease sea turtle nest hatching success. The most common predators in the southeastern U.S. are ghost crabs (*Ocypode quadrata*), raccoons (*Procyon lotor*), feral hogs (*Sus scrofa*), foxes (*Urocyon cinereoargenteus* and *Vulpes vulpes*), coyotes (*Canis latrans*), armadillos (*Dasypus novemcinctus*), and fire ants (*Solenopsis invicta*) (Dodd 1988; Stancyk 1995). In the absence of nest protection programs in a number of locations throughout the southeast U.S., raccoons may depredate up to 96 percent of all nests deposited on a beach (Davis and Whiting 1977; Hopkins and Murphy 1980; Stancyk et al. 1980; Talbert et al. 1980; Schroeder 1981; Labisky et al. 1986).

Beach Driving

The operation of motor vehicles on the beach affects sea turtle nesting by interrupting or striking a female turtle on the beach, headlights disorienting or misorienting emergent hatchlings, vehicles running over hatchlings attempting to reach the ocean, and vehicle tracks traversing the beach that interfere with hatchlings crawling to the ocean. Hatchlings appear to become diverted not because they cannot physically climb out of the rut (Hughes and Caine 1994), but because the sides of the track cast a shadow and the hatchlings lose their line of sight to the ocean horizon (Mann 1977). The extended period of travel required to negotiate tire tracks and ruts may increase the susceptibility of hatchlings to dehydration and depredation during migration to the ocean (Hosier et al. 1981). Driving on the beach can cause sand compaction which may result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings, decreasing nest success and directly killing pre-emergent hatchlings (Mann 1977; Nelson and Dickerson 1987; Nelson 1988).

The physical changes and loss of plant cover caused by vehicles on dunes can lead to various degrees of instability, and therefore encourage dune migration. As vehicles move either up or down a slope, sand is displaced downward, lowering the trail. Since the vehicles also inhibit plant growth, and open the area to wind erosion, dunes may become unstable, and begin to migrate. Unvegetated sand dunes may continue to migrate across stable areas as long as vehicle traffic continues. Vehicular traffic through dune breaches or low dunes on an eroding beach may cause an accelerated rate of overwash and beach erosion (Godfrey et al. 1978). If driving is required, the area where the least amount of impact occurs is the beach between the low and high tide water lines. Vegetation on the dunes can quickly reestablish provided the mechanical impact is removed.

Climate Change

The varying and dynamic elements of climate science are inherently long term, complex, and interrelated. Regardless of the underlying causes of climate change, glacial melting and expansion of warming oceans are causing sea level rise, although its extent or rate cannot as yet be predicted with certainty. At present, the science is not exact enough to precisely predict when and where climate impacts will occur. Although we may know the direction of change, it may not be possible to predict its precise timing or magnitude. These impacts may take place gradually or episodically in major leaps.

Climate change is evident from observations of increases in average global air and ocean temperatures, widespread melting of snow and ice, and rising sea level, according to the Intergovernmental Panel on Climate Change Report (IPCC 2007a). The IPCC Report (2007a) describes changes in natural ecosystems with potential widespread effects on many organisms, including marine mammals and migratory birds. The potential for rapid climate change poses a significant challenge for fish and wildlife conservation. Species' abundance and distribution are dynamic, relative to a variety of factors, including climate. As climate changes, the abundance and distribution of fish and wildlife will also change. Highly specialized or endemic species are likely to be most susceptible to the stresses of changing climate. Based on these findings and other similar studies, the U.S. Department of the Interior (DOI) requires agencies under its direction to consider potential climate change effects as part of their long-range planning activities (USFWS 2007).

In the southeastern U.S., climatic change could amplify current land management challenges involving habitat fragmentation, urbanization, invasive species, disease, parasites, and water management. Global warming will be a particular challenge for endangered, threatened, and other "at risk" species. It is difficult to estimate, with any degree of precision, which species will be affected by climate change or exactly how they will be affected. The Service will use Strategic Habitat Conservation planning, an adaptive science-driven process that begins with explicit trust resource population objectives, as the framework for adjusting our management strategies in response to climate change (USFWS 2006). As the level of information increases relative to the effects of global climate change on sea turtles and its designated critical habitat, the Service will have a better basis to address the nature and magnitude of this potential threat and will more effectively evaluate these effects to the range-wide status of sea turtles.

Temperatures are predicted to rise from 1.6°F to 9°F for North America by the end of this century (IPCC 2007a, b). Alterations of thermal sand characteristics could result in highly female-biased sex ratios because sea turtles exhibit temperature dependent sex determination (e.g., Glen and Mrosovsky 2004; Hawkes et al. 2008).

Along developed coastlines, and especially in areas where shoreline protection structures have been constructed to limit shoreline movement, rising sea levels will cause severe effects on nesting females and their eggs. Erosion control structures can result in the permanent loss of dry nesting beach or deter nesting females from reaching suitable nesting sites (National Research Council 1990a). Nesting females may deposit eggs seaward of the erosion control structures potentially subjecting them to repeated tidal inundation or washout by waves and tidal action.

Based on the present level of available information concerning the effects of global climate change on the status of sea turtles and their designated critical habitat, the Service acknowledges the potential for changes to occur in the Action Area, but presently has no basis to evaluate if or how these changes are affecting sea turtles or their designated critical habitat. Nor does our present knowledge allow the Service to project what the future effects from global climate change may be or the magnitude of these potential effects.

Recreational Beach Use

Human presence on or adjacent to the beach at night during the nesting season, particularly recreational activities, can reduce the quality of nesting habitat by deterring or disturbing and causing nesting turtles to avoid otherwise suitable habitat. In addition, human foot traffic can make a beach less suitable for nesting and hatchling emergence by increasing sand compaction and creating obstacles to hatchlings attempting to reach the ocean (Hosier et al. 1981).

The use and storage of lounge chairs, cabanas, umbrellas, catamarans, and other types of recreational equipment on the beach at night can also make otherwise suitable nesting habitat unsuitable by hampering or deterring nesting by adult females and trapping or impeding hatchlings during their nest to sea migration. The documentation of non-nesting emergences (also referred to as false crawls) at these obstacles is becoming increasingly common as more recreational beach equipment is left on the beach at night. Sobel (2002) describes nesting turtles being deterred by wooden lounge chairs that prevented access to the upper beach.

Sand Placement

Sand placement projects may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand (Nelson and Dickerson 1988a). These changes could result in adverse impacts on sea turtle nest site selection, digging behavior, clutch viability, and hatchling emergence (Nelson and Dickerson 1987; Nelson 1988).

Beach nourishment projects create an elevated, wider, and unnatural flat slope berm. Sea turtles nest closer to the water the first few years after nourishment because of the altered profile (and perhaps unnatural sediment grain size distribution) (Ernest and Martin 1999; Trindell 2005)

Beach compaction and unnatural beach profiles resulting from beach nourishment activities could negatively impact sea turtles regardless of the timing of projects. Sand compaction may increase the length of time required for female sea turtles to excavate nests and cause increased physiological stress to the animals (Nelson and Dickerson 1988b). These impacts can be minimized by using suitable sand.

A change in sediment color on a beach could change the natural incubation temperatures of sea turtle nests in an area, which, in turn, could alter natural sex ratios. To provide the most suitable sediment for nesting sea turtles, the color of the nourished sediments should resemble the natural beach sand in the area. Natural reworking of sediments and bleaching from exposure to the sun would help to lighten dark nourishment sediments; however, the timeframe for sediment mixing and bleaching to occur could be critical to a successful sea turtle nesting season.

In-water and Shoreline Alterations

Many navigable mainland or barrier island tidal inlets along the Atlantic and Gulf of Mexico coasts are stabilized with jetties or groins. Jetties are built perpendicular to the shoreline and extend through the entire nearshore zone and past the breaker zone to prevent or decrease sand deposition in the channel (Kaufman and Pilkey 1979). Groins are also shore-perpendicular structures that are designed to trap sand that would otherwise be transported by longshore currents and can cause downdrift erosion (Kaufman and Pilkey 1979).

These in-water structures have profound effects on adjacent beaches (Kaufman and Pilkey 1979). Jetties and groins placed to stabilize a beach or inlet prevent normal sand transport, resulting in accretion of sand on updrift beaches and acceleration of beach erosion downdrift of the structures (Komar 1983; Pilkey et al. 1984). Witherington et al. (2005) found a significant negative relationship between loggerhead nesting density and distance from the nearest of 17 ocean inlets on the Atlantic coast of Florida. The effect of inlets in lowering nesting density was observed both updrift and downdrift of the inlets, leading researchers to propose that beach instability from both erosion and accretion may discourage sea turtle nesting.

Following construction, the presence of groins and jetties may interfere with nesting turtle access to the beach, result in a change in beach profile and width (downdrift erosion, loss of sandy berms, and escarpment formation), trap hatchlings, and concentrate predatory fishes, resulting in higher probabilities of hatchling predation. In addition to decreasing nesting habitat suitability, construction or repair of groins and jetties during the nesting season may result in the destruction of nests, disturbance of females attempting to nest, and disorientation of emerging hatchlings from project lighting.

Threats to loggerhead sea turtle terrestrial habitat

Recreational beach use: beach cleaning, human presence (e.g., dog beach, special events, piers, and recreational beach equipment);

Beach driving: essential and nonessential off-road vehicles, all-terrain vehicles, and recreational access and use;

Predation: depredation of eggs and hatchlings by native and nonnative predators;

Beach sand placement activities: beach nourishment, beach restoration, inlet sand bypassing, dredge material disposal, dune construction, emergency sand placement after natural disaster, berm construction, and dune and berm planting;

In-water and shoreline alterations: artificial in-water and shoreline stabilization measures (e.g., in-water erosion control structures, such as groins, breakwaters, jetties), inlet relocation, inlet dredging, nearshore dredging, and dredging and deepening channels;

Coastal development: residential and commercial development and associated activities including beach armoring (e.g., sea walls, geotextile tubes, rock revetments, sandbags, emergency temporary armoring); and activities associated with construction, repair, and maintenance of upland structures, stormwater outfalls, and piers;

Artificial lighting: direct and indirect lighting, skyglow, and bonfires;

Beach erosion: erosion due to aperiodic, short-term weather-related erosion events, such as atmospheric fronts, northeasters, tropical storms, and hurricanes;

Climate change: includes sea level rise;

Habitat obstructions: tree stumps, fallen trees, and other debris on the beach; nearshore sand bars; and ponding along beachfront seaward of dry beach;

Human-caused disasters and response to natural and human-caused disasters: oil spills, oil spill response including beach cleaning and berm construction, and debris cleanup after natural disasters;

Military testing and training activities: troop presence, pyrotechnics and nighttime lighting, vehicles and amphibious watercraft usage on the beach, helicopter drops and extractions, live fire exercises, and placement and removal of objects on the beach.

C. Effects of the Action

1) Factors to be Considered

Proximity of action: Construction of the groin and sand placement activities would occur within and adjacent to nesting habitat for sea turtles and dune habitats that ensure the stability and integrity of the nesting beach. Specifically, the project would potentially impact loggerhead, green, leatherback, and Kemp's ridley nesting females, their nests, and hatchling sea turtles.

Distribution: Construction and presence of the groin and sand placement activities may impact nesting and hatchling sea turtles and sea turtle nests occurring along Ocean Isle Beach and Holden Beach adjacent to the Atlantic Ocean and Shallotte Inlet. The Service expects the proposed construction activities could directly and indirectly affect the availability of habitat for nesting and hatchling sea turtles.

Timing: The timing of the sand placement activities and construction of the groin could directly and indirectly impact nesting females, their nests, and hatchling sea turtles when conducted between May 1 and November 15. The presence of the groin and future sand placement activities could directly and indirectly impact nesting females, their nests, and hatchling sea turtles for each subsequent nesting season within the Action Area.

Nature of the effect: The effects of the construction and presence of the groin and sand placement activities may change the nesting behavior of adult female sea turtles, diminish nesting success, and cause reduced hatching and emerging success. Sand placement can also change the incubation conditions within the nest. Any decrease in productivity and/or survival rates would contribute to the vulnerability of the sea turtles nesting in the southeastern United States.

The Service expects the action will result in direct and indirect, long-term effects to sea turtles, including the Northwest Atlantic DPS of the loggerhead sea turtle. Due to downdrift erosion, there may be loss or degradation of loggerhead terrestrial Critical Habitat Unit LOGG-T-NC-08. The Service expects there may be morphological changes to adjacent nesting habitat. Activities that affect or alter the use of optimal habitat or increase disturbance to the species may decrease the survival and recovery potential of the loggerhead and other sea turtles.

Duration: The construction of the groin is to be a one-time activity and may take 4 ½ months to complete. The sand placement activity is likely to be a multiple-year activity, and each sand placement project may take 10 weeks to complete. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact nesting and hatchling sea turtles and sea turtle nests in subsequent nesting seasons. In addition, the placement of the groin represents a long-term impact since the groin could be in place for many years.

Disturbance frequency: Sea turtle populations in the southeastern United States may experience decreased nesting success, hatching success, and hatchling emerging success that could result from the construction and sand placement activities being conducted during one nesting season, or during the earlier or later parts of one or two nesting seasons.

The frequency of maintenance dredging activities varies greatly, and can be as often as annually or semiannually, depending on the rate of shoaling and funding availability. Sand placement activities as a result of shore protection activities typically occur once every 3 to 5 years. For this project, sand placement is anticipated every 5 years. Dredging and sand placement typically occurs during the winter work window, but can occur at any time during the year based on availability of funding and of dredges to conduct the work. The disturbance frequency related to groin and jetty repair and replacement varies greatly based on the original construction methodology, the construction materials, and the conditions under which the structure is placed.

Disturbance intensity and severity: Depending on the timing of the construction and sand placement activities during the sea turtle nesting season, effects to the sea turtle populations in the southeastern United States could be important. The placement of the groin represents a long-term impact within the Action Area since the groin could be in place for many years.

2) Analyses for Effects of the Action

The Action Area encompasses 24,500 lf of shoreline on the Atlantic coast of North Carolina.

Beneficial Effects: Groins constructed in appropriate high erosion areas, or to offset the effects of shoreline armoring, may reestablish a beach where none currently exists, stabilize the beach in rapidly eroding areas and reduce the potential for escarpment formation, reduce destruction of nests from erosion, and reduce the need for future sand placement events by extending the interval between sand placement events. However, caution should be exercised to avoid automatically assuming the reestablishment of a beach will wholly benefit sea turtle populations without determining the extent of the groin effect on nesting and hatchling sea turtle behavior.

The placement of sand on a beach with reduced dry foredune habitat may increase sea turtle nesting habitat if the placed sand is highly compatible (i.e., grain size, shape, color, etc.) with naturally occurring beach sediments in the area, and compaction and escarpment remediation measures are incorporated into the project. In addition, a nourished beach that is designed and constructed to mimic a natural beach system may benefit sea turtles more than an eroding beach it replaces.

Direct Effects: Potential adverse effects during the project construction include disturbance of existing nests, which may have been missed by surveyors and thus not marked for avoidance, disturbance of females attempting to nest, and disorientation of emerging hatchlings. In addition, heavy equipment will be required to re-distribute the sand to the original natural beach template and to construct the groin. This equipment will have to traverse the beach portion of the Action Area, which could result in harm to nesting sea turtles, their nests, and emerging hatchlings. In addition, for groin construction, a trench will be excavated on the beach and may be present during the night for some portion of construction, creating a potential threat to nesting females and emerging hatchlings.

Following construction, the presence of the groin has the potential to adversely affect sea turtles. For instance, they may interfere with the egress and ingress of adult females at nesting sites; alter downdrift beach profiles through erosion, escarpment formation, and loss of berms; trap or obstruct hatchlings during a critical life-history stage; increase hatchling and adult female energy expenditure in attempts to overcome the structures; and attract additional predatory fish or concentrate existing predatory fish, thereby increasing the potential of hatchling predation.

Placement of sand on a beach in and of itself may not provide suitable nesting habitat for sea turtles. Although sand placement activities may increase the potential nesting area, significant negative impacts to sea turtles may result if protective measures are not incorporated during project construction. Sand placement activities during the nesting season can cause increased loss of eggs and hatchlings and, along with other mortality sources, may significantly impact the long-term survival of the species. For instance, projects conducted during the nesting and hatching season could result in the loss of sea turtles through disruption of adult nesting activity and by burial or crushing of nests or hatchlings. While a nest monitoring and egg relocation program would reduce these impacts, nests may be inadvertently missed (when crawls are obscured by rainfall, wind, or tides) or misidentified as false crawls during daily patrols. In addition, nests may be destroyed by operations at night prior to beach patrols being performed. Even under the best of conditions, about 7 percent of the nests can be misidentified as false crawls by experienced sea turtle nest surveyors (Schroeder 1994).

a. *Equipment during construction*

The use of heavy machinery on beaches during a construction project may also have adverse effects on sea turtles. Equipment left on the nesting beach overnight can create barriers to nesting females emerging from the surf and crawling up the beach, causing a higher incidence of false crawls and unnecessary energy expenditure.

The operation of motor vehicles or equipment on the beach to complete the project work at night affects sea turtle nesting by: interrupting or colliding with a nesting turtle on the beach, headlights disorienting or misorienting emergent hatchlings, vehicles running over hatchlings attempting to reach the ocean, and vehicle ruts on the beach interfering with hatchlings crawling to the ocean. Apparently, hatchlings become diverted not because they cannot physically climb out of a rut (Hughes and Caine 1994), but because the sides of the track cast a shadow and the hatchlings lose their line of sight to the ocean horizon (Mann 1977). The extended period of travel required to negotiate tire ruts may increase the susceptibility of hatchlings to dehydration and depredation during migration to the ocean (Hosier et al. 1981). Driving directly above or over incubating egg clutches or on the beach can cause sand compaction, which may result in adverse impacts on nest site selection, digging behavior, clutch viability, and emergence by hatchlings, as well as directly kill pre-emergent hatchlings (Mann 1977; Nelson and Dickerson 1987; Nelson 1988).

The physical changes and loss of plant cover caused by vehicles on vegetated areas or dunes can lead to various degrees of instability and cause dune migration. As vehicles move over the sand, sand is displaced downward, lowering the substrate. Since the vehicles also inhibit plant growth, and open the area to wind erosion, the beach and dunes may become unstable. Vehicular traffic on the beach or through dune breaches or low dunes may cause acceleration of overwash and erosion (Godfrey et al. 1978). Driving along the beachfront should be between the low and high tide water lines. To minimize the impacts to the beach, dunes, and dune vegetation, transport and access to the construction sites should be from the road to the maximum extent possible. However, if vehicular access to the beach is necessary, the areas for vehicle and equipment usage should be designated and marked.

b. *Artificial lighting as a result of an unnatural beach slope on the adjacent beach*

Visual cues are the primary sea-finding mechanism for hatchling sea turtles (Mrosovsky and Carr 1967; Mrosovsky and Shettleworth 1968; Dickerson and Nelson 1989; Witherington and Bjorndal 1991). When artificial lighting is present on or near the beach, it can misdirect hatchlings once they emerge from their nests and prevent them from reaching the ocean (Philibosian 1976; Mann 1977; FWC 2007). In addition, a significant reduction in sea turtle nesting activity has been documented on beaches illuminated with artificial lights (Witherington 1992). Therefore, construction lights along a project beach and on the dredging vessel may deter females from coming ashore to nest, misdirect females trying to return to the surf after a nesting event, and misdirect emergent hatchlings from adjacent non-project beaches.

The unnatural sloped beach adjacent to the structure exposes sea turtles and their nests to lights that were less visible, or not visible, from nesting areas before the sand placement activity, leading to a higher mortality of hatchlings. Review of over 10 years of empirical information from beach nourishment projects indicates that the number of sea turtles impacted by lights increases on the post-construction berm. A review of selected nourished beaches in Florida (South Brevard, North Brevard, Captiva Island, Ocean Ridge, Boca Raton, Town of Palm Beach, Longboat Key, and Bonita Beach) indicated disorientation reporting increased by approximately 300 percent the first nesting season after project construction and up to 542 percent the second year compared to pre-nourishment reports (Trindell et al. 2005).

Specific examples of increased lighting disorientations after a sand placement project include Brevard and Palm Beach Counties, Florida. A sand placement project in Brevard County, completed in 2002, showed an increase of 130 percent in disorientations in the nourished area. Disorientations on beaches in the County that were not nourished remained constant (Trindell 2007). This same result was also documented in 2003 when another beach in Brevard County was nourished and the disorientations increased by 480 percent (Trindell 2007). Installing appropriate beachfront lighting is the most effective method to decrease the number of disorientations on any developed beach including nourished beaches. A shoreline protection project was constructed at Ocean Ridge in Palm Beach County, Florida, between August 1997 and April 1998. Lighting disorientation events increased after nourishment. In spite of continued aggressive efforts to identify and correct lighting violations in 1998 and 1999, 86 percent of the disorientation reports were in the nourished area in 1998 and 66 percent of the reports were in the nourished area in 1999 (Howard and Davis 1999).

c. *Entrapment/physical obstruction*

Groins have the potential to interfere with the egress or ingress of adult females at nesting sites where they may proceed around them successfully, abort nesting for that night, or move to another section of beach to nest. This may cause an increase in energy expenditure, and, if the body of the groin is exposed, may act as a barrier between beach segments and also prevent nesting on the adjacent beach. In general, the groin is exposed to dissipate wave energy and facilitate sand bypass, functioning in many cases to stabilize the beach and adjacent areas.

Typically, sea turtles emerge from the nest at night when lower sand temperatures elicit an increase in hatchling activity (Witherington et al. 1990). After emergence, approximately 20 to 120 hatchlings crawl en *masse* immediately to the surf, using predominately visual cues to orient them (Witherington and Salmon 1992; Lohmann et al. 1997). Upon reaching the water, sea turtle hatchlings orient themselves into the waves and begin a period of hyperactive swimming activity, or swim frenzy, which lasts for approximately 24 hours (Salmon and Wyneken 1987; Wyneken et al. 1990; Witherington 1991). The swim frenzy effectively moves the hatchling quickly away from shallow, predator rich, nearshore waters to the relative safety of deeper water (Gyuris 1994; Wyneken et al. 2000). The first hour of a hatchling's life is precarious and predation is high, but threats decrease as hatchlings distance themselves from their natal beaches (Stancyk 1995; Pilcher et al. 2000). Delays in hatchling migration (both on the beach and in the water) can cause added expenditures of energy and an increase of time spent in predator rich nearshore waters. On rare occasions hatchlings will encounter natural nearshore features that are similar to the emergent structures proposed for this project. However, observations of hatchling behavior during an encounter with a sand bar at low tide, a natural shore-parallel barrier, showed the hatchlings maintained their shore-perpendicular path seaward, by crawling over the sand bar versus deviating from this path to swim around the sand bar through the trough, an easier alternative. In spite of the groin design features, the groin may adversely affect sea turtle hatchlings by serving as a barrier or obstruction to sea turtle hatchlings and delaying offshore migration; depleting or increasing expenditure of the "swim frenzy" energy critical for allowing hatchlings to reach the relative safety of offshore development areas; and possibly entrapping hatchlings within the groin or within eddies or other associated currents.

d. *Nest relocation*

Besides the potential for missing nests during surveys and a nest relocation program, there is a potential for eggs to be damaged by nest movement or relocation, particularly if eggs are not relocated within 12 hours of deposition (Limpus et al. 1979). Nest relocation can have adverse impacts on incubation temperature (and hence sex ratios), gas exchange parameters, hydric environment of nests, hatching success, and hatchling emergence (Limpus et al. 1979; Ackerman 1980; Parmenter 1980; Spotila et al. 1983; McGehee 1990). Relocating nests into sands deficient in oxygen or moisture can result in mortality, morbidity, and reduced behavioral competence of hatchlings. Water availability is known to influence the incubation environment of the embryos and hatchlings of turtles with flexible-shelled eggs, which has been shown to affect nitrogen excretion (Packard et al. 1984), mobilization of calcium (Packard and Packard 1986), mobilization of yolk nutrients (Packard et al. 1985), hatchling size (Packard et al. 1981; McGehee 1990), energy reserves in the yolk at hatching (Packard et al. 1988), and locomotory ability of hatchlings (Miller et al. 1987).

In a 1994 Florida study comparing loggerhead hatching and emerging success of relocated nests with nests left in their original location, Moody (1998) found that hatching success was lower in relocated nests at nine of 12 beaches evaluated. In addition, emerging success was lower in relocated nests at 10 of 12 beaches surveyed in 1993 and 1994. Many of the direct effects of beach nourishment may persist over time. These direct effects include increased susceptibility of relocated nests to catastrophic events, the consequences of potential increased beachfront development, changes in the physical characteristics of the beach, the formation of escarpments, repair/replacement of groins and jetties, and future sand migration.

Indirect Effects: Many of the direct effects of a groin or beach nourishment may persist over time and become indirect impacts. These indirect effects include increased susceptibility of relocated nests to catastrophic events, the consequences of potential increased beachfront development, changes in the physical characteristics of the beach, the formation of escarpments, and future sand migration.

a. *Changes in the physical environment*

The presence of the groin may alter the natural coastal processes and result in an unnatural beach profiles resulting from the presence of groin, which could negatively impact sea turtles regardless of the timing of projects. The use of heavy machinery can cause sand compaction (Nelson et al. 1987; Nelson and Dickerson 1988a). Significant reductions in nesting success (i.e., false crawls occurred more frequently) have been documented on severely compacted beaches (Fletemeyer 1980; Raymond 1984; Nelson and Dickerson 1987; Nelson et al. 1987), and increased false crawls may result in increased physiological stress to nesting females.

Beach nourishment may result in changes in sand density (compaction), beach shear resistance (hardness), beach moisture content, beach slope, sand color, sand grain size, sand grain shape, and sand grain mineral content if the placed sand is dissimilar from the original beach sand (Nelson and Dickerson 1988a). These changes could result in adverse impacts on nest site selection, digging behavior, clutch viability, and hatchling emergence (Nelson and Dickerson 1987; Nelson 1988).

Beach nourishment projects create an elevated, wider, and unnatural flat slope berm. Sea turtles nest closer to the water the first few years after nourishment because of the altered profile (and perhaps unnatural sediment grain size distribution) (Ernest and Martin 1999; Trindell 2005).

Beach compaction and unnatural beach profiles resulting from beach nourishment activities could negatively impact sea turtles regardless of the timing of projects. Very fine sand or the use of heavy machinery can cause sand compaction on nourished beaches (Nelson et al. 1987; Nelson and Dickerson 1988a). Significant reductions in nesting success (i.e., false crawls occurred more frequently) have been documented on severely compacted nourished beaches (Fletemeyer 1980; Raymond 1984; Nelson and Dickerson 1987; Nelson et al. 1987), and increased false crawls may result in increased physiological stress to nesting females. Sand compaction may increase the length of time required for female sea turtles to excavate nests and cause increased physiological stress to the animals (Nelson and Dickerson 1988b). Nelson and Dickerson (1988c) concluded that, in general, beaches nourished from offshore borrow sites are harder than natural beaches, and while some may soften over time through erosion and accretion of sand, others may remain hard for 10 years or more.

These impacts can be minimized by using suitable sand and by tilling (minimum depth of 36 inches) compacted sand after project completion. The level of compaction of a beach can be assessed by measuring sand compaction using a cone penetrometer (Nelson 1987). Tilling of a nourished beach with a root rake may reduce the sand compaction to levels comparable to unnourished beaches. However, a pilot study by Nelson and Dickerson (1988c) showed that a tilled nourished beach will remain uncompacted for only up to 1 year. Thus, multi-year beach compaction monitoring and, if necessary, tilling would help to ensure that project impacts on sea turtles are minimized.

A change in sediment color on a beach could change the natural incubation temperatures of nests in an area, which, in turn, could alter natural sex ratios. To provide the most suitable sediment for nesting sea turtles, the color of the nourished sediments should resemble the natural beach sand in the area. Natural reworking of sediments and bleaching from exposure to the sun would help to lighten dark nourishment sediments; however, the timeframe for sediment mixing and bleaching to occur could be critical to a successful sea turtle nesting season.

b. *Escarpment formation*

On nourished beaches, steep escarpments may develop along their water line interface as they adjust from an unnatural construction profile to a more natural beach profile (Coastal Engineering Research Center 1984; Nelson et al. 1987). Escarpments may also develop on beaches between groins as the beaches equilibrate to their final profiles. Escarpments can hamper or prevent access to nesting sites (Nelson and Blihovde 1998). Researchers have shown that female sea turtles coming ashore to nest can be discouraged by the formation of an escarpment, leading to situations where they choose marginal or unsuitable nesting areas to deposit eggs (e.g., in front of the escarpments, which often results in failure of nests due to prolonged tidal inundation). This impact can be minimized by leveling any escarpments prior to the nesting season.

c. *Increased susceptibility to catastrophic events*

Nest relocation within a nesting season may concentrate eggs in an area making them more susceptible to catastrophic events. Hatchlings released from concentrated areas also may be subject to greater predation rates from both land and marine predators, because the predators learn where to concentrate their efforts (Glenn 1998; Wyneken et al. 1998).

d. *Increased beachfront development*

Pilkey and Dixon (1996) stated that beach replenishment frequently leads to more development in greater density within shorefront communities that are then left with a future of further replenishment or more drastic stabilization measures. Dean (1999) also noted that the very existence of a beach nourishment project can encourage more development in coastal areas. Following completion of a beach nourishment project in Miami during 1982, investment in new and updated facilities substantially increased tourism there (National Research Council 1995). Increased building density immediately adjacent to the beach often resulted as much larger buildings that accommodated more beach users replaced older buildings. Overall, shoreline management creates an upward spiral of initial protective measures resulting in more expensive development that leads to the need for more and larger protective measures. Increased shoreline development may adversely affect sea turtle nesting success. Greater development may support larger populations of mammalian predators, such as foxes and raccoons, than undeveloped areas

(National Research Council 1990a), and can also result in greater adverse effects due to artificial lighting, as discussed above.

e. *Future sand migration and erosion*

Groins and jetties are shore-perpendicular structures that are designed to trap sand that would otherwise be transported by longshore currents. Jetties are defined as structures placed to keep sand from flowing into channels (Kaufman and Pilkey 1979; Komar 1983). In preventing normal sand transport, these structures accrete updrift beaches while causing accelerated beach erosion downdrift of the structures (Komar 1983; Pilkey et al. 1984; National Research Council 1987), a process that results in degradation of sea turtle nesting habitat. As sand fills the area updrift from the groin or jetty, some littoral drift and sand deposition on adjacent downdrift beaches may occur due to spillover. However, these groins and jetties often force the stream of sand into deeper offshore water where it is lost from the system (Kaufman and Pilkey 1979). The greatest changes in beach profile near groins and jetties are observed close to the structures, but effects eventually may extend many miles along the coast (Komar 1983).

Jetties are placed at ocean inlets to keep transported sand from closing the inlet channel. Together, jetties and inlets are known to have profound effects on adjacent beaches (Kaufman and Pilkey 1979). Witherington et al. (2005) found a significant negative relationship between loggerhead nesting density and distance from the nearest of 17 ocean inlets on the Atlantic coast of Florida. The effect of inlets in lowering nesting density was observed both updrift and downdrift of the inlets, leading researchers to propose that beach instability from both erosion and accretion may discourage sea turtle nesting.

Erosion control structures (e.g., terminal groins, T-groins, and breakwaters), in conjunction with beach nourishment, can help stabilize U.S. Gulf and Atlantic coast barrier island beaches (Leonard et al. 1990). However, groins often result in accelerated beach erosion downdrift of the structures (Komar 1983; National Research Council 1987) and corresponding degradation of suitable sea turtle nesting habitat (NMFS and Service 1991; 1992). Initially, the greatest changes are observed close to the structures, but effects may eventually extend significant distances along the coast (Komar 1983).

Groins operate by blocking the natural longshore transport of littoral drift (Kaufman and Pilkey 1979; Komar 1983). Conventional rubble mound groins control erosion by trapping sand and dissipating some wave energy. In general, except for terminal groins at the downdrift limit of a littoral cell, groins are not considered favorable erosion control alternatives because they usually impart stability to the updrift beach and transfer erosion to the downdrift side of the structure. In addition, groins deflect longshore currents offshore, and excess sand builds up on the updrift side of the structure which may be carried offshore by those currents. This aggravates downdrift erosion and erosion escarpments are common on the downdrift side of groins (Humiston and Moore 2001).

Future sand displacement on nesting beaches is a potential effect of the nourishment project. Dredging of sand offshore from an Action Area has the potential to cause erosion of the newly created beach or other areas on the same or adjacent beaches by creating a sand sink. The remainder of the system responds to this sand sink by providing sand from the beach to attempt to reestablish equilibrium (National Research Council 1990b).

f. *Erosion control structure breakdown*

If erosion control structures fail and break apart, the resulting debris may be spread upon the beach, which may further impede nesting females from accessing suitable nesting sites (resulting in a higher incidence of false crawls) and trap hatchlings and nesting turtles (NMFS and Service 1991; 1992; 1993).

3) Species' Response to a Proposed Action

The Service determined there is a potential for long-term adverse effects on sea turtles, particularly hatchlings, as a result of the presence of the groin. However, the Service acknowledges the potential benefits of the erosion control structure since it may minimize the effects of erosion on sea turtle nesting habitat and extend the sand placement interval. Nonetheless, an increase in sandy beach may not necessarily equate to an increase in suitable sea turtle nesting habitat.

The following summary illustrates sea turtle responses to and recovery from a nourishment project comprehensively studied by Ernest and Martin (1999). A significantly larger proportion of turtles emerging on nourished beaches abandoned their nesting attempts than turtles emerging on natural or pre-nourished beaches. This reduction in nesting success is most pronounced during the first year following project construction and is most likely the result of changes in physical beach characteristics associated with the nourishment project (e.g., beach profile, sediment grain size, beach compaction, frequency and extent of escarpments). During the first post-construction year, the time required for turtles to excavate an egg chamber on untilled, hard-packed sands increases significantly relative to natural conditions. However, tilling (minimum depth of 36 inches) is effective in reducing sediment compaction to levels that did not significantly prolong digging times. As natural processes reduced compaction levels on nourished beaches during the second post-construction year, digging times returned to natural levels (Ernest and Martin 1999).

During the first post-construction year, nests on nourished beaches are deposited significantly seaward of the toe of the dune and significantly landward of the tide line than nests on natural beaches. More nests are washed out on the wide, flat beaches of the nourished treatments than on the narrower steeply sloped natural beaches. This phenomenon may persist through the second post-construction year monitoring and result from the placement of nests near the seaward edge of the beach berm where dramatic profile changes, caused by erosion and scarping, occur as the beach equilibrates to a more natural contour.

The principal effect of beach nourishment on sea turtle reproduction is a reduction in nesting success during the first year following project construction. Although most studies have attributed this phenomenon to an increase in beach compaction and escarpment formation, Ernest and Martin (1999) indicated that changes in beach profile may be more important. Regardless, as a nourished beach is reworked by natural processes in subsequent years and adjusts from an unnatural construction profile to a natural beach profile, beach compaction and the frequency of escarpment formation decline, and nesting and nesting success return to levels found on natural beaches.

D. Cumulative Effects

This project occurs on non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion.

It is reasonable to expect continued shoreline stabilization, inlet dredging, and beach renourishment projects in this area in the future since erosion and sea-level rise increases would impact the existing beachfront development.

V. PIPING PLOVER

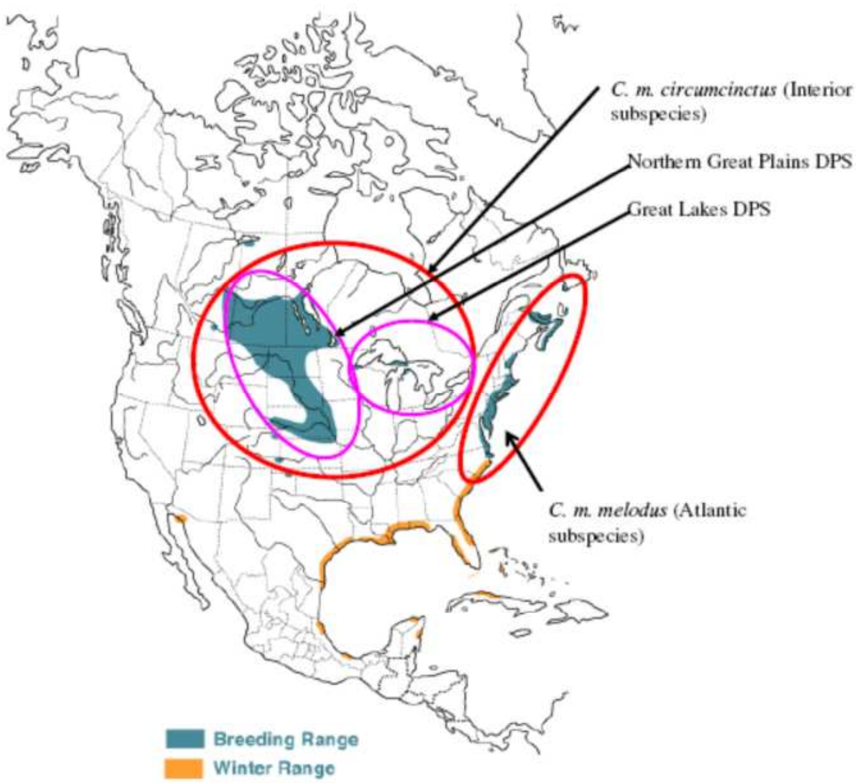
A. Status of the Species/Critical Habitat

1) Species/Critical Habitat Description

Listing: On January 10, 1986, the piping plover was listed as endangered in the Great Lakes watershed and threatened elsewhere within its range, including migratory routes outside of the Great Lakes watershed and wintering grounds (USFWS 1985). Piping plovers were listed principally because of habitat destruction and degradation, predation, and human disturbance. Protection of the species under the Act reflects the species’ precarious status range-wide.

Three separate breeding populations have been identified, each with its own recovery criteria: the northern Great Plains (threatened), the Great Lakes (endangered), and the Atlantic Coast (threatened). Piping plovers that breed on the Atlantic Coast of the U.S. and Canada belong to the subspecies C. m. melodus. The second subspecies, C. m. circumcinctus, is comprised of two Distinct Population Segments (DPSs). One DPS breeds on the Northern Great Plains of the U.S. and Canada, while the other breeds on the Great Lakes. Each of these three entities is demographically independent. The Piping plover winters in coastal areas of the U.S. from North Carolina to Texas, and along the coast of eastern Mexico and on Caribbean islands from Barbados to Cuba and the Bahamas (Haig and Elliott-Smith 2004) (**Figure 2**).

Figure 2. Distribution and range of piping plovers (base map from Elliott-Smith and Haig 2004). Conceptual presentation of subspecies and DPS ranges are not intended to convey precise boundaries.



Piping plovers in the Action Area may include individuals from all three breeding populations. Piping plover subspecies are phenotypically indistinguishable, and most studies in the nonbreeding range report results without regard to breeding origin. Although a recent analysis shows strong patterns in the wintering distribution of piping plovers from different breeding populations, partitioning is not complete and major information gaps persist.

North Carolina is the only state where the piping plover's breeding and wintering ranges overlap and the birds are present year-round. Piping plovers nest above the high tide line on coastal beaches; on sand flats at the ends of sand spits and barrier islands; on gently sloping foredunes; in blowout areas behind primary dunes (overwashes); in sparsely vegetated dunes; and in overwash areas cut into or between dunes. The species requires broad, open, sand flats for feeding, and undisturbed flats with low dunes and sparse dune grasses for nesting. Piping plovers from the federally endangered Great Lakes population as well birds from the threatened populations of the Atlantic Coast and Northern Great Plains overwinter on North Carolina beaches. Piping plovers arrive on their breeding grounds in late March or early April. Following establishment of nesting territories and courtship rituals, the pair forms a depression in the sand, where the female lays her eggs. By early September both adults and young depart for their wintering areas.

Designated critical habitat: The Service has designated Critical Habitat for the piping plover on three occasions. Two of these designations protected different piping plover breeding populations. Critical Habitat for the Great Lakes breeding population was designated May 7, 2001 (66 Federal Register [FR] 22938; Service 2001a), and Critical Habitat for the northern Great Plains breeding population was designated September 11, 2002 (67 FR 57637; Service 2002). The Service designated Critical Habitat for wintering piping plovers on July 10, 2001 (66 FR 36038; Service 2001b). Wintering piping plovers may include individuals from the Great Lakes and northern Great Plains breeding populations as well as birds that nest along the Atlantic Coast. The three separate designations of piping plover Critical Habitat demonstrate diversity of PCEs between the two breeding populations as well as diversity of PCEs between breeding and wintering populations.

The Action Area includes piping plover Critical Habitat Unit NC-17 (Shallotte Inlet – Brunswick County). This 296-acre unit begins just west of Skimmer Court on the western end of Holden Beach. It includes land south of SR 1116, to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur to the MLLW along the Atlantic Ocean. It includes the contiguous shoreline from MLLW to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur along the Atlantic Ocean, Shallotte Inlet, and Intracoastal Waterway stopping north of Skimmer Court Road. The unnamed island and emergent sandbars to MLLW within Shallotte Inlet are also included.

The PCEs essential for the conservation of wintering piping plovers are those habitat components that support foraging, roosting, and sheltering and the physical features necessary for maintaining the natural processes that support these habitat components. The PCEs include intertidal beaches and flats (between annual low tide and annual high tide) and associated dune systems and flats above annual high tide. Important components of intertidal flats include sand and/or mud flats with no or very sparse emergent vegetation. In some cases, these flats may be covered or partially covered by a mat of blue-green algae. Adjacent non-or sparsely vegetated sand, mud, or algal flats above high tide are also important, especially for roosting piping plovers, and are PCEs of piping plover wintering habitat. Such sites may have debris, detritus (decaying organic matter), or micro-topographic relief (less than 50 cm above substrate surface) offering refuge from high winds and cold weather. Important components of the beach/dune ecosystem include surfcast algae, sparsely vegetated backbeach and salterns (beach area above mean high tide seaward of the permanent dune line, or in cases where no dunes exist, seaward of a delineating feature such as a vegetation line, structure, or road), spits, and washover areas. Washover areas are broad, unvegetated zones, with little or no topographic relief, that are formed and maintained by the action of hurricanes, storm surge, or other extreme wave action. Critical habitat does not include existing developed sites consisting of buildings, marinas, paved areas, boat ramps, exposed oil and gas pipelines and similar structures. Only those areas containing these PCEs within the designated boundaries are considered critical habitat.

The critical habitat in the project area has been relatively undisturbed since designation in 2001. It is unclear whether the Corps' dredging of Shallotte Inlet and/or the AIWW has resulted in impacts to the critical habitat unit. Although various other planning efforts have proposed dredging or nourishment within the critical habitat unit over the past decade, to the Service's knowledge, no destruction of critical habitat has occurred. As is expected in a dynamic inlet shoreline area, natural coastal processes have altered the location and configuration of the intertidal shoals and other PCEs within the unit. However, it does not appear that the general extent of critical habitat has been affected.

2) Life History

The piping plover is a small, pale sand-colored shorebird, about seven inches long with a wingspan of about 15 inches (Palmer 1967). Cryptic coloration is a primary defense mechanism for piping plovers where nests, adults, and chicks all blend in with their typical beach surroundings.

Piping plovers live an average of 5 years, although studies have documented birds as old as 11 (Wilcox 1959) and 15 years. Plovers are known to begin breeding as early as one year of age (MacIvor 1990; Haig 1992); however, the percentage of birds that breed in their first adult year is unknown. Piping plover breeding activity begins in mid-March when birds begin returning to their nesting areas (Coutu et al. 1990; Cross 1990; Goldin et al. 1990; MacIvor 1990; Hake 1993). Piping plovers generally fledge only a single brood per season, but may re-nest several times if previous nests are lost. The reduction in suitable nesting habitat due to a number of factors is a major threat to the species, likely limiting reproductive success and future recruitment into the population (USFWS 2009).

Plovers depart their breeding grounds for their wintering grounds between July and late August, but southward migration extends through November. More information about the three breeding populations of piping plovers can be found in the following documents:

a. Piping Plover, Atlantic Coast Population: 1996 Revised Recovery Plan (USFWS 1996a);
b. 2009 Piping Plover (*Charadrius melodus*) 5-Year Review: Summary and Evaluation (USFWS 2009);
c. 2003 Recovery Plan for the Great Lakes Piping Plover (*Charadrius melodus*) (USFWS 2003a);
d. Questions and Answers about the Northern Great Plains Population of Piping Plover (USFWS 2002).

North Carolina is one of the only states in which piping plovers may be found year-round. Piping plovers migrate through and winter in coastal areas of the U.S. from North Carolina to Texas and in portions of Mexico and the Caribbean. Data based on four rangewide mid-winter (late January to early February) population surveys, conducted at 5-year intervals starting in 1991, show that total numbers have fluctuated over time, with some areas experiencing increases and others decreases. Regional and local fluctuations may reflect the quantity and quality of suitable foraging and roosting habitat, which vary over time in response to natural coastal formation processes as well as anthropogenic habitat changes (e.g., inlet relocation, dredging of shoals and spits). Fluctuations may also represent localized weather conditions (especially wind) during surveys, or unequal survey coverage. Changes in wintering numbers may also be influenced by growth or decline in the particular breeding populations that concentrate their wintering distribution in a given area.

Gratto-Trevor et al. (2009) found strong patterns (but no exclusive partitioning) in winter distribution of uniquely banded piping plovers from four breeding populations. All eastern Canada and 94 percent of Great Lakes birds wintered from North Carolina to southwest Florida. However, eastern Canada birds were more heavily concentrated in North Carolina, and a larger proportion of Great Lakes piping plovers were found in South Carolina and Georgia. Northern Great Plains populations were primarily seen farther west and south, especially on the Texas Gulf Coast.

Breeding and wintering plovers feed on exposed wet sand in swash zones; intertidal ocean beach; wrack lines; washover passes; mud , sand , and algal flats; and shorelines of streams, ephemeral ponds, lagoons, and salt marshes by probing for invertebrates at or just below the surface (Coutu et al. 1990; USFWS 1996a). They use beaches adjacent to foraging areas for roosting and preening. Small sand dunes, debris, and sparse vegetation within adjacent beaches provide shelter from wind and extreme temperatures. Behavioral observations of piping plovers on the wintering grounds suggest that they spend the majority of their time foraging (Nicholls and Baldassarre 1990; Drake 1999a; 1999b). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986; Coutu et al. 1990; McConnaughey et al. 1990; Loegering 1992; Goldin 1993; Hoopes 1993). Feeding activities may occur during all hours of the day and night (Staine and Burger 1994; Zonick 1997), and at all stages in the tidal cycle (Goldin 1993; Hoopes 1993). Wintering plovers primarily feed on invertebrates such as polychaete marine worms, various crustaceans, fly larvae, beetles, and occasionally bivalve mollusks found on top of the soil or just beneath the surface (Bent 1929; Cairns 1977; Nicholls 1989; Zonick and Ryan 1996).

Piping plovers exhibit a high degree of intra- and interannual wintering site fidelity (Nicholls and Baldassarre 1990; Drake et al. 2001; Noel and Chandler 2005; Stucker and Cuthbert 2006). However, local movements during winter are more common. In South Carolina, Maddock et al. (2009) documented many cross-inlet movements by wintering banded piping plovers as well as occasional movements of up to 11.2 miles by approximately 10 percent of the banded population. Larger movements within South Carolina were seen during fall and spring migration.

Atlantic Coast plovers nest on coastal beaches, sand flats at the ends of sand spits and barrier islands, gently-sloped foredunes, sparsely-vegetated dunes, and washover areas cut into or between dunes. Plovers arrive on the breeding grounds from mid-March through mid-May and remain for three to four months per year; the Atlantic Coast plover breeding activities begin in March in North Carolina with courtship and territorial establishment (Coutu et al., 1990; McConnaughey et al., 1990). Egg-laying begins around mid-April with nesting and brood rearing activities continuing through July. They lay three to four eggs in shallow scraped depressions lined with light colored pebbles and shell fragments. The eggs are well camouflaged and blend extremely well with their surroundings. Both sexes incubate the eggs which hatch within 30 days, and both sexes feed the young until they can fly. The fledgling period, the time between the hatching of the chicks and the point at which they can fly, generally lasts 25 to 35 days.

Atlantic Coast and Florida studies highlighted the importance of inlets for nonbreeding and breeding piping plovers. Almost 90 percent of roosting piping plovers at ten coastal sites in southwest Florida were on inlet shorelines (Lott et al. 2009b). Piping plovers were among seven shorebird species found more often than expected ($p = 0.0004$; Wilcoxon Test Scores) at inlet locations versus non-inlet locations in an evaluation of 361 International Shorebird Survey sites from North Carolina to Florida (Harrington 2008).

3) Population Dynamics

The International Piping Plover Breeding Census is conducted throughout the breeding grounds every 5 years by the Great Lakes/Northern Great Plains Recovery Team of the U.S. Geological Survey (USGS). The census is the largest known, complete avian species census. It is designed to determine species abundance and distribution throughout its annual cycle. The last survey in 2006 documented 3,497 breeding pairs, with a total of 8,065 birds throughout Canada and the U.S. (Elliot-Smith et al. 2009). A more recent 2010 Atlantic Coast breeding piping plover population estimate was 1,782 pairs, which was more than double the 1986 estimate of 790 pairs. This was determined to be a net increase of 86 percent between 1989 and 2010 (USFWS 2011). The 2006 International Piping Plover Census surveys documented 84 wintering piping plovers at 39 sites along approximately 344 km of North Carolina shoreline, and 87 breeding plovers at 29 sites along 338 km of shoreline (Elliott-Smith et al. 2009). Midwinter surveys may underestimate the abundance of nonbreeding piping plovers using a site or region during other months. In late September 2007, 104 piping plovers were counted at the south end of Ocracoke Island, North Carolina (National Park Service 2007), where none were seen during the 2006 International Piping Plover Winter Census (Elliott-Smith et al. 2009). Local movements of non-breeding piping plovers and number of surveyor visits to the site may also affect abundance estimates (Maddock et al. 2009; Cohen 2009).

The most consistent finding in the various population viability analyses conducted for piping plovers (Ryan et al. 1993; Melvin and Gibbs 1996; Plissner and Haig 2000; Wemmer et al. 2001; Larson et al. 2002; Amirault et al. 2005; Calvert et al. 2006; Brault 2007) indicates even small declines in adult and juvenile survival rates will cause increases in extinction risk. A banding study conducted between 1998 and 2004 in Atlantic Canada concluded lower return rates of juvenile (first year) birds to the breeding grounds than was documented for Massachusetts (Melvin and Gibbs 1996), Maryland (Loegering 1992), and Virginia (Cross 1996) breeding populations in the mid-1980s and very early 1990s. This is consistent with failure of the Atlantic Canada population to increase in abundance despite high productivity (relative to other breeding populations) and extremely low rates of dispersal to the U.S. over the last 15 plus years (Amirault et al. 2005). This suggests maximizing productivity does not ensure population increases. However, other studies suggest that survivability is good at wintering sites (Drake et al. 2001). Please see the Piping Plover 5-Year Review: Summary and Evaluation for additional information on survival rates at wintering habitats (USFWS 2009).

In 2001, 2,389 piping plovers were located during a winter census, accounting for only 40 percent of the known breeding birds recorded during a breeding census (Ferland and Haig 2002). About 89 percent of birds that are known to winter in the U.S. do so along the Gulf Coast (Texas to Florida), while 8 percent winter along the Atlantic Coast (North Carolina to Florida). The status of piping plovers on winter and migration grounds is difficult to assess, but threats to piping plover habitat used during winter and migration identified by the Service during its designation of Critical Habitat continue to affect the species. Unregulated motorized and pedestrian recreational use, inlet and shoreline stabilization projects, beach maintenance and nourishment, and pollution affect most winter and migration areas. Conservation efforts at some locations have likely resulted in the enhancement of wintering habitat.

Northern Great Plains Population

The Northern Great Plains plover breeds from Alberta to Manitoba, Canada and south to Nebraska; although some nesting has recently occurred in Oklahoma. Currently the most westerly breeding piping plovers in the United States occur in Montana and Colorado. The decline of piping plovers on rivers in the Northern Great Plains has been largely attributed to the loss of sandbar island habitat and forage base due to dam construction and operation. Nesting occurs on sand flats or bare shorelines of rivers and lakes, including sandbar islands in the upper Missouri River system, and patches of sand, gravel, or pebbly-mud on the alkali lakes of the northern Great Plains. Plovers do nest on shorelines of reservoirs created by the dams, but reproductive success is often low and reservoir habitat is not available in many years due to high water levels or vegetation. Dams operated with steady constant flows allow vegetation to grow on potential nesting islands, making these sites unsuitable for nesting. Population declines in alkali wetlands are attributed to wetland drainage, contaminants, and predation.

Since the Northern Great Plains population is geographically widespread, with many birds in very remote places, especially in the U.S. and Canadian alkali lakes. Thus, determining the number of birds or even identifying a clear trend in the population is a difficult task. The International Piping Plover Census (IPPC) was designed, in part, to help deal with this problem by instigating a large effort every five years in which an attempt is made to survey every area with known or potential piping plover breeding habitat during a two-week window (i.e., the first two weeks of June). The relatively short window is designed to minimize double counting if birds move from one area to another. The 1988 recovery plan uses the numbers from the IPPC as a major criterion for delisting, as does the 2006 Canadian Recovery Plan (Environment Canada 2006).

Participation in the IPPC has been excellent on the Northern Great Plains, with a tremendous effort put forth to attempt to survey areas during the census window (Elliot-Smith et al. 2009). The large area to be surveyed and sparse human population in the Northern Great Plains make annual surveys of the entire area impractical, so the IPPC provides an appropriate tool for helping to determine the population trend. Many areas are only surveyed during the IPPC years.

Figure 3 shows the number of adult plovers in the Northern Great Plains (U.S. and Canada) for the four International Censuses. The IPPC shows that the U.S. population decreased between 1991 and 1996, then increased in 2001 and 2006. The Canadian population showed the reverse trend for the first three censuses, increasing slightly as the U.S. population decreased, and then decreasing in 2001. Combined, the IPPC numbers suggest that the population declined from 1991 through 2001, then increased almost 58% between 2001 and 2006 (Elliott-Smith et al. 2009).

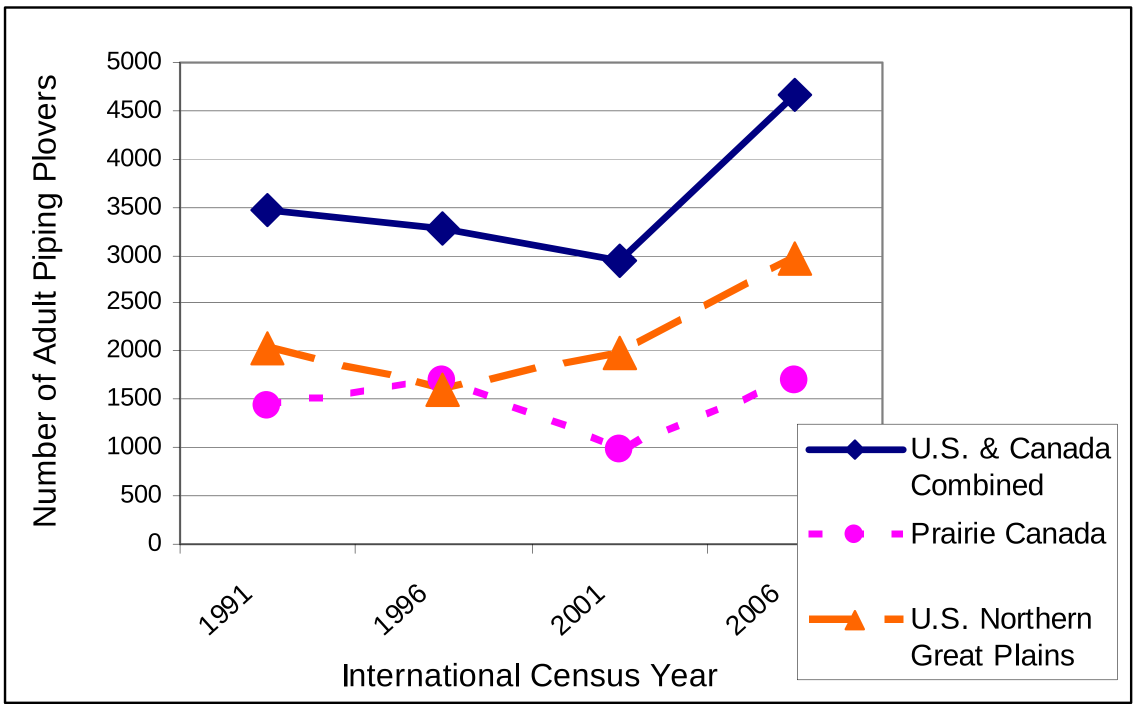


Figure 3. The number of adults reported for the U.S. and Canada Northern Great Plains during the International Censuses compared with the U.S. recovery goal.

The increase in 2006 is likely due in large part to a multi-year drought across the much of the region starting in 2001 that exposed thousands of acres of nesting habitat. The Corps ran low flows on the riverine stretches of the Missouri River for most of the years between censuses, allowing more habitat to be exposed and resulting in relatively high fledge ratios (USACE 2008a). The Corps also began to construct habitat using mechanical means (dredging sand from the riverbed) on the Missouri River in 2004, providing some new nesting and foraging habitat. The drought also caused reservoir levels to drop on many reservoirs throughout the Northern Great Plains (e.g. Missouri River Reservoirs (ND, SD), Lake McConaughey (NE)), providing shoreline habitat. The population increase may also be partially due to more intensive management activities on the alkali lakes, with increased management actions to improve habitat and reduce predation pressures.

While the IPPC provides an index to the piping plover population, the design does not always provide sufficient information to understand the population's dynamics. The five-year time interval between IPPC efforts may be too long to allow managers to get a clear picture of what the short-term population trends are and to respond accordingly if needed. As noted above, the first three IPPCs (1991, 1996, and 2001) showed a declining population, while the fourth (2006) indicated a dramatic population rebound of almost 58% for the combined U.S. and Canada Northern Great Plains population between 2001 and 2006. The preliminary results for 2011 indicate a similar grand population total as 2006, but a declining population in the United States (USFWS 2012). The larger overall population total in 2011 can be attributed to the larger numbers of plovers observed in the Bahamas. With only five data points over 20 years, it is impossible to determine if and to what extent the data reflects a real population trend versus error(s) in the 2011 census counts and/or a previous IPPC. The 2006 IPPC included a detectability component, in which a number of pre-selected sites were visited twice by the same observer(s) during the two-week window to get an estimate of error rate. This study found an approximately 76% detectability rate through the entire breeding area, with a range of between 39% to 78% detectability among habitat types in the Northern Great Plains. The results from the IPPC have been slow to be released, adding to the time lag between data collection and possible management response.

<u>Great Lakes Population</u>

The Great Lakes plovers once nested on Great Lakes beaches in Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, Wisconsin, and Ontario. Great Lakes piping plovers nest on wide, flat, open, sandy or cobble shoreline with very little grass or other vegetation. Reproduction is adversely affected by human disturbance of nesting areas and predation by foxes, gulls, crows and other avian species. Shoreline development, such as the construction of marinas, breakwaters, and other navigation structures, has adversely affected nesting and brood rearing.

The Recovery Plan (USFWS 2003a) sets a population goal of at least 150 pairs (300 individuals), for at least 5 consecutive years, with at least 100 breeding pairs (200 individuals) in Michigan and 50 breeding pairs (100 individuals) distributed among sites in other Great Lakes states.

The Great Lakes piping plover population, which has been traditionally represented as the number of breeding pairs, has increased since the completion of the recovery plan in 2003 (Cuthbert and Roche 2007; 2006; Westbrock et al. 2005; Stucker and Cuthbert 2004; Stucker et al. 2003). The Great Lakes piping plover recovery plan documents the 2002 population at 51 breeding pairs (USFWS 2003a). The most recent census conducted in 2008 found 63 breeding pairs, an increase of approximately 23%. Of these, 53 pairs were found nesting in Michigan, while 10 were found outside the state, including six pairs in Wisconsin and four in Ontario, Canada. The 53 nesting pairs in Michigan represent approximately 50% of the recovery criterion. The 10 breeding pairs outside Michigan in the Great Lakes basin, represents 20% of the goal, albeit the number of breeding pairs outside Michigan has continued to increase over the past five years. The single breeding pair discovered in 2007 in the Great Lakes region of Canada represented the first confirmed piping plover nest there in over 30 years, and in 2008 the number of nesting pairs further increased to four.

In addition, the number of non-nesting individuals has increased annually since 2003. Between 2003-2008 an annual average of approximately 26 non-nesting piping plovers were observed, based on limited data from 2003, 2006, 2007, and 2008. Although there was some fluctuation in the total population between 2002-2008, the overall increase from 51 to 63 pairs combined with the increased observance of non-breeding individuals indicates the population is increasing. (**Figure 4**).

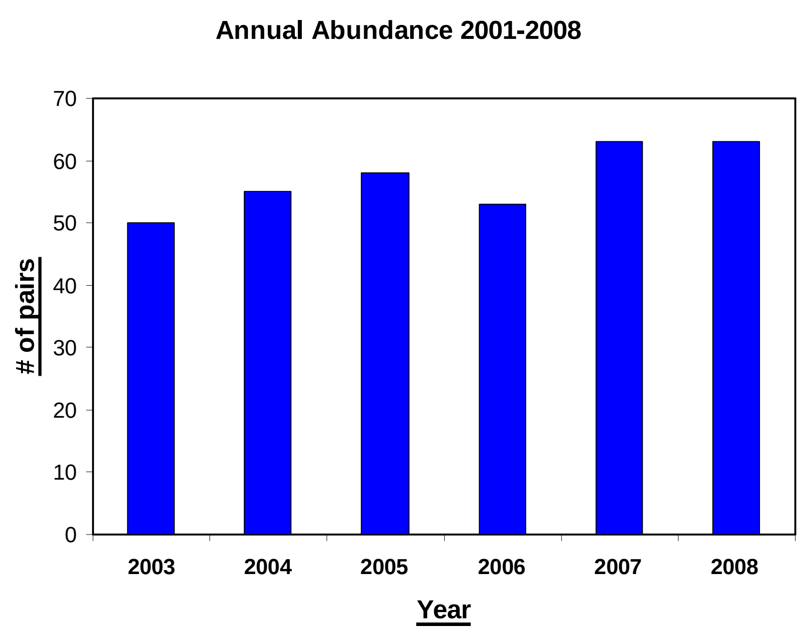


Figure 4. Annual Abundance Estimates for Great Lakes Piping Plovers (2003-2008).

Atlantic Coast Population

The Atlantic Coast piping plover breeds on coastal beaches from Newfoundland and southeastern Quebec to North Carolina. Historical population trends for the Atlantic Coast piping plover have been reconstructed from scattered, largely qualitative records. Nineteenth-century naturalists, such as Audubon and Wilson, described the piping plover as a common summer resident on Atlantic Coast beaches (Haig and Oring 1987). However, by the beginning of the 20th Century, egg collecting and uncontrolled hunting, primarily for the millinery trade, had greatly reduced the population, and in some areas along the Atlantic Coast, the piping plover was close to extirpation. Following passage of the Migratory Bird Treaty Act (40 Stat. 775; 16 U.S.C. 703-712) in 1918, and changes in the fashion industry that no longer exploited wild birds for feathers, piping plover numbers recovered to some extent (Haig and Oring 1985).

Available data suggest that the most recent population decline began in the late 1940s or early 1950s (Haig and Oring 1985). Reports of local or statewide declines between 1950 and 1985 are numerous, and many are summarized by Cairns and McLaren (1980) and Haig and Oring (1985). While Wilcox (1939) estimated more than 500 pairs of piping plovers on Long Island, New York, the 1989 population estimate was 191 pairs (see Table 4, USFWS 1996a). There was little focus on gathering quantitative data on piping plovers in Massachusetts through the late 1960s because the species was commonly observed and presumed to be secure. However, numbers of piping plover breeding pairs declined 50 to 100 percent at seven Massachusetts sites between the early 1970s and 1984 (Griffin and Melvin 1984). Piping plover surveys in the early years of the recovery effort found that counts of these cryptically colored birds sometimes went up with increased census effort, suggesting that some historic counts of piping plovers by one or a few observers may have underestimated the piping plover population. Thus, the magnitude of the species decline may have been more severe than available numbers imply.

Annual estimates of breeding pairs of Atlantic Coast piping plovers are based on multiple surveys at most occupied sites. Sites that cannot be monitored repeatedly in May and June (primarily sites with few pairs or inconsistent occupancy) are surveyed at least once during a standard nine-day count period (Hecht and Melvin 2009).

Since its 1986 listing under the ESA, the Atlantic Coast population estimate has increased 234%, from approximately 790 pairs to an estimated 1,849 pairs in 2008, and the U.S. portion of the population has almost tripled, from approximately 550 pairs to an estimated 1,596 pairs. Even discounting apparent increases in New York, New Jersey, and North Carolina between 1986 and 1989, which likely were due in part to increased census effort (USFWS 1996a), the population nearly doubled between 1989 and 2008. The largest population increase between 1989 and 2008 has occurred in New England (245%), followed by New York-New Jersey (74%). In the

Southern (DE-MD-VA-NC) Recovery Unit, overall growth between 1989 and 2008 was 66%, but almost three-quarters of this increase occurred in just two years, 2003-2005. The eastern Canada population fluctuated from year to year, with increases often quickly eroded in subsequent years; net growth between 1989 and 2008 was 9%.

The overall population growth pattern was tempered by periodic rapid declines in the Southern and Eastern Canada Recovery Units. The eastern Canada population decreased 21% in just three years (2002-2005), and the population in the southern half of the Southern Recovery Unit declined 68% in seven years (1995-2001). The recent 64% decline in the Maine population, from 66 pairs in 2002 to 24 pairs in 2008, following only a few years of decreased productivity, provides another example of the continuing risk of rapid and precipitous reversals in population growth.

4) Status and Distribution

Reason for Listing: Hunting during the 19th and early 20th centuries likely led to initial declines in the species; however, shooting piping plovers has been prohibited since 1918 pursuant to the provisions of the Migratory Bird Treaty Act (MBTA). Other human activities, such as habitat loss and degradation, disturbance from recreational pressure, contaminants, and predation are likely responsible for continued declines. These factors include development and shoreline stabilization. The 1985 final rule stated the number of piping plovers on the Gulf of Mexico coastal wintering grounds might be declining as indicated by preliminary analysis of the Christmas Bird Count data. Independent counts of piping plovers on the Alabama coast indicated a decline in numbers between the 1950s and early 1980s. At the time of listing, the Texas Parks and Wildlife Department stated 30 percent of wintering habitat in Texas had been lost over the previous 20 years. The final rule also stated, in addition to extensive breeding area problems, the loss and modification of wintering habitat was a significant threat to the piping plover.

Range-wide Trend: Five range-wide population surveys have been conducted for the piping plover; the 1991 (Haig and Plissner 1992), 1996 (Plissner and Haig 1997), 2001, 2006 (Elliott-Smith et al. 2009), and 2011 (USFWS 2012) International Piping Plover Censuses. These surveys were completed to help determine the species distribution and to monitor progress toward recovery.

Recovery Criteria

Delisting of the three piping plover populations may be considered when the following criteria are met:

Northern Great Plains Population (USFWS 1988; 1994)

1. Increase the number of birds in the U.S. northern Great Plains states to 2,300 pairs (USFWS 1994).
2. Increase the number of birds in the prairie region of Canada to 2,500 adult piping plovers (USFWS 1988).
3. Secure long term protection of essential breeding and wintering habitat (USFWS 1994).

Great Lakes Population (USFWS 2003a)

1. At least 150 pairs (300 individuals), for at least 5 consecutive years, with at least 100 breeding pairs (200 individuals) in Michigan and 50 breeding pairs (100 individuals) distributed among sites in other Great Lakes states.
2. Five-year average fecundity within the range of 1.5-2.0 fledglings per pair, per year, across the breeding distribution, and ten-year population projections indicate the population is stable or continuing to grow above the recovery goal.
3. Protection and long-term maintenance of essential breeding and wintering habitat is ensured, sufficient in quantity, quality, and distribution to support the recovery goal of 150 pairs (300 individuals).
4. Genetic diversity within the population is deemed adequate for population persistence and can be maintained over the long-term.
5. Agreements and funding mechanisms are in place for long-term protection and management activities in essential breeding and wintering habitat.

Atlantic Coast Population (USFWS 1996a)

1. Increase and maintain for 5 years a total of 2,000 breeding pairs, distributed among 4 recovery units.

Recovery Unit	*Minimum Subpopulation*
Atlantic (eastern) Canada	*400 pairs*
New England	*625 pairs*
New York-New Jersey	*575 pairs*
Southern (DE-MD-VA-NC)	*400 pairs*

2. Verify the adequacy of a 2,000 pair population of piping plovers to maintain heterozygosity and allelic diversity over the long term.
3. Achieve a 5-year average productivity of 1.5 fledged chicks per pair in each of the

4 recovery units described in criterion 1, based on data from sites that collectively support at least 90% of the recover unit's population.

4. Institute long-term agreements to assure protection and management sufficient to maintain the population targets and average productivity in each recovery unit.
5. Ensure long-term maintenance of wintering habitat, sufficient in quantity, quality, and distribution to maintain survival rates for a 2,000-pair population.

Breeding Range

Northern Great Plains Population

The IPPC numbers indicate that the Northern Great Plains population (including Canada) declined from 1991 through 2001, and then increased dramatically in 2006. This increase corresponded with a multi-year drought in the Missouri River basin that exposed a great deal of nesting habitat, suggesting that the population can respond fairly rapidly to changes in habitat quantity and quality. Despite this recent improvement, we do not consider the numeric, distributional, or temporal elements of the population recovery criteria achieved.

As the Missouri River basin emerges from drought and breeding habitat is inundated, the population will likely decline. The management activities carried out in many areas during drought conditions have undoubtedly helped to maintain and increase the piping plover population, especially to mitigate for otherwise poor reproductive success during wet years when habitat is limited.

While the population increase seen in recent years demonstrates the possibility that the population can rebound from low population numbers, ongoing efforts are needed to maintain and increase the population. In the U.S., piping plover crews attempt to locate most piping plover nests and take steps to improve their success. This work has suffered from insufficient and unstable funding in most areas.

Emerging threats, such as energy development (particularly wind, oil and gas and associated infrastructure) and climate change are likely to impact piping plovers both on the breeding and wintering grounds. The potential impact of both of these threats is not well understood, and measures to mitigate for them are also uncertain at this time.

In the recently completed status review, the Service concluded that the Northern Great Plains piping plover population remains vulnerable, especially due to management of river systems throughout the breeding range (USFWS 2009). Many of the threats identified in the 1988 recovery plan, including those affecting Northern Great Plains piping plover population during the two-thirds of its annual cycle spent in the wintering range, remain today or have intensified.

Great Lakes Population

The population has shown significant growth, from approximately 17 pairs at the time of listing in 1986, to 63 pairs in 2008. The total of 63 breeding pairs represents approximately 42% of the current recovery goal of 150 breeding pairs for the Great Lakes population. Productivity goals, as specified in the 2003 recovery plan, have been met over the past 5 years. During this time period the average annual fledging rate has been 1.76, well above the 1.5 fledglings per breeding pair recovery goal. A recent analysis of banded piping plovers in the Great Lakes, however, suggests that after hatch year survival (adult) rates may be declining. Continued population growth will require the long-term maintenance of productivity goals concurrent with measures to sustain or improve important vital rates.

Although initial information considered at the time of the 2003 recovery plan suggested the population may be at risk from a lack of genetic diversity, currently available information suggests that genetic diversity may not pose a high risk to the Great Lakes population. Additional genetic information is needed to assess genetic structure of the population and verify the adequacy of a 150 pair population to maintain long-term heterozygosity and allelic diversity.

Several years of population growth is evidence of the effectiveness of the ongoing Great Lakes piping plover recovery program. Most major threats, however, including habitat degradation, predation, and human disturbance remain persistent and pervasive. Severe threats from human disturbance and predation remain ubiquitous within the Great Lakes. Expensive labor-intensive management to minimize the effects of these continuing threats, as specified in recovery plan tasks, are implemented every year by a network of dedicated governmental and private partners. Because threats to Great Lakes piping plovers persist, reversal of gains in abundance and productivity are expected to quickly follow if current protection efforts are reduced.

Emerging potential threats to piping plovers in the Great Lakes basin include disease, wind turbine generators and, potentially, climate change. A recent out-break of Type E botulism in the Northern Lake Michigan basin resulted in several piping plover mortalities. Future outbreaks in areas that support a concentration of breeding piping plovers could impact survival rates and population abundance. Wind turbine projects, many of which are currently in the planning stages, need further study to determine potential risks to piping plovers and/or their habitat, as well as the need for specific protections to prevent or mitigate impacts. Climate change projections for the Great Lakes include the potential for significant water-level decreases.

The degree to which this factor will impact piping plover habitat is unknown, but prolonged water-level decreases are likely to alter habitat condition and distribution.

In the recently completed status review, the Service concluded that the Great Lakes population remains at considerable risk of extinction due to its small size, limited distribution and vulnerability to stochastic events, such as disease outbreak (USFWS 2009). In addition, the factors that led to the piping plover's 1986 listing remain present.

Atlantic Coast Population

Substantial population growth, from approximately 790 pairs in 1986 to an estimated 1,849 pairs in 2008, has decreased the Atlantic Coast piping plover's vulnerability to extinction since ESA listing. Thus, considerable progress has been made towards the overall goal of 2,000 breeding pairs articulated in recovery criterion 1. As discussed in the 1996 revised recovery plan, however, the overall security of the Atlantic Coast piping plover is fundamentally dependent on even distribution of population growth, as specified in subpopulation targets, to protect a sparsely-distributed species with strict biological requirements from environmental variation (including catastrophes) and increase the likelihood of interchange among subpopulations. Although the New England Recovery Unit has sustained its subpopulation target for the requisite five years, and the New York-New Jersey Recovery Unit reached its target in 2007 (but dipped below again in 2008), considerable additional growth is needed in the Southern and Eastern Canada Recovery Units (recovery criterion 1).

Productivity goals (criterion 3) specified in the 1996 recovery plan must be revised to accommodate new information about latitudinal variation in productivity needed to maintain a stationary population. Population growth, particularly in the three U.S. recovery units, provides indirect evidence that adequate productivity has occurred in at least some years. However, overall security of a 2,000 pair population will require long-term maintenance of these revised recovery-unit-specific productivity goals concurrent with population numbers at or above abundance goals.

Twenty years of relatively steady population growth, driven by productivity gains, also evidences the efficacy of the ongoing Atlantic Coast piping plover recovery program. However, all of the major threats (habitat loss and degradation, predation, human disturbance, and inadequacy of other (non-ESA) regulatory mechanisms) identified in the 1986 ESA listing and 1996 revised recovery plan remain persistent and pervasive. Indeed, recent information heightens the importance of conserving the low, sparsely vegetated beaches juxtaposed with abundant moist foraging substrates preferred by breeding Atlantic Coast piping plovers; development and artificial shoreline stabilization pose continuing widespread threats to this habitat. Severe threats from human disturbance and predation remain ubiquitous along the Atlantic Coast. Expensive labor-intensive management to minimize the effects of these continuing threats, as specified in recovery plan tasks, are implemented every year by a network of dedicated governmental and private cooperators. Because threats to Atlantic Coast piping plovers persist (and in many cases have increased since listing), reversal of gains in abundance and productivity would quickly follow diminishment of current protection efforts.

Finally, two emerging potential threats, wind turbine generators and climate change (especially sea-level rise) are likely to affect Atlantic Coast piping plovers throughout their life cycle. These two threats must be evaluated to ascertain their effects on piping plovers and/or their habitat, as well as the need for specific protections to prevent or mitigate impacts that could otherwise increase overall risks the species.

In the recently completed status review, the Service concluded that the Atlantic Coast piping plover remains vulnerable to low numbers in the Southern and Eastern Canada (and, to a lesser extent, the New York-New Jersey) Recovery Units (USFWS 2009). Furthermore, the factors that led to the piping plover's 1986 listing remain operative rangewide (including in New England), and many of these threats have increased. Interruption of costly, labor-intensive efforts to manage these threats would quickly lead to steep population declines.

Nonbreeding Range

Piping plovers spend up to 10 months of their life cycle on their migration and winter grounds, generally July 15 through as late as May 15. Piping plover migration routes and habitats overlap breeding and wintering habitats, and, unless banded, migrants passing through a site usually are indistinguishable from breeding or wintering piping plovers. Migration stopovers by banded piping plovers from the Great Lakes have been documented in New Jersey, Maryland, Virginia, and North Carolina (Stucker and Cuthbert 2006). Migrating breeders from eastern Canada have been observed in Massachusetts, New Jersey, New York, and North Carolina (Amirault et al. 2005). As many as 85 staging piping plovers have been tallied at various sites in the Atlantic breeding range (Perkins 2008 pers. communication), but the composition (e.g., adults that nested nearby and their fledged young of the year versus migrants moving to or from sites farther north), stopover duration, and local movements are unknown. In general, distance between stopover locations and duration of stopovers throughout the coastal migration range remains poorly understood.

Review of published records of piping plover sightings throughout North America by Pompei and Cuthbert (2004) found more than 3,400 fall and spring stopover records at 1,196 sites. Published reports indicated that piping plovers do not concentrate in large numbers at inland sites and that they seem to stop opportunistically. In most cases, reports of birds at inland sites were single individuals.

Piping plovers migrate through and winter in coastal areas of the U.S. from North Carolina to Texas and in portions of Mexico and the Caribbean. Gratto-Trevor et al. (2009) reported that six of 259 banded piping plovers observed more than once per winter moved across boundaries of the seven U.S. regions. This species exhibits a high degree of intra- and inter-annual wintering site fidelity (Nicholls and Baldassarre 1990; Drake et al. 2001; Noel et al. 2005; Stucker and Cuthbert 2006). Of 216 birds observed in different years, only eight changed regions between years, and several of these shifts were associated with late summer or early spring migration periods (Gratto-Trevor et al. 2009). Local movements are more common. In South Carolina, Maddock et al. (2009) documented many cross-inlet movements by wintering banded piping plovers as well as occasional movements of up to 18 km by approximately 10% of the banded population; larger movements within South Carolina were seen during fall and spring migration. Similarly, eight banded piping plovers that were observed in two locations during 2006-2007 surveys in Louisiana and Texas were all in close proximity to their original location, such as on the bay and ocean side of the same island or on adjoining islands (Maddock 2008).

Gratto-Trevor et al. (2009) found strong patterns (but no exclusive partitioning) in winter distribution of uniquely banded piping plovers from four breeding populations (**Figure 5**). All eastern Canada and 94% of Great Lakes birds wintered from North Carolina to southwest Florida. However, eastern Canada birds were more heavily concentrated in North Carolina, and a larger proportion of Great Lakes piping plovers were found in South Carolina and Georgia. Northern Great Plains populations were primarily seen farther west and south, especially on the Texas Gulf Coast. Although the great majority of Prairie Canada individuals were observed in Texas, particularly southern Texas, individuals from the U.S. Great Plains were more widely distributed on the Gulf Coast from Florida to Texas.

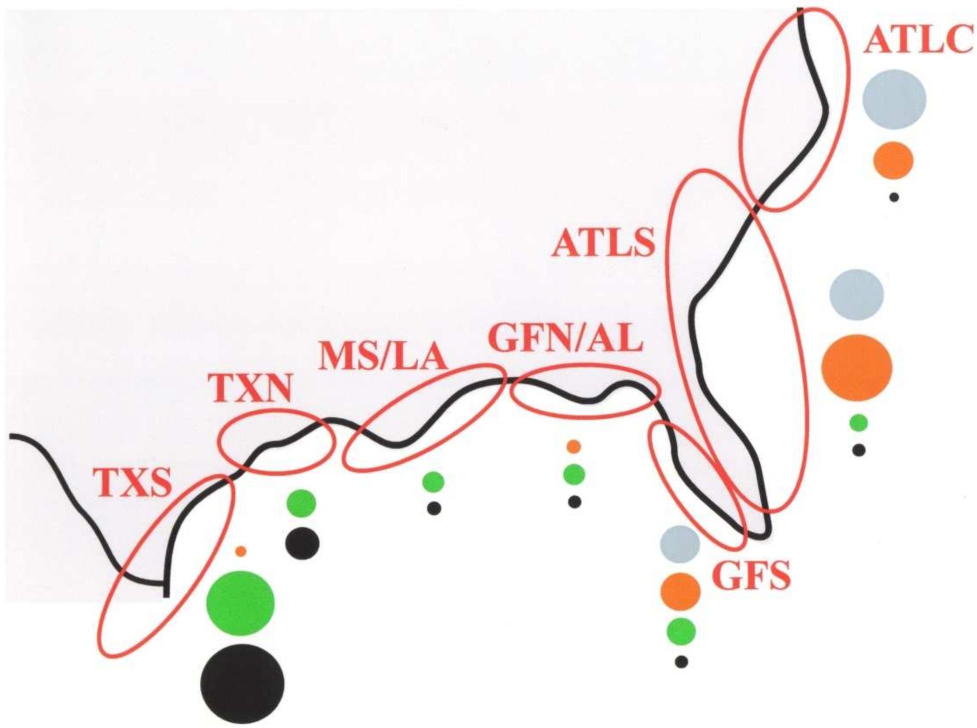


Figure 5. (from Gratto-Trevor et al. 2009, reproduced by permission). Breeding population distribution in the wintering/migration range. Regions: ATLC=Atlantic (eastern) Canada; GFS=Gulf Coast of southern Florida; GFN=Gulf Coast of north Florida; AL=Alabama; MS/LA=Mississippi and Louisiana; TXN=northern Texas; and TXS=southern Texas. For each breeding population, circles represent the percentage of individuals reported wintering along the eastern coast of the U.S. from the central Atlantic to southern Texas/Mexico up to December 2008. Each individual was counted only once. Grey circles represent Eastern Canada birds, Orange U.S. Great Lakes, Green U.S. Great Plains, and Black Prairie Canada. The relative size of the circle represents the percentage from a specific breeding area seen in that winter region. Total number of individuals observed on the wintering grounds was 46 for Eastern Canada, 150 for the U.S. Great Lakes, 169 for the U.S. Great Plains, and 356 for Prairie Canada.

The findings of Gratto-Trevor et al. (2009) provide evidence of differences in the wintering distribution of piping plovers from these four breeding areas. However, the distribution of birds by breeding origin during migration remains largely unknown. Other major information gaps include the wintering locations of the U.S. Atlantic Coast breeding population (banding of U.S. Atlantic Coast piping plovers has been extremely limited) and the breeding origin of piping plovers wintering on Caribbean islands and in much of Mexico. Banded piping plovers from the Great Lakes, Northern Great Plains, and eastern Canada breeding populations showed similar patterns of seasonal abundance at Little St. Simons Island, Georgia (Noel et al. 2007). However, the number of banded plovers originating from the latter two populations was relatively small at that study area.

Four rangewide mid-winter (late January to early February) population surveys, conducted at five-year intervals starting in 1991, are summarized in **Table 4**. Total numbers have fluctuated over time, with some areas experiencing increases and others decreases. Regional and local fluctuations may reflect the quantity and quality of suitable foraging and roosting habitat, which vary over time in response to natural coastal formation processes as well as anthropogenic habitat changes (e.g., inlet relocation, dredging of shoals and spits). Fluctuations may also represent localized weather conditions (especially wind) during surveys, or unequal survey coverage. Changes in wintering numbers may also be influenced by growth or decline in the particular breeding populations that concentrate their wintering distribution in a given area.

Mid-winter surveys may substantially underestimate the abundance of nonbreeding piping plovers using a site or region during other months. In late September 2007, 104 piping plovers were counted at the south end of Ocracoke Island, North Carolina (NPS 2007), where none were seen during the 2006 International Piping Plover Winter Census (Elliott-Smith et al. 2009). Noel et al. (2007) observed up to 100 piping plovers during peak migration at Little St. Simons Island, Georgia, where approximately 40 piping plovers wintered in 2003–2005. Differences among fall, winter, and spring counts in South Carolina were less pronounced, but inter-year fluctuations (e.g., 108 piping plovers in spring 2007 versus 174 piping plovers in spring 2008) at 28 sites were striking (Maddock et al. 2009). Even as far south as the Florida Panhandle, monthly counts at Phipps Preserve in Franklin County ranged from a mid-winter low of four piping plovers in December 2006 to peak counts of 47 in October 2006 and March 2007 (Smith 2007). Pinkston (2004) observed much heavier use of Texas Gulf Coast (ocean-facing) beaches between early September and mid-October (approximately 16 birds per mile) than during December to March (approximately two birds per mile).

Table 4. Results of the 1991, 1996, 2001, and 2006 International Piping Plover Winter Censuses (Haig et al. 2005; Elliott-Smith et al. 2009).

Location	**1991**	**1996**	**2001**	**2006**
Virginia	not surveyed (ns)	ns	ns	1
North Carolina	20	50	87	84
South Carolina	51	78	78	100
Georgia	37	124	111	212
Florida	**551**	**375**	**416**	**454**
-Atlantic	***70***	***31***	***111***	***133***
-Gulf	***481***	***344***	***305***	***321***
Alabama	12	31	30	29
Mississippi	59	27	18	78
Louisiana	750	398	511	226
Location	**1991**	**1996**	**2001**	**2006**
Texas	1,904	1,333	1,042	2,090
Puerto Rico	0	0	6	Ns
U.S. Total	**3,384**	**2,416**	**2,299**	**3,355**
Mexico	27	16	Ns	76
Bahamas	29	17	35	417
Cuba	11	66	55	89
Other Caribbean Islands	0	0	0	28
GRAND TOTAL	**3,451**	**2,515**	**2,389**	**3,884**
Percent of Total International Piping Plover Breeding Census	62.9%	42.4%	40.2%	48.2%

Local movements of nonbreeding piping plovers may also affect abundance estimates. At Deveaux Bank, one of South Carolina's most important piping plover sites, five counts at approximately 10-day intervals between August 27 and October 7, 2006, oscillated from 28 to 14 to 29 to 18 to 26 (Maddock et al. 2009). Noel and Chandler (2008) detected banded Great Lakes piping plovers known to be wintering on their Georgia study site in 73.8 $\pm$ 8.1 % of surveys over

three years.
Abundance estimates for nonbreeding piping plovers may also be affected by the number of surveyor visits to the site. Preliminary analysis of detection rates by Maddock et al. (2009) found 87% detection during the mid-winter period on core sites surveyed three times a month during fall and spring and one time per month during winter, compared with 42% detection on sites surveyed three times per year (Cohen 2009 pers. communication).

The 2004 and 2005 hurricane seasons affected a substantial amount of habitat along the Gulf Coast. Habitats such as those along Gulf Islands National Seashore have benefited from increased washover events, which created optimal habitat conditions for piping plovers. Conversely, hard shoreline structures put into place following storms throughout the species range to prevent such shoreline migration prevent habitat creation (see *Factors Affecting Species Environment within the Action Area*). Four hurricanes between 2002 and 2005 are often cited in reference to rapid erosion of the Chandeleur Islands, a chain of low-lying islands in Louisiana where the 1991 International Piping Plover Census tallied more than 350 piping plovers. Comparison of imagery taken three years before and several days after Hurricane Katrina found that the Chandeleur Islands lost 82% of their surface area (Sallenger et al. 2009 in review), and a review of aerial photography prior to the 2006 Census suggested little piping plover habitat remained (Elliott-Smith et al. 2009). However, Sallenger et al. (2009 in review) noted that habitat changes in the Chandeleurs stem not only from the effects of these storms but rather from the combined effects of the storms, long-term (>1,000 years) diminishing sand supply, and sea-level rise relative to the land.

The Service is aware of the following site-specific conditions that benefit several habitats piping plover use while wintering and migrating, including critical habitat units. In Texas, one critical habitat unit was afforded greater protection due to the acquisition of adjacent upland properties by the local Audubon chapter. In another unit in Texas, vehicles were removed from a portion of the beach decreasing the likelihood of automobile disturbance to plovers. Exotic plant removal that threatens to invade suitable piping plover habitat is occurring in a critical habitat unit in South Florida. The Service and other government agencies remain in a contractual agreement with the USDA for predator control within limited coastal areas in the Florida panhandle, including portions of some critical habitat units. Continued removal of potential terrestrial predators is likely to enhance survivorship of wintering and migrating piping plovers. In North Carolina, one critical habitat unit was afforded greater protection when the local Audubon chapter agreed to manage the area specifically for piping plovers and other shorebirds following the relocation of the nearby inlet channel.

The status of piping plovers on winter and migration grounds is difficult to assess, but threats to piping plover habitat used during winter and migration identified by the Service during its designation of critical habitat continue to affect the species. Unregulated motorized and pedestrian recreational use, inlet and shoreline stabilization projects, beach maintenance and nourishment, and pollution affect most winter and migration areas. Conservation efforts at some locations have likely resulted in the enhancement of wintering habitat.

Threats to Piping Plovers

The three recovery plans stated that shoreline development throughout the wintering range poses a threat to all populations of piping plovers. The plans further stated that beach maintenance and nourishment, inlet dredging, and artificial structures, such as jetties and groins, could eliminate wintering areas and alter sedimentation patterns leading to the loss of nearby habitat.

Important components of ecologically sound barrier beach management include perpetuation of natural dynamic coastal formation processes. Structural development along the shoreline or manipulation of natural inlets upsets the dynamic processes and results in habitat loss or degradation (Melvin et al. 1991). Throughout the range of migrating and wintering piping plovers, inlet and shoreline stabilization, inlet dredging, beach maintenance and nourishment activities, and seawall installations continue to constrain natural coastal processes. Dredging of inlets can affect spit formation adjacent to inlets and directly remove or affect ebb and flood tidal shoal formation. Jetties, which stabilize an island, cause island widening and subsequent growth of vegetation on inlet shores. Seawalls restrict natural island movement and exacerbate erosion. As discussed in more detail below, all these efforts result in loss of piping plover habitat. Construction of these projects during months when piping plovers are present also causes disturbance that disrupts the birds' foraging efficiency and hinders their ability to build fat reserves over the winter and in preparation for migration, as well as their recuperation from migratory flights. In addition, up to 24 shorebird species migrate or winter along the Atlantic Coast and almost 40 species of shorebirds are present during migration and wintering periods in the Gulf of Mexico region (Helmers 1992). Continual degradation and loss of habitats used by wintering and migrating shorebirds may cause an increase in intra-specific and inter-specific competition for remaining food supplies and roosting habitats. In Florida, for example, approximately 825 miles of coastline and parallel bayside flats (unspecified amount) were present prior to the advent of high human densities and beach stabilization projects. We estimate that only about 35% of the Florida coastline continues to support natural coastal formation processes, thereby concentrating foraging and roosting opportunities for all shorebird species and forcing some individuals into suboptimal habitats. Thus, intra- and inter-specific competition most likely exacerbates threats from habitat loss and degradation.

Sand placement projects

In the wake of episodic storm events, managers of lands under public, private, and county ownership often protect coastal structures using emergency storm berms; this is frequently followed by beach nourishment or renourishment activities (nourishment projects are considered "soft" stabilization versus "hard" stabilization such as seawalls). Berm placement and beach nourishment deposit substantial amounts of sand along Gulf of Mexico and Atlantic beaches to protect local property in anticipation of preventing erosion and what otherwise will be considered natural processes of overwash and island migration (Schmitt and Haines 2003).

Past and ongoing stabilization projects fundamentally alter the naturally dynamic coastal processes that create and maintain beach strand and bayside habitats, including those habitat components that piping plovers rely upon. Although impacts may vary depending on a range of factors, stabilization projects may directly degrade or destroy piping plover roosting and foraging habitat in several ways. Front beach habitat may be used to construct an artificial berm that is densely planted in grass, which can directly reduce the availability of roosting habitat. Over time, if the beach narrows due to erosion, additional roosting habitat between the berm and the water can be lost. Berms can also prevent or reduce the natural overwash that creates roosting habitats by converting vegetated areas to open sand areas. The vegetation growth caused by impeding natural overwash can also reduce the maintenance and creation of bayside intertidal feeding habitats. In addition, stabilization projects may indirectly encourage further development of coastal areas and increase the threat of disturbance.

At least 668 of 2,340 coastal shoreline miles (29% of beaches throughout the piping plover winter and migration range in the U.S.) are bermed, nourished, or renourished, generally for recreational purposes and to protect commercial and private infrastructure (**Table 5**). However, only approximately 54 miles or 2.31% of these impacts have occurred within critical habitat. In Louisiana, sediment placement projects are deemed environmental restoration projects by the Service, because without the sediment, many areas would erode below sea level.

Table 5. Summary of the extent of nourished beaches in piping plover wintering and migrating habitat within the conterminous U.S. From Service unpublished data (project files, gray literature, and field observations).

State	Sandy beach shoreline miles available	Sandy beach shoreline miles nourished to date (within critical habitat units)	Percent of sandy beach shoreline affected (within critical habitat units)
North Carolina	301[1]	117[5] (unknown)	39 (unknown)
South Carolina	187[1]	56 (0.6)	30 (0.32))
Georgia	100[1]	8 (0.4)	8 (0.40)
Florida	825[2]	404 (6)[6]	49 (0.72)
Alabama	53[1]	12 (2)	23 (3.77)
Mississippi	110[3]	≥6 (0)	5 (0)
Louisiana	397[1]	Unquantified (usually restoration-oriented)	Unknown
Texas	367[4]	65 (45)	18 (12.26)
Overall Total	2,340 (does not include Louisiana)	≥668 does not include Louisiana (54 in CH)	29% (≥2.31% in CH)

Data from [1]www.50states.com; [2] Clark 1993; [3]N.Winstead, Mississippi Museum of Natural Science 2008; [4] www.Surfrider.org; [5] H. Hall, USFWS, pers. comm. 2009; [6] partial data from Lott et al. (2009a).

Inlet stabilization/relocation

Many navigable mainland or barrier island tidal inlets along the Atlantic and Gulf of Mexico coasts are stabilized with jetties, groins, or by seawalls and/or adjacent industrial or residential development. Jetties are structures built perpendicular to the shoreline that extend through the entire nearshore zone and past the breaker zone (Hayes and Michel 2008) to prevent or decrease sand deposition in the channel. Inlet stabilization with rock jetties and associated channel dredging for navigation alter the dynamics of longshore sediment transport and affect the location and movement rate of barrier islands (Camfield and Holmes 1995), typically causing downdrift erosion. Sediment is then dredged and added back to islands which subsequently widen. Once the island becomes stabilized, vegetation encroaches on the bayside habitat, thereby diminishing and eventually destroying its value to piping plovers. Accelerated erosion may compound future habitat loss, depending on the degree of sea-level rise. Unstabilized inlets naturally migrate, re-forming important habitat components, whereas jetties often trap sand and cause significant erosion of the downdrift shoreline. These combined actions affect the availability of piping plover habitat (Cohen et al. 2008).

Using Google Earth© (accessed April 2009), Service's biologists visually estimated the number of navigable mainland or barrier island tidal inlets throughout the wintering range of the piping plover in the conterminous U.S. that have some form of hardened structure. This includes seawalls or adjacent development, which lock the inlets in place (**Table 6**).

Table 6. Number of hardened inlets by state. Asterisk (*) represents an inlet at the state line, in which case half an inlet is counted in each state.

State	**Visually estimated number of navigable mainland and barrier island inlets per state**	**Number of hardened inlets**	**% of inlets affected**
North Carolina	20	2.5*	12.5%
South Carolina	34	3.5*	10.3%
Georgia	26	2	7.7%
Florida	82	41	50%
Alabama	14	6	42.9%
Mississippi	16	7	43.8%
Louisiana	40	9	22.5%
Texas	17	10	58.8%
Overall Total	249	81	32.5%

Tidal inlet relocation can cause loss and/or degradation of piping plover habitat; although less permanent than construction of hard structures, effects can persist for years. Service biologists are aware of at least seven inlet relocation projects (two in North Carolina, three in South Carolina, two in Florida), but this number likely under-represents the extent of this activity.

Sand mining/dredging

Sand mining, the practice of extracting (dredging) sand from sand bars, shoals, and inlets in the nearshore zone, is a less expensive source of sand than obtaining sand from offshore shoals for beach nourishment. Sand bars and shoals are sand sources that move onshore over time and act as natural breakwaters. Inlet dredging reduces the formation of exposed ebb and flood tidal shoals considered to be primary or optimal piping plover roosting and foraging habitat. Removing these sand sources can alter depth contours and change wave refraction as well as cause localized erosion (Hayes and Michel 2008). Exposed shoals and sandbars are also valuable to piping plovers, as they tend to receive less human recreational use (because they are only accessible by boat) and therefore provide relatively less disturbed habitats for birds. We do not have a good estimate of the amount of sand mining that occurs across the piping plover wintering range, nor do we have a good estimate of the number of inlet dredging projects that occur. Most jettied inlets need maintenance dredging, but non-hardened inlets are often dredged as well.

Groins

Groins (structures made of concrete, rip rap, wood, or metal built perpendicular to the beach in order to trap sand) are typically found on developed beaches with severe erosion. Although groins can be individual structures, they are often clustered along the shoreline. Groins can act as barriers to longshore sand transport and cause downdrift erosion (Hayes and Michel 2008), which prevents piping plover habitat creation by limiting sediment deposition and accretion. These structures are found throughout the southeastern Atlantic Coast, and although most were in place prior to the piping plover's 1986 ESA listing, installation of new groins continues to occur.

Seawalls and revetments

Seawalls and revetments are vertical hard structures built parallel to the beach in front of buildings, roads, and other facilities to protect them from erosion. However, these structures often accelerate erosion by causing scouring in front of and downdrift from the structure (Hayes and Michel 2008), which can eliminate intertidal foraging habitat and adjacent roosting habitat. Physical characteristics that determine microhabitats and biological communities can be altered after installation of a seawall or revetment, thereby depleting or changing composition of benthic communities that serve as the prey base for piping plovers. At four California study sites, each comprised of an unarmored segment and a segment seaward of a seawall, Dugan and Hubbard (2006) found that armored segments had narrower intertidal zones, smaller standing crops of macrophyte wrack, and lower shorebird abundance and species richness. Geotubes (long cylindrical bags made of high-strength permeable fabric and filled with sand) are softer alternatives, but act as barriers by preventing overwash. We did not find any sources that summarize the linear extent of seawall, revetment, and geotube installation projects that have occurred across the piping plover's wintering and migration habitat.

Exotic/invasive vegetation

A recently identified threat to piping plover habitat, not described in the listing rule or recovery plans, is the spread of coastal invasive plants into suitable piping plover habitat. Like most invasive species, coastal exotic plants reproduce and spread quickly and exhibit dense growth habits, often outcompeting native plant species. If left uncontrolled, invasive plants cause a habitat shift from open or sparsely vegetated sand to dense vegetation, resulting in the loss or degradation of piping plover roosting habitat, which is especially important during high tides and migration periods.

Beach vitex (*Vitex rotundifolia*) is a woody vine introduced into the southeastern U.S. as a dune stabilization and ornamental plant (Westbrooks and Madsen 2006). It currently occupies a very small percentage of its potential range in the U.S.; however, it is expected to grow well in coastal communities throughout the southeastern U.S. from Virginia to Florida, and west to Texas (Westbrooks and Madsen 2006). In 2003, the plant was documented in New Hanover, Pender, and Onslow counties in North Carolina, and at 125 sites in Horry, Georgetown, and Charleston counties in South Carolina. Beach vitex has been documented from two locations in northwest Florida, but one site disappeared after erosional storm events. The landowner of the other site has indicated an intention to eradicate the plant, but follow through is unknown (Farley 2009 pers. communication). Task forces formed in North and South Carolina in 2004-05 have made great strides to remove this plant from their coasts. To date, about 200 sites in North Carolina have been treated, with 200 additional sites in need of treatment. Similar efforts are underway in South Carolina.

Unquantified amounts of crowfootgrass (*Dactyloctenium aegyptium*) grow invasively along portions of the Florida coastline. It forms thick bunches or mats that may change the vegetative structure of coastal plant communities and alter shorebird habitat.

The Australian pine (*Casuarina equisetifolia*) changes the vegetative structure of the coastal community in south Florida and islands within the Bahamas. Shorebirds prefer foraging in open areas where they are able to see potential predators, and tall trees provide good perches for avian predators. Australian pines potentially impact shorebirds, including the piping plover, by reducing attractiveness of foraging habitat and/or increasing avian predation. The propensity of these exotic species to spread, and their tenacity once established, make them a persistent threat, partially countered by increasing landowner awareness and willingness to undertake eradication activities.

Wrack removal and beach cleaning

Wrack on beaches and baysides provides important foraging and roosting habitat for piping plovers (Drake 1999a; Smith 2007; Maddock et al. 2009; Lott et al. 2009b; and many other shorebirds on their winter, breeding, and migration grounds. Because shorebird numbers are positively correlated with wrack cover and biomass of their invertebrate prey that feed on wrack (Tarr and Tarr 1987; Hubbard and Dugan 2003; Dugan et al. 2003), grooming will lower bird numbers (Defreo et al. 2009).

There is increasing popularity in the Southeast, especially in Florida, for beach communities to carry out "beach cleaning" and "beach raking" actions. Beach cleaning occurs on private beaches, where piping plover use is not well documented, and on some municipal or county beaches that are used by piping plovers. Most wrack removal on state and federal lands is limited to post-storm cleanup and does not occur regularly.

Man-made beach cleaning and raking machines effectively remove seaweed, fish, glass, syringes, plastic, cans, cigarettes, shells, stone, wood, and virtually any unwanted debris (Barber Beach Cleaning Equipment 2009). These efforts remove accumulated wrack, topographic depressions, and sparse vegetation nodes used by roosting and foraging piping plovers. Removal of wrack also eliminates a beach's natural sand-trapping abilities, further destabilizing the beach. In addition, sand adhering to seaweed and trapped in the cracks and crevices of wrack is removed from the beach. Although the amount of sand lost due to single sweeping actions may be small, it adds up considerably over a period of years (Nordstrom et al. 2006; Neal et al. 2007). Beach cleaning or grooming can result in abnormally broad unvegetated zones that are inhospitable to dune formation or plant colonization, thereby enhancing the likelihood of erosion (Defreo et al. 2009).

Predation

The 1996 Atlantic Coast Recovery Plan summarized evidence that human activities affect types, numbers, and activity patterns of some predators, thereby exacerbating natural predation on breeding piping plovers. The impact of predation on migrating or wintering piping plovers remains largely undocumented.

Recreational disturbance

Intense human disturbance in shorebird winter habitat can be functionally equivalent to habitat loss if the disturbance prevents birds from using an area (Goss-Custard et al. 1996), which can lead to roost abandonment and local population declines (Burton et al. 1996). Pfister et al. (1992) implicate anthropogenic disturbance as a factor in the long-term decline of migrating shorebirds at staging areas. Disturbance, i.e., human and pet presence that alters bird behavior, disrupts piping plovers as well as other shorebird species. Disturbance can cause shorebirds to spend less time roosting or foraging and more time in alert postures or fleeing from the disturbances (Johnson and Baldassarre 1988; Burger 1991; Burger 1994; Elliott and Teas 1996; Lafferty 2001a, 2001b; Thomas et al. 2002), which limits the local abundance of piping plovers (Zonick and Ryan 1995; Zonick 2000). Shorebirds that are repeatedly flushed in response to disturbance expend energy on costly short flights (Nudds and Bryant 2000).

Shorebirds are more likely to flush from the presence of dogs than people, and birds react to dogs from farther distances than people (Lafferty 2001a; 2001b; Thomas et al. 2002). Dogs off leash are more likely to flush piping plovers from farther distances than are dogs on leash; nonetheless, dogs both on and off leashes disturb piping plovers (Hoopes 1993). Pedestrians walking with dogs often go through flocks of foraging and roosting shorebirds; some even encourage their dogs to chase birds.

Off-road vehicles can significantly degrade piping plover habitat (Wheeler 1979) or disrupt the birds' normal behavior patterns (Zonick 2000). The 1996 Atlantic Coast recovery plan cites tire ruts crushing wrack into the sand, making it unavailable as cover or as foraging substrate (Hoopes 1993; Goldin 1993). The plan also notes that the magnitude of the threat from off-road vehicles is particularly significant, because vehicles extend impacts to remote stretches of beach where human disturbance will otherwise be very slight. Godfrey et al. (1980 as cited *in* Lamont et al. 1997) postulated that vehicular traffic along the beach may compact the substrate and kill marine invertebrates that are food for the piping plover. Zonick (2000) found that the density of off-road vehicles negatively correlated with abundance of roosting piping plovers on the ocean beach. Cohen et al. (2008) found that radio-tagged piping plovers using ocean beach habitat at Oregon Inlet in North Carolina were far less likely to use the north side of the inlet where off-road vehicle use is allowed, and recommended controlled management experiments to determine if recreational disturbance drives roost site selection. Ninety-six percent of piping plover detections were on the south side of the inlet even though it was farther away from foraging sites (1.8 km from the sound side foraging site to the north side of the inlet versus 0.4 km from the sound side foraging site to the north side of the inlet; Cohen et al. 2008).

Based on surveys with land managers and biologists, knowledge of local site conditions, and other information, we have estimated the levels of eight types of disturbance at sites in the U.S. with wintering piping plovers. There are few areas used by wintering piping plovers that are devoid of human presence, and just under half have leashed and unleashed dog presence (Smith 2007; Lott et al. 2009b; Service unpubl. data 2009; Maddock and Bimbi unpubl. data).

Table 7 summarizes the disturbance analysis results. Data are not available on human disturbance at wintering sites in the Bahamas, other Caribbean countries, or Mexico.

Table 7. Percent of known piping plover winter and migration habitat locations, by state, where various types of anthropogenic disturbance have been reported.

	Percent by State							
Disturbance Type	**AL**	**FL**	**GA**	**LA**	**MS**	**NC**	**SC**	**TX**
Pedestrians	67	92	94	25	100	100	88	54
Dogs on leash	67	69	31	25	73	94	25	25
Dogs off leash	67	81	19	25	73	94	66	46
Bikes	0	19	63	25	0	0	28	19
ATVs	0	35	0	25	0	17	25	30
ORVs	0	21	0	25	0	50	31	38
Boats	33	65	100	100	0	78	63	44
Kite surfing	0	10	0	0	0	33	0	0

Although the timing, frequency, and duration of human and dog presence throughout the wintering range are unknown, studies in Alabama and South Carolina suggest that most disturbances to piping plovers occurs during periods of warmer weather, which coincides with piping plover migration (Johnson and Baldassarre 1988; Lott et al. 2009b; Maddock et al. 2009). Smith (2007) documents varying disturbance levels throughout the nonbreeding season at northwest Florida sites.

LeDee (2008) collected survey responses in 2007 from 35 managers (located in seven states) at sites that were designated as critical habitat for wintering piping plovers. Ownership included federal, state, and local governmental agencies and non-governmental organizations managing national wildlife refuges; national, state, county, and municipal parks; state and estuarine research reserves; state preserves; state wildlife management areas; and other types of managed lands. Of 44 reporting sites, 40 allowed public beach access year-round and four sites were closed to the public. Of the 40 sites that allow public access, 62% of site managers reported >10,000 visitors during September-March, and 31% reported >100,000 visitors. Restrictions on visitor activities on the beach included automobiles (at 81% of sites), all-terrain vehicles (89%), and dogs during the winter season (50%). Half of the survey respondents reported funding as a primary limitation in managing piping plovers and other threatened and endangered species at their sites. Other limitations included "human resource capacity" (24%), conflicting management priorities (12%), and lack of research (3%).

Disturbance can be addressed by implementing recreational management techniques such as vehicle and pet restrictions and symbolic fencing (usually sign posts and string) of roosting and feeding habitats. In implementing conservation measures, managers need to consider a range of site-specific factors, including the extent and quality of roosting and feeding habitats and the types and intensity of recreational use patterns. In addition, educational materials such as informational signs or brochures can provide valuable information so that the public understands the need for conservation measures.

In sum, although there is some variability among states, disturbance from human beach recreation and pets poses a moderate to high and escalating threat to migrating and wintering piping plovers. Systematic review of recreation policy and beach management across the nonbreeding range will assist in better understanding cumulative impacts. Site-specific analysis and implementation of conservation measures should be a high priority at piping plover sites that have moderate or high levels of disturbance and the Service and state wildlife agencies should increase technical assistance to land managers to implement management strategies and monitor their effectiveness.

Climate Change (sea-level rise)

Over the past 100 years, the globally-averaged sea level has risen approximately 10-25 centimeters (Rahmstorf et al. 2007), a rate that is an order of magnitude greater than that seen in the past several thousand years (Douglas et al. 2001 as cited in Hopkinson et al. 2008). The IPCC suggests that by 2080 sea-level rise could convert as much as 33% of the world's coastal wetlands to open water (IPCC 2007). Although rapid changes in sea level are predicted, estimated time frames and resulting water levels vary due to the uncertainty about global temperature projections and the rate of ice sheets melting and slipping into the ocean (IPCC 2007; CCSP 2008).

Potential effects of sea-level rise on coastal beaches may vary regionally due to subsidence or uplift as well as the geological character of the coast and nearshore (CCSP 2009; Galbraith et al. 2002). In the last century, for example, sea-level rise along the U.S. Gulf Coast exceeded the global average, and averages as high as 0.32 inches per year, because those areas are subsiding (USEPA 2014). Sediment compaction and oil and gas extraction compound tectonic subsidence (Penland and Ramsey 1990; Morton et al. 2003; Hopkinson et al. 2008). Low elevations and proximity to the coast make all nonbreeding coastal piping plover foraging and roosting habitats vulnerable to the effects of rising sea level. Sea-level rise was cited as a contributing factor in the 68% decline in tidal flats and algal mats in the Corpus Christi area (i.e., Lamar Peninsula to Encinal Peninsula) in Texas between the 1950s and 2004 (Tremblay et al. 2008). Mapping by

Titus and Richman (2001) showed that more than 80% of the lowest land along the Atlantic and Gulf coasts was in Louisiana, Florida, Texas, and North Carolina, where 73.5% of all wintering piping plovers were tallied during the 2006 International Piping Plover Census (Elliott-Smith et al. 2009).

Inundation of piping plover habitat by rising seas could lead to permanent loss of habitat if natural coastal dynamics are impeded by numerous structures or roads, especially if those shorelines are also armored with hardened structures. Without development or armoring, low undeveloped islands can migrate toward the mainland, pushed by the overwashing of sand eroding from the seaward side and being re-deposited in the bay (Scavia et al. 2002). Overwash and sand migration are impeded on developed portions of islands. Instead, as sea-level increases, the ocean-facing beach erodes and the resulting sand is deposited offshore. The buildings and the sand dunes then prevent sand from washing back toward the lagoons, and the lagoon side becomes increasingly submerged during extreme high tides (Scavia et al. 2002), diminishing both barrier beach shorebird habitat and protection for mainland developments.

Modeling for three sea-level rise scenarios (reflecting variable projections of global temperature rise) at five important U.S. shorebird staging and wintering sites predicted loss of 20-70% of current intertidal foraging habitat (Galbraith et al. 2002). These authors estimated probabilistic sea-level changes for specific sites partially based on historical rates of sea-level change (from tide gauges at or near each site); they then superimposed this on projected 50% and 5% probability of global sea-level changes by 2100 of 34 cm and 77 cm, respectively. The 50% and 5% probability sea level change projections were based on assumed global temperature increases of 2° C (50% probability) and 4.7° C (5% probability). The most severe losses were projected at sites where the coastline is unable to move inland due to steep topography or seawalls. The Galbraith et al. (2002) Gulf Coast study site, Bolivar Flats, Texas, is a designated critical habitat unit known to host high numbers of piping plovers during migration and throughout the winter; e.g., 275 individuals were tallied during the 2006 International Piping Plover Census (Elliott-Smith et al. 2009). Under the 50% likelihood scenario for sea-level rise, Galbraith et al. (2002) projected approximately 38% loss of intertidal flats at Bolivar Flats by 2050; however, after initially losing habitat, the area of tidal flat habitat was predicted to slightly increase by the year 2100, because Bolivar Flats lacks armoring, and the coastline at this site can thus migrate inland. Although habitat losses in some areas are likely to be offset by gains in other locations, Galbraith et al. (2002) noted that time lags may exert serious adverse effects on shorebird populations. Furthermore, even if piping plovers are able to move their wintering locations in response to accelerated habitat changes, there could be adverse effects on the birds' survival rates or reproductive fitness.

Table 8 displays the potential for adjacent development and/or hardened shorelines to impede response of habitat to sea-level rise in the eight states supporting wintering piping plovers. Although complete linear shoreline estimates are not readily obtainable, almost all known piping plover wintering sites in the U.S. were surveyed during the 2006 International Piping Plover Census. To estimate effects at the census sites, as well as additional areas where piping plovers have been found outside of the census period, Service biologists reviewed satellite imagery and spoke with other biologists familiar with the sites. Of 406 sites, 204 (50%) have adjacent structures that may prevent the creation of new habitat if existing habitat were to become inundated. These threats will be perpetuated in places where damaged structures are repaired and replaced, and exacerbated where the height and strength of structures are increased. Data do not exist on the amount or types of hardened structures at wintering sites in the Bahamas, other Caribbean countries, or Mexico.

Table 8. Number of sites surveyed during the 2006 winter International Piping Plover Census with hardened or developed structures adjacent to the shoreline.

State	**Number of sites surveyed during the 2006 winter Census**	**Number of sites with some armoring or development**	**Percent of sites affected**
North Carolina	37 (+2)*	20	51
South Carolina	39	18	46
Georgia	13	2	15
Florida	188	114	61
Alabama	4 (+2)*	3	50
Mississippi	16	7	44
Louisiana	25 (+2)*	9	33
Texas	78	31	40
Overall Total	406	204	50

An asterisk (*) indicates additional piping plovers sites not surveyed in the 2006 Census.

Sea-level rise poses a significant threat to all piping plover populations during the migration and wintering portion of their life cycle. Ongoing coastal stabilization activities may strongly influence the effects of sea-level rise on piping plover habitat. Improved understanding of how sea-level rise will affect the quality and quantity of habitat for migrating and wintering piping plovers is an urgent need.

Storm events

Although coastal piping plover habitats are storm-created and maintained, the 1996 Atlantic Coast Recovery Plan also noted that storms and severe cold weather may take a toll on piping plovers, and the 2003 Great Lakes Recovery Plan postulated that loss of habitats such as overwash passes or wrack, where birds shelter during harsh weather, poses a threat.

Storms are a component of the natural processes that form coastal habitats used by migrating and wintering piping plovers, and positive effects of storm-induced overwash and vegetation removal have been noted in portions of the wintering range. For example, Gulf Islands National Seashore habitats in Florida benefited from increased washover events that created optimal habitat conditions during the 2004 and 2005 hurricane seasons, with biologists reporting piping plover use of these habitats within six months of the storms (Nicholas 2005 pers. communication). Hurricane Katrina (2005) overwashed the mainland beaches of Mississippi, creating many tidal flats where piping plovers were subsequently observed (Winstead 2008). Hurricane Katrina also created a new inlet and improved habitat conditions on some areas of Dauphin Island, Alabama (LeBlanc 2009 pers. communication). Conversely, localized storms, since Katrina, have induced habitat losses on Dauphin Island (LeBlanc 2009 pers. communication).

Noel and Chandler (2005) suspect that changes in habitat caused by multiple hurricanes along the Georgia coastline altered the spatial distribution of piping plovers and may have contributed to winter mortality of three Great Lakes piping plovers. Following Hurricane Ike in 2008, Arvin (2009) reported decreased numbers of piping plovers at some heavily eroded Texas beaches in the center of the storm impact area and increases in plover numbers at sites about 100 miles to the southwest. However, piping plovers were observed later in the season using tidal lagoons and pools that Ike created behind the eroded beaches (Arvin 2009).

The adverse effects on piping plovers attributed to storms are sometimes due to a combination of storms and other environmental changes or human use patterns. For example, four hurricanes between 2002 and 2005 are often cited in reference to rapid erosion of the Chandeleur Islands, a chain of low-lying islands in Louisiana where the 1991 International Piping Plover Census tallied more than 350 piping plovers. Comparison of imagery taken three years before and several days after Hurricane Katrina found that the Chandeleur Islands lost 82% of their surface area (Sallenger et al. 2009 in review), and a review of aerial photography prior to the 2006 Census suggested little piping plover habitat remained (Elliott-Smith et al. 2009). However, Sallenger et al. (2009 in review) noted that habitat changes in the Chandeleurs stem not only from the effects of these storms but rather from the combined effects of the storms, long-term (>1,000 years) diminishing sand supply, and sea-level rise relative to the land.

Other storm-induced adverse effects include post-storm acceleration of human activities such as beach nourishment, sand scraping, and berm and seawall construction. Such stabilization activities can result in the loss and degradation of feeding and resting habitats. Storms also can cause widespread deposition of debris along beaches. Removal of debris often requires large machinery, which can cause extensive disturbance and adversely affect habitat elements such as wrack. Another example of indirect adverse effects linked to a storm event is the increased access to Pelican Island (LeBlanc 2009 pers. communication) due to merging with Dauphin Island following a 2007 storm (Gibson et al. 2009).

Recent climate change studies indicate a trend toward increasing hurricane numbers and intensity (Emanuel 2005; Webster et al. 2005). When combined with predicted effects of sea-level rise, there may be increased cumulative impacts from future storms.

In sum, storms can create or enhance piping plover habitat while causing localized losses elsewhere in the wintering and migration range. Available information suggests that some birds may have resiliency to storms and move to unaffected areas without harm, while other reports suggest birds may perish from storm events. Significant concerns include disturbance to piping plovers and habitats during cleanup of debris, and post-storm acceleration of shoreline stabilization activities, which can cause persistent habitat degradation and loss.

Summary

Habitat loss and degradation on winter and migration grounds from shoreline and inlet stabilization efforts, both within and outside of designated critical habitat, remain a serious threat to all piping plover populations. Modeling strongly suggests that the population is very sensitive to adult and juvenile survival. Therefore, while there is a great deal of effort extended to improve breeding success, to improve and maintain a higher population over time, it is also necessary to ensure that the wintering habitat, where birds spend most of their time, is secure. On the wintering grounds, the shoreline areas used by wintering piping plovers are being developed, stabilized, or otherwise altered, making it unsuitable. Even in areas where habitat conditions are appropriate, human disturbance on beaches may negatively impact piping plovers' energy budget, as they may spend more time being vigilant and less time in foraging and roosting behavior. In many cases, the disturbance is severe enough, that piping plovers appear to avoid some areas altogether. Threats on the wintering grounds may impact piping plovers' breeding success if they start migration or arrive at the breeding grounds with a poor body condition.

5) Analysis of the Species Likely to be Affected

The proposed action has the potential to adversely affect wintering and migrating piping plovers and their habitat from all breeding populations that may use the Action Area. The Atlantic Coast breeding population of piping plover is listed as threatened, while the Great Lakes breeding population is listed as endangered. Potential effects to piping plover include direct loss of foraging and roosting habitat in the Action Area and in the updrift and downdrift portions the beach, degradation of foraging habitat and destruction of the prey base from sand disposal, and attraction of predators due to food waste from the construction crew. Plovers face predation by avian and mammalian predators that are present year-round on the wintering and nesting grounds. The stabilization of the shoreline may also result in less suitable nesting habitat for the piping plover and other nesting shorebirds.

B. Environmental Baseline

North Carolina barrier beaches are part of a complex and dynamic coastal system that continually responds to inlets, tides, waves, erosion and deposition, longshore sediment transport, and depletion, fluctuations in sea level, and weather events. The location and shape of the coastline perpetually adjusts to these physical forces. Winds move sediment across the dry beach forming dunes and the island interior landscape. The natural communities contain plants and animals that are subject to shoreline erosion and deposition, salt spray, wind, drought conditions, and sandy soils. Vegetative communities include foredunes, primary and secondary dunes, interdunal swales, sand pine scrub, and maritime forests.

During storm events, overwash across the barrier islands is common, depositing sediments on the bayside, clearing vegetation and increasing the amount of open, sandflat habitat ideal for shoreline dependent shorebirds. However, the protection or persistence of these important natural land forms, processes, and wildlife resources is often in conflict with long-term beach stabilization projects and their indirect effects, i.e., increases in residential development, infrastructure, and public recreational uses, and preclusion of overwash which limits the creation of open sand flats preferred by piping plovers.

1) Status of the Species within the Action Area

On Ocean Isle and Holden Beach, the 2006 International Piping Plover Census surveys documented 4 wintering piping plovers on the east end of Ocean Isle, and no breeding piping plovers (Elliott-Smith et al. 2009). Data provided by the NCWRC indicate as many as 39 piping plovers on Ocean Isle and Holden Beach in 2001, with a high of 13 observations in March of that year. See **Table 9**, below.

Table 9. Number of piping plovers observed between 1987 and 2012 on Ocean Isle and Holden Beach. The data includes some years with multiple surveys, so numbers may not represent individual birds.

Year	Number of Piping Plovers
1987	2
1988	0
1989	4
1990	8
1991	6
1992	8
1993	8
1994	2
1995	2
1996	1
1997	7
1998	8
1999	7
2000	8
2001	39
2002	25
2003	0
2004	3
2005	4
2006	7
2007	8
2008	14
2009	2
2011	9
2012	0

From data provided in the BA, as many as 4 breeding pairs of piping plovers have been documented in the Action Area between 1987 and 2012. (**Table 10**).

Table 10. Number of breeding pairs of piping plovers observed between 1987 and 2012 on Ocean Isle and Holden Beach.

Year	Number of Piping Plover breeding pairs
1987	1
1988	0
1989	2
1990	2
1991	2
1992	4
1993	4
1994	1
1995	1
1996	0
1997	2
1998	4
1999	0
2000	0
2001	0
2002	0
2003	0
2004	0
2005	0
2006	0
2007	1
2008	0
2009	0
2011	0
2012	0

2) Factors Affecting the Species Environment within the Action Area

A number of recent and on-going beach disturbance activities have altered the proposed Action Area and, to a greater extent, the North Carolina coastline, and many more are proposed along the coastline for the near future. **Table 3** (page 53) lists the most recent projects within the past 5 years.

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets, including those individuals originating from hotels, beachfront and nearby residences.

Sand nourishment: The beaches of Ocean Isle and Holden Beach are regularly nourished with sand from the Corps' CSDR project. Nourishment activities widen beaches, change their sedimentology and stratigraphy, alter coastal processes and often plug dune gaps and remove overwash areas.

Inlet dredging activities alter the sediment dynamics on adjacent shorelines and stabilize these dynamic environments; beach disposal of dredge material further alters the natural habitat adjacent to inlets. Estuarine dredging of navigational channels can alter water circulation patterns and sediment transport pathways, as well as increase the frequency and magnitude of boat wakes; sound-side sand or mud flats may be impacted by increased erosion rates as a result. The Corps has regularly dredged Shallotte Inlet every few years since 2001 as part of the Ocean Isle Coastal Storm Damage Reduction (CSDR), and the sediment has been disposed on Ocean Isle.

Beach scraping or bulldozing can artificially steepen beaches, stabilize dune scarps, plug dune gaps, and redistribute sediment distribution patterns. Artificial dune building, often a product of beach scraping, removes low-lying overwash areas and dune gaps. As chronic erosion catches up to structures throughout the Action Area, artificial dune systems are constructed and maintained to protect beachfront structures either by sand fencing or fill placement. Beach scraping or bulldozing has been frequent on North Carolina beaches in recent years, in response to storms and the continuing retreat of the shoreline with rising sea level. These activities primarily occur during the winter months. Artificial dune or berm systems have been constructed and maintained in several areas. These dunes make the artificial dune ridge function like a seawall that blocks natural beach retreat, evolution, and overwash.

Sandbags and revetments are vertical structures built parallel to the beach in front of buildings, roads, and other facilities to protect them from erosion. However, these structures often accelerate erosion by causing scouring in front of and downdrift from the structure (Hayes and

Michel 2008), which can eliminate piping plover habitat. Geotubes (long cylindrical bags made of high-strength permeable fabric and filled with sand) and sandbag revetments are softer alternatives, but act as barriers by preventing overwash. There are two existing rock revetments along the coast of North Carolina: one at Fort Fisher (approximately 3,040 lf), and another along Carolina Beach (approximately 2,050 lf). Sandbags and sandbag revetments have been placed along at least 1,400 lf of the Action Area on Ocean Isle Beach. A sandbag revetment at least 1,500 lf long was constructed in 2015 at the north end of North Topsail Beach.

C. Effects of the Action

This section is an analysis of the beneficial, direct and indirect effects of the proposed action on migrating, wintering, and breeding piping plovers within the Action Area. The analysis includes effects interrelated and interdependent of the project activities. An interrelated activity is an activity that is part of a proposed action and depends on the proposed activity. An interdependent activity is an activity that has no independent utility apart from the action.

1) Factors to be Considered

The proposed project will occur within habitat used by migrating, wintering, and breeding piping plovers and construction will occur during a portion of the migration and winter seasons. Long-term and permanent impacts could preclude the creation of new habitat and increase recreational disturbance. Short-term and temporary impacts to piping plovers could result from project work disturbing roosting plovers and degrading currently occupied foraging areas.

Proximity of the action: Construction of the groin and sand placement activities would occur within and adjacent to foraging and roosting breeding habitats for migrating or wintering piping plovers, and potential breeding habitat.

Distribution: Project construction activities that may impact migrants and the wintering population of piping plovers, and potential breeding piping plovers would occur along the eastern end of Ocean Isle and western end of Holden Beach.

Timing: The timing of project construction could directly and indirectly impact migrating and wintering piping plovers. Piping plovers and red knots may be present year-round in the Action Area, however, the timing of sand placement and groin construction activities will likely occur during the migration and wintering period (July to May).

Nature of the effect: The effects of the project construction include a temporary reduction in foraging and resting habitat and nesting habitat, a long-term decreased rate of change that may preclude habitat creation, and increased recreational disturbance. A decrease in the survival of piping plovers on the migration and winter grounds due to the lack of optimal habitat may contribute to decreased survival rates, decreased productivity on the breeding grounds, and increased vulnerability to the three populations.

Although the Service expects direct short-term effects from disturbance during project construction, it is anticipated the action will also result in direct and indirect, long term effects to piping plovers. Direct effects to piping plovers and their habitat as a result of groin and jetty repair or replacement will primarily be due to construction ingress and egress when construction is required to be conducted from land. In addition, construction materials and equipment may need to be stockpiled on the beach. Piping plover habitats would remain disturbed until the project is completed and the habitats are restored. The direct effects would be expected to be short-term in duration, until the benthic community reestablishes within the new beach profile. Indirect effects from the activity, including those related to altered sand transport systems, may continue to occur as long as the groin remains on the beach. Due to downdrift erosion, there may be loss or degradation of piping plover Critical Habitat Unit NC-17. The Service expects there may be morphological changes to piping plover habitat and critical habitat, including roosting, foraging, and nesting habitat.

Duration: Groin installation will be a one-time activity, which will take as long as 4 ½ months to complete. Sand fillet maintenance will be a recurring activity and will take up to 10 weeks to complete each time. Thus, the direct effects would be expected to be short-term in duration. After each dredging event, the loss of any Critical Habitat in the intertidal shoals will not be recovered unless and until sand movement again creates shoals in the project area. Indirect effects from the activity may continue to impact migrating, wintering, and breeding plovers in subsequent seasons after sand placement. The habitat will be temporarily unavailable to wintering plovers during the construction period, and the quality of the habitat will be reduced for several months or perhaps years following project activities. The mean linear distance moved by wintering plovers from their core area is estimated to be approximately 2.1 miles (Drake et al. 2001), suggesting they could be negatively impacted by temporary disturbances anywhere in their core habitat area. Erosion and loss of habitat down-drift of the groin may increase after project completion and have long term-impacts.

Disturbance frequency: Disturbance from groin construction activities will be short-term lasting up to two years. Recreational disturbance may increase after project completion and have long term-impacts. Disturbance from maintenance of the sand fillet can be anticipated every 5 years for the life of the project.

Disturbance intensity and severity: Project construction is anticipated to be conducted during portions of the piping plover migration, winter, and nesting seasons. Conservation measures have been incorporated into the project to minimize impacts. The Action Area encompasses an area in the nesting and wintering range of the piping plover; however, the overall intensity of the disturbance is expected to be minimal. The intensity of the effect on piping plover habitat may vary depending on the frequency of the sand placement activities, the existence of staging areas, and the location of the beach access points. The severity of direct impacts is also likely to be slight, as plovers located within the Action Area are expected to move outside of the construction zone due to disturbance; therefore, no plovers are expected to be directly taken as a result of this action.

2) Analyses for Effects of the Action

Beneficial effects: For some highly eroded beaches, sand placement will have a beneficial effect on the habitat's ability to support wintering piping plovers. Narrow beaches that do not support a productive wrack line may see an improvement in foraging habitat available to piping plovers following sand placement. The addition of sand to the sediment budget may also increase a sand-starved beach's likelihood of developing habitat features valued by piping plovers, including washover fans and emergent nearshore sand bars.

Direct effects: Direct effects are those direct or immediate effects of a project on the species or its habitat. The construction window (i.e., beach renourishment and groin installation) will extend through one or more piping plover migration and winter seasons. Since piping plovers can be present on these beaches year-round, construction is likely to occur while this species is utilizing these beaches and associated habitats. Heavy machinery and equipment (e.g., trucks and bulldozers operating on Action Area beaches, the placement of the dredge pipeline along the beach, and sand disposal) may adversely affect piping plovers in the Action Area by disturbance and disruption of normal activities such as roosting and foraging, and possibly forcing birds to expend valuable energy reserves to seek available habitat elsewhere.

Burial and suffocation of invertebrate species will occur during each nourishment and renourishment cycle. Impacts from maintenance of the sand fillet will affect at least 3,214 lf of shoreline. Timeframes projected for benthic recruitment and re-establishment following beach nourishment are between 6 months to 2 years.

Maintenance dredging of shallow-draft inlets can occasionally require the removal of emergent shoals that may have formed at the location of the Federally-authorized channel from the migration of the channel over time. In these cases, the dredging activities would result in a complete take of that habitat. However, this take could be either temporary or more permanent in nature depending upon the location of future shoaling within the inlet.

Indirect effects: The proposed project includes beach renourishment and groin installation along approximately 3,500 lf of shoreline as protective elements against shoreline erosion to protect man-made infrastructure. Indirect effects include reducing the potential for the formation of optimal foraging, roosting, and nesting habitat, erosion and loss of habitat downdrift of the groin, and increasing the attractiveness of these beaches for recreation increasing recreational pressures within the Action Area. Recreational activities that potentially adversely affect plovers include disturbance by unleashed pets and increased pedestrian use.

3) Species' Response to the Proposed Action

The Service anticipates potential adverse effects throughout the Action Area by limiting proximity to roosting, foraging, and nesting habitat, degrading occupied foraging habitat, and increasing disturbance from increased recreational use.

Elliott and Teas (1996) found a significant difference in actions between piping plovers encountering pedestrians and those not encountering pedestrians. Piping plover encountering pedestrians spend proportionately more time in non-foraging behavior. This study suggests that interactions with pedestrians on beaches cause birds to shift their activities from calorie acquisition to calorie expenditure. In winter and migration sites, human disturbance continues to decrease the amount of undisturbed habitat and appears to limit local piping plover abundance (Zonick and Ryan 1996).

Disturbance also reduces the time migrating shorebirds spend foraging (Burger 1991). Pfister et al. (1992) implicate disturbance as a factor in the long-term decline of migrating shorebirds at staging areas. While piping plover migration patterns and needs remain poorly understood and occupancy of a particular habitat may involve shorter periods relative to wintering, information about the energetics of avian migration indicates that this might be a particularly critical time in the species' life cycle.

D. Cumulative Effects

This project occurs on non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion.

It is reasonable to expect continued shoreline stabilization and beach renourishment projects in this area in the future since erosion and sea-level rise increases would impact the existing beachfront development.

VI. RED KNOT

A. Status of the Species/Critical Habitat

1) Species/Critical Habitat Description

On December 11, 2014, the Service listed the rufa red knot (*Calidris canutus rufa*) (or red knot) as threatened throughout its range.

The red knot is a medium-sized shorebird about 9 to 11 inches (in) (23 to 28 centimeters (cm)) in length. The red knot migrates annually between its breeding grounds in the Canadian Arctic and several wintering regions, including the Southeast United States (Southeast), the Northeast Gulf of Mexico, northern Brazil, and Tierra del Fuego at the southern tip of South America. During both the northbound (spring) and southbound (fall) migrations, red knots use key staging and stopover areas to rest and feed. Red knots migrate through and overwinter in North Carolina. The term "winter" is used to refer to the nonbreeding period of the red knot life cycle when the birds are not undertaking migratory movements. Red knots are most common in North Carolina during the migration season (mid-April through May and July to Mid-October), and may be present in the state throughout the year (Fussell 1994; Potter et al. 1980). Wintering areas for the red knot include the Atlantic coasts of Argentina and Chile, the north coast of Brazil, the Northwest Gulf of Mexico from the Mexican State of Tamaulipas through Texas to Louisiana, and the Southeast United States from Florida to North Carolina (Newstead et al. 2013; Niles et al. 2008). Smaller numbers of knots winter in the Caribbean, and along the central Gulf coast, the mid-Atlantic, and the Northeast United States. Little information exists on where juvenile red knots spend the winter months (USFWS and Conserve Wildlife Foundation 2012), and there may be at least partial segregation of juvenile and adult red knots on the wintering grounds. There is no designation of critical habitat for red knot.

2) Life History

Each year red knots make one of the longest distance migrations known in the animal kingdom, traveling up to 19,000 miles (mi) (30,000 kilometers (km) annually between breeding grounds in the Arctic Circle and wintering grounds. Red knots undertake long flights that may span thousands of miles without stopping. As they prepare to depart on long migratory flights, they undergo several physiological changes. Before takeoff, the birds accumulate and store large amounts of fat to fuel migration and undergo substantial changes in metabolic rates. In addition, leg muscles, gizzard (a muscular organ used for grinding food), stomach, intestines, and liver all decrease in size, while pectoral (chest) muscles and heart increase in size. Due to these physiological changes, red knots arriving from lengthy migrations are not able to feed maximally until their digestive systems regenerate, a process that may take several days. Because stopovers are time-constrained, red knots require stopovers rich in easily-digested food to achieve adequate weight gain (Niles et al. 2008; van Gils et al. 2005a; van Gils et al. 2005b; Piersma et al. 1999) that fuels the next migratory flight and, upon arrival in the Arctic, fuels a body transformation to breeding condition (Morrison 2006). Red knots from different wintering areas appear to employ different migration strategies, including differences in timing, routes, and stopover areas. However, full segregation of migration strategies, routes, or stopover areas does not occur among red knots from different wintering areas.

Major spring stopover areas along the Mid- and South Atlantic coast include Río Gallegos, Península Valdés, and San Antonio Oeste (Patagonia, Argentina); Lagoa do Peixe (eastern Brazil, State of Rio Grande do Sul); Maranhão (northern Brazil); the Virginia barrier islands (United States); and Delaware Bay (Delaware and New Jersey, United States) (Cohen et al. 2009; Niles et al. 2008; González 2005). Important fall stopover sites include southwest Hudson Bay (including the Nelson River delta), James Bay, the north shore of the St. Lawrence River, the Mingan Archipelago, and the Bay of Fundy in Canada; the coasts of Massachusetts and New Jersey and the mouth of the Altamaha River in Georgia, United States; the Caribbean (especially Puerto Rico and the Lesser Antilles); and the northern coast of South America from Brazil to Guyana (Newstead et al. 2013; Niles 2012; Niles et al. 2010; Schneider and Winn 2010; Niles et al. 2008; Antas and Nascimento 1996; Morrison and Harrington 1992; Spaans 1978). However, large and small groups of red knots, sometimes numbering in the thousands, may occur in suitable habitats all along the Atlantic and Gulf coasts from Argentina to Canada during migration (Niles et al. 2008).

Some red knots wintering in the Southeastern United States and the Caribbean migrate north along the U.S. Atlantic coast before flying overland to central Canada from the mid-Atlantic, while others migrate overland directly to the Arctic from the Southeastern U.S. coast (Niles et al. 2012). These eastern red knots typically make a short stop at James Bay in Canada, but may also stop briefly along the Great Lakes, perhaps in response to weather conditions (Niles et al. 2008; Morrison and Harrington 1992). Red knots are restricted to the ocean coasts during winter, and occur primarily along the coasts during migration. However, small numbers of rufa red knots are reported annually across the interior United States (i.e., greater than 25 miles from the Gulf or Atlantic Coasts) during spring and fall migration—these reported sightings are concentrated along the Great Lakes, but multiple reports have been made from nearly every interior State (eBird.org 2012).

Long-distance migrant shorebirds are highly dependent on the continued existence of quality habitat at a few key staging areas. These areas serve as stepping stones between wintering and breeding areas. Conditions or factors influencing shorebird populations on staging areas control much of the remainder of the annual cycle and survival of the birds (Skagen 2006; International Wader Study Group 2003). At some stages of migration, very high proportions of entire populations may use a single migration staging site to prepare for long flights. Red knots show some fidelity to particular migration staging areas between years (Duerr et al. 2011; Harrington 2001).

Habitats used by red knots in migration and wintering areas are similar in character, generally coastal marine and estuarine (partially enclosed tidal area where fresh and salt water mixes) habitats with large areas of exposed intertidal sediments. In North America, red knots are commonly found along sandy, gravel, or cobble beaches, tidal mudflats, salt marshes, shallow coastal impoundments and lagoons, and peat banks (Cohen et al. 2010; Cohen et al. 2009; Niles et al. 2008; Harrington 2001; Truitt et al. 2001). The supra-tidal (above the high tide) sandy habitats of inlets provide important areas for roosting, especially at higher tides when intertidal habitats are inundated (Harrington 2008).

The red knot is a specialized molluscivore, eating hard-shelled mollusks, sometimes supplemented with easily accessed softer invertebrate prey, such as shrimp- and crab-like organisms, marine worms, and horseshoe crab (*Limulus polyphemus*) eggs (Piersma and van Gils 2011; Harrington 2001). Mollusk prey are swallowed whole and crushed in the gizzard (Piersma and van Gils 2011). Foraging activity is largely dictated by tidal conditions, as red knots rarely wade in water more than 0.8 to 1.2 in (2 to 3 cm) deep (Harrington 2001). Due to bill morphology, the red knot is limited to foraging on only shallow-buried prey, within the top 0.8 to 1.2 in (2 to 3 cm) of sediment (Gerasimov 2009; Zwarts and Blomert 1992).

The primary prey of the rufa red knot in non-breeding habitats include blue mussel (*Mytilus edulis*) spat (juveniles); *Donax* and *Darina* clams; snails (*Littorina spp*.), and other mollusks, with polycheate worms, insect larvae, and crustaceans also eaten in some locations. A prominent departure from typical prey items occurs each spring when red knots feed on the eggs of horseshoe crabs, particularly during the key migration stopover within the Delaware Bay of New Jersey and Delaware. Delaware Bay serves as the principal spring migration staging area for the red knot because of the availability of horseshoe crab eggs (Clark et al. 2009; Harrington 2001; Harrington 1996; Morrison and Harrington 1992), which provide a superabundant source of easily digestible food.

Red knots and other shorebirds that are long-distance migrants must take advantage of seasonally abundant food resources at intermediate stopovers to build up fat reserves for the next non-stop, long-distance flight (Clark et al. 1993). Although foraging red knots can be found widely distributed in small numbers within suitable habitats during the migration period, birds tend to concentrate in those areas where abundant food resources are consistently available from year to year.

3) Population Dynamics

In the United States, red knot populations declined sharply in the late 1800s and early 1900s due to excessive sport and market hunting, followed by hunting restrictions and signs of population recovery by the mid-1900s (Urner and Storer 1949; Stone 1937; Bent 1927). However, it is unclear whether the red knot population fully recovered its historical numbers (Harrington 2001) following the period of unregulated hunting. More recently, long-term survey data from two key areas (Tierra del Fuego wintering area and Delaware Bay spring stopover site) both show a roughly 75 percent decline in red knot numbers since the 1980s (Dey et al. 2011; Clark et al. 2009; Morrison et al. 2004; Morrison and Ross 1989; Kochenberger 1983; Dunne et al. 1982; Wander and Dunne, 1982).

For many portions of the knot's range, available survey data are patchy. Prior to the 1980s, numerous natural history accounts are available, but provide mainly qualitative or localized population estimates. No population information exists for the breeding range because, in breeding habitats, red knots are thinly distributed across a huge and remote area of the Arctic. Despite some localized survey efforts, (e.g., Niles et al. 2008), there are no regional or comprehensive estimates of breeding abundance, density, or productivity (Niles et al. 2008).

Counts in wintering areas are useful in estimating red knot populations and trends because the birds generally remain within a given wintering area for a longer period of time compared to the areas used during migration. This eliminates errors associated with turnover or double-counting that can occur during migration counts. Harrington et al. (1988) reported that the mean count of birds wintering in Florida was 6,300 birds (± 3,400, one standard deviation) based on 4 aerial surveys conducted from October to January in 1980 to 1982. Based on these surveys and other work, the Southeast wintering group was estimated at roughly 10,000 birds in the 1970s and 1980s (Harrington 2005a).

Based on resightings of birds banded in South Carolina and Georgia from 1999 to 2002, the Southeast wintering population was estimated at 11,700 ± 1,000 (standard error) red knots. Although there appears to have been a gradual shift by some of the southeastern knots from the Florida Gulf coast to the Atlantic coasts of Georgia and South Carolina, population estimates for the Southeast region in the 2000s were at about the same level as during the 1980s (Harrington 2005a). Based on recent modeling using resightings of marked birds staging in Georgia in fall, as well as other evidence, the Southeast wintering group may number as high as 20,000 (B.

Harrington pers. comm. November 12, 2012), but field survey data are not available to corroborate this estimate.

Beginning in 2006, coordinated red knot surveys have been conducted from Florida to Delaware Bay during 2 consecutive days from May 20 to 24 (**Table 11**). This period is thought to represent the peak of the red knot migration. There has been variability in methods, observers, and areas covered. From 2006 to 2010, there was no change in counts that could not be attributed to varying geographic survey coverage (Dey et al. 2011); thus, we do not consider any apparent trends in these data before 2010.

Table 11. Red knot counts along the Atlantic coast of the United States, May 20 to 24, 2006 to 2012 (A. Dey pers. comm. October 12, 2012; Dey et al. 2011).

<table>
<tr><th>State</th><th>2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th></tr>
<tr><td>New Jersey</td><td>7,860</td><td>4,445</td><td>10,045</td><td rowspan="2">16,229</td><td>8,945</td><td>7,737</td><td>23,525</td></tr>
<tr><td>Delaware</td><td>820</td><td>2,950</td><td>5,350</td><td>5,530</td><td>5,067</td><td>3,433</td></tr>
<tr><td>Maryland</td><td></td><td></td><td>663</td><td>78</td><td>5</td><td>83</td><td>139</td></tr>
<tr><td>Virginia</td><td>5,783</td><td>5,939</td><td>7,802</td><td>3,261</td><td>8,214</td><td>6,236</td><td>8,482</td></tr>
<tr><td>North Carolina</td><td>235</td><td>304</td><td>1,137</td><td>1,466</td><td>1,113</td><td>1,868</td><td>2,832</td></tr>
<tr><td>South Carolina</td><td></td><td>125</td><td>180</td><td>10</td><td>1,220</td><td>315</td><td>542</td></tr>
<tr><td>Georgia</td><td>796</td><td>2,155</td><td>1,487</td><td></td><td>260</td><td>3,071</td><td>1,466</td></tr>
<tr><td>Florida</td><td></td><td></td><td>868</td><td>800</td><td>41</td><td></td><td>10</td></tr>
<tr><td>Total</td><td>15,494</td><td>15,918</td><td>27,532</td><td>21,844</td><td>25,328</td><td>24,377</td><td>40,429</td></tr>
</table>

Because red knot numbers peak earlier in the Southeast than in the mid-Atlantic (M. Bimbi pers. comm. June 27, 2013), the late-May coast-wide survey data likely reflect the movement of some birds north along the coast, and may miss other birds that depart for Canada from the Southeast along an interior (overland) route prior to the survey window. Thus, greater numbers of red knots may utilize Southeastern stopovers than suggested by the data in **Table 11**. For example, a peak count of over 8,000 red knots was documented in South Carolina during spring 2012 (South Carolina Department of Natural Resources 2012). Dinsmore et al. (1998) found a mean of 1,363 (±725) red knots in North Carolina during spring 1992 and 1993, with a peak count of 2,764 birds.

4) Status and Distribution

Reason for listing: The Service has determined that the rufa red knot is threatened due to loss of both breeding and nonbreeding habitat; potential for disruption of natural predator cycles on the breeding grounds; reduced prey availability throughout the nonbreeding range; and increasing frequency and severity of asynchronies ("mismatches") in the timing of the birds' annual migratory cycle relative to favorable food and weather conditions.

Range-Wide Trends:

Wintering areas for the red knot include the Atlantic coasts of Argentina and Chile, the north coast of Brazil, the Northwest Gulf of Mexico from the Mexican State of Tamaulipas through Texas to Louisiana, and the Southeast United States from Florida to North Carolina (Newstead et al. 2013; L. Patrick pers. comm. August 31, 2012; Niles et al. 2008). Smaller numbers of knots winter in the Caribbean, and along the central Gulf coast (Alabama, Mississippi), the mid-Atlantic, and the Northeast United States. *Calidris canutus* is also known to winter in Central America and northwest South America, but it is not yet clear if all these birds are the *rufa* subspecies.

In some years, more red knots have been counted during a coordinated spring migration survey than can be accounted for at known wintering sites, suggesting there are unknown wintering areas. Indeed, geolocators have started revealing previously little-known wintering areas, particularly in the Caribbean (Niles et al. 2012; L. Niles pers. comm. January 8, 2013).

The core of the Southeast wintering area (i.e., that portion of this large region supporting the majority of birds) is thought to shift from year to year among Florida, Georgia, and South Carolina (Niles et al. 2008). However, the geographic limits of this wintering region are poorly defined. Although only small numbers are known, wintering knots extend along the Atlantic coast as far north as Virginia (L. Patrick pers. comm. August 31, 2012; Niles et al. 2006), Maryland (Burger et al. 2012), and New Jersey (BandedBirds.org 2012; H. Hanlon pers. comm. November 22, 2012; A. Dey pers. comm. November 19, 2012). Still smaller numbers of red knots have been reported between December and February from Long Island, New York, through Massachusetts and as far north as Nova Scotia, Canada (eBird.org 2012).

Recovery Criteria

A Recovery Plan for the red knot has not yet been completed. It will be developed, pursuant to Subsection 4(f) of the ESA, in the near future.

Threats to the Red Knot

Within the nonbreeding portion of the range, red knot habitat is primarily threatened by the highly interrelated effects of sea level rise, shoreline stabilization, and coastal development. Lesser threats to nonbreeding habitat include agriculture and aquaculture, invasive vegetation, and beach maintenance activities. Within the breeding portion of the range, the primary threat to red knot habitat is from climate change. With arctic warming, vegetation conditions in the breeding grounds are expected to change, causing the zone of nesting habitat to shift and perhaps contract. Arctic freshwater systems—foraging areas for red knots during the nesting season—are particularly sensitive to climate change. For more information, please see the proposed and final rules and supplemental documents on the Internet at *http://www.regulations.gov* (Docket Number FWS–R5–ES–2013–0097).

Climate Change & Sea Level Rise

The natural history of Arctic-breeding shorebirds makes this group of species particularly vulnerable to global climate change (Meltofte et al. 2007; Piersma and Lindström 2004; Rehfisch and Crick 2003; Piersma and Baker 2000; Zöckler and Lysenko 2000; Lindström and Agrell 1999). Relatively low genetic diversity, which is thought to be a consequence of survival through past climate-driven population bottlenecks, may put shorebirds at more risk from human-induced climate variation than other avian taxa (Meltofte et al. 2007); low genetic diversity may result in reduced adaptive capacity as well as increased risks when population sizes drop to low levels.

In the short term, red knots may benefit if warmer temperatures result in fewer years of delayed horseshoe crab spawning in Delaware Bay (Smith and Michaels 2006) or fewer occurrences of late snow melt in the breeding grounds (Meltofte et al. 2007). However, there are indications that changes in the abundance and quality of red knot prey are already underway (Escudero et al. 2012; Jones et al. 2010), and prey species face ongoing climate-related threats from warmer temperatures (Jones et al. 2010; Philippart et al. 2003; Rehfisch and Crick 2003), ocean acidification (NRC 2010; Fabry et al. 2008), and possibly increased prevalence of disease and parasites (Ward and Lafferty 2004). In addition, red knots face imminent threats from loss of habitat caused by sea level rise (NRC 2010; Galbraith et al. 2002; Titus 1990), and increasing asynchronies ("mismatches") between the timing of their annual breeding, migration, and wintering cycles and the windows of peak food availability on which the birds depend (Smith et al. 2011; McGowan et al. 2011; Meltofte et al. 2007; van Gils et al. 2005a; Baker et al. 2004).

With arctic warming, vegetation conditions in the red knot's breeding grounds are expected to change, causing the zone of nesting habitat to shift and perhaps contract, but this process may take decades to unfold (Feng et al. 2012; Meltofte et al. 2007; Kaplan et al. 2003). Ecological shifts in the Arctic may appear sooner. High uncertainty exists about when and how changing interactions among vegetation, predators, competitors, prey, parasites, and pathogens may affect the red knot, but the impacts are potentially profound (Fraser et al. 2013; Schmidt et al. 2012; Meltofte et al. 2007; Ims and Fuglei 2005).

For most of the year, red knots live in or immediately adjacent to intertidal areas. These habitats are naturally dynamic, as shorelines are continually reshaped by tides, currents, wind, and storms. Coastal habitats are susceptible to both abrupt (storm-related) and long-term (sea level rise) changes. Outside of the breeding grounds, red knots rely entirely on these coastal areas to fulfill their roosting and foraging needs, making the birds vulnerable to the effects of habitat loss from rising sea levels. Because conditions in coastal habitats are also critical for building up nutrient and energy stores for the long migration to the breeding grounds, sea level rise affecting conditions on staging areas also has the potential to impact the red knot's ability to breed successfully in the Arctic (Meltofte et al. 2007).

According to the NRC (2010), the rate of global sea level rise has increased from about 0.02 in (0.6 mm) per year in the late 19th century to approximately 0.07 in (1.8 mm) per year in the last half of the 20th century. The rate of increase has accelerated, and over the past 15 years has been in excess of 0.12 in (3 mm) per year. In 2007, the IPCC estimated that sea level would "likely" rise by an additional 0.6 to 1.9 feet (ft) (0.18 to 0.59 meters (m)) by 2100 (NRC 2010). This projection was based largely on the observed rates of change in ice sheets and projected future thermal expansion of the oceans but did not include the possibility of changes in ice sheet dynamics (e.g., rates and patterns of ice sheet growth versus loss). Scientists are working to improve how ice dynamics can be resolved in climate models. Recent research suggests that sea levels could potentially rise another 2.5 to 6.5 ft (0.8 to 2 m) by 2100, which is several times larger than the 2007 IPCC estimates (NRC 2010; Pfeffer et al. 2008). However, projected rates of sea level rise estimates remain rather uncertain, due mainly to limits in scientific understanding of glacier and ice sheet dynamics (NRC 2010; Pfeffer et al. 2008). The amount of sea level change varies regionally because of different rates of settling (subsidence) or uplift of the land, and because of differences in ocean circulation (NRC 2010). In the last century, for example, sea level rise along the U.S. mid- Atlantic and Gulf coasts exceeded the global average by 5 to 6 in (13 to 15 cm) because coastal lands in these areas are subsiding (USEPA 2013). Land subsidence also occurs in some areas of the Northeast, at current rates of 0.02 to 0.04 in (0.5 to 1 mm) per year across this region (Ashton et al. 2007), primarily the result of slow, natural geologic processes (NOAA 2013). Due to regional differences, a 2-ft (0.6-m) rise in global sea level by the end of this century would result in a relative sea level rise of 2.3 ft (0.7 m) at New York City, 2.9 ft (0.9 m) at Hampton Roads, Virginia, and 3.5 ft (1.1 m) at Galveston, Texas (U.S. Global Change Research Program (USGCRP) 2009). **Table 12** shows that local rates of sea level rise in the range of the red knot over the second half of the 20th century were generally higher than the global rate of 0.07 in (1.8 mm) per year.

Table 12. Local sea level trends from within the range of the red knot (NOAA 2012)

Station	Mean Local Sea Level Trend (mm per year)	Data Period
Pointe-Au-Père, Canada	-0.36 ± 0.40	1900–1983
Woods Hole, Massachusetts	2.61 ± 0.20	1932–2006
Cape May, New Jersey	4.06 ± 0.74	1965–2006
Lewes, Delaware	3.20 ± 0.28	1919–2006
Chesapeake Bay Bridge Tunnel, Virginia	6.05 ± 1.14	1975–2006
Beaufort, North Carolina	2.57 ± 0.44	1953–2006
Clearwater Beach, Florida	2.43 ± 0.80	1973–2006
Padre Island, Texas	3.48 ± 0.75	1958–2006
Punto Deseado, Argentina	-0.06 ± 1.93	1970–2002

Data from along the U.S. Atlantic coast suggest a relationship between rates of sea level rise and long-term erosion rates; thus, long-term coastal erosion rates may increase as sea level rises (Florida Oceans and Coastal Council 2010). However, even if such a correlation is borne out, predicting the effect of sea level rise on beaches is more complex. Even if wetland or upland coastal lands are lost, sandy or muddy intertidal habitats can often migrate or reform. However, forecasting how such changes may unfold is complex and uncertain. Potential effects of sea level rise on beaches vary regionally due to subsidence or uplift of the land, as well as the geological character of the coast and nearshore (U.S. Climate Change Science Program (CCSP) 2009b; Galbraith et al. 2002). Precisely forecasting the effects of sea level rise on particular coastal habitats will require integration of diverse information on local rates of sea level rise, tidal ranges, subsurface and coastal topography, sediment accretion rates, coastal processes, and other factors that is beyond the capability of current models (CCSP 2009b; Frumhoff et al. 2007; Thieler and Hammar-Klose 2000; Thieler and Hammar-Klose 1999).

Because the majority of the Atlantic and Gulf coasts consist of sandy shores, inundation alone is unlikely to reflect the potential consequences of sea level rise. Instead, long-term shoreline changes will involve contributions from inundation and erosion, as well as changes to other coastal environments such as wetland losses. Most portions of the open coast of the United States will be subject to significant physical changes and erosion over the next century because the majority of coastlines consist of sandy beaches, which are highly mobile and in a state of continual change (CCSP 2009b).

By altering coastal geomorphology, sea level rise will cause significant and often dramatic changes to coastal landforms including barrier islands, beaches, and intertidal flats (CCSP 2009b; Rehfisch and Crick 2003), primary red knot habitats. Due to increasing sea levels, storm-surge-driven floods now qualifying as 100-year events are projected to occur as often as every 10 to 20 years along most of the U.S. Atlantic coast by 2050, with even higher frequencies of such large floods in certain localized areas (Tebaldi et al. 2012). Rising sea level not only increases the likelihood of coastal flooding, but also changes the template for waves and tides to sculpt the coast, which can lead to loss of land orders of magnitude greater than that from direct inundation alone (Ashton et al. 2007).

Red knot migration and wintering habitats in the U.S. generally consist of sandy beaches that are dynamic and subject to seasonal erosion and accretion. Sea level rise and shoreline erosion have reduced availability of intertidal habitat used for red knot foraging, and in some areas, roosting sites have also been affected (Niles et al. 2008). With moderately rising sea levels, red knot habitats in many portions of the United States would be expected to migrate or reform rather than be lost, except where they are constrained by coastal development or shoreline stabilization (Titus et al. 2009). However, if the sea rises more rapidly than the rate with which a particular coastal system can keep pace, it could fundamentally change the state of the coast (CCSP 2009b).

Climate change is also resulting in asynchronies during the annual cycle of the red knot. The successful annual migration and breeding of red knots is highly dependent on the timing of departures and arrivals to coincide with favorable food and weather conditions. The frequency and severity of asynchronies is likely to increase with climate change. In addition, stochastic encounters with unfavorable conditions are more likely to result in population-level effects for red knots now than when population sizes were larger, as reduced numbers may have reduced the resiliency of this subspecies to rebound from impacts.

For unknown reasons, more red knots arrived late in Delaware Bay in the early 2000s, which is generally accepted as a key causative factor (along with reduced supplies of horseshoe crab eggs) behind red knot population declines that were observed over this same timeframe. Thus, the red knot's sensitivity to timing asynchronies has been demonstrated through a population-level response. Both adequate supplies of horseshoe crab eggs and high-quality foraging habitat in Delaware Bay can serve to partially mitigate minor asynchronies at this key stopover site. However, the factors that caused delays in the spring migrations of red knots from Argentina and Chile are still unknown, and we have no information to indicate if this delay will reverse, persist, or intensify. Superimposed on this existing threat of late arrivals in Delaware Bay are new threats of asynchronies emerging due to climate change. Climate change is likely to affect the reproductive timing of horseshoe crabs in Delaware Bay, mollusk prey species at other stopover sites, or both, possibly pushing the peak seasonal availability of food outside of the windows when red knots rely on them. In addition, both field studies and modeling have shown strong links between the red knot's reproductive output and conditions in the Arctic including insect abundance and snow cover. Climate change may also cause shifts in the period of optimal arctic conditions relative to the time period when red knots currently breed.

Shoreline stabilization

Structural development along the shoreline and manipulation of natural inlets upset the naturally dynamic coastal processes and result in loss or degradation of beach habitat (Melvin et al. 1991). As beaches narrow, the reduced habitat can directly lower the diversity and abundance of biota (life forms), especially in the upper intertidal zone. Shorebirds may be impacted both by reduced habitat area for roosting and foraging, and by declining intertidal prey resources, as has been documented in California (Defeo et al. 2009; Dugan and Hubbard 2006). In Delaware Bay, hard structures also cause or accelerate loss of horseshoe crab spawning habitat (CCSP 2009b; Botton et al. in Shuster et al. 2003; Botton et al. 1988), and shorebird habitat has been, and may continue to be, lost where bulkheads have been built (Clark in Farrell and Martin 1997). In addition to directly eliminating red knot habitat, hard structures interfere with the creation of new shorebird habitats by interrupting the natural processes of overwash and inlet formation. Where hard stabilization is installed, the eventual loss of the beach and its associated habitats is virtually assured (Rice 2009), absent beach nourishment, which may also impact red knots. Where they are maintained, hard structures are likely to significantly increase the amount of red knot habitat lost as sea levels continue to rise.

In a few isolated locations, however, hard structures may enhance red knot habitat, or may provide artificial habitat. In Delaware Bay, for example, Botton et al. (1994) found that, in the same manner as natural shoreline discontinuities like creek mouths, jetties and other artificial obstructions can act to concentrate drifting horseshoe crab eggs and thereby attract shorebirds. Another example comes from the Delaware side of the bay, where a seawall and jetty at Mispillion Harbor protect the confluence of the Mispillion River and Cedar Creek. These structures create a low energy environment in the harbor, which seems to provide highly suitable conditions for horseshoe crab spawning over a wider variation of weather and sea conditions than anywhere else in the bay (G. Breese pers. comm. March 25, 2013). Horseshoe crab egg densities at Mispillion Harbor are consistently an order of magnitude higher than at other bay beaches (Dey et al. 2011), and this site consistently supports upwards of 15 to 20 percent of all the knots recorded in Delaware Bay (Lathrop 2005). Notwithstanding localized red knot use of artificial structures, and the isolated case of hard structures improving foraging habitat at Mispillion Harbor, the nearly universal effect of such structures is the degradation or loss of red knot habitat.

Sand Placement

Where shorebird habitat has been severely reduced or eliminated by hard stabilization structures, beach nourishment may be the only means available to replace any habitat for as long as the hard structures are maintained (Nordstrom and Mauriello 2001), although such habitat will persist only with regular nourishment episodes (typically on the order of every 2 to 6 years). In Delaware Bay, beach nourishment has been recommended to prevent loss of spawning habitat for horseshoe crabs (Kalasz 2008; Carter et al. in Guilfoyle et al. 2007; Atlantic States Marine Fisheries Commission (ASMFC) 1998), and is being pursued as a means of restoring shorebird habitat in Delaware Bay following Hurricane Sandy (Niles et al. 2013; USACE 2012). Beach nourishment was part of a 2009 project to maintain important shorebird foraging habitat at Mispillion Harbor, Delaware (Kalasz pers. comm. March 29, 2013; Siok and Wilson 2011). However, red knots may be directly disturbed if beach nourishment takes place while the birds are present. On New Jersey's Atlantic coast, beach nourishment has typically been scheduled for the fall, when red knots are present, because of various constraints at other times of year. In addition to causing disturbance during construction, beach nourishment often increases recreational use of the widened beaches that, without careful management, can increase disturbance of red knots. Beach nourishment can also temporarily depress, and sometimes permanently alter, the invertebrate prey base on which shorebirds depend. In addition to disturbing the birds and impacting the prey base, beach nourishment can affect the quality and quantity of red knot habitat (M. Bimbi pers. comm. November 1, 2012; Greene 2002). The artificial beach created by nourishment may provide only suboptimal habitat for red knots, as a steeper beach profile is created when sand is stacked on the beach during the nourishment process. In some cases, nourishment is accompanied by the planting of dense beach grasses, which can directly degrade habitat, as red knots require sparse vegetation to avoid predation. By precluding overwash and Aeolian transport, especially where large artificial dunes are constructed, beach nourishment can also lead to further erosion on the bayside and promote bayside vegetation growth, both of which can degrade the red knot's preferred foraging and roosting habitats (sparsely vegetated flats in or adjacent to intertidal areas). Preclusion of overwash also impedes the formation of new red knot habitats. Beach nourishment can also encourage further development, bringing further habitat impacts, reducing future alternative management options such as a retreat from the coast, and perpetuating the developed and stabilized conditions that may ultimately lead to inundation where beaches are prevented from migrating (M. Bimbi pers. comm. November 1, 2012; Greene 2002).

The quantity and quality of red knot prey may also be affected by the placement of sediment for beach nourishment or disposal of dredged material. Invertebrates may be crushed or buried during project construction. Although some benthic species can burrow through a thin layer of additional sediment, thicker layers (over 35 in (90 cm)) smother the benthic fauna (Greene

2002). By means of this vertical burrowing, recolonization from adjacent areas, or both, the benthic faunal communities typically recover. Recovery can take as little as 2 weeks or as long as 2 years, but usually averages 2 to 7 months (Greene 2002; Peterson and Manning 2001). Although many studies have concluded that invertebrate communities recovered following sand placement, study methods have often been insufficient to detect even large changes (e.g., in abundance or species composition), due to high natural variability and small sample sizes (Peterson and Bishop 2005). Therefore, uncertainty remains about the effects of sand placement on invertebrate communities, and how these impacts may affect red knots.

Dredging/sand mining

Many inlets in the U.S. range of the red knot are routinely dredged and sometimes relocated. In addition, nearshore areas are routinely dredged ("mined") to obtain sand for beach nourishment. Regardless of the purpose, inlet and nearshore dredging can affect red knot habitats. Dredging often involves removal of sediment from sand bars, shoals, and inlets in the nearshore zone, directly impacting optimal red knot roosting and foraging habitats (Harrington in Guilfoyle et al. 2007; Winn and Harrington in Guilfoyle et al. 2006). These ephemeral habitats are even more valuable to red knots because they tend to receive less recreational use than the main beach strand. In addition to causing this direct habitat loss, the dredging of sand bars and shoals can preclude the creation and maintenance of red knot habitats by removing sand sources that would otherwise act as natural breakwaters and weld onto the shore over time (Hayes and Michel 2008; Morton 2003). Further, removing these sand features can cause or worsen localized erosion by altering depth contours and changing wave refraction (Hayes and Michel 2008), potentially degrading other nearby red knot habitats indirectly because inlet dynamics exert a strong influence on the adjacent shorelines. Studying barrier islands in Virginia and North Carolina, Fenster and Dolan (1996) found that inlet influences extend 3.4 to 8.1 mi (5.4 to 13.0 km), and that inlets dominate shoreline changes for up to 2.7 mi (4.3 km). Changing the location of dominant channels at inlets can create profound alterations to the adjacent shoreline (Nordstrom 2000).

Reduced food availability

Commercial harvest of horseshoe crabs has been implicated as a causal factor in the decline of the rufa red knot, by decreasing the availability of horseshoe crab eggs in the Delaware Bay stopover (Niles et al. 2008). Notwithstanding the importance of the horseshoe crab and Delaware Bay, other lines of evidence suggest that the rufa red knot also faces threats to its food resources throughout its range.

During most of the year, bivalves and other mollusks are the primary prey for the red knot. Mollusks in general are at risk from climate change-induced ocean acidification (Fabry et al. 2008). Oceans become more acidic as carbon dioxide emitted into the atmosphere dissolves in the ocean. The pH (percent hydrogen, a measure of acidity or alkalinity) level of the oceans has decreased by approximately 0.1 pH units since preindustrial times, which is equivalent to a 25 percent increase in acidity. By 2100, the pH level of the oceans is projected to decrease by an additional 0.3 to 0.4 units under the highest emissions scenarios (NRC 2010). As ocean acidification increases, the availability of calcium carbonate declines. Calcium carbonate is a key building block for the shells of many marine organisms, including bivalves and other mollusks (USEPA 2012; NRC 2010). Vulnerability to ocean acidification has been shown in bivalve species similar to those favored by red knots, including mussels (Gaylord et al. 2011; Bibby et al. 2008) and clams (Green et al. 2009). Reduced calcification rates and calcium metabolism are also expected to affect several mollusks and crustaceans that inhabit sandy beaches (Defeo et al. 2009), the primary nonbreeding habitat for red knots. Relevant to Tierra del Fuego-wintering knots, bivalves have also shown vulnerability to ocean acidification in Antarctic waters, which are predicted to be affected due to naturally low carbonate saturation levels in cold waters (Cummings et al. 2011).

Blue mussel spat is an important prey item for red knots in Virginia (Karpanty et al. 2012). The southern limit of adult blue mussels has contracted from North Carolina to Delaware since 1960 due to increasing air and water temperatures (Jones et al. 2010). Larvae have continued to recruit to southern locales (including Virginia) via currents, but those recruits die early in the summer due to water and air temperatures in excess of lethal physiological limits. Failure to recolonize southern regions will occur when reproducing populations at higher latitudes are beyond dispersal distance (Jones et al. 2010). Thus, this key prey resource may soon disappear from the red knot’s Virginia spring stopover habitats (Karpanty et al. 2012).

Reduced food availability at the Delaware Bay stopover site due to commercial harvest and subsequent population decline of the horseshoe crab is considered a primary causal factor in the decline of the rufa subspecies in the 2000s (Escudero et al. 2012; McGowan et al. 2011; CAFF 2010; Niles et al. 2008; COSEWIC 2007; González et al. 2006; Baker et al. 2004; Morrison et al. 2004), although other possible causes or contributing factors have been postulated (Fraser et al. 2013; Schwarzer et al. 2012; Escudero et al. 2012; Espoz et al. 2008; Niles et al. 2008). Due to harvest restrictions and other conservation actions, horseshoe crab populations showed some signs of recovery in the early 2000s, with apparent signs of red knot stabilization (survey counts, rates of weight gain) occurring a few years later. Since about 2005, however, horseshoe crab population growth has stagnated for unknown reasons. Under the current management framework (known as Adaptive Resource Management, or ARM), the present horseshoe crab harvest is not considered a threat to the red knot because harvest levels are tied to red knot populations via scientific modeling. Most data suggest that the volume of horseshoe crab eggs is currently sufficient to support the Delaware Bay's stopover population of red knots at its present size. However, because of the uncertain trajectory of horseshoe crab population growth, it is not yet known if the egg resource will continue to adequately support red knot populations over the next 5 to 10 years. In addition, implementation of the ARM could be impeded by insufficient funding for the shorebird and horseshoe crab monitoring programs that are necessary for the functioning of the ARM models. Many studies have established that red knots stopping over in Delaware Bay during spring migration achieve remarkable and important weight gains to complete their migrations to the breeding grounds by feeding almost exclusively on a superabundance of horseshoe crab eggs. A temporal correlation occurred between increased horseshoe crab harvests in the 1990s and declining red knot counts in both Delaware Bay and Tierra del Fuego by the 2000s. Other shorebird species that rely on Delaware Bay also declined over this period (Mizrahi and Peters in Tanacredi et al. 2009), although some shorebird declines began before the peak expansion of the horseshoe crab fishery (Botton et al. in Shuster et al. 2003).

Hunting

Legal and illegal sport and market hunting in the mid-Atlantic and Northeast United States substantially reduced red knot populations in the 1800s, and we do not know if the subspecies ever fully recovered its former abundance or distribution. Neither legal nor illegal hunting are currently a threat to red knots in the United States, but both occur in the Caribbean and parts of South America. Hunting pressure on red knots and other shorebirds in the northern Caribbean and on Trinidad is unknown. Hunting pressure on shorebirds in the Lesser Antilles (e.g., Barbados, Guadeloupe) is very high, but only small numbers of red knots have been documented on these islands, so past mortality may not have exceeded tens of birds per year. Red knots are no longer being targeted in Barbados or Guadeloupe, and other measures to regulate shorebird hunting on these islands are being negotiated. Much larger numbers (thousands) of red knots occur in the Guianas, where legal and illegal subsistence shorebird hunting is common. About 20 red knot mortalities have been documented in the Guianas, but total red knot hunting mortality in this region cannot be surmised. Subsistence shorebird hunting was also common in northern Brazil, but has decreased in recent decades. We have no evidence that hunting was a driving factor in red knot population declines in the 2000s, or that hunting pressure is increasing. In addition, catch limits, handling protocols, and studies on the effects of research activities on survival all indicate that overutilization for scientific purposes is not a threat to the red knot.

Threats to the red knot from overutilization for commercial, recreational, scientific, or educational purposes exist in parts of the Caribbean and South America. Specifically, legal and illegal hunting does occur. We expect mortality of individual knots from hunting to continue into the future, but at stable or decreasing levels due to the recent international attention to shorebird hunting.

Predation

In wintering and migration areas, the most common predators of red knots are peregrine falcons (*Falco peregrinus*), harriers (*Circus spp*.), accipiters (Family Accipitridae), merlins (*F. columbarius*), shorteared owls (*Asio flammeus*), and greater black-backed gulls (*Larus marinus*) (Niles et al. 2008). Other large are anecdotally known to prey on shorebirds (Breese 2010). In migration areas like Delaware Bay, terrestrial predators such as red foxes (*Vulpes vulpes*) and feral cats (*Felis catus*) may be a threat to red knots by causing disturbance, but direct mortality from these predators may be low (Niles et al. 2008).

Although little information is available from the breeding grounds, the long-tailed jaeger (*Stercorarius longicaudus*) is prominently mentioned as a predator of red knot chicks in most accounts. Other avian predators include parasitic jaeger (*S. parasiticus*), pomarine jaeger (*S. pomarinus*), herring gull and glaucous gulls, gyrfalcon (*Falcon rusticolus*), peregrine falcon, and snowy owl (*Bubo scandiacus*). Mammalian predators include arctic fox (*Alopex lagopus*) and sometimes arctic wolves (*Canis lupus arctos*) (Niles et al. 2008; COSEWIC 2007). Predation pressure on Arctic-nesting shorebird clutches varies widely regionally, interannually, and even within each nesting season, with nest losses to predators ranging from close to 0 percent to near 100 percent (Meltofte et al. 2007), depending on ecological factors. Abundance of arctic rodents, such as lemmings, is often cyclical, although less so in North America than in Eurasia. In the Arctic, 3- to 4-year lemming cycles give rise to similar cycles in the predation of shorebird nests. When lemmings are abundant, predators concentrate on the lemmings, and shorebirds breed successfully. When lemmings are in short supply, predators switch to shorebird eggs and chicks (Niles et al. 2008; COSEWIC 2007; Meltofte et al. 2007; USFWS 2003b; Blomqvist et al. 2002; Summers and Underhill 1987).

Recreational disturbance

In some wintering and stopover areas, red knots and recreational users (e.g., pedestrians, ORVs, dog walkers, boaters) are concentrated on the same beaches (Niles et al. 2008; Tarr 2008). Recreational activities affect red knots both directly and indirectly. These activities can cause habitat damage (Schlacher and Thompson 2008; Anders and Leatherman 1987), cause shorebirds to abandon otherwise preferred habitats, and negatively affect the birds' energy balances. Effects to red knots from vehicle and pedestrian disturbance can also occur during construction of shoreline stabilization projects including beach nourishment. Red knots can also be disturbed by motorized and nonmotorized boats, fishing, kite surfing, aircraft, and research activities (Niles et al. 2008; Peters and Otis, 2007; Harrington 2005b; Meyer et al. 1999; Burger 1986) and by beach raking or cleaning.

5) Analysis of the Species Likely to be Affected

The proposed action has the potential to adversely affect wintering and migrating red knots and their habitat. Potential effects to red knots include direct loss of foraging and roosting habitat in the Action Area and in the updrift and downdrift portions of Ocean Isle Beach and Holden Beach, degradation of foraging habitat and destruction of the prey base from sand disposal, and attraction of predators due to food waste from the construction crew. Like the piping plover, red knots face predation by avian and mammalian predators that are present year-round on the migration and wintering grounds.

B. Environmental Baseline

1) Status of the Species within the Action Area

Data provided by the NCWRC for the BA indicate that red knots have been observed on Holden Beach and Ocean Isle Beach for decades. 200 red knots were reported in one survey on Ocean Isle Beach in 1986, while 112 were reported on Ocean Isle Beach in one survey in 2012. See **Table 13**.

Table 13. Number of red knot observations between 1986 and 2012 on Ocean Isle and Holden Beach.

Year	Number of Red Knot observations	
	Ocean Isle Beach	Holden Beach
1986	200	
2006	6	5
2009	11	
2011	23	15
2012	112	56

2) Factors Affecting the Species Environment within the Action Area

A number of recent and on-going beach disturbance activities have altered the proposed Action Area. **Table 3** (page 53) lists the most recent projects, within the past 5 years.

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets, including those individuals originating from hotels, beachfront and nearby residences.

Sand nourishment: The beaches of Ocean Isle and Holden Beach are regularly nourished with sand from the Corps' CSDR project. Nourishment activities widen beaches, change their sedimentology and stratigraphy, alter coastal processes and often plug dune gaps and remove overwash areas.

Inlet dredging activities alter the sediment dynamics on adjacent shorelines and stabilize these dynamic environments; beach disposal of dredge material further alters the natural habitat adjacent to inlets. Estuarine dredging of navigational channels can alter water circulation patterns and sediment transport pathways, as well as increase the frequency and magnitude of boat wakes; sound-side sand or mud flats may be impacted by increased erosion rates as a result. The Corps has regularly dredged Shallotte Inlet every few years since 2001 as part of the Ocean Isle Coastal Storm Damage Reduction (CSDR), and the sediment has been disposed on Ocean Isle.

Beach scraping or bulldozing can artificially steepen beaches, stabilize dune scarps, plug dune gaps, and redistribute sediment distribution patterns. Artificial dune building, often a product of beach scraping, removes low-lying overwash areas and dune gaps. As chronic erosion catches up to structures throughout the Action Area, artificial dune systems are constructed and maintained to protect beachfront structures either by sand fencing or fill placement. Beach scraping or bulldozing has been frequent on North Carolina beaches in recent years, in response to storms and the continuing retreat of the shoreline with rising sea level. These activities primarily occur during the winter months. Artificial dune or berm systems have been constructed and maintained in several areas. These dunes make the artificial dune ridge function like a seawall that blocks natural beach retreat, evolution, and overwash.

Sandbags and revetments are vertical structures built parallel to the beach in front of buildings, roads, and other facilities to protect them from erosion. However, these structures often accelerate erosion by causing scouring in front of and downdrift from the structure (Hayes and Michel 2008), which can eliminate red knot habitat. Geotubes (long cylindrical bags made of high-strength permeable fabric and filled with sand) and sandbag revetments are softer alternatives, but act as barriers by preventing overwash. There are two existing rock revetments along the coast of North Carolina: one at Fort Fisher (approximately 3,040 lf), and another along Carolina Beach (approximately 2,050 lf). Sandbags and sandbag revetments have been placed along at least 1,400 lf of the Action Area on Ocean Isle Beach. A sandbag revetment at least 1,500 lf long was constructed in 2015 at the north end of North Topsail Beach.

C. Effects of the Action

This section is an analysis of the beneficial, direct and indirect effects of the proposed action on migrating and wintering red knots within the Action Area. The analysis includes effects interrelated and interdependent of the project activities. An interrelated activity is an activity that is part of a proposed action and depends on the proposed activity. An interdependent activity is an activity that has no independent utility apart from the action.

1) Factors to be Considered

The proposed project will occur within habitat used by migrating and wintering red knots and construction will occur during a portion of the migration and winter seasons. Long-term and permanent impacts could preclude the creation of new habitat and increase recreational disturbance. Short-term and temporary impacts to red knots could result from project work disturbing roosting red knots and degrading currently occupied foraging areas.

Proximity of action: Beach renourishment and groin installation will occur within and adjacent to red knot roosting and foraging habitat.

Distribution: Project construction activities that may impact migrants and the wintering population of red knots on Ocean Isle and Holden Beach would occur along the shoreline on the east end of Ocean Isle and the west end of Holden Beach.

Timing: The timing of project construction could directly and indirectly impact migrating and wintering red knots.

Nature of the effect: The effects of the project construction include a temporary or permanent reduction in foraging habitat, a long term decreased rate of change that may preclude habitat creation, and increased recreational disturbance. A decrease in the survival of red knots on the migration and winter grounds due to the lack of optimal habitat may contribute to decreased survival rates, decreased productivity on the breeding grounds, and increased vulnerability to the population.

Duration: Groin installation will be a one-time activity, which will take up to 4 ½ months to complete. Sand fillet maintenance will be a recurring activity and will take up to 10 weeks to complete each time. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact migrating and wintering red knots in subsequent seasons after sand placement.

Disturbance frequency: Disturbance from construction activities will be short term, lasting up to 4 ½ months. Disturbance from maintenance of the sand fillet can be anticipated every 5 years for the life of the project. Recreational disturbance may increase after project completion and have long-term impacts.

Disturbance intensity and severity: Project construction is anticipated to be conducted during portions of the red knot migration and winter seasons. Conservation measures have been incorporated into the project to minimize impacts.

2) Analyses for Effects of the Action

Beneficial effects: For some highly eroded beaches, sand placement may have a beneficial effect on the habitat's ability to support wintering or migrating red knots. The addition of sand to the sediment budget may increase a sand-starved beach's likelihood of developing habitat features valued by red knots.

Direct effects: Direct effects are those direct or immediate effects of a project on the species or its habitat. The construction window (i.e., sand placement and groin installation) will extend into one or more red knot migration and winter seasons. Heavy machinery and equipment (e.g., trucks and bulldozers operating on Action Area beaches, the placement of the dredge pipeline along the beach, and sand disposal) may adversely affect migrating and wintering red knots in the Action Area by disturbance and disruption of normal activities such as roosting and foraging, and possibly forcing birds to expend valuable energy reserves to seek available habitat elsewhere.

Burial and suffocation of invertebrate species will occur during each sand fillet maintenance activity. Impacts will affect the 3,500 lf of shoreline. Timeframes projected for benthic recruitment and re-establishment following beach nourishment are between 6 months to 2 years. Depending on actual recovery rates, impacts will occur even if nourishment activities occur outside the red knot migration and wintering seasons.

Indirect effects: The proposed project includes beach renourishment and groin installation along 3,500 lf of shoreline as protective elements against shoreline erosion to protect man-made infrastructure. Indirect effects include reducing the potential for the formation of optimal habitats (coastal marine and estuarine habitats with large areas of exposed intertidal sediments) and erosion of foraging and resting habitat downdrift of the groin.

The proposed project may limit the creation of optimal foraging and roosting habitat, and may increase the attractiveness of these beaches for recreation increasing recreational pressures within the Action Area, including disturbance by unleashed pets and increased pedestrian use.

3) Species' Response to the Proposed Action

The proposed project will occur within habitat that is used by migrating and wintering red knots. Since red knots can be present on these beaches almost year-round, construction is likely to occur while this species is utilizing these beaches and associated habitats. Short-term and temporary impacts to red knot activities could result from project work occurring on the beach that flushes birds from roosting or foraging habitat. Long-term impacts could include a hindrance in the ability of migrating or wintering red knots to recuperate from their migratory flight from their breeding grounds, survive on their wintering areas, or to build fat reserves in preparation for migration. Long-term impacts may also result from changes in the physical characteristics of the beach from the placement of the groin and the sand.

D. Cumulative Effects

This project occurs on non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion.

It is reasonable to expect continued shoreline stabilization and beach renourishment projects in this area in the future since erosion and sea-level rise increases would impact the existing beachfront development.

VII. SEABEACH AMARANTH

A. Status of the Species/Critical Habitat

1) Species/Critical Habitat Description

Seabeach amaranth (*Amaranthus pumilus*) is an annual plant that grows on Atlantic barrier islands and ocean beaches currently ranging from South Carolina to New York. It was listed as threatened under the Act on April 7, 1993 (58 FR 18035) because of its vulnerability to human and natural impacts and the fact that it had been eliminated from two-thirds of its historic range (USFWS 1996b). Seabeach amaranth stems are fleshy and pink-red or reddish, with small rounded leaves that are 0.5 to 1.0 inches in diameter. The green leaves, with indented veins, are clustered toward the tip of the stems, and have a small notch at the rounded tip. Flowers and fruits are relatively inconspicuous, borne in clusters along the stems. Seabeach amaranth will be considered for delisting when the species exists in at least six states within its historic range and when a minimum of 75 percent of the sites with suitable habitat within each state are occupied by populations for l0 consecutive years (USFWS 1996b). The recovery plan states that mechanisms must be in place to protect the plants from destructive habitat alterations, destruction or decimation by off-road vehicles or other beach uses, and protection of populations from debilitating webworm predation. There is no designation of critical habitat for seabeach amaranth.

2) Life History

Seabeach amaranth is an annual plant. Germination of seabeach amaranth seeds occurs over a relatively long period, generally from April to July. Upon germinating, this plant initially forms a small unbranched sprig, but soon begins to branch profusely into a clump. This clump often reaches one foot in diameter and consists of five to 20 branches. Occasionally, a clump may get as large as three feet or more across, with 100 or more branches. Flowering begins as soon as plants have reached sufficient size, sometimes as early as June, but more typically commencing in July and continuing until the death of the plant in late fall. Seed production begins in July or August and peaks in September during most years, but continues until the death of the plant. Weather events, including rainfall, hurricanes, and temperature extremes, and predation by webworms have strong effects on the length of the reproductive season of seabeach amaranth. Because of one or more of these influences, the flowering and fruiting period can be terminated as early as June or July. Under favorable circumstances, however, the reproductive season may extend until January or sometimes later (Radford et al. 1968; Bucher and Weakley 1990; Weakley and Bucher1992).

3) Population Dynamics

Within North Carolina and across its range, seabeach amaranth numbers vary from year to year. Data in North Carolina is available from 1987 to 2013. Recently, the number of plants across the entire state dwindled from a high of 19,978 in 2005 to 165 in 2013. This trend of decreasing numbers is seen throughout its range. 249,261 plants were found throughout the species' range in 2000. By 2013, those numbers had dwindled to 1,320 plants (USFWS, unpublished data).

Seabeach amaranth is dependent on natural coastal processes to create and maintain habitat. However, high tides and storm surges from tropical systems can overwash, bury, or inundate seabeach amaranth plants or seeds, and seed dispersal may be affected by strong storm events. In September of 1989, Hurricane Hugo struck the Atlantic Coast near Charleston, South Carolina, causing extensive flooding and erosion north to the Cape Fear region of North

Carolina, with less severe effects extending northward throughout the range of seabeach amaranth. This was followed by several severe storms that, while not as significant as Hurricane Hugo, caused substantial erosion of many barrier islands in the seabeach amaranth's range. Surveys for seabeach amaranth revealed that the effects of these climatic events were substantial (Weakley and Bucher 1992). In the Carolinas, populations of amaranth were severely reduced. In South Carolina, where the effects of Hurricane Hugo and subsequent dune reconstruction were extensive, amaranth numbers declined from 1,800 in 1988 to I88 in 1990, a reduction of 90 percent. A 74 percent reduction in amaranth numbers occurred in North Carolina, from 41,851 plants in 1988 to 10,898 in 1990. Although population numbers in New York increased in 1990, range-wide totals of seabeach amaranth were reduced 76 percent from 1988 (Weakley and Bucher 1992). The extent stochastic events have on long-term population trends of seabeach amaranth has not been assessed.

4) Status and Distribution

The species historically occurred in nine states from Rhode Island to South Carolina (USFWS 2003c). By the late 1980s, habitat loss and other factors had reduced the range of this species to North and South Carolina. Since 1990, seabeach amaranth has reappeared in several states that had lost their populations in earlier decades. However, threats like habitat loss have not diminished, and populations are declining overall. It is currently found in New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, and South Carolina. The typical habitat where this species is found includes the lower foredunes and upper beach strands on the ocean side of the primary sand dunes and overwash flats at accreting spits or ends of barrier islands.

Seabeach amaranth has been and continues to be threatened by destruction or adverse alteration of its habitat. As a fugitive species dependent on a dynamic landscape and large-scale geophysical processes, it is extremely vulnerable to habitat fragmentation and isolation of small populations. Further, because this species is easily recognizable and accessible, it is vulnerable to taking, vandalism, and the incidental trampling by curiosity seekers. Seabeach amaranth is afforded legal protection in North Carolina by the General Statutes of North Carolina, Sections 106-202.15, 106- 202.19 (N.C. Gen. Stat. section 106 (Supp. 1991)), which provide for protection from intrastate trade (without a permit).

The most serious threats to the continued existence of seabeach amaranth are construction of beach stabilization structures, natural and man-induced beach erosion and tidal inundation, fungi (i.e., white wilt), beach grooming, herbivory by insects and mammals, and off-road vehicles. Herbivory by webworms, deer, feral horses, and rabbits is a major source of mortality and lowered fecundity for seabeach amaranth. However, the extent to which herbivory affects the species as a whole is unknown.

Potential effects to seabeach amaranth from vehicle use on the beaches include vehicles running over, crushing, burying, or breaking plants, burying seeds, degrading habitat through compaction of sand and the formation of seed sinks caused by tire ruts. Seed sinks occur when blowing seeds fall into tire ruts, then a vehicle comes along and buries them further into the sand preventing germination. If seeds are capable of germinating in the tire ruts, the plants are usually destroyed before they can reproduce by other vehicles following the tire ruts. Those seeds and their reproductive potential become lost from the population.

Pedestrians also can negatively affect seabeach amaranth plants. Seabeach amaranth occurs on the upper portion of the beach which is often traversed by pedestrians walking from parking lots, hotels, or vacation property to the ocean. This is also the area where beach chairs and umbrellas are often set up and/or stored. In addition, resorts, hotels, or other vacation rental establishments may set up volleyball courts or other sporting activity areas on the upper beach at the edge of the dunes. All of these activities can result in the trampling and destruction of plants. Pedestrians walking their dogs on the upper part of the beach, or dogs running freely on the upper part of the beach, may result in the trampling and destruction of seabeach amaranth plants.
The extent of the effects that dogs have on seabeach amaranth is not known.

Recovery Criteria

Delisting of seabeach amaranth will be considered when a minimum of 75 percent of the sites with suitable habitat within at least six of the nine historically occupied States are occupied by seabeach amaranth populations for 10 consecutive years.

5) Analysis of the Species Likely to be Affected

The predominant threat to seabeach amaranth is the destruction or alteration of suitable habitat, primarily because of beach stabilization efforts and storm-related erosion (USFWS 1993). Other important threats to the plant include beach grooming and vehicular traffic, which can easily break or crush the fleshy plant and bury seeds below depths from which they can germinate; and predation by webworms (caterpillars of small moths) (USFWS 1993). Webworms feed on the leaves of the plant and can defoliate the plants to the point of either killing them or at least reducing their seed production. Beach vitex (*Vitex rotundifulia*) is another threat to seabeach amaranth, as it is an aggressive, invasive, woody plant that can occupy habitat similar to seabeach amaranth and outcompete it (Invasive Species Specialist Group (ISSG) 2010).

The proposed action has the potential to adversely affect seabeach amaranth within the proposed Action Area. Potential effects include burying, trampling, or injuring plants as a result of construction operations and/or sediment disposal activities; burying seeds to a depth that would prevent future germination as a result of construction operations and/or sediment disposal activities; and, destruction of plants by trampling or breaking as a result of increased recreational activities. The Applicant proposes to construct the groin and place sand between November 16 and April 30. However, given favorable weather, seabeach amaranth plants may persist until January. Therefore, there is still the potential for sand placement to adversely impact plants in the Action Area.

B. Environmental Baseline

1) Status of the Species within the Action Area

Since 1992, seabeach amaranth surveys have been conducted on Ocean Isle and Holden Beach. The numbers of seabeach amaranth vary widely from year to year. On Holden Beach, the numbers vary from 1 individual in 1997 to 1954 individuals in 2006. On Ocean Isle Beach, the numbers vary from 1 individual in 2012 and 2013 to 819 in 1996. See **Table 14** for data from the Corps.

Table 14. Annual seabeach amaranth results on Ocean Isle and Holden Beach, NC between 1992 and 2013.

Year	Number of Seabeach Amaranth	
	Ocean Isle	Holden Beach
1992	5	21
1993	15	52
1994	112	239
1995	22	59
1996	819	99
1997	7	1
1998	11	32
1999	5	268
2000	4	10
2001	5	223
2002	45	702
2003	206	843
2004	49	79
2005	545	800
2006	337	1954
2007	20	281
2008	110	574
2009	36	123
2010	4	434
2011	5	116
2012	1	46
2013	1	108

2) Factors Affecting the Species Environment within the Action Area

A number of recent and on-going beach disturbance activities have altered the proposed Action Area. **Table 3** (page 53) lists the most recent projects, within the past 5 years.

Pedestrian Use of the Beach: There are a number of potential sources of pedestrians and pets, including those individuals originating from hotels, beachfront and nearby residences.

Sand nourishment: The beaches of Ocean Isle and Holden Beach are regularly nourished with sand from the Corps' Federal CSDR project.

Shoreline stabilization: Approximately 1,400 lf of the Action Area has been stabilized with sandbags.

C. Effects of the Action

1) Factors to be Considered

Proximity of action: Beach renourishment and groin installation will occur within and adjacent to seabeach amaranth habitat.

Distribution: Project construction activities that may affect seabeach amaranth plants on Ocean Isle would occur along the eastern shoreline of the island.

Timing: The timing of project construction could directly and indirectly impact seabeach amaranth.

Nature of the effect: The effects of the project construction include burying, trampling, or injuring plants as a result of construction operations and/or sediment disposal activities; burying seeds to a depth that would prevent future germination as a result of construction operations and/or sediment disposal activities; and, destruction of plants by trampling or breaking as a result of increased recreational activities.

Duration: Groin installation will be a one-time activity, which will take up to 4 ½ months to complete. Sand fillet maintenance will be a recurring activity and will take up to 10 weeks to complete each time. Thus, the direct effects would be expected to be short-term in duration. Indirect effects from the activity may continue to impact seabeach amaranth in subsequent seasons after sand placement.

Disturbance frequency: Disturbance from the initial construction activities will be short term, lasting up to 4 ½ months. Disturbance from maintenance of the sand fillet can be anticipated every 5 years for the life of the project. Recreational disturbance may increase after project completion and have long-term impacts.

Disturbance intensity and severity: Project construction is anticipated to be conducted during portions of the seabeach amaranth growing and flowering season. Conservation measures have been incorporated into the project to minimize impacts.

2) Analyses for Effects of the Action

Beneficial Effects: The placement beach-compatible sand may benefit this species by providing additional suitable habitat or by redistributing seed sources buried during past storm events, beach disposal activities, or natural barrier island migration. Disposal of dredged sand may be compatible with seabeach amaranth provided the timing of beach disposal is appropriate, the material placed on the beach is compatible with the natural sand, and special precautions are adopted to protect existing seabeach amaranth plants. Further studies are needed to determine the best methods of beach disposal in seabeach amaranth habitat (Weakley and Bucher 1992).

Direct Effects: Groin construction and sand placement activities may bury or destroy existing plants, resulting in mortality, or bury seeds to a depth that would prevent future germination, resulting in reduced plant populations. Increased traffic from recreationists and their pets can also destroy existing plants by trampling or breaking the plants.

Indirect Effects: Future tilling of the beach may be necessary if beach compaction hinders sea turtle nesting activities. Thus, the placement of heavy machinery or associated tilling equipment on the beach may destroy or bury existing plants.

3) Species' Response to the Proposed Action

The construction of the groin and placement of sand in the Action Area could bury existing plants if work is conducted during the growing season. Sand placement at any time of year could also bury seeds to a depth that would prevent germination.

Sand placement beaches could also have positive impacts on seabeach amaranth by creating additional habitat for the species. Although more study is needed before the long-term impacts can be accurately assessed, several populations are shown to have established themselves on beaches receiving dredged sediments, and have thrived through subsequent applications of dredged material (Weakley and Bucher 1992).

D. Cumulative Effects

This project occurs on non-federal lands. Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the Action Area considered in this biological opinion.

It is reasonable to expect continued shoreline stabilization and beach renourishment projects in this area in the future since erosion and sea-level rise increases would impact the existing beachfront development.

VIII. CONCLUSION

Sea Turtles

After reviewing the current status of the nesting loggerhead sea turtle, green sea turtle, leatherback sea turtle, and Kemp's ridley sea turtle, the environmental baseline for the Action Area, the effects of the proposed sand placement and groin construction, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that the placement of sand and construction and presence of the groin as proposed, is not likely to jeopardize the continued existence of the loggerhead sea turtle, green sea turtle, leatherback sea turtle, and Kemp's ridley sea turtle. The Service has determined that the project is not likely to destroy or adversely modify designated critical habitat for nesting loggerhead sea turtles.

The conservation of the five loggerhead recovery units in the Northwest Atlantic is essential to the recovery of the loggerhead sea turtle. Each individual recovery unit is necessary to conserve genetic and demographic robustness, or other features necessary for long-term sustainability of the entire population. Thus, maintenance of viable nesting in each recovery unit contributes to the overall population. The NRU, one of the five loggerhead recovery units in the Northwest Atlantic occurs within the Action Area. The NRU averages 5,215 nests per year (based on 1989-2008 nesting data). Of the available nesting habitat within the NRU, construction will occur and/or will likely have an effect on 24,500 lf of nesting shoreline.

Generally, green, leatherback, and Kemp's ridley sea turtle nesting overlaps with or occurs within the beaches where loggerhead sea turtles nest on both the Atlantic and Gulf of Mexico beaches. Thus, for green, leatherback, and Kemp's ridley sea turtles, dredging and sand placement activities will affect 24,500 lf of shoreline.

Long-term adverse effects to adult and hatchling sea turtles are anticipated as a result of the presence of the groin. The permanent placement of the groin is expected to affect nesting, hatching, and hatchling emerging success within that area for the life of the structure. Although a variety of factors, including some that cannot be controlled, can influence how an erosion control structure construction project will perform from an engineering perspective, measures can be implemented to minimize adverse impacts to sea turtles. Take of sea turtles will be minimized by implementation of the Reasonable and Prudent Measures, and Terms and Conditions outline below. These measures have been shown to help minimize adverse impacts to sea turtles.

Research has shown that the principal effect of sand placement on sea turtle reproduction is a reduction in nesting success, and this reduction is most often limited to the first year or two following project construction. Research has also shown that the impacts of a nourishment project on sea turtle nesting habitat are typically short-term because a nourished beach will be reworked by natural processes in subsequent years, and beach compaction and the frequency of escarpment formation will decline. Although a variety of factors, including some that cannot be controlled, can influence how a nourishment project will perform from an engineering perspective, measures can be implemented to minimize impacts to sea turtles.

Piping Plovers

Construction will occur and/or will likely have an effect on 24,500 lf of shoreline. After reviewing the current status of the northern Great Plains, Great Lakes, and Atlantic Coast wintering piping plover populations, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that implementation of these actions, as proposed, is not likely to jeopardize the continued existence of the piping plover.

Red Knot

Construction will occur and/or will likely have an effect on 24,500 lf of shoreline. After reviewing the current status of the migrating and wintering red knot populations, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that implementation of these actions, as proposed, is not likely to jeopardize the continued existence of the red knot.

Seabeach Amaranth

Construction will occur and/or will likely have an effect on 24,500 lf of shoreline. After reviewing the current status of the seabeach amaranth population, the environmental baseline for the Action Area, the effects of the proposed activities, the proposed Conservation Measures, and the cumulative effects, it is the Service's biological opinion that implementation of these actions, as proposed, is not likely to jeopardize the continued existence of the seabeach amaranth.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered or threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the Act provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below in Sections IX and X are non-discretionary, and must be implemented by the Corps so that they become binding conditions of any grant or permit issued to the Applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps (1) fails to assume and implement the terms and conditions or (2) fails to require the Applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the Corps must report the progress of the action and its impacts on the species to the Service as specified in the incidental take statement [50 CFR §402.14(i)(3)].

Sections 7(b)(4) and 7(o)(2) of the Act generally do not apply to listed plant species. However, limited protection of listed plants from take is provided to the extent that the Act prohibits the removal and reduction to possession of Federally listed endangered plants or the malicious damage of such plants on areas under Federal jurisdiction, or the destruction of endangered plants on non-Federal areas in violation of state law or regulation, or in the course of any violation of a State criminal trespass law.

AMOUNT OR EXTENT OF TAKE

Amount of Extent of Take – Loggerhead, Green, Leatherback, and Kemp's Ridley Sea Turtles

The Service anticipates 24,500 lf of nesting beach habitat could be taken as a result of this proposed action. Take is expected to be in the form of: (1) Destruction of all nests that may be constructed and eggs that may be deposited and missed by a nest survey and nest mark and avoidance program within the boundaries of the proposed project; (2) destruction of all nests deposited during the period when a nest survey and nest mark and avoidance program is not required to be in place within the boundaries of the proposed project; (3) harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities; (4) misdirection of nesting sea turtles or hatchling turtles on beaches within the boundaries of the proposed project or beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of increased sand accretion due to the presence of the groin or jetty; (5) behavior modification of nesting females due to escarpment formation, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs; (6) destruction of nests from escarpment leveling within a nesting season when such leveling has been approved by the Service; (7) behavior modification of nesting females or hatchlings due to the presence of the groin which may act as a barrier to movement or cause disorientation of turtles while on the nesting beach; (8) physical entrapment of hatchling sea turtles on the nesting beach due to the presence of the groin; behavior modification of nesting females if they dig above a buried portion of the structure, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas; and (9) obstructed or entrapped an unknown number of adult and hatchling sea turtles during ingress or egress at nesting sites.

Incidental take is anticipated for only the 24,500 lf of beach that has been identified. The Service anticipates incidental take of sea turtles will be difficult to detect for the following reasons: (1) the turtles nest primarily at night and all nests are not found because [a] natural factors, such as rainfall, wind, and tides may obscure crawls and [b] human-caused factors, such as pedestrian and vehicular traffic, may obscure crawls, and result in nests being destroyed because they were missed during a nesting survey and nest mark and avoidance program (2) the total number of hatchlings per undiscovered nest is unknown; (3) an unknown number of females may avoid the project beach and be forced to nest in a less than optimal area; (5) lights may misdirect an unknown number of hatchlings and cause death; (6) an unknown number of adult and hatchling sea turtles may be obstructed or entrapped during ingress or egress at nesting sites; and (7) escarpments may form and prevent an unknown number of females from accessing a suitable nesting site. However, the level of take of these species can be anticipated by the construction and presence of the groin and sand placement on suitable turtle nesting beach habitat because: (1) turtles nest within the project site; (2) the groin construction project will modify beach profile and width and increase the presence of escarpments; (3) the renourishment project will modify the incubation substrate, beach slope, and sand compaction; and (4) artificial lighting will deter and/or misdirect nesting hatchling turtles.

Amount or Extent of Take – Piping Plover and Red Knot

It is difficult for the Service to estimate the exact number of piping plovers and red knots that could be migrating through or wintering within the Action Area at any one point in time and place during project construction. Disturbance to suitable habitat resulting from both construction and sand placement activities within the Action Area would affect the ability of an undetermined number of piping plovers and red knots to find suitable foraging and roosting habitat during any given year.

The Service anticipates that directly and indirectly an unspecified amount of piping plovers and red knots along 24,500 lf of shoreline, all at some point, potentially usable by piping plovers and red knots, could be taken in the form of harm and harassment as a result of this proposed action; however, incidental take of piping plovers and red knots will be difficult to detect for the following reasons:

(1) harassment to the level of harm may only be apparent on the breeding grounds the following year; and
(2) dead plovers and red knots may be carried away by waves or predators.

The level of take of this species can be anticipated by the proposed activities because:

(1) piping plovers and red knots migrate through and winter in the Action Area;
(2) the placement of the constructed beach is expected to affect the coastal morphology and prevent early successional stages, thereby precluding the maintenance and creation of additional recovery habitat;
(3) increased levels of pedestrian disturbance may be expected; and
(4) a temporary reduction of food base will occur.

The Service has reviewed the biological information and other information relevant to this action. The take is expected in the form of harm and harassment because of: (1) decreased fitness and survivorship of plovers and red knots due to loss and degradation of foraging and roosting habitat; (2) decreased fitness and survivorship of plovers and red knots attempting to migrate to breeding grounds due to loss and degradation of foraging and roosting habitat; and (3) decreased fitness and survivorship of piping plovers attempting to nest in the Action Area.

EFFECT OF THE TAKE

Sea Turtles

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the loggerhead sea turtle, green sea turtle, leatherback sea turtle, and Kemp’s ridley sea turtle species. The Service has determined that the proposed project will not result in destruction or adverse modification of designated critical habitat for the loggerhead sea turtle.

Incidental take of nesting and hatchling sea turtles is anticipated to occur during project construction and during the life of the project. Take will occur on nesting habitat on 24,500 lf of shoreline.

Piping Plovers

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the piping plover species. The Service has determined that the proposed project will not result in destruction or adverse modification of critical habitat for the piping plover. Incidental take of piping plovers is anticipated to occur along 24,500 lf of shoreline.

Red Knot

In the accompanying biological opinion, the Service determined that this level of anticipated take is not likely to result in jeopardy to the red knot species. Incidental take of red knots is anticipated to occur along 24,500 lf of shoreline.

Seabeach Amaranth

In the accompanying biological opinion, the Service determined that the potential of the project to damage or destroy seabeach amaranth is not likely to result in jeopardy to the seabeach amaranth species. Damage or destruction of seabeach amaranth plants is anticipated to occur along approximately 24,500 feet of shoreline.

IX. REASONABLE AND PRUDENT MEASURES

The Service believes the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize take of loggerhead sea turtles, green sea turtles, leatherback sea turtles, Kemp's ridley sea turtles, piping plovers, red knots, and seabeach amaranth. Unless specifically addressed below, these RPMs are applicable for the construction of the terminal groin and for any maintenance activities for the life of the permit. If the Applicant is unable to comply with the RPMs and Terms and Conditions, the Corps as the regulatory authority may inform the Service why the RPM or Term and Condition is not reasonable and prudent for the specific project or activity and request exception under the biological opinion.

RPMs – All Species

1. All derelict material or other debris must be removed from the beach prior to any construction.

2. Conservation Measures included in the permit application/project plans must be implemented in the proposed project. If a RPM and Term and Condition address the same requirement, the requirements of the RPM and Term and Condition take precedent over the Conservation Measure. This includes the timing of the proposed project to avoid the sea turtle nesting season, to reduce the possibility of sea turtle nest burial, crushing of eggs, or nest excavation.

3. Predator-proof trash receptacles must be installed and maintained at all beach access points used for the initial project construction and all maintenance events, to minimize the potential for attracting predators of sea turtles, piping plovers, and red knots.

4. A meeting between representatives of the Applicant's contractor, Corps, Service, NCWRC, the permitted sea turtle surveyor, bird and other species surveyors, as appropriate, must be held prior to the commencement of construction of the terminal groin.

5. In the event the terminal groin structure begins to disintegrate, all debris and structural material must be removed.

6. The Applicant or Corps must submit all reports produced pursuant to the Inlet Management Plan (referenced in the revisions to North Carolina General Statute 113A-115.1(e)(5)) to the Service's Raleigh Field Office, within 30 days of completion of each report.

7. The groin must be removed or modified if it is determined to not be effective as determined pursuant to the Inlet Management Plan listed above, or if it is determined to be causing a significant adverse impact to the beach and dune system.

8. During construction of the terminal groin, and for the life of the permit, all sand placement activities to maintain the sand fillet must be conducted within the winter work window (November 16 to April 30), unless necessitated by an emergency condition and allowed after consultation with the Service.

9. The pipeline placement must be coordinated with the Corps, the Raleigh Field Office, and the NCWRC.

RPMs – Loggerhead, Green, Leatherback, and Kemp's Ridley Sea Turtle

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of loggerhead, green, Kemp's ridley, and leatherback sea turtles:

1. Beach compatible sand suitable for sea turtle nesting, successful incubation, and hatchling emergence must be used on the project site for initial groin construction and all maintenance events.

2. No construction shall be conducted during the nesting season and hatching season from May 1 through November 15.

3. No permanent exterior lighting will be installed in association with this construction project, unless required by the U.S. Coast Guard. Temporary lighting will be allowed if safety lighting is required at any excavated trenches that must remain on the beach at night.

4. If the construction of the groin will be conducted during the period from April 15 to April 30, daily early morning surveys for early nesting sea turtles must be conducted. If the construction project will be conducted during the period from November 16 through November 30, surveys for late nesting sea turtles must be conducted. If nests are laid in the area of construction, the nests must be marked and avoided. Nesting surveys and nest marking must be initiated 65 days prior to construction activities or by April 15, whichever is later.

5. Visual surveys for escarpments along the Action Area must be made following completion of the terminal groin and any sand maintenance events, and also prior to May 1 for two subsequent years (after sand is placed on the beach). Escarpment formation must be monitored and leveling must be conducted if needed to reduce the likelihood of impacting nesting and hatchling sea turtles.

6. Staging areas for earth-moving equipment must be located off the beach during the early (April 15 through April 30) and late (November 16 through November 30) portions of the nesting season. Nighttime storage of earth-moving equipment not in use must be off the beach to minimize disturbance to sea turtle nesting and hatching activities. All

excavations and temporary alteration of beach topography will be filled or leveled to the natural beach profile prior to 9:00 p.m. each day.

7. Sand compaction must be monitored in the area of sand placement immediately after completion of the project, after any future sand maintenance events, and also prior to May 1 for two subsequent years after sand is placed on the beach.

8. Daily sea turtle nesting surveys must be conducted by the Applicant or Corps for three nesting seasons following construction of the groin or sand maintenance events, if the groin remains on the beach. All nests from a point 3,200 feet west (updrift) of the groin (at approximately Highpoint Street) to a point 2,000 feet east (downdrift) of the groin must be marked for three (3) years post-construction. These nests must be monitored daily until the end of incubation to determine whether those nests are eroded and whether the groin is a potential barrier to hatchlings moving off the beach and through the surf zone. If the groin is found to be an obstruction, Corps will notify NCWRC and the Service immediately for remedial action.

9. A report describing the fate of the nests and hatchlings and any actions taken, must be submitted to the Service following completion of the proposed work for each year when an activity has occurred (such as sand placement).

10. A post-construction survey of all artificial lighting visible from the adjacent beach (1,000 lf on either side of the groin) must be completed by the Applicant or Corps to determine if sand accretion caused by the groin created an increased impact due to artificial lighting within the vicinity of the groin structures.

RPMs – Piping Plover and Red Knot

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of piping plovers and red knots:

1. All personnel involved in the construction or sand placement process along the beach shall be trained to recognize the presence of piping plovers and red knots prior to initiation of work on the beach. Before start of work each morning, a visual survey must be conducted along the ingress routes and in the area of work for that day, to determine if piping plovers or red knots are present.

2. A bird monitoring plan must be developed to monitor piping plover, red knot, waterbirds, colonial waterbirds and other shorebirds in the Shallotte Inlet area during and after

construction. Monitoring must be conducted for a minimum of three (3) full years past the completion of groin construction, or until the end of the shorebird nesting season (August 31) of the third year, whichever is later.

RPM – Seabeach Amaranth

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize take of seabeach amaranth:

1. Seabeach amaranth surveys must be conducted in the Action Area for a minimum of three years after completion of construction.

X. TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the Corps must comply with the following terms and conditions, which implement the RPMs described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. Unless addressed specifically below, the terms and conditions are applicable for the construction of the terminal groin and for any maintenance activities for the life of the permit.

Terms and Conditions – All Species

1. All derelict coastal armoring geotextile material and other debris must be removed from the beach prior to any sand placement or construction to the maximum extent possible.

2. Conservation Measures included in the permit application/project plans must be implemented in the proposed project. If a RPM and Term and Condition address the same requirement, the requirements of the RPM and Term and Condition take precedent over the Conservation Measure.   This includes the timing of the proposed project to avoid the sea turtle nesting season, to reduce the possibility of sea turtle nest burial, crushing of eggs, or nest excavation.

3. Predator-proof trash receptacles must be installed and maintained during construction at all beach access points used for the project construction and sand maintenance events, to minimize the potential for attracting predators of sea turtles, piping plovers, and red knots. All contractors conducting the work must provide predator-proof trash receptacles for the construction workers. All contractors and their employees must be briefed on the importance of not littering and keeping the Action Area free of trash and debris. See **Appendix A** for examples of suitable receptacles.

4. A meeting between representatives of the contractor, the Service, NCWRC, the permitted sea turtle surveyor, bird and other species surveyors, as appropriate, must be held prior to the commencement of construction of the terminal groin. At least 10 business days advance notice must be provided prior to conducting this meeting. The meeting will provide an opportunity for explanation and/or clarification of the required measures in the BO, as well as follow-up meetings during construction.

5. In the event the structure begins to disintegrate, all debris and structural material must be removed from the nesting beach area and deposited off-site immediately upon coordination with the Service. If removal of the structure is required during the period from May 1 to November 15, no work will be initiated without prior coordination with the Corps and the Service.

6. The Applicant or Corps must submit all reports produced pursuant to the Inlet Management Plan (referenced in the revisions to North Carolina General Statute 113A-115.1(e)(5)) to the Service's Raleigh Field Office, within 30 days of completion of each report.

7. The groin must be removed or modified if it is determined to not be effective as determined by the Inlet Management Plan referred to above, or if it is determined to be causing a significant adverse impact to the beach and dune system.

8. During construction of the terminal groin, and for the life of the permit, all sand placement activities to maintain the sand fillet must be conducted within the winter work window (November 16 to April 30), unless necessitated by an emergency condition and allowed after consultation with the Service.

9. The pipeline placement must be coordinated with the Corps, the Raleigh Field Office, and the NCWRC.

Terms and Conditions – Loggerhead, Green, Kemp's ridley, and Leatherback Sea Turtle

1. Beach compatible fill must be placed on the beach or in any associated dune system. Beach compatible fill must be sand that is similar to a native beach in the vicinity of the site that has not been affected by prior sand placement activity. Beach compatible fill must be sand solely of natural sediment and shell material, containing no construction debris, toxic material, large amounts of rock, or other foreign matter. The beach compatible fill must be similar in both color and grain size distribution (sand grain frequency, mean and median grain size and sorting coefficient) to the native material in

the Action Area. Beach compatible fill is material that maintains the general character and functionality of the material occurring on the beach and in the adjacent dune and coastal system. In general, fill material that meets the requirements of the North Carolina Technical Standards for Beach Fill (15A NCAC 07H .0312) is considered compatible.

2. During the nesting season (May 1 through November 15), no construction will be allowed on the beach, and no equipment may be placed and/or stored on the beach.

3. No permanent exterior lighting will be installed in association with this construction project, unless required by the U.S. Coast Guard. Temporary lighting will be allowed if safety lighting is required at any excavated trenches that must remain on the beach at night.

4. If the construction of the groin will be conducted during the period from April 15 to April 30, daily early morning surveys for early nesting sea turtles must be conducted. If the construction project will be conducted during the period from November 16 through November 30, surveys for late nesting sea turtles must be conducted. If nests are laid in the area of construction, the nests must be marked and avoided. Nesting surveys and nest marking must be initiated 65 days prior to construction activities or by April 15, whichever is later.

5. Visual surveys for escarpments along the Action Area must be made immediately after completion of construction, after sand maintenance events, and within 30 days prior to May 1 for two subsequent years after any construction or sand placement event. Escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet must be leveled and the beach profile must be reconfigured to minimize scarp formation by the dates listed above. Any escarpment removal must be reported by location. The Service must be contacted immediately if subsequent reformation of escarpments that interfere with sea turtle nesting or that exceed 18 inches in height for a distance of 100 feet occurs during the nesting and hatching season to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the Service or NCWRC will provide a brief written authorization within 30 days that describes methods to be used to reduce the likelihood of impacting existing nests. An annual summary of escarpment surveys and actions taken must be submitted to the Service's Raleigh Field Office.

6. Staging areas for earth-moving equipment must be located off the beach during the early (April 15 through April 30) and late (November 16 through November 30) portions of the nesting season. Nighttime storage of earth-moving equipment not in use must be off the

beach to minimize disturbance to sea turtle nesting and hatching activities. All excavations and temporary alteration of beach topography will be filled or leveled to the natural beach profile prior to 9:00 p.m. each day. During any periods when excavated trenches must remain on the beach at night, nighttime sea turtle monitoring by the sea turtle permit holder will be required in the project area in order to further reduce possible impacts to nesting and hatchling sea turtles. Nighttime monitors will record data on false crawls, successful nesting, and any additional activities of nesting or hatchling sea turtles in the project area.

7. Sand compaction must be monitored in the area of sand placement immediately after completion of the construction, after any sand maintenance event, and also prior to May 1 for two subsequent years after any construction or sand placement event. Out-year compaction monitoring and remediation are not required if the placed material no longer remains on the dry beach.
   h. Within 7 days of completion of sand placement and prior to any tilling, a field meeting shall be held with the Service, NCWRC, and the Corps to inspect the Action Area for compaction, and determine whether tilling is needed.
   i. If tilling is needed, the area must be tilled to a depth of 36 inches.
   j. All tilling activity shall be completed prior to May 1.
   k. Tilling must occur landward of the wrack line and avoid all vegetated areas that are 3 square feet (sf) or greater, with a 3 sf buffer around the vegetated areas.
   l. If tilling occurs during shorebird nesting season (after April 1), shorebird surveys are required prior to tilling per the Migratory Bird Treaty Act.
   m. A report on the results of compaction monitoring will be submitted to the Raleigh Field Office and NCWRC prior to any tilling actions being taken. An annual summary of compaction assessments and the actions taken will be submitted to the Service, as required in REPORTING REQUIREMENTS, below.
   n. This condition will be evaluated annually and may be modified if necessary to address sand compaction problems identified during the previous year.

8. Daily sea turtle nesting surveys must be conducted by the Applicant or Corps for three (3) full nesting seasons following construction if the groin structure remains in place. All nests from a point 3,200 feet west (updrift) of the groin (at approximately High Point Street) to a point 2,000 feet east (downdrift) of the groin must be marked for three (3) years post-construction. The survey area must be divided into three segments: Updrift Zone, Project Zone, and Downdrift Zone. The parameters listed in **Appendix B** shall be recorded for each crawl encountered on a daily survey. In addition, any obstructions (natural or man-made) encountered by the turtle and the turtle's response to that obstruction must be reported. These nests must be monitored daily till the end of

hatching to determine whether those nests are eroded and whether the groin is a potential barrier to hatchlings moving off the beach and through the surf zone. This information will be provided to the Raleigh Field Office pursuant to the REPORTING REQUIREMENTS section, below, and will be used to periodically assess the cumulative effects of these projects on sea turtle nesting and hatchling production and monitor suitability for nesting. The Corps will notify the NCWRC and the Service immediately for remedial action.

9. A report describing the fate of sea turtle nests and hatchlings and any actions taken, must be submitted to the Raleigh Field Office following completion of the proposed work for each year when an activity has occurred (e.g. sand placement or groin construction). Please see REPORTING REQUIREMENTS below, for more information.

10. A post construction survey(s) of all artificial lighting visible from the adjacent beach (100 feet on either side of the groin must be completed by the Applicant or Corps. Two surveys must be conducted of all lighting visible from the construction area by the Applicant or the Corps, using standard techniques for such a survey (**Appendix C**), in the year following construction. The first survey must be conducted between May 1 and May 15 and a brief summary provided to the Raleigh Field Office. The second survey must be conducted between July 15 and August 1. A summary report of the surveys, (include the following information: methodology of the survey, a map showing the position of the lights visible from the beach, a description of each light source visible from the beach, recommendations for remediation, and any actions taken), must be submitted to the Raleigh Field Office within 3 months after the last survey is conducted. After the annual report is completed, a meeting must be set up with the Applicant, county or municipality, NCWRC, Corps, and the Service to discuss the survey report, as well as any documented sea turtle disorientations in or adjacent to the project area.

Terms and Conditions – Piping Plover and Red Knot

1. All personnel involved in the construction or sand placement process along the beach shall be trained to recognize the presence of piping plovers and red knots prior to initiation of work on the beach. Before start of work each morning, a visual survey must be conducted along the ingress route and in the area of work for that day, to determine if piping plovers or red knots are present. If plovers or red knots are present in the work area, careful movement of equipment in the early morning hours should allow those individuals to move out of the area. If piping plovers or red knots are observed, the observer shall make a note on the Quality Assurance form for that day, and submit the information to the Corps and the Service's Raleigh Field Office the following day.

2. A bird monitoring plan must be developed to monitor piping plover, red knot, waterbirds, colonial waterbirds and other shorebirds during and after construction. Monitoring must be conducted for a minimum of three (3) full years past the completion of groin construction, or until the end of the shorebird nesting season (August 31) of the third year after construction, whichever is later. Post-construction monitoring may only be ceased after the review of at least three years' worth of data and approval by the Corps, Service, NCDCM, and NCWRC.
    e. The bird monitoring plan, including methods and a figure showing the proposed locations and extent of monitoring, must be submitted for review and approval to the Corps, Service, NCDCM, and NCWRC, at least 60 days prior to the anticipated start of construction.
    f. During construction, bird monitoring must be conducted weekly. For at least three years after construction is completed, bimonthly (twice-monthly) bird surveys shall be conducted in all intertidal and shoreline areas from a point 3,200 lf west (updrift) of the groin (at approximately Highpoint Street) to a point just west of Skimmer Court on Holden Beach. All intertidal and supratidal unvegetated areas of the oceanfront, inlet shoulders, and sandy shoreline along the AIWW (in the vicinity of Shallotte Inlet and piping plover critical habitat unit NC-17) must be included. Field observations must be conducted during daylight hours, and primarily during high tide.
    g. Shorebird identification, especially when in non-breeding plumage, can be difficult. The person(s) conducting the survey must demonstrate the qualifications and ability to identify shorebird species and be able to provide the information listed below. The bird monitoring plan should include the collection and reporting of the following:
        i. Date, location, time of day, weather, and tide cycle when survey was conducted;
        ii. Latitude and longitude of observed piping plover and red knot locations (decimal degrees preferred);
        iii. Any color bands observed on piping plovers or red knots or other birds;
        iv. Behavior (e.g., foraging, roosting, preening, bathing, flying, aggression, walking, courtship, copulation);
        v. Landscape features(s) where birds are located (e.g., inlet spit, tidal creeks, shoals, lagoon shoreline);
        vi. Habitat features(s) used by birds when observed (e.g., intertidal, fresh wrack, old wrack, dune, mid-beach, vegetation);
        vii. Substrata used by birds (e.g., sand, mud/sand, mud, algal mat); and
        viii. The amount and type of recreational use (e.g., people, dogs on or off leash, vehicles, kite-boarders).

h. All monitoring information shall be provided in standardized form on an Excel spreadsheet. Monitoring results shall be submitted (datasheets, maps, database) on standard electronic media (e.g., CD, DVD) to the Raleigh Field Office. Please see REPORTING REQUIREMENTS below, for more information.

Terms and Conditions – Seabeach Amaranth

1. Seabeach amaranth surveys must be conducted updrift and downdrift of the terminal groin in the Action Area, from a point 3,200 lf west of the groin (at approximately Highpoint Street) along Ocean Isle Beach to a point 2,000 lf east of the groin, for a minimum of three years after completion of groin construction. Surveys should be conducted in August of each year. Habitat known to support this species, including the upper edges of the beach, lower foredunes, and overwash flats must be visually surveyed for the plant. Annual reports should include numbers of plants, latitude/longitude, and habitat type. Please see REPORTING REQUIREMENTS, below, for more information.

XI. REPORTING REQUIREMENTS

An annual report detailing the monitoring and survey data collected during the preceding year (required in the above Terms and Conditions) and summarizing all piping plover, red knot, shorebird, seabeach amaranth, and sea turtle data must be provided to the Raleigh Field Office by January 31 of each year for review and comment. In addition, any information or data related to a conservation measure or recommendation that is implemented should be included in the annual report. The contact for these reporting requirements is:

Pete Benjamin, Supervisor
Raleigh Field Office
U.S. Fish and Wildlife Service
Post Office Box 33726
Raleigh, North Carolina 27636-3726
(919) 856-4520

Upon locating a dead, injured, or sick individual of an endangered or threatened species, initial notification must be made to the Service Law Enforcement Office below. Additional notification must be made to the Service's Ecological Services Field Office identified above and to the NCWRC at (252) 241-7367. Care should be taken in handling sick or injured individuals and in the preservation of specimens in the best possible state for later analysis of cause of death or injury.

Tom Chisdock
U.S. Fish and Wildlife Service
160 Zillicoa St.
Asheville, NC 28801
828-258-2084

XII. COORDINATION OF INCIDENTAL TAKE STATEMENT WITH OTHER LAWS, REGULATIONS, AND POLICIES

The Service will not refer the incidental take of any migratory bird for prosecution under the Migratory Bird Treaty Act of 1918, as amended (16 USC S 703-712), if such take is in compliance with the terms and conditions specified herein. Take resulting from activities that are not in conformance with the Corps permit or this biological opinion (e.g. deliberate harassment of wildlife, etc.) are not considered part of the proposed action and are not covered by this incidental take statement and may be subject to enforcement action against the individual responsible for the act.

XIII. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

For the benefit of Loggerhead, Green, Leatherback, and Kemp’s ridley sea turtles, the Service recommends the following conservation recommendations:

1. Construction activities for this project and similar future projects should be planned to take place outside the main part of the sea turtle nesting and hatching season, as much as possible.

2. Appropriate native salt-resistant dune vegetation should be established on the restored dunes.

3. Educational signs should be placed where appropriate at beach access points explaining the importance of the area to sea turtles and/or the life history of sea turtle species that nest in the area.

For the benefit of the piping plover and red knot, the Service recommends the following conservation recommendations:

1. The Corps' and/or Applicant should maintain suitable piping plover and red knot migrating and wintering habitat. Natural accretion at inlets should be allowed to remain. Accreting sand spits on barrier islands provide excellent foraging habitat for migrating and wintering plovers and red knots.

2. A conservation/education display sign would be helpful in educating local beach users about the coastal beach ecosystem and associated rare species. The sign could highlight the life histories and basic biology of piping plovers and red knots, and ways recreationists can assist in species protection efforts (e.g., keeping pets on a leash, removing trash to sealed refuse containers, etc.). The Service would be willing to assist the Applicant in the development of such a sign, in cooperation with NCWRC, interested non-governmental stakeholders (i.e., National Audubon Society), the Corps, and the other interested stakeholders (i.e., property owners, etc.).

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

XIV. REINITIATION NOTICE – CLOSING STATEMENT

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion or the project has not been completed within five years of the issuance of this biological opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action.

In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

For this biological opinion, the incidental take will be exceeded when the groin construction and nourishment of 24,500 lf of beach extends beyond the project's authorized boundaries. Incidental take of an undetermined number of young or eggs of sea turtles, piping plovers, red knots, and seabeach amaranth plants has been exempted from the prohibitions of section 9 by this opinion.

LITERATURE CITED

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Appendix A

EXAMPLES OF PREDATOR PROOF TRASH RECEPTACLES

Example of predator proof trash receptacle at Gulf Islands National Seashore. Lid must be tight fitting and made of material heavy enough to stop animals such as raccoons.

Example of trash receptacle anchored into the ground so it is not easily turned over.

Example of predator proof trash receptacle at Perdido Key State Park. Metal trash can is stored inside. Cover must be tight fitting and made of material heavy enough to stop animals such as raccoons.

Example of trash receptacle must be secured or heavy enough so it is not easily turned over.

Appendix B
Parameters to be recorded for turtle crawls

CHARACTERISTIC	PARAMETER	MEASUREMENT	VARIABLE
Nesting Success	False crawls - number	Visual assessment of all false crawls	Number and location of false crawls in nourished areas and non-nourished areas: any interaction of turtles with obstructions, such as groins, seawalls, or scarps, should be noted.
	False crawl - type	Categorization of the stage at which nesting was abandoned	Number in each of the following categories: emergence-no digging, preliminary body pit, abandoned egg chamber.
	Nests	Number	The number of sea turtle nests in nourished and non-nourished areas should be noted. If possible, the location of all sea turtle nests must be marked on a project map, and approximate distance to seawalls or scarps measured in meters. Any abnormal cavity morphologies should be reported as well as whether turtle touched groins, seawalls, or scarps during nest excavation.
	Nests	Lost nests	The number of nests lost to inundation or erosion or the number with lost markers.
	Nests	Relocated nests	The number of nests relocated and a map of the relocation area(s). The number of successfully hatched eggs per relocated nest.
	Lighting impacts	Disoriented sea turtles	The number of disoriented hatchlings and adults.

Appendix C

Assessments: Discerning Problems Caused by Artificial Lighting

Excerpt from:

Understanding, Assessing, and resolving light-pollution problems on sea turtle nesting beaches
Florida Wildlife Research institute technical report tr-2
revised 2003

LIGHTING INSPECTIONS

WHAT ARE LIGHTING INSPECTIONS?

During a lighting inspection, a complete census is made of the number, types, locations, and custodians of artificial light sources that emit light visible from the beach. The goal of lighting inspections is to locate lighting problems and to identify the property owner, manager, caretaker, or tenant who can modify the lighting or turn it off.

WHICH LIGHTS CAUSE PROBLEMS?

Although the attributes that can make a light source harmful to sea turtles are complex, a simple rule has proven to be useful in identifying problem lighting under a variety of conditions:

An artificial light source is likely to cause problems for sea turtles if light from the source can be seen by an observer standing anywhere on the nesting beach.

If light can be seen by an observer on the beach, then the light is reaching the beach and can affect sea turtles. If any glowing portion of a luminaire (including the lamp, globe, or reflector) is directly visible from the beach, then this source is likely to be a problem for sea turtles. But light may also reach the beach indirectly by reflecting off buildings or trees that are visible from the beach. Bright or numerous sources, especially those directed upward, will illuminate sea mist and low clouds, creating a distinct glow visible from the beach. This "urban skyglow" is common over brightly lighted areas. Although some indirect lighting may be perceived as nonpoint-source light pollution, contributing light sources can be readily identified and include sources that are poorly directed or are directed upward. Indirect lighting can originate far from the beach.

Although most of the light that sea turtles can detect can also be seen by humans, observers should realize that some sources, particularly those emitting near-ultraviolet and violet light (e.g., bug-zapper lights, white electric-discharge lighting) will appear brighter to sea turtles than to humans. A human is also considerably taller than a hatchling; however, an observer on the dry beach who crouches to the level of a hatchling may miss some lighting that will affect turtles. Because of the way that some lights are partially hidden by the dune, a standing observer is more likely to see light that is visible to hatchlings and nesting turtles in the swash zone.

HOW SHOULD LIGHTING INSPECTIONS BE CONDUCTED?

Lighting inspections to identify problem light sources may be conducted either under the purview of a lighting ordinance or independently. In either case, goals and methods should be similar.

GATHER BACKGROUND INFORMATION

Before walking the beach in search of lighting, it is important to identify the boundaries of the area to be inspected. For inspections that are part of lighting ordinance enforcement efforts, the jurisdictional boundaries of the sponsoring local government should be determined. It will help to have a list that includes the name, owner, and address of each property within inspection area so that custodians of problem lighting can be identified. Plat maps or aerial photographs will help surveyors orient themselves on heavily developed beaches.

PRELIMINARY DAYTIME INSPECTIONS

An advantage to conducting lighting inspections during the day is that surveyors will be better able to judge their exact location than they would be able to at night. Preliminary daytime inspections are especially important on beaches that have restricted access at night. Property owners are also more likely to be available during the day than at night to discuss strategies for dealing with problem lighting at their sites.

A disadvantage to daytime inspections is that fixtures that are not directly visible from the beach will be difficult to identify as problems. Moreover, some light sources that can be seen from the beach in daylight may be kept off at night and thus present no problems. For these reasons, daytime inspections are not a substitute for nighttime inspections. Descriptions of light sources identified during daytime inspections should be detailed enough so that anyone can locate the lighting. In addition to a general description of each luminaire (e.g., HPS floodlight directed seaward at top northeast corner of the building at 123 Ocean Street), photographs or sketches of the lighting may be necessary. Descriptions should also include an assessment of how the specific lighting problem can be resolved (e.g., needs turning off; should be redirected 90° to the east). These detailed descriptions will show property owners exactly which luminaries need what remedy.

NIGHTTIME INSPECTIONS

Surveyors orienting themselves on the beach at night will benefit from notes made during daytime surveys. During nighttime lighting inspections, a surveyor walks the length of the nesting beach looking for light from artificial sources. There are two general categories of artificial lighting that observers are likely to detect:

1. Direct lighting. A luminaire is considered to be direct lighting if some glowing element of the luminaire (e.g., the globe, lamp [bulb], reflector) is visible to an observer on the beach. A source not visible from one location may be visible from another farther down the beach. When direct lighting is observed, notes should be made of the number, lamp type (discernable by color), style of fixture, mounting (pole, porch, *etc.*), and location (street address, apartment number, or pole identification number) of the luminaire(s). If exact locations of problem sources were not determined during preliminary daytime surveys, this should be done during daylight soon after the nighttime survey. Photographing light sources (using long exposure times) is often helpful.

2. Indirect lighting. A luminaire is considered to be indirect lighting if it is not visible from the beach but illuminates an object (e.g., building, wall, tree) that is visible from the beach. Any object on the dune that appears to glow is probably being lighted by an indirect source. When possible, notes should be made of the number, lamp type, fixture style, and mounting of an indirect-lighting source. Minimally, notes should be taken that would allow a surveyor to find the lighting during a follow-up daytime inspection (for instance, which building wall is illuminated and from what angle?).

WHEN SHOULD LIGHTING INSPECTIONS BE CONDUCTED?

Because problem lighting will be most visible on the darkest nights, lighting inspections are ideally conducted when there is no moon visible. Except for a few nights near the time of the full moon, each night of the month has periods when there is no moon visible. Early-evening lighting inspections (probably the time of night most convenient for inspectors) are best conducted during the period of two to 14 days following the full moon. Although most lighting problems will be visible on moonlit nights, some problems, especially those involving indirect lighting, will be difficult to detect on bright nights.

A set of daytime and nighttime lighting inspections before the nesting season and a minimum of three additional nighttime inspections during the nesting-hatching season are recommended. The first set of day and night inspections should take place just before nesting begins. The hope is that managers, tenants, and owners made aware of lighting problems will alter or replace lights before they can affect sea turtles. A follow-up nighttime lighting inspection should be made approximately two weeks after the first inspection so that remaining problems can be identified. During the nesting-hatching season, lighting problems that seemed to have been remedied may reappear because owners have been forgetful or because ownership has changed. For this reason, two midseason lighting inspections are recommended. The first of these should take place approximately two months after the beginning of the nesting season, which is about when hatchlings begin to emerge from nests. To verify that lighting problems have been resolved, another follow-up inspection should be conducted approximately one week after the first midseason inspection.

WHO SHOULD CONDUCT LIGHTING INSPECTIONS?

Although no specific authority is required to conduct lighting inspections, property managers, tenants, and owners are more likely to be receptive if the individual making recommendations represent a recognized conservation group, research consultant, or government agency. When local ordinances regulate beach lighting, local government code-enforcement agents should conduct lighting inspections and contact the public about resolving problems.

WHAT SHOULD BE DONE WITH INFORMATION FROM LIGHTING INSPECTIONS?

Although lighting surveys serve as a way for conservationists to assess the extent of lighting problems on a particular nesting beach, the principal goal of those conducting lighting inspections should be to ensure that lighting problems are resolved. To resolve lighting problems, property managers, tenants, and owners should be give the information they need to make proper alterations to light sources. This information should include details on the location and description of problem lights, as well as on how the lighting problem can be solved. One should also be prepared to discuss the details of how lighting affects sea turtles. Understanding the nature of the problem will motivate people more than simply being told what to do.

Lighting Survey Form for NC

Lighting survey must be conducted to include a landward view from the seaward most extent of the beach profile. Survey must occur after 9pm. The survey shall follow standard techniques for such a survey and include the number and type of visible lights, location of lights and photo documentation.

Date: ____

Location (name of beach): ________________________________

Contact information of person conducting the lighting survey: _________________________

____

Time survey started: _______

Time survey ended: _______

Location survey began (include address or GPS location):________________________________

____

Location survey ended (include address or GPS location): ________________________________

____

Date summarizing report sent to the following:
seaturtle@fws.gov:_________________________________

Contact information for follow up meeting with the FWS and State Wildlife Agency:
____

For each light visible from the nesting beach provide the following information:

Location of Light (include cross street and nearest beach access)	GPS location of Light	Description of light (type and location)	Photo take (YES/ NO)