2017 DARE COUNTY BEACH NOURISHMENT PROJECT

PROJECT COMPLETION REPORT

(Dredge Liberty Island during the Dare County Nourishment Project. Photo Courtesy of Dare County)

Prepared For:

Dare County
Town of Duck
Town of Southern Shores
Town of Kitty Hawk
Town of Kill Devil Hills

Prepared By:

Aptim Coastal Planning & Engineering of North Carolina, Inc.
4038 Masonboro Loop Road
Wilmington, NC 28409

May 2018

2017 DARE COUNTY BEACH NOURISHMENT PROJECT
PROJECT COMPLETION REPORT

EXECUTIVE SUMMARY

This report describes the construction results and the post-construction condition of the Dare County Beach Nourishment Project. The project was constructed between May 2017 and October 2017 during which a total of 3,926,669 cubic yards of sand were placed within the Towns of Duck, Southern Shores, Kitty Hawk, and Kill Devil Hills. The distribution of the total volume among the four towns was: Duck – 1,263,181 cubic yards, Southern Shores – 80,510 cubic yards, Kitty Hawk – 1,765,619 cubic yards, and Kill Devil Hills – 817,359 cubic yards.

The following summarizes changes in the Mean High Water (MHW) shoreline position and volumetric changes on the beach profile that occurred as a result of the project. The added width of the beach measured at the MHW shoreline were determined by comparing the Before Dredge (BD) and After Dredge (AD) surveys (2017 As-Built) as well as the Before Dredge survey (BD) and the December 2017 Post-Construction Monitoring survey (BD-December 2017). The BD-AD comparison represents the increased width of the beach at MHW immediately following construction while the Pre-Construction to December 2017 comparison represents the net gain in beach width at the MHW shoreline following initial post-fill adjustments.

Volumetric changes were measured by comparing the Before Dredge (BD) and After Dredge (AD) surveys. These two surveys were the basis of the pay volumes. Volumetric changes were also computed for the Town of Duck by comparing the April 2017 Pre-Construction survey with the December 2017 Post-Construction Monitoring survey. Similarly, Pre-Construction and Post-Construction volume changes for the Towns of Kitty Hawk, Kill Devil Hills and Southern Shores were determined by comparing the June 3 to 11, 2017 Pre-Construction surveys and the December 2017 Post-Construction Monitoring survey. The Pre-Construction (April/June 2017) to December 2017 volumes measured above the -24 ft. NAVD88 contour, which include initial fill adjustments, will be used in subsequent monitoring reports to track the performance of the four projects.

Average Increase in the width of the beach
at the Mean High Water (+1.2' NAVD88) Shoreline

	2017 As-Built	Pre-Construction to December 2017
Town of Duck	240.9 ft.	110.9 ft.
Town of Southern Shores	115.4 ft.	60.1 ft.
Town of Kitty Hawk	158.4 ft.	97.8 ft.
Town of Kill Devil Hills	126.6 ft.	37.1 ft.

Volumetric Changes

	2017 As-Built[1]	Pre-Construction to December 2017[2]
Town of Duck	1,263,181 cy	966,300 cy
Town of Southern Shores	80,510 cy	121,713 cy
Town of Kitty Hawk	1,765,619 cy	2,120,195 cy
Town of Kill Devil Hills	817,359 cy	895,413 cy

[1] Volume change computed along the portion of the profile where AD and BD surveys overlap.
[2] Volume change computed above the -24 ft. NAVD88 contour.

Overall, the project was constructed as designed and is providing increased storm damage reduction and a wider recreational beach.

2017 DARE COUNTY BEACH NOURISHMENT PROJECT
PROJECT COMPLETION REPORT

Table of Contents

I. INTRODUCTION 1
II. PROJECT DESCRIPTION 1
III. PROFILE AND HYDROGRAPHIC SURVEYS 4
IV. SHORELINE CHANGES 5
V. VOLUMETRIC CHANGES 11
VII. PROJECT CHALLENGES 21
VIII. ENVIRONMENTAL MONITORING 24
IX. CONSTRUCTION CHANGE ORDERS 27
X. CONSTRUCTION FIELD ADJUSTMENTS 29
XI. REQUEST FOR INFORMATION 30
XII. PROJECT GEOTECHNICAL DATA 31
XIII. CONSTRUCTION COSTS 33
XIV. SUMMARY 33

List of Figures

Figure 1. Project Location Map 3
Figure 2. Town of Duck MHW Shoreline Changes 7
Figure 3. Towns of Kitty Hawk, Southern Shores and Kill Devil Hills MHW Shoreline Changes. 10
Figure 4. Town of Duck Volumetric Changes 14
Figure 5. Town of Kitty Hawk with Southern Shores Extension and Kill Devil Hills Volumetric Changes 17
Figure 6. View of the beach nourishment project within the Town of Duck, looking north - Pre-Construction (left), Post-Construction (right). 18
Figure 7. View of the completed Town of Duck project, ... 19
Figure 8. View of the beach nourishment project within the Town of Kitty Hawk 19
Figure 9. View of the beach nourishment project within the Town of Kill Devil Hills, looking south - Pre-Construction (left), Post-Construction (right). 19
Figure 10. View of the beach nourishment project within the Towns of Kitty Hawk and Southern Shores, looking north - Pre-Construction (left), Post-Construction (right). 20
Figure 11. Wave Heights during Tropical Storms Irma (9/11 – 9/12), Jose (9/17 – 9/23) and Maria (9/25 – 9/28). 22
Figure 12. View of the accumulation of sand near the installed sand fencing at White Road in Kitty Hawk prior to (left) and after (right) the storms that affected the Dare County project in September 2017. 22

Figure 13. Subline at Lillian Street being uncovered on October 11, 2017. 23
Figure 14. Network for Endangered Sea Turtles (NEST) relocating the 1 nest. 25
Figure 15. Trawler working ahead of the Hopper Dredge Padre Island. 26

List of Tables

Table 1. Significant Construction Dates 3
Table 2. Construction Volume Summary 4
Table 3. Town of Duck MHW Shoreline Changes 6
Table 4. Town of Southern Shores, Kitty Hawk, and Kill Devil Hills MHW Shoreline Changes 8
Table 5. Fill Density Summary (CY/LF) 11
Table 6. Town of Duck Volumetric Changes (CY) 13
Table 7. Town of Southern Shores, Kitty Hawk, and Kill Devil Hills Volumetric Changes (CY) 15
Table 8. Sieve Analysis Summary of Dare County Project Samples 32

List of Appendices

Appendix No.

A As-Built Plan View and Cross-Section Drawings
B Post-Construction (December 2017) Survey Report
C As-Built Borrow Area Drawings
D Pre- and Post-Construction Borrow Area Survey Data
E APTIM Daily Observation Reports
F GLDD Daily Quality Control Reports
G Sea Turtle Capture and Relocation Forms & Sea Turtle Incidental Take Forms
H Change Orders
I Construction Plans - Final
J Field Adjustment Reports
K Requests For Information
L Sediment Granularmetric Reports
M Pay Applications

2017 DARE COUNTY BEACH NOURISHMENT PROJECT
PROJECT COMPLETION REPORT

I. INTRODUCTION

This report summarizes the results of the 2017 Dare County Beach Nourishment Project. The 2017 Restoration Project commenced dredging on May 23, 2017 and finished placing sand on October 21, 2017. The sand for the project was obtained from two (2) offshore borrow areas and placed on the beach using three (3) hopper dredges owned and operated by Great Lakes Dredge and Dock Company (GLDD). Results of the 2017 project are reported in terms of both As-Built conditions and Pre-Construction/Post-Construction conditions. The contractor's Before Dredge (BD) surveys and After Dredge (AD) surveys were used to determine pay yardages. Volumes computed using the Pre-Construction surveys (April/June 2017) and the December 2017 Post-Construction monitoring survey (Pre-Construction-December 2017) represent conditions following initial fill adjustments. Future tracking of the performance of the four projects will be based on the Pre-Construction December 2017 survey results in terms of both shoreline and volume changes. For the Town of Duck, the Pre-Construction survey was made in April 2017 whereas the Southern Shores, Kitty Hawk, and Kill Devil Hills Pre-Construction surveys were obtained between June 3 and 11, 2017. The Post-Construction monitoring survey for all four towns was obtained in December 2017.

This information is submitted in accordance with BOEM Lease No. OCS-A 0513; CAMA Permit Nos. 132-15, 133-15, 134-15, and 59-17; USACE Permit Nos. SAW-2014-02202, SAW-2014-02203 and SAW-2014-02204, in addition to terms and conditions detailed in the U.S. Fish and Wildlife Service Biological Opinion (BO) dated November 4, 2015 (Log Nos. 04EN2000-2015-F-0443, 04EN2000-2015-F-0444 and 04EN2000-2015-F-0445) for the post-construction monitoring period.

II. PROJECT DESCRIPTION

The Towns of Duck, Southern Shores, Kitty Hawk, and Kill Devil Hills, in cooperation with Dare County, completed the beach nourishment project between May and October 2017. The project consisted of the placement of 3,926,669 cubic yards of sand along 8.3 miles of shoreline within the Towns of Duck, Southern Shores, Kitty Hawk, and Kill Devil Hills. A total of 1,263,181 cubic yards of sand was placed along 1.6 miles of shoreline in the Town of Duck; 1,765,619 cubic yards along 3.8 miles of shoreline in the Town of Kitty Hawk; 80,510 cubic yards along 1,500 feet of shoreline in Southern Shores; and 817,359 cubic yards along 2.6 miles of the Kill Devil Hills shoreline. The project utilized sand from two (2) existing Outer Continental Shelf borrow sites located off of the Towns of Duck and Kill Devil Hills.

The designs were based on conditions surveyed for Duck during September 2013, for Kitty Hawk during April 2014, and for Kill Devil Hills during July 2012. A vertical tolerance of +/- 0.5 ft. was provided to the contractor to account for construction inaccuracies. The As-Built Plan View drawings and cross sections of the constructed Dare County project are included in Appendix A. These drawings detail the elevation and location of the placed beach fill.

The beach fill design for the Town of Duck included a 20-foot wide dune at elevation +20.0 feet NAVD fronted by a variable width berm at elevation +6.0 feet NAVD. The width of the berm along the project shoreline was based on the results of a one-year simulation of shoreline response using the computer program GENESIS. A main fill section was constructed covering 7,970 feet of shoreline beginning on the north at profile station D-10, which is located near 140 Skimmer Way, and ending on the south near station D-19 which is located at the south property line of 137 Spindrift Lane. A five hundred (500) foot taper was constructed on the north end of the fill to provide a gradual merger of the project shoreline with the existing shoreline. Due to concerns with possible damage to sensitive instruments buried on its property, the USACE Field Research Facility requested no material be deposited directly along its shoreline. As a result, a taper was not provided at the south end of the project, rather, the volume of material originally included in the south taper was distributed along the southern extent of the main fill.

The beach fill design for the Town of Kitty Hawk included a 10-foot wide dune at elevation +12.0 feet NAVD fronted by a 60-foot wide berm at elevation +6.0 feet NAVD. A main fill section was constructed covering 18,989 feet of shoreline beginning on the north at profile station 0+00, which is located approximately 120 feet north of the pier at the Hilton Garden Inn, and ending on the south near station 189+87, which is located between East Sibbern Drive and East Arch Street. Since the Kitty Hawk project was constructed in conjunction with Kill Devil Hills, only one taper on the north end of the main fill was constructed. Originally, the north taper was designed to extend 1,000 ft. into the Town of Southern Shores. In January 2017, the Town of Southern Shores initiated the process to include the southern 1,500 ft. of its shoreline into the Kitty Hawk Project. Subsequently, an additional taper was added to the northern end of the Southern Shores portion of the project. Thus, the Kitty Hawk with Southern Shores extension project included a total of 21,489 feet of shoreline.

The beach fill design for the Town of Kill Devil Hills included a 20-foot wide dune at elevation +15.0 feet NAVD fronted by a 40-foot wide berm at elevation +6.0 feet NAVD. SBEACH results and topographic data review suggested that no dune construction was required between 240+42 and 269+49 and south of 304+82 to achieve the design level of storm damage reduction. A main fill section was constructed covering 12,501 feet of shoreline beginning on the north at profile 189+87, which is located at the north Town limit, and ending on the south near station 314+88 which is located at Windsong Way. Since the Kill Devil Hills project was constructed in conjunction with Kitty Hawk, only one taper on the south end of the main fill was constructed. The south taper measured 1,009 feet and ended just north of the Prospect Avenue public access at station 324+97.

GLDD completed the dredging work for the Dare County Nourishment project in 153 days using three (3) hopper dredges; the Liberty Island, Dodge Island and Padre Island. Dredging began on May 23, 2017 in the Town of Duck and was concluded on October 23, 2017 in the Town of Kitty Hawk with final acceptance on December 22, 2017. The borrow area post-construction survey shows that approximately 3,543,800 cubic yards were removed from the offshore borrow area A during the project and 1,042,900 from offshore borrow area C. The difference between the as-built volumes measured in place on the beach and the volume removed from the borrow areas represents a retention rate of over 85%.

The borrow areas used to construct the project are located in Federal waters approximately 4.1 to 6.5 miles offshore. Borrow area A had varying excavation limits with the deepest being -68 ft. NAVD and the shallowest at -58.5 ft. NAVD. Borrow area C also had varying excavation limits with the deepest being -65 ft. NAVD and the shallowest at -61 ft. NAVD. Figure 1 shows the location of the borrow areas in relation to the Towns of Duck, Southern Shores, Kitty Hawk and Kill Devil Hills project area limits.

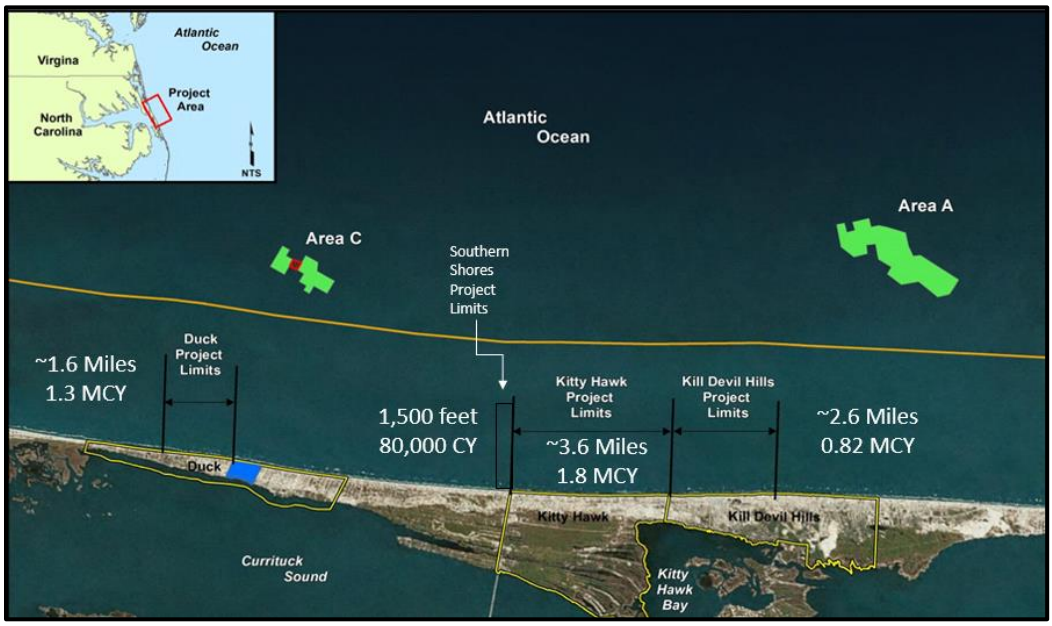

Figure 1. Project Location Map

Table 1 summarizes the significant project construction dates.

Table 1. Significant Construction Dates

CONSTRUCTION ITEM	DATE
Bid Opening	March 8, 2016
Construction Contract Awarded	April 19, 2016
Pre-Construction Conference	February 16, 2017
Start of Beach and Dune Construction	May 23, 2017
Completion of Beach and Dune Construction	October 21, 2017
Substantial Completion - Town of Duck	July 22, 2017
Substantial Completion - Town of Southern Shores	August 17, 2017
Substantial Completion - Town of Kill Devil Hills	August 18, 2017
Completion of Beach and Dune Construction	October 21, 2017
Substantial Completion - Town of Kitty Hawk	October 25, 2017
Final Acceptance	December 22, 2017

The design, as-built, and pay volumes over the project area are provided in Table 2. Due to contractual conditions, the pay volumes for Kitty Hawk and Southern Shores differed slightly from the measured, i.e., as-built volumes.

Table 2. Construction Volume Summary

PROJECT AREA	EFFECTIVE DISTANCE	VOLUMES IN CUBIC YARDS		
		DESIGN	AS-BUILT	PAY
Town of Duck	8,358	1,180,000	1,263,181	1,129,747
Town of Kitty Hawk	19,989	1,765,000	1,765,619	1,765,000
Town of Southern Shores	1,500	80,000	80,510	80,000
Town of Kill Devil Hills	13,577	840,000	817,359	817,359

III. PROFILE AND HYDROGRAPHIC SURVEYS

The Pre-Construction, Before Dredge (BD) and After Dredge (AD) profile surveys were performed by TI Coastal, Inc., under contract to GLDD. Profiles for the AD-BD surveys were spaced approximately 100 feet throughout the project. The BD-AD surveys for the Town of Duck extended from D-10 (Skimmer Way) to D-19 (northern boundary of the USACE Field Research Facility). Surveys for the Towns of Southern Shores, Kitty Hawk, and Kill Devil Hills extended from station -25+00 (approximately 400 feet north of Skyline Road in Southern Shores) to 325+66 (Prospect Avenue in Kill Devil Hills). The Pre-Construction surveys were spaced approximately 500 feet. The Pre-Construction survey for the Town of Duck was completed in April 2017 with Pre-Construction surveys for the Towns of Kitty Hawk, Kill Devil Hills and Southern Shores obtained between June 3 and June 11, 2017. APTIM conducted the post-construction monitoring survey in December 2017. The post-construction survey extended both north and south of the project areas in order to capture the effects of sediment spreading along the project area.

A plan view of the As-Built design template is provided in Appendix A. Comparisons of the Pre-Construction, Before Dredge (BD), After Dredge (AD), and December 2017 post-construction profiles are provided in Appendix A. The complete post-construction survey report, which includes survey methodology, monument information reports, ground digital photography, field book notes and survey data files, is included as Appendix B.

Hydrographic surveys providing multibeam bathymetry of the borrow area were also conducted pre- and post-construction by TI Coastal, Inc. under contract with GLDD. All surveys were conducted in the North American Vertical Datum of 1988 (NAVD88). A plan view of the As-Built borrow area survey and a comparison of the pre- and post-construction surveys are provided in Appendix C. Survey Data files for the pre- and post-construction borrow area surveys are provided in Appendix D.

IV. SHORELINE CHANGES

The Mean High Water (MHW) elevation measured at each profile are used to represent the shoreline position at each profile along the beach. The MHW elevation for the Towns of Duck, Kitty Hawk, Southern Shores and Kill Devil Hills is +1.2 feet NAVD. The shoreline changes and added beach widths are determined by comparing MHW shoreline positions of two different surveys. The shoreline change measured as a direct result of the construction of the beach nourishment projects (As-Built) was determined by comparing the Before Dredging (BD) and After Dredging (AD) surveys. Changes in the MHW shoreline position was also measured between the BD survey and the December 2017 post-construction survey to account for post-fill adjustments that occur shortly after placement of the fill. This post-fill adjustment is generally referred to as equilibration. The shoreline changes for Duck are listed in Table 3 and shown graphically in Figure 2. Shoreline changes for Southern Shores, Kitty Hawk, and Kill Devil Hills are listed in Table 4 and shown graphically in Figure 3.

As-Built

The average added beach width for the Town of Duck project area was 240.9 feet at the MHW line. The largest increase in beach widths occurred near D-14 and D-15.

In Southern Shores, the average added beach width between stations 0+00 to -20+00 was 115.4 feet at the MHW line.

The average added beach width for the Town of Kitty Hawk project area was 158.4 feet at the MHW line. The largest increase in beach width in Kitty Hawk occurred near station 20+02, 109+99 and 160+00.

The average added beach width for the Town of Kill Devil Hills main fill project area was 121.6 feet at the MHW line. The largest increase in beach widths occurred near station 189+87, 269+49 and 299+92.

Pre-Construction to Post-Construction (December 2017)

The December 2017 Post-Construction survey showed the Town of Duck main fill project area has maintained an average beach width of 110.9 feet based on the change of the MHW shoreline since the project was constructed. The difference between the As-Built and December 2017 beach widths indicates that the shoreline is equilibrating as expected. Beach equilibration was accounted for in the development of the Town of Duck project design. Once the project has reached equilibrium, the shoreline change rates are expected to stabilize.

Between stations 0+00 and -20+00 in Southern Shores, the beach fill project maintained an averaged beach width of 60.1 feet as of December 2017 relative to Pre-Construction. The December 2017 post-construction survey showed that the Town of Kitty Hawk main fill project area has maintained an average beach width of 97.8 feet based on the change of

the MHW shoreline since the project was constructed. The difference between the As-Built and post-construction beach widths also indicates that the shorelines are equilibrating as expected. Beach equilibration was accounted for in the development of the Kitty Hawk project design. Once the project has reached equilibrium, the shoreline change rates are expected to stabilize.

The December 2017 Post-Construction survey showed that the Town of Kill Devil Hills main fill project area has maintained an average beach width of 37.1 feet based on the change of the MHW shoreline since the project was constructed. The relatively high losses in beach width along portions of Kill Devil Hills may be associated with the existence of a series of shore oblique depressions that exist offshore of Kill Devil Hills beginning near the -20-foot NAVD contour and extending seaward. These depressions could be affecting the way waves impact the shoreline, possibly setting up differences in sediment transport rates which could result in an imbalance of sediment moving into and out of various shoreline reaches. The discovery of the depressions was obtained by combining an offshore multi-beam survey by GLDD taken in 2017 with the single beam survey conducted by APTIM in 2017-2018. The possible impact of the depressions will be evaluated in greater detail as part of the continuing project monitoring program. Notwithstanding the offshore depressions, the shoreline is equilibrating and sand bars are forming nearshore in areas that no sand bars were present prior to the construction of the project.

Table 3. Town of Duck MHW Shoreline Changes

PROFILE	AS-BUILT (feet)	APRIL 2017 TO DECEMBER 2017 (feet)
D-10	21.1	26.7
D-11	218.3	74.8
D-12	270.7	94.5
D-13	283.7	124.6
D-14	314.9	164.3
D-15	278.3	145.8
D-16	295.2	143.9
D-17	253.2	126.7
D-18	232.3	96.4
PROJECT AREA (D-10 TO D-18)	240.9	110.9

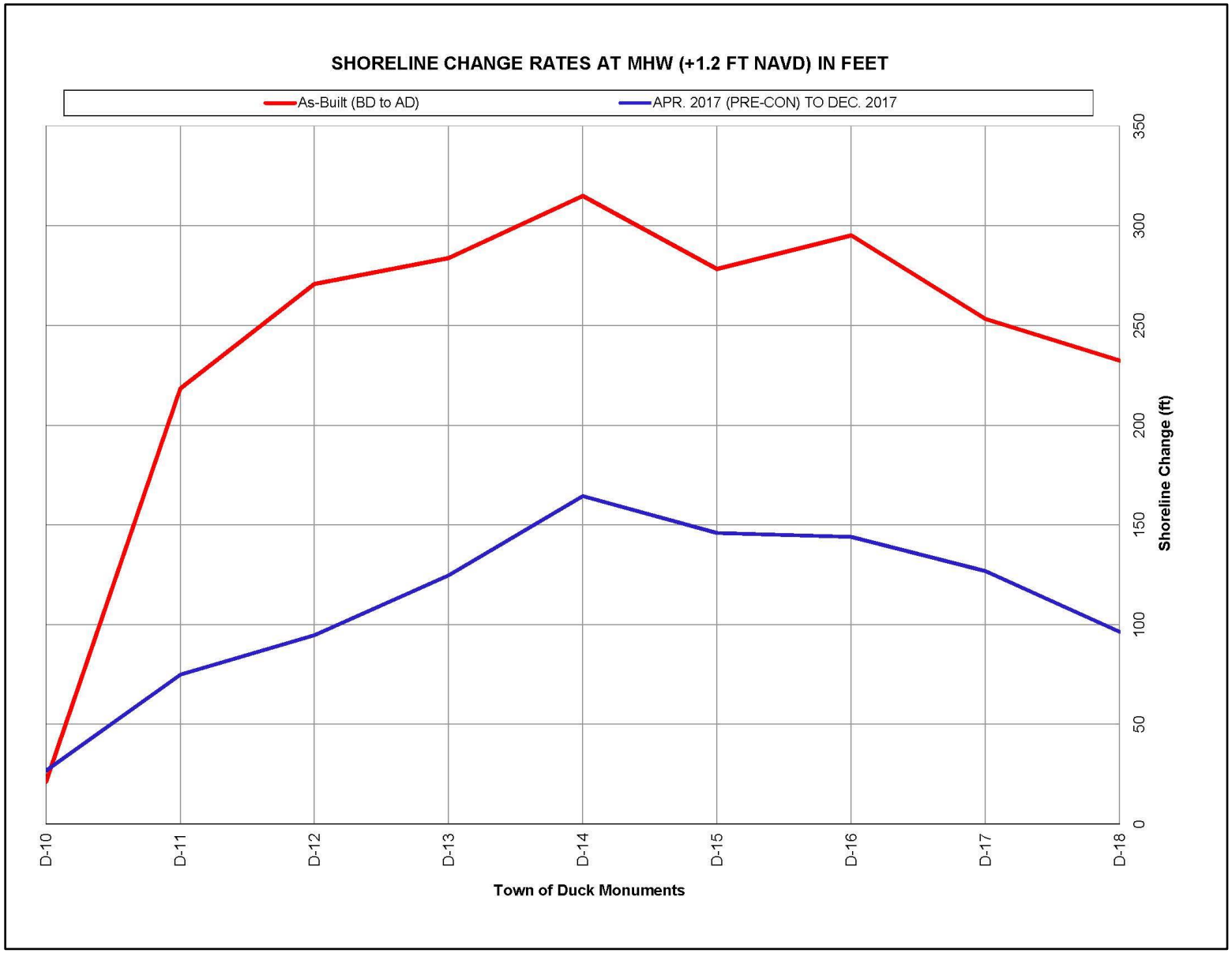

Figure 2. Town of Duck MHW Shoreline Changes

Table 4. Towns of Southern Shores, Kitty Hawk, and Kill Devil Hills MHW Shoreline Changes

PROFILE	AS-BUILT (feet)	JUNE 2017 TO DECEMBER 2017 (feet)
-20+00	73.7	28.4
-10+00	121.5	73.2
0+00	150.9	78.8
9+99	147.9	40.5
20+02	205.9	78.0
30+05	129.5	102.7
40+24	189.4	97.4
50+28	168.5	64.9
60+50	151.4	63.8
70+03	164.1	107.5
80+15	102.9	88.3
89+57	157.4	119.6
99+99	190.4	134.7
109+99	249.9	108.3
119+99	56.8	134.0
130+33	110.2	180.7
138+28	193.6	189.0
149+99	116.0	152.0
159+99	243.1	53.1
169+70	164.0	49.6
179+87	104.1	61.8
189+87	172.0	52.0
199+93	54.6	31.0
209+74	80.6	32.0
219+99	90.8	-19.0
229+83	90.3	22.2
240+41	88.4	39.9
249+81	76.2	39.5
260+17	124.3	39.5
269+49	181.0	48.6
279+80	168.1	63.2
289+99	146.9	57.7
299+92	170.5	54.8
309+71	137.0	20.6
320+05	60.6	4.5
KITTY HAWK (0+00 TO 189+87)	158.4	97.8
SOUTHERN SHORES (-20+00 TO 0+00)	115.4	60.1

KILL DEVIL HILLS (189+87 TO 320+05)	121.6	37.1
PROJECT AREA (-20+00 TO 320+05)	138.1	71.2

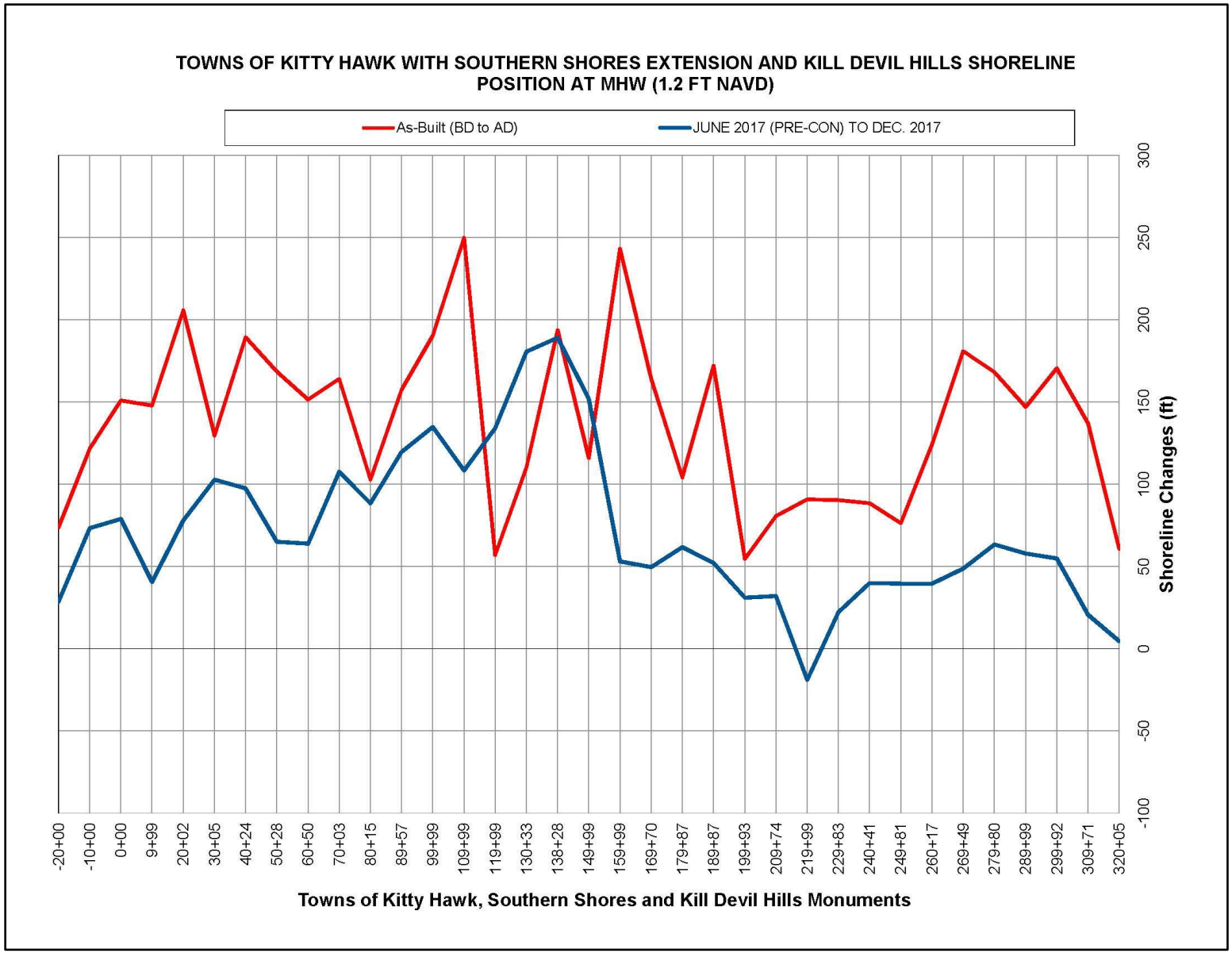

Figure 3. Towns of Kitty Hawk, Southern Shores and Kill Devil Hills MHW Shoreline Changes.

V. VOLUMETRIC CHANGES

The volumetric changes discussed in this report represent the difference in the quantity of sand measured along the beach between surveys. The volumes were computed using the average end area method, which is standard practice. Pay volumes were computed using the BD and AD construction profiles on approximately 100-foot spacing. Material placed by the contractor outside of the specified beach fill template was not eligible for pay. The as-built volume is the total amount of sand placed by GLDD. The pay volume is the volume of material placed within the specified beach fill template. Overall, due to the coarseness of the material, the pay volumes were comparable to the as-built volumes.

Fill densities, given in terms of cubic yards per linear foot of shoreline (cy/ft) for each project area is provided in Table 5. As-Built volumes for the Town of Duck are listed in Table 6 and are shown in Figure 4 while As-Built volumes for Southern Shores, Kitty Hawk, and Kill Devil Hills are provided in Table 7 and shown in Figure 5.

Table 5. Fill Density Summary (CY/FT.)

PROJECT AREA	EFFECTIVE	DENSITY IN CUBIC YARDS/FOOT		
	DISTANCE	DESIGN	PAY	AS-BUILT
Town of Duck Sta. D-10 to D-19	8,358	141.2	135.2	151.1
Town of Southern Shores Sta. 0+00 to -15+00	1,500	53.3	53.3	53.7
Town of Kitty Hawk Sta. 0+00 to 189+89 and -15+00 to -25+00	19,989	88.3	88.3	88.3
Town of Kill Devil Hills Sta. 189+89 to 325+66	13,577	61.9	60.2	60.2

For the Town of Duck project, GLDD was given the option of constructing the entire project with material from Borrow area C (BA-C) or using a combination of material from Borrow area A (BA-A) and Borrow area C. With the mean grain size of the material in Borrow area C being finer than the mean grain size of the recipient beach, the use of material from BA-C for the entire Duck project would have required approximately 20% more material to achieve the design fill conditions. However, if one cubic yard of material from Borrow area C was mixed with 2 cubic yards of material from Borrow area A, the resulting mix would have a mean grain size comparable with the recipient beach. GLDD elected to build the portion of the Duck project between the northern limits at station 87+63 to station 148+00 solely from Borrow area C and the remaining portion of the project with material using a ratio of 2 loads from Borrow area A for every one load

from Borrow area C. Thus, for the portion of the Duck project from station 87+63 to 148+00, the in place design volume was increased 20% to account for the finer material and the fill template adjusted accordingly.

In order to monitor the overall performance of the project, volumetric changes are calculated between the dunes (upland) and the approximate depth of closure. The depth of closure is defined by the USACE as a theoretical depth along a beach profile where sediment transport is very small or non-existent, dependent on wave height and period, and occasionally, sediment grain size. During the design phase of the projects, the depth of closure for these projects was determined to be -24.0 feet NAVD88. Therefore, the -24-foot NAVD88 contour is used to determine volumetric changes in the monitoring area. The volumes computed between the Pre-Construction and Post-Construction surveys (i.e., April/June 2017 and December 2017) will be used as the starting volumes to monitor the performance of the beach fill over time. These volumes are listed in Table 6 for Duck and Table 7 for Southern Shores, Kitty Hawk, and Kill Devil Hills. The Pre-Construction to December 2017 volume changes are shown graphically in Figure 4 and Figure 5 for Duck and the other three towns, respectively.

As-Built

For the Town of Duck, the measured Pay volume was 1,129,747 cubic yards calculated from stations D-10 to D-19. The actual measured volume placed, when accounting for the 20% increase in fill between stations 87+63 and 148+00, was 1,263,181 cubic yards. The average design density between stations D-10 to D-19 was 141.2 cy/ft. while the pay and As-Built densities were 135.2 cy/ft. and 151.1 cy/ft., respectively.

For the Town of Southern Shores, the measured As-Built volume was 80,501 cubic yards calculated from stations -15+00 to 0+00. The average design density between -15+00 to 0+00 was 53.3 cy/ft. while As-Built density was 53.7 cy/ft.

For the Town of Kitty Hawk, the measured As-Built volume was 1,765,619 cubic yards calculated from stations 0+00 to 189+89. The average design density between stations 0+00 and 189+89 was 88.3 cy/ft. while the As-Built density was also 88.3 cy/ft.

For the Town of Kill Devil Hills, the measured Pay volume was 817,359 cubic yards calculated from stations 189+89 to 325+66. The average design density between stations 189+89 and 325+66 was 61.9 cy/ft. while the As-Built density was 60.2 cy/ft.

Table 6. Town of Duck Volumetric Changes (CY)

PROFILE AREA	EFFECTIVE DISTANCE (FT)	AS-BUILT	APRIL 2017 TO DECEMBER 2017
D-10	506	15,658	13,200
D-11	897	111,153	77,300
D-12	900	120,788	97,900
D-13	997	165,661	135,900
D-14	975	178,708	156,500
D-15	975	157,250	127,500
D-16	973	184,377	141,700
D-17	1,010	148,902	127,200
D-18	823	133,308	89,100
D-19	300	47,376	13,200
TOTAL AREA (D-10 TO D-19)	8,358	1,263,181	966,300

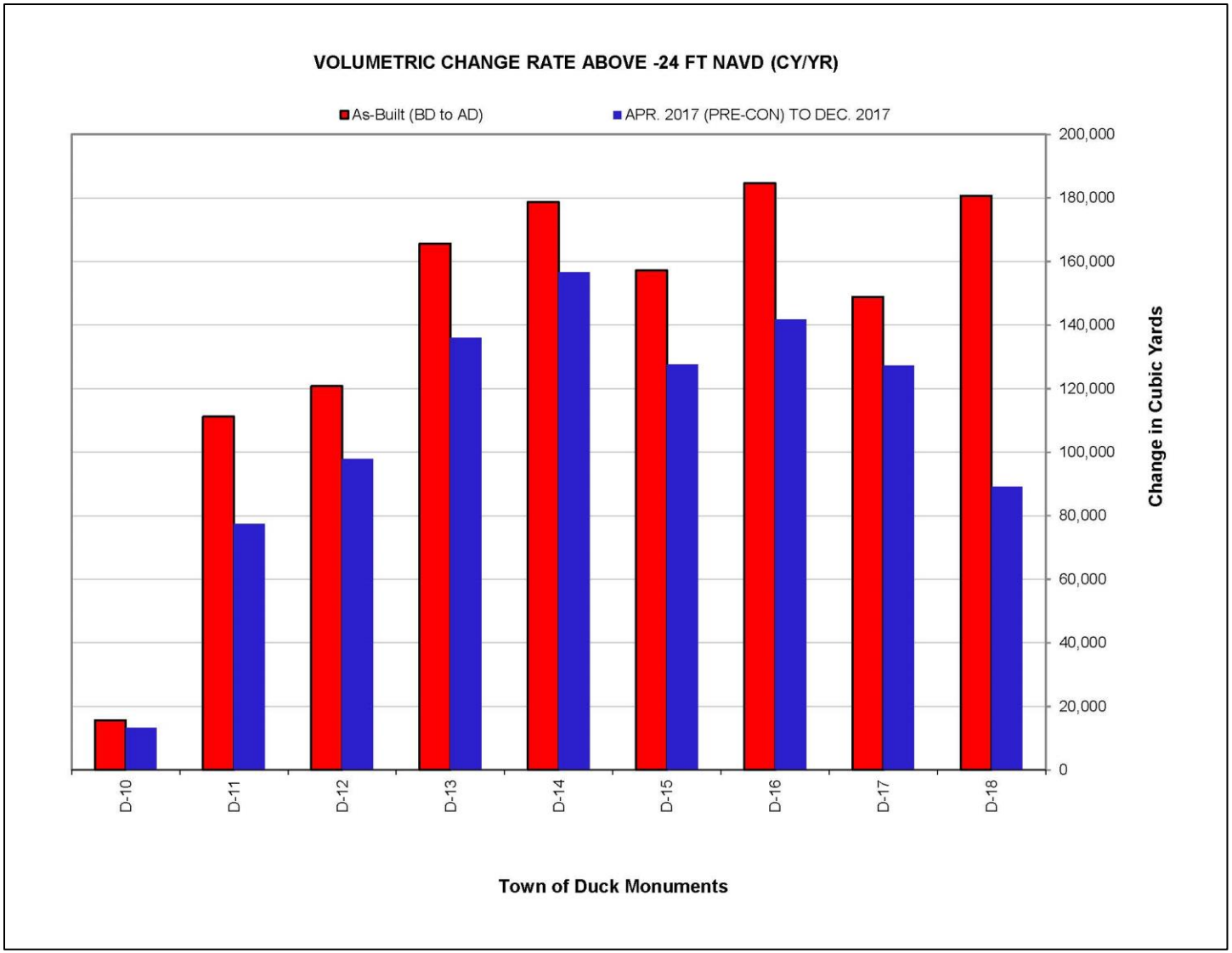

Figure 4. Town of Duck Volumetric Changes

Table 7. Towns of Southern Shores, Kitty Hawk, and Kill Devil Hills Volumetric Changes (CY)

PROFILE	EFFECTIVE DISTANCE (FT)	VOLUMETRIC CHANGES (CY)	
		BD vs AD	JUNE 2017 TO DECEMBER 2017
-20+00	1,000	47,605	64,040
-10+00	1,000	56,707	89,693
0+00.00	1,000	92,712	115,800
9+99.90	1,001	61,477	53,254
20+02.68	1,003	134,313	95,402
30+05.52	1,011	71,734	119,829
40+23.88	1,011	102,360	117,569
50+28.29	1,013	100,719	101,205
60+50.00	987	73,218	84,272
70+02.90	983	83,980	120,733
80+15.19	977	41,529	99,573
89+56.91	992	75,346	120,323
99+99.71	1,021	94,857	170,130
109+99.46	1,000	125,985	104,337
119+99.14	1,017	74,919	104,595
130+33.04	914	87,958	132,014
138+27.64	983	132,024	153,030
149+99.46	1,086	108,797	96,814
159+99.55	985	112,659	71,580
169+70.21	994	100,398	99,822
179+87.62	1,008	75,300	111,114
189+87.10	1,003	123,380	213,396
199+93.01	994	56,307	83,248
209+74.44	1,003	68,362	105,432
219+99.94	1,004	44,730	12,607
229+83.39	1,021	42,021	-72,683
240+41.84	999	41,357	51,762
249+81.53	988	33,656	31,782
260+17.44	984	66,028	46,437
269+49.25	982	85,368	66,746
279+80.81	1,025	74,747	82,278
289+99.14	1,006	68,846	108,416
299+92.48	986	92,173	83,585
309+71.20	1,006	59,697	60,714
320+05.37	1,078	22,376	128,391
SOUTHERN SHORES (-15+00 TO 0+00)	1,500	80,510	121,713

KITTY HAWK (0+00 TO 189+87)	19,989	1,765,619	2,120,195
KILL DEVIL HILLS (189+87 TO 325+66)	13,578	817,359	895,413
PROJECT AREA (-20+00 TO 325+66)	35,065	2,733,645	3,227,241

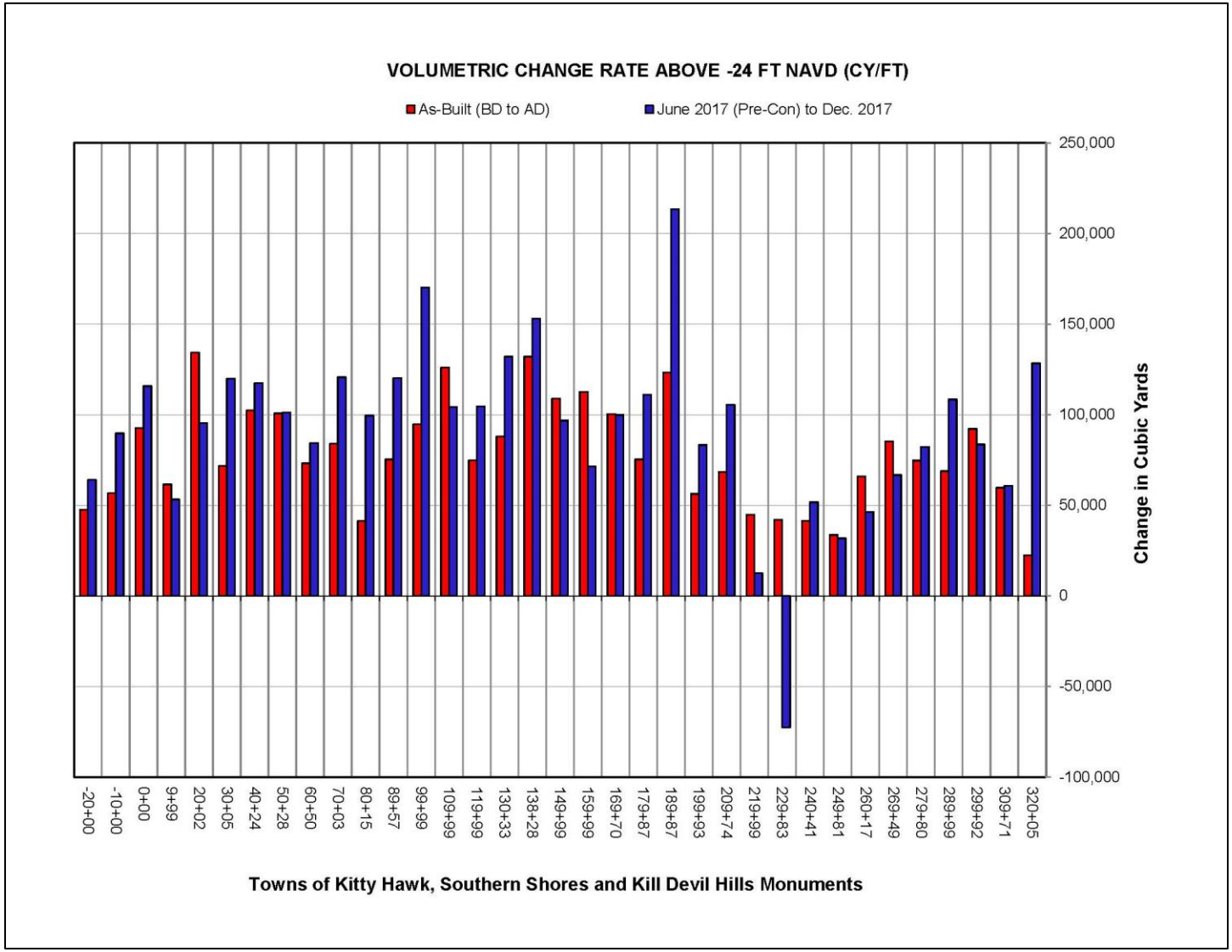

Figure 5. Town of Kitty Hawk with Southern Shores Extension and Kill Devil Hills Volumetric Changes

April/June 2017 (Pre-Construction) to December 2017 (Post-Construction)

The Town of Duck project area (D-10 to D-19) had a volumetric change of 966,300 cubic yards from the Pre-Construction (April 2017) to Post-Construction (December 2017) monitoring survey. The Post-Construction survey was conducted approximately 7 months after the completion of the Town of Duck project.

The Town of Kitty Hawk project area and Southern Shores extension (-25+00 to 189+87) had a volumetric change of 2,241,908 cubic yards from the Pre-Construction (June 2017) to Post-Construction (December 2017) monitoring survey. The December 2017 post-construction survey was conducted approximately 2 months after the completion of the Town of Kitty Hawk project.

The Town of Kill Devil Hills project area (189+87 to 325+66) had a volumetric change of 895,413 cubic yards from the Pre-Construction (June 2017) to Post-Construction (December 2017) monitoring survey. The Post-Construction survey was conducted approximately 4 months after the completion of the Town of Kill Devil Hills project.

Photographs in Figure 6 through Figure 10 illustrate pre- and post-construction conditions along the constructed beaches in the Towns of Duck, Kitty Hawk, Kill Devil Hills and Southern Shores.

Figure 6. View of the beach nourishment project within the Town of Duck, looking north - Pre-Construction (left), Post-Construction (right).

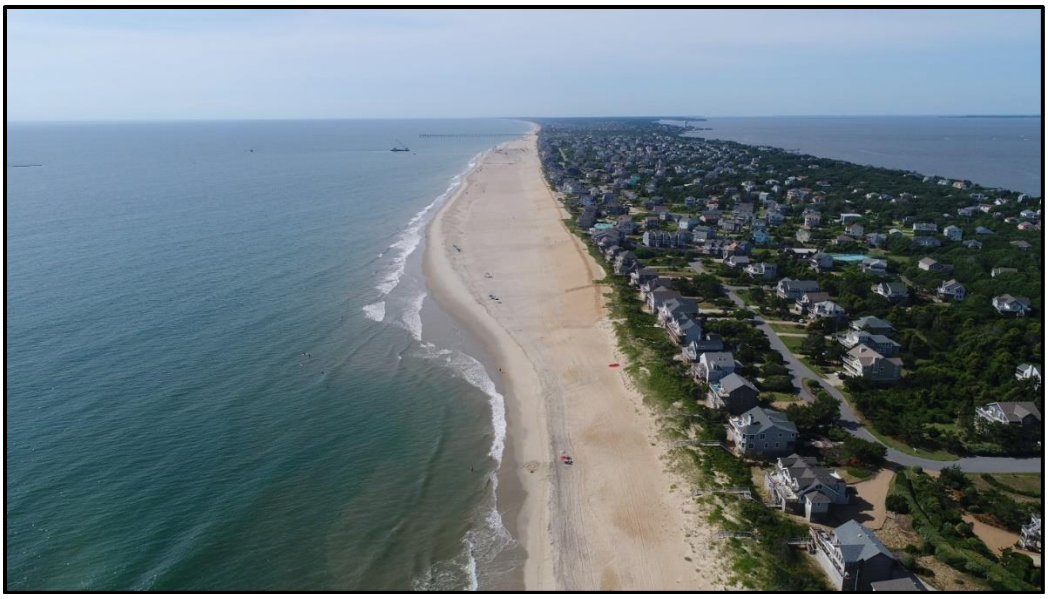

Figure 7. View of the completed Town of Duck project, looking south from north of the project.

Figure 8. View of the beach nourishment project within the Town of Kitty Hawk Pre-Construction (left), Post-Construction (right).

Figure 9. View of the beach nourishment project within the Town of Kill Devil Hills, looking south - Pre-Construction (left), Post-Construction (right).

Figure 10. View of the beach nourishment project within the Towns of Kitty Hawk and Southern Shores, looking north - Pre-Construction (left), Post-Construction (right).

VI. BORROW AREA SURVEY

The 2017 project utilized two (2) offshore borrow areas which had not been previously dredged. The Pre- and Post-Construction borrow area surveys were conducted in accordance with BOEM Lease No. OCS-A 0513. The Pre-Construction survey was performed between April 29 and May 4, 2017. A Post-Construction survey was performed between October 27 and November 21, 2017. In accordance with BOEM Lease No. OCS-A 0513, survey data, hydro-logs, plan view drawings, cross section drawings and a pre- and post-construction statistical analysis were provided to BOEM via email on January 8, 2018. A plan view of the post-construction contours within the borrow areas are provided in Appendix B. Appendix B also includes profile drawings showing the pre- and post-construction conditions in the borrow area. The survey results indicate that no apparent dredging occurred outside of the approved limits.

A final review of the post-dredging surveys did not indicate any permit violations as defined as AD surveys indicating depths in excess of those allowed by BOEM Lease No. OCS-A 0513; CAMA Permit Nos. 132-15, 133-15, 134-15, and 59-17; USACE Permit Nos. SAW-2014-02202, SAW-2014-02203 and SAW-2014-02204. During excavation of the borrow area, equipment was allowed to extended below the permitted borrow area depths shown on the permits without the contractor being in violation of the permit as long as the AD surveys did not indicate depths in excess of those allowed by permit. Construction plans showed a "Maximum Disturbance Elevation" below which material may not be suitable for beach placement. The tracking data for the excavation equipment showed that on several occasions equipment was below the "Maximum Disturbance Elevation". These occasions were described in the APTIM Daily Observation Reports (Appendix C) along with discussions between APTIM representatives and GLDD representatives.

Volumetric changes in the borrow areas were measured between pre- and post-construction. These volumes were calculated using a gridded surface of the two borrow area surveys. Approximately 3,543,800 cubic yards were dredged from Borrow area A. Approximately 12,829,500 cubic yards remain within the limits of Borrow area A used to construct the Dare County Nourishment Project. For Borrow area C, approximately 1,042,900 cubic yards were dredged from within the limits of the borrow area. Approximately 911,900 cubic yards remain within the limits of Borrow area C. The difference between the as-built volumes measured in place on the beach and the volume removed from the borrow areas represents a retention rate of over 85%.

VII. PROJECT CHALLENGES

Construction during Tourist Season

The 2017 Beach Nourishment Project was completed during peak tourist season in the Outer Banks. The project commenced dredging on May 23, 2017 and finished placing sand on October 21, 2017. Throughout the project, the beaches experienced high pedestrian traffic. Safety was of the utmost importance throughout construction. GLDD continually maintained on-site security at each end of the active construction area to ensure that pedestrians did not encroach into the active work zone.

Throughout construction, Dare County along with each of the towns, provided updates via the MoreBeachToLove.com website. The site continually provided updates regarding the active construction area, progress to date, project milestones and construction photos. Between March 2017 and September 31, 2017, the MoreBeachtoLove.com website was visited 192,961 times by 177,065 unique users. The average time spent on the page was 2 minutes and 8 seconds. Additionally, 1,435 website visitors subscribed to receive email updates on beach nourishment projects with an average open rate of 73% on the 71 email updates sent before September 31, 2017.

Also included on the MoreBeachtoLove.com website was an interactive beach nourishment map for each project with information about construction areas, beach closures and parking. The total map views for each town were: Kill Devil Hills – 38,113 views; Kitty Hawk/Southern Shores – 46,412 views; Duck – 89,2798 views.

APTIM and GLDD representatives also held bi-weekly project briefings open to the public in which a progress update was provided and attendees had the opportunity to ask questions. Additionally, Dare County produced a weekly video update for projects that was featured on the website, in email blasts, on social media and shared by local online news outlets. The videos have been viewed a total of 50,723 times.

Based on the number of views, and attendance during the public bi-weekly project meetings that occurred throughout the project, construction during the peak tourist season was feasible. Communication with the public was imperative and contributed to the success of the project while minimizing the effect on tourism during peak season.

Storm Events

During the first several months of the project, GLDD experienced relatively few work stoppages due to weather. However, during the month of September, three (3) named storms affected the Dare County project while construction was still underway. Figure 11 illustrates the wave heights during each of the storms: Irma (9/11 – 9/12), Jose (9/17 – 9/23) and Maria (9/25 – 9/28) as recorded by the AWAC04 gauge located in 11 meters of water offshore the USACE Field Research Facility in Duck, North Carolina.

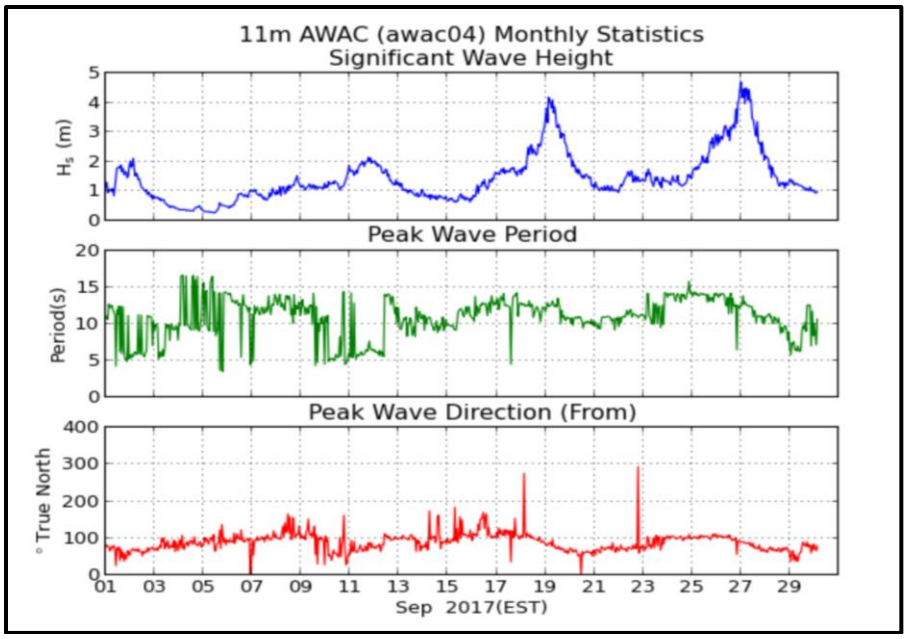

Figure 11. Wave Heights during Tropical Storms Irma (9/11 – 9/12), Jose (9/17 – 9/23) and Maria (9/25 – 9/28).

During these storms as the constructed berm was overtopped by wave runup, material accumulated on the upper portion of the profiles. This re-working of the constructed template resulted in a more natural configuration. Although typically this process may take several months, the large storm events accelerated the process. Figure 12 illustrates the accumulation of sand on the upper portion of the beach profile prior to and after the September 2017 storm events.

Figure 12. View of the accumulation of sand near the installed sand fencing at White Road in Kitty Hawk prior to (left) and after (right) the storms that affected the Dare County project in September 2017.

Additionally, during the wave events of tropical storm Irma, the subline at Lillian Street was buried by the movement of sand. Between tropical storm Irma and October 11, 2017, GLDD intermittently attempted to uncover the subline on several occasions (Figure 13). Additional sublines were utilized while the Lillian Street subline was being uncovered. On September 23,

GLDD was able to remove a blank that had been welded onto the Lillian Street subline and continued to attempt to re-position the subline. Removing the blank, allowed GLDD to pump material through the subline. As material stacked in the vicinity of the subline, heavy machinery was utilized to re-positon the end of the subline.

On September 24, GLDD began attempting to weld additional sections of shore pipeline to the end of the subline. The end of the subline had bent during the removal of the blank, requiring GLDD to cut off the end of the subline to weld the additional sections. On September 25, GLDD was able to weld 3 additional sections of shore pipeline to the end of the pipe, allowing GLDD to pump from the Lillian subline.

During Hurricane Maria, the additional sections of shore pipeline that had been previously welded to the end of the Lillian Street subline were separated. This required GLDD to re-weld the shore pipeline. On October 2, a leak in the subline at Lillian Street was detected and dredging operations were suspended until repairs could be made. On October 11, GLDD successfully uncovered and repositioned the Lillian Street subline. The subline was then utilized to complete the remaining portion of the project.

Figure 13. Subline at Lillian Street being uncovered on October 11, 2017.

Munitions and Explosives of Concern (MEC)

On July 28, 2017 two (2) munitions were recovered in the Liberty Island dredge screen box during dredging from Borrow area A. The munitions were sucked up through the drag arm, passed through the dredge pump, and were recovered in the screener basket after the hopper was filled. Explosive Ordnance Disposal (EOD) staff from Joint Expeditionary Base Little Creek, Virginia, initially indicated that the rounds did not appear volatile and that they believed it was safe to

discharge the load and to continue dredging. In the interim, GLDD was asked by EOD to stow the munitions in a safe place on the boat and EOD would retrieve them the next day which it did. Following the discharge of the load in which the munitions were recovered, GLDD conducted a magnetometer survey on the beach and found no evidence of additional munitions/MEC.

APTIM reviewed the Cultural Resource survey and found that there were 2 sidescan and 1 magnetometer anomalies in the general area that GLDD was dredging when they recovered the MEC. Although identified as sonar targets, these anomalies were not characterized as submerged cultural resources. Since these anomalies were characterized as modern marine debris, no avoidance protocol were recommended for the anomalies. Review of the tracklines of the dredge determined that the drag arm passed approximately 50 feet from the anomalies. The proximity of the trackline of the pass that recovered the munition and the sidescan anomaly may indicate that the sidescan anomaly is associated with a debris field in which the munitions were a part. GLDD indicated they would avoid that general portion of the borrow area and other sonar targets as a precaution.

On July 19, 2017 at 22:36, GLDD indicated that a testing cartridge was recovered on the Liberty Island while dredging from Borrow area A. The testing cartridge was sucked up through the drag arm, passed through the dredge pump, and was recovered in the screener basket. EOD master tech out of Little Creek, Virginia, was immediately notified. At 23:45, GLDD indicated that the EOD master tech stated that it was safe for work to continue and that it was not a hazard.

The trackline of where the dragheads were in the borrow area during the dredging of the load, indicated that the testing cartridge was a substantial distance away from the previous munitions.

VIII. ENVIRONMENTAL MONITORING

Nesting Birds

Bird monitoring was conducted in accordance with the conservation measures detailed in the U.S. Fish and Wildlife Service Biological Opinion (BO) dated November 4, 2015 (Log Nos. 04EN2000-2015-F-0443, 04EN2000-2015-F-0444 and 04EN2000-2015-F-0445). APTIM staff verified monitoring activities and documented those activities that took place in the Daily Observation Reports (Appendix E). All personnel involved in the construction or sand placement process along the beach were trained to recognize the presence of piping plovers and red knots prior to initiation of work on the beach as documented in the GLDD Daily Quality Control Reports. These daily reports are provided in Appendix F.

A GLDD representative, authorized to stop or redirect work, was responsible for conducting a shorebird survey prior to 9:00 am each day to determine if piping plovers or red knots are present. The survey covered the work area and any location where equipment was expected to travel. GLDD noted on their Quality Assurance Form for each day any observance of red knots and/or piping plovers. No plovers or red knots were observed in the work area during the construction of the project.

Sea Turtles

Turtle monitoring was conducted in accordance with the conservation measures, reasonable and prudent measures, and terms and conditions detailed in the U.S. Fish and Wildlife Service Biological Opinion (BO) dated November 4, 2015 (Log Nos. 04EN2000-2015-F-0443, 04EN2000-2015-F-0444 and 04EN2000-2015-F-0445). The turtle monitoring commenced on the night of May 23, 2017. The monitoring was conducted on a daily basis until September 15, 2017 by sea turtle monitors from the Network for Endangered Sea Turtles. The monitors had sea turtle monitoring experience and had permits from the NCWRC for conducting sea turtle monitoring and relocation efforts in North Carolina. A minimum of at least two (2) sea turtle monitors were present at the project site on a continuous basis from dusk to dawn to monitor sea turtle activity. One (1) monitor was required to do continuous monitoring between safety fences within the active construction area (discharge area) and the other conducted three (3) monitoring sessions during the night along the pipeline route. In addition, a monitor was also required to accompany any vehicle traveling from the construction area to the off-beach access point and vice-versa in order to observe for turtle nesting activity ahead of the vehicle. In the early mornings at/or immediately after sunrise, additional volunteer sea turtle monitor(s) would conduct morning nesting activity surveys and drive the limits of the entire project area to look for any sea turtle crawl activity (i.e. false crawl or nesting).

One loggerhead sea turtle nest was relocated during the project on July 6, 2017 near 4th Street in Kill Devil Hills (Figure 14). The nest was relocated outside of the project limits by the NEST organization by approximately 08:30 on July 6.

Figure 14. Network for Endangered Sea Turtles (NEST) relocating the 1 nest.

In accordance with the Biological Opinion issued by NMFS for the project, trawling to determine relative abundance of sea turtles in the area, was required five days prior to the commencement of hopper dredging if SST is above 10°C. An abundance of a minimum of one turtle captured during preliminary abundance trawling would trigger the need for relocation trawling to be employed

during the remainder of the dredging operation. Figure 15 shows a view of the trawler from the bridge of the Padre Island Dredge. On May 22, 2017, a loggerhead turtle was captured during preliminary abundance trawling. Therefore, relocation trawling was required during the remainder of the dredging operation. Once relocation trawling was required, it continued simultaneous with dredging operations. Relocation trawling occurred ahead of the dredges throughout the duration of dredging. During relocation trawling, 1 trawling vessel operated in tandem with each dredge actively digging in the borrow area.

A total of 74 sea turtles were relocated during the construction of the project, 47 loggerheads and 9 leatherbacks from Borrow area A and 1 leatherback, 15 loggerheads, and 2 Kemp's ridley relocated from Borrow area C. Turtles captured during relocation trawling were photographed, measured, biopsied for genetics, scanned for tags, and if necessary PIT or Inconel tagged. They were relocated at least 3 nautical miles (nmi) away from the dredging area. All sea turtles captured by relocation trawling were flipper-tagged prior to release.

Two (2) lethal takes of loggerhead turtles occurred during the entire project. A lethal take of a loggerhead sea turtle occurred on June 14 from the starboard draghead of the Padre Island after load #84. The dredge was operating in Borrow area C at the time. As required by the permit, BOEM was notified via phone and the incidental take form was provided to the USACE. Trawlers were onsite and operational during the lethal take. A second lethal take of a loggerhead sea turtle occurred on August 20 at 04:52 from the port draghead of the Liberty Island after load #451. The dredge was operating in Borrow area A at the time. As required by the permit, BOEM was notified and the incidental take form was provided to the USACE. Trawlers were onsite and operational during the lethal take. GLDD re-conducted an updated BOEM dredge checklist and paint tests for both dragheads after lethal take #2.

Appendix G includes the Sea Turtle Capture & Relocation Forms and Sea Turtle Incidental Take Forms.

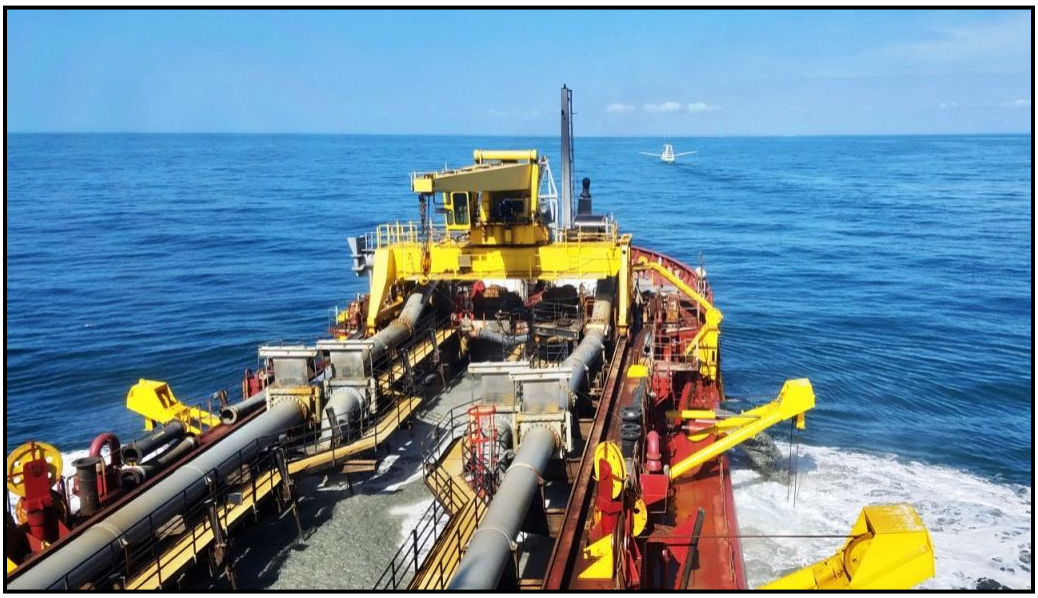

Figure 15. Trawler working ahead of the Hopper Dredge Padre Island.

As a part of the permit conditions for the sea turtle monitoring, two (2) sea turtle Lighting Inspection Surveys will be conducted by the Towns at night to document the location and description of any light source that can be seen from the beach in the year following construction. The first survey will be conducted between May 1 and May 15. The second survey must be conducted between July 15 and August 1.

IX. CONSTRUCTION CHANGE ORDERS

A total of 4 change orders were issued during the construction of the project. A summary of each change order is provided below. Copies of the authorized change orders are provided in Appendix H. Appendix I includes a set of the most updated construction plans that take into consideration all change orders and field adjustments.

Change Order #1 – May 31, 2017

As previously stated, permit requirements stated that if one turtle was captured during preliminary abundance trawling, then relocation trawling shall be employed during the remainder of the dredging operation. On May 22, 2017, a loggerhead turtle was captured during preliminary abundance trawling. Therefore, relocation trawling was required during the remainder of the dredging operation.

Change Order #1 was issued to codify that relocation trawling began no later than 24 hours in advance of any hopper dredging at the borrow site(s). As there was ample time to mobilize a second trawler for use in both Borrow areas A and C, GLDD was not be eligible for standby time due to trawling.

The cost for Base Bid Item I.D. Sea Turtle Abundance Trawling decreased from $23,000.00 to $0.00 as a result of Change Order #1. The cost for Discretionary Bid Item VII.D. Sea Turtle Relocation Trawling increased from $0.00 to $819,000.00. Additive Bid Item V.A. Sand Fencing for Kitty Hawk was also included in the contract as a result of Change Order #1, for a cost of $76,000. As a result of Change Order #1, the total contract cost increased $796,000.00 from $38,596,850.00 to $39,392,850.00.

Change Order #2 – June 27, 2017

The Town of Southern Shores in coordination with APTIM and the Town of Kitty Hawk obtained all authorizations, permits, and permit modifications required to allow for the construction of a beach fill along 2,500 feet of their ocean beach. The beach fill included a 1,500-foot main fill section within the Town of Southern Shores and a 1,000-foot taper that was previously included at the Kitty Hawk/Southern Shores Town border.

Through negotiations with GLDD, an agreed upon cost of $85,000 for Additional Mobilization and Demobilization and $9.70 per cubic yard for Hydraulic Beach Fill Placement was established. Payment for mobilization was made in accordance with Section 10 of the Supplemental General

Conditions. Payment for Hydraulic Beach Fill Placement was made in accordance with Section 14 of the Supplemental General Conditions.

Specifications were amended to account for the change in work established by this change order. The Kitty Hawk Project was referred to as the "Kitty Hawk Beach Nourishment Project with Southern Shores Extension". The following amended Contract Documents were included in Change Order #2 as attachments:

Attachment 1. Plan Drawings for Kitty Hawk Beach Nourishment Project with Southern Shores Extension
Attachment 2. 00900 Supplemental General Conditions
Attachment 3. 01000 Technical Provisions
Attachment 4. 01100 Supplemental Technical Provisions (Environmental Protection & Monitoring)
Attachment 5. Appendix E – NC DENR CAMA and Water Quality Permits
Attachment 6. Appendix F – Batched USFWS Biological Opinion for the Duck, Kitty Hawk with Southern Shores Extension and Kill Devil Hills Shoreline Protection Projects and three (3) Amendments.
Attachment 7. Appendix G – National Marine Fisheries Service ESA – Section 7 Consultation Biological Opinion
Attachment 8. Appendix J – BOEM Lease OCS-A 0513 and First Amendment
Attachment 9. Appendix K – Department of the Army Permits for Duck, Kitty Hawk and Kill Devil Hills Shoreline Protection Projects and the amendment to the Kitty Hawk Permit, which includes the Southern Shores Extension.

As a result of Change Order #2, the Mobilization/Demobilization (Southern Shores) cost increased from $0.00 to $85,000.00. The cost for the Hydraulic Beach Fill for the Town of Southern Shores Extension increased from $0.00 to $776,000.00. The total contract cost increased $861,000.00 from $39,392,850.00 to $40,253,850.00.

Change Order #3 – August 31, 2017

The Kitty Hawk dune between stations 6+50 and 47+00 was constructed with a 1V:2H slope landward dune slope beginning at the "Landward Limit of Dune" line as directed. Due to the landward location of the houses between stations 35+00 and 46+00, there was a gap between the constructed dune and the existing dune pushes. Therefore, the constructed starter dune between stations 35+00 and 46+00 was relocated landward so that the landward dune crest was constructed at the "Landward Limit of Dune" line. The landward dune slope was also constructed at a 1V:5H slope to allow for pedestrian access to the beach.

The cost for 2 bulldozers and beach security to realign the dune between stations 35+00 and 46+00 was estimated at $572.38 per hour by GLDD. Furthermore, GLDD estimated that the dune realignment would take no more than 12 hours for a maximum cost of $6,868.50. Change Order #3 assumed that GLDD would utilize equipment that was currently on-site.

As a result of Change Order #3, the Kitty Hawk Dune Realignment cost increased $6,868.50 from $0.00 to $6,868.50. The total contract cost increased $6,868.50 from $40,253,850.00 to $40,260,718.56.

Change Order #4 – December 19, 2017

Upon completion of construction activities, the quantities of the contract line items were revised to reflect final quantities placed/installed and eligible for payment. Change Order #4 fixed the final values for demobilization, the total volume of beach fill (cy), staging area beach access mats (lf), Kitty Hawk dune realignment hours, sand fencing sections, and sea turtle relocation trawling.

As a result of Change Order #4 the total contract cost decreased from Change Order #3 by $729,550.30 from $40,260,718.56 to $39,531,168.27.

X. CONSTRUCTION FIELD ADJUSTMENTS

A total of 3 field adjustments were issued during the construction of the project. A summary of each field adjustment is provided below. Copies of the field adjustments are provided in Appendix J.

Field Adjustment #1 – May 22, 2017

On May 9, 2017, the Office of State Archaeology – Underwater Branch, provided the last known locations and proper course of action for cultural resource sites on the beach. Through the issuance of Field Adjustment #1, the cultural resource sites previously shown on the bid document construction plans within the Town of Duck (2 cultural resource sites), Town of Kitty Hawk (1 cultural resource site) and the Town of Kill Devil Hills (2 cultural resource sites) were replaced with updated locations.

Field Adjustment #2 – August 31, 2017

Both the Town of Duck and Kill Devil Hills projects were constructed under the contract quantity due to the equilibration and alongshore transport of beach fill during the construction at each subline location. For that reason, the berm crest location was adjusted to allow for an additional 32,900 cubic yards in the remaining portion of the Kitty Hawk template. Therefore, the template volume as shown on the Plans provided to GLDD on August 4, 2017 was 1,797,900 cubic yards.

The breakdown of the Kitty Hawk volume as it related to the contract pay volume of 1,765,000 cy that was reflected in the updated Plans was as follows: 1,624,000 cy for the main fill section; 32,200 cy for the northern taper between stations -15+08 and -25+08; 11,000 cubic yards for the Kitty Hawk dune between stations 147+00 to 150+00, 157+00 to 171+00 and 185+00 to 189+89 and 97,800 cy for the Kitty Hawk dune between stations 6+50 to 114+00 and 125+00 to 147+00.

It was understood that construction of the updated plans to the upper tolerance would result in a greater volume than the max pay volume. Furthermore, as stated above, the updated plans included an additional 32,900 cubic yards to account for alongshore transport. Field Adjustment #2 stated

that the pay volume would not exceed the value of 1,765,000 cy for Kitty Hawk. The additional volume associated with the upper tolerance and additional berm width were provided to allow GLDD to account for limitations of construction methodology, to control the placement of beach fill to meet specifications and to provide the Contractor additional placement capacity to achieve payment of up to the contract quantity of 1,765,000 cy. It was reiterated that the Contractor would not be paid for any quantity of material above 1,765,000 cy for Kitty Hawk. Field Adjustment #2 also stated that the remaining volume not paid for Duck and Kill Devil Hills would not be used for Kitty Hawk and that each Town is only eligible for their respective maximum contract quantities as indicated in the Agreement.

Additionally, Field Adjustment #2 codified that the Kitty Hawk dune between stations 147+00 to 171+00 and 185+00 to 189+87 was constructed with an average template density of 5.0 cy/ft. and that the Kitty Hawk dune between stations 6+50 to 114+00 and 125+00 to 147+00 shall be constructed with an average template density of 7.5 cy/ft. Specifications were updated to reflect these changes.

Field Adjustment #3 – September 12, 2017

The Kitty Hawk dune between stations 150+00 to 126+00 was constructed with a 30 ft. wide dune crest width and tied into the existing dune at elevation +14.0 ft. NAVD88. A dune was also constructed between stations 125+00 to 114+00 that tied into the existing dune at elevation +14.0 ft. NAVD88. The dune between stations 125+00 and 114+00 was constructed with a dune crest width of 12 ft. Field Adjustment #3 stated that if necessary to avoid existing vegetation, a 1V:5H landward dune slope tying into the existing conditions could be constructed. A 1V:5H seaward dune slope was utilized.

Additionally, Field Adjustment #3 authorized GLDD to re-pump material at stations 147+00, 148+00, 149+00 and 150+00 to re-build the template at their discretion. The revised dune configuration along with re-pumping material at stations 147+00, 148+00, 149+00 and 150+00 were provided to allow the Contractor additional placement capacity to achieve payment of up to the contract quantity of 1,765,000 cy. Field Adjustment #3 again reiterated that the pay volume will not exceed the value of 1,765,000 cy for Kitty Hawk and the remaining volume not paid for Duck and Kill Devil Hills may not be used for Kitty Hawk.

XI. REQUEST FOR INFORMATION

The contractor submitted one request for information during the construction of the project. A summary of the request for information is provided below. A copy of the request for information is provided in Appendix K.

Request for Information #1 – May 26, 2017

On May 26, 2017 during a survey, the CRAB hit an obstruction at station 98+00 on Duck Beach. The obstruction was located between the beach and the bar, approximately 200 ft offshore. GLDD noted that this location risks the damage of the Survey Vessel St. John's River and the CRAB by approaching the obstruction point again. GLDD proposed this portion of the line be represented by interpolation utilizing the survey data from the two neighboring lines. The BD survey data provided by GLDD on May 25, 2017 at stations 97+00, 98+00 and 98+83 was reviewed, and based on the provided survey data, this proposal is acceptable.

XII. PROJECT GEOTECHNICAL DATA

Sediment samples were collected and visually inspected along the entire project area at approximately 100 ft. intervals as the beach was constructed in order to verify the compatibility of the material. APTIM Daily Observation Reports included in Appendix C provide the sample station number as well as visual estimates of shell percentage, silt/clay content, grain size, and color. In addition to the visual inspection, twenty-one (21) grab samples collected during the construction of the project underwent mechanical sieve analysis. The results of the sieve analysis are provided in Table 8. The granularmetric tables and grain size distribution curves are provided in Appendix L.

Table 8. Sieve Analysis Summary of Dare County Project Samples

Sample	Station	Borrow Area	Mean Grain Size		Sorting	Silt	Average Wet Munsell
			(mm)	(phi)	(phi)	(%)	Color Value
DUCK017	98+00	C	0.28	1.85	0.74	0.47	5Y/5/2
DUCK004	104+00	C	0.29	1.81	0.95	0.56	5Y/4/2
DUCK007	150+00	Mix	0.38	1.39	1.07	0.67	2.5Y/5/2
DUCK001	152+00	A	0.36	1.46	0.8	0.84	5Y/4/2
DUCK011	154+00	Mix	0.44	1.2	1.13	0.68	2.5Y/5/2
KH 063	150+00	A	0.64	0.64	1.1	0.46	2.5Y/5/2
KH 053	160+00	A	0.65	0.63	0.96	0.37	2.5Y/5/2
KH 042	169+72	A	0.47	1.08	0.82	0.3	2.5Y/5/2
KH 011	181+00	A	0.46	1.11	1.08	0.31	5Y/5/2
KDH/KH 005	189+89	A	0.44	1.19	0.83	0.43	2.5Y/5/2
KDH 075	202+00	A	0.75	0.41	1.59	0.07	2.5Y/5/2
KDH 076	204+00	A	0.91	0.13	1.38	0.3	2.5Y/5/2
KDH 077	212+00	A	1.08	-0.11	1.5	0.58	2.5Y/5/2
KDH 119	243+00	A	0.52	0.95	0.74	0.02	2.5Y/5/2
KDH 089	248+00	A	0.35	1.53	0.66	0.3	5Y/5/2
KDH 087	249+83	A	0.49	1.03	1.01	0.39	2.5Y/5/2
KDH 093	252+00	A	0.37	1.45	0.76	0.25	5Y/5/2
KDH 095	258+00	A	0.37	1.42	0.84	0.36	2.5Y/5/2
KDH 034	279+83	A	0.39	1.35	1.2	0.56	5Y/5/2
KDH 020	299+96	A	0.33	1.62	0.72	0.33	5Y/5/2
KDH 018	307+00	A	0.35	1.5	0.88	0.4	5Y/5/2

XIII. CONSTRUCTION COSTS

GLDD submitted monthly pay applications in accordance with the agreement with Dare County. These pay applications were reviewed by APTIM and pay recommendation letters were submitted by APTIM to the County and Town's along with the GLDD monthly pay application. The total construction cost paid to GLDD for the project, including mobilization/demobilization, performance and payment bonds, compliance surveys, sea turtle relocation trawling, hydraulic beach fill, staging area beach access mats, and sand fencing was $39,531,168.27. The breakdown of this cost by Town is as follows: Town of Duck - $12,713,351.58; Town of Southern Shores - $879,200.00; Town of Kitty Hawk - $17,859,002.09; and Town of Kill Devil Hills - $8,079,614.60. Appendix M includes the Pay Applications and Pay Recommendation Letters submitted by GLDD and APTIM, respectively.

XIV. SUMMARY

Between May 23 and October 21, 2017, approximately 3,926,000 cubic yards of fill were placed along portions of the Towns of Duck, Southern Shores, Kitty Hawk, and Kill Devil Hills by GLDD to construct the designed beach nourishment project. Each Town's project aimed at achieving a specific design goal, which included storm damage reduction and flood reduction. The projects were designed by APTIM in coordination with the Towns of Duck, Southern Shores, Kitty Hawk, Kill Devil Hills and Dare County.

APTIM provided construction administration services to the Towns and County throughout construction of the project. During construction, APTIM provided a representative to provide onsite administrative services on a full time basis. APTIM provided open communication with the Towns and County staff to inform them of the construction status and address outstanding issues or complaints. Specifically APTIM staff observed GLDD's work and recommended if it was compliant with the permits and contract documents; held bi-weekly (every other week) progress meetings to discuss the construction status with GLDD and the public; provided daily project updates to the Towns and County regarding the construction progress; and notified the County, Towns, and regulatory agencies of any observed non-compliant items of work as required by the permit and contract documents.

Through the close coordination between APTIM, the Towns, the County, GLDD, and regulatory agencies, the project overcame several challenges. Through sufficient and deliberate communication via meetings, emails, and website updates, construction during the peak tourist season was successfully accomplished while minimizing the effect on tourism during peak season. Close coordination with GLDD and the work that their staff undertook minimized the impacts of several storms that impacted the project area in September. Close coordination between APTIM, Town Staff, GLDD and staff of the EOD allowed the project to continue without delay while keeping construction crews and the public safe after discovery of several munitions in the borrow area. Furthermore, coordination between APTIM, GLDD, regulatory agencies, and NEST monitors ensured the minimization of adverse impacts on birds and sea turtles.

Post-Construction beach profile surveys conducted in December 2017 indicate that the project has undergone the expected equilibration and that as of December 2017 the Duck, Kitty Hawk,

Southern Shores, and Kill Devil Hills Projects resulted in a seaward movement of the pre-construction MHW line of 110.9 ft., 97.8 ft., 60.1 ft., and 37.1 ft., respectively. Based on a comparison of the pre-construction and post-construction (December 2017) surveys, the Duck, Kitty Hawk (including Southern Shores extension), and Kill Devil Hills project areas have gained 966,300 cy, 2,241,908 cy, and 895,413 cy, respectively. Future performance of the project will be based on these volumes and comparison with future beach profile surveys to be conducted annually in the spring.

APPENDIX A

AS-BUILT PLAN VIEW DRAWINGS
AND
COMPARATIVE BEACH PROFILE CROSS SECTIONS

April/June 2017 (Pre-Construction)
Before Dredge (BD)
After Dredge (AD)
December 2017 (Post-Construction)

APPENDIX B

POST-CONSTRUCTION (DECEMBER 2017) SURVEY REPORT

APPENDIX C

AS-BUILT BORROW AREA DRAWINGS

APPENDIX D

PRE- AND POST-CONSTRUCTION BORROW AREA SURVEY DATA
(Available in Digital Format Only)

APPENDIX E

APTIM DAILY OBSERVATION REPORTS
(Available in Digital Format Only)

APPENDIX F

GLDD DAILY QUALITY CONTROL REPORTS
(Available in Digital Format Only)

APPENDIX G

SEA TURTLE CAPTURE AND RELOCATION FORMS
AND
SEA TURTLE INCIDENTAL TAKE FORMS
(Available in Digital Format Only)

APPENDIX H

CHANGE ORDERS
(Available in Digital Format Only)

APPENDIX I

CONSTRUCTION PLANS - FINAL

APPENDIX J

FIELD ADJUSTMENT REPORTS
(Available in Digital Format Only)

APPENDIX K

REQUESTS FOR INFORMATION
(Available in Digital Format Only)

APPENDIX L

SEDIMENT GRANULARMETRIC REPORTS
(Available in Digital Format Only)

APPENDIX M

PAYMENT APPLICATIONS
(Available in Digital Format Only)