Town of Duck
North Carolina

Town of Duck Shore Protection Project

Photograph taken by Town of Duck (August 6, 2019).

Beach Maintenance Plan

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TOWN OF DUCK
SHORE PROTECTION PROJECT
BEACH MAINTENANCE PLAN

EXECUTIVE SUMMARY

The Town of Duck has implemented a shore protection project aimed at sustaining the beaches that support a significant portion of their local economy and maintaining the tax base of the Town. The project has, and will continue to, provide increased protection to the Town's economy and coastal development. Part of the project includes implementing a maintenance program to document construction achievements and project performance. Anticipated future costs have been estimated and are also included in the maintenance plan.

The Town successfully completed the initial construction of the Shore Protection Project in June 2017. Periodic maintenance or renourishment is included in the Town's maintenance plan for the Shore Protection Project. The renourishments are expected to occur on a 5 year cycle and will initially involve dredging of Borrow Area A offshore Kill Devil Hills and Nags Head. The Dept. of the Army and North Carolina Division of Coastal Management permits issued for the initial construction will require modifications to use Borrow Area A for future maintenance. Likewise, the Town will be required to obtain a new lease from the Bureau of Ocean Energy Management (BOEM) to use Borrow Area A for maintenance events. As of the date of this last revision, the Town is currently working on developing the necessary environmental and design documentation to submit the necessary permit applications and authorizations to conduct the maintenance event scheduled for 2022. The estimated volume of material required for maintenance of the Duck project is 254,000 cy every five (5) years. However, post-Hurricane Dorian surveys indicated storm-related losses of 170,800 cy. The project planned for 2022 will include the placement of 424,800 cy. Post-construction surveys of Borrow Area A show that sufficient sand is available for future maintenance.

Project monitoring has been implemented to track performance of the placed material and is used to update nourishment requirements. The initial baseline monitoring event was conducted in December 2017 followed by annual monitoring data collection in June 2018 (Year-1), May 2019 (Year-2), and June 2020 (Year-3). Additional data were collected in December 2019 to determine volumetric losses due to Hurricane Dorian, which impacted the project in September 2019. Furthermore, the Town has implemented a Rapid Beach Assessment Monitoring Program using Unmanned Aerial Systems (UAS) technology. The data obtained through the Rapid Beach Assessment program allows Town staff and engineers to assess dune and beach response to storm events. The Maintenance Plan may be updated throughout the monitoring phase to reflect any modifications to the protocol. Surveys of the beach profiles have been designed and conducted to capture changes along the active profile of the beach both within the project area and adjacent to the project.

This Maintenance Plan serves as documentation that the Town of Duck's Shore Protection Project meets the criteria established by 44 CFR 206.226(j)(2). The Maintenance Plan has been developed in a way consistent with FEMA's Public Assistance Program and Policy Guide (Version 4). This Maintenance Plan will be updated regularly to reflect results of monitoring, construction of additional projects, maintenance events, and changes in schedules.

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TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The Town of Duck has implemented a long-term beach management program to sustain the beaches that support a significant portion of their local economy and maintains the tax base of the Town. In order to accomplish these stated goals, the Town has taken steps to maintain its oceanfront beach and dune to a configuration that 1) provides a reasonable level of storm damage reduction to public and private development, 2) mitigates long-term erosion that could threaten public and private development, recreational opportunities, and biological resources, and 3) maintains a healthy beach that supports valuable shorebird and sea turtle nesting habitat.

The Town of Duck completed an Erosion and Shoreline Management feasibility study in 2013, which evaluated potential management options for the oceanfront shoreline (CPE-NC, 2013). The recommendation of that feasibility study was a beach nourishment project along a portion of the Town's shoreline that was vulnerable to impacts of a design storm with wave and water level characteristics matching Hurricane Isabel, which impacted the coast in 2003. The project was also designed to include 5 years of advanced fill to account for predicted background erosion of the project during the maintenance interval.

Initial construction of the beach nourishment project was completed in June 2017. The project included placement of 1,263,181 cubic yards of beach compatible sand, which equates to an average fill density of 150 cy/lf, along 8,413 feet or approximately 1.6 miles. Sand was dredged from two offshore borrow sources. Following the construction of the project, the Town implemented a maintenance program to monitor the performance of the Shore Protection Project and determine when periodic renourishment is needed to maintain the goals of the project.

Documentation of the construction and subsequent monitoring events have been archived as evidence of the Town's commitment towards maintaining the Shore Protection Project. This information is required for eligibility under the Public Assistance (PA) program administered by FEMA. If the project is impacted by a presidentially declared disaster or emergency, justification that the maintenance plan has been implemented must be provided to receive federal aid. This stipulation is mandated by 44 CFR 206.226(j)(2), which states:

> *Work on an improved beach may be eligible under the following conditions:*
> *(i) The beach was constructed by the placement of sand (of proper grain size) to a designed elevation, width, and slope; and,*
> *(ii) A maintenance program involving periodic renourishment of sand must have been established and adhered to by the applicant.*

The amount of sand replacement eligible for FEMA funding is limited to the material volume lost as a result of the declared disaster or emergency. Pre- and post-storm profiles, when available, are used to determine the eligible volume of sand. If pre-storm profiles are not available, the estimated erosion from the design study and renourishment history can be used to determine a pre-storm condition. Surveys collected during the monitoring can also be used to determine the pre-storm condition.

This Maintenance Plan serves as documentation that the Town of Duck's Shore Protection Project meets the criteria established by 44 CFR 206.226(j)(2). The Maintenance Plan has been developed in a way consistent with FEMA's Public Assistance Program and Policy Guide (Version 4). The Maintenance Plan includes a description of the project design, construction activities to date, anticipated volume and cost for maintenance, schedule of maintenance and the monitoring protocols being employed by the Town of Duck. This Maintenance Plan will be updated regularly to reflect results of monitoring, construction of additional projects, maintenance events, and changes in schedules.

CONSTRUCTION EVENTS

Beach Fill

The initial construction of the Town of Duck Shore Protection Project was completed in June 2017. The project included the construction of a dune and berm beach fill design along 7,913 feet of the Town of Duck Shoreline located just north of the US Army Corps of Engineer's Coastal and Hydraulics Laboratory Field Research Facility (FRF). In addition to the 7,913 ft. design fill section, the project also included a 500-foot long taper on the north end. In total, the project placed sand from baseline station 87+63 (128 Skimmer Way) to 171+75 (137 Spindrift Ln.). Figure 1 shows the extent of the project including the main fill construction template, the northern taper, and the construction baseline. Sand used to construct the project was dredged from two permitted offshore borrow areas using trailing suction hopper dredges (Figure 2).

The beach fill constructed in June 2017 included placement of 1,263,181 cy of beach compatible sand, which equates to an average fill density of approximately 150 cy/lf, along 8,413 feet of beach (approximately 1.6 miles). The volume placed included both the volume necessary to construct the designed dune and berm as well as the volume needed for advanced fill. Advanced fill is the sacrificial portion of the fill required to protect the design section from anticipated sediment losses during the time between subsequent maintenance cycles. The volume of advanced fill needed was based on background erosion rates, anticipated diffusion losses, and a five (5) year maintenance cycle. Ultimately, the performance of the beach fill dictates when constructed sections require maintenance, which is referred to as renourishment.

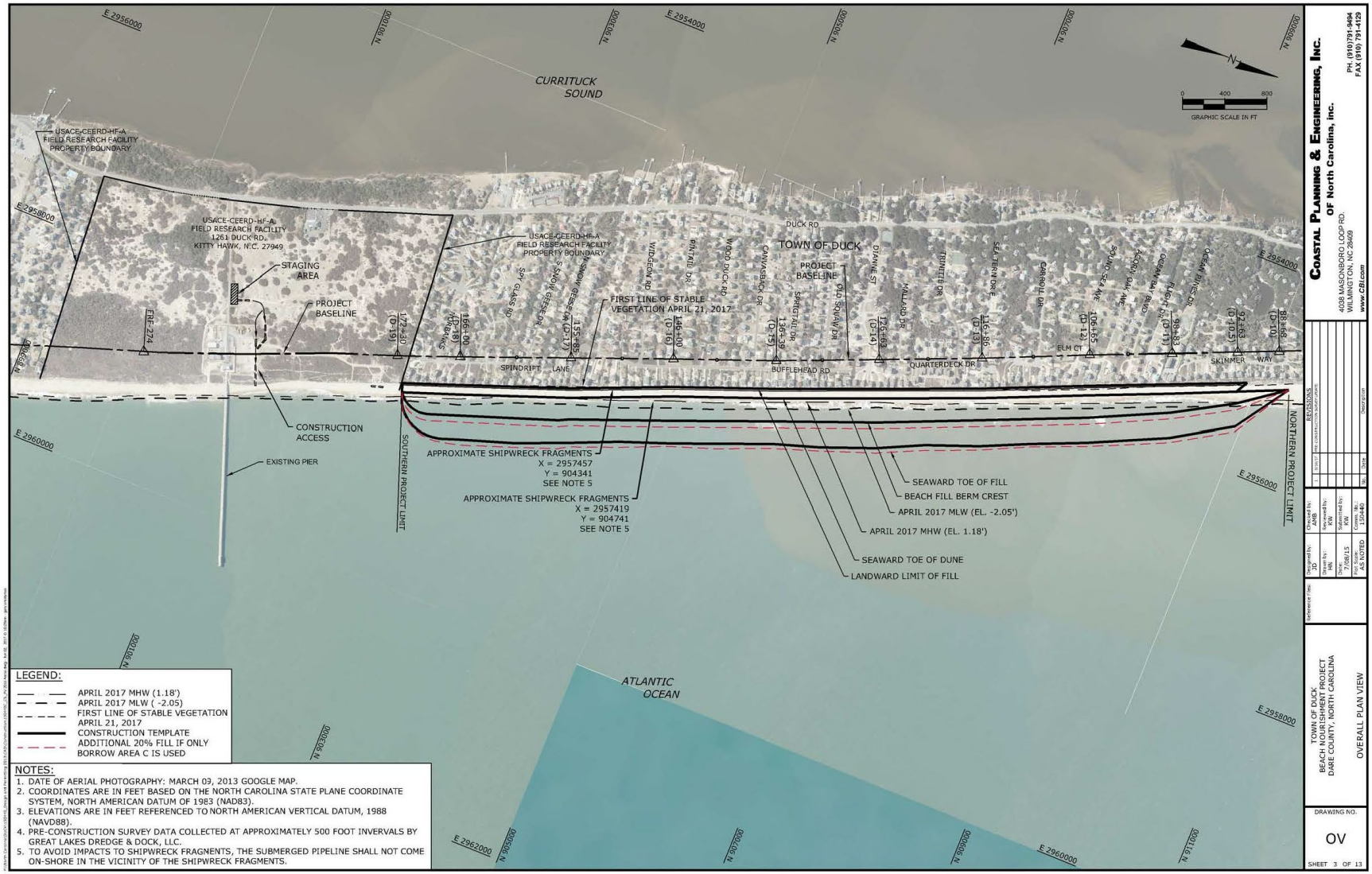

Figure 1. Map showing the extent of the project including the main fill construction template, the northern taper, and the construction baseline.

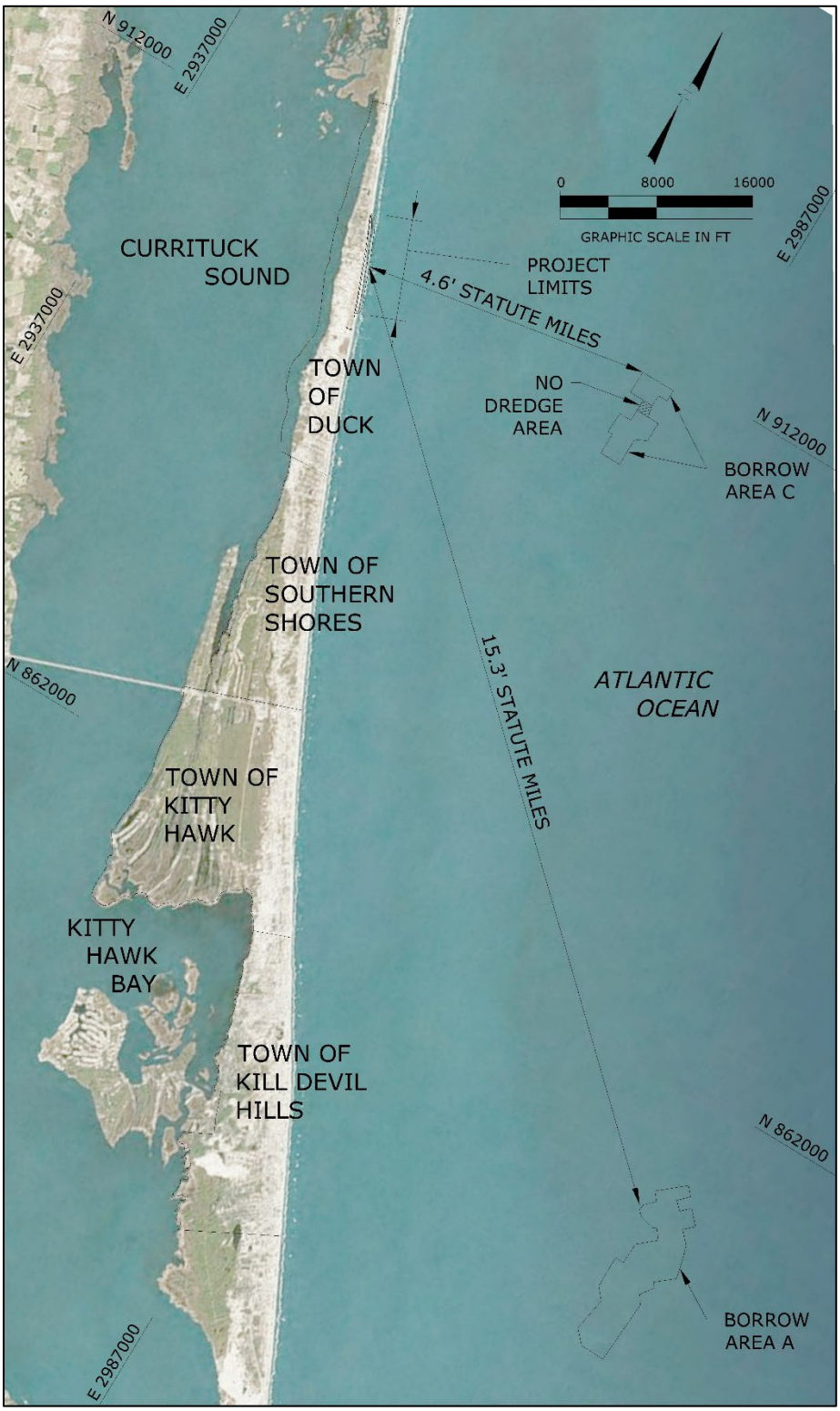

Figure 2. Map showing the location of offshore borrow areas used for the construction of the June 2017 Duck Shore Protection Project.

Dune Vegetation

The Town established a dune vegetation program following construction of the 2017 project. The initial dune vegetation program include planting of American Beach Grass and Sea Oats as follows.

Planting of American Beach Grass in the nourishment area along the top of dune east to the start of the dune slope to include:

- Two beach grass sprigs (type 'cape') installed 8" deep on 12" centers, 10-15 rows deep;

Planting of American Beach Grass in the nourishment area along the face of the dune 15' east of the crest to include:

- One beach grass sprig (type 'cape') installed 8" deep on 18' centers, not to exceed 10 rows deep;
- Fertilize with 18-6-6 or 16-8-8 (400 lbs. per acre broadcasted across top of planted beach grass).

Planting of American Beach Grass occurs between November and March with fertilization occurring no later than April 15th of any year for the single sprig planting.

Planting local Sea Oat stock in the nourishment area along the crest of the dune eastward to include:

- One sea oat sprig installed a minimum of 8" deep staggered on 4' centers, not to exceed 3 rows deep;
- Fertilize each planting hole with one level teaspoon of time-release (18-6-12 Osmocote or similar type) fertilizer.

Planting of Sea Oats occurs between May and August with fertilization occurring at planting.

Beginning in October 2019, the planting protocol was modified as follows:

Planting of American Beach Grass from the crest of dune, east to 3' from the east toe of the dune to include:

- Two beach grass sprigs (type 'cape') installed a minimum of 8" deep on 18" centers, not to exceed 10 rows deep;
- Fertilizer applied as previously stated.

Planting local Sea Oat stock in the nourishment area along the crest of the dune eastward to include:

- One sea oat sprig installed a minimum of 8" deep staggered on 4' centers, not to exceed 3 rows deep;
- Fertilizer applied as previously stated.

Planting of local Bitter Panicum stock east of the dune crest and mid-way to the base of the dune to include:

- One stem with a part of the rhizome attached or a minimum 8-12" length of rhizome without the above ground parts, installed a minimum of 8" deep staggered on 6' centers, one row only;
- Fertilize each planting in a one foot broadcast circle with time-release (18-6-12 Osmocote or similar type) fertilizer.

Sand Fencing

The Town has installed 752 sections of sand fencing 2 rows deep with a length of 10 ft. each. Sand fencing sections were spaced 7-10' apart on an approximate 45 degree angle along the eastern crest of the dune in the nourishment area. A third row of fencing was installed near the base of the dune slope. Each section of the third row was 10 ft. long, spaced approximately 30' apart on an approximate 45-degree angle. The fencing will continue to be maintained and supplemented as needed on an annual basis.

Funding

The project was funded through revenue derived from the Dare County Beach Nourishment Fund and the Town of Duck. The Town of Duck portion of the project was raised through a combination of General Fund appropriation and Municipal Service Districts (MSDs). In essence, the Town of Duck portion of the cost of the project was funded by a contribution from all of the taxpayers in Duck with additional funding provided by property owners in the project area, both oceanfront and non-oceanfront (MSDs).

MAINTENANCE

As-built surveys of the Duck Shore Protection Project were provided by the construction contractor, which represents conditions along each profile as sections of the project were constructed. The first post-construction survey of the project was conducted in December 2017. The December 2017 survey was compared to the pre-construction surveys conducted in April 2017 to establish a baseline condition of the beach out to the depth of closure. The comparisons of these two surveys showed an increase of 963,100 cubic yards of sand measured above the depth of closure. The Year-1 monitoring event was conducted in June 2018, followed by the Year-2 monitoring event conducted in May 2019 and Year-3 event in June 2020.

All annual monitoring surveys are conducted along beach profiles at approximately 1,000-foot intervals. Figure 3 shows the location of these beach profiles.

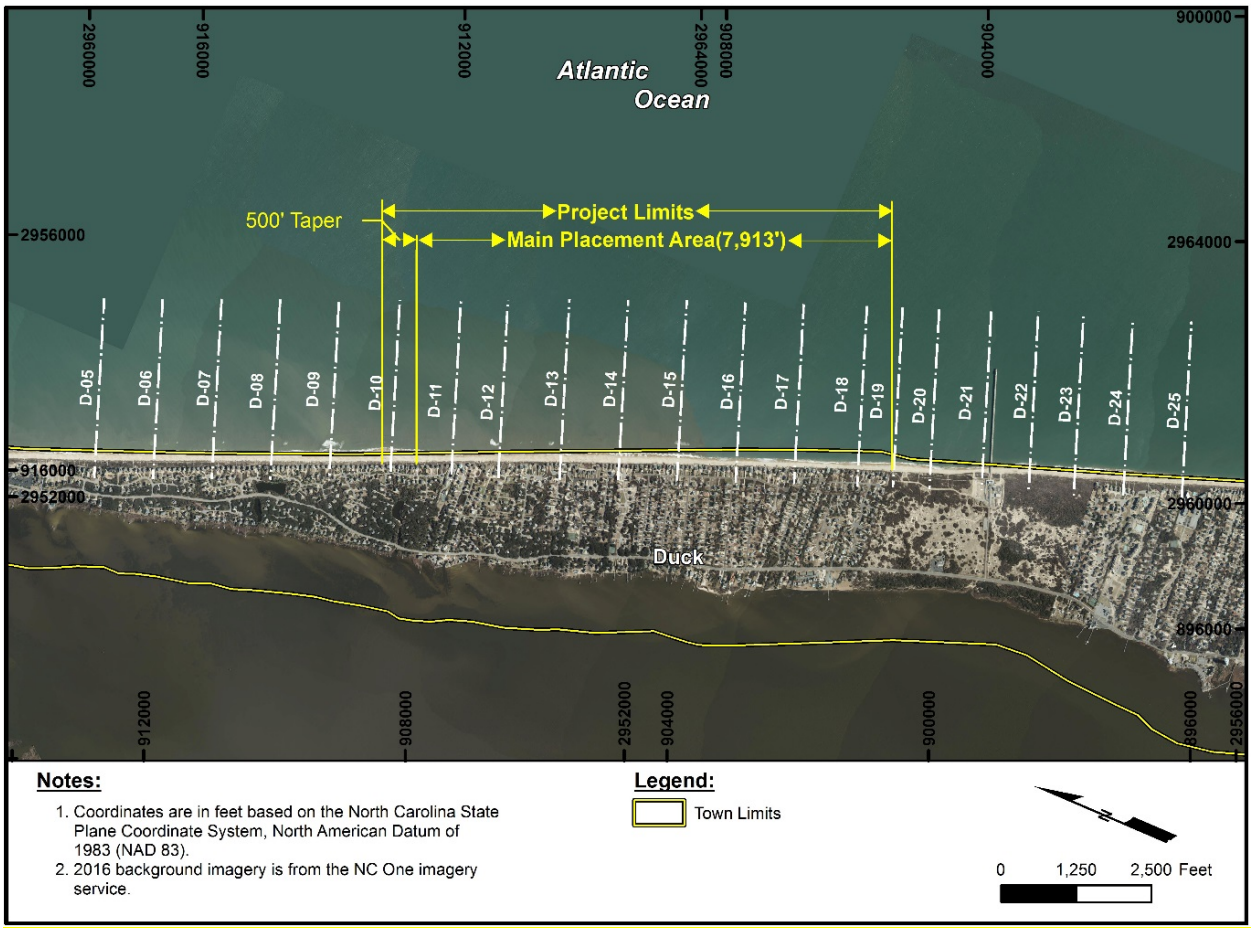

Figure 3. Map of Duck Shore Protection Project Monitoring Beach Profiles.

The Duck Shore Protection Project includes a 20 ft. wide dune at a height of 20.0 ft. NAVD, and a variable width berm at elevation +6.0 ft. NAVD. The project included five (5) years of advanced fill. As previously stated, the Town is conducting annual surveys to monitor the beach fill performance.

Annual monitoring will assess the volume of sand in excess of the design that remains in place to determine the timing of, and volume needed for, subsequent beach renourishment. At present, the first renourishment is scheduled for the spring/summer of 2022. Construction of the June 2017 project used most of the sand available in the offshore borrow area located approximately 4.6 miles offshore of the Town of Duck project. However, post-construction surveys show that there is sufficient sand available in Borrow Area A, located offshore of Kill Devil Hills and Nags Head, to provide maintenance of the Duck Shore Protection Project.

RENOURISHMENT REQUIREMENTS

During the design of the Duck Shore Protection Project, Coastal Protection Engineering of North Carolina (CPE, formerly Coastal Planning & Engineering of North Carolina, Inc. and Aptim Coastal Planning & Engineering of North Carolina, Inc.) conducted an analysis of background erosion losses and diffusion losses to determine the volume of advanced fill to include in the project design. Based on these analyses, the design included 234,000 cy of advanced fill (CPE-NC, 2015). More recent analysis conducted by CPE for the Town of Duck and Dare County to determine future re-nourishment costs assumed a renourishment volume of 254,000 cy. This volume assumes an average fill density of 30 cy/ft. CPE has estimated that the cost to conduct maintenance of the Duck Shore Protection Project in 2022 would be $4,559,000, assuming renourishment occurred simultaneously with the Kitty Hawk and Kill Devil Hills renourishment projects and that the mobilization and demobilization costs were allocated based on the percentage of the total renourishment volumes. Additionally, this cost estimate is based on construction cost to place 254,000 cy of sand. This cost does not reflect engineering or environmental permitting costs for the maintenance event.

On the morning of September 6th, 2019, Hurricane Dorian traveled northeast along the North Carolina coast and made landfall at Cape Hatteras as a Category 1 hurricane. Although Dorian was only a Category 1 hurricane when it impacted the area, its slow movement and prolonged onshore flow generated heavy surf and elevated water levels for several days prior to the storm in the vicinity of the Town of Duck. The *Post-Storm Design Report* completed in June 2020 indicated that the effective volumetric change attributed to Hurricane Dorian was 170,800 CY (CPE, 2020). The *Post-Storm Design Report*, estimated the additional cost to replace the 170,800 CY of sand to be $2,972,000 (CPE, 2020).

During the permitting of the Duck Shore Protection Project, CPE conducted a comprehensive marine sand search and borrow area design (CPE-NC, 2015A). Two borrow sites, referred to as Borrow Areas A and C, were designed during the investigation (Figure 2). Borrow Area A is located on the Outer Continental Shelf (OCS) between 5.0 and 6.5 miles offshore of the Towns of Kill Devil Hills and Nags Head in water depths between 50 and 60 ft. (NAVD88). The borrow area covers 1,173 acres and initially contained approximately 16,335,000 cy of sand. The mean grain size of the sand was found to be 0.36 mm with a sorting value of 0.90. The sand in the borrow area was characterized as fine to medium grained quartz sand with trace silt, shell hash, and shell fragments. The average wet Munsell color value was determined to be 5 and dry color value 6. The borrow area was broken up into 6 different cuts with cut depths ranging from -58.5 to -68.0 ft. NAVD88.

Borrow Area C is located on the Outer Continental Shelf between 4.1 and 5.2 miles offshore of the Town of Duck in water depths between 55 and 65 ft. (NAVD88) (Figure 2). The proposed borrow area covers 354 acres and initially contained approximately 1,905,000 cy of sand. The mean grain size of the sand was found to be 0.28 mm with a sorting value of 1.09. The sand in the borrow area was characterized as fine grained quartz sand with trace silt, shell hash, and shell fragments. The average wet Munsell color value was determined to be 5 and dry color value 6.

The borrow area was broken up into 5 different cuts with cut depths ranging from -61.0 to -65.0 ft. NAVD88.

The Dept. of the Army (USACE) and North Carolina Division of Coastal Management issued permits for the Town of Duck to use these borrow areas for the initial construction of the Duck Shore Protection Project. Furthermore, since the borrow sites are located in Outer Continental Shelf (OCS) waters, the Town was required to obtain a lease from the Bureau of Ocean Energy Management (BOEM) to use the sand in the permitted borrow sites. The majority of the sand available in Borrow Area C was used in the construction of the Duck project in 2017. Therefore, this borrow area is unlikely to provide sand for future maintenance events. However, a sufficient volume of sand is still present within the permitted dimensions of Borrow Area A to provide sand for future maintenance events.

MONITORING PROTOCOL

A monitoring plan has been developed and is being implemented for the Duck Shore Protection Project. Topographic and hydrographic surveys of the beach profiles are conducted to monitor project performance and potential impacts. The beach profile surveys include the fill area and adjacent shoreline within a minimum distance of 5,000 feet.

Supplemental beach profile surveys may also be required following significant storm events as were conducted in 2019 following the impact of Hurricane Dorian. Reports for each monitoring event are archived by the Town. The reports contain volumetric and shoreline change calculations to describe how the project is performing. Erosion rates and shoreline change rates along the beach are also documented throughout the monitoring process. The monitoring results are also used to identify erosion 'hot spots' and to estimate sediment needs for future maintenance events.

In the Summer of 2019, a supplemental monitoring technique was implemented that uses UAS technology to assess the impacts on the Town's beaches and dunes as a result of storm events. This technology allows the Town to conduct rapid assessment UAS surveys of its beaches and dunes immediately before and after storm events. The results of each survey are provided in a letter report to the Town that visually document the changes along the beach through comparison of orthomosaic imagery and provide an estimate of the volume change due to the impacts of the storm based on analysis of photogrammetric point cloud data derived from the UAS imagery collected during the pre- and post-storm flights. The rapid assessment is also used as a mechanism to determine whether further analysis such as full beach profile surveys out to the depth of closure are warranted to document net volume changes along the entirety of the beach profile as a result of the storm event.

CONCLUSION

The Town of Duck has implemented a long-term beach management program to sustain the beaches that support a significant portion of their local economy and maintain the tax base of the Town. The

project has and will continue to provide increased protection to the Town's economy and coastal development. Part of the project includes implementing a maintenance program to document construction achievements and project performance. Anticipated future costs have been estimated and are also included in the maintenance plan.

The Town successfully completed the initial construction of the Shore Protection Project in June 2017. Periodic maintenance or renourishment is included in the Town's maintenance plan for the Shore Protection Project. The renourishments are expected to occur on a 5 year cycle and will initially involve dredging of Borrow Area A offshore Kill Devil Hills and Nags Head. The Dept. of the Army and North Carolina Division of Coastal Management permits issued for the initial construction will require modifications to use Borrow Area A for future maintenance. Likewise, the Town will be required to obtain a new lease from BOEM to use Borrow Area A for maintenance events. As of the date of this last revision (November 2020), the Town is currently working on developing the necessary environmental and design documentation to submit permit the necessary permit applications and authorizations to conduct the maintenance event scheduled for 2022. The estimated volume of material required for maintenance of the Duck project is 254,000 cy every five (5) years. However, post-Hurricane Dorian surveys indicated storm-related losses of 170,800 cy. The project planned for 2022 will include the placement of 424,800 cy. Post-construction surveys of Borrow Area A show that sufficient sand is available for future maintenance.

Project monitoring has been implemented to track performance of the placed material and is used to update nourishment requirements. The initial baseline monitoring event was conducted in December 2017 followed by annual monitoring data collection in June 2018 (Year-1), May 2019 (Year-2), and June 2020 (Year-3). Additional data were collected in December 2019 to determine volumetric losses due to Hurricane Dorian, which impacted the project in September 2019. Furthermore, the Town has implemented a Rapid Beach Assessment Monitoring Program using UAS technology. The data obtained through the Rapid Beach Assessment program allows Town staff and engineers to assess dune and beach response to storm events. The maintenance plan may be updated throughout the monitoring phase to reflect any modifications to the protocol. Surveys of the beach profiles have been designed and conducted to capture changes along the active profile of the beach both within the project area and adjacent to the project.

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CPE-NC (2015 A) Comprehensive Marine Sand Search and Borrow Area Design Report. Prepared For: The Towns of Duck Kitty Hawk and Kill Devil Hills, North Carolina, 49 pgs.

CPE-NC (2015 B) Town of Duck Erosion and Shoreline Management Design Report. Prepared For: The Town of Duck, North Carolina, 96 pgs.

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