2019 Nags Head Beach Renourishment Project

FINAL CONSTRUCTION REPORT

Volume 1 — Project Summary

Prepared for:

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[CSE2458–TASK 8]
OCTOBER 2019

COVER PHOTOS: Pumping through Jennette's Pier (Nags Head, Dare County, North Carolina) on 28 July 2019. Offshore dredging was permitted to be conducted during fair-weather summer months in this relatively high-energy setting for both the 2011 nourishment and the 2019 renourishment projects. The construction window was coincident with peak tourist season as well as sea turtle nesting season. Due to protection measures implemented under state and federal permits, no environmental or safety incidents occurred on the beach during the 2011 and the 2019 projects.

EXECUTIVE SUMMARY

Introduction

The 2019 beach renourishment project at Nags Head, Dare County, North Carolina was completed between 1 May and 18 August 2019 by the Contractor, Great Lakes Dredge & Dock Company, Inc (GLDD, Oak Brook, Illinois). A total of four (4) million cubic yards (cy) of sand was placed along the 10-mile stretch of beach during 110 days of dredging and pumping operations. The Town of Nags Head served as project owner and administrator, and Coastal Science & Engineering (CSE, Columbia, South Carolina) was the Project Engineer. The renourishment project was completed in one phase under a single contract between GLDD and the Town of Nags Head. The funding of the project included contributions from the Dare County Beach Nourishment Fund, ad valorem taxes within the project limits, and reimbursement from FEMA for sand loss due to Hurricane *Matthew*.

The first nourishment project at Nags Head was conducted between 24 May and 27 October 2011, and approximately 4.6 million cubic yards of sand was placed along the same 10-mile stretch of beach. The construction duration of the 2011 project was 156 days. Following the successful completion of the 2011 nourishment, the Town of Nags Head monitored performance and developed strategies for beach maintenance and preservation with the goal of improving protection to all properties and recreational beach areas. The short-term plan was renourishment, and the long-term plan targeted a timeframe of 30 years.

The 2011 project withstood three major hurricanes (*Irene* in August 2011, *Sandy* in October 2012, and *Matthew* in October 2016) as well as numerous fall and winter storms. There was negligible damage to oceanfront properties and town infrastructure during these storms. The latest hurricane, *Matthew*, impacted the project area on 8–9 October 2016. This storm produced high water levels, increased wave energy, and brought strong winds as it approached Nags Head. A comprehensive beach condition survey conducted after *Matthew*'s passage showed that ~1.43 million cubic yards of sand shifted out of the project area. This volume loss is equivalent to ~30 percent of the nourishment volume placed during the 2011 project.

Consistent with the short-term plan and maintenance threshold which called for renourishment when ~50 percent of the 2011 volume eroded from the project area, the Town of Nags Head incorporated restoration of the volume loss of Hurricane *Matthew* into a planned four (4) million cubic yards renourishment project along the same 10-mile oceanfront with the following purpose and goals:

1) Restore sand losses due to chronic erosion and Hurricane *Matthew* (2016)
2) Provide a higher level of storm protection
3) Provide wider recreational beach and create habitat for wildlife
4) Address high erosion rates at the south end of Nags Head
5) Integrate a dune management plan into the renourishment design
6) Maintain Nags Head's eligibility for future FEMA community assistance funds

Project Plan, Permits, and Bids

The 2019 renourishment project area encompassed 10.0 miles of shoreline beginning ~1 mile from the Town's northern limit near the Bonnett Street public beach access (milepost 11.25) and extending south to the Town line (milepost 21) adjacent to the Cape Hatteras National Seashore. Nourishment quantities varied by reach according to the gradient in erosion rates as well as the Town's purposes and goals for the project.

The overall project limits and reaches are shown in Figure A along with approved borrow areas. Borrow Area 3A was situated between the 2011 renourishment project borrow areas 2 and 3 which are within the USACE designated borrow area S1. Borrow Area 3A contained ~4.3 million cubic yards of beach quality material if excavated to the maximum permitted depth of 8 ft below the existing grade. It was designated as the primary area for the 2019 project. Borrow Area 4 contained ~1.4 million cubic yards of beach quality material if excavated to the maximum permitted depth of 5.9 ft below the existing grade. It was located ~5.6 miles north of Borrow Area 3A and ~1.5 miles offshore from the north central portion of Nags Head beach. Borrow Area 4 was added in the 2019 project to enable the dredger to reach northern Nags Head more easily, and therefore potentially reduce operational costs. In total, these two borrow areas contained approximately 5.7 million cubic yards of sand, which was 45 percent (%) more than the maximum permitted volume. The sand quantity in the borrow areas was deemed sufficient for the Contractor to complete the full scope of renourishment, and the strategic locations of the borrow areas were chosen to allow the Contractor to use any type of dredge that was considered to be efficient and cost-effective.

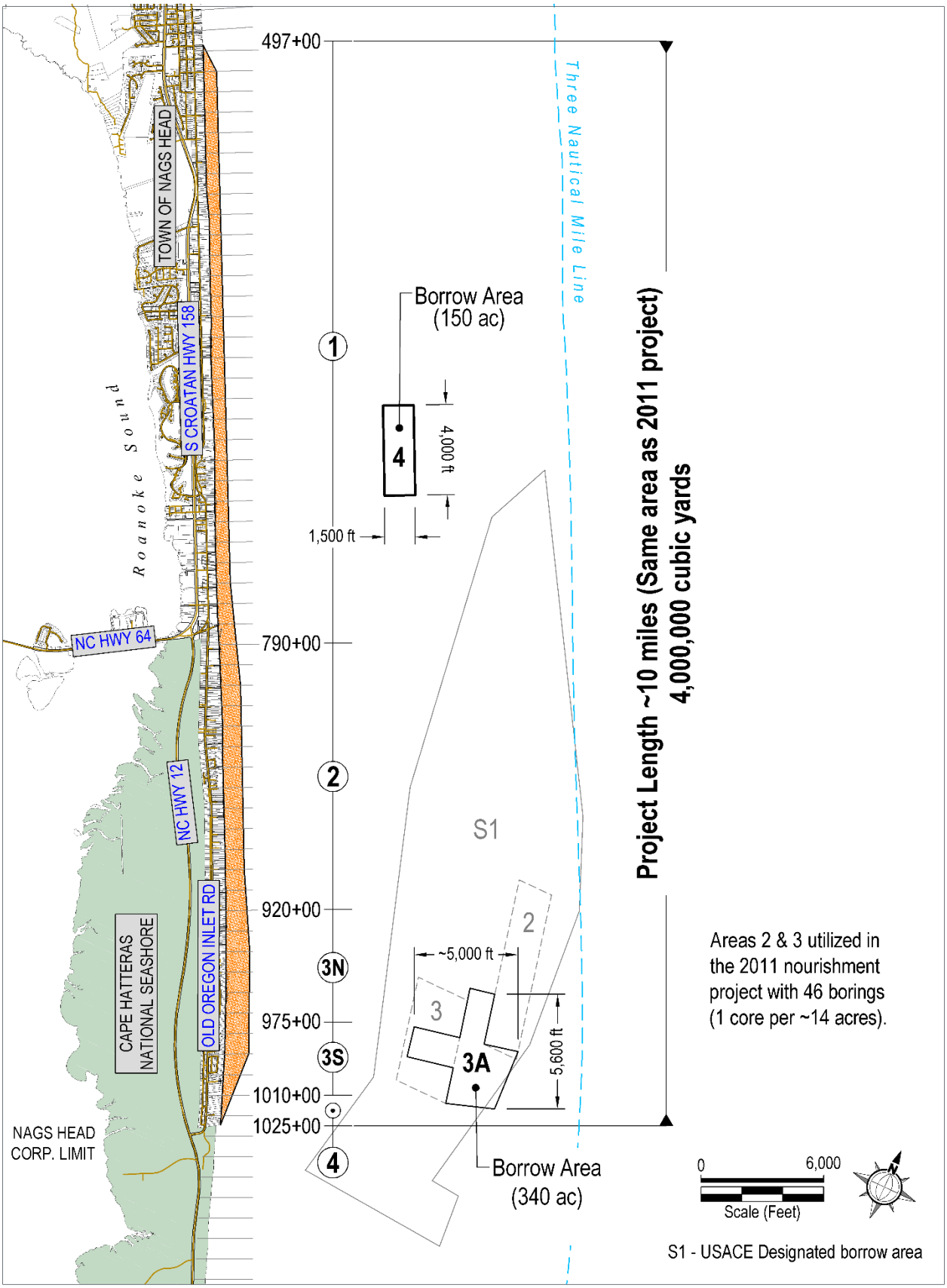


FIGURE A. Nags Head (NC) 2019 renourishment project reaches and offshore Borrow Areas 3A and 4.

The work included dredging, placement, grading, and environmental protection as specified under federal and state permits of 4,000,000 cy along 52,800 linear feet (10 miles) of Nags Head beach in five reaches designated as follows:

1) Reach 1 (Stations 497+00 to 790+00) — 1,758,000 cy over 29,300 linear feet
2) Reach 2 (Stations 790+00 to 920+00) — 845,000 cy over 13,000 linear feet
3) Reach 3N (Stations 920+00 to 975+00) — 622,000 cy over 5,500 linear feet
4) Reach 3S (Stations 975+00 to 1010+00) — 543,000 cy over 3,500 linear feet
5) Reach 4 (Stations 1010+00 to 1025+00) — 232,000 cy over 1,500 linear feet

Initial dunes were designed and constructed along Reaches 3N, 3S, and 4 where there was lack of a dune or the dune volume was significantly lower than the average dune volume of the entire project length.

The Town of Nags Head obtained permits under the National Environmental Policy Act (NEPA) and the state Coastal Area Management Act (CAMA) permitting process, including preparation of a comprehensive Environmental Assessment (CSE 2017a). The environmental documentation was necessitated by the need to accomplish the work during the summer months.

The US Fish and Wildlife Service (USFWS) issued the Biological Opinion on 20 December 2017, and North Carolina Modification/Major CAMA Permit (45–110) was received on 12 February 2018. The federal permit (SAW 2006–40282) was received on 28 March 2018. CSE prepared a final design, plans, specifications, and bid documents (CSE 2018a), and made them available to contractors on 15 February 2018 following review by Town officials.

Bids were requested for mobilization and pumping of a base quantity of two (2) million cubic yards over the length of the project and two alternate (supplementary) quantities of up to 570,000 cy for Alternate Bid 1 and up to 1.43 million cubic yards for Alternate Bid 2. Bidders were requested to submit two bids (ie – Bid A for 2018 construction and Bid B for 2019 construction). GLDD offered the lowest bid for 2019 construction which equated to $36,644,500 (which included mobilization/demobilization and pumping) for four (4) million cubic yards (the maximum volume allowed under the permits). The net price equated to (~)$9.16 per cubic yard (which was considered to be in line with current market conditions).

Construction

The Contractor (GLDD) opted to accomplish the work by two hopper dredges, utilizing multiple "landing" areas for pumpout in either direction along the beach (Fig B). The first hopper dredge that arrived on site was the *Ellis Island*, America's largest dredge with a maximum capacity of 15,000 cy per load. The *Ellis Island* was on site for 47 days between 1 May and 16 June 2019 and placed 1,765,360 cy of sand, which is equivalent to ~44 percent of the total contract volume. The *Ellis Island* utilized Borrow Area 3A and primarily pumped along South Nags Head from Stations 878+00 to 1025+00. The fill areas on the beach by this dredge are marked by red bars in Figure B.

The second hopper dredge that arrived on site was the *Liberty Island*. She was the main hopper dredge utilized by GLDD in the 2011 nourishment project at Nags Head. During her 83 days on site between 28 May and 18 August 2019, the dredge was able to place 2,239,265 cy of sand along Reaches 1 and 2. Between June 10 and 16, *Ellis Island* and *Liberty Island* ran "round-robin" to share the same discharge point in Reach 1 around Stations 535+00 and 613+50 (see Figure B). The *Liberty Island* first utilized Borrow Area 4 to pump along the northern section of Nags Head. After the *Ellis Island* left the job site and as work progressed to the south, the *Liberty Island* began using Borrow Area 3A to leverage the most-efficient hauling distance.

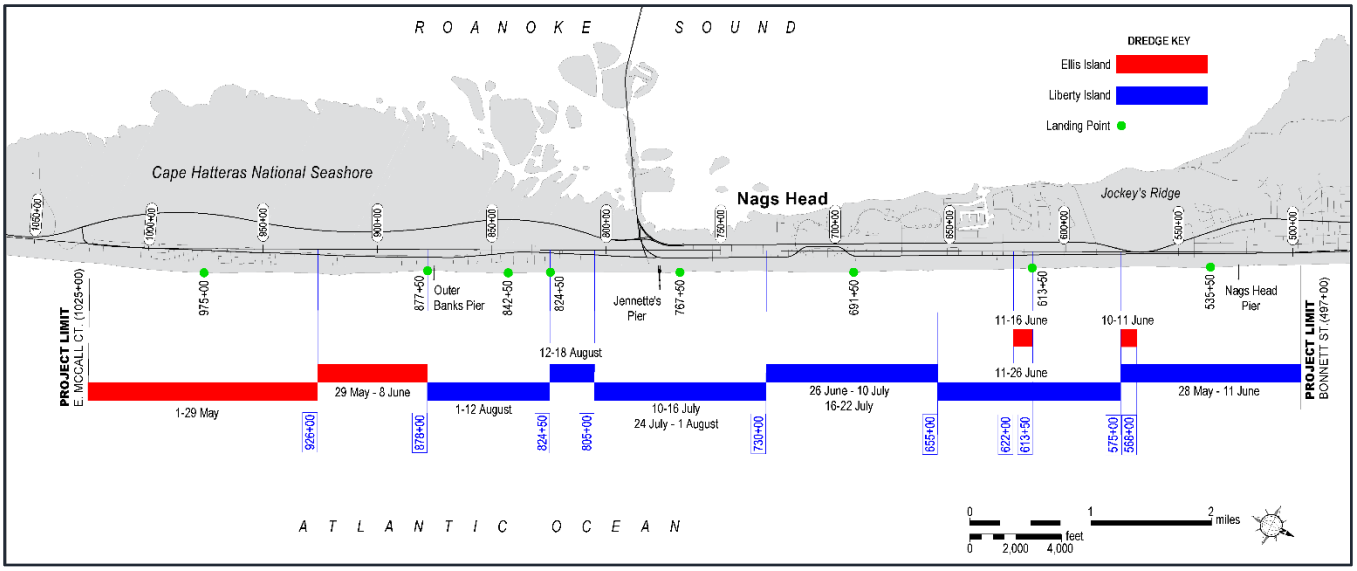


FIGURE B. Multiple landing areas, fill ranges, and dates for the dredges GLDD utilized in the Nags Head beach renourishment project between 1 May and 18 August 2019.

Construction directly impacted ~300–1,000 ft of beach each day with completed sections reopened for recreation the following day. By setting the construction berm at +6 ft NAVD (which is approximately the average natural berm elevation for Nags Head), the fill template intersected the dry beach, leaving a narrow corridor for public access adjacent to the active beach-filling operations for most areas.

Conditions for dredging operations were generally favorable from the initial pumping in early May through the end of pumping in mid-August. Some delays occurred for dredge maintenance and/or refueling which required the equipment to be moved to the nearest port (Norfolk VA) for several days at a time. The 2019 renourishment construction was completed ahead of the Contractor's schedule and within the time frame that was set forth in the Agreement between the Town and the Contractor. Renourishment was completed within the Town's budget and without any change order (or additional cost) during construction.

The *Liberty Island* demobilized from the job on the morning of 18 August 2019 after GLDD confirmed that the total contract volume had been completed. The Town of Nags Head signed off its acceptance of the project on 28 August 2019, and the final demobilization of all equipment was completed by 30 August 2019.

Environmental Protection Measures and Results

Similar to the initial 2011 beach nourishment project, the principal environmental issue associated with the Nags Head 2019 renourishment project was sea turtle nesting. To be approved for summer dredging, the Town of Nags Head was required to provide turtle monitoring on the beach each night and every morning during construction, and the Contractor was required to have endangered species monitoring onboard the dredges. Open-net turtle trawling was also required during hopper dredging to stimulate turtles to move away from the ocean floor ahead of the dredge.

Overall, non-capture trawling at the borrow areas was highly effective. A humpback whale was sighted in Borrow Area 3A on 14 July 2019, and NOAA and other resource agencies were notified immediately. There were 14 individual observations of sea turtles in the water column as reported in the trawlers' daily logs during construction, but no sea turtles were collected in any trawler sweeps.

A juvenile green turtle (*Chelonia mydas*) was observed at 3:20 pm on 10 August in the inflow box on the dredge *Liberty Island*. The turtle was retrieved alive but injured, and was transferred to the Star Rehabilitation Center at the NC Aquarium on Roanoke Island that afternoon. Unfortunately, the turtle did not survive, and passed away on 14 August 2019. The protocols established in the USACE permit for Turtle Takes by Hopper Dredge (Special Conditions #62) were immediately followed, and the dredge *Liberty Island* ceased operations and was on standby. The CSE Project Engineer, the NC Wildlife Resources Committee (NCWRC), and the USACE project manager (c/o Josh Pelleier) were immediately notified. The USACE project manager instructed GLDD to have all turtle protection measures checked thoroughly by the onboard endangered species observer (ESO) before operations could resume. It was confirmed by GLDD and the onboard ESO that all screening and Turtle Exclusion Devices (TED) were in proper working condition and that everything appeared to be in compliance with the permit conditions. Dredging operations were resumed around 6:30 pm that evening.

A total of eight (8) successful nests were laid within the project limits during construction, and no nests were laid within the active construction zones (Fig C).

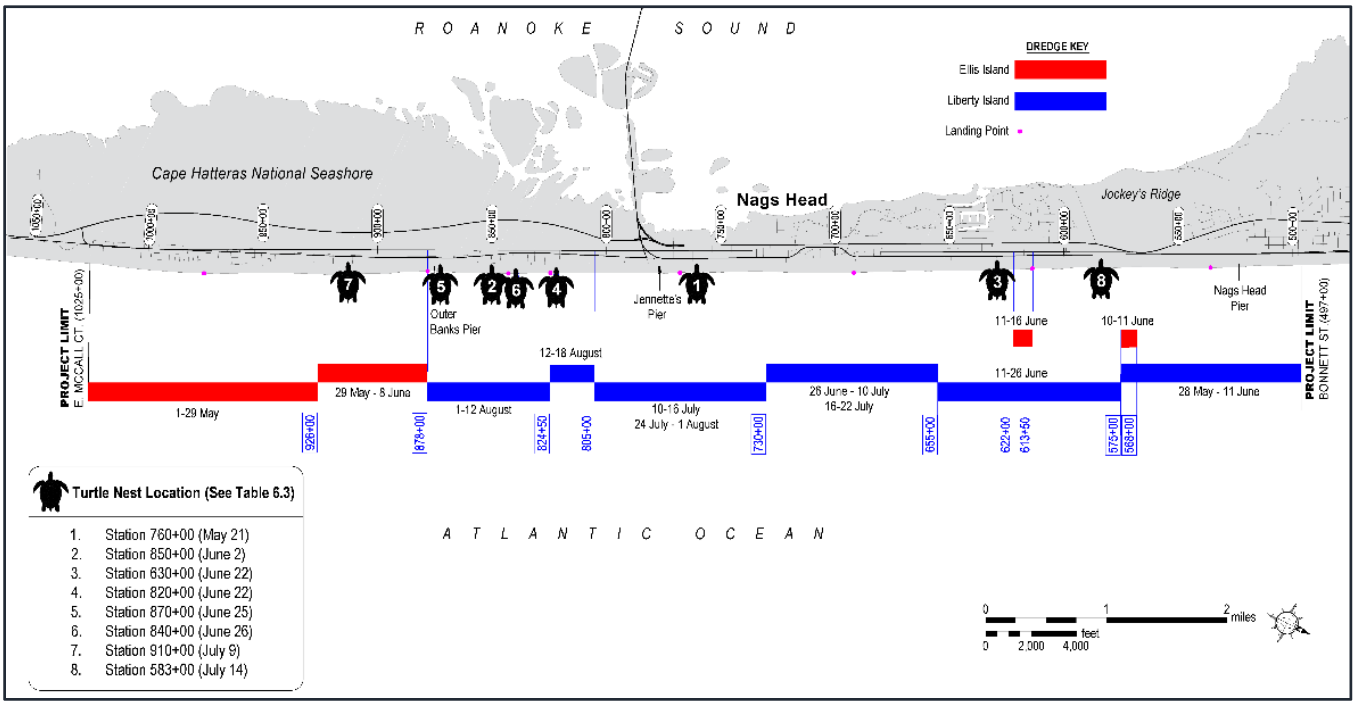


FIGURE C. A map of turtle nests laid at the Nags Head project area during the 2019 renourishment project along with the construction sequence map. No nests were laid within active construction zones, and all turtle nests were relocated by N.E.S.T. professionals outside of the project area.

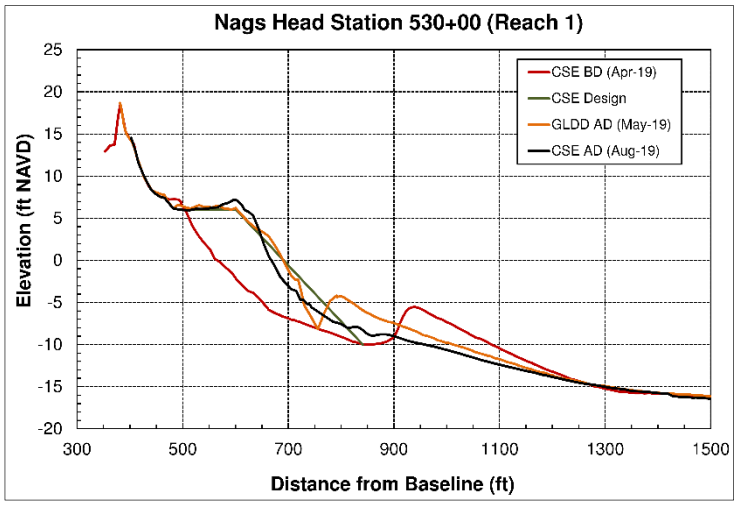
Project Volume Evaluation and Confirmation

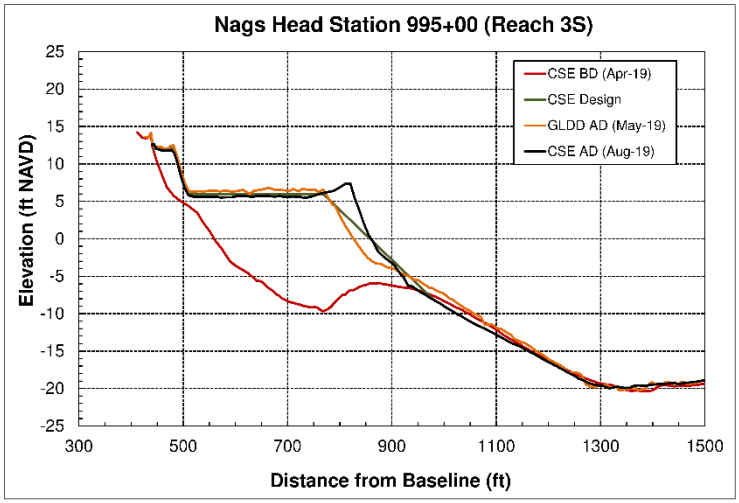
GLDD's construction surveys for purposes of payment confirmed that a total of 4,004,625 cy were placed along the project area between 1 May and 18 August 2019. CSE completed a detailed survey of the beach and inshore zone within a few days of project completion and compared the post-project conditions against the pre-project condition in April 2019. CSE confirmed that there were **3,882,400 cubic yards** more sand in the ten-mile project area after renourishment (Table A).

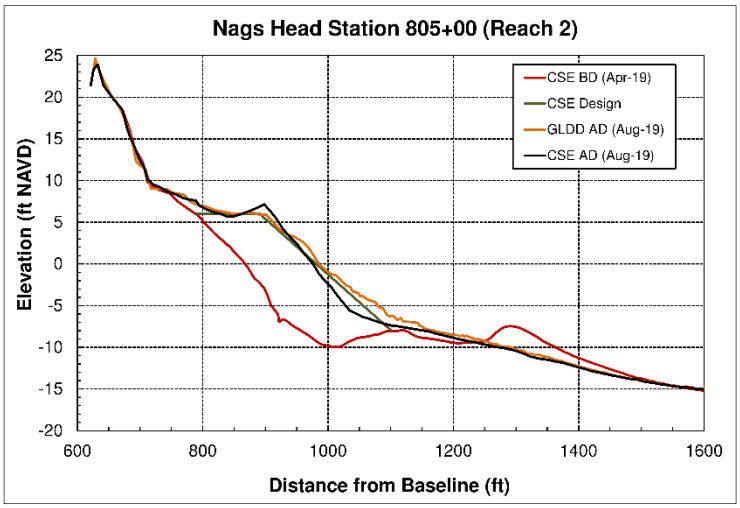
TABLE A. Summary of fill volume versus design volume for each reach based on before-dredging (BD) and after-dredging (AD) surveys by GLDD and the April (pre-project) and August 2019 (post-project) surveys by CSE.

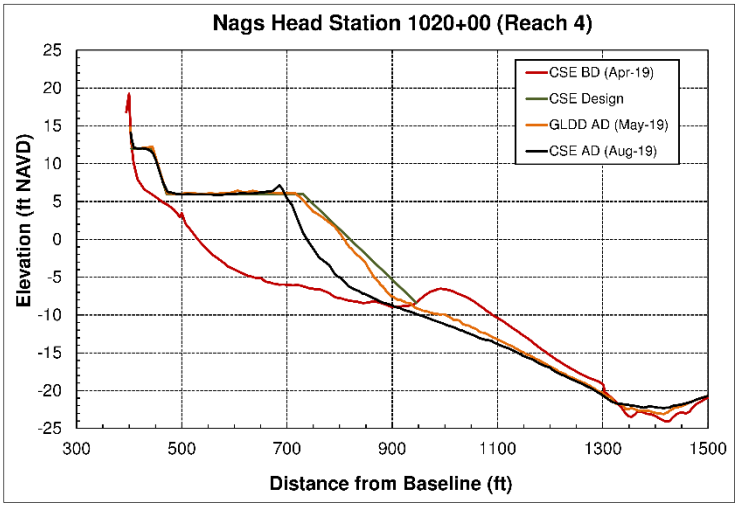
Reach		Station	Length (lf)	Design Volume (cy)	Fill Volume by GLDD (cy)	Difference between Design and Fill (%)	Confirmed Volume by CSE (cy)
1		497+00 to	29,300	1,758,000	1,734,863	-1.3%	1,795,175
2		790+00 to	13,000	845,000	866,189	+2.5%	932,600
3N		920+00 to	5,500	622,000	577,772	-7.1%	492,375
3S		975+00 to	3,500	543,000	539,006	-0.7%	458,425
4		1010+00 to	1,500	232,000	239,197	+3.1%	203,825
Total		497+00 to	52,800	4,000,000	**4,004,635**	+0.1%	**3,882,400**

Under normal construction practice, a portion of the nourishment sand on the construction berm is designed to shift underwater by wave action and eventually reach equilibrium. The newly placed sand serves to absorb storm-wave energy, reduce the degree of wave runup, and prevent damage to the foredune, buildings, and roads during future nor'easters or storms. CSE's post-project survey profiles show that Nags Head beach, particularly the sections that received renourishment sand at the beginning of construction, has experienced profile adjustment (which is simply the beach's response to changing wave heights and water levels) (see black lines in Figure D). As the fill equilibrates, the crest may build higher than the construction berm. Such natural adjustment occurred at several localities during construction leaving the middle of the berm slightly lower than the seaward crest which caused ponding to occur on the beach or under some houses. As the tide receded, the ponds drained completely, and no mechanical measures were needed to mitigate these issues. CSE expects the higher dry beach will remain dry most of the time and will serve as a feeder for dune growth. The landward and offshore shift of sand has the important effect of creating a more natural profile with new sand bars forming in shallow water.









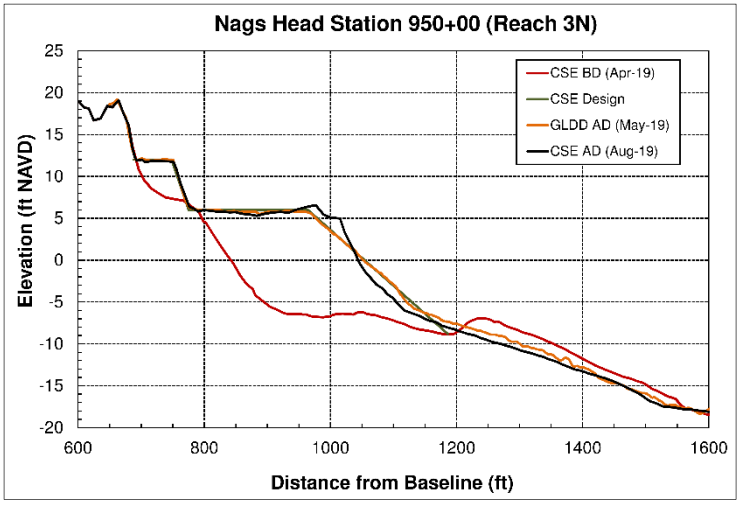


FIGURE D. Typical beach profiles of each reach before and after the 2019 renourishment. Initial dunes were designed and constructed along Reaches 3N, 3S, and 4. The construction berm was set at +6 ft NAVD, and the dune crest elevation was set at +12 ft NAVD.

Monitoring & Maintenance Recommendations

The Town of Nags Head integrated a dune management plan with the present project including initial dune construction along South Nags Head, installation of sand fencing, and planting of vegetation along the entire project area following the 2019 renourishment.

Coastal Transplants (c/o Steve Mercer) was contracted by the Town of Nags Head for sand fencing and dune planting. Work began on 18 July 2019 and is expected to be completed in November. Through the construction of initial dunes, the installation of sand fencing, planting of vegetation, and natural dune-building processes, the backshore areas of Nags Head are expected to be enhanced gradually after nourishment.

In accordance with FEMA Publication 321 and Code of Federal Regulations 44 CFR 206.226(j), a maintenance program involving periodic renourishment of sand must be established and adhered to by the Town of Nags Head to qualify for FEMA assistance.

In conjunction with the initial 2011 beach nourishment project, the Town of Nags Head adopted a Beach Monitoring and Maintenance Plan in August 2011. The purpose of such a maintenance plan is to track the physical condition of the beach after nourishment, quantify sand volume changes, and determine whether the project qualifies for emergency renourishment following declared disasters. It also is intended to identify erosion hot spots and recommend small-scale maintenance renourishment, placement of sand fencing, and/or sand scraping so as to increase the life of the project.

CSE believes that the 2011 Plan remains generally applicable to Nags Head after the 2019 renourishment, and some adjustment should be considered to better define renourishment thresholds for various reaches or sub-reaches. We recommend that the Town of Nags Head continue to conduct an annual assessment of the physical condition of the nourished shoreline using the transect plan established by CSE. Such surveys will give the Town an annual assessment of the beach condition and will reveal problem areas or erosion hot spots that require attention. Annual surveys also serve to document the beach condition prior to the occurrence of a major erosion event, such as a hurricane. Should a major storm event occur, a post-storm survey should be completed for damage assessment as soon after the storm as possible (as has been done by the Town of Nags Head after Hurricane *Matthew*). Since the project is an engineered beach fill, annual and post-storm surveys could provide

a basis for reimbursement and reconstruction of the beach through federal disaster funds under a community assistance grant (eg – FEMA Category G post-storm restoration funds) (FEMA 2018).

Nourishment sand placed on the beach was found to be consistent with the borings obtained by CSE in 2017. It contained negligible mud, very little shell material ($CaCO_3$) and a minor fraction of gravel-sized grains (ie – >2 mm mean diameter). The mean arithmetic grain size of all samples collected during construction was 0.373 mm (ranging from 0.235 mm to 0.523 mm), which is classified as medium sand (0.25 – 0.50 mm diameter). The nourishment sand is similar in texture to the native beach and is expected to provide similar performance as the native beach, with respect to annual erosion losses. Due to the compatible renourishment sand placed on the beach, tilling is not required after construction.

Additionally, benthic monitoring of the biological response to the nourished beach and borrow areas is not required by the state or federal permit for the 2019 beach renourishment.

ACKNOWLEDGMENTS

The Nags Head beach renourishment project was sponsored by the Town of Nags Head and the Federal Emergency Management Agency (FEMA) and was paid for by a combination of local and federal funds as described in Section 1.1.

We thank former Mayors Bob Oakes and Robert Edwards, current Mayor Ben Cahoon, and members (past and present) of the Board of Commissioners (including John Ratzenberger, Marvin Demers, Susie Walters, Renee Cahoon, Webb Fuller, and Mike Siers) for their pioneering effort and close oversight during the planning, permitting, and funding process. We especially thank Town Manager Cliff Ogburn, Deputy Town Manager Andy Garman, and Town Engineer David Ryan for their dedication to the project. Construction and project communication proceeded smoothly through excellent coordination by Town Public Information Officer Roberta Thuman and other Town staff: Ralph Barile, Kate Jones, Todd Krafft, Michelle Gray, Carolyn Morris, and Phil Webster. It has been truly a pleasure to work with such a dedicated Board and Town staff over the past ~15 years.

CSE thanks the Wilmington District and Washington Regulatory Office of USACE-SAW for providing guidance and support during permitting and construction — especially Regulatory Project Manager Josh Pelletier for his coordination and input. We would also like to recognize representatives of USFWS (Raleigh Office, c/o Kathryn Matthews) and NMFS (Morehead City) for their review of and comments on the permit application and construction.

Numerous state agencies reviewed the environmental documentation and permit application, and performed regular site visits during construction. We especially thank Doug Huggett (NCDCM Major Permits Manager, Morehead City), Heather Coats (Beach & Inlet Management Project Coordinator, Wilmington), Lynn Mathis (Environmental Specialist II, Elizabeth City), and Yvonne Carver (Environmental Specialist II, Elizabeth City) for their attention and coordination of the project. Additionally, NCWRC reviewed the permit application, provided helpful comments, and had field meetings during construction (special thanks to Maria Dunn and Matthew Godfrey).

NEST (Network for Endangered Sea Turtles) professionals John Cece and Christian Legner coordinated daytime and nighttime sea turtle monitoring on the beach. We thank them and their teams for their professionalism and dedication to these tasks.

We especially thank Great Lakes Dredge & Dock Company (GLDD) — in particular Vice President and Area Manager Russ Zimmerman, Project Managers Bryan Dast and Tim Kremer, Quality Control Manager Christy DiFelice, and Project Engineer Kile Alford, and the dredge and beach crews of the *Ellis Island* and *Liberty Island* for their outstanding performance in delivering the completed project volume efficiently, on time, and within budget.

We were impressed with the group of dedicated residents of Nags Head who voluntarily devoted hours of their time to support the planning and construction phase of the project through meeting attendance, beach observation, and comments. It was a pleasure to work with them.

CSE's work was directed by Dr. Tim Kana (PG, NC 1752), founder and President of CSE. Dr. Haiqing Liu Kaczkowski (PE, NC 37281) served as the Project Engineer, prepared the final design, and supervised construction. Captain Drew Giles was the chief of field data collection, Steven Traynum (Senior Coastal Scientist) was responsible for field data compilation and analysis, Dr. Patrick Barrineau evaluated sediment samples and prepared the geotechnical information, Trey Hair (Senior CADD Specialist) prepared project drawings, Luke Fleniken assisted with fieldwork, Ashley Fleniken conducted sediment tests, and Stephen Kaczkowski (Airman Certificate #2157587) assisted with construction observations and collected drone photography. Carrie Marks (Publications Manager) prepared progress newsletters and report manuscripts. The present report was prepared by Haiqing Kaczkowski, Tim Kana, Patrick Barrineau, Trey Hair, and Carrie Marks. All photos were taken by CSE staff unless otherwise noted.

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LIST OF APPENDICES

1.0 INTRODUCTION

This report is prepared in connection with the 2019 beach renourishment project at Nags Head, Dare County, North Carolina. It provides a summary of pumping operations completed between 1 May and 18 August 2019 as well as mobilization and demobilization through 30 August by the Contractor, Great Lakes Dredge & Dock Company, Inc (GLDD, Oak Brook, Illinois). Coastal Science & Engineering (CSE, Columbia, South Carolina) served as the project engineer.

This report includes:

- A brief summary of the project setting, purpose, and project description
- Project timeline and construction sequence
- Tide and wave analyses during construction
- Sediment analyses of borrow area and beach fill
- Environmental protection measures and results
- Borrow area dredging impact
- Summary of beach changes and fill volumes
- Monitoring and maintenance recommendations

The work described herein was completed in one phase under a single contract between GLDD and the Town of Nags Head.

1.1 Project Sponsor

The 2019 beach renourishment project was sponsored by the Town of Nags Head, Dare County, North Carolina. The Town of Nags Head served as project owner and administrator.

The funding of the project included contributions from the Dare County Beach Nourishment Fund, revenue bond from the Town of Nags Head, and reimbursement from FEMA (Federal Emergency Management Agency) for sand volume loss due to Hurricane *Matthew* under Public Assistance Program Category G – Beaches.

1.2 Project Setting

The Town of Nags Head encompasses ~11 miles of ocean shoreline on North Carolina's Outer Banks, a chain of barrier islands along the Atlantic Ocean, 90 miles south of Norfolk, Virginia. Figure 1.1 shows the project location.

The Town faces east to northeast and is bordered by the Town of Kill Devil Hills to the north and the Cape Hatteras National Seashore to the south. The Roanoke Sound borders the Town on the west, and the Atlantic Ocean makes up the Town's eastern limits. The northern boundary of the Town is situated about 15 miles from the U.S. Army Corps of Engineers (USACE) Field Research Facility (FRF) and pier at Duck (NC) and about 40 miles from the Virginia border. Oregon Inlet, the closest inlet to Nags Head, is located about 5 miles south of the town line.

The Town is exposed to high wave energy during storm events (particularly hurricanes and nor'easters) which are common in fall and winter. Net sand transport is south along Nags Head. There are presently three ocean piers and five stormwater outfalls crossing the beach along the Town of Nags Head. The beach is composed of medium sand with a mean grain size of ~0.4 millimeters (mm). The mean monthly average significant wave height ranges from 2.1 ft (July) to 3.9 ft (October) based on USACE-FRF data from 1986–2006. Details regarding the morphological setting are provided in the Environmental Assessment (CSE 2017a).

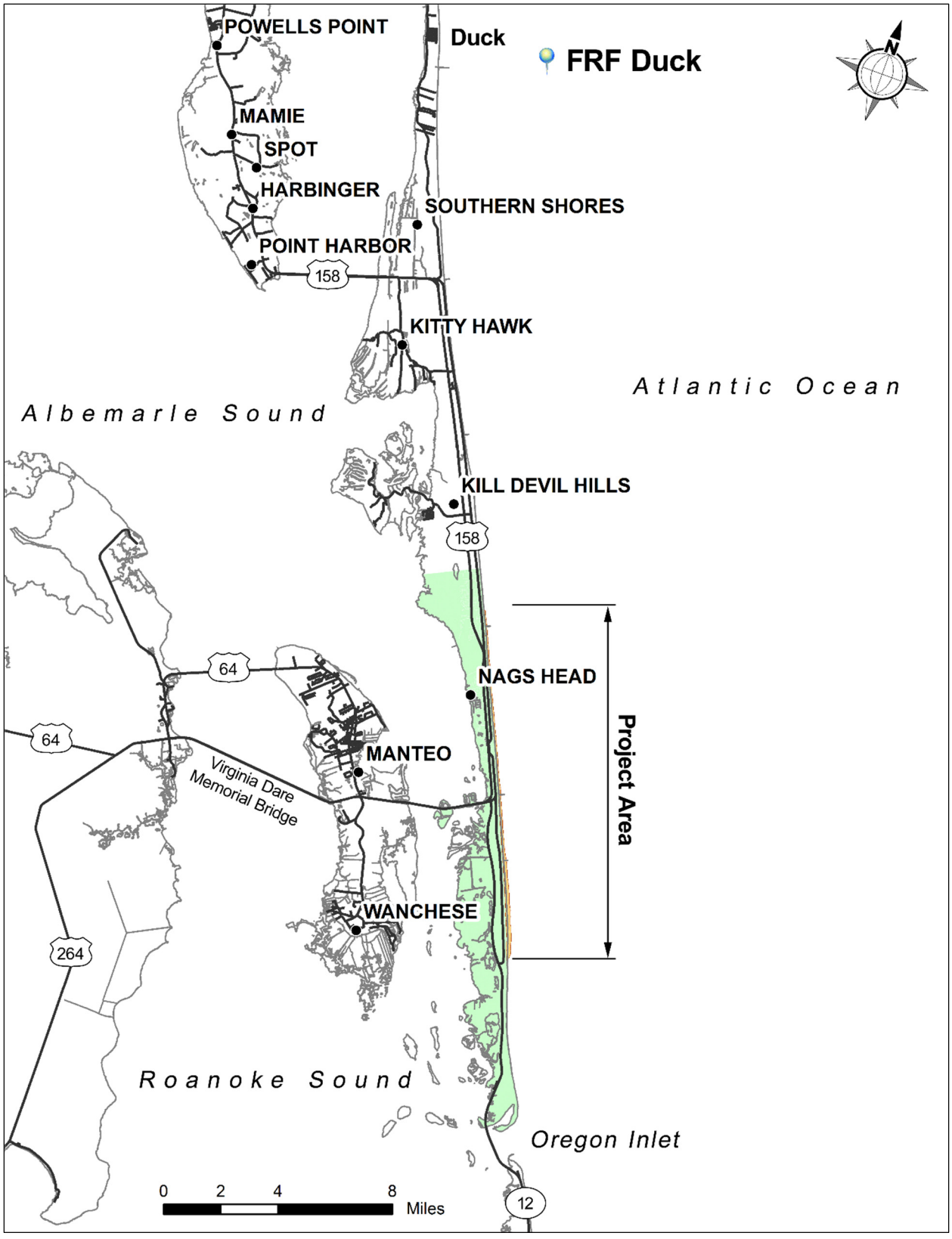

FIGURE 1.1. Nags Head renourishment project area location and vicinity map (Dare County, North Carolina).

1.3 Background, Purpose, and Need

The initial nourishment project at Nags Head was conducted between 24 May and 27 October 2011, and approximately 4.6 million cubic yards (cy) of sand was placed along the 10-mile stretch of beach from Bonnett Street public beach access (milepost 11.25) extending south to the Town line (milepost 21) (Figure 1.2; CSE 2012). These project limits were consistent with a planned federal project (USACE 2000). It is the largest locally-funded nourishment accomplished to date in the United States. Following the completion of the 2011 nourishment, the Town of Nags Head monitored performance and developed strategies for beach maintenance and preservation with the goal of improving protection to all properties and recreational beach areas. The short-term plan is renourishment, and the long-term plan targets a timeframe of 30 years.

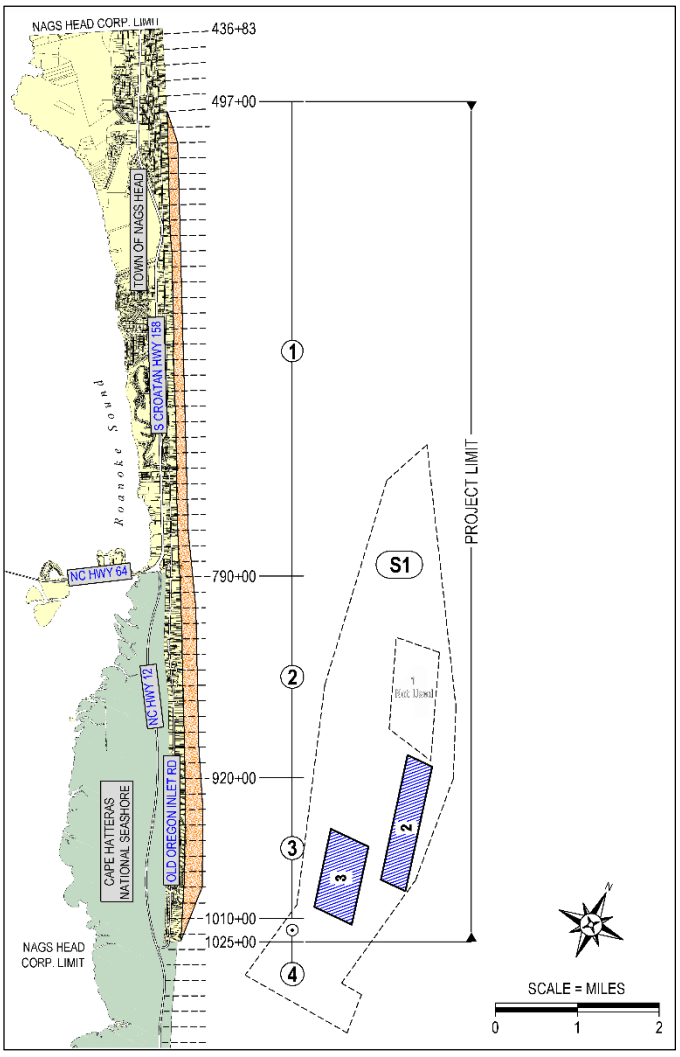

FIGURE 1.2. Nags Head 2011 beach nourishment project map. Two offshore borrow areas (located within the USACE designated Borrow Area S1) were used in the project. [CSE 2012]

Annual beach condition surveys in June-July for the first five years after completion of the 2011 project showed that the project area retained ~93 percent of the nourishment sand as of June 2016 with a loss of only ~430,000 cy (defined as the foredune to −19 ft NAVD). While the project performed better overall than predicted during the first five years (CSE 2016a), erosion losses varied significantly from north to south in the range of (+)2.8 cubic yards per foot per year (cy/ft/yr) to (−)20 cy/ft/yr.

The 2011 project withstood three major hurricanes (*Irene* in August 2011, *Sandy* in October 2012, and *Matthew* in October 2016) as well as numerous fall and winter storms. There was negligible damage to oceanfront properties and town infrastructure during these storms. The latest hurricane, *Matthew*, impacted the project area on 8−9 October 2016. This storm produced high water levels, increased wave energy (significant waves >17 ft), and brought strong winds as it approached Nags Head. A comprehensive beach condition survey conducted after *Matthew*'s passage showed that ~1.43 million cubic yards of sand shifted out of the project area. This volume loss is equivalent to ~30 percent of the nourishment volume placed during the 2011 project.

Consistent with the short-term plan and maintenance threshold which called for renourishment when ~50 percent of the 2011 volume eroded from the project area, the Town of Nags Head incorporated restoration of the volume loss of Hurricane *Matthew* into a planned four (4) million cubic yards renourishment project along the same 10-mile oceanfront with the following purpose and goals:

1) Restore sand losses due to chronic erosion and Hurricane *Matthew* (2016)
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6) Maintain Nags Head's eligibility for future FEMA community assistance funds

1.4 Permitting

The Town of Nags Head obtained permits under the National Environmental Policy Act (NEPA) and the state Coastal Area Management Act (CAMA) permitting process, including the preparation of a comprehensive Environmental Assessment and its eight (8) appendices (CSE 2017a). The environmental documentation was necessitated by the need to accomplish the work during summer months and turtle nesting season.

Two main alternatives were evaluated for the 2019 renourishment project:

- Alternative 1 – No-Action Alternative
- Alternative 2 – Nourishment in Summer with Offshore Sand Source

Alternative 2 – Construction During Summer Months was deemed necessary in this setting because of high wave conditions during the remainder of the year. The northern Outer Banks does not provide safe working conditions for offshore dredging during fall and winter. The full scope of work under Alternative 2 was determined to best meet the goals and objectives of the Town. Construction impacts and the short-term biological impacts of the 2019 project were expected to be similar to the 2011 project because borrow sources and sediment quality were nearly identical. Alternative 2 would add a large volume of sand to the beach system and increase sea turtle and shorebird nesting habitat. It would also significantly increase nourishment longevity and reduce the frequency of future remedial or emergency measures. Therefore, Alternative 2 was the Town's preferred alternative and was permitted by the state and federal resource agencies with special conditions for environmental protection measures.

Additional alternatives were considered during the planning stages of the initial 2011 project and the 2019 project but were dismissed from further analysis by resource and regulatory agencies due to environmental, geological, technical, or economic reasons (cf – USACE 2010; CSE 2017a).

The principal environmental issue at Nags Head for construction during summer months is sea turtle nesting. As part of the Southeast Region, Nags Head is subject to the same turtle protection measures and "take statements" as Florida, where the majority of nests are located (NMFS 1997). Being subject to the Southeast Region's "take statements" severely limits the use of hopper dredges. Virginia Beach (VA), 50 miles north of Nags Head, is situated along the same bight but is under the environmental protection rules of the Northeast (USA) Region, where turtle nesting is of less concern.

Nags Head (situated near the northern limit of the sea turtle nesting range) had an average of 1.8 nests per year along the project shoreline over the 25 years prior to the 2011 initial beach nourishment project (source: NC Wildlife Resources Commission (NCWRC) database; USACE 2010). By comparison, South Carolina beaches average upward of 15 nests per mile per year (NMFS 1997).

Volunteers with the non-profit organization, Network for Endangered Sea Turtles (NEST) have conducted surveys and collected nest data along a 53-mile corridor of the northern Outer Banks from the southern end of Nags Head to the Virginia border since 1981. Figure 1.3 shows numbers of sea turtle nests by species from 1993 to 2016 within this corridor, and Table 1.1 summarizes the sea turtle stranding data from 1998 to 2016 (CSE/CZR 2017 – Environmental Assessment Appendix B – Biological Assessment).

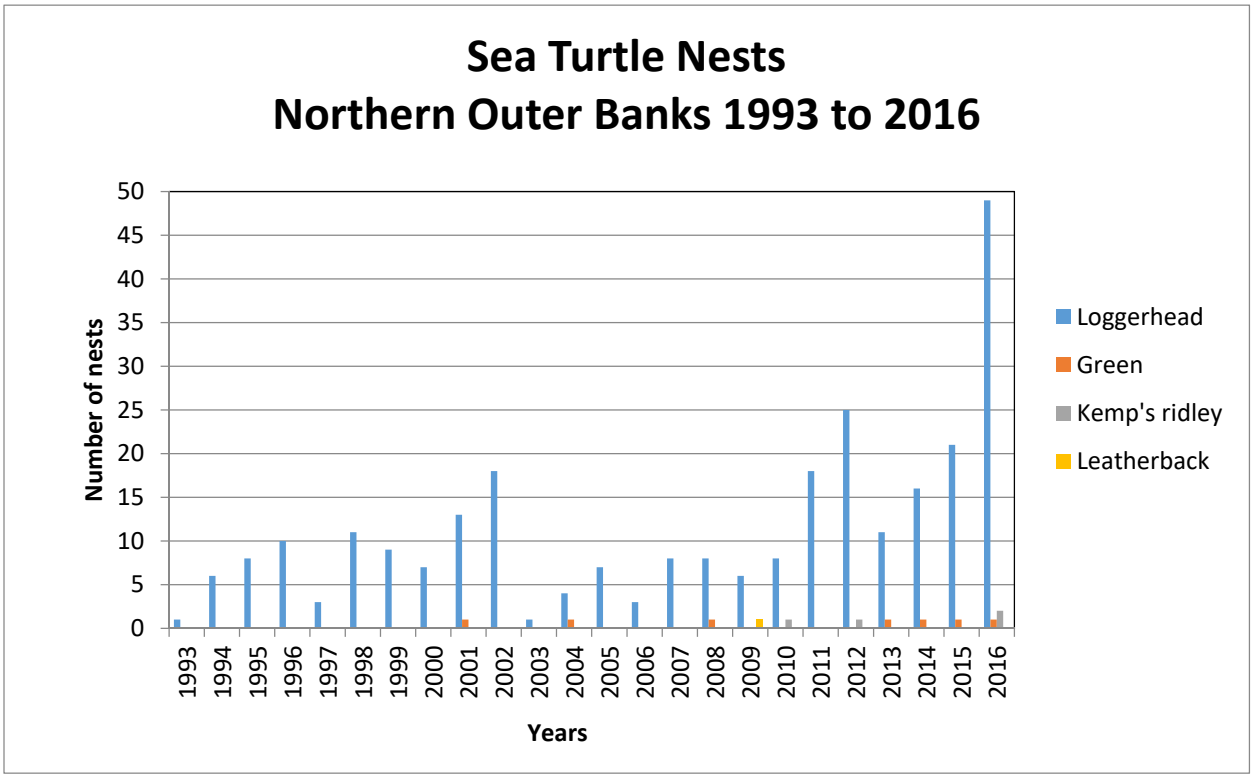


FIGURE 1.3. Numbers of sea turtle nests documented within the 53-mile NEST corridor in the northern Outer Banks from the southern end of Nags Head to the Virginia border during the period of 1993–2016 (source: www.seaturtle.org).

TABLE 1.1. Sea turtle stranding data from 1998–2016 (source: www.seaturtle.org).

Sea Turtle Strandings								
	Northern Outer Banks (NOBX)						Total Dare Co	Total NC
Year	Loggerhead	Green	Kemp's ridley	Leatherback	Hawksbill	**Total NOBX**		
1998	0	0	0	0	0	0	101	357
1999	0	0	0	0	0	0	260	602
2000	0	0	0	0	0	0	425	832
2001	2	0	0	1	0	3	116	358
2002	0	0	0	0	0	0	183	471
2003	0	0	0	1	0	1	198	478
2004	0	0	0	1	0	1	114	454
2005	0	0	1	1	0	2	93	379
2006	1	0	0	0	0	1	95	326
2007	0	0	0	0	0	0	95	345
2008	0	0	0	0	0	0	199	555
2009	48	5	9	1	1	64	271	645
2010	16	0	1	0	0	17	366	910
2011	33	2	7	5	0	47	150	513
2012	31	2	6	1	0	40	129	507
2013	46	0	9	0	0	55	323	902
2014	31	2	7	0	0	40	320	640
2015	24	3	12	1	0	40	326	800
2016	35	2	12	1	0	50	1,136	2,561
Total	**267**	**16**	**64**	**13**	**1**	**361**	**4,900**	**12,635**
Average	14.1	0.8	3.4	0.7	0.1	19	257.9	665.0
Average 1998-2008	0.3	0.0	0.1	0.4	0.0	0.7	170.8	468.8
Average 2009-2016	33.0	2.0	7.9	1.1	0.1	44.1	377.6	934.8

Note: 1 unknown nest in the 2016 data set was not included in this table.

As mitigation for summer dredging, the Town of Nags Head and the Contractor were required to implement a series of environmental protection measures. Such measures included (1) sea turtle monitoring on the beach within the active construction zones and along the shore pipe route each night; (2) nesting surveys and egg relocation each morning along the entire project area during construction; and (3) endangered species monitoring onboard each hopper dredge. Open-net turtle trawling was also required during hopper dredging for purposes of stimulating sea turtles to move out of the dredge path.

The North Carolina Modification/Major CAMA permit (#45–10; the same Permit Number as the 2011 initial nourishment project) was issued on 12 February 2018, and the federal permit (ID SAW 2017–02098) was issued on 28 March 2018. The Town of Nags Head was authorized to excavate up to 4 million cubic yards of sand from the designated offshore borrow areas 3A and 4 and to deposit the material along the 10.0 miles of ocean shoreline (Figure 1.4). It is the same 10.0 miles of shoreline as the 2011 project, beginning ~1 mile from the Town's northern limit near the Bonnett Street public beach access (milepost 11.25) and extending south to the Town line (milepost 21) adjacent to the Cape Hatteras National Seashore. The average fill density (volume of nourishment per linear foot of beach) is 75 cubic yards per linear foot (cy/ft) of shoreline, which is equivalent to an average beach width increase after natural profile adjustment of ~60 ft. The two offshore borrow areas (3A and 4) were located 1.0–2.5 miles offshore of Nags Head within state waters. Borrow Area 3A encompassed ~340 acres and contained ~4.3 million cubic yards of material if excavated to the maximum permitted depth of 8 ft below the existing grade. Borrow Area 4 encompassed ~150 acres and contained ~1.4 million cubic yards of material if excavated to the maximum permitted depth of 5.9 ft below the existing grade. In total, these two borrow areas contained approximately 5.7 million cubic yards of sand, which is 45 percent (45%) more than the maximum permitted volume and should be sufficient for the Contractor to use any type of dredge to complete the full scope of renourishment.

The Town of Nags Head was also permitted to implement a dune management plan which included initial dune construction along south Nags Head, installation of sand fencing, and planting of vegetation along the entire project area following renourishment.

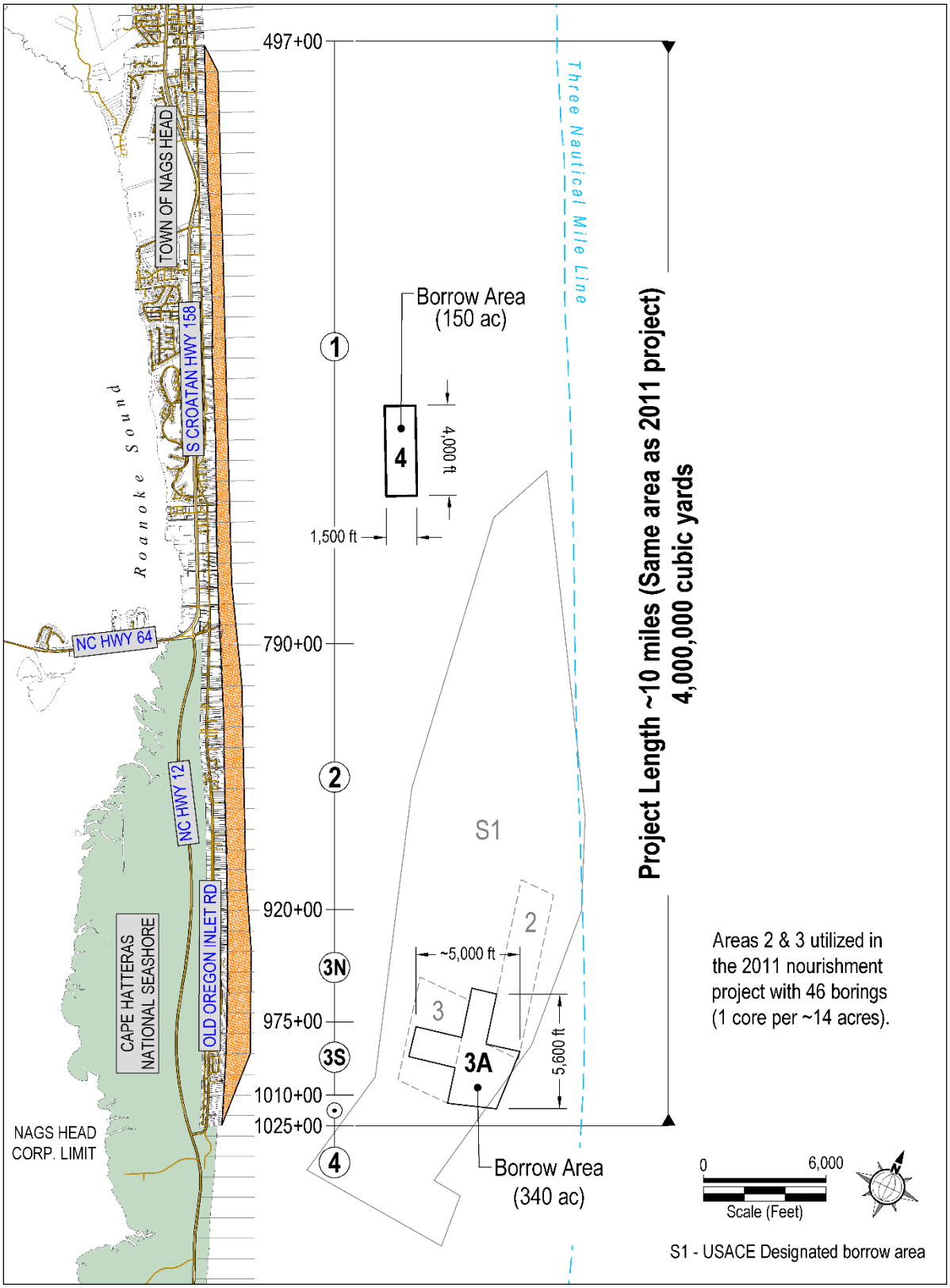


FIGURE 1.4. Project map showing the 2019 renourishment project area. One sand source (3A) situated between 2011 areas 2 and 3 (including some unused areas) was designated as the primary area for the 2019 project. This is located about 2 miles offshore of south Nags Head. The second sand source is new Borrow Area 4 located approximately 1.5 miles north of the central portion of Nags Head beach.

1.5 Project Bids

CSE prepared a final design, plans, specifications, and bid documents, and made them available to contractors on 15 February 2018 following review by Town officials. Bids were received and opened at 2:15 pm on 15 March 2018. Because work involved offshore excavations, ocean-certified dredges were required under US Coast Guard regulations. Therefore, only about five US dredging firms were qualified to perform this work. Four out of these five firms submitted bids for the project: Dutra Group (Dutra), Great Lakes Dredge & Dock Company (GLDD), Manson Construction (Manson), and Weeks Marine (Weeks).

Bids were requested for mobilization and pumping of a Base Bid quantity of 2 million cubic yards over the length of the project and two alternate (supplementary) quantities of up to 570,000 cy for Alternate Bid 1 and up to 1.43 million cubic yards for Alternate Bid 2. Bidders were requested to submit two bids (ie – Bid A for 2018 construction and Bid B for 2019 construction). The itemized bid tabulation for all of the bids submitted is listed in Table 1.2.

Based on the bid items submitted, the Town and CSE evaluated the bids by the *total* cost of the work for 3.73 million cubic yards (ie – 2.3 million cubic yards for the "Town" portion of the project and 1.43 million cubic yards for the "FEMA" portion of the project) as well the work of 4 million cubic yards (permitted maximum quantity) for Bid A (2018 construction) and Bid B (2019 construction) (respectively). The total cost of each bid was compared with the construction budget of (~)$34.2 million which was estimated at the time of bid opening [ie – the Town's reserved (~)$22.2 million construction budget plus (~)$12 million of FEMA funds].

Additionally, the equivalent unit cost of the low bid was compared with the 2011 Nags Head nourishment project (bids received in February 2011), the "Three-Towns" (Duck, Kitty Hawk, and Kill Devil Hills) nourishment project (bids received in March 2016), and the Buxton nourishment project (bids received in April 2016).

TABLE 1.2. Bid tabulation for Nags Head beach renourishment (Dare County, North Carolina).

BID TABULATION Beach Renourishment at Nags Head, Dare County, North Carolina 2 PM March 15, 2018				
	Bidder 1	**Bidder 2**	**Bidder 3**	**Bidder 4**
Name	Dutra Group 2350 Kerner Blvd. San Rafael, CA 94901	Great Lakes Dredge & Dock Co. 2122 York Roak Oakbrook, Illinois 60523	Manson Construction 5985 Richard Street Jacksonville, Florida 32216	Weeks Marine Inc. 304 Gaille Drive Innwoods Business Park Covington, LA 70433
Addendum Acknowledged	1√ 2√ 3√	1√ 2√ 3√	1√ 2√ 3√	1√ 2√ 3√
Bid Items				
Base Bid A1 - Mob/Demob	14,400,000	8,500,000	8,450,000	4,950,000
Base Bid A2 - Dredging and Placement of 2.0 MCY	36,000,000	20,800,000	21,500,000	25,500,000
Alt Bid A3 - Mob/Demob	18,000	0	500,000	0
Alt Bid A4 - unit price of 570,000 CY	19.00	10.80	10.75	12.75
Total Base Bid A and Alt Bid A1 of 2.57 MCY	61,248,000	35,456,000	36,577,500	37,717,500
Alt Bid A5 - Mob/Demob	2,000,000	0	500,000	1,250,000
Alt Bid A6 - Dredging and Placement of 1.43 MCY	31,000,000	16,588,000	15,372,500	18,232,500
Total Alt Bid A2 of 1.43 MCY	33,000,000	16,588,000	15,872,500	19,482,500
Bid A7 - unit price of sand fencing	80.00	50.00	70.00	75.00
Suspension Cost per day	188,000	300,000	450,000	100,000
Total price of 3,300 units of sand fencing	264,000	165,000	231,000	247,500
Total Bid A Price of 4 MCY *without* sand fencing	**94,248,000**	**52,044,000**	**52,450,000**	**57,200,000**
Base Bid B1 - Mob/Demob	6,400,000	4,000,000	7,850,000	4,750,000
Base Bid B2 - Dredging and Placement of 2.0 MCY	36,000,000	16,600,000	20,900,000	16,000,000
Alt Bid B3 - Mob/Demob	18,000	0	250,000	0
Alt Bid B4 - unit price of 570,000 CY	19.00	7.20	10.45	7.50
Total Base Bid B and Alt Bid B1 of 2.57 MCY	53,248,000	24,704,000	34,956,500	25,025,000
Alt Bid B5 - Mob/Demob	2,000,000	0	250,000	1,250,000
Alt Bid B6 - Dreding and Placement of 1.43 MCY	31,000,000	11,940,500	14,943,500	13,585,000
Total Alt Bid B2 of 1.43 MCY	33,000,000	11,940,500	15,193,500	14,835,000
Bid B7 - unit price of sand fencing	80.00	50.00	70.00	75.00
Suspension Cost per day	188,000	270,000	250,000	100,000
Total price of 3,300 units of sand fencing	264,000	165,000	231,000	247,500
Total Bid B Price of 4 MCY *without* sand fencing	**86,248,000**	**36,644,500**	**50,150,000**	**39,860,000**

1) Bid A (2018 Construction):

As requested, all four bidders submitted bids for Bid A. The total price to complete the maximum permitted work (4 million cubic yards) proposed by the four companies, from the lowest to the highest, are summarized as follows:

(1) GLDD — $52,044,000
(2) Manson — $52,450,000
(3) Weeks — $57,200,000
(4) Dutra — $94,248,000

These amounts included the cost of mobilization and demobilization, dredging, placement, grading, tilling, and environmental protection measures as required under federal and state permits. The lowest two bids submitted by GLDD and Manson were very close with only a difference of $406,000 (~0.8 percent of the lowest bid price submitted by GLDD). However, both submissions for Bid A were over 50 percent above the total construction budget (~$17.8 million more than the reserved ~$34.2 million).

2) Bid B (2019 Construction)

As requested, all four bidders submitted bids for Bid B. The total price to complete the maximum permitted work (4 million cubic yards) proposed by the four companies, from the lowest to the highest, are summarized as follows:

(1) GLDD — $36,644,500
(2) Weeks — $39,860,000
(3) Manson — $50,150,000
(4) Dutra — $86,248,000

Based on the lowest bid submitted by GLDD ($36,644,500), the construction cost of the maximum permitted 4 million cubic yards of work was estimated to be **$2,444,500 above the total construction budget** of (~)$34.2 million.

The second-lowest bid, submitted by Weeks, was $3.2 million higher than the bid provided by GLDD and $10.3 million less than the next lowest bid (provided by Manson). Dutra submitted the highest total price for both Bid A at (~)$94 million and Bid B at (~)$86 million.

The equivalent unit price (ie – total price divided by 4 million cubic yards) of GLDD's Bid B was **(~)$9.16 per cubic yard (cy)**. The 2011 Nags Head beach nourishment project (4.6 million cubic

yards) was bid at (~)$6.56/cy on 22 February 2011. The "Three-Towns" beach nourishment project received bids on 8 March 2016 for construction in 2017, and the equivalent unit price of their lowest bid was (~)$10.20/cy (based on $38,596,850 for 3.785 million cubic yards of work). The Buxton beach nourishment project received bids on 7 April 2016 for construction in 2017, and the equivalent unit price of their lowest bid was (~)$8.52/cy (based on $22,150,000 for 2.6 million cubic yards of work). Each project involved different logistical and operational constraints, making direct comparisons unreliable. Nevertheless, the bid price for the Nags Head renourishment project was considered to be in line with current market conditions.

3) Sand Fencing

The unit price of each 10-foot (ft) section of sand fencing (including material and installation) proposed by each bidder remained the same for Bid A and Bid B, indicating relatively stable pricing for 2018 and 2019.

The unit price of each 10-ft section and the total price to complete the maximum 3,300 sections proposed by the four companies, from the lowest to the highest, are summarized as follows:

GLDD — $50.00 per unit, resulting in a total price of $165,000
Manson — $70.00 per unit, resulting in a total price of $231,000
Weeks — $75.00 per unit, resulting in a total price of $247,500
Dutra — $80.00 per unit, resulting in a total price of $264,000

As all four bids were above the Town's reserved $125,000 for this task, the Town decided not to award this portion of the work to any of the bidders.

4) Conclusions

Based on the total cost of all bids, the Town decided to reject all bids for Bid A because they were more than 50 percent above the total construction budget. GLDD was the apparent lowest bidder for Bid B and was awarded a contract volume of 3,731,661 cy on 16 July 2018.

After the Town secured additional funds for construction, a Change Order was issued to GLDD on 6 February 2019 for an additional volume of 268,339 cy, making the total contract volume of 4 million cubic yards with the total contract price of $36,644,500.

2.0 PROJECT DESCRIPTION

2.1 Project Plan

The beach renourishment project constructed along Nags Head was implemented between 1 May and 18 August 2019 by two hopper dredges by the Contractor, Great Lakes Dredge & Dock Company (GLDD). The work included dredging, placement, grading, and environmental protection measures (as specified under federal and state permits) of 4,000,000 cubic yards (cy) along 52,800 linear feet (lf) of Nags Head in five reaches designed as follows:

1) Reach 1 (Stations 497+00 to 790+00) — 1,758,000 cy over 29,300 linear feet
2) Reach 2 (Stations 790+00 to 920+00) — 845,000 cy over 13,000 linear feet
3) Reach 3N (Stations 920+00 to 975+00) — 622,000 cy over 5,500 linear feet
4) Reach 3S (Stations 975+00 to 1010+00) — 543,000 cy over 3,500 linear feet
5) Reach 4 (Stations 1010+00 to 1025+00) — 232,000 cy over 1,500 linear feet

The average fill density was ~75 cy/ft, varying from north to south in relation to design rationale (CSE 2017a). CSE conducted a before-dredging (BD) survey in mid-April 2019 before the commencement of construction. Based on the BD survey results, fill templates for construction were revised and provided to GLDD on 22 April 2019 (Appendix B1). Initial dunes were designed along Reaches 3N, 3S, and 4 where there was lack of a dune or the dune volume was significantly lower than the average dune volume of the entire project length. The revised fill templates were submitted to the NC Division of Coastal Management (NCDCM) for approval. The NCDCM issued a Letter of Authorization on 9 May 2019 and the letter serves as an approval of these revised fill plans.

As illustrated in Figure 1.4, the sand was dredged from the designated offshore borrow areas 3A and 4 by dredges, pumped onto the beach, and shaped to the grades and quantities indicated on the project drawings (CSE 2018a). The maximum depth of excavation allowed was 8 ft including over-dredge for Borrow Area 3A and 5.9 ft for Borrow Area 4. The maximum area of excavation allowed was 490 acres, and the Contractor was required to not exceed the cut depth and allowance indicated on the project plans for the borrow areas.

2.2 Dredges Used in the Project

GLDD elected to complete the full scope of work by hopper dredges. They started mobilizing submerged pipeline and land-based equipment on 11 April 2019, and the first load of material was delivered via America's largest dredge, *Ellis Island*, around 7:00 pm on 1 May. *Ellis Island* has a maximum capacity of 15,000 cy per load and was able to deliver approximately 11,000 cy per load during this project. *Ellis Island* dug in Borrow Area 3A and was on site until 16 June (a total of 47 days). GLDD reported that *Ellis Island* placed 1,765,360 cy of sand and was able to complete the volumes along Reaches 3N, 3S, and 4 and part of Reaches 1 and 2. During her last week on site from June 10–16, she worked with the other hopper dredge, *Liberty Island*, and ran "round-robin" to share the same discharge points around Stations 535+00 and 613+50 in Reach 1.

The second hopper dredge, *Liberty Island*, arrived at the job site on 28 May and delivered her first load around 1:00 pm that day. She first used Borrow Area 4 followed by Borrow Area 3A after *Ellis Island* left the job site. *Liberty Island* was on site for 83 days and departed a few hours after the full contract amount of 4 million cubic yards was completed around 4:17 am on 18 August 2019. Photos of the two hopper dredges are shown in Figure 2.1 and their specifications along with work summary are listed in Table 2.1.

TABLE 2.1. Specifications and work summary of the two ocean-certified hopper dredges that GLDD used in the 2019 Nags Head renourishment project.

Name	Dimensions (ft)			Capacity (cy)	For the Nags Head 2019 Project			
	Breadth	Length	Draft		Total Days	Total Loads	Total Volume (cy)	Average Capacity (cy) per Load
Ellis Island	92	480	30	14,800	47 days (05/01–06/16)	172	1,765,360	~10,500
Liberty Island	59	325	28	6,540	83 days (05/28–08/18)	518	2,234,640	~4,300

FIGURE 2.1. The two GLDD ocean-certified hopper dredges used in the 2019 Nags Head beach renourishment project. The *Ellis Island* is America's largest hopper dredge with a maximum capacity of ~15,000 cy. The *Liberty Island* was used in the 2011 project. **[UPPER]** *Ellis Island* **[LOWER**] *Liberty Island* (Lower photo provided by GLDD).

2.3 Pumping Operations

Pumping operations on the beach started around 7:00 pm on 1 May 2019 by the *Ellis Island* and were completed at 4:17 am on 18 August 2018 by the *Liberty Island*. GLDD submitted daily quality control report packages (Appendix A2 to A7) for each dredge's daily operations which included the volume dredged and placed, work progress on the beach, borrow areas utilized, reasons for any downtime, quality control comments, safety comments, and trawling activities etc. The volume dredged shown on the records is based on the daily forward progress of the dredge and an assumed cut face. It is a quick estimate before survey data are collected and processed, and therefore, it does not equal the total volume placed on the beach. There is an expected volume loss between what is measured in the cut and the volume placed and measured on the beach—typically about 10–25 percent depending on the quality of the material and other operational factors. For this project, the volume loss was found to be under 10 percent because the dredged materials contained negligible mud and incompatible debris.

A daily Dredging Quality Management (DQM) report was generated and monitored directly by the USACE Mobile District Operations Division. Formerly known as Silent Inspector (SI), the DQM program verifies, collects, and stores dredging instrumentation data for the USACE and provides tools to interpret and utilize this data for USACE dredging management. It contains proprietary dredging data and has not been provided to the Town or the Engineer so as to maintain competition among contractors.

GLDD representatives confirmed that the DQM reports they submitted for this project were in good order and did not lead to any violations of reporting requirements under the federal permit for the project.

2.4 Environmental Protection Measures

Based on the state and federal permits, there were no seasonal or environmental time restrictions for the execution of this project. However, dredging and placement operations were subject to certain strict environmental protection measures as detailed in the special conditions section of the permits. Required protection measures included sea turtle non-capture trawl sweeping ahead of the dredge(s) during designated periods, use of deflectors and specific equipment modification onboard hopper dredges, specific operations requirements and use of Dredging Quality Management (DQM) on the dredges, and use of certified endangered species monitors onboard dredges, etc.

Daytime (before 9:00 am) nesting surveys and egg relocation was required to be conducted because construction occurred during the sea turtle nesting period which runs from May 1 through November 15. No daytime movement of equipment up or down the beach (outside of the active nighttime construction area) could commence until completion of the sea turtle nesting survey each morning.

Nighttime beach patrols for turtle nesting activity along the pipeline were also required by the permits. Special conditions called for two experienced (permitted by NCWRC) sea turtle monitors to work continuously from dusk to dawn along the project area where the pipeline was present.

Federal and state resource agencies approved the contractor's environmental protection plan and the Town's daytime and nighttime sea turtle monitoring plan before the project began, and also checked the implementation of such plans during the project. The pumping operations started on 1 May 2019 and were completed on 18 August 2019 in compliance with the permits and without environmental incidents on the beach. There was one turtle take by a dredge on the ocean. Details of this incident are discussed in Section 6.

2.5 Mean High Water Contour

The Town of Nags Head was required to delineate the mean high water (MHW) contour prior to the initiation of beach nourishment activity. GeoDynamics (Newport, North Carolina) was retained by the Town to locate and survey the MHW line along the oceanfront.

The survey work was conducted on 30 March 2019 by means of VRS RTK-GNSS topographic rover shots and mobile laser scanning utilizing the elevation value of +1.18 NAVD. This elevation is referenced from the MHW value at the nearest ocean tidal station in Duck (NC). Figure 2.2 illustrates the various relationships among key reference datum for the tide station (ID 8651370) at the pier of the USACE FRF in Duck (NC), ~15 miles north of the project area. Survey results were prepared in an x-y-z ASCII point file and an MHW line plot. They were delivered to Town on 10 April 2019 and were then forwarded to the NCDCM after the Town's and the Engineer's review.

The GeoDynamics MHW line plot and survey report are included in Appendix D.

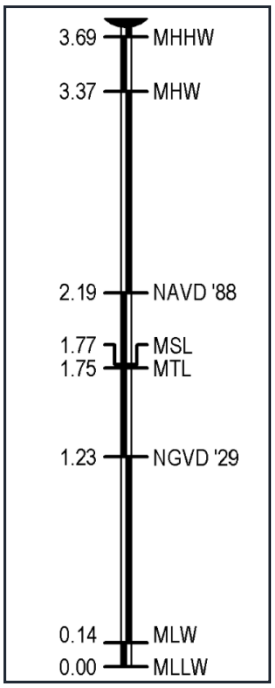


FIGURE 2.2. Relationship of various water levels and survey datum at Duck (NC). (Source: NGS–NOAA)

2.6 CSE Construction Management

During construction, representatives from CSE visited the site several times per day except for periods when dredging operations ceased due to weather issues or equipment maintenance. Additionally, whenever the dredge shifted to a different portion of the borrow areas, CSE representatives monitored the first few hours of discharge. Generally, twice per day, observers recorded wind and wave conditions, made visual inspections of the most recent sediment placed, and noted the location of the beach-grading operation.

While on site, CSE also collected composite grab sand samples from the last station completed. A composite sample consisted of a series of grab samples at ~10-ft spacing along a transect from the landward limit of fill to the low-tide line mixed together to form one representative sample for a given station. Some additional single-point grab samples in the vicinity of the discharge point were also collected. Sand samples were analyzed after collection, and results are discussed in Section 5.

Ground photos of pre-project and post-project conditions were taken during site visits, and oblique aerial photos were taken by a drone when weather conditions allowed. The photographs offered a simple visual assessment of construction progress, dry beach width, dune condition, escarpments, and general condition of the beach through time. Photos were also taken of areas or features of particular importance or interest observed during the construction phase. Site visits were recorded in CSE's daily observation reports (provided in Appendix A1) along with other construction management documents.

During construction, a weekly project meeting was held every Thursday from 2 May to 22 August 2019 at the Nags Head Town Hall, and a call-in number was provided. Representatives from the Town, GLDD, USACE, USFWS, NCDCM, NCWRC, sea turtle monitoring team, and CSE attended these meetings and reviewed work progress, upcoming areas of impact, and anticipated public events in the project area. GLDD prepared a series of meeting agendas and minutes before and after each meeting (see Appendix A3).

In addition to daily observations around the discharge point(s) and weekly project meetings, CSE periodically inspected the entire project site, including the active construction area as well as finished and unnourished sections. The purpose of these inspections was to evaluate the overall adjustment of the project and to identify any escarpments that developed on the beach.

2.6.1 Escarpments on the Beach

According to the state major CAMA permit (Item #28f), *"During beach nourishment activities, daily monitoring shall be conducted to determine if escarpments have formed. Any escarpments greater than 18 inches that are present between May 1 and August 30 shall be leveled."*

Escarpments greater than 18 inches formed several times during construction. One group of significant escarpments was observed around 16 June 2019 after some brisk winds from the south-southwest blew toward Nags Head for a few days. Wave action had cut back the nourishment berm and left escarpments that were 2–3 ft high at the edge of the surf along the nourished beach south of the Outer Banks Fishing Pier (Figure 2.3). Beachgoers, lifeguards, and the town staff also noticed such escarpments. Another group of significant escarpments occurred on 16 August 2019 along the nourished beach in the historic district (Figure 2.4).

After the Town and CSE identified the problems, GLDD used a bulldozer or tractor to level these escarpments in a timely manner. CSE closely monitored these areas over the next few days. If escarpments re-occurred at some sections, CSE coordinated with GLDD to re-level any remaining escarpments.

After nourishment was completed, the Town, GLDD, and CSE thoroughly inspected the project area: (1) from the Outer Banks Fishing Pier to the south limit of the project on Monday, 12 August; and (2) from the Outer Banks Fishing Pier to the north limit of the project on Thursday, 22 August. The following places were identified to include escarpments or uneven surfaces on the beach for GLDD to address before they demobilized the dozers and the tractor.

Escarpments from Stations 555+00 to 575+00

Escarpments from Stations 600+00 to 610+00

An uneven surface around Station 818+00 near Hargrove Street

Escarpments and uneven surface from Station 822+00 to 833+00 near Dare Street

Uneven surface around Station 842+00

GLDD conducted the final leveling work by Saturday, August 24 according to the Town and CSE's instructions. A nor'easter event impacted the project area over that weekend and left 18" to 42"

escarpments along most of the Nags Head oceanfront. These newly formed escarpments healed naturally within several days of formation. CSE representative inspected the project area on 27 August 2019 and confirmed that there were no escarpments remaining, and all previously identified problematic areas appeared to return to normal compared to their adjacent areas. The Town of Nags Head signed off its acceptance of the beach renourishment project by 28 August 2019, and GLDD demobilized the last few pieces of equipment by 30 August 2019, marking the final completion of the 2019 Nags Head beach renourishment project.

FIGURE 2.3. Escarpments formed along the nourished beach south of the Outer Banks Fishing Pier on 16 June 2019. [Source: D Ryan, Town Engineer of Nags Head]

FIGURE 2.4. Another group of escarpments formed along the nourished beach in the historic district along the north half of Nags Head on 16 August 2019. [Source: C. Ogburn, Town Manager of Nags Head]

2.6.2 Beach Compaction

It is specified by the USACE permit Special Conditions #41 that:

> "*… Sand compaction must be monitored in the project area immediately after completion of any sand placement event… Within 7 days of completion of sand placement and prior to any tilling (if needed), a field meeting shall be held with the USFWS, NCWRC and the USACE to inspect the project area for compaction and determine whether tilling is needed.*"

CSE coordinated with representatives of USFWS, NCWRC, NCDCM, NEST, and the USACE and scheduled two field meetings based on the work progress during construction. The first field meeting was held on Friday, 28 June 2019 when approximately 50 percent of the nourishment sand was placed. The second field meeting was held on Thursday, 22 August 2019 after nourishment was completed.

Decisions by the resource agencies after the two field meetings were consistent. Nourishment sand was deemed to be compatible with the native beach and no tilling was required at the time.

2.6.3 Construction Management Documentation

In addition to CSE's daily observation reports, construction management documents prepared and reviewed by CSE are listed in Table 2.4.

TABLE 2.4. Construction management documentation.

Prepared by	Period	Object	Name of Report
CSE	Daily	Overall	Observation report
	Daily	Sand quality	Sediment analysis
	Daily	Overall — particularly the active construction zone(s)	Photographs (ground and aerial)
	Periodically	Overall	Newsletter and presentation at a Town Board of Commissioners meeting
GLDD	Daily	Overall	Quality Control Report
	Daily	Active construction zone(s)	Beach advance report
	Daily	Overall	Safety report
	Daily	Trawlers in the borrow area	Trawler logs for each hopper dredge
	Daily & Weekly	Endangered species observed on the dredges	Endangered Species Observer Program Daily Report
	Weekly	Overall	Agenda and minutes of weekly project meetings
	Periodically	Overall	Survey transmittals
	Monthly	Completed sections	Payment application
	Periodically	Overall	Photographs (ground and aerial)
Turtle Monitors	Daily	Sea turtles on the beach	Sea Turtle Daytime and Nighttime Monitoring Report

3.0 PROJECT SEQUENCE

The 2019 Nags Head beach renourishment was successfully completed on 18 August 2019 after 110 days of construction. Table 3.1 provides the sequence of major events that comprised the planning, project design, permitting, bidding, and construction of this project.

The first nourishment project at Nags Head was conducted between 24 May and 27 October 2011, and approximately 4.6 million cubic yards of sand was placed along the 10-mile stretch of beach (Kaczkowski and Kana 2012). Following the successful completion of the 2011 nourishment, the Town of Nags Head monitored performance and developed strategies for beach maintenance and preservation with the goal of improving protection to all properties and recreational beach areas. The short-term plan was renourishment, and the long-term plan targeted a timeframe of 30 years.

CSE conducted semi-annual or annual beach condition surveys after the completion of the 2011 nourishment project and was retained by the Town of Nags Head in 2016 to plan the renourishment project. CSE's involvement included meetings with Town officials and the Town's Shoreline Management Committee; development of project plans; preparation of project budgets; assistance to the Town with the application for FEMA's Category G post-disaster funds; preparation of applications for state and federal permits; and responses to comments from federal and state resource agencies and regulators during permit review. Key dates of the project are listed in Table 3.1, and key technical reports prepared by CSE between 2016 and 2018 are listed as follows:

- Environmental Assessment and its appendices (CSE 2017a).
    - Littoral Processes
    - Biological Assessment
    - Geotechnical Data Analyses
    - Essential Fish Habitat Assessment
    - Cultural Resources Survey
    - Monitoring & Mitigation Measures
- Monitoring and analyses of the 2011 Nags Head beach nourishment project – Year 5 (CSE 2016a)
- Memorandum of Post-*Matthew* Survey Preliminary Results (CSE 2016b)
- Monitoring and analyses of the 2011 Nags Head beach nourishment project – Year 6 (CSE 2017b)
- Monitoring and analyses of the 2011 Nags Head beach nourishment project – Year 7 (CSE 2018b)

TABLE 3.1. Project timeline for the 2019 beach renourishment project at Nags Head.

10 June 2016	CSE retained by the Town of Nags Head to plan and design the renourishment project.
12 July 2016	First meeting with the Town's shoreline management committee.
9 August 2016	Second meeting with the Town's shoreline management committee.
13 September 2016	Third meeting with the Town's shoreline management committee.
October 2016	Hurricane *Matthew* impacted Nags Head on 6 October 2016; CSE conducted a comprehensive beach condition survey from October 26 to November 2; and submitted a memo to the Town on 4 November to summarize the ~1.43 million cubic yards sand volume loss after *Matthew*.
7 November 2016	Fourth meeting with the Town's shoreline management committee.
12 December 2016	Fifth meeting with the Town's shoreline management committee.
18 January 2017	Sixth meeting with the Town's shoreline management committee.
23 March 2017	First inter-agency scoping meeting.
28 April 2017	FEMA issued the CEF Fact Sheet and determined the project estimate to restore the sand loss caused by Hurricane *Matthew* was $16,053,263 which included $13,763,278.17 for construction.
August 2017	Second inter-agency scoping meeting on 8 August 2017
September 2017	CSE submitted permit applications to USACE and NCDEQ for review. The permit application package included Biological Assessment (BA), Geotechnical Data Analyses, Essential Fish Habitat Assessment (EFH), Biological Monitoring, Monitoring & Mitigation Measures, and FEMA Authorization Documents.
October 2017	CSE submitted the second package to USACE and NCDCM to support permit applications. This package included Environment Assessment (EA) and Appendix A – Littoral Processes.
November 2017	CSE responded to comments from NCDEQ and updated Geotechnical Data Analyses and Cultural Resources Survey.
4 December 2017	CSE submitted the final application package which included the revised permit application and the final Environmental Assessment with its eight appendices.
20 December 2017	Biological Opinion by USFWS was issued.
15 February 2018	CSE prepared plans, specifications, and bid documents for the project — bid documents were made available to qualified companies on 15 February 2018.
27 February 2018	**Pre-Bid meeting at Nags Head**
28 February 2018	**NCDCM Major CAMA permit (45–10)** was issued (expires on 31 December 2021).
15 March 2018	**Bid opening** — four qualified companies provided valid bids — Great Lakes Dredge & Dock Company (GLDD) provided the lowest apparent bid — after factoring in mobilization and unit pumping costs under two alternate schedules (2018 construction and 2019 construction), the Town selected Bid B (2019 construction) for 3,731,661 cubic yards along the 10-mile stretch of beach at $34,712,459.20.
28 March 2018	**Federal permit SAW–2017–02098** was issued.
22 June 2018	The Town issued Notice of Award to GLDD.
16 July 2018	The Town executed the Agreement with GLDD.
26 July 2018	The Town issued Notice to Proceed to GLDD.
6 February 2019	The Town issued Change Order #1 to increase the total project volume to the maximum permitted volume of 4 million cubic yards. The contract price after this Change Order became $36,644,500.

14 March 2019	Regulatory pre-construction meeting
30 March 2019	Mean High Water survey was completed by GeoDynamics (Newport, NC), and the survey report and data were submitted to the Town on 10 April 2019.
8 April 2019	CSE initiated a survey for the before-dredging (BD) condition.
11 April 2019	Pre-construction meeting with the permitting agencies, Town, GLDD, and CSE.
11 April 2019	GLDD set up the first landing point on the beach at Station 975+50 and initiated a daily quality control report.
17 April 2019	CSE collected a complete set of BD drone photos along the project area.
27 April 2019	CSE provided revised fill templates to GLDD based on the BD survey results.
1 May 2019	**The first load** of sand was pumped at Station 975+50 (Limulus Street) via the *Ellis Island* at 7:05 pm
9 May 2019	NCDCM issued permit modification to authorize CSE's revision of fill templates dated 27 April 2019.
28 May 2019	The *Liberty Island* arrived at the job site around 8:00 am and delivered her first load in the afternoon around 3:00 pm
31 May 2019	Pumping through the Nags Head Fishing Pier via the *Liberty Island*.
7 June 2019	USFWS issued Biological Opinion Amendment #1 to increase the active construction area up to 1,000 linear feet of sand placement during the period of dusk to dawn.
16 June 2019	The *Ellis Island* completed her last load around 8:35 am and left the borrow area around 11:00 am
28 June 2019	First field meeting with USFWS, NCDCM, NEST, Town, GLDD, and CSE.
23 July 2019	USFWS issued Biological Opinion Amendment #2 to include consideration of the installation of sand fencing and sprigging with native plant species along the entire 10-mile project area.
28 July 2019	Pumping through Jennette's Pier.
10 August 2019	Pumping through the Outer Banks Fishing Pier via the *Liberty Island*.
12 August 2019	Final walk-through from the Outer Banks Fishing Pier to the southern limit of the project (Stations 875+00 to 1025+00) with the Town, GLDD, and CSE. The Town signed off this section of the beach for nourishment completion on 15 August 2019.
18 August 2019	**The Last load** was delivered via the *Liberty Island* around 4:20 am and the dredge left the borrow area around 7:30 am
19 August 2019	CSE initiated a beach survey for the after-dredging (AD) condition.
22 August 2019	Final walk-through from the Outer Banks Fishing Pier to the northern limit of the project (Stations 875+00 to 497+00) with the Town, GLDD, and CSE. The Town signed off this section of the beach for nourishment completion on 28 August 2019.
22 August 2019	Second field meeting with USFWS, NCDCM, NEST, Town, GLDD, and CSE.
29 August 2019	CSE collected a complete set of AD drone photos along the project area.
30 August 2019	GLDD completed demobilization.
31 October 2019	CSE submitted the final report summarizing the 2019 renourishment construction.

The Contractor (GLDD) opted to accomplish the work using two ocean-certified hopper dredges, utilizing multiple "landing points" for pumpout in either direction along the beach. Eight such landing points were used during construction. Their locations along with the sections of beach that were nourished from these points are listed in Table 3.2 and shown in (Fig 3.1).

TABLE 3.2. The eight "landing points" (from north to south) used in the 2019 beach renourishment project at Nags Head and the sections of beach that were nourished from these points.

Landing Point	Closest Street Name	Dredge Name	Nourished Sections	Nourishment Duration
Station 535+50	Curlew Street	*Liberty Island* *Ellis Island*	497+00 to 575+00 568+00 to 575+00	28 May to 11 June 10–11 June
Station 613+50	Dixie Street	*Liberty Island* *Ellis Island*	575+00 to 655+00 613+59 to 622+00	11–26 June 11–16 June
Station 691+50	Epstein Street	*Liberty Island*	655+00 to 730+00	26 June to 10 July 16–22 July
Station 767+50	Gull Street	*Liberty Island*	730+00 to 805+00	10–16 July 24 July to 1 August
Station 824+50	Sea Bird Street	*Liberty Island*	805+00 to 824+50	12–18 August
Station 842+50	Harvest Street	*Liberty Island*	824+50 to 878+00	1–12 August
Station 877+50	Islington Street	*Ellis Island*	878+00 to 926+00	29 May to 8 June
Station 975+00	Limulus Street	*Ellis Island*	926+00 to 1025+00	1–29 May

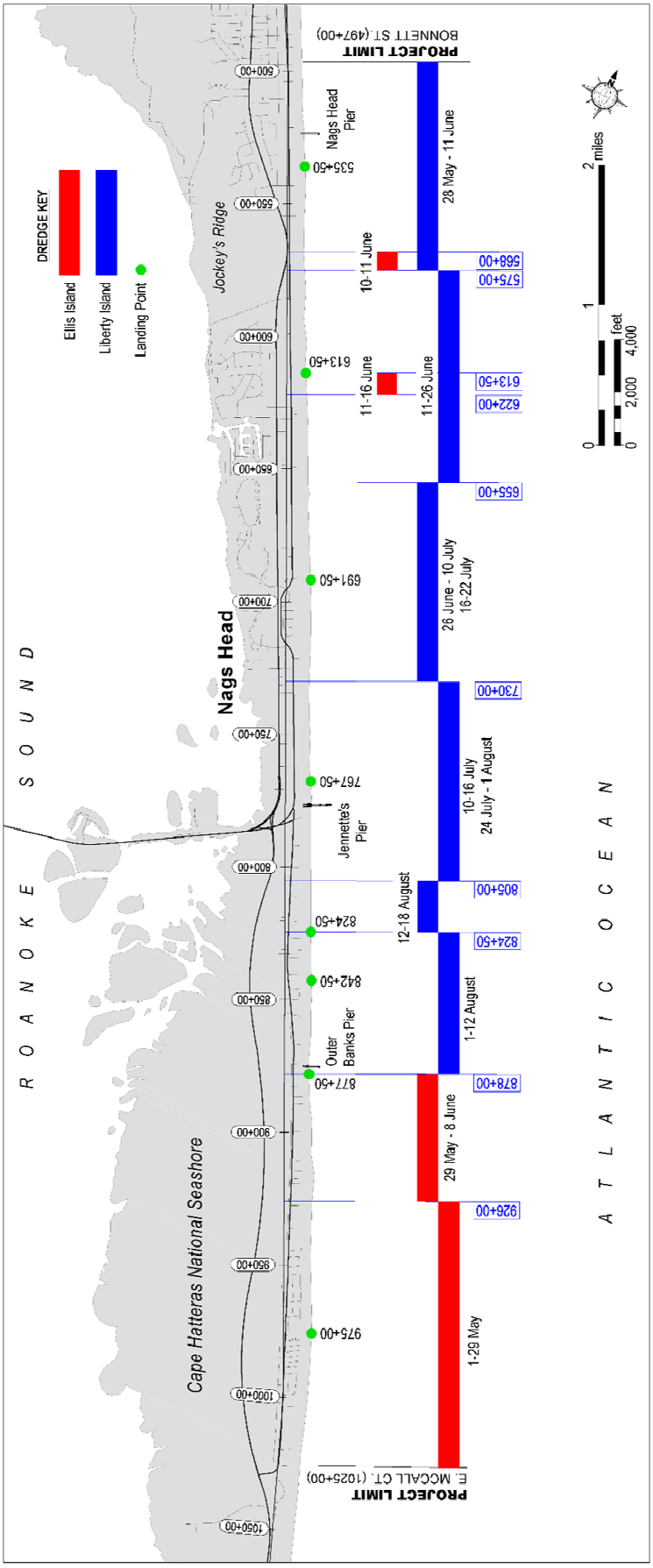


FIGURE 3.1. Multiple landing areas, fill ranges, and dates for the dredges GLDD utilized in the Nags Head beach renourishment project between 1 May and 18 August 2019.

4.0 TIDE AND WAVE CONDITIONS DURING CONSTRUCTION

The 2019 Atlantic hurricane season is an ongoing event in the annual formation of tropical cyclones in the Northern Hemisphere. The season officially began on 1 June and will end on 30 November. These dates historically describe the period each year when most tropical cyclones form in the Atlantic basin and are adopted by convention. From early April to the end of August 2019 during mobilization, pumping operations, and demobilization phases, no hurricane impacted the project area.

Measured versus predicted tides during pumping operations from May to August at the USACE Field Reach Facility (FRF) at Duck (Station 8651370) are shown in a series plots in Figure 4.1, and the wave conditions at National Data Buoy Center (NDBC) Station 44100 at the FRF during the same period of time are shown in a series plots in Figure 4.2.

The escarpment events discussed in Section 2.6.1 were coincident with the spring tide* and surge** occurrence, higher-than-average wave actions, and onshore wind.

> ****Spring Tides*** – *In the lunar month, the highest tides occur roughly every 14 days, at the new and full moons, when the gravitational pull of the Moon and the Sun are in alignment. These highest tides in the lunar cycle are called spring tides.*
>
> ***Surge*** – *The abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide. The surge is caused primarily by a storm's winds pushing water onshore.*

During construction, "ponding" on the nourished beach or underneath houses was observed several times. Such ponding was caused by wave overtopping the berm crest during a higher than normal tide. CSE's nourishment design called for a construction berm at +6 ft NAVD, which approximates the average natural berm elevation for Nags Head. As the fill equilibrates during fair weather conditions, the crest may build higher than the construction berm. Such natural adjustment occurred at several localities leaving the middle of the berm slightly lower than the seaward crest so ponding occurred on the beach or under some houses where the ground elevation was lower than the adjacent areas. As the tide receded, the ponds drained completely, as seen in Figures 4.3 and 4.4.

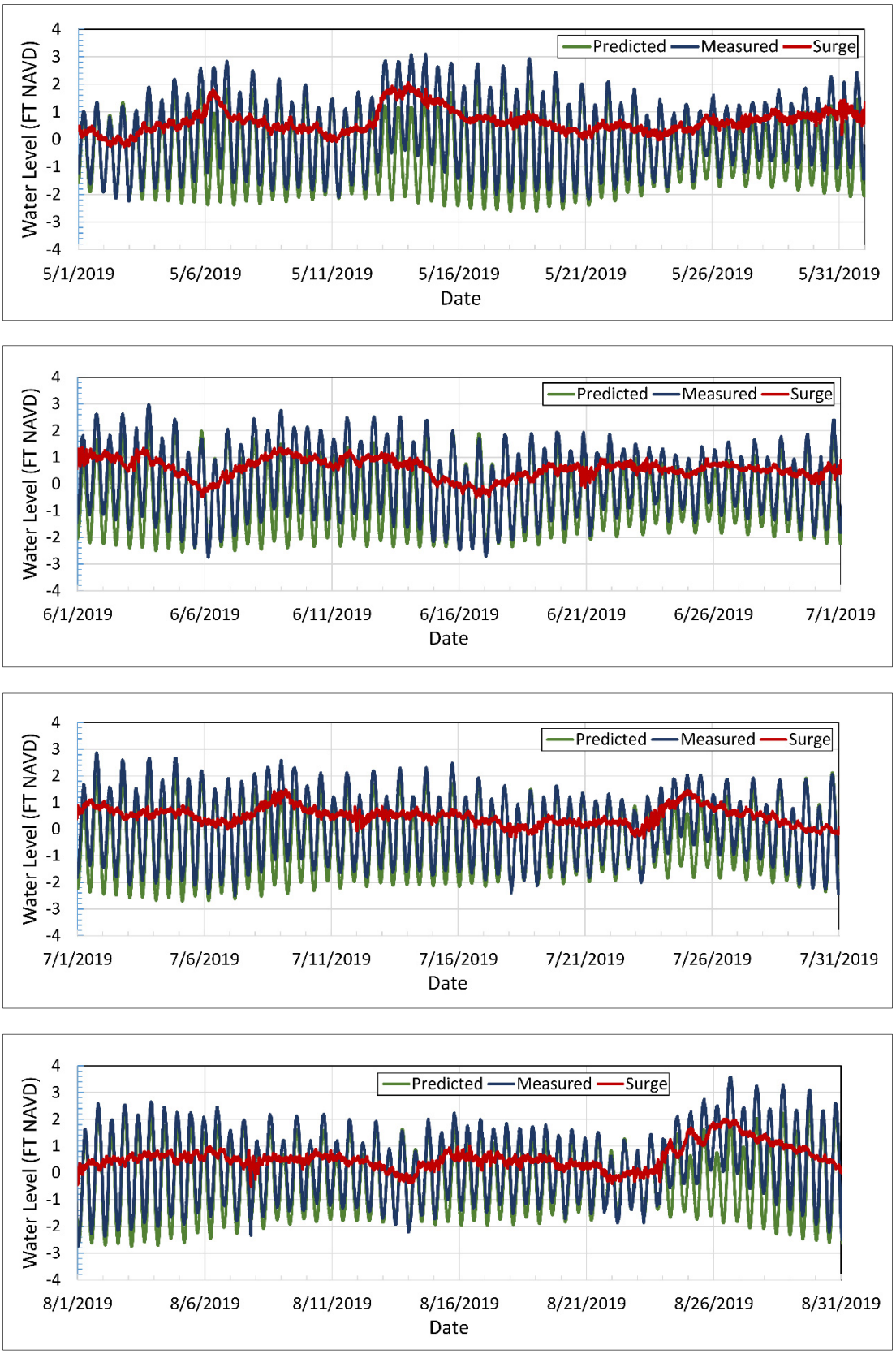


FIGURE 4.1. Measured versus predicted tides at the NOAA Station 8651370 at the USACE Field Research Facility (FRF) at Duck (NC) from May to August 2019 during pumping operations. [Source: NOAA-USACE]

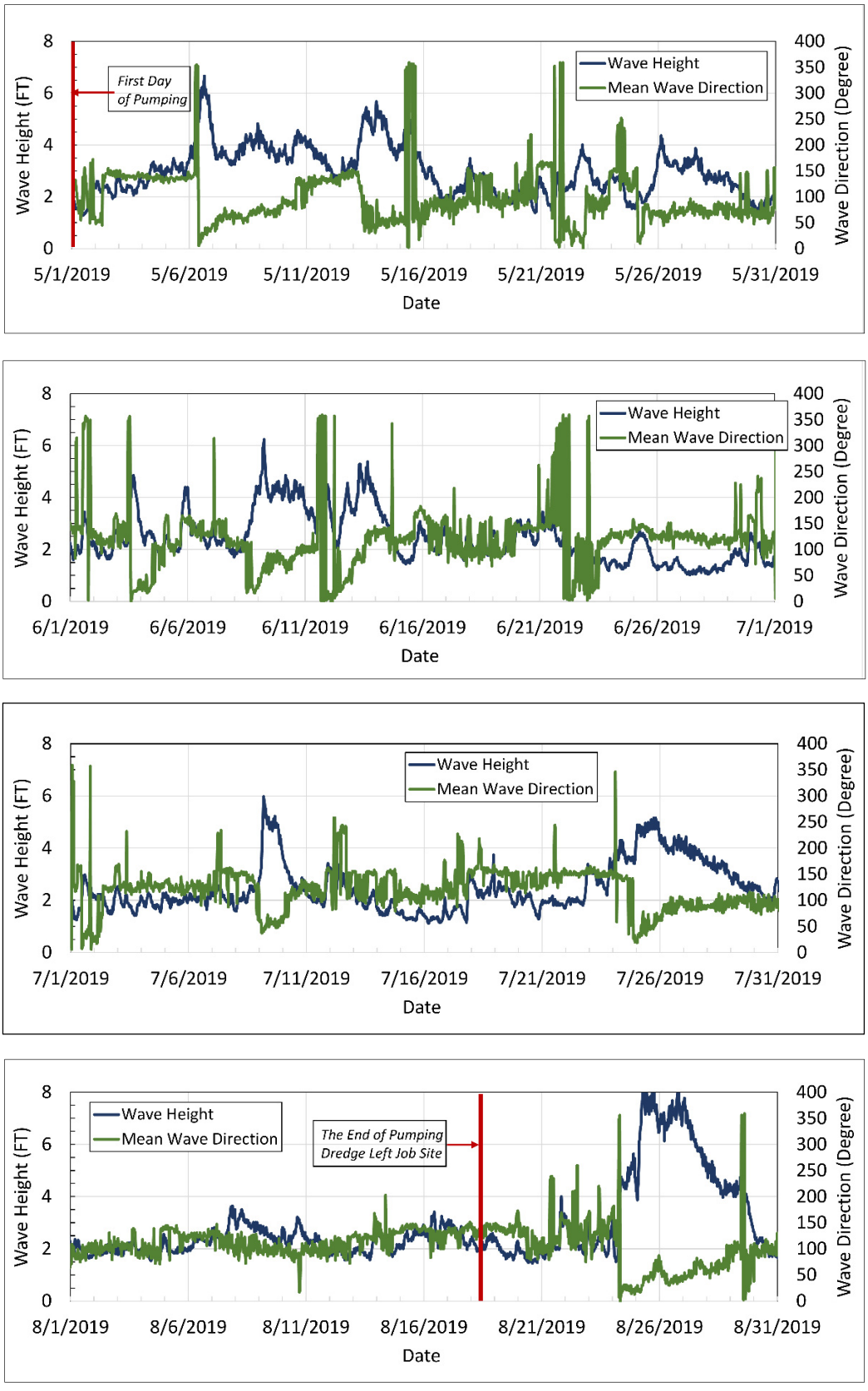


FIGURE 4.2. Wave data at NDBC Station 44100 at the USACE Field Research Facility (FRF) at Duck (NC) from May to August 2019 during pumping operations. [Source: NDBC-FRF]

FIGURE 4.3. Ponding occurred after spring tides under some houses along South Nags Head near Pioneer Street and drained naturally after tides receded. **[UPPER]** Photo on 9 May 2019. **[LOWER]** Photo on 14 May 2019.

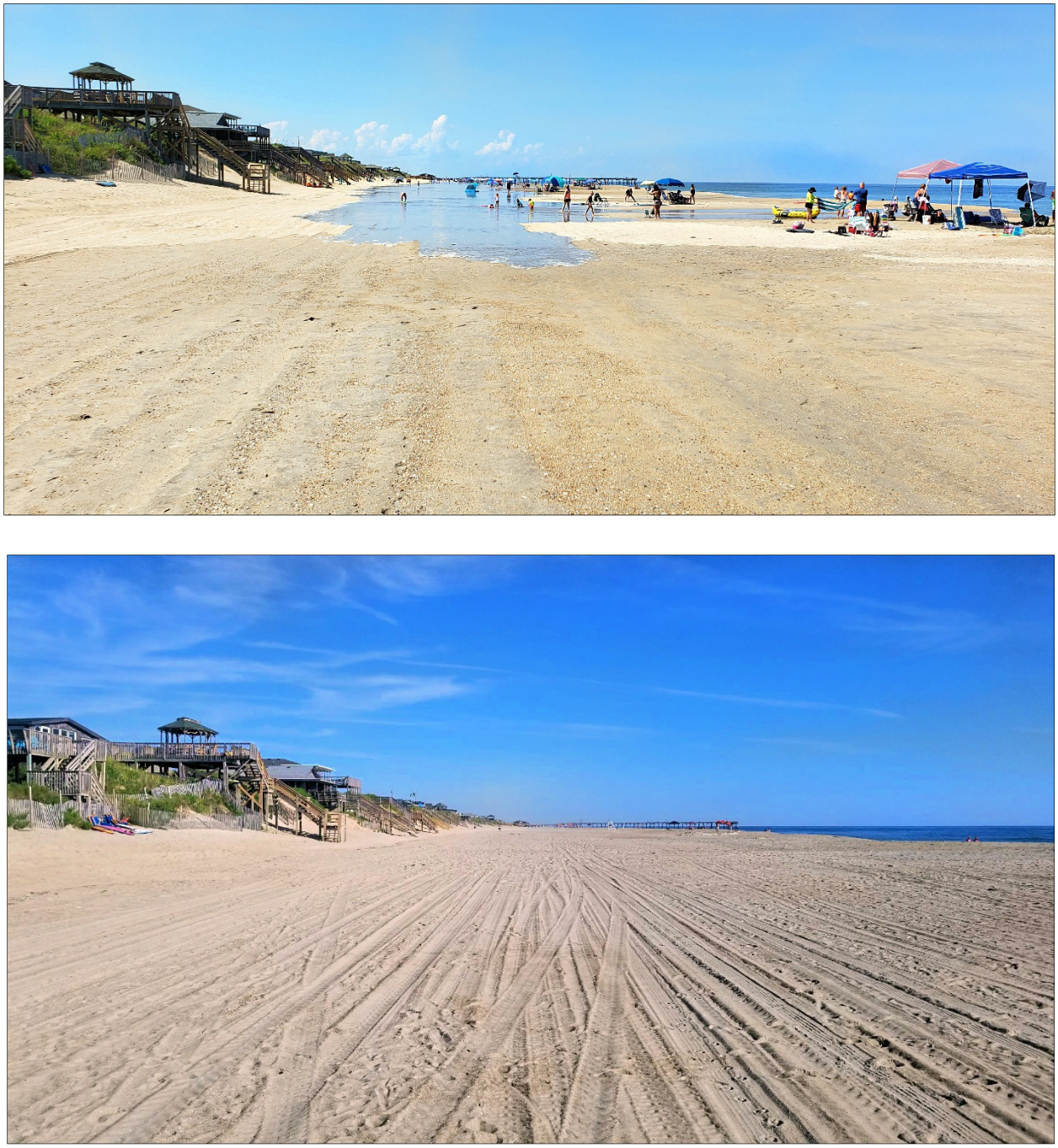


FIGURE 4.4a. Ponding occurred after spring tides on the beach along North Nags Head near Conch Street Public Beach Access and drained naturally after tides receded. **[UPPER]** Photo on 8 August 2019 looking north. **[LOWER]** Photo on 11 August 2019 looking north.

FIGURE 4.4b. Ponding occurred after spring tides on the beach along North Nags Head near Conch Street Public Beach Access and drained naturally after tides receded. **[UPPER]** Photo on 8 August 2019 looking south. **[LOWER]** Photo on 11 August 2019 looking south.

5.0 SUMMARY OF SEDIMENT ANALYSES

5.1 Sediment Analyses for the Recipient Beach and the Borrow Areas

Pre-project sediment samples were collected by CSE in June 2016 along the native beach during the project planning phase. Sediment characteristics were evaluated to confirm the sediment quality of the nourished beach would closely match the pre-nourishment beach. The mean grain size of all native beach sand samples (composite) before the renourishment project ranged from 0.140 mm to 2.393 mm, and averaged 0.288 mm. Shell content ranged from 0.2% to 13.2% and averaged only 1.7%. Out of 182 samples collected in June 2016, only 6 contained gravel content (greater than 2.0 mm grain size) higher than 10% by weight. The average gravel-size grain content was 1.6% for all samples. Dry-sieved fine-grained material (less than 0.0625 mm) represented a tiny fraction of one percent (0.025%) of the composite weight of all samples together. Individually, dry-sieved fine-grained content ranged from 0.0% to 0.7%. The percentage of sand-sized grains in individual samples ranged from 44.1% to 100%. On average, sand-sized grains (0.0625 to 2.0 mm) represented 99.9% of the volume of all samples by weight.

Borrow areas 3A and 4 were delineated based on the collection of 56 borings by CSE in July and October 2017. Borrow Area 3A is located within USACE borrow area "S1" (USACE 2000), which previous studies have indicated may contain up to 100 million cubic yards (cy) of beach-quality sediment to be used as the borrow source for a federal beach nourishment project. Approximately five (5) million cubic yards of material was excavated from Borrow Area 2 and Borrow Area 3 (within "S1") during the 2011 nourishment project (see Figure 1.2). Borrow Area 3A (approximately 2 miles offshore of South Nags Head) consists of the remainder of Borrow Area 3 and extends into Borrow Area 2 (see Figure 1.4). Borrow Area 4 is located ~1 mile offshore from North Nags Head (~5-6 miles north of Borrow Area 3A). Borrow Area 4 was added in 2019 to enable the dredger to reach northern Nags Head more easily, and potentially reduce operational costs. Core density in Borrow Area 3A was 1 boring per ~20 acres, and core density in Borrow Area 4 was 1 core per ~13 acres. The State of North Carolina requires that beach nourishment projects surpass 1 core per ~23 acres, in order to ensure adequate quality of dredged material.

Borings obtained by CSE in the borrow areas were designed to confirm sediment quality and the limit of the area of impact so that large areas would remain available for future use. Cores were logged and

analyzed for grain size, shell content, and mud content using sample splits at distinct changes in lithology. Core logs and photos can be found in Appendix C (Geotechnical Report) of the Environmental Assessment (CSE 2017a). The mean grain size for the offshore samples was 0.362 mm in Borrow Area 3A and 0.376 mm in Borrow Area 4, composited to an 8-foot cut depth. Coarse material, as well as carbonates (shell content) to 8 ft, were low across both borrow areas (averaging ~2.2% and ~2.7% respectively). Borrow Area 3A had a slightly higher quality of material, with ~2.5% less gravel and ~1.0% less shell content than Borrow Area 4.

Similarities of median grain sizes, shell content, and the percent gravel and fine-grained content by weight, suggested the nourishment sand would look and perform well once placed on the beach. The designed borrow areas met the North Carolina Coastal Resources Commission (NCCRC) sediment criteria, as well as CSE's internal criteria — to produce a stable project as economically and environmentally compatible as possible.

5.2 Sediment Analyses During Construction Phase

As discussed in Section 2 (construction management), CSE representatives collected a composite sand sample at a 500-ft spacing from the last station completed during their daily construction observations. A composite sample consists of a series of grab samples collected at ~10-ft spacing along a transect from the landward limit of fill to the low-tide line mixed together to form one representative sample for each given station. Some additional grab samples were collected in the vicinity of the discharge point for immediate checking purposes. These samples were analyzed to determine grain-size characteristics and shell content as a means of monitoring the quality of material placed on the beach. These results are summarized in Table 5.1. Grain-size distribution for selected individual sand samples is given in detail in Appendix C of this report.

Nourishment sand placed on the beach was found to be consistent with the borings obtained by CSE in 2017. It contained negligible mud, very little carbonates and shells, and a minor fraction of gravel-sized grains. The mean arithmetic grain size of all samples collected during construction was 0.373 mm (ranging from 0.235 mm to 0.523 mm), which is classified as medium sand (0.25 – 0.50 mm diameter). The nourishment sand is similar in texture to the native beach and is expected to provide similar performance as the native beach, with respect to annual erosion losses.

TABLE 5.1a. Summary of grab sand samples during Nags Head renourishment construction.

2458 Nags Head NC		Method of Moments						Folk Graphical Method				Shell	Gravel	Fine
		Mean	STD	Skew	Kurt	Mean	Std	Mean	STD	Skew	Kurt			
Sample	Interval	ϕ				mm		ϕ				%	%	%
500+00	COMP	1.22	1.21	-1.51	4.85	**0.429**	0.431	1.20	0.99	-0.52	1.57	1.2	7.8	0.0
505+00	COMP	1.32	0.98	-1.52	5.87	**0.401**	0.506	1.26	0.81	-0.40	1.25	1.5	3.8	0.0
510+00	COMP	1.03	1.16	-1.17	4.03	**0.491**	0.448	0.96	1.04	-0.43	1.17	2.3	7.5	0.0
515+00	COMP	1.10	1.05	-1.13	4.15	**0.465**	0.482	1.02	0.95	-0.40	1.13	2.1	5.2	0.0
520+00	COMP	1.14	1.26	-1.40	4.34	**0.454**	0.417	1.10	1.05	-0.55	1.57	2.0	9.2	0.0
525+00	COMP	1.42	0.88	-1.87	8.88	**0.373**	0.543	1.37	0.68	-0.35	1.27	1.4	2.2	0.0
530+00	COMP	0.93	1.15	-1.08	3.68	**0.523**	0.450	0.87	1.08	-0.43	1.11	1.7	8.5	0.0
535+00	COMP	1.04	1.01	-1.30	4.79	**0.488**	0.498	0.98	0.88	-0.40	1.17	1.2	5.2	0.0
540+00	COMP	1.43	0.87	-1.49	6.72	**0.371**	0.546	1.38	0.69	-0.29	1.26	1.7	2.3	0.0
545+00	COMP	1.42	0.78	-1.12	4.48	**0.373**	0.581	1.35	0.67	-0.31	1.25	1.6	1.5	0.0
550+00	COMP	1.52	0.99	-1.19	4.79	**0.350**	0.503	1.44	0.89	-0.37	1.13	2.5	2.4	0.0
555+00	COMP	1.22	0.88	-1.38	6.84	**0.429**	0.544	1.14	0.74	-0.15	1.00	2.8	2.6	0.0
560+00	COMP	1.57	0.90	-1.35	5.43	**0.337**	0.534	1.51	0.75	-0.37	1.37	2.0	2.0	0.0
565+00	COMP	0.94	1.42	-1.30	4.19	**0.520**	0.374	0.89	1.22	-0.53	1.42	3.1	12.0	0.0
570+00	COMP	1.51	0.78	-1.06	4.50	**0.352**	0.581	1.43	0.69	-0.34	1.20	2.1	1.2	0.0
575+00	COMP	1.60	0.83	-1.07	4.66	**0.329**	0.562	1.53	0.72	-0.32	1.25	2.0	1.5	0.1
580+00	COMP	1.44	0.82	-1.16	4.30	**0.368**	0.568	1.35	0.75	-0.39	1.21	2.9	1.8	0.0
585+00	COMP	1.52	1.08	-2.46	10.81	**0.349**	0.474	1.54	0.66	-0.39	1.66	2.0	4.1	0.0
590+00	COMP	1.62	0.73	-1.18	5.21	**0.325**	0.602	1.54	0.64	-0.33	1.21	3.4	0.9	0.0
595+00	COMP	1.55	0.87	-2.09	9.72	**0.342**	0.547	1.51	0.65	-0.40	1.42	1.9	2.0	0.0
600+00	COMP	1.35	1.15	-1.94	7.52	**0.393**	0.451	1.34	0.83	-0.48	1.53	4.1	5.1	0.0
605+00	COMP	1.41	0.86	-1.21	5.35	**0.376**	0.551	1.33	0.78	-0.33	1.05	1.9	1.6	0.0
610+00	COMP	1.54	0.82	-1.63	7.09	**0.345**	0.565	1.49	0.66	-0.37	1.35	1.5	1.7	0.0
615+00	COMP	1.56	0.70	-0.74	4.52	**0.340**	0.616	1.46	0.64	-0.19	1.12	1.2	0.5	0.0
620+00	COMP	1.47	0.85	-0.91	4.22	**0.362**	0.556	1.39	0.76	-0.32	1.13	1.8	1.9	0.1
625+00	COMP	1.63	0.82	-0.87	4.77	**0.323**	0.565	1.54	0.71	-0.30	1.24	2.4	1.3	0.2
630+00	COMP	1.24	1.31	-1.81	6.65	**0.423**	0.403	1.26	0.96	-0.48	1.57	3.5	7.1	0.1
635+00	COMP	1.03	1.22	-1.16	4.42	**0.490**	0.429	0.97	1.09	-0.39	1.12	4.9	7.2	0.0
640+00	COMP	1.20	1.17	-1.22	4.51	**0.435**	0.444	1.15	1.01	-0.43	1.27	1.4	6.1	0.1
645+00	COMP	1.05	1.52	-1.49	4.95	**0.482**	0.349	1.07	1.19	-0.53	1.64	5.1	10.3	0.2
650+00	COMP	1.11	1.23	-1.39	5.61	**0.462**	0.426	1.08	0.95	-0.39	1.43	4.6	6.6	0.2
655+00	COMP	1.43	0.69	-1.03	5.10	**0.371**	0.619	1.33	0.58	-0.21	1.16	1.0	1.0	0.0
660+00	COMP	1.35	0.69	-1.01	4.73	**0.392**	0.621	1.27	0.60	-0.23	1.10	1.9	1.0	0.0
665+00	COMP	1.47	0.99	-0.82	4.85	**0.360**	0.503	1.39	0.86	-0.24	1.14	3.9	2.1	0.4
670+00	COMP	1.26	1.21	-1.11	4.73	**0.419**	0.433	1.21	0.99	-0.31	1.36	3.6	6.0	0.4
675+00	COMP	1.70	0.88	-0.94	4.88	**0.307**	0.544	1.61	0.75	-0.29	1.18	4.1	1.9	0.4
680+00	COMP	1.50	1.09	-1.71	6.90	**0.354**	0.471	1.49	0.80	-0.39	1.34	3.2	4.2	0.2
685+00	COMP	1.44	0.72	-0.91	4.36	**0.370**	0.607	1.34	0.65	-0.21	1.09	1.4	0.8	0.0
690+00	COMP	1.40	0.71	-0.69	3.79	**0.378**	0.612	1.30	0.68	-0.17	0.99	1.4	0.6	0.0
695+00	COMP	1.42	0.69	-1.34	6.06	**0.374**	0.622	1.34	0.54	-0.27	1.21	1.2	1.4	0.0
700+00	COMP	1.81	0.47	-1.33	9.14	**0.285**	0.723	1.71	0.38	-0.12	1.27	1.3	0.1	0.0
705+00	COMP	1.67	0.54	-1.09	6.39	**0.313**	0.686	1.58	0.45	-0.20	1.25	1.0	0.2	0.0
710+00	COMP	1.58	0.64	-1.11	5.67	**0.335**	0.640	1.49	0.54	-0.24	1.26	1.1	0.6	0.0
715+00	COMP	1.75	0.49	-0.93	7.14	**0.297**	0.713	1.65	0.41	-0.09	1.29	1.6	0.1	0.0
720+00	COMP	1.72	0.65	-1.20	6.15	**0.304**	0.638	1.63	0.53	-0.20	1.33	1.1	0.6	0.0
725+00	COMP	1.67	0.56	-1.06	7.05	**0.315**	0.678	1.57	0.47	-0.12	1.18	1.0	0.5	0.0
730+00	COMP	1.60	0.56	-0.57	4.33	**0.330**	0.680	1.48	0.50	-0.15	1.18	1.4	0.0	0.0
735+00	COMP	1.39	0.59	-0.71	3.86	**0.382**	0.665	1.28	0.56	-0.20	1.02	0.8	0.1	0.0
740+00	COMP	1.60	0.47	-0.54	4.22	**0.329**	0.723	1.48	0.43	-0.19	1.04	0.7	0.0	0.0
745+00	COMP	1.58	0.55	-0.97	5.51	**0.334**	0.684	1.48	0.48	-0.19	1.12	0.9	0.2	0.0
750+00	COMP	1.57	0.59	-0.92	5.36	**0.337**	0.665	1.47	0.52	-0.19	1.13	2.7	0.4	0.0

TABLE 5.1b. Summary of grab sand samples during Nags Head renourishment construction.

2458 Nags Head NC		Method of Moments						Folk Graphical Method				Shell	Gravel	Fine
		Mean	STD	Skew	Kurt	Mean	Std	Mean	STD	Skew	Kurt			
Sample	Interval	ϕ				mm		ϕ				%	%	%
755+00	COMP	1.58	0.63	-0.94	6.22	**0.334**	0.645	1.49	0.54	0.04	1.12	1.6	0.8	0.0
760+00	COMP	1.46	0.59	-0.71	4.61	**0.364**	0.666	1.34	0.55	-0.10	1.10	1.6	0.3	0.0
765+00	COMP	1.44	0.65	-0.92	4.66	**0.368**	0.639	1.33	0.58	-0.22	1.05	2.0	0.6	0.0
770+00	COMP	1.60	0.61	-1.01	5.93	**0.329**	0.653	1.50	0.52	-0.20	1.23	1.0	0.5	0.0
775+00	COMP	1.64	0.65	-1.02	5.47	**0.321**	0.638	1.55	0.55	-0.27	1.24	1.8	0.4	0.1
780+00	COMP	1.58	0.67	-0.96	4.80	**0.334**	0.627	1.49	0.59	-0.17	1.04	1.7	0.5	0.0
785+00	COMP	1.53	0.61	-1.03	5.43	**0.347**	0.653	1.43	0.52	-0.22	1.18	1.4	0.4	0.0
790+00	COMP	1.33	0.99	-2.64	12.79	**0.399**	0.505	1.31	0.62	-0.31	1.22	2.7	3.0	0.0
795+00	COMP	1.52	0.65	-1.11	5.36	**0.348**	0.638	1.43	0.56	-0.26	1.17	1.7	0.6	0.0
800+00	COMP	1.50	0.65	-0.96	4.84	**0.354**	0.637	1.40	0.59	-0.23	1.07	1.4	0.5	0.0
805+00	COMP	1.55	0.62	-0.83	4.40	**0.342**	0.650	1.45	0.59	-0.22	1.07	1.3	0.3	0.0
810+00	COMP	1.45	0.71	-1.07	5.17	**0.366**	0.611	1.36	0.60	-0.27	1.15	1.2	1.1	0.1
815+00	COMP	1.33	0.73	-0.91	4.32	**0.397**	0.603	1.24	0.65	-0.23	1.07	2.1	1.1	0.0
820+00	COMP	1.26	0.81	-0.86	3.92	**0.416**	0.572	1.17	0.74	-0.25	1.09	1.5	1.9	0.0
825+00	COMP	1.29	1.02	-2.10	9.54	**0.409**	0.494	1.26	0.72	-0.31	1.28	1.3	3.6	0.0
830+00	COMP	1.60	0.59	-0.82	4.97	**0.329**	0.664	1.50	0.55	-0.18	1.08	1.3	0.3	0.0
835+00	COMP	1.48	0.68	-1.01	4.46	**0.359**	0.623	1.39	0.61	-0.26	1.17	1.5	0.4	0.0
840+00	COMP	1.49	0.65	-0.89	4.67	**0.356**	0.638	1.39	0.59	-0.20	1.09	0.9	0.5	0.0
845+00	COMP	1.38	0.76	-0.92	4.22	**0.383**	0.592	1.29	0.67	-0.25	1.10	1.5	1.1	0.0
850+00	COMP	1.43	0.67	-0.91	4.46	**0.371**	0.630	1.33	0.59	-0.22	1.08	1.1	0.5	0.0
855+00	COMP	1.22	0.92	-1.45	6.49	**0.431**	0.529	1.15	0.77	-0.28	1.12	1.6	2.8	0.0
860+00	COMP	1.34	0.75	-0.97	4.37	**0.395**	0.593	1.25	0.66	-0.26	1.12	1.8	1.3	0.0
865+00	COMP	1.42	0.92	-1.78	8.39	**0.374**	0.528	1.38	0.70	-0.29	1.24	1.3	2.4	0.0
870+00	COMP	1.52	0.72	-0.96	5.10	**0.348**	0.606	1.43	0.62	-0.23	1.19	2.3	1.0	0.0
875+00	COMP	1.70	0.51	-0.44	4.68	**0.308**	0.701	1.59	0.47	-0.13	1.12	1.3	0.1	0.0
880+00	COMP	1.32	0.73	-0.89	4.27	**0.401**	0.604	1.22	0.66	-0.20	1.04	1.9	1.2	0.0
885+00	COMP	1.66	0.60	-1.45	7.43	**0.316**	0.661	1.59	0.44	-0.24	1.48	1.2	0.5	0.0
890+00	COMP	1.42	0.92	-1.86	8.65	**0.373**	0.530	1.38	0.68	-0.32	1.32	1.3	2.6	0.0
895+00	COMP	1.38	0.87	-1.98	9.18	**0.383**	0.548	1.33	0.63	-0.36	1.27	1.2	2.4	0.0
900+00	COMP	1.38	0.72	-0.98	4.59	**0.384**	0.606	1.29	0.62	-0.22	1.09	1.1	1.1	0.0
905+00	COMP	1.60	0.72	-1.18	5.54	**0.330**	0.607	1.53	0.61	-0.27	1.27	1.9	1.2	0.0
910+00	COMP	1.49	0.80	-0.79	4.26	**0.355**	0.575	1.41	0.71	-0.17	1.16	2.6	1.4	0.0
915+00	COMP	2.09	0.65	-0.59	3.99	**0.235**	0.636	1.99	0.61	-0.04	1.10	1.4	0.0	0.0
920+00	COMP	1.62	0.66	-1.27	6.01	**0.325**	0.633	1.54	0.55	-0.32	1.28	1.5	0.6	0.0
925+00	COMP	1.46	0.79	-1.89	10.02	**0.363**	0.579	1.39	0.61	-0.31	1.21	1.0	1.4	0.0
930+00	COMP	1.55	0.65	-1.05	5.54	**0.341**	0.635	1.46	0.55	-0.25	1.24	1.5	0.6	0.0
935+00	COMP	1.41	0.77	-1.09	4.71	**0.377**	0.588	1.32	0.65	-0.27	1.15	3.3	1.7	0.0
940+00	COMP	1.34	0.85	-1.46	6.64	**0.395**	0.557	1.26	0.69	-0.28	1.12	1.6	2.1	0.0
945+00	COMP	1.37	1.16	-1.71	6.18	**0.387**	0.448	1.36	0.85	-0.42	1.52	1.8	5.7	0.0
950+00	COMP	1.55	0.73	-1.15	5.35	**0.342**	0.605	1.47	0.59	-0.26	1.40	2.0	1.1	0.0
955+00	COMP	1.50	0.65	-1.05	5.00	**0.353**	0.636	1.40	0.57	-0.26	1.13	0.9	0.5	0.0
960+00	COMP	1.29	0.81	-1.46	6.61	**0.409**	0.572	1.22	0.66	-0.23	1.08	1.6	2.0	0.0
965+00	COMP	1.24	0.86	-1.38	5.75	**0.422**	0.550	1.17	0.72	-0.30	1.17	2.9	2.9	0.0
970+00	COMP	1.46	0.67	-0.98	4.66	**0.363**	0.629	1.36	0.60	-0.22	1.09	1.3	0.6	0.0
975+00	COMP	1.14	0.82	-0.89	3.90	**0.453**	0.568	1.06	0.75	-0.28	1.18	1.8	2.7	0.0
980+00	COMP	1.21	0.72	-0.78	4.36	**0.433**	0.608	1.12	0.65	-0.17	1.07	1.2	1.4	0.0
985+00	COMP	1.08	0.88	-1.21	5.08	**0.473**	0.543	1.02	0.78	-0.27	1.12	2.0	3.2	0.0
990+00	COMP	1.16	0.84	-1.46	6.82	**0.449**	0.558	1.09	0.71	-0.24	1.11	2.6	2.3	0.0
995+00	COMP	1.19	0.88	-1.45	6.35	**0.438**	0.543	1.12	0.73	-0.29	1.16	2.1	2.7	0.0
1000+00	COMP	1.29	0.71	-1.03	4.69	**0.409**	0.612	1.21	0.61	-0.21	1.08	1.9	1.4	0.0
1005+00	COMP	1.29	0.77	-0.91	4.03	**0.408**	0.585	1.19	0.70	-0.25	1.09	1.5	1.5	0.0

TABLE 5.1c. Summary of grab sand samples during Nags Head renourishment construction.

2458 Nags Head NC		Method of Moments						Folk Graphical Method				Shell	Gravel	Fine
		Mean	STD	Skew	Kurt	Mean	Std	Mean	STD	Skew	Kurt			
Sample	Interval	ϕ				mm		ϕ				%	%	%
1010+00	COMP	1.42	0.72	-1.14	4.88	**0.374**	0.605	1.33	0.62	-0.27	1.13	1.7	1.3	0.0
1015+00	COMP	1.29	0.78	-0.76	3.70	**0.410**	0.581	1.17	0.72	-0.14	0.99	2.0	1.4	0.0
1020+00	COMP	1.54	0.52	-0.46	3.75	**0.345**	0.695	1.41	0.49	-0.17	1.03	2.0	0.0	0.0
1025+00	COMP	1.40	0.71	-1.20	5.16	**0.379**	0.613	1.31	0.59	-0.28	1.16	1.6	1.3	0.0
Reach 1	COMP	1.43	0.92	-1.73	7.98	**0.372**	0.529	1.38	0.70	-0.32	1.30	2.4	2.7	0.0
Reach 2	COMP	1.48	0.76	-1.33	7.09	**0.359**	0.590	1.40	0.64	-0.24	1.17	1.6	1.2	0.0
Reach 3N	COMP	1.39	0.82	-1.48	6.88	**0.381**	0.568	1.33	0.65	-0.28	1.19	1.8	2.0	0.0
Reach 3S	COMP	1.23	0.80	-1.22	5.66	**0.425**	0.575	1.15	0.69	-0.25	1.09	1.8	2.0	0.0
Reach 4	COMP	1.41	0.68	-1.02	4.83	**0.375**	0.623	1.31	0.59	-0.19	1.07	1.9	0.9	0.0
Post-Project	COMP	1.42	0.86	-1.62	7.78	**0.373**	0.551	1.37	0.67	-0.29	1.24	2.1	2.2	0.0
Pre-Project	Visible Beach	1.32	0.89	-0.81	3.97	**0.402**	0.538	1.25	0.90	-0.21	1.01	1.8	1.6	0.0
Pre Project	All Beach COMP	1.80	1.00	-1.06	4.44	**0.288**	0.500	1.70	0.93	-0.30	1.04	1.7	1.6	0.0

6.0 ENDANGERED SPECIES PROTECTION MEASURES & SUMMARY

6.1 Environmental Protection Measures on Hopper Dredges

One of the principal planning objectives for the Nags Head beach renourishment project was the preservation of the environmental resources in the project area, especially threatened or endangered species (including sea turtles, sturgeons, and whales). Since construction activities were performed during the peak of the sea turtle nesting season, dredging and placement operations were subject to certain environmental protection measures as detailed in federal and state permits (discussed in Section 1.4 of this report). Protection measures included open-net trawling for turtles ahead of the dredges during designated periods, use of deflectors and specific equipment modification onboard hopper dredges, specific operations requirements and use of the Dredging Quality Management (DQM) system, and the use of certified endangered species monitors onboard dredges.

Coastwise Consulting (Athens GA) was GLDD's subcontractor for endangered species monitoring and trawling. GLDD and its subcontractor maintained a quality control system that addressed environmental protection for all items set forth in the specifications (as discussed in the following sections).

6.1.1 Hopper Dredge Operations

Before dredging operations commenced, GLDD submitted detailed Turtle Exclusion Device (TED) drawings showing the proposed rigid sea turtle deflector device, the proposed drag head grating systems and drag heads, and documentation that supports grate sizing such as the dredge pump manufacturer's recommended maximum particle size dimensions, etc. All hopper dredges used in this project were equipped with a certified and functioning Dredge Quality Management (DQM) system. This arrangement was previously titled Silent Inspector (SI) and is a system that monitors and records a myriad of positioning, depth, and production data, and transmits the information to the DQM Support Center. These operational procedures were intended to stress the importance of balancing the suction pipe densities and velocities to prevent sea turtle takes.

A pre-dredging inspection of the endangered species equipment was performed by USACE–Wilmington District inspectors in accordance with the protocol Sea Turtle Compliance Inspection checklist. Table 6.1 lists the summary of such inspections for each hopper dredge. GLDD maintained the USACE-approved equipment (including sea turtle deflectors, in-flow basket screening, and drag head grating)

in operational condition to minimize the possibility of incidental sea turtle takes during the project, and adhered to the protocols and requirements contained in the Regional Biological Opinions (USFWS 2017) and the state and federal permits.

TABLE 6.1. Endangered species equipment inspection summary.

Dredge Name	Inspection Date	USACE Inspector	CSE Staff	Inspection Comments	GLDD Actions
Ellis Island	1 May 2019	Josh Pelletier	Drew Giles	The paint test on the STBD dragarm was successful, but the port side dragarm lower inclinometer sensor was clogged and a paint test on that dragarm could not be conducted.	Repairs to the port side dragarm were completed within 24 hours and a paint test was conducted with satisfactory results.
Liberty Island	29 May 2019	Josh Pelletier	Steven Traynum	All tests were successful.	Not needed

6.1.2 Endangered Species Observers

During dredging operations, observers approved by the NMFS were required to provide 24 hours per day, year-round coverage onboard all the hopper dredges to monitor for the presence of endangered species including sea turtles, sturgeon, and whales.

During dredging operations, the observers monitored the inflow boxes for the presence of any threatened or endangered species. After each dredge load, the observer inspected the drag heads to ensure that no turtles were caught in the head itself. Inflow boxes and screens were then inspected for any endangered species. Any abiotic and biotic debris caught in the screens were documented and removed so the screens were clear for the next load. A camera was used by the observers should they need to document a take event. Reports of all findings and observations were completed for each day in addition to a weekly summary. Completed load, daily, and weekly reports were included in GLDD's daily quality control report packages and submitted to the Owner (Nags Head) and the Project Engineer (CSE) as well as to resource agencies including the USACE Regulatory Project Manager and representatives from the USFWS, NCDCM, and NCWRC.

Overall, observers confirmed that the material dredged from borrow areas was clean, medium-coarse sand with few shell fragments. All inflow screening was in good condition and highly effective. Sample screen contents included plastic debris, metal debris, wire debris, rubber debris, fishing line, rock, rope or netting, wood debris, shell, clear-nose skate, horseshoe crab, blue crab, spider crab, clam, angel shark, cow-nose ray, butterfly ray, stingray, shrimp, miscellaneous fish, etc.

Sea Turtle Incident on 10 August 2019

A juvenile green turtle (*Chelonia mydas*) was observed at 3:20 pm in the inflow box on the dredge *Liberty Island*. The turtle was retrieved alive but injured. Scuff marks were found on its head, and a 4-centimeter nuchal notch crack was bleeding. Other superficial scuff marks were found on its plastron and carapace (Figure 6.1).

The protocols established in the USACE permit for Turtle Takes by Hopper Dredge (Special Conditions #62) were immediately followed, and the dredge *Liberty Island* ceased operations and was on standby. CSE Project Engineer, the NC Wildlife Resources Committee (NCWRC), and the USACE project manager (c/o Josh Pelleier) were immediately notified. GLDD along with the onboard Endangered Species Obsevers (ESOs) made arrangements to send the turtle ashore in a timely manner to be acquired by the North Carolina Fish & Wildlife Commission. The turtle was measured, weighed, and transported to the Star Rehabilitation Center (Center) at the NC Aquarium on Roanoke Island that afternoon.

The USACE project manager instructed GLDD to have all turtle protection measures checked thoroughly by the onboard ESO before operations could resume. It was confirmed by GLDD and the onboard ESO that all screening and Turtle Exclusion Devices (TED) were in proper working condition and everything appeared to be in compliance with the permit conditions. Dredging operations were resumed around 6:30 pm that evening.

The injured turtle started rehabilitation procedures after it arrived at the Center. Unfortunately, the turtle did not survive, and passed away on 14 August 2019.

GLDD was consequently required by the USACE to use the online Operations and Dredging Endangered Species System (ODESS) for the last few days of dredging operations until construction completion.

There were no other environmental incidents during the 110 days of dredging operations.

FIGURE 6.1. Photos of the injured green turtle captured on 10 August 2019. [Source: Endangered Species Observer Program – Sea Turtle Incidental Take Data Form dated 10 August 2019]

6.2 Non-Capture Trawling for Hopper Dredges

To minimize or reduce incidental takes of turtles during hopper dredging operations, non-capture sweep trawling was required and utilized in this project. This type of trawling is designed to sweep a trawl in the proximity of the dredging operations and to stimulate any sea turtles present to move out of the dredge path. The open trawl is intended to allow sea turtles to pass through the net without capture.

In compliance with the permits, GLDD and its subcontractor conducted non-capture trawl sweeping 48 hours prior to initiating dredging and continued throughout hopper-dredging operations. Trawlers conducted non-capture trawl sweeping operations in the vicinity of dredge operations but maintained a safe distance from the dredge(s). Each trawler was equipped with two 60-ft, flat-style trawling nets with the bag or cod end of the nets removed to create a completely open net. Additionally, lead lines across the mouth of the trawls were rigged to ensure they maintained contact with the sediment bottom.

In accordance with the permits, one operating trawler was working per hopper dredge during dredging operations; however, trawling was not required during periods when a hopper dredge was not dredging (due to weather or mechanical delays). When both *Ellis Island* and *Liberty Island* were on site, they were digging in different borrow areas. Therefore, a trawler was designated for each dredge so that adequate protection was provided during all digging operations.

Two trawling boats were used for the project, *Reva Rose* (Figure 6.2) and *Jessica Marie* (Figure 6.3). A summary of trawler operations is listed in Table 6.2. A daily log was kept for all non-capture trawl sweeping operations and is included in Appendix A7 of this report. Data recorded in this daily log included GIS times and coordinates of trawl locations of the first sweep and the last sweep of each day, general notes as appropriate (such as condition of equipment, snags occurring during each sweep, incidental debris), and water quality and physical measurements (such as water temperature, air temperature, wind speed and direction, tidal information, sea state, precipitation, etc).

FIGURE 6.2. Trawling Vessel *Reva Rose* used during the 2019 Nags Head Renourishment project.

FIGURE 6.3. Trawling Vessel *Jessica Mari*e used during the 2019 Nags Head Renourishment project.

TABLE 6.2. Summary of trawler operations.

Trawler Name	Dredge Name	Borrow Area	Duration	Trawler Incidents
Reva Rose	*Ellis Island*	3A	27 April 2019 to 16 June 2019	NO
Jessica Marie	*Liberty Island*	4	20 May 2019 to 16 June 2019	NO
Reva Rose	*Liberty Island*	3A or 4	17 June 2019 to 18 August 2019	NO

The trawler *Reva Rose* began operations in offshore Borrow Area 3A at Nags Head at 12:20 am on the morning of 27 April 2019, more than 48 hours before *Ellis Island* started dredging on 1 May in Borrow Area 3A. The trawler *Jessica Marie* began operations in Borrow Area 4 at 2:53 pm on 20 May 2019, more than seven days before *Liberty Island* started dredging on 28 May. A sweep is one single unidirectional pass, and a tow is completed each time the nets are actually hauled back and inspected. A tow is comprised of several sweeps. Per USACE requirements, trawling in the vicinity of the dredge shall be conducted continuously, stopping after every 4 to 6 hours to check the condition of the trawl equipment and ensure that no turtles are captured. The trawler would alert GLDD to the exact locations of any bottom obstructions that were encountered.

Overall, non-capture trawling at borrow areas was highly effective. A few clear-nose skates, cow-nose rays, and crabs were caught and released alive. A humpback whale was sighted ~200 yards in Borrow Area 3A southeast of the dredge *Liberty Island* on 14 July 2019 from 9:15 am to 10:15 am and NOAA and the dredge *Liberty Island* were notified immediately.

The first sea turtle sighted by *Reva Rose* was on 1 May 2019 around 2:00 am in the water column of Borrow Area 3A. There was another turtle sighted on the same day around 10:20 am in the same borrow area. There were 14 individual observations of sea turtles in the water column by endangered species observers onboard the trawler *Reva Rose*, 9 in Borrow Area 3A and 5 in Borrow Area 4. Daily maximum individual turtle observations occurred on 24 June 2019 by *Reva Rose* in Borrow Area 4, and a total of 5 turtles were spotted that day. No sea turtle observations were documented by the trawler *Jessica Marie*.

No sea turtles were collected in any sweeps.

6.3 Sea Turtle Monitoring on the Beach

The project was conducted within the sea turtle nesting moratorium, which extends from 1 May through 15 November. To avoid impacts to sea turtle nesting, nest incubation, and/or hatchlings on the beach, detailed monitoring requirements were developed in coordination with NCWRC, USFWS, and USACE. The scope of work for the sea turtle monitoring services reflected requirements in the NCDCM Consistency Determination and the USFWS Biological Opinion (USFWS 2017). The Request for Proposals (RFP) issued by the Town of Nags Head for the nighttime sea turtle monitoring can be found in Appendix A8. A summary of the monitoring work during the project is as follows.

1) Nighttime Monitoring:

At least two sea turtle monitors were present at the project site on a continuous basis from dusk to dawn to monitor sea turtle activity for the period coinciding with any construction activities on the beach and ending upon completion of all construction activities (ie – until all construction equipment or pipeline was removed from the beach). One monitor provided continuous monitoring between safety fences at the actual discharge site and the other conducted four monitoring sessions during the night along the pipeline route. In cases where more than one discharge site was active, there was a team of monitors dedicated to each construction area.

a) One or two sea turtle monitors were provided for each section of the "Non-Active Construction Area" (ie – pipeline route) for 10 hours per night as required by the USACE. Monitors patrolled (on foot) the pipeline route four times per night looking for injured/stranded sea turtles, nesting sea turtles, signs of crawls, and hatchlings on either side of the pipeline. Patrols took place approximately between 9:30 pm and 10:30 pm, 12:30 am and 1:30 am, 3:30 am and 4:30 am, and close to dawn. Turtle activities were documented including latitude and longitude of event and appropriate contacts with NCWRC and Network for Endangered Sea Turtles (NEST) representatives.

b) During pipeline patrols, monitors observed the "Active Construction Area" from outside the safety fence. As necessary, (if there were indications of activity) one monitor would be scheduled to continuously monitor the "Active" area from outside the safety fence or go inside the fence by escort for safety. There was **no** sea turtle activity observed around

the active construction area or along the pipeline route during the project. If there had been, the foreman of GLDD would have been notified and instructed to stop work per the special conditions of the permits.

c) Monitors accompanied vehicles operating along the beach at night and watched for signs of turtle activity ahead of the vehicle. If turtle activity was discovered, the vehicle would stop or reverse direction until the activity ceased and the monitor cleared the forward progress of the vehicle. The monitoring of vehicle operation was coordinated with the GLDD crew foreman with the aid of two-way radios.

d) Monitoring hours were determined by the dusk and dawn times for Nags Head (NC). Between 1 May and 18 August 2019, the dusk and dawn times were 8:00 pm to 6:00 am every day.

2) Morning Monitoring:

a) Daily morning monitoring was conducted by NEST personnel beginning at sunrise. Signs of sea turtle activity were documented (including latitude and longitude of the event). Appropriate NCWRC and NEST representatives were contacted if any activity was discovered.

b) Morning patrols used all-terrain vehicles (ATVs) and were coordinated to arrive just after the nighttime patrols had completed their shift.

c) Observations made by the morning patrols were reported as part of the overall monitoring.

A daily quality control report was prepared for each day that activities were conducted. Specific encounters with strandings, false crawls, nesting sea turtles, incubating nests, and/or hatchlings (along with the actions taken) were recorded in the daily status reports (Appendix A8).

6.3.1 Turtle Nesting During Construction

Turtle nesting was more active than normal for Nags Head in 2019. There were a total of eight (8) nests laid within the project area. All nests were first found by NEST staff during their morning ATV patrols outside of the active work areas, and all of them were loggerhead sea turtle nests. Nests were laid outside the active work areas and pipeline corridors at various times between 21 May and 14 July. Each nest was relocated outside of the 10-mile project area by NEST personnel and was carefully monitored. As is customary for research purposes whenever a nest is relocated, one egg was removed from the nest for DNA study later in NEST's lab.

A map of nest locations is shown in Figure 6.4, and details of the eight (8) nests within the project area are listed in Table 6.3.

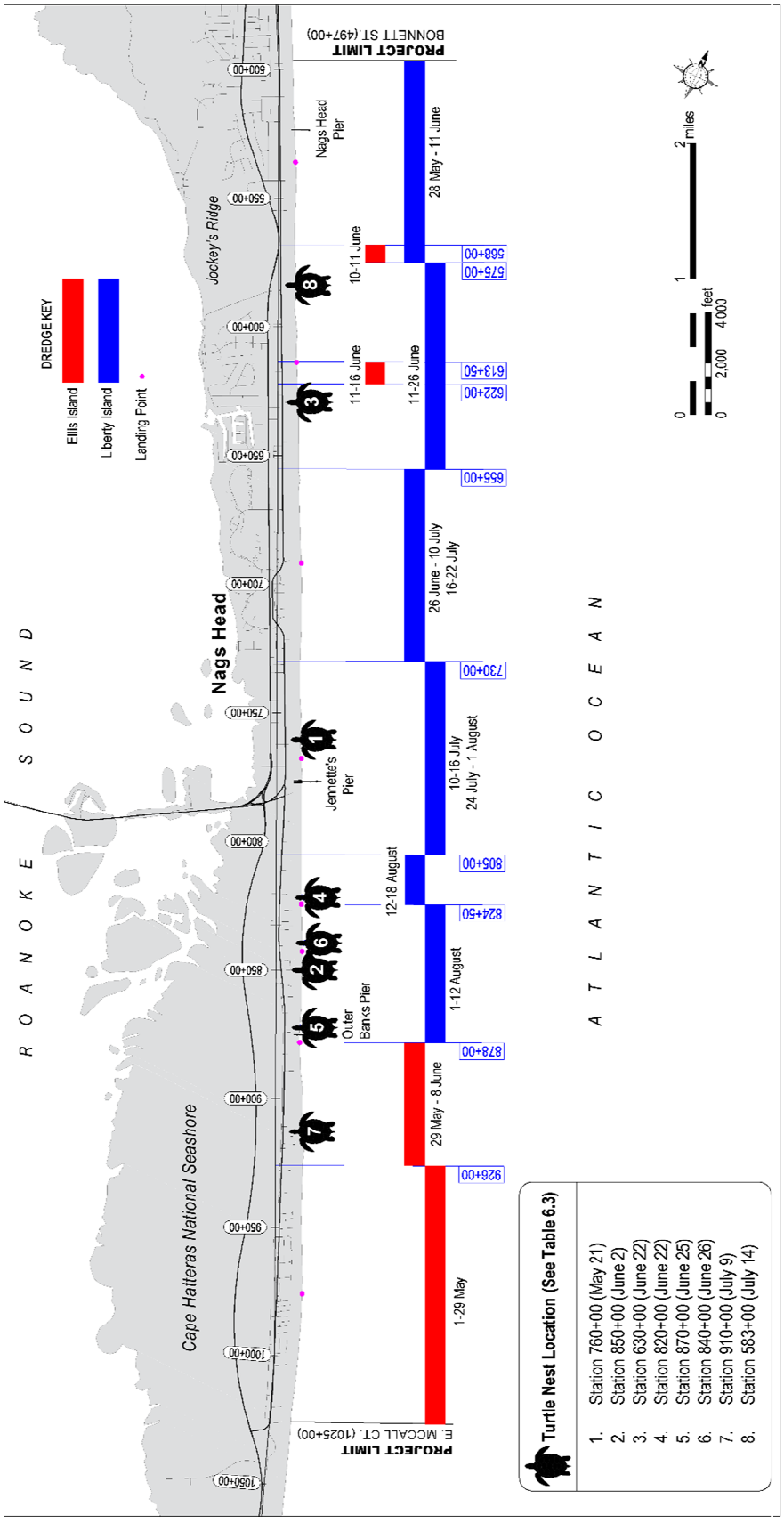


FIGURE 6.4. Locations of the eight sea turtle nests found during the 2019 Nags Head renourishment project. No nests were found in active construction zones.

TABLE 6.3. Sea turtle nests observed at the Nags Head project area in 2019 during construction.

Date	Coordinates Lat. – Long.	Street Name	CSE Station	Nest Type	Egg Number
May 21	35.91427N -75.59842W	Gull Street	760+00	Loggerhead	120
June 2	35.96811N -75.62890W	Hollowell Street	850+00	Loggerhead	104
June 22	35.9516N –75.6193W	Small Street	630+00	Loggerhead	98
June 22	35.8999N –75.59058W	Hargrove Street	820+00	Loggerhead	98
June 25	35.99948N –75.58444W	North of Outer Banks Fishing Pier	870+00	Loggerhead	104
June 26	35.89404N –75.58722W	Harvest Street	840+00	Loggerhead	106
July 9		June Street	910+00		
July 14	35.957694N –75.624694W	Soundside Road	583+00	Loggerhead	138

6.3.2 Turtle Events

There was one non-dredging-related turtle incident on the beach during the time of construction. It occurred on 13 May 2019. A 119 lb loggerhead turtle stranded near Jennette's Pier (Station 777+00) in the morning of that day. It had an amputated right front flipper, but the injury appeared to be old and had already healed. It was taken to the Star Rehabilitation Center at the NC Aquarium for treatment and rehabilitation. Per NCWRC (c/o Matthew Godfrey), it was unlikely the injury was due to interaction with a dredge based on blood values and the damage to the flipper was old enough to not be associated with the dredging activity at Nags Head.

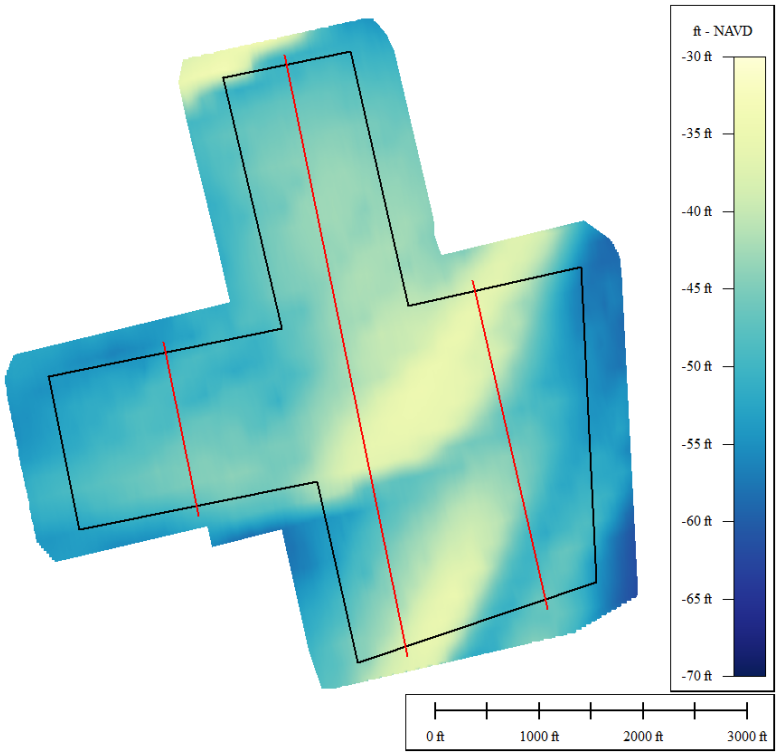
According to the NEST observers on the scene and the turtle-monitoring coordinator, such strandings are common and occur nearly every summer along Dare County beaches. For example, seven (7) strandings were found in 2009, three (3) dead sea turtle strandings occurred in Nags Head in 2010, and two (2) were reported in 2011 during the first beach nourishment project.

7.0 SUMMARY OF BORROW AREA DREDGING IMPACT

The 2019 Nags Head beach renourishment project was completed between 1 May and 18 August 2019. Confirmed by CSE's before-dredging (BD) and after-dredging (AD) surveys in the borrow areas, a total of ~3,900,000 cubic yards of material was excavated from the two USACE-approved offshore borrow areas known as Borrow Area 3A and Borrow Area 4 (locations are shown in Fig 1.4). Before-dredging bathymetry data were collected on 11 April 2019 before construction commenced, and after-dredging bathymetry data were collected on 20 August 2019 after construction was completed.

The two plots in Figure 7.1 are color-coded digital terrain models (DTM) showing the before-dredging and after-dredging bathymetric conditions for Borrow Area 3A, and the two plots in Figure 7.2 for Borrow Area 4. Figures 7.3 and 7.4 include representative cross-sections through each borrow area, highlighting the excavation. Approximately 2,989,000 cy of material (out of the ~4,380,000 cy available volume) was removed from Borrow Area 3A, and approximately 910,900 cy of material (out of the ~1,400,000 cy available volume) was removed from Borrow Area 4.

Because construction took place over a 110-day period and the borrow areas have been subject to some degrees of wave action, the margins of the borrow areas show some evidence of sloughing into the excavation basins. Both borrow areas were excavated via hopper dredges, therefore, ridges and variable depths were left on the bottom of the seafloor as shown in bottom plots of Figures 7.1 and 7.2. This type of excavation tends to leave some relatively undisturbed areas within the active borrow area from which recruitment of organisms can occur. Detailed biological monitoring after the 2011 nourishment project (CZR/CSE 2013) documented relatively rapid biological recovery of Areas 2 and 3. The irregular topography of borrow areas 3A and 4 is expected to even out under high waves during storms. Post-project surveys are expected to be scheduled each year to document infilling and physical recovery of each borrow area. Note: Vertical exaggeration in Figures 7.3 and 7.4 is approximately 70:1.



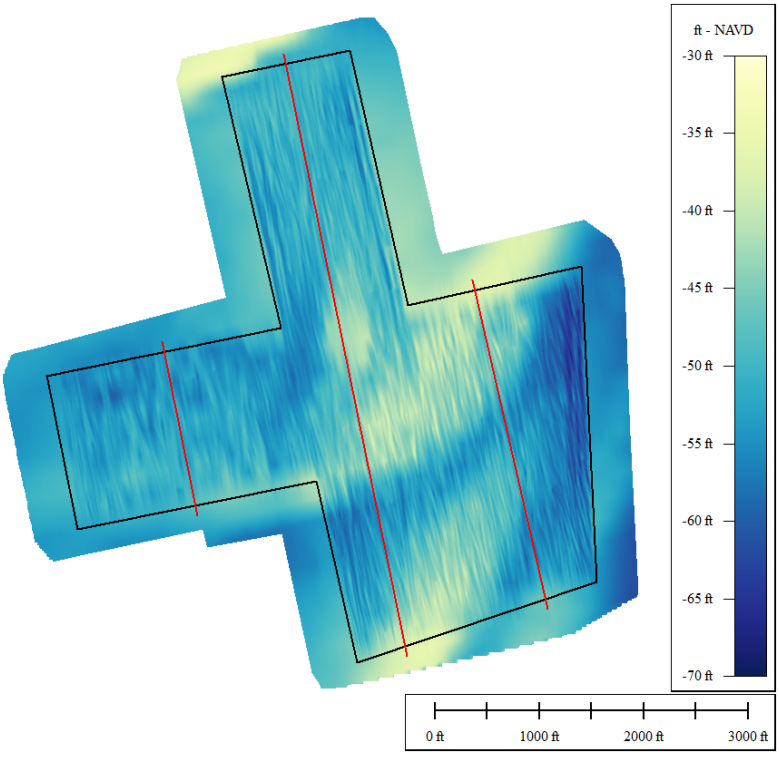
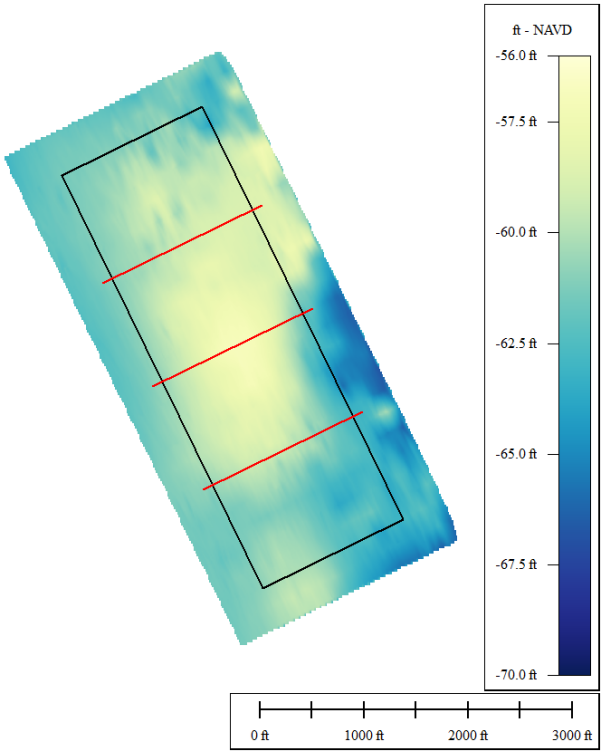


FIGURE 7.1. Color-coded bathymetric condition for Borrow Area 3A. **[UPPER]** Before-dredging condition. Data were collected by CSE on 11 April 2019 before construction began. **[LOWER]** After-dredging condition. Data were collected by CSE on 20 August 2019 after construction was completed.



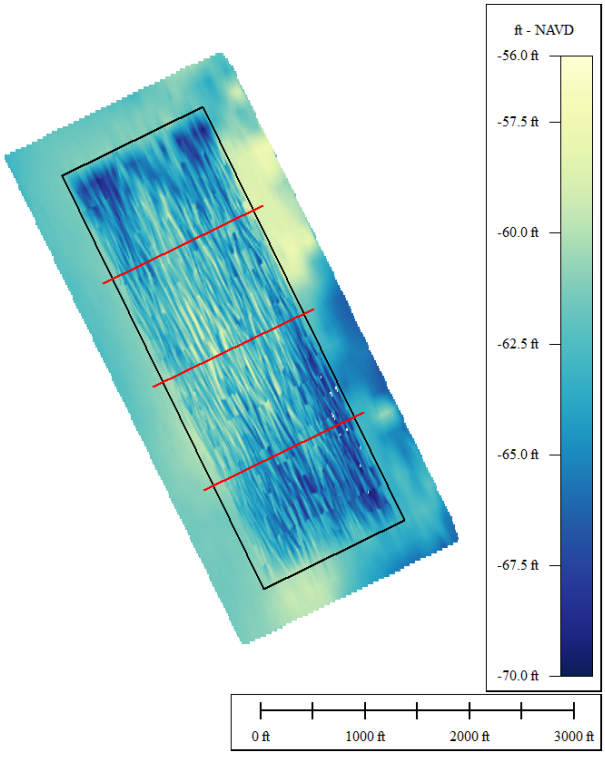


FIGURE 7.2. Color-coded bathymetric condition for Borrow Area 4. **[UPPER]** Before-dredging condition. Data were collected by CSE on 11 April 2019 before construction began. **[LOWER]** After-dredging condition. Data were collected by CSE on 20 August 2019 after construction was completed.

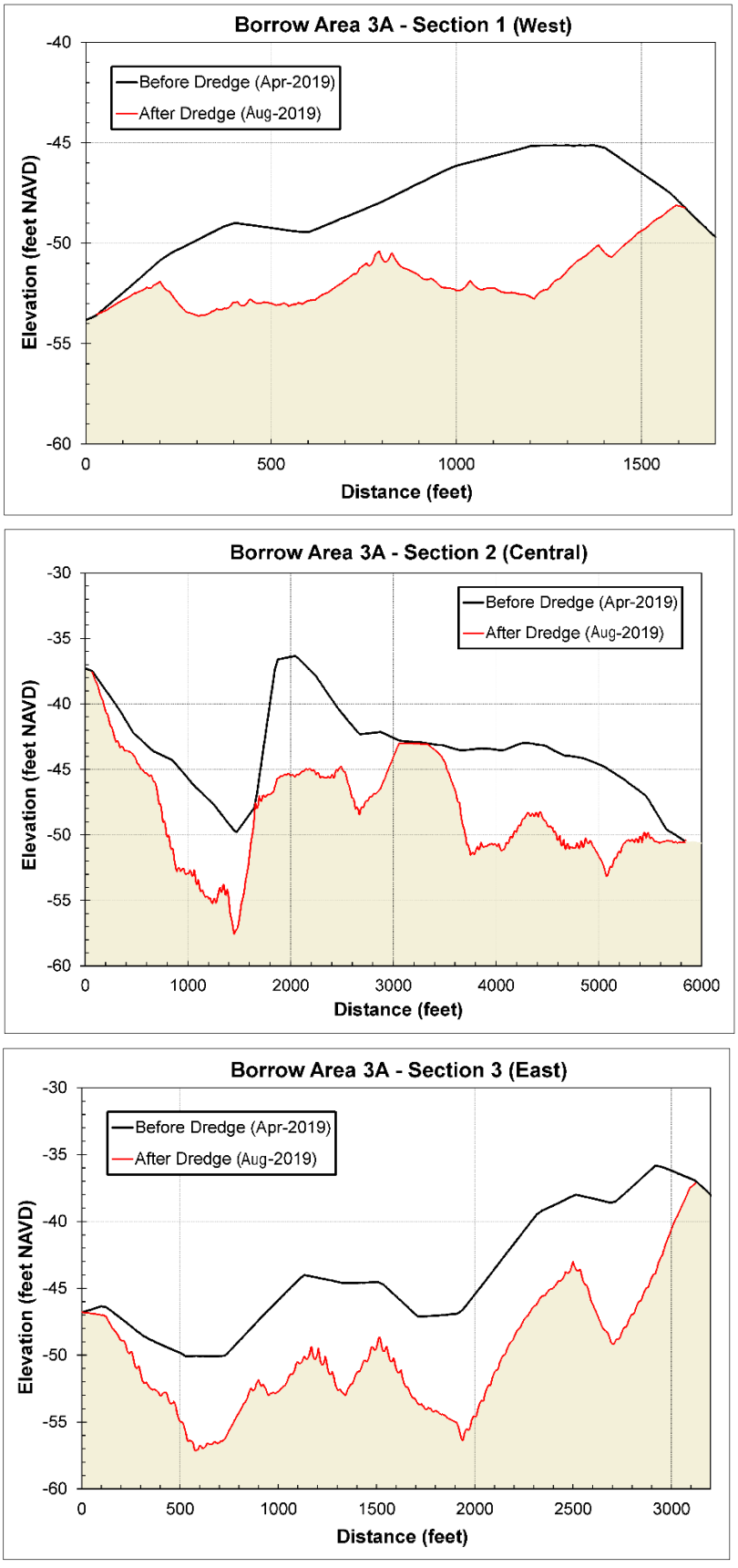


FIGURE 7.3. Representative cross-sections through Borrow Area 3A highlighting excavation during construction. Locations of these cross-sections are marked in Figure 7.1.

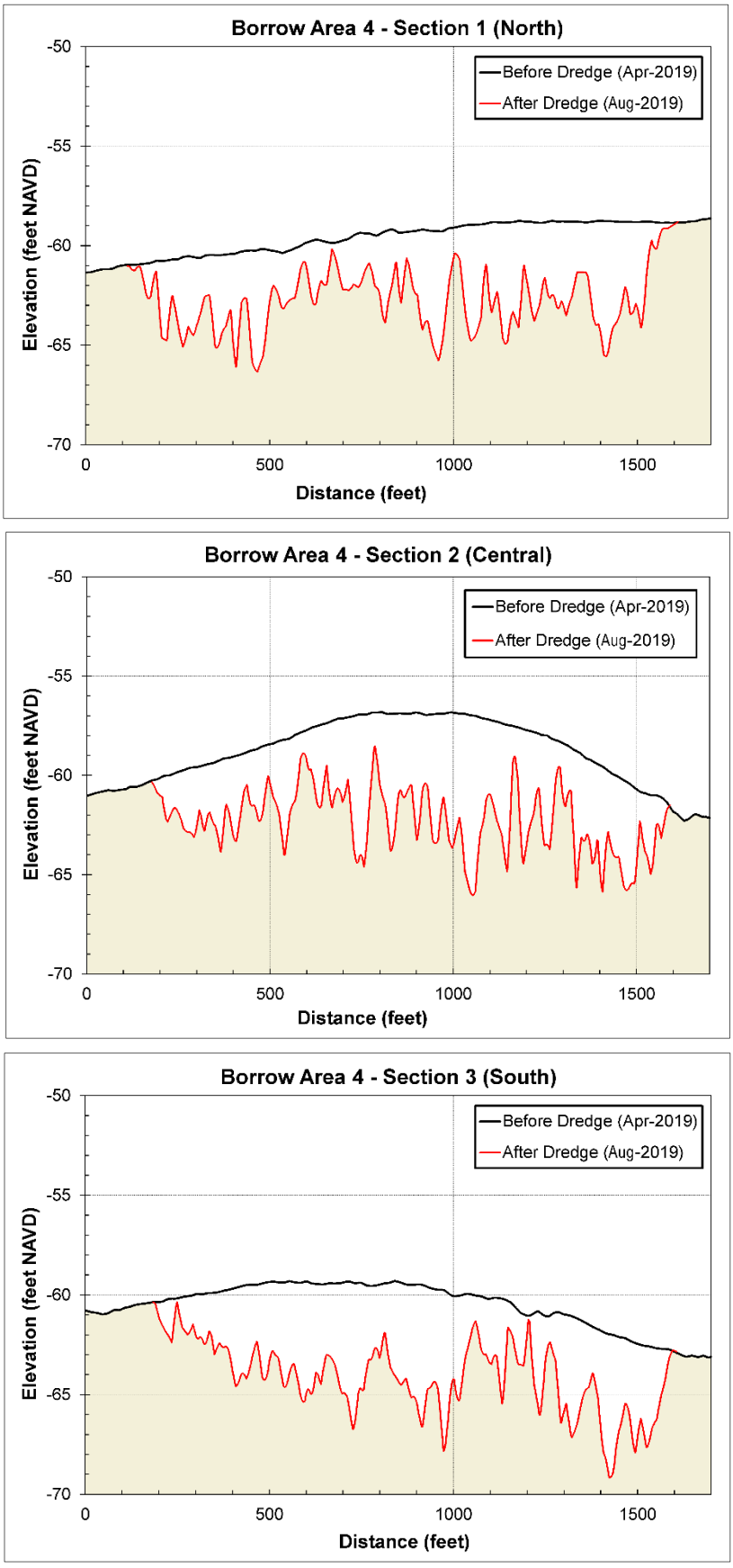


FIGURE 7.4. Representative cross-sections through Borrow Area 4 highlighting excavation during construction. Locations of these cross-sections are marked in Figure 7.2.

8.0 SUMMARY OF BEACH PROFILES AND FILL VOLUMES

Between 1 May and 18 August 2019, the Contractor (GLDD) placed approximately 4,000,000 cy of sand along the ten-mile project area at Nags Head based on GLDD's 100-ft spacing before-dredging (BD) and after-dredging (AD) surveys. The comparison of actual fill volume and design volume for each reach is listed in Table 8.1. CSE completed BD and AD surveys of the beach and inshore zone in April 2019 before nourishment and within a few days of project completion in August 2019. CSE's surveys were conducted at 500-ft spacing which was consistent with previous surveys during the planning and designing of the 2011 and 2019 projects. CSE's survey results are listed in Table 8.1 as the confirmed volume of the project.

TABLE 8.1. Summary of fill volume versus design volume for each reach based on before-dredging and after-dredging surveys by GLDD and CSE.

Reach	Station	Length (lf)	Design Volume (cy)	Fill Volume (cy)	Difference between Design and Fill (%)	Confirmed Volume (cy) by CSE
1	497+00 to 790+00	29,300	1,758,000	1,734,863	-1.3%	1,795,175
2	790+00 to 920+00	13,000	845,000	866,189	+2.5%	932,600
3N	920+00 to 975+00	5,500	622,000	577,772	-7.1%	492,375
3S	975+00 to 1010+00	3,500	543,000	539,006	-0.7%	458,425
4	1010+00 to 1025+00	1,500	232,000	239,197	+3.1%	203,825
Total	497+00 to 1025+00	52,800	4,000,000	**4,004,635**	+0.1%	**3,882,400**

GLDD's BD and AD survey data indicated that ~73 percent of the nourishment sand was placed above MLW (−2.05 ft NAVD) and ~27 percent was placed below MLW. GLDD's BD and AD data plots along with design templates for stations at 100-ft spacing are included in Appendix B2 and volume calculations based on the instructions in the Project Manual (CSE 2018a) are listed in Appendix B3.

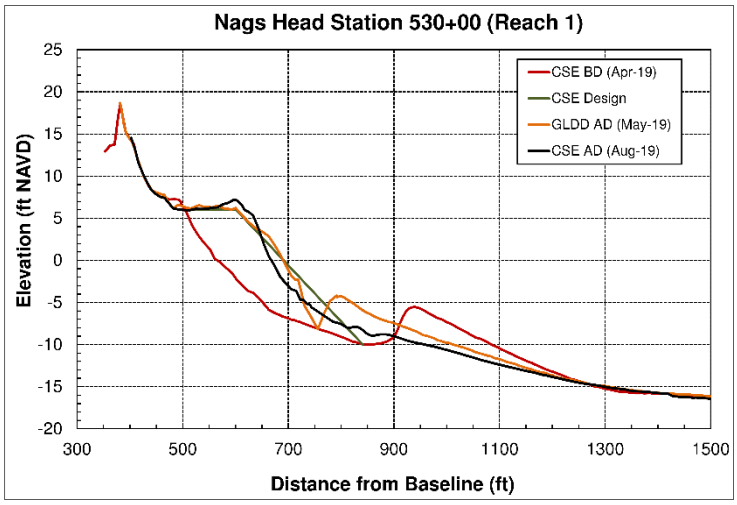
CSE's survey profiles of the pre-project and post-project conditions for stations at 500-ft spacing are including in Appendix B4, and a summary of unit volumes and total volumes of each station surveyed is listed in Appendix B5. CSE confirmed that there are 3,882,400 cubic yards more sand in the ten-mile project area after nourishment (Table 8.1). Following initial adjustment after sand placement, ~65 percent of the nourishment sand remains above MLW, and 35 percent is contained underwater. After the 110 days of construction, sand losses out of the project area have been negligible. The project's nourishment profile was designed to adjust rapidly to changing wave conditions with an expected gradual shift of sand into deeper water as the profile equilibrates. CSE's AD survey precedes Hurricane *Dorian* which impacted the Northern Outer Banks on 6 September, and high tide nor'easters which occurred in October 2019.

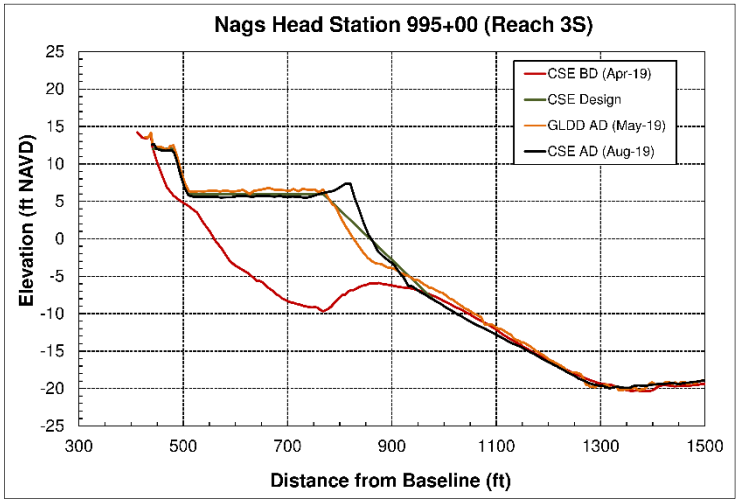
Figure 8.1 shows typical cross-sections (known as beach profiles) of each reach before and after nourishment along with the design fill templates. The green lines in the diagrams represent the design, and the brown lines represent the initial shape of the nourished beach as sand was pumped into place. Red lines represent the beach condition before nourishment in April 2019, and black lines represent the beach condition after nourishment in August 2019. Sections completed during the early stages of construction have already been through the initial adjustment under wave actions as seen in the AD profiles for Stations 995+00, 1020+00, and 1025+00.

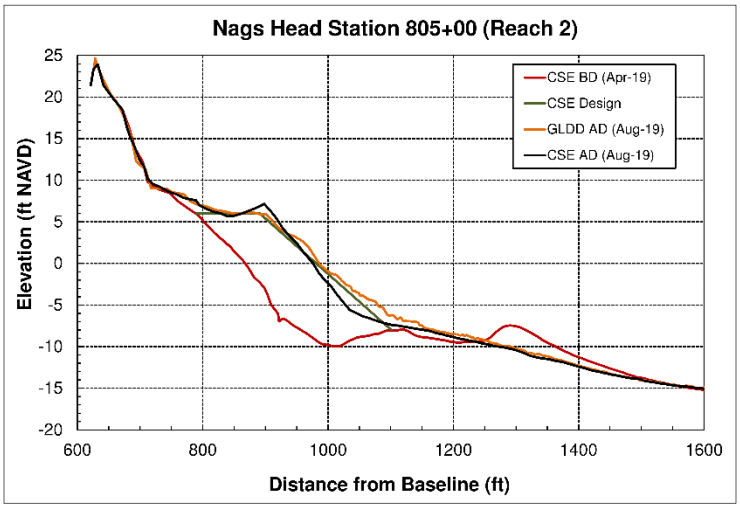
Dunes were constructed along Reaches 3N, 3S, and 4 with an elevation at +12 ft NAVD and a typical width from 40–60 ft. The constructed berm was set at +6 ft NAVD and the width averaged from ~100 feet (Reach 1) to ~250 ft (in Reaches 3S and 4). Nearly all the new sand was contained within 400 ft seaward of the foredune. This beach shape allowed the Contractor to control the volume placed with the expectation that waves would soon reshape the nourishment sand into a natural profile.

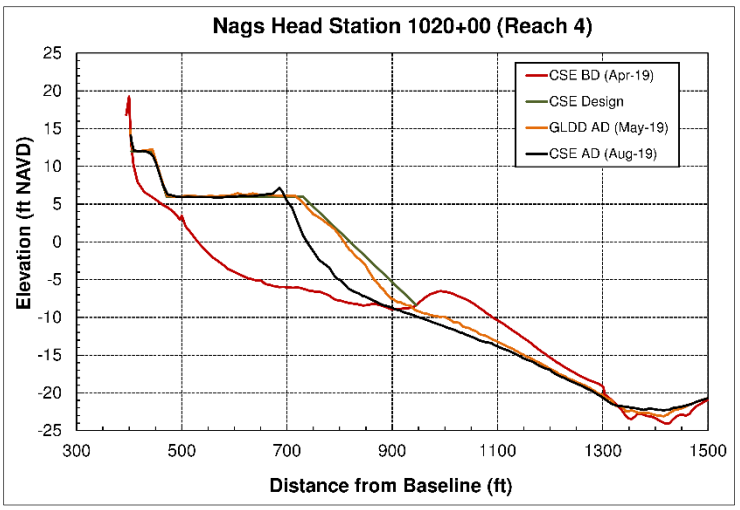
It is typical to build a "fill template" whereby more sand is initially placed on the visible beach and the sloping seaward edge is steeper than normal (Dean 2002). This is a practical way to control the sediment slurry and ensure that each section of the beach receives its allotted volume. Such fill templates create an unnatural profile which is inherently unstable. A simple analogy is that of an iceberg that has most of its volume below water. If ice is added to the tip of the iceberg, it will settle lower in the water until a new hydrostatic balance is achieved. Similarly, if nourishment sand is placed entirely on top of the visible beach, some of it will be unstable and will shift underwater until a balanced profile with a normal slope is achieved.

Figure 8.2 illustrates beach profiles before and after nourishment at Seagull Drive at Station 994+00, where a condemned house was sitting in the surf before renourishment. As state regulations prohibited the placement of nourishment sand over exposed sandbags and under houses, the project had to work around this structure. This resulted in no sand placement in the low areas around the house, thus leaving a pond not only under the house but also landward of the house. It was unsafe to survey the ground elevation under the house after dredging, but it was estimated based on the before-dredging survey that the water depth could be as deep as 8 ft. GLDD immediately installed orange safety fencing and warning signs around the pond area. This pond raised public safety concerns and also interrupted normal passage on the beach behind the house. NCDCM evaluated the situation and issued The Town of Nags Head a permit modification for filling the area behind the house so that the ponding area could be minimized and passage on the beach landward of this house would not be interrupted.









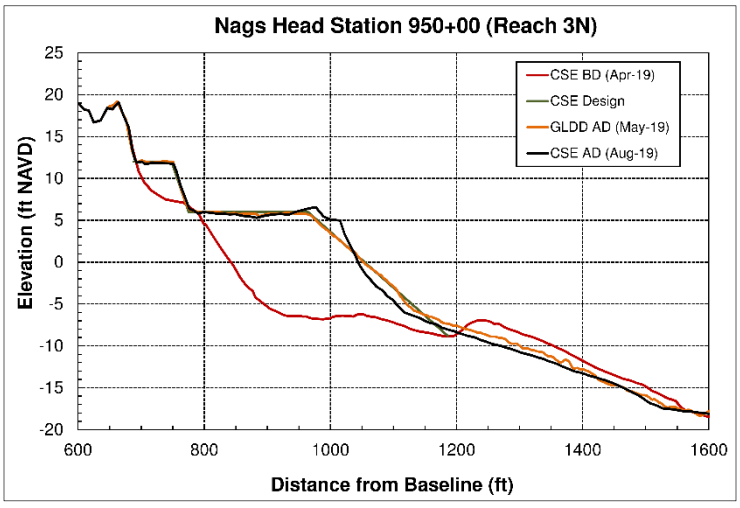


FIGURE 8.1. Typical beach profiles of each reach before and after the 2019 renourishment. Initial dunes were designed and constructed along Reaches 3N, 3S, and 4. The construction berm was set at +6 ft NAVD, and the dune crest elevation was set at +12 ft NAVD.

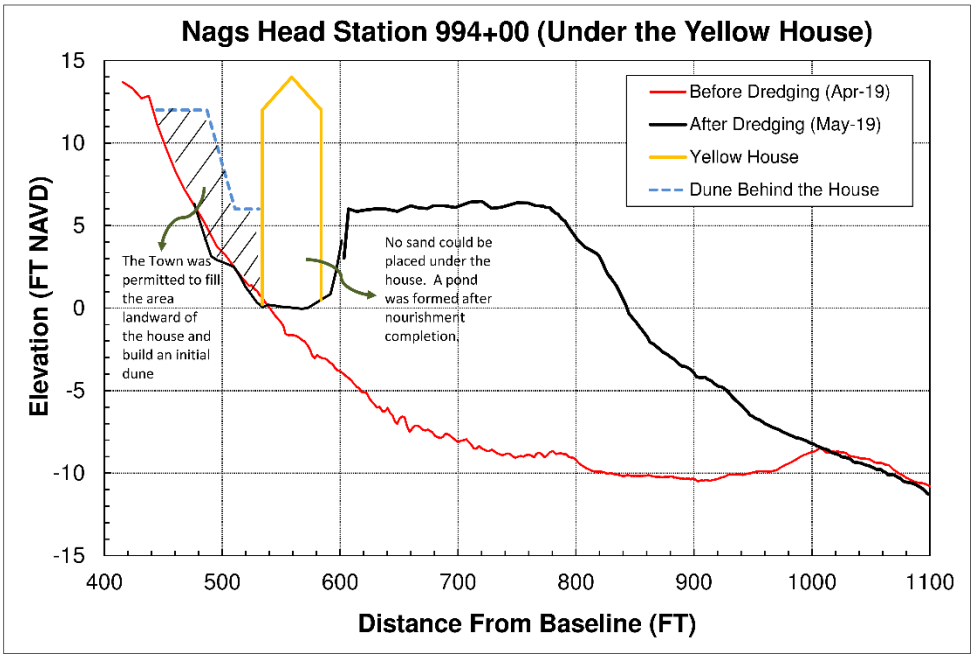


FIGURE 8.2. Beach profiles at Station 994+00. This station is located under the condemned house shown in Figure 8.3.

Wind blowing sand into the pond and wave overtopping the berm shifted sand under the house causing the ponding area to gradually reduce over time. Finally, fall nor'easters eventually pushed sand into the pond making the area dry as of mid-October (five months after the nourished sand was placed in this area). Figure 8.3 includes a series of photos showing the transformation of this area.

All beaches experience profile adjustment which is simply the beach's response to changing wave heights and water levels. Beaches absorb and dissipate wave energy with the universal response being a flattening of the profile as wave energy increases (Komar 1998). A flatter profile provides a broader wet-sand beach over which waves lose their energy. The character of breaking waves and swash also produces favorable changes. This is why the wave runup across the wide nourished beach did not attain the heights that occurred along some narrow-beach sections of Dare County. After storms subside, the flatter profile tends to adjust again. Lower waves will shift sand from the shallow-water bars back to the dry beach.

The initial adjustment of the Nags Head beach nourishment project was, therefore, a combination of offshore movement due to the inherently unstable configuration of sand upon placement and adjustment due to storms. Profile volumes (as measured before and after the project) between the foredune and −19-ft NAVD contour, provide an objective measurement of the net impact. The volume of nourishment sand remaining in that cross shore zone over time will define the performance of the project.

FIGURE 8.3. Aerial photos of the area near Station 994+00. **[UPPER]** Ground photo was taken on 14 May 2019. Four days after nourishment was completed in this area and also after spring tides, a ponding area was formed under and around the house. Safety fence was installed by the Contractor around the ponding area. **[MIDDLE]** Aerial photo was taken on 14 May 2019 showing the footprint of the ponding area relative to the properties behind the condemned, yellow house. **[LOWER]** Ground photo was taken on 15 October 2019 showing the pond has been filled naturally.

9.0 SAND FENCING AND DUNE PLANTING AFTER CONSTRUCTION

The Town of Nags Head integrated a dune management plan with the present project including initial dune construction along South Nags Head, installation of sand fencing, and planting of vegetation along the entire project area following the 2019 renourishment. Installation of sand fencing and planting of vegetation was permitted by the NCDCM and specified in the CAMA permit conditions (No. 19–25) as follows.

> *19) Sand fencing shall not impede existing public access to the beach, recreational use of the beach or emergency vehicle access. Sand fencing shall not be installed in a manner that impedes or restricts established common law and statutory rights of public access and use of public trust lands and waters.*
>
> *20) Sand fencing shall not be placed on the wet sand beach area.*
>
> *21) Sand fencing shall not be installed in a manner that impedes, traps or otherwise endangers sea turtles, sea turtle nests or sea turtle hatchling.*
>
> *22) Sand fencing shall be placed as far landward as possible to avoid interference with sea turtle nesting, existing public access, recreational use of the beach, and emergency vehicle access.*
>
> *23) The permittee (the Town of Nags Head) shall immediately remove non-functioning, damaged, or unsecured sand fencing.*
>
> *24) Sand fencing shall be constructed from evenly spaced thin wooden vertical slats connected with twisted wire, no more than 5 feet in height. Wooden posts or stakes no larger than 2" by 4" or 3" diameter shall support sand fencing.*
>
> *25) Sand fencing shall be installed at an angle no less than 45 degrees to the shoreline. Individual sections of sand fence shall not exceed more than 10 feet in length and shall be spaced no less than seven feet apart, and shall not extend more than 10 feet waterward of the toe of the reconstructed dune.*

The Town of Nags Head submitted sand fencing and dune plans to the permitting agencies by 18 July 2019. The USFWS issued an amendment of the Biological Opinion for sand fencing and dune planting on 23 July 2019 (Appendix E3). The Amendment specified the sand fencing installation methods as follows.

> *Sand fencing will use a tractor-mounted hole drilling attachment to dig 4-foot holes, and a tractor and wagon to carry fencing materials and equipment to the work zone, where the fencing will be assembled on-site. Sea oats and bitter panicum will be installed with a tractor-mounted planter and/or a tractor-pulled water tank. Sand fencing and vegetative sprigging will be performed in accordance with the /town of Nags Head Sand Fence and Vegetative Sprigging Plans and Project Specifications (dated July 15, 2019), and the Operational Plan for the Town of Nags Head (as revised on July 18, 2019).*

Coastal Transplants (c/o Steve Mercer) was contracted by the Town of Nags Head for sand fencing and dune planting. Work began on 18 July 2019 from Juncos Street public beach access and proceeded south. It is expected to be completed in November. Figures 9.1 and 9.2 show Coastal Transplants' progress. Through the installation of sand fencing, planting of vegetation, and natural dune-building processes, the backshore areas of Nags Head are expected to be enhanced gradually post-nourishment.

FIGURE 9.1. Sand fencing installed by Coastal Transplants. The photo was taken on 2 August 2019 from Juncos Street Public Beach Access looking south.

FIGURE 9.2. Dune vegetation planted by Coastal Transplants. The photo was taken on 16 August 2019 from Juncos Street Public Beach Access looking south.

10.0 MONITORING & MAINTENANCE RECOMMENDATIONS

In accordance with FEMA Publication 321 and the Code of Federal Regulations 44 CFR 206.226(j), a maintenance program involving periodic renourishment of sand must be established and followed by the Town of Nags Head to qualify for FEMA assistance. In conjunction with the initial 2011 beach nourishment project, the Town of Nags Head adopted a Beach Monitoring and Maintenance Plan (Plan) win August 2011. The purpose of the Plan is to track the physical condition of the beach following nourishment, quantify sand volume changes, and determine whether the project area qualifies for emergency renourishment following declared disasters. It is also intended to identify erosion hot spots and recommend small-scale maintenance renourishment, placement of sand fencing, and/or sand scraping to increase the life of the project.

Certain thresholds are specified in the 2011 Plan for renourishment, including:

- Net sand losses due to a storm (declared disaster) measured within defined project limits which, for Nags Head, span 10.0 miles of oceanfront between the foredune and the −19 feet (ft) NAVD offshore contour.
- Chronic sand losses equating to more than 50 percent of the placed sand (ie – >2.3 million cubic yards).

CSE believes that the 2011 Plan remains generally applicable to Nags Head after the 2019 renourishment, and some adjustment should be considered to better define renourishment thresholds for various reaches or sub-reaches. We recommend that the Town of Nags Head continue to conduct an annual assessment of the physical condition of the nourished shoreline using the transect plan initiated by CSE. Physical condition surveys following the 2019 project should include the following:

- Annual beach and inshore profiles at minimum 500-ft spacing at USACE/CSE stations, including upcoast and downcoast areas to track the spread of nourishment sand to adjacent areas.
- Annual or bi-annual survey of borrow areas to determine the degree of infilling and sediment modification after dredging.
- Two lighting surveys to determine all lighting sources that are visible from the beach during the first year following construction.
- Compaction inspection for two years prior to the sea turtle nesting season.

- Sediment sample collection and analysis for monitoring the as-built quality of sand on the beach and verify that it meets the NCCRC sediment criteria for nourishment projects.
- Aerial and ground photography to document the general conditions of the shoreline each year and periodic controlled vertical photography approximately once every three years.
- Data analysis to determine nourishment volumes remaining by reach and volumes remaining with respect to the renourishment threshold.
- Contour movement analysis and mapping to illustrate for the community the shift of key reference contours over time including local mean high water, the edge of the dry-sand beach, and the face of the foredune, etc.
- Assessment of dune dimensions and plan for sand relocation along the areas where sand migrates landward after the project resulting in encroachment onto existing structures.

Lighting surveys and compaction inspections are required by the USFWS Biological Opinion (USFWS 2017). Annual beach condition surveys are the primary means of documenting the performance of the nourishment/renourishment and quantifying the volume of sand remaining within the project boundaries. These surveys will give the Town an annual assessment of the beach condition and will reveal problem areas or erosion hot spots that require attention. Annual surveys also serve to document the beach condition prior to the occurrence of a major erosion event, such as a hurricane. Should a major storm event occur, a post-storm survey should be completed for a damage assessment as soon after the storm as possible, as has been done by the Town of Nags Head after Hurricane *Matthew*. Since the project is an engineered beach fill, annual and post-storm surveys could provide a basis for reimbursement and reconstruction of the beach with federal disaster funds under a community assistance grant (eg – FEMA Category G post-storm restoration funds) (FEMA 2018).

Benthic monitoring of the biological response to the nourished beach and borrow areas is not required by the state or federal permit for the 2019 beach renourishment.

11.0 SELECTED PHOTOGRAPHS BEFORE, DURING, AFTER CONSTRUCTION

PHOTO 1. The dredge *Ellis Island* delivered her first load around 7:00 pm on 1 May 2019. The discharge point was at Station 975+50 south of Limulus Street beach access.

PHOTO 2. First sunrise on 2 May 2019 after pumping commenced. The dredge *Ellis Island* is in the photo.

PHOTO 3. Pumping operations were conducted 24/7 (including nights and holidays) as long as the weather conditions allowed.

PHOTO 4. Pumping through Nags Head Fishing Pier on 31 May 2019 via the *Liberty Island*.

PHOTO 5. Pumping through Jennette's Pier on 28 July 2019 via the *Liberty Island*.

PHOTO 6. Pumping through Outer Banks Fishing Pier on 10 August 2019 via the *Liberty Island*.

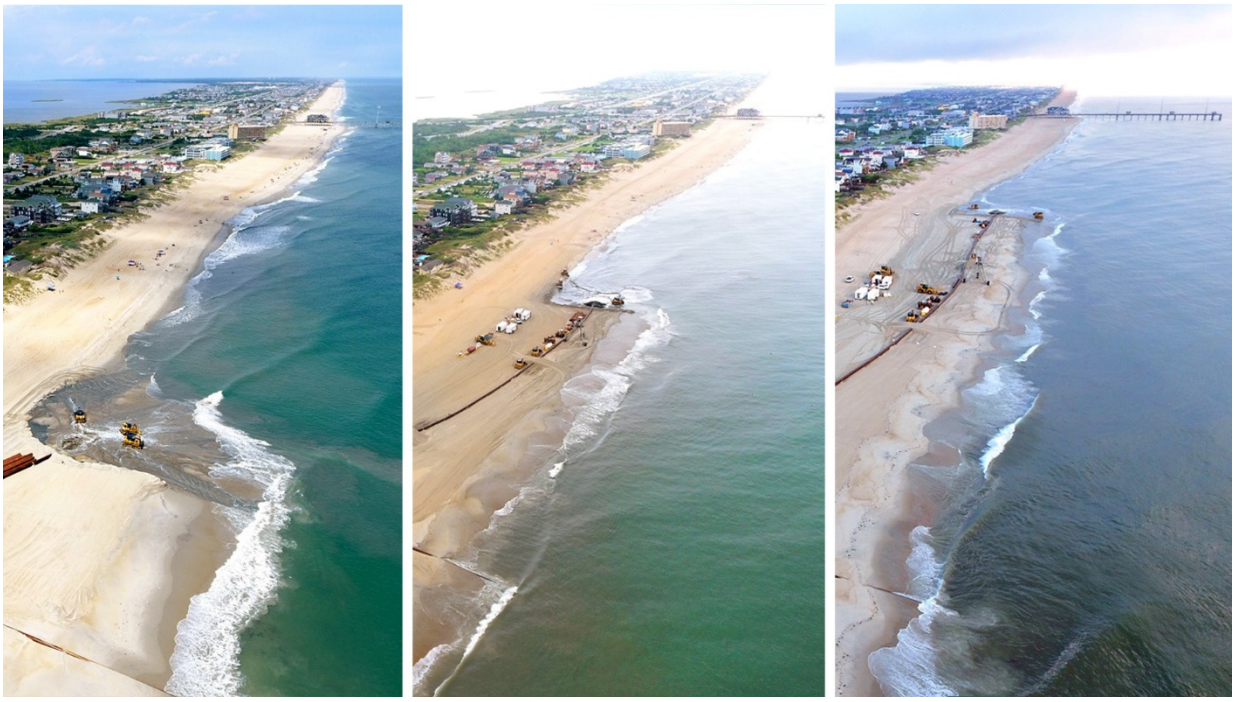


PHOTO 7. The last few days of pumping showing the work progress on the beach. From left to right, photos were taken on August 15, 16, and 17 (respectively).

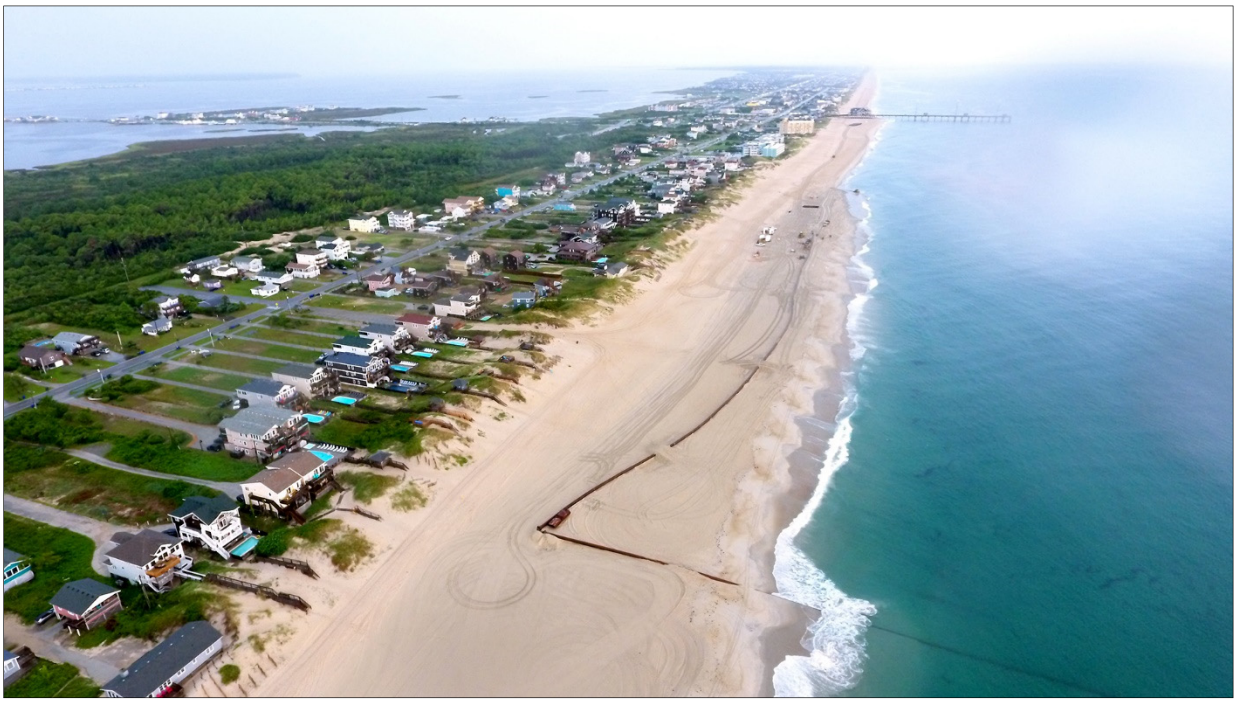


PHOTO 8. Last day of pumping on 18 August 2019 via the *Liberty Island*.

PHOTO 9. Wherever deemed to be safe, the back beach was opened to the public during pumping. No safety incidents occurred during the entire 110 days of construction.

PHOTO 10. Sand ramps were built over the shore pipes after a section of beach was nourished and opened to the public for ocean access.

PHOTO 11. The Coastal Research Amphibious Buggy (CRAB) used by the Contractor to measure the sand volume placed on the beach.

PHOTO 12. The USACE Project Manager, Josh Pelletier (left on the photo) inspected the dredge *Ellis Island* on 1 May 2019. GLDD's Quality Control Managers, Christy DiFelice (second from right) and Mario Martinez (first on the right), and Site Manager, Jeremy Remme (second from left) accompanied the inspection.

PHOTO 13. A visit to the dredge *Ellis Island* on 22 May 2019. From left to right: Tim Kana (CSE President and Project Director), Jamey Falkenbury (Director of Innovations, Office of the Lt Governor), Ben Cahoon (Town Mayor), Susie Walters (Town Mayor Pro Tem), and Andy Garman (Town Deputy Manager).

PHOTO 14. Dredge visits during the 2011 and 2019 projects. **[LEFT]** Visiting the dredge *Ellis Island* on 4 June 2019. From left to right: Todd Kraft (Town Environmental Planner), Haiqing Kaczkowski (CSE Project Engineer), and David Ryan (Town Engineer). **[TOP RIGHT]** Visiting the dredge L*iberty Island* on 17 August 2011. From left to right: Raleigh Bland (USACE Project Manager for the 2011 project), Josh Pelletier (USACE Project Manager for the 2019 project), Roberta Thuman (Town Public Information Officer), Tim Kana (CSE President and Project Director), and Dave Allen (GLDD Project Manager). **[BOTTOM RIGHT]** Visiting the dredge *Liberty Island* on 24 May 2011. Right on the photo: Cliff Ogburn (Town Manager).

PHOTO 15. GLDD managers and staff on the job site 13 June 2019. From left to right: Barry Jones (Foreman), Mike Huebsch (Site Manager), Bryan Dast (Project Manager), Russ Zimmerman (Vice President), and Tim Kremer (Project Manager until 13 June 2019).

PHOTO 16. State and federal resource agencies (USFWS, NCDCM, and NCWRC) visited the job site and had field meetings with the Town and Engineer.

PHOTO 17. Beach condition comparison near the Outer Banks Fishing Pier before and after the 2019 renourishment project. **[LEFT]** Photo was taken on 17 April 2019. **[RIGHT]** The photo was taken on 29 August 2019.

PHOTO 18. Beach condition comparison at the south end of Nags Head before and after the 2019 renourishment project looking south. **[LEFT]** Photo was taken on 17 April 2019. **[RIGHT]** The photo was taken on 29 August 2019.

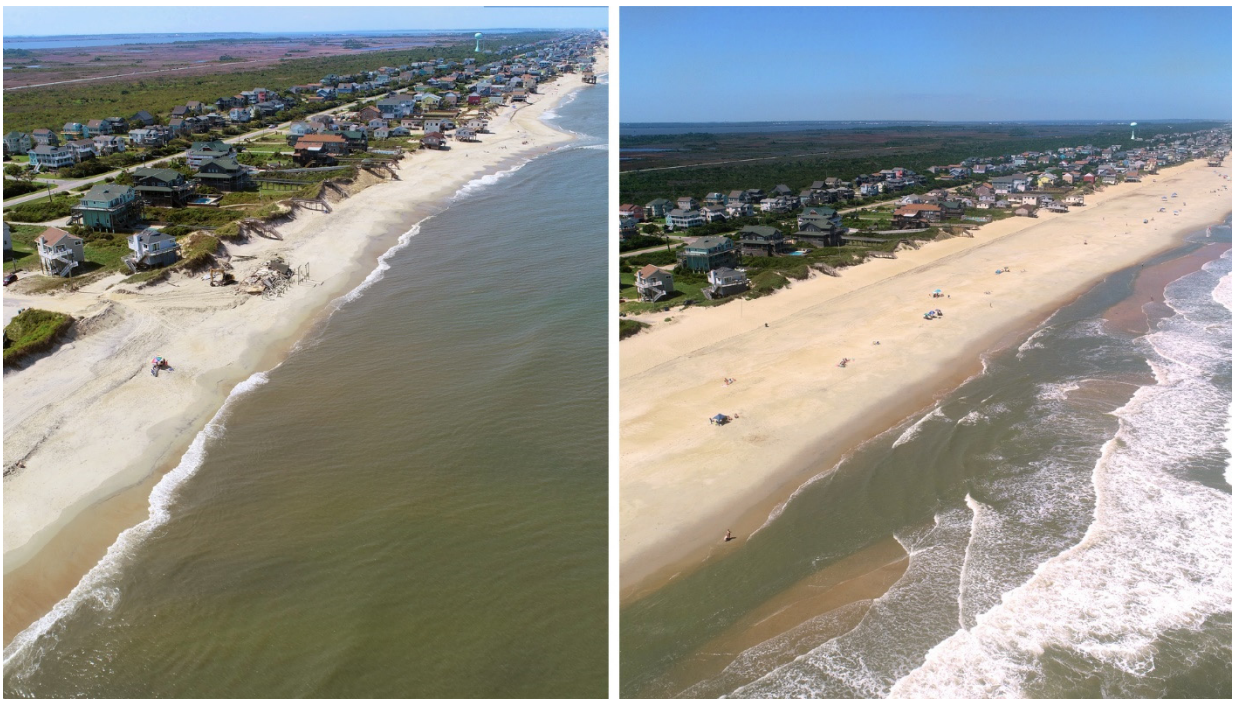


PHOTO 19. Beach condition comparison at the south end of Nags Head before and after the 2019 renourishment project from the southern limit of the project area looking north. **[LEFT]** Photo was taken on 17 April 2019. **[RIGHT]** The photo was taken on 29 August 2019.

PHOTO 20. Photos taken on the rooftop of the Comfort Inn at Nags Head. **[UPPER]** Photo taken on 18 November 2010 before the initial 2011 nourishment. **[LOWER]** The photo was taken on 3 August 2019 after the 2019 renourishment.

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