FINAL REPORT

2017 BEACH RESTORATION AND GROIN LENGTHENING PROJECT

Edisto Beach Colleton County SC

Prepared for:

Town of Edisto Beach
2414 Murray Street Edisto Island SC 29438

Prepared by:

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[CSE–2416FR]

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EXECUTIVE SUMMARY

This final report outlines a beach restoration and groin extension project at Edisto Beach (SC), which was sponsored by the Town of Edisto Beach. The project occurred January–June 2017 and included nourishment of the beach and extension of 26 of the groins along the Atlantic Ocean facing shoreline of the beach. The work included placement of 1,006,000 cubic yards (cy) of sand over ~19,000 linear feet of beach between Edisto Beach State Park and Edisto Street. Groins were extended between 20 and 100 feet (ft) with a total lengthening of 1,630 ft. Sand was excavated by cutterhead dredge from the shoal on the north side of the South Edisto River Inlet.

Nourishment was completed by Marinex Construction (Charleston SC). The groin work was completed by Crowder Construction (Charlotte NC). The total project was completed under authorization by state (SCDHEC–OCRM) and federal (USACE) permit P/N 2015-00528. Coastal Science & Engineering Inc (CSE) (Columbia SC) served as project engineer.

Planning for the project evaluated nourishment alternatives and volume requirements, groin extension design, coastal processes, potential downdrift impacts, costs, and potential environmental impacts. Design and planning documents included submission of groin analysis studies, monitoring reports, cultural resource assessments, geotechnical investigations, and environmental assessments. The project permit application was submitted on 27 April 2015 with public notice being issued 3 June 2015. The state permit was issued by South Carolina Department of Health and Environmental Control–Office of Ocean & Coastal Resource Management (SCDHEC–OCRM) on 26 May 2016, and the US Army Corps of Engineers (USACE) permit on 19 August 2016. Hurricane *Matthew* (October 2016) forced the Town to postpone the bid opening so that the project could be reassessed, allowing incorporation of minor changes to the design.

Funding for the project was provided by a combination of sources including the Town of Edisto Beach, Colleton County, the state of South Carolina, and the Federal Emergency Management Agency (FEMA). The total nourishment cost was $12,198,780 including $2,683,800 for mobilization and an average of $9.46 per cubic yard of sand. Groin extensions totaled $5,424,642.29, which is an average cost of $3,328 per linear foot of extension.

Mobilization for the work began in December 2016 with heavy equipment being delivered to the site. Crowder initiated work on the groins on 3 January 2017 and completed the work on 7 June. Marinex began pumping on 25 January and completed the fill on 14 April 2017. All equipment was removed from the beach by 15 June.

The nourishment design was based on pre-project beach conditions and included a dune in areas where no existing dune was present and varying berm widths based on design volume. The northern end of the beach (Reach 1 and the state park) generally showed lower pre-project volumes and, therefore, received the greatest fill quantity. Reach volumes ranged from 32.4

cubic yards per foot (cy/ft) to 68.3 cy/ft. The initial berm widths reached up to 125 ft in the highest fill density areas.

Groins were lengthened based on a combination of recommended scenarios by CSE and the USACE. Extensions were designed to extend the sloping section as necessary until the elevation reached −1 ft NAVD, then extensions were built seaward at −1 ft elevation. Thirteen of the extensions included composite sheet-pile and armor-stone scour aprons, and the remaining were constructed with grouted armor stone. Groins with sheet pile included a concrete cap along the top edge of the sheets to protect the sheets from wave action and moving armor stone. Marine mattresses were placed under all armor-stone areas to prevent the stones from settling lower in the sand.

Following construction, the Town installed sand fencing and planted dune vegetation along the project area. Similarly, South Carolina Department of Parks, Recreation & Tourism (SCPRT) installed fence and dune plants along the state park area. CSE completed a post-project survey of the nourished beach in April 2017 and surveyed each groin extension in August 2017.

Aerial view of the Edisto Beach project on 31 January 2017. [Photo by SB Traynum]

ACKNOWLEDMENTS

CSE would like to acknowledge the council and staff of the Town of Edisto Beach for their support and dedication to the project as well as for their support of CSE and our team. We would especially like to thank Iris Hill (Town Administrator) and Jane Darby (Mayor) for their leadership in planning and executing the project. The Edisto Beach Police Department (EBPD) was also instrumental in execution of the project and in maintaining a safe working environment for the crews and public. CSE also wishes to acknowledge the Town staff, EBPD, South Carolina National Guard, and many local volunteers for their efforts in damage relief and restoration following Hurricane *Matthew* in the fall of 2016. Their hard work allowed the project to proceed in a timely manner and restored the beach for the residents of South Carolina and beyond.

CSE would also like to thank the South Carolina Department of Parks, Recreation & Tourism (SCPRT) for their partnership in the project, both financially and logistically. A special thanks to Phil Gaines, David Simms, and Jon Greider for their assistance in planning and executing the project.

Marinex Construction (Charleston SC) was the nourishment contractor. We thank Thomas Payne and the shore and dredge crews for accomplishing the work in a timely manner and for the donation of additional sand beyond the contract amount to rebuild a dune at the state park.

Groin construction was performed by Crowder Construction (Charlotte NC). Kyle Wylie served as project manager, and Patrick Merli served as site superintendent. CSE appreciates Crowder's efforts in working in a difficult environment, constantly dealing with changing tides, unpredictable weather, and difficulty in scheduling material delivery around uncertain conditions and new uses of material.

CSE's work was supervised by Dr. Tim Kana (project director). Project engineer, Dr. Haiqing Kaczkowski (PE), was responsible for final design of the nourishment and groin extensions. Mike Rentz (PE) and Jason Cothran (Rentz Engineering) prepared the detailed structure design and material recommendations for the groin extensions. CSE's project manager was Steven Traynum. Technical assistance was provided by Trey Hair, Captain Andrew Giles, and Luke Fleniken. Diana Sangster and Julie Lumpkin provided editorial assistance and liaison. The final report was written by Mr. Traynum with graphics preparation by Trey Hair and report production by Diana Sangster.

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1.0 INTRODUCTION

This report is prepared following completion of the 2017 beach restoration and groin lengthening project at Edisto Beach, South Carolina. It provides a summary of the project rationale, design, and implementation. The Town of Edisto Beach sponsored the project. Nourishment was accomplished by Marinex Construction (Charleston SC). Groin extensions were completed by Crowder Construction Co (Charlotte NC). Project engineering was provided by Coastal Science & Engineering Inc (CSE – Columbia SC).

This report includes:

- Summary of the project setting, purpose, and project description.
- Summary of historical beach processes and rationale for the project.
- Project time line.
- Summary of project implementation.
- Summary of surveys and as-built conditions.
- Summary of sediment analysis.
- Summary of regulatory compliance measures.
- Project photos.
- Maintenance and monitoring recommendations.

1.1 Project At-a-Glance

Nourishment

Design quantity of 1,006,000 cy placed over 19,000 linear feet (lf) of beach:

- State Park – 200,000 cy along 3,300 lf (60.6 cubic yards per foot—cy/ft)
- Reach 1 – 410,000 cy along 6,000 lf (68.3 cy/ft)
- Reach 2 – 141,000 cy along 3,000 lf (47.0 cy/ft)
- Reach 3 – 165,000 cy along 5,100 lf (32.4 cy/ft)
- Reach 4 – 90,000 cy along 1,900 lf (47.4 cy/ft)

Nourishment Cost

$12,198,780 including $2,683,800 for mobilization and demobilization and an average of $9.46 per cubic yard.

Nourishment Schedule

- 4 January 2017 – Mobilizing equipment to the beach
- 25 January 2017 – First Pumping
- 14 April 2017 – Last Pumping
- 26 April 2017 – Demobilization Complete

Groin Construction

- 26 extensions totaling 1,630 linear ft
- 10,130 tons of armor stone
- 37,800 square feet of marine mattress
- 13 concrete caps
- 1,165 ft of composite (CMI UC95) sheet pile

Groin Cost — $5,424,642.29

Groin Construction Schedule

- December 2016 – Mobilization of Equipment
- 3 January 2017 – First Rock Work
- 12 January 2017 – First Grout Work
- 3 March 2017 – First Concrete Cap
- 7 June 2017 – Last Cap Finished
- 15 June 2017 – Crowder Demobilized

Funding Sources

• Town of Edisto Beach:	$3,000,000
• Colleton County Capital Project Sales Tax:	$4,000,000
• State of South Carolina Grant:	$6,070,843
• South Carolina Parks Recreation & Tourism:	$3,270,624
• FEMA:	$2,509,465
TOTAL	**$18,850,932**

2.0 BACKGROUND

2.1 Setting

Edisto Beach is a ~5.8-mile-long barrier island situated on the northern boundary of St. Helena Sound in South Carolina (Fig 2.1). It is bounded by Jeremy Inlet to the northeast and South Edisto River Inlet to the southwest. Edisto Beach makes up the southern half of the larger littoral system which includes Edingsville Beach and Botany Bay. The littoral system encompasses the length between the North and South Edisto Rivers, and there is a general divergence of sediment transport away from the center of the littoral cell (Fig 2.2).

FIGURE 2.1. Aerial image of Edisto Beach in October 2016 following Hurricane *Matthew*.

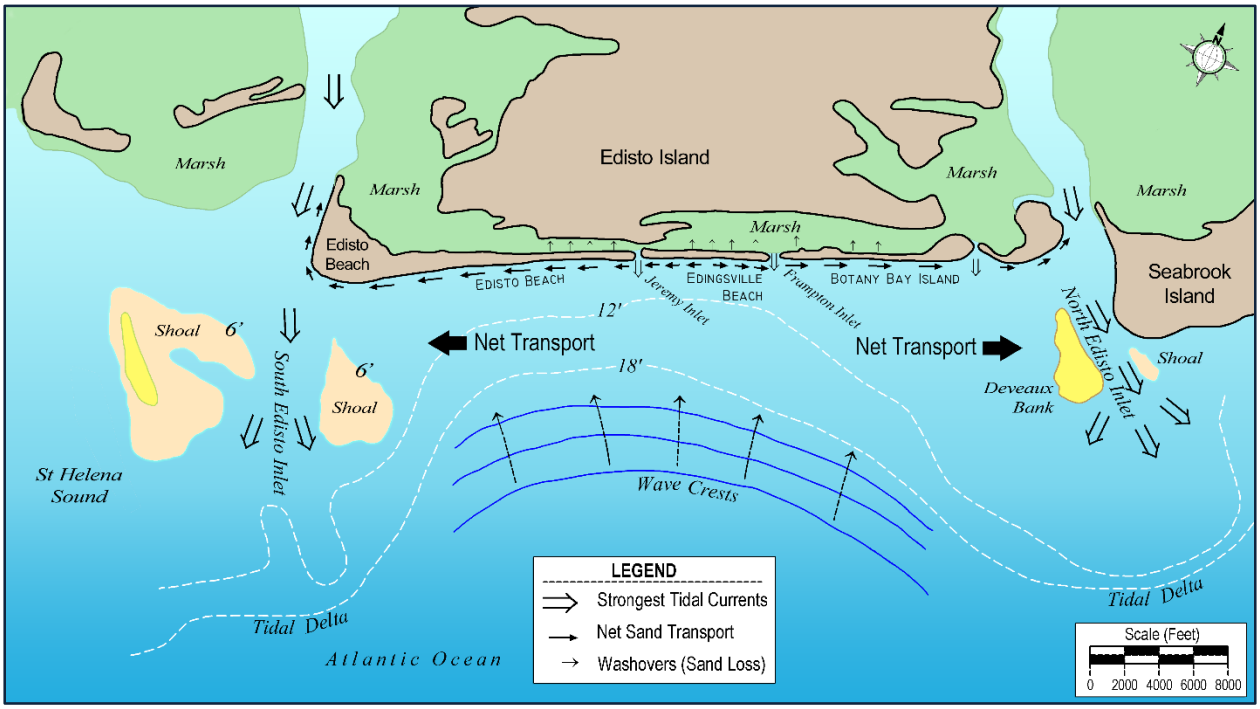


FIGURE 2.2. Schematic of sediment transport pathways at Edisto Beach (SC).

The ~1.4-mile-long portion of Edisto Beach north of Hwy 174 is maintained by the South Carolina Department of Parks, Recreation & Tourism (SCPRT) and is the site of Edisto Beach State Park. The park has designated camping areas and a day-use area with facilities. The Town of Edisto Beach is responsible for the portion of the beach south of Hwy 174 (~4.4 miles). Along most of the island, one row of houses is present seaward of Hwy 174 with relatively narrow lots separating the ocean from the highway. Along the southern end of the front beach, the island widens, accommodating two rows of ocean-side beach homes. These homes are located on Point Street, which lies between the Atlantic Ocean and Hwy 174. A network of 34 groins are in place, extending from the southern end of the state park to Ebbtide Street on the South Edisto River Inlet shoreline.

2.2 Erosion History

During the past century, depletion of the sand supply along Edingsville Beach and Botany Bay Island has left a low washover beach and exposed marsh at the seaward edge (Fig 2.3). The result is high erosion rates and insufficient downcoast movement of sand toward Edisto Beach. Edingsville Beach (just north of Edisto Beach) has been retreating at upward of 15 feet per year (ft/yr) (Stephen et al 1975, CSE 2003a). Further, the sediments being supplied to Edisto Beach tend to have a high proportion of mud and shells derived from the eroding marsh deposits.

FIGURE 2.3. Aerial image of Edingsville Beach and Botany Bay Island in April 2018. Note exposed marsh on the active beach.

By the 1950s, erosion near the Pavilion (Groin 1) on Edisto Beach reached upward of 10 ft/yr. The downcoast end of Edisto Beach (at "The Point" and along St. Helena Sound) has generally remained stable or accretional during the past century. Erosion along Edisto Beach led to construction of the first groins in 1948 near the Pavilion (Fig 2.4).

During the next decade, 17 groins were built from north to south in an attempt to halt the loss of sand, or at least to slow its southerly movement. However, erosion continued downcoast of the structures as each group of groins was built, sometimes to "The Point" where houses were washed out (CSE 2001). This prompted construction of more groins up to 1975 (Table 2.1). Groin 34 (the last one built) is situated along the South Edisto River Inlet shoreline about 3,000 ft from Big Bay Creek.

The sand-trapping capacity of individual groins impacts erosion rates along the beachfront. Gaps in deteriorating groins allow sand piping and leaking, which results in erosion within the groin cell and accretion downcoast. Conversely, when updrift groins are repaired and their trapping capacity is restored, downcoast areas may erode (unless repairs are accompanied by nourishment). Sand volumes around "The Point" area (at the southern tip of Edisto Beach) are particularly influenced by the condition of groins along the oceanfront (Kana et al 2004).

TABLE 2.1. Edisto Beach groin construction chronology. Groins are numbered from updrift to downdrift. [After Cubit 1981]

Groin #	Constructed
1	1948
2	1948
3-4	1949
5-8	1954
9-12	1953
13-17	1958
18-19	1962
20-21	1964
22-25	1969
26	1970
27-29	1972
30-33	1974
34	1975

FIGURE 2.4. Typical Edisto Beach (SC) groin prior to the 1995 repair project.

2.3 Previous Projects

In the mid-1950s, erosion near the Pavilion had progressed so far that groins alone were not sufficient to protect Palmetto Boulevard. The South Carolina Highway Department combined groin construction with the first nourishment of Edisto Beach in 1954 using sand, shells, and mud from the marsh behind the island (Fig 2.5). Excavations created the "boat basin" and reclaimed nearly 1.2 miles of shoreline between Groins 1 and 12. Although dredging volumes totaled 830,000 cy, much of the material was unsuitable for the beach, washing away quickly because it was too fine. The coarser sand and broken shells remained, adding to the accumulations of sediment derived from Edingsville Beach.

In April 1995, selected areas of Edisto Beach were nourished (a total of ~155,000 cy were placed between Groins 1 to 17 and Groins 24 to 28), and groins were repaired [CSE 1996(a,b), 1997, 1999a, 2001]. The borrow area was located ~2,500 ft off "The Point" at the southern tip of Edisto Beach and was characterized by coarse, beach-quality sand. By summer 2001 (six years after construction), roughly one-third of the nourishment volume was still present in the project area (CSE 2001). With erosion of the 1995 nourishment sand, Edisto's groins became more exposed and therefore effective for sand retention. Thus, less sand was available to downcoast areas, which was the case some years after the 1954 nourishment project as well. Between 2001 and 2006, erosion downcoast of the groin field accelerated (CSE 2003b).

The 2006 beach restoration project was necessitated by increased erosion rates in downcoast areas, insufficient protection for beachfront properties, and insufficient beach width to support dune formation and recreational beach access. The cleanup costs of frequent washovers onto Palmetto Boulevard, along with the possibility of decreased tax revenues due to loss of properties and tourist revenues, were among the factors that led the Town Council to pursue the project.

FIGURE 2.5. Aerial image (1954) of Edisto Beach showing the first restoration project. The dredge is visible in the marsh.

Nourishment was considered the only viable alternative allowed under the South Carolina Beach Management Act to improve beach conditions, given an inadequate natural supply of sand from Edingsville Beach.

Low sand volumes before 2006 nourishment provided little or no recreational high-tide beach and little storm protection to numerous properties. Whereas in 1995, a relatively small nourishment quantity was required to satisfy trapping of the groins after repairs, the 2006 project involved nourishment volumes that greatly exceeded the trapping capacity of the groins.

Engineered by CSE, the project was constructed between March and May of 2006 by Great Lakes Dredge & Dock Company (GLDD) of Oakbrook (IL). The length of the project area was 18,258 linear feet, including 3,200 linear feet in the state park area. Fill volumes varied along the beach with the goal of achieving a standard, minimum profile volume of at least 100 cy/ft (+9 ft to −7 ft NGVD'29) for the length of the project area. Average design fill volumes were 20–70 cy/ft. The greatest volumes were added to the park and updrift areas in anticipation of sand moving south.

The total measured volume of sand added during the 2006 restoration was 922,000* cy, of which 325,775 cy (24.6 percent) were placed along the park (north of Groin 1) and 694,900 cy (75.4 percent) were placed along the Town (between Groins 1 and 27) (CSE 2006). The contract volume of 850,000 cy was exceeded; however, the excess sand was not a pay quantity as per terms of the contract.

*[*Note that volumes reported here differ from prior reports due to adjustments in the volume calculation limits.*]

The final cost of the project was $7,697,500, of which $1,960,000 (25.5 percent) covered mobilization and demobilization. The Town of Edisto Beach and SCPRT sponsored the project with a combination of local, county, and state funds. Details of the restoration project and nourishment volumes are given in the 2006 project final report (CSE 2006).

2.4 2006 Project Performance

The Town of Edisto Beach has sponsored annual beach monitoring every year since completion of the 2006 project. CSE established or reoccupied over 85 monitoring stations between Jeremy Inlet and Big Bay Creek. Additional surveys were completed of the channel at Big Bay Creek to monitor potential infilling of the channel. Surveys include stations along the state park, three stations for each groin cell between cells 1 and 22, and 2 profiles per cell between cells 23 and 28. Stations along the South Edisto River correspond to previously established OCRM monitoring stations. Figure 2.6 shows the monitoring stations and monitoring reaches, which are used to generalize beach changes into larger areas.

Annual volume changes in the 2006 project area ranged from −8.2 cubic yards per foot per year (cy/ft/yr) to +0.9 cy/ft/yr with an average annual loss of 3.0 cy/ft/yr between August 2006 and December 2016. This includes the impacts of Hurricanes *Joaquin* and *Matthew* in 2015 and 2016 (respectively). Generally, the northern end of the island was more erosional, losing an average of 3.3–3.6 cy/ft/yr along the campground and Reaches 1 and 2 (100–1100 blocks). Reaches 3 and 4 lost 2.4 cy/ft and 1.3 cy/ft (respectively), while the downcoast reaches along St. Helena Sound were stable or accretional. Including the non-nourished areas, all of Edisto beach lost an average of 1.8 cy/ft/yr of sand between 2006 and 2016. Overall, the project reaches lost 583,900 cy of the 922,000 cy gained in the 2006 project, which equals 63.3 percent. Approximately 37 percent of the sand placed in 2006 remained in the project area as of December 2016.

Figure 2.7 shows beach unit volumes for each reach and for the project areas and entire island between 2006 and 2017. The beach volume increase due to the 2006 nourishment is visible in the volume difference between November 2005 (pink) and August 2006 (orange) bars. The 2017 nourishment is shown by the increase between the December 2016 (blue) and April 2017 (yellow) bars.

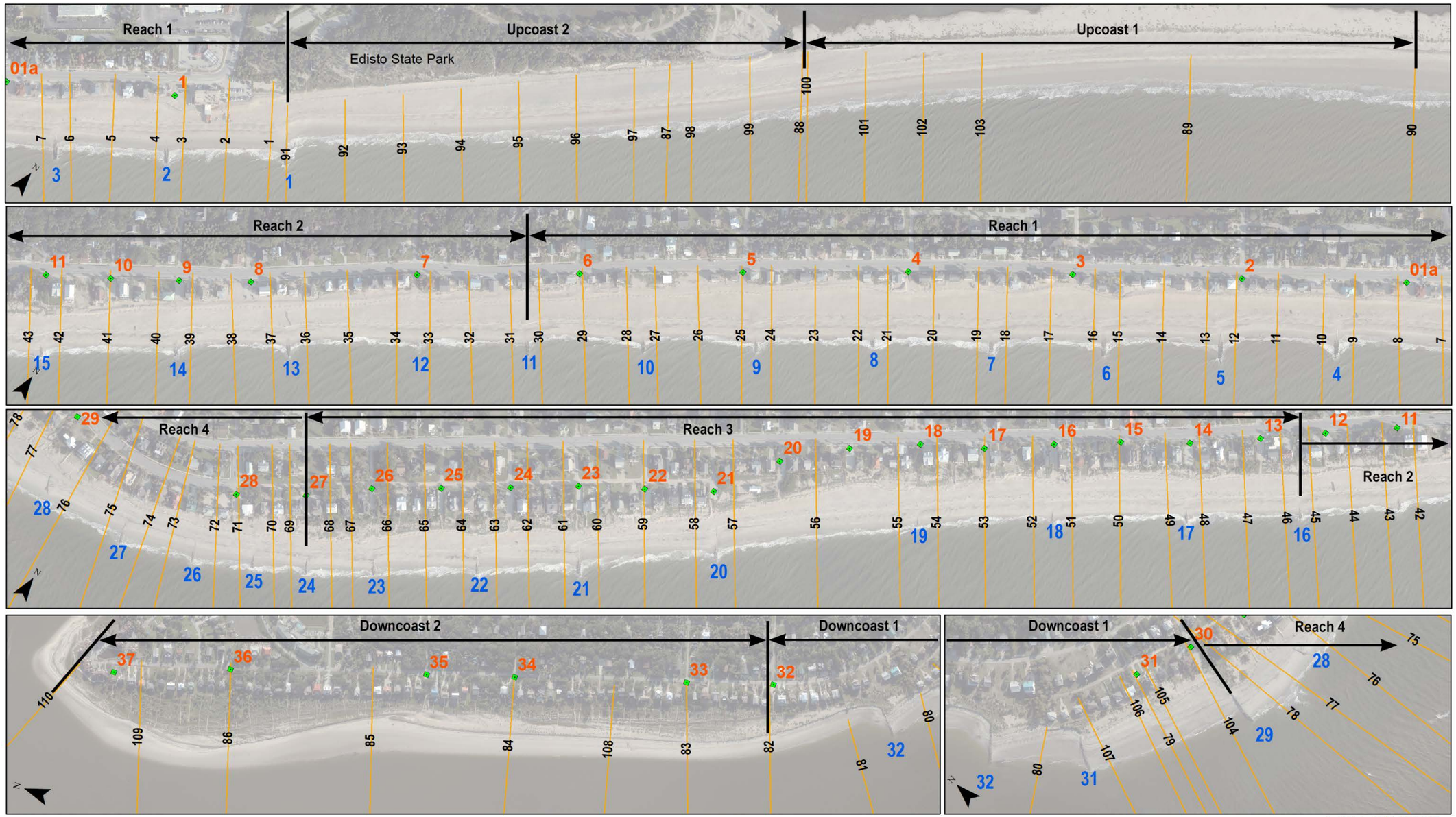


FIGURE 2.6. Map panels showing monitoring reaches (arrows), beach profile stations (black numbers), groins (blue numbers), and beach access points (red numbers) at Edisto Beach.

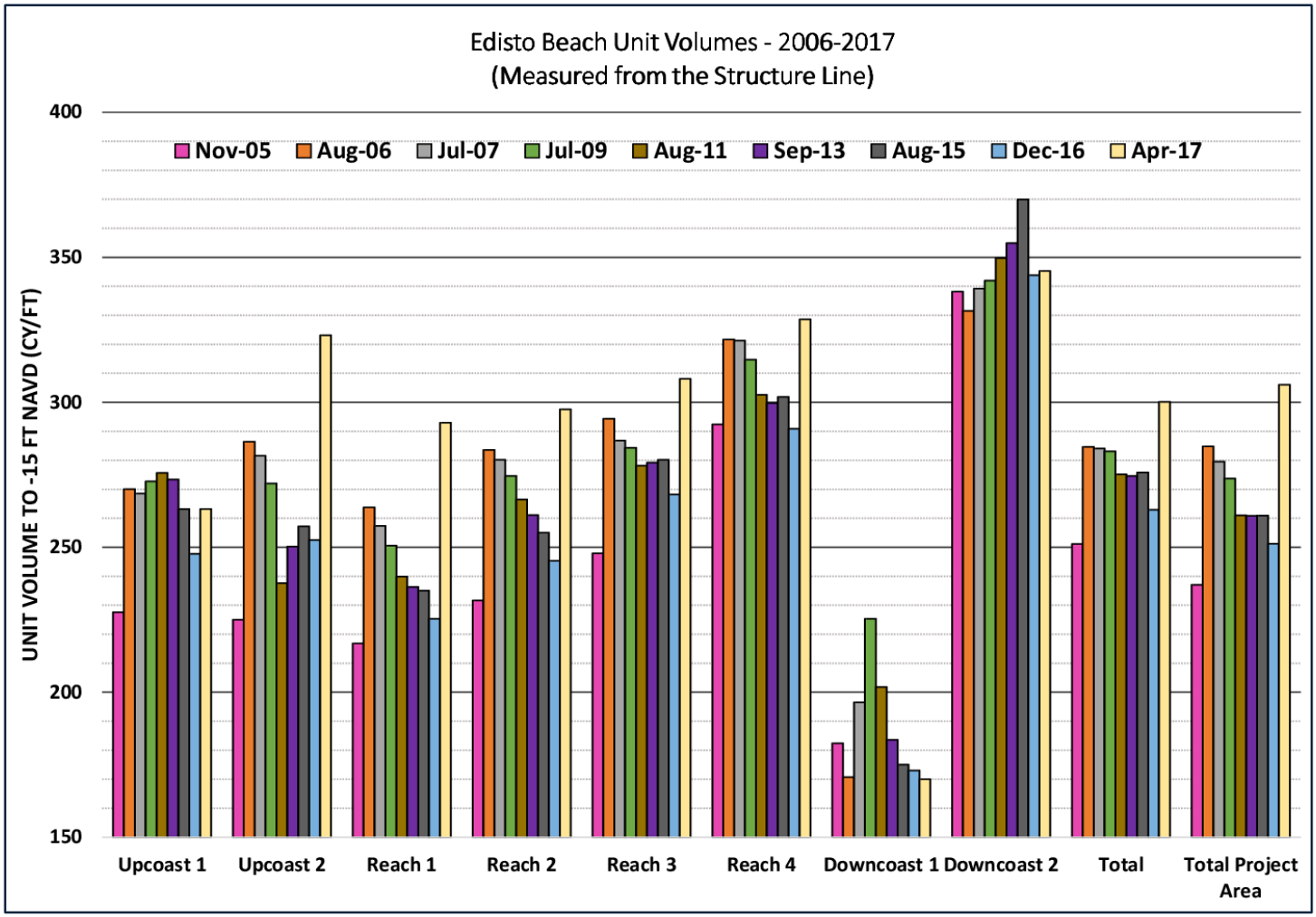


FIGURE 2.7. Unit volumes for each monitoring reach since 2005 at Edisto Beach. Impacts of the 2006 and 2017 nourishment projects are visible. Volumes are measured from the structure line to −15 ft NAVD.

Figure 2.8 shows the total island volume from 2005 to 2017 and includes a projection of the theoretical volume if 10 percent (85,000 cy) of the 2006 nourishment project was lost each year (forecast of a 10-year design life). The chart shows that for the first five years, the project was tracking fairly well with the 10-year projection. The next five years showed less erosion, and the actual beach volume within the project area was 350,000 cy above the 10-year projection by August 2016.

Photos of the beach condition near the 100 block before and after the 2006 project are shown in Figure 2.9 as well as the 2016 pre- and post-*Matthew* conditions. Immediately following nourishment, the majority of the groins were mostly buried by sand. Initial adjustment of the profile led to more exposure of the structures, and over time, additional sand losses resulted in significant exposure of each groin (typically 4–6 ft high). Aerial images show that the first several groin cells had little-to-no vegetative buffer between the houses and the high-tide line by the time Hurricane *Matthew* hit in October 2016. Little dune also existed near the point (cells 25–28).

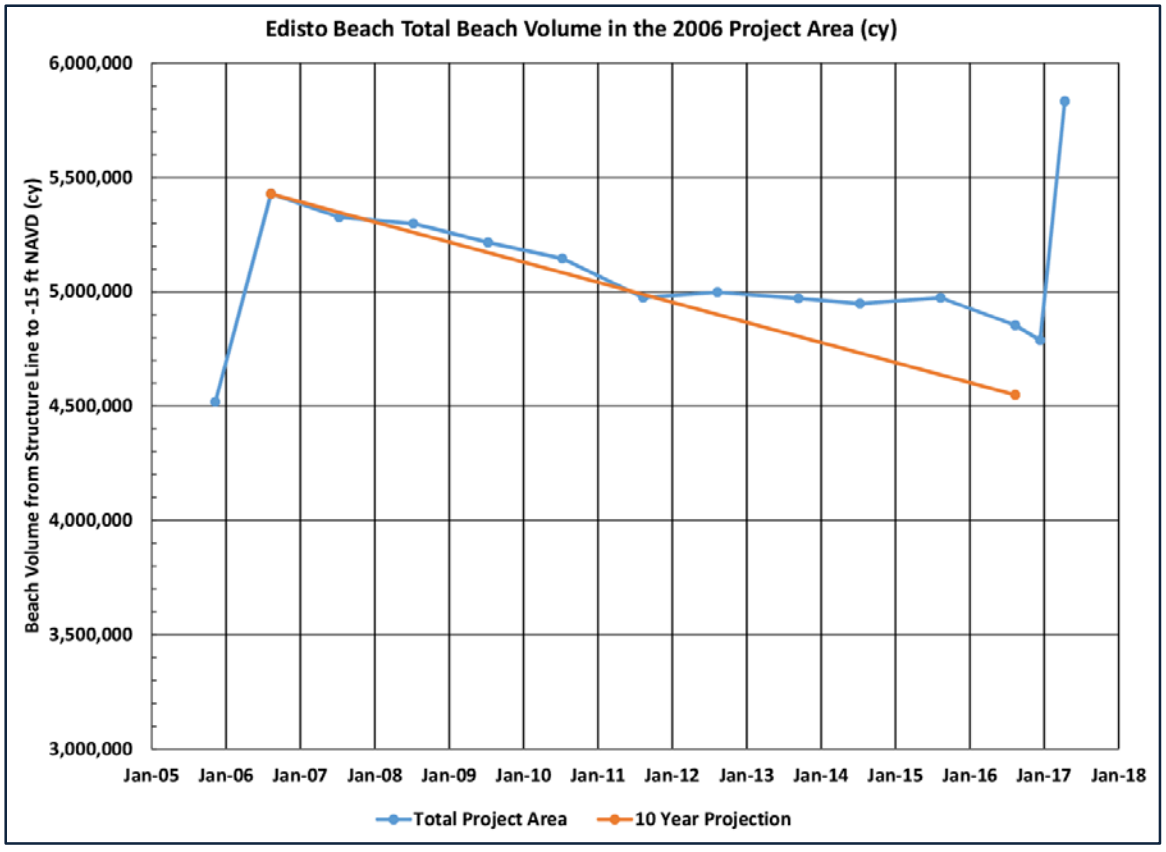


FIGURE 2.8. Total beach volumes for the 2006 project area, showing the gradual loss of sand and comparison to a "10-year" project life scenario. Note that the erosion rate followed the ten-year projection through 2011, then slowed through 2016.

FIGURE 2.9. Image of the beach in the 100 block before (top left) and after (top right) the 2006 project. The middle left and right photos show the same locations in 2016 before and after Hurricane *Matthew*. The aerial photos show the beach after the 2006 project (lower left) and after Hurricane *Matthew* in October 2016 (lower right).

2.5 Project Planning

Following the 2006 nourishment project, the Town of Edisto Beach anticipated the need for another project around 2016. The Town accumulated local funds each year to build a reserve for the next project. Planning for the project began in 2012 with the initiation of a groin-lengthening study by CSE. Following this study, the Town and CSE initiated Phase 1 work which involved preliminary design of the nourishment fill and groin extensions as well as preparation of permit applications, drawings, and environmental assessment reports. Where possible, CSE utilized work completed by the US Army Corps of Engineers (USACE) for the federal storm-damage reduction project feasibility report. Specific studies generated in the planning and execution of the project include:

- CSE 2013b – Assessment of the Groin Field and Conceptual Plan for Groin Lengthening – Edisto Beach, South Carolina, 51 pp.
- TAR 2016 – Submerged Cultural Resource Remote-Sensing Survey of a Proposed Borrow Site off Edisto Island, South Carolina, 26 pp.

Additionally, a supplement to the USACE (2013) environmental assessment was completed to facilitate Section 7 consultation for the Town project.

The beach restoration and groin construction project had several objectives, including:

- Restoring a recreational beach.
- Restoring protective dunes.
- Restoring sea-turtle nesting habitat.
- Extending longevity of nourishment sand and increasing the renourishment interval.
- Protecting park infrastructure and maintaining revenues dependent on park attendance.

2.5.1 Groin Extensions

2.5.1.1 Length Analysis

Lengthening of certain groins was incorporated into the project for the primary reason of maintaining an adequate berm width to support the protective dune and beach, which aid in storm damage reduction. Essentially, several of the groins are too short to hold a beach that can withstand seasonal fluctuations in the shoreline position. The rationale and methods for the USACE groin-lengthening plan are provided in the USACE feasibility study (Section 9 of Appendix A in USACE 2013).

CSE completed an independent, groin-lengthening feasibility study in 2013 (CSE 2013a,b), obtaining two alternatives for lengthening. One alternative was based on an ideal beach profile (similar in nature to the USACE method, but using a more substantial beach profile), while the other was based on comparison of the widths of vegetated areas and existing groin conditions (Fig 2.10).

The applicant also received input from local citizens and the Town's Beachfront Management Committee. Results of the above-referenced studies were compiled into a proposed groin lengthening plan, which called for extension of up to 26 groins at a cumulative total of up to 1,765 linear feet. The maximum extension for a single groin would be limited to 100 ft. CSE recommended that a minimum extension be considered for any groin to justify the expense of mobilizing equipment and material to any structure.

The original groins were built by South Carolina Department of Transportation (SCDOT) and were constructed solely of timber with a typical slope of ~1 on 50. Deterioration of the timber led to the addition of armor stone and, in some cases, overall shortening of some groins. A 1995 project (P/N 94-1T-009-P) restacked loose stone and added grout in the void spaces to make a monolithic structure, but did not lengthen the groins. The extension design attempted to adjust the profile of the groins to match modern design guidelines, which include a beach-face section sloping to match the native beach and horizontal low-tide-terrace section (Figs 2.11–12). The slope of the extension was determined by the length of each extension and the existing profile of each groin, seeking to match the native beach to the maximum extent practicable (generally 1 on 15 to 1 on 20). The final lengths for the extended groins as constructed were 1,630 ft. Table 2.2 shows the final constructed extension length and material for each groin.

Per state regulations, enough sand to meet or exceed the trapping capacity of each extension had to be placed into the updrift (north) groin cell of any lengthened groin. Trapping capacity was determined by applying the Brunn (1952) Rule to each extension and assuming a triangular fillet extending four times the length of the extension. This method was based on recent observations at Hunting Island (SC) (Traynum et al 2010) and Folly Beach (SC) and is considered conservative (requiring more sand) as it assumes a 1 to 1 ratio of groin lengthening to increased berm width. For the maximum 100-ft individual groin lengthening, ~15,500 cy of sand are required in each applicable cell to meet the trapping capacity of the extension. If all groins are lengthened the maximum distance, the total trapping volume is ~221,000 cy.

Prior to the project, Groins 29–32 consisted of loose armor stone without grout or timber. This allowed sand to pass through the structure and resulted in slumping of the stone at Groin 29. As part of the project, the Town planned to restacked stone at Groin 29 so that the slope of the groin matched the natural slope of the beach in the area.

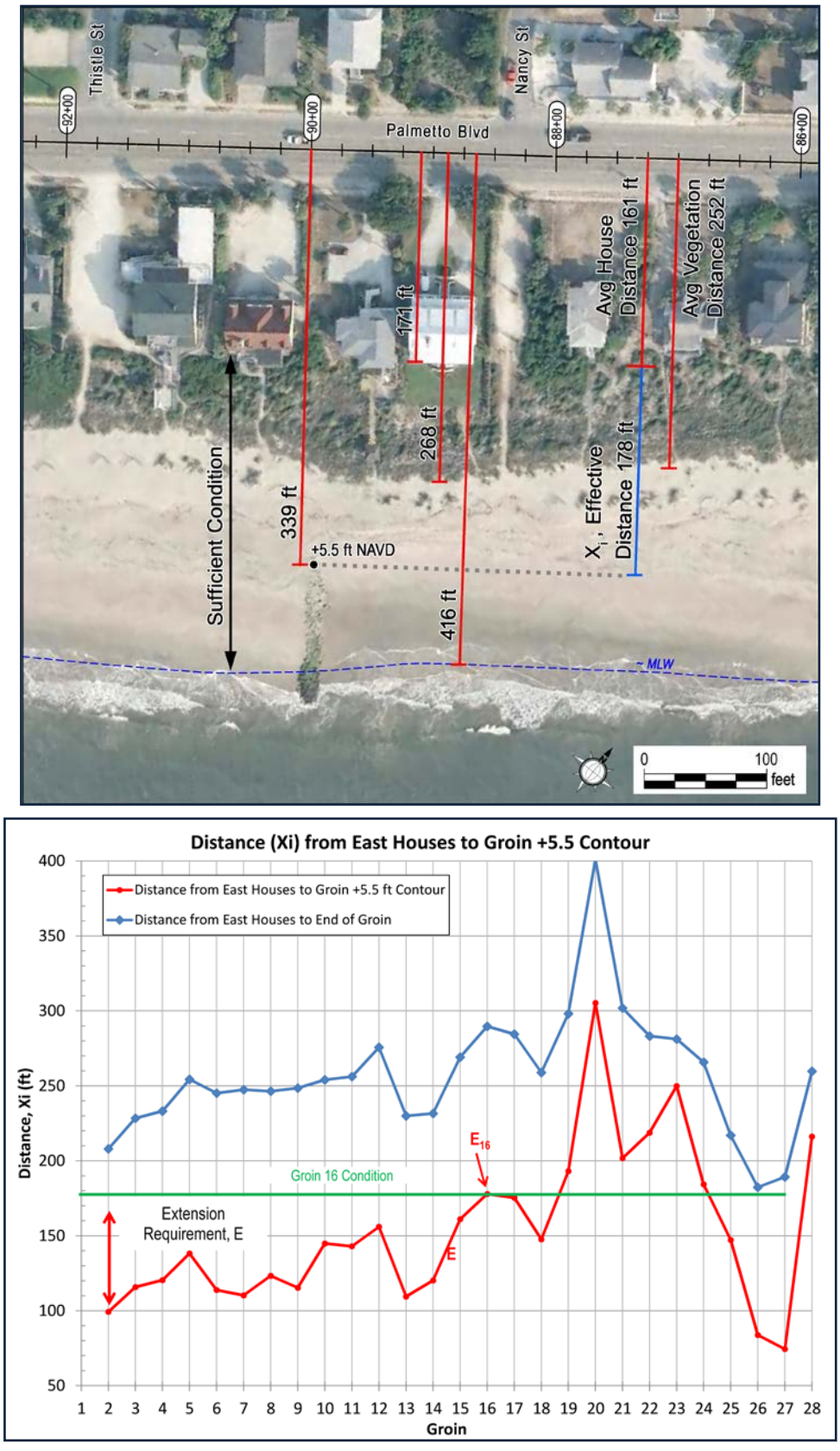
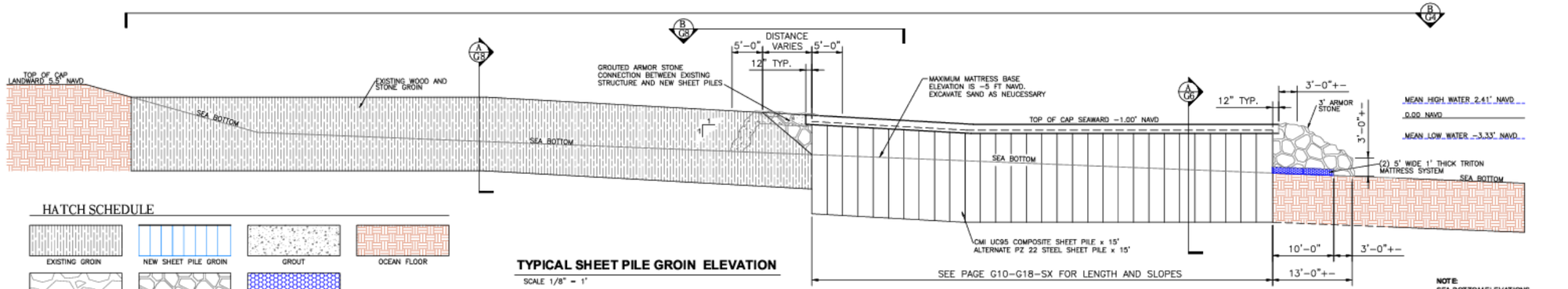


FIGURE 2.10. CSE's groin-lengthening plan was based on the condition of the beach across the island, comparing an "ideal" area at Groin 16 to other areas.

TABLE 2.2. Final constructed extension lengths and materials for the groins.

Groin No.	Estimated Maximum Extension (ft)	Extended By Sheetpile	Extended By Armor Stone
1	90	✔	
2	85	✔	
3	90	✔	
4	90	✔	
5	100	✔	
6	100	✔	
7	90	✔	
8	90	✔	
9	95	✔	
10	95	✔	
11	95	✔	
12	45		✔
13	80	✔	
14	65	✔	
15	40		✔
16	20		✔
17	20		✔
18	40		✔
19	0		
20	40		✔
21	30		✔
22	30		✔
23	30		✔
24	30		✔
25	40		✔
26	50		✔
27	50		✔
28	0		
Total	1,630	1,165	465



HATCH SCHEDULE

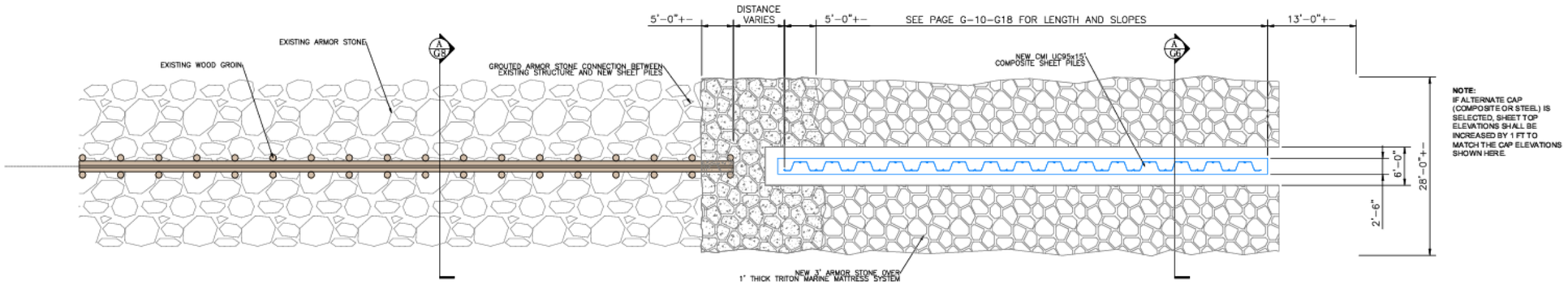
EXISTING GROIN | NEW SHEET PILE GROIN | GROUT | OCEAN FLOOR

EXISTING ARMOR STONE | NEW ARMOR STONE | TRITON MARINE MATTRESS

TYPICAL SHEET PILE GROIN ELEVATION

SCALE 1/8" = 1'

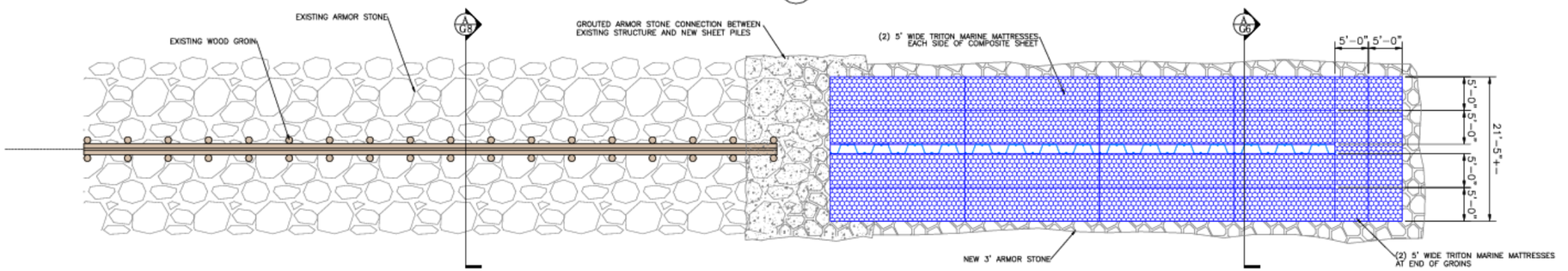
NOTE:
SEA BOTTOM ELEVATIONS VARY FOR EACH GROIN AND ON EITHER SIDE OF GROINS.



TYPICAL SHEET PILE GROIN PLAN VIEW (B / G4)

SCALE 1/8" = 1'

NOTE:
IF ALTERNATE CAP (COMPOSITE OR STEEL) IS SELECTED, SHEET TOP ELEVATIONS SHALL BE INCREASED BY 1 FT TO MATCH THE CAP ELEVATIONS SHOWN HERE.



TYPICAL SHEET PILE GROIN SECTION AT MATTRESS ELEVATION

SCALE 1/8" = 1'

NOTES:

FIGURE 2.11. Typical sheet-pile groin extension.

CLIENT:
Town of Edisto Beach
2414 Murray St
Edisto Island, SC 29438

PROJECT:
EDISTO BEACH
GROIN LENGTHENING PROJECT

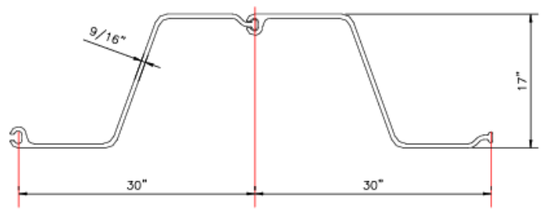
DRAWING TITLE:
TYPICAL GROIN EXTENSION

SOUTH CAROLINA No. 24737 — 4/19/16

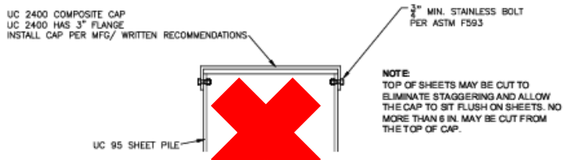
SOUTH CAROLINA No. 9134 GEORGE MICHAEL BENTLEY

SCALE:	AS SHOWN
DATE:	19 Sep 2016
DRAWN BY:	JC
APPROVED BY:	MR
PROJECT #	2416

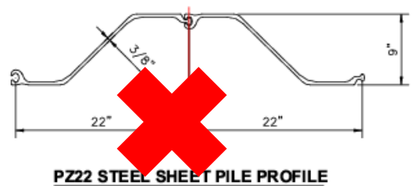
SHEET NO: **G6**



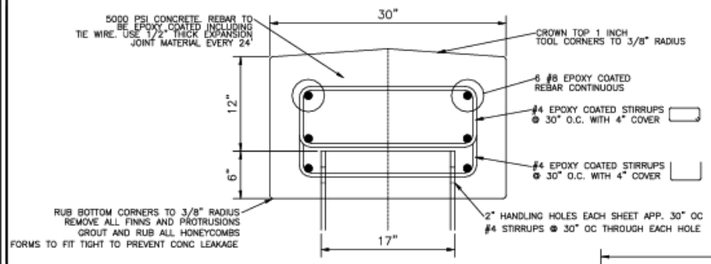
UC 95 COMPOSITE SHEET PILE PROFILE
SCALE 1 1/2" = 1'



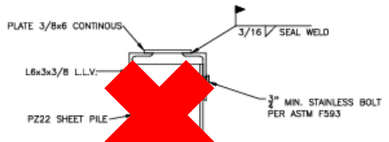
UC95 COMPOSITE CAP DETAIL B G6
SCALE 1 1/2" = 1' ALTERNATE



PZ22 STEEL SHEET PILE PROFILE
SCALE 1 1/2" = 1' ALTERNATE



UC95 CONCRETE CAP DETAIL B G6
SCALE 1 1/2" = 1'



PZ22 STEEL CAP DETAIL B G6
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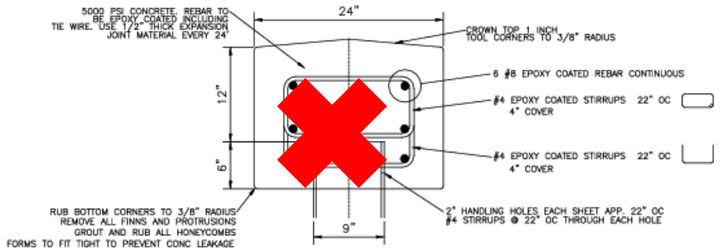
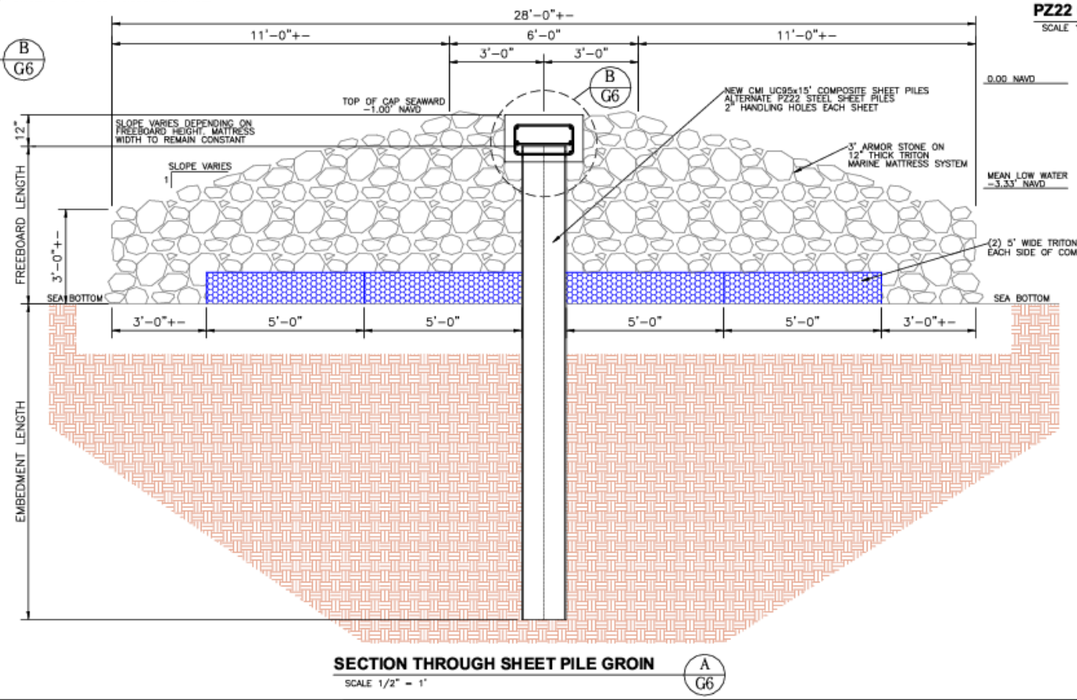


PZ22 CONCRETE CAP DETAIL B G6
SCALE 1 1/2" = 1' ALTERNATE



SECTION THROUGH SHEET PILE GROIN A G6
SCALE 1/2" = 1'

NOTE:
THE MAXIMUM ELEVATION OF THE BASE OF THE MATTRESS LAYER IS -5 FT NAVD. IF SAND LEVEL IS HIGHER THAN -5 FT NAVD, THE CONTRACTOR SHALL EXCAVATE SUFFICIENT SAND TO PLACE THE MATTRESS AT -5 FT NAVD ONCE THE SEABED REACHES ELEVATIONS LOWER THAN -5 FT, THE MATTRESS CAN REST ON THE SEAFLOOR FOLLOWING THE EXISTING CONTOURS. SAND LEVELS WILL VARY ON EITHER SIDE OF THE GROINS AND WITH NOURISHMENT PROGRESS.

CONTRACTOR MAY UTILIZE EXISTING SAND NEAR EACH GROIN AS NECESSARY TO FACILITATE CONSTRUCTION (INCLUDING CREATING TEMPORARY BERMS).

CONTRACTOR SHALL ASSUME SOME WORK MAY BE IN THE WATER FOR PORTIONS OR ALL OF A TIDAL CYCLE. NOURISHMENT ALONG THE GROIN FIELD WILL BE COMPLETE BY 27 JANUARY 2017.

NOTES:

FIGURE 2.12. Groin cap details.

CLIENT:
Town of Edisto Beach
2414 Murray St
Edisto Island, SC 29438

PROJECT:
EDISTO BEACH
GROIN LENGTHENING PROJECT

DRAWING TITLE:
GROIN CAP DETAILS

SOUTH CAROLINA PROFESSIONAL ENGINEER No. 24737 — 4/19/16

SOUTH CAROLINA PROFESSIONAL ENGINEER No. 9934 GEORGE MICHAEL MIRTL

SCALE:	AS SHOWN
DATE:	19 Sep 2016
DRAWN BY:	JC
APPROVED BY:	MR
PROJECT #	2416

SHEET NO: G8

2.5.1.2 Materials and Design

The groins were constructed using fiberglass-reinforced vinyl composite sheet pile, marine mattresses, armor stone, and concrete (see Figs 2.11–2.12). Groin extensions exceeding 60 ft were constructed using sheet pile with concrete caps and armor stone. Groin extensions of less than 60 ft were constructed using stone only; however, concrete grout was added to these groins.

The Town received bids for steel and composite sheet pile, electing to use the composite sheets for increased longevity and reduced maintenance of the piles (Fig 2.13). The sheets were model UC–95 from Crane Materials International (Atlanta GA). Each sheet was 20 ft long with a 17-inch width and 30-inch longitudinal run (meaning each pair of sheets creates a 60-inch length of wall). The sheeting is 9/16-inch-thick, fiberglass-infused vinyl that will not rust as steel sheets are prone to do. Sheets are connected via integrated channel locks running the vertical length of each sheet.

FIGURE 2.13. Staging of UC95 composite sheet piles.

Sheet piles were capped with a reinforced poured concrete cap. The design called for a 30-inch-wide by 18-inch-deep cap to cover at least the top 6 inches of each sheet. Concrete would be poured in sections up to 40 ft in length with expansion joints between sections. Six lengths of rebar ran the length of the cap, and stirrups were spaced 30 inches on center and running through handling holes of the sheets. The top of the concrete cap was crowned to improve water runoff.

South Carolina Department of Transportation (SCDOT) Class F armor stone would serve as scour protection for sheet-pile groins and would serve as the main sand-trapping component of the shorter groins when coupled with grout. Stone would generally be no larger than 3 ft along the longest axis. The stone design included a 3-ft crest width extending on either side of the cap and a slope extending a total of 13 ft on either side of the sheets. With a relatively low freeboard height and large stone sizes, the slope would be fairly insignificant along most of the stone width. Stone would also extend 13 ft past the seaward end of the sheet pile in a similar configuration.

The design called for armor stone to be placed on 1-ft-thick marine mattresses manufactured by Tensar®. The mattresses are made of a heavy-duty plastic grid woven together with UV-resistant polyrope. Mattresses would be filled with granite stone between 2 inches and 6 inches in diameter. Each mattress section is 5 ft wide and of a variable length.

2.5.2 Nourishment

2.5.2.1 Slope / Berm / Dune

The design for the nourishment portion of the project followed similar parameters as the 2006 project. The design berm elevation was set at +7 ft NAVD, similar to the natural berm elevation during normal tides. Following the 2006 project, the berm elevation increased naturally due to sand washing over the berm. CSE elected to maintain the elevation to allow this process to continue as, over time, it provides a more natural looking berm. The design berm widths ranged from 55 ft to 165 ft, generally increasing from south to north. The seaward slope of the fill was set at 1 on 10 based on the pre-project beach slope and expected grain-size distribution of the borrow material; however, the contractor was allowed to adjust the slope during construction to account for variation in sediment characteristics in the borrow area. A typical design section from Reach 1 is shown in Figure 2.14.

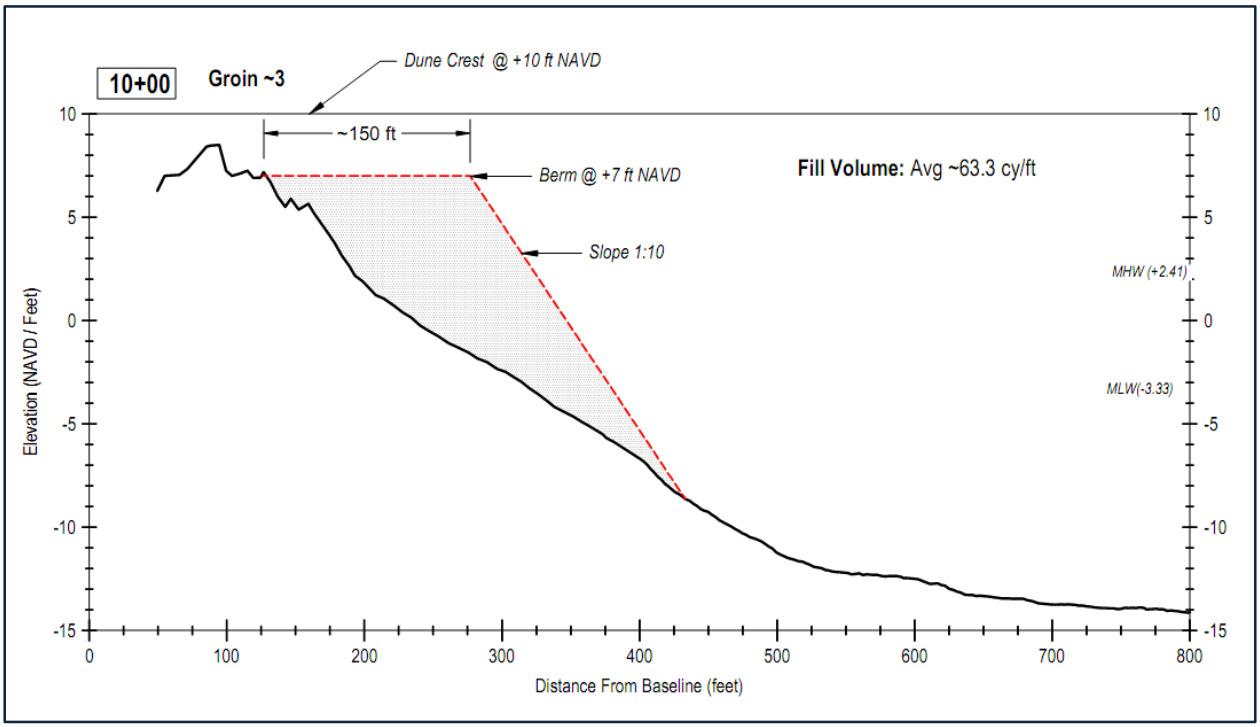


FIGURE 2.14. Typical nourishment design fill section in Reach 1. Note the dune placement is not indicated on the graphic. The contractor worked onsite with CSE to determine the best dune placement as the project progressed.

2.5.2.2 Fill Schedule

The nourishment fill schedule was determined by evaluating the existing condition of the beach and expected erosion rates for the post-project beach. As per state regulations, the fill quantities needed to ensure the trapping capacity of each groin were included in the fill design. Nourishment quantities were generated for each groin cell based on the volume of sand seaward of the structure line prior to construction. The structure line represents an average position of the seaward side of beachfront structures. Individual houses may lie landward or seaward of this line.

Figure 2.15 shows the pre-project beach volumes for each reach (blue bars) and the design nourishment fill quantity (red bars). The graphic highlights the lower beach volume in Reach 1 and Reach 2, which were both below 250 cy/ft. (See Figure 2.6 for reach limits.) The fill design accounted for the variation in existing sand volume by placing more fill in areas with less volume. Reach 4 was an exception due to the desire to have additional sand available to feed downcoast beaches. The design attempted to work within the available project budget to provide a fairly even post-project beach volume. The final design called for between 33 cy/ft and 68 cy/ft of sand to be added to each reach, which would result in each reach holding ~300 cy/ft or more sand volume. Excess sand placed in the state park and in Reach 4 would help account for "end losses," which occur in all nourishment projects as sand shifts more rapidly from the nourished to non-nourished areas.

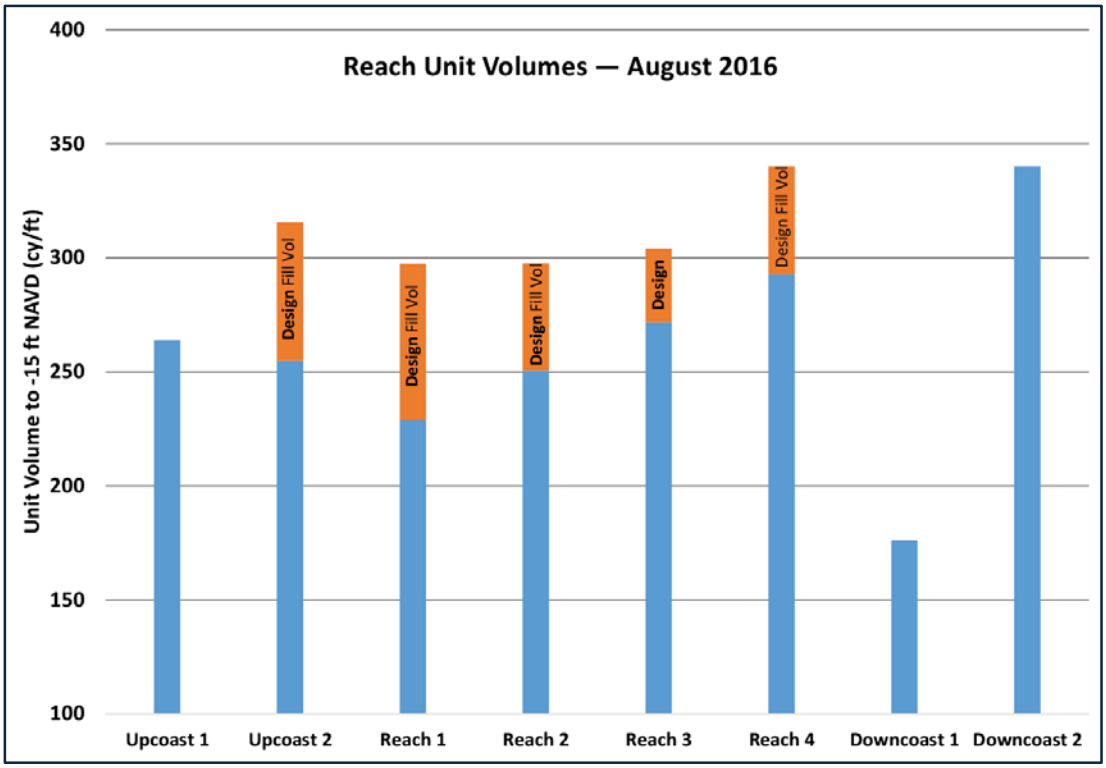


FIGURE 2.15. Pre-project and design fill volumes for the 2017 nourishment project at Edisto Beach.

Within each groin cell, the fill template would be adjusted to the site conditions at the time of the project to produce a straight seaward edge of the fill berm. Since the groins typically produce a fillet on the south side of each groin cell in the winter, more fill would be needed on the north side to produce a consistent final beach width.

2.5.2.3 Borrow Area

For planning purposes, CSE sought to identify a borrow area containing at least 1.5 million cubic yards of beach-compatible material. Providing excess material in the designated borrow areas allows the contractor to account for handling losses and relocate to other areas if unsuitable material is encountered. CSE utilized data collected as part of the federal feasibility study (USACE 2013) to identify a potential borrow area for the USACE project (Fig 2.16). That project included collection of ~100 borings and collection of detailed bathymetry stretching from Otter Island to Deveaux Bank. CSE provided the data to the USACE for development of a borrow area holding sufficient sand volume for a 50-year federal project. The level of coverage was intended to provide a general assessment of sediment resources; however, it was not sufficient for final design purposes.

For the final design of the locally funded project, CSE obtained an additional ~25 borings at the northwestern end of the USACE search area. Figure 2.17 shows the location of the final borrow areas identified for the project. Borrow Area A and the western portion of Area B were the original primary borrow areas identified; however, between initial the survey completed in 2014 and another survey in 2016, the area northeast of Area B (portion of the 2006 borrow area) infilled substantially with clean beach-compatible sand. A permit modification was obtained to allow this area to be included in the 2017 project.

CSE sampled each boring to determine the grain size distribution of the sediment and the amount of shell material present. The borrow areas were determined based on these sediment characteristics, as well as consideration of the sediment color. Figure 2.18 is an example core log showing the typical data utilized for confirming suitable borrow material. The final borrow areas were drawn around a group of 17 borings (Borrow Area A) and 12 borings (Borrow Area B) located landward (northwest) of the USACE-identified borrow area (see Fig 2.17). Table 2.3 provides the sediment characteristics for the borrow areas. Borrow Area A showed a mean grain size of 0.719 millimeters (mm) with 31 percent shell content. Borrow Area B contained finer sand with an average grain size of 0.656 mm and 26.7 percent shell content. These averages were skewed by a few borings, which showed a higher average grain size due to higher shell concentrations.

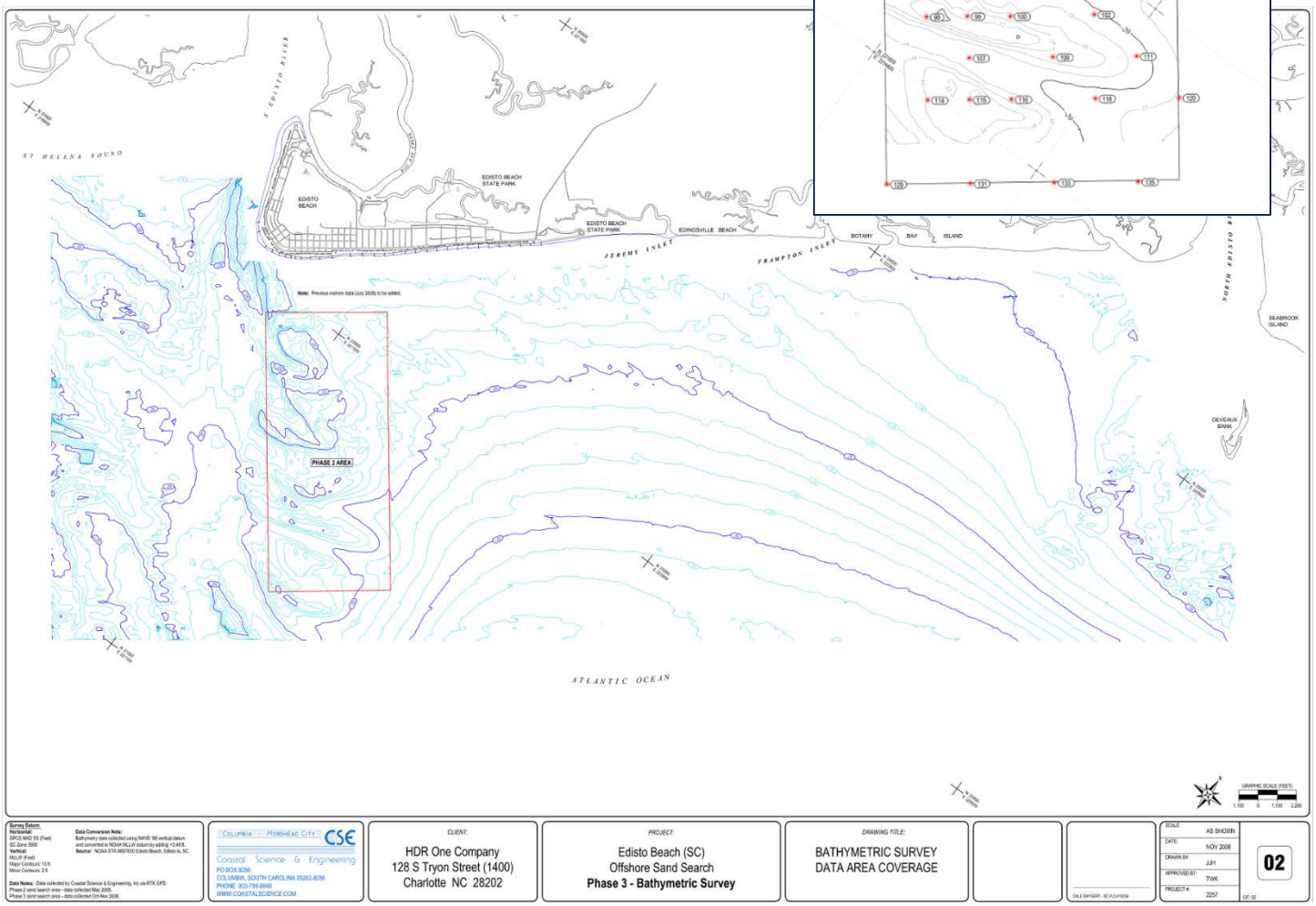
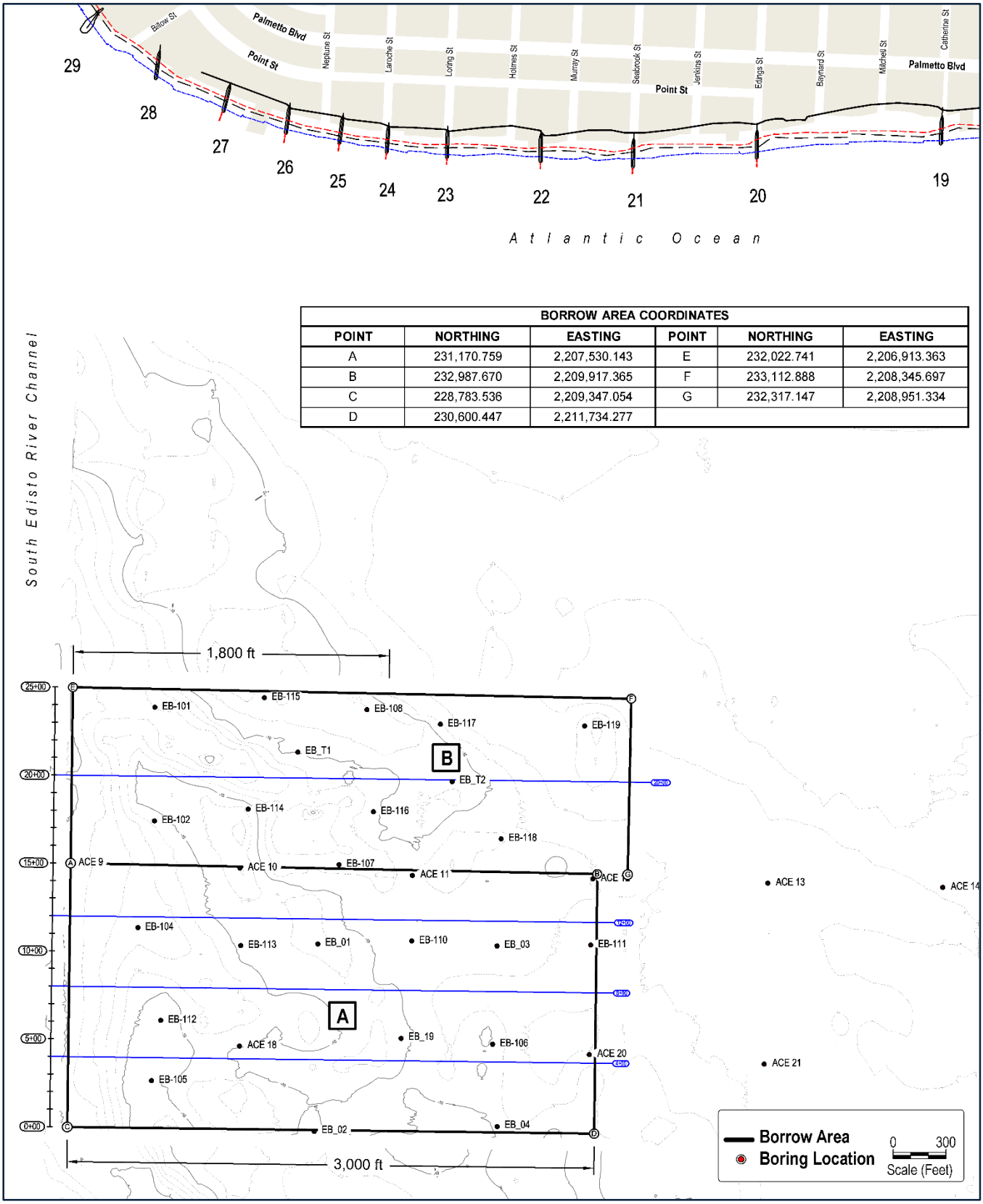


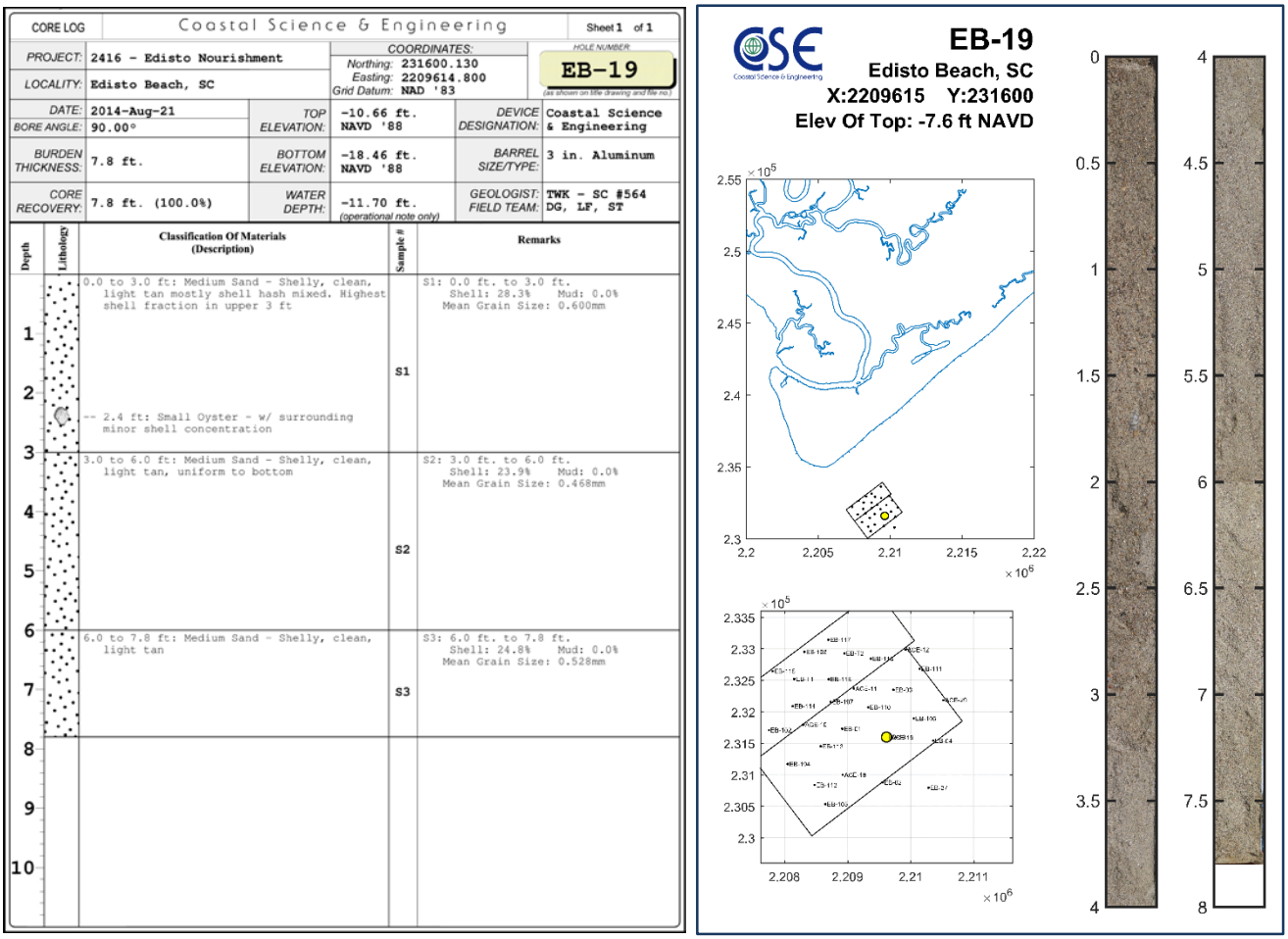
FIGURE 2.16.

Bathymetric map (lower) and boring location map (right) produced as part of the geotechnical investigations for the USACE (2013) federal feasibility study.



BORROW AREA COORDINATES					
POINT	NORTHING	EASTING	POINT	NORTHING	EASTING
A	231,170.759	2,207,530.143	E	232,022.741	2,206,913.363
B	232,987.670	2,209,917.365	F	233,112.888	2,208,345.697
C	228,783.536	2,209,347.054	G	232,317.147	2,208,951.334
D	230,600.447	2,211,734.277			

FIGURE 2.17. Map showing boring locations and borrow area limits for the 2017 project at Edisto Beach. Borrow Area B was also used in 2006 and has infilled with beach-compatible sand.



CORE LOG — Coastal Science & Engineering — Sheet 1 of 1

PROJECT:	2416 – Edisto Nourishment	COORDINATES: Northing: 231600.130 Easting: 2209614.800 Grid Datum: NAD '83		HOLE NUMBER: EB-19 (as shown on title drawing and file no.)	
LOCALITY:	Edisto Beach, SC				
DATE:	2014-Aug-21	TOP ELEVATION:	-10.66 ft. NAVD '88	DEVICE DESIGNATION:	Coastal Science & Engineering
BORE ANGLE:	90.00°				
BURDEN THICKNESS:	7.8 ft.	BOTTOM ELEVATION:	-18.46 ft. NAVD '88	BARREL SIZE/TYPE:	3 in. Aluminum
CORE RECOVERY:	7.8 ft. (100.0%)	WATER DEPTH:	-11.70 ft. (operational note only)	GEOLOGIST: FIELD TEAM:	TWK – SC #564 DG, LF, ST

Depth	Lithology	Classification Of Materials (Description)	Sample #	Remarks
1–2		0.0 to 3.0 ft: Medium Sand – Shelly, clean, light tan mostly shell hash mixed. Highest shell fraction in upper 3 ft	S1	S1: 0.0 ft. to 3.0 ft. Shell: 28.3% Mud: 0.0% Mean Grain Size: 0.600mm
2		-- 2.4 ft: Small Oyster – w/ surrounding minor shell concentration		
3–5		3.0 to 6.0 ft: Medium Sand – Shelly, clean, light tan, uniform to bottom	S2	S2: 3.0 ft. to 6.0 ft. Shell: 23.9% Mud: 0.0% Mean Grain Size: 0.468mm
6–7		6.0 to 7.8 ft: Medium Sand – Shelly, clean, light tan	S3	S3: 6.0 ft. to 7.8 ft. Shell: 24.8% Mud: 0.0% Mean Grain Size: 0.528mm
8–10				

FIGURE 2.18. Example boring log showing the sediment characteristics of a portion of the borrow areas. Data like these were used to identify the borrow areas for the project.

TABLE 2.3. Borrow area sediment characteristics. Gravel is considered any sediment/shell greater than 2 mm in size.

		Mean Grain Size	STD	Shell	Gravel
Sample	Interval	mm		%	%
EB-1-1	Composite	1.510	0.366	53.9	34.4
EB-2-1	Composite	0.239	0.583	10.0	2.0
EB-3-1	Composite	0.475	0.324	28.9	11.0
EB-4-1	Composite	0.584	0.257	15.3	23.4
EB-19-1	Composite	0.600	0.491	25.8	5.6
EB-104	Composite	0.854	0.392	32.9	16.8
EB-105	Composite	1.226	0.495	26.3	20.7
EB-106	Composite	0.225	0.526	20.7	1.5
EB-110	Composite	0.447	0.410	45.4	5.9
EB-111	Composite	0.617	0.291	28.0	18.2
EB-112	Composite	1.077	0.458	58.0	20.2
EB-113	Composite	0.779	0.531	26.6	7.7
EB-101	Composite	0.919	0.315	9.3	24.6
EB-102	Composite	0.953	0.498	50.4	18.6
EB-107	Composite	0.759	0.516	33.8	7.7
EB-108	Composite	0.258	0.500	9.5	2.8
EB-114	Composite	1.110	0.488	48.9	18.1
EB-115	Composite	0.299	0.592	8.0	0.7
EB-116	Composite	1.136	0.425	24.2	22.6
EB-117	Composite	0.213	0.583	27.4	1.4
EB-118	Composite	0.399	0.466	23.5	4.4
EB-119	Composite	0.657	0.596	27.1	3.8
T-101-1	Composite	1.006	0.395	36.5	21.0
T-102-1	Composite	0.160	0.750	22.1	0.1
Borrow Area A	Average	**0.719**	**0.427**	**31.0**	**13.9**
Borrow Area B	Average	**0.656**	**0.510**	**26.7**	**10.5**

2.6 Permitting

The Town and CSE initiated permitting in 2014, beginning with a pre-application interagency meeting in October. CSE prepared a joint permit application and submitted it to the agencies in April 2015. CSE received comments from environmental resource agencies and interested parties, responding to the comments in October 2015. Additional correspondence was provided during the permitting phase to individual homeowners or other parties. On 10 September 2015, CSE provided the USACE a supplement to the existing environmental assessment [created as part of the USACE (2013) federal study]. This would allow US Fish and Wildlife Service (USFWS) to revise the biological opinion (BO) that was provided for the federal study with the updated project information for the local project. USFWS (2016) issued a BO for the local project on 21 January 2016. The Town received a permit from SCDHEC–OCRM on 26 May 2016, and the USACE permit followed on 19 August 2016. The permits are provided in Appendix A.

Following Hurricane *Matthew* in October 2016, the Town requested a permit modification to allow for additional sand volume, additional borrow area acreage, and an extended construction window for groin work. The permit modification would allow the total project volume to increase from 835,000 cy to 1.1 million cubic yards. The USACE issued an approval for the requested changes on 30 November 2016, and SCDHEC–OCRM issued a revised permit on 15 December 2016.

A final modification was requested on 17 February 2017 that would allow for installation of sand fencing and vegetation following construction. CSE prepared a modification request letter and drawings showing the details of the sand-fence installation. The modification would allow installation of fencing and vegetation over the full 19,000 linear feet of beach within the project area.

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3.0 PROJECT IMPLEMENTATION

3.1 Bidding

CSE prepared a bid specification package and plan drawings for the project. Bids were released to the public on 19 September 2016 that contained separate packages for the groin and nourishment projects. Mandatory pre-bid conferences were scheduled for 28 September for each project, and bids were scheduled to be due on 11 October. Hurricane *Matthew* impacted the beach around 8–10 October, and CSE and the Town elected to postpone the bid opening until the damage could be assessed and any modifications to the project scope or design could be determined. An optional pre-bid meeting and site visit were held on 9 November 2016 to enable contractors to view the post-*Matthew* beach. Bids were opened on 16 November 2016 at Edisto Beach Town Hall.

One bid was received for the groin extension project. Crowder Construction Company bid a total of $5,324,000 for the full scope of groin repair. This included extending a total of 26 groins (13 by composite sheet pile and 13 by grouted armor stone). The following unit prices were agreed to by Crowder for modifications for quantities and progress payments:

15-ft-long Composite Sheet Piles	$450/lf
20-ft-long Composite Sheet Piles	$550/lf
30-inch-wide Concrete Cap	$265/lf
Armor Stone	$90/ton
Marine Mattress	$17/sq ft
Concrete Grout	$650/cy
Repair Work	$200/hr

Two bids were received from dredging contractors, Great Lakes Dredge and Dock (Oak Brook IL) and Marinex Construction (Charleston SC). The bids were similar in total price for the maximum potential project quantity; however, the budget for nourishment limited the scope of the project. After considering the cost of the groin repair, the Town had a nourishment budget of $11.7 million. Table 3.1 provides a summary of the project scenarios possible for each contractor given the provided bids. Marinex was the low bidder at that budget with a total volume of 896,000 cy possible. GLDD would allow for 846,000 cy at the same price. CSE recommended the Town award the project to Marinex to allow for the greatest volume of sand to be placed. Following the notice of award, Marinex offered to provide an additional 60,000 cy of sand at no cost to the Town. The Town and Marinex signed an agreement for a 956,000-cy project for a total lump-sum price of $11,698,780. Table 3.1 (lower) provides the final fill plan as specified in the agreement. Figure 3.1 shows the contract fill plan (prior to any change orders).

TABLE 3.1. Bid prices and cost scenarios for nourishment. The cost scenarios assumed a budget of $11.7 million. At that budget, Marinex was able to place a higher quantity of sand. Following contract award, Marinex offered to increase the contract quantity at no coast as shown in the adjusted fill quantity in the bottom table.

Edisto Beach Bid Tabulation						
Nourishment Project						
Bidder	Mobilization ($)	Base Bid Lump Sum Price ($)	Alt - Park Unit Price ($/cy)	Alt Reach 1 Unit Price ($/cy)	Alt Reach 2 Unit Price ($/cy)	Alt Reach 3-4 Unit Price ($/cy)
GLDD	4,258,000	5,580,000	10.30	7.50	7.90	5.50
Marinex	2,683,900	6,053,400	10.74	10.23	9.36	9.62

Nourishment Scenarios for Nourishment Budget of $11.7 Million.

Marinex Final Plan	Length (ft)	Base Quantity (cy)	Alternate Quantity (cy)	Alt Fill Density (cy/ft)	Total Fill Density (cy/ft)	Base Price ($)	Alt Price ($)	Total Price ($)
Park	3,300	150,000	35,000	10.6	56.1	1,513,350	375,900	1,889,250
Reach 1	6,000	220,000	146,000	24.3	61.0	2,219,580	1,493,580	3,713,160
Reach 2	3,000	80,000	55,000	18.3	45.0	807,120	514,800	1,321,920
Reach 3	5,100	100,000	50,000	9.8	29.4	1,008,900	481,000	1,489,900
Reach 4	1,900	50,000	10,000	5.3	31.6	504,450	96,200	600,650
Total	19,300	600,000	296,000	15.3	46.4	6,053,400	2,961,480	9,014,880
		Total CY	**896,000**				Mobilization ($)	2,683,900
							Project Total ($)	**11,698,780**

GLDD Final Plan	Length (ft)	Base Quantity (cy)	Alternate Quantity (cy)	Alt Fill Density (cy/ft)	Total Fill Density (cy/ft)	Base Price	Alt Price	Total Price
Park	3,300	150,000	35,000	10.6	56.1	1,395,000	360,500	1,755,500
Reach 1	6,000	220,000	110,000	18.3	55.0	2,046,000	825,000	2,871,000
Reach 2	3,000	80,000	50,000	16.7	43.3	744,000	395,000	1,139,000
Reach 3	5,100	100,000	45,000	8.8	28.4	930,000	247,500	1,177,500
Reach 4	1,900	50,000	6,000	3.2	29.5	465,000	33,000	498,000
Total	19,300	600,000	246,000	12.7	43.8	5,580,000	1,861,000	7,441,000
		Total CY	**846,000**				Mobilization ($)	4,258,000
							Project Total ($)	**11,699,000**

FINAL FILL PLAN

	Base Bid Quantity	Alternate Bid Quantity	Adjusted Quantity	Total Fill Quantity	Change Order Quantity	Final Project Quantity
State Park	150,000	35,000	15,000	200,000		200,000
Reach 1	220,000	146,000	14,000	380,000	30,000	410,000
Reach 2	80,000	55,000	6,000	141,000		141,000
Reach 3	100,000	50,000	15,000	165,000		165,000
Reach 4	50,000	10,000	10,000	70,000	20,072	90,072
Total	**600,000**	**296,000**	**60,000**	**956,000**	**50,072**	**1,006,072**

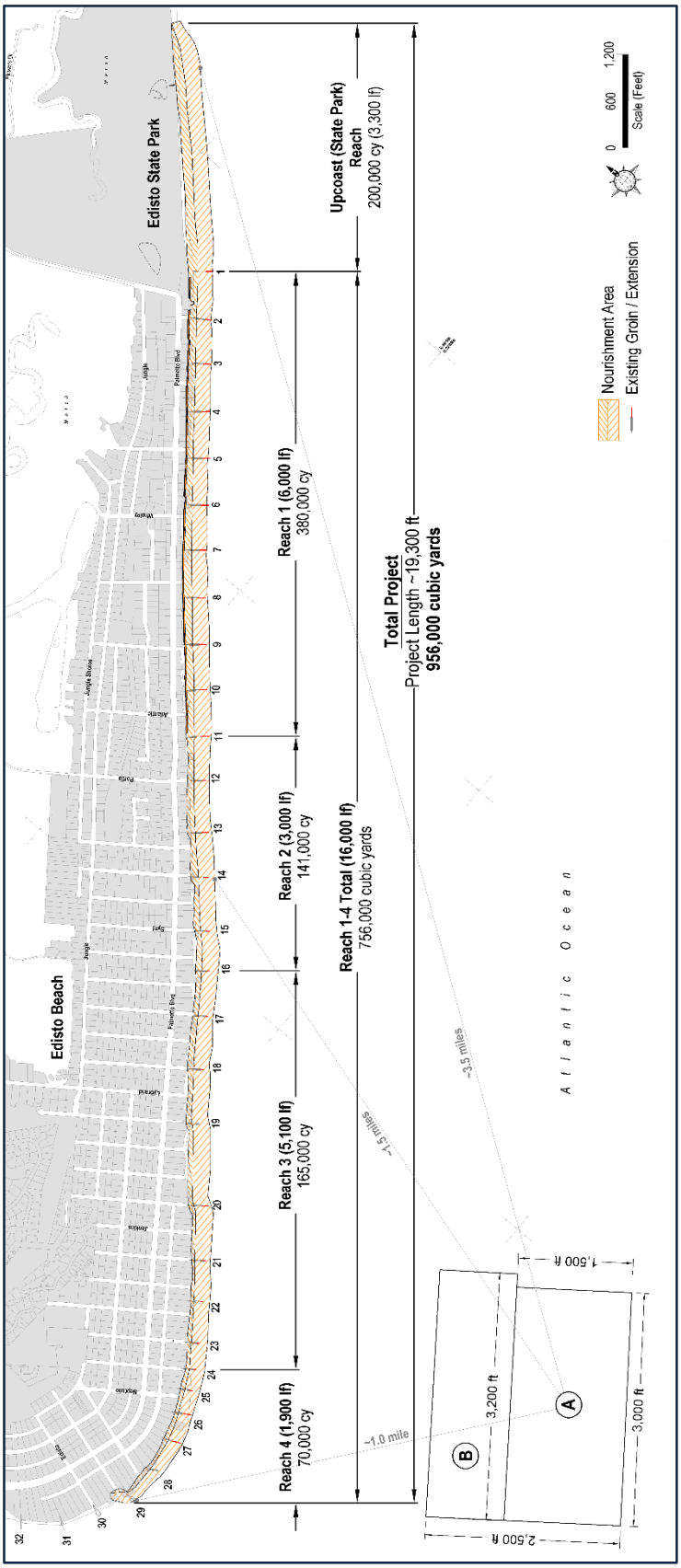

FIGURE 3.1. Contract fill plan (prior to any change orders).

3.2 Nourishment

Mobilization for the nourishment project began on 4 January 2017 with delivery of a bulldozer to the beach. Additional equipment continued to arrive over the next several days, along with the first shore pipe on 7 January. Marinex focused delivery of equipment and pipe near the 500 block, and effort was made to ensure that material was staged off vegetated areas (Fig 3.2). A total of ~10,000 lf of shore pipe was mobilized to the beach. The dredge *Savannah* arrived at Edisto Beach on 16 January and staged along the South Edisto River. Pumping started the night of 25–26 January in the 500 block between Groins 9 and 10. The initial work sought to build a "pad," which is a broad platform used as a landing site for the subline and begins the berm at the design elevation. Once the pad was complete, pipe was placed on the new berm directed to the north to begin the normal fill plan (Fig 3.3).

FIGURE 3.2.

[UPPER] The dredge, *Savannah*, offshore of Edisto Beach. **[MIDDLE]** Shore pipe staged prior to first pumping. **[LOWER]** The subline that connects the dredge to the beach comes ashore between Groin 9 and Groin 10.

FIGURE 3.3. **[UPPER LEFT]** Early in the nourishment project, showing the subline coming onshore and the nourishment fill moving north. **[CENTER RIGHT]** The active fill area showing slurry coming from the discharge pipe. **[CENTER LEFT]** A tug towing new 500-ft sections of plastic shore pipe to the beach. **[LOWER RIGHT]** Fill in the state park area.

Nourishment progressed in a northerly direction with production of up to 27,000 cy per day. Typical daily averages ranged from 15,000 cy to 20,000 cy per day. Weather and mechanical delays are typical of any dredging project and periodically reduced daily production or forced the dredge to return to the river. Marinex would construct temporary dikes to keep nourishment sand in the upper beach profile, especially as they approached each groin (see Fig 3.3). The project reached the state park on 19 February 2017. Work continued north through the state park through 7 March.

Following completion of the state park, Marinex repositioned the subline to the beach between Groins 19 and 20 (near Baynard Street). Pumping resumed on 9 March, building a new pad. Marinex initially pumped sand to the north, reaching Groin 18 before switching back and pumping south. Work continued south to the southern end of the project at Groin 30 (Edisto Street), reaching it on 28 March (Fig 3.4).

FIGURE 3.4. **[LEFT]** The completed beach at the state park. **[RIGHT]** Fill progress around Groin 27 at "The Point."

The last area of beach to be filled was the area between Groins 9 and 18. Marinex continued working to the north from where they previously left off at Groin 18. The final pumping occurred on 14 April 2017 where the original subline was placed between Groins 9 and 10. A total of 79 working days were required for placement of the 1,006,072 cy fill volume. Production averaged ~12,700 cy per day including all weather and mechanical delays. Marinex submitted daily construction logs that included information on estimated production and delays, quantities and locations of discharge pipe, and weather information (Appendix B). Before and after photos are shown in Figure 3.5.

FIGURE 3.5 (page 1 of 2). Before (left) and after (right) images of the beach nourishment project at Edisto Beach (SC). **[UPPER]** Edisto State Park area. **[LOWER]** Reach 1.

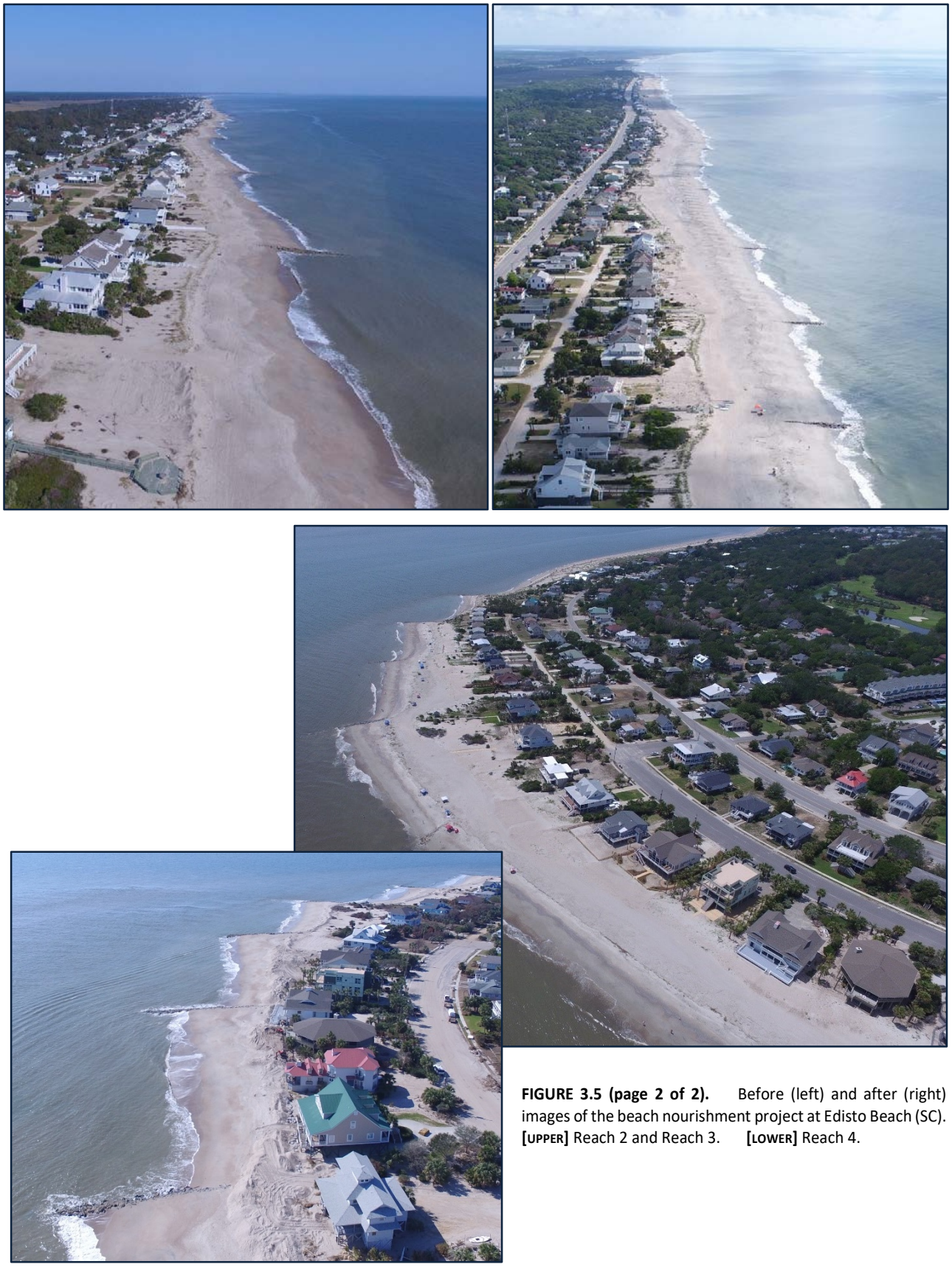

FIGURE 3.5 (page 2 of 2). Before (left) and after (right) images of the beach nourishment project at Edisto Beach (SC). **[UPPER]** Reach 2 and Reach 3. **[LOWER]** Reach 4.

Sand was dredged from the permitted borrow areas. The limit for dredging was −20 ft NAVD, which resulted in a thickness of cut of up to 14 ft. The dredge would shift within the borrow area if unsuitable material was present, which only occurred when higher-than-anticipated shell content was observed in the discharge. Overall, the material met expectations from pre-project borings in the borrow area. Details on grain-size characteristics of the fill material are provided in Section 5.

3.3 Groins

The groins extension portion of the project began with mobilization of equipment in December 2016. The contractor used the beach access and adjacent empty lot at the 800 block for the majority of staging and also used the old parking lot adjacent to Finn's Restaurant for initial mobilization and staging of stone. The first material delivery was a load of stone on 3 January 2017, and Crowder immediately began working on repairing Groin 4 by adding additional stone along the trunk section of the structure (Fig 3.6). Crowder completed repair work on Groins 1, 2, 4, 28 and 29 between 3 and 12 January. Repairs were completed by restacking loose stone or adding additional armor stone. Grout was added to Groins 1, 2, and 28 to hold the stones in place.

FIGURE 3.6. Before (left) and after (right) images of the beach nourishment project at Edisto Beach (SC). **[UPPER]** Reach 2 and Reach 3. **[LOWER]** Reach 4.

Material for the mattresses arrived on site beginning 16 January 2017. Crowder subcontracted with JLS (Kennesaw GA) to fill and tie the mattresses. The mattresses (manufactured by Tensar®) consisted of a plastic grid held together by UV-resistant polyrope. Mattresses were filled with stone typically 4–6 inches in size. To fill the mattresses, JLS would tie three sides of each ~20-ft-long unit and position the mattress on a rotating table. The mattress would be rotated vertically, and rocks would be placed in the opened end of each cell (Fig 3.7). Once filled, the top side would be tied closed, and the mattress would be rotated horizontally and

lifted from the table with a long-reach forklift. Filled mattresses were stockpiled in staging areas near each groin.

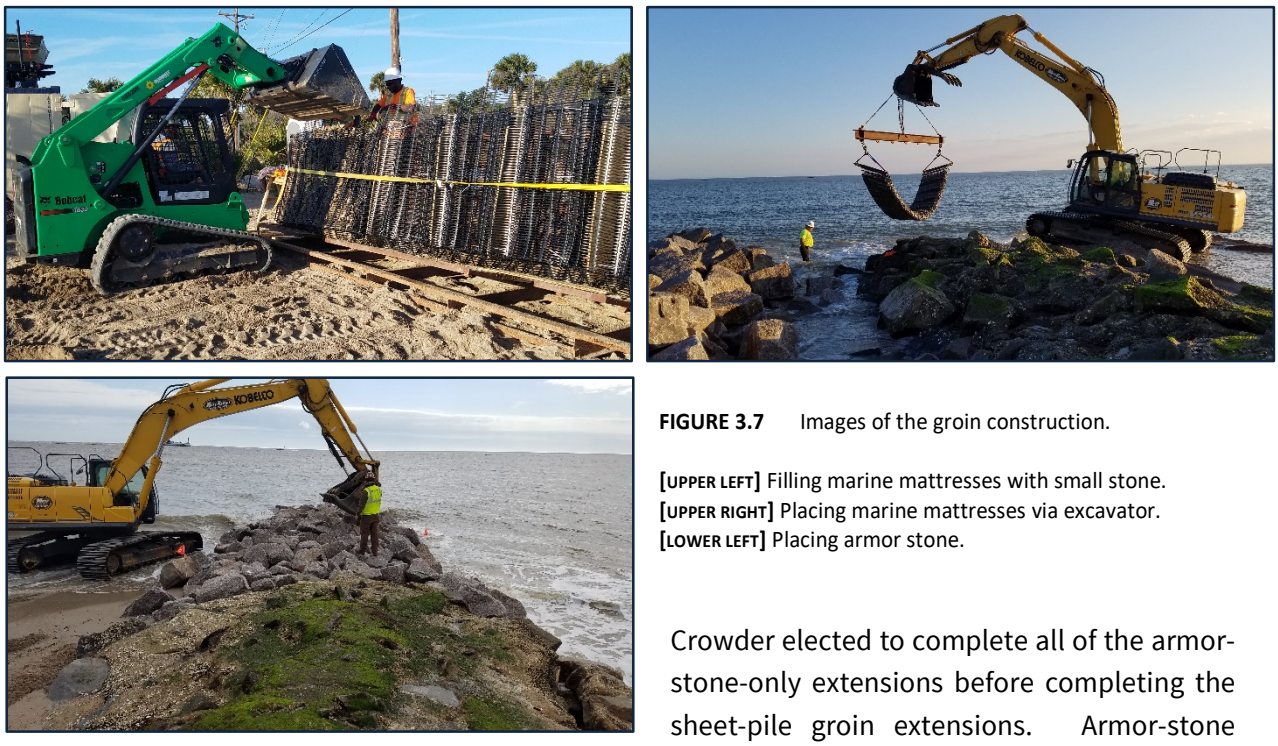

FIGURE 3.7 Images of the groin construction.

[UPPER LEFT] Filling marine mattresses with small stone.
[UPPER RIGHT] Placing marine mattresses via excavator.
[LOWER LEFT] Placing armor stone.

Crowder elected to complete all of the armor-stone-only extensions before completing the sheet-pile groin extensions. Armor-stone groins were extended by excavating sand to the design depth, then placing mattresses with an excavator or crane. Once the mattresses were in place, armor stone was placed to the design grade using an excavator. All mattresses were completed by 12 February 2017, which was also the last day of stone additions to the armor-stone-only groins. Crowder added grout to the armor-stone-only groins as weather, tides, and availability allowed.

The installation of sheet-pile groins began on 13 February at Groin 9. Crowder elected to begin at the landward end of the extension and initially used a moveable platform as a guide to drive the sheets; however, they quickly determined that a more robust template would be required to accurately drive the sheets. Crowder constructed a new form out of I–beams that would surround the sheet piles on two sides as they were being driven. The first sheets were driven using the excavator, which proved to be difficult with the composite sheets, as any variation from vertical would result in cracking of the top of the sheet. Crowder switched the vibratory hammer to the crane, and sheet driving improved. Crowder would drive a series of sheets until they reached the end of the template, and then would shift the template seaward (Fig 3.8). Once all of the sheets were driven to an elevation near mean sea level, the operators would drive the sheets to the final grade, checking elevations with a rod and level.

FIGURE 3.8. **[UPPER]** Installation of UC–95 composite sheets. **[LOWER]** Installation of marine mattress at the end of a sheet-pile groin.

Following installation of the sheet pile, Crowder placed mattresses and a portion of the armor stone alongside the sheets. Once the armor stone was at an elevation near the bottom of the concrete cap design, Crowder placed forms around the tops of the sheets in preparation for pouring the concrete caps (Fig 3.9). Concrete pours needed to occur during periods of lower-than-average tides and very calm weather to prevent the concrete from washing away before it could cure. Once the concrete was poured, workers shaped a crown on the surface and the forms were left in place for at least 24 hours to allow the concrete to cure. Once the concrete was cured and the forms were removed, Crowder added additional armor stone to bring the section to the design grade. At that point, the groin extension was complete (Fig 3.10). Generally, multiple groin extensions were being constructed at any given time.

Crowder completed the groin extension work on 12 June 2017 and began demobilizing equipment from the beach. Daily construction logs are included in Appendix C. The majority of equipment, including the crane, were removed by 15 June. Crowder rebuilt the dune in front of their worksite at Beach Access 8 and cleaned the worksite to complete demobilization.

FIGURE 3.9. **[UPPER]** Pouring concrete into the forms. Note the epoxy-coated rebar (green). **[LOWER]** Aerial view of groin construction at Groin 2.

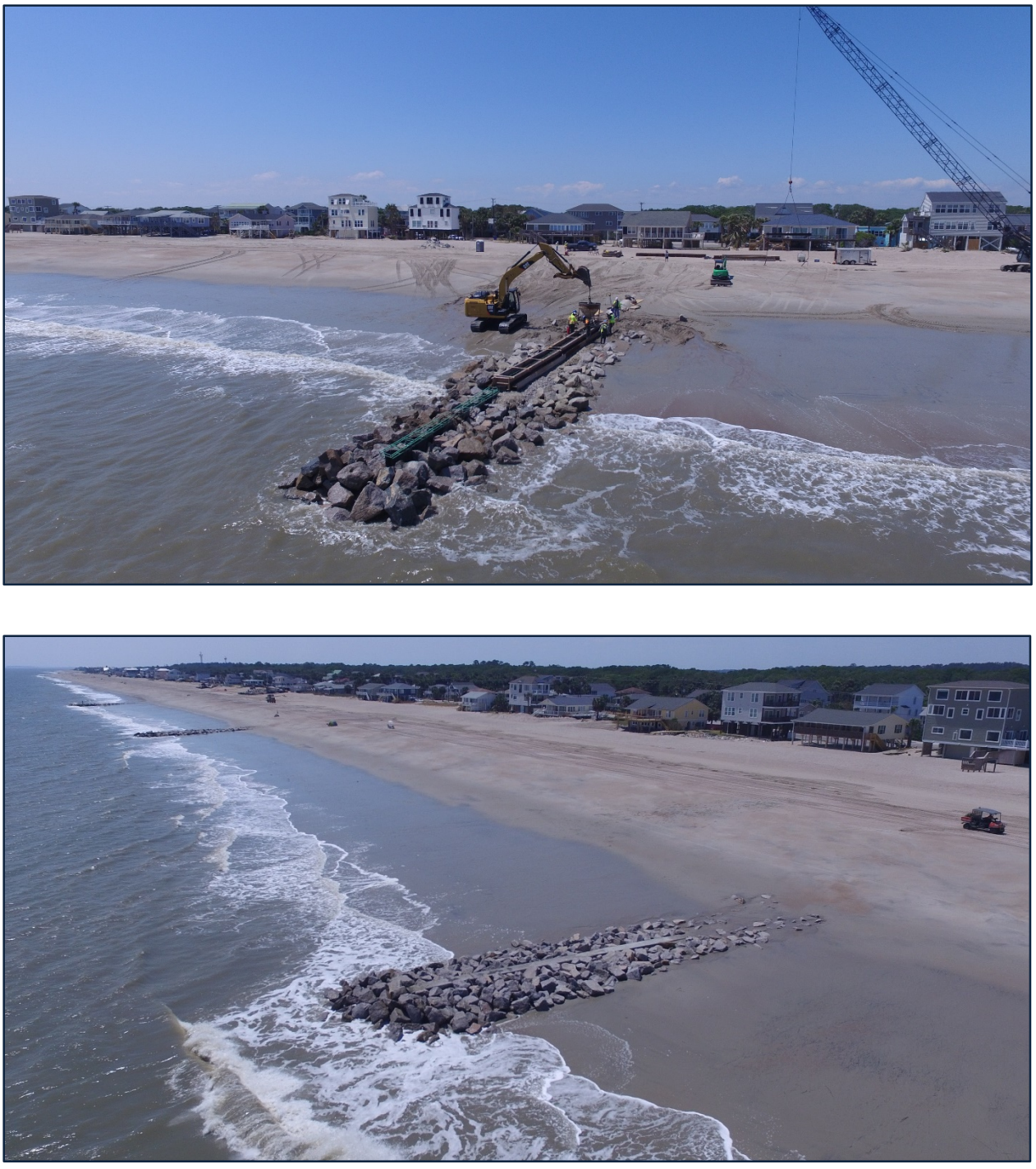

FIGURE 3.10. **[UPPER]** Pouring concrete cap on the landward end of groin extension. **[LOWER]** Completed extensions for Groin 7 (foreground), Groin 8 (middle), and Groin 9 (background).

4.0 SURVEYS AND AS BUILTS

4.1 Nourishment

Surveys before and after fill placement (BD – Before Dredging; AD – After Dredging), were completed by the contractor as the work was being completed. These surveys were used to determine payment quantities and to track fill progression according to the design volumes. Survey data were collected every 100 ft along the fill area and extended landward and seaward of the fill limits. Marinex provided cross-section profiles and x-y-z data to CSE for confirmation of volume calculations. For payment purposes, compensating slopes were allowed, which means that the contractor is credited for sand placed beyond the design template to account for a steeper slope of the fill material. The overall design section volume may not exceed 10 percent above the design quantity per project specifications. The complete set of BD/AD cross-sections is provided in Appendix D.

The BD/AD survey data show a total of 1,176,209 cy of sand were added to the beach during the project; however, the payment quantity was capped at 1,006,000 cy. Any additional sand was not included in payment calculations.

CSE completed additional BD and AD surveys to use as final design (BD) and pre-project baseline conditions for future project monitoring. CSE obtained profile data including three profiles per groin cell from Groins 1 to 22, and two profiles per groin cell from Groins 23 to 31. Additional data were collected along the state park at 300-ft intervals and along the South Edisto River shoreline. The BD survey served as the basis for final design and was collected following Hurricane *Matthew* in December 2016. AD survey data were collected in April 2017 following nourishment.

Appendix E shows CSE's BD and AD survey data as well as the 2006 post-nourishment condition. CSE computed volume for each profile using custom software, and calculated volumes for each groin cell and for the eight monitoring reaches identified in previous reports to the Town (Fig 4.1). Volumes from before and after the 2006 project are also provided for reference. The increase in volume is shown by the difference between the red (pre-project) and black (post-project) lines, and tabular data are provided in Table 4.1. Unit volumes for each station are shown in Figure 4.2. Fill volumes ranged from ~30 cy/ft to ~80 cy/ft with a few higher values due to isolated overpumping. **Overall, CSE data shows a net gain of 1,096,176 cy between December 2016 and April 2017.** This volume accounts for any background erosion occurring during the survey interval and compares well with the contractor BD/AD surveys.

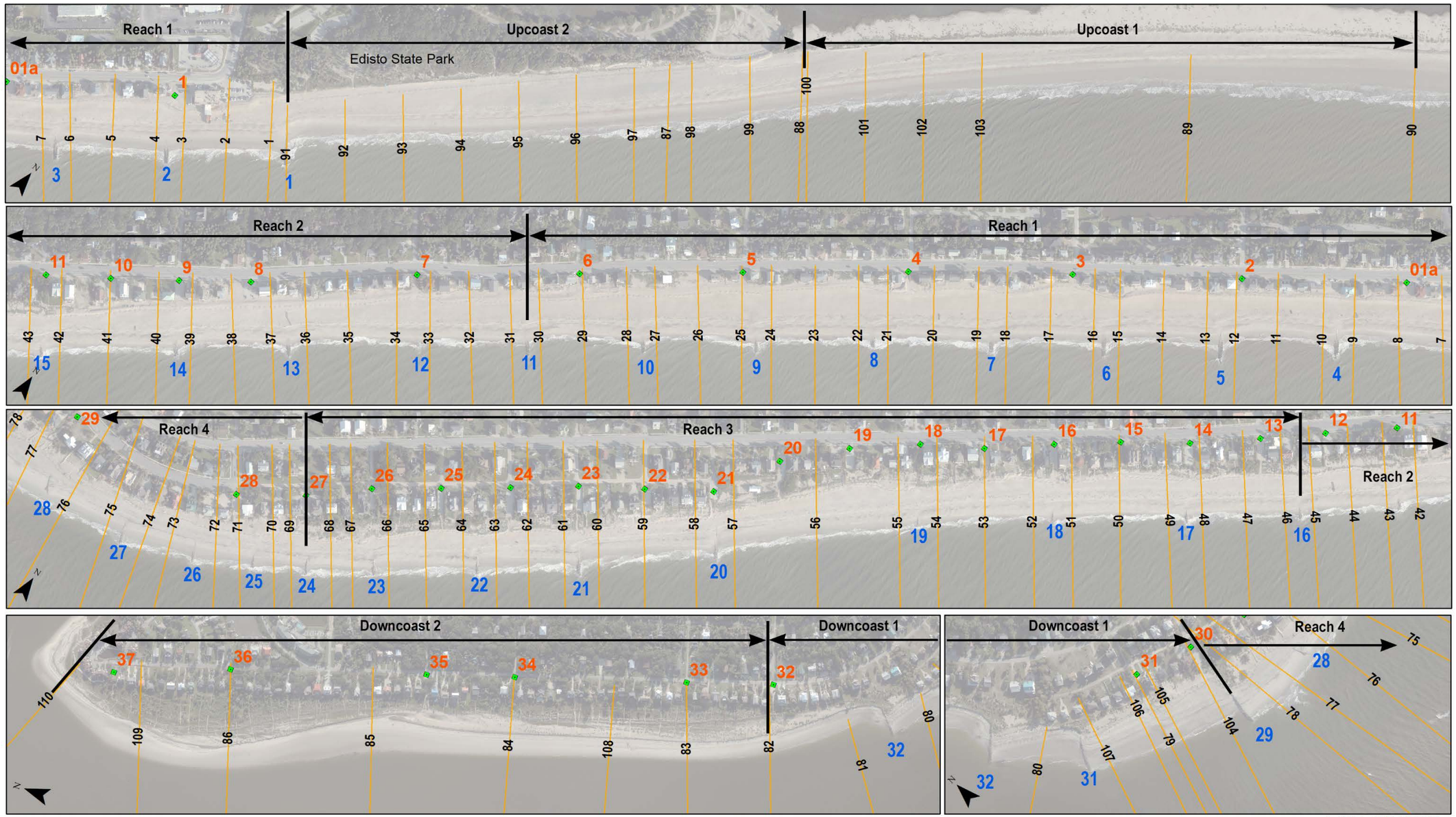

FIGURE 4.1. Location map showing beach profile lines surveyed by CSE before and after the project (orange lines with black labels). Groin number are shown in blue, and beach access points are shown in red.

TABLE 4.1. Station unit volumes for the post-2006 (August) project, and pre- and post-2017 nourishment project. Volumes are −15 ft NAVD.

Line Number	Station	Aug-06	Dec-16	Apr-17	Added Volume	Line Number	Station	Aug-06	Dec-16	Apr-17	Added Volume
90	SCCC 2270	295.5	282.3	280.2	-2.1	31	14+100	266.6	214.2	275.7	61.5
89	SCCC 2250	241.4	243.1	243.3	0.2	32	14+350	278.6	244.5	286.4	41.9
103	Park 3600		249.3	267.0	17.6	33	14+600	278.2	267.3	308.6	41.2
102	Park 3300	251.6	234.5	265.9	31.4	34	15+65	295.7	266.3	312.4	46.1
101	Park 3000	264.3	223.6	278.7	55.0	35	15+245	308.6	279.3	316.7	37.4
100	Park 2700	274.8	218.4	286.7	68.3	36	15+450	300.4	282.8	319.3	36.5
88	SCCC 2230	289.6	236.5	308.6	72.1	37	16+75	304.0	271.0	322.5	51.4
99	Park 2400	299.8	257.0	343.7	86.7	38	16+300	316.1	279.6	322.0	42.5
98	Park 2100	303.1	268.7	348.3	79.7	39	16+525	310.7	272.6	309.5	37.0
87	SCCC 2210	310.5	271.6	353.6	82.0	40	17+75	305.1	243.2	295.3	52.1
97	Park 1800	300.1	264.9	342.5	77.6	41	17+300	280.1	237.2	281.3	44.2
96	Park 1500	306.5	268.9	339.1	70.1	42	17+525	288.1	257.5	303.5	46.0
95	Park 1200	299.6	266.2	333.5	67.3	43	18+75	283.2	243.0	284.7	41.7
94	Park 900	294.8	262.1	325.8	63.7	44	18+300	287.6	256.2	288.7	32.5
93	Park 600	268.7	241.4	302.3	60.9	45	18+525	312.0	279.0	308.8	29.8
92	Park 300	237.8	235.6	287.0	51.3	46	19+100	309.7	262.2	315.2	53.0
91	Park 0	256.2	206.4	287.2	80.8	47	19+525	332.4	291.5	337.1	45.6
1	1+75	266.8	211.3	275.1	63.8	48	19+955	275.8	273.7	313.3	39.6
2	1+300	257.9	213.3	283.4	70.1	49	20+100	257.0	237.0	268.9	31.9
3	1+525	250.1	221.8	305.7	83.9	50	20+350	267.8	248.3	276.5	28.3
4	2+75	258.6	208.6	319.9	111.3	51	20+600	278.3	270.4	303.8	33.5
5	2+300	244.6	216.2	299.7	83.5	52	21+75	285.7	266.6	298.6	32.0
6	2+525	239.9	211.7	275.5	63.8	53	21+265	287.7	272.7	306.9	34.2
7	3+75	242.8	190.9	255.4	64.5	54	21+430	300.2	287.9	320.7	32.8
8	3+300	233.7	209.3	265.1	55.8	55	22+75	289.3	281.7	324.9	43.2
9	3+525	242.1	212.4	259.2	46.8	56	22+268	296.3	286.6	326.3	39.8
10	4+75	243.8	194.3	247.9	53.5	57	22+460	298.6	296.1	326.4	30.3
11	4+300	260.8	198.9	253.4	54.5	58	23+100	294.6	279.2	324.1	44.9
12	4+525	258.8	225.6	270.3	44.7	59	23+220	299.0	281.1	321.6	40.5
13	5+75	261.1	205.9	270.7	64.8	60	24+100	266.7	262.4	309.2	46.8
14	5+300	266.5	216.0	278.9	62.9	61	24+190	258.4	259.6	303.4	43.8
15	5+525	267.6	222.3	292.1	69.8	62	25+100	241.5	238.6	289.3	50.7
16	6+75	263.9	200.0	279.9	80.0	63	25+200	238.6	236.4	277.5	41.0
17	6+300	278.6	215.9	294.7	78.8	64	26+115	222.4	194.8	251.8	57.0
18	6+525	272.3	231.9	309.6	77.7	65	26+235	233.8	199.8	247.2	47.4
19	7+75	269.1	211.4	304.8	93.3	66	27+78	262.4	214.7	259.6	44.9
20	7+300	256.1	208.9	289.5	80.6	67	27+290	322.6	278.1	302.3	24.2
21	7+525	270.3	249.9	322.0	72.1	68	28+130	394.2	396.2	426.5	30.3
22	8+75	279.7	224.2	300.4	76.2	69	28+277	436.3	383.3	431.1	47.7
23	8+300	268.8	227.3	299.4	72.2	70	29+75		370.5	402.4	31.9
24	8+525	279.8	266.7	336.2	69.5	71	29+340		345.3	362.1	16.8
25	9+75	300.4	262.0	328.2	66.2	72	2135	394.2	332.2	320.0	-12.2
26	9+300	281.6	256.7	304.8	48.1	73	30+85		300.6	297.2	-3.4
27	9+525	284.7	275.3	328.8	53.5	74	30+345		292.9	291.9	-1.0
28	10+75	273.9	262.7	321.9	59.2	75	2130B	169.0	144.8	136.1	-8.7
29	10+300	270.1	251.6	311.5	59.9	76	2130A	24.2	22.9	22.7	-0.2
30	10+525	264.3	248.3	298.9	50.6	77	2130	217.1	296.3	296.0	-0.4
31	11+75	279.5	246.0	307.9	61.9	78	2120	271.2	330.8	333.8	2.9
32	11+300	281.9	266.3	322.5	56.3	104			331.1	334.5	3.4
33	11+525	281.3	253.0	310.3	57.3	105	2115	293.3	325.6	315.3	-10.2
34	12+75	284.8	223.8	298.2	74.3	79	2113	301.6	303.3	304.5	1.2
35	12+300	285.4	232.9	293.5	60.6	106	2110	422.8	463.0	463.4	0.4
36	12+525	290.2	233.1	284.4	51.3	107			369.7	387.7	18.0
37	13+75	276.0	214.2	270.9	56.7	80			251.5	249.8	-1.7
38	13+300	277.7	231.0	283.9	52.9	81					0.0
39	13+525	267.2	227.9	277.3	49.3	82					0.0

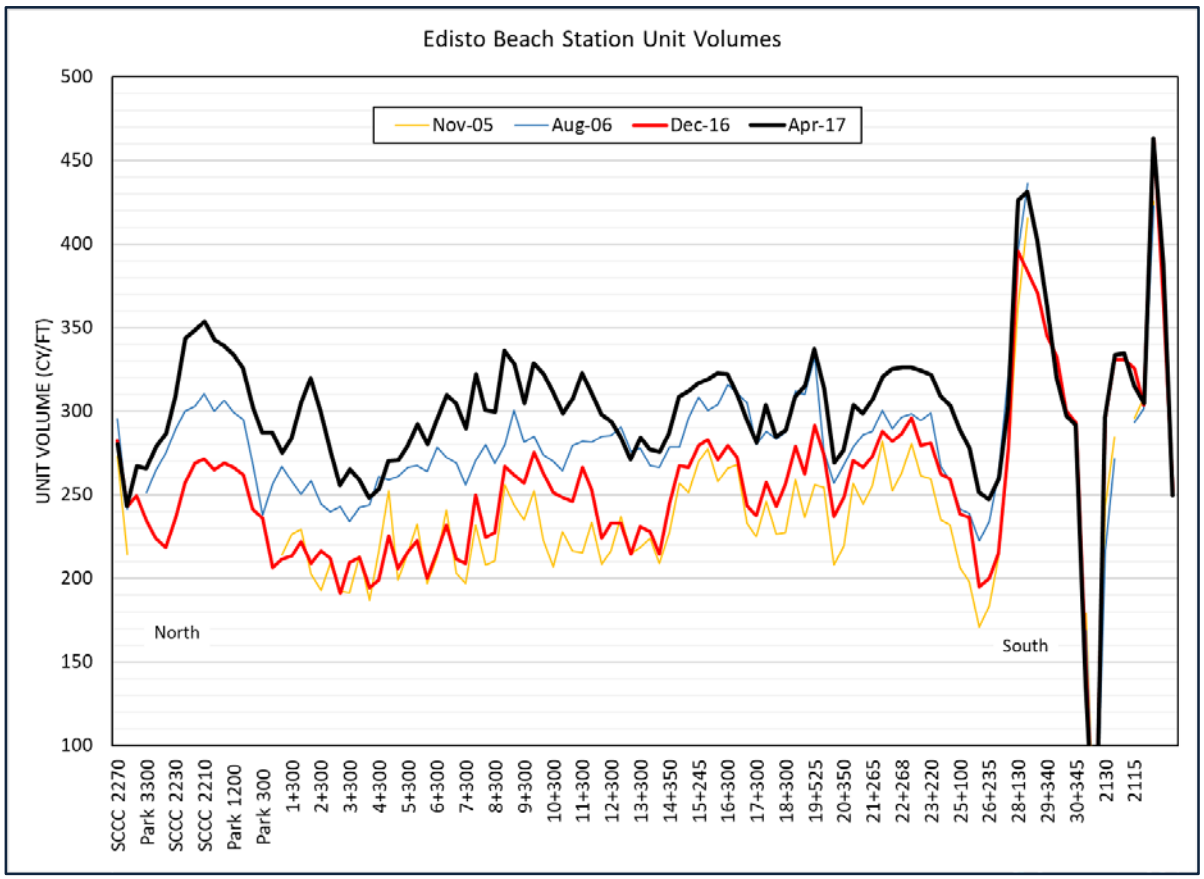

FIGURE 4.2. Beach unit volumes from before and after the 2006 and 2017 nourishment projects. Volumes are measured to −15 ft NAVD and are generally started at the structure line.

CSE has typically consolidated areas of the island into reaches to provide a more general assessment of beach condition over the island. Nourishment volumes by reach are shown in Figure 4.3. Measured fill volume in the project area ranged from 38 cy/ft to 71 cy/ft, increasing from south to north. Of note is that the post-project volume in 2017 was ~30–35 cy/ft higher in the state park and Reach 1 than after the 2006 project (Table 4.2). In Reaches 2 and 3, the volumes were ~14 cy/ft higher in 2017 than in 2006. Overall, the project added 54.8 cy/ft of sand within the project areas and 37.2 cy/ft of sand to the island as a whole.

4.2 Borrow Area Surveys

CSE completed surveys of the borrow area before the project and in June 2018. Surveys are used to confirm the excavation limits provided in the plans were not exceeded during the project and to monitor the rate of sediment infilling over time. The borrow area was positioned on the northern shoal of the South Edisto River Inlet channel. CSE anticipated the dredged needing to enter the borrow area from the channel side to have sufficient depth for operations.

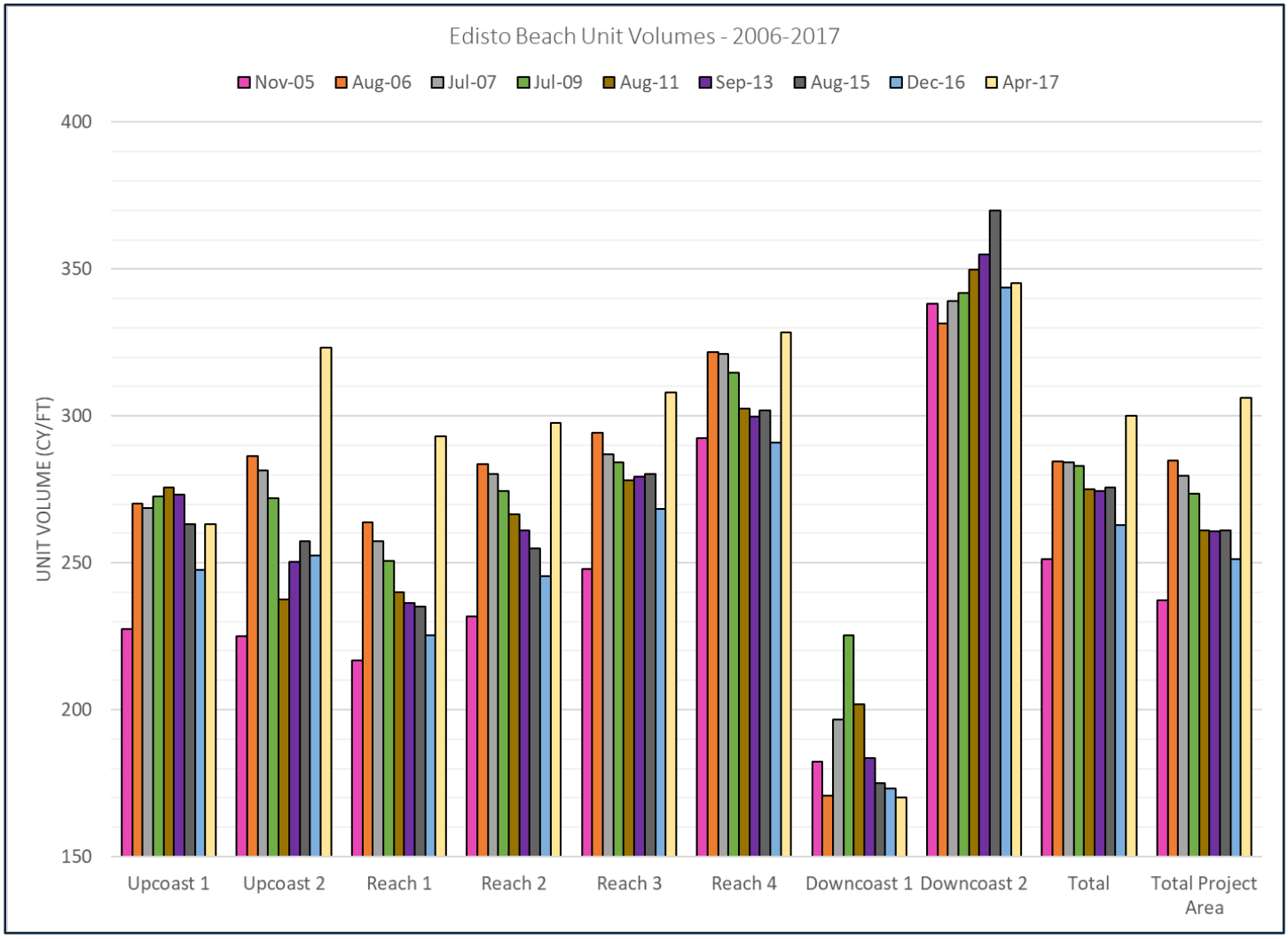

FIGURE 4.3. Reach unit volumes for selected surveys since 2005. Volumes are to −15 ft NAVD measured from the structure line.

TABLE 4.2. Reach unit volume values for the 2017 nourishment.

Reach	Length (ft)	Aug 2006 Unit Volume (cy/ft)	Dec 2016 Unit Volume (cy/ft)	April 2017 Unit Volume (cy/ft)	2017 Project Unit Volume Change (cy/ft)	Aug 2006 Total Volume (cy)	Dec 2016 Total Volume (cy)	April 2017 Total Volume (cy)	2017 Project Total Volume Change (cy)
Upcoast 1	3,145	270.1	247.7	263.2	15.5	849,462	779,083	827,790	48,707
Upcoast 2 (Park)	2,790	286.4	252.5	323.1	70.6	799,153	704,558	901,546	196,988
Reach 1	6,009	263.7	225.3	292.9	67.6	1,584,697	1,354,027	1,760,149	406,122
Reach 2	3,065	283.6	245.3	297.6	52.2	869,184	751,943	911,999	160,056
Reach 3	5,085	294.3	268.2	308.1	39.8	1,496,645	1,364,044	1,566,501	202,456
Reach 4	2,110	321.7	290.9	328.6	37.7	678,695	613,775	693,305	79,530
Downcoast 1	1,846	170.8	173.0	170.0	-3.0	315,236	319,398	313,878	-5,520
Downcoast 2	5,401	331.5	343.8	345.3	1.5	1,790,447	1,857,003	1,864,841	7,838
Total	29,451	284.7	262.9	300.2	37.2	8,383,519	7,743,832	8,840,008	1,096,176
Total Project Area	19,059	284.8	251.2	306.1	54.8	5,428,373	4,788,348	5,833,500	1,045,152

Marinex began excavations at the northwest corner of Borrow Area B and proceeded to the northeast along the inner margin of the borrow area. Marinex continued to work within Borrow Area B, using the majority of the area except for the southeastern portion. Marinex used the northern half of Borrow Area A, but did not work in the southern half. Figure 4.4 shows before-dredge (BD) and after-dredge (AD) surveys of the borrow area. The excavated areas are visible in the darker blue shades within the borrow area boundary.

CSE calculated the volume change between the surveys within the borrow area limits. As occurred following the 2006 project, significant infilling of sand is expected to occur over the next several years as sand moves in the shoal system. Between the 2016 and 2018 surveys, there was a measured loss of 1,100,885 cy of sand in the borrow area. This compares well to the volume measured in place on the beach, taking into consideration some infilling occurring in 2017 and losses occurring during the dredging project (typically, 10 percent handling losses are common in dredging projects, meaning more sand is excavated from the borrow area than is measured on the fill beach). CSE will continue to monitor the infilling of the borrow area over the next several years per permit conditions.

4.3 Groins

CSE completed surveys of the groin extensions following construction to verify placement elevations and extents. Survey data were obtained along the longitudinal axis of the groin (along the centerline) and around the accessible limit of the armor-stone apron. Cross-sectional profiles from the groins are provided in Appendix F. Figure 4.5 shows an example section from Groin 7. The post-construction condition is shown as the black line. Note that the survey includes the post-nourished beach sand, which is higher than the contructed extension in some cases. For example, at Groin 7, the old groin and the landward portion of the extension is buried at all distances landward of ~220 ft from the monument. The extension is seen as the horizontal portion near −1 ft NAVD elevation. The end of the cap at this groin is ~285 ft from the monument, and the armor-stone apron extends seaward.

Crowder recorded all material quantities for groin installation as shown in Table 4.3. Quantities include length of sheet pile, tons of armor stone, areas of marine mattress, and quantity of concrete. Overall, the project added 1,165 linear feet of sheet pile, 10,127 tons of stone, 37,800 square feet of mattress, and over 500 cy of concrete (cap and grout). Individual groins were lengthened up to 100 ft and required up to 850 tons of armor stone. Groin 5 required the most stone because the profile in that location was deeper than the other extensions. Figure 4.6 shows a plan view of a completed groin extension with elevations along the centerline and points located along the accessible limits of stone placement. The pre-project groin ended near the 0 ft NAVD elevation contour, and the extension is visible seaward of that point with the wider armor stone apron.

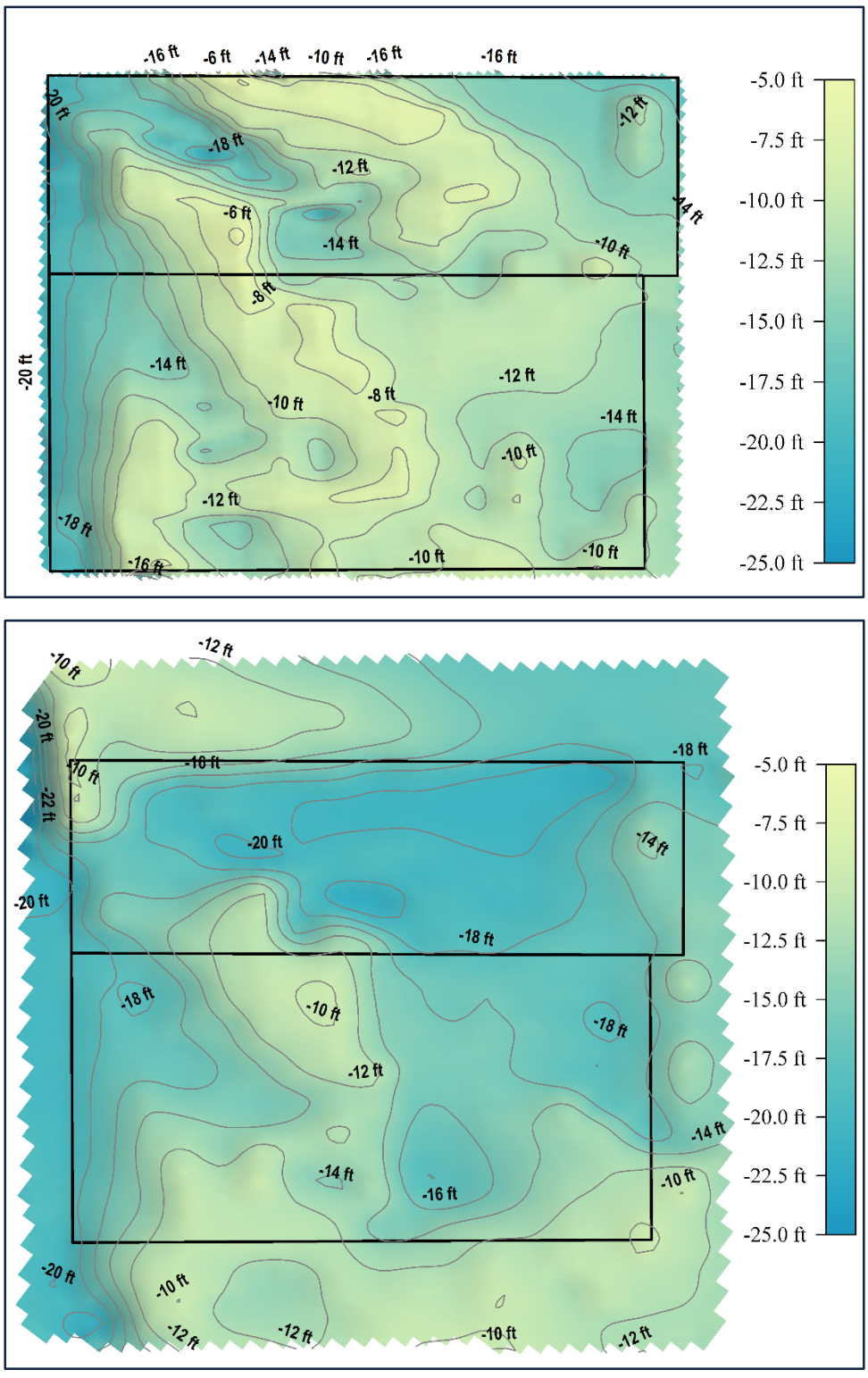

FIGURE 4.4. Before (August 2016) and after (June 2018) bathymetric models of the borrow area.

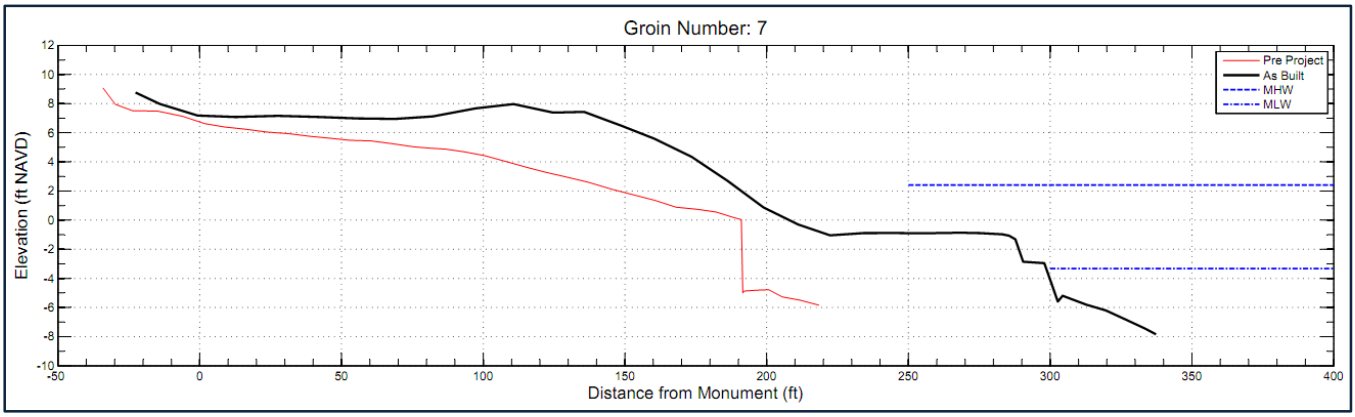

FIGURE 4.5. Before and after surveys at Groin 7 showing the extension cross-section. [See text on page 48 for details.]

TABLE 4.3. Groin extension quantity data.

Location	Length (lf)	Sheeting In Place (lf)	Class F Armor Stone (ton)	Mattresses In Place (Sq Ft)	Grout In Place (cy)	Est Cap Concrete (cy)
Groin 1	90	90	512	2,020	6	13
Groin 2	85	85	432	1,920	6	12
Groin 3	90	90	459	2,020	4	13
Groin 4	90	90	469	2,020	4	13
Groin 5	100	100	856	2,220	4	14
Groin 6	100	100	525	2,220	3	14
Groin 7	90	90	459	2,020	3	13
Groin 8	90	90	462	2,020	4	13
Groin 9	95	95	486	2,120	3	13
Groin 10	95	95	510	2,120	5	13
Groin 11	95	95	505	2,120	5	13
Groin 12	45		317	1,120	35	
Groin 13	80	80	425	1,820	5	11
Groin 14	65	65	440	1,520	5	9
Groin 15	40		286	1,020	28	
Groin 16	20		178	620	20	
Groin 17	20		180	620	20	
Groin 18	40		286	1,020	28	
Groin 19	0		0			
Groin 20	40		286	1,020	27	
Groin 21	31		236	820	23	
Groin 22	30		232	820	24	
Groin 23	30		232	820	23	
Groin 24	30		241	820	21	
Groin 25	40		286	1,020	25	
Groin 26	50		415	1,220	32	
Groin 27	50		412	1,220	33	
Groin 28	0		0		3	
Groin 29	0		0			
Total	**0**	**1,165**	**10,127**	**38,320**	**395**	**165**

FIGURE 4.6. Plan view of a typical groin extension using sheet pile and concrete cap. Elevations are labeled in white and the footprint of the accessible armor stone is shown in yellow. This extension began near the "0 ft NAVD" contour.

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5.0 SUMMARY OF SAND ANALYSIS

All excavations involved beach-quality sand similar in texture to the native beach. Edisto Beach has a much higher shell content than typical beaches in South Carolina. The majority of the shell is <2 millimeters (mm) (shell hash) and is similar in nature to coarse sand, although large shells are abundant. The project matched the character of the native beach by placing sand containing similar coarse sand and shell hash as presently exists on the beach.

Sand on the native beach prior to nourishment was sampled by CSE in April 2015. This established a native size distribution for purposes of compatibility analyses. The mean grain size of native beach sand samples (composite) was 0.487 mm with 5.4 percent of the material coarser than 2 mm. The beach samples (composite) tested as 24.8 percent (by weight) calcium carbonate ($CaCO_3$).

During construction, a representative from CSE visited the site several times per day (with the exception of periods when dredging operations were stopped because of weather or equipment maintenance). Additionally, whenever the dredge changed to a new borrow area, a CSE representative monitored the first few hours of discharge. Generally, twice per day, the observer made a visual inspection of the most recent sediment placed. These site visits were recorded in daily observation reports (Appendix G).

While on site, the observer also collected a composite grab sand sample from the last station completed. Each sample was analyzed to determine the grain-size characteristics and shell content as a means of monitoring the quality of the material placed on the beach. Results from analyses of all samples collected showing grain-size distributions and descriptions are attached in Appendix H. Grab sample analysis results are summarized in Table 5.1.

TABLE 5.1. Beach sand sample statistical results for each survey station along the project area.

	Mean	STD	Shell	Gravel
Sample	mm		%	%
SP 1+00	0.423	0.397	25.0	5.8
SP 4+00	0.769	0.464	36.6	9.8
SP 5+00	0.605	0.406	32.3	9.2
SP 7+00	0.327	0.423	27.9	3.3
SP 9+00	0.216	0.514	20.8	1.2
SP 10+00	0.302	0.392	23.0	5.1
SP 14+00	0.463	0.298	31.9	13.5
SP 17+00	0.691	0.310	43.2	18.4
SP 19+00	0.858	0.284	44.2	26.5
SP 24+00	0.383	0.345	30.0	8.6
SP 26+00	0.384	0.340	30.7	9.4
SP 28+00	0.380	0.421	25.0	7.3
Groin 1+100	0.486	0.384	31.5	8.4
Groin 2+100	0.218	0.486	11.7	2.0
Groin 3+00	0.398	0.358	23.7	7.6
Groin 3+100	0.611	0.352	32.2	12.4
Groin 3+300	0.580	0.392	31.5	8.0
Groin 3-100	0.554	0.386	30.3	8.0
Groin 4+00	0.620	0.423	36.0	7.6
Groin 5+00	0.519	0.446	30.2	5.4
Groin 5+200	0.672	0.425	33.7	9.4
Groin 6+00	0.519	0.399	36.6	7.4
Groin 6+300	0.534	0.446	35.7	6.4
Groin 7+00	0.489	0.359	28.1	9.8
Groin 7+300	0.739	0.376	41.3	14.8
Groin 8+00	0.382	0.363	30.3	7.6
Groin 8+300	0.448	0.381	33.2	7.9
Groin 9+000	0.603	0.394	35.9	9.7
Groin 9+300	0.574	0.358	33.7	11.3
Groin 10+300	0.663	0.347	38.7	11.8
Groin 10+300	0.430	0.486	27.1	5.0
Groin 11+300	0.538	0.473	43.6	6.4
Groin 12+300	0.502	0.392	37.0	9.4
Groin 13+300	0.525	0.426	44.8	7.6
Groin 14+300	0.550	0.498	33.5	6.0
Groin 15+00	0.697	0.312	28.4	14.9
Groin 15+300	0.386	0.524	26.3	2.8
Groin 16+00	0.435	0.515	31.8	5.7
Groin 16+300	0.445	0.518	25.0	4.0
Groin 17+00	0.516	0.403	31.0	8.5
Groin 17+300	0.402	0.551	18.8	2.9
Groin 19+100	0.484	0.391	34.7	8.4
Groin 19+300	0.580	0.406	30.7	8.9
Groin 20+00	0.634	0.361	28.7	13.8
Groin 21+00	0.632	0.365	43.1	13.2
Groin 2-100	0.629	0.371	35.0	11.4
Groin 22+00	0.652	0.358	35.7	14.2
Groin 23+00	0.788	0.317	49.8	21.3
Groin 24+00	0.622	0.343	32.0	14.9
Groin 25+00	0.589	0.340	26.2	14.3
Groin 26+00	0.575	0.285	29.7	15.1
Groin 27+00	0.535	0.319	27.1	10.7
Groin 28+00	0.487	0.386	25.2	7.9
Groin 29+00	0.394	0.478	25.1	4.6
ALL	0.508	0.372	31.8	9.4

Nourishment sand placed on the beach was found to be consistent with the borings obtained by CSE. The mean grain size of all samples collected during project construction by CSE was calculated to be 0.508 mm. The nourishment sand is slightly coarser than the native beach sand; however, the sand contained less large shell fragments. Post-project observations show the beach generally has a shallower slope than the pre-project condition, which is partially a result of sediment grain size.

FIGURE 5.1. Example of sediment character of the fill sand. As the dredge moved within the borrow area, sediment characteristics changed slightly. Over time, exposed sediment will become more uniform over the length of the beach.

6.0 REGULATORY COMPLIANCE

Standard protection measures common to similar projects were incorporated into the project design. Protection measures followed recommendations outlined by the USFWS in previous biological opinions (BO) issued for similar projects (Isle of Palms 2008, Folly Beach 2013). Also, the permit application for the beach restoration project included protection measures contained in the revised USFWS BO (2014) issued for the USACE-proposed Edisto Beach Coastal Storm Damage Reduction Civil Works Project (USACE 2014).

The USACE completed extensive work in support of a feasibility study for a beach nourishment and groin lengthening project to provide storm damage reduction for a 50-year project design life. Work accomplished by the USACE included a feasibility report and environmental assessment, coastal engineering, economic analysis, structural inventory, geotechnical engineering, impact analysis, a biological assessment (BA) and essential fish habitat (EFH) assessment, 404(b)1 evaluation, and a hard bottom and cultural resource survey. The USACE also corresponded with local, state, and federal resource and regulatory offices and completed formal Section 7 consultation with USFWS, receiving the BO referenced above on 14 March 2014. Documentation for the USACE project can be found at http://www.sac.usace.army.mil/Missions/CivilWorks/NEPA Documents.

In its permit application for the locally sponsored project, the USFWS allowed the Town of Edisto Beach to supplement the USACE BA and EFH prepared for the federal storm-damage reduction project. CSE prepared a supplement to the USACE EA, and USFWS issued a new BO for the local project, which is provided in Appendix I (USFWS, 21 January 2016). The project was intended to be constructed during the winter season (1 November to 30 April); however, due to impacts of Hurricane *Matthew*, CSE anticipated the project might need to extend into a portion of turtle nesting season. CSE requested a permit modification to allow the groin installation portion of the work to extend into nesting season under the condition that all terms and conditions of the BO and standard sea turtle protection measures included in the permits be included in the contractor's scope of work.

Each contractor was required to comply with all terms and conditions of the project permits (federal and state), as well as the conditions of the USFWS BO. In addition to the sediment sampling described in the previous section, additional compliance measures in the project included:

- Monitoring for escarpments during construction.
- Sediment compaction monitoring following nourishment.
- Daily sea turtle patrols beginning 1 May 2017.
- Equipment storage off of the beach to the extent possible.
- Fencing to prevent sea turtle entrapment around equipment or material storage areas.

- Filling of holes, track marks, or leveling of ridges each day to allow turtles to move freely.
- Incorporation of measures to prevent oil, fuel, and other pollutants from spilling or entering the waterway.

Marinex completed the nourishment portion of the project, including tilling of the beach and demobilization of equipment prior to turtle nesting season. Crowder needed additional time to complete the groin installation and coordinated with the local turtle patrol to identify areas where nesting activity may have occurred. Patrol members would locate and mark any nest (Fig 6.1), and inform Crowder of the location so that work activity would avoid the area. Crowder avoided areas near the dune and attempted to restrict equipment to the wet-sand beach as much as possible. Crowder did not work at night to avoid potential impacts of lighting. No incidents of impacts to turtles were reported by Crowder or the turtle team. All equipment was off of the beach by 12 June 2017.

FIGURE 6.1. Example of turtle nest located and marked on the already constructed berm. A completed groin extension is visible in the background.

8.0 MAINTENANCE AND MONITORING RECOMMENDATIONS

Beach nourishment projects typically involve varying levels of post-project monitoring, depending on the site and project complexity. Regular monitoring provides updated assessments of project performance, impacts, and storm losses, and allows for planning of future projects. The Town of Edisto Beach has monitoring responsibilities required by the state and federal permits (see Appendix A). Specific monitoring to be completed in the future includes the following.

Annual beach profile and hydrographic surveys of the project area for a minimum of five years. Surveys will extend from the back berm or dune to a minimum of -15 ft NAVD or a distance of 1,000 ft, whichever is reached first. Survey data will be used to determine project performance, calculate erosion rates, and determine potential downcoast impacts.

Semiannual monitoring of the same area for five years post-construction. These monitoring events will span the same limits as the annual monitoring, but are only required to extend to −6 ft NAVD (low-tide wading depth).

Hydrographic surveys of the borrow area in Years 1, 3 and 5 post-construction. Survey data will be used to monitor infilling of the area following dredging.

Aerial photography for five years following construction. High-resolution vertical photos georeferenced and covering the entire project area are required annually for five years following construction.

Compaction and escarpment monitoring for Years 1–3 post-construction. Compaction measurements are to be taken in the project area and compared to native areas. If compaction values are greater than the 500 psi threshold and exceed native values, the area will require tilling prior to 1 May following consultation with USFWS. Escarpments measuring greater than 100 linear feet and 18 inches high are required to be graded prior to 1 May.

Reports following each survey to be submitted to permitting and resource agencies as required by project permits. Reports will update the condition of the beach, and compare erosion rates to established thresholds to assist in determining potential downdrift impacts.

Data and information regarding the above-listed items must be submitted to SCDHEC–OCRM, USACE, USFWS, and SCDNR following each monitoring event.

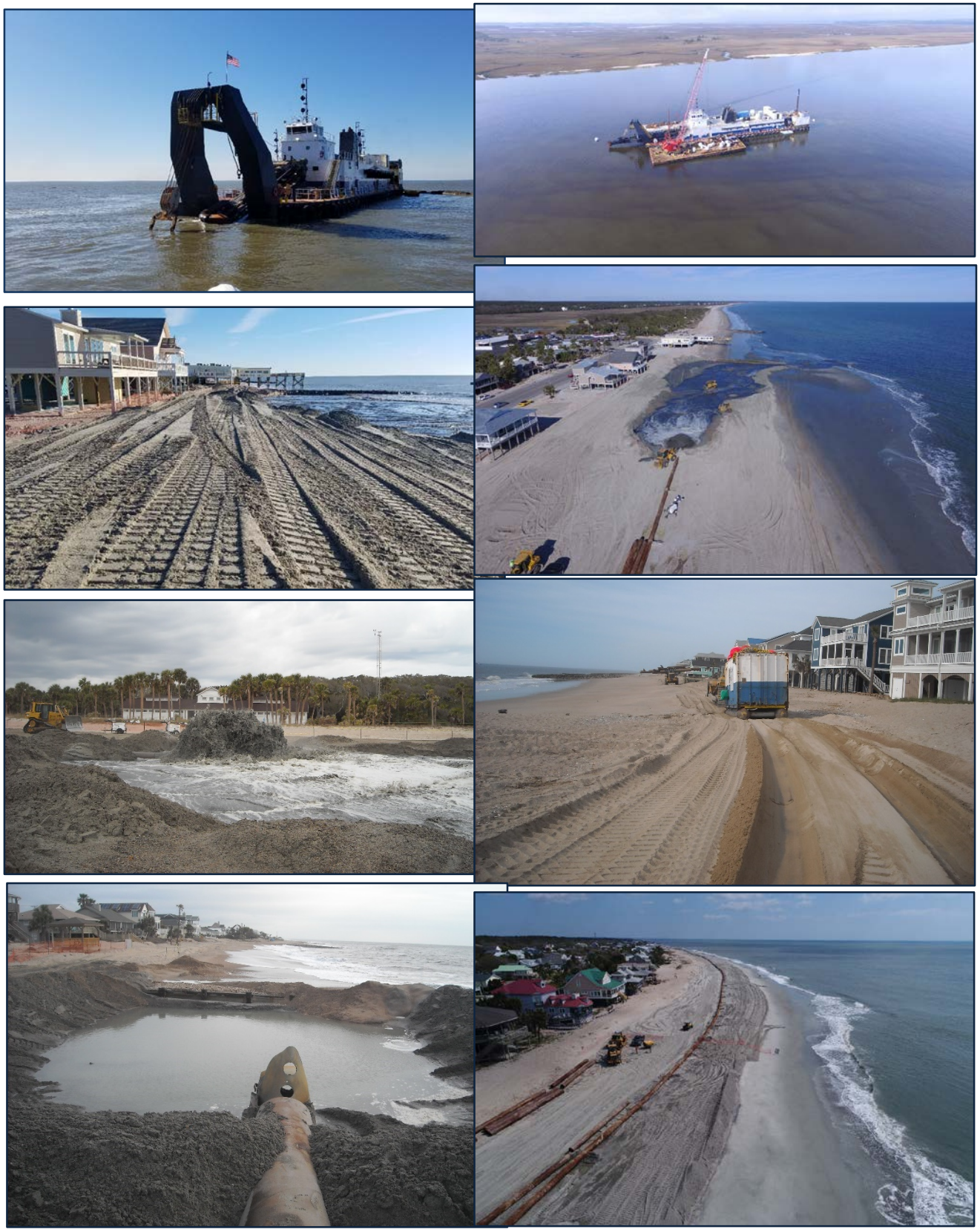
In the event of a future declared disaster, the Town would potentially be eligible for post-storm beach restoration funds from FEMA under a Community Assistance Grant—Category G— Improved Projects. This fund is available to cover the cost of renourishment such that sand losses due to a major storm are replaced. The Town received funds for Hurricane Joaquin and Matthew under this program. These funds were used to add additional sand to Edisto during the 2017 project. The key in each case was an ongoing monitoring and maintenance program along with post-storm surveys that documented losses due to these storms. This is an important program for sites that otherwise do not receive federal assistance for beach protection. FEMA continues to fund these grants in recognition that healthy beaches generally lower property damages in storms.

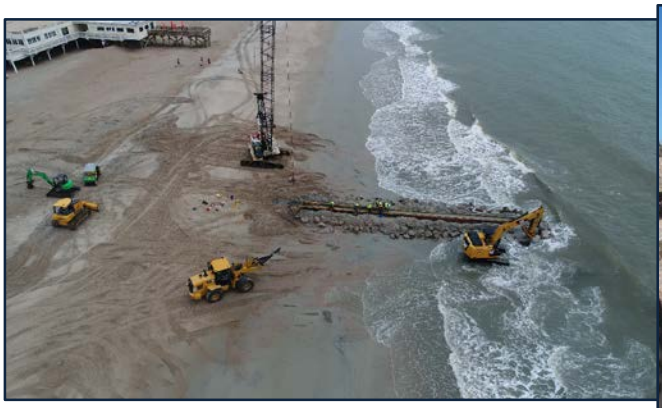
Turtle nesting is expected to be tracked in the future by the Edisto Beach Turtle Patrol. Should this program be terminated, CSE recommends the town seek ways to continue seasonal surveys and implement appropriate nest tracking and protection measures according to USFWS protocols.

The groins should be inspected yearly for evidence of displacement, corrosion, local scour, or loss of rock protection around the head. Visual inspections should be made frequently to note obvious damage to the cap, warning marker, or armor stone. The amount of exposure (height and length of groin section above sand level) should be documented when surveys are conducted. Other things to note when observing the groin condition are:

- Burial of the landward end—means the nourished berm/dry beach remains stable.
- Even reveal along the sloping section—means the nourished profile continues to follow a natural profile.
- Partial burial of rock above the low-tide beach and exposure of sheet piles near the head of the structure—may indicate toe protection is settling.
- Width of dry beach on the east and west side of the groin—measure of beach stability.

7.0 PROJECT PHOTOS



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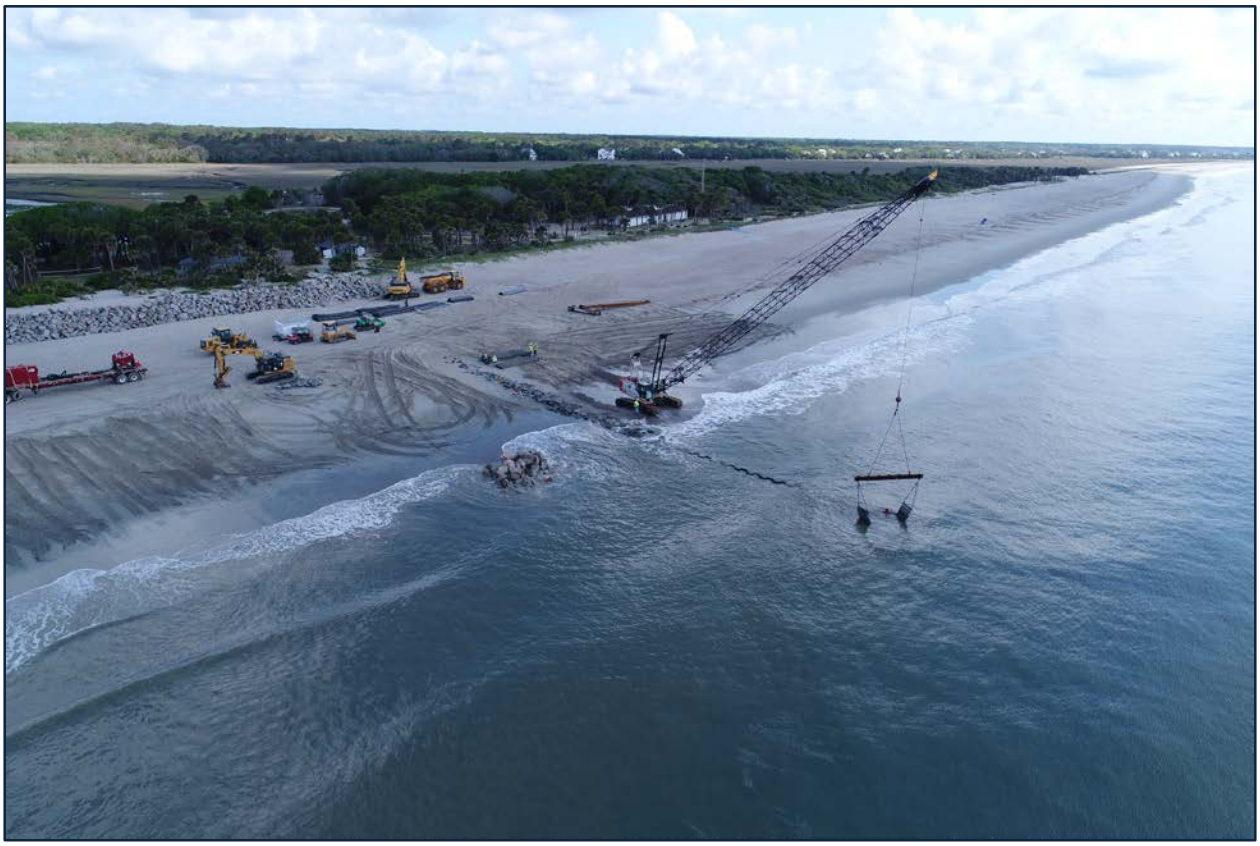

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REFERENCES & BIBLIOGRAPHY

ASCE. 1994. Coastal Groins and Nearshore Breakwaters. Technical Engineering and Design Guides as Adapted from the US Army Corps of Engineers, No 6, American Society of Civil Engineers, New York, NY, 87 pp.

Basco, DR, and J Pope. 2004. Groin functional design guidance from the Coastal Engineering Manual. Jour of Coastal Research, Spec Issue 33, pp 121-130.

Bruun, P. 1952. Measures against erosion at groins and jetties. In Proceedings of the 3rd Conference on Coastal Engineering, ASCE, New York, NY.

CERC. 1984. Shore Protection Manual. 4th Edition, US Army Corps of Engineers, Coastal Engineering Research Center, Ft Belvoir, VA; US Government Printing Office, Washington, DC, 2 vols.

CSE. 1990. Erosion assessment and beach restoration alternatives for Edisto Beach State Park, South Carolina. Feasibility Study for SC Department of Parks Recreation & Tourism, Columbia. Coastal Science & Engineering (CSE), Columbia, SC, 61 pp + appendices.

CSE. 1992. Edisto Beach nourishment project — engineering report: geotechnical studies, bathymetric and beach surveys, wave modeling studies. Draft Report for South Carolina Department of Parks, Recreation & Tourism, Columbia; CSE, Columbia, SC, 120 pp + appendices.

CSE. 1993. Edisto Beach groin study. Report for Town of Edisto Beach, SC; CSE, Columbia, SC, 132 pp + data appendices.

CSE. 1996a (April). Edisto Beach 1995 beach nourishment project. Survey Report No 1 for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 11 pp + appendices.

CSE. 1996b (June). Edisto Beach 1995 beach nourishment project. Survey Report No 2 for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 15 pp + appendices.

CSE. 1997 (September). Edisto Beach 1995 beach nourishment project. Survey Report No 3 for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 31 pp + appendices.

CSE. 1999a(September). Edisto Beach 1995 beach nourishment project. Survey Report No 4 for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 33 pp + appendices (CSE 2006).

CSE. 1999b. Shoreline assessment and preliminary beach restoration plan – Bogue Banks, North Carolina. Executive Summary for Carteret County, Beaufort, NC. CSE, Columbia, SC, 42 pp.

CSE. 2001 (November). Edisto Beach 1995 beach nourishment project. Survey Report No. 5 to Town of Edisto Beach, SC. CSE, Columbia, SC, 49 pp + appendices (CSE 2006-1).

CSE. 2003a. Beach restoration plan, Edisto Beach, South Carolina. Draft Summary Report to Town of Edisto Beach, SC. CSE, Columbia, SC, 48 pp (CSE 2092).

CSE. 2003b. Groin conditions and repair recommendations, Edisto Beach, South Carolina. Summary Report to Town of Edisto Beach, SC. CSE, Columbia, SC, 42 pp plus appendices (CSE 2134).

CSE. 2004 (July). Reconnaissance borings in potential offshore borrow areas: Edisto Beach restoration project. Data Report for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 24 pp + appendices (CSE 2092-01).

CSE. 2005a. Project plans and specifications, Edisto Beach, South Carolina. Prepared for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC.

CSE. 2005b (February). Beach condition survey, Edisto Beach, South Carolina. Memorandum Report for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 15 pp + appendix (CSE 2092-A02).

CSE. 2006. Beach restoration project, Edisto Beach, Colleton County, South Carolina. Final Report for Town of Edisto Beach, Edisto Island, SC; and SC Department of Parks Recreation & Tourism, Columbia, SC. CSE, Columbia, SC, 75 pp + 7 appendices.

CSE. 2007. Annual beach and inshore surveys – assessment of beach and groin conditions – survey report 1, 2006 beach restoration project, Edisto Beach, Colleton County, South Carolina. Report for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 67 pp + 3 appendices.

CSE. 2008. Annual beach and inshore surveys – assessment of beach and groin conditions – survey report 2, 2006 beach restoration project, Edisto Beach, Colleton County, South Carolina. Report for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 65 pp + 3 appendices.

CSE. 2009. Annual beach and inshore surveys – assessment of beach and groin conditions – survey report 3, 2006 beach restoration project, Edisto Beach, Colleton County, South Carolina. Report for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 71 pp + 3 appendices.

CSE. 2010. Annual beach and inshore surveys – assessment of beach and groin conditions – survey report 4 — 2006 beach restoration project, Edisto Beach, Colleton County, South Carolina. Report for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 107 pp + appendix.

CSE. 2010. Coastal Erosion Primer. Second Edition, Columbia, SC, 40 pp.

CSE. 2011. Annual beach and inshore surveys – assessment of beach and groin conditions – survey report 5 — 2006 beach restoration project, Edisto Beach, Colleton County, South Carolina. Report for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 87 pp + appendix.

CSE. 2013a. Assessment of the groin field and conceptual plan for groin lengthening. Report for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 51 pp + appendices.

CSE. 2013b. Annual beach and inshore surveys – assessment of beach and groin conditions – 2006 beach restoration project, Edisto Beach, Colleton County, South Carolina. Survey Report 6 for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 81 pp + appendices.

CSE. 2014. Annual beach and inshore surveys – assessment of beach and groin conditions – 2006 beach restoration project, Edisto Beach, Colleton County, South Carolina. Survey Report 7 for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 82 pp + appendices.

CSE. 2015. Annual beach and inshore surveys – assessment of beach and groin conditions – 2006 beach restoration project, Edisto Beach, Colleton County, South Carolina. Survey Report 8 for Town of Edisto Beach, Edisto Island, SC. CSE, Columbia, SC, 81 pp + appendix.

CUBIT. 1981. Edisto Beach groin field evaluation. Cubit Engineering, Ltd, Clemson, SC.

CUR. 1987. Manual on Artificial Beach Nourishment. Rept. No. 130, Center for Civil Engineering Research, Codes and Specifications (CUR), Rijkswaterstaat, Delft Hydraulics Laboratory, Gouda, The Netherlands, 190 pp + app.

Dean, RG. 2002. *Beach Nourishment: Theory and Practice*. World Scientific, NJ, 399 pp.

Emery, KO. 1961. A simple method of measuring beach profiles. Limnology and Oceanography, Vol 6, pp 90–93.

James, WR. 1975. Techniques in evaluating suitability of borrow material for beach nourishment. Rept. No. TM-60, CERC, U.S. Army Waterways Experiment Station, Vicksburg, Miss.

Kana, TW. 1990. Conserving South Carolina Beaches Through the 1990s: A Case for Beach Nourishment. South Carolina Coastal Council, Charleston, SC, 33 pp.

Kana, TW. 1993. The profile volume approach to beach nourishment. In DK Stauble and NC Kraus (eds), Beach Nourishment Engineering and Management Considerations, ASCE, New York, NY, pp. 176-190.

Kana, TW, TE White, and PA McKee. 2004. Management and engineering guidelines for groin rehabilitation. Jour Coastal Research, Special Issue 33 (NC Kraus and KL Rankin, eds), pp 57-82.

Kana, TW, SB Traynum, D Gaudiano, HL Kaczkowski, and T Hair. 2013. The physical condition of South Carolina beaches 1980–2010. Jour Coastal Research, Special Issue 69, pp 61-82.

Kraus, NC, H Hanson, and SH Blomgren. 1994. Modern functional design of groin systems. In Proc 24th Intl Coastal Engineering Conference 1994, ASCE, New York, NY, pp 1327-1342.

NRC. 1995. Beach Nourishment and Protection. Committee on Beach Nourishment and Protection, Marine Board, Commission on Engineering and Technical Systems, National Research Council; National Academy Press, National Academy of Sciences, Washington, DC, 334 pp.

Stephen, MF, PJ Brown, DM FitzGerald, DK Hubbard, and MO Hayes. 1975. Beach erosion inventory of Charleston County, South Carolina: a preliminary report. South Carolina Sea Grant, Tech Rept No 4, prepared by the University of South Carolina, 79 pp.

TAR. 2016. Submerged cultural resource remote-sensing survey of a proposed borrow site off Edisto Island, South Carolina. Tidewater Atlantic Research, Inc, Washington (NC), 26 pp.

Traynum, SB, TW Kana, and DR Simms. 2010. Construction and performance of six template groins at Hunting Island, South Carolina. Shore & Beach, Vol 78(3), pp 21-32.

USACE. 1949. Cooperative beach erosion study: State of South Carolina. Interim Report, U.S. Army Corps of Engineers, Charleston District, 23 pp. + app.

USACE. 1965. Hurricane survey: Edisto and Hunting Island beaches, South Carolina. Interim Report, US Army Corps of Engineers, Charleston District, 13 pp. + appendices.

USACE. 2002. *Coastal Engineering Manual.* U.S. Army Corps of Engineers, Engineer Manual 1110-2-1100, Washington, DC (in 6 volumes).

USACE. 2013. Integrated feasibility report and environmental assessment – coastal storm damage reduction general investigation study, Edisto Beach, Colleton County, South Carolina. US Army Corps of Engineers, Charleston District, SC, 108 pp + appendices.

USACE. 2014. Interim final integrated feasibility report and environmental assessment—coastal storm damage reduction general investigation study, Edisto Beach, Colleton County, South Carolina. US Army Corps of Engineers, Charleston District, SC, 133 pp + appendices.

USFWS. 2014. Biological opinion:

USFWS. 2016. Biological opinion for Town of Edisto Beach, Colleton County, SC. US Department of Interior, US Fish & Wildlife Service, FWS Log No 2015-CPA-0102/04ES1000-2015-F-0697, Charleston, SC, 73 pp.

Van Dolah, R.F., V.J. Digre, P.T. Gayes, P. Donovan-Ealy, and M.W. Dowd. 1998. An evaluation of physical recovery rates in sand borrow sites used for beach nourishment projects in South Carolina. Final Report to SC Task Force on Offshore Resources and Minerals Management Service Office of International Activities and Marine Minerals; SCDNR, Charleston, SC, 76 pp. + appendices.

Verhagen, HJ. 1992. Method for artificial beach nourishment. In Proc 23rd Intl Coastal Engineering Conf, ASCE, New York, NY, pp 2474-2485.