FINAL REPORT

2011 NAGS HEAD BEACH NOURISHMENT PROJECT

Nags Head North Carolina

Prepared for:

Town of Nags Head
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Prepared by:

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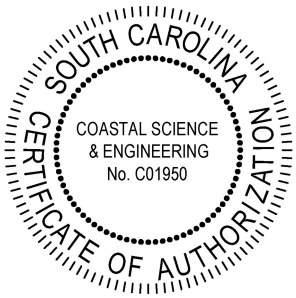
[2203-08 FR]
JANUARY 2012



EXECUTIVE SUMMARY

Introduction

The 2011 beach nourishment project at Nags Head, Dare County, North Carolina was completed between May and October 2011 by the contractor, Great Lakes Dredge & Dock Company, Inc (GLDD, Oak Brook, Illinois). The Town of Nags Head served as project owner and administrator, and Coastal Science & Engineering (CSE, Columbia, South Carolina) was the project engineer. The nourishment project was completed in one phase under a single contract between GLDD and the Town of Nags Head.

The purpose of the project is to restore a protective beach for a minimum of ten years, replace sand lost during the period of delay in the startup of the federal Dare County beach erosion control project, and expand the recreational beach for the benefit of the community.

Nags Head has sustained chronic erosion over the past 50 years due to storms and sand losses to Oregon Inlet. Erosion rates increase from north to south and remain high in the National Seashore reach between Nags Head and Oregon Inlet as shown in Figure A.

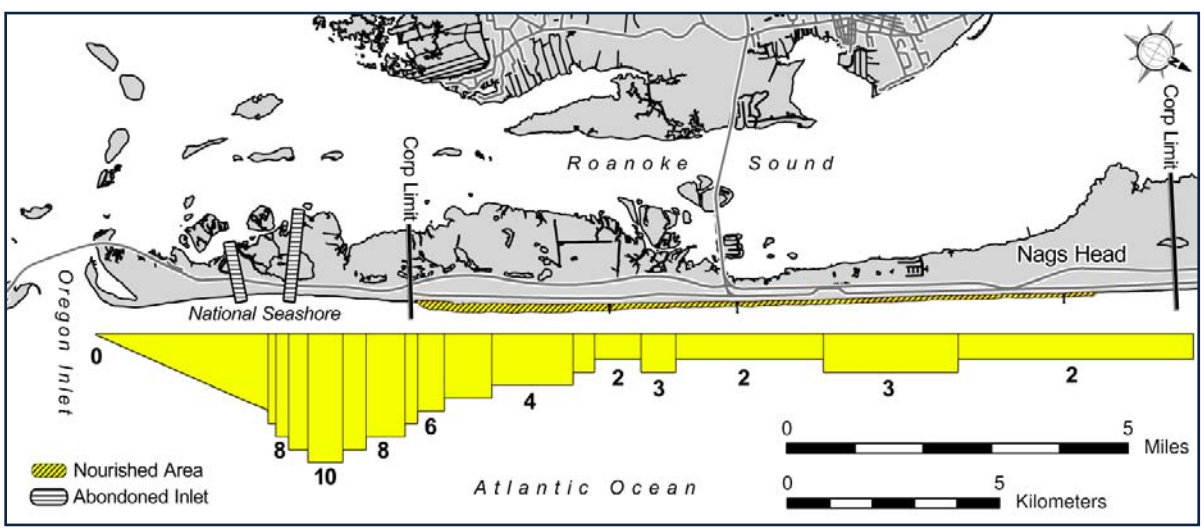


FIGURE A. Official 50-year erosion rates in feet per year (ft/yr) at Nags Head (NC) based on aerial photography circa 1950–2000. [Source: NCDENR 1998, 2004]

The Nags Head project formulation was based on a replacement volume and profile needed for storm protection at a defined storm-return period. The project totals ~10.0 miles of shoreline beginning ~1 mile from the Town's northern limit near the Bonnett Street public beach access (milepost 11.25) and extending south to the Town line (milepost 21) adjacent to the Cape Hatteras National Seashore. Nourishment quantities were varied by reach according to the gradient in volumetric losses. Thus, Reach 1 was scheduled to receive a lower fill density than Reach 3. The final design (CSE 2011) refined the fill densities and incorporated more subreaches within the basic parameters and restrictions of state and federal permits. The overall project limit and project reaches are shown in Figure B along with the borrow areas approved for use within USACE-designated borrow area S1. Subareas 2 and 3 were used in the present project.

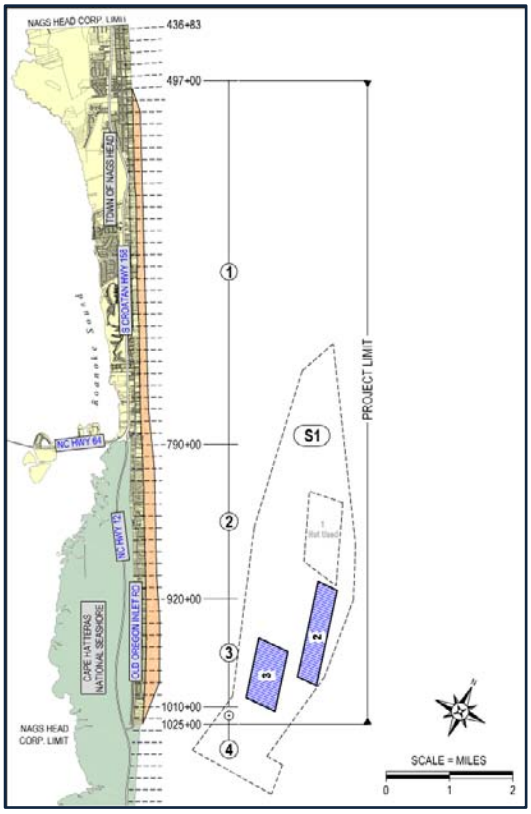


FIGURE B. Nags Head (NC) project reaches and borrow areas 2 and 3.

The work included dredging, placement, grading, and environmental protection as specified under federal and state permits of 4,600,000 cy along 52,800 linear feet (10 miles) of Nags Head beach in four reaches identified as follows:

1) Reach 1 – 1,634,700 cy over 29,300 linear feet (stations 497+00 to 790+00).

2) Reach 2 – 1,366,500 cy over 13,000 linear feet (lines 790+00 to 920+00).

3) Reach 3 – 1,480,000 cy (base bid plus alternate bid quantity) over 9,000 linear feet (lines 920+00 to 1010+00).

4) Reach 4 – 118,800 cy over 1,500 linear feet (lines 1010+00 to 1025+00).

The Town of Nags Head obtained permits under the National Environmental Policy Act (NEPA) and the state Coastal Area Management Act (CAMA) permitting process, including preparation of comprehensive EIS's (CSE 2008, USACE 2010). The

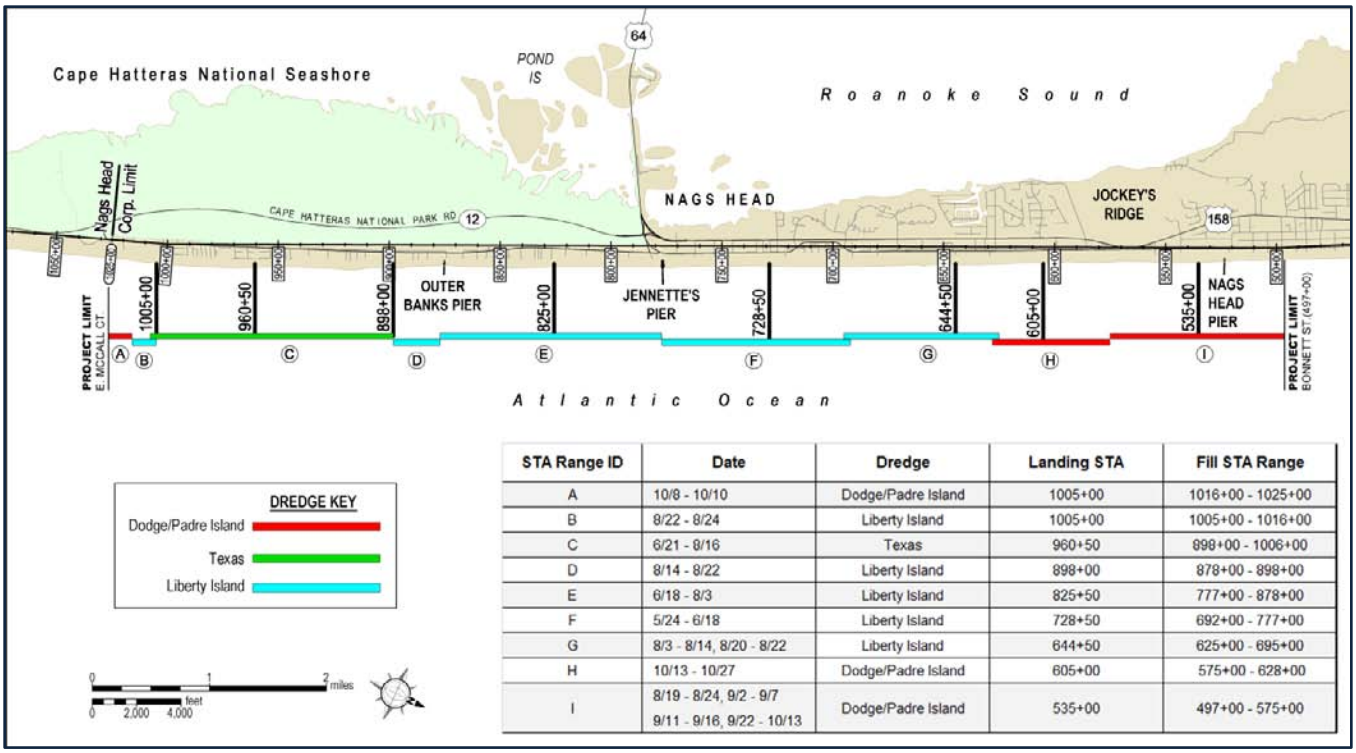
environmental documentation was necessitated by the need to accomplish the work during summer months.

The North Carolina major CAMA permit (45-110) was received on 29 April 2011, and the federal permit (SAW 2006-40282) was received on 30 November 2011. CSE prepared a final design (CSE 2011), plans, specifications, and bid documents, and made them available to contractors in January 2011 following review by Town officials.

Bids were requested for mobilization and pumping of a base quantity of 3.0 million cubic yards over the length of the project and an alternate (supplementary) quantity of up to 1.6 million cubic yards. GLDD offered the lowest bid which equated to $30,184,000 (included mobilization/demobilization and pumping) for 4.6 million cubic yards (maximum volume allowed under the permits). The net price equated to (~)$6.56 per cubic yard (in-place volume based on measurements on the beach). The Town's authorized construction budget (limit) was $32 million. Therefore, the total construction price was ~94.3 percent of the construction budget and ~81.6 percent of the project funds ($37 million) allocated by the Town of Nags Head. Engineering and field data collection, environmental permitting, and environmental monitoring costs (2005–2011) were (~)$1.8 million (~4.9 percent of project funds allocated). Funds remaining for post-project monitoring (physical and environmental), sand fencing, legal, administration, contingencies, and future renourishment total (~)$5 million.

Construction & Project Performance During Hurricane Season

The contractor (GLDD) opted to accomplish the work using a combination of ocean-certified hopper dredges and a traditional cutterhead-suction dredge, utilizing multiple "landing" areas for pumpout in either direction along the beach (Fig C). Three hopper dredges (GLDD's *Liberty Island, Padre Island,* and *Dodge Island*) and the cutterhead dredge (*Texas*) were mobilized to the project site at various times, completed all pumping and sand placement between 24 May and 27 October 2011, and were demobilized from the project site. The *Texas* utilized borrow subarea 3 and pumped directly to shore over line lengths of about 9,000-15,000 linear feet (~2,750-4,500 m). The hopper dredges mainly utilized borrow subarea 2 and accomplished the balance of the work. Mooring buoys for the hopper dredges were positioned 3,000 ft (~900 m) offshore in water depths of ~35-40 ft (~10-12 m).



STA Range ID	Date	Dredge	Landing STA	Fill STA Range
A	10/8 - 10/10	Dodge/Padre Island	1005+00	1016+00 - 1025+00
B	8/22 - 8/24	Liberty Island	1005+00	1005+00 - 1016+00
C	6/21 - 8/16	Texas	960+50	898+00 - 1006+00
D	8/14 - 8/22	Liberty Island	898+00	878+00 - 898+00
E	6/18 - 8/3	Liberty Island	825+50	777+00 - 878+00
F	5/24 - 6/18	Liberty Island	728+50	692+00 - 777+00
G	8/3 - 8/14, 8/20 - 8/22	Liberty Island	644+50	625+00 - 695+00
H	10/13 - 10/27	Dodge/Padre Island	605+00	575+00 - 628+00
I	8/19 - 8/24, 9/2 - 9/7 9/11 - 9/16, 9/22 - 10/13	Dodge/Padre Island	535+00	497+00 - 575+00

FIGURE C. Multiple landing areas, fill ranges and dates for the dredges GLDD utilized in the Nags Head beach nourishment project between 24 May and 27 October 2011.

Construction directly impacted ~300-1,000 ft (~90-300 m) of beach each day with completed sections reopened for recreation the following day (typical). By setting the construction berm at +6 ft (1.8 m) NAVD which is slightly lower than the native back beach elevation, the fill template intersected the dry beach, leaving a narrow corridor for public access adjacent to the active beach-filling operations.

Conditions for dredging operations were generally favorable from the initial pumping in late May through mid August. Certain delays occurred for dredge maintenance whereby the equipment moved to the nearest port (Norfolk VA) for several days at a time. Three months into construction, GLDD had placed ~3.8 million cy (~2.9 million m³) on the beach, representing almost 85 percent of the contracted volume. Reaches 2 and 3 were complete by late August, leaving about half of Reach 1 and Reach 4 (taper section at the downcoast end) incomplete when Hurricane *Irene* impacted the project area on 27 August 2011. Figure D shows the areas completed and remaining at the time of the storm.

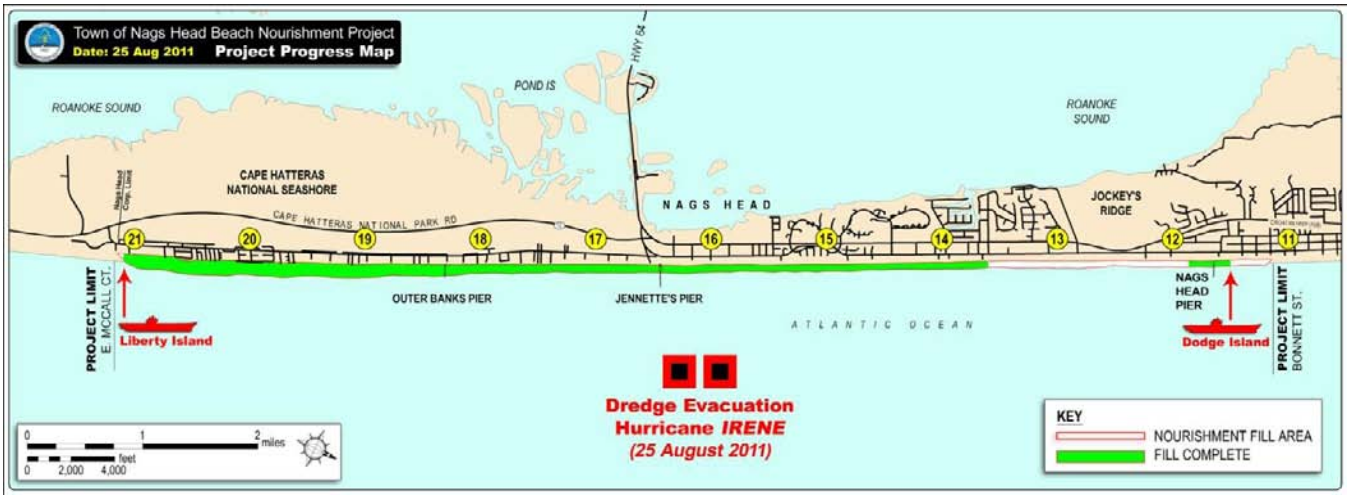


FIGURE D. Progress map before Hurricane *Irene*'s landfall. [Source: CSE]

The *Texas* and the *Liberty Island* demobilized from the job before *Irene* impacted the project site. The smaller hopper dredges, *Padre Island* and *Dodge Island*, returned from a safe harbor after the storm to finish construction. The remaining work on the project was accomplished by 27 October 2011 with numerous weather delays in September and October, associated with passage offshore of Hurricanes *Katia* (8 September) and *Maria* (16 September) and at least five extratropical cyclones.

Under normal construction practice, a portion of the nourishment sand on the construction berm is designed to shift underwater by wave action and eventually reach equilibrium. Northeasters or storms like *Irene* accelerate this process. Some sections had just received new sand days before the storm, and nearly all sections had not fully adjusted and that is why there was an extensive shift of sand from the visible beach into shallow water. The volume shifted beyond Mean Low Water (MLW, -2.05 ft NAVD) reported from CSE's 28 August 2011 survey was ~930,000 cy. Fortunately, the storm's intensity and surge were insufficient to penetrate across the nourishment berm and cut back the dunes. Even the condemned properties at Seagull Drive, which received nourishment about two weeks before the storm, made it through the storm without further damage.

The Town and CSE obtained additional profile data and completed another post-storm survey in late September. The net change to MLW as of 28 September was ~700,000 cy, already indicating some recovery of the low-tide beach compared to the ~930,000 cy volume loss to MLW estimated from CSE's 28 August survey. The post storm surveys indicated only a minor net loss of ~100,000 cy or about 3 percent of the placed volume

measured to the −12-ft NAVD contour along the entire project area. Based on this result, CSE concluded that *Irene* did not produce sufficient net volume losses in the project area to justify an application for sand replacement under a FEMA, post-disaster community assistance grant.

The newly placed sand served to absorb storm-wave energy, reduced the degree of wave runup, and prevented damage to the foredune, buildings, and roads during *Irene*. While the construction berm was overtopped by waves, no ocean overwash penetrated the dunes or left dune escarpments along the nourished sections.

Environmental Protection Measures and Results

The principal environmental issue associated with the Nags Head nourishment project was sea-turtle nesting. As mitigation for summer dredging, the Town of Nags Head was required to provide turtle monitoring on the beach each night during construction and endangered species monitoring onboard the dredges. Open-net turtle trawling was also required during hopper dredging for purposes of scaring up turtles from the bottom ahead of the dredge. There were no turtle incidents during the Nags Head nourishment project (May to October 2011) and a total of five successful nests were laid within the Town limits in 2011 outside the areas of active construction (Fig E).

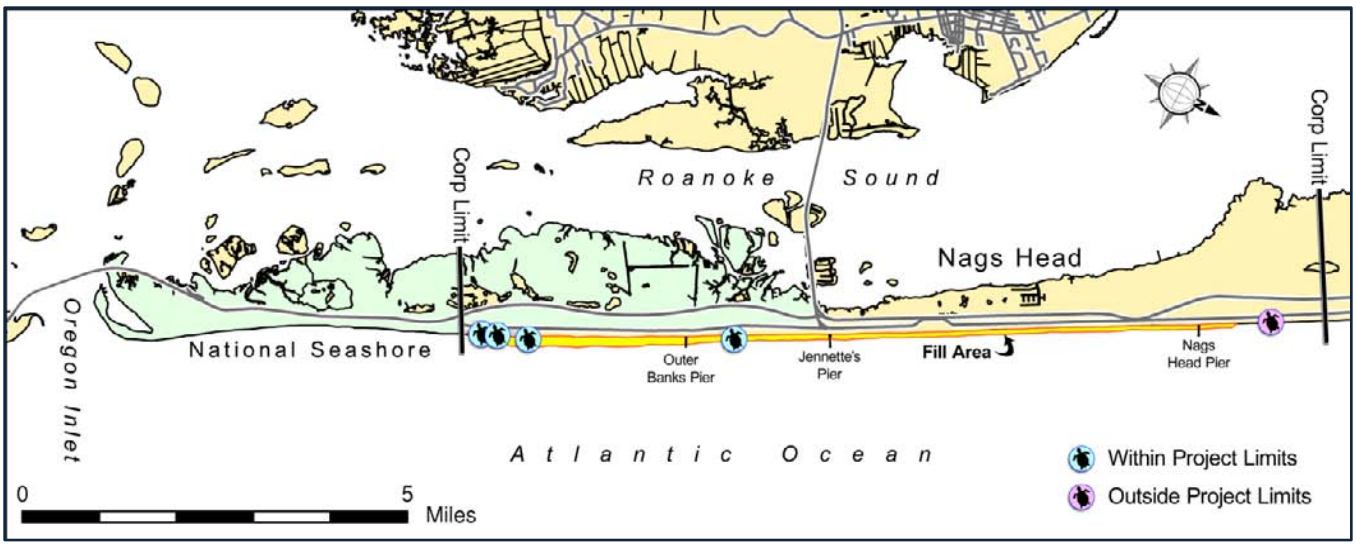


FIGURE E. A map of turtle nests laid at Nags Head during the 2011 turtle-nesting season. Four nests were found within the project limits but outside the active work area and pipeline corridor, and were subsequently relocated. Hatching success rates ranged from 77 percent to 94 percent, making 2011 one of the most productive years on record at Nags Head (NC).

Project Volume Evaluation and Confirmation

Construction surveys for purposes of payment confirmed a total of 4,615,126 cy were placed along 10.0 miles between 24 May and 27 October 2011, making Nags Head the largest locally-funded beach nourishment project completed to date (under one phase) in the United States. CSE completed a detailed survey of the beach and inshore zone in November 2011 within one month of project completion and compared the post-project conditions against the November 2010 condition (same-season comparison). CSE confirmed that there are 4,713,927 (±3 percent) cubic yards more sand volume in the ten-mile project area after nourishment (Table A).

TABLE A. Summary of fill volume versus design volume for each reach based on before-dredging and after-dredging surveys by GLDD and November 2010 (pre-project) and November 2011 (post-project) surveys by CSE. Volume calculations for the November 2011 survey extended to the -12 FT depth contour approximately 800 FT from the foredune.

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Reach	Limits	Length (ft)	CSE Design Volume (cy)	GLDD Applied Fill Volume (cy)	Diff between Design and Fill (%)	CSE Verified Volume (cy)
1	497+00 to 790+00	29,900	1,634,700	1,645,812	0.68%	1,819,532
2	790+00 to 920+00	13,000	1,366,500	1,405,498	2.85%	1,358,359
3	920+00 to 1010+00	9,000	1,480,000	1,423,771	-3.80%	1,377,313
4	1010+00 to 1025+00	1,500	118,800	140,045	17.88%	158,723
Total	**497+00 to 1025+00**	**52,800**	**4,600,000**	**4,615,126**	**0.33%**	**4,713,927**

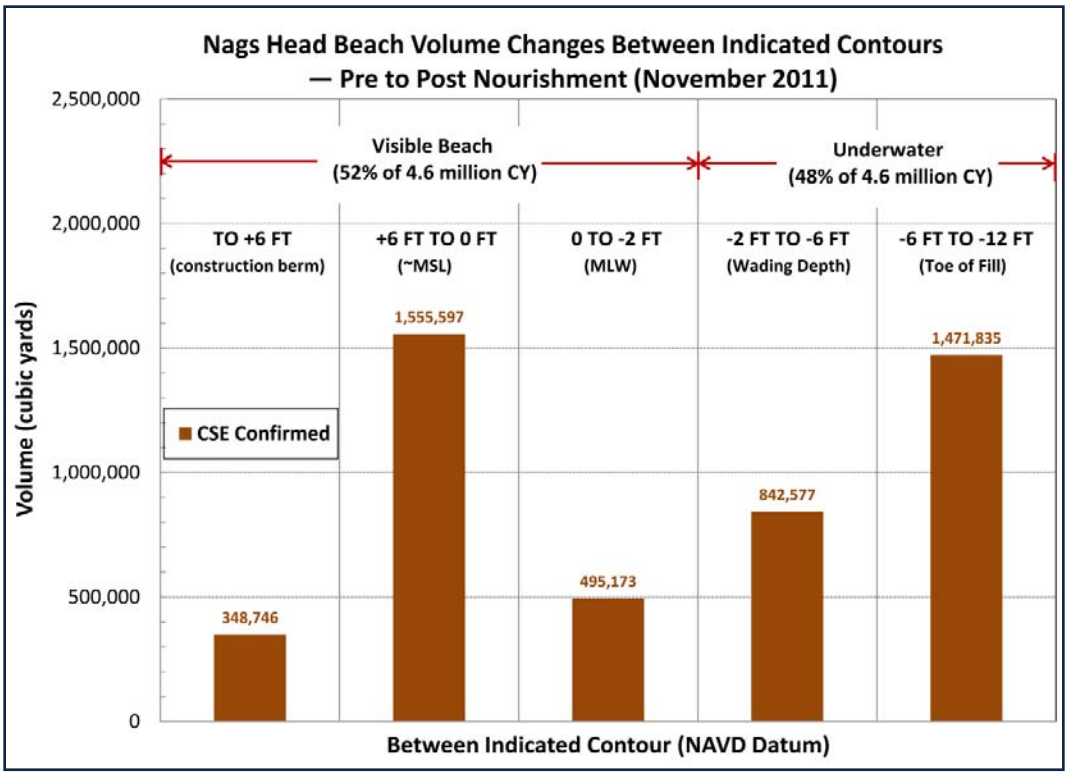
Figure F (upper) shows the sand volumes contained in particular slices of the beach. Note that after adjustment, 52 percent of the nourishment volume was contained in the visible beach above MLW, and ~48 percent was located close to shore between MLW and the 12-ft depth contour (~800 ft from the foredune). At least half of the nourishment volume had been expected to end up below low water after initial profile adjustment in accordance with the normal boundaries of the littoral zone along Nags Head. The initial shift of some sand into shallow water is a necessary adjustment to create a stable profile that is similar in form to the native beach.

Figure F (lower) shows the accumulated total volumes between the foredune and indicated depth contour. GLDD's survey during construction confirmed that ~94 percent of the nourishment sand (~4.3 million cubic yards) was placed above low-tide wading depth (−6 ft NAVD) and only ~6 percent settled in deeper water. After Hurricane *Irene* and the fall storms, CSE's post-project survey confirmed that ~70 percent of the

nourishment sand (~3.2 million cubic yards) remained above low-tide wading depth. The remainder was found between the 6-ft and 12-ft depth contours, which are about 400–800 ft from the foredune. CSE's measurements in November 2011 detected over 4.7 million cubic yards **more** sand along Nags Head beach (calculated to −12 ft contour) compared with conditions in November 2010. This result is better than expected and suggests there has been no loss of sand by natural processes over the past year within the project limits and a gain of at least 4.6 million cubic yards via nourishment.

In summary, the Nags Head nourishment project is performing better than expected, and the profile is adjusting to a shape and configuration which is indistinguishable from a natural beach. CSE expects the higher dry beach (formed by storm overwash) will remain dry most of the time and will serve as a feeder for dune growth. The landward and offshore shift of sand had the important effect of creating a more natural profile with new sand bars forming in shallow water. Prior to the adjustment of the nourishment project, surfing conditions were unfavorable and dangerous in some areas because of the steep slope of the wet beach. However, after storms impacted Nags Head and modified the profile, the resulting underwater bars produced more favorable surfing conditions.* Areas where the dry beach is wide are also likely to sprout vegetation in spring.

> **All beaches experience profile adjustment which is simply the response of the beach to changing wave heights and water levels. Beaches absorb and dissipate wave energy with the universal response being a flattening of the profile as wave energy increases (Komar 1998). A flatter profile provides a broader wet-sand beach over which waves lose their energy. The character of breaking waves and swash also produces favorable changes. This is why the wave runup across the wide nourished beach did not attain the heights experienced along some narrow-beach sections of Dare County. After storms subside, the flatter profile tends to adjust again. Lower waves will shift sand from the shallow-water bars back to the dry beach.*
>
> *The initial adjustment of the Nags Head beach nourishment project was, therefore, a combination of offshore movement due to the inherently unstable configuration of sand upon placement and the adjustment due to storms. Profile volumes, as measured before and after the project, provide an objective measure of the net impact. CSE believes the single most important finding of the pre- and post-construction surveys is the negligible loss of nourishment sand within the project limits. The critical boundaries of concern are the ten-mile alongshore length and the cross-shore between the foredune and −19-ft NAVD contour. These boundaries define a box which contained 4.6 million cubic yards less sand before the project. The volume of nourishment sand remaining in that box over time will define the performance of the project.*



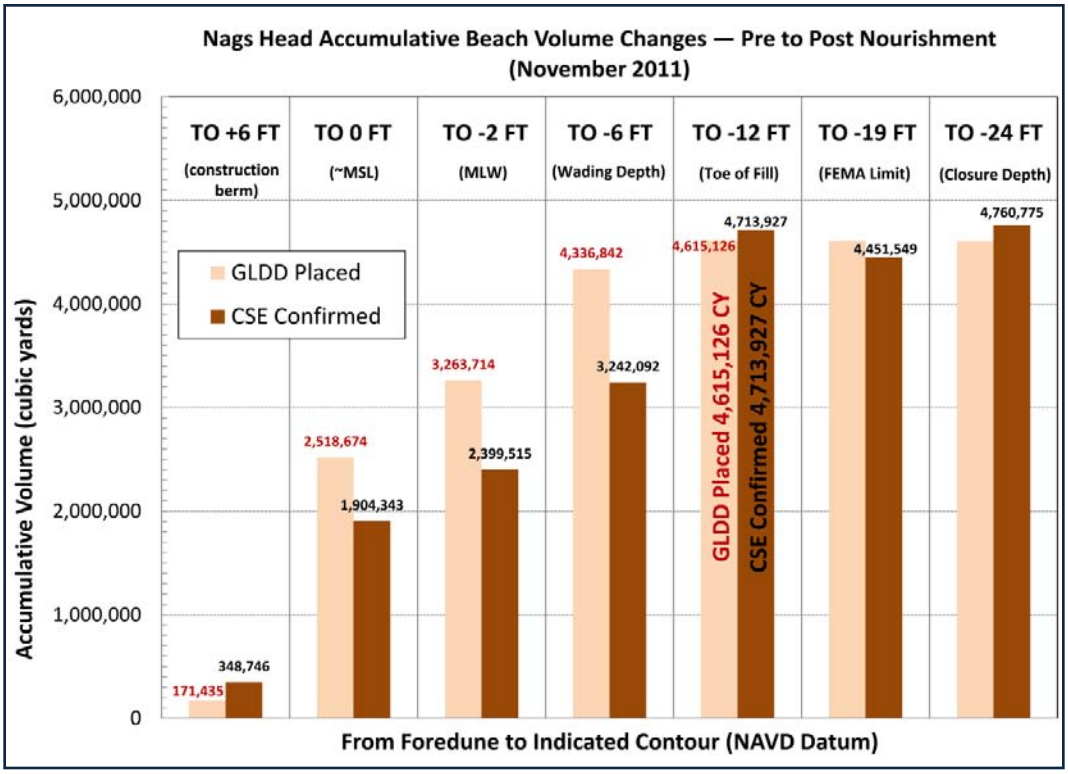


FIGURE F. Beach volume changes between November 2010 and November 2011. **[UPPER]** Sand volume changes between representative contours. **[LOWER]** Accumulated volume changes between the foredune crest and the indicated contour.

Monitoring & Maintenance Recommendations

In accordance with FEMA Publication 321 (Appendix B) and Code of Federal Regulations 44 CFR 206.226(j), a maintenance program involving periodic renourishment of sand must be established and adhered to by the Town of Nags Head to qualify for FEMA assistance. The purpose of such maintenance program is to track the physical condition of the beach after nourishment, quantify sand volume changes, and determine whether the project qualifies for emergency renourishment following declared disasters. It also is intended to identify erosion hot spots and recommend small-scale maintenance renourishment, placement of sand fencing, and/or sand scraping so as to increase the life of the project.

CSE recommends that the Town of Nags Head conduct an annual assessment of the physical condition of the nourished shoreline. The beach should be surveyed semi-annually the first year and annually in subsequent years using the transect plan initiated by the USACE and CSE. Such surveys will give the Town an annual assessment of the beach condition and will reveal problem areas or erosion hot spots that require attention. Annual surveys also serve to document the beach condition prior to the occurrence of a major erosion event, such as a hurricane. Should a major storm event occur, a post-storm survey should be completed for damage assessment as soon after the storm as possible. Since the project is an engineered beach fill, the annual and post-storm surveys could provide a basis for reimbursement and reconstruction of the beach with federal disaster funds under a community assistance grant (eg – FEMA Category G post-storm restoration funds).

Benthic monitoring of the biological response of the nourished beach and borrow areas is required by the state permit (CAMA 45-10 Item #15). The Town of Nags Head is required to implement escarpment monitoring and associated leveling for three (3) years post construction (CAMA 45-10 Item #16f) As per special conditions of USACE permit (SAW-2006-40282 Paragraph #28), prior to the next three (3) turtle nesting seasons, beach compaction is to be monitored by the Town and coordinated with the Corps and NCWRC.

ACKNOWLEDGMENTS

The Nags Head beach nourishment project was sponsored by the Town of Nags Head and was paid for by a combination of local funds as described in Section 1.1. The genesis of the plan was developed in 2005 under the impetus of the Board of Commissioners (Mayor Bob Muller, Town Manager Webb Fuller, and Public Works Director Dave Clark PE). Subsequent administrations continued to support the project until completion. We thank former Mayor Muller, Mayor Renee Cahoon, Mayor Bob Oakes, and members (past and present) of the Board of Commissioners (including Wayne Gray, Doug Remaley and Anna Sadler) for their pioneering effort and close oversight during the lengthy planning, permitting, and funding process. We especially thank former Town Manager Charlie Cameron and present Town Manager Cliff Ogburn for their dedication and support of our work. Construction and project communication proceeded smoothly, partly through excellent support and coordination by Town staff (including Ralph Barile, Michelle Gray, Carolyn Morris, Roberta Thuman, and Kevin Zorc). It was truly a pleasure for us to work with such a dedicated Board and Town staff over the past decade.

CSE developed the plan for the interim nourishment project drawing on the considerable efforts of the USACE–Wilmington District for the federal Dare County project. We thank the District for providing early survey data (1994) and guidance during permitting. Any differences between the two projects are CSE's responsibility, and the present project should not be construed as a substitute for the federal project. We thank the Wilmington District and the Washington Regulatory Office of the USACE, especially District Counsel Justin McCorkle and Regulatory Project Manager Raleigh Bland, for their coordination and input during the permitting and EIS process. We also thank representatives of USFWS (Raleigh), NMFS (Morehead City), and the EPA (Atlanta) for their review of and comments on the permit application and EIS.

Numerous state agencies reviewed the environmental documentation and permit application, and performed weekly site visits during construction. We especially thank Doug Huggett (NCDCM major permits manager, Morehead City), Frank Jennings (district manager), Lynn Mathis (compliance and enforcement representative, Elizabeth City), and John Cece (Dare County field officer) for their attention and coordination of the project. Other state resource agencies that reviewed the EIS and permit application, and provided

helpful comments included NCDMF (c/o Ann Deaton), NCWRC (c/o Maria Dunn and Matthew Godfrey), and NCDWQ (c/o Roberto Scheller).

Christian Legner with NEST was the coordinator of sea turtle monitors on the beach. We thank her and her team for their professionalism and dedication to this task.

We especially thank Great Lakes Dredge & Dock Company (in particular project sponsor Sam Morrison, project manager Dave Allen, and vice president Bill Hanson) and the crews of the dredges (*Texas, Liberty Island, Padre Island,* and *Dodge Island*) for their outstanding performance in delivering the completed project volume efficiently and without incident. They were the backbone of the project.

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

CSE's work was directed by Dr. Tim Kana, founder and president of CSE. Dr. Haiqing Liu Kaczkowski (PE) prepared the final design and supervised construction. Steven Traynum (senior physical scientist) was responsible for field data compilation and analysis. Captain Philip McKee was on-site technical representative and chief of field data collection. Trey Hair (senior CADD specialist) prepared project drawings. Diana Sangster prepared contract documents and report manuscripts. Dennis Burns assisted with construction observations. The present report was prepared by Haiqing Kaczkowski (PE, NC 37281), Tim Kana (PG, NC 1752), Trey Hair, and Diana Sangster.

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A5) GLDD Dredges Operations Reports
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J2) CSE Letter to NCDCM (dated 28 June 2011)
J3) What to Expect when Your Beach is Nourished (dated 9 August 2011)
J4) Hurricane *Irene* Impacts (dated 31 August 2011)
J5) Digital Terrain Model (DTM) for pre and post Irene conditions
J6) CSE Letter to NCDCM (dated 12 September 2011)
J7) Updated Post-Hurricane *Irene* Erosion Assessment (dated 29 September 2011)
J8) Post-Project Survey Preliminary Results (dated 6 December 2011)
J9) CSE Payment Recommendations (#1 to #7)

1.0 INTRODUCTION

This report is prepared in connection with the beach nourishment project at Nags Head, Dare County, North Carolina. It provides a summary of the nourishment completed between May and October 2011 by the contractor, Great Lakes Dredge & Dock Company, Inc (GLDD, Oak Brook, Illinois). Coastal Science & Engineering (CSE, Columbia, South Carolina) was the project engineer.

This report includes:

- Brief summary of the project setting, purpose, and project description.
- Project time line and construction sequence.
- Project performance under 2011 hurricane season.
- Sediment analyses of borrow area and beach fill.
- Environmental protection measures and results.
- Borrow area dredging impact.
- Summary of beach changes and fill volumes.
- Monitoring and maintenance recommendations.

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

1.1 Project Sponsor

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

Since construction funding for the federal Dare County hurricane protection and beach erosion control project has not been appropriated yet, Nags Head used local funding for the project to meet the urgent problem of erosion in the town. The local funding includes:

- $18 million in cash from the Dare County Beach Nourishment Fund (fund will replenish $3-3.5 million per year from the 1 percent occupancy tax that it currently receives).

- $18 million revenue bond to be paid back over 6 years with proceeds from a 1 percent increase to the occupancy tax. The 1 percent tax increase will generate about $2 million per year. Nags Head will be able to use the $2 million-per-year revenue for five years to pay back $10 million of the bond. The remainder of the bond will be paid back through an increase in taxes. The Board has adopted a town-wide tax increase of 2 cents (from last year's town tax rate of 15.75 cents to 17.75 cents) and a tax increase of 16 cents for the ocean side from Bonnett Street (about Mile Post 11.25) south to the National Park Service line.
- $1 million from the Town's general fund (engineering costs).

1.2 Project Setting

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

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

The Town is exposed to high wave energy during storm events (particularly hurricanes and northeasters) which are common in fall and winter. Net sand transport is south along Nags Head. There are presently three ocean piers and five stormwater outfalls crossing the beach along the Town of Nags Head. The beach is composed of medium sand with a mean grain size of ~0.4 millimeters (mm). Mean monthly average significant wave height ranges from 2.1 ft (July) to 3.9 ft (October) based on USACE-FRF data from 1986-2006. Details regarding the morphological setting are given in CSE (2005) and CSE (2011a).

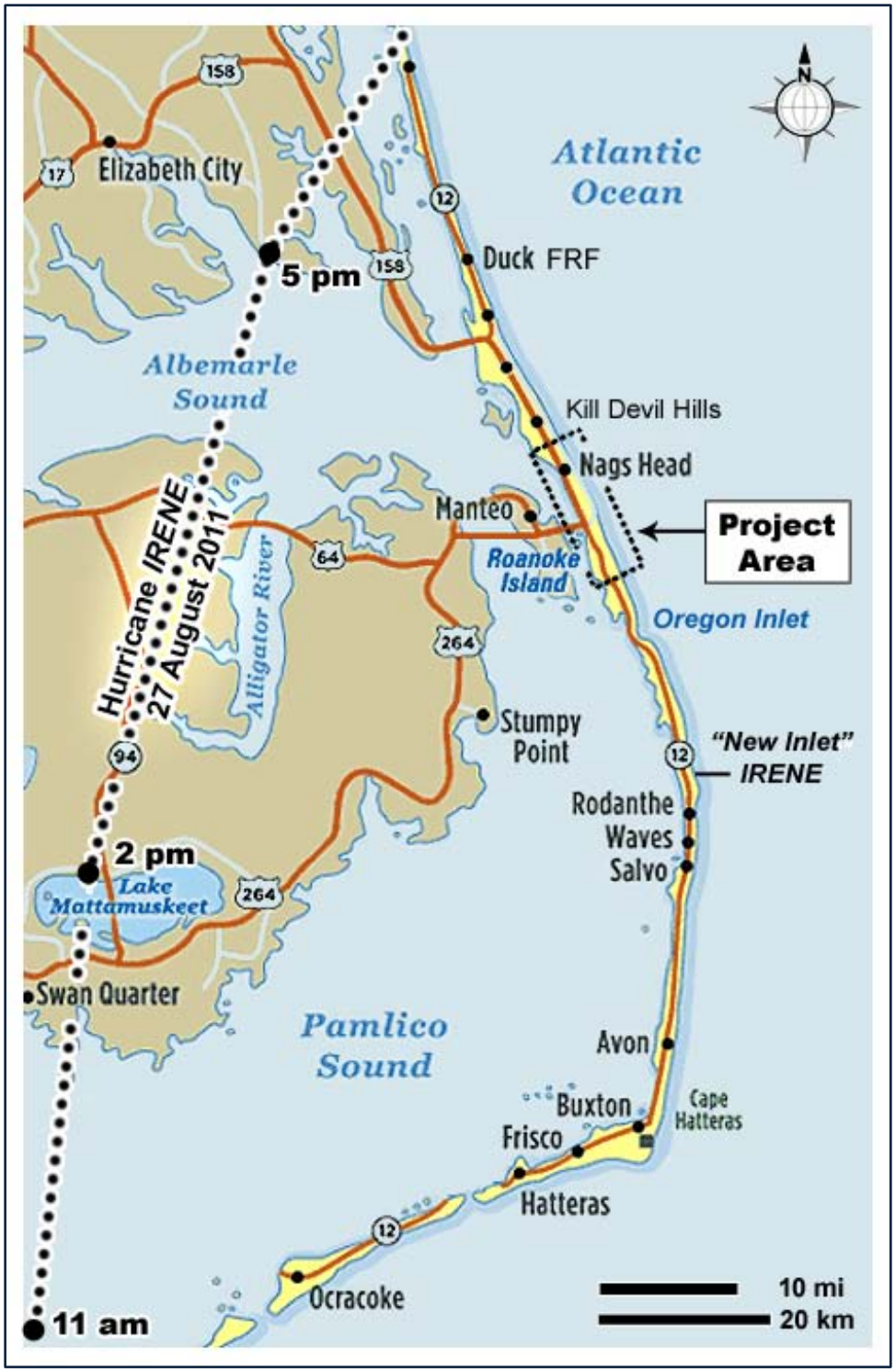

FIGURE 1.1. Project location map. Also shown is the Hurricane *Irene* storm track on 27 August 2011 which impacted the project area prior to completion.

1.3 Background, Purpose and Need

Nags Head has sustained chronic erosion over the past 50 years due to storms and sand losses to Oregon Inlet. Erosion rates increase from north to south and remain high in the National Seashore reach between Nags Head and Oregon Inlet as shown in Figure 1.2. Erosion rates ranging from ~2 feet per year (ft/yr) to upward of 10 ft/yr (NCDENR 1998, 2004) have forced abandonment of property and have left numerous buildings with no dune protection. Under state regulations and local ordinances (Town Code Section 48-7, Section 48-87), buildings are condemned if the active beach encroaches on septic systems. As of summer 2010, ~25 houses were positioned seaward of the active beach line and are therefore subject to possible removal. All condemned properties are located south of Whalebone Junction, an intersection which divides Nags Head into north and south reaches. While the official erosion rates for Nags Head vary widely from north to south, sustained erosion over many years at some level has left nearly all oceanfront properties vulnerable to damaging storms. The shore-protection needs for Dare County beaches have been investigated as early as 2000 by the US Army Corps of Engineers (USACE 2000). The federal Dare County beach project includes the communities of Nags Head, Kill Devil Hills, and Kitty Hawk. It extends along ~14.2 miles of the oceanfront at these communities (Fig 1.3).

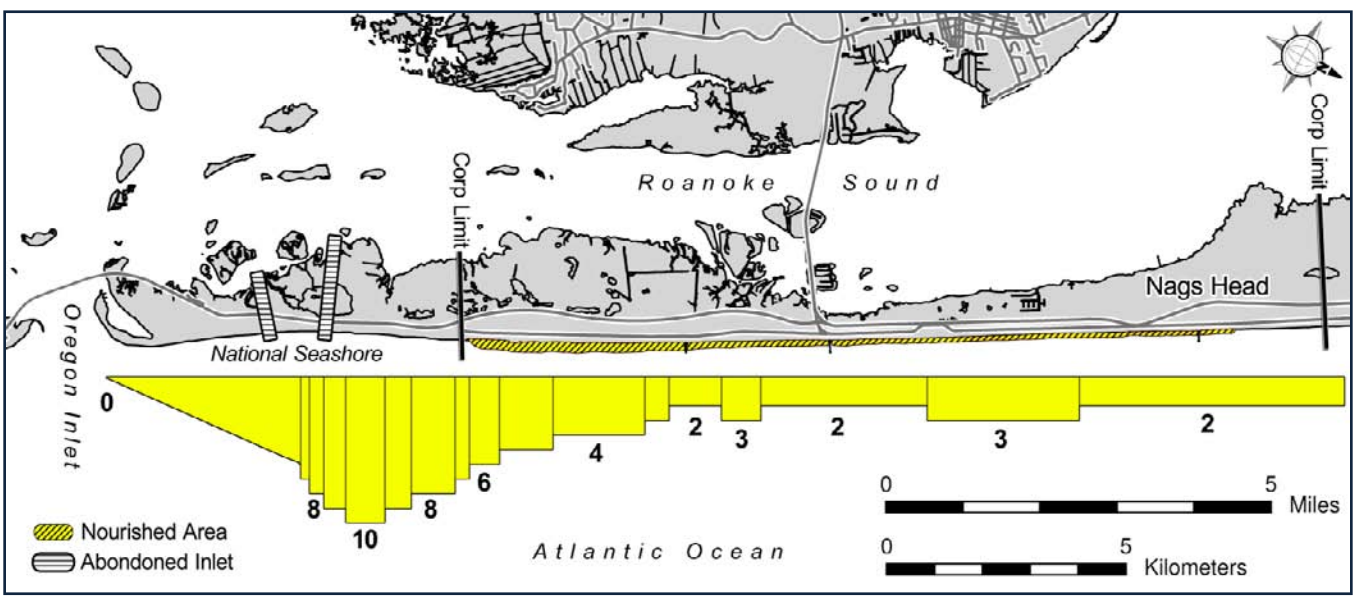

FIGURE 1.2. Official 50-year erosion rates in feet per year (ft/yr) at Nags Head (NC) based on aerial photography circa 1950–2000. [Source: NCDENR 1998, 2004]

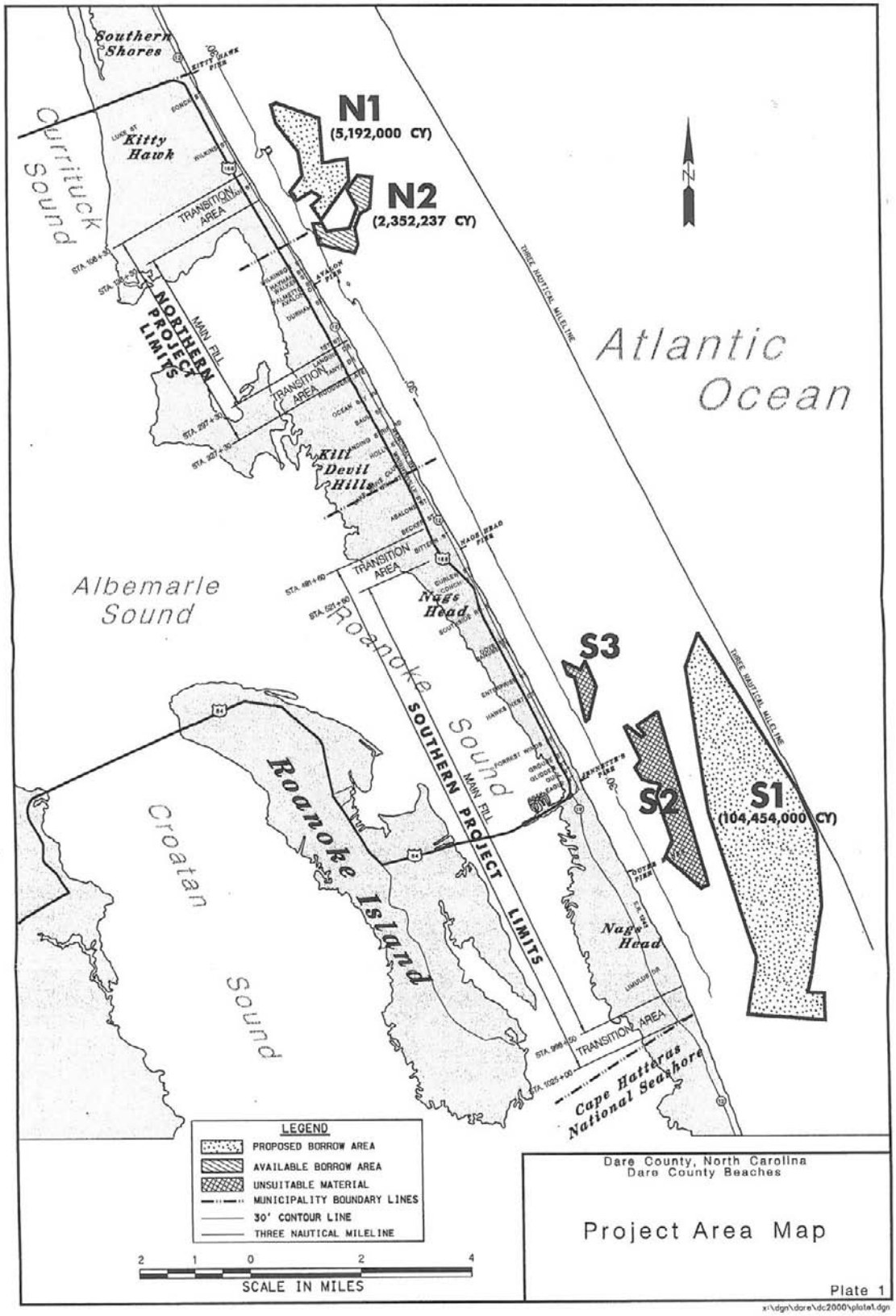

FIGURE 1.3. Project limits of the federal Dare County beach project and one of the primary, federal borrow areas ("S1") off south Nags Head (after USACE 2000).

The federal project is divided into the north project area and south project area. The south project area includes 10.1 miles along Nags Head. The federal plan for the initial nourishment of the south project area calls for 8.04 million cubic yards (cy) of sand, and periodic renourishment at a rate of 2.835 million cubic yards of sand. The north project area encompasses 4.1 miles along Kill Devil Hills and Kitty Hawk.

Based on the plan formulation of the federal project, the total inflation-adjusted (fully funded) project costs were estimated to be $1.662 billion over the 50-year period of federal participation. The federal share of the fully funded project costs was estimated at $843.3 million. As the single, largest beach restoration plan ever formulated by the USACE (Fig 1.4), the 14-mile-long Dare County project represents upward of 25 percent of the federal backlog of nourishment projects waiting for appropriation (letter from General JP Woodley Jr to Honorable Tom Coburn, US Senate, 1 May 2008).

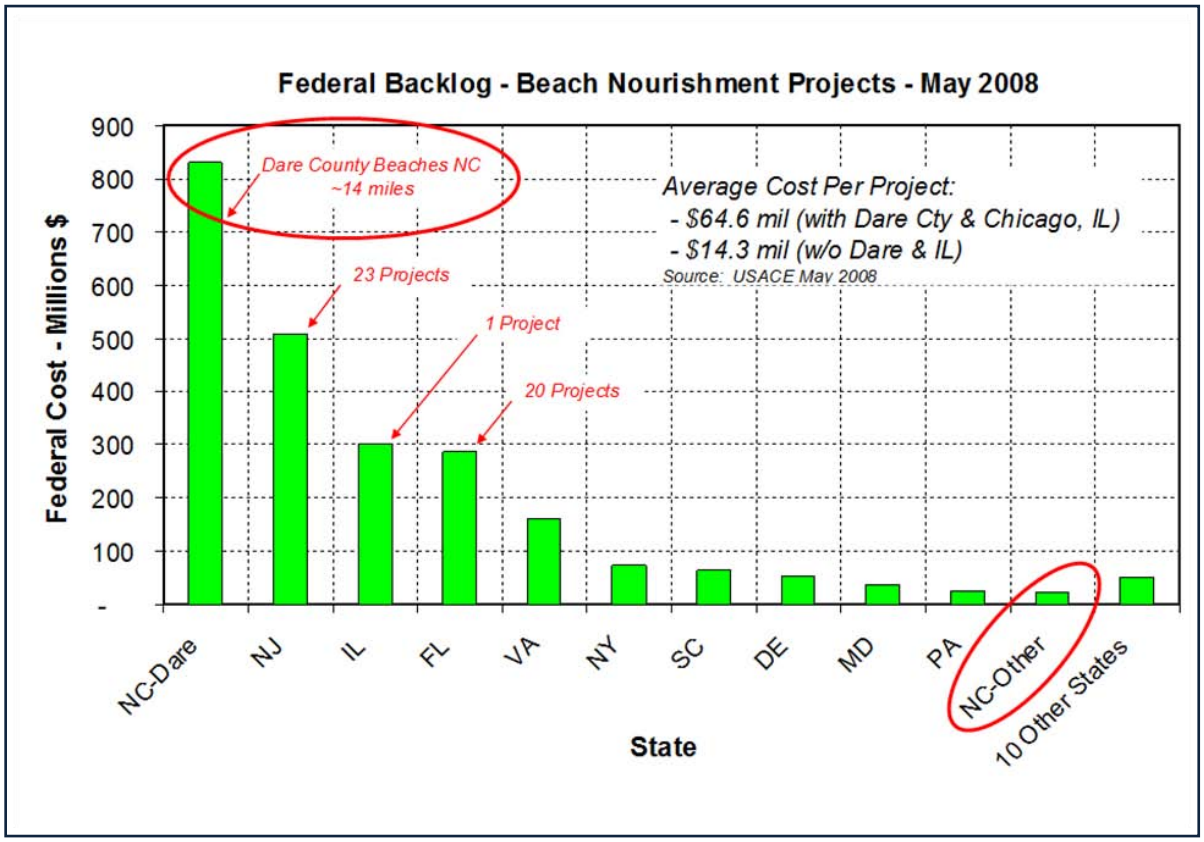

FIGURE 1.4. Backlog of 92 federal beach nourishment projects as of May 2008 was (~)$2.4 billion. The federal Dare County project represented one-third of the estimated total cost.

The genesis for the Nags Head beach nourishment project was a recognition by the Town's Board of Commissioners that the 50-year federal Dare County project would be delayed until funds could be appropriated by Congress. CSE was retained in 2005 by the Town of Nags Head to perform planning and design work on a locally-sponsored, interim beach nourishment project. The interim project was intended to be consistent with the "South Project Area" of the federal Dare County project to the extent possible. This included maintaining the same project limits and utilizing a portion of the USACE-designated offshore borrow area.

The major differences between the federal Dare County project and the Town of Nags Head project are the reduced scale (fill density), the plan to conduct all work in warm-season months (April through September) under one phase, and the anticipated utilization of a combination of ocean-certified hopper dredges and cutterhead dredges as determined to be feasible and safe by the dredging contractor. The Town of Nags Head requested authorization for construction in summer months when wave climate is favorable based on input from dredging companies and analysis of wave climate by USACE (2009, 2010) and CSE (2005, 2008, 2011). The proposal for summer dredging during the turtle-nesting period generated the requirement for formal, Section 7 consultation between the applicant and federal resource agencies [US Fish & Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS)].

1.4 Permitting

The Town of Nags Head obtained permits under the National Environmental Policy Act (NEPA) and the state Coastal Area Management Act (CAMA) permitting process, including preparation of comprehensive EIS's (CSE 2008, USACE 2010). The environmental documentation was necessitated by the need to accomplish the work during summer months. The principal environmental issue at Nags Head was sea-turtle nesting. As part of the Southeast Region, Nags Head is subject to the same turtle-protection measures and "take statements" as Florida, where the majority of nests are located (NMFS 1997). Virginia Beach (VA), 50 miles north of Nags Head, is situated along the same bight, but is under the environmental protection rules of the Northeast (USA) Region, where turtle nesting is of less concern.

Sea turtles, while present in low numbers in some Northeast Region waters, are not subject to the Southeast Region "take statements," which severely limit the use of hopper dredges. Nags Head, situated near the northern limit of the sea-turtle nesting range, has an average of 1.8 nests per year along the project shoreline over the past 25 years (source: NC Wildlife Resources Commission (NCWRC) database; USACE 2010). The average nest density in the OBX (north of Oregon Inlet) is <0.2 nests per mile per year (source: NCWRC database). By comparison, South Carolina beaches average upward of 15 nests per mile per year (NMFS 1998).

As mitigation for summer dredging, the Town of Nags Head was required to provide turtle monitoring on the beach each night during construction and endangered species monitoring onboard the dredges. Open-net turtle trawling was also required during hopper dredging for purposes of scaring up turtles from the bottom ahead of the dredge.

The North Carolina major CAMA permit (#45-110) was received on 29 April 2011, and the federal permit (ID SAW 2006-40282) was received on 30 November 2011. The Town of Nags Head was authorized to excavate up to 4.6 million cubic yards of sand from the USACE-designated offshore borrow areas (subareas 1, 2, and/or 3) and to deposit the material along ~10.0 miles of ocean shoreline. This permitted volume is significantly lower than the initial nourishment plan (8.04 million cubic yards) recommended by the USACE (2000) as part of the federal Dare County project (south project area, 50-year plan).

The Nags Head beach nourishment project totals ~10.0 miles of shoreline beginning ~1 mile from the Town's northern limit near the Bonnett Street public beach access (milepost 11.25) and extending south to the Town line (milepost 21) adjacent to the Cape Hatteras National Seashore (Fig 1.5). The purpose of the project is to restore a protective beach for a minimum of ten years, replace sand lost during the period of delay in the startup of the federal Dare County beach erosion control project, and expand the recreational beach for the benefit of the community.

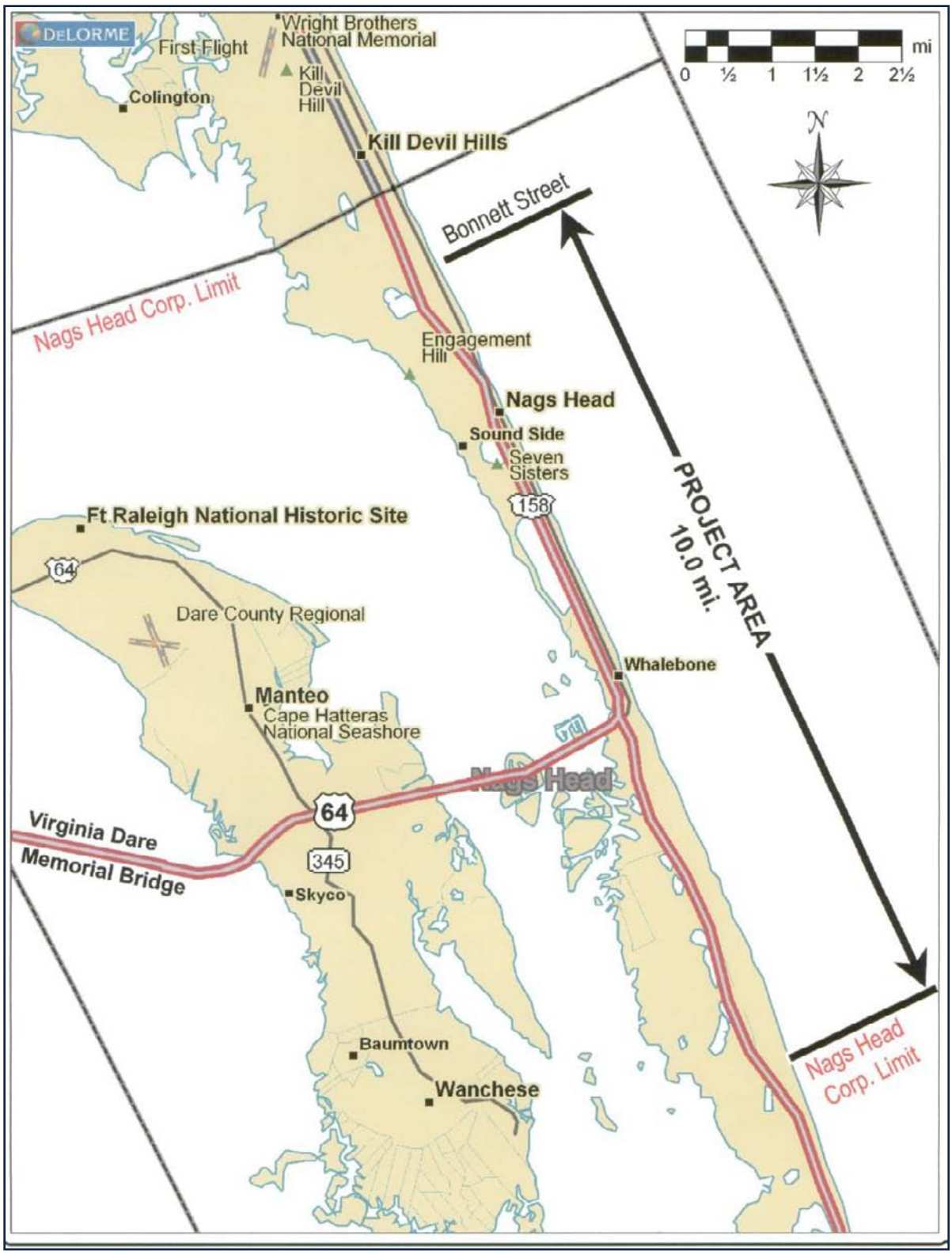

FIGURE 1.5. Nags Head (NC) beach nourishment project limits (CSE 2011b).

1.5 Project Bids

CSE prepared a final design (CSE 2011), plans, specifications, and bid documents, and made them available to contractors in January 2011 following review by Town officials. Bids were received and opened on 22 February 2011. Because work involved excavations offshore, ocean-certified dredges were required under US Coast Guard regulations. Three (out of five) US dredging firms, having ocean-certified equipment, bid on the project: Great Lakes Dredge & Dock Company (GLDD), Manson Construction, and Weeks Marine. The Town's authorized construction budget (limit) was $32 million.

Bids were requested for mobilization and pumping of a base quantity of 3.0 million cubic yards over the length of the project and an alternate (supplementary) quantity of up to 1.6 million cubic yards. GLDD offered the lowest bid which equated to $30,184,000 (included mobilization/demobilization and pumping) for 4.6 million cubic yards (maximum volume allowed under the permits—Table 1.1). The net price equated to (~)$6.56 per cubic yard (in-place volume based on measurements on the beach). The total construction price was ~94.3 percent of budget and ~81.6 percent of the project funds allocated by the Town of Nags Head. Engineering and field data collection, environmental permitting, and environmental monitoring costs (2005–2011) were (~)$1.8 million (~4.9 percent of project funds allocated). Funds remaining for post-project monitoring (physical and environmental), sand fencing, legal, administration, contingencies, and future renourishment total (~)$5 million.

Table 1.1. Bid evaluation for the Nags Head beach nourishment project.

	Bidder 1	**Bidder 2**	**Bidder 3**
	Great Lakes Dredge & Dock Company	Manson Construction Company	Weeks Marine Inc
Evaluated by Total Cost ($) of Permitted 4.6 million cubic yards of Work			
Bid A (completed by December 12, 2011)	30,184,000	40,120,000	38,450,000
Bid B (completed by August 12, 2012)	28,394,000	36,650,000	37,450,000

2.0 PROJECT DESCRIPTION

2.1 Project Plan

The beach nourishment project constructed along Nags Head was implemented by three ocean-certified hopper dredges and one cutterhead suction dredge by the contractor, GLDD. The work included dredging, placement, grading, and environmental protection as specified under federal and state permits of 4,600,000 cy along 52,800 linear feet of Nags Head beach in four reaches identified as follows:

5) Reach 1 – 1,634,700 cy over 29,300 linear feet (stations 497+00 to 790+00).

6) Reach 2 – 1,366,500 cy over 13,000 linear feet (lines 790+00 to 920+00).

7) Reach 3 – 1,480,000 cy (base bid plus alternate bid quantity) over 9,000 linear feet (lines 920+00 to 1010+00).

8) Reach 4 – 118,800 cy over 1,500 linear feet (lines 1010+00 to 1025+00).

The average fill density was 86 cy/ft, varying from north to south in relation to historic erosion rates. The overall project plan is shown in Figure 2.1, and the detailed fill schedule is listed in Table 2.1.

The sand was dredged from two designated offshore borrow areas (subareas #2 and #3 as illustrated in Fig 2.1) by dredges, pumped onto the beach, and shaped to the grades and quantities indicated on the project drawings. The maximum depth of excavation allowed was 8 ft including over-dredge. The maximum area of excavation allowed was 575 acres. The contractor was required to not exceed the cut depth and allowance indicated on the project plans for the borrow area.

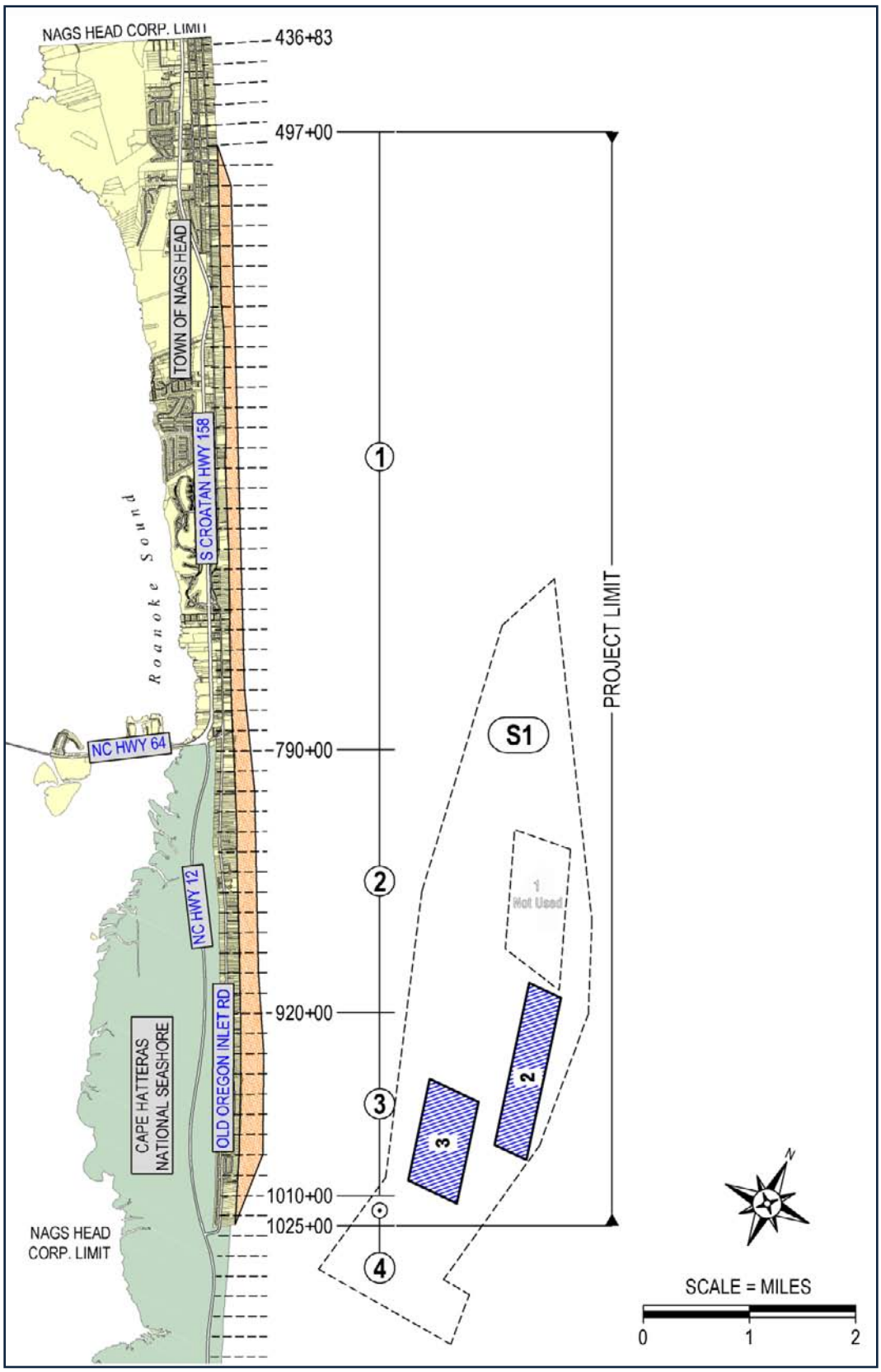

FIGURE 2.1. Nags Head (NC) project reaches and borrow areas 2 and 3.

TABLE 2.1. Detailed fill schedule for construction based on the final design (CSE 2011).

Project Plan Fill Schedule (4.6 million cy)				
Reach #	**Limits**	**Linear ft**	**Avg Unit Vol (cy/ft)**	**Reach Volume (cy)**
1	497+00 to 500+00	300	24	7,200
	500+00 to 635+00	13,500	47	634,500
	635+00 to 640+00	500	49	24,500
	640+00 to 645+00	500	55	27,500
	645+00 to 735+00	9,000	58	522,000
	735+00 to 740+00	500	63	31,500
	740+00 to 745+00	500	73	36,500
	745+00 to 790+00	4,500	78	351,000
2	790+00 to 855+00	6,500	78	507,000
	855+00 to 860+00	500	89	44,500
	860+00 to 865+00	500	110	55,000
	865+00 to 895+00	3,000	120	360,000
	895+00 to 900+00	500	132	66,000
	900+00 to 905+00	500	158	79,000
	905+00 to 920+00	1,500	170	255,000
3	920+00 to 995+00	7,500	170	1,275,000
	995+00 to 1000+00	500	158	79,000
	1000+00 to 1005+00	500	132	66,000
	1005+00 to 1010+00	500	120	60,000
4	1010+00 to 1014+80	480	120	57,600
	1014+80 to 1025+00	1,020	60	61,200
Totals	***497+00 to 1025+00***	***52,800***	***86***	***4,600,000***
REACH TOTALS				
Reach #	**Limits**	**Linear ft**	**Avg Unit Vol (cy/ft)**	**Reach Volume (cy)**
1	497+00 to 790+00	29,900	55	1,634,700
2	790+00 to 920+00	13,000	105	1,366,500
3	920+00 to 1010+00	9,000	164	1,480,000
4	1010+00 to 1025+00	1,500	79	118,800
Total	***497+00 to 1025+00***	***52,800***	***86***	***4,600,000***

2.2 Four Dredges Used in the Project

GLDD used a total of three hopper dredges and one cutter head dredge in the Nags Head beach nourishment project. Names, dimensions and capacities of the four dredges are listed in Table 2.2, and their photos are shown in Figure 2.2.

TABLE 2.2. Specifications of the four ocean-certified dredges that GLDD used in the project.

Type	Name	Dimensions (ft)			Capacity (yd^3)
		Breadth	Length	Draft	
Hopper Dredge	Liberty Island	59	315	28	6,540
	Dodge Island	53	281	22	3,600
	Padre Island	53	281	21.5	3,600
Cutter Suction	Texas	66	305	15	N/A

FIGURE 2.2. Four of GLDD's ocean-certificated dredges which were used in the Nags Head beach nourishment project. [Source: www.gldd.com]

2.3 Pumping Operations

Pumping operations on the beach started at 8:20 pm on 24 May 2011 by the *Liberty Island* and were completed at 8:20 am on 27 October 2011 by the *Padre Island*. GLDD submitted daily production reports (Appendix A5) for each day's operations of the dredges which included the volume dredged, borrow areas utilized, and reasons for any down time. The volume dredged shown on the records is based on the daily forward progress of the dredge and an assumed cut face, and does not necessarily equal the total volume placed on the beach. There is an expected volume loss between what is measured in the cut and the volume placed and measured on the beach—typically about 10-25 percent depending on the character of the material and other operational factors. For this project, the volume loss was found to be under 10 percent because the dredged materials contained negligible mud and incompatible debris. A summary of proprietary dredging production from contractor records has been provided to the Town under separate cover so as to maintain competitive advantages among contractors.

A weekly Dredging Quality Management (DQM) report from the USACE Mobile District Operations Division was provided to the Town, the contractor, and CSE for each hopper dredge in operation. The DQM report is a summary of the dredge profile during a given week. Formerly known as Silent Inspector (SI), the DQM program verifies, collects, and stores dredging instrumentation data for the USACE and provides tools to interpret and utilize this data for the USACE dredging management. Some issues addressed in the reports and GLDD's response are listed as follows.

1) Short data gaps within loads

   GLDD's response: *The data gaps may be caused when the positioning computer is taken out of active mode in order to install new hydro survey background drawings or change any settings for the dredge displays. The minimum rate of good data return required by the DQM specification is 95 percent. Despite the gaps noted in some of the reports, the good data return rate is over 99.9 percent, which is well within specified ranges.*

2) Noisy ullage sensor data

   GLDD's response: *The ullage sensors are the ultrasonic sensors that measure the level of water or sand in the hopper dredge. They are located out over the dredge where the sand and water discharge into the dredge. The sand and water mist data can be noisy when the sensors are not clean. Despite some spikes in the record, they can still provide good data.*

3) Tide sensor reporting outliers

   GLDD's response: *The tide sensor is not installed on board the dredge. A reported value may come from a gauge onshore or from other sources. It could be post processed if necessary.*

GLDD representatives stated that in light of their past experience, the DQM reports they received for this project were good and did not lead to any violations of reporting requirements under the federal permit for the project.

2.4 Environmental Protection Measures

Based on the state and federal permits, there were no seasonal or environmental time restrictions for execution of this project. However, dredging and placement operations were subject to certain strict environmental protection measures as detailed in special conditions of the permits. Required protection measures included open-net trawling for turtles ahead of the dredge(s) during designated periods, use of deflectors and specific equipment modification onboard hopper dredges, specific operations requirements and use of silent inspectors (DQM) onboard dredges, and use of certified endangered species monitors onboard dredges.

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

Federal and state resource agencies approved the contractor's environmental protection plan and the Town's sea-turtle monitoring plan submitted before the commencement of the project, and also checked the implementation of such plans during the project. The pumping operations started on 24 May 2011 and were completed on 27 October 2011 in compliance with the permits and without environmental incidents. Details will be discussed in Section 6.

2.5 Mean High Water Contour

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