ATTACHMENT 3

PURPOSE OF THE PROJECT & BASIS OF THE DESIGN
Excerpted from CSE (2005, 2007)

1.0 INTRODUCTION, PURPOSE & PROPOSED PROJECT

1.1 Introduction and Purpose

This Biological Assessment (BA) is prepared at the request of the US Fish & Wildlife Service (USFWS) following submittal of the draft Environmental Impact Statement (EIS) for the Nags Head emergency nourishment, Dare County, North Carolina (NC) (CSE 28 April 2006– this volume). It is preliminary to formal consultation and preparation of a Biological Opinion by USFWS which is necessitated by certain anticipated impacts to threatened and endangered species known to be present in the proposed project area.

1.2 Prior Correspondence and Communication

The applicant received preliminary comments on the draft EIS from the USFWS (letter from Pete Benjamin to Raleigh Bland dated 5 September 2006, Attachment 1) and prepared a response dated 6 October 2006 (letter from Timothy Kana to Raleigh Bland, Attachment 2). The USFWS raised agency concerns regarding:

- Construction schedule.
- Construction duration.
- Sea turtle nesting.
- Piper plover foraging.
- Seabeach amaranth.

The applicant's response provided additional information on the above-listed concerns and reiterated the similarities between the proposed federal Dare County Nourishment Project – South Project Area and the proposed locally funded emergency nourishment project. Because the federal project has been thoroughly reviewed by federal and state resource agencies (cf, USACE 2000, Vol 1), the applicant believed at that time that the various coordinations and review of the federal project by the USFWS would remain applicable for the proposed project. Specific supplementary data and information given by the applicant in response to the USFWS preliminary comments (Attachments 1 and 2) included the following:

- Similarities and differences between the federal nourishment plan (USACE 2000) and the locally funded emergency nourishment plan.
- Supplementary turtle-nesting data for North Carolina.
- Description of planned mitigation measures for dredging operations during the Sea Turtle Moratorium and Beach Nesting Waterbird Moratorium periods.
- Anticipated construction duration.

- Seabeach amaranth data for other North Carolina nourished beaches.
- Proposed prenourishment and postnourishment environmental monitoring.

The applicant received additional comments from the USFWS (letter from Pete Benjamin to Raleigh Bland dated 13 November 2006, Attachment 3) and prepared a response (letter from Timothy Kana to David Lekson dated 10 December 2006, Attachment 4). Specific supplementary data and information given by the applicant in response to the USFWS comments of 13 November included:

- Advantages and disadvantages of hopper dredging during warm-water construction periods.
- Additional information on turtle-nesting activity in Nags Head and Dare County.
- Mitigation measures for turtle protection anticipated to be implemented by the applicant.
- Seabeach amaranth information.
- Piping plover information.
- USFWS Coordination Act issues, including use of multiple dredges to shorten the construction duration.

The applicant's 10 December 2006 response reiterated a request for waiver of a requirement to prepare a separate BA for the proposed project in light of the existing Biological Opinion for the federal project (USACE 2000) and the similarities between the federal project and the locally sponsored emergency project. The applicant requested a meeting with the USFWS and USACE at the earliest time to attempt to resolve remaining issues.

Following submission of the 10 December response, the applicant obtained additional information from prospective dredging contractors regarding feasible schedules for construction. A series of informal conversations between the applicant's consultant (Coastal Science & Engineering–CSE) and qualified dredging firms indicated deep concerns within the dredging industry about working offshore of Nags Head during winter months. Because of the competitive nature of the industry, company representatives were not willing to be quoted in the present document. However, off-the-record comments strongly suggested the five companies in the United States (Bean Stuyvesant Dredging Company, Great Lakes Dredge & Dock Company, Manson Dredging, Norfolk Dredging, and Weeks Marine) that have ocean-certified equipment:

- Would **not** risk their equipment offshore of Nags Head during January, February, or March.

- Would anticipate over 50 percent down time if restricted from performing any work during summer months.

- Would not bid the job or would provide an inflated courtesy bid well out of reach of the available budget for the proposed project.

The applicant requested an opinion of the feasibility of dredge operations offshore during winter months from the Dredging Contractors of America, an independent representative of the industry (letter dated 24 January 2007 from Charlie Cameron to Barry Holiday, Attachment 5) and received a response dated 1 February (letter from Barry Holiday to Charlie Cameron, Attachment 6). A portion of the response follows (from Attachment 6, pg 2):

> *My opinion is that it would be extremely dangerous and expensive to place a dredge and the support equipment needed to accomplish a beach nourishment project in the offshore waters north of Oregon Inlet during the winter months. This would be extremely unsafe and warrant very high prices to address the risk and extra equipment and vessels needed to attempt to operate in this high energy environment. I hope that the regulatory agencies that are seeking this restriction will consider the extreme danger to the dredge crews in resolving this issue.*

A meeting was arranged and held 31 January 2007 at the USACE Regulatory Field Office in Washington, North Carolina. In attendance were:

– A representative of the USFWS (Mr. Howard Hall).
– The USACE representative (Mr. Raleigh Bland).
– The applicant (Mr. Charles Cameron, interim town manager).
– The applicant's consultant (CSE – Dr. Timothy Kana, Mr. Jeremy Ganey).

Mr. Hall informed the applicant that unless dredging operations were restricted to cold-water months as per schedule of the North Carolina Turtle Moratorium, formal consultation and a new Biological Opinion would be required for the proposed project. According to Mr. Hall, the Fish & Wildlife Coordination Act (FWCA) and the Endangered Species Act (ESA) apply because the proposed project, if constructed outside the NC Turtle Moratorium window, is "likely to adversely affect certain threatened or endangered species" and result in a "take" as broadly defined by USFWS.

The applicant has elected to prepare and submit this BA in response to requirements under the FWCA and ESA because there appears to be no viable alternative to construction during portions of the turtle-nesting season and seasons for certain other threatened or endangered species in the Nags Head setting.

The following section summarizes the proposed project. Later sections address the anticipated impacts on relevant threatened and endangered species.

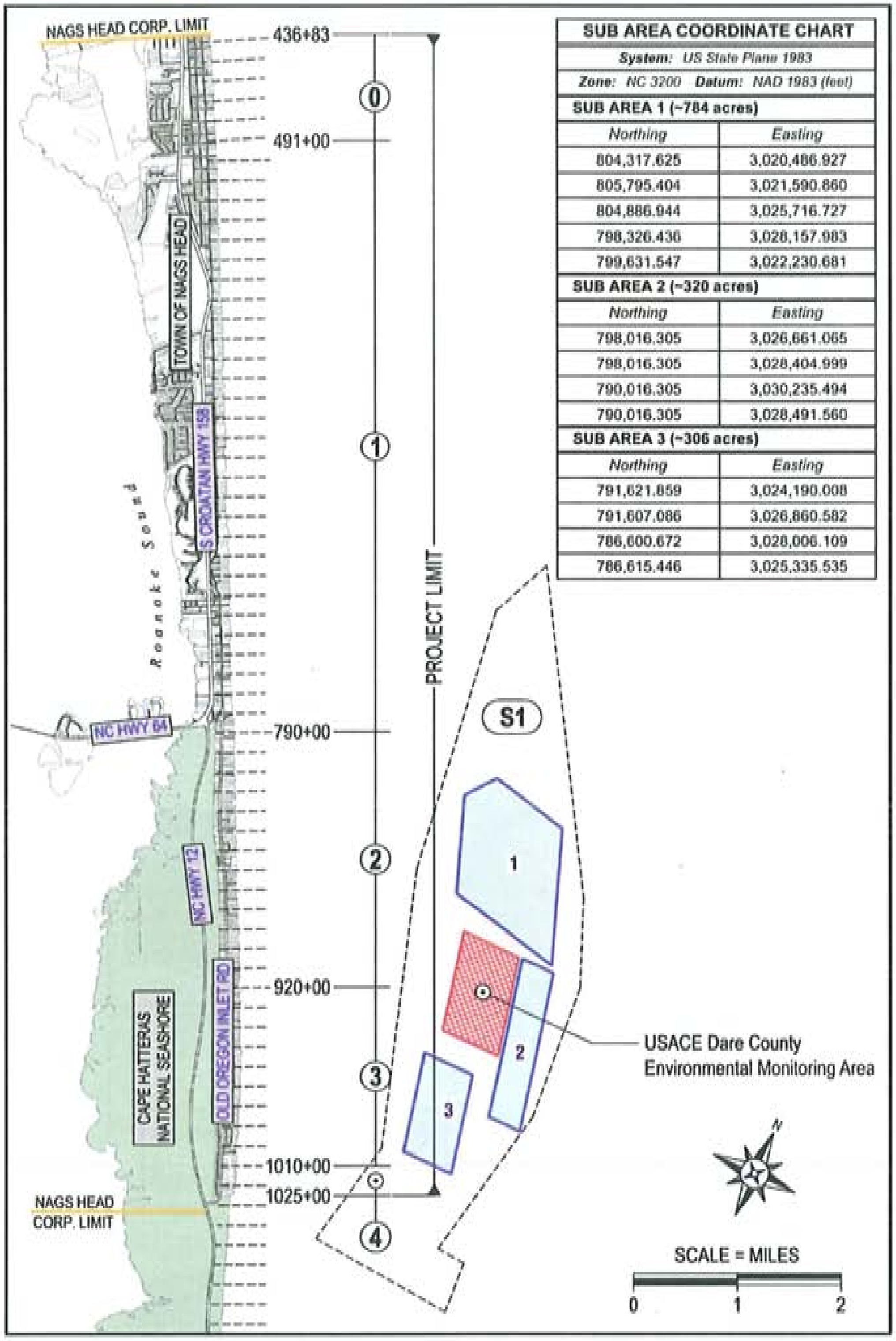
1.3 Proposed Project

The proposed project (Fig 1.1) consists of excavating by hydraulic dredge up to 4.6 million cubic yards of beach-quality sediment from ocean borrow area(s) situated ~1.5–3 miles offshore of the proposed project area. Sediment would be pumped onto the beach between the toe of the existing dune and the low waterline and shaped by bulldozers into a profile that closely matches the contours and elevations of the natural beach. Approximately 50 percent of the excavations would be deposited by run-out from the discharge point between mean low water and the outer bar (~500 feet offshore). Typical fill sections would add ~50–130 cubic yards per linear foot (cy/ft) of beach and advance the shoreline 50–125 ft (Fig 1.2). The work would be performed continuously, covering all or portions of each of four designated reaches according to the following plan (subject to local funding availability).

- ***Reach 1*** – Stations 491+00** to 790+00 – 5.7 miles – up to 1.74 million cubic yards*
- ***Reach 2*** – Stations 790+00 to 920+00 – 2.5 miles – up to 1.3 million cubic yards*
- ***Reach 3*** – Stations 920+00 to 1010+00 – 1.7 miles – up to 1.44 million cubic yards*
- ***Reach 4*** – Stations 1010+00 to 1025+00 – 0.3 miles – up to 120,000 cy*

[*Volumes per reach may be adjusted by ±15 percent according to conditions at the time of construction. Maximum overall volume will not exceed 4.6 million cubic yards. **This corresponds to Blackmon Street.]

The proposed borrow areas are portions of offshore area S1, the boundary of which is designated by the USACE (2000) in the federal Dare County project. Several sub areas within S1 have been sampled and tested for sediment compatibility (detailed results are contained in the main text of the present EIS, Section 4.16, CSE 28 April 2006 – this volume). Sediments have been confirmed over a 2–3 square-mile area within offshore area S1 (~10 square miles) to a section thickness averaging ~8 ft. This yields potentially >20 million cubic yards of beach-quality sediment with overfill ratios (R_A's, CERC 1984) averaging under 1.5. Water depths in the borrow areas are ~40–55 ft, well beyond the estimated depth of closure for littoral profiles in this setting.



SUB AREA COORDINATE CHART	
System: US State Plane 1983	
Zone: NC 3200 **Datum:** *NAD 1983 (feet)*	
SUB AREA 1 (~784 acres)	
Northing	*Easting*
804,317.625	3,020,486.927
805,795.404	3,021,590.860
804,886.944	3,025,716.727
798,326.436	3,028,157.983
799,631.547	3,022,230.681
SUB AREA 2 (~320 acres)	
Northing	*Easting*
798,016.305	3,026,661.065
798,016.305	3,028,404.999
790,016.305	3,030,235.494
790,016.305	3,028,491.560
SUB AREA 3 (~306 acres)	
Northing	*Easting*
791,621.859	3,024,190.008
791,607.086	3,026,860.582
786,600.672	3,028,006.109
786,615.446	3,025,335.535

FIGURE 1.1. Proposed emergency beach nourishment project limits for Nags Head using borrow sand from offshore area S1 (designated by USACE 2000). Work would consist of excavation and placement of up to 4.6 million cubic yards by hydraulic dredge within Reach 1 through Reach 4 (~10 miles). Subareas 1, 2, and 3 contain >20 million cubic yards of beach-quality sediment to ~8 ft. Final borrow area selection will be in coordination with the USACE so as to avoid federal environmental monitoring stations. Only a portion of subareas 1, 2, or 3 would be used in the proposed project, leaving undisturbed subareas for future projects.

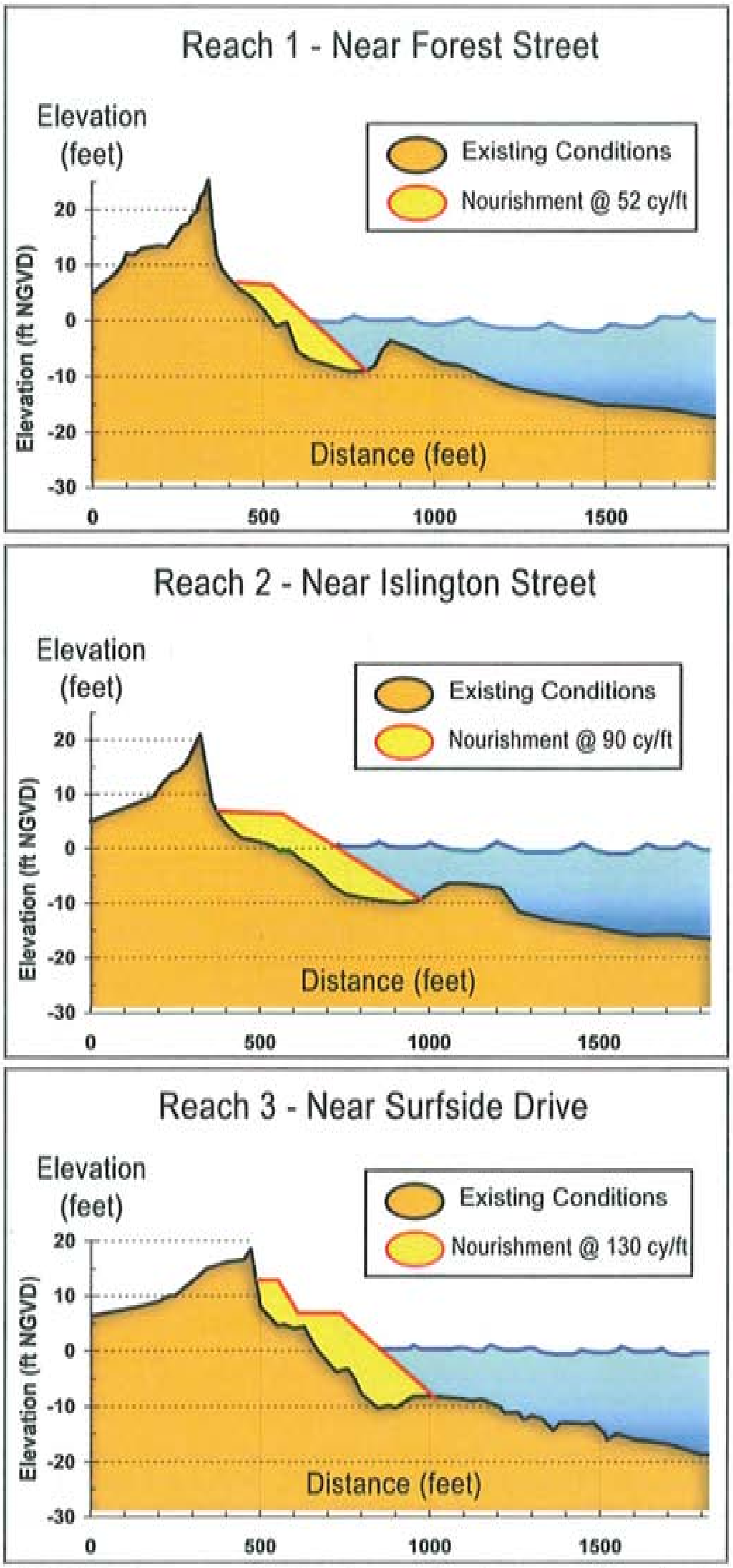


FIGURE 1.2 Representative fill sections for Reaches 1, 2, and 3 — showing the anticipated areas of impact across the surf zone.

The anticipated optimal equipment for excavations will be ocean-certified, self-contained hopper dredges. Such equipment typically excavates shallow trenches (~2-3 ft of section) in each pass (leaving narrow, undisturbed areas at the margins of each cut), then travels to a buoyed pipeline anchored close to shore. Discharge to the beach will be via submerged pipeline across the surf zone, then by way of shore-based pipe positioned along the dry beach. Only a small portion of offshore borrow area S1 will be required to provide up to 4.6 million cubic yards of beach-quality material.

The applicant is coordinating the specific area for use in the proposed project with the US Army Corps of Engineers with the following understanding:

- The final borrow area required for the proposed nourishment project can be limited to the equivalent of a 0.9-square-mile (~575 acres) area.
- The borrow areas used will be contiguous to the extent practicable, depending on the type of equipment used (hopper dredges versus cutterhead dredges).
- Once used, the borrow area will no longer be available for use, consistent with the federal Dare County project.
- The borrow area will be delineated so as to avoid ongoing biological monitoring stations established by the USACE in connection with the Dare County project (cf, Fig 1).

The proposed project will be built in ~1–2 mile sections, optimizing the disposition of pipeline. Sections will be pumped into place with the aid of temporary dikes pushed up by bulldozer in the surf zone. Daily operations will directly impact ~500–1,000 ft of shoreline as work progresses in either direction from the submerged pipeline. Areas of active filling will be cordoned off for protection of the public, then immediately reopened for use as the project progresses. Any given ~500-ft section of beach is expected to be off-limits for users for only about 2–3 days. Completed sections will be made accessible via temporary sand ramps over the pipeline, which will be positioned near the center of the dry beach well away from the surf zone. Upon completion of a 1–2 mile length of beach, the submerged pipe and beach-building equipment will be shifted to the next reach.

As construction progresses, sections will be graded to final contours, dressed to eliminate low areas, and opened for use by the community. Support equipment will be shifted out of completed sections as soon as practicable, such that construction activities in a given reach will disrupt normal beach use for only a month or so at any locality. The finished sections will be allowed to adjust to natural processes for several months. Then in applicable areas, dune fencing and/or dune plantings will be installed.

1.3.1 Historical Erosion Rates

Nags Head has sustained chronic and storm erosion for many years. The NC Department of Environment and Natural Resources (NCDENR) periodically estimates 50-year erosion rates based on an analysis of historical aerial photography. NCDENR (2004) official 50-year erosion rate maps (Fig 1.3a–c) show an increase in erosion from north to south along Nags Head. Reach 1 (north of Whalebone Junction at Hwy 64 and Hwy 12) and Reach 2 (0–2 miles south of Whalebone Junction) average 2–3 feet per year (ft/yr) dune recession. Reach 3 (1.7 miles long, Fig 1.1) ranges from 3 ft/yr to 5 ft/yr recession, and Reach 4 (southernmost 1,500 linear feet of Nags Head) has eroded at 5–7 ft/yr. South of the proposed project area, erosion along the first three miles of the Cape Hatteras National Seashore ranges from 5 ft/yr to 10 ft/yr. Closer to Oregon Inlet, the rate of erosion has averaged about 2 ft/yr for the past 50 years (Fig 1.3c).

Quantitative Surveys

As part of the planning for the federal Dare County project (USACE 2000), the Corps of Engineers established a baseline from the northern Kitty Hawk town line to Oregon Inlet. Stationing in engineering notation ranges from 0+00 in Kitty Hawk to (~)1025+00 at the south Nags Head town line. The northern limit of Nags Head is situated around USACE station 436+83. Therefore, Nags Head encompasses ~58,817 linear feet (11.14 miles) of shoreline. In August 1994, a contractor for the Corps of Engineers surveyed profiles at ~1,000-ft spacing along the baseline from the backshore to a distance of about 3,000 ft offshore. This was the first comprehensive survey of beach and offshore profiles along Nags Head.

CSE (2005a) used the USACE baseline to resurvey profiles at 1,000-ft spacing along nearly the same alignments as the 1994 survey. CSE's surveys typically extend from the foredune to ~2,500 ft offshore. Profiles from 1994 and 2005 were then overlaid and compared for purposes of computing sand losses and gains. The resulting volumetric changes provide a more reliable indicator of erosion losses along Nags Head and serve as a direct comparison with beach nourishment volumes.

The five shoreline segments ("reaches")* (Fig 1.4) show the location of available profiles along with town boundaries and the road grid for Nags Head. Additional profiles were surveyed in Kill Devil Hills (410+00 to 430+00) and along the National Seashore to Oregon Inlet (1030+00 to 1290+00). The USACE 1994 survey terminated at profile 1010+00; therefore, no comparative data are available in the National Seashore.

[*NOTE: "Reach 1" in the present erosion analysis (Section 1.3.1) begins at station 500+00 for simplification of station breaks. The proposed project will include nourishment in a taper section between stations 500+00 and 491+00 (Blackmon Street) so as to create a gradual transition from unnourished to nourished areas.]

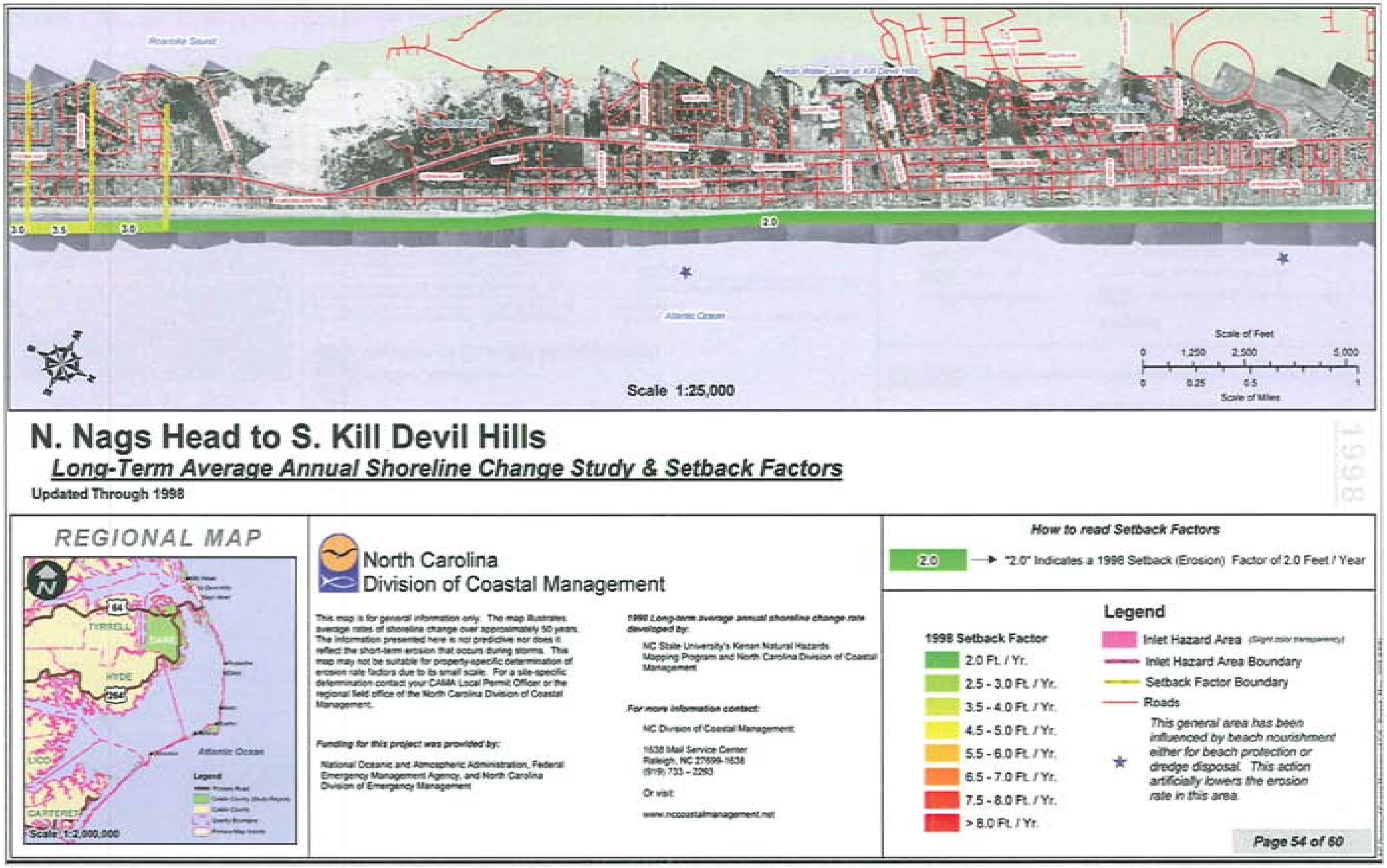


FIGURE 1.3a. Official NCDENR (2004) 50-year erosion rates for Nags Head and vicinity. [From http://dcm2.enr.state.nc.us/Maps/ER_1998/Dare_Rate.htm).

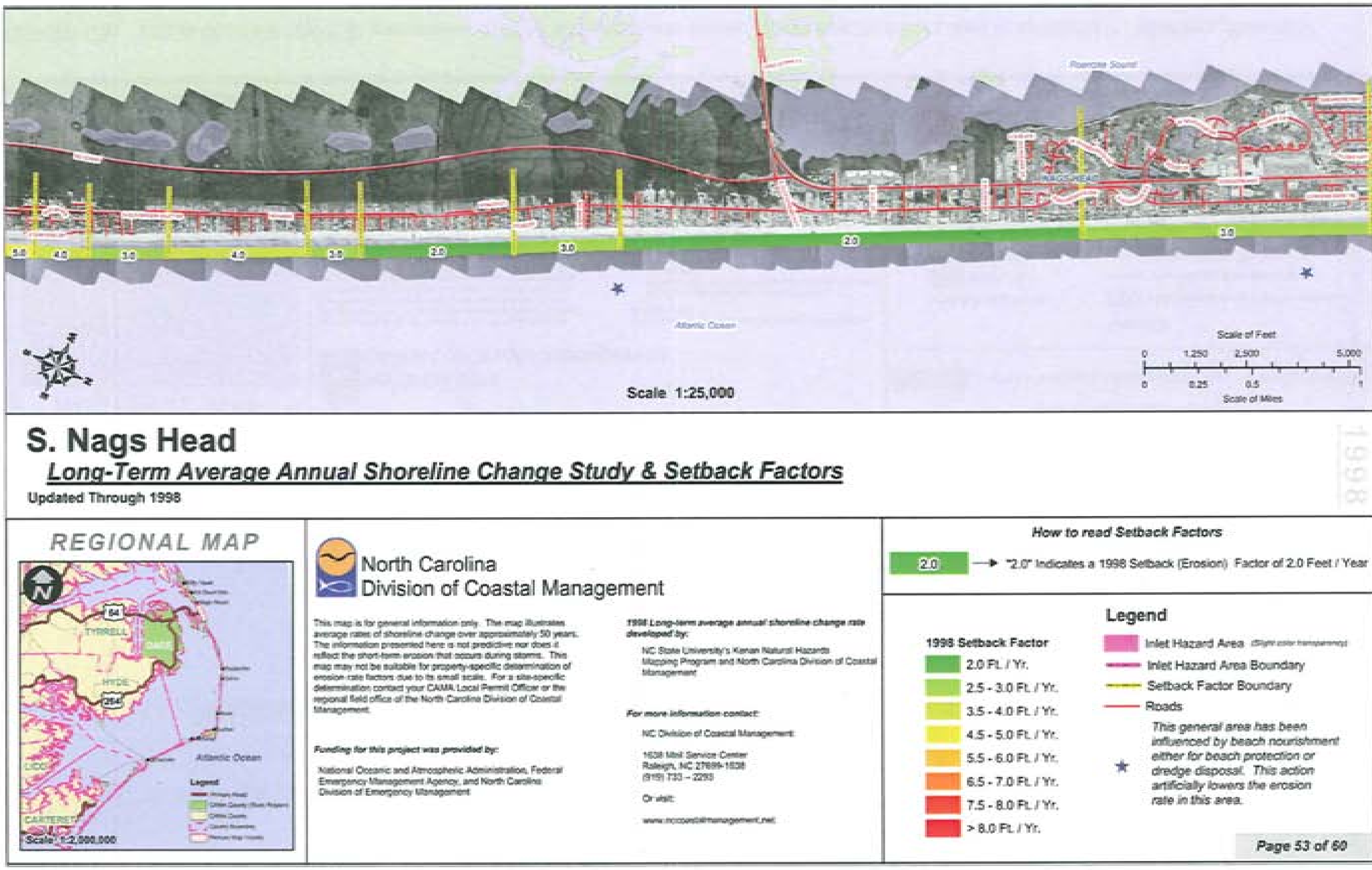


FIGURE 1.3b. Official NCDENR (2004) 50-year erosion rates for Nags Head and vicinity. [From http://dcm2.enr.state.nc.us/Maps/ER_1998/Dare_Rate.htm).

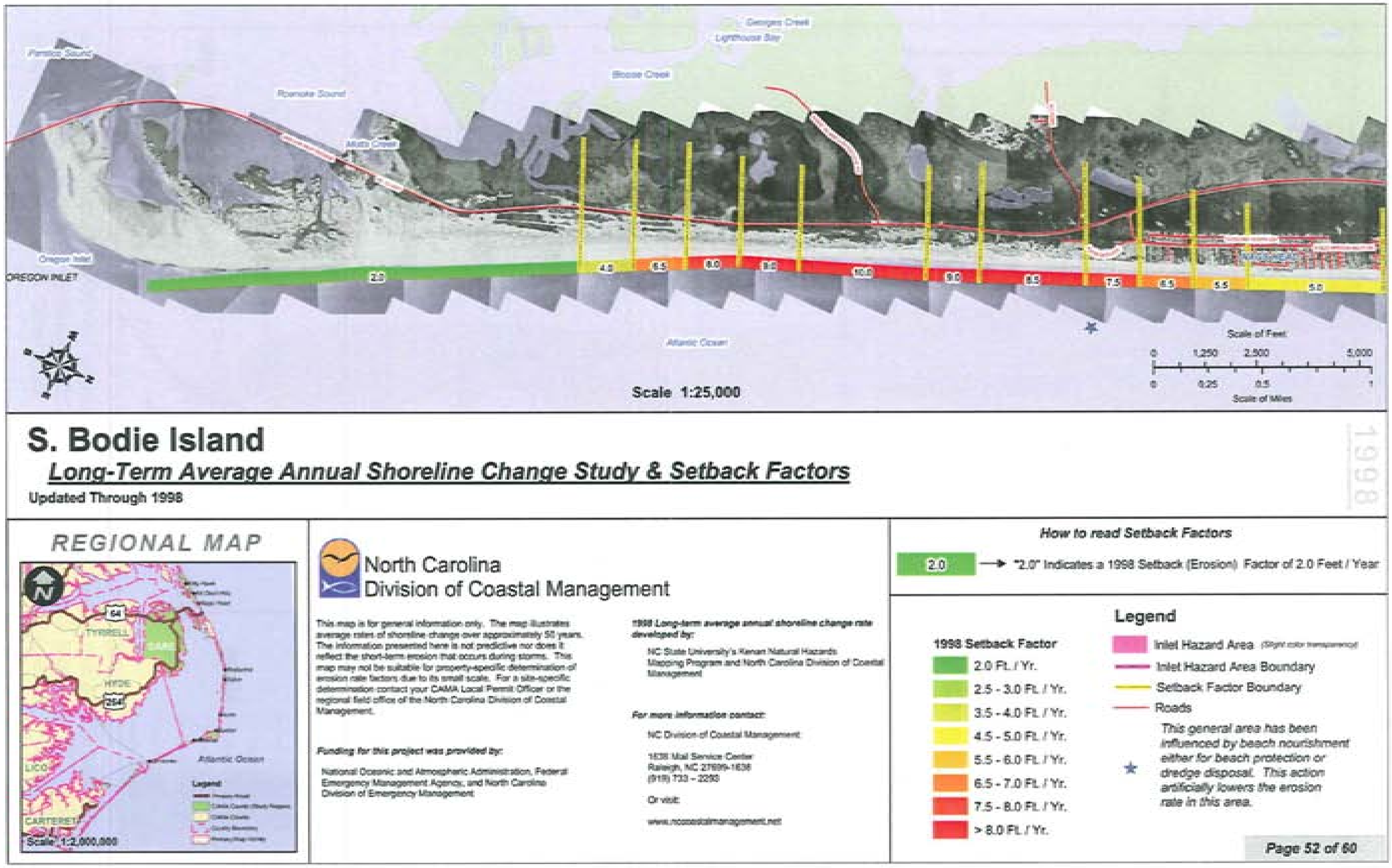


FIGURE 1.3c. Official NCDENR (2004) 50-year erosion rates for Nags Head and vicinity. [From http://dcm2.enr.state.nc.us/Maps/ER_1998/Dare_Rate.htm).

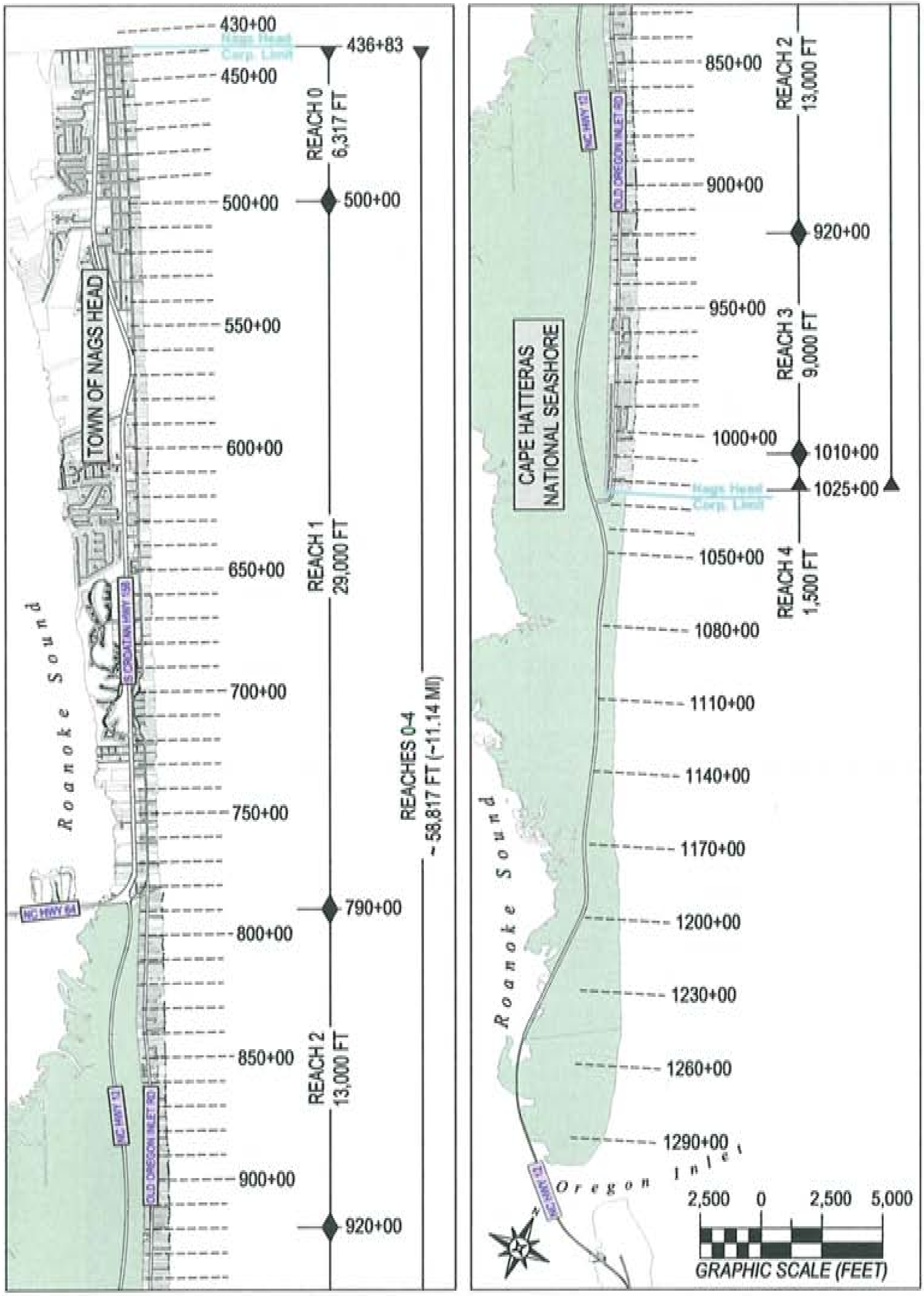
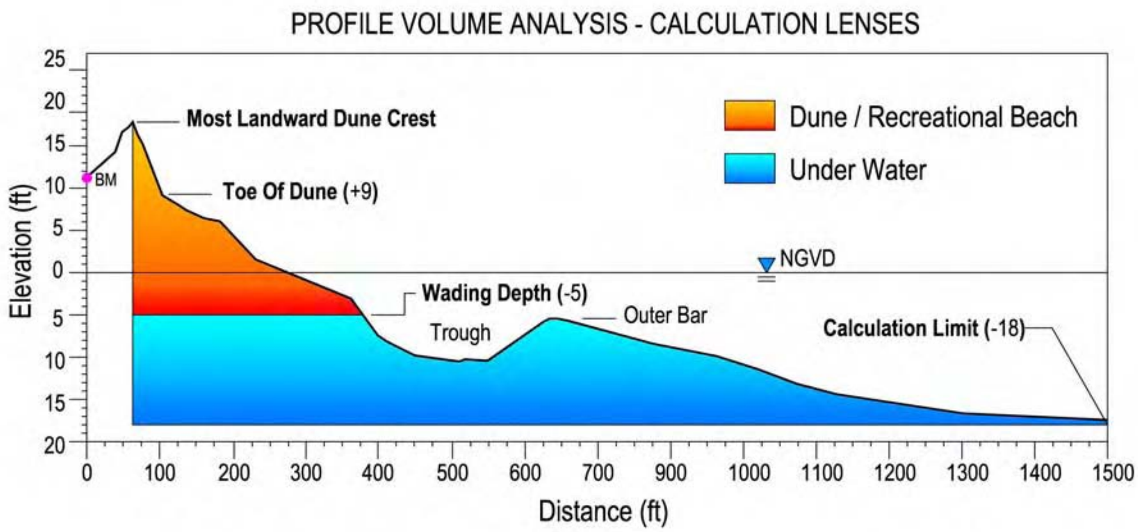


FIGURE 1.4. General location map of beach profile lines established in 1994 (USACE 2000) and resurveyed by CSE in April 2005. CSE established lines south of Nags Head in 2005 by extending the USACE baseline south to Oregon Inlet. [NOTE: The project will include a north taper section which extends ~900 ft north of station 500+00 to station 491+00 (see Fig 1.1).] [From CSE 2005a]

Unit-width profile volumes for common reference points and contours were computed for each profile and survey date (Fig 1.5). The selection of contours (vertical boundaries) was arbitrary but was based on site-specific conditions and inspection of the USACE 1994 and the CSE 2005 profiles. It was also based on work by researchers at the USACE field research facility at Duck (NC) (Birkemeier 1985) and on experience at other sites because the chosen contours represent a useful division of the beach in the cross-shore dimension.

Unit-volume* calculations (cf, Fig 1.6) distinguish the quantity of sediment in the dunes, on the dry beach, in the intertidal zone to wading depth, and in the remaining area offshore to the approximate limit of profile change. At decadal scales, the assumed limit of measurable change for Nags Head is in depths of (~)–20 ft NGVD. At longer time periods, the depth of measurable profile change is likely to increase, as noted by Birkemeier (1985) and others, and may be of the order 25 ft in this setting. This depth cannot be determined accurately until more comparative surveys become available. For the proposed project, the primary reference boundary used was –18 ft. CSE also computed beach volumes to –5 ft (ie, low-tide wading depth) because this shallower zone represents the prime recreational area of the beach. Depths around –18 ft NGVD off Nags Head are believed to capture nearly all of the sand moving in the cross-shore direction from year to year.

[*Figure 1.6 illustrates the concept of unit beach volume between reference contours applied over one linear foot of shoreline. When common boundaries are used from profile to profile or survey to survey, the relative as well as absolute variation in beach condition can be determined. In the example, the "eroded" beach profile contains half as much sand volume to low tide wading depth as the "normal" beach profile. This is analogous to present conditions along parts of south Nags Head.]



Dune/Recreational Beach — Defined as the cross-section (unit volume) from the most landward foredune crest (among available surveys) to –5 ft NGVD. This area incorporates the active dune, dry beach, and wet beach out to low-tide wading depth.

Underwater — This lens extends the profile across the trough and outer bar ending close to the seaward limit of yearly profile change ("Closure Depth") based on observations of historical profiles.

FIGURE 1.5. The reference zones used for calculation of sand volume changes along Nags Head (1994–2005). Integrating both lenses yields volumes that encompass nearly 100 percent of the sediment volume moving in the littoral zone from year to year. [Source: CSE 2005a]

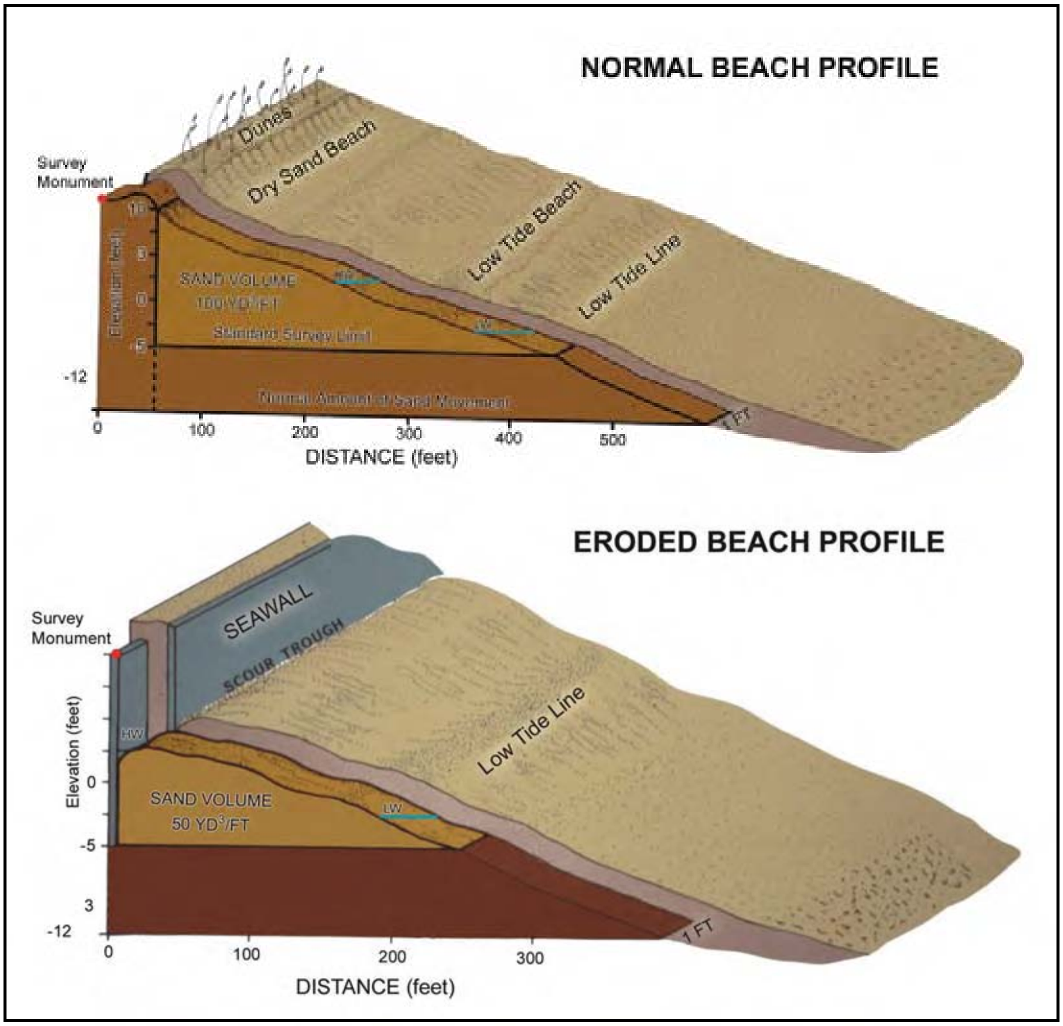


FIGURE 1.6. The concept of unit sand volume along the beach, which provides a quantitative measure of beach condition and changes before and after nourishment. The yearly limit of measurable sand movement ("profile closure depth") along Nags Head is thought to occur at depths of about 18 ft (deeper than indicated on the top diagram). [From Kana 1990]

Figure 1.7 shows comparative profiles for station 800+00 at Huron Street (Reach 2) and differences between 1994 and 2005. In this case, there is little change across a 500-ft zone offshore (distances 1,700–2,200 ft from the baseline). This suggests that profile volume calculations to –18 ft capture the majority of changes between the two surveys in this case. In the example shown, the volume of sand in the profile ranges from 561.2 cy/ft (1994) to 473.3 cy/ft (2005). These quantities provide a measure of absolute sand quantity seaward of the dunes for comparison with other stations. The difference between the two volumes (–87.9 cy/ft) provides a measure of losses (or gains) from the time of the first survey (1994) to the time of the second survey (2005).

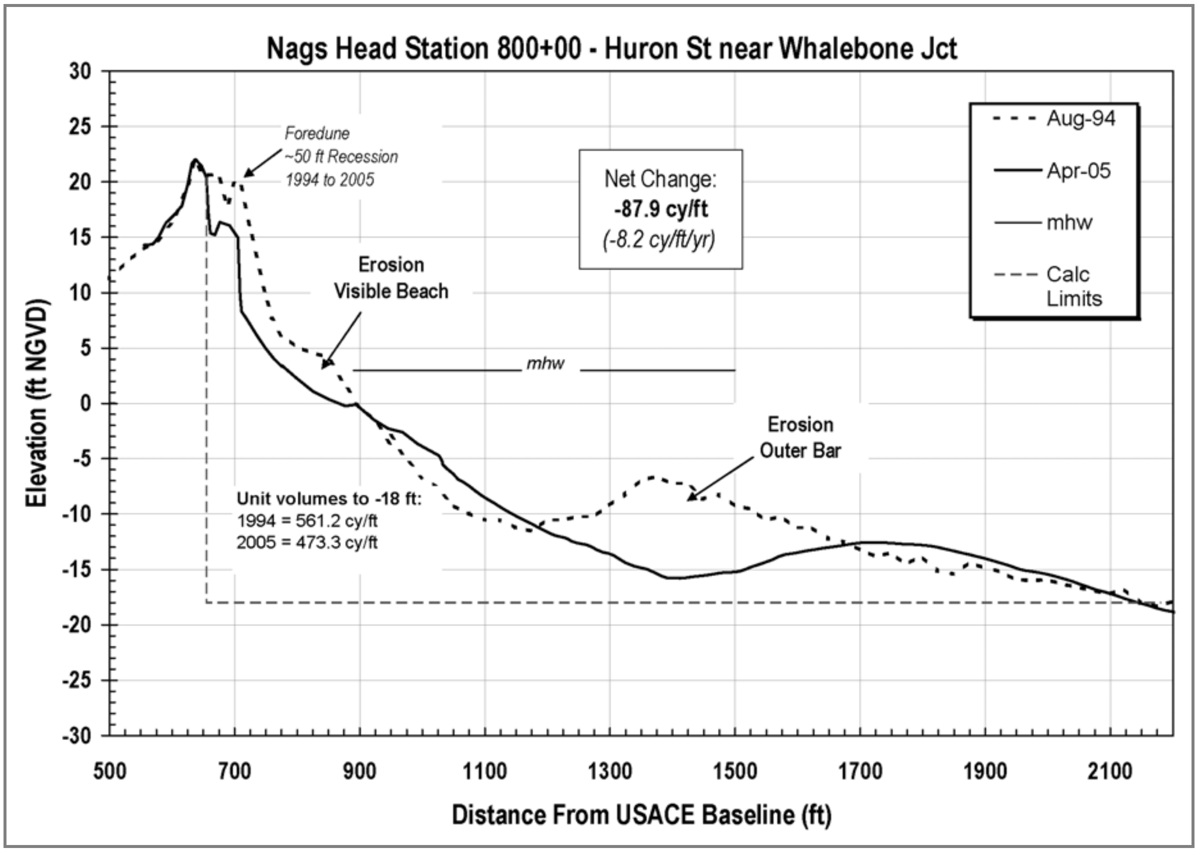


FIGURE 1.7. Available profiles from station 800+00 showing significant changes between 1994 and 2005 out to about –15 ft or 2,000 ft from the baseline (~1,300 ft offshore). The zone between the foredune and –18 ft is assumed to account for nearly all changes in sand volume for the period 1994–2005 along Nags Head. [From CSE 2005a]

Volumetric Erosion Rates

Figure 1.8 illustrates the variation in average annual volume change from north to south along Nags Head. The trend line in Figure 1.8 shows the tendency for increasing erosion rates from north to south. Reach 0 (northernmost 1.2 miles of Nags Head) experienced negligible change per year (average annual trend for 10.75 years) between 1994 and 2005, although one station gained sand while other stations lost sand during the period. Reach 1 (~5.5 miles long) includes several stations that gained sand (stations 660+00 and 690+00 in the vicinity of East Mall Drive and Epstein Street, respectively). However, station 680+00 (East Hawks Nest) in between was highly eroded. Changes such as this often reflect rhythmic shoreline features associated with breaks and accumulation zones in the outer bar. Over time, such differences shift alongshore as sand moves through the littoral zone. The overall trend for Reach 1 was erosion at rates averaging about 2.5 cy/ft/yr. Reaches 2, 3, and 4 also show variable erosion and accretion rates but a trend of higher losses to the south. Results for certain individual stations (eg, 920+00 to 950+00) are affected by the presence of sand bags placed to stabilize portions of the backshore.

Figures 1.9 and 1.10 show average unit volumes by reach for the two calculation limits (–5 ft and –18 ft NGVD). The shallower calculation depth encompasses the recreational beach. Figure 1.9 shows two important trends. In 1994, there was more sand on the visible beach (on average) in Reaches 2, 3, and 4 (southern 40 percent of the Nags Head shoreline) than existed in Reaches 0 and 1 (northern 60 percent of the shoreline). By 2005, Reaches 2 through 4 had much less sand than Reach 0. Experience at other sites shows that profile volumes to –5 ft NGVD along the South Carolina and North Carolina coasts tend to fall in the range of 80–120 cy/ft (Kana 1993). By 2005, Reaches 3 and 4 were well below this range, and Reaches 1 and 2 were at the low end of the range — indicating a major sand deficit for most of Nags Head.

Generally, higher unit volumes reflect more gently sloping profiles. In the case of Nags Head, the higher volumes at the southern end of town in 1994 partly reflect finer sediment (discussed later). The volume trends for 2005 are quite different and reflect armoring of the shoreline via sand bags at some stations and loss of dunes at other stations along the southern half of town. The average unit volume for all stations had declined from ~110 cy/ft in 1994 to ~80 cy/ft in 2005. Thus, to restore the beach to 1994 conditions, at least 30 cy/ft (~1.6 million cubic yards over ten miles) would have to be added along the entire beach (plus an additional volume to build up the underwater portion of the profile).

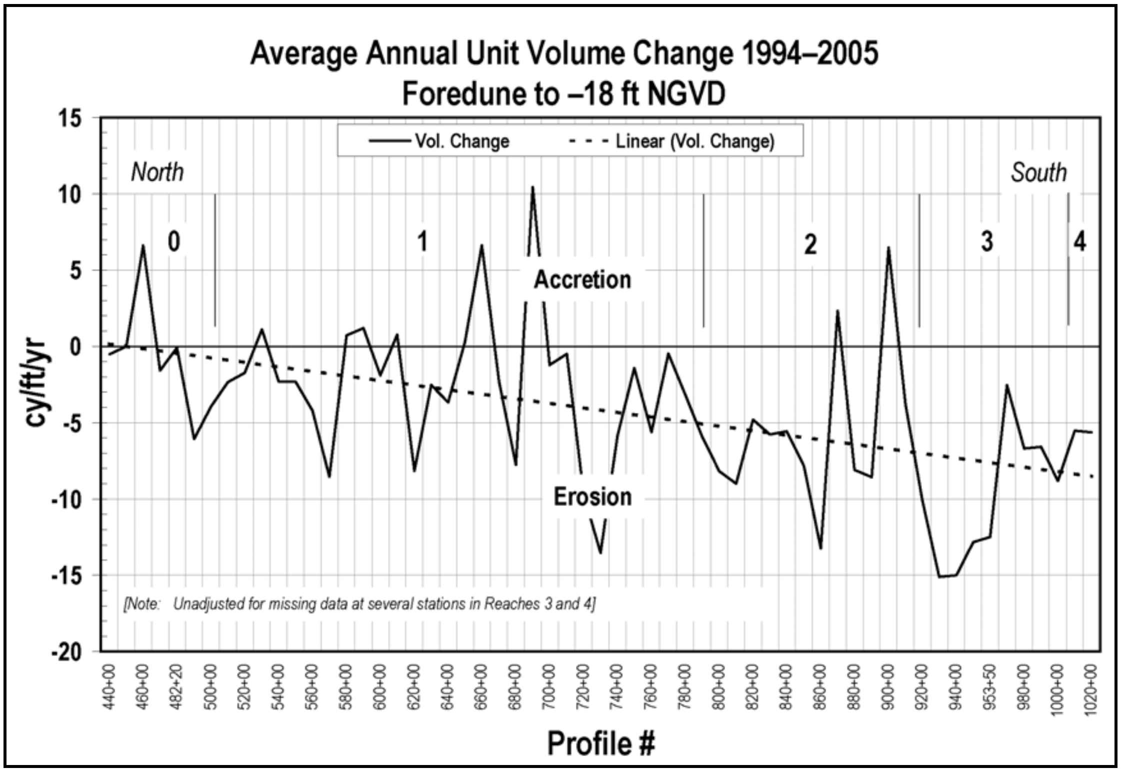


FIGURE 1.8. Average annual unit volume change by profile line and reach along Nags Head between August 1994 and April 2005 (10.75 years), calculated between the foredune and –18 ft NGVD (~1,500–2,000 ft offshore). [From CSE 2005a]

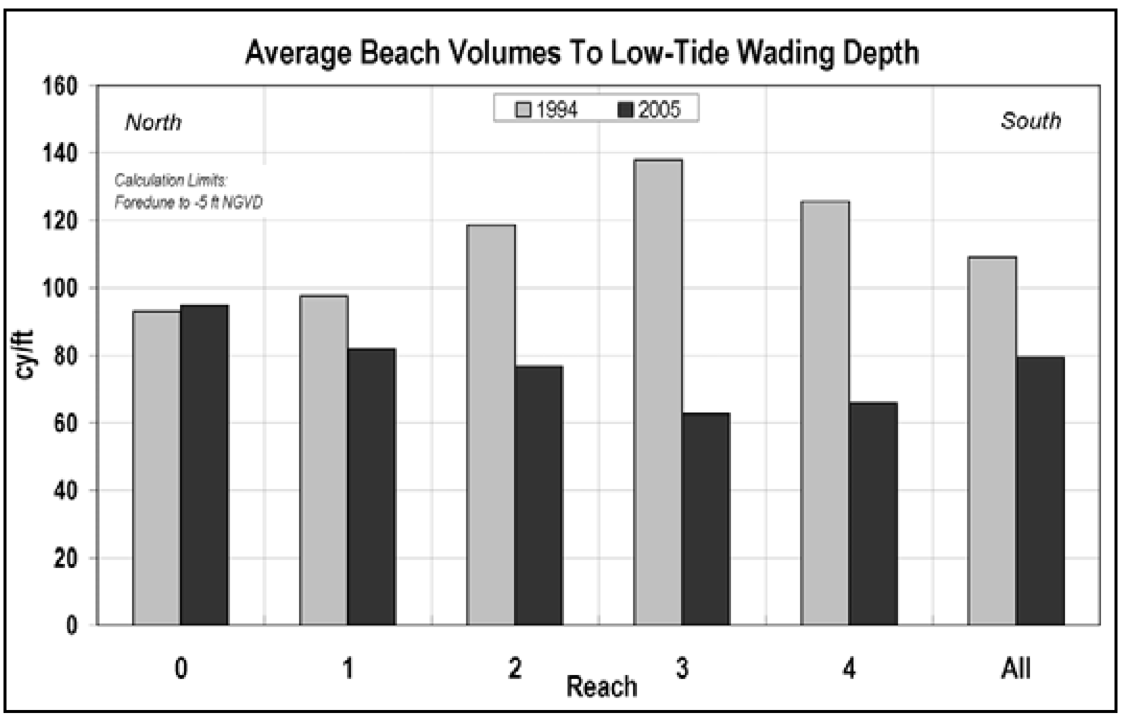


FIGURE 1.9. Average unit-width beach volume by reach to low-tide wading depth in August 1994 versus April 2005. [From CSE 2005a]

Figure 1.10 extends the calculation limit to –18 ft or about 1,500–2,000 ft offshore. This is considered to represent the majority of the zone of active sand movement and profile volume changes. Because the calculation limit is in deeper water, unit volumes are much higher, of the order 400–500 cy/ft. However, the difference in unit volumes between 1994 and 2005 for all stations averages about 40 cy/ft. In other words, the average change to –18 ft is only about one-third greater than the change to –5 ft.

Figure 1.11 compares the average volume **change** per year for wading depths and deeper profiles. The annual rates of change generally increase from north to south. Reaches 0 and 1 (northern 60 percent of Nags Head) experienced relatively small changes. Reach 0 actually gained sand in the offshore zone, whereas Reach 1 lost about 2.5 cy/ft/yr on average. Table 1.1 provides tabulated results. **The net sand loss for Reaches 0 and 1 has averaged ~60,000 cy/yr. This equates to an average annual erosion rate of 1.7 cy/ft/yr for the northern 6.7 miles of Nags Head.**

Reach 2, which extends from approximately Governors Street to James Street, lost an average of ~3.9 cy/ft/yr to low-tide wading depth and ~5.7 cy/ft/yr between the foredune and –18 ft contour. This equates to a total loss of ~800,000 cy over 10.75 years in this 13,000-ft reach. Reach 3, which extends 9,000 ft from James Street to south of East Loon Court, lost upward of 12 cy/ft/yr between the foredune and –18 ft. This equates to a net loss of ~1.2 million cubic yards between 1994 and 2005. Reach 4, around McCall Court, is estimated to have eroded at a similar rate (~11.2 cy/ft/yr).

CSE's estimated erosion losses and volume change rates for Nags Head (1994–2005) are summarized in Figure 1.12. Excluding the positive change in Reach 0, the estimated loss for Nags Head is ~2.9 million cubic yards or ~275,000 cy/yr over the past decade. This equates to an average annual erosion rate of ~5.2 cy/ft/yr (Reaches 1–4). As Figure 1.12 shows, fully 60 percent of the shoreline (Reaches 0 and 1) accounts for only about 27 percent of the sand losses. Reach 2, representing ~22 percent of the shoreline, accounts for ~27 percent of all sand losses. Reach 3, representing only 15 percent of the shoreline, accounts for nearly 40 percent of the sand losses.

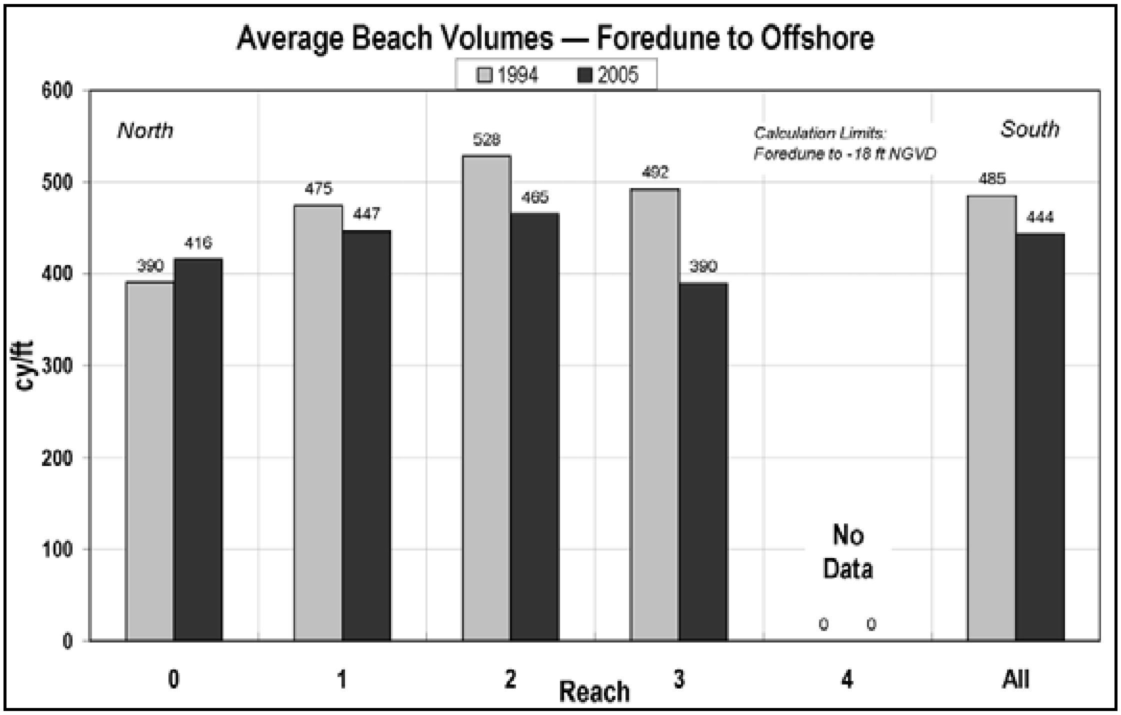


FIGURE 1.10. Average unit-width beach volume by reach to –18 ft NGVD (about 1,500–2,000 ft offshore) in August 1994 versus April 2005. [From CSE 2005a]

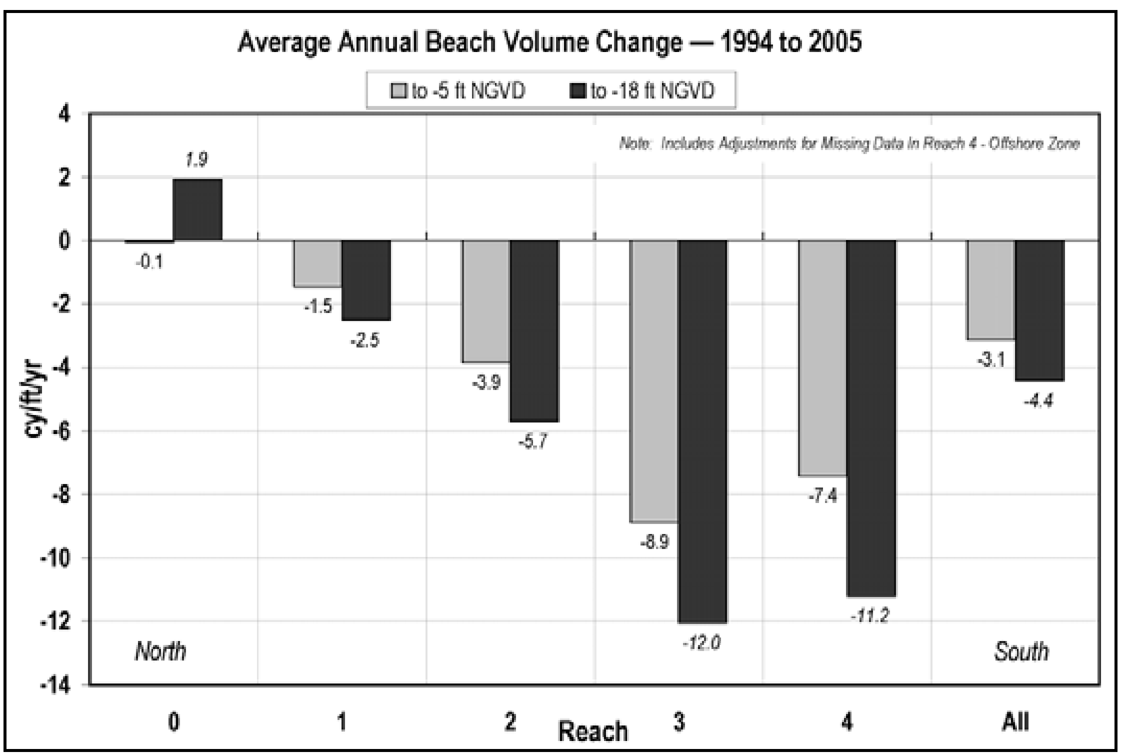


FIGURE 1.11. Average annual unit-width beach volume change to low-tide wading depth and offshore in August 1994 versus April 2005. [From CSE 2005a]

TABLE 1.1. Nags Head beach volume changes by reach – August 1994 to April 2005 (10.75 years). Notes: No data – Reach 4 seaward of –6 ft NGVD. Missing data – Reach 3 seaward of –6 ft NGVD. [From CSE 2005a]

Nags Head Reach - Beach Volume Changes August 1994 to April 2005													
		to -5 ft NGVD				-5 ft to -18 ft NGVD				to -18 ft NGVD			
				Annualized	Annualized Unit			Annualized	Annualized Unit			Annualized	Annualized Unit
Reach	Length	Net Change	Unit Chg.	Net Change	Net Change	Net Change	Unit Chg.	Net Change	Net Change	Net Change	Unit Chg.	Net Change	Net Change
	(ft)	(cy)	(cy/ft)	(cy/yr)	(cy/ft/yr)	(cy)	(cy/ft)	(cy/yr)	(cy/ft/yr)	(cy)	(cy/ft)	(cy/yr)	(cy/ft/yr)
0	6,317	-3,898	-0.6	-363	-0.1	135,224	21.4	12,579	2.0	131,326	20.8	12,216	1.9
1	29,000	-458,101	-15.8	-42,614	-1.5	-326,486	-11.3	-30,371	-1.0	-784,587	-27.1	-72,985	-2.5
2	13,000	-538,325	-41.4	-50,077	-3.9	-257,368	-19.8	-23,941	-1.8	-795,693	-61.2	-74,018	-5.7
3	9,000	-668,316	-74.3	-62,169	-6.9	-239,953	-26.7	-22,321	-2.5	-908,269	-100.9	-84,490	-9.4
4	1,500	-89,999	-60.0	-8,372	-5.6	-394	-0.3	-37	0.0	-90,393	-60.3	-8,409	-5.6
	58,817	-1,758,639	-29.9	-163,594	-2.8	-688,977	-11.7	-64,091	-1.1	-2,447,615	-41.6	-227,685	-3.9
R1-R4	**52,500**	**-1,754,741**	**-33.4**	**-163,232**	**-3.1**	**-824,202**	**-15.7**	**-76,670**	**-1.5**	**-2,578,941**	**-49.1**	**-239,902**	**-4.6**

Nags Head Reach - Beach Volume Changes August 1994 to April 2005 With Adjustments For Missing Data													
		to -5 ft NGVD				-5 to -18 ft NGVD				to -18 ft NGVD			
				Annualized	Annualized Unit			Annualized	Annualized Unit			Annualized	Annualized Unit
Reach	Length	Net Change	Unit Chg.	Net Change	Net Change	Net Change	Unit Chg.	Net Change	Net Change	Net Change	Unit Chg.	Net Change	Net Change
	(ft)	(cy)	(cy/ft)	(cy/yr)	(cy/ft/yr)	(cy)	(cy/ft)	(cy/yr)	(cy/ft/yr)	(cy)	(cy/ft)	(cy/yr)	(cy/ft/yr)
0	6,317	-3,898	-0.6	-363	-0.1	135,224	21.4	12,579	2.0	131,326	20.8	12,216	1.9
1	29,000	-458,101	-15.8	-42,614	-1.5	-326,486	-11.3	-30,371	-1.0	-784,587	-27.1	-72,985	-2.5
2	13,000	-538,325	-41.4	-50,077	-3.9	-257,368	-19.8	-23,941	-1.8	-795,693	-61.2	-74,018	-5.7
3	9,000	-858,181	-95.4	-79,831	-8.9	-307,287	-34.1	-28,585	-3.2	-1,165,468	-129.5	-108,416	-12.0
4	1,500	-119,711	-79.8	-11,136	-7.4	-61,074	-40.7	-5,681	-3.8	-180,785	-120.5	-16,817	-11.2
All	58,817	-1,978,216	-33.6	-184,020	-3.1	-816,991	-13.9	-75,999	-1.3	-2,795,207	-47.5	-260,019	-4.4
R1-R4	**52,500**	**-1,974,318**	**-37.6**	**-183,657**	**-3.5**	**-952,216**	**-18.1**	**-88,578**	**-1.7**	**-2,926,534**	**-55.7**	**-272,236**	**-5.2**

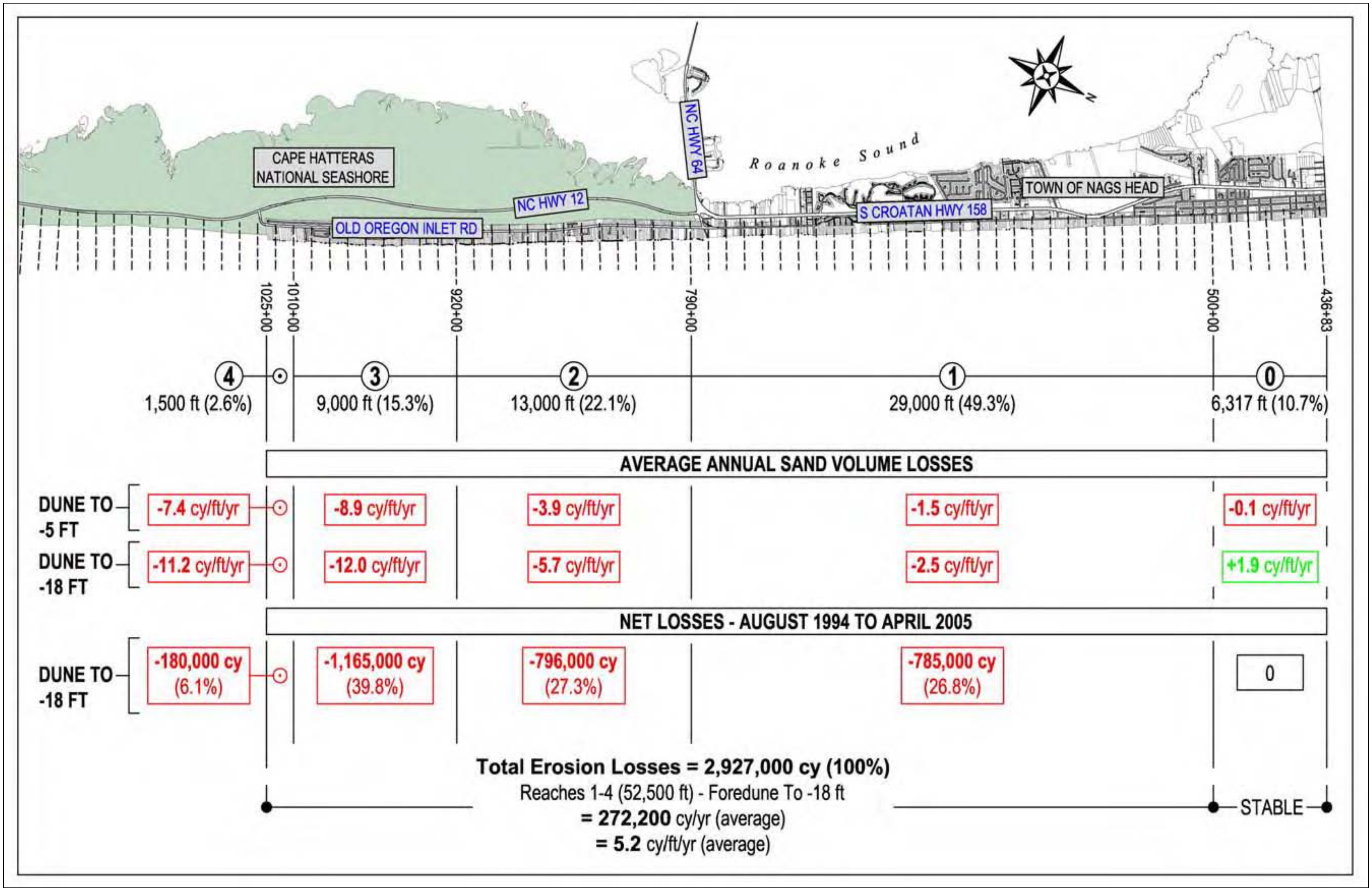


FIGURE 1.12. Summary of 1994–2005 beach volume changes between the foredune and low-tide wading depth (–5 ft NGVD) and between the foredune and –18 ft NGVD along Nags Head. [Source Data: 1994 courtesy USACE–Wilmington District; CSE 2005a]

Comparison with USACE (2000) Erosion Estimates

The 1994 and 2005 profiles into deep water offer the first opportunity to estimate true, sand-volume losses along Nags Head. While there are likely to be errors and inconsistencies between the 1994 and 2005 data sets because they were collected using different survey systems, they nevertheless are more reliable measures of erosion rates than historical shorelines derived from aerial photography (cf, Fig 1.3a–c).

USACE (2000, Appendix D, Figs D16–D35), without the benefit of comparative historical surveys, reported a range of erosion rates for Nags Head with highest rates along south Nags Head (similar in magnitude to those determined by CSE–2005a). Yet for purposes of nourishment planning, the adopted federal rate appears to be the equivalent of ~17.8 cy/ft/yr for the entire project area (~10 miles). A more realistic erosion rate for Nags Head is ~5.2 cy/ft/yr (ie, about 30 percent of the rate adopted in the Dare County plan–USACE 2000).

The federal Dare County project (USACE 2000), as presently formulated, assumes average annual erosion losses of ~950,000 cy/yr for Nags Head. The proposed locally sponsored beach restoration project assumes annual losses of the order 275,000 cy/yr based on the average annual change from 1994 to 2005 along Nags Head.

1.3.2 Relationship of Erosion Rates to Proposed Nourishment Project

Because erosion rates increase from north to south along Nags Head, the proposed project calls for variable nourishment volumes by reach and within each reach. The applicant's goal is to place sufficient sand on the beach and restore the deficit that has developed over the past decade (cf, Figs 1.9 and 1.10) as well as the anticipated average annual losses over an approximate ten-year period into the future (cf, Fig 1.11). The plan also takes into account the net southerly transport of sand along Nags Head.

Fill sections will be varied systematically from north to south and within each reach (cf, Fig 1.2 for representative sections). The ends of the proposed project will incorporate long tapers as follows:

- Northern ~3,000 ft will taper from 0 cy/ft at station 491+00 to ~60 cy/ft (station 520+00).

- Southern ~3,000 ft will taper from 0 cy/ft at the boundary with the Cape Hatteras National Seashore (station 1025+00) to ~130 cy/ft at station 995+00.

No sand will be placed north of station 491+00* (Blackmon Street) in the northernmost ~1 mile of Nags Head (Reach 0) because:

a) This area is not included in the federal Dare County nourishment plan.

b) Volumetric erosion rates in Reach 0 have been negligible in the past decade (cf, Table 1.1 and Fig 1.12).

[*The federal Dare County project (south project area – Nags Head) nominally begins at USACE station 491+60 (USACE 2000). The applicant proposes to end the project at a public access street end (Blackmon Street), the centerline of which falls close to station 491+00 according to the best-available community plats. The intent is to begin the taper at the street end and continue it south for about 3,000 ft so as to yield a gradual transition between the unnourished area (Reach 0) and nourished areas (Reaches 1, 2, etc).]

Beach fill sections will consist of a berm (dry beach) extending seaward from the toe of foredune or existing storm berm (at elevation +8.5 ft NGVD) for a width that approximately equals the unit fill volume at the section (eg, 50 cy/ft will yield a 50-ft berm width; 120 cy/ft will yield an ~120-ft berm width, etc). The seaward edge of the berm will mark the start of the slope into the surf zone. The finished slope will be approximately 1 on 20 so as to match the average beach-face slope for the setting. As was illustrated in Figure 1.2, the fill will toe into the trough (runnel) between the existing beach and outer bar. Limited areas of Reach 2 (eg, near Surfside Drive) will receive extra sand to restore a minimal protective dune where there is no dune protection in front of buildings, roads, and other infrastructure. The primary purpose of the dune will be to reduce the frequency of wash-overs into town beach accesses, roads, sewer lines, and other community infrastructure.

Scales and Areas Impacted

Upon placement of nourishment sand, the project would directly impact a 300–600-ft-wide section of the existing littoral zone measured from the toe of the foredune to the outer bar. The average impact width will be ~85 ft for the berm, ~250 ft for the sloping wet beach to low water, and ~200 ft for the underwater toe of the fill. This equates to the following areas over the ten-mile project length:

- New dry beach ~103 acres
- Displaced wet beach ~182 acres
- Displaced inshore area ~242 acres

Following completion, the nourished profile is expected to adjust to incident waves and undergo the same transport processes as the native beach. Sand will shift offshore in high wave-energy events, then return onshore during calm periods (ie, the natural beach cycle). This will cause nourishment sediment to mix with native sediment and be selectively sorted such that finest material remains offshore and coarser material accumulates in the swash zone. Such processes are inexorable and a desired outcome of the proposed project.

The applicant expects to lose nourishment sand each year at rates comparable to historical averages. If the average fill volume is 75 cy/ft (~4 million cubic yards over ten miles) and losses average 5 cy/ft/yr, approximately 30 percent of the fill will remain in the proposed project area at the end of ten years. Given uncertainties in future erosion rates, the plan allows for 50 percent higher loss rates before all nourishment volumes are eroded within ten years. The applicant also recognizes that high erosion rates at the south end of Nags Head may remove all the sand in some areas before others. This is an unavoidable consequence of the variable erosion rates in this setting and the fact that some properties are presently situated on the active beach, dozens of feet seaward of the dune escarpment (Fig 1.13).

FIGURE 1.13.

Existing beach conditions along portions of south Nags Head showing emergency sand bags and houses situated seaward of the foredune. Photos taken by CSE in December 2003 (upper and middle) and April 2005 (lower).

1.3.3 Borrow Area Use Plan

The applicant has conducted extensive geotechnical data collection in offshore borrow area S1 (cf, Fig 1.1) as a supplement to data collected for the federal project (USACE 2000). Three subareas ("1",2" and "3") within offshore borrow area S1 are being considered for use in the proposed project. These areas, combined, contain at least 20 million cubic yards of beach-quality sediment; therefore, only about 20 percent of the sand resources in the subareas will be required to accomplish the proposed project. The final borrow area will depend on determination of the type of dredging equipment that is feasible in this setting (ie, self-propelled hopper dredges or cutterhead suction dredges), the dredging production rates, and the dredging window.

The EIS (Section 4.16 and Appendix D) provides detailed data and information on the native beach-sediment quality and the sediment quality in offshore borrow subareas 1, 2, and 3. Other relevant geotechnical data for offshore borrow area S1 are given in USACE (2000). Table 1.2 summarizes the proposed Nags Head project borrow area sediment characteristics.

TABLE 1.2. Nags Head locally sponsored nourishment project borrow area (S1) characteristics. [Source: CSE 2005a]

(1) Applicable Borings: Subarea 1 — NH 5, 6, 8, 16, 20, 22, 24, 26, 50, 52, 55, 56
Subarea 2 — NH 10, 12, 46, 48, 49, 57
Subarea 3 — NH 38, 39, 40, 61
(2) Weighted average through upper 5 ft of substrate for applicable borings.
(3) Assumes native M_z = 0.474 mm Standard Deviation = 0.471 mm (CSE criteria)
(4) Assumes native M_z = 0.362 mm Standard Deviation = 0.469 mm (NCCRC criteria)
(5) Borings have confirmed sediment quality through the upper ~8.5 ft of substrate in subareas 1, 2, and 3. The listed overfill ratios are composites for the upper 5 ft of section, assuming shallower excavations will be made via hopper dredges. Additional data are being acquired to further refine the borrow areas.

(1)	(2)	(2)		(3)	(4)				(5)
Borrow Subarea	Composite Grain Size	Material Passing #230 Sieve	Material >2 mm	Composite Overfill Ratio #1 (R_A)	Composite Overfill Ratio #2 (R_A)	Estimated Volume in Cubic Yards (size acres)	Distance Offshore (statute miles)	Substrate Elevation (ft NGVD)	Confirmed Section Thickness (ft)
1	0.501	<1%	8.7	1.67	<1.02	6,325,000 (784 acres)	2.0–3.0	–45 to –55	5
2	0.485	<1%	4.3	1.99	<1.02	2,580,000 (320 acres)	2.4–2.8	–35 to –50	5
3	0.425	<1%	3.1	2.89	<1.02	2,470,000 (306 acres)	1.6–2.1	–45 to –50	5
					TOTALS	11,375,000 (1,410 acres)			

CSE (2005a) sampled the native beach at 5,000-ft stations (eg, 800+00, 850+00, etc), collecting eight (8) cross-shore samples at each station. Samples were collected from the foredune, toe of the foredune, berm (dry beach), approximate mean high water (upper swash zone), low-tide terrace (inner breaker line), trough, bar, and offshore zone (depth ~15 ft).

Figure 1.14 (upper) shows the mean grain size for Nags Head by cross-shore sample position. The active beach from the dune to the low-tide terrace contains sediment that ranges in mean size from ~0.32 millimeters (mm) to over 1.6 mm. Mean grain size in the trough, outer bar, and offshore zone (~15 ft NGVD) is typically in the 0.2–0.25 mm size range (ie, fine sand).

Figure 1.14 (lower) pools groups of samples and shows the longshore trend by station along Nags Head. The results show a trend of decreasing mean grain size from north to south with considerable variability from station to station in the recreational beach zone (dry beach to low-tide terrace). There is little variation in grain size offshore.

For purposes of project planning, the applicant elected to adopt two "native beach" size distributions for Nags Head, using results compiled in "Preliminary Coastal Engineering Analyses for Large-Scale Beach Restoration at Nags Head (CSE 2005a–August, Section 2). Figure 1.15 shows the characteristic grain-size-distribution (GSD) curves for the two composites. The upper graphs shows a composite native-size distribution based on toe of dune, dry beach, mean high water, low-tide terrace, and trough samples — consistent with CSE's prior practice for determining native GSDs (CSE–Stroud 2001). The lower graph shows a composite based on foredune to outer (offshore) samples, similar to present North Carolina Coastal Resources Commission (NCCRC 2007) sampling guidelines (Attachment 7*). Resulting mean grain sizes are 0.47 mm (CSE criteria) and 0.36 mm (NCCRC criteria).

* The NCCRC sediment sampling protocols call for 13 samples per transect. The proposed project has 8 samples per transect. Additional samples will be collected and considered in the final design. Because NCCRC sediment criteria had not been finalized when the draft EIS for the proposed project was submitted, the applicant elected to use the available data which are believed to accurately reflect beach and inshore sediment quality along Nags Head.

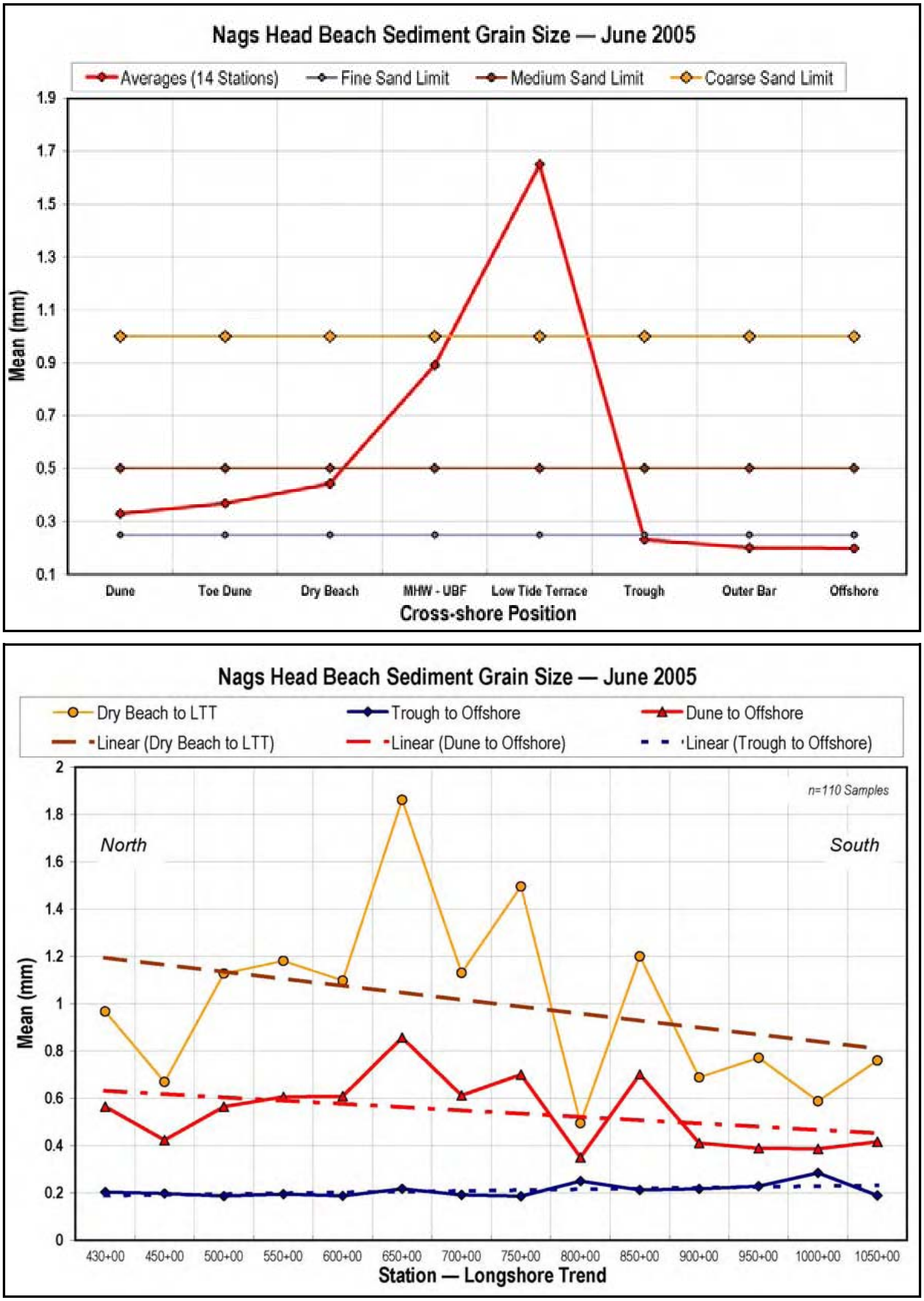
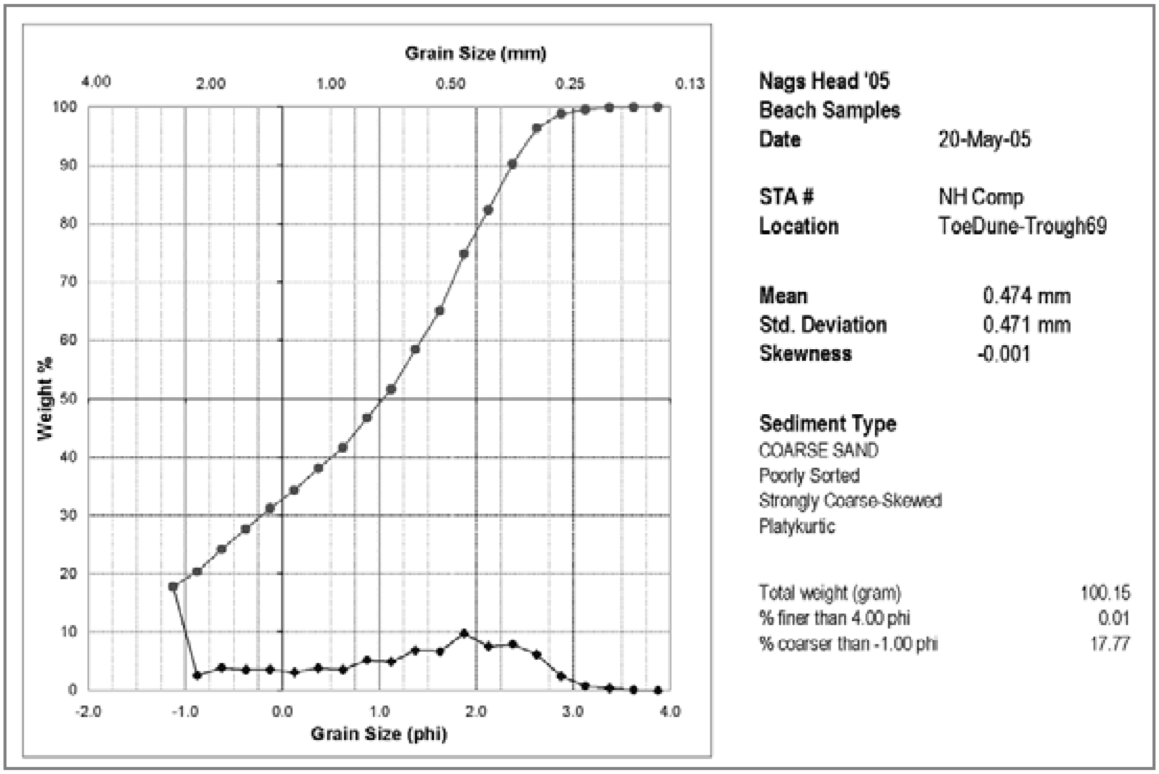


FIGURE 1.14. Overall trends in mean grain size by position and station across the profile. Red lines pool all samples. Trend line (dashed red line in lower graph) shows decrease in mean grain size from north to south. [From CSE 2005a]



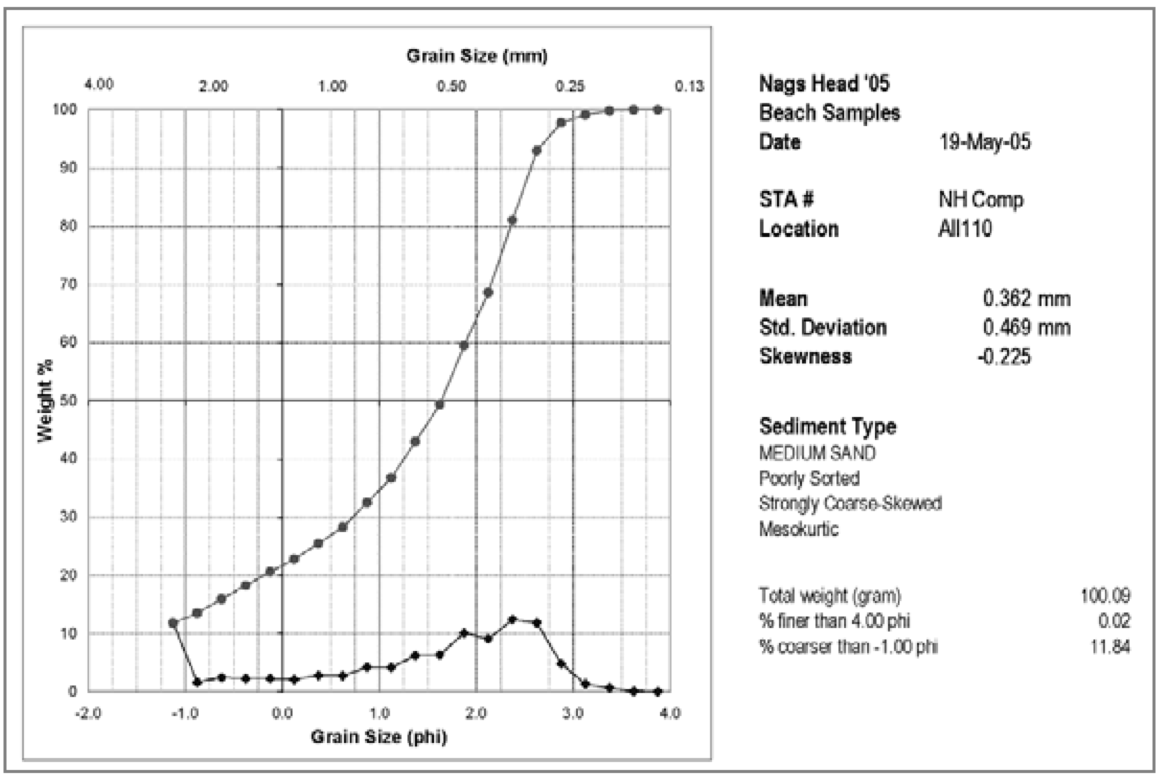


FIGURE 1.15. Nags Head composite grains-size distributions (GSDs) for the “native beach” as adopted herein. The lower graph (based on110 samples) approximately follows the 2005 draft NCCRC (now final NCCRC 2007) sampling protocols. The upper graph shows the result for a more limited zone of sampling between the toe of dune and trough. [From CSE 2005a]

Table 1.2 provided summaries of the borrow area sediment in subareas 1, 2, and 3 in offshore borrow area S1 and presented two sets of overfill ratios. One is based on CSE's standard practice (using only sediment samples from the recreational beach zone), and the other is based on composite averages for onshore and offshore samples. The latter approximates NCCRC technical standards that went into effect 1 February 2007, before the applicant could expand the sampling plan. Nevertheless, the applicant's 8 samples per profile line closely match the expected results using 13 samples per profile line because they encompass nearly the same width of the littoral zone (ie, dune to –15 ft for the proposed project versus dune to –20 ft for NCCRC criteria). Overfill ratios under CSE's standard practice range from 1.67 to 2.89 (Table 1.2). Using all samples (approximating NCCRC criteria), the overfill ratios are <1.02 for each subarea. The CSE criteria enable the applicant to better distinguish subtle differences in sediment quality within the potential borrow areas so as to improve performance of the proposed project. The results using the approximate NCCRC native sampling criteria, not unexpectedly, yield lower ratios (ie, more compatible sediments). This reflects the much lower mean grain size of native sediments when the fine sand from offshore is combined with much coarser sand on the dry beach and swash zone.

Borrow Area Contingency Plan

Sand compatibility results in offshore borrow area S1 (subareas 1, 2, and 3) (Table 1.2) are based on analyses from borings taken prior to construction. The spacing of borings ranges from 1,000 ft to1,500 ft. Forty additional borings have been obtained by the applicant in subareas 1, 2, and 3 so as to provide data at 500–1,000 ft spacing. These data will be submitted later in 2007. There is a relatively high degree of similarity of sediment quality among the cores analyzed to date (see EIS, Section 4.16 and Appendix D). The predominant material is ~0.4-0.5 mm, medium-to-coarse quartz sand with ~8 percent gravel (grain diameter >2 mm) and ~4 percent shell content. Percent fines (silt and clay material passing the #230 sieve) represent less than 1 percent of the samples collected to date. Additional borings will increase the level of confidence for borrow material compatibility and decrease the degree of interpolation between boring locations. Upon completion of these additional borrow area analyses, a more specific borrow area utilization plan will be developed.

Even after further refinement of the borrow area characterization, the applicant recognizes there will be some degree of uncertainty in the interpolation of results between core locations. During excavation and fill placement, some material may be encountered that appears incompatible with the native beach. While it is not feasible or practicable to conduct real-time sediment sampling and determination of grain-size distributions, some qualitative review can be performed at the discharge point and in the hopper of the dredge (applicable only for hopper dredge operations). The applicant will have trained personnel on the dredge as well as on the beach to monitor sediment quality each day. Samples will be collected and analyzed within three days of collection and the data made available to regulatory agencies and interested parties. Such procedures are ongoing for a post-*Ophelia* beach restoration project at Bogue Banks (federal permit number Action ID SAW-2006-32753-016 and NC CAMA #181–06). Of greatest concern is the placement of rock fragments (indicating excavations of hard bottom or lithified substrate) or muddy material. The borings in offshore borrow subareas 1, 2 and 3 have not detected such material. Nevertheless, should such material be encountered, the applicant would direct the dredge to relocate at the earliest feasible time (measured in hours to approximately one day). Further, if significant quantities of mud are encountered, the contractor's production would greatly diminish. This creates a strong incentive for the contractor to relocate the dredge as soon as possible so as to resume efficient production.

Federal and state environmental agencies will be notified if (and how much) potentially incompatible material is encountered. If necessary, the applicant (in consultation with the contractor's operations personnel) will make the decision on an appropriate contingency measure (including moving the dredge to another site within a borrow subarea or to another subarea) and notify the agencies of this contingency measure.

Borrow Area Parameters

Offshore borrow area S1 (subareas 1,2, and 3) is located within the three-nautical-mile limit of federal waters and, therefore, is not subject to the federal mining requirements of the US Minerals Management Service (MMS). The USACE (2000) estimates borrow area S1 contains ~100 million cubic yards of beach-quality sediment, a volume sufficient to accomplish the 50-year federal project (north and south areas). In addition to these sand resources, MMS has identified nearby beach-quality deposits suitable for nourishment along Nags Head and other Dare County Beaches totaling over 100 million cubic yards (Byrnes et al 2003). These deposits are situated beyond the three-nautical-mile limit. The proposed project is a one-time event that will remove ~4 percent of the sand reserves in borrow area S1 and ~2 percent of the **confirmed** sand reserves offshore of Nags Head. If the offshore area of Nags Head is defined as an 11-mile-long by 6-mile-wide area of ocean bottom, the proposed project will impact ~1.3 percent of the bottom (~550 acres out of ~42,250 acres).

Borrow area S1 (subareas 1, 2, and 3) is located 1.5 to 3.0 statute miles offshore. Pipeline/hopper dredge distances are 1.5 to ~7 miles from the designated fill areas. For hopper dredge operations, there would be little difference in transportation costs among subareas 1, 2, and 3. However, for a pipeline cutterhead dredge, subarea 1 would be more cost effective for construction of Reach 1 and subarea 3 would be more cost effective for Reach 3. Costs increase significantly with pumping distance. Further, for the type of material in the borrow area (coarse sand), additional pumping capacity would be required according to dredging contractors. A cutterhead dredge would require a booster pump (separate dredge platform) to accomplish Reach 1 nourishment. Some qualified dredging contractors who requested anonymity believe that use of cutterhead suction dredges even with booster pump(s) in this setting is not possible. Because of the uncertainty regarding (1) what construction schedule will be allowed by the regulatory agencies and (2) whether cutterhead suction dredges are even feasible in this setting, the applicant has not finalized selection of subareas 1, 2, or 3.

1.3.4 Dredging Production

The USACE prepared an analysis of dredging production rates for the federal Dare County project based on the expected wave environment in this setting (USACE 2000, Appendix D). They drew on production rates for Kure Beach (located in the southern part of the state near Wilmington) and for Oregon Inlet (about five miles south of Nags Head). When the federal EIS for Dare County was prepared, Kure Beach was the only project that had ever utilized an offshore borrow source along the North Carolina coast. Since then, offshore borrow areas have been used for projects at Pine Knoll Shores, Indian Beach, and Emerald Isle (CSE 2003a,b). Following are relevant excerpts from USACE (2000) regarding estimated production rates for the federal Dare County project (table and figure numbers referenced in the original document have been changed for sequencing in the present report).

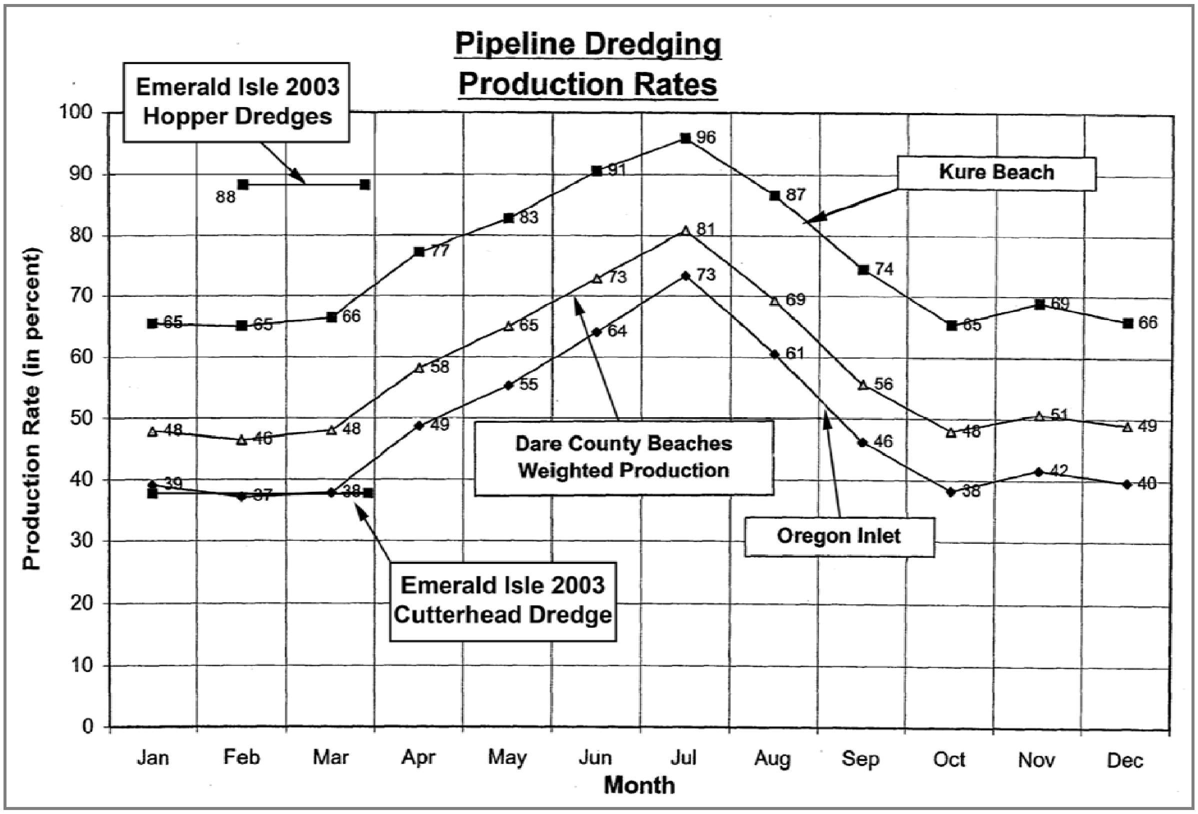
Production Rates – *Dredging production data for two recently completed projects by the Wilmington District (Oregon Inlet and Kure Beach) were utilized to develop relationships reflecting the expected production rates for the Dare County Beach project. Oregon Inlet is about 5 miles south of the southern end of the proposed Dare County beach-fill project. Kure Beach is located along the North Carolina coastline in the southern part of the state, well south of Dare County. Production data for the two projects were converted to monthly production efficiency. Conversion to monthly efficiency was based on a pipeline dredging with a maximum daily production rate of 15,000 cubic yards. The result of the production analysis is shown in Table 1.3 and is also shown graphically on Figure 1.16 (upper).*

TABLE 1.3 Pipeline dredging production efficiencies. Note: For each project, efficiency is based on a pipeline dredge with a maximum daily production rate of 15,000 cy. [After USACE 2000, Table D–4]

		Oregon Inlet Project		Kure Beach Project		Dare Co.
Month	Days	Production (cy/mo)	Efficiency (%)	Production (cy/mo)	Efficiency (%)	Efficiency (%)
January	31	181,858	39	304,473	65	48
February	28	156,181	37	273,202	65	46
March	31	176,071	38	308,765	66	48
April	30	219,033	49	347,436	77	58
May	31	257,325	55	384,648	83	65
June	30	288,315	64	407,646	91	73
July	31	341,112	73	445,656	96	81
August	31	281,623	61	402,662	87	69
September	30	207,804	46	335,147	74	56
October	31	178,092	38	304,022	65	48
November	30	187,161	42	310,019	69	51
December	31	184,605	40	306,602	66	49

Dredging production efficiencies for the two projects were vastly different, with the Kure Beach project showing production values 65 to 75 percent higher than the Oregon Inlet project in the months of November through March and 30 to 60 percent higher than the Oregon Inlet project during the remainder of the year. Dredging production rates for the Oregon Inlet project were hampered by the severe wave climate in the vicinity of Oregon Inlet. Due to the proximity of the Dare County project to Oregon Inlet, greater weight (2 to 1) was given to the Oregon Inlet production data. The production efficiencies for Dare County shown in Table 1.3 are weighted monthly efficiencies which were used as the basis for developing dredging costs for this study.

Storm Reduction Adjustment *– The weighted production efficiency values from the previous table were then adjusted for occurrence of severe storms in the dredging work area. The storm reduction adjustment corrects for the time that the dredge vessel would have to relocate from the job site to a safe haven to ride out the storm. Since there is no safe haven in the immediate vicinity of the work area, any dredging plant equipment would likely relocate to either Norfolk (VA) or Morehead City (NC). The assumption is that a severe storm event would cause a loss of seven dredging days, which includes reaction time to the incoming storm, travel to the safe haven and back, and wait time. Table 1.4 (USACE 2000, Table D–4) displays the severe storm history in the project area over a seven-year period (1984–1990). The table shows that there were 16 severe storm events over the seven-year period, an average of just over two events per year.*



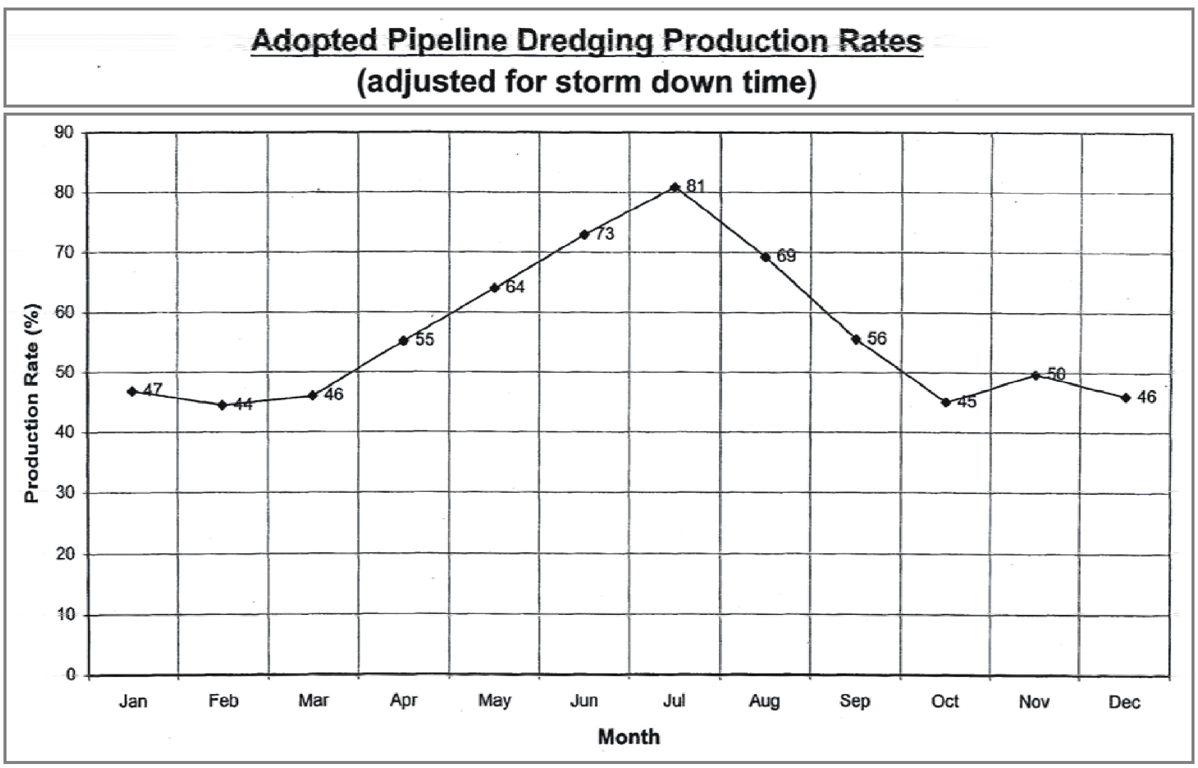


FIGURE 1.16 [UPPER] Dredging production rates for Kure Beach, Oregon Inlet, Emerald Isle, and the federal Dare County project (projected). [LOWER] USACE (2000) adopted dredging production rates for the federal Dare County project. [From USACE (2000), Figs D-5, D-6; data for Emerald Isle from CSE (2003), Table 5]

TABLE 1.4 Pipeline dredging down time for severe storms (storm events that would require dredging vessel to seek safe haven). [After USACE 2000, Table D–4]

Storm Events (1984-1990)			Storm Down Time (Events/month/year)			
Begin	End	Peak Elevation	Month	Days per Year	Total Storm Events	Events per Year
01/11/84	01/14/84	9.0	January	31	1	0.14
10/11/84	10/15/84	10.7	February	28	2	0.29
10/28/85	11/04/85	8.6	March	31	2	0.29
04/18/86	04/19/86	9.0	April	30	3	0.43
05/09/86	05/12/86	9.8	May	31	1	0.14
12/01/86	12/03/86	9.7	June	30	0	0.00
02/17/87	02/18/87	10.6	July	31	0	0.00
03/10/87	03/16/87	10.9	August	31	0	0.00
04/26/87	04/27/87	9.6	September	30	0	0.00
10/12/87	10/15/87	9.1	October	31	3	0.43
04/08/88	04/14/88	10.2	November	30	1	0.14
02/24/89	02/25/89	12.4	December	31	3	0.43
03/07/89	03/10/89	10.6				
12/09/89	12/10/89	9.7				
12/22/89	12/25/89	14.2				
10/25/90	10/28/90	10.5				

Adopted Production Efficiencies

Table 1.5 (USACE 2000, Table D–6) shows the adopted production efficiencies for the Dare County study with adjustments for severe storms. Figure 1.16 (lower) is a plot of the adopted efficiencies for the Dare County study. As can be seen, the July peak summer production rate of 81 percent is nearly double the October through March production rates that are consistently below 50 percent. A May through August time frame would be ideal for pipeline dredging efficiency, with values ranging from 64 to 81 percent; however, (existing) dredging windows will limit most operations to the winter months when less than 50 percent efficiency is the rule.

TABLE 1.5. Adopted pipeline dredging efficiencies for the federal Dare County project. [After USACE 2000, Table D–6]

	Production Efficiency (%)		
Month	Weighted Average	Storm Reduction	Adopted Values
January	48	1	47
February	46	2	44
March	48	2	46
April	58	3	55
May	65	1	64
June	73	0	73
July	81	0	81
August	69	0	69
September	56	0	56
October	48	3	45
November	51	1	50
December	49	3	46

[END OF QUOTES FROM USACE 2000]

Nourishment projects along Bogue Banks were completed in 2002 and 2003 (CSE 2003a, b) using offshore borrow areas and both hopper dredges and cutterhead suction dredges. Emerald Isle was nourished as part of Phase 2 of a locally sponsored project (Fig 1.17). Portions were accomplished using hopper dredges and a cutterhead suction dredge (CSE 2003b).

Bogue Banks is a south-facing beach with nearby safe harbor at Beaufort Inlet. It is sheltered completely during northeasters which predominate during winter months. Hopper dredge operations were found to be feasible in this setting during cold water months. However, production with the cutterhead suction dredge was well below expectations despite the relatively short pumping distances to shore (<1 mile). While sheltered from northeasters, the cutterhead dredges had to suspend operations numerous times because of persistent ground swell in the area. The dredge ladder which supports the cutterhead and intake pipe would be thrust into and out of the cut during operations when long-period waves (ie, >7–8 seconds) occurred. This made control of the cut difficult while placing extreme strain on the equipment. The ladder of the dredge was damaged and had to be repaired at a cost of several days of down time (CSE, unpublished project records). Problems associated with use of the cutterhead dredge at Emerald Isle reduced the final production to only 20.7 percent of Phase 2 (by length) and 25 percent of Phase 2 by volume. The balance of the project was accomplished with hopper dredges (CSE 2003b).

Table 1.6 details the dredging efficiencies for two hopper dredges and one cutterhead suction dredge during the Emerald Isle project. The cutterhead dredge efficiency was ~38 percent. By comparison, the efficiency of the hopper dredges was 87–91 percent. Daily production of the cutterhead dredge averaged ~11,800 cubic yards per day (cy/day). The hopper dredges averaged 14,650 and 14,300 cy/day (Table 1.6). Weather-related delays occurred 20 percent of the time for the cutterhead dredge but only 6–9 percent of the time for the hopper dredges. In the case of the cutterhead dredge, weather-related delays encompassed not only periods of storms, but fair-weather periods when long-period waves (ie, ground swell) occurred. Hopper dredges are less affected by ground swell because they are not thrusting a cutterhead into an underwater embankment. Instead, hopper dredges drag two relatively small suction heads across the bottom leaving shallow cuts with each pass. Since the Phase 2 project at Emerald Isle, there have been several nourishment projects using offshore borrow areas but none has been accomplished using a cutterhead dredge.

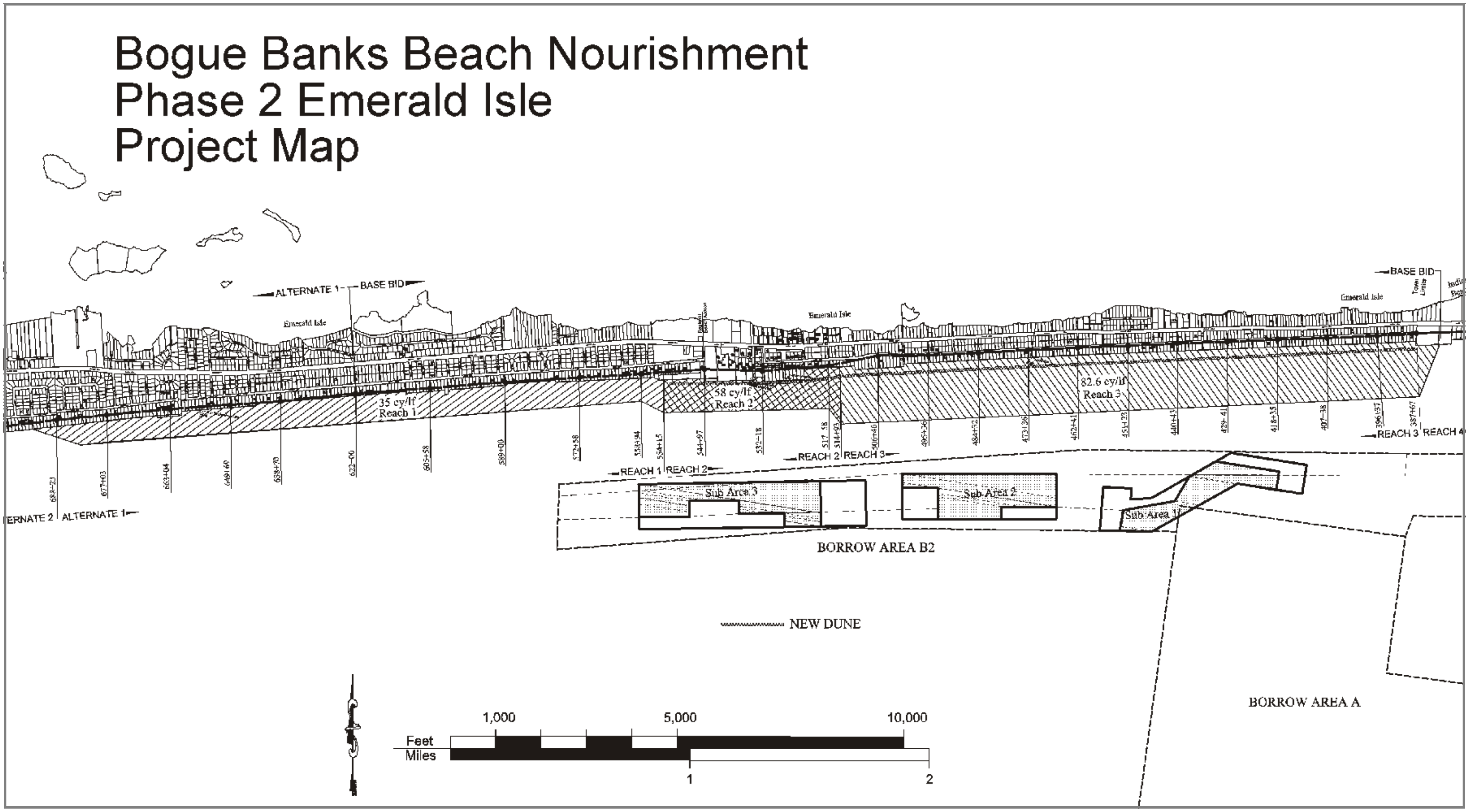


FIGURE 1.17. Phase 2 Emerald Isle nourishment project showing the offshore borrow areas and project area (from CSE 2003b, Fig 2).

The results of the USACE (2000) analysis with project data for Emerald Isle added are shown on Figure 1.16 (upper). This suggests that dredging efficiencies at Nags Head are not likely to exceed 50 percent until April and will only approach 80 percent in June, July, and August. Fall northeasters (September, October, and November) are expected to reduce production dramatically as shown in the graph. The adopted dredging production rates for the federal Dare County project as estimated by the USACE (2000, Fig D–6) are shown on the lower graph of Figure 1.16.

Based on the dredging production analysis by USACE (2000) for Dare County, the results of projects involving offshore borrow areas along Bogue Banks, and off-the-record communications with qualified dredging companies — dredging offshore of Nags Head is not considered feasible during winter. Using the 50 percent efficiency threshold, the adopted production rates given in Figure 1.16 (lower), and the apparent reluctance of dredging contractors to work offshore of Nags Head during winter, the applicant now believes the only feasible construction window is mid April through mid September, an approximate five-month period.

TABLE 1.6. Bogue Banks beach nourishment project, Phase 2, Town of Emerald Isle – summary of dredging operations. The *RS Weeks* is an ocean-certified cutterhead suction dredge. [From CSE 2003b, Table 5]

HYDRAULIC DREDGE SUMMARY – *RS Weeks*	
Total Hours Worked	668.9
Hours Lost Weather & Mech	1,076
Overall Efficiency	38.3%
Avg Beach Feet Completed/Day	143
AVG CY/DAY	11,833
Work & Pay Status	
Working (days)	51
Working/Mech	0
Not on Job	0
Weather	15
Mech	7
Down/Turtles	0
Total Days	73
Total cy Delivered	860,518
Total LF Completed	10,400

HOPPER DREDGE SUMMARY

R N Weeks				*BE Lindholm*		
Total Loads B2		52		Total Loads B2		0
Total Loads A		235		Total Loads A		132
Total Loads		287		Total Loads		132
Total cy B2		115,127		Total cy B2		0
Total cy A		632,012		Total cy A		314,359
Total cy to Date		747,139		Total cy to Date		314,359
Avg Beach Feet Completed/Day		403		Avg Beach Feet Completed/Day		501
AVG CY/DAY		13,836		AVG CY/DAY		14,289
Work & Pay Status	**Days**	**% of Total**		**Work & Pay Status**	**Days**	**% of Total**
Working	47	87.0%		Working	20	90.9%
Working/Mech	0	0.0%		Working/Mech	0	0.0%
Not on Job	3	5.6%		Not on Job	0	0.0%
Weather	3	5.6%		Weather	2	9.1%
Mech	1	1.9%		Mech	0	0.0%
Down/Turtles	0	0.0%		Down/Turtles	0	0.0%
Total Days	54			Total Days	22	
Total Prelim Pay Vol	747,139			Total Prelim Pay Vol	314,359	
Total LF Completed	21,785			Total LF Completed	11,015	

Dredging Window

Dredging window restrictions with respect to nesting sea turtles were reviewed, using a 16 November to 30 April window for cutterhead suction dredges and 1 December to 31 March window for hopper dredges (NC Turtle Moratorium). Assuming that a contractor is willing to work during calm periods of the months of December, January, February, and March – the anticipated efficiency rates would be well under 50 percent. With the passage of each winter front (typically 3–4 per month), the dredge would have to shut down and wait for wave conditions to diminish. Storm events (~1 per month, USACE 2000) would force the dredge to move to the safe harbor at Norfolk, Virginia (~60 miles away). The USACE (2000) estimates each relocation of a dredge to the nearest safe harbor would result in seven days of lost production. This takes into account the need to relocate the dredge before a storm event (one day transit), the duration of the storm and its associated high waves (typical 3-5 days for northeasters in winter in this setting), and the return of the dredge to the site.

The applicant believes that winter storm events and delays due to excessive wave energy in the borrow area would reduce production to only 10–12 days per month (ie, <50 percent efficiency). Assuming a median winter operations period of 12 days per month per dredge and a typical daily production of 20,000 cy per dredge when dredging — one dredge could only accomplish about 240,000 cy per month. The equivalent of 16–20 dredge-months would be required to accomplish a 4–4.6 million cubic yard project at such rates. A 4–5 month dredge window would therefore mean that 4-5 dredges would have to be assigned to the proposed project to accomplish all work under one mobilization.

Based on the foregoing data and experience at Bogue Banks, the existing dredging window (16 November to 30 April) will not allow sufficient time to accomplish the proposed project because:

1) Ocean-certified cutterhead dredges cannot safely work in this setting during winter months (ie, mid December through March).

2) No qualified contractor appears willing to risk equipment offshore of Nags Head during winter months; therefore, it is unlikely any viable bids will be received if the construction window matches the NC Turtle Moratorium dates.

3) It is likely that only hopper dredges can operate safely offshore of Nags Head and only during calmer months of the year (ie, April through September).

The applicant concludes that the only viable period for accomplishing the proposed project is mid April though mid September.

Following is the recommended construction plan.

Nags Head Recommended Dredging Production Plan

The applicant plans for all dredging to be performed under one mobilization. Table 1.7 lists the average production rates necessary to accomplish the proposed project within ~5 months (150 days). Three nourishment volume scenarios are given with the largest quantity representing the requested maximum volume and the least quantity representing the minimum volume considered necessary to achieve ten-year benefits (ie, minimal nourishment volume remaining in the proposed project area after ten years).

Using experience at Bogue Banks (cf, Table 1.6), the applicant believes that production of ~13,500 cy per day per hopper dredge is realistic for planning purposes – assuming a construction period extending from mid April through mid September. Table 1.7 shows that a minimum of two hopper dredges will be required to accomplish the proposed project. A third dredge would have to be mobilized for a portion of the proposed project if the final nourishment volume is in the range 4,000,000 cy to 4,600,000 cy.

The applicant does not believe the proposed project could be accomplished in this setting by means of a cutterhead suction dredge because of the high probability there would be no bids submitted by qualified dredging contractors. The experience at Emerald Isle in 2002–2003 (Table 1.6) illustrates the wide difference between efficiencies of hopper dredges and cutterhead dredges in a lower wave energy setting.* Such differences will apply at Nags Head because wave energy is even greater (USACE 2000).

[*Emerald Isle on Bogue Banks is completely sheltered from northeasters in winter and can take advantage of extended periods when winds are northwest blowing off the land and thus reducing the height of the incident waves along the beach.]

TABLE 1.7. Average dredge production required to accomplish the proposed Nags Head project in ~5 months (150 days). Rates approaching 14,000 cy per day (net actual production and stand-down time) are considered possible based on experience at other sites (cf, Table 1.6).

Nourishment Volume (cy)	Average Daily Production Per Dredge (cy per day)		
	1 Dredge	2 Dredges	3 Dredges
4,600,000	30,667	15,333	10,222
4,000,000	26,667	13,333	8,889
3,500,000	23,333	11,667	7,778

Differences Between the Proposed Dredging Production Plan and the Federal Dare County Project

The proposed project differs from the federal project in the following ways with respect to the dredging production plan:

- Proposed project will be a one-time event versus multiple nourishment projects over a 50-year period under the federal plan.

- Proposed project's size is ~50–57 percent of the initial federal nourishment plan for Nags Head (ie, ~4–4.6 million cubic yards versus 8.04 million cubic yards).

- Proposed project anticipates the only viable period for dredging is mid April through mid September based on the high wave energy in this setting, high frequency of fall and winter storms, experience with other NC offshore borrow areas since 2000, communication with representatives of the dredging industry warning about safety issues during winter construction (Attachment 6), and informal communication from qualified contractors strongly suggesting no viable bids would be received if work is restricted to winter months. The federal project (Nags Head area) anticipates initial construction would be performed over three phases (years) with each phase beginning November 16 and proceeding until completion between May and October of the following year (USACE 2000, pg D-18).

- Proposed project anticipates that hopper dredges are the only feasible equipment that can operate safely and efficiently offshore of Nags Head and no US contractors are willing to risk equipment offshore in this setting during winter months (ie, January, February, and March). The USACE (2000) plan anticipated that pipeline dredging would be feasible from November 16 through the winter. (Note: There was no experience with cutterhead suction dredges or hopper dredges operating offshore of North Carolina north of Wilmington when the federal EIS was prepared in 2000.)

- Proposed project would be accomplished using a minimum of two dredges so as to complete all work within ~5 months. The initial federal project time line anticipates a construction duration of 6–11 months for each of three Nags Head phases. The federal time line also assumes portions of the work would be performed during the months of April, May, June, July, August, September, and October (USACE 2000, pg D-18).

The applicant believes that given up to an 11-month window to accomplish each phase of the federal project (ie, 16 November through October), contractors would elect to optimize construction by delaying starts until April then accomplishing the initial federal work before the end of the summer. Mobilizing multiple dredges and accomplishing the federal project when efficiencies are highest are considered the only way that project could be accomplished based on North Carolina operations data obtained since the federal plan was prepared (2000) and on informal discussions with prospective contractors. Further, there is little evidence a cutterhead suction dredge is economically feasible for either the federal or the proposed, locally funded project off Nags Head at anytime of the year.

Dredging Experience in Nearby Jurisdictions – Norfolk District USACE

The nearest previous dredging experience involving hydraulic dredging (hopper or cutterhead suction dredges) is the Oregon Inlet navigation project (5 miles south of Nags Head) (USACE 2001), Rudee Inlet (~50 miles north), the Virginia Beach nourishment project (55 miles north), and the Chesapeake Bay entrance channels (60–70 miles north) (NMFS 2003). Figure 1.18 shows the general location of these sites.

Oregon Inlet Navigation Project (c/o Wilmington District USACE) — Periodic maintenance dredging has been performed numerous times using relatively shallow draft hopper dredges and side-cast dredges. Project depth is –14 ft mean lower low water (MLLW), and conditions in the outer bar preclude deeper draft or fully loaded hopper dredges from operating. Side-cast dredges have been used to maintain a channel through the outer bar (GAO 2002). According to the GAO report, the 14-ft design depth was maintained 23 percent of the time between August 1983 and March 1994 at an average annual dredging expenditure of (~)$4.1 million. Since 1994 through circa 2000, dredging expenditures have averaged about $2 million per year, and the 14-ft depth (over the full length of the authorized channel) has only been maintained about 15 percent of the time (GAO 2002, pg14). One reason for the low percentage of time the channels are maintained is the dynamic nature of Oregon Inlet.

> *Oregon Inlet experiences more high winds, strong tides, and shifting sand than any other inlet on the Atlantic coast of the United States. Between 1990 and 1998, the Oregon Inlet area was affected by more than 100 significant storms, some of them hurricanes. Storms heighten ocean waves and increase sand movement in the inlet. Based on Corps studies, an average of about 2.1 million cubic yards of sand move in and around Oregon Inlet each year. In comparison annual sand movement . . . is about 471,000 cubic yards for Rudee Inlet . . .”* (GAO 2002, pp 14-15)

FIGURE 1.18. Nearest known hydraulic dredging projects to Nags Head. [Sources: USACE–Wilmington District, Norfolk District, NMFS (2003), http://ocs-spatial.ncd.noaa.gov/encdirect/viewer.htm]

Rudee Inlet Navigation Project (c/o Norfolk District USACE) — Situated ~5 miles south of Cape Henry, Rudee Inlet is a small, jettied inlet that is periodically dredged to maintain a 10-ft-deep channel. It has been maintained by small truck-mounted hydraulic pumps (jet pumps) as well as small harbor dredges working under the protection of the jetties. The jetties incorporate a weir section for collection of sediment in a deposition basin. Periodic maintenance dredging bypasses sand to the north, the predominant sand transport direction.

Virginia Beach Nourishment and Hurricane Projection Project (c/o Norfolk District USACE) — This project involves hopper dredging of nearby entrance shoals between the Virginia Capes (entrance to Chesapeake Bay) and placement along ~6 miles of ocean shoreline at Virginia Beach. The most recent and largest beach fill was ~4 million cubic yards accomplished in 2001–2002 (NMFS 2003, Campbell and Benedet 2004). Thimble Shoal Channel and Cape Henry Channel provided the majority of the material for the Virginia Beach federal project. Both borrow sources are situated at or just inside the Virginia Capes a distance of ~ 5-12 miles from the nourished area.

Chesapeake Bay Entrance Channels (c/o Norfolk District USACE) — Several projects comprise the Chesapeake Bay Entrance Channels including the Cape Henry Channel, York Spit Channel, York River Entrance Channel, and Rappahannock Shoal Channel (NMFS 2003). These channels are routinely maintained by hopper dredges.

Based on the review of available reports, there does not appear to have been any dredging and nourishment utilizing a true offshore borrow source between Cape Hatteras and the Chesapeake Bay entrance. Dredging operations to date appear to have been confined to navigation channels, the outer bars of inlet deltas, and various bay channels. The nearest analogous borrow area for the proposed project is considered to be the Cape Henry Channel at the entrance to Chesapeake Bay (cf, Fig 1.18). Environmental Impact Statements and Biological Opinions are available for most of the above-referenced projects.

The most recent Biological Opinion for the US Army Corps of Engineers maintenance dredging in the Chesapeake Bay entrance channels is believed to be NMFS (2003) (Attachment 8). Attachment 8 is included herein because it addresses the endangered and the threatened species impacts for nearby similar projects, although the applicant recognizes that Norfolk District projects fall under the Northeast Regional Biological Opinion and the Nags Head Project falls under the Southeast Region jurisdiction. Obviously, the Nags Head setting is near the northern limit of the Southeast Region and the Chesapeake Bay entrance is near the southern limit of the Northeast Region. While biological opinions for the two regions necessarily must take into account differing climate influences, there are expected to be numerous similarities between climate conditions and the occurrence of endangered and threatened species between the lower Virginia coast the upper North Carolina coast.

The following section describes the species considered under this assessment.