Monitoring and Analyses of the 2011 Nags Head Beach Nourishment Project

2014
BEACH MONITORING REPORT

Prepared for:

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[CSE2387–YR3]
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COVER PHOTOS: Aerial photo of north Nags Head looking south on 11 September 2014 (by TW Kana). As confirmed by CSE's June 2014 survey, north Nags Head (Reach 1 between MP 11 and 16.8) has gained ~7 cy/ft of sand since project completion, and the average beach width between the +10 ft and +5 ft NAVD contours is ~65 ft. The seaward vegetation line along the pre-nourishment dune remains discontinuous. Vegetation gaps are areas where excess sand is encroaching on some structures. The present report outlines methods for enhancing and stabilizing the foredune after nourishment.

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EXECUTIVE SUMMARY

This report presents results of Year 3 (2014) physical monitoring surveys along Nags Head (NC) following construction of the 2011 nourishment project (24 May to 27 October). The project involved dredging 4.6 million cubic yards of sand from offshore borrow areas and placing it onto a 10-mile stretch of beach in Nags Head. The Beach Monitoring & Maintenance Plan (Appendix 1) (Ogburn 2011) prescribes methodology and requirements for annual monitoring after nourishment to satisfy special conditions of the permits and to provide a measure of beach condition each year. Annual surveys define the condition of the beach prior to major storm events and are used by FEMA for evaluation of post-disaster claims for beach restoration under Category G community assistance grants. The scope of monitoring is detailed in a proposal and agreement dated 20 April 2012 between the Town of Nags Head and CSE, and is summarized in Section 2.0 of the present report.

Monitoring in 2014 included compaction measurements in March prior to turtle nesting season, controlled aerial orthophotography in June, beach and inshore surveys at 500-foot profile spacing in June, supplementary dune inspections and profiles in March and June, and additional analytical work. CSE submitted preliminary results in late June documenting nourishment volumes remaining within the project area (by reach and by reference depth contour). The present report expands on these survey findings, providing station by station results. Also included in the 2014 report are sections describing the wave conditions from June 2013 to June 2014 compared with historical data.

CSE completed a detailed analysis of dune growth and evaluated alternatives for minimizing encroachment of sand into existing structures. The report includes a dune management plan which addresses site specific conditions along the beach.

Following are highlights of the report.

Sediment Compaction (Section 3.0)

CSE's measurements confirmed that the nourished beach to the 12-inch depth meets or exceeds the USFWS threshold of 500 psi as do control beaches north and south of Nags Head. Many measurements at the 18-inch depth in the nourished beach as well as the control beaches failed the 500 psi criterion. There are no major differences in compaction between nourished and natural beaches three years after the project. No tilling was performed, given the general conformity of the results. See Section 3.0 for details.

Wave Conditions (Section 4.0)

Data buoys at Duck Field Research Facility (FRF) near the project showed that mean wave height was significantly higher between June 2013 and June 2014 compared with the 21-year historical average between 1986 and 2006. Although waves were higher than normal, there were no major storms during the period. An early season "exiting" hurricane (*Arthur*) passed through Nags Head on July 4th (after the wave record herein) without significant impact. Wave direction during the monitoring year was principally from easterly directions, producing net northerly transport at Duck. Similar wave direction likely occurred along Nags Head, accounting for some observed accretion along Reach 1 (north project limit to Comfort Inn near Jennette's Pier).

Although the historical longshore sediment transport at Nags Head is from north to south, CSE's survey results confirmed strong net northerly transport for 2003–2005, and the majority of waves during that period were incident from the east-southeast (70–130°True) with an occurrence probability of ~67 percent. The east-southeast wind occurrence probability was ~63 percent between June 2013 and June 2014, likely producing net northerly transport.

Beach Surveys and Nourishment Sand Remaining (Sections 5.0 and 6.0)

Beach surveys were used to compute sand volumes between the foredune and various contours (Fig A). Integrating over the entire 10 mile project area between the foredune and -19 ft NAVD (FEMA reference limit offshore for purposes of post-storm renourishment funds), there were an estimated 4,396,000 cy more sand in June 2014 than pre nourishment conditions (November 2010). This quantity represents ~96 percent of the placed volume, suggesting that net losses have been well below the projected ~6 percent per year. As much as 15 percent of the nourishment sand has shifted landward and built up the foredune and upper beach (landward of the +6-ft NAVD contour). Another major quantity has shifted into deeper water between the −12 ft and −19 ft NAVD contours. During the past 1.5 years, the offshore bar has reformed further seaward compared with the early post-project bar.

While overall sand retention has been good, results vary by reach and by station. Figure B shows reach-by-reach results to −19 ft NAVD (other reference depths are shown in Sections 5 and 6). Reach 1 has gained sand on average and has roughly 10 percent more volume than the post-nourishment condition. Reach 2 (Comfort Inn to East James Street) averages roughly the same volume to −19 ft since November 2011. Reach 3 and Reach 4 (encompassing the southern 2 miles of the project) have lost ~30 percent of their nourishment volume as of June 2014.

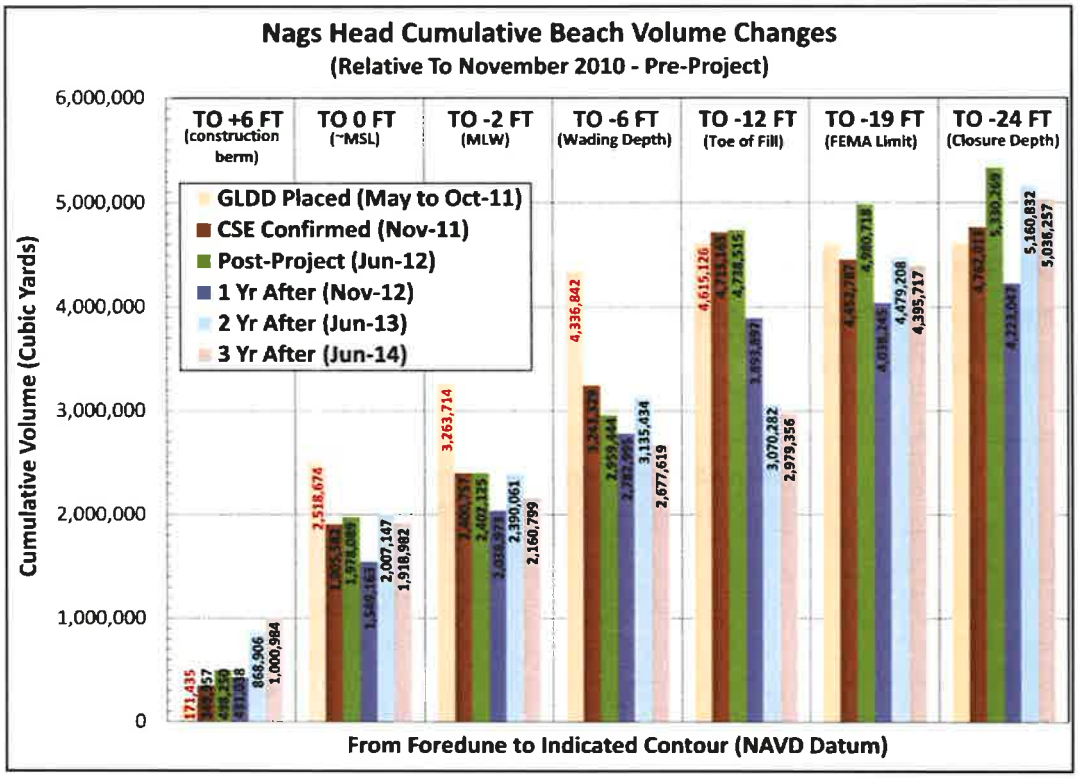

FIGURE A. Accumulated overall beach volume changes relative to November 2010 survey results between the foredune and indicated contours.

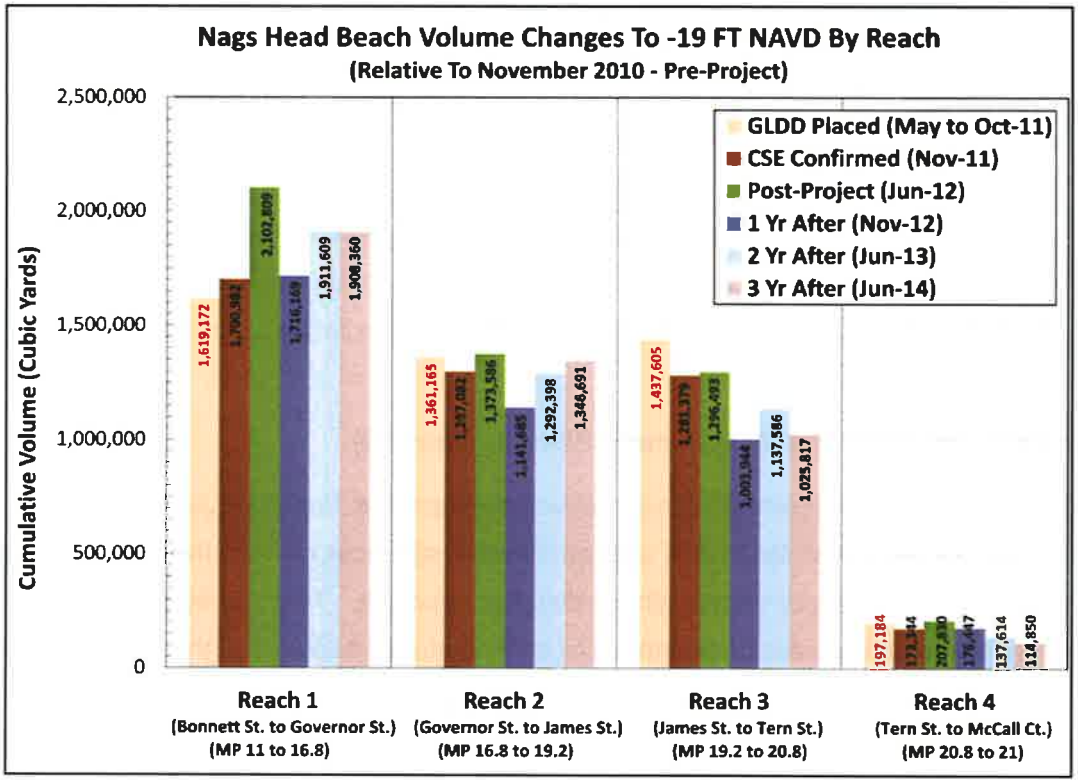

FIGURE B. Accumulated overall beach volume changes by reach relative to November 2010 survey results between the foredune and -19 ft NAVD contour.

Figure C shows considerable variation in sand volumes from station to station along with the trend lines for November 2010 and June 2014. At a handful of stations (eg 525+00 and 780+00), the lines cross meaning those areas are local "hot spots" which temporarily have less sand than the pre nourishment condition. The report describes the migration of hot spots alongshore, a process that is common along high-energy beaches like Nags Head. As the trend lines illustrate, there is considerably more sand at nearly all stations compared with the pre nourishment condition.

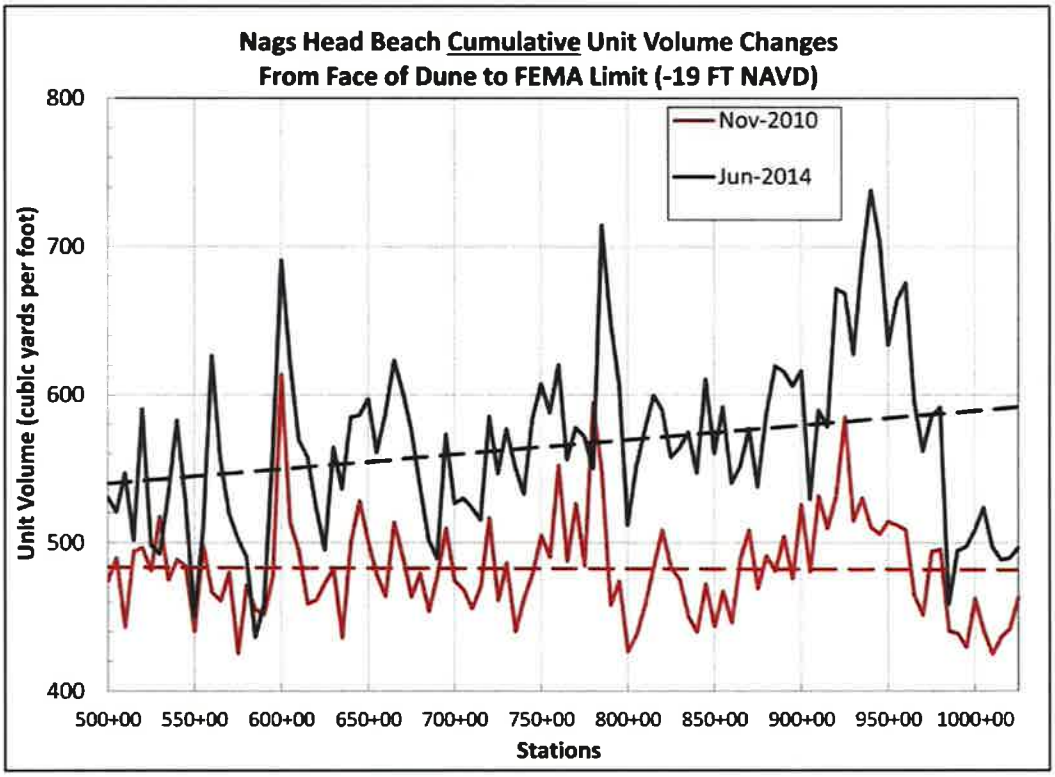

FIGURE C. Comparison of cumulative unit volumes by station between the face of dune and -19 ft NAVD.

Dune Encroachment and Management Plan (Section 7.0)

Dune encroachment worsened along numerous properties between June 2013 and June 2014. Encroachment on structures was particularly significant where there were no significant dune, sand fencing, or vegetation fronting the structure. Many of the properties experiencing excessive buildup are positioned at or some distance seaward of the "stable vegetation line" which is intermittent along some parts of Nags Head. The nourishment permit was modified by NCDCM to allow certain removal of sand under four levels of encroachment (Section 7.1).

CSE evaluated the pre-project and post-project dune growth as well as the mechanics of dune formation for purposes of developing rational criteria for dune management. Prior to nourishment, the dunes were losing ~1 cubic yard per foot per year (cy/ft/yr) from 1994 to 2010. Since nourishment, the dunes have gained an average of 4.7 cy/ft/yr, which is a much higher-than-normal accretion. Post-nourishment growth rates at Nags Head reflect strong winds plus a much wider dry beach which feeds the dunes. Over time, the rate of dune growth will diminish as the beach narrows.

The recommended strategy for dune enhancement and mitigation of encroachment is sand fencing and vegetation as illustrated conceptually for three categories of properties (Fig D):

Category 1 – Structures positioned landward of the stable vegetation line. Place sand fencing close to the stable vegetation line, and re-vegetate bare areas. Category 1 applicable to a majority of Nags Head properties.

Category 2 – Structures positioned close to the stable vegetation line (or projection of the line from adjacent properties). If the berm is at least ~75 ft wide, place fencing ~25 ft seaward of the structure and promote dune buildup via fencing and vegetation.

Category 3 – Structures positioned seaward of the stable vegetation line. These structures generally should not install sand fences on the seaward side unless there is at least 75 ft of dry-sand beach seaward of the structure.

Details of the plan and some practical criteria for guidance are given in Section 7.

Upcoast and Downcoast Changes (Section 8.0)

Surveys along the upcoast and downcoast reaches extended about 1 mile in either direction from the project area. Profiles are plotted in Appendix 4, and volume changes are discussed in Section 8.0 and listed in Appendices 5 and 6.

The June 2014 results show minor losses compared with 2013 but a continued gain north of the project (upcoast) in all lenses. The majority of the gain is underwater with a net gain of ~230,000 cy to the −19-ft contour relative to the November 2010 condition, which is consistent with the accretion trend observed in the project area.

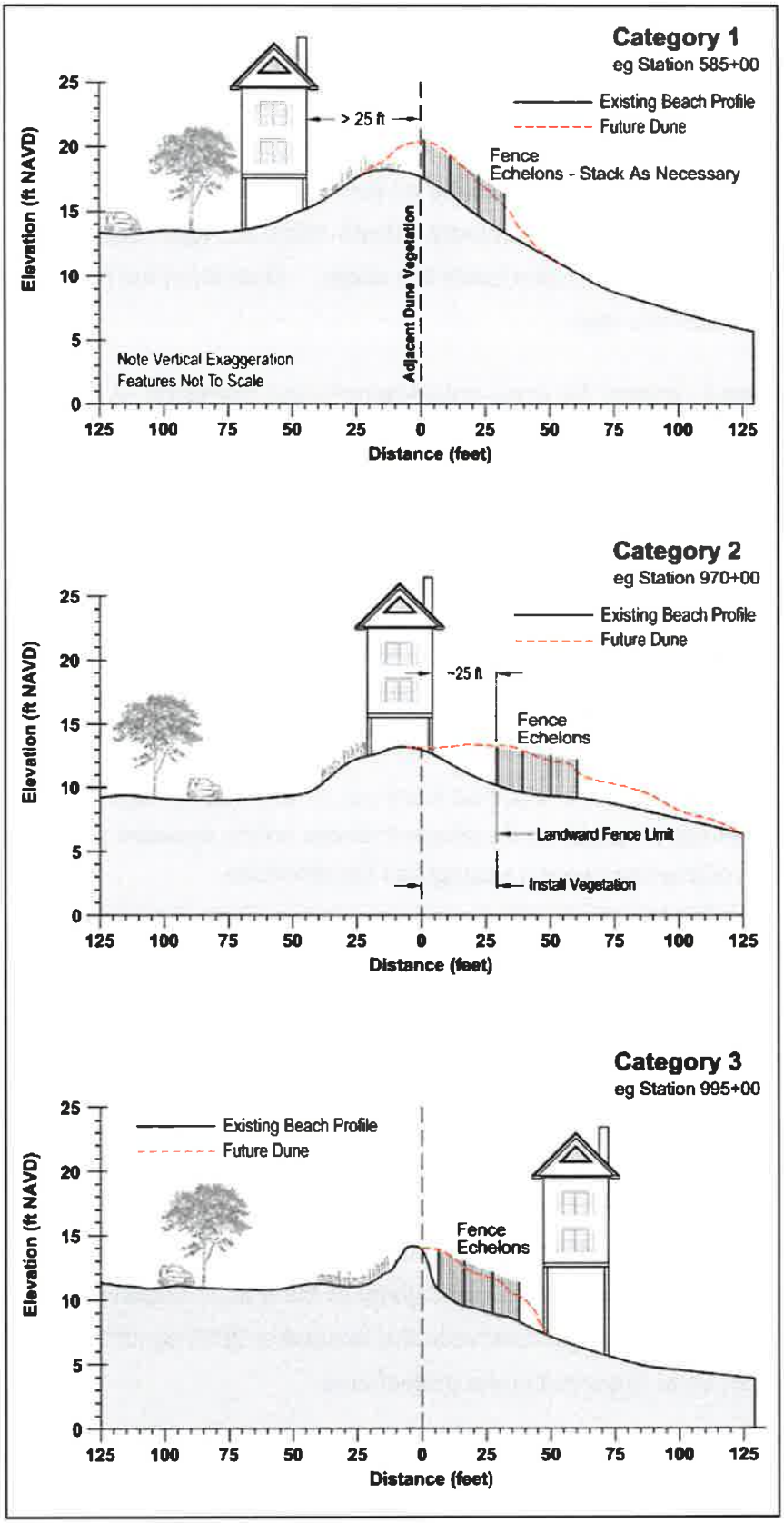

FIGURE D. General plan for dune enhancement to minimize encroachment along Nags Head for three categories of properties. The distances reference the stable vegetation line projected from adjacent properties.

The ~1-mile-long downcoast reach lost sand in all lenses over the past year except for the lens between the face of dune to the +6-ft contour (ie – continued dune accretion). This indicates an erosional trend during the past winter. Nevertheless, the downcoast reach contained over 170,000 cy more sand measured to −19 ft in June 2014 relative to November 2010 conditions.

Nourishment Profile Adjustment, Seasonal Variation of Dry Beach Width, and Movement of Erosion Hot Spots

The majority (~94 percent) of the 2011 nourishment sand volume was initially placed between +6 ft NAVD and −6 ft NAVD (low-tide wading depth). It is a common practice in beach nourishment to place the majority of the sand above low-tide wading depth for construction convenience. Nourishment sand will then shift underwater by wave action, and the newly constructed beach will be gradually reshaped toward its equilibrium profile. Over the 2.6 years since project completion, there have been Hurricanes *Irene* (27 August 2011) and *Sandy* (28 October 2012), and numerous other winter storms. These extreme conditions accelerated the profile adjustment, and the nourished beach quickly reached equilibrium with profiles responding seasonally to changing waves just as a natural beach.

As of June 2014, ~58 percent of the nourishment sand remains above low-tide wading depth, and the balance of nourishment volume has shifted underwater as far as the −19-ft NAVD contour (FEMA reference depth limit). The ratio between the volume in the subaerial beach and volume underwater is similar to other projects. In all cases, there is some portion of nourishment that must shift seaward to create a stable profile.

One important volume change relative to the pre-project condition is that Nags Head has accumulated over 1 million cy more sand in the upper beach and dune areas between the face of dune and +6 ft NAVD, resulting in higher and wider dunes that protect oceanfront properties during major storms. Seaward dune growth combined with expanded vegetation reduces the apparent width of the dry-sand beach compared with initial post-project conditions. In spite of different perspectives, as of June 2014, the Town still has an average of ~65 ft of dry beach between the toe of dune and the edge of dry sand (ie – between +10 ft and +5 ft NAVD), compared to an average of ~46 ft of dry beach before nourishment in November 2010.

As readily observed, the summer beach tends to have a wide, well-developed berm with a vegetated dune while the winter beach has a lower, flatter, and narrower berm with signs of beach grass loss. In the late spring and early summer months, smaller, calmer waves dominate, and sand slowly returns to the dry-sand beach. Once on the dry beach, the sand

grains become more mobile and are moved by wind action to form higher, wider sand dunes. During the fall and winter months, winds and waves change directions and wave heights increase, resulting in beach berms and dunes eroding as sand is pulled offshore from the upper portions of the beach and deposited in protective offshore sandbars. For a setting like Nags Head, the seasonal variation of beach width can be around 50 ft.

As the beach width varies from season to season, it varies from place to place as well. Identifying possible "erosion hot spots" is one of the purposes of annual monitoring efforts. After the first three-year beach condition surveys and additional site visits, CSE noticed that erosion hot spots in one survey or in one time were generally not persistent for other surveys or other times. When the beach develops "rhythmic" topography, some areas located at the "trough" appear narrower than the adjacent beach. Since the overall beach condition was much healthier in June 2014 than the pre-nourishment condition, scattered erosion hot spots are not an immediate concern and are expected to recover naturally as "sand waves" propagate alongshore under littoral processes.

Other Recommendations

The June 2014 survey and aerial photography depict variable conditions within each reach with developing hot spots in some areas. As time passes, the areas with localized erosion are expected to shift as sand moves in "packages" alongshore, creating salients and broad erosional arcs. In addition to localized hot spots, CSE expects to see "end losses" at south Nags Head propagating north. By fall 2014, some sections within ~0.5 mile of the project limit were exhibiting accelerated erosion compared with conditions in June. CSE recommends additional monitoring of south Nags Head where the worst losses are expected. An extra semi-annual survey along Reach 2, Reach 3, and Reach 4 would help identify problem areas and indicate whether any remedial measures should be considered.

ACKNOWLEDGMENTS

The Year 3 monitoring was funded by the Town of Nags Head under its budget for beach nourishment and monitoring. CSE thanks the Nags Head Board of Commissioners and the Town staff (c/o Cliff Ogburn, Town Manager, and David Ryan, Project Coordinator) for their continued support. CSE thanks the Public Information Officer (c/o Roberta Thuman), the Nags Head Public Works Department (c/o Ralph Barile) and the Nags Head Police Department (c/o Kevin Brinkley) for their assistance during our surveys.

Field data collection and analysis were directed by Dr. Haiqing Liu Kaczkowski (PE, NC 37281 — project engineer) with assistance by Drew Giles, Steven Traynum, Trey Hair, and Luke Fleniken. The report was written by Dr. Kaczkowski and Dr. Tim Kana (PG, NC 1752) with assistance by Steven Traynum, Trey Hair, and Diana Sangster. Photos were taken by Kaczkowski unless otherwise specified in the report.

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