



August 8, 2016

MEMORANDUM

TO: Cliff Ogburn, Town of Nags Head (NC)

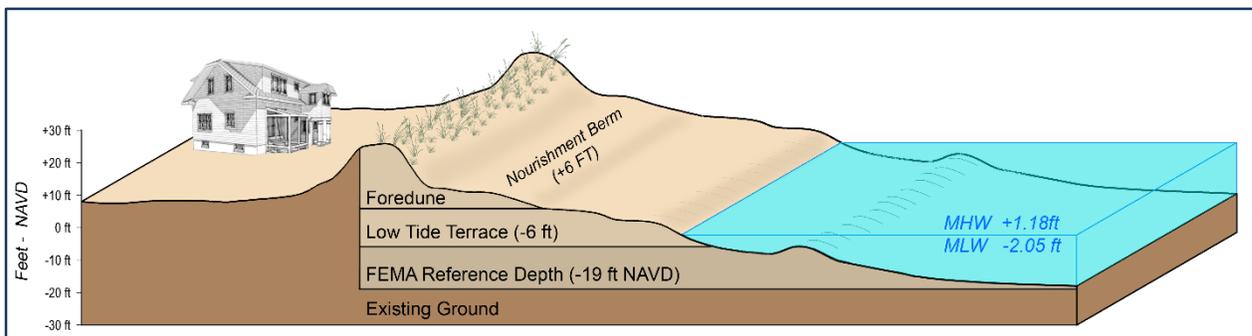
FROM: HL Kaczowski, Project Engineer
TW Kana, Project Director

RE: Nags Head Post-Project Monitoring [CSE 2387–Year 5]
Annual Beach Condition Survey – June 2015 – Preliminary Results

This memorandum offers preliminary results of CSE’s June 2016 condition survey of Nags Head. We measured profiles at 500 feet (ft) spacing between the foredune and deep water at the same stations used before and after nourishment. The June 2016 profiles are compared with corresponding profiles obtained in November 2010 (pre–project), November 2011 (post–construction), June 2012 (Year 1 post–project and before 2012 hurricane season), November 2012 (Year 1 post–project and after Hurricane *Sandy*), June 2013 (Year 2 post–project), June 2014 (Year 3 post–project), and June 2015 (Year 4 post–project). Each survey provides a measure of the total volume of sand contained within the Nags Head littoral zone out to a depth of the FEMA reference limit at 19 ft NAVD. Similar to prior reports, we have computed the volume of sand contained between the foredune and three reference depth contours as below.

- Lens 1 – Foredune – From the face of dune to +6 ft NAVD
- Lens 2 – Beach – Between +6 ft and -6 ft NAVD
- Lens 3 – Underwater – Between -6 ft and -19 ft NAVD

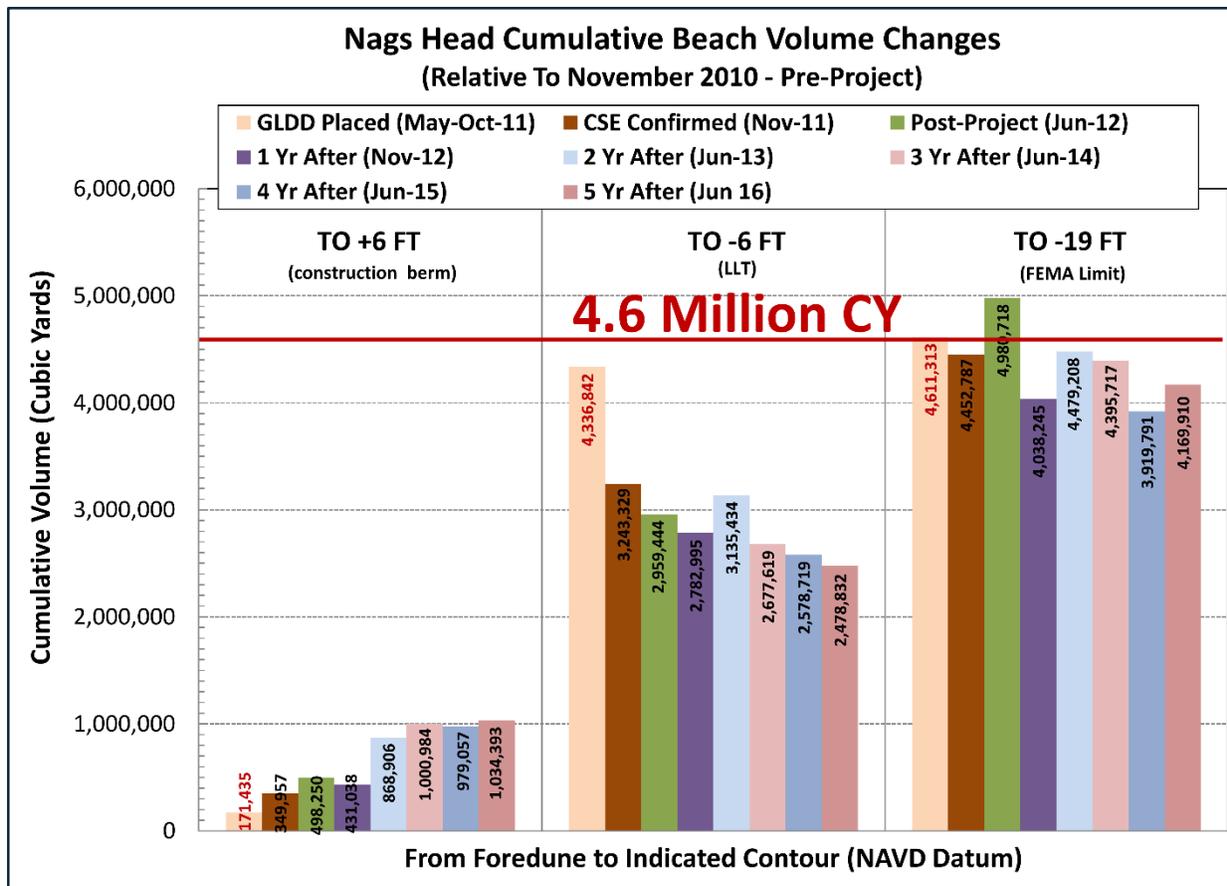
Illustration of these three lenses used in the volume analysis is shown in Figure A.



Graph A. Illustration of the three lenses used in the profile volume analysis for Nags Head.

We have also subdivided the shoreline by the same project reaches used in the original design. We use the volumes from November 2010 as the baseline condition (pre-nourishment) and subtract them from the results of subsequent surveys. This yields the change in beach volume with respect to conditions prior to nourishment.

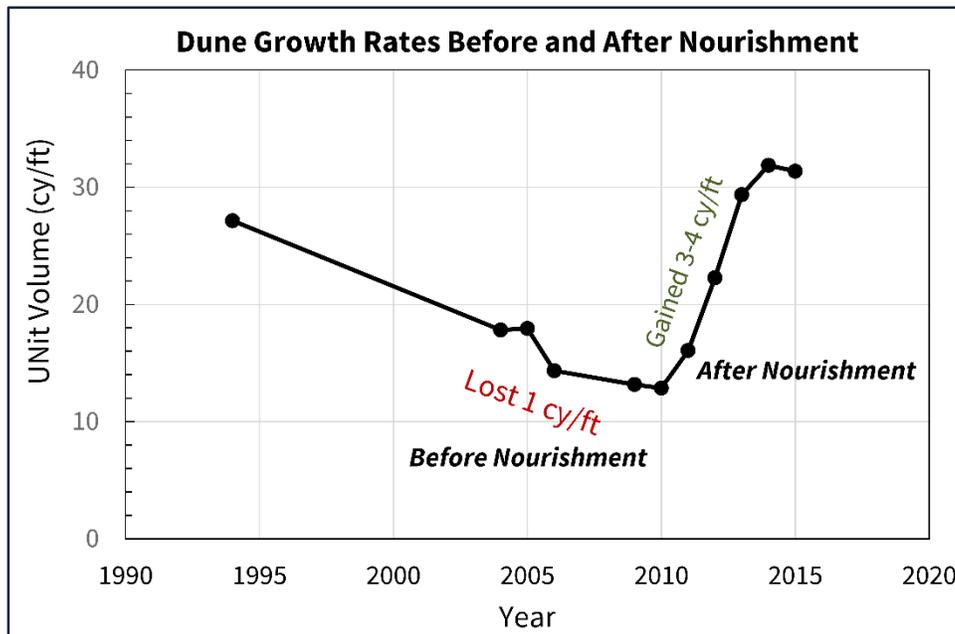
Graph B provides overall results for the project area relative to November 2010. The first set of bars represent net volume changes in foredune (ie – Lens 1), the second set of bars represent net volume changes along foredune and beach (ie – Lenses 1&2), and the third set of bars represent net volume changes from foredune to beach and underwater (ie – the “sand box” or Lenses 1, 2 and 3).



Graph B. Cumulative overall volume changes relative to November 2010 (pre-project) survey results between the foredune and indicated contours.

Foredune (Lens 1)

As of June 2016, the back beach and dune areas (the first set of bars in Graph B) have accumulated over 1 million cy more sand than the condition before nourishment. This is equivalent to a gain of ~19 cy per foot (cy/ft) or ~4 cy/ft per year (cy/ft/yr) above +6 ft NAVD (nourishment berm elevation). Such gain is considered significant for Nags Head because before nourishment between 1994 and 2010 Nags Head experienced sand loss averaging ~ 1 cy/ft/yr in this portion of beach, as shown in Graph C.



Graph C. Dune growth/loss rates before and after nourishment.

Foredune and Beach (Lenses 1&2)

The second set of bars in Graph B show the total volume changes from the face of the dune to low-tide wading depth (-6 ft NAVD). After the initial sand adjustment occurred in the first year since project completion, the beach volume has been relatively stable over the past three years. The June 2016 survey shows over 50% of nourishment sand remains in the foredune and the beach.

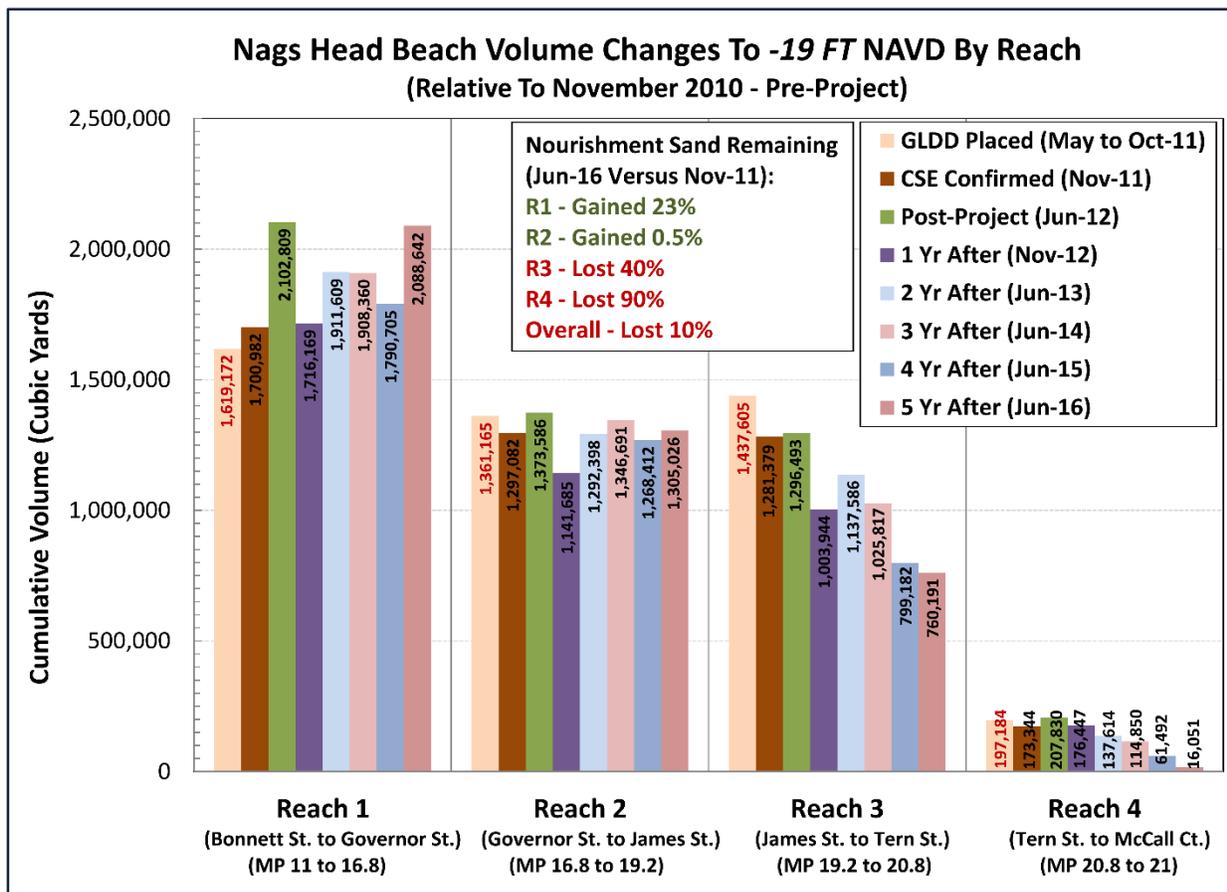
Foredune, Beach and Underwater (Lenses 1, 2&3)

The third set of bars in Graph B show the cumulative volume change from the face of the dune to -19 ft (FEMA limit). The June 2016 results indicate that ~10% of the nourishment sand has shifted away from the “sand box” due to the chronic erosion at Nags Head, resulting in an average loss of ~90,000 cy/yr (0.3

cy/ft/yr) since project completion. This average erosion rate is much lower than the 275,000 cy/yr (5.2 cy/ft/yr) historical erosion rate (1994 – 2005) adopted in the 2011 project formulation.

Volume Changes by Reach

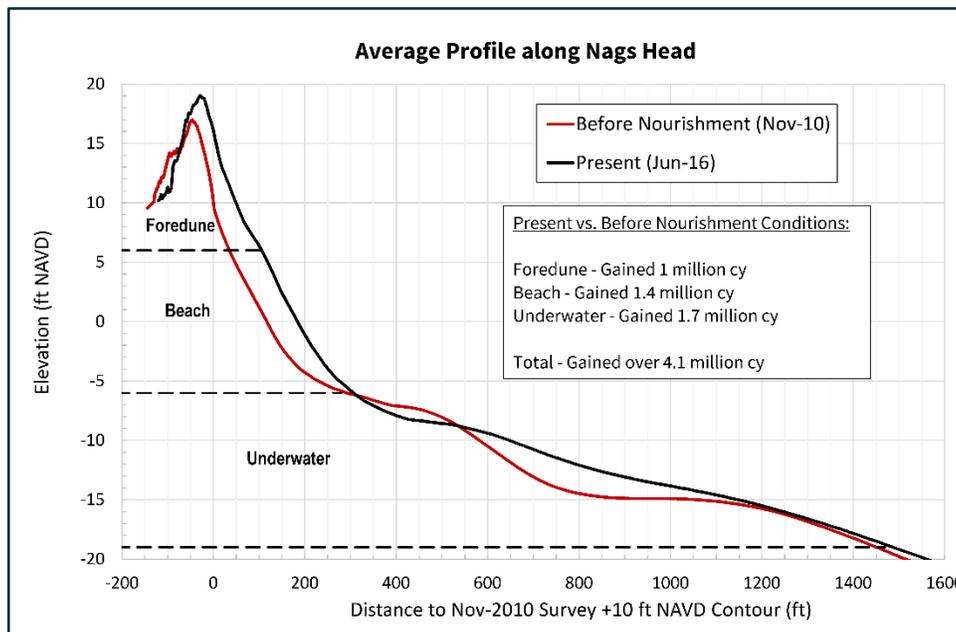
Graph D provides comparisons of volumes remaining by reach relative to the November 2010 pre-project condition. It shows that Reach 1 (northern half of the project) has gained over 380,000 cy and Reach 2 (middle to southern ~2.5 miles of project area) has remained stable (almost no gain and no loss) between the foredune and -19 ft contour. Reaches 3 and 4, representing the southern most ~2 miles of the project area, have lost ~680,000 cy since November 2011. The annual loss rate for Reaches 3 and 4 since November 2011 has been ~13 cy/ft/yr which is significantly higher than the overall project area but consistent with CSE’s design estimates for the reach.



Graph D. Volume changes by reach relative to November 2010 (pre-project) survey results between the foredune and -19 ft NAVD.

Average Profile Before Nourishment and at Present Condition

At each survey, CSE collects 106 profiles within the 10-mile project area. Each profile represents the unique condition of that location, and varies from place to place. To simplify the profile analysis, we juxtaposed all profiles and averaged them along Nags Head. The average profile represents the overall condition of the entire beach at the time of the survey. Graph E shows the average profiles before nourishment (Nov 2010) and at June 2016. The significant elevation difference in the foredune area illustrates dunes are 2-ft taller and 40-ft wider today than before nourishment, equivalent to over 1 million cy of sand gain in this portion of beach (refer to Graph B). It can also be seen from the graph that the beach has shifted seaward by ~70-ft, and the underwater portion has more volume today than 2010.



Graph E. Average profiles for Nags Head before and after nourishment.

In conclusion, the total volume remaining after nourishment to -19 ft NAVD (FEMA-reference limit) in June 2016 is ~4.17 million cy (~90% of the project volume) along the 10-mile Nags Head beach. The results to date indicate the project is performing well, and the erosion gradient from the north to the south is consistent with the historical trend.

The average profile method eliminates profile variations from location to location, and makes it easier to compare beach conditions between various dates. This will help us develop a target beach condition for the 2018 renourishment project.

Please contact us if you have any questions about these preliminary results. Survey methodology and data analysis results will be discussed in more detail in the final monitoring report. The full report is expected to be delivered to the Town for review before the end of September 2016.