

## VI. SUMMARY AND RECOMMENDATIONS

This monitoring report evaluated shoreline and volume changes along the 5.9 mile shoreline of the Town of Duck and the adjacent shorelines north and south. Data collected in December 2017 was used to update shoreline and volume change analyses conducted during the feasibility study (CPE-NC 2013) and the design analysis associated with the beach nourishment project (CPE-NC 2015). Both the shoreline and volume change results were influenced by the beach fill project constructed in June 2017, which placed 1,263,181 cy of material along the beach between station D-10 and D-19.

**Shoreline Change Analysis:** Shoreline change analysis examined the change in the MHW line (+1.2 ft. NAVD contour) between May 2015 and December 2017 and compared those changes with those measured between September 2013 and May 2015 and October 1996 and December 2017. In general, the average shoreline change rates were positive from May 2015 to December 2017 and are primarily attributed to the beach nourishment project completed in June 2017. The average shoreline change rate measured within the monitoring area (Stations PI-17 to SS-02) between 2015 and 2017 was an advance at 13.5 feet per year. Within the project area (D-10 to D-19) the advance of the shoreline was equivalent to 44.0 feet per year. The shoreline changes within the monitoring area range from an advance of 12.8 ft./yr. between Stations D-05 and D-08 (south end of Station Bay Dr. to Waxwing Ct.) to a recession of -19.6 ft./yr. between Stations D-23 and D-24 which lies between the southern portion of the USACE Field Research Facility and Ship Watch Drive.

A review of the long-term changes show the average shoreline change rate measured within the monitoring area between 1996 and 2017 was +1.2 feet per year. This advance rate measured between 1996 and 2017 is a deviation from the trend of recession observed when comparing the measured long-term rates from 1996 to 2011, 1996 to 2012, 1996 to 2013, and 1996 to 2015, which were -0.6 ft./yr., -1.4 ft./yr., -0.3 ft./yr., and -0.5 ft./yr. respectively. This reversal is driven by the construction of the beach fill project between Stations D-10 and D-19 in June 2017.

**Volume Change Analysis:** Volumetric changes discussed in this report represent the change in the quantity of sediment measured through comparison of the beach profile survey data between the recent changes computed between May 2015 and December 2017 and the long-term changes measured between September 2013 and December 2017.

The total volumetric change measured between May 2015 and December 2017 above the -24.0 ft. NAVD contour within the monitoring area (Stations PI-17 to SS-02) was a gain of 1,343,100 cubic yards. This translates into an average volume change rate of 14.7 cy/ft./yr. (accretion) throughout the monitoring area. The volume change within the project area (Stations D-10 to D-19) over the same 2.6-year period, was a gain of approximately 1,039,200 cubic yards. Although the overall average rates were predominantly positive throughout the monitoring area, the analysis identified

several profiles with high rates of erosion. The highest erosion rates were measured at Stations D-09 (-19.3 cy/ft./yr.), D-23 (-41.3 cy/ft./yr.), D-24 (-24.8 cy/ft./yr.) and D-30 (-50.2 ft./yr.).

The long-term volumetric change measured between September 2013 and December 2017 within the monitoring area (PI-17 to SS-02) was a gain of 947,000 cubic yards, or 222,900 cubic yards per year above the -24.0 ft. NAVD contour. The long-term changes over the 4.3-year period within the project area (D-10 to D-19) measured a volumetric gain of approximately 1,027,100 cubic yards, which is equivalent to 241,600 cubic yards per year.

In 2015, the analysis of the beach profile monitoring data identified two (2) primary areas of erosion between Stations PI-17 and D-11 (-25.6 cy/ft./yr.) and Stations D-25 and SS-01 (-9.9 cy/ft./yr.). The recent changes showed those areas experienced volumetric gains from May 2015 to December 2017 with measured average annual change rates of 13.7 cy/ft./yr. (accretion) from Station PI-17 to D-11 and 5.7 cy/ft./yr. (accretion) from D-25 to SS-01. The area in the vicinity of Profile D-30 (Lala Ct.) was an exception to the accretion that occurred between D-25 and SS-01. Volume change analysis showed a rate of erosion of -50.2 cy/ft./yr. for profile D-30. This anomaly is most likely temporary and may have resulted from a natural redistribution of the accreted material to adjacent portions of the beach or possibly due to the influence of offshore topographic features.

The previous Town-wide monitoring report (CPE-NC, 2016) updated the SBEACH storm vulnerability analysis based on the May 2015 beach profile survey data. The 2015 analysis identified the beach areas between Stations D-9 to D-11 (Pelican Way to Ocean Pines Dr.) and D-25 to D-29 (Sea Colony Dr. to Ocean Front Dr.) as having experienced an increase in the number of vulnerable structures. The recent changes computed between May 2015 and December 2017 show the D-9 to D-11 shoreline advanced seaward at 18.6 ft./yr. and gained approximately 212,700 cubic yards, equivalent to an average volume change rate of 30 cy/ft./yr. (accretion). The recent changes are a reversal from the -0.9 ft./yr. average shoreline recession rate and -29.8 cy/ft./yr. average volume change rate measured between 2013 and 2015. These changes are primarily attributed to the recent beach fill project. For the area between D-25 and D-29, recent changes show a seaward advance of the shoreline at a rate of 1.4 ft./yr. and experienced an approximate gain of 180,300 cubic yards, equivalent to an average volume change rate of 14.3 cy/ft./yr. (accretion) between May 2015 and December 2017. These positive changes are not directly attributed to the recent beach fill project. While the SBEACH vulnerability analysis was not updated for this report, the positive changes observed in these two areas has likely reduced the number of vulnerable structures previously identified.

The two areas north and south of the project area described above as having the highest erosion rates in 2015 (Stations PI-17 to D-11 and D-25 to SS-01), should continue to be monitored to determine if the recent accretion measured in those areas between May 2015 and December 2017 continues to persist. The volume changes and overall accretion measured within the monitoring area (14.7 cy/ft./yr.) and the project area (46.2 cy/ft./yr.) between May 2015 and December 2017 are primarily attributed to the construction of the beach nourishment project that was completed in June 2017. The recent high rates of accretion are expected to moderate over time as the beach continues to adjust to a more equilibrated state. Changes within the project area are anticipated to

continue to slow (or maintain the long-term trend) as the equilibrium is achieved and the changes begin to align with historic change rates. The long-term volume changes for the monitoring area (6.6 cy/ft./yr.) and project area (26.7 cy/ft./yr.) computed from September 2013 to December 2017 are higher than the rate of change factored into the design of the beach fill project (-2.5 cy/ft./yr.). Variations of this magnitude are to be expected as the project design change rate was measured over the longer term of approximately 15 years (1996 and 2011) while the volume changes in this analysis were measured over spans of 2.6 and 4.3 years.

APTIM recommends the Town continue to monitor the entire Town oceanfront shoreline in order to assess if the trends measured in the volume change analysis persist in those regions identified. This monitoring will be instrumental for the Town to evaluate future areas of concerns and to develop successful shoreline management strategies to deal with issues as they arise. The monitoring program will also provide valuable information on the performance of the 2017 beach fill project and aid in the determination as to when additional nourishment is needed in the project area. The measured performance of the beach fill will also serve as a valuable tool to aid in the development and design of future beach nourishment projects the Town may consider.