

VI. DISCUSSION


This monitoring report evaluated shoreline and volumetric changes along the portions of shoreline nourished in 2017 within the Town of Duck as well as portions of the adjacent shorelines to the north and south. The monitoring area extends south from station D-01, located at the northern limits of the Town of Duck, to station D-34, located near the Town of Duck town limits with the Town of Southern Shores. With the construction of the beach nourishment project in June 2017, the monitoring area was divided into three sections, namely, the Project Area (D-10 to D-19), the Area North of the Project (D-01 to D-10), and the Area South of the Project (D-19 to D-34). Data collected in April 2021 was used to evaluate shoreline and volumetric changes that have occurred since the baseline survey was conducted in September 2013, since the construction of the 2017 beach nourishment project, and over the past year between the 2020 and 2021 monitoring surveys.

Shoreline Change Analysis

Project Area. Surveys conducted in April 2017 and December 2017 indicated that the beach fill effectively relocated the +6.0 ft. NAVD88 contour an average of +89.5 feet seaward (from D-10 to D-18). D-19 was not surveyed during the April 2017 pre-construction survey and therefore, is not included in the project average. The construction of the project resulted in a seaward movement of the +6.0 ft. NAVD88 contour of 183 feet on average; however, between the project completion in June 2017 and the post-construction survey conducted in December 2017, the project experienced considerable equilibration and therefore the December 2017 +6.0 ft. NAVD88 design contour is assumed to be equilibrated. The average shoreline change measured within the Project Area from December 2017 to April 2021 from D-10 to D-18 was -70.5 ft.

Figure 7 shows that in some areas, particularly along the northern part of the project from 140 Skimmer Way (D-10) to Sound Sea Ave. (D-12) the current +6.0 ft. NAVD88 contour is landward of the pre-project (April 2017) location of the +6.0 ft. NAVD88 contour. Along the southern portion of the project, where the pre-project condition was most severely eroded, the +6.0 ft. NAVD88 contour is still seaward of the pre-project condition. The average shoreline change rate along the Project Area measured between December 2017 and April 2021 was -17.7 ft./yr. However, over the 10-month period between June 2020 and April 2021 the rate was +18.8 ft./yr. (seaward movement).

The average position of the +6.0 ft. NAVD88 contour is 19.6 ft. seaward of the September 2013 baseline survey as of April 2021. In comparison, the average MHW shoreline position is 22.8 ft. seaward of the September 2013 baseline position suggesting the beach slope is almost the same as it was in September 2013. In the 2020 monitoring report, a similar comparison of the +6.0 ft. NAVD88 and MHW contour indicated a much less steep profile than the baseline condition (CPE, 2020). The steepness of the beach is influenced by wave conditions preceding the observations and the grain size of the sand. In the 2020 monitoring report, the discrepancy between the average slope measured in 2013 and the average slope observed in June 2020 was suggested to be associated with grain size. When the beach fill project was constructed, the material used to construct the southern 2,500 feet of the project (south of approximately D-16) came from a combination of sand from Borrow Area A and C at a ratio of 2 loads from Borrow Area A for every 1 load from Borrow Area C; whereas the material used to construct the rest of the project to the north all came from Borrow Area C. The mean grain sizes of the sand in Borrow Areas A and C were determined to have an average mean grain size of 0.36 mm and 0.26 mm, respectively (CPE-NC, 2015B). The fact that Borrow Area C was known to be finer than Borrow Area A and finer than the native beach led to the directive that additional sand was required to be placed along sections constructed with sand from Borrow Area C alone. Samples taken along the beach following construction of the project showed the average mean grain size of the samples collected in areas constructed with material from Borrow Area A had a mean grain size of approximately 0.39 mm, compared to the mean grain size of samples collected



along the portion of the project constructed with material from Borrow Area C, which had a mean grain size of 0.29 mm.

While placement of finer material may have contributed to a shallower beach slope, the fact that the 2021 beach profile data indicates an average beach slope similar to the September 2013 baseline conditions may be indicative of sediment mixing to form a similar average grain size over time and/or the result of coincidental wave conditions preceding the observations. The fill for the 2022 project will all be dredged from Borrow Area A only. Future monitoring of the project following the 2022 project should evaluate whether the slope along the beach is more consistent than what has been observed between the construction of the 2017 project and the April 2021 monitoring.

Area North of Project. The average long-term shoreline changes computed along the Area North of the Project (D-01 to D-10), was 1.1 ft (seaward movement), between September 2013 and April 2021. This time period includes the construction of the beach nourishment project. This is equivalent to a rate of +0.1 ft./yr. The average rate between D-01, located near the northern Town Boundary and D-05, located at S Station Bay Dr, was 0.6 ft./yr. (seaward movement); whereas the average long-term shoreline change from S Station Bar Dr south to the Project Area (D-05 to D-10) was a negative -0.3 ft./yr. (landward movement). In summary, the shoreline has remained essentially stable along the portion of the Town north of the project since September 2013.

Recent surveys (June 2020 and April 2021) indicate an overall average change in the +6.0 ft. NAVD88 contour of +7.5 ft. (seaward movement). However, there is a clear distinction between the trend directly north of the project from D-10 to D-04, located at the Sanderling Resort, and the portion of the Town's beach north of the Sanderling Resort. The average change in the +6.0 ft. NAVD88 contour position from D-10 to D-04 was -1.3 ft. (landward movement), whereas, from D-04 to D-01 the average change was +26.7 ft. (seaward movement).

Area South of Project. Long-term shoreline changes computed along the Area South of the Project (D-19 to D-34), was -12.0 ft (landward movement), between September 2013 and April 2021. This time period includes the construction of the beach nourishment project. This is equivalent to a rate of -1.6 ft./yr. It should be noted that the portion of the beach located between the northern boundary of the USACE FRF and 1,000 ft. north of the USACE FRF pier (stations D-19 and D-21) experienced a positive trend of seaward movement, with an average shoreline change of +28.1 ft., or a rate of +3.7 ft./yr.. Between stations D-23 (approximately 500 feet north of the southern boundary of the FRF property) and D-29 (located along Ocean Way), the average shoreline change rate was approximately -4.0 ft./yr. between September 2013 and April 2021. South of D-29 to D-34 (southern Town boundary), the average shoreline change rate over the same time period was -1.6 ft./yr.

Recent surveys (June 2020 and April 2021) indicate an overall average change in the +6.0 ft. NAVD88 contour of -3.7 ft. However, there is a clear distinction between the trend directly south of the project from the northern boundary of the USACE FRF property (D-19) to approximately 600 ft. south of USACE FRF pier (D-22), and the trend from approximately 600 ft. south of USACE FRF pier (D-22) south to the Town southern boundary (D-34). In the area directly south of the project, the average change was +34.6 ft. over the approximate 10-month period from June 2020 to April 2021. In contrast, the average shoreline change measured from 600 ft. south of USACE FRF pier to the Town southern boundary was -14.2 ft. Within this area, the +6.0 ft. NAVD88 contour between the end of Plover Dr (D-31) and Bias Ln. E. (D-33) experienced a landward movement of -30.9 ft. on average.

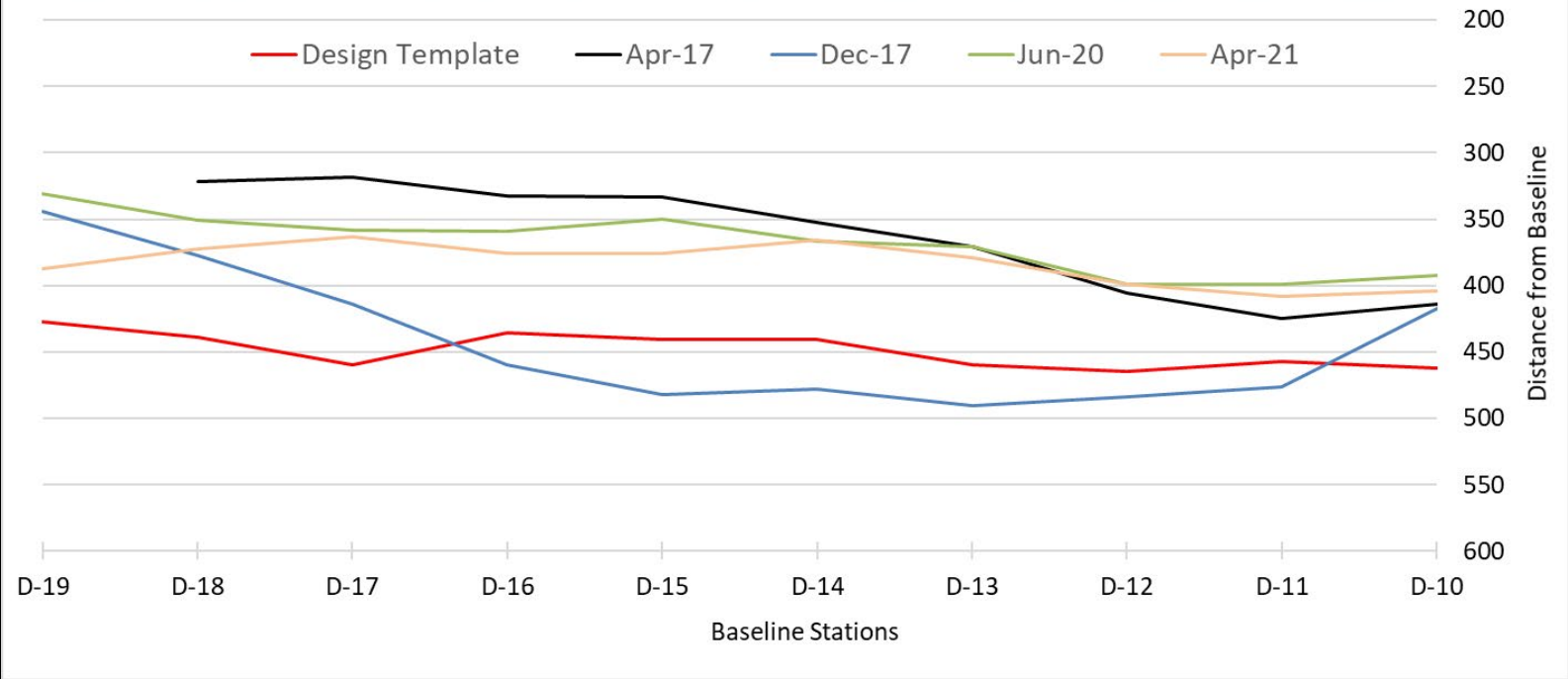


Figure 7. +6.0 ft. NAVD88 Contour Position throughout the Project Area compared to the +6.0 ft. NAVD88 Contour for the Project Design

Volumetric Change Analysis

Project Area. Beach profile surveys indicate that during the most recent survey interval (June 2020 to April 2021), a volumetric loss of approximately 178,000 cubic yards was measured. The highest losses occurred between Sound Sea Ave. and Pintail Dr. (D-13 to D-16). Since the completion of Town of Duck beach nourishment project, the Project Area has lost a total of approximately 450,000 cubic yards (December 2017 to April 2021). This equates to approximately 47% of the fill measured in the Project Area in December 2017. As of April 2021, the analysis indicates that the Town of Duck beach nourishment project had 53% of the initial fill volume remaining as measured above the -24-foot NAVD88 contour in December 2017.

As discussed in the Shoreline Change portion of this Section, the +6.0 ft. NAVD88 contour position at every profile within the project area is landward of the designed berm position. In other words, in terms of the design berm, the project has eroded back into the project design at the berm elevation. In fact, on average, the +6.0 ft. NAVD88 contour is approximately 65.4 ft. landward of where it was designed to be between D-10 and D-19. That said, as mentioned above, approximately 53% of the material placed along the Project Area as measured in December 2017 is still located within the Project Area. This suggests that a considerable amount of sand is being stored in the offshore portion of the profile.

Area North of Project. Since the project was constructed, the average volumetric change in the Area North of the Project was +5.5 cy/ft./yr. The long-term average volumetric change rate measured between September 2013 and April 2021, was +0.7 cy/ft./yr. The trend observed since the project was constructed is higher than the long-term average of +0.7 cy/ft./yr. This may be in part due to the spreading of material from the project to the Area North of the Project. However, the volumetric change rate North of the Project is slightly lower than the rate documented in the 2020 Monitoring report due to recent negative volumetric change measured between June 2020 to April 2021. The average volumetric change along this area over that 10-month period was -2.4 cy/ft. or -2.9 cy/ft./yr.

Area South of Project. Since the project was constructed (Dec. 2017 to April 2021), the average volumetric change south of the Project Area was -3.6 cy/ft./yr. The long-term average volumetric change rate in the area south of the project, measured between September 2013 and April 2021, was -0.1 cy/ft./yr. The negative volumetric trend observed since the project was constructed is greater than the long-term average of -0.1 cy/ft./yr. However, this is a reversal of the post-project volumetric change rate reported along the Area South of the Project between December 2017 and June 2020 (+3.5 cy/ft./yr.) (CPE, 2020). The reversal in the post-project trend is due to significant negative volumetric changes measured between June 2020 and April 2021, which can be seen in Figure 5. The average volumetric change along this area over that 10-month period was -20.7 cy/ft. or -24.9 cy/ft./yr.

In June 2018, an anomalous wide and deep trough was identified just offshore at station D-21. The volumetric change measured at station D-21 between December 2017 and June 2018 was a negative 55.4 cy/ft. Between June 2018 and May 2019, a positive volumetric change of 36.9 cy/ft. was measured along D-21; however, the net volumetric change that occurred between December 2017 and May 2019 was still negative. Most recently, between June 2020 and April 2021, a negative volumetric change of -7.9 cy/ft. was measured along D-21, bringing the net volumetric change measured since December 2017 at station D-21 to a +12.5 cy/ft. This is significant, because the development of the anomalous trough offshore of D-21 shortly after the construction of the project may have obscured the volumetric gains experienced along the area directly south of the project related to the spreading of the beach fill.



VII. RECOMMENDATIONS

CPE recommends the Town continue to monitor the beach along the entire Town oceanfront in order to assess long-term shoreline and volumetric changes. That said, with the re-nourishment scheduled for 2022, pre-construction surveys will be collected by the dredge contractor, which can serve as the year 5 monitoring surveys for the Project Area. Furthermore, as part of the construction contract, the dredge contractor will conduct a post-construction survey within 2 weeks of completion of beach fill placement, which will serve as the new baseline conditions for the Duck beach nourishment project. As part of the project completion report for the construction project, CPE will provide updated volumetric changes within the project area based on a comparison of the December 2017 and Pre-Construction surveys conducted by the dredge contractor. These rates will be used in the planning of the 2027 maintenance event. Following construction of the beach project in 2022, the continued annual monitoring of the project provides not only a pre-storm condition survey that can be used to estimate storm damages, as was the case following the impact of Hurricane Dorian, but also the continued assessment of volume trends, which will also be used in the planning of future maintenance events.

Outside the Project Area, continued monitoring is instrumental for the Town to evaluate future areas of concerns and longshore transport trends, and to develop successful shoreline management strategies to deal with issues as they arise. In that regard, post-construction surveys, which will be conducted by the dredge contractor within 2-weeks following the 2022 project, will include the Area North and Area South of the Project. Data collected in April 2021 indicate that since construction of the project in 2017, the volumetric trend along the Town's beaches in the Area North of the Project has been positive change (accretion). It is not uncommon to see positive volumetric changes adjacent to a beach nourishment project due to the spreading of material that serves to feed the adjacent beaches.

In contrast, the Area South of the Project has experienced a negative volumetric change trend (erosion) since December 2017. Continued monitoring of the areas outside the Project Area is vital to achieving the Town's goal of providing a reasonable level of storm damage reduction to public and private development. In that regard, CPE recommends that given the continued trend of erosion along the Area South of the Project, that the storm vulnerability analysis, last conducted in 2019, be updated using the 2022 monitoring data to be collected following construction of the beach nourishment project. The results of the analysis will be important as the Town transitions from preparation and construction of the 2022 project to planning for the 2027 project.