South Padre Island Beach and Dune Assessment Project

July 2021 Progress Update

Integral Project Managers:
Dr. Cheryl Hapke, chapke@integral-corp.com; 727.434.0024
Dr. Patrick Friend, pfriend@integral-corp.com

Summary Overview

Completed contract for add-on work to provide html data visualization tool of profiles and morphometrics as a deliverable.

Task 1:

- 2021 survey of CBI profiles completed mid-June
- Extracted morphometrics and added 2021 data to data viewers
- Phase 1 Report delivered to SPI.

Task 2:

- Identified profiles for XBeach Modeling
- Set up and began initial model runs.

Progress Narrative: 2021 Beach Profiles

As part of this project, Integral subcontracted to T. Baker Smith, LLC, to conduct a survey of the 25 CBI profiles that are part of the data analysis. In addition to collecting XYZ data on the profile lines, the surveyors noted where there was vegetation versus sand and any other notable characteristics. One profile (CBI-22) is missing data of the upper beach due to beach nourishment activities taking place at the location at the time of the survey (Figure 1). The surveyors also took photographs looking north and south on the beach at each profile.

The 2021 profiles were analyzed and compared to 2020, as well as to 1995, to provide a long-term perspective on morphologic change. The southern and central portion of the subaerial beach and dunes at SPI remained relatively stable over the 1-year time period with CBI-1 to -19 and -25 showing little to no change of the beach and dunes with the exception of CBI-12, along which the shoreline and dunes eroded substantially (80–100 ft). In the northern portion of SPI, with the exception of CBI-25, there was much more variation in the beach profiles alongshore. For example, there was >75 ft of shoreline erosion at CBI-21, while at profile CBI-23 the beach prograded substantially (Figure 2).

Figure 1. Surveyors were unable to survey the beach on profile CBI-22 due to beach nourishment activities at the site.

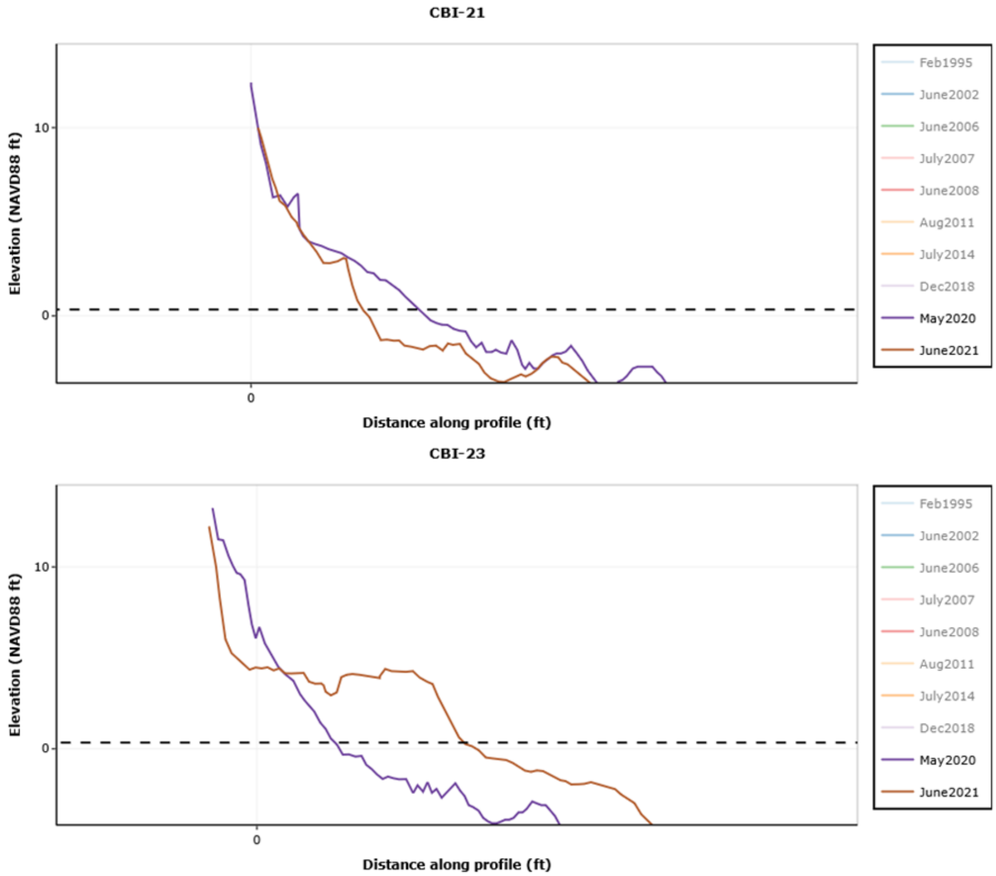

Figure 2. Changes in profile morphology from 2020 to 2021 on profiles CBI-21 (top) and -23 (bottom). Profile CBI-21 experienced ~75 ft of erosion, but the dune remained stable. On CBI-23, the dune eroded, but the beach prograded substantially.

Progress Narrative: 2021 Morphometrics

All morphometrics were extracted from the profiles and included with the previously reported time series. There was little change to the dune crest elevation in the central portion of SPI, and slightly more variation to the north and south (Figure 3). Overall, there was a gain in mean elevation between 2020 and 2021 of 0.4 ft. The dune toe elevation also varied alongshore between the two time periods, but the mean elevation remained the same, 7.0 ft.

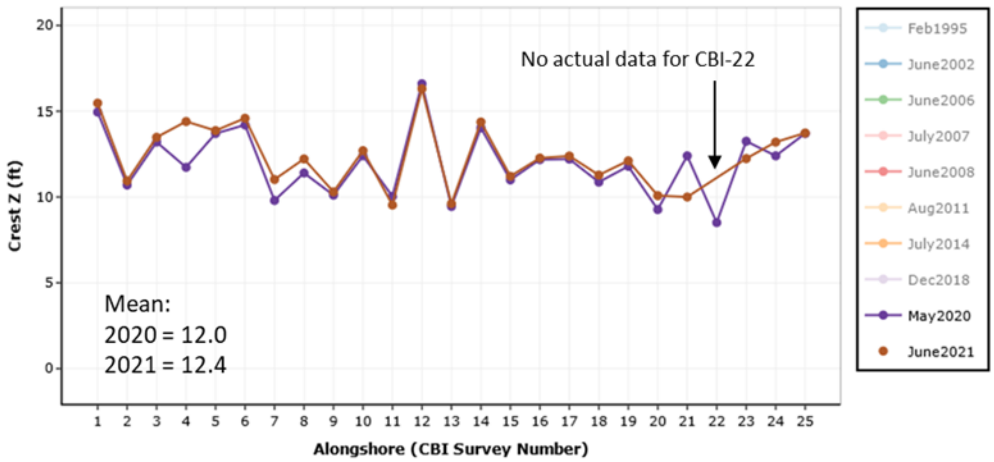

Figure 3. Dune crest elevation changes between 2020 and 2021. Note that there are no actual data for CBI-22 in 2021 due to lack of access from active beach nourishment (Figure 1).

The beach width increased substantially (Figure 4) and is likely a function of the ongoing beach nourishment projects that placed sand on the beach following the May 2020 survey and that were actively occurring at the time of the 2021 survey. The mean beach width increased by 135 ft; the only location where the beach lost material is CBI-21, which is immediately down coast (south) of the active beach nourishment at the time of the 2021 survey.

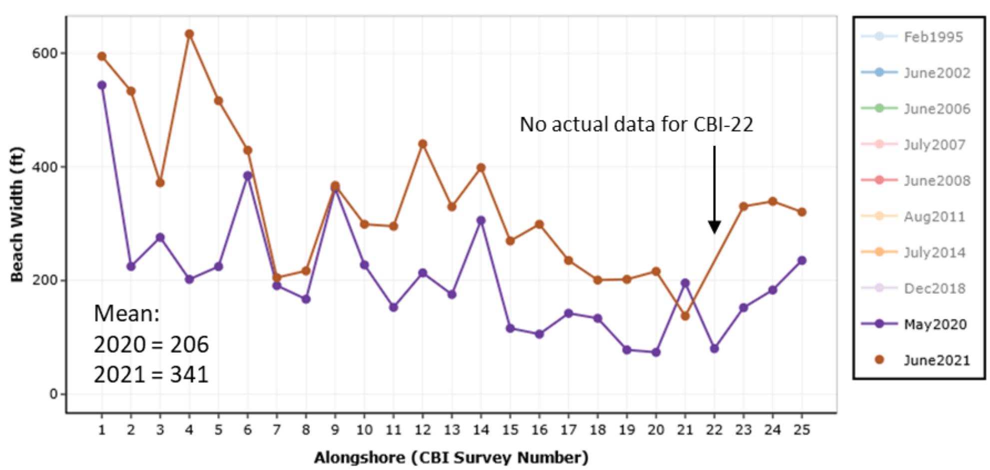

Figure 4. Beach width changes between 2020 and 2021. Note that there are no actual data for CBI-22 in 2021 due to lack of access from active beach nourishment (Figure 1).

The total profile volume, while variable alongshore, followed similar overall trends in 2021 as compared to 2020 (Figure 5). The amount of volume change (17 yd^3) is almost negligible, and likely within the uncertainty range of the survey data.

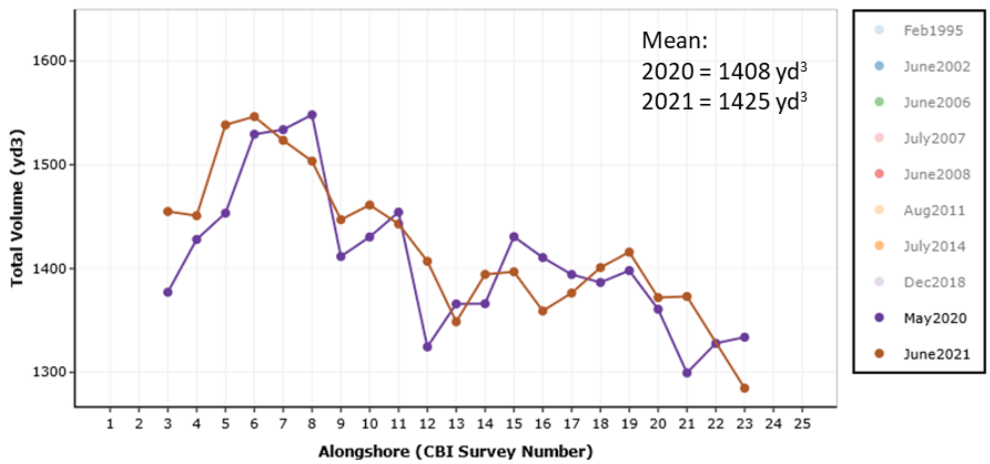

Figure 5. Total profile volume changes between 2020 and 2021. Note that CBI-1, -2, -24, and -25 do not have values because the landward cut-off for the volume calculations is the established SPI building line, which does not exist for those four profiles.

Progress Narrative: XBeach Modeling

To assess the resiliency of the various dune configurations to different types of storms and hurricanes and to identify potential changes to the profiles, XBeach geomorphic modeling is being conducted.

Extreme Value Analysis

The range of wave processes necessitates a qualitative and quantitative understanding of existing wave conditions. To determine the impact of extreme storm events on the coastal resiliency on SPI, extreme values of wave height must be computed to input into XBeach. An extreme value analysis (EVA) of wave height data was performed using data from NOAA Station 42020 Corpus Christi, Texas, ~110 km northeast of the Brazos Santiago Channel at the south end of SPI. This EVA analysis provided the highest wave heights for various return periods (e.g., 1, 2, 5, 10, 100 years) from a 30-year measured data record (Table 1). These data were also included in the Phase 1 Report.

Table 1. Wave Height Return Period Values from EVA for the Offshore NOAA Buoy

Return Period (years)	Significant Wave Height (ft)
1	9.6
2	16.2
5	19.7
10	22.9
100	41.7

XBeach Modeling

XBeach ("the model") is being used to model coastal erosion potential along a selected set of shoreline profiles under a range of storm wave and future sea level rise conditions. XBeach is particularly suited for modeling coastal erosion (e.g., volume, width, elevation) processes on timescales of single storm and wave events, as it simulates tidal- and wave-driven sediment transport and coastal erosion, and is a readily available free open-source model. The model is forced with offshore wave conditions derived from the EVA described above.

XBeach is a numerical model used to predict wave run-up and total water level elevations (sum of tides, storm surge, and wave run-up). This model assesses the interaction of waves with offshore bottom features and the subaerial beach and dune profiles for a range of storm wave and future sea level rise conditions.

Five shoreline profiles were selected from the available profiles along SPI to perform XBeach simulations. The selected profiles were CBI-03, CBI-06, CBI-13, CBI-17, CBI-22, and CBI-24. The profiles were selected based on unique morphologies and historical behavior to be a subset that is representative of different distinct morphologies and geography. These include representing the three portions of the island that have been identified in long-term analyses as having variable evolution (south, central, and north). The following describe the specific characteristics of the chosen profiles:

- CBI-3: southern portion of SPI; development set far back (more representative of natural location)
- CBI-6: southern portion of SPI without potential jetty impacts; has experienced consistent vegetation progradation
- CBI-13: central portion of SPI; stable profile morphology
- CBI-17: central portion of SPI; stable profile morphology

- CBI-22: northern portion of SPI; lack of vegetation and dune, historically; low dune maintained in more recent times, since ~2008
- CBI-24: northern portion of study area; undeveloped region (no building line); dune field widened and has maintained stable configuration in recent years (2018–2021).

XBeach Grid

Each of the five selected profiles was discretized into a number of grid cells representing a discrete distance in the cross-shore direction, and the averaged water depth within that length. There is only a single grid cell in the alongshore direction. The cross-shore spacing of the grid cells varied from ~40 ft at the farthest offshore cells where erosion and accretion are expected to be limited, to ~1.5 ft along the beach and dune profile. This varying cross-shore resolution was used to provide high-resolution predictions along the beach and dune, where erosion and accretion would be the highest, while minimizing the number of grid cells to maintain computational efficiency. The starting morphology using CBI-3 as an example is shown in Figure 6.

XBeach Boundary Conditions

XBeach was set up to run for 30 hours, representative of a typical storm event duration. During this 30-hour period, constant wave and time varying water level boundary conditions were applied.

The significant wave height, the dominant parameter, was computed during the EVA. The wave parameters were held constant to represent the worst case scenario during a storm event. In addition to the wave conditions at the offshore boundary, a time varying water level was applied. These data were sourced from NOAA station # 8779749, SPI Brazos Santiago, Texas.

In addition to the wave and water level boundary conditions, vegetation and sediment physical characteristics were defined along each of the selected profiles. The vegetation data along each of the profiles were defined from the vegetation survey data. This feature in XBeach provides additional roughness for predicting the wave run-up and erosion of the dunes.

XBeach Results

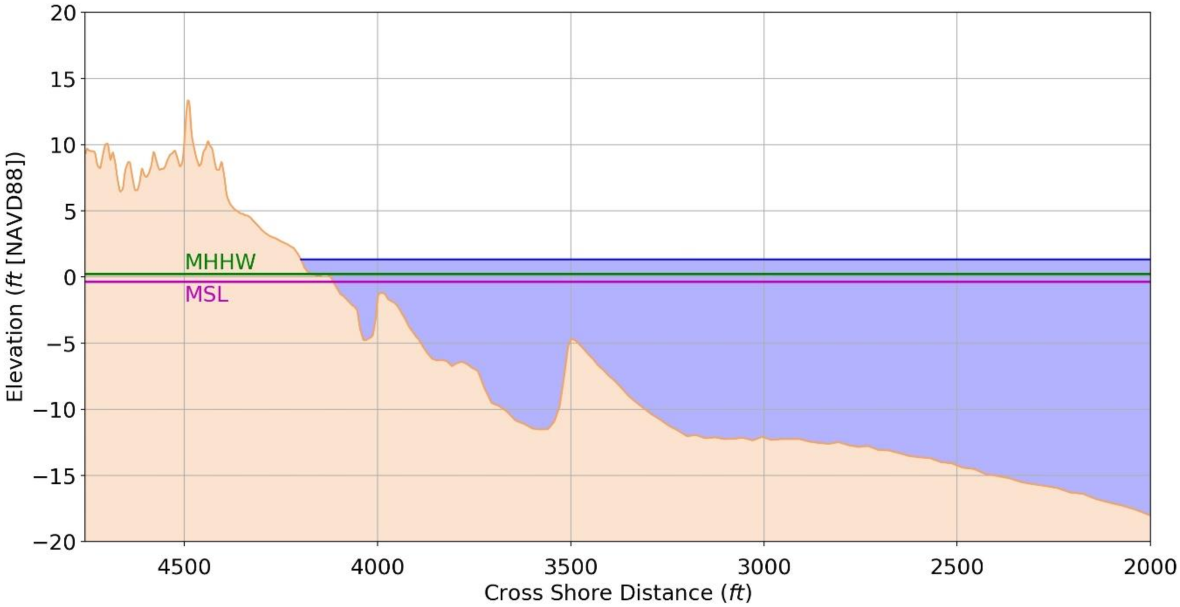

Figure 6. Initial still water level and bed elevation for profile CBI-03. MSL and MHHW datums are also shown for reference.

The model predictions after 30 hours of exposure to a 2-year wave event over a neap to spring tidal cycle are shown as erosion and accretion along the profile (Figure 7). Below 12–13 ft elevation, the model predicts little change in the bottom topography, though closer inshore, especially along the steeper bars and troughs, large amounts of erosion were predicted. This simulated storm event also demonstrates significant erosion of the subaerial portion of the beach and the foredune. As a result, there is overall steepening of the entire profile.

While the predicted change in morphology is representative of change during the identified 2-year storm event, in intervening years with fewer or smaller storms, portions of the system will return to a dynamic equilibrium after an acute event.

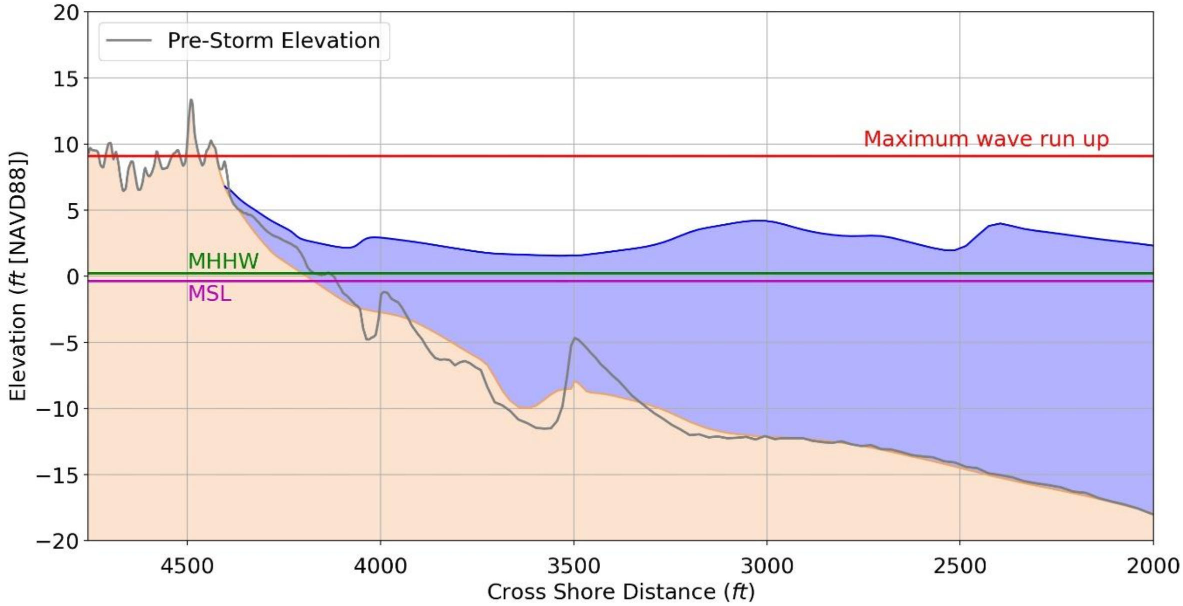

Figure 7. Final output for profile CBI-03 after 30 hours of simulation of a 2-year storm event. The pre-storm (solid black line) elevation represents the profile at the initialization of the XBeach simulation.

Next Steps

The setup and simulation of multiple storm events along each of the five profiles will comprise the bulk of the continuing work. The remainder of the tasks are:

- Evaluate the predicted erosion and accretion along each of the profiles and perform qualitative and quantitative analysis
- Assess erosion and accretion potential to inform site decisions
- Continue drafting report summarizing the model results and analysis.