US Army Corps
of Engineers ®
Wilmington District

General Re-evaluation Report and Environmental Assessment
Surf City, Onslow and Pender Counties, North Carolina
Coastal Storm Risk Management Project

Appendix B: GenCade Transitions

Draft

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1.0 Introduction

The objective of this analysis is to compile and query historical data necessary to develop and calibrate a planform evolution model necessary to conduct analytical calculations relative to post-nourishment shoreline change rates of Future With Project (FWP) scenarios. This study focuses on the transition between the Surf City, North Carolina (**Figure 1**) coastal storm risk management (CSRM) project area and the existing shoreline.

The currently Authorized Project at Surf City consists of a 14' NAVD88 elevation dune with a 25' wide crest, combined with a 50' wide berm set at elevation 6' NAVD88. The project initially extended further north through North Topsail Beach (NTB). This evaluation of transition lengths became necessary due to the withdrawal of NTB from the project and reduction of its overall length. Initial construction is planned for 2024 with a planned nourishment interval of 6 years through the life of the 50-year project.

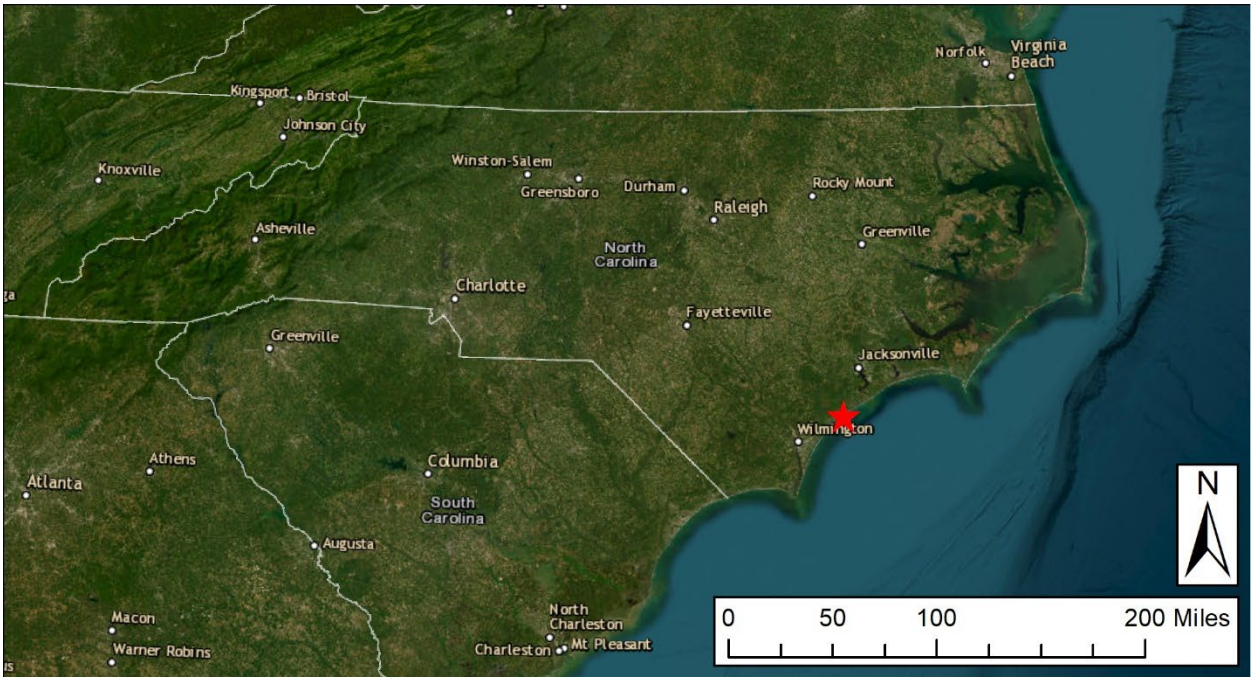

Figure 1. Location of Surf City, North Carolina.

2.0 Model Setup and Calibration

The USACE GenCade one-line, one-dimensional shoreline evolution model was used for the Surf City shoreline change rate analysis. GenCade was developed by the USACE's Coastal Inlets Research Program (CIRP) to combine and improve upon the capabilities of previous shoreline response models GENESIS and Cascade.

The GenCade shoreline model for Surf City was created using hindcast conditions, shoreline locations derived from profile surveys obtained from the town of Surf City, and historical erosion rates. The model was calibrated and validated using historical erosion rates with the mean high water (MHW) contour derived from the most recent profile survey, taken on July 5th, 2022. This contour was estimated at an elevation of 1.39 ft

NAVD88, which corresponds to the MHW datum according to NOAA Station 8658163 at Wrightsville Beach (NOAA, 2023a).

The model was developed using a one-dimensional grid that travels approximately parallel to the Surf City ocean-side shoreline (**Figure 2**). The grid is represented by a black, marked line, the initial shoreline is represented by brown points, and the location of the wave gauge used for driving the simulation is located offshore, perpendicular to the location of the red circle relative to the grid. Shoreline positions are measured as distance from 100-ft intervals, or "cells", along this grid. The grid has a total length of 37,000 ft (370 cells) and lies at an azimuth of 232.5°.

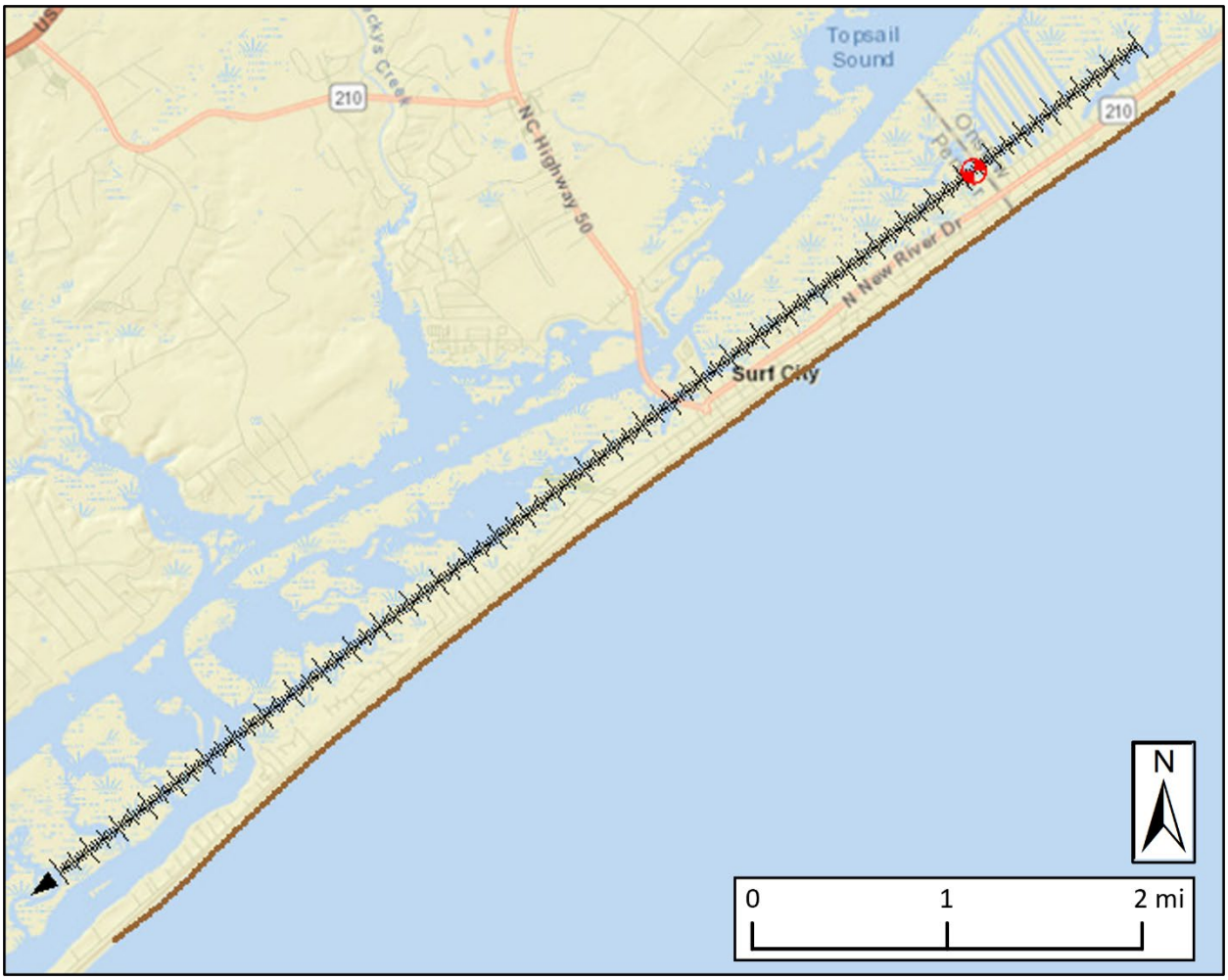

Figure 2. GenCade Model Setup.

Simulations were run to calibrate the model, comparing modeled erosion rates to historical erosion rates. Model parameters were adjusted until a minimum root mean squared error (RMSE) was achieved. Wave data from NDBC Station 41159, located at a depth of 98 ft, 9.4 miles offshore from Surf City, were used for the model runs in both the calibration phase and FWP phase (NOAA, 2023b). Parameters used to drive the model are shown in **Table 1** and calibrated shoreline positions compared to positions from historical rates are shown in **Figure 3**.

Table 1. GenCade Input Variables.

Parameter Name	Value
Grid size	37,000 ft
Cell size	100 ft
Grid angle	232.5°
Simulation start date	July 18th, 2019 (00:00)
Simulation end date	June 13th, 2022 (00:00)
Grain size	0.35 mm
Average berm height	6.0 ft
Closure depth	24.0 ft
Longshore sand transport coefficient, K1	0.5
Longshore sand transport coefficient, K2	0.25

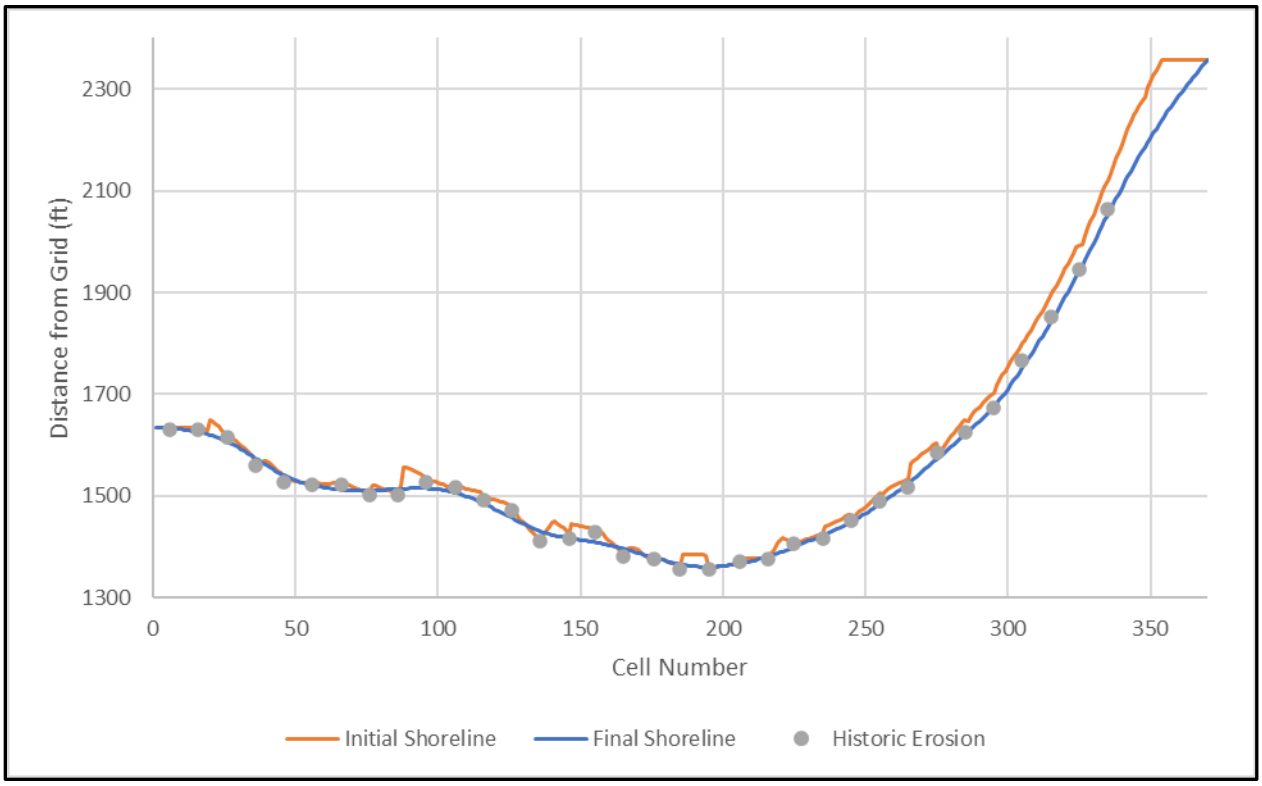

Figure 3. Simulated results vs. historical erosion rates.

After determining the necessary input variables for calibration, FWP simulations were run. These simulations used the same input data as those used in calibration runs, but each with a new constructed initial shoreline. The FWP shoreline was created using the MHW location of the design berm, with transitions tying into the existing MHW contour based on the 2022 survey. Transition lengths of 1000 ft, 1500 ft, and 2000 ft were tested, each as its own simulation with an appropriate initial shoreline reflecting each transition length. The initial shoreline positions of each transition length are shown in **Figures 4** and **5**.

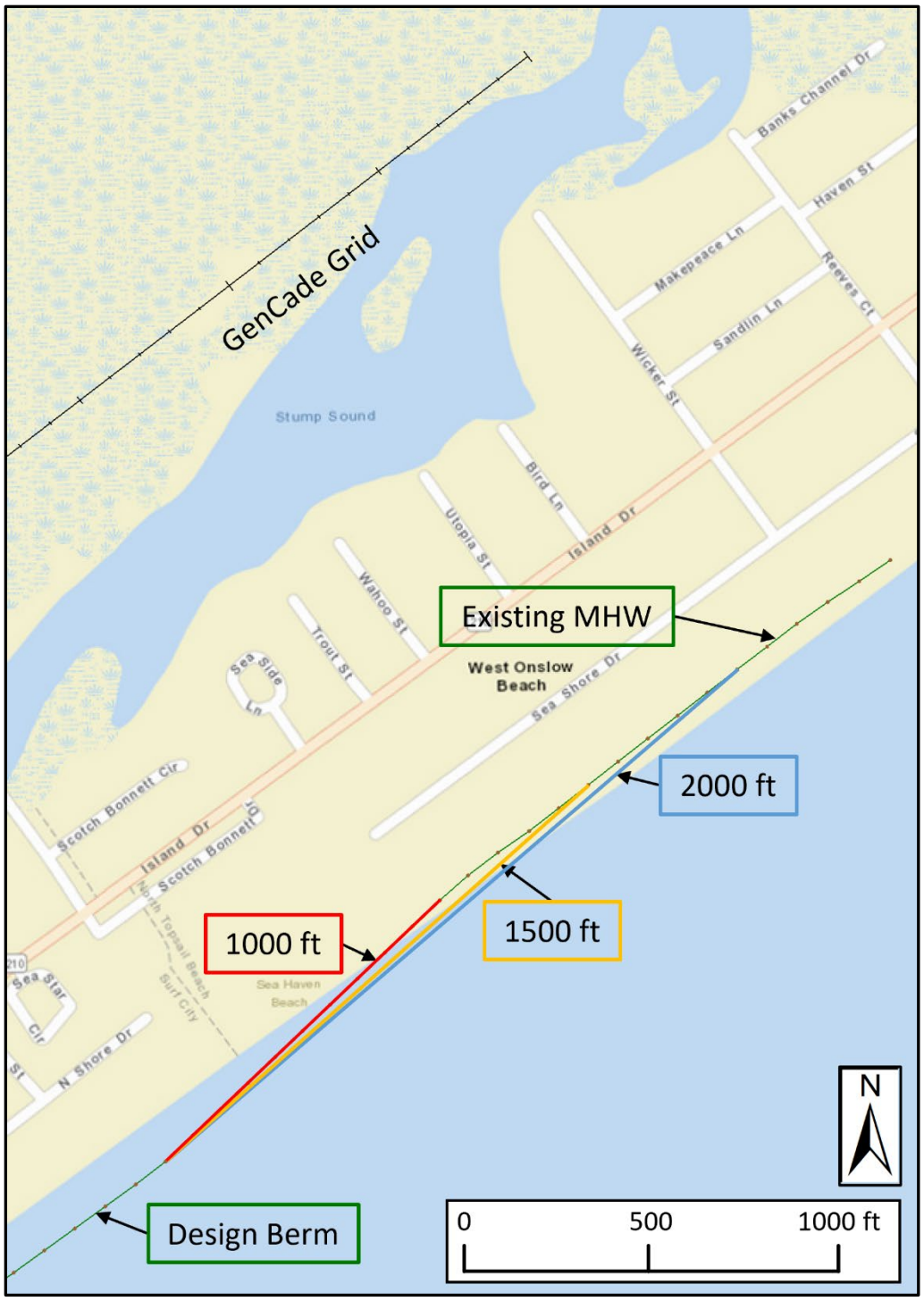

Figure 4. FWP Transition design MHW contours – northeast shoreline.

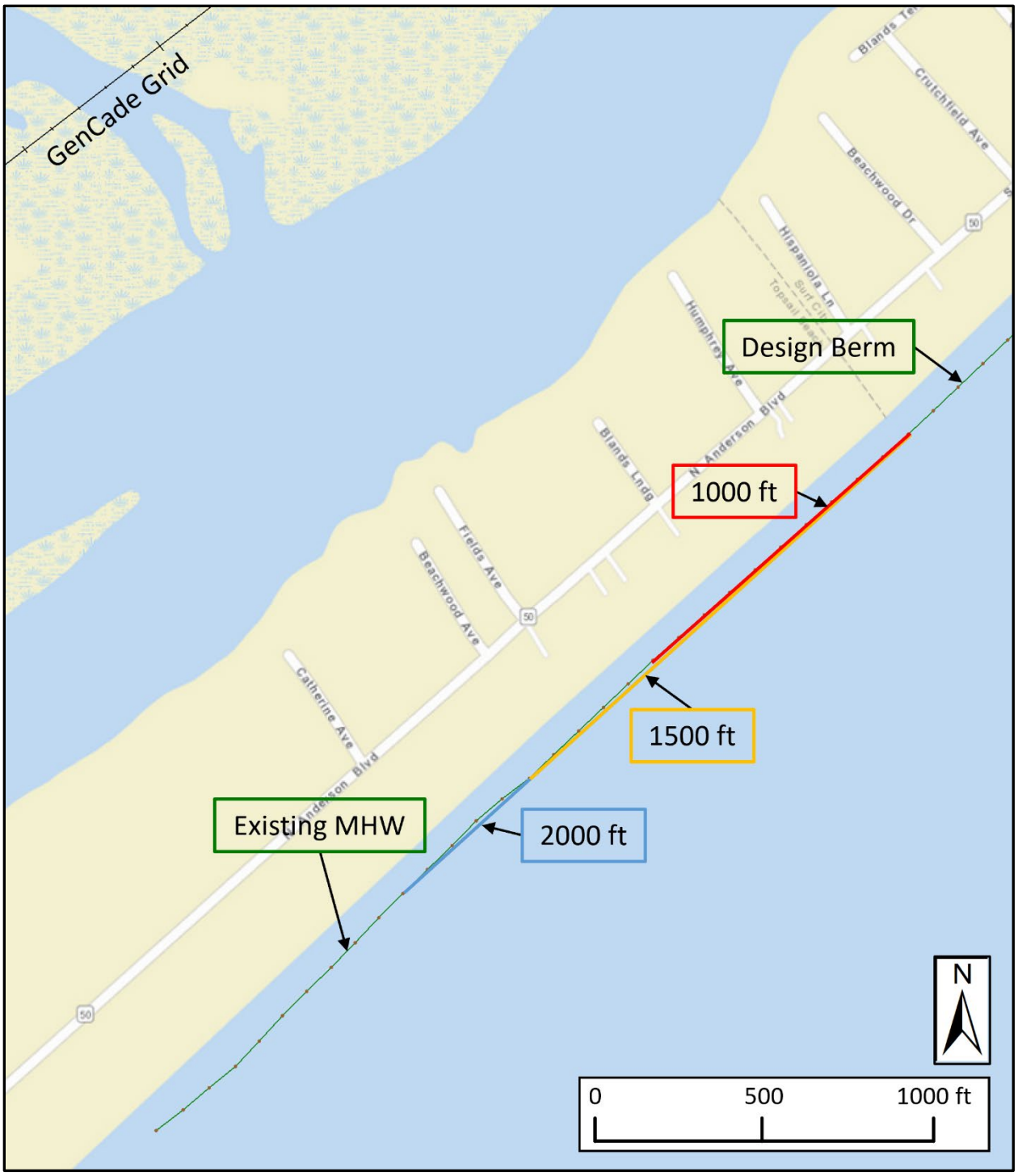

Figure 5. FWP transition design MHW contours – southwest shoreline.

3.0 Results and Discussion

Using the design berm MHW contours, each of the three transition lengths was modeled using the same boundary conditions. The performance of each transition design was analyzed based on the position of the shoreline at the end of each simulation, relative to the position at the beginning. The simulations each ran for the same measured wave

conditions as those used in calibration, totaling in 2.9 years of data. Therefore, application of rates derived from these simulations would require a method of interpolation. Because the purpose of this study was to simply assess the sensitivity of project performance to transition lengths, only the 2.9-year period was needed.

Results of these simulations were analyzed separately for each transition. These transitions will herein be referred to as the northeast transition (closest to North Topsail Beach) and the southwest transition (closest to Topsail Beach). Final positions of the 2.9-year simulation are shown in **Figures 6** and **7** and **Tables 2** and **3**, where negative (red) values in the tables indicate erosion and positive (green) values represent accretion. Plots in the figures have been oriented to reflect the shoreline for easier comprehension.

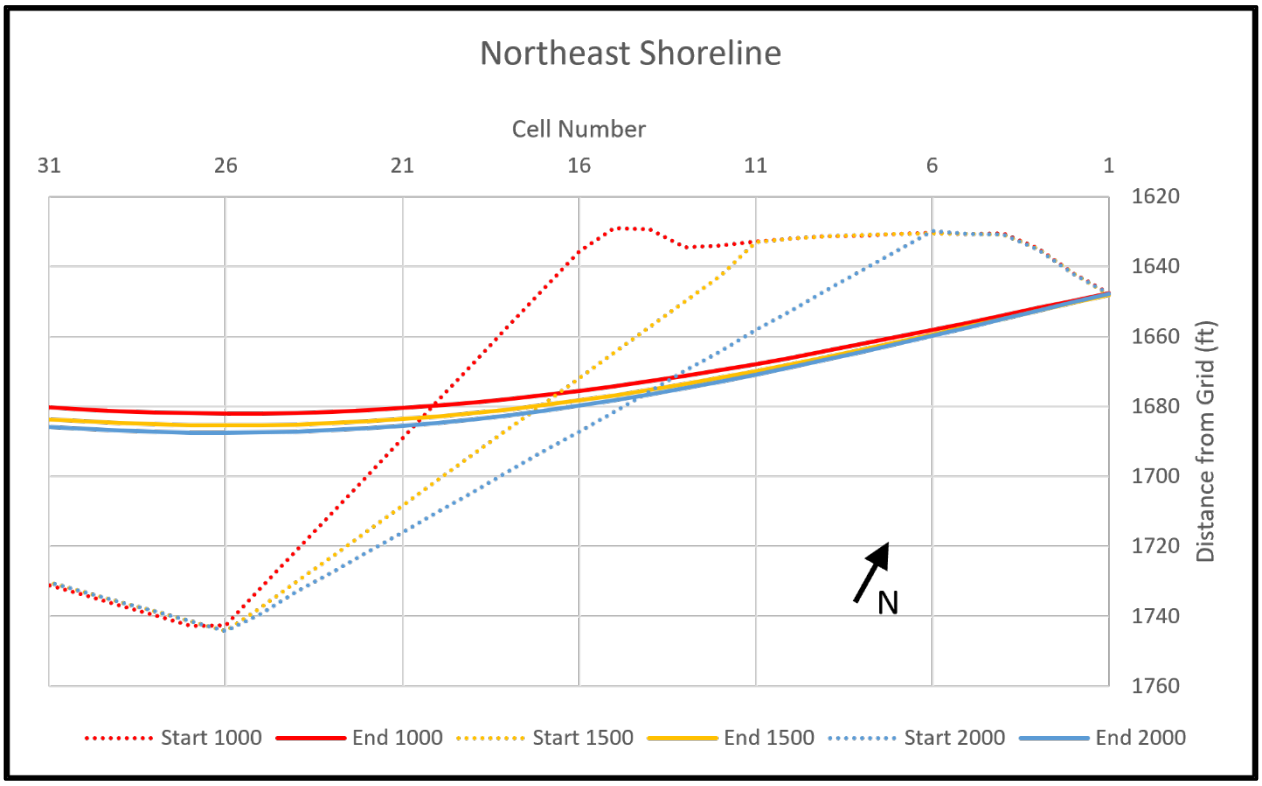

Figure 6. Initial vs. final simulated shorelines for all FWP scenarios – northeast shoreline.

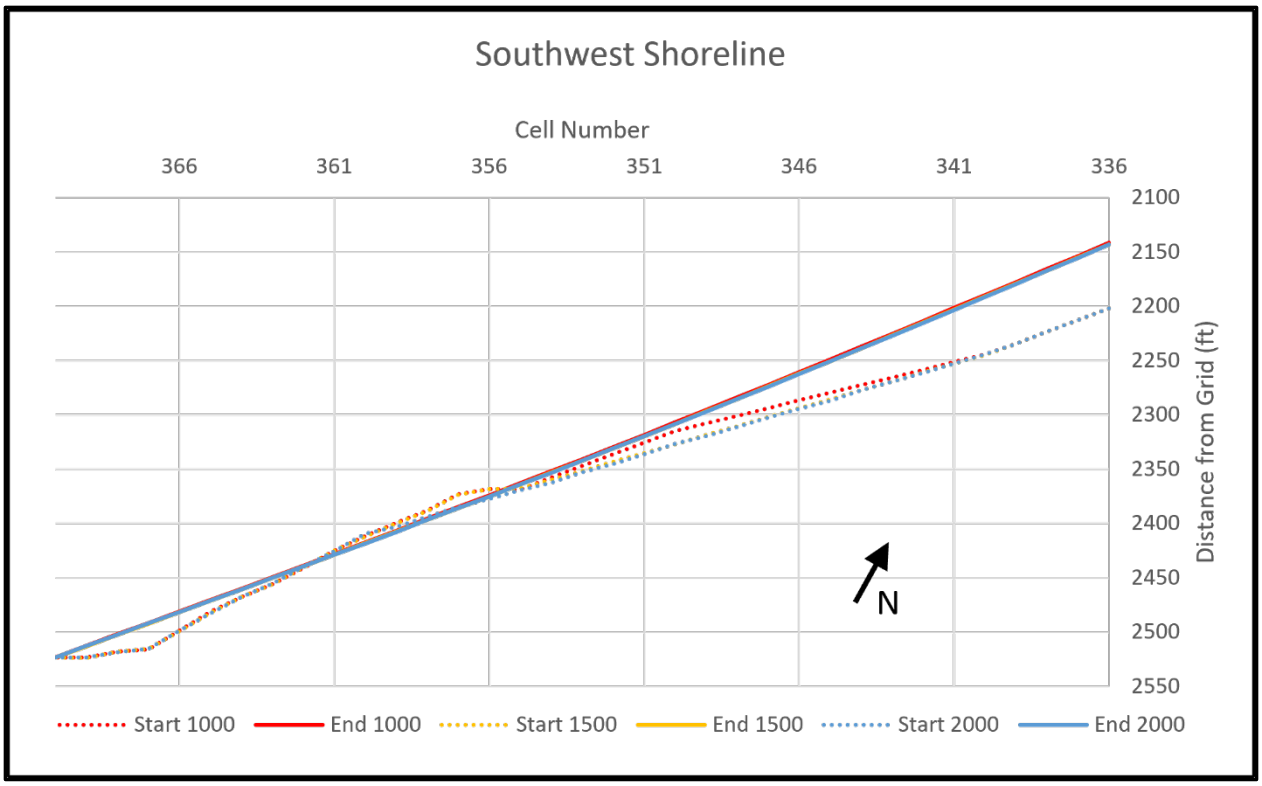

Figure 7. Initial vs. final simulated shorelines for all FWP scenarios – southwest shoreline.

Table 2. Simulated FWP MHW contour positions – northeast shoreline.

Cell ID	Reach	Distance from Grid (ft)						Difference (ft)			Total Erosion Reduction (ft)		
		1000 ft Initial	1000 ft Final	1500 ft Initial	1500 ft Final	2000 ft Initial	2000 ft Final	1000 ft Final - Initial	1500 ft Final - Initial	2000 ft Final - Initial	1500 ft vs. 1000 ft	2000 ft vs. 1000 ft	2000 ft vs. 1500 ft
1	Existing MHW Contour	1647.6	1647.6	1647.6	1647.6	1647.6	1647.6	0.0	0.0	0.0	0.0	0.0	0.0
2		1641.9	1649.7	1642.0	1650.3	1642.1	1650.2	7.8	8.3	8.1	0.6	0.4	-0.2
3		1634.8	1651.8	1635.0	1652.6	1635.1	1652.6	17.1	17.6	17.5	0.8	0.7	0.0
4		1630.5	1653.9	1630.9	1654.9	1630.7	1655.0	23.4	24.0	24.2	1.0	1.0	0.1
5		1630.7	1656.0	1630.6	1657.2	1630.7	1657.4	25.3	26.5	26.7	1.1	1.3	0.2
6		1630.2	1658.1	1630.5	1659.4	1629.8	1659.8	27.9	29.0	30.0	1.3	1.6	0.3
7	2000 ft Transition	1630.6	1660.2	1630.7	1661.6	1635.5	1662.1	29.6	30.9	26.6	1.4	1.9	0.5
8		1631.2	1662.2	1631.0	1663.8	1641.2	1664.4	30.9	32.8	23.2	1.6	2.2	0.6
9		1631.3	1664.1	1631.3	1665.9	1646.8	1666.6	32.8	34.6	19.8	1.8	2.5	0.7
10		1631.9	1666.0	1631.9	1667.9	1652.6	1668.8	34.1	36.0	16.1	1.9	2.8	0.9
11		1632.7	1667.8	1632.9	1669.9	1658.1	1670.9	35.1	37.0	12.8	2.1	3.0	1.0
12	1500 ft Transition	1633.9	1669.6	1642.7	1671.8	1664.2	1672.9	35.7	29.1	8.6	2.2	3.3	1.1
13		1634.4	1671.2	1650.0	1673.6	1669.8	1674.8	36.8	23.6	5.0	2.3	3.5	1.2
14		1629.3	1672.8	1657.2	1675.3	1675.8	1676.6	43.5	18.0	0.8	2.5	3.8	1.3
15		1629.0	1674.2	1664.5	1676.8	1681.5	1678.2	45.2	12.3	-3.2	2.6	4.0	1.4

16		1635.6	1675.6	1671.8	1678.3	1687.1	1679.8	39.9	6.5	-7.4	2.7	4.2	1.5
17	1000 ft Transition	1646.3	1676.8	1679.1	1679.6	1692.7	1681.2	30.5	0.5	-11.5	2.8	4.4	1.6
18		1657.0	1677.9	1686.4	1680.8	1698.6	1682.5	20.9	-5.6	-16.1	2.9	4.6	1.7
19		1667.7	1678.9	1693.7	1681.9	1704.4	1683.6	11.2	-11.8	-20.8	3.0	4.8	1.7
20		1678.4	1679.7	1701.0	1682.8	1710.2	1684.6	1.3	-18.2	-25.6	3.1	4.9	1.8
21		1689.1	1680.5	1708.3	1683.6	1716.0	1685.5	-8.6	-24.7	-30.5	3.2	5.0	1.9
22		1699.8	1681.0	1715.6	1684.3	1721.6	1686.2	-18.7	-31.3	-35.4	3.2	5.2	1.9
23		1710.4	1681.5	1722.9	1684.8	1727.5	1686.8	-29.0	-38.1	-40.7	3.3	5.3	2.0
24		1721.1	1681.8	1730.2	1685.1	1733.0	1687.2	-39.3	-45.1	-45.8	3.3	5.4	2.0
25		1731.8	1682.0	1737.5	1685.3	1739.2	1687.4	-49.9	-52.1	-51.8	3.4	5.5	2.1
26		1742.5	1682.0	1744.3	1685.4	1744.3	1687.5	-60.5	-58.8	-56.8	3.4	5.5	2.1
27	Design Berm MHW Contour	1741.5	1681.9	1741.5	1685.3	1741.5	1687.5	-59.6	-56.1	-54.0	3.4	5.6	2.1
28		1738.7	1681.7	1738.7	1685.1	1738.7	1687.3	-57.0	-53.6	-51.4	3.4	5.6	2.2
29		1735.9	1681.3	1735.9	1684.8	1735.9	1686.9	-54.6	-51.1	-48.9	3.5	5.6	2.2
30		1733.1	1680.8	1733.1	1684.3	1733.1	1686.4	-52.3	-48.8	-46.6	3.4	5.6	2.2
31		1730.3	1680.2	1730.3	1683.6	1730.3	1685.8	-50.1	-46.6	-44.5	3.4	5.6	2.2
32		1727.5	1679.5	1727.5	1682.9	1727.5	1685.1	-48.0	-44.6	-42.4	3.4	5.6	2.2
33		1724.7	1678.7	1724.7	1682.1	1724.7	1684.3	-46.0	-42.6	-40.5	3.4	5.5	2.2

34		1721.9	1677.8	1721.9	1681.2	1721.9	1683.3	-44.1	-40.7	-38.6	3.4	5.5	2.1
35		1719.1	1676.9	1719.1	1680.2	1719.1	1682.3	-42.2	-38.9	-36.8	3.3	5.4	2.1
36		1716.3	1675.9	1716.3	1679.1	1716.3	1681.2	-40.5	-37.2	-35.1	3.3	5.4	2.1
37		1713.5	1674.8	1713.5	1678.0	1713.5	1680.1	-38.7	-35.5	-33.5	3.2	5.3	2.1
38		1710.7	1673.7	1710.7	1676.8	1710.7	1678.9	-37.0	-33.9	-31.9	3.1	5.2	2.0
39		1709.3	1672.5	1709.3	1675.6	1709.3	1677.6	-36.7	-33.7	-31.7	3.1	5.1	2.0
40		1708.0	1671.4	1708.0	1674.4	1708.0	1676.3	-36.6	-33.6	-31.7	3.0	5.0	2.0
41		1706.7	1670.2	1706.7	1673.1	1706.7	1675.0	-36.5	-33.6	-31.7	2.9	4.8	1.9
42		1705.4	1669.0	1705.4	1671.9	1705.4	1673.7	-36.4	-33.5	-31.7	2.9	4.7	1.9
43		1704.1	1667.9	1704.1	1670.7	1704.1	1672.5	-36.2	-33.4	-31.6	2.8	4.6	1.8
44		1702.8	1666.9	1702.8	1669.6	1702.8	1671.3	-36.0	-33.3	-31.5	2.7	4.5	1.8
45		1701.5	1665.9	1701.5	1668.5	1701.5	1670.2	-35.7	-33.1	-31.3	2.6	4.3	1.7
46		1700.2	1664.9	1700.2	1667.5	1700.2	1669.1	-35.3	-32.8	-31.1	2.5	4.2	1.7
47		1699.0	1664.1	1699.0	1666.6	1699.0	1668.1	-34.9	-32.4	-30.8	2.5	4.0	1.6
48		1697.7	1663.3	1697.7	1665.7	1697.7	1667.2	-34.3	-32.0	-30.4	2.4	3.9	1.5
49		1696.4	1662.6	1696.4	1664.9	1696.4	1666.4	-33.8	-31.5	-30.0	2.3	3.8	1.5
50		1695.1	1662.0	1695.1	1664.2	1695.1	1665.6	-33.1	-30.9	-29.5	2.2	3.6	1.4

Table 3. Simulated FWP MHW contour positions – southwest shoreline.

Cell ID	Reach	Distance from Grid (ft)						Difference (ft)			Total Erosion Reduction (ft)		
		1000 ft Initial	1000 ft Final	1500 ft Initial	1500 ft Final	2000 ft Initial	2000 ft Final	1000 ft Final - Initial	1500 ft Final - Initial	2000 ft Final - Initial	1500 ft vs. 1000 ft	2000 ft vs. 1000 ft	2000 ft vs. 1500 ft
321	Design Berm MHW Contour	2041.6	1973.0	2041.6	1973.9	2041.6	1974.1	-68.6	-67.7	-67.4	0.9	1.2	0.3
322		2052.3	1983.2	2052.3	1984.1	2052.3	1984.4	-69.1	-68.2	-67.9	0.9	1.2	0.3
323		2063.0	1993.6	2063.0	1994.5	2063.0	1994.8	-69.4	-68.5	-68.2	1.0	1.2	0.3
324		2073.7	2004.1	2073.7	2005.1	2073.7	2005.4	-69.6	-68.6	-68.3	1.0	1.3	0.3
325		2084.4	2014.9	2084.4	2015.9	2084.4	2016.2	-69.6	-68.5	-68.2	1.0	1.3	0.3
326		2095.1	2025.8	2095.1	2026.8	2095.1	2027.1	-69.4	-68.3	-68.0	1.0	1.3	0.3
327		2105.9	2036.9	2105.9	2037.9	2105.9	2038.2	-69.0	-67.9	-67.6	1.1	1.4	0.3
328		2116.6	2048.1	2116.6	2049.2	2116.6	2049.5	-68.5	-67.4	-67.1	1.1	1.4	0.3
329		2127.3	2059.5	2127.3	2060.6	2127.3	2060.9	-67.8	-66.7	-66.4	1.1	1.5	0.3
330		2138.0	2071.0	2138.0	2072.1	2138.0	2072.5	-67.0	-65.9	-65.6	1.2	1.5	0.3
331		2148.7	2082.6	2148.7	2083.8	2148.7	2084.1	-66.1	-64.9	-64.6	1.2	1.5	0.3
332		2159.4	2094.4	2159.4	2095.6	2159.4	2095.9	-65.0	-63.9	-63.5	1.2	1.5	0.3
333		2170.1	2106.2	2170.1	2107.4	2170.1	2107.7	-64.0	-62.8	-62.4	1.2	1.6	0.3
334		2180.9	2118.0	2180.9	2119.3	2180.9	2119.6	-62.8	-61.6	-61.3	1.2	1.6	0.3
335		2191.6	2129.9	2191.6	2131.2	2191.6	2131.5	-61.7	-60.4	-60.1	1.3	1.6	0.3

336		2202.3	2141.9	2202.3	2143.1	2202.3	2143.5	-60.4	-59.2	-58.8	1.3	1.6	0.3
337		2213.0	2153.8	2213.0	2155.1	2213.0	2155.5	-59.2	-57.9	-57.6	1.3	1.6	0.3
338		2223.7	2165.8	2223.7	2167.1	2223.7	2167.4	-57.9	-56.6	-56.3	1.3	1.6	0.3
339		2234.4	2177.8	2234.4	2179.1	2234.4	2179.4	-56.6	-55.3	-55.0	1.3	1.6	0.3
340		2244.4	2189.8	2244.6	2191.1	2244.2	2191.4	-54.6	-53.5	-52.7	1.3	1.6	0.3
341	1000 ft Transition	2251.5	2201.8	2252.9	2203.1	2252.8	2203.4	-49.7	-49.8	-49.4	1.3	1.6	0.3
342		2258.5	2213.7	2261.1	2215.0	2261.2	2215.4	-44.8	-46.1	-45.8	1.3	1.6	0.3
343		2265.6	2225.6	2269.3	2226.9	2269.6	2227.3	-40.0	-42.4	-42.4	1.3	1.6	0.3
344		2272.7	2237.5	2277.6	2238.7	2277.5	2239.1	-35.2	-38.8	-38.4	1.3	1.6	0.3
345		2279.8	2249.2	2285.8	2250.5	2286.9	2250.8	-30.5	-35.3	-36.0	1.3	1.6	0.3
346		2286.8	2260.9	2294.0	2262.2	2294.6	2262.5	-25.9	-31.8	-32.1	1.3	1.6	0.3
347		2293.9	2272.6	2302.3	2273.8	2302.7	2274.1	-21.3	-28.5	-28.6	1.2	1.5	0.3
348		2301.0	2284.1	2310.5	2285.4	2311.1	2285.7	-16.8	-25.1	-25.5	1.2	1.5	0.3
349		2308.1	2295.6	2318.7	2296.8	2319.6	2297.1	-12.4	-21.9	-22.5	1.2	1.5	0.3
350		2315.1	2307.1	2327.0	2308.2	2326.9	2308.5	-8.1	-18.7	-18.4	1.2	1.5	0.3
351	1500 ft Transition	2325.7	2318.4	2335.2	2319.6	2336.1	2319.8	-7.3	-15.6	-16.3	1.2	1.4	0.3
352		2336.3	2329.7	2343.4	2330.8	2345.2	2331.1	-6.6	-12.6	-14.2	1.1	1.4	0.3
353		2346.9	2340.9	2351.7	2342.0	2352.7	2342.2	-6.1	-9.7	-10.5	1.1	1.3	0.2

354		2357.6	2352.0	2359.9	2353.1	2362.2	2353.3	-5.6	-6.8	-8.9	1.1	1.3	0.2
355		2369.0	2363.1	2368.1	2364.1	2369.5	2364.3	-5.9	-4.0	-5.2	1.0	1.2	0.2
356	2000 ft Transition	2368.3	2374.1	2368.5	2375.1	2377.5	2375.3	5.8	6.6	-2.2	1.0	1.2	0.2
357		2373.3	2385.0	2373.5	2386.0	2385.2	2386.1	11.7	12.5	0.9	1.0	1.1	0.2
358		2388.0	2395.9	2388.5	2396.8	2394.1	2397.0	7.9	8.4	2.8	0.9	1.0	0.1
359		2399.6	2406.7	2400.1	2407.6	2403.0	2407.7	7.1	7.5	4.7	0.9	1.0	0.1
360		2411.8	2417.5	2412.0	2418.3	2409.3	2418.4	5.7	6.4	9.1	0.8	0.9	0.1
361	Existing MHW Contour	2425.0	2428.2	2425.1	2429.0	2425.5	2429.1	3.3	3.9	3.6	0.8	0.8	0.1
362		2441.3	2438.9	2440.6	2439.6	2440.0	2439.7	-2.4	-1.0	-0.4	0.7	0.8	0.0
363		2455.9	2449.5	2455.9	2450.2	2455.3	2450.2	-6.4	-5.7	-5.1	0.7	0.7	0.0
364		2467.9	2460.1	2467.8	2460.8	2467.8	2460.8	-7.7	-7.0	-7.1	0.6	0.6	0.0
365		2481.4	2470.7	2482.3	2471.3	2482.6	2471.2	-10.7	-11.0	-11.3	0.6	0.6	0.0
366		2499.0	2481.2	2499.1	2481.7	2498.9	2481.7	-17.8	-17.4	-17.2	0.5	0.5	0.0
367		2515.7	2491.7	2515.4	2492.2	2515.5	2492.1	-24.0	-23.2	-23.4	0.5	0.4	-0.1
368		2518.4	2502.3	2518.1	2502.7	2518.7	2502.6	-16.1	-15.4	-16.1	0.4	0.3	-0.1
369		2523.4	2512.8	2523.7	2513.1	2523.5	2513.0	-10.6	-10.6	-10.5	0.4	0.2	-0.1
370		2523.3	2523.3	2523.3	2523.3	2523.3	2523.3	0.0	0.0	0.0	0.0	0.0	0.0

These results show that increasing the transition length adds minimal benefit in decreasing overall planform erosion. At the southwest transition, the existing MHW contour nearly ties in with the design berm location, causing the transition to be nearly unnoticeable. However, at the northeast end of the shoreline, the design berm protrudes from the existing MHW contour more significantly. This causes transition lengths to have a stronger effect on the total planform erosion over the 2.9-year simulation, but the reduction in erosion is still minimal. At cell 29, which is the location in which the maximum erosion differences between transition lengths occurs, the total erosion between the initial shoreline and final simulated position is only 3.5 ft less for the 1500 ft transition and 5.7 ft less for the 2000 ft transition, compared to erosion occurring with the 1000 ft transition. The differences between these total erosion values for each transition length are small relative to the total erosion occurring throughout the simulation.

4.0 Conclusions

A GenCade model was calibrated using an existing MHW contour and hindcast wave data to match historical erosion rates. Three FWP scenarios were then simulated to analyze the effects of transition lengths on overall planform erosion rates. FWP scenarios were modeled using the design MHW location throughout the project, with transitions tying into the existing MHW contour. Transitions modeled had widths along shore of 1000 ft, 1500 ft, and 2000 ft and were analyzed separately for the northeast and southwest ends of the project.

Because more sediment is required to build a longer transition, the 2000 ft transition performed best over the 2.9-year simulation. However, relative to the total erosion occurring throughout the simulation, the reduction in total erosion was minor in both the northeast and southeast portions. Based on these results a 1,000’ transition length is recommended.

5.0 References

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