

# Smathers Beach Nourishment Project

## Three-Year Post-Construction Engineering Report

City of Key West

June 22, 2023



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# Executive Summary

Beach nourishment is a coastal construction technique involving the placement of sand along the shoreline to supplement sand on an existing beach or to build up an eroded beach. Coastal erosion can often be exacerbated by storm events, as was the case with Smathers Beach, located along south Roosevelt Boulevard on the southern coast of Key West, Florida (24° 33' 06" N Latitude, -81° 46' 15" W Longitude). Due to the eroded state of Smathers Beach, the City of Key West was authorized for the periodic placement of sand along the 3,000 linear feet of beach.

This report evaluates the performance of the material placed between monuments PL-J4-W to PL-J1-E (the westernmost jetty) within all three cells, as shown in Figure 1, at Smathers Beach between May 21 and June 5, 2019. Smathers Beach had a total added material volume of 12,267 cubic yards (CY) placed during the 2019 nourishment event. This volume was calculated comparing the As-Built survey completed on June 20, 2019 to the pre-construction survey completed on May 7, 2019. The monitoring of this project is evaluated based on the added volumes and added beach widths remaining in comparison to the As-Built survey. Table 1 and Table 2 below summarize the Mean High Water (MHW) shoreline changes and volume changes that have been recorded since the 2019 nourishment event. Figure 1 depicts the changes in MHW (-0.24 feet NAVD88) throughout the construction and monitoring period.

Over the current monitoring period (July 2021 to September 2022), the Smathers Beach shoreline had an average shoreline change of -4.4 feet across all three cells when compared to the post-construction survey, with Cell 2 experiencing the largest average shoreline erosion. The Smathers Beach shoreline has also experienced a total loss of 2,021 cubic yards across all three cells, with Cell 1 experiencing the largest loss of material.

The Smathers Beach shoreline has retained approximately 65% (7,929 cubic yards) of the 12,267 cubic yards of material that was placed in May/June 2019. The shoreline also has 9.6 feet of average added beach width remaining from the 2019 nourishment event.

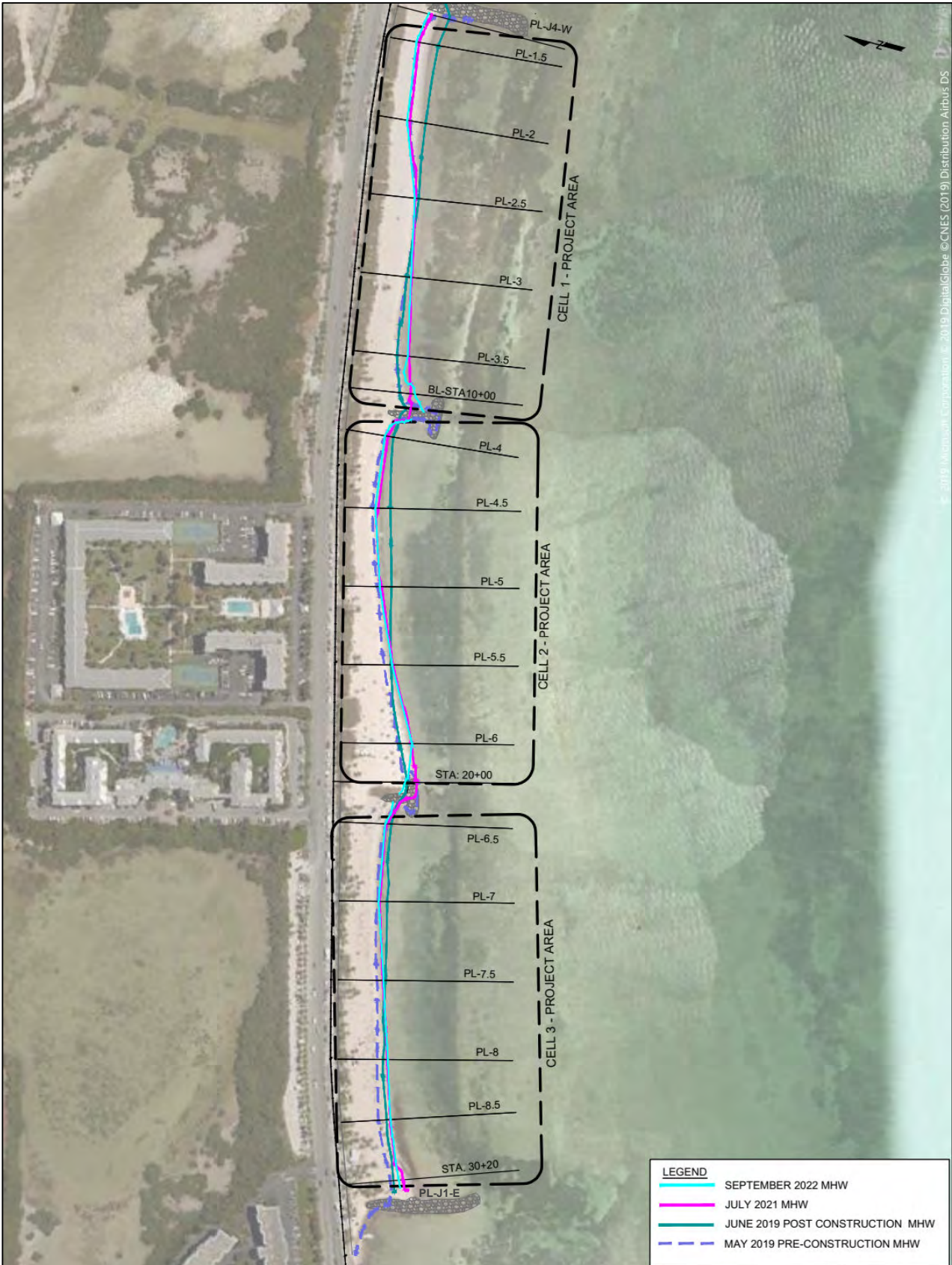
**Table 1 – Average MHW Shoreline Changes (ft) at Smathers Beach (May 2019 to September 2022)**

| Location                        | Added Beach Width Remaining (ft) |                       |                        | Shoreline Change (ft)   |
|---------------------------------|----------------------------------|-----------------------|------------------------|-------------------------|
|                                 | May 2019 to June 2019            | May 2019 to July 2021 | May 2019 to Sept. 2022 | July 2021 to Sept. 2022 |
| Cell 1 (PL-J4W to BL-STA-10+00) | 16.3                             | 6.3                   | 3.6                    | -2.7                    |
| Cell 2 (PL-4 to BL-STA-20+00)   | 20.2                             | 18.5                  | 10.0                   | -8.5                    |
| Cell 3 (PL-6.5 to BL-STA-30+20) | 17.2                             | 18.5                  | 16.3                   | -2.1                    |
| Total Project Area              | 17.8                             | 14.0                  | 9.6                    | -4.4                    |

**Table 2 – Volume Changes (CY) at Smathers Beach (May 2019 to September 2022)**

| Location                        | Volume Remaining (CY) |                       |                        | Volumetric Changes (CY) |
|---------------------------------|-----------------------|-----------------------|------------------------|-------------------------|
|                                 | May 2019 to June 2019 | May 2019 to July 2021 | May 2019 to Sept. 2022 | July 2021 to Sept. 2022 |
| Cell 1 (PL-J4W to BL-STA-10+00) | 3,970                 | 1,370                 | 98                     | -1,272                  |
| Cell 2 (PL-4 to BL-STA-20+00)   | 4,326                 | 4,535                 | 3,469                  | -1,066                  |
| Cell 3 (PL-6.5 to BL-STA-30+20) | 3,970                 | 4,045                 | 4,362                  | 317                     |
| Total Project Area              | 12,267                | 9,949                 | 7,929                  | -2,021                  |

Figure 1 – Project Vicinity and MHW Location Timeline



# 1. Introduction

## 1.1. Project Background

Beach nourishment is a coastal construction technique involving the placement of sand fill along the shoreline to supplement sand on an existing beach or to build up an eroded beach. Coastal erosion can often be exacerbated by storm events, as was the case with Smathers Beach, located along south Roosevelt Boulevard on the southern coast of Key West, Florida (24° 33' 06" N Latitude, -81° 46' 15" W Longitude). Due to the eroded state of Smathers Beach, the City of Key West was issued a Consolidated Joint Coastal Permit (JCP) and a Sovereign Submerged Lands Authorization in July 1998 from the Florida Department of Environmental Protection (FDEP) through permit number 0129031-001-JC. This permit authorized the periodic placement of sand along the 3,000 linear feet of beach. A U.S. Army Corps of Engineers (USACE) Department of the Army (DA) permit (1998-01667 (IP-DSG)) was issued in June 1999, which authorized the restoration and stabilization of approximately 3,000 feet of beach shoreline along Smathers Beach. The initial beach restoration project in 2000 involved the placement of 36,000 cubic yards of sand and mitigated for 5.2 acres of seagrass habitat at a site known as the Blimp Pad. A permit modification was issued by FDEP in 2002 (0129031-003-JC) to mechanically fill the interior groins at Smathers Beach. In February 2011, the City of Key West was issued a DA permit (SAJ-1998-01677 (IP-MLC)), authorizing the placement of a maximum of 12,891 cubic yards of sand along Smathers Beach in 2011. Sand was placed within Cells 2 and 3 on Smathers Beach under that authorization in June/July of 2011. In July 2013, the City was issued a new JCP (0129031-005-JC) to maintain the full length of the beach. In August 2013, approximately 4,800 cubic yards of beach compatible sand material was placed within Cell 1 on Smathers Beach under the FDEP authorization and a modification to the DA permit (SAJ-1998-01677 (IP-MLC) Mod-1).

Since the 2011-2013 sand placement events, Key West has experienced tropical storm events, including Hurricane Irma on September 10, 2017, which was a Category 4 hurricane with sustained winds of 130 mph that made landfall on Cudjoe Key located approximately 20 miles east-northeast of Key West. To combat the resulting erosion, the City of Key West (City) placed an additional 14,428 cubic yards of sand by truck volume on Smathers Beach in May/June of 2019 to nourish the beach within the permitted fill template.

## 1.2. Project Description

On July 17, 2018, the City of Key West contracted Earth Tech Enterprises to place 20,000 tons of sand on Smathers Beach. The sand was obtained from the Witherspoon Sand Plant in Moore Haven, Florida, operated by Vulcan Materials Company, and truck hauled to the nourishment location. Construction activities began in May of 2019 and concluded on June 5, 2019, with a total of 19,925 tons (14,428 cubic yards) of sand placed within Cells 1, 2, and 3 (between PL-J4W and PL-J1E – the westernmost jetty west of BL-STA-30+20; Figure 1).

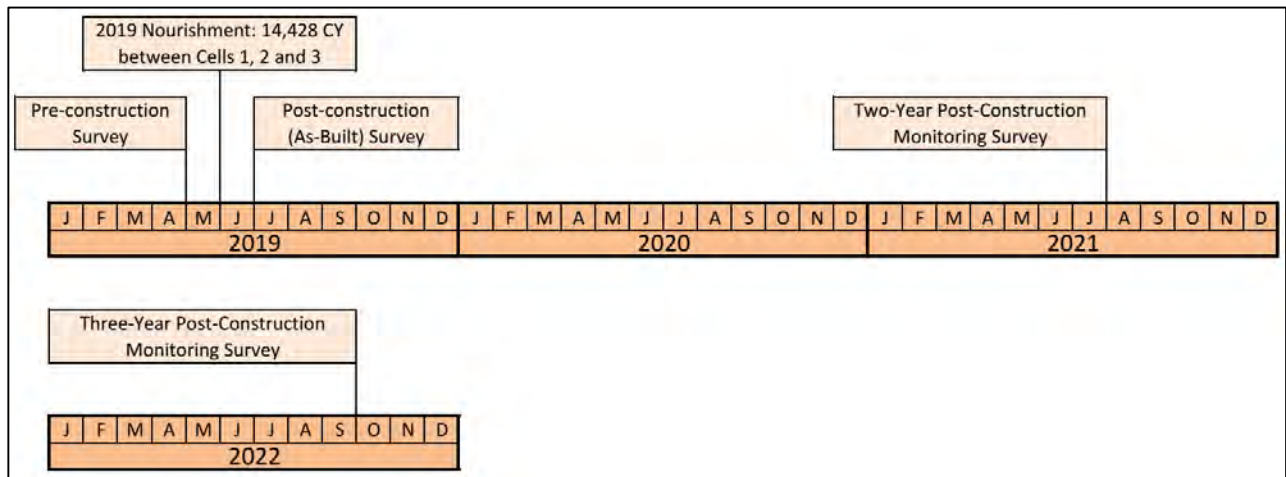
Atkins North America, Inc (Atkins) was contracted by the City of Key West to assist with the Smathers Beach nourishment project by providing topographic survey, as well as construction, biological, and physical monitoring services. Additionally, Atkins is assisting with the general compliance of the conditions outlined in the Federal and State permits (0129031-005-JC, SAJ-1998-01677 (IP-MLC), and FKNMS-2019-030). It should be noted that while the contractor reported the placement of 14,428 cubic yards of material based on truck volume, the post-construction monitoring analysis based on the June 2019 As-Built survey only calculated a total added volume of 12,267 cubic yards. The monitoring of this project is evaluated based on the added volumes and added beach widths remaining in comparison to the As-Built survey quantities.

Physical monitoring surveys were performed along 16 profile lines (FDEP monuments PL-J4-W and PL-1.5 through PL-8.5). Three additional profiles lines (BL-STA-10+00, BL-STA-20+00, and BL-STA-30+20) were added for this monitoring cycle to help account for the accretion of material along the east sides of the structures (west side of cells). A project area map depicting Smathers Beach and the profile line locations is given in Figure 1.

In accordance with the permit requirements for FDEP permit number 0129031-005-JC, Atkins has collected and submitted profile data and project performance information for the 2019 Smathers Beach Nourishment Project at the following time periods: Prior to construction (May 2019; collected by construction contractor); at construction completion (June 2019; As-Built); two-years post-construction (July 2021); and three-years post-construction (September 2022; collected by Florida Keys Land Surveying). It should be noted that a one-year post-construction survey was not performed in the summer of 2020 due to complications associated with COVID-19.

This report summarizes the three-year post-construction physical monitoring of the 2019 nourishment project conducted within Cells 1, 2, and 3 on Smathers Beach. The projects' effectiveness is assessed in terms of shoreline and volumetric changes through September 2022. The monitoring timeline of the project area for the 2019 nourishment event is shown in Figure 2. A list of the profile lines survey used for each monitoring event is provided in Table 3.

**Figure 2 – Smathers Beach Survey Timeline**



**Table 3 – Smathers Beach Survey Breakdown**

| Station  |               | May 2019<br>Pre-Construction<br>Survey | June 2019<br>Post-Construction<br>(As-Built) Survey | July 2021<br>Two-Year<br>Post-Construction<br>Survey | September 2022<br>Three-Year<br>Post-Construction<br>Survey |
|----------|---------------|----------------------------------------|-----------------------------------------------------|------------------------------------------------------|-------------------------------------------------------------|
| PL-J4-W  |               | 0                                      | •                                                   | •                                                    | •                                                           |
| Cell 1   | PL-1.5        | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-2          | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-2.5        | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-3          | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-3.5        | •                                      | •                                                   | •                                                    | •                                                           |
|          | BL-STA-10+00* | •                                      | 0                                                   | 0                                                    | 0                                                           |
| PL-J3-E  |               | 0                                      | •                                                   | •                                                    | •                                                           |
| Cell 2   | PL-4          | 0                                      | •                                                   | •                                                    | •                                                           |
|          | PL-4.5        | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-5          | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-5.5        | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-6          | •                                      | •                                                   | •                                                    | •                                                           |
|          | BL-STA-20+00* | •                                      | 0                                                   | 0                                                    | 0                                                           |
| PL-J2-CL |               | 0                                      | •                                                   | •                                                    | •                                                           |
| Cell 3   | PL-6.5        | 0                                      | •                                                   | •                                                    | •                                                           |
|          | PL-7          | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-7.5        | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-8          | •                                      | •                                                   | •                                                    | •                                                           |
|          | PL-8.5        | 0                                      | •                                                   | •                                                    | •                                                           |
|          | BL-STA-30+20* | 0                                      | 0                                                   | 0                                                    | 0                                                           |
| PL-J1-E  |               | 0                                      | •                                                   | •                                                    | •                                                           |

\* – Baseline Profiles added to the survey to analyze changes adjacent to existing structures.

0 – Profiles not surveyed but extracted from the surface for analysis. Pre-construction survey provided by contractor surveyed on 50-foot increments rather than along survey monuments.

## 2. Technical Approach

### 2.1. Monitoring Project Area

For the purposes of this 2019 physical monitoring cycle, the monitoring area and the 2019 project area (Cells 1, 2, and 3) have the same extents as fill material was placed within all three cells. The monitoring area is defined as the entire length of Smathers Beach (Cells 1, 2, and 3, including PL-1.5 through PL-8.5). It should be noted that in physical monitoring reports prepared by Atkins prior to 2019, the monitoring area was defined the same as above, but the nourishment project areas were broken into different events: the 2011 project area (Cells 2 and 3) and the 2013 project area (Cell 1). It should also be noted that in physical monitoring reports prior to 2014, the 2013 project area (Cell 1) was referred to as the 'east of fill' area.

### 2.2. Monitoring Tasks

#### 2.2.1. Profile Survey

The physical monitoring of Smathers Beach is comprised of the collection and analyses of topographic surveys along each monument, at prescribed azimuths, of the beach and immediate offshore areas. This data is required for the City and the FDEP to continually assess the condition of Smathers Beach. The annual topographic surveys are needed to observe the performance of beach nourishment projects and assess effects of these projects. Analyses of the surveys and scientific monitoring also provide information necessary to plan, design, and optimize future nourishment projects.

Beach profile data was collected throughout the Smathers Beach project area at the following time periods:

- May 2019 – Pre-construction (collected by Earth Tech Enterprises), completed on May 7, 2019.
- June 2019 – As-built post-construction (collected by Atkins), completed on June 20, 2019.
- July 2021 – Two-year post-construction (collected by Atkins), completed on July 21, 2021.
- September 2022 – Three-year post-construction (collected by Florida Keys Land Surveying), completed on September 29, 2022. It should be noted that all survey data for this year was collected prior to Hurricane Ian, with supplemental control checks occurring in late September.

During each survey, onshore beach profiles were collected along the azimuths using differential levelling to determine the elevation of the beach. Coordinates for the survey monuments were supplied by the FDEP and verified by Atkins surveyors using static GPS (Leica GPS System 1230). Surveyors measured the elevations along the profile alignment at 25-foot intervals and breaks in slope from the back of the existing sidewalk to the offshore extent of the surveys at wading depth. Atkins obtained elevation data using a Leica TC1800 Total Station, while Florida Keys Land Surveying obtained elevation data using a wide area continuously operating GPS reference station network (Trimble VRS), with ties to the national geodetic survey control network. The profile data collected for the September 2022 topographic survey are being submitted electronically to FDEP in conjunction with this report.

For the May 2019, June 2019, July 2021, and September 2022 surveys, recorded elevations were in reference to the North American Vertical Datum of 1988 (NAVD88) datum, as required by the FDEP. The elevations for the control points were also given in NAVD88. The water level information for this project location was obtained from the Land Boundary Information System (LABINS) Tide Interpolation Point 6140 at Smathers Beach and approved for application in the Smathers Beach area by the FDEP in a letter dated April 8, 2011. Table 4 gives the approved tidal information at Smathers Beach in reference to NAVD88, showing a MHW elevation of -0.24 feet NAVD88.

All final vertical elevations for this project are referenced to NAVD88 and all horizontal data are referenced to the Florida State Plane Coordinate System, East Zone - US Feet, North American Datum of 1983/90 (NAD 83/90).

**Table 4 – Tidal Information for Smathers Beach**

| Tidal Datum           | Tidal Datum Elevations (ft NAVD88) |
|-----------------------|------------------------------------|
| Mean High Water (MHW) | -0.24                              |
| Mean Low Water (MLW)  | -1.46                              |

### 2.2.2. Shoreline Change Analysis

The shoreline changes for Smathers Beach were calculated as follows:

- The elevation representing Mean High Water (MHW) was identified as -0.24 feet NAVD88.
- The horizontal difference of the MHW elevation between each survey data set was measured to determine the shoreline change.

The shoreline change analysis assists in evaluating the effectiveness of the project and determining when the added beach width from this nourishment project has been eroded or displaced from the Smathers Beach project area.

### 2.2.3. Volumetric Change Analysis

The volumetric changes for Smathers Beach were calculated utilizing the ‘average end area’ method. This method is as follows:

- The difference in cross-sectional area was calculated between two sets of survey data along each profile line.
- The average cross-sectional area difference was multiplied by the effective distance between monument locations to yield the net volume change for each profile and the given survey data sets being compared.

The volume change analysis assists in evaluating the effectiveness of the project and determining when the added fill material volume from this project has been eroded or displaced from the Smathers Beach project area. Volumetric changes were calculated from the upland extent of the fill template, seaward to the overlapping extent of the valid survey data offshore using surface area differences between the survey data sets. The plan view and comparative profiles for PL-J4W through BL-STA-30+20 are provided in Appendix A.

## 3. Results

### 3.1. Shoreline Change

The 2019 Smathers Beach nourishment project supplied additional sand to all three Cells of Smathers Beach and was completed between May and June of 2019. This section evaluates the effectiveness of the project based on the shoreline change and added beach width remaining as of the three-year post-construction monitoring survey from September 2022. The MHW elevation at Smathers Beach of approximately -0.24 feet NAVD88 was used as the shoreline location at which to evaluate shoreline change in this analysis.

#### 3.1.1. July 2021 to September 2022

Within Cell 1, the westernmost profile experienced shoreline advancement, while all six of the other profiles experienced shoreline erosion over this monitoring period. PL-J4W, PL-1.5, and PL-2 experienced the largest shoreline erosion, with shoreline losses of 8.3 feet, 6.7 feet, and 7.3 feet, respectively. PL-2.5, PL-3, and PL-3.5 all experienced shoreline losses on a smaller magnitude, ranging from approximately 1.8 feet to 2.9 feet. Conversely, BL-STA-10+00 experienced the only shoreline advancement, with a shoreline gain of 10.5 feet. Overall, Cell 1 had an average shoreline change of -2.7 feet over this monitoring period, which supports the movement of placed material within the cell from east to west.

Within Cell 2, the trend in shoreline change over this monitoring period was similar to Cell 1, with the majority profiles experiencing shoreline erosion with typically higher shoreline losses on the eastern side of the cell. However, the westernmost profile experienced the most significant shoreline erosion, which may be partially influenced by the T-Groin structure along this profile alignment. The largest shoreline erosion occurred at BL-STA-20+00, with a shoreline loss of 29.8 feet. Significant shoreline erosion also occurred along the eastern end of the cell at PL-4, PL-4.5, and PL-5, with shoreline losses of 8.3 feet, 6.8 feet, and 4.9 feet, respectively. PL-5.5, located in the middle of the cell, experienced a smaller shoreline loss of 2.5 feet. PL-6 experienced the only shoreline advancement within the cell, with a shoreline gain of 1.4 feet. Overall, Cell 2 experienced the largest average shoreline erosion over this monitoring period with a shoreline change of -8.5 feet, which is reflected by the large shoreline erosion at BL-STA-20+00 and the additional erosion for all but one profile.

Within Cell 3, the trend in shoreline change generally supports sediment transport from east to west, with the two eastern profiles experiencing shoreline erosion and three of the four western profiles experiencing shoreline advancement. Similar to Cell 2, the westernmost profile, BL-STA-30+20, experienced the largest shoreline erosion, with a shoreline loss of 10.4 feet. PL-6.5 and PL-7 at the eastern end of the cell also experienced shoreline erosion, with shoreline losses of 4.5 feet and 3.3 feet, respectively. PL-7.5, PL-8, and PL-8.5 experienced shoreline advancement, with shoreline gains of 2.4 feet, 2.0 feet and 0.9 feet, respectively. Overall, Cell 3 had the smallest average shoreline erosion, with an average shoreline change of -2.1 feet over this monitoring period.

The average shoreline change across all three cells of Smathers Beach over this monitoring period was -4.4 feet. All three cells had a similar trend, with all cells experiencing shoreline erosion along the eastern end of each respective cell and the largest shoreline advancement in the western half of each respective cell; however, Cells 2 and 3 also showed shoreline erosion at the westernmost profile. This trend in shoreline change supports the general sediment transport pattern from east to west along the Smathers Beach project area. Figure 3 below provides a visual representation of the shoreline change over this monitoring period at each profile along the 2019 Smathers Beach project area based on the July 2021 and September 2022 surveys, while Table 5 provides a summary and averages by cell.

#### 3.1.2. May 2019 to September 2022

Cell 1 has an average added beach width remaining of 3.6 feet, which is the smallest average added beach width remaining of the three cells. The largest added beach widths remaining in Cell 1 are located on the western side of the cell where PL-3, PL-3.5, and BL-STA-10+00 have added beach widths remaining of 10.8 feet, 26.2 feet, and 38.9 feet, respectively. Shoreline widths for all four of the profiles on the eastern side of the cell show a shoreline loss compared to the pre-construction survey, with the most significant shoreline loss compared to the pre-construction survey of -33.2 feet at PL-J4W, which is the easternmost profile. This trend

in added beach width remaining supports movement of placed material from the eastern end of the cell to the western end of the cell.

Cell 2 has an average added beach width remaining of 10.0 feet, with all but two profiles showing a positive added beach width remaining. This suggests a more stable condition for this cell compared to Cell 1. The largest added beach widths remaining in Cell 2 are located in the western half of the cell where PL-5.5 and PL-6 have added beach widths remaining of 20.2 feet and 35.2 feet, respectively. PL-4.5 and PL-5 have added beach widths remaining of 7.2 feet and 5.9 feet, respectively. The two profiles at either end of the cell show a shoreline loss compared to the pre-construction survey, with PL-4 (eastern end) and BL-STA-20+00 (western end) showing shoreline losses of -2.0 feet and -6.4 feet, respectively. It should be noted that the significant shoreline loss over the current monitoring period (July 2021 to September 2022) at BL-STA-20+00, which may be partially influenced by the T-Groin structure along this profile alignment, is a contributing factor to the shoreline loss compared to the pre-construction survey. This trend in added beach width remaining generally supports movement of placed material from the eastern end of the cell to the western end of the cell.

Cell 3 has an average added beach width remaining of 16.3 feet, with all but one profile showing a positive added beach width remaining. Similar to Cell 2, this suggests a more stable condition for this cell compared to Cell 1. PL-8, PL-8.5, and BL-STA-30+20 on the western side of the cell have the largest added beach widths remaining of 27.3 feet, 30.5 feet, and 22.2 feet, respectively. The magnitude of the added beach widths remaining towards the eastern side of Cell 3 are smaller where PL-7 and PL-7.5 have added beach widths remaining of 2.3 feet and 17.2 feet, respectively. The easternmost profile, PL-6.5, shows a slight shoreline loss compared to the pre-construction survey of -1.7 feet. This trend in added beach width remaining supports movement of placed material from the eastern end of the cell to the western end of the cell.

The average added beach width remaining from the 2019 nourishment project across all three cells of Smathers Beach as of the three-year post-construction survey in September 2022 is 9.6 feet. All three cells had a similar trend, with the largest added beach width remaining primarily along the western end of each respective cell, which supports the overall trend in sediment transport from East to West along the Smathers Beach project area. Figure 4 below gives a visual representation of the added beach width remaining at each profile along the 2019 Smathers Beach project area based on the three-year post-construction monitoring survey conducted in September 2022, while Table 5 provides a summary and averages by cell. It should be noted that in Figure 4, 'zero' represents the pre-construction (May 2019) shoreline position.

Figure 3 – Shoreline Change (ft) from July 2021 to September 2022

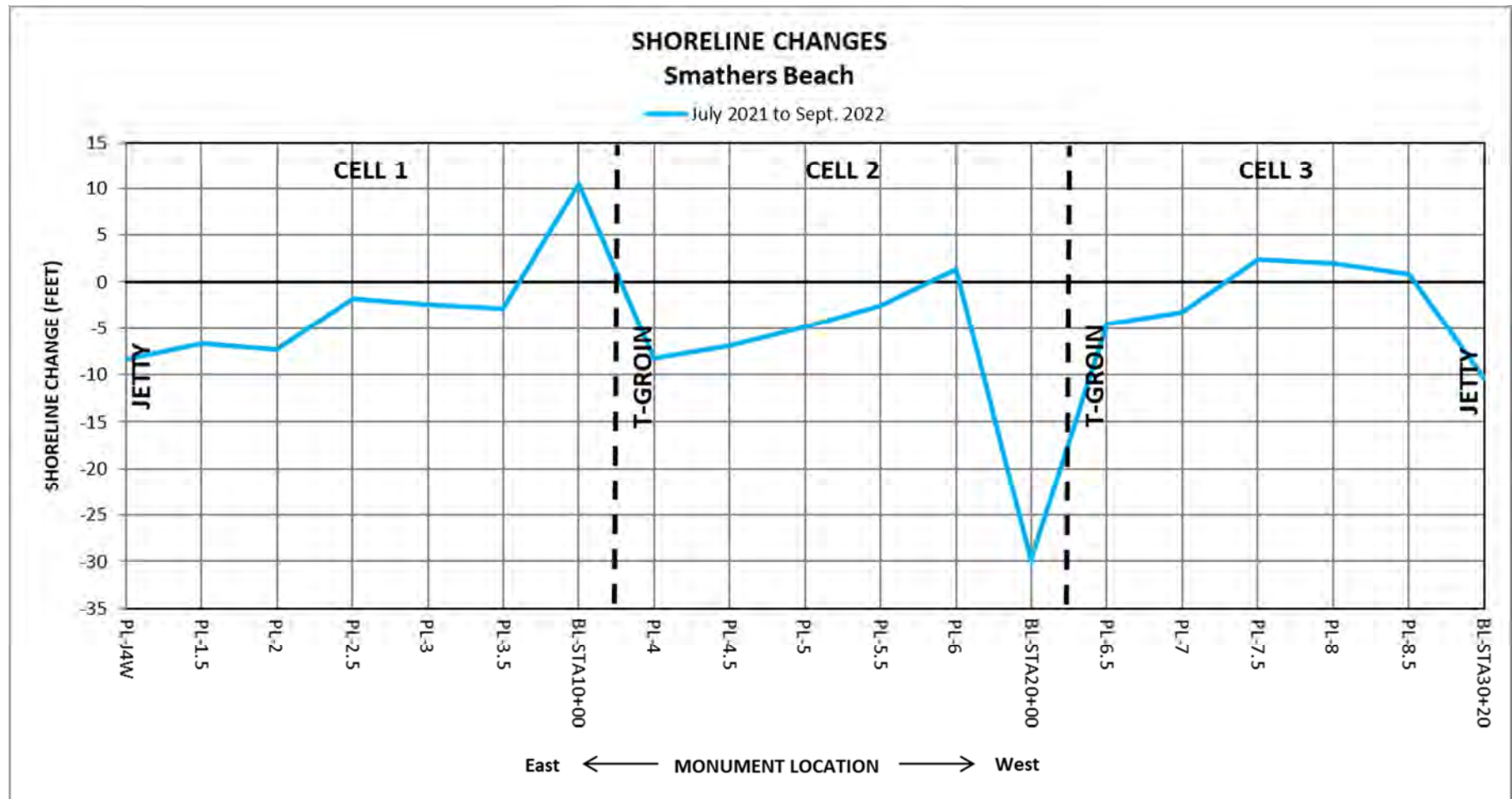
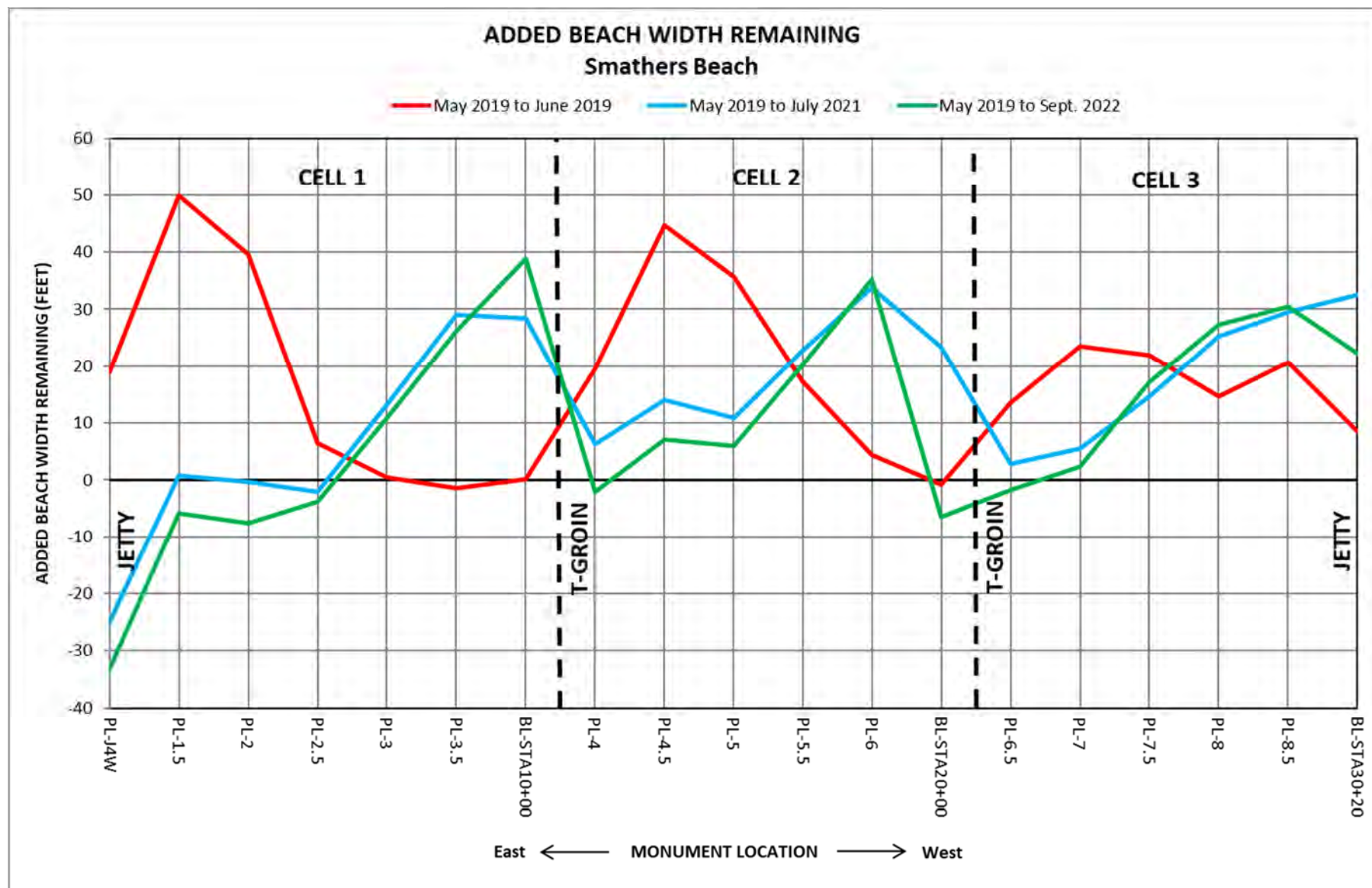


Figure 4 – Changes in Added Beach Width Remaining (ft)



**Table 5 – MHW Shoreline Changes and Added Beach Widths Remaining (ft)**

| Cell              | Monument/Transect      | Added Beach Width Remaining (ft) | Shoreline Change (ft) |                        |                         |
|-------------------|------------------------|----------------------------------|-----------------------|------------------------|-------------------------|
|                   |                        | May 2019 to Sept. 2022           | May 2019 to June 2019 | June 2019 to July 2021 | July 2021 to Sept. 2022 |
| Jetty             |                        |                                  |                       |                        |                         |
| 1                 | PL-J4W                 | -33.2                            | 18.9                  | -43.8                  | -8.3                    |
|                   | PL-1.5                 | -5.9                             | 49.8                  | -49.1                  | -6.7                    |
|                   | PL-2                   | -7.7                             | 39.6                  | -39.9                  | -7.3                    |
|                   | PL-2.5                 | -3.8                             | 6.5                   | -8.5                   | -1.8                    |
|                   | PL-3                   | 10.8                             | 0.4                   | 12.8                   | -2.4                    |
|                   | PL-3.5                 | 26.2                             | -1.5                  | 30.6                   | -2.9                    |
|                   | BL-STA-10+00           | 38.9                             | 0.1                   | 28.3                   | 10.5                    |
| T-Groin           |                        |                                  |                       |                        |                         |
| 2                 | PL-4                   | -2.0                             | 19.6                  | -13.3                  | -8.3                    |
|                   | PL-4.5                 | 7.2                              | 44.7                  | -30.7                  | -6.8                    |
|                   | PL-5                   | 5.9                              | 35.8                  | -24.9                  | -4.9                    |
|                   | PL-5.5                 | 20.2                             | 17.3                  | 5.4                    | -2.5                    |
|                   | PL-6                   | 35.2                             | 4.3                   | 29.5                   | 1.4                     |
|                   | BL-STA-20+00           | -6.4                             | -0.8                  | 24.2                   | -29.8                   |
| T-Groin           |                        |                                  |                       |                        |                         |
| 3                 | PL-6.5                 | -1.7                             | 13.6                  | -10.8                  | -4.5                    |
|                   | PL-7                   | 2.3                              | 23.6                  | -18.0                  | -3.3                    |
|                   | PL-7.5                 | 17.2                             | 21.9                  | -7.2                   | 2.4                     |
|                   | PL-8                   | 27.3                             | 14.8                  | 10.6                   | 2.0                     |
|                   | PL-8.5                 | 30.5                             | 20.7                  | 8.9                    | 0.9                     |
|                   | BL-STA-30+20           | 22.2                             | 8.5                   | 24.1                   | -10.4                   |
| Jetty             |                        |                                  |                       |                        |                         |
| Average Per Reach |                        |                                  |                       |                        |                         |
| 1                 | PL-J4W to BL-STA-10+00 | 3.6                              | 16.3                  | -9.9                   | -2.7                    |
| 2                 | PL-4 to BL-STA-20+00   | 10.0                             | 20.2                  | -1.6                   | -8.5                    |
| 3                 | PL-6.5 to BL-STA-30+20 | 16.3                             | 17.2                  | 1.3                    | -2.1                    |
|                   |                        |                                  |                       |                        |                         |
| 1, 2, & 3         | Project Area           | 9.6                              | 17.8                  | -3.8                   | -4.4                    |
|                   | PL-J4W to BL-STA-30+20 |                                  |                       |                        |                         |

## 3.2. Volumetric Change

The 2019 Smathers Beach nourishment project supplied additional sand to all three cells of Smathers Beach and was completed between May and June of 2019. This section evaluates the effectiveness of the project based on the volume change and volume of fill material remaining as of the three-year post-construction monitoring survey from September 2022. Volumetric changes for beach reaches were calculated using the Average-End-Area method, which is calculated as the average difference in cross-sectional area between each survey data set multiplied by the effective distance between two adjacent profile lines. For beach reaches immediately adjacent to structures, the cross-sectional area of the nearest profile was applied across the distance to the structure. The extent of the volume calculations for the post-construction survey is from the upland extent of the fill template to the overlapping extent of valid survey data offshore.

### 3.2.1. July 2021 to September 2022

Within Cell 1, the westernmost reach gained material, while the remaining six reaches lost material over this monitoring period. The largest volume losses occurred toward the eastern end of the cell and the middle of the cell from PL-1.5 to PL-2, PL-2 to PL-2.5, PL-2.5 to PL-3, and PL-3 to PL-3.5, which lost 429 cubic yards, 263 cubic yards, 222 cubic yards, and 265 cubic yards, respectively. The reaches from PL-J4W to PL-1.5 and PL-3.5 to BL-STA-10+00 also experienced minor volume losses of 88 cubic yards and 22 cubic yards, respectively. Conversely, the only volume gain occurred at the western end of the cell from BL-STA-10+00 to the T-Groin, which gained 18 cubic yards. Overall, Cell 1 experienced a total volume loss over this monitoring period of 1,272 cubic yards, which was largest volume loss experienced by any individual cell during this monitoring period.

Within Cell 2, the reaches at both ends of the cell experienced volume losses and two of the middle reaches experienced volume gains. The volume losses toward the eastern end of the cell from the T-Groin to PL-4, PL-4 to PL-4.5, and PL-4.5 to PL-5 were 104 cubic yards, 432 cubic yards, and 238 cubic yards, respectively. The volume losses toward the western end of the cell from PL-6 to BL-STA-20+00 and BL-STA-20+00 to the T-Groin were 285 cubic yards and 166 cubic yards, respectively, which may both be partially influenced by the T-Groin structure along the BL-STA-20+00 profile alignment. Conversely, the volume gains occurred toward the middle of the cell from PL-5 to PL-5.5 and PL-5.5 to PL-6 which gained 54 cubic yards and 104 cubic yards, respectively. Overall, Cell 2 had total volume loss of 1,066 cubic yards.

Within Cell 3, the trend in volume change over this monitoring period was similar to Cell 2, with volume losses at each end of the cell and volume gains towards the middle of the cell. However, the magnitude of volume losses in Cell 3 are smaller than those experienced within the other two cells. The eastern end of the cell had the largest volume losses from the T-Groin to PL-6.5 and PL-6.5 to PL-7 experiencing volume losses of 66 cubic yards and 135 cubic yards, respectively. The two reaches at the western side of Cell 3 from PL-8.5 to BL-STA-30+20 and BL-STA-30+20 to the jetty at the western end of the cell also experienced volume losses of 13 cubic yards and 34 cubic yards, respectively. PL-7 to PL-7.5, PL-7.5 to PL-8, and PL-8 to PL-8.5 in the middle of the cell had volume gains of 103 cubic yards, 287 cubic yards, and 175 cubic yards, respectively. Overall, Cell 3 had a total volume gain of 317 cubic yards over this monitoring period and was the only cell to experience a net volume gain during this monitoring period.

All three cells of Smathers Beach combined have experienced an overall loss of 2,021 cubic yards of material over this monitoring period from July 2021 to September 2022. Both Cell 1 and Cell 2 experienced a net volume loss, while Cell 3 was the only cell to experience a net volume gain over the past year. The largest volume losses were typically seen at the eastern ends of each cell and the largest volume gains were typically seen towards the middle or at the western ends of each cell. Figure 5 below gives a visual representation of the volume change over this monitoring period for each reach along the 2019 Smathers Beach project area based on the July 2021 and September 2022 surveys, while Table 6 provides a summary and total volume change by cell.

### 3.2.2. May 2019 to September 2022

Cell 1 has a total volume remaining of 98 cubic yards, which is the smallest total volume remaining of the three cells. This is supported by the larger total volume change seen over this monitoring period in this cell. The largest volumes remaining in Cell 1 are located on the western side of the cell where the reaches from PL-3 to PL-3.5 and PL-3.5 to BL-STA-10+00 have volumes remaining of 904 cubic yards and 713 cubic yards,

respectively. The three reaches on the eastern side of the cell from PL-J4W to PL-2.5, which had the largest volumes of material placed during construction, have actually lost material compared to the pre-construction survey. This trend in volume remaining supports movement of placed material from the eastern end of the cell to the western end of the cell.

Cell 2 has a total volume remaining of 3,469 cubic yards, with all but the westernmost reach showing volume remaining from the 2019 nourishment project. This suggests a more stable condition for this cell compared to Cell 1. The largest volumes remaining in Cell 2 are located in the middle of the cell where the reaches from PL-4 to PL-6 have volumes remaining ranging from 441 cubic yards to 1,366 cubic yards. BL-STA-20+00 to the T-Groin showed a loss of material compared to the pre-construction survey on the order of 80 cubic yards, which may be partially influenced by the T-Groin structure along the BL-STA-20+00 profile alignment. The shift of the volume remaining from the eastern end of the cell towards the middle and western ends of the cell generally supports the anticipated movement of placed material from the eastern end of the cell to the western end of the cell.

Cell 3 has a total volume remaining of 4,362 cubic yards, with all reaches showing volume remaining from the 2019 nourishment project. This exceeds the total placed volume in this cell of 3,970 cubic yards based on the 2019 As-Built survey data. Like Cell 2, this suggests a more stable condition for this cell compared to Cell 1. The largest volumes remaining in Cell 3 are located in the middle of the cell where the reaches from PL-7 to PL-8.5 have volumes remaining ranging from 902 cubic yards to 1,282 cubic yards. The reaches from PL-6.5 to PL-7 and PL-8.5 to BL-STA-30+20 also had significant volumes remaining of 409 cubic yards and 569 cubic yards, respectively. The shift of the volume remaining from the eastern end of the cell towards the middle and western ends of the cell supports the anticipated movement of placed material from the eastern end of the cell to the western end of the cell.

The total volume remaining across all three cells of Smathers Beach from the 2019 nourishment project as of the three-year post-construction survey in September 2022 is 7,929 cubic yards. All three cells have volume remaining from the 2019 nourishment project. However, Cell 1 has a significantly smaller volume remaining than the other two cells. For all cells, the volume remaining has shifted west within the cells, which supports the overall trend in sediment transport from east to west along the Smathers Beach project area. Figure 6 below gives a representation of the post-construction volumes (May 2019 to June 2019), as well as the volume of material remaining two years after construction (May 2019 to July 2021) and three years after construction (May 2019 to September 2022). Figure 7 depicts the long-term trend of volume remaining for each survey period after construction. Table 6 provides a summary of volume remaining by reach, as well as total volume remaining by cell. It should be noted that in Figure 6 and Figure 7, 'zero' represents the pre-construction (May 2019) condition.

Figure 5 – Volume Change (CY) from July 2021 to September 2022

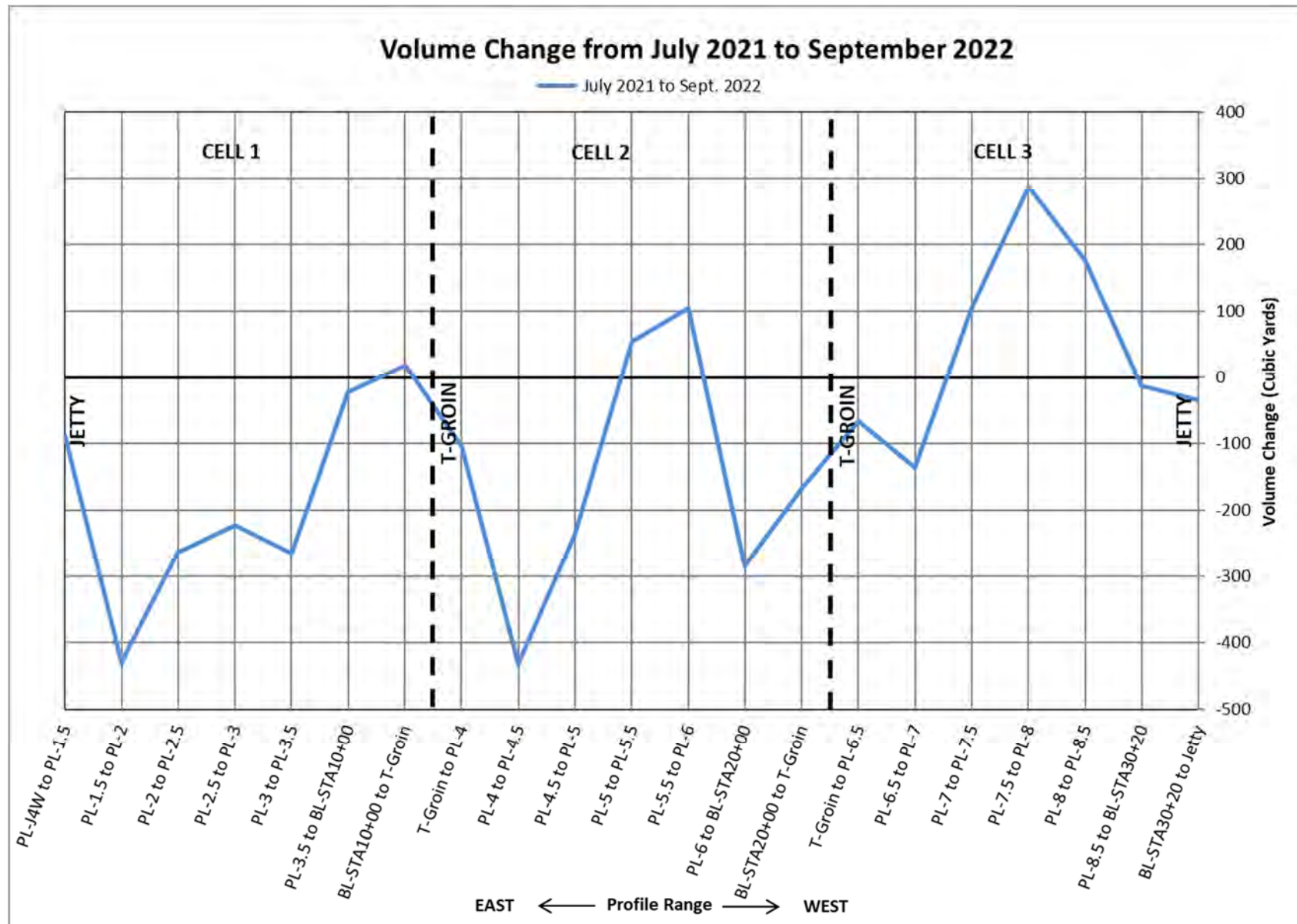


Figure 6 – Changes in Volume of Material Remaining (CY)

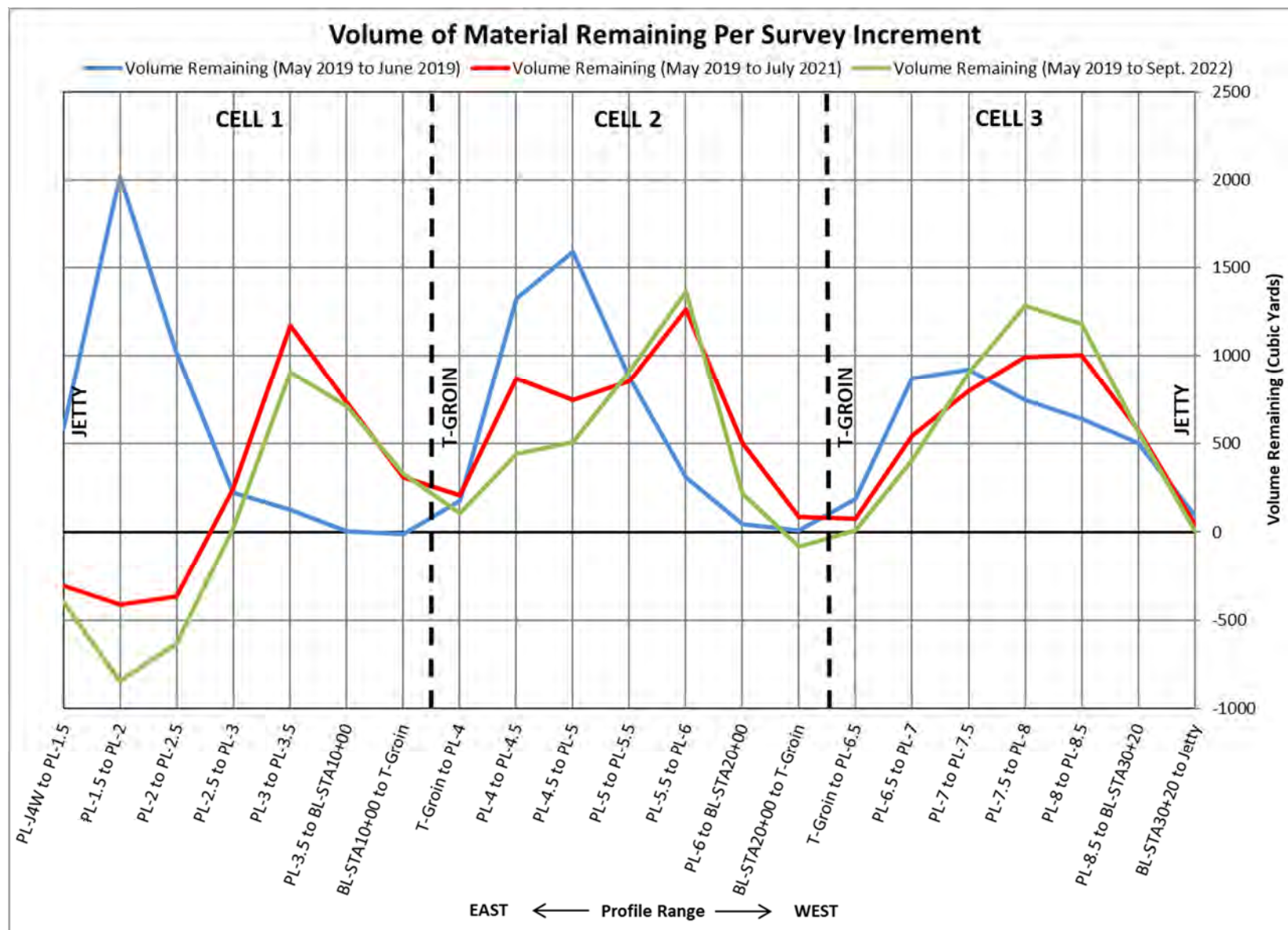
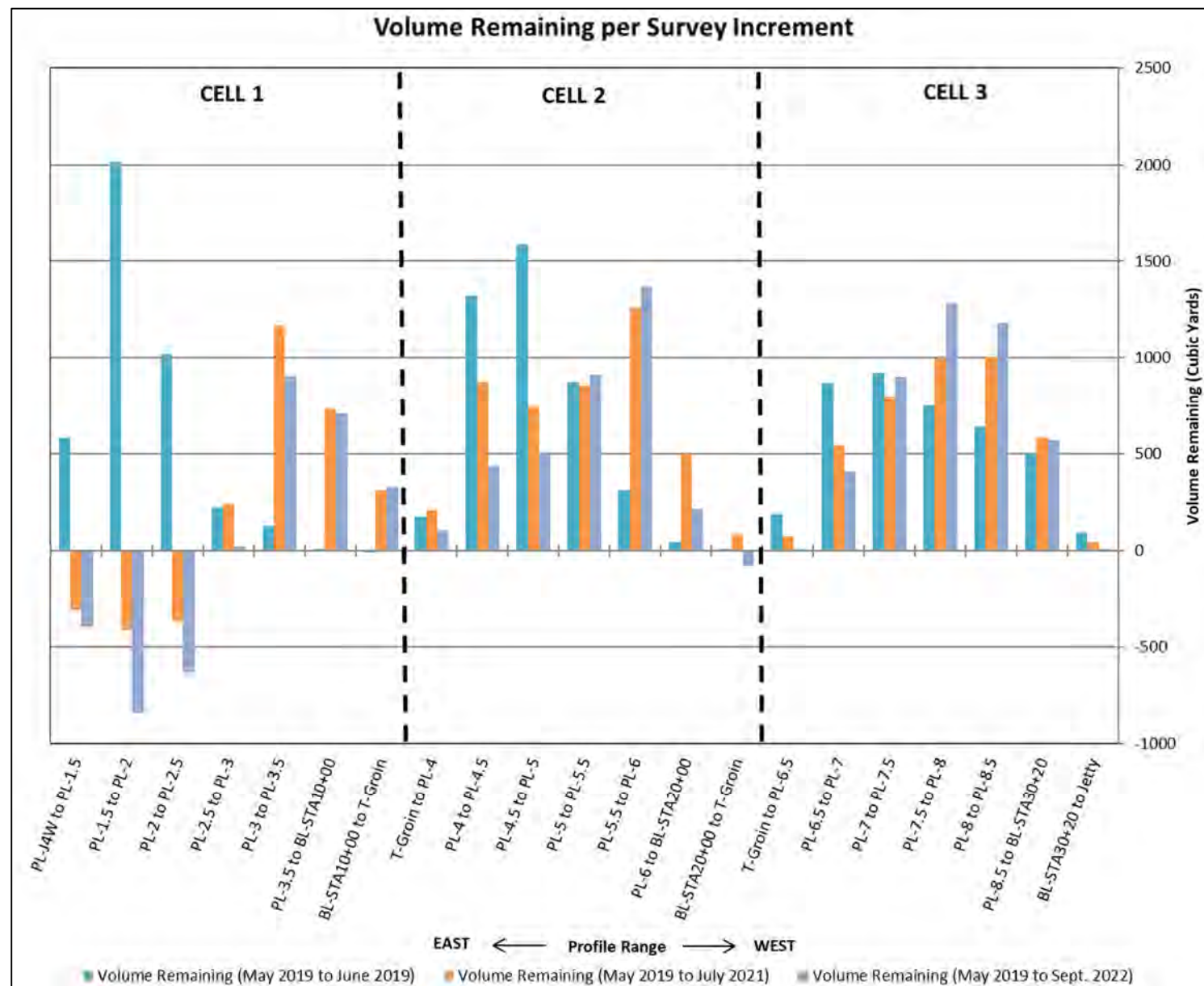


Figure 7 – Trend of Volume of Material Remaining (CY) from May 2019 to September 2022



**Table 6 – Volumetric Changes and Volume Remaining (CY)**

| Cell             | Monument Range<br>(To/From) | Effective<br>Distance<br>Between<br>Monuments<br>(ft) | Volume<br>Remaining<br>(CY) | Volumetric Changes (CY)  |                           |                            |
|------------------|-----------------------------|-------------------------------------------------------|-----------------------------|--------------------------|---------------------------|----------------------------|
|                  |                             |                                                       | May 2019 to<br>Sept. 2022   | May 2019 to<br>June 2019 | June 2019 to<br>July 2021 | July 2021 to<br>Sept. 2022 |
| Jetty            |                             |                                                       |                             |                          |                           |                            |
| 1                | PL-J4W to PL-1.5            | 82                                                    | -396                        | 586                      | -894                      | -88                        |
|                  | PL-1.5 to PL-2              | 200                                                   | -843                        | 2,015                    | -2,430                    | -429                       |
|                  | PL-2 to PL-2.5              | 199                                                   | -632                        | 1,019                    | -1,388                    | -263                       |
|                  | PL-2.5 to PL-3              | 200                                                   | 21                          | 225                      | 18                        | -222                       |
|                  | PL-3 to PL-3.5              | 199                                                   | 904                         | 128                      | 1,041                     | -265                       |
|                  | PL-3.5 to BL-STA-10+00      | 94                                                    | 713                         | 7                        | 728                       | -22                        |
|                  | BL-STA-10+00 to T-Groin     | 44                                                    | 331                         | -10                      | 323                       | 18                         |
| T-Groin          |                             |                                                       |                             |                          |                           |                            |
| 2                | T-Groin to PL-4             | 51                                                    | 105                         | 176                      | 33                        | -104                       |
|                  | PL-4 to PL-4.5              | 200                                                   | 441                         | 1,322                    | -450                      | -432                       |
|                  | PL-4.5 to PL-5              | 199                                                   | 510                         | 1,587                    | -839                      | -238                       |
|                  | PL-5 to PL-5.5              | 200                                                   | 911                         | 876                      | -18                       | 54                         |
|                  | PL-5.5 to PL-6              | 198                                                   | 1,366                       | 312                      | 949                       | 104                        |
|                  | PL-6 to BL-STA-20+00        | 98                                                    | 217                         | 44                       | 458                       | -285                       |
|                  | BL-STA-20+00 to T-Groin     | 27                                                    | -80                         | 9                        | 76                        | -166                       |
| T-Groin          |                             |                                                       |                             |                          |                           |                            |
| 3                | T-Groin to PL-6.5           | 55                                                    | 11                          | 190                      | -113                      | -66                        |
|                  | PL-6.5 to PL-7              | 200                                                   | 409                         | 869                      | -325                      | -135                       |
|                  | PL-7 to PL-7.5              | 199                                                   | 902                         | 923                      | -124                      | 103                        |
|                  | PL-7.5 to PL-8              | 200                                                   | 1,282                       | 751                      | 244                       | 287                        |
|                  | PL-8 to PL-8.5              | 161                                                   | 1,180                       | 642                      | 362                       | 175                        |
|                  | PL-8.5 to BL-STA-30+20      | 158                                                   | 569                         | 501                      | 81                        | -13                        |
|                  | BL-STA-30+20 to Jetty       | 51                                                    | 10                          | 94                       | -50                       | -34                        |
| Jetty            |                             |                                                       |                             |                          |                           |                            |
| Totals Per Reach |                             |                                                       |                             |                          |                           |                            |
| 1                | PL-J4W to BL-STA-10+00      | 1,019                                                 | 98                          | 3,970                    | -2,601                    | -1,272                     |
| 2                | PL-4 to BL-STA-20+00        | 973                                                   | 3,469                       | 4,326                    | 209                       | -1,066                     |
| 3                | PL-6.5 to BL-STA-30+20      | 1,024                                                 | 4,362                       | 3,970                    | 74                        | 317                        |
|                  |                             |                                                       |                             |                          |                           |                            |
| 1, 2, & 3        | Project Area                | 3,016                                                 | 7,929                       | 12,267                   | -2,318                    | -2,021                     |
|                  | PL-J4W to BL-STA-30+20      |                                                       |                             |                          |                           |                            |

## 4. Summary of Findings

### 4.1. Project Performance Summary

For the 2019 Smathers Beach Nourishment Project, performance is generally defined by the added beach width remaining compared to the pre-construction survey (May 2019). This report evaluates the added beach width remaining as a result of the 2019 beach nourishment project from the pre-construction survey in May 2019 to the three-year post-construction monitoring survey in September 2022. Figure 8 shows a schematic of how this criterion is determined. Added beach width, which was presented in Figure 3 and Table 5, is measured from the shoreline, according to MHW, in the pre-construction survey.

**Figure 8 – Beach Width Design Description**

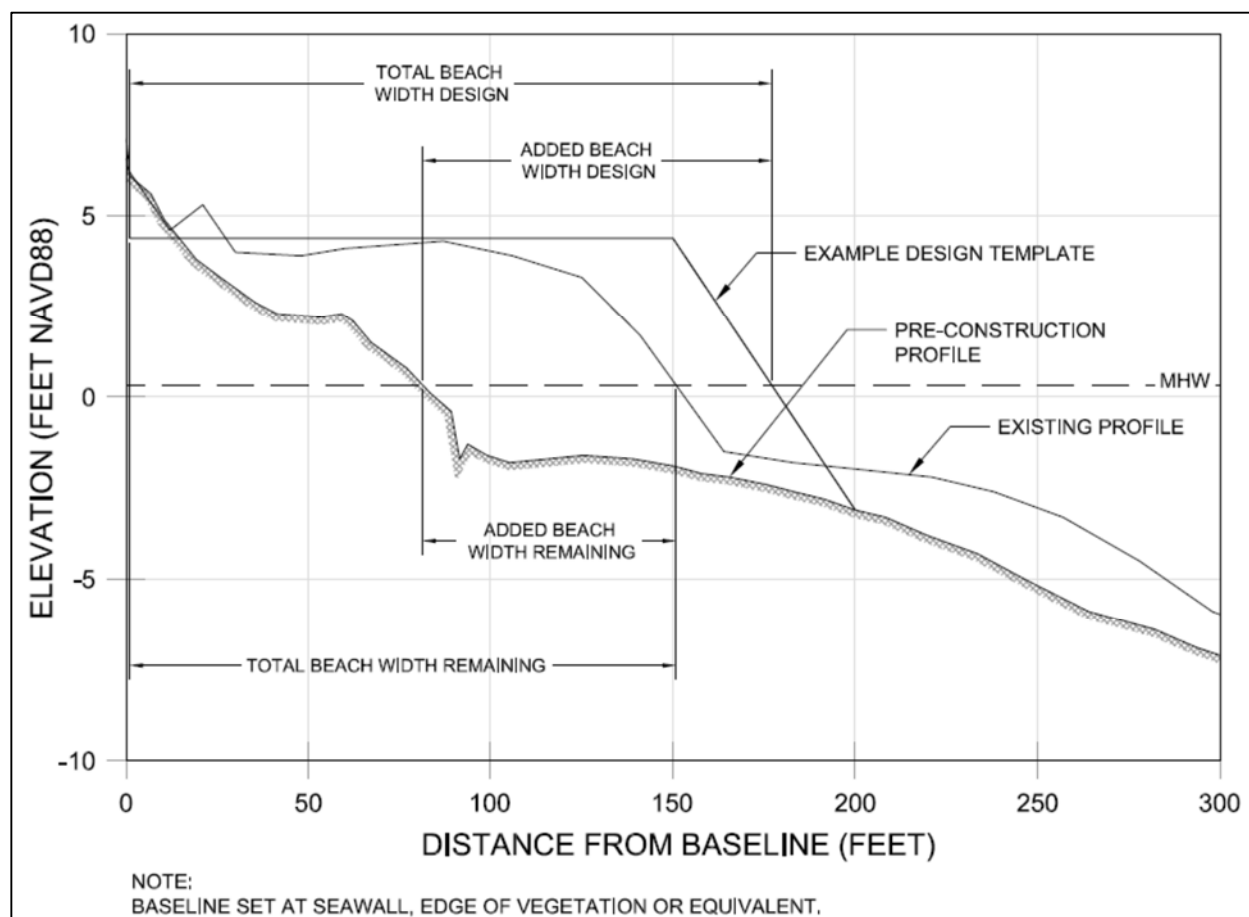
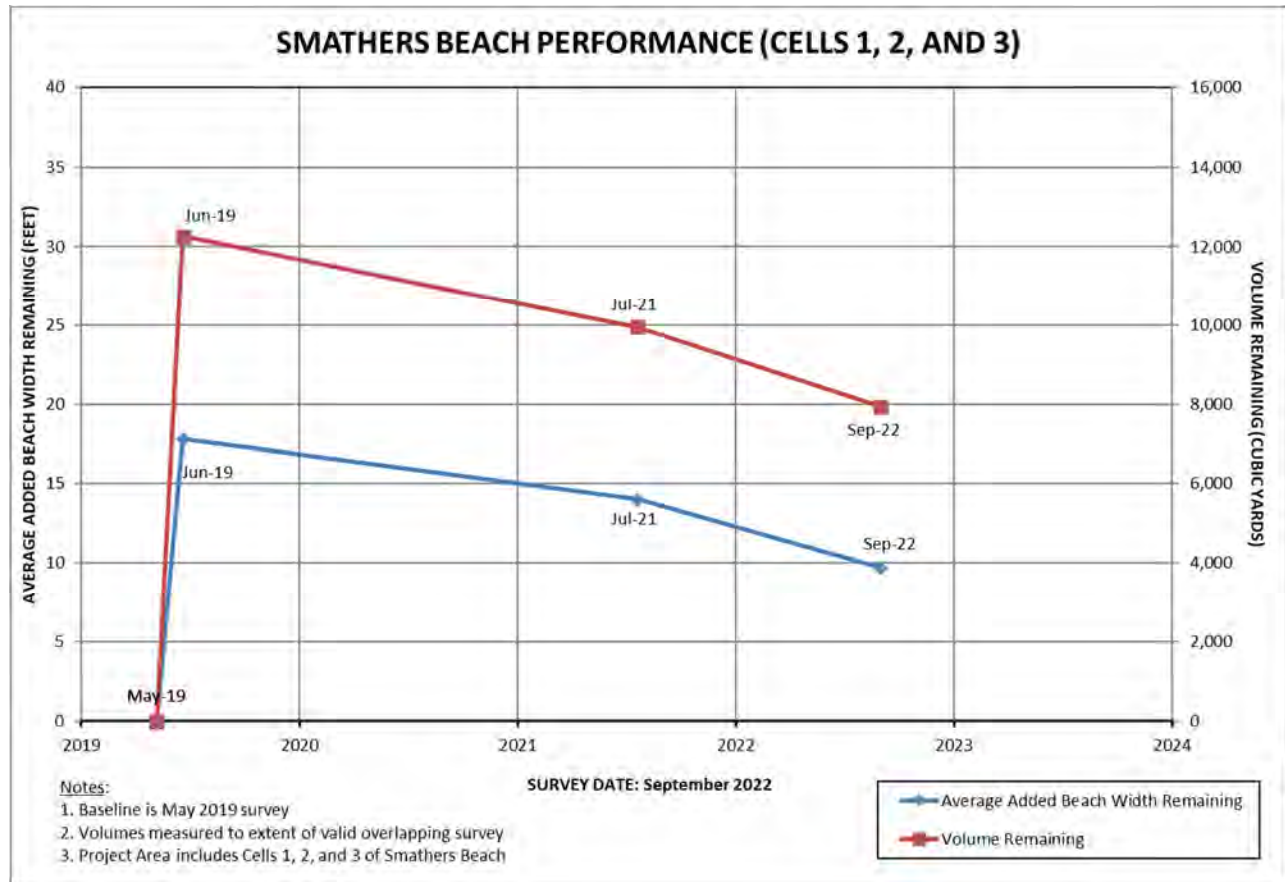


Figure 9 shows a performance summary for the 2019 Smathers Beach Project Area (Cells 1, 2, and 3). The left y-axis represents the total average added beach width remaining (feet) within the 2019 project area referenced to the pre-construction survey in May 2019. The right y-axis represents the total volume remaining (cubic yards) within the 2019 project area referenced to the pre-construction survey in May 2019.

The total beach fill material volume added within the active beach due to the nourishment project (from the landward extent of the fill template seaward to the extent of the valid overlapping survey data) showed a gain in volume from May 2019 to June 2019 of 12,267 cubic yards across all three cells. Additionally, the average added beach width across all cells showed a shoreline advancement of 17.7 feet due to the nourishment event. Over this monitoring period (July 2021 to September 2022), the beach lost a total of 2,021 cubic yards of material and the total volume remaining within the active beach due to the nourishment project from May 2019 to September 2022 is 7,929 cubic yards across all three cells. Furthermore, this monitoring period showed an

average shoreline change of approximately -4.4 feet and the average added beach width remaining across all three cells is 9.6 feet.

**Figure 9 – Smathers Beach Performance**



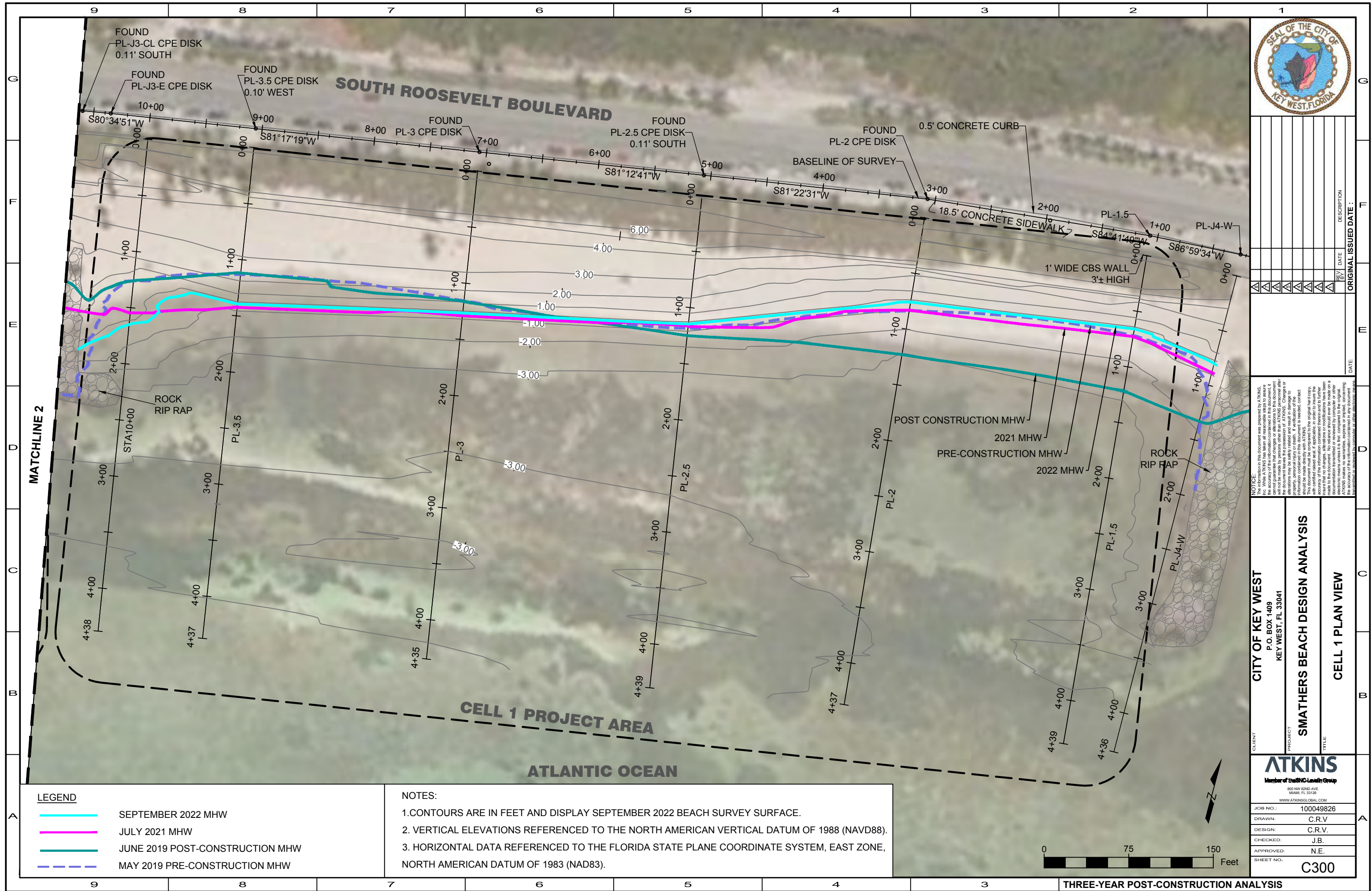
## 4.2. Conclusions

The 2019 Smathers Beach nourishment project, which was constructed by Earth Tech Enterprises between May 21 and June 5, 2019, included the placement of beach fill material within all three cells of Smathers Beach. Over this monitoring period (July 2021 to September 2022), the Smathers Beach project area lost a total of 2,021 cubic yards of material and the shoreline retreated an average of 4.4 feet across its three cells. Between the May 2019 pre-construction survey and the September 2022 three-year post-construction monitoring survey, Smathers Beach has a total volume remaining of 7,929 cubic yards, which accounts for approximately 65% of the volume added during the 2019 nourishment event. Further, Smathers Beach has an average added beach width remaining of 9.6 feet across all three cells, accounting for approximately 54% of the average added beach width established during the 2019 nourishment event.

# Appendices

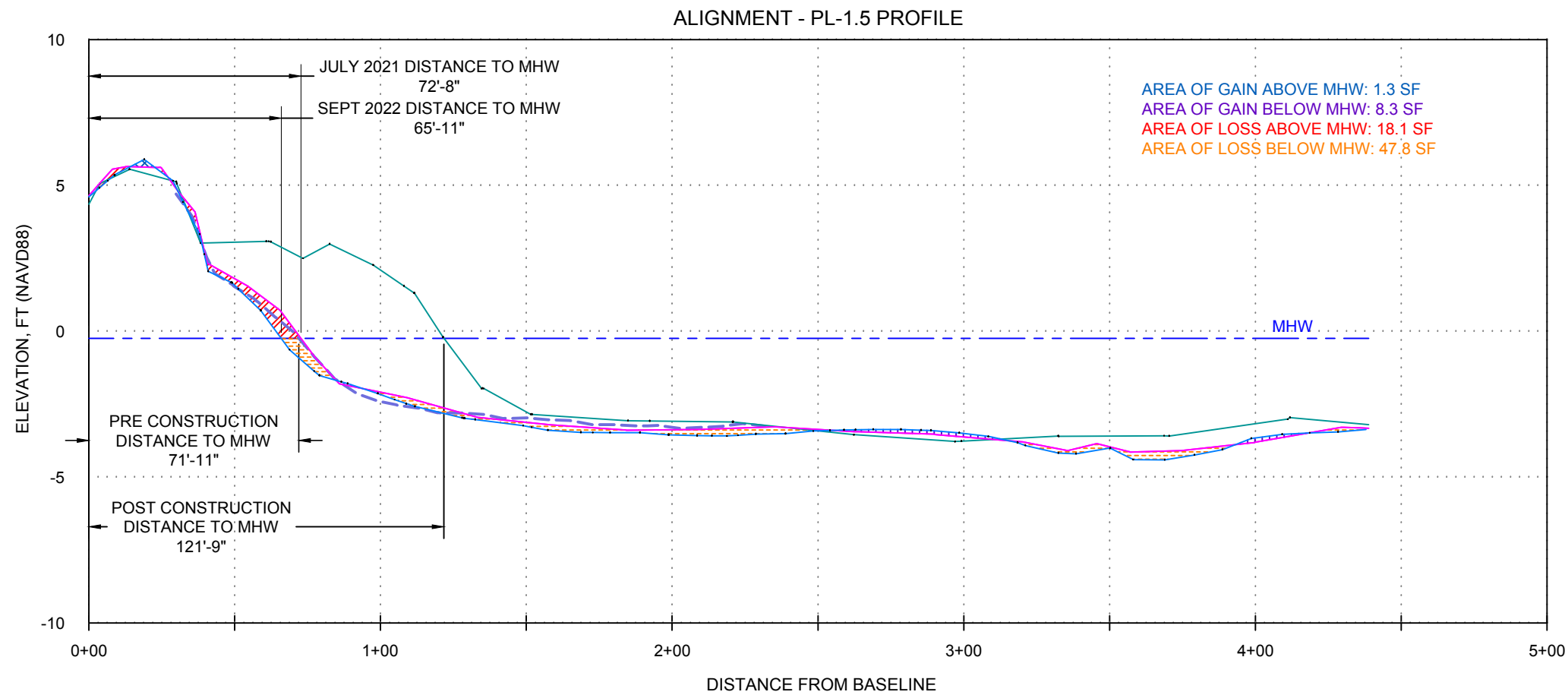
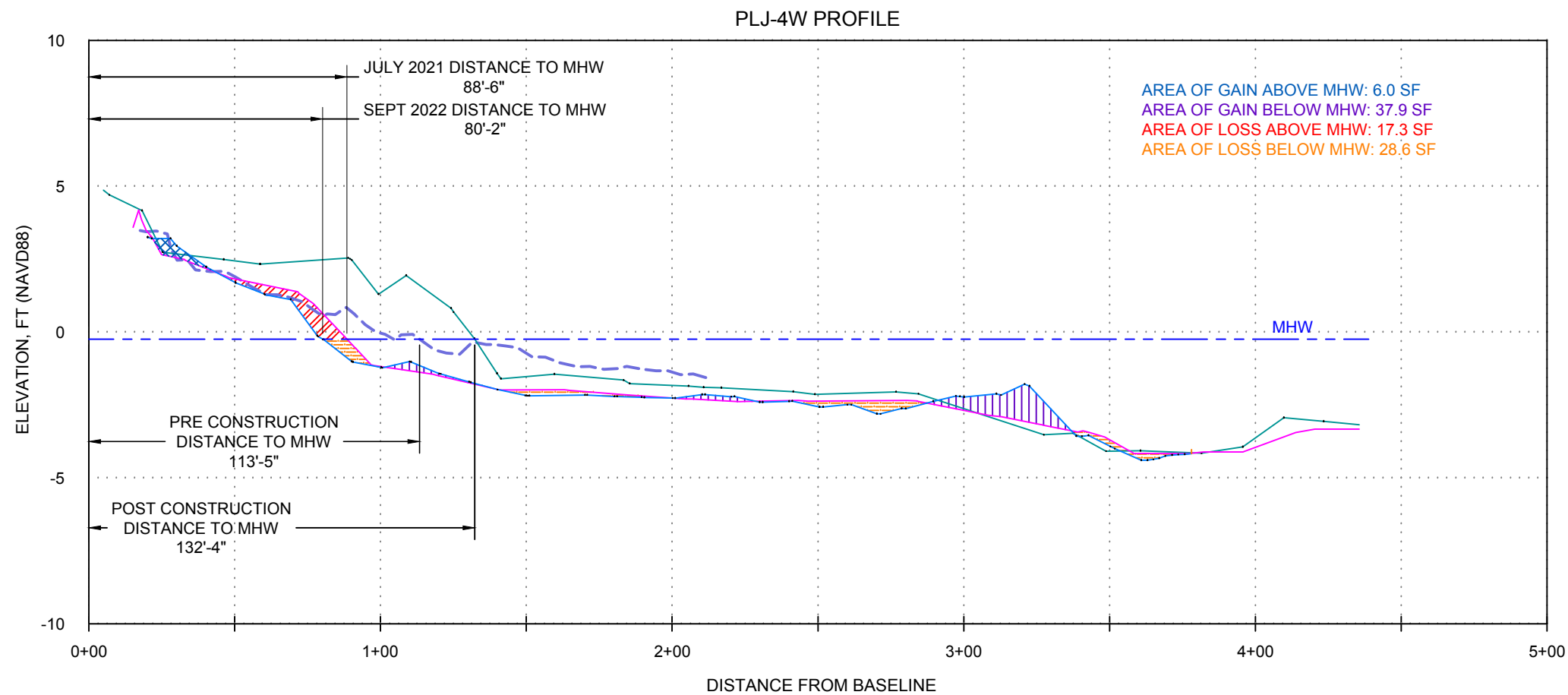


# Appendix A. Plan View and Comparative Profiles for Smathers Beach (May 2019 – September 2022)









**LEGEND**

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|  | SEPTEMBER 2022 BEACH SURVEY                         |
|  | JULY 2021 BEACH SURVEY                              |
|  | JUNE 2019 AS-BUILT SURVEY                           |
|  | MAY 2019 PRE-CONSTRUCTION SURVEY                    |
|  | MEAN HIGH WATER LINE (MHW)<br>MHW = -0.24' (NAVD88) |
|  | AREA OF GAIN ABOVE MHW                              |
|  | AREA OF GAIN BELOW MHW                              |
|  | AREA OF LOSS ABOVE MHW                              |
|  | AREA OF LOSS BELOW MHW                              |

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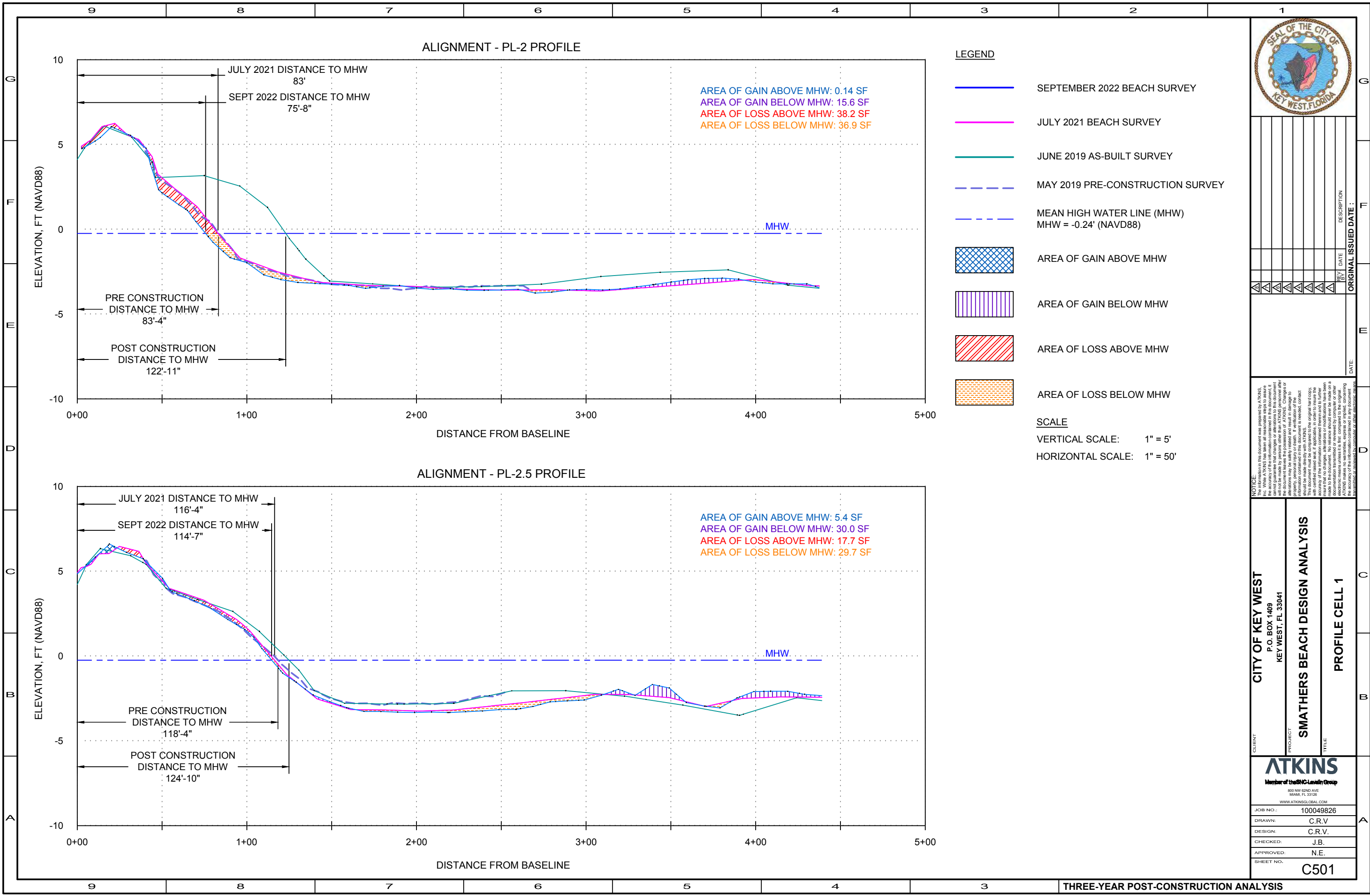
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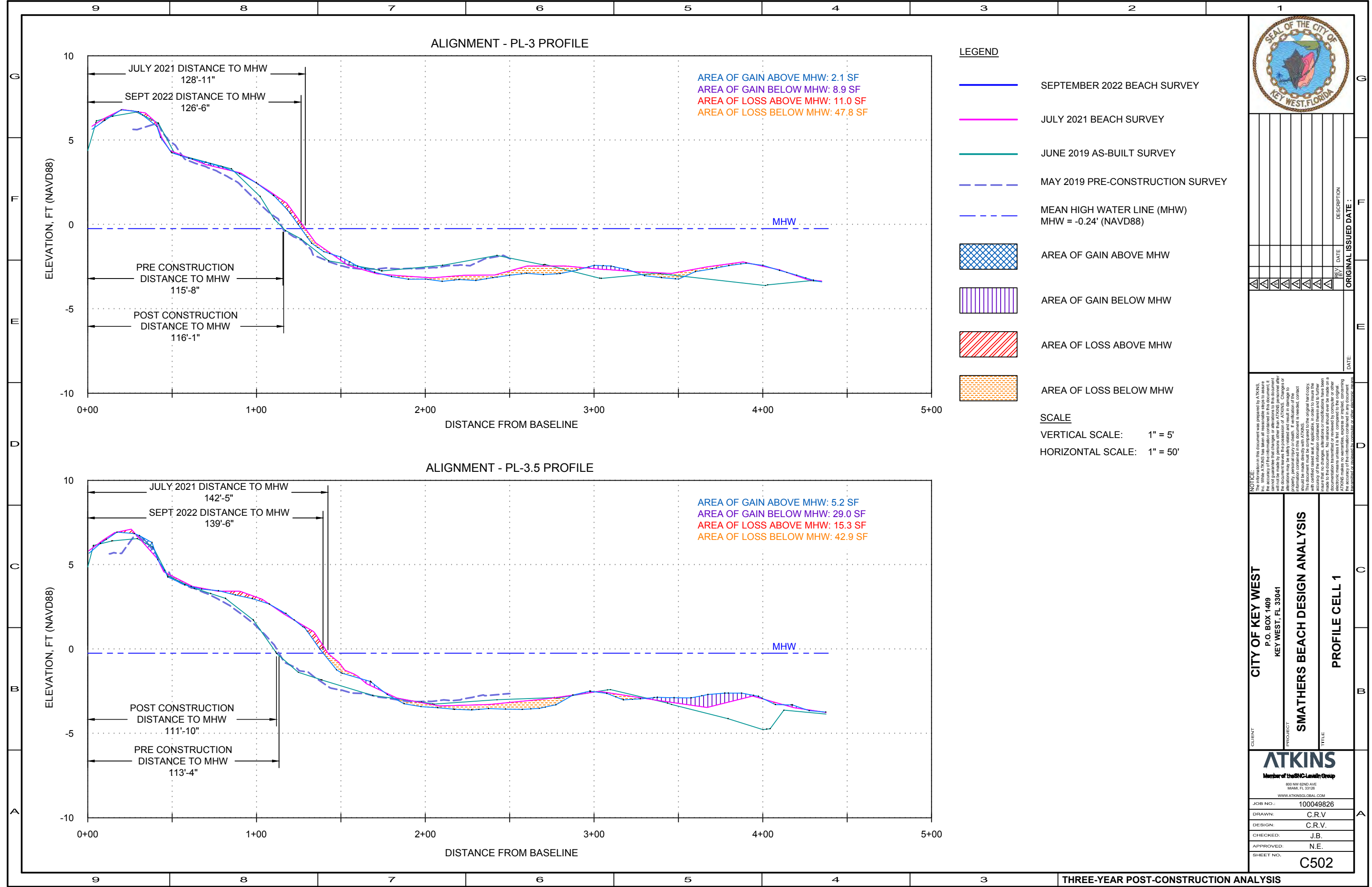
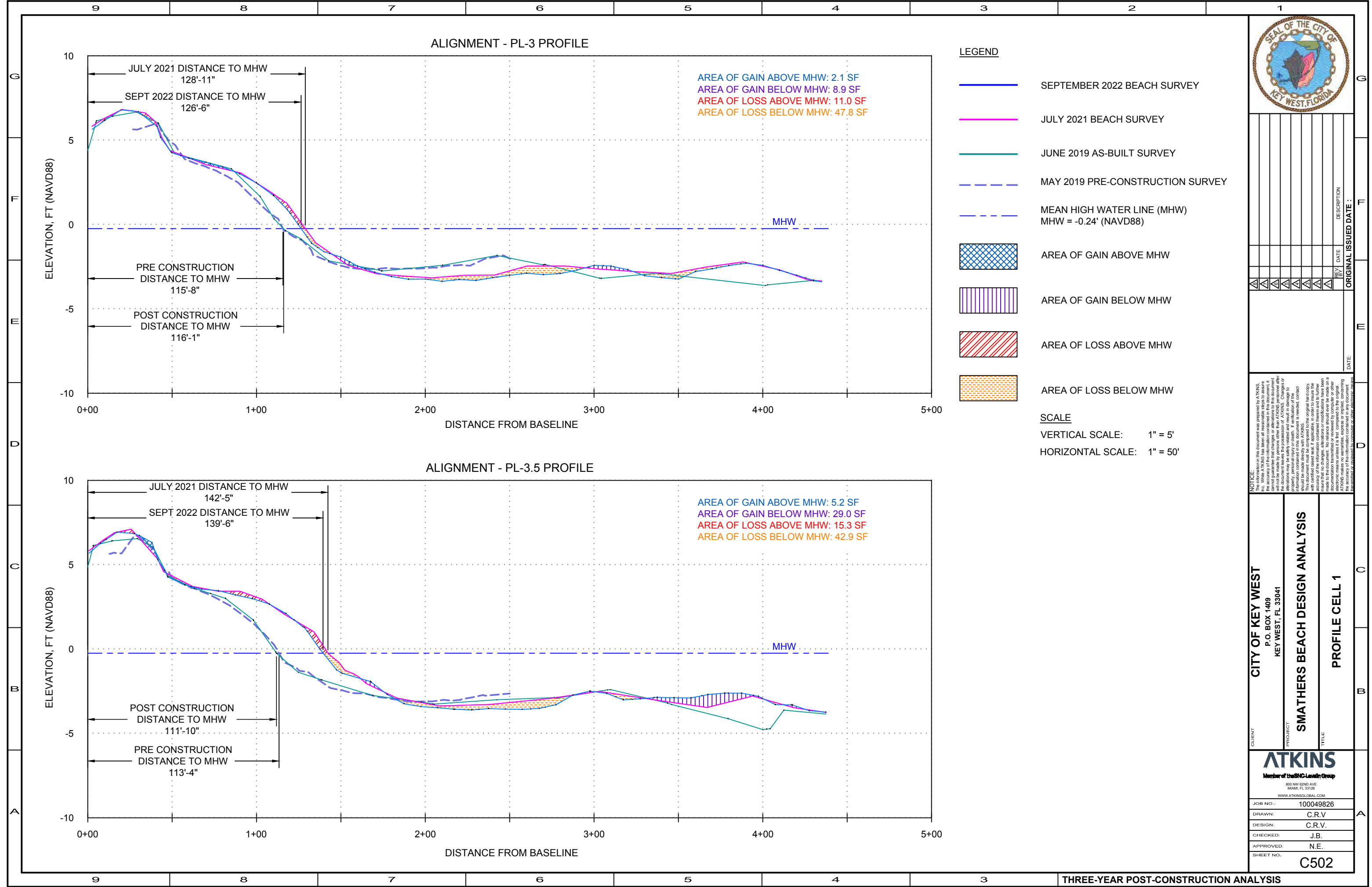
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### THREE-YEAR POST-CONSTRUCTION ANALYSIS





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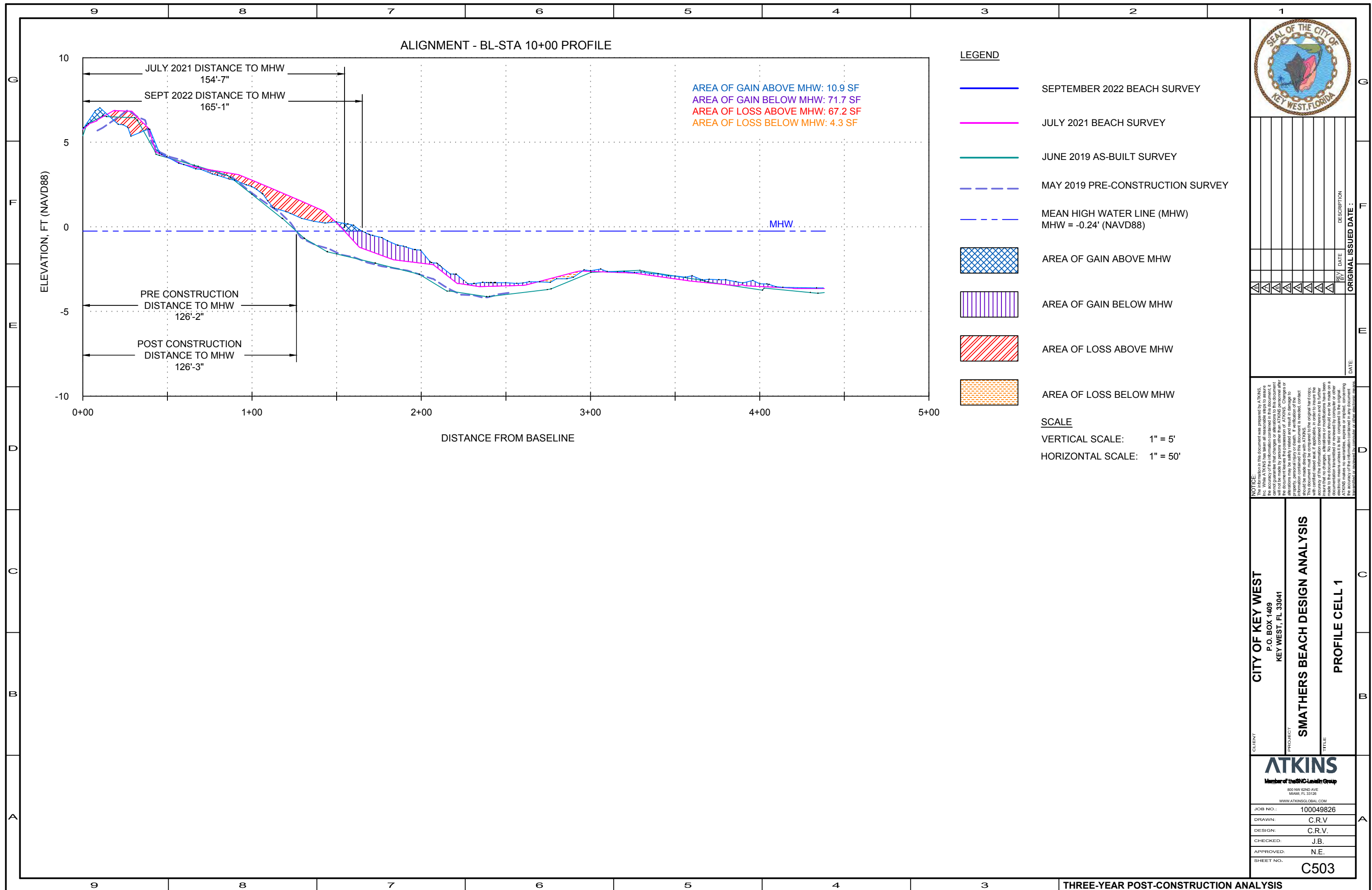
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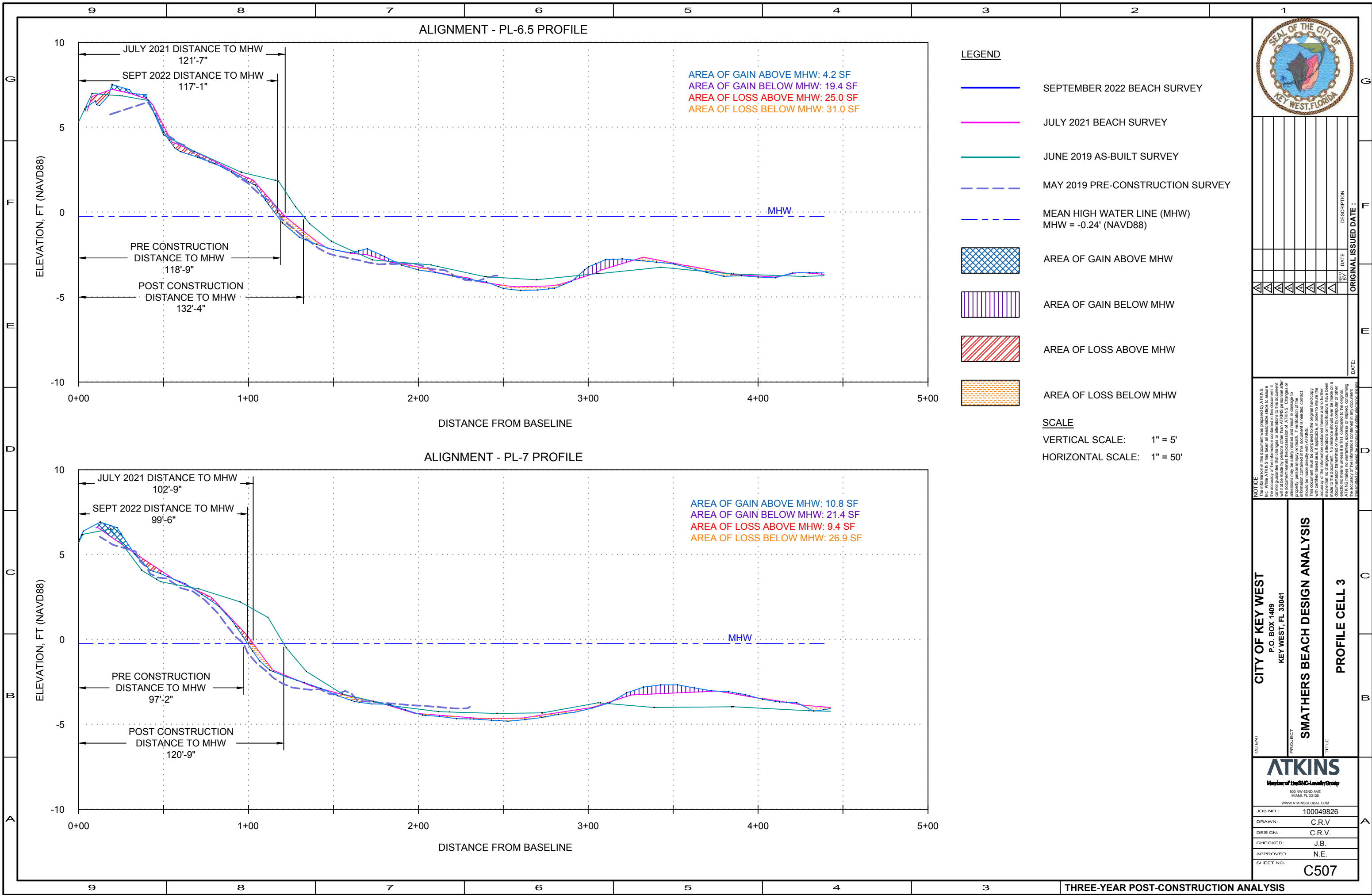
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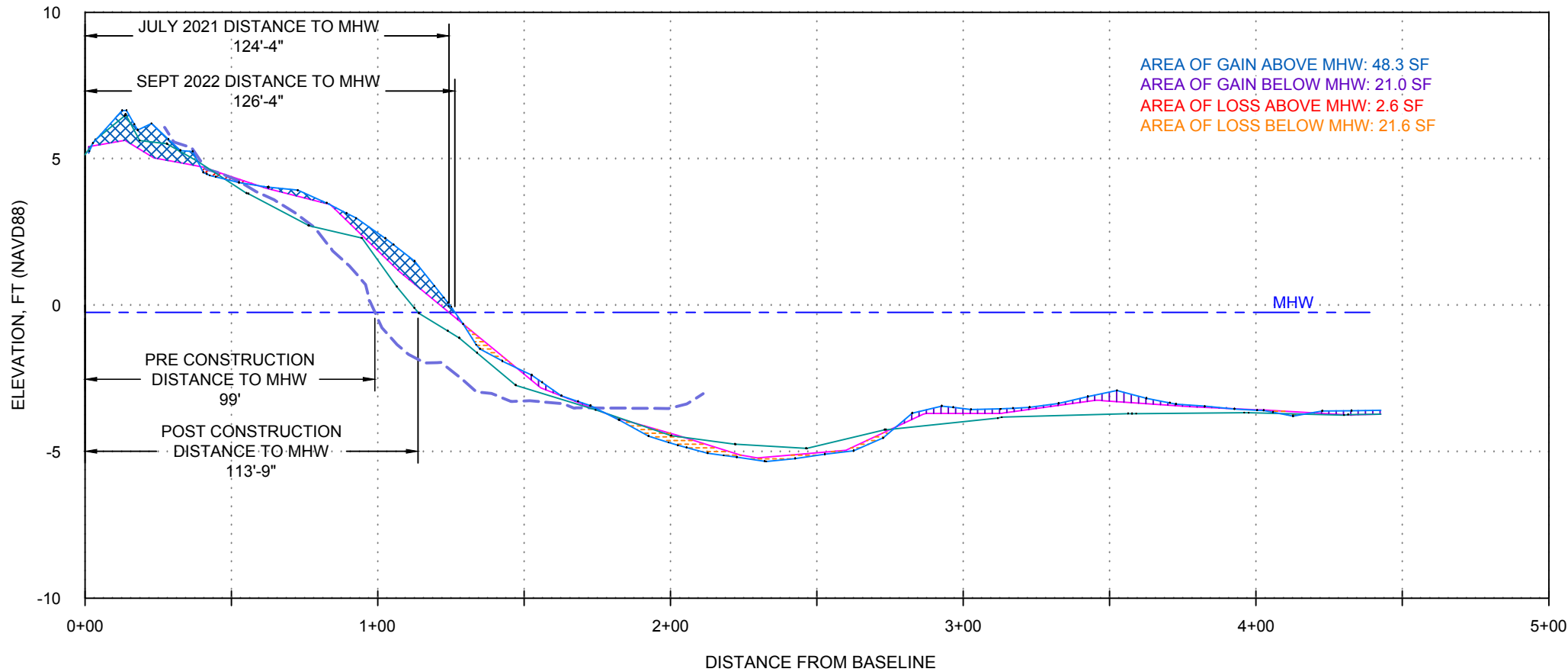
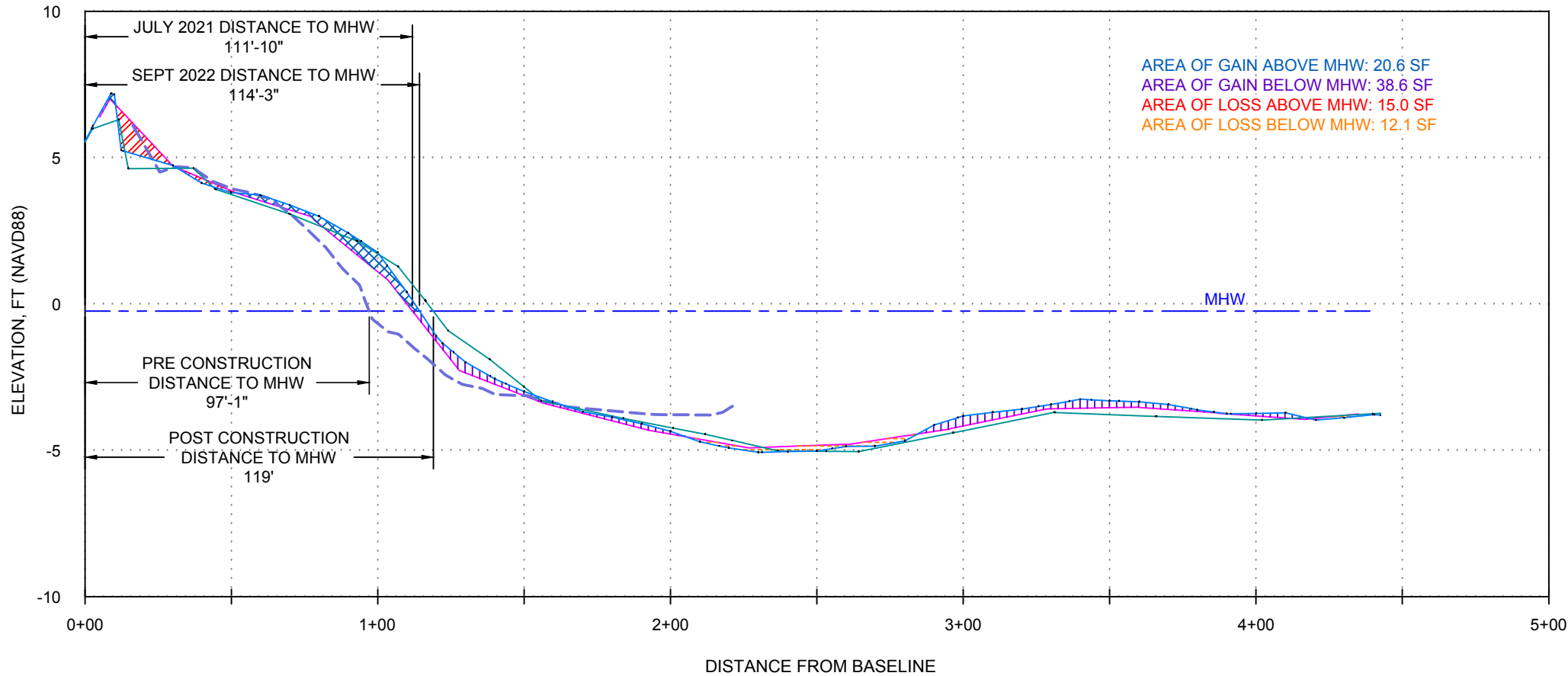


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|  | SEPTEMBER 2022 BEACH SURVEY                         |
|  | JULY 2021 BEACH SURVEY                              |
|  | JUNE 2019 AS-BUILT SURVEY                           |
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|  | AREA OF GAIN BELOW MHW                              |
|  | AREA OF LOSS ABOVE MHW                              |
|  | AREA OF LOSS BELOW MHW                              |

SCALE

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HORIZONTAL SCALE: 1" = 50'

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| MODEL: | C.R.V |

DESIGN: C.R.V.

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