April 5, 2021

TIGERTAIL LAGOON & SAND DOLLAR ISLAND ECOSYSTEM RESTORATION

Engineering Management Plan

Prepared for

City of Marco Island

Abstract

This report provides engineering analysis of the evolution of the Tigertail Lagoon/ Sand Dollar Island system and a proposed Management Plan for the restoration of this environmentally sensitive system. The analysis includes documentation of the degradation of the system and evaluates the proposed management plan to restore the system, improve its resiliency, habitat, and recreational value.

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Tigertail Lagoon / Sand Dollar Island Ecosystem Restoration Plan
April 2021

Executive Summary

Tigertail Lagoon and Sand Dollar Island Ecological and Public Value
Tigertail Lagoon and Sand Dollar Island have developed from the evolution of the former ebb shoal at Big Marco Pass which provided navigation from the Marco River to the Gulf of Mexico on the northwest coast of Marco Island, Florida. The Tigertail Lagoon and Sand Dollar Island ecosystem is a protected natural preserve and a critical wildlife area that provides valuable habitat for a variety of birds, sea turtles, manatees, and seagrasses. Tigertail Lagoon and Sand Dollar Island are also valuable Marco Island recreational resources for residents and tourists for birding, fishing, kayaking, paddle boarding, kitesurfing, and, on the northern half, boating. The ecosystem can be accessed by the public via Collier County's Tigertail Beach Park and Marco Island Beaches at the southern end of the lagoon and via boat at the northern end of the lagoon. Tigertail Beach is one of 510 points on the Great Florida Birding and Wildlife Trail and is considered one of the best all-around birding spots in southwest Florida. It is one of only two public beach access points on Marco Island and has a large public parking area. Private, rental, and commercial tourist boats access the lagoon from its northern entrance. On a recent March, 2021 weekend there were approximately 100 boats in the lagoon and anchored on the beaches on both sides.

Ecosystem Degradation and Existing Conditions
The decline of Tigertail Lagoon has progressed rapidly since Hurricane Irma in 2017. Irma reduced the height and resiliency of the central section of Sand Dollar Island resulting in wave and sand overwash into the lagoon during high frequency storms. Between November, 2016 and June, 2020, Tigertail Lagoon lost approximately 15 acres of wetland habitat or 45% of the total in the central area of the lagoon due to landward migration of Sand Dollar Island. In addition, bird and turtle habitat along the gulf fronting middle portion of the island has declined in acreage and no longer supports successful nesting due to frequent overwash. The narrow water channel in the central area of the lagoon lost 45 feet of width in the eight months between June, 2020 and February, 2021. At low tide it is ankle deep. Given that the narrow section of the channel was only 43 feet wide in February, 2021, it is expected to close within the next year and Tigertail Lagoon in front of the county beach will become a landlocked pond. If Sand Dollar Island collapses onto Marco Island in the central section, it will reduce coastal resiliency and expose the mangrove shoreline to coastal erosion. This will result in mangrove loss and eventually threaten the properties behind them.

In the narrowest area of the lagoon, where the seagrasses were the densest, there has been significant loss of seagrasses, because sand continues to overwash and cover seagrass areas. No action means that all seagrasses and their habitat functions for a variety of species will be lost. Multiple manatee strandings occurred in the fall of 2020 due to insufficient water at low tide. The shoaling throughout the lagoon has resulted in insufficient tidal flow and flushing of the water in the lagoon, raising water quality concerns, particularly at the county beach.

Between November, 2016 and June, 2020 longshore currents have caused the northern spit of Sand Dollar Island to grow northeastward and expand by 12 acres. Its northern end is approaching the Marco River navigation channel. The northern entrance to the lagoon has been kept open and prevented from attaching to the Hideaway Beach upland by permitted dredging every three years. If nothing is done, the continued spit growth will result in increased entrance dredging frequency and cost, increased sand flow into navigation channels, and eventual lagoon closure.

Proposed Restoration Plan
The goal of the proposed restoration plan is to maintain Tigertail Lagoon as a wetland lagoon habitat with good tidal exchange and flushing. The plan has three main components: a sand trap at the northern end of Sand Dollar Island, a southwest extension of the current dredged channel, and construction of an enhanced beach berm along the gulf facing middle portion of Sand Dollar Island. The sand trap will help slow the rate of growth of the northern spit of

Sand Dollar Island and be a renewable sand source for restoring the central section of Sand Dollar Island. It will; reduce the dredging frequency/cost at the northern entrance, slow the flow of sand into the Marco River, and help prevent complete lagoon closure. The southwest extension of the current dredged channel will improve tidal flow and flushing and have a positive impact on natural resources. The enhanced beach berm on Sand Dollar Island will enhance and increase sandy beach habitat and improve coastal resiliency.

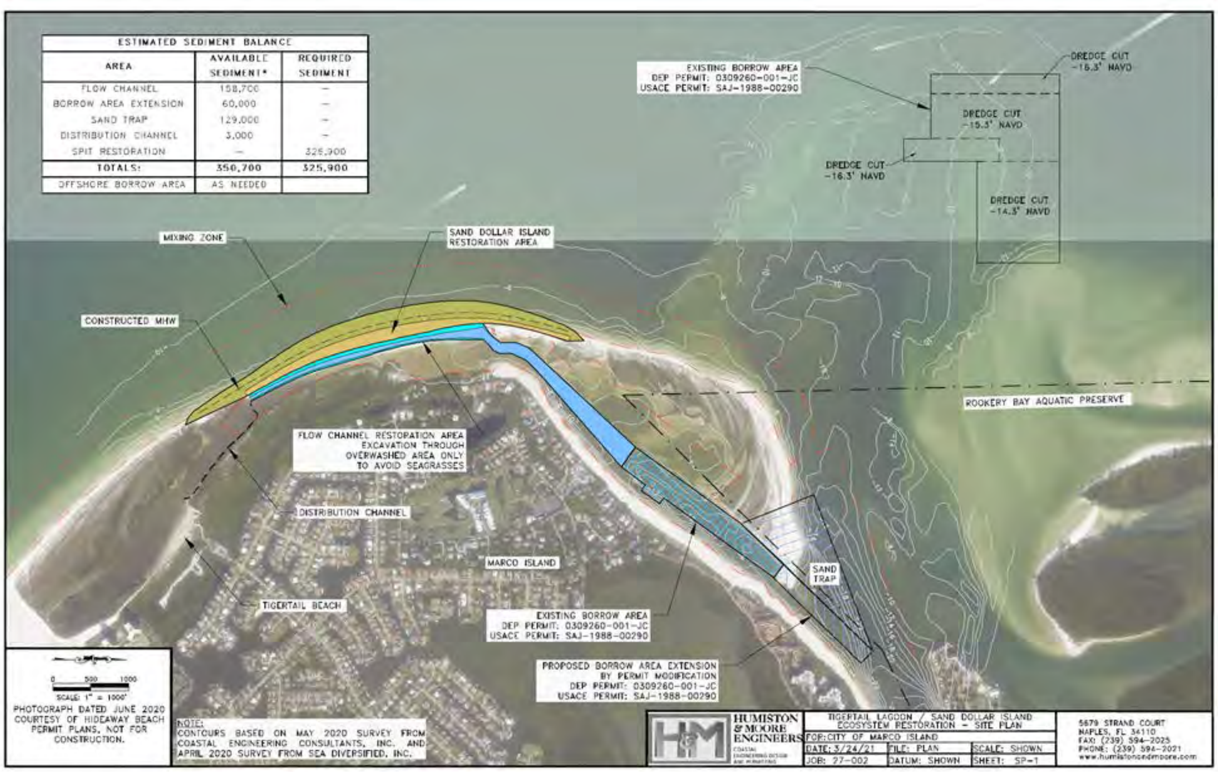
Overall, restoring Tigertail Lagoon and Sand Dollar Island will result in the following ecosystem enhancements:

- Approximately 10 acres of added wetlands to the tidal lagoon.
- Over 11 acres of added/enhanced potential beach nesting bird habitat and turtle habitat.
- Improved conditions for seagrasses and manatees.
- Improved tidal flushing and water quality.

The plan will provide enhanced sustainability and improved coastal resiliency to the northwest part of Marco Island through the following:

- Implementation of a nature-based solution for coastal protection with a Sand Dollar Island resilient to high frequency storms.
- Maintenance of the lagoon and sand spit features by recycling sand from the sand trap and dredged areas to the fill area.
- Protection of the sand resource within the active system
- Minimization of potential sand infilling at navigation inlets through the sand trap at the northern spit of Sand Dollar Island

The plan will include continued coordination with key stakeholders to compile physical and biological monitoring data in support of an adaptive management and operational maintenance.



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1. Introduction

This report provides engineering analysis for the proposed management plan for the Tigertail Lagoon / Sand Dollar Island Ecosystem Restoration Project. This report focuses on the physical evolution and restoration plan of the lagoon and island. The tidal wetland and large island/sand spit have provided vital environmental habitat for wildlife, coastal protection, and recreational benefits for over two decades. Monitoring data indicates onshore migration and degradation of these features over the past decade, especially following Hurricane Irma, a major hurricane that landed on Marco Island in 2017. Irma reduced the height and resiliency of the central section of Sand Dollar Island resulting in high frequency storm wave and sand over wash into the lagoon. By the end of 2020 the degradation of the system became critical and the middle part of Sand Dollar Island was near collapsing on the upland mangrove shoreline, which threatens to reduce the two mile long tidal lagoon into a landlocked pond.

The plan presented here is based on four years of engineering and environmental data collection, analysis, design, and coordination with stakeholders. This study and proposed restoration plan are supported by the Hideaway Beach Tax District and the City of Marco Island. The project team included Humiston & Moore Engineers and Turrell, Hall & Associates. The environmental plan is presented in the Tigertail Lagoon / Sand Dollar Island Ecosystem Restoration Project Environmental Management Plan by Turrell, Hall & Associates, 2021.

2. Evolution of Tigertail Lagoon and Sand Dollar Island

Figure 1 shows the location of the study area which extends from the central part of Marco Island's gulf coast to the northwest part of the island. The evolution of Tigertail Lagoon and Sand Dollar Island is part of ongoing large scale natural tidal inlet evolution at the north end of Marco Island. Prior to the 1960's, Big Marco Pass was the main inlet between Marco Island and Sea Oat Island. In 1967 Capri Pass was opened on the up-drift side of Big Marco Pass creating a dual inlet system for few decades until Capri Pass became the main inlet for this system in the early 2000's.

Figure 1: Study area location

Figure 2 shows the inlet configuration in 1969, two years after Capri Pass was opened, and a comparison of more recent conditions represented by 2011 aerial photos with the 1965 shoreline before Capri Pass opened. The opening of Capri Pass created a dual inlet system of Capri Pass and Big Marco Pass separated by a small island (Coconut Island) and by a large and complex ebb shoal system (Dabees and Kraus, 2004).

The reduction of tidal prism of the original inlet resulted in onshore migration of its large ebb shoal rendering the pass more restrictive to tidal flow. The newer inlet became more dominant as it gradually captured a larger share of the tidal prism. This dual inlet process continued until the south inlet closed in the 2000's. Onshore movement of the ebb shoal at the closed inlet provided a large volume of sand to the down-drift beach (Marco Island) and formation of the active ebb shoal to the north. Formation of the new ebb shoal caused significant erosion on the north side of Capri Pass, along the south end of Sea Oat Island. The up-drift beach erosion is represented on the right end side of **Figure 2** which compares the 1965 and existing conditions represented in the figure by the 2011 aerial photo.

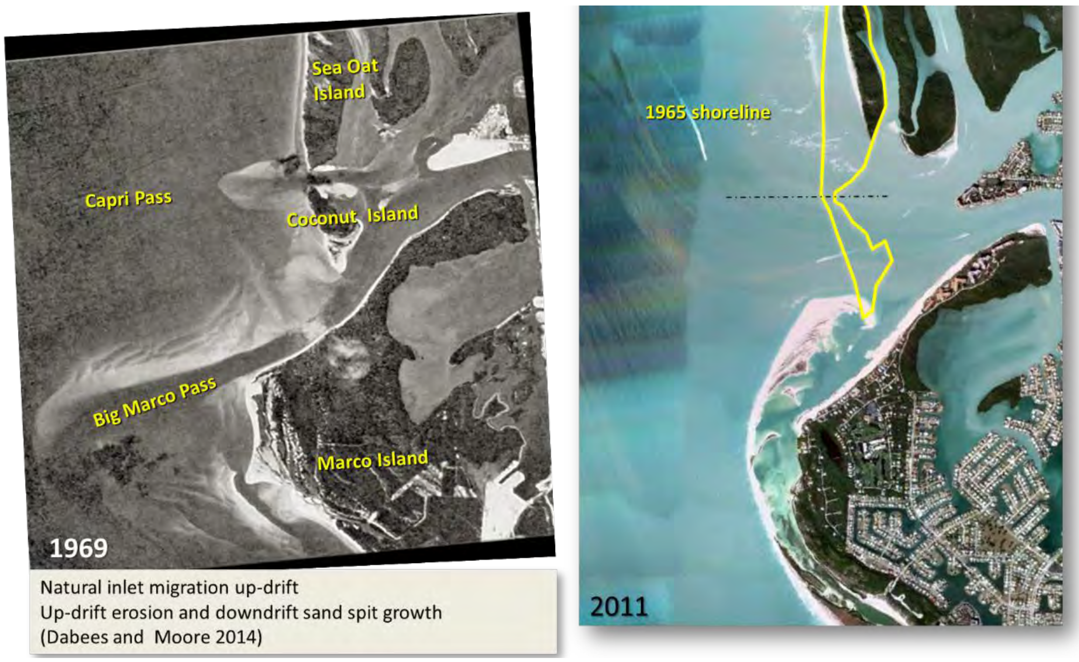


Figure 2: Comparison of the 1960's and existing conditions at the study area

Figure 3 shows the varying stages of sand Dollar Island in decadal stages. First, Sand Dollar Island was a detached emergent shoal in the 1980's along the south side of the Big Marco Pass. The island then became a sand spit when the south end of it attached to Marco Island in the 1990's. During the 2000's Sand Dollar Island continued to migrate onshore causing Big Marco Pass to close. In the mid 2000's, the small island that separated Big Marco Pass from Capri Pass collapsed onshore and eventually welded with the north end of the Sand Dollar Island sand spit during the 2010's.

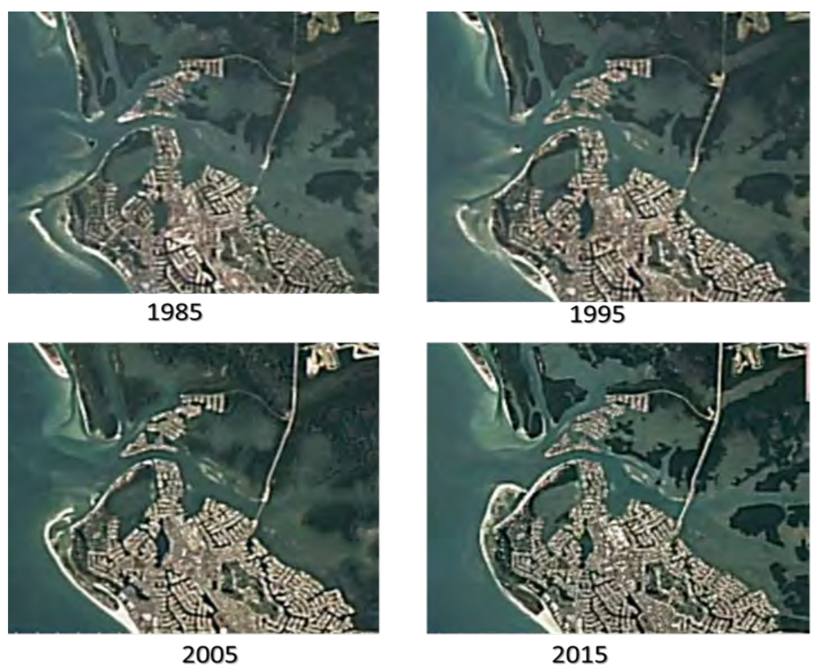


Figure 3: Decadal stages of Sand Dollar Island evolution

2.1 Existing Conditions and Recent Morphologic Changes

Recent morphologic changes from 2010 to present (2021), indicate continued onshore migration of the sand spit along the northwest end of Marco Island. **Figure 4** illustrates the change in the sand spit shoreline from 2010 to 2018.

Figure 4: Recent shoreline changes of Sand Dollar Island

The morphologic changes associated with the closure of Big Marco Pass include the shoaling and narrowing of Tigertail Lagoon, the water body between the Sand Dollar Island sand spit and Marco Island. In the absence of tidal currents from Big Marco Pass, waves dominating the coastal processes along the north end of Marco Island continue to transport sand from the westernmost point near the center of the sand spit towards the lateral ends of Sand Dollar Island (north & south). Along the south part of the island, sand is transported from north to south towards the attachment point south of Tigertail Beach creating a very wide beach. On the north part of the sand spit sand is transported from south to north causing the growth and elongation of the sand spit. The sand spit growth and interaction with waves and currents push the north end of the sand spit towards Hideaway Beach. The sand spit attachment to Hideaway Beach, which would close off the opening of Tigertail Lagoon to the Gulf of Mexico, is managed by periodic dredging. The maintenance dredging of the Hideaway Beach borrow area keeps the lagoon open to tidal exchange which is essential to the water quality and ecology of the lagoon.

2.2 Storm Effects on Sand Spit Evolution

In addition to the typical coastal processes contributing to the elongation and onshore migration of Sand Dollar Island, storm events have significant influence on the sand spit evolution. The effects of Hurricane Irma on Sand Dollar Island are discussed here to illustrate the magnitude of change due to storm events.

2.2.1 Hurricane Irma

Hurricane Irma was a major hurricane in the 2017 tropical season that reached category 5 and caused catastrophic damage in parts of the northeastern Caribbean and the Florida Keys. Irma was the strongest observed storm and the most intense in the Atlantic since 2005. Irma developed on August 30, 2017 near the west African coast then intensified into a hurricane on the Saffir–Simpson scale within one day. Irma became a major storm at Category 3 hurricane on September 5, 2017 then reached its peak of Category 5 hurricane with intensity of 185 mph (295 km/h) winds. Irma was a Category 4 hurricane, before making landfall in the Florida Keys and was a major Category 3 by the time it made a second Florida landfall on Marco Island and Naples in Southwest Florida on Sunday September 10, 2017. Irma weakened to a category 2 hurricane later that day as it tracked along the Florida peninsula.

Irma made its landfall on Florida's mainland on Marco Island south of Naples as a major hurricane then tracked north along southwest Florida. The storm track and wind circulation influenced water levels and waves with high intensity and varying conditions over a relatively short time. Ahead of the storm passing, hurricane force winds pushed water offshore out of bays and estuaries approximately 3 feet below still water levels. As the storm eye passed, the wind direction reversal caused the water levels to surge to over 5 feet above still water levels. This rapid change in water levels occurred over approximately 3 hours. The waves accompanied by the onshore storm surge phase added to the forcings affecting beaches, inlets and estuaries that make up the coastal system of southwest Florida.

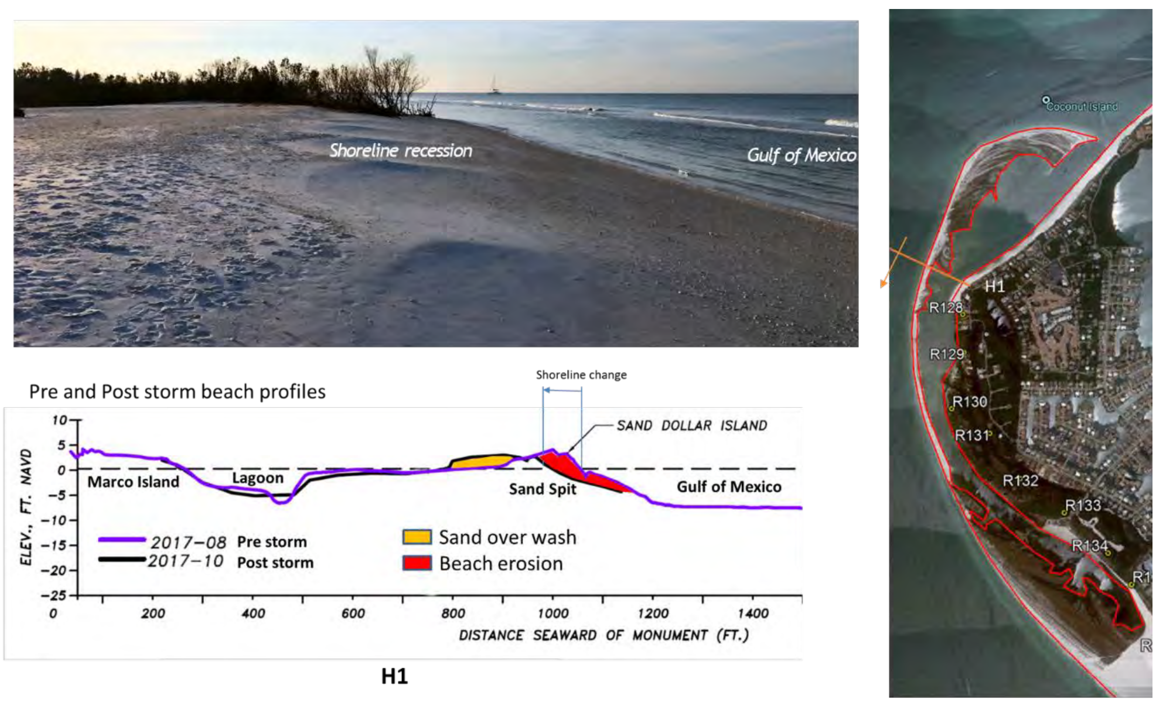


Figure 5: Morphologic response to hurricane Irma at a profile across the lagoon and sand spit

Post storm observations and data from survey data collection pre and post storm along the study area of Sand Dollar Island highlighted the morphological response to the storm surge and waves on the sand spit. General trends included beach and dune erosion with significant sand over wash landward. **Figure 5** shows an example of the morphologic response to Hurricane Irma on the lagoon and sand spit. The survey data and aerial photos indicated a landward migration of the sand spit of over 50 feet and sand over wash on the lagoon side of the spit of over 70 feet. The beach profile comparisons shown in the figure quantify the scale of the morphologic change in this area.

2.2.2 High frequency storms

Major storms such as Hurricanes Wilma (2005) and Irma (2017) occur at approximately decadal frequency. When they occur, they cause significant morphologic response. In the case of Sand Dollar Island the storms caused lowering of the beach elevations in the middle part of the sand spit leaving it more vulnerable to erosion and overwash during typical storm events that may occur several times a year. For example, over the tropical season of 2020, two tropical storms passed offshore in the Gulf of Mexico, Cristóbal (June 2020) and Eta (November 2020). These two events generated mild storm surge and wave height but caused significant morphologic response at the middle section of Sand Dollar Island due to the low elevation of that section. **Figure 6** shows aerial photos taken post tropical storm Eta, indicating over wash and breaching at the middle section of the sand spit.

Figure 6: Central Sand Dollar Island beach overwash following tropical storm Eta (November 2020)

Figure 7. illustrates the progression of Sand Dollar Island overwash and onshore migration over the 8-month period between June 2020 and February 2021. The figure illustrates the shoreline change of Sand Dollar Island and highlights the change in wetland width at DEP reference monument R-130. The figure is based on rectified aerial photos taken in June 2020, in November 2020 following the tropical season and Tropical Storms Cristobal and Eta, and in February 2021 following the cold fronts of January 2021. The figure tabulates shoreline positions and wetland widths at DEP reference monuments and highlights the wetland width at R-130 where the narrow width of lagoon was approximately 88 feet in June 2020 and narrowed further over the eight month period to 43 feet in February 2021. This indicates the vulnerability of the system to shoaling and over wash at the low crested berm of Sand Dollar Island between R128 and R131 and the potential for lagoon closure in less than 1 year.

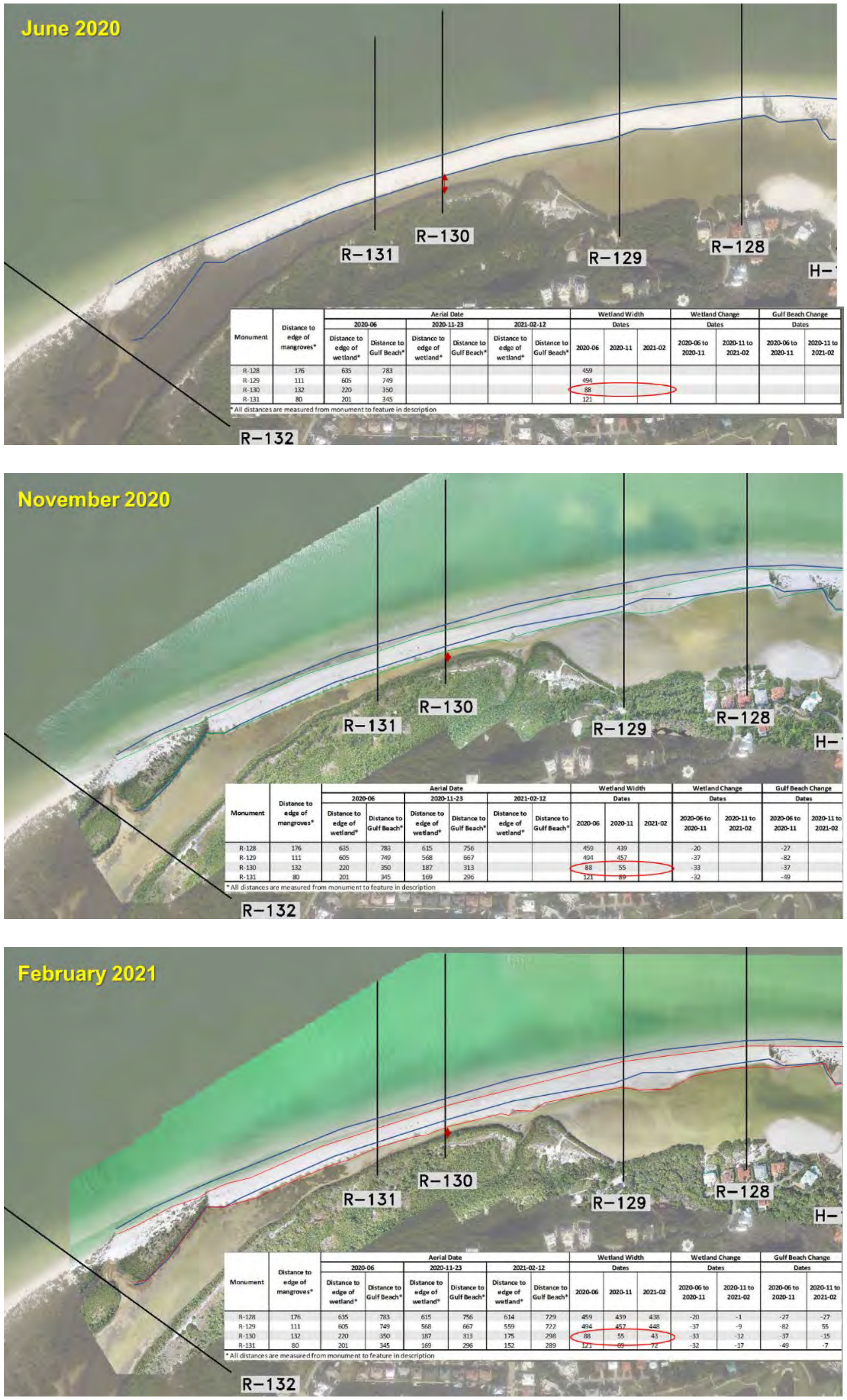


Figure 7: Sand Dollar Island shoreline and Tigertail Lagoon width change (June 2020-February 2021)

3. Monitoring Program

Physical and biological monitoring for this system were initiated in 2017 by this project team and monitoring reports and analysis of the ecosystem were provided in 2018 with recommendations for system restoration. System degradation reached a critical stage in 2020. The critical degradation of the ecosystem was acknowledged by various stakeholders and the project team was authorized by the Hideaway Beach Tax District and City of Marco Island for design and permitting of an ecosystem restoration project. This section summarizes the monitoring data analysis of the system.

3.1 Physical Conditions

Survey data was collected to document the topographic and bathymetric conditions. Comparisons to previous data sets were used to document the morphologic changes and establish background information for future monitoring. **Appendix C** includes the physical condition survey scope and plotted profiles at established stations along Sand Dollar Island and Tigertail Lagoon. Sand Dollar Island continues to migrate landward as shown on the plan views in **Figure 8.** This compiles the shore positions interpreted from aerial imagery collected in:

- January 2006
- January 2010
- November 2016
- November 2019

Figure 8: Shoreline changes on Sand Dollar Island

The aerial imagery illustrates the recession of the spit between R-128 and R-131 from near its most seaward location in January 2006 to November 2019. Accompanied by the recession has been growth of a large emergent area to the north of R-128 wrapping into the Big Marco River and accretion south of R-132 over the same time period.

Beach profiles collected at state Reference Monuments are included in **Appendix C**. These were gathered from surveys conducted for the City of Marco Island and other publicly available sources. These show clearly defined lagoon and spit areas, and illustrate the movement of the spit over time. The profiles indicate an ongoing deflation seaward of the spit, ranging from 2 to 5 feet in elevation as illustrated by R-129 in **Figure 9**. This pattern extends beyond the scope of the surveys and is not included in the calculations in this report. The deflation represents collapse of the former Big Marco Pass ebb shoal and would provide an unquantified but significant source of offshore sediment to nearshore beaches.

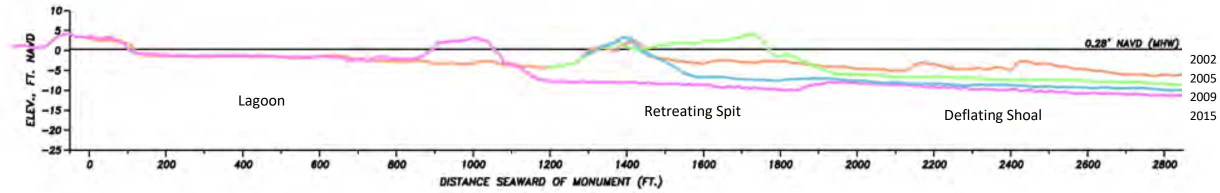


Figure 9: Sand Dollar Island Beach profile evolution

Figure 10 shows the lagoon width over time at R-128 through R-131. The lagoon has shown essentially no change in width at R-132 through R-135. **Table 1** provides lagoon width, change in width, and annualized rates of change between 2001 and 2020. There is a consistent trend of recession of the spit and loss of lagoon area since 2005. The lagoon has reached a critical point where the spit will soon weld onto the mangrove shoreline, isolating the lagoon at Tigertail Beach from the Gulf of Mexico.

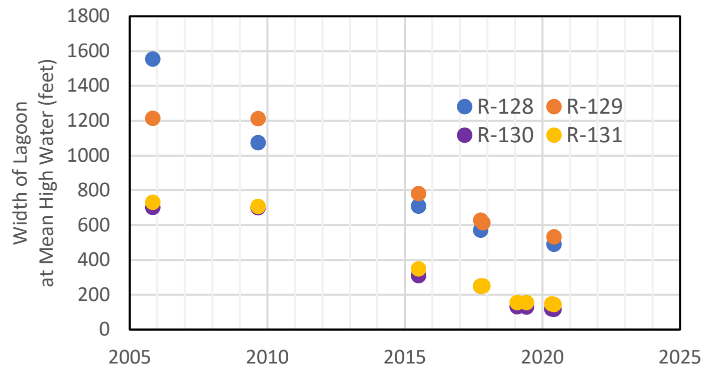


Figure 10: Lagoon width over time at DEP monuments R 128-R131

Over this same period of time, the spit has experienced loss of volume due to overwash and lateral transport to the north and south. Transport to the north has resulted in ongoing accretion of the spit as it has wrapped around Marco Island and now shelters much of Hideaway Beach. Transport to the south has nourished Marco Island beaches, creating a beach berm over 1,000' wide at the attachment. The supply of sediment from the Tigertail Beach portion of the spit has maintained relatively stable beach positions in the transition areas between R-128 and H-1 moving north and between R-132 and R-133 moving south. Areas beyond the stable transition zones have been generally accreting or stable over the past 20 years.

Volume losses from the Sand Dollar Island segment are provided in **Table 2**. Volume change is documented for both loss from the beach face due to overwash and loss from the beach face due to lateral transport. Losses to the beach face due to overwash represent a significant driver of shoreline recession, as well as loss of lagoon habitat. However, overwash is not a true loss to the system, since the rapid retreat of the spit reworks the overwashed material in subsequent years. Losses due to longshore transport cause the bulk of apparent sediment loss to the beach face.

Table 1: Lagoon Physical Condition over Time.

Year	Duration	Lagoon Width (ft)			
		R-128	R-129	R-130	R-131
2001	--	956	1198	680	759
2005	3.9	1555	1215	703	732
2009	3.8	1074	1212	701	709
2015	5.8	710	782	310	350
2017*	2.3	572	629	250	251
2020	2.7	492	534	118	145

*Prior to Hurricane Irma

Year	Duration	Change in Lagoon Width (ft)			
		R-128	R-129	R-130	R-131
2001	--	--	--	--	--
2005	3.9	599	17	23	-27
2009	3.8	-481	-3	-2	-23
2015	5.8	-364	-430	-391	-359
2017*	2.3	-138	-153	-60	-99
2020	2.7	-80	-95	-132	-106
Total Reduction		-1,063	-681	-585	-614

*Prior to Hurricane Irma

Year	Duration	Annualized Lagoon Width Change (ft/yr)			
		R-128	R-129	R-130	R-131
2001	--	--	--	--	--
2005	3.9	153	4	6	-7
2009	3.8	-125	-1	-1	-6
2015	5.8	-62	-74	-67	-62
2017*	2.3	-61	-68	-27	-44
2020	2.7	-30	-36	-49	-40

*Prior to Hurricane Irma

Table 2: Volume Change Along Sand Dollar Island

Volume Change - R-128 through R-131								
			Volume Change			Rate of Volume Change		
Year		Duration	Overwash	Longshore	Total Beach Face	Overwash	Longshore	Total Rate Beach Face
From	To		(cy)	(cy)	(cy)	(cy/yr)	(cy/yr)	(cy/yr)
2001	2005	3.9	9,700	54,500	64,200	2,477	13,915	16,391
2005	2009	3.8	12,703	74,135	86,838	3,314	19,340	22,653
2009	2013/2015	4.9	16,456	42,074	58,529	3,347	8,557	11,904
2013/2015	2017*	3.2	23,739	38,435	62,174	7,497	12,137	19,634
2017*	2020	2.7	24,148	44,370	68,519	9,056	16,639	25,694
Overall		**19**	86,746	253,514	**340,260**	4,689	13,703	**18,392**

*Post Hurricane Irma

It is noted that rates of overwash have increased from 2,500 to 9,000 cy/yr over the record, increasing by several multiples between 2015 and 2020. Rates of longshore transport are highly variable but show an increasing trend since a low between 2009 and 2013/2015. Longshore transport rates have increased consistently since 2009.

Surveys since 2001 have shown loss of approximately 250,000 cy of sediment and retreat of the spit on the order of 500 to 1,000 feet. The apparent loss of sediment from the beach face was approximately 340,000 cy.

Table 3: Acreage of Spit North of R-128

Upland Areas North of R-128				
		Total Acreage (Acres)		
Year	Duration	Vegetated	Non Vegetated	Total Acreage
2002		4.0	5.0	9.0
2006	4	2.3	23.3	25.6
2010	4	21.7	17.0	38.7
2016	6	43.9	14.1	58.0
2019	3	48.3	15.8	64.1

		Total Change (Acres)		
Year	Duration	Vegetated	Non Vegetated	Total Acreage
2002		--	--	--
2006	4	-1.7	18.3	16.6
2010	4	19.5	-6.3	13.1
2016	6	22.2	-2.8	19.4
2019	3	4.4	1.7	6.1

		Rate of Growth (Acres per Year)		
Year	Duration	Vegetated	Non Vegetated	Total Acreage
2002		--	--	--
2006	4	-0.4	4.6	4.1
2010	4	4.9	-1.6	3.3
2016	6	3.7	-0.5	3.2
2019	3	1.6	0.6	2.1

3.2 Northern Sand Dollar Island.

Total acreage of the sand spit north of R-128 was determined based upon interpretation of aerial imagery at selected intervals. All imagery was captured in January, except for 2019 which was captured in December, 2018.

Beginning in 2002, there was essentially no spit north of R-128. However, Coconut Island was located adjacent to Hideaway Beach in the vicinity of the present shoal. Coconut Island did not persist and became a submerged shoal between 2002 and 2006.

The spit north of R-128 has grown from essentially nothing in 2002 to over 60 acres in 2020. Areas, changes, and growth rates are given in **Table 3**. Growth rates have declined from an initial 4.1 acres per year to the present 2.1 acres per year, but the spit continues to grow. The active growth area has migrated approximately 5,000’ between 2002 and 2019, moving along Hideaway Beach toward Collier Creek. The distance from Collier Creek has steadily declined from 8,300’ in 2002 to approximately 3,300’ in 2019.

3.3 Total Area of Sand Dollar Island

The total spit area from R-131 to the northern tip at Hideaway Beach is given in **Table 4** and **Figure 11.** Both illustrate the continued growth of the spit, while the total unvegetated area has remained relatively consistent since 2010, due to the spread of vegetation across the northern tip as it has expanded.

Of over 70 acres, less than 23 acres are unvegetated. Of this, about half are located along the narrow central portion of Sand Dollar Island, which is low and frequently overwashed during wave events. The remainder is located along a narrow band between the vegetation line and high water line where the dynamic coastal system prevents the establishment of vegetation.

Table 4: Upland acreage north of R-131

Upland Areas North of R-131				
Year	Duration	Total Acreage (Acres)		
		Vegetated	Non Vegetated	Total Acreage
2002		4.0	17.2	21.2
2006	4	8.2	31.2	39.4
2010	4	23.6	20.4	44.0
2016	6	43.9	21.0	64.9
2019	3	48.3	22.6	70.9

Figure 11: Upland acreage north of R-131

3.4 Regional Volume Change Analysis

Regional volume change analysis was carried out in support of the application for the Marco Central Regrade project. This documented regional volume changes and trends throughout Marco Island. Bathymetry and elevation change are shown in **Figure 12**. The changes clearly illustrate the deflation of the former ebb shoal and the growth of Marco Island beaches and the Hideaway Beach portion of the spit.

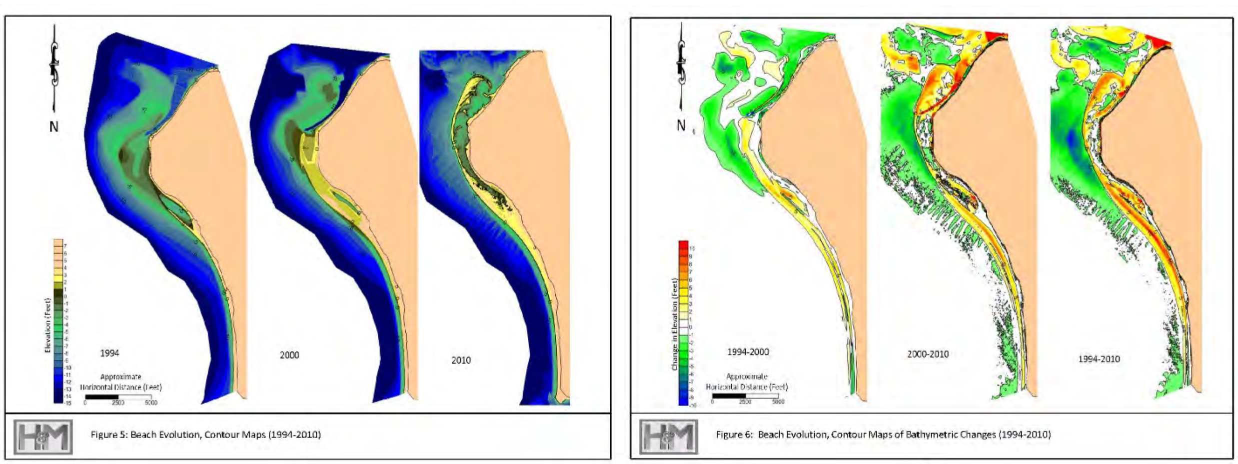


Figure 12: Bathymetry and Elevation Change at Marco Island - 1994 to 2010 (H&M, 2015)

Volume change generally consisted of offshore deflation of the profile and accretion in the nearshore, extending nearly the entire length of the island. Total volume change and annualized rates of change over the two periods considered is shown in **Figure 13**. This clearly illustrates the significant volume losses offshore of the gulf facing middle portion of the spit and the volume gains to the north and south.

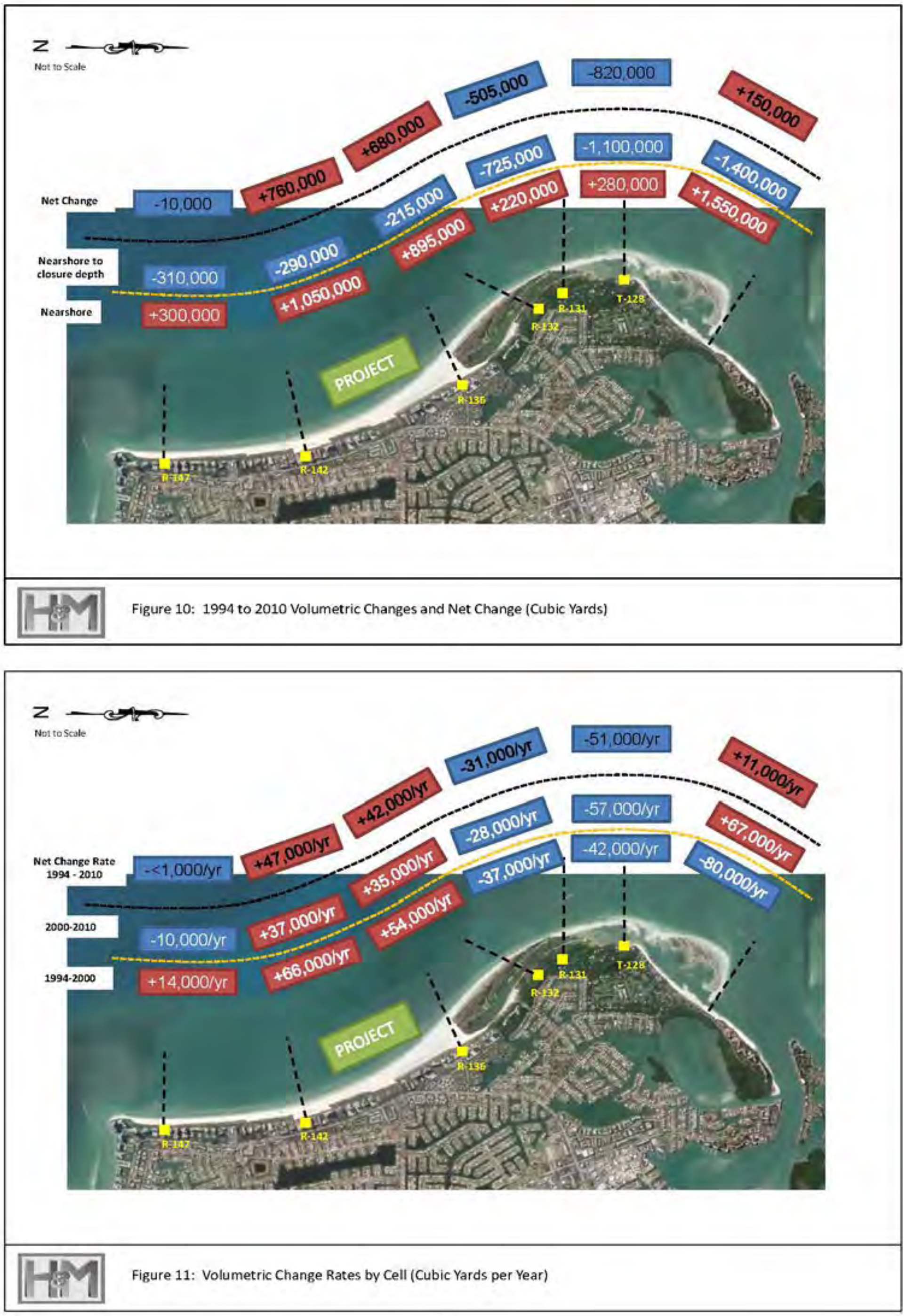


Figure 13: Marco Island regional volumetric change (H&M, 2015)

4. Ecological System

In addition to the physical monitoring, Turrell Hall & Associate (THA) provided data collection and analysis of environmental resources . The purpose of the THA study was to provide a submerged resource survey to document any existing seagrass beds and other resources found within the estuarine lagoon system lying between Marco Island and Sand Dollar Island and to characterize its habitats, wildlife utilization and any other observations within the system that might be pertinent to future studies and/or activities. A separate report titled "***Tigertail Lagoon-Sand Dollar Island Environmental Management Plan, by Turrell, Hall & Associates*** is provided as an attachment to this report in **Appendix B**.

4.1 Summary of Data Analysis

The Sand Dollar Island and Tigertail Lagoon data collected as part of this study and comparisons to historic data indicate the dynamic nature of this system. The sand spit and lagoon system are transient features of the large inlet and barrier island system where tidal inlets and its morphologic features evolve over long time scales. In fact, the north part of Marco Island gulf coast was formed through similar sequences of sand spits forming then welding on shore as sand ridges. The evolution of Sand Dollar Island and Tigertail Lagoon is expected to continue following the established morphologic trend discussed above. This may require regional management efforts to maintain the ecological system and recreational benefits of the system while it is evolving. As discussed above, the ongoing dredging of the borrow area near the north end of the Sand Dollar Island spit has helped maintain the tidal exchange to the lagoon. However, recent morphologic changes indicate narrowing and shoaling of the lagoon further restricting tidal flow through to the south part of the lagoon.

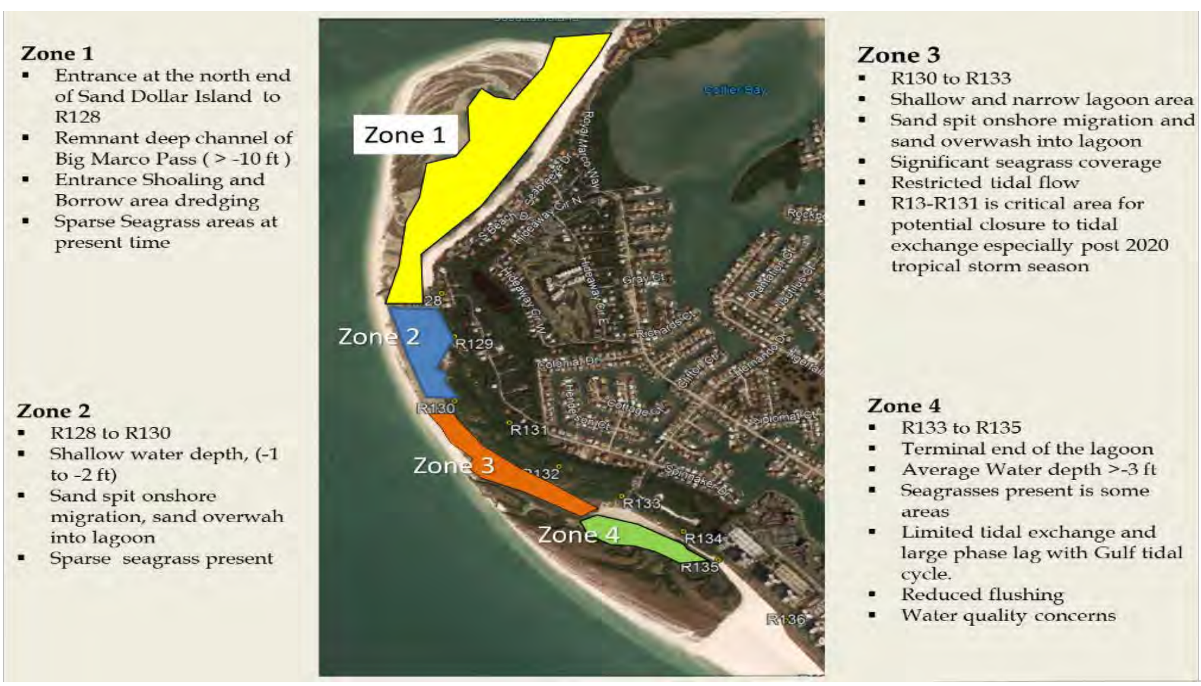


Figure 14: Tigertail lagoon zones

Figure 14 summarizes the physical and submerged marine resources conditions of the lagoon. In this analysis, the lagoon is divided into 4 zones as shown in the figure.

Zone 1 is the area from the north end of the lagoon entrance to DEP reference monument R128. This zone represents relatively deep-water depth greater than 10 feet where the remnant channel of Big Marco Pass existed. A localized small area of seagrass was identified near the north part of zone 1. **Figure 15.** Shows ground photo of zone 1 showing the boating activities on both sides of the lagoon.

Figure 15: Tigertail Lagoon zone 1

Zone 2 represents the lagoon area between DEP R monuments R128 to R130. This area is where significant narrowing and shoaling occurred over the past few years. The water depths are shallow, varying between 1 and 2 feet deep. The submerged resource survey indicates no sea grass beds in this zone in 2018 and a sparse sea grass bed in 2020. **Figure 16** shows a ground view at low tide of zone 2 indicating the shoaling of the lagoon.

Figure 16: Tigertail Lagoon zone 2 at low tide

Zone 3 represents the lagoon area between DEP R monuments R130 to R133. This area is shallow and very narrow where flow is restricted especially during low tides. The submerged resource survey indicates significant sea grass beds in this section. **Figure 17** shows ground view taken in March 2021 at low tide of zone 3 showing the significant narrowing of zone 3. In this area, the shoaling and overwash continues to cover seagrass beds that existed in years past.

Zone 3 low tide conditions (March 2021)

Figure 17: Tigertail Lagoon zone 3 at low tide

Zone 4 represents the south end of the lagoon area between DEP R monuments R133 to R135. This area has deeper water depths than zones 2 and 3 and typically greater than three feet. The submerged resource survey indicates areas of sea grass beds are present in this section. Water quality concerns in this part of the lagoon were raised by Friends of Tigertail and other stakeholders. The tidal flushing efficiency of this area has diminished due to the shallowing and narrowing of zones 2 and 3 leading to degrading effects in flushing the terminal end of the lagoon.

4.2 <u>Water Quality</u>

The narrowing of the lagoon along Sand Dollar Island, overwash, and the lengthening of the channel along Hideaway Beach would all be expected to reduce the tidal circulation in the lagoon at Tigertail Beach (Zone 4). These changes constrict water flow, limiting the ability of the tide to flush contaminants and exchange the lagoon water with relatively cleaner water from the Gulf of Mexico.

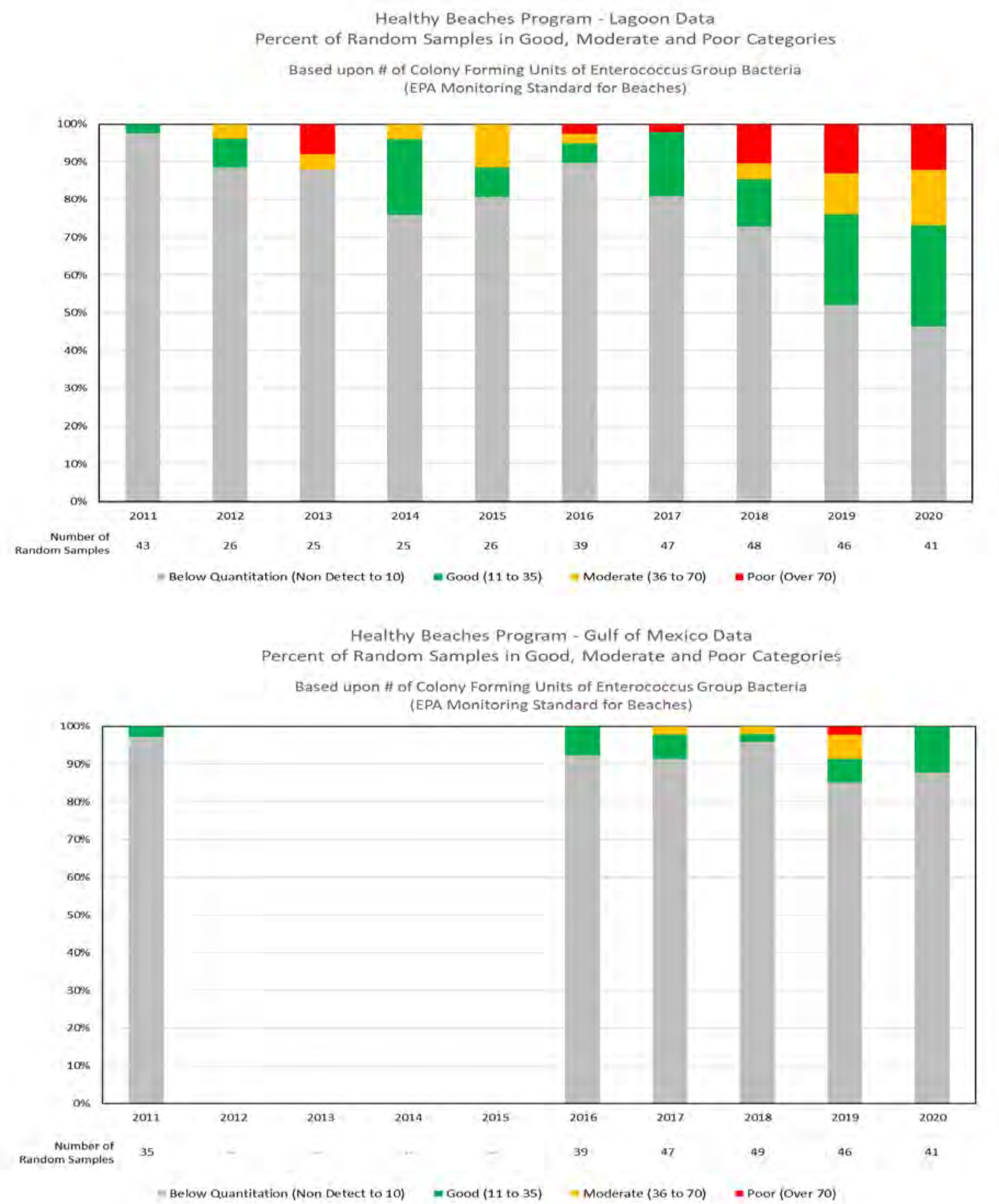


Figure 18: Enterococcus concentrations in Tigertail Lagoon and gulf beach

The Florida Healthy Beaches program conducts water quality monitoring of beaches throughout Florida, including Tigertail Lagoon. Monitoring is conducted for Enterococcus bacteria as a surrogate for wastewater to identify potential impacts to human health as recommended by the US EPA. Enterococcus lives in the digestive tract of mammals and birds. It is a naturally occurring bacteria found in fresh and marine waterbodies. Random samples are collected, and if elevated levels are detected, a second sample is collected to confirm that conditions have returned to safe levels. If elevated levels continue, beach warnings or closures may be implemented.

Enterococcus results for Tigertail Lagoon were downloaded from Florida DEP databases Storet and WIN for 2011 through 2020. Data from the random samples were compiled to determine the proportion of samples in each of the state designated categories: Good, Moderate, and Poor. A fourth category, Below Quantitation was applied to the entire dataset based on the lowest resolution results available for consistency. During this time period the frequency of sampling varied based on available funding. Sampling frequency varied from weekly to twice monthly, with occasional gaps. The frequency is illustrated in **Figure 18**. The chart shows a general trend of increased frequency of detection and increasing severity of Enterococcus within the lagoon. A review of maximum observed concentrations shows values less than 100 cfu in five of the ten years. 2013, 2017 and 2018 had peak concentrations between 100 and 200 cfu. 2019 and 2020 both recorded peak concentrations of 600 cfu, indicating a significant increase in peak concentrations.

For comparison, Enterococcus concentrations for the Gulf of Mexico water at Sand Dollar Island were also downloaded. Data were not collected for full years at this location for 2012 through 2015. However, complete records for only 2011 and 2016 through 2020 were available. These indicated quantifiable concentrations in no more than 15% of samples, with 4 of the 6 years at less than 10%. Concentrations in the Poor category were detected in only one year, 2019.

This analysis is not intended to identify the source of the bacteria or determine the causes of the increase. However, the trend is consistent with reduced flushing of the lagoon, particularly in recent years after Hurricane Irma, 2018, 2019, and 2020. The data illustrate a system that would benefit from improved flushing.

5. Ecosystem Restoration Plan

The proposed plan for restoration of the ecosystem of Tigertail Lagoon and Sand Dollar Island centers around restoration of the system to approximate pre-Hurricane Irma conditions. This can be achieved by restoring the central part of Sand Dollar Island, improving its resiliency to high frequency storms, and stabilizing the northern lagoon entrance, utilizing its excess sand as a renewable resource. Maintenance of the tidal circulation channel in the lagoon and the resiliency of Sand Dollar Island by recycling sand between those areas provides a sustainable solution that benefits the entire system. A detailed description of the proposed plan is provided in the permit drawings included in **Appendix A.**

5.1 Numerical Modeling and Design Development

Hydrodynamic modeling was included in this analysis to evaluate tidal circulation at varying temporal conditions. Morphology modeling of vulnerability to high frequency storms and improved resiliency offered by the proposed plan were also included in this analysis.

5.1.1 Water Level Measurements

Two tide gages were deployed for approximately 20 days in August, 2020. One tide gage was placed at the entrance of Capri Pass to measure the water depth from the Gulf of Mexico and the other was placed in Tigertail Lagoon. The measured water depth was normalized to the average elevation and a portion of the data is presented in **Figure 19**.

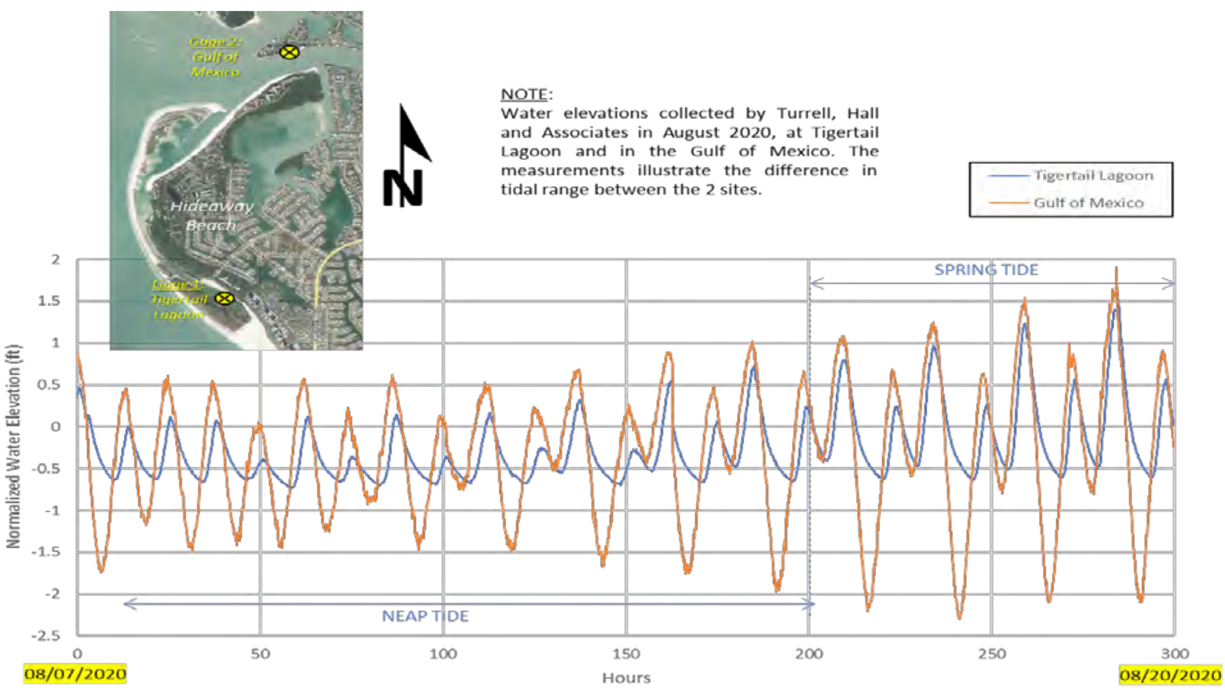


Figure 19: Water level measurements at Tigertail Lagoon and Gulf of Mexico (August 2020)

Comparison of the two datasets in the figure highlights the difference in tidal range between the Gulf of Mexico and Tigertail Lagoon. The shallow entrance channel prevents the water levels in the lagoon from dropping below a given threshold, limiting the amount of tidal exchange available in each tide cycle. The reduction in tidal exchange is most significant during neap tide cycles but is also apparent in spring tide cycles as well. Regardless of tide cycle, the water levels in the lagoon never reached the lows of the Gulf of Mexico. Tidal ratios comparing the lagoon tide range to the gulf tide range varied between 0.17 and 0.41. These ratios indicate that the lagoon only experiences a fraction of the Gulf tidal range.

5.1.2 Hydrodynamic and tidal circulation modeling

The Coastal Modeling System (CMS) numerical model was used to perform detailed Hydrodynamic modeling of the Tigertail Lagoon system. CMS was developed by the US Army Corps of Engineers Coastal and Hydraulics Laboratory. The modeling system includes a two-dimensional, finite-difference numerical simulation of the flow, sediment transport and morphology. Recent software releases of the model program allow for the creation of nested grids of varying resolution to allow higher definition in areas of concern. In this case, these were applied to the nearshore and in the vicinity of shallow water areas to provide more detailed and accurate simulations. **Figure 20** shows the CMS-Flow model grid with the nested cells varying in size from 5m (16ft) nearshore to 160m (524) offshore. The model domain included the entire Tigertail Lagoon and north end of Hideaway Beach. The model was forced by the tidal water levels with the assumption that flow from Capri Pass and Big Marco Pass has negligible effects on Tiger Tail Lagoon.

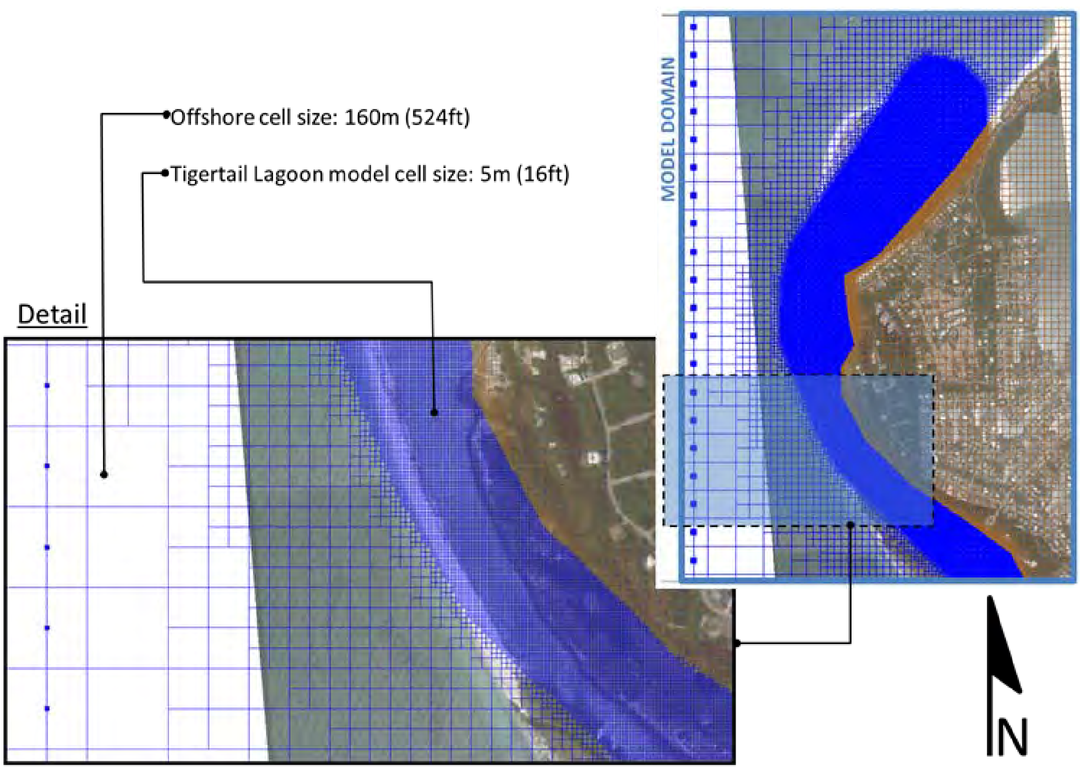


Figure 20: CMS-Flow model grid

5.1.3 Initial model results

A preliminary model run was prepared to visualize the tidal phases in the lagoon. **Figure 21** shows the preliminary model results at high tide and low tide for 2017 conditions. For each stage a color-coded map shows the water elevation in the Gulf of Mexico and in the lagoon. In the figure, low tide is represented by blue and high tide by orange/red. The preliminary results indicate that at both tidal stages, there is a phase lag between the south end of the lagoon and the north end. The transition where the lag starts to appear is between DEP monuments R-129 and R-130 (Zone 3, Figure 20). The preliminary results also indicate that the phase lag between the north end of the lagoon and the Gulf of Mexico is minimal.

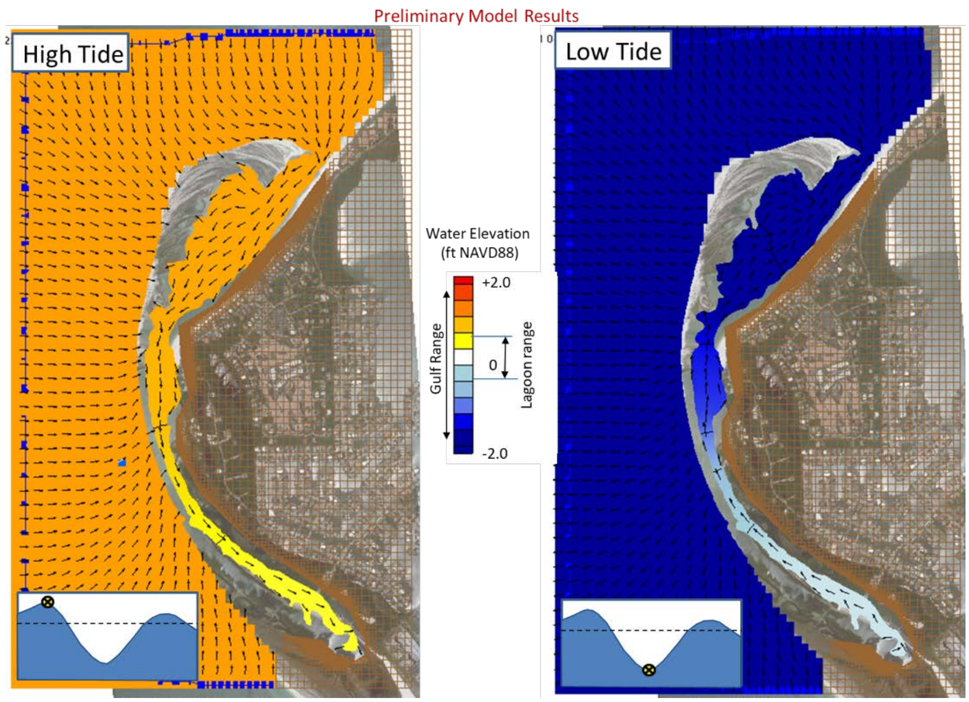


Figure 21: Model results for tidal flow (2017 conditions)

5.1.4 Model Calibration

The model was calibrated with tidal information from two tide gages deployed by Turrell & Associates Inc. The gages were deployed at the north and south end of the Tiger Tail Lagoon. Figure 16 shows the tide gage results. The elevations from the Big Marco Pass tide gage (north) showed some abnormalities at low tide. These are most likely the results of the water levels reaching very low values during spring tide and may have exposed the tide gage. The tide elevations from the Naples Pier were superimposed in the graph (green) with a good match at high tide. The Tigertail Lagoon gage showed a significantly lower range and lag during low tide. The calibration of the model consisted of several iterations to evaluate the level of bottom roughness along the narrow stretch between R-129 and R-133 and assign a proper roughness coefficient. **Figure 22** shows results of the calibrated model. Overall, the calibrated model is able to replicate similar lower tidal amplitude in the lagoon and tidal phase calibration was also only off by a small margin of few minutes.

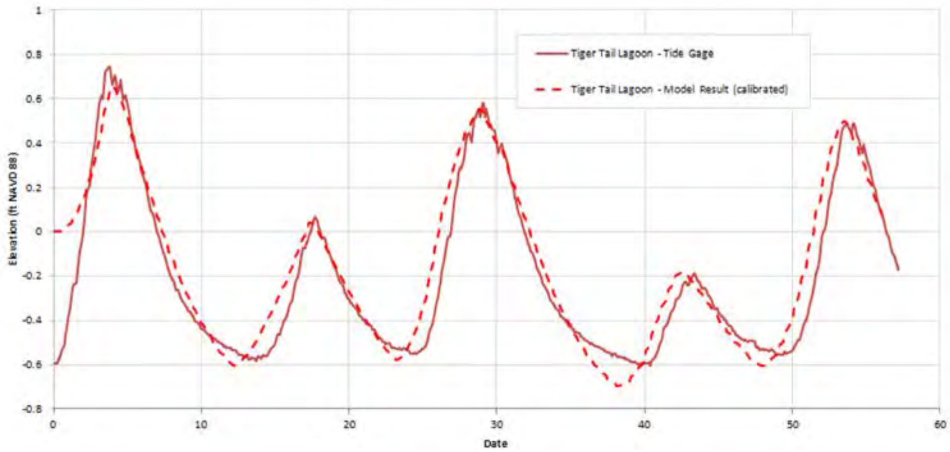


Figure 22: CMS model calibration results

5.1.5 <u>CMS Model Results</u>

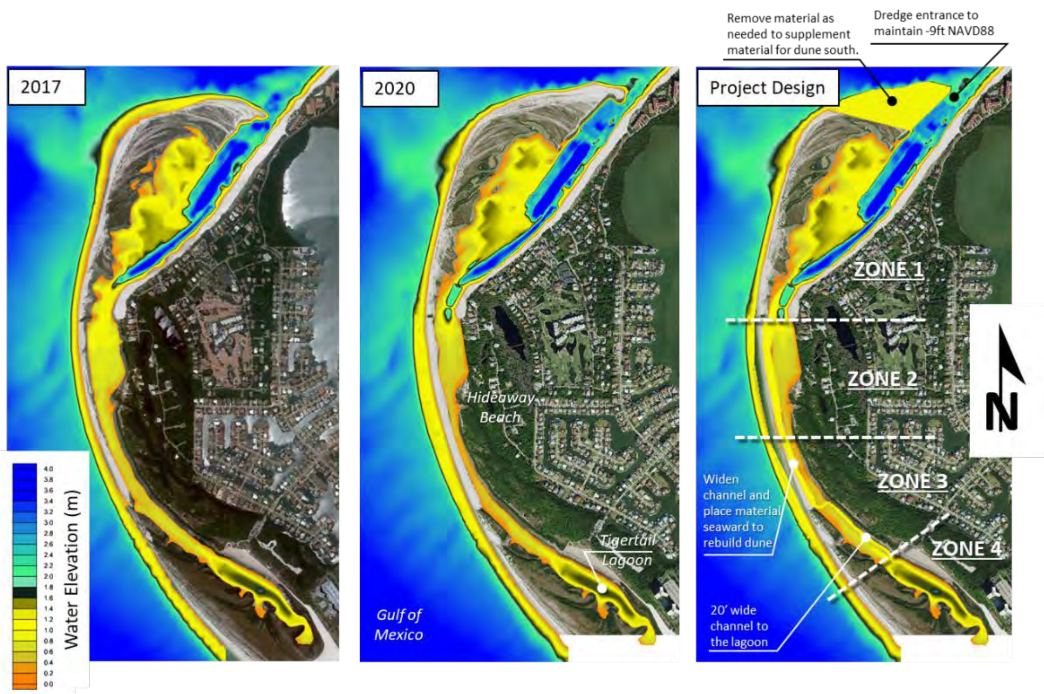


Figure 23: CMS-Flow model bathymetry input GRID for 2017, 2020 and project design

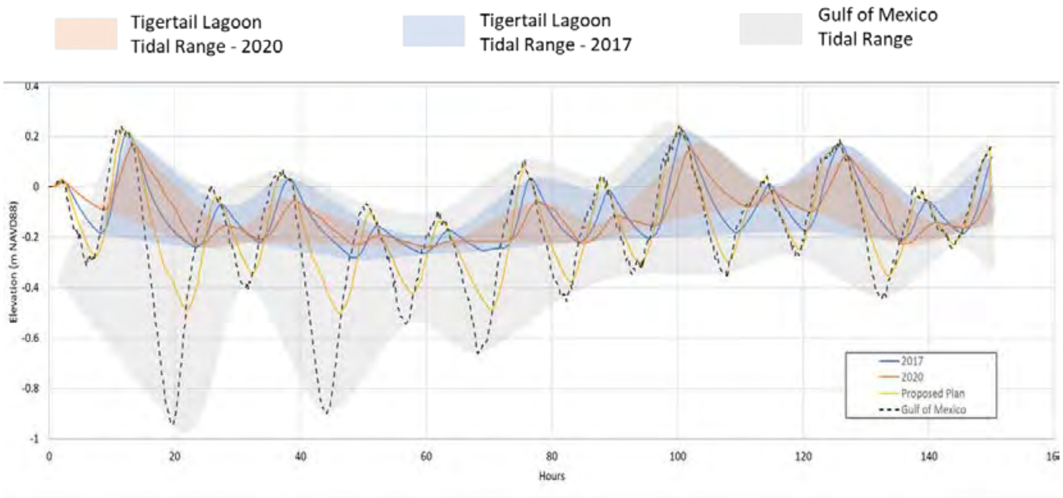
Figure 23 presents the input bathymetries used in the model simulations, these consisted of:

- *<u>2017 conditions</u>*: The previous recent survey, it is used as the base to compare conditions of the system.
- *<u>2020 conditions</u>*: The most recent survey, it is used to show the evolution of the system
- *<u>Proposed plan</u>*: The proposed plan is based on the 2020 survey and illustrates the proposed improvements moving forward.

The proposed plan is illustrated on the right panel in **Figure 23**. It consists of expanding the Hideaway borrow area template (Zone 1) to maintain a consistent depth throughout the entrance to the lagoon area. Widening of the channel through the central lagoon area (Zones 2 & 3) is also proposed, and the material moved would be placed west, directly on the adjacent beach for added storm protection and to help prevent overwash. Finally, an approximately 20 foot wide and 3 foot deep distribution channel would be established at the south end of Zone 3 outside of mapped natural resources to connect the main channel to the southern end of the lagoon (Zone 4).

Figure 24: CMS model results -Water levels at high tide

Figure 25: CMS model results -Water levels at high tide



CMS-Flow Model Results
Gulf to Lagoon Tidal Range Ratios

2017	2020	Project Design
0.41	0.23	0.76

Figure 26: CMS model results summary at Tigertail Lagoon – tidal range comparison

The results from the simulations are presented in **Figures 24 to 26**. **Figure 24** presents a sample model result for one timestep during high tide. The results indicate that at high tide, the water levels in the lagoon are lower than in the Gulf of Mexico for the 2017 & 2020 conditions. With the proposed improvements to the system, the lagoon water levels would be slightly higher indicating a more efficient system. **Figure 25** presents the same simulation results during low tide. The model shows that at low tide, conditions have deteriorated between 2017 and 2020, and in 2020 the lagoon becomes completely disconnected from the Gulf of Mexico at low tide. The project design improves flushing of the lagoon to levels similar to that of 2017.

The water levels were extracted from the model at the lagoon location and presented as a time series for all simulations in **Figure 26**. The water level from the Gulf of Mexico was added as a black dashed line for comparison. Tidal range envelope for the Gulf of Mexico, 2017, and 2020 conditions are overlaid with different colors to highlight the differences in tidal ranges. The figure illustrates the deterioration of conditions from 2017 to 2020 as shown in the tidal range decrease between the two survey dates. The water levels with the project design illustrate an increased water level range when compared to both the 2017 and 2020 conditions. The increased range will improve flushing of the lagoon. The average tidal range was computed for all simulations and compared to the tidal range from the Gulf of Mexico. These ratios are presented at the bottom of the figure. They indicate that the average Lagoon to Gulf tidal range ratio for the water level simulated was 0.41 in 2017 and down to 0.23 in 2020. The project design would bring this ratio up to 0.76, suggesting improved flushing of the lagoon.

5.2 Resiliency of the Proposed Design – XBeach Morphology Model

In addition to improving flow circulation, the proposed design also offers additional protection to high frequency storm events such as the recent tropical storm Eta in November 2020. Such storms occur on an annual basis and over the long term may result in the landward migration of the Sand Dollar Island and shoaling of Tigertail Lagoon. The proposed design would offer storm protection for high frequency storm and typical winter fronts in the form of a slightly elevated berm design with a mild slope beach face and a submerged berm which would achieve the desired habitat for wildlife and improve resiliency to high frequency storms and associated surge. **Figure 27** shows a typical cross section of the proposed design. A complete set of the proposed plans and cross sections are provided in **Appendix A**.

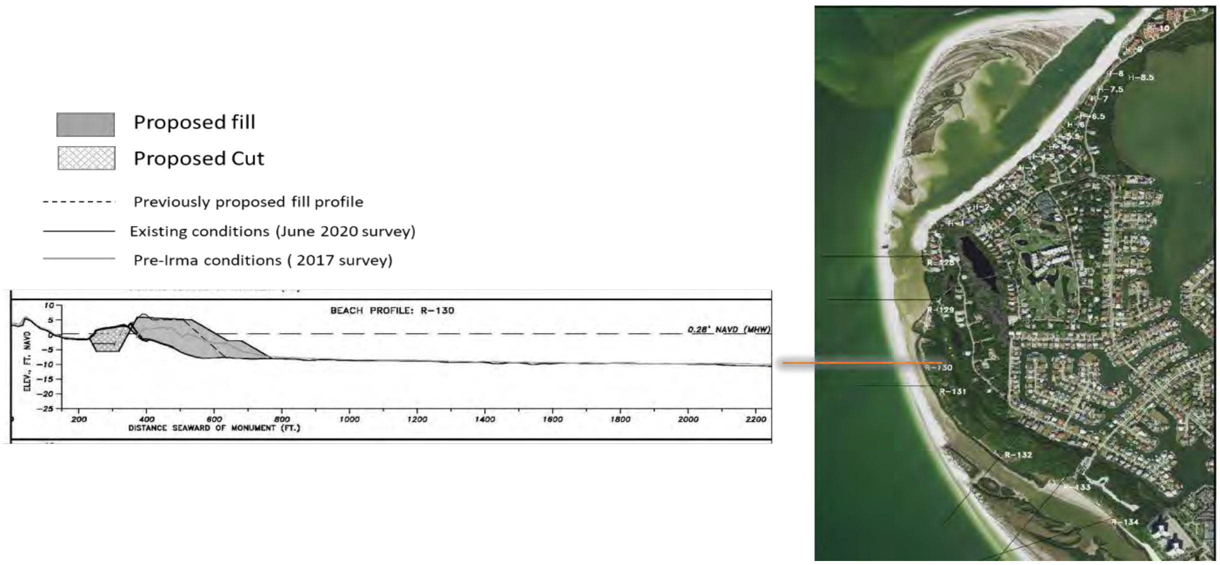


Figure 27: Sand Dollar Island proposed restoration profile

This section presents the numerical model simulations prepared to illustrate the proposed design performance. The XBeach model was used for this task.

5.2.1 XBeach Model Description

XBeach was developed by Deltares (a research institute in the Netherlands) with major funding from the US Army Corps of Engineers. XBeach produces computations at very small-time steps, on the order of seconds, based upon principles of physics. It was designed to provide insight into the nearshore coastal processes such as swash zone and berm interactions, as well as dune dynamics and breaching. The computational intensity of the model requires that a relatively small area is modeled over a relatively short time period in order to have a practical simulation run-time. As such, it was designed for and is typically applied for shorter durations, such as storm events.

The model includes the hydrodynamic processes of short-wave transformation (refraction, shoaling and breaking), long wave (infragravity wave) transformation (generation, propagation and dissipation), wave-induced setup and unsteady currents, as well as overwash and inundation. The morphodynamic processes include bed load and suspended sediment transport, dune face avalanching, bed update and breaching. Effects of vegetation and of hard structures can also be incorporated. The model has been validated with a series of analytical, laboratory, and field test cases using a standard set of parameter settings. The model takes into account the variation in wave height in time and is able to resolve long waves. This so-called 'surf beat' is responsible for most of the swash waves that reach the dune front or overtop it. This innovation makes the XBeach model better suited than other models to simulate the development of dune erosion and wave run-up. In addition, the model allows for inclusion and interaction with coastal structures and seawalls. These are represented in the model as hard boundaries with selective friction coefficients.

Model Validation of XBeach

The XBeach model was validated in the 1D mode using an available pre-hurricane Irma survey profile from 08/2017 and a post storm survey profile from 10/2017 for monument H-1 along Tigertail Lagoon. Sensitivity testing of the model was conducted to fine tune the model response to storm surge. **Figure 28** presents the results for the XBeach model validation simulation. The top exhibit shows the pre-Irma profile in a dash line, the post-Irma profile in yellow from the 10/2017 survey, and the model result in red. The bottom exhibit presents the model input. The hydrograph was obtained from the Naples tide gage and the wave time series was extracted from the nearest NOAA Wave Watch III (WWIII) station. While simulating the migration of a barrier island is a complex, multi-dimensional task, overall the model results are reasonable. The model receded the shoreline comparably to the actual storm, the top of the berm was lowered, and the Sand Dollar Island berm moved landward in a similar fashion to the survey data.

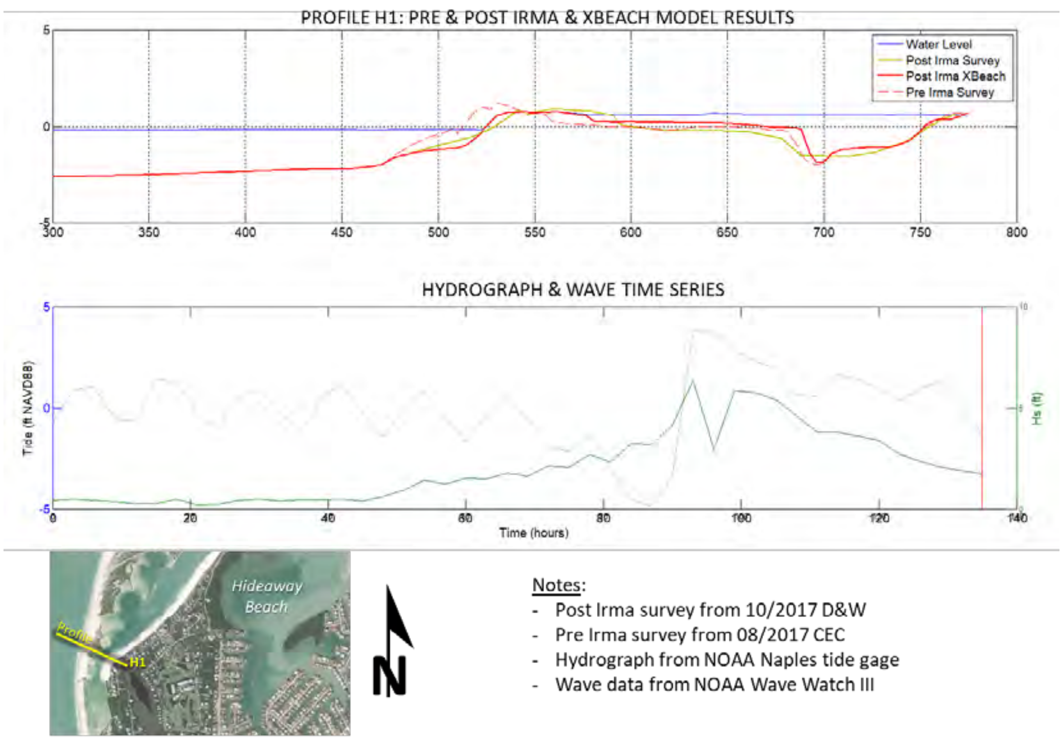


Figure 28: XBeach model validation for Hurricane Irma effects on Sand Dollar Island

5.2.2 XBeach Model Simulations

Using the validated model, the analysis was expanded to 2D mode with the most recent May 2020 survey from CEC, supplemented with observations from recent aerial photographs. The purpose of the simulation was to compare the performance of Sand Dollar Island during a high frequency storm, such as the recent Tropical Storm Eta, with and without the restoration project. The inputs consisted of a hydrograph from Eta and assumed waves of approximately 4.5 feet from the west.

5.2.3 Simulation of Existing Conditions

Figure 29 presents the simulation results for existing conditions (2020). Three time steps were extracted from the model at T1 (initial condition), T2 (conditions at peak surge) and T3 (conditions at end of simulation). Each timestep is presented in the figure as a regional contour map of Hideaway Beach. The maps are color coded as described in the figure for elevations ranging from 0m to -2.5m (-8.2ft) NAVD88. The water surface is represented as a semitransparent blue overlay.

At peak surge (T2), the model shows the water level (including waves) overtopping Sand Dollar Island. At that stage the berm has already started to shift landward (towards the east). At the end of the simulation (T3), the model results show the shifted shoreline. The lagoon channel is narrower than the initial conditions. The model also shows breaches through the berm connecting the Gulf of Mexico to the lagoon. Such breaches were documented during tropical storm Eta. Their exact location can vary and will typically follow areas along the berm with the lowest elevations. Because of the high sediment transport in the region and low tidal prism from the lagoon, these breaches tend to fill in with sand carried along the shore through wave action.

Figure 30 presents the same model results extracted at 4 profiles along Tigertail. For each profile, the initial conditions are shown as a dashed line and the final profile is indicated in blue with areas of erosion and shoaling shaded in blue and orange respectively. Profiles 1 through 3 show a landward shift of the berm, shoreline recession, and narrowing of the channel. Profile 4 falls in one of the areas which experienced breaching during the simulated storm, therefore the eroded profile is flat because the berm completely eroded.

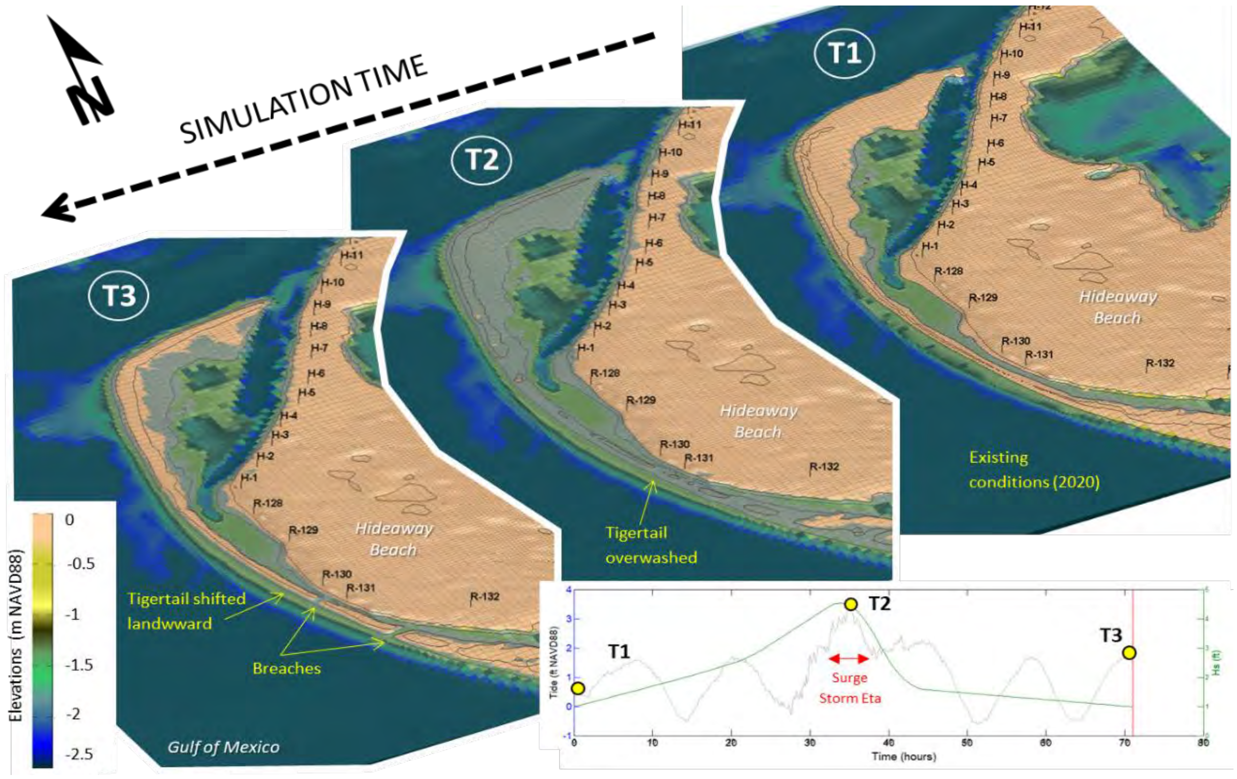


Figure 29: XBeach Model Results – Storm Eta – Existing Conditions

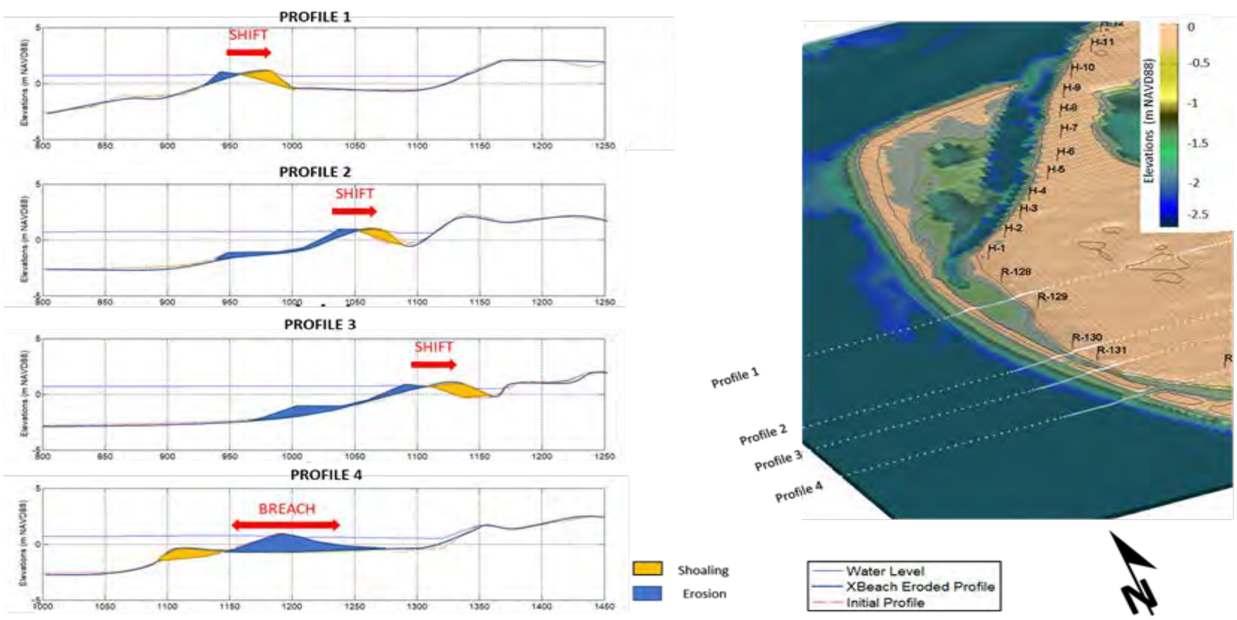


Figure 30: XBeach Profile Change Results – Storm Eta – Existing Conditions

5.2.4 Simulation for Project Design

The same simulation was generated for the 2020 conditions with the proposed enhanced berm design. The enhanced berm included an approximately 150 foot wide berm and mild sloped beach face that includes a submerged berm near MLLW that further assists in wave energy dissipation and provides a milder profile that supports ecological needs in the area.

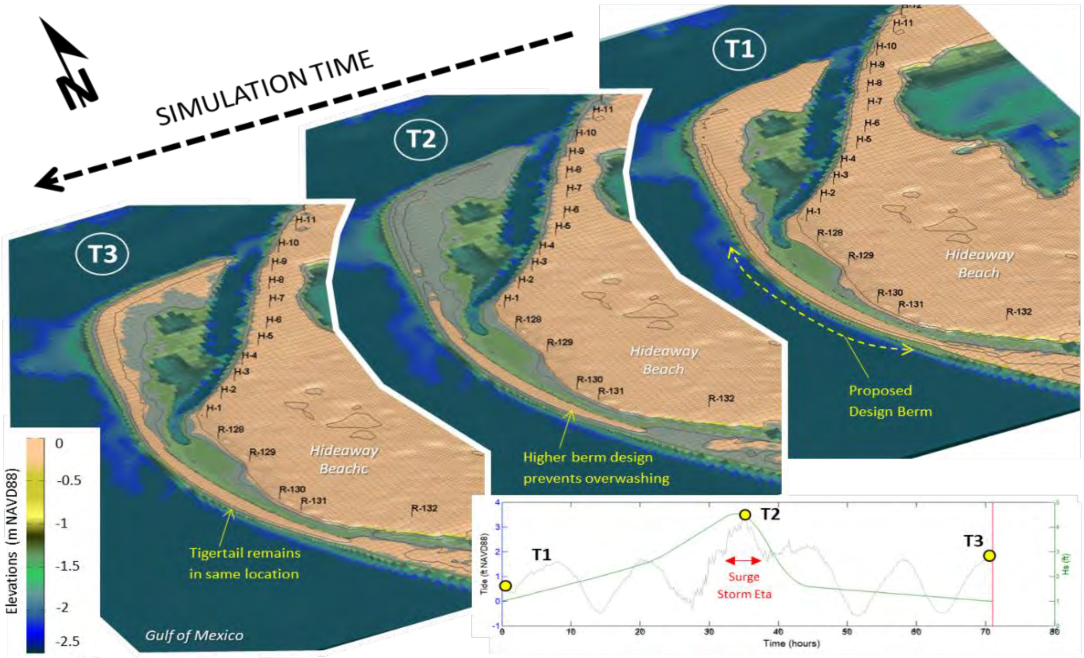


Figure 31: XBeach Model Results – Storm Eta –Design Conditions

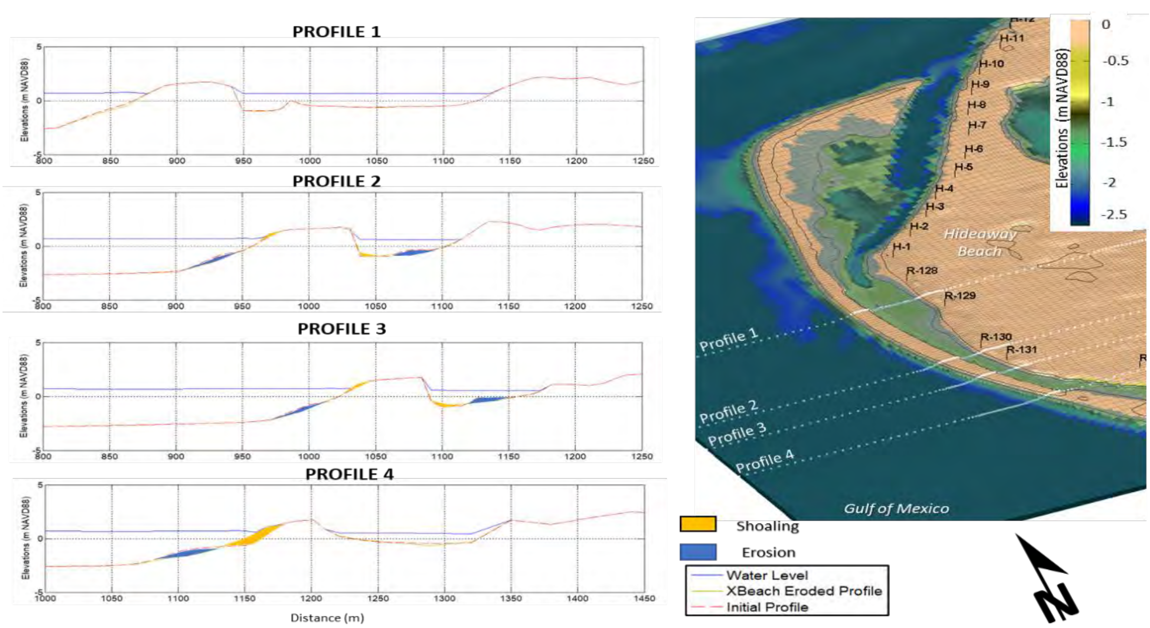


Figure 32: XBeach Model Results – Storm Eta –Design Conditions

Figure 31 presents the 2D model results for timesteps 1 through 3. At peak surge (T2), the results show that Tigertail would be overwashed except for the area of the project. At the end of simulation (T3), the model results show that with the proposed design of Sand Dollar Island would be significantly more resilient to the level of high frequency storms that have been impacting Sand Dollar Island and Tigertail Lagoon.

Figure 32 shows the model results for the enhanced berm for the same 4 profiles along Sand Dollar Island that were presented for existing conditions in Figure 28. The cross sections show typical profile adjustment on the shore face without overwash or shoaling in the lagoon. The model also indicated the model berm function in separating the lagoon water from the open gulf for that level storm. This functioning of the beach berm and enhanced profile effectively reduces shoaling with the lagoon from overwash and minimizes potential for suspended sediment settling in the lagoon under high frequency storms.

Figure 32 shows comparison of the model results for existing conditions and proposed conditions at the peak of the storm. Overall, the model results show that the proposed berm design would enhance the resiliency of Sand Dollar Island to high frequency storms similar to the recent tropical storm Eta. The improved resiliency of Sand Dollar Island will help maintain the lagoon channel, tidal flushing, and water quality.

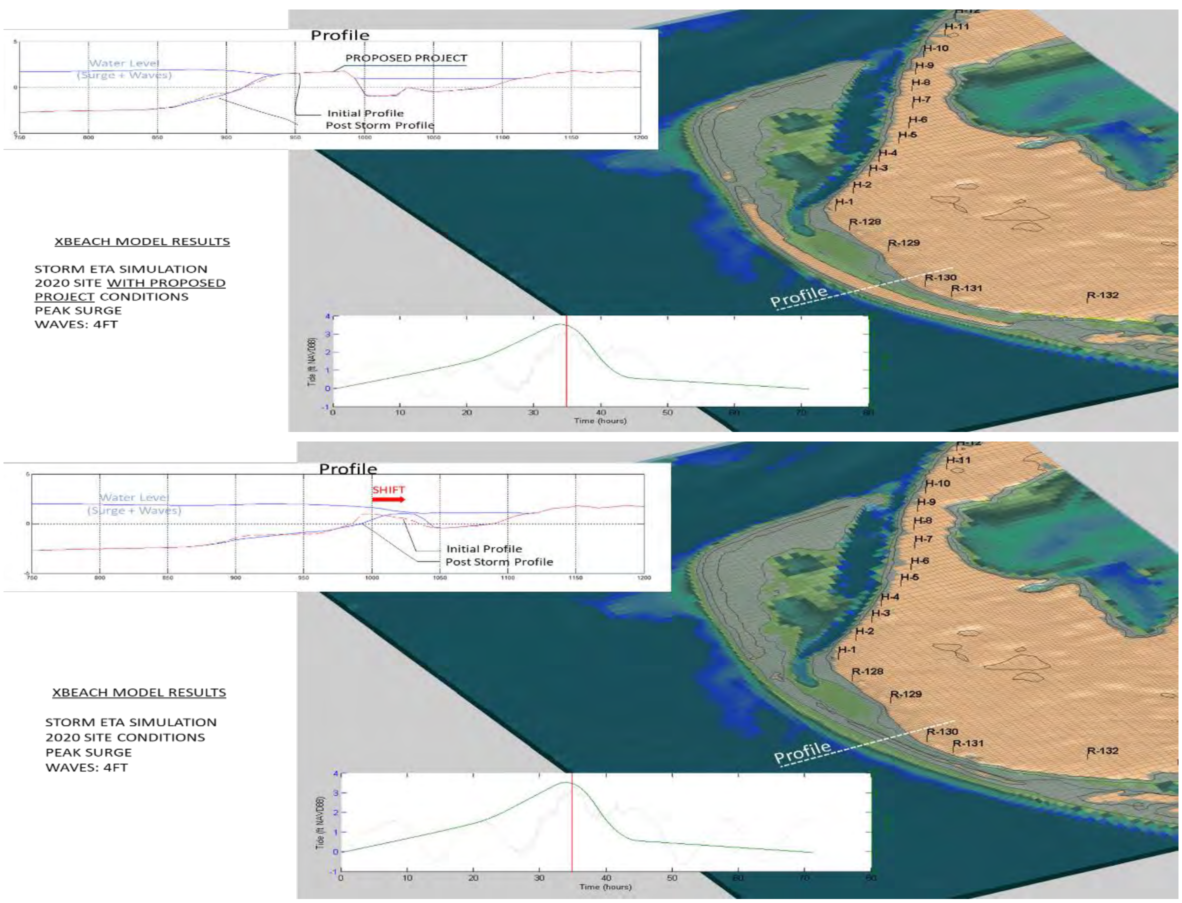


Figure 33: Comparison of existing and proposed conditions at peak of high frequency storm

6. Design Development and Plan formulation

6.1 Preliminary Designs and Minimization Efforts

Initial proposals for work in this area (H&M 2018) consisted of dredging the waterway to place sediment on the Sand Dollar Island segment and creating a borrow area at the north end of the spit off Hideaway Beach. After consultations with permitting and resource agencies, several modifications were made to the plan. These are summarized below:

- Flushing channel to be located in areas of over wash. This dredges the frequently over washed dry beach to reclaim wetland areas in the lagoon along Sand Dollar Island. No work is conducted in or through existing wetlands, which avoids seagrass beds.
- Sand trap area reduction from 17.0 acres to 6.4 acres. The area of the sand trap has been reduced by close to two thirds. Of the 6.4 emergent acres within the designed sand trap in December 2019, about 2.5 acres are vegetated, which provides inferior habitat for several bird species.
    - The shape of the sand trap and fill template have been reconfigured to encourage and enhance development of intertidal shoals, creating improved habitat for wading birds. This is done by reconfiguring the sand trap to encourage wrapping of the spit and adding a submerged berm to the spit template.
    - The profile of the Sand Dollar Island beach was designed with guidance from environmental agencies to be suitable beach bird nesting habitat while maintaining resiliency during high frequency storms.
- The permitted offshore borrow area is added as a sediment source to be available if necessary. This will ensure sufficient sediment to construct the more resilient Sand Dollar Island.

6.2 Proposed Plan

The proposed plan would restore the Sand Dollar Island to its 2016 Mean High Water position, provide enhanced resiliency of the spit, and create an enhanced tidal circulation channel within Tigertail Lagoon. This is accomplished by connecting the existing nearshore borrow area at Hideaway Beach with the sand trap and creating a flow channel along the back of Sand Dollar Island to provide enhanced flushing to the southern lagoon area. A general sketch and highlights of the proposed plan are shown in **Figure 34.**

Figure 34: Outline of proposed plan

The middle area of Sand Dollar Island would be reconstructed seaward of its current location along the pre-Irma November 2016 shoreline. As illustrated in **Figure 27**, the reconstructed berm would slope from +6’ to +5’ NAVD over approximately 150’ width at the crest, with a beach facing slope of 1V:15H. The spit is estimated to require 325,000 cy for initial construction.

The flow channel along Sand Dollar Island will have a bottom elevation of -5’ NAVD and will yield almost 95,000 cy of sediment. The flow channel connecting the existing Nearshore Borrow Area to the Sand Dollar Island flow channel will have a bottom elevation consistent with the adjacent borrow area at -8’ NAVD and contains approximately 65,000 cy. The proposed sand trap will also have a bottom elevation of -8’ NAVD. The Sand Trap is expected to contain at least 130,000 cy at dredging. At least 60,000 cy are anticipated to be available from the proposed extension of the Nearshore Borrow Area. A distribution channel that may be considered through the existing seagrass beds to the deep lagoon could yield up to an additional 3,000 cy. Taken together, over 350,000 cy of sediment will be dredged. The balance of sediment will be placed in or taken from the Offshore Borrow Area as necessary. A summary is provided in **Table 5**.

Table 5: Sediment Balance

Estimated Sediment Balance		
Location	Available	Required
Flow Channel - Tigertail	95,000	-
Flow Channel - Hideaway	65,000	-
Sand Trap	130,000	-
Borrow Area Extension	60,000	-
Distribution Channel	3,000	-
Spit Restoration	-	325,000
Total:	**353,000**	**325,000**
Offshore Borrow Area	As Needed	

Creating the flow channel at Sand Dollar Island will displace approximately 6.8 acres of unvegetated upland. However, the newly constructed spit will provide 15.1 acres of unvegetated upland resulting in an 8.3 acre gain of improved habitat. The plan will also enhance an additional 3.0 acres of existing uplands by raising the grade and removing vegetation. This provides a net benefit of 11.3 acres. Initial dredging of the sand trap will remove approximately 6.4 acres of the tip of the spit, of which 3.9 acres are unvegetated. In total, the project exchanges 10.7 unvegetated acres and 2.5 vegetated acres (13.2 acres total) for 15.1 acres of newly constructed, resilient unvegetated uplands and improvement of an additional 3.0 acres (18.1 acres total). A summary is provided in **Table 6**. Unvegetated uplands constructed along Sand Dollar Island will be maintained unvegetated according to a vegetation management plan coordinated with DEP and Rookery Bay Aquatic Preserve.

Table 6: Acreage Balance - Upland

Borrow Areas - Upland Acreage	
Sand Trap	6.4
Flow Channel	6.8
Total	**13.2**

Constructed Uplands (acres)	
Restored	15.1
Enhanced	3.0
Total	**18.1**

6.3 Benefits of the Plan

Figure 35 shows the plan view of the proposed plan and its main elements. The full set of the plan drawings is included in **Appendix A.**

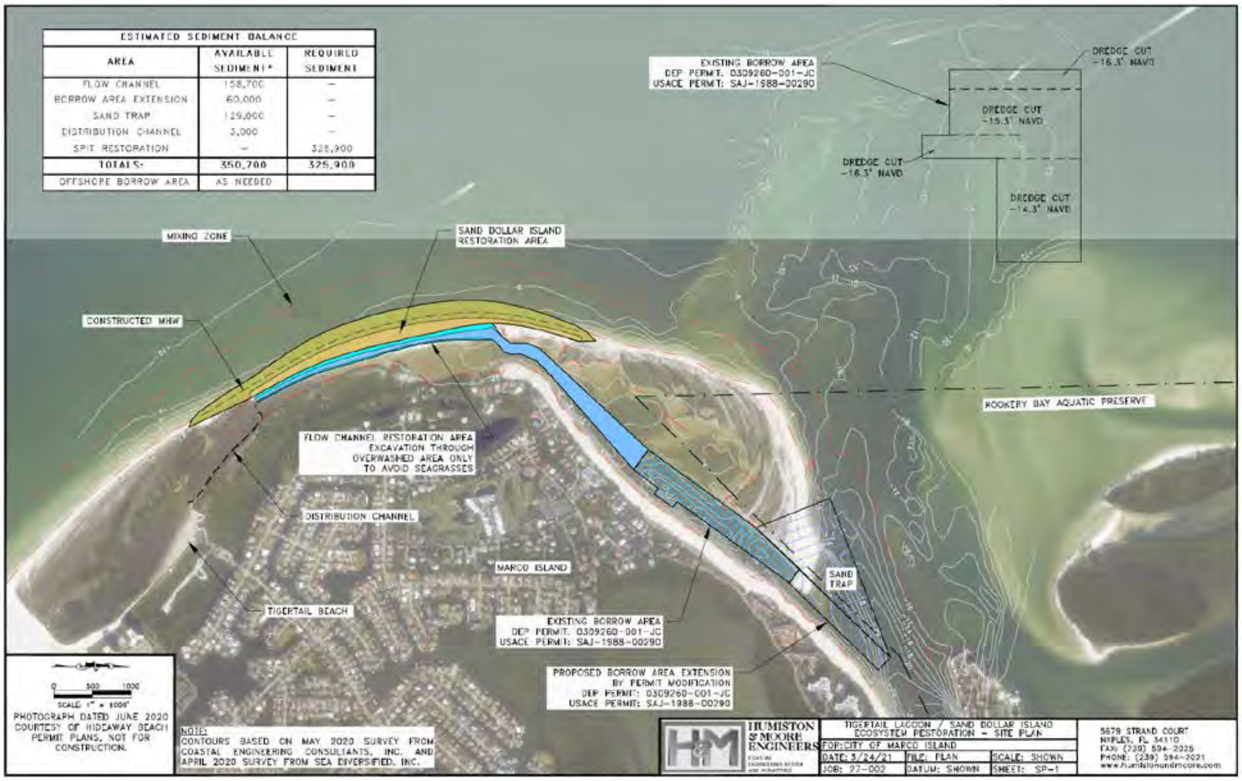


Figure 35: The plan view of the proposed plan for the restoration of Tigertail Lagoon- Sand Dollar Island

Figure 36 summarizes a comparison between the No-Action alternative and the proposed plan. The Figure lists the likely effects of the system closure compared to the benefits of the proposed plan.

In the absence of the project, the complex aquatic ecosystems of the lagoon and seagrass beds will be buried or will deteriorate. Upland habitat would also deteriorate with the loss of the Sand Dollar Island and Tigertail Lagoon intertidal flats. Erosion would continue, leading to loss of mangroves and eventually threatening upland development. Preserving these habitats and the natural environment is the objective of the City of Marco and the Friends of Tigertail.

The plan preserves and enhances existing aquatic and terrestrial habitat, producing a net gain in both habitats. There are a variety of direct and indirect benefits associated with the plan, some of which are identified below:

- Preserved and enhanced seagrass, lagoon, and terrestrial habitats.
- Improved tidal flushing and water quality.
- Improved sediment management by recycling sand from the growing northern tip of Sand Dollar Island to the eroding shoreline.
- Maintaining a source of sediment along Sand Dollar Island as a feeder beach.
- Enhanced nature-based erosion protection to mangrove shoreline and upland development by the more resilient Sand Dollar Island.

- **No action**
  - ***Closure of central part of the lagoon***
    - ***Loss of wetland habitat and seagrasses***
    - ***Coastal erosion and vulnerability to mangrove areas***
  - ***Landlocked pond at Tigertail lagoon***
    - ***Water quality problem***
    - ***Loss of coastal lagoon environment***
  - ***Limited northern coastal lagoon if entrance dredging continues***
  - ***Increased entrance dredging frequency/ costs***
  - ***Continued spit growth to northeast and increased sand flow into navigation channels***
  - ***Likely complete lagoon closure***

- **Recommended Plan**
  - ***Maintain lagoon area as wet estuary***
  - ***Address shoaling in the lagoon through initial dredging and future maintenance dredging with consideration to seagrasses***
  - ***Restore Tigertail Lagoon and Sand Dollar Island to Pre Irma (2017 conditions)***
  - ***Restore and enhance Sand Dollar Island for coastal resiliency and for bird and turtle nesting habitat***
  - ***Restore tidal circulation channel on backside of Sand Dollar Island to improve lagoon flushing***

Figure 36: Alternative's comparison of No-Action Vs Proposed Plan

7. References

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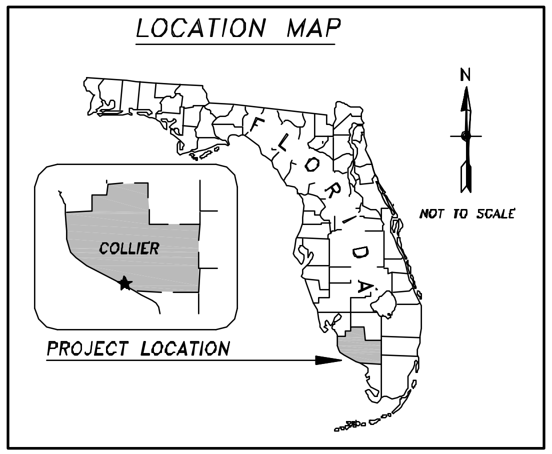
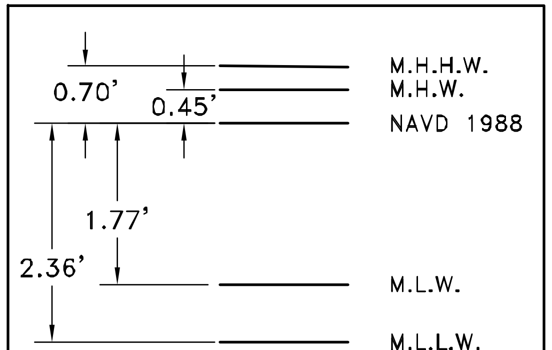
Appendix A

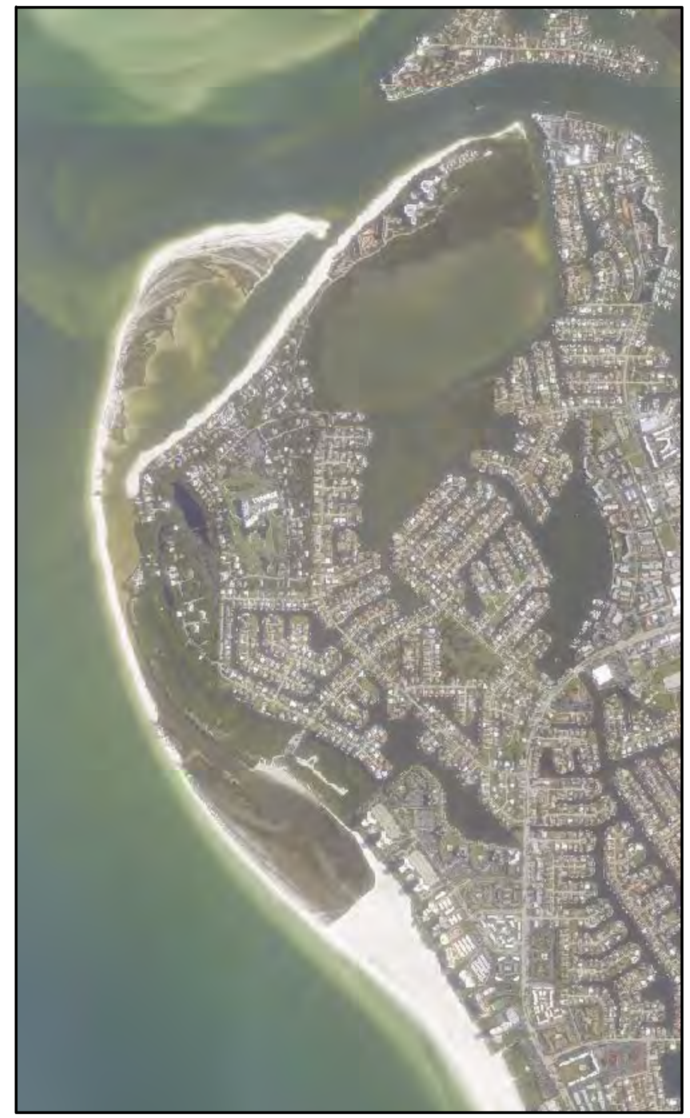
Tigertail Lagoon & Sand Dollar Island Restoration Permit Plans

TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ECOSYSTEM RESTORATION
MARCO ISLAND, FLORIDA
PERMIT PLANS





RELATIONSHIP BETWEEN NAVD 1988, AND TIDAL DATUMS FROM NOAA STATION 8724967 MARCO ISLAND WATER TIDAL DATUM (1983–2001 EPOCH)



SHEET INDEX

COVER	COVER SHEET
SP–1	OVERALL SITE PLAN
SP–2	BEACH CONSTRUCTION SITE PLAN
XS–1	HIDEAWAY BEACH CROSS SECTIONS
XS–2	HIDEAWAY BEACH AND SAND TRAP CROSS SECTIONS
XS–3	HIDEAWAY BEACH AND SAND TRAP CROSS SECTIONS
XS–4	HIDEAWAY BEACH CROSS SECTIONS
XS–5	SPIT RESTORATION CROSS SECTIONS
XS–6	TIGERTAIL BEACH CROSS SECTIONS

NOTES:

1. AERIAL PHOTOGRAPH JUNE 2020 PROVIDED COURTESY OF HIDEAWAY BEACH TAXING DISTRICT.
2. COORDINATES SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN DATUM OF 1983, EAST ZONE (NAD83).
3. ELEVATIONS SHOWN ARE IN FEET BASED ON THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).
4. THESE PERMIT DRAWINGS SHALL NOT BE USED FOR CONSTRUCTION.

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – COVER		
FOR: CITY OF MARCO ISLAND		
DATE: 3/24/21	FILE: PLAN	SCALE: N/A
JOB: 27–002	DATUM: SHOWN	SHEET: COVER

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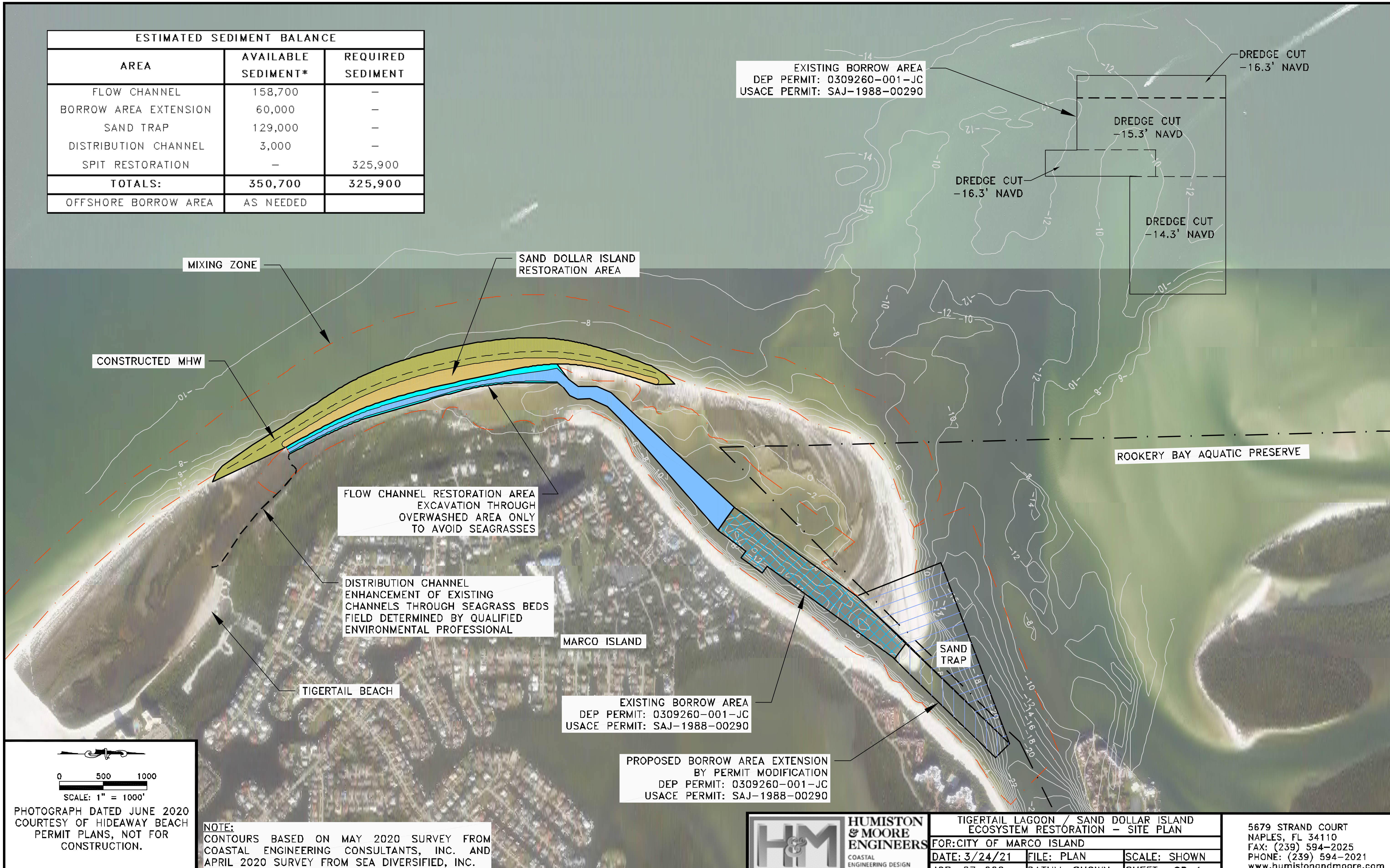
ESTIMATED SEDIMENT BALANCE		
AREA	AVAILABLE SEDIMENT*	REQUIRED SEDIMENT
FLOW CHANNEL	158,700	–
BORROW AREA EXTENSION	60,000	–
SAND TRAP	129,000	–
DISTRIBUTION CHANNEL	3,000	–
SPIT RESTORATION	–	325,900
TOTALS:	350,700	325,900
OFFSHORE BORROW AREA	AS NEEDED	



PHOTOGRAPH DATED JUNE 2020 COURTESY OF HIDEAWAY BEACH PERMIT PLANS, NOT FOR CONSTRUCTION.

NOTE:
CONTOURS BASED ON MAY 2020 SURVEY FROM COASTAL ENGINEERING CONSULTANTS, INC. AND APRIL 2020 SURVEY FROM SEA DIVERSIFIED, INC.

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – SITE PLAN		
FOR: CITY OF MARCO ISLAND		
DATE: 3/24/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: SHOWN	SHEET: SP-1

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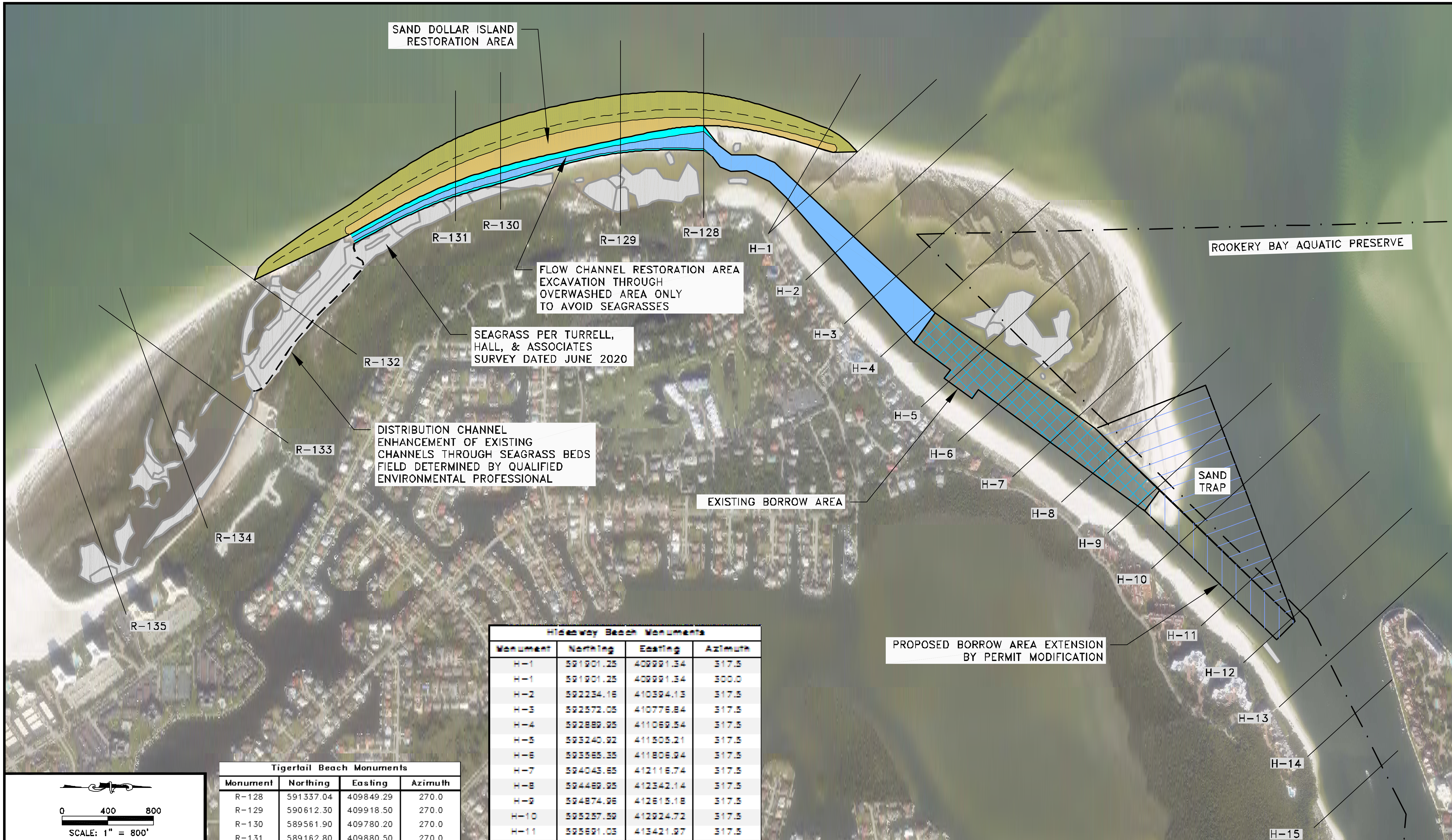

PHOTOGRAPH DATED JUNE 2020
COURTESY OF HIDEAWAY BEACH.
PERMIT PLANS, NOT FOR
CONSTRUCTION.

Tigertail Beach Monuments

Monument	Northing	Easting	Azimuth
R-128	591337.04	409849.29	270.0
R-129	590612.30	409918.50	270.0
R-130	589561.90	409780.20	270.0
R-131	589162.80	409880.50	270.0
R-132	588297.70	411044.00	216.0
R-133	587701.20	411823.90	216.0
R-134	586991.90	412565.80	250.0
R-135	586281.30	413324.80	250.0

Hideaway Beach Monuments

Monument	Northing	Easting	Azimuth
H-1	591901.25	409991.34	317.5
H-1	591901.25	409991.34	300.0
H-2	592234.16	410394.13	317.5
H-3	592572.05	410776.84	317.5
H-4	592889.95	411069.54	317.5
H-5	593240.92	411505.21	317.5
H-6	593565.35	411806.94	317.5
H-7	594043.65	412116.74	317.5
H-8	594469.95	412342.14	317.5
H-9	594874.96	412615.18	317.5
H-10	595257.59	412924.72	317.5
H-11	595691.03	413421.97	317.5
H-12	596064.95	413748.34	317.5
H-13	596373.55	414134.34	317.5
H-14	596628.95	414569.14	317.5
H-15	596680.15	415191.14	317.5

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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ECOSYSTEM RESTORATION – BEACH SITE PLAN

FOR: CITY OF MARCO ISLAND

DATE: 3/24/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: SHOWN	SHEET: SP-2

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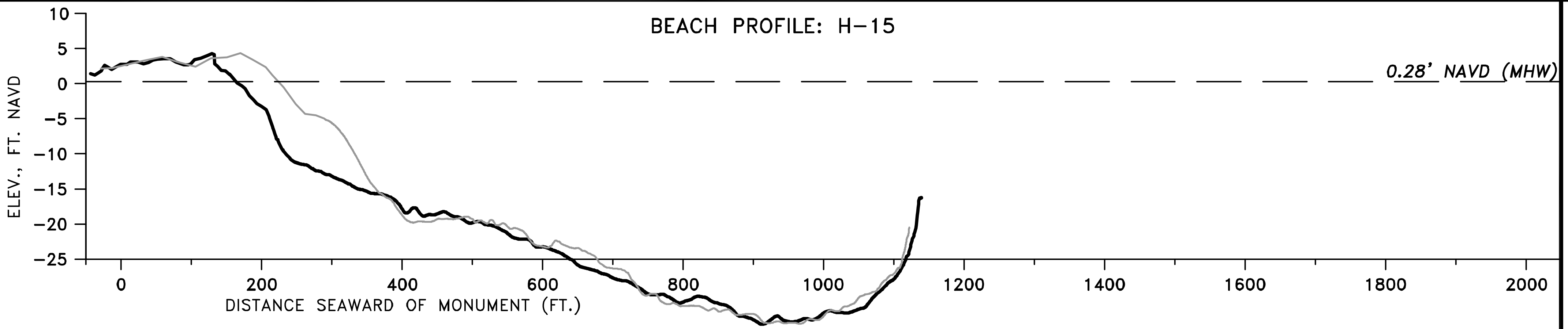

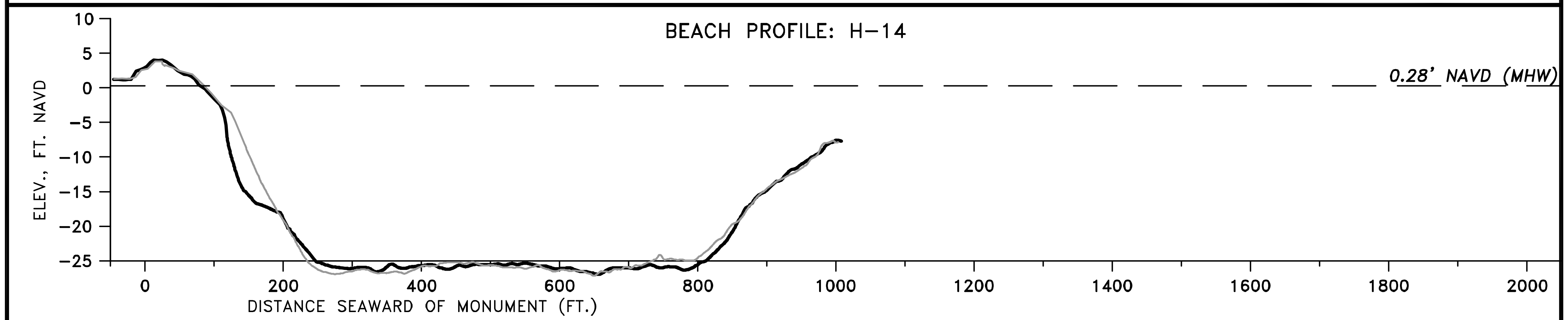

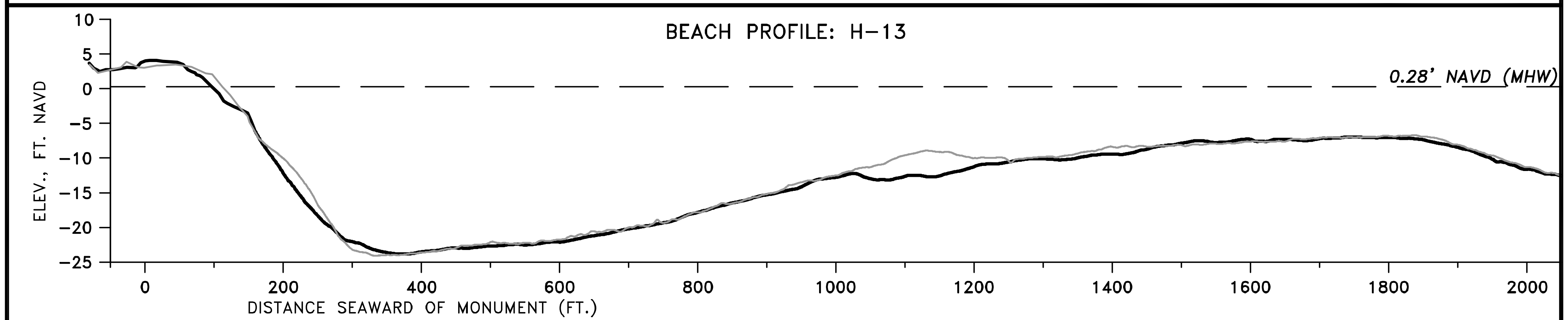

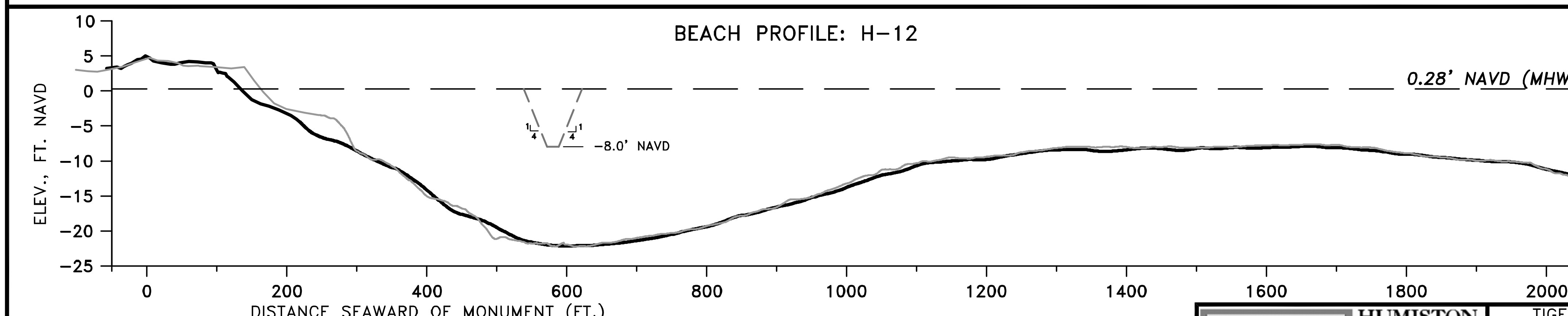

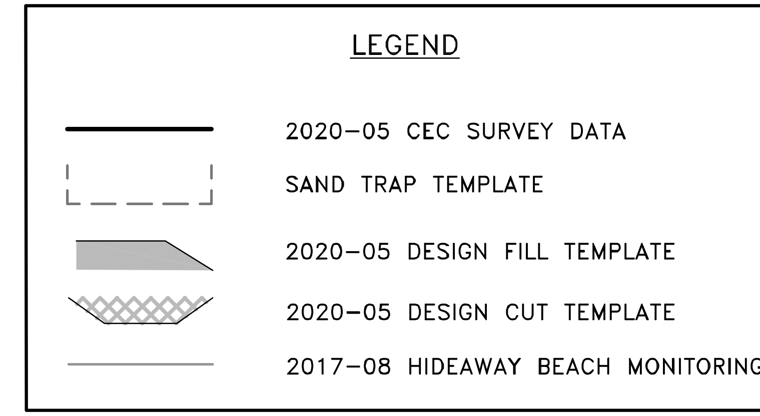

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS

FOR: CITY OF MARCO ISLAND		
DATE: 3/24/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: XS-1

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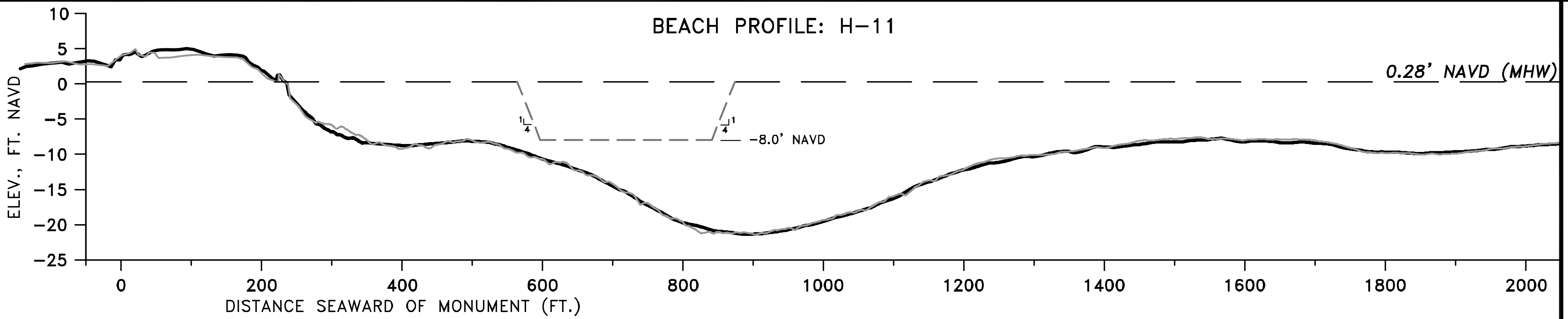

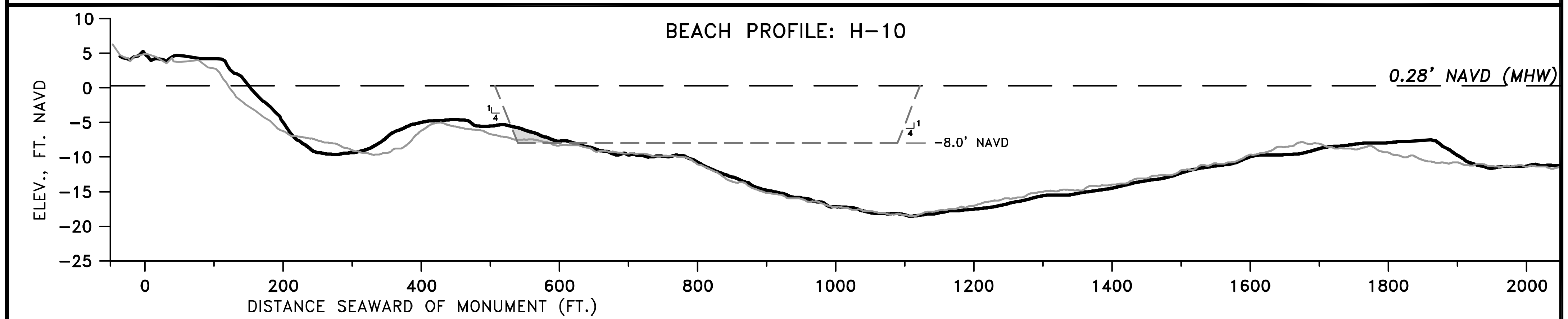

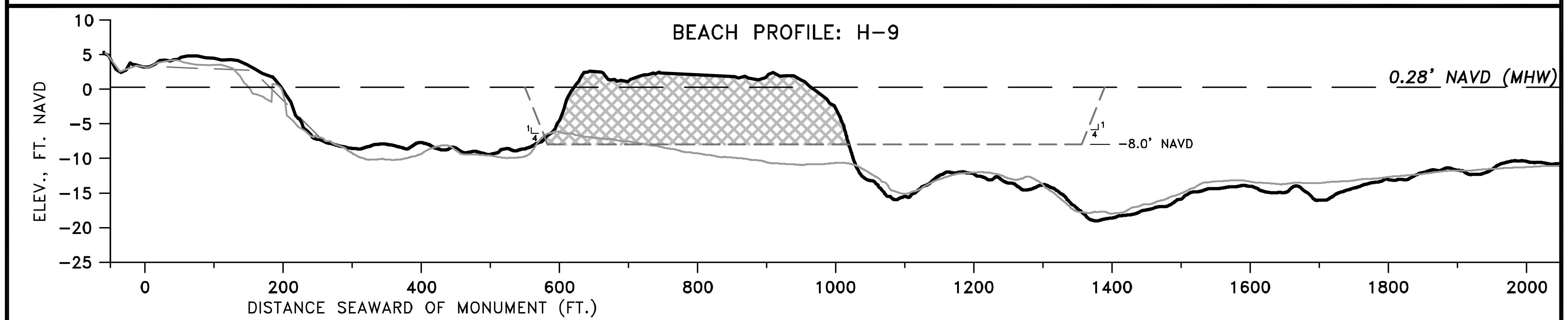

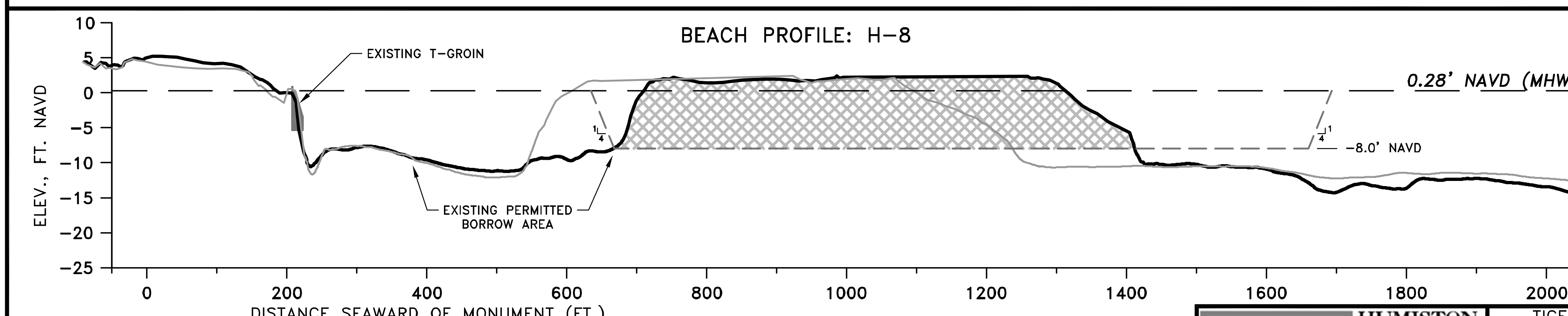

LEGEND

- 2020-05 CEC SURVEY DATA
- SAND TRAP TEMPLATE
- 2020-05 DESIGN FILL TEMPLATE
- 2020-05 DESIGN CUT TEMPLATE
- 2017-08 HIDEAWAY BEACH MONITORING

SAND TRAP			
MONUMENT	EFFECTIVE DISTANCE (FT)	CUT VOLUME (CY/FT)	VOLUME AVAILABLE (CY)
H-8	238	245.9	58,400
H-9	481	142.7	68,600
H-10	573	3.4	2,000
H-11	325	0.0	0
H-12	589	0.0	0
		TOTALS:	129,000

HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS

FOR: CITY OF MARCO ISLAND

DATE: 3/24/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: XS-2

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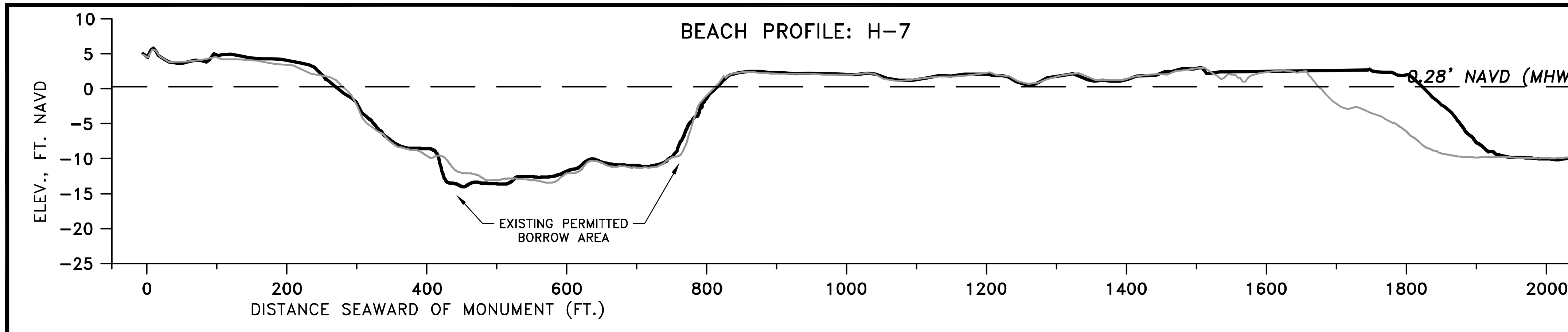

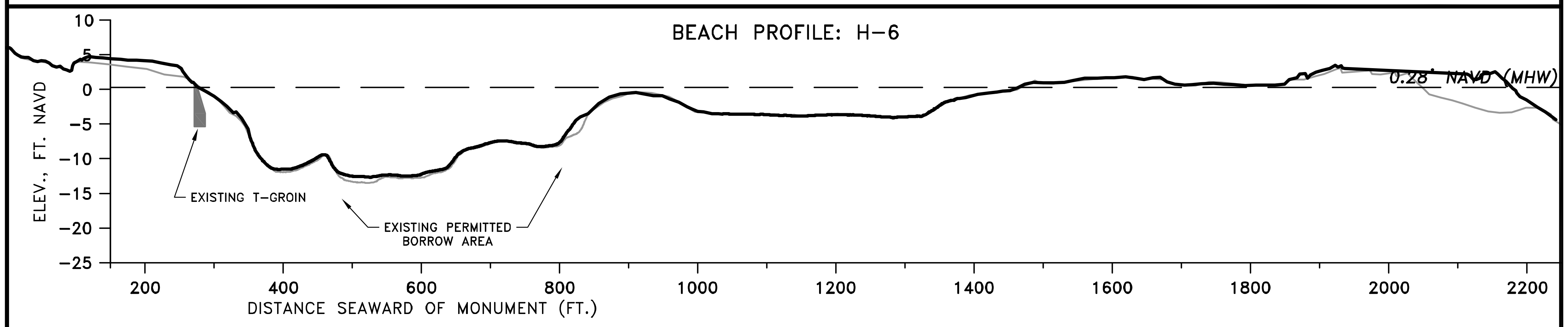

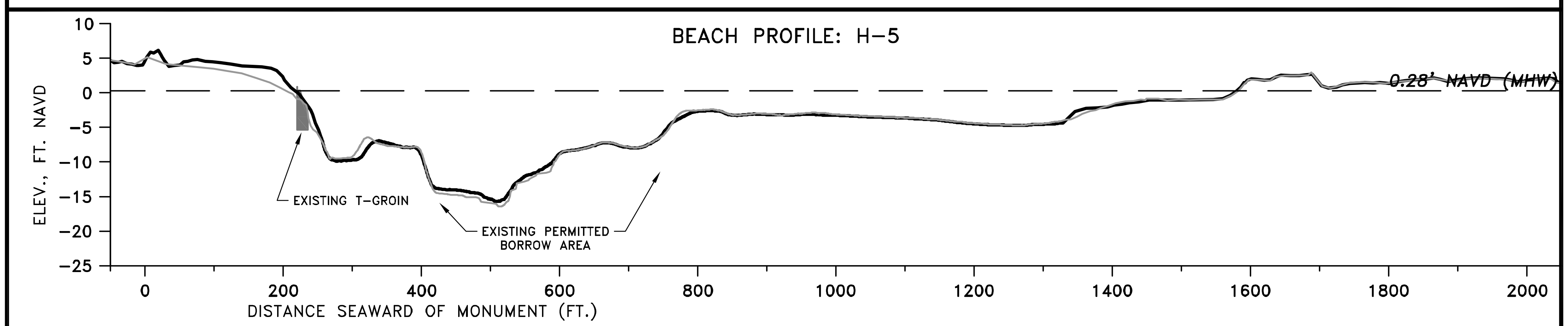

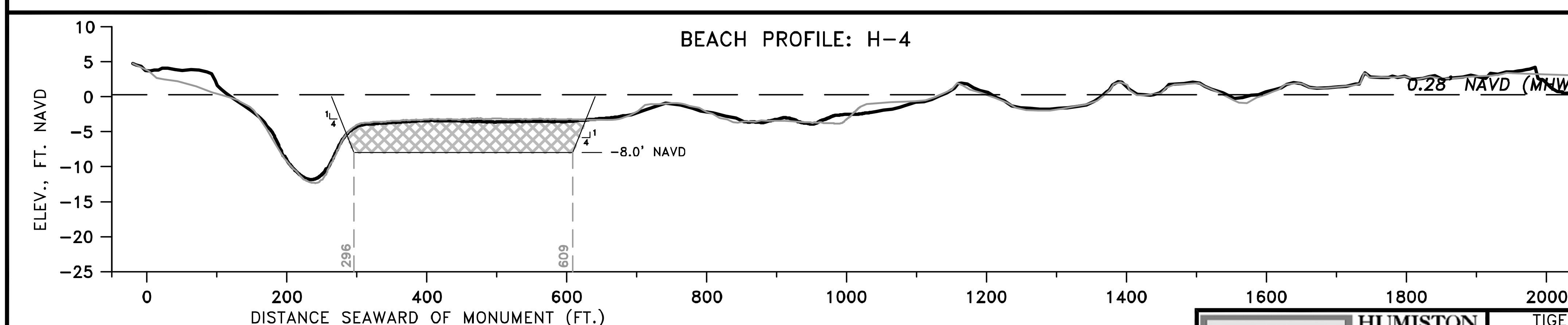

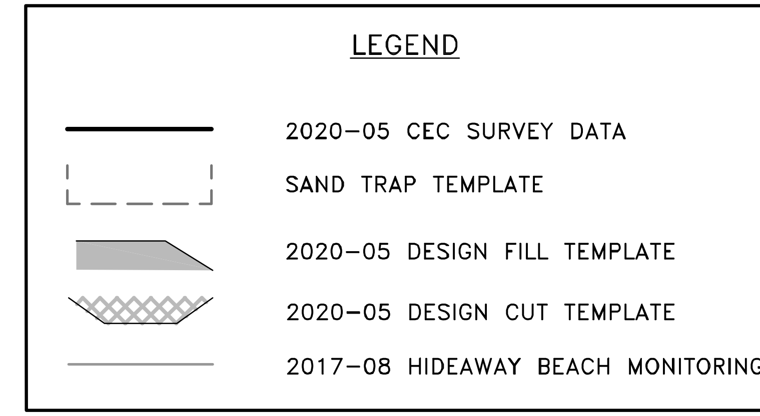

FLOW CHANNEL

MONUMENT	EFFECTIVE DISTANCE (FT)	CUT VOLUME (CY/FT)	VOLUME AVAILABLE (CY)
H-4	287	53.3	15,300
H-3	471	37.4	17,600
H-2	517	20.4	10,600
H-1 @ 317	325	15.2	4,900
H-1 @ 300	589	27.2	16,000
		TOTALS:	64,400

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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ECOSYSTEM RESTORATION - CROSS SECTIONS

FOR: CITY OF MARCO ISLAND		
DATE: 3/24/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: XS-3

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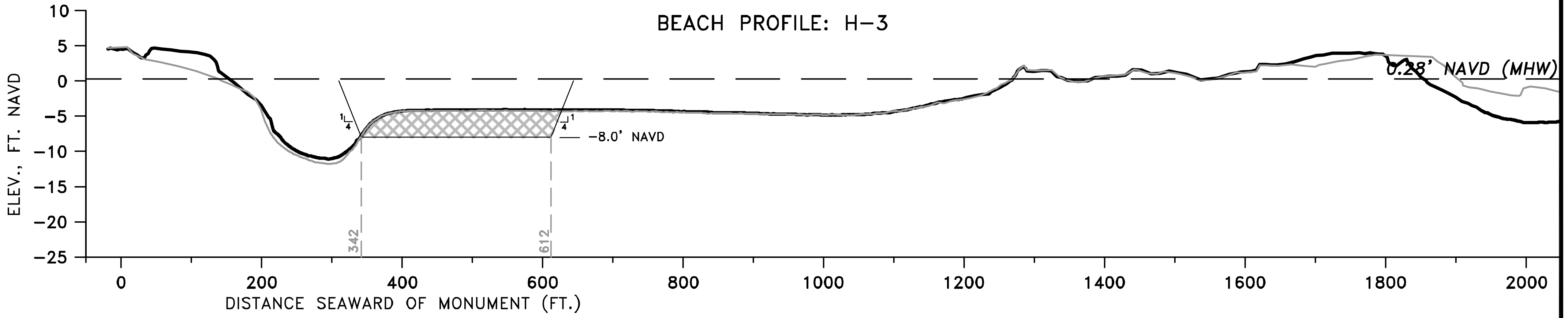

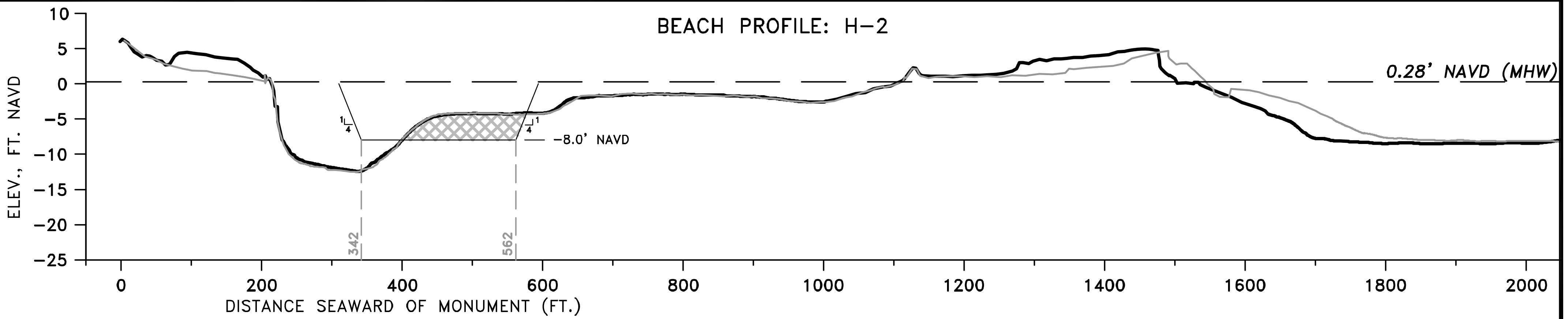

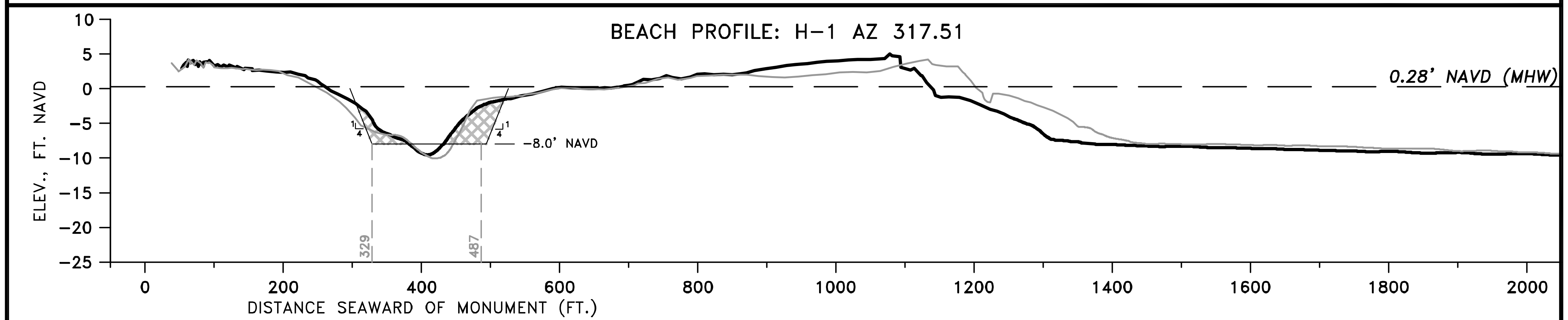

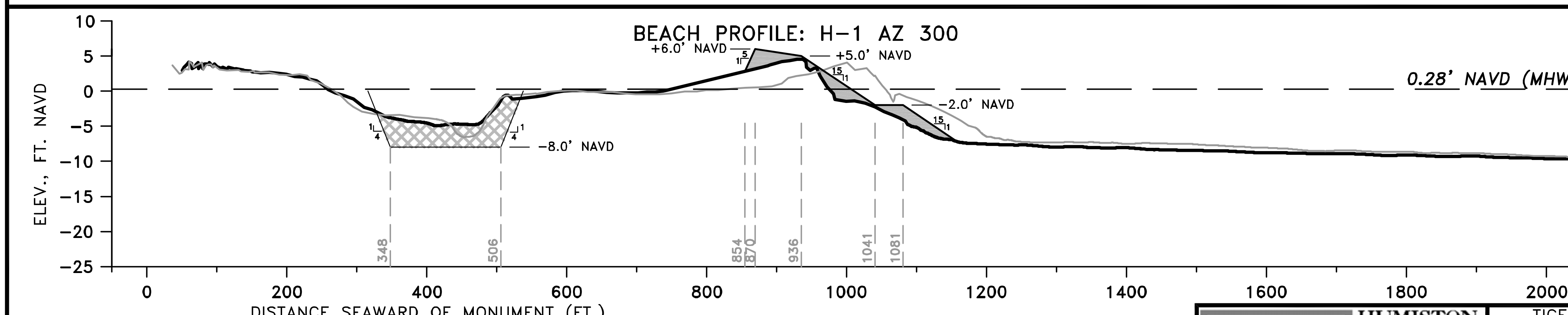

LEGEND

- 2020-05 CEC SURVEY DATA
- SAND TRAP TEMPLATE
- 2020-05 DESIGN FILL TEMPLATE
- 2020-05 DESIGN CUT TEMPLATE
- 2017-08 HIDEAWAY BEACH MONITORING

NOTE: BEACH SLOPES 1:15
CHANNEL SLOPES 1:5

FLOW CHANNEL

MONUMENT	EFFECTIVE DISTANCE (FT)	CUT VOLUME (CY/FT)	VOLUME AVAILABLE (CY)
H-4	287	53.3	15,300
H-3	471	37.4	17,600
H-2	517	20.4	10,600
H-1 @ 317	325	15.2	4,900
H-1 @ 300	589	27.2	16,000
		TOTALS:	64,400

BERM FILL

MONUMENT	EFFECTIVE DISTANCE (FT)	FILL DENSITY (CY/FT)	FILL VOLUME REQUIRED (CY)
H-1	526	15.6	8,200
R-128	889	74.1	60,200
R-129	888	101.5	90,100
R-130	725	111.1	80,500
R-131	1253	73.1	86,900
		TOTALS:	325,900

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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS
FOR: CITY OF MARCO ISLAND

DATE: 3/24/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: XS-4

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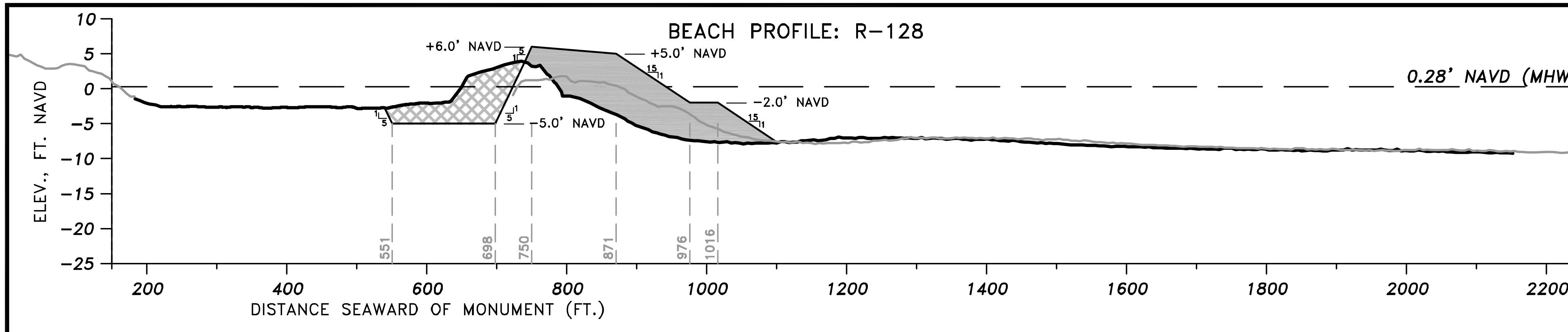

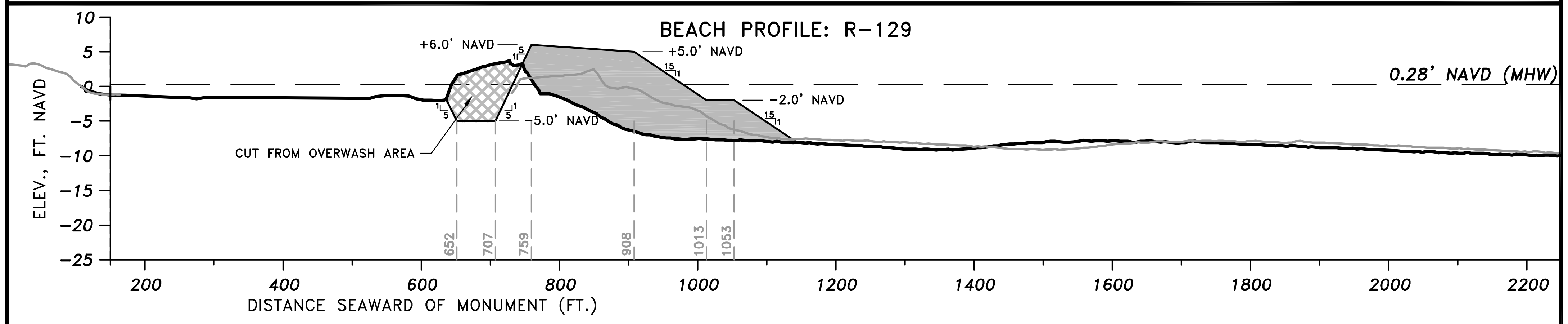

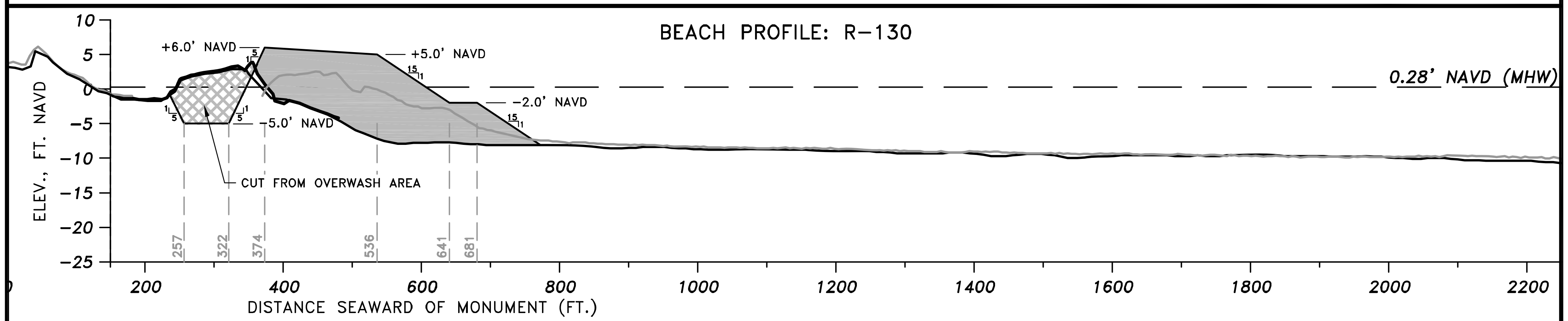

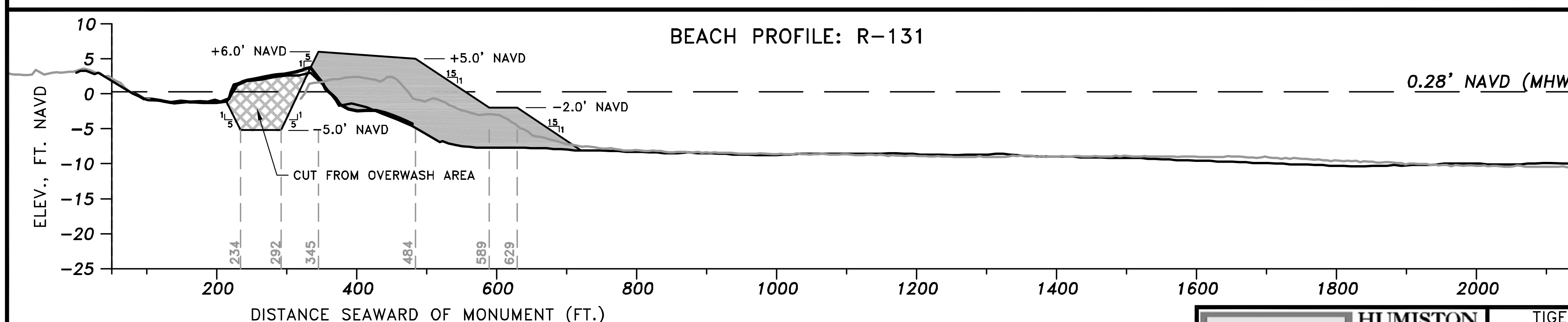

LEGEND

- 2020-05 CEC SURVEY DATA
- 2020-04 SDI SURVEY DATA
- SAND TRAP TEMPLATE
- 2020-05 DESIGN FILL TEMPLATE
- 2020-05 DESIGN CUT TEMPLATE
- 2017-08 HIDEAWAY MONITORING

NOTE: BEACH SLOPES 1:15
CHANNEL SLOPES 1:5

BERM FILL			
MONUMENT	EFFECTIVE DISTANCE (FT)	FILL DENSITY (CY/FT)	FILL VOLUME REQUIRED (CY)
H-1	526	15.6	8,200
R-128	889	74.1	60,200
R-129	888	101.5	90,100
R-130	725	111.1	80,500
R-131	1253	73.1	86,900
		TOTALS:	325,900

FLOW CHANNEL			
MONUMENT	EFFECTIVE DISTANCE (FT)	CUT BOTTOM ELEVATION -5' (CY/FT)	CUT VOLUME AVAILABLE -5' (CY)
R-128	812	30.9	25,100
R-129	888	23.6	20,900
R-130	725	28.9	21,000
R-131	1190	23.0	27,300
		TOTALS:	94,300

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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION - SPIT CROSS SECTIONS

FOR: CITY OF MARCO ISLAND

DATE: 3/24/21 | FILE: PLAN | SCALE: SHOWN

JOB: 27-002 | DATUM: NONE | FIGURE: XS-5

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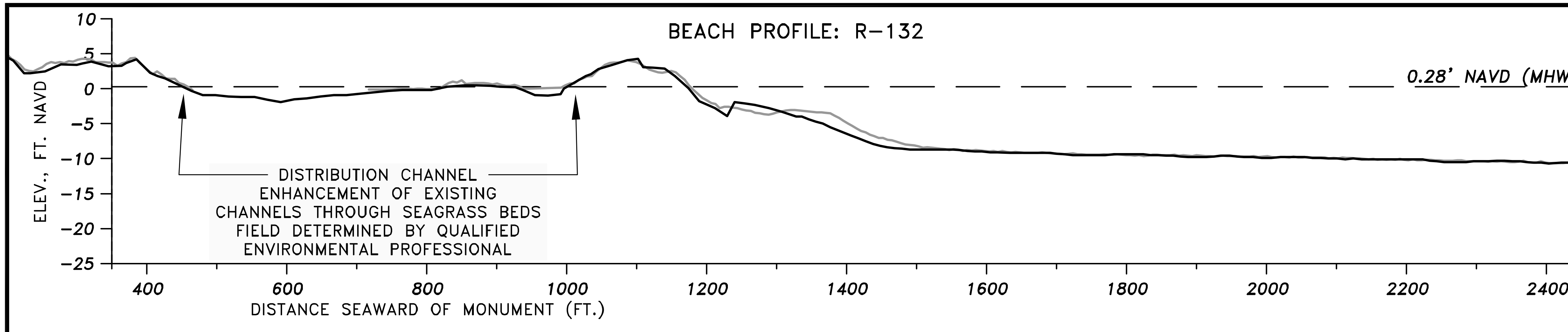

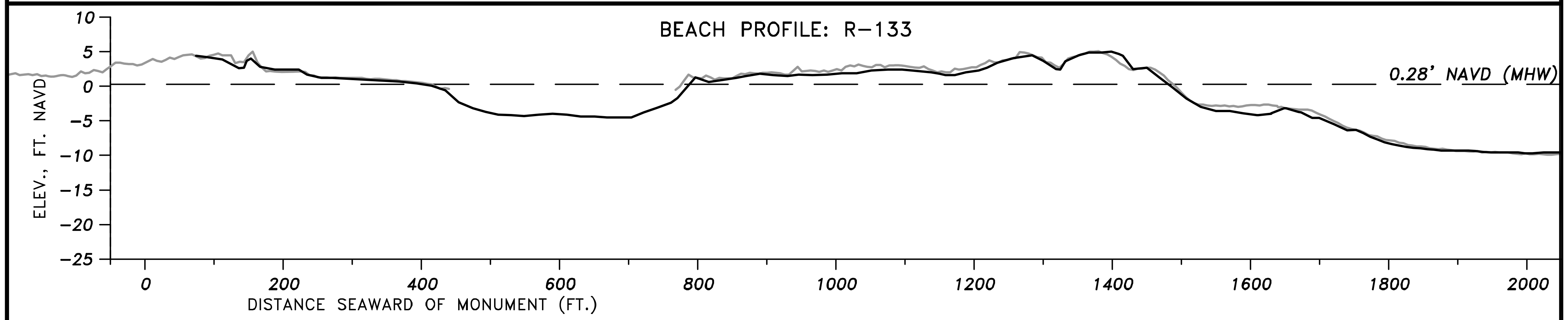

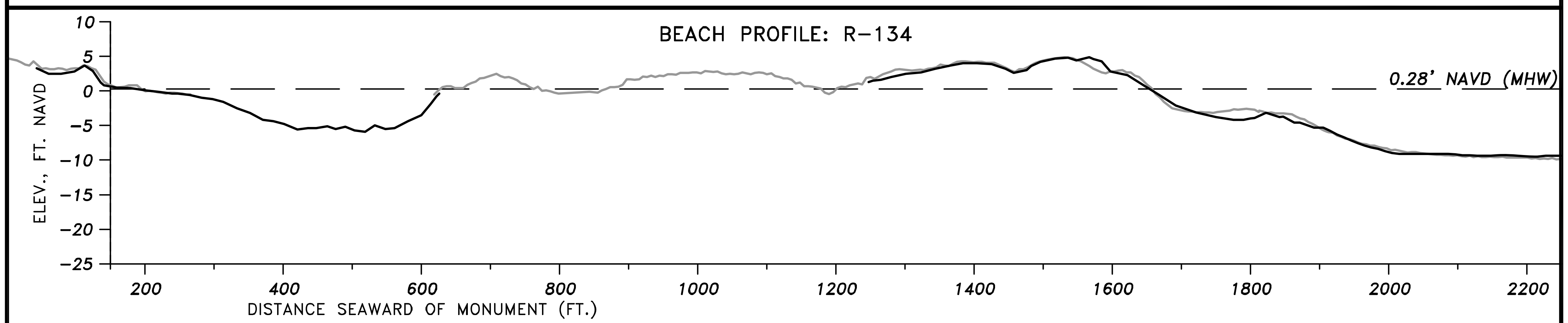

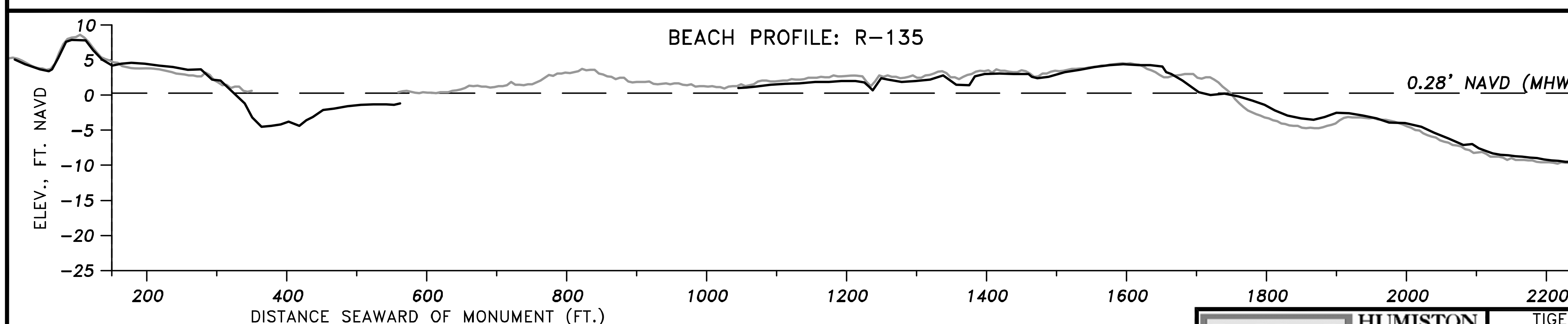

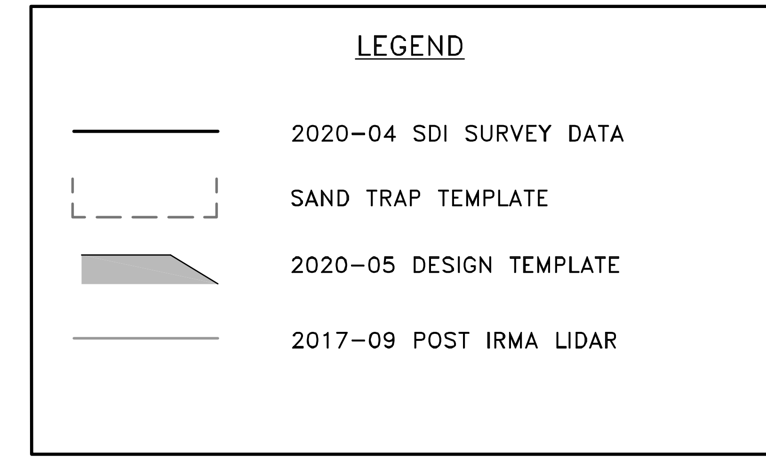

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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ECOSYSTEM RESTORATION – CROSS SECTIONS

FOR: CITY OF MARCO ISLAND		
DATE: 3/24/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: XS-6

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Appendix B

Tigertail Lagoon & Sand Dollar Island Restoration Environmental Management Plan

Tigertail Lagoon/ Sand Dollar Island Ecosystem Restoration Project

Environmental Management Plan

April 6, 2021

Prepared By:
Turrell, Hall & Associates, Inc.
3584 Exchange Avenue
Naples, FL 34104
tuna@thanaples.com

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TABLES

FIGURES

EXHIBITS

APPENDICES

1.0 INTRODUCTION

1.1 Purpose of the Management Plan

The purpose of this Management Plan, hereto referred to as the Plan, is to provide guidance and direction for the protection, preservation and maintenance associated with the Tigertail Lagoon/Sand Dollar Island restoration project. This plan provides a recommended program for the methodology, timing, and goals for physical and hydrological monitoring events, and describes how the various stakeholder monitoring and surveying will be coordinated and incorporated into an annual report and will form the framework for future decision-making regarding adaptive measures needed for the sustainability of the system's natural resources.

1.2 Historical Overview

Sand Dollar Island is a half-enclosed peninsular spit, which is the result of the collapse of the Big Marco Pass ebb shoal migrating east towards the mainland of Marco Island over many years and eventually welding to the mainland at its southern end. Storm events and general wave hydrodynamics have molded and reshaped what is now a system attached to the mainland at the southern terminus, with open shallow waters from that south end (Tigertail Lagoon) to what is the mouth of the system now at Hideaway Beach and Big Marco Pass on the north end. Without maintenance dredging every two to three years, the north end of the system would now be completely closed and attached to the mainland as well, resulting in a stagnant lagoon system.

The area was designated as a Critical Wildlife Area (CWA) in 1988 by the Florida Fish and Wildlife Conservation Commission (FWC). In 2001, it was also designated as Critical Habitat for the piping plover by the US Fish and Wildlife Service (FWS). Several protected shorebirds utilize the spit for nesting and foraging and this use is another component of the system which must be taken into account and protected under any management operations.

The Hideaway Beach Taxing District, through the City of Marco Island, conducts regular maintenance dredging of the mouth of the lagoon system under Florida Department of Environmental Protection Permit (0309260-001-JC) and U.S. Army Corps of Engineers Permit (SAJ-1998-00290). Activities associated with those permits include the re-shaping of Sand Dollar Island's northern terminus and keeping that pass open during each dredge event, maintenance of a sand borrow area inside of the northern lagoon, and Hideaway beach renourishment with sand removed from the spit and/or borrow locations.

The southern lagoon system known as Tigertail Lagoon (also Tigertail Park), identified in drawings as Area 4, has largely stabilized with wide perimeter beaches and mature mangroves lining a large portion of the lagoon. Few changes in this portion of the system have been noted over the last few years.

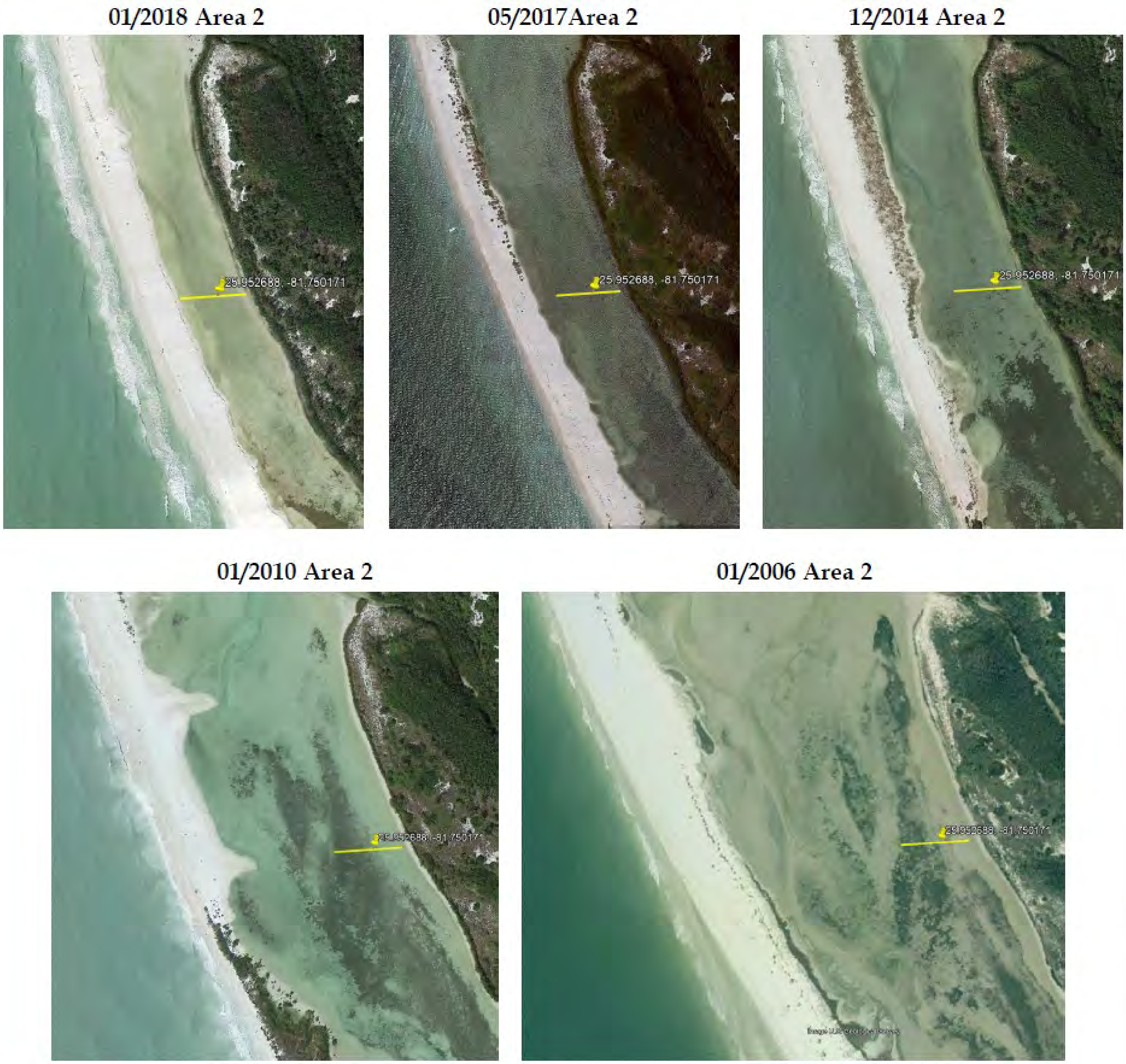
With the exception of the dredging at the north end of the system, nothing has been done to manage the areas in between the north and south ends. This area, which will be referred to hereafter as Areas 2 and 3, are some of the most critical bird foraging areas within the entire system due to their extreme shallow depths and fairly abundant seagrass beds, yet they are disappearing at an alarming rate as the spit shifts 40 to 50 feet a year towards the mainland.

Figure 1 – Project Area Map.

Figure 2 – Sand Dollar Island 1989 (open at both ends).

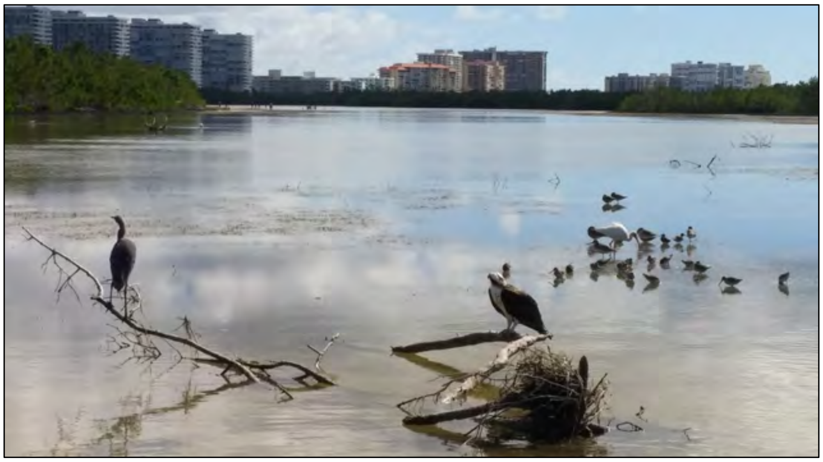
Figure 3 – Sand Dollar Island 1993 (closed at south end).

Figure 4 – Reference aerials on loss of seagrass mudflat and mudflat acreage in Area 2.



Just north of the Tigertail Lagoon is Area 3 which becomes substantially shallower, has significant seagrass coverage and moderately sized mangrove growth on both sides of the area but is generally not entirely exposed at low tide. Area 3 is mostly stable with the exception of a periodic breach point in its northwest corner. Heavy storm events will create openings to the Gulf periodically which tend to re-close within 30 days' time.

Figure 5 – Area 3 post-Hurricane Irma in 2017.



Area 2, north of Area 3, is the primary subject of this restoration project. It has also been described as the “pinch point” for the system due to a significantly narrower barrier island geography and the shallowest aquatic section of the entire system. Where a western dune once existed, it has been beaten down by several storm systems and lowered to the point where it now is over washed even during moderate storms. This area is being pushed toward the mainland at an average rate of approximately 40 to 50 feet per year, overtaking/burying existing mudflats and seagrass mudflats which have been identified as critical foraging areas for the various shorebirds which rest on the island during migratory flights and nesting shorebirds. It is expected that within the next twelve months, barring any severe storm events in 2021, this portion of the system will finally attach to the mainland mangroves, thus severing the flow between the mouth of the system and Tigertail lagoon and eliminating this critical foraging habitat area.

Figure 6 – Typical view of Area 2 (2021).

Area 1 extends from the mudflats of Area 2 to the mouth of the system and occupies the lagoonal areas seaward of the Hideaway Beach waterfront homes. The system is bordered on the east by beach, some native vegetative habitat, residences and one beach club, while the western side of the lagoon is dominated by Coastal Vegetation and Sand habitats which do shift to a lesser degree over time. The most dynamic portion of the system other than Area 2 is the sand spit at the mouth of Marco Pass which is continually affected by tides and currents where it is situated. This area is maintenance dredged and reshaped every two to three years under permits described above.

Figure 7 – Northern-most sand spit of Area 1.

1.3 Description of the Proposed Restoration Project

This ecosystem restoration project will entail re-aligning Area 2 with its 2017 footprint by dredging sand from the backside of the beach and placing it seaward to expand and reshape the habitat into a functioning beach for the purposes of providing protection for Area 2 mudflats and nesting habitat for birds and sea turtles. Sand will be dredged out of the current over wash zone and used to re-establish the MHW line where it was situated in 2017 and creating a channel along the back side of the beach to help alleviate flushing issues between the north and south portions of the system. Area 2 has experienced over wash to such a degree that the lagoon elevation is significantly higher here than to the north and south. The sand required for the beach restoration work will come from channel and sand spit dredging in Area 1. Additional sand may come from the borrow area in Big Marco Pass if there are insufficient quantities generated from the channel and spit dredging.

The reconstructed beach berm will provide greater protection to the waterway and lagoon from overwash so that it continues to provide the essential foraging habitat for listed and migratory avian species.

1.4 Stakeholders and Roles

There are numerous volunteer groups, non-governmental organizations (NGOs) and governmental organizations which have been individually managing, monitoring, and collecting data on various aspects of the system over time, but none of that data has been compiled to present an overview snapshot of the entire system health. This Management Plan proposes to accomplish the pooling of their efforts annually into one document so that open stakeholder discussions can be held to identify system needs. Currently data being collected by group is as follows:

- Collier County – Island-wide sea turtle nesting monitoring and Enterococci monitoring in Tigertail Lagoon Park
- Florida Fish & Wildlife Conservation Commission – Breeding bird surveys, nest area vegetative maintenance, and protective signage and staking
- Hideaway Beach Community Control District – Bi-annual seagrass and hydrological monitoring of the system
- Friends of Tigertail Lagoon – General island maintenance (refuse removal, trail maintenance, etc.)
- Audubon Society - Non-breeding bird surveys

Other stakeholders include:

- Rookery Bay
- The City of Marco Island

2.0 NATURAL RESOURCE DESCRIPTION AND ASSESSMENT

2.1 Habitats

Within the Sand Dollar Island lagoon system several primary habitats exist which are described below in more detail. Photographs of each habitat are also included. Acreage of those habitats within the project boundaries are noted below in Table 1.

Table 1 - Sand Dollar Island Project Area Habitats (2021)

Habitat Type	Acreage
Sand	43.92
Coastal Vegetation	48.14
Seagrass	12.96
Seagrass Mudflat	3.87
Open Mudflat	1.78
Open Water	100.61
Total	211.28

2.1.1 Sand (43.92 acres)

The Sand habitat type is described as coarse exposed substrate with little to no vegetative cover. Vegetation within this habitat exists at levels varying from 0 to 3% total cover. Typical floral species located in the Sand habitat include shoreline sea purslane (*Sesuvium portulacastrum*), scrubby inkberry (*Scaevola plumieri*), scrubby buttonwood (*Conocarpus erectus*), scrubby black mangrove (*Avicennia germinans*), sea oats (*Uniola paniculata*), railroad vine (*Ipomoea pes-caprae* subsp. *brasiliensis*), coastal sandbur (*Cenchrus spinifex*) and saltgrass (*Distichlis spicata*). Species which grow to midstory and canopy heights tend to be very low growing in these areas due to wind and periodic wave or overwash action. Most specimens did not exceed twenty-four inches in height. The dominant species was generally shoreline sea purslane.

Figure 8 – Sand Habitat.

2.1.2 Coastal Vegetation (48.14 Acres)

There is a wide range of coastal vegetation found on site, which includes tree species and groundcover. A list of the observed species can be found below in Table 2. Most of the plant species identified were present in all of the areas surveyed, but their size and dominance varied considerably. In some instances, the beach foredune was dominated by forbs and grasses while in other cases it was dominated by mid and ground-level shrubs (Figure 7). Black mangrove (*Avicennia germinans*) was a prevalent shrub even in foredune habitats varying from six feet in height to ten inches which is indicative of the elevation issues existing on-island. Mangrove species or buttonwood consistently were the lagoon shoreline species, with saltwort (*Batis maritima*) and mangrove seedlings occupying the understory.

It appeared as though some vegetation management was occurring in the areas owned by Rookery Bay at the north end of the island. Evidence of dead crab grass was noted throughout this area and some targeting of sandbur was also observed.

Figure 9 – Dune vegetation west of Tigertail Lagoon.

Figure 10 – North island dune vegetation dominated by shoreline sea purslane.

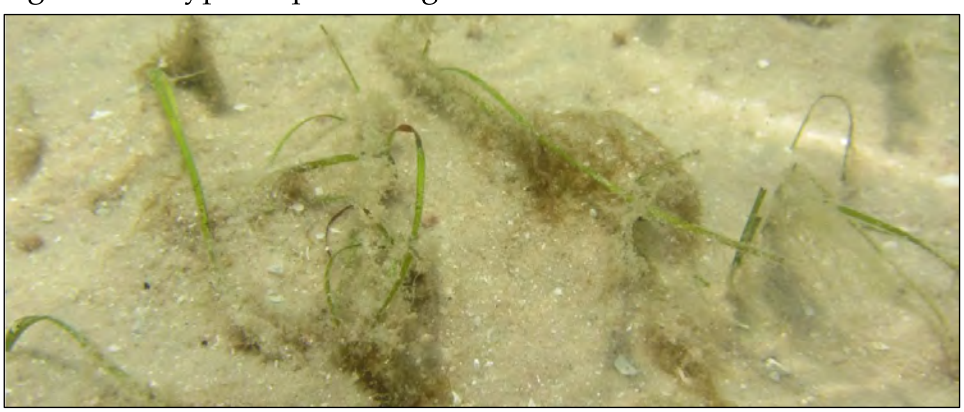
2.1.3 Seagrass (12.96 Acres)

Most of the seagrass patches identified during the 2017, 2018, and 2020 Seagrass Surveys consisted of shoal grass (*Halodule wrightii*), however some paddle grass (*Halophila decipiens*) was also located on the northern end of the survey area (Area 1) in smaller amounts, as were several species of *Caulerpa*. Because the seagrass beds reticulate to such a degree within the system the seagrass was quantified in areas with a range that described the low and high ends of coverage. More detailed discussions can be found in the 2017, 2018 and 2020 Seagrass Survey Reports (Appendices I, II, and III).

Area 1 grass beds have been monitored periodically since 2008 in conjunction with dredging permit conditions, however the first seagrass monitoring south of Area 1 occurred in 2017 in the fall following Hurricane Irma and then again in the summer months of 2020.

Figure 11 – Typical dense seagrass bed.

Figure 12 – Typical sparse seagrass bed.



2.1.4 Seagrass Mudflat (3.87 Acres)

Based on monitoring data it appears that grass beds to the south of Area 1 are either shrinking in general outline where not overtaken by sand from storm over wash or they are trending towards high algal growth cover. Algae in 2017, although present in Area 2, was a minor occurrence. By 2020 red and brown algae had become much more prevalent within the grass beds. A recent brief inspection of Area 2 beds depicted a nearly complete coverage of grasses by thick mats of green filamentous algae (Figures 14 and 15). The cause for this trend has not been positively identified as of yet, but lack of flushing is suspect.

Figure 13 – 2017 shallow seagrass image (turbid conditions).

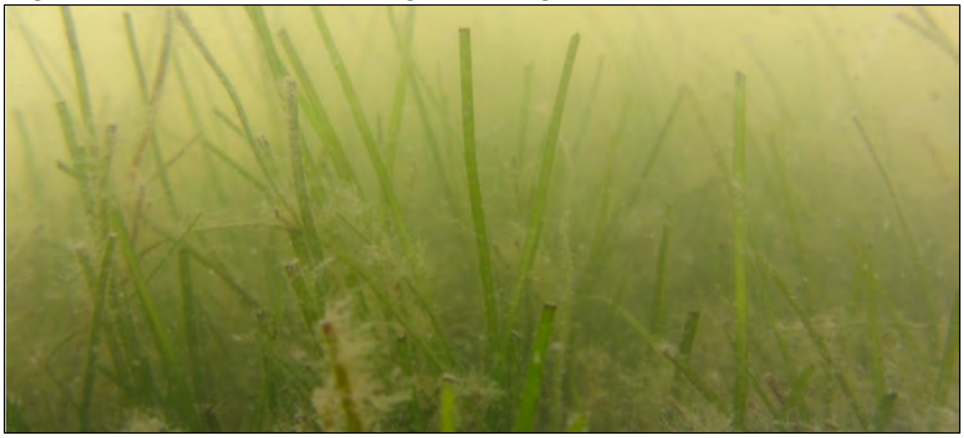


Figure 14 – 2020 shallow seagrass image (increased algal presence).

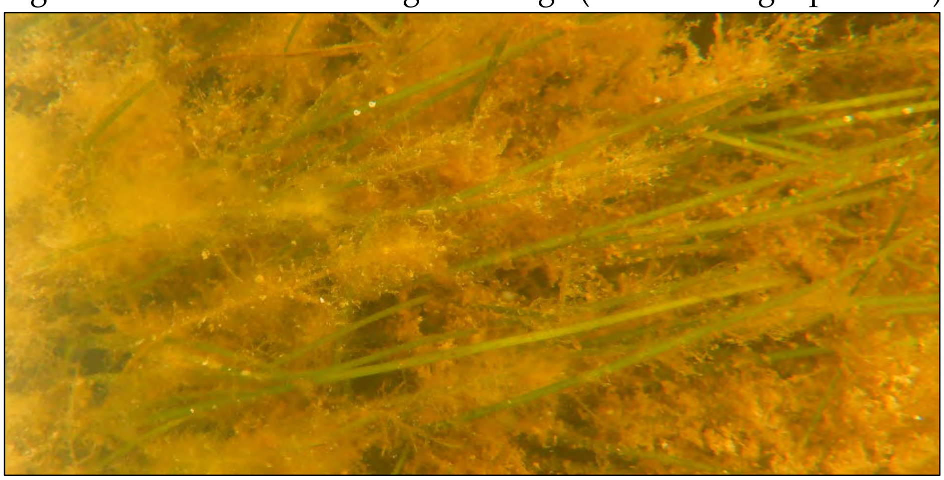


Figure 15 – 2021 above-water view of algal covered grass beds and sample of algae.

2.1.5 *Open Mudflat (1.78 Acres)*

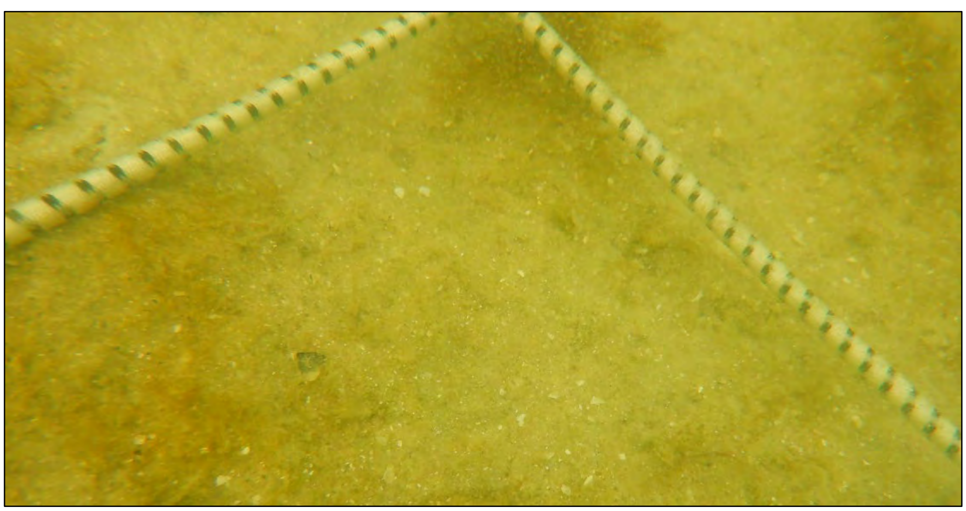
This habitat lies within areas which were barren of seagrasses at the time of the seagrass survey but were exposed at low tide either totally or partially. Frequently small mollusks are found on the flats in abundance so wading and shorebird foraging is common.

Figure 16 – Open mudflat and bird foraging.

2.1.6 *Open Water (100.61 Acres)*

Open water includes all areas that did not contain seagrass beds and are not exposed during low tides. Depths could vary from 12 inches to over 10 feet. Substrate varied by area and could be classified as soft sand, coarse sand, sand with shell debris, and shell debris.

Figure 17 – Typical open water bottom with coarse sand and shell fragments.



2.2 Project Impacts

Associated with this ecosystem restoration project are dredge and fill activities to create a lagoon circulation channel in Areas 1 and 2, and to reconfigure the beach in Area 2 (Exhibit 9- Site Plan). The project has been meticulously designed to avoid impacts to upland and marine flora. (Exhibit 10 Impacts Map). As proposed the dredge work will impact 80.89 acres of Open Water Habitat, 18.25 acres of Sand Habitat, and 2.36 acres of coastal vegetation, while filling activities will result in sand being placed on top of existing sand and within the nearshore Gulf of Mexico limits, waterward of existing Area 2 Sand habitat.

2.3 Floral and Faunal Inventory

Floral and faunal inventories from site visits during 2017, 2018, 2020 and 2021 are documented below by species, location (if pertinent), stratum (if pertinent) and by protection status (if pertinent) in Tables 2 through 4.

Table 2 – Observed Upland Flora

Area	*Scientific Name*	Common Name	Stratum	Status
R-135 – R-133	*Andropogon glomeratus*	bushy broomgrass	G	None
R-135 – R-133	*Avicennia germinans*	black mangrove	C,M,G	None
R-135 – R-133	*Aristida patula*	tall threeawn	G	None
R-135 – R-133	*Baccharis halimifolia*	groundsel tree	M,G	None
R-135 – R-133	*Batis maritima*	saltwort	G	None
R-135 – R-133	*Borrichia frutescens*	bushy seaside oxeye	G	None
R-135 – R-133	*Coccoloba uvifera*	seagrape	M	None
R-135 – R-133	*Conocarpus erectus*	buttonwood	C,M,G	None
R-135 – R-133	*Dalbergia ecastaphyllum*	coinvine	M,G	None
R-135 – R-133	*Distichlis spicata*	saltgrass	G	None
R-135 – R-133	*Eustachys glauca*	saltmarsh finger grass	G	None
R-135 – R-133	*Fimbristylis cymosa*	hurricanegrass	G	None
R-135 – R-133	*Flaveria floridana*	Florida yellowtop	G	None
R-135 – R-133	*Ipomoea pes-caprae subsp. brasiliensis*	railroad vine	G	None
R-135 – R-133	*Iva imbricata*	seacoast marsh elder	M,G	None
R-135 – R-133	*Laguncularia racemosa*	white mangrove	C,M,G	None
R-135 – R-133	*Rhizophora mangle*	red mangrove	C,M,G	None
R-135 – R-133	*Scaevola plumieri*	inkberry	G	ST
R-135 – R-133	*Scaevola taccada*	beach naupaka	M, G	Cat I
R-135 – R-133	*Sesuvium portulacastrum*	shoreline sea purslane	G	None
R-135 – R-133	*Solidago sempervirens*	seaside goldenrod	G	None
R-135 – R-133	*Spermacoce verticillata*	shrubby false buttonweed	G	Cat II
R-135 – R-133	*Sporobolus virginicus*	seashore dropseed	G	None
R-135 – R-133	*Suriana maritima*	bay cedar	G	None
R-135 – R-133	*Uniola paniculata*	sea oats	G	None

R-133 – R-132	*Avicennia germinans*	black mangrove	C,M,G	None
R-133 – R-132	*Batis maritima*	saltwort	G	None
R-133 – R-132	*Borrichia frutescens*	bushy seaside oxeye	G	None
R-133 – R-132	*Conocarpus erectus*	buttonwood	M,G	None
R-133 – R-132	*Distichlis spicata*	saltgrass	G	None
R-133 – R-132	*Laguncularia racemosa*	white mangrove	C,M,G	None
R-133 – R-132	*Rhizophora mangle*	red mangrove	M,G	None
R-133 – R-132	*Sporobolus virginicus*	seashore dropseed	G	None
R-132 – R-128	*Scaevola plumieri*	inkberry	G	ST
R-132 – R-128	*Conocarpus erectus*	buttonwood	G	None
R-132 – R-128	*Uniola paniculata*	sea oats	G	None
R-132 – R-128	*Ipomoea pes-caprae subsp. brasiliensis*	railroad vine	G	None
R-132 – R-128	*Sesuvium portulacastrum*	shoreline sea purslane	G	None
R-128 – V-316	*Avicennia germinans*	black mangrove	M,G	None
R-128 – V-316	*Conocarpus erectus*	buttonwood	M,G	None
R-128 – V-316	*Laguncularia racemosa*	white mangrove	M,G	None
R-128 – V-316	*Scaevola plumieri*	inkberry	M,G	ST
R-128 – V-316	*Sesuvium portulacastrum*	shoreline sea purslane	G	None
R-128 – V-316	*Suriana maritima*	bay cedar	M,G	None
R-128 – V-316	*Uniola paniculata*	sea oats	G	None
V-316 – North	*Andropogon glomeratus*	bushy broomgrass	G	None
V-316 – North	*Avicennia germinans*	black mangrove	M,G	None
V-316 – North	*Aristida patula*	tall threeawn	G	None
V-316 – North	*Baccharis halimifolia*	groundsel tree	M,G	None
V-316 – North	*Batis maritima*	saltwort	G	None
V-316 – North	*Borrichia frutescens*	bushy seaside oxeye	G	None
V-316 – North	*Cenchrus spinifex*	coastal sandbur	G	None
V-316 – North	*Conocarpus erectus*	buttonwood	M,G	None
V-316 – North	*Distichlis spicata*	saltgrass	G	None
V-316 – North	*Eustachys glauca*	saltmarsh finger grass	G	None
V-316 – North	*Fimbristylis cymosa*	hurricanegrass	G	None
V-316 – North	*Ipomoea pes-caprae subsp. brasiliensis*	railroad vine	G	None
V-316 – North	*Iva imbricata*	seacoast marsh elder	M,G	None
V-316 – North	*Laguncularia racemosa*	white mangrove	M,G	None
V-316 – North	*Rhizophora mangle*	red mangrove	M,G	None
V-316 – North	*Scaevola plumieri*	inkberry	G	ST
V-316 – North	*Scaevola taccada*	beach naupaka	M, G	Cat I
V-316 – North	*Sesuvium portulacastrum*	shoreline sea purslane	G	None
V-316 – North	*Solidago sempervirens*	seaside goldenrod	G	None
V-316 – North	*Spermacoce verticillata*	shrubby false buttonweed	G	Cat II
V-316 – North	*Sporobolus virginicus*	seashore dropseed	G	None
V-316 – North	*Suriana maritima*	bay cedar	G	None
V-316 – North	*Uniola paniculata*	sea oats	G	None

N Sand Spit	*Batis maritima*	saltwort	G	None
N Sand Spit	*Distichlis spicata*	saltgrass	G	None
N Sand Spit	*Eustachys glauca*	saltmarsh finger grass	G	None
N Sand Spit	*Sesuvium portulacastrum*	shoreline sea purslane	G	None
N Sand Spit	*Flaveria floridana*	Florida yellowtop	G	None

ST= State Threatened, Cat I= FLEPPC Category I Invasive Exotic, Cat II= FLEPPC Category II Invasive Exotic

Table 3 – Observed Marine Flora

Scientific Name	**Common Name**	**Status**
Caulerpa ashmeadii	Caulerpa	None
Caulerpa mexicana	feather algae	None
Caulerpa prolifera	common Caulerpa	None
Caulerpa sertularoides	feather algae	None
Gracilaria spp.	graceful red algae	None
Halophila decipiens	Paddle grass	None
Halodule wrightii	Shoal grass	None
Penicillus spp.	shaving brush algae	None
unidentified multiple species	red algae	None
unidentified multiple species	brown algae	None
unidentified multiple species	green algae	None

Table 4 – Observed Fauna

Scientific Name	**Common Name**	**Status**
BIRDS		
Anhinga anhinga	anhinga	None
Ardea herodias occidentalis	great white heron	None
Ardea herodias	great blue heron	None
Arenaria interpres	ruddy turnstone	None
Butorides virescens	green heron	None
Calidris alba	sanderling	None
Calidris aplina	dunlin	None
Cathartes aura	turkey vulture	None
Catoptrophorus semipalmatus	willet	None
Ceryle alcyon	belted kingfisher	None
Charadrius semipalmatus	semipalmated plover	None
Charadrius vociferus	killdeer	None
Charadrius wilsonia	Wilson's plover	None
Corvus ossifragus	fish crow	None
Egretta caerulea	little blue heron	ST

Egretta rufescens	reddish egret	ST
Egretta thula	snowy egret	None
Egretta tricolor	tri-color heron	ST
Eudocimus albus	white ibis	None
Larus atricilla	laughing gull	None
Pandion haliaetus	osprey	None
Pelecanus occidentalis	brown pelican	None
Phalacrocorax auritus	double-crested cormorant	None
Platalea ajaja	roseate spoonbill	ST
Rynchops niger	black skimmer	ST
Tringa semipalmata	willet	None
MAMMALS		
Trichechus manatus	West Indian manatee	FT
Tursiops truncatus	common bottlenose dolphin	None
MOLLUSKS		
Atrina seminuda	half-naked pen shell	None
Bursatella leachii	ragged sea hare	None
Busycon sinistrum	lightning whelk	None
Busycotypus spiratus	pear whelk	None
Cerithium atratum	Florida cerith	None
Tellina lineata	rose petal tellin	None
Fasciolaria lilium	banded tulip	None
Macrocallista nimbosa	sunray venus	None
Melongena corona	crown conch	None
Neverita duplicata	shark's eye (eggs and collar)	None
Ostreola equestris	crested oyster	None
Strombus alatus	Florida fighting conch	None
Triplofusus giganteus	Florida horse conch	None
unidentified species	octopus	None
FISH		
Archosargus probatocephalus	sheepshead	None
Centropomus undecimalis	snook	None
Lutjanus griseus	Grey snapper	None
Mugil curema	White mullet	None
Pristis pectinata	Smalltooth sawfish	FE
Sciaenops ocellatus	red drum	None
Trachinotus falcatus	permit	None
unidentified species	mullet	None
unidentified species	bat fish	None
ECHINODERMS		
Luidia senegalensis	nine-armed sea star	None
Ocnus suspectus	hidden sea cucumber	None

Echinaster spinulosa	orange-ridges sea star	None
CRUSTACEANS		
Callinectes sapidus	blue crab and molt	None
Hepatus epheliticus	calico box crab	None
Libinia sp.	spider crab	None
Limulus polyphemus	horseshoe crab	None
Menippe mercenaria	Florida stone crab	None
Rhithropanopeus harrisii	Harris mud crab	None
unidentified species	hermit crab (in tulip shell)	None
unidentified species	barnacle	None
CHORDATA		
Styela plicata	Leathery sea squirt	None
Botryllus planus	Royal tunicate	None
Botrylloides nigrum	flat tunicate	None
PORIFERA		
Cliona sp.	Red boring sponge	None
Microciona prolifera	red beard sponge	None
CTENOPHORES		
unidentified species	comb jellyfish	None
CNIDARIANS		
unidentified species	tube-dwelling anemone	None

ST= State Threatened, FT= Federally Threatened, FE= Federally Endangered

2.4 Listed Species

Sand Dollar Island and Tigertail Lagoon host a variety of protected species, both onshore and inside the lagoon. Big Marco Pass (Sand Dollar Island) was designated as Critical Wintering Habitat for the piping plover by the U.S. Fish &Wildlife Service, while the Florida Fish and Wildlife Conservation Commission has designated it as a Critical Wildlife Area for least terns, black skimmers, Wilson's plover, and wintering shorebirds. Unfortunately, preferred nesting areas have been or are being overtaken by vegetation to a degree that has already made it unsuitable to these nesting species. Other historic nesting sites have been over washed and diminished to the point that they are likewise no longer suitable for nesting. For example, snowy plovers, a state-threatened species which used to nest on the island have not nested here for over a decade now.

Other nesting which used to occur within the Section 2 area has shifted further north with the changes to the spit. Vegetation growth and dredging maintenance activities at the north end will result in smaller areas available for the nesting activities over time. This can be ameliorated through a vegetation management program which would keep the spit open enough to remain favorable for the nesting birds but would not increase the nesting area available. The proposed plan will maintain the reconstructed beach berm within Sections 2 and part of Section 3 free from vegetation to be more conducive to shorebird nesting as well as more protective of sea turtle nesting. Exhibits 10 through 12 depict the shift in shorebird nesting away from the southern nesting areas due to the loss of height and width of the beach in these areas.

Similarly, sea turtle nesting within Section 2 has been generally unsuccessful since Hurricane Irma due to the loss of nests from inundation. The proposed plan would provide for better nest protection from inundation by raising the berm elevation, widening the top, and creating a secondary plateau around the MLW line to protect the new beach from overwash and breaching.

Commonly noted listed/protected species include inkberry (*Scaevola plumieri*), West Indian manatee (*Trichechus manatus*), loggerhead sea turtle-nests (*Caretta caretta*), little blue heron (*Egretta caerulea*), reddish egret (*Egretta rufescens*), tricolor heron (*Egretta tricolor*), roseate spoonbill (*Platalea ajaja*), piping plover (*Charadrius melodus*), snowy plover (*Charadrius nivosus*), red knot (*Calidris canutus rufa*), and black skimmer (*Rynchops niger*).

In 2020 one juvenile Smalltooth sawfish (*Pristis pectinata*) was observed in Area 1, within the western bay seagrass beds during the submerged aquatic vegetation (SAV) survey.

Portions of the project area also fall with FWS consultation area for the American crocodile (*Crocodylus acutus*), though no crocodiles have been observed in recent years and the habitat present is not suitable for crocodile nesting.

2.5 Hydrology

Tidal gauges were installed within Tigertail Lagoon and Marco River during 2017 and 2020 seagrass monitoring events to document the tidal cycle difference between the north lagoon and south lagoon. With Area 2 as shallow as it is at low tide, tidal exchange is severely hampered between Areas 1, 3 and 4. Data depicted a decreased tidal prism in the south lagoon as follows: the 2017 ratio of lagoon to Gulf tide was 0.41 and the 2020 ratio was 0.23, a 56% reduction within a three-year period. Area 4 has also become a much softer sediment environment with less light penetration over the past twenty plus years since the island became attached to the mainland at its southern tip. Seagrasses are limited to shallow perimeter areas. The central portion of the lagoon is significantly deeper than the grass bed areas.

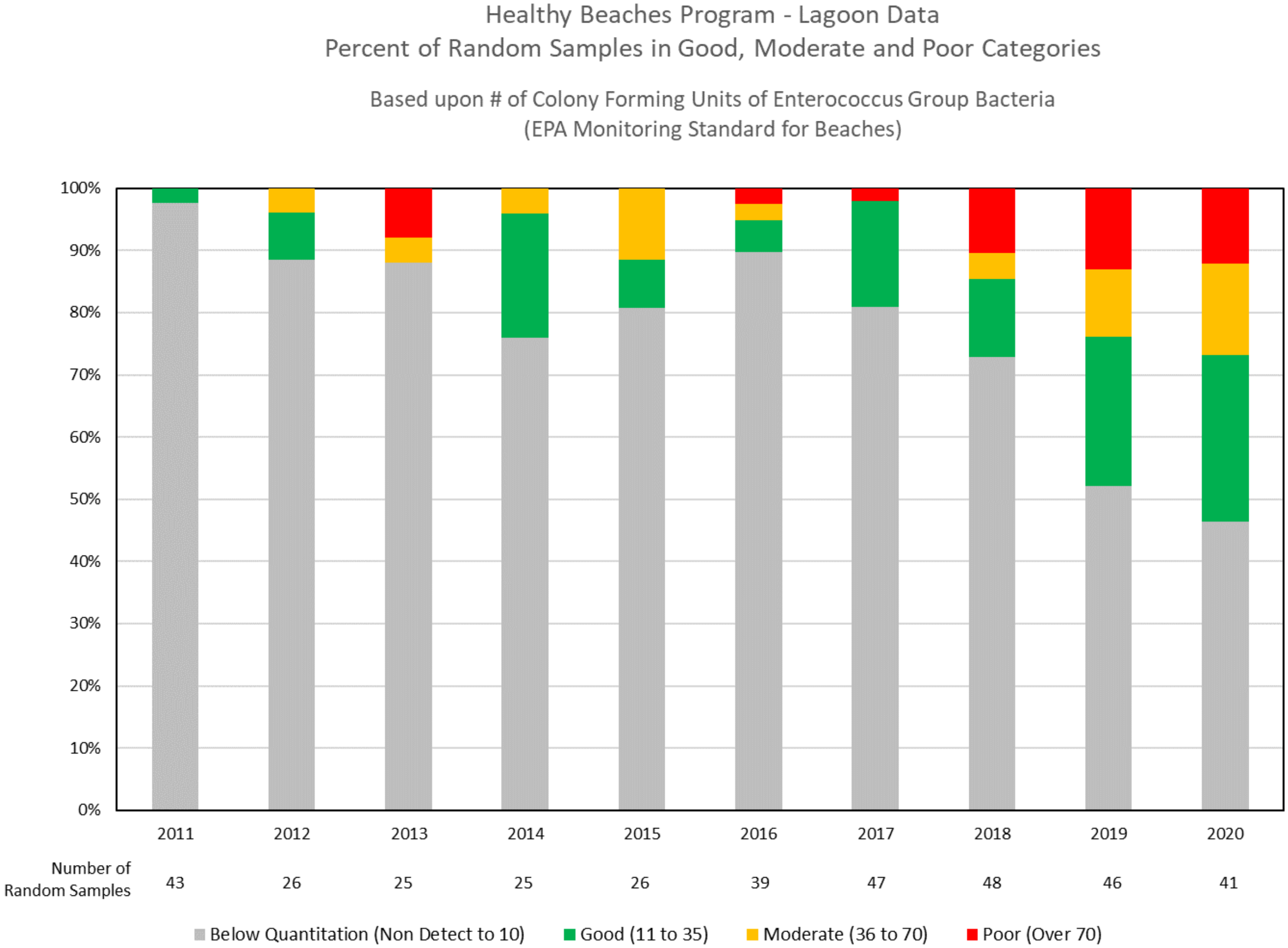
Area 2 hydrology has also changed with sand being constantly added to the flats from overwash. This area has built up higher than surrounding lagoon waters and is often exposed out of water at lower tides.

It is not unusual to be in Area 2 with incoming tide from the north and outgoing tide from the south meeting because of the tide lag.

2.6 Water Quality

At this time water quality monitoring within the system is done only at the Tigertail Lagoon park shoreline for Enterococcus bacteria by the Collier County Health Department. A graph below (Figure 18) depicts trends in their sampling since 2011.

Figure 18 – Tigertail Lagoon bacterial monitoring graph 2011 to 2020.



Many questions have been raised with respect to water quality within the lagoon system and not much testing has been done. It is expected that, with the current trend of movement of the spit, it will soon weld into the mainland and isolate Tigertail Lagoon from tidal flushing. This would make the lagoon more susceptible to water quality problems which could affect local wildlife as well as the use of the County park. A component of the proposed enhancement plan should include water quality monitoring to include multiple parameters. The suite of parameters to be tested and the timing of the sample collections will need to be coordinated with stakeholders but at a minimum, nutrients, metals, chlorophyll and phaeophytin, and dissolved oxygen should be sampled.

2.7 Recreation

Both the lagoon and the island are heavily used for recreational purposes by local and out-of-town guests. Tigertail Park rents kayaks and paddleboards, so frequently renters are observed paddling throughout the system. Netting of bait and fishing are also commonplace in the southern and northern lagoon areas along the beaches. Sunbathing and swimming constitute a large portion of the recreational uses as well, but primarily occur from Area 2 south to the end of the island since beach goers tend to arrive on-foot.

There are two ways to access the lagoon if you do not live along its shores: by boat from the Marco River or by foot from Tigertail Park. Generally, foot traffic visitors remain on the southern half of the island due to distance, with the exception of beach combers. Boat traffic congregates in the very north end of the lagoon primarily where water depths make it accessible. On any given good-weather weekend vessel numbers can top one hundred. They beach themselves and anchor on both the northern sand spit, behind the protected south side and along the Hideaway Beach inside the inlet. From there they will either float or walk the beaches, including walking the dune system on the north spit where the largest number of bird nests have been identified. Figure 18 below is a photograph taken by a Hideaway Beach resident on March 28th (2021). Boats on the far right in the background on located on that north tip sand spit.

Figure 19 – Typical weekend view at the lagoon's north end.

Boaters have also been known to utilize the southern end of Area 1, but generally they are in low numbers and would require a shallower draft boat for access.

3.0 MANAGEMENT PLAN ENVIRONMENTAL GOALS AND METHODS

This management plan is designed to provide guidelines, means, and methods for both the initial physical ecosystem restoration work proposed as well as ongoing maintenance to keep the system at the targeted conditions. Goals for the management plan are outlined below in terms of proposed work, protection measures, monitoring, and annual reporting. Besides ecosystem restoration, the plan is primarily geared to create a document each year which will provide stakeholders with a large-scale view of the system health and a basis on which to make decisions for future activities that might be beneficial for preservation or enhancement of existing conditions and protecting the habitat which supported the basis for establishment of the CWA and Critical Habitat designations.

3.1 Maintain and Protect Existing Mudflat and Seagrass Mudflat Acreage

3.1.1 Goal

The goal of this work is preservation of the existing flats and improvement of their condition so that no further foraging area within this habitat is lost to the spit migration. Health and size of the flats would be surveyed during the annual SAV monitoring event and the quantification and qualification of their status will be provided in the annual report for stakeholders.

3.1.2 Proposed Work

No dredging is proposed within the mudflat or seagrass areas. These areas are critical to shorebird and wading bird foraging within the system and is one of the system components which is being protected by the proposed work. At the rate, the spit is being pushed towards the mainland, it is likely that the majority of this habitat within Section 2 will be lost or severely compromised within the next year. Proposed work adjacent to the mudflat and seagrass mudflat areas within Area 2 will consist of dredging the eastern-most portion of existing sand spit to create a flushing channel to -5 feet NAVD that is generally greater than 50 feet wide. Material from this dredge work will be placed to the west of the spit in an effort to relocate and reshape the beach system further west. This will in turn minimize the potential for overwash and transport of sand into the mudflat areas thereby burying the mudflat and compromising or eliminating the foraging habitat value of the mudflat. Additional sand from other work in the system will also be added to the western side of the beach to create a spit which is better able to withstand normal storms without overwash. All fill will be placed westward of the created channel and the mudflat areas. The flushing improvements provided by the created channel are also expected to improve the tidal prism within the system. The higher tidal fluctuations will in turn expose more areas to foraging at low tides and so will protect the existing areas as well as expand potential foraging into areas not currently commonly available.

3.1.3 Protection Measures

Because the dredging and fill activities associated with this project will occur adjacent to important seagrass and mudflats which have been designated as critical for shorebird foraging, maintenance of this area's function is of the utmost importance.

Protection measures will include:

- *Limiting dredge and fill work to a period of November 1st to February 14th* to the extent practical so that it does not coincide with shorebird or sea turtle nesting seasons. Those seasons are defined as: shorebirds – February 15th to September 1st and sea turtles – March 1st to October 31st ,
- *Clear delineation of work areas.* Fencing, staking and other means of delineating the work areas will be put in place to prevent accidental impacts, especially along the eastern beach construction perimeter, which is adjacent to the mudflat and seagrass habitats,
- *Turbidity curtains* surrounding dredge work, to minimize siltation impacts to the adjacent seagrass habitats and benthic fauna,
- *Turbidity monitoring* during construction. Turbidity testing will be conducted as directed by specially conditioned state and federal permit requirements, and
- Any dredging proposed adjacent to mangroves will maintain a buffer adequate to protect the mangroves from impact. This buffer may vary depending on the depth of adjacent waters and the proposed depth of the dredge area.

3.2 Increase Shorebird & Sea Turtle Nesting Habitat Area

3.2.1 Goal

The goal of this restoration item is to provide and maintain an enlarged protected beach system which is elevated and sloped properly to create additional area which is conducive and desirable to shorebirds and sea turtles for nesting, without the threat of wash out or easy predation.

3.2.2 Proposed Work

The proposed project will result in a net increase of 8.3 acres of reconstructed, widened or elevated beach berm at Areas 2 and 3. .The beach will incorporate several features to make it more conducive to shorebird and sea turtle nesting. Rather than creating a crested dune ridge, the top will be shaped to create a gentle, relatively flat slope ranging from 5 – 6 feet NAVD. This would then transition down to the MLW line with a gentle slope conducive to nesting sea turtles. At the MLW line there will be a secondary flat which will protect the beach by dissipating some wave energy and creating a wider "base" to the exposed face. This will in turn make the beach more stable and less prone to overwash.

3.2.3 Protection Measures

Construction protection measures would include:

-
- *Protective fencing* adjacent to plant communities and back slopes facing grass beds. Fencing, staking and other means of delineating the work areas will be put in place to prevent accidental impacts, especially along the eastern beach construction perimeter, which is adjacent to the mudflat and seagrass habitats,
- *Turbidity curtains* where needed to prevent sedimentation, and
- *Turbidity monitoring* during construction activities. Turbidity testing will be conducted as directed by specially conditioned state and federal permit requirements.
- *Physical monitoring* post-construction, and
- *Vegetative monitoring and maintenance* post-construction.

<u>Physical monitoring and maintenance</u> will focus on annual inspections of the overall elevation changes and scarp angles. The shorebirds expected to utilize this habitat for nesting prefer high, relatively level beach berms with very low vegetative cover. In addition, sea turtles prefer nesting areas with slopes of 75 to 100:1 with enough elevation to prevent nest inundation. Sea Turtles generally will not crawl over steep scarps to nest. Examination of conditions each year will document if areas of the beach are not meeting elevation and angle needs of targeted species for utilization and will help to drive adaptive work initiatives. Physical monitoring from established monitoring locations will be included in the annual stakeholder reporting.

<u>Vegetative monitoring and maintenance</u> will require the beach to be quarterly surveyed for plant species coverage and spot maintenance needs. Since all of the nesting bird species which are targeted by this plan for repopulation of nesting zones prefer an open view to reduce predation, vegetation will be maintained at levels below 10% overall using a combination of hand-pulling and herbicidal spot treatment on sandburs. Vegetation treated will be documented in the annual stakeholder as well as conditions at the annual monitoring time period. At this time Florida Fish and Wildlife Conservation Commission staff are doing spot treatments of sandburs at the northern end of the island where most of the most recent bird nesting has occurred.

3.3 Improve Hydrological Connections to the Southern Lagoon

3.3.1 Goal

Increase tidal exchange to promote seagrass and general water quality and clarity improvements in the southern portion of the system (Areas 3 and 4).

3.3.2 Proposed Work

A flushing/flow channel is proposed to be dredged from monument V-315 to an area between R-131 and R-132 that will counteract the decreasing tidal exchange in between the northern and southern lagoon areas. In 2017 the ratio of lagoon to Gulf tidal range was 0.41. By 2020 that already low ratio had been cut in half to 0.23. The most recent observations of the system indicate that the flow cross-section out of Sections 2 and 3 is even narrower and more restricted than when the 0.23 ratio was determined. Increasing the tidal exchange will help to ensure flushing of the southern lagoon while improvements to the tidal prism will expose more areas to foraging on a more consistent basis.

The proposed plan provides for a defined channel through Section 2. Due to seagrasses shoreline vegetation and benthic resources in Section 3, work will be avoided or much more limited within this area. A route for a smaller, potentially hand-dug channel location will be looked for during the previously mentioned construction activities to see if the flushing channel and associated benefits can be extended into or through Section 3. If possible, to do without impacting seagrasses, this less extensive connector would extend from the southern end of the proposed dredged flushing channel to just north of monument R-133, which is also where the Tigertail Lagoon crossing occurs to access beach areas along the north end of the county park. If an alignment can be found at the time of construction which would avoid seagrass impacts, then Additional coordination will be undertaken with FDEP and FWC to clearly define the route of the proposed channel and determine the feasibility of constructing it without causing impacts to adjacent resources. Due to the variability of resources within this area, it won't be known definitively until construction on the rest of the project is underway if this small component can be accomplished or not.

As part of the post-construction activities associated with this element, tidal gauges will be installed in the southern and northern ends of the system for a period of one month to document any tidal flow changes brought about as a result of the flushing channel.

3.3.3 Protection Measures

Dredging of this flushing channel will be done by mechanical dredge, by suction dredge, or by a combination of both. Typical dredging protection measures will apply to this activity, including:

- *Turbidity curtains* will be used to the extent practical to prevent plumes and sedimentation,
- *Turbidity testing* will be conducted as directed by specially conditioned state and federal permit requirements.
- *Dredging timing* will be limited to a window of November 1 – February 14 to avoid issues with both bird and sea turtle nesting seasons.

- *Manatee protection* will be accomplished by educating the contractor(s) about the potential for manatees in the area and protocols to stop work and wait for the manatee to leave if one is observed within or adjacent to the work area.

3.4 Create and Maintain a Sand Trap on the North Island Tip

3.4.1 Goal

Minimize maintenance dredging activities by creating a sand collection area or "trap" that can be used to monitor sand accumulation, protect the local waterways, provide ongoing bird nesting habitat, and provide sand for beach maintenance and protection in other Sections of the spit.

3.4.2 Proposed Work

This element of the restoration work has been minimized to the smallest extent possible and will entail dredging 2.5 acres of sand and 3.9 acres of vegetation from the sand spit at the northern tip of Sand Dollar Island. This essentially resets this location and provides an area (trap) for sand being moved along the spit by wave and tidal action to collect and reform the end of the spit. This trap will prevent large quantities of sand which would be eroded off the island, from ending up in the mouth of the river. This sand would end up filling in the mouth of this system as well as the mouth of Collier Bay, resulting in a more frequent need for maintenance dredging without suitable locations to place the dredged material.

By including this area in the dredging plan, the time frames between maintenance dredging activities should be extended and the sand is essentially recycled back through the system by placing it into the Section 2 area. The sand placed in Section 2 will eventually be pushed north along the beach by waves to the sand trap at the tip of the spit. When the trap area is full and starts expanding into the mouth of the pass, it will be maintenance dredged and placed back into Section 2 so the cycle can be repeated.

As the spit is dredged and reforms in the sand trap area, it also maintains the open sand habitat favored by the nesting shorebirds found using the spit. The periodic activity interrupts the normal successional stages and prevents the area from being overgrown with vegetation which would inhibit or discourage nesting.

3.4.3 Protection Measures

Protection of the remaining sand spit which is utilized by shorebirds will be the primary focus of construction protection efforts. Protection measures will include:

- *Construction work* will be scheduled between November 1 – February 14 to the extent possible to avoid issues with both bird and sea turtle nesting seasons,

- Construction perimeters will be staked with *visible barriers* to prevent encroachment into nesting areas and vegetation, as well as to prevent sedimentation,
- *Turbidity curtains* will be deployed during construction to the extent practical, and
- *Turbidity testing* will be conducted as directed by specially conditioned state and federal permit requirements.
- Physical monitoring surveys documenting the sand accumulation will be included in the annual stakeholder reporting.

3.5 Monitor the Health and Abundance of Seagrass Beds

Ultimately both the dredge and beach restoration work are expected to help declining seagrass bed health by reducing the introduction of sand into the beds during storms and by increasing the tidal prism of the system. In order to quantify the restoration project effects on seagrasses an annual Submerged Aquatic Vegetation (SAV) survey will be performed from the northern to the southern lagoon limits in June each year. Survey methodology is outlined as follows:

- Survey transects will not exceed 20 feet apart except in large barren areas.
- Random quadrat sampling will be employed along transects where visibility allows, documenting species composition, percent coverage, sediment composition, and epiphyte load.
- Percent cover will be described by using the Braun-Blanquet analysis system which was utilized in previous surveys of this system. The Braun-Blanquet scores will be further converted into median percent cover per proposed FDEP seagrass survey protocol changes.
- In addition to grasses, other floral and faunal observations in the system will be documented in the report by scientific name, common name, location, and any special listing status.
- Photographs of various habitats throughout the system will be taken during the survey and will be provided as an appendix to the report.
- Transect and quantified seagrass maps will be included as exhibits to each report.

Annual SAV monitoring will be included in the stakeholder reports.

3.6 Compile Data Already Being Collected by Various Stakeholders into One Annual Report

In the annual report a summary of the items below and appendices of data collected throughout the year will provide stakeholders the opportunity to review the system's health as a whole. If adaptive measures are needed to improve some aspect of this restoration project then those recommendations will be made within the report for consideration by various stakeholders.

3.6.1 Submerged Aquatic Vegetation Monitoring and Data

The annual SAV survey described in Section 3.6 above will include a summary report which will be included as an appendix in the overall annual monitoring report for stakeholder use and discussion. This report can be used to help decision making efforts regarding the health of the system and potential maintenance needs.

3.6.2 Shorebird Nesting and Non-Nesting Survey Data

Each year the previous year's survey data will be collected for shorebirds (nesting and non-nesting). Data will be collected from the Florida Fish and Wildlife Conservation Commission (FWC) and Audubon (if available for Sand Dollar Island specifically) for mapping and inclusion in the annual monitoring report for comparison to previous data sets to help to identify trends in shorebird utilization and the success of the restoration endeavors. Any nesting which relocates back into the Section 2 zone will be specifically noted in terms of species, nest initiation, and nesting success.

3.6.3 Sea turtle Nesting Data

As with the shorebird data each year, sea turtle nesting locations and counts will be collected from Collier County, mapped, and included in the annual monitoring report for review by stakeholders to document trends. Any other pertinent information provided by County staff on contributing factors to nesting trends will also be included in the annual report. Success or failure of nesting within the restored Section 2 area will be specifically noted.

3.6.4 Water Quality Data

Any data from water quality sampling and monitoring will be collected and compared to previous year's data (if available) to see if any trends are discernable as a result of the ongoing management efforts.

3.6.5 Physical and Hydrological Monitoring Data

At least one month of tidal data will be collected each year at the southern and northern ends of the lagoon system to help quantify differences observed as a result of the flushing channels in terms of tidal prism improvements. This data will be summarized in the annual monitoring report.

Physical monitoring of flow channel and beach restoration work, including scarp and vegetation, will be done each year by the environmental consultant, surveyors and/or project engineers to help identify the timing of maintenance work needed within the project limits. Any data or survey and analysis work will be included in the annual report for review by the stakeholders.

3.7 Stakeholder Input

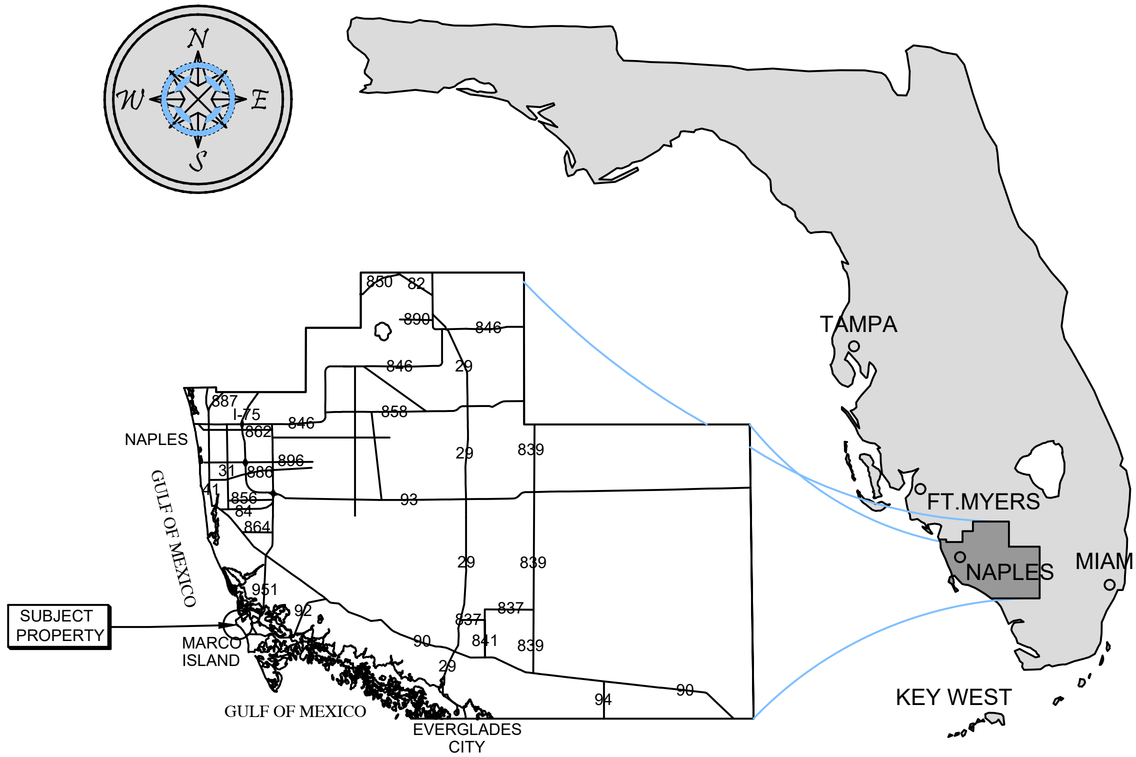
After the submittal of an annual report documenting the items outlined and discussed above in sections 3.1 to 3.6 to the various stakeholders and permitting authorities, discussions on conclusions and recommendations will be held to facilitate decisions regarding the sustainability of system natural resources. Ongoing coordination with FWC, Collier County, FDEP, Rookery Bay, Audubon, and others will be undertaken, and comments solicited by the various entities conducting investigations on the spit to make sure the on-going management is adaptive and responsive to issues that may be noted.

EXHIBITS

Exhibit 1

Location Map

STATE OF FLORIDA

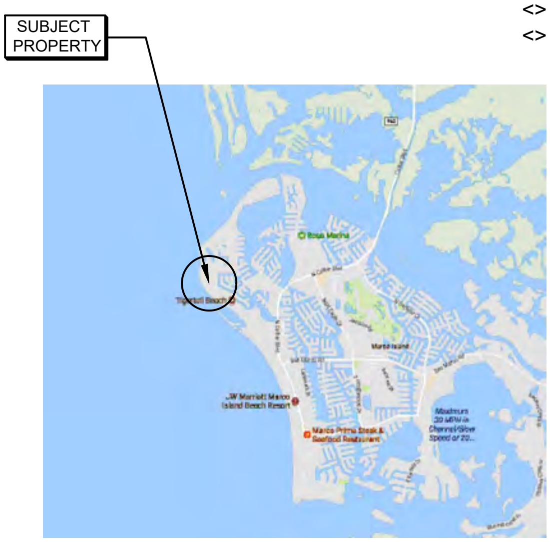


COLLIER COUNTY

SITE ADDRESS:
<> 250 S BEACH DRIVE
MARCO ISLAND, FL 34145

NOTES:
<> THESE DRAWINGS ARE FOR PERMITTING PURPOSES ONLY AND ARE NOT INTENDED FOR CONSTRUCTION USE.

<> LATITUDE: N 25.953529
<> LONGITUDE: W -81.750569



VICINITY MAP

COUNTY AERIAL

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ESCOSYSTEM RESTORATION PROJECT
LOCATION MAP

DESIGNED	MN	REVISION	TAB NAME	Location
DRAWN	RMJ	N/A	SHEET	01 OF 12
DATE	03-20-21	N/A	SCALE	
JOB NO.	1782	N/A		

SECTION- 6 & 7 TOWNSHIP- 52 S RANGE-26 E

EXHIBIT 2

OVERALL SURVEY AREA

HABITAT WITHIN PROJECT BOUNDARY	
HABITAT TYPE	AREA (AC)
SAND	43.92
COASTAL VEGETATION	48.14
SEAGRASS	12.96
SEAGRASS MUDFLAT	3.87
OPEN MUDFLAT	1.78
OPEN WATER	100.61
TOTAL	211.28

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ESCOSYSTEM RESTORATION PROJECT
OVERALL SURVEY AREA

DESIGNED	MN	REVISION	TAB NAME	Overall
DRAWN	RMJ	N/A	SHEET	02 OF 12
DATE	03-20-21	N/A	SCALE	
JOB NO.	1782	N/A		

SECTION- 7 TOWNSHIP- 52 S RANGE-26 E

EXHIBIT 3

RESOURCE SURVEY AREA 1

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ESCOSYSTEM RESTORATION PROJECT
RESOURCE SURVEY AREA 1

DESIGNED	MN	REVISION	TAB NAME	Area 1
DRAWN	RMJ	N/A	SHEET	03 OF 12
DATE	03-20-21	N/A	SCALE	
JOB NO.	1782	N/A		

SECTION- 6 & 7 TOWNSHIP- 52 S RANGE-26 E

EXHIBIT 4

RESOURCE SURVEY AREA 2

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ESCOSYSTEM RESTORATION PROJECT
RESOURCE SURVEY AREA 2

DESIGNED	MN	REVISION	TAB NAME	Area 2
DRAWN	RMJ	N/A	SHEET	04 OF 12
DATE	03-20-21	N/A	SCALE	
JOB NO.	1782	N/A		

SECTION-7 TOWNSHIP-52 S RANGE-26 E

EXHIBIT 5

AREA 2 SAND LINE COMPARISON

(2020 – 2021)

HABITAT WITHIN PROJECT BOUNDARY		
HABITAT TYPE	2020 AREA (AC)	2021 AREA (AC)
SAND	34.58	43.92
COASTAL VEGETATION	48.14	48.14
SEAGRASS	14.62	12.96
SEAGRASS MUDFLAT	5.56	3.87
OPEN MUDFLAT	0.77	1.78
OPEN WATER	100.61	100.61
TOTAL	204.28	211.28

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ESCOSYSTEM RESTORATION PROJECT
AREA 2 - SAND LINE COMPARISON

DESIGNED	MN	REVISION	TAB NAME	Area 2
DRAWN	RMJ	N/A	SHEET	05 OF 12
DATE	04-02-21	N/A	SCALE	
JOB NO.	1782	N/A		

SECTION- 7 TOWNSHIP- 52 S RANGE-26 E

EXHIBIT 6

RESOURCE AREA 3

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ESCOSYSTEM RESTORATION PROJECT
RESOURCE SURVEY AREA 3

DESIGNED	MN	REVISION	TAB NAME	Area 3
DRAWN	RMJ	N/A	SHEET	06 OF 12
DATE	03-20-21	N/A	SCALE	
JOB NO.	1782	N/A		

SECTION- 7 TOWNSHIP- 52 S RANGE-26 E

EXHIBIT 7

RESOURCE AREA 4

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ESCOSYSTEM RESTORATION PROJECT
RESOURCE SURVEY AREA 4

DESIGNED	MN	REVISION	TAB NAME	Area 4
DRAWN	RMJ	N/A	SHEET	07 OF 12
DATE	03-20-21	N/A	SCALE	
JOB NO.	1782	N/A		

SECTION-7 TOWNSHIP- 52 S RANGE-26 E

EXHIBIT 8

SITE PLAN

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ESCOSYSTEM RESTORATION PROJECT
SITEPLAN

DESIGNED	MN	REVISION	TAB NAME	WATER SAMPLING
DRAWN	RMJ	N/A	SHEET	08 OF 12
DATE	03-21-20	N/A	SCALE	
JOB NO.	1782	N/A		

SECTION- 6 & 7 TOWNSHIP- 52 S RANGE-26 E

EXHIBIT 9

IMPACTS MAP

IMPACTS TABLE

HABITAT TYPE	SAND (AC)	COASTAL VEG. (AC)	OPEN WATER (AC)	TOTAL (AC)
PROPOSED DREDGE IN GULF	7.24	2.36	16.78	26.38
PROP. DREDGE IN OPEN WATER AND SAND	8.12		12.50	20.62
PROP. FILL ON SAND BEACH	1.83		9.35	11.18
PROP. FILL IN THE GULF OF MEXICO	1.06		23.84	24.90
TOTAL	18.25	2.36	62.47	83.08

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ESCOSYSTEM RESTORATION PROJECT
IMPACTS MAP

DESIGNED	MN	REVISION	TAB NAME	WATER SAMPLING
DRAWN	RMJ	N/A	SHEET	09 OF 12
DATE	04-02-21	N/A	SCALE	
JOB NO.	1782	N/A		

SECTION- 6 & 7 TOWNSHIP- 52 S RANGE-26 E

EXHIBIT 10

WILSON'S PLOVER NESTS

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ECOSYSTEM RESTORATION PROJECT
WILSON'S PLOVER NESTS

SOURCE: FLORIDA SHOREBIRD DATABASE

DRAWN BY:	RMJ	REVISION:	SCALE: 1 "=1,100 '
CREATED:	03-22-21	N/A	FILE PATH: P:\1782-Sand Dollar Island SRS\GIS\1782_WILSONS_PLOVER.mxd
JOB NO.:	1782	N/A	
SHEET:	10 OF 12	N/A	

SECTION- 7 TOWNSHIP- 52S RANGE- 26E

EXHIBIT 11

KILLDEER NESTS

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ECOSYSTEM RESTORATION PROJECT
KILLDEER NESTS

SOURCE: FLORIDA SHOREBIRD DATABASE

DRAWN BY:	RMJ	REVISION:	SCALE: 1 "=1,100 '
CREATED:	03-22-21	N/A	FILE PATH:
JOB NO.:	1782	N/A	P:\1782-Sand Dollar Island SRS\GIS\1782_KILLDEER.mxd
SHEET:	11 OF 12	N/A	

SECTION- 7 TOWNSHIP- 52S RANGE- 26E

EXHIBIT 12

COLONIAL SHOREBIRD NESTING AREAS

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ECOSYSTEM RESTORATION PROJECT
COLONIAL SHOREBIRD NESTING AREAS

SOURCE: FLORIDA SHOREBIRD DATABASE

DRAWN BY:	RMJ	REVISION:	SCALE:	1 "=1,100 '
CREATED:	04-02-21	N/A	FILE PATH:	
JOB NO.:	1782	N/A	P:\1782-Sand Dollar Island SRS\ GIS\1782_COLONIAL_ SHOREBIRDS.mxd	
SHEET:	12 OF 12	N/A		

SECTION- 7 TOWNSHIP- 52S RANGE- 26E

Appendix C

Tigertail Lagoon & Sand Dollar Island Restoration Survey data profiles

PHOTOGRAPH DATED JUNE 2020
COURTESY OF HIDEAWAY BEACH.

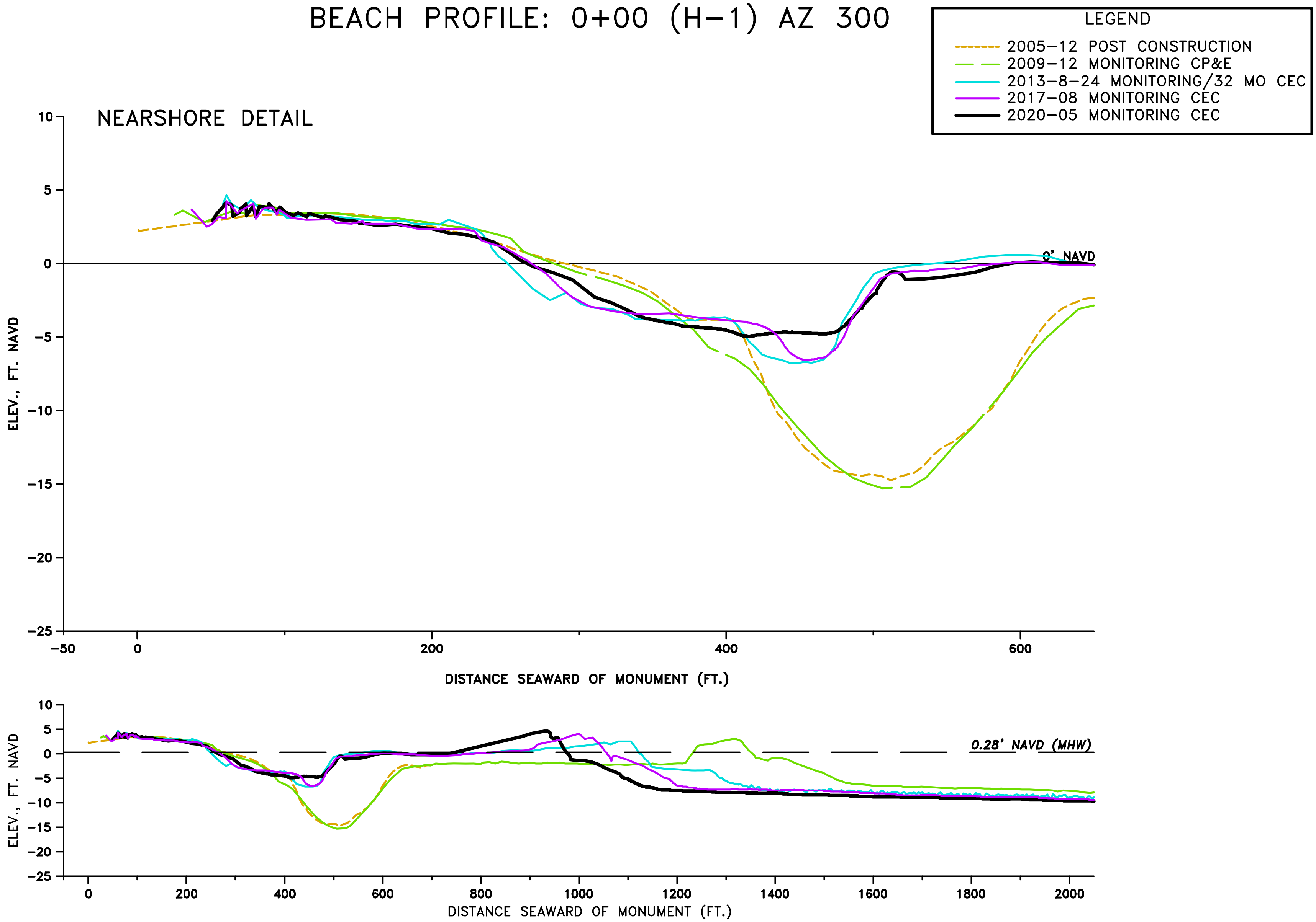
HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON RESTORATION PROJECT
PROFILE LOCATION SITE PLAN

FOR: CITY OF MARCO ISLAND		
DATE: 3/24/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE:

5679 STRAND COURT
NAPLES, FL 34110
FAX: (239) 594-2025
PHONE: (239) 594-2021
www.humistonandmoore.com

BEACH PROFILE: 0+00 (H-1) AZ 300



HUMISTON & MOORE ENGINEERS
COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 1

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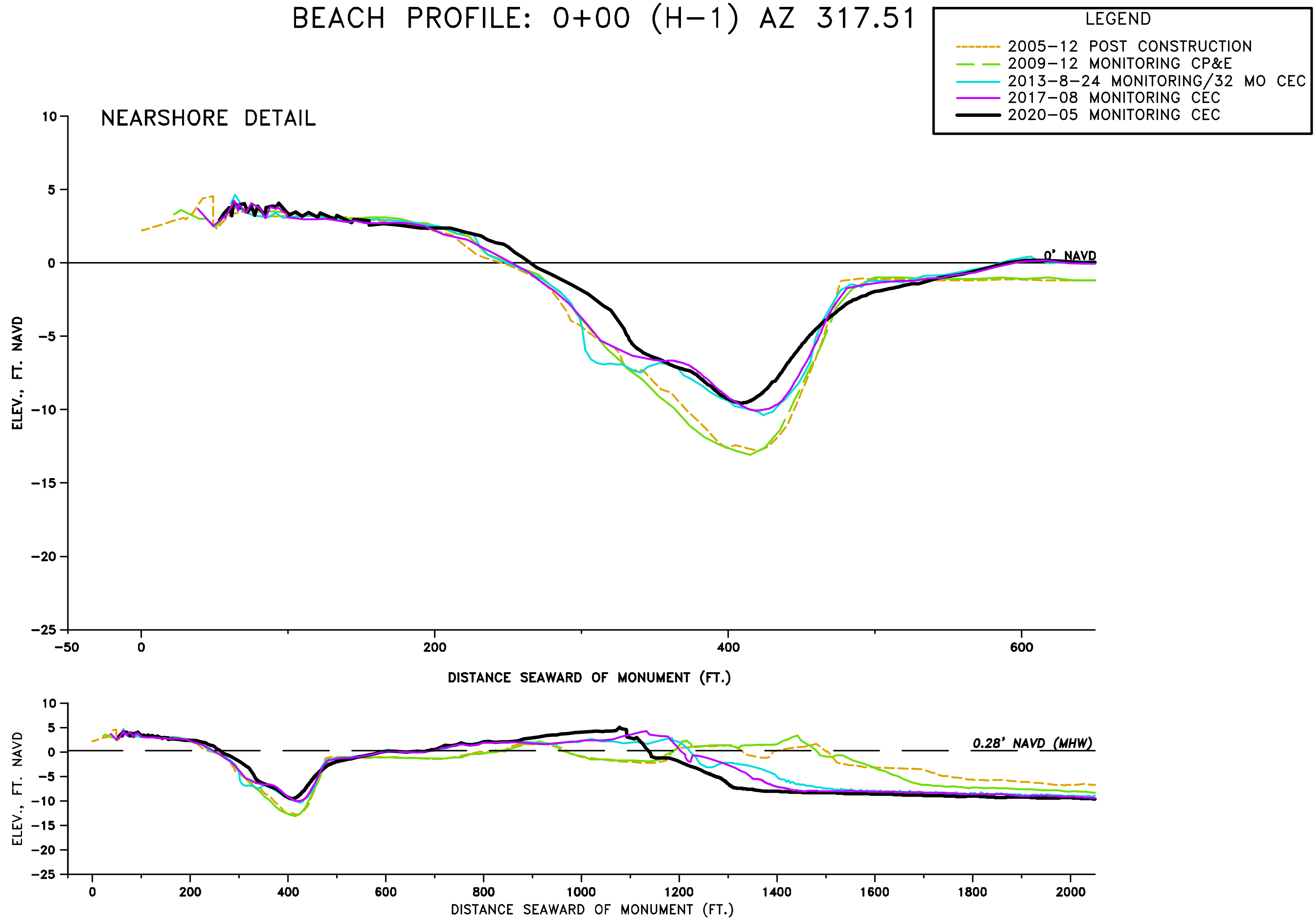
BEACH PROFILE: 0+00 (H-1) AZ 317.51



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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION - CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 2

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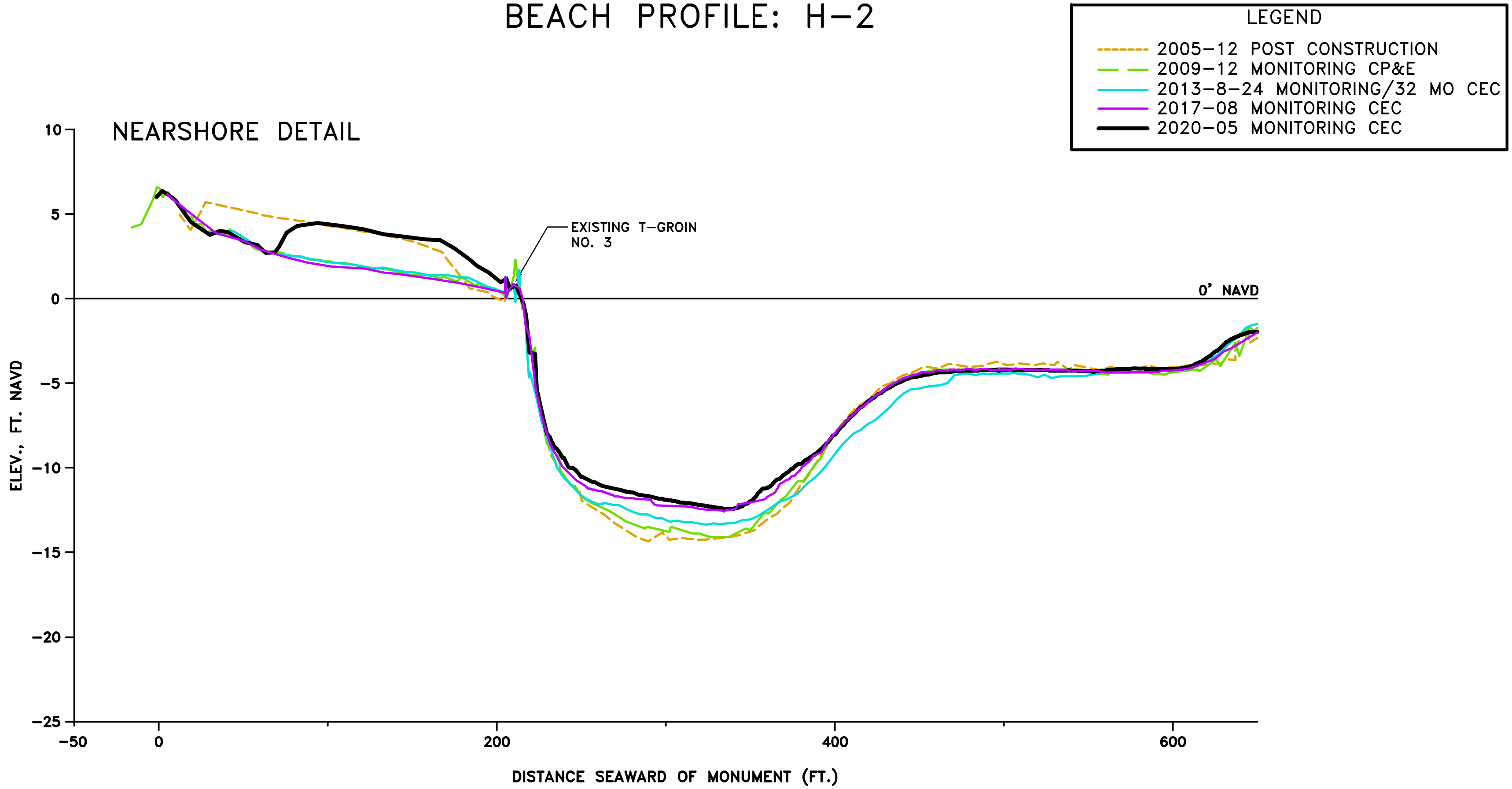
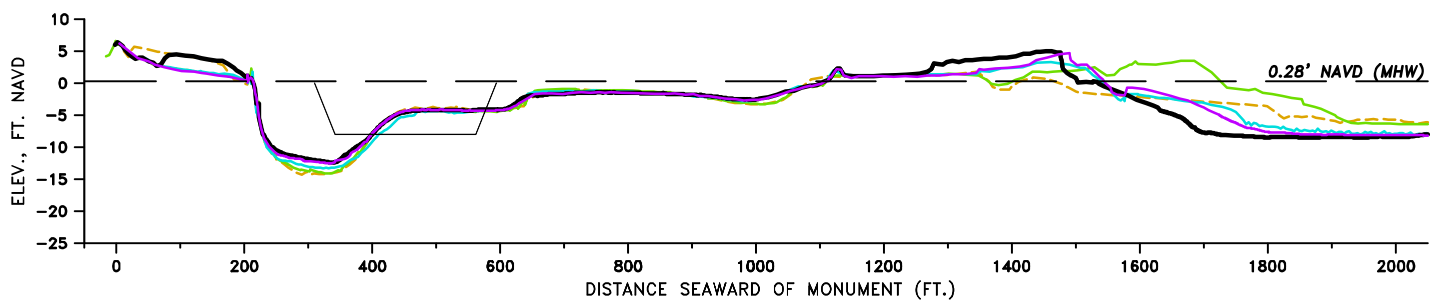
BEACH PROFILE: H-2





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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 3

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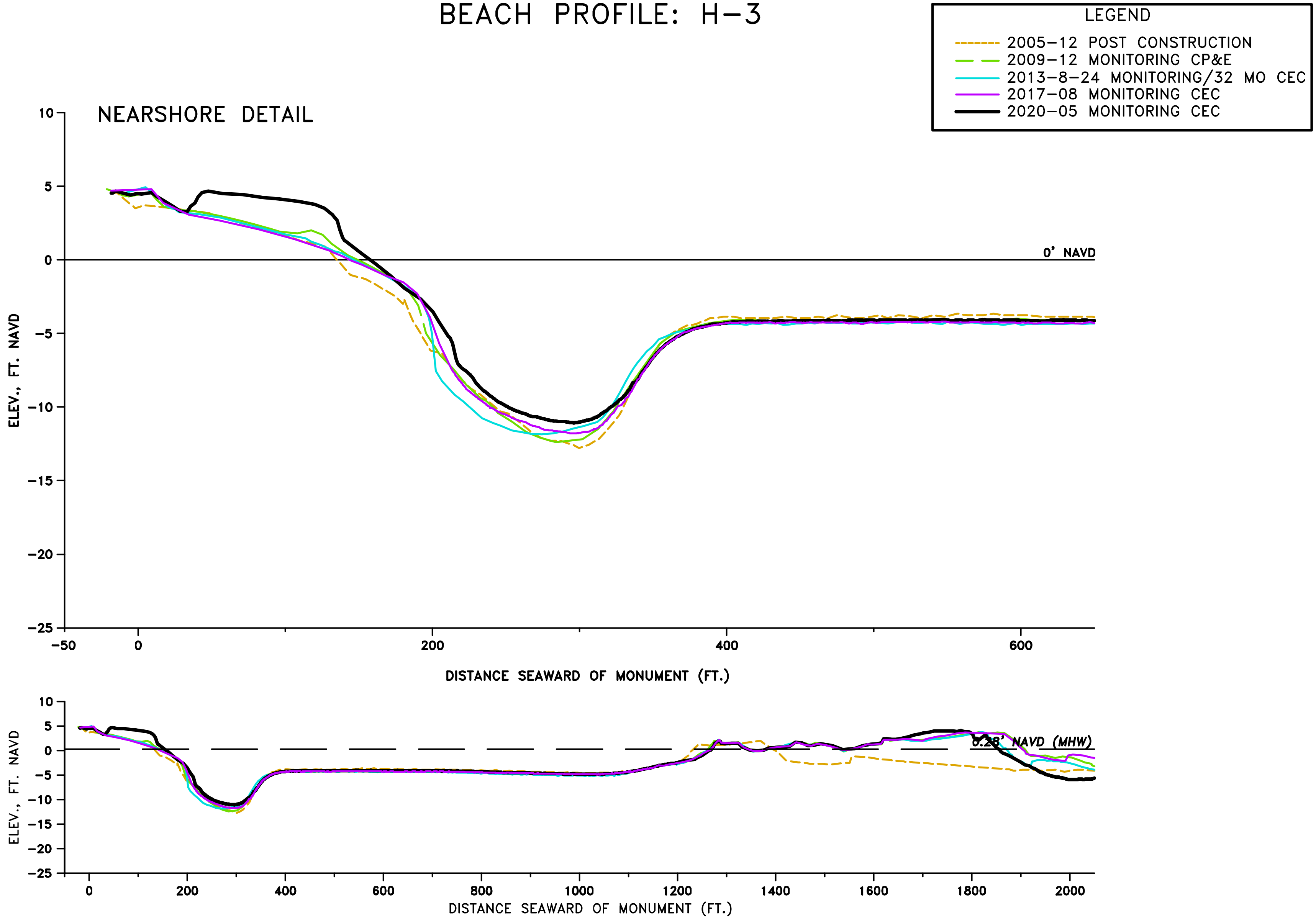
BEACH PROFILE: H-3



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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 4

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BEACH PROFILE: H-4

LEGEND
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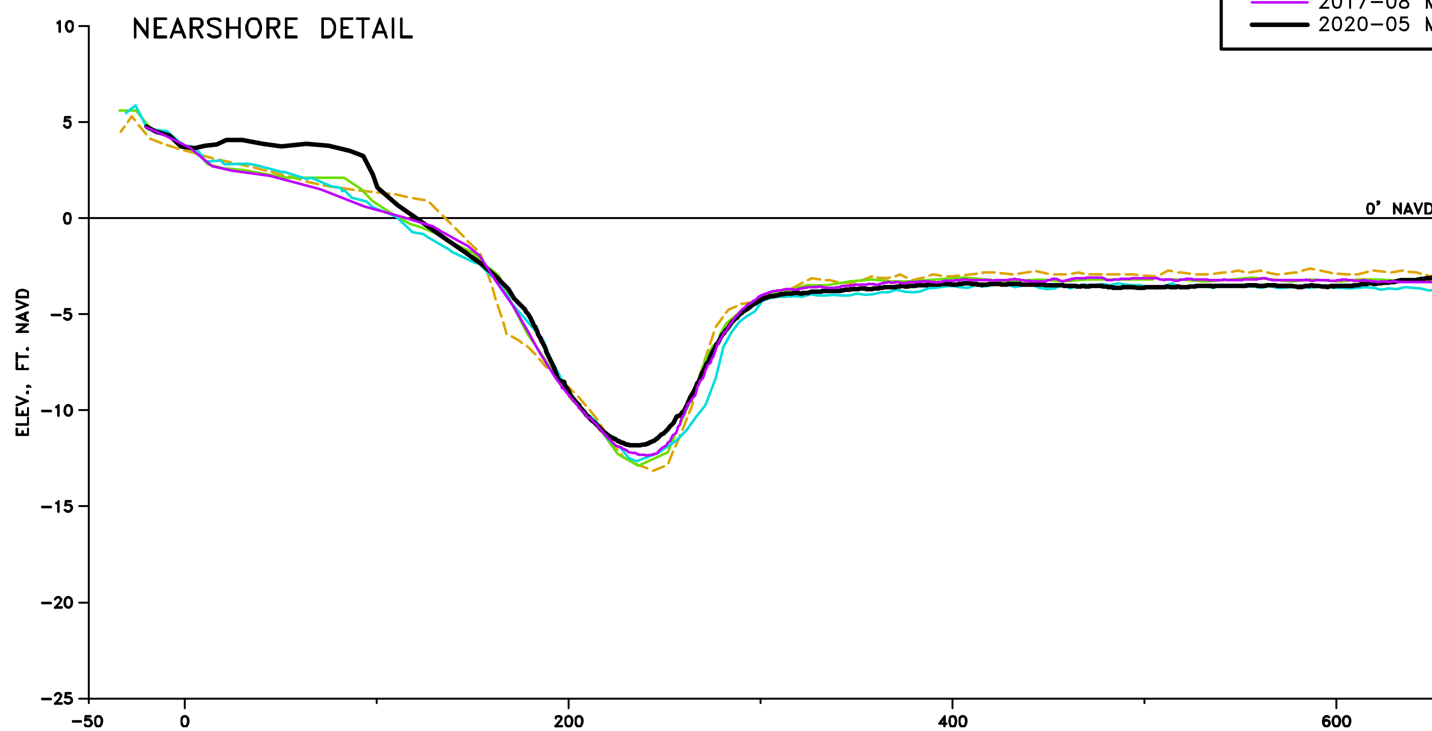
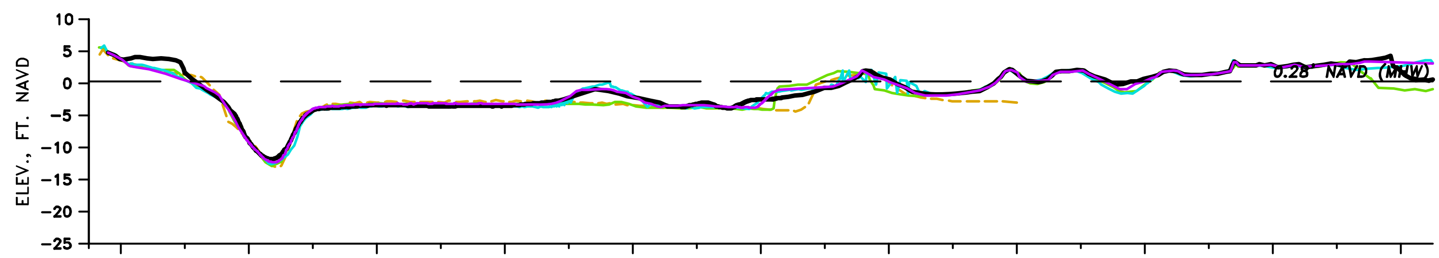
- 2009-12 MONITORING CP&E
- 2013-8-24 MONITORING/32 MO CEC
- 2017-08 MONITORING CEC
- 2020-05 MONITORING CEC





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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 5

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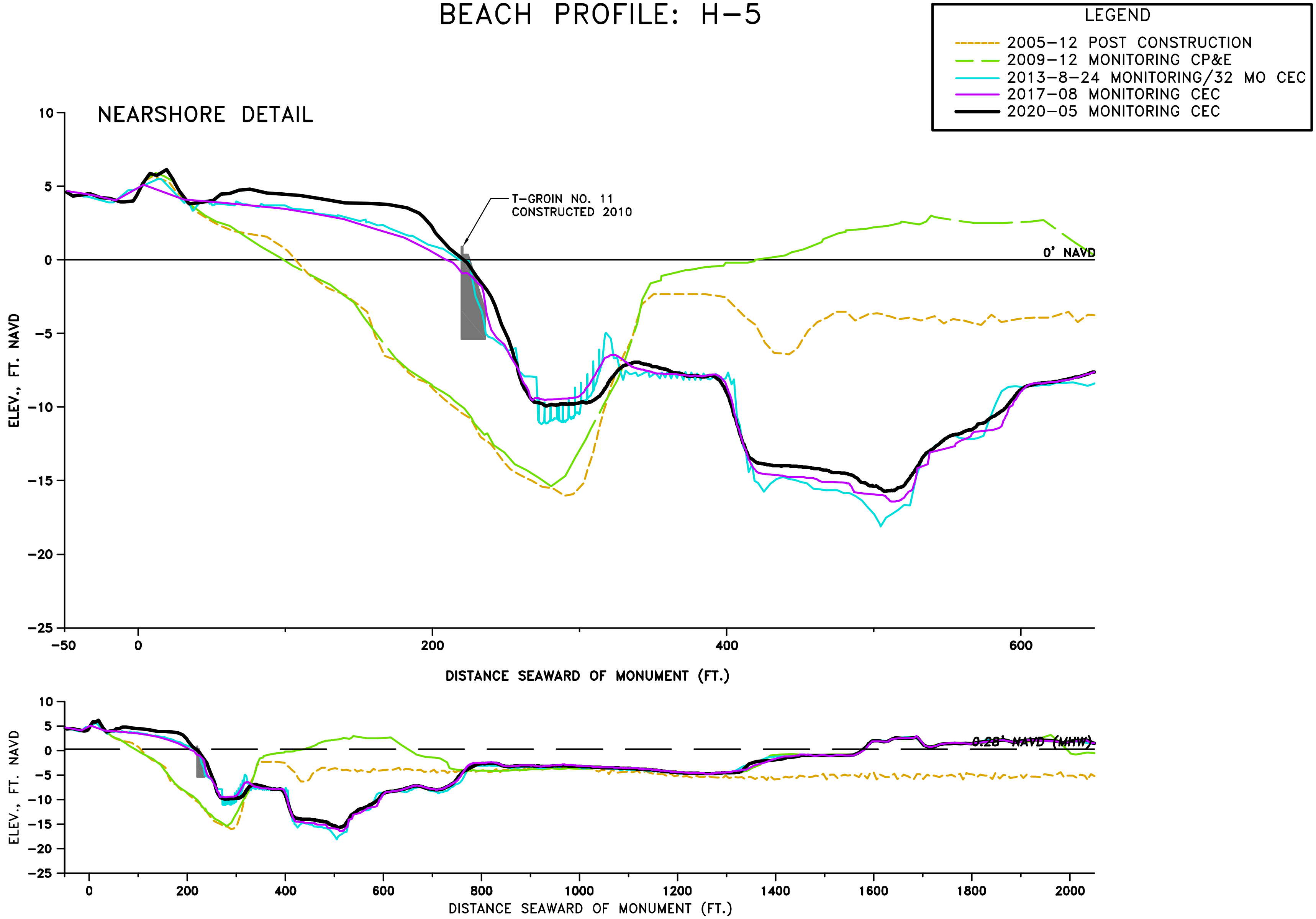
BEACH PROFILE: H-5



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	FOR: CITY OF MARCO ISLAND		
	DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
	JOB: 27-002	DATUM: NONE	FIGURE: 6

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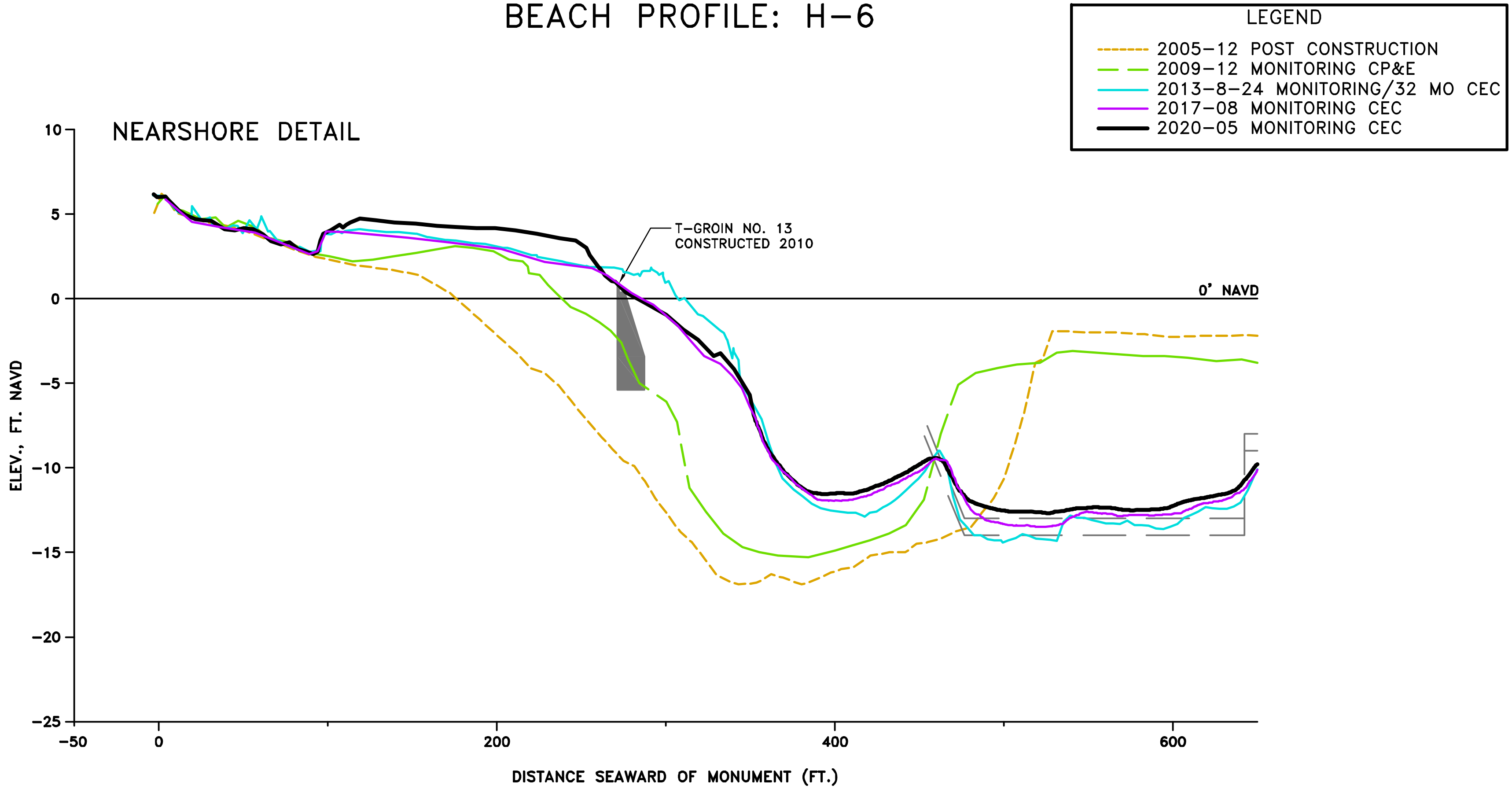
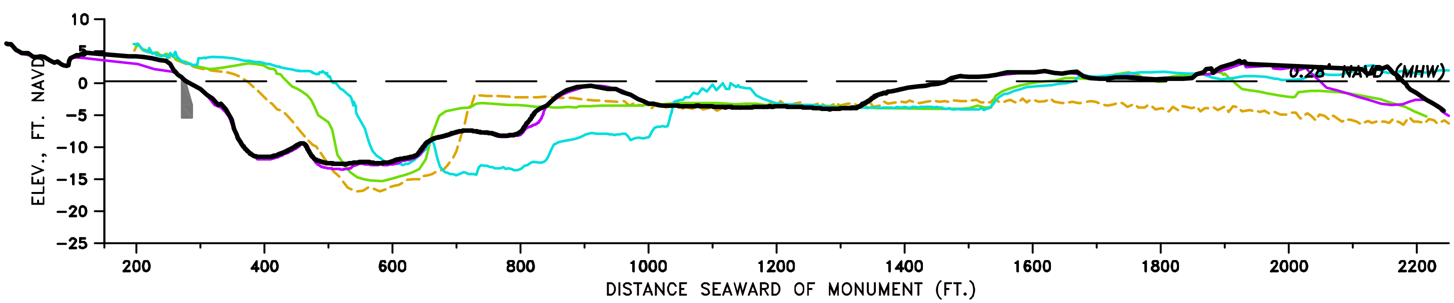
BEACH PROFILE: H-6





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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION - CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 7

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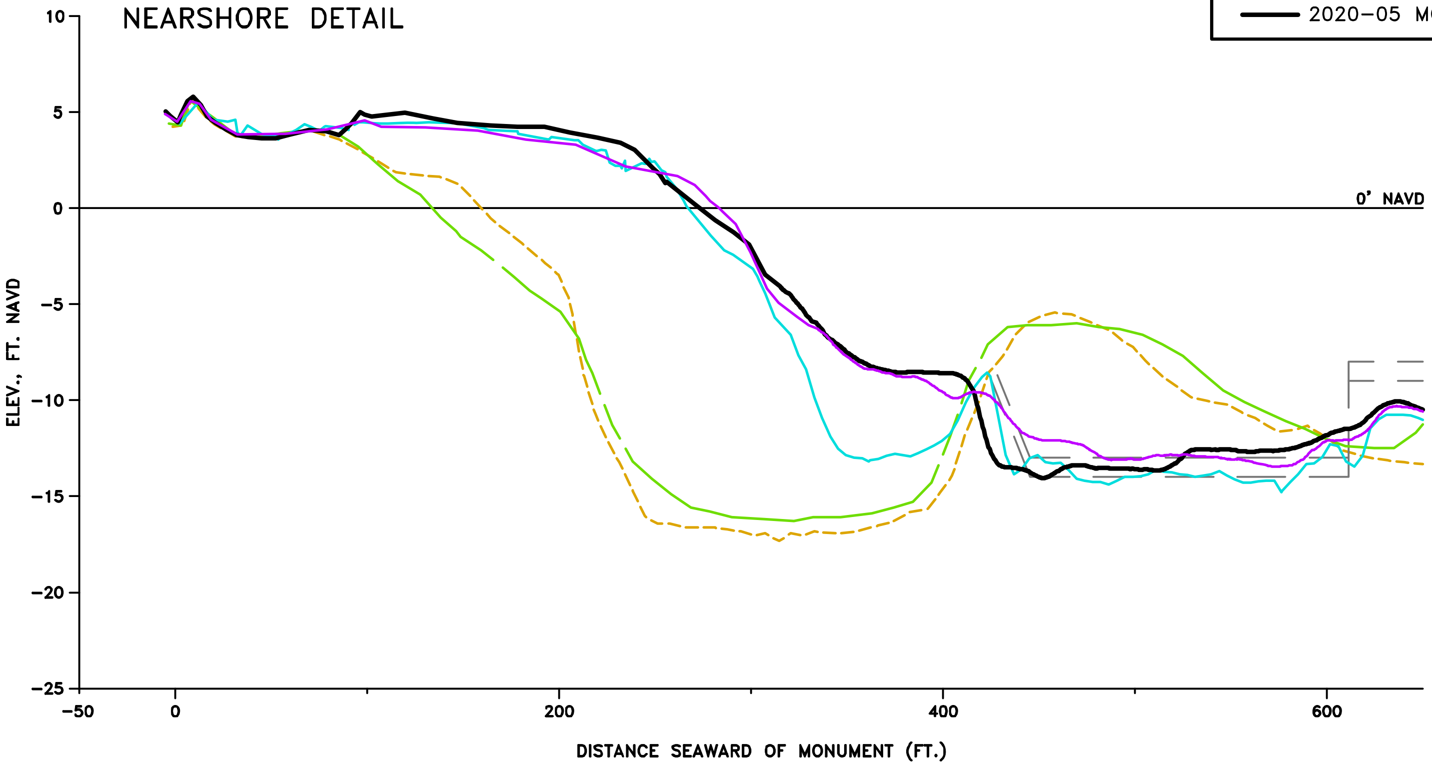
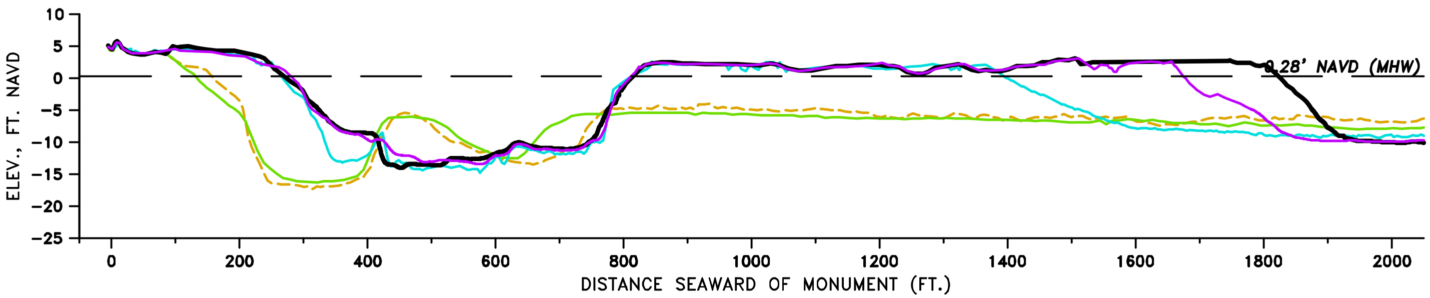
BEACH PROFILE: H-7

LEGEND
- 2005-12 POST CONSTRUCTION
- 2009-12 MONITORING CP&E
- 2013-8-24 MONITORING/32 MO CEC
- 2017-08 MONITORING CEC
- 2020-05 MONITORING CEC

NEARSHORE DETAIL





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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 8

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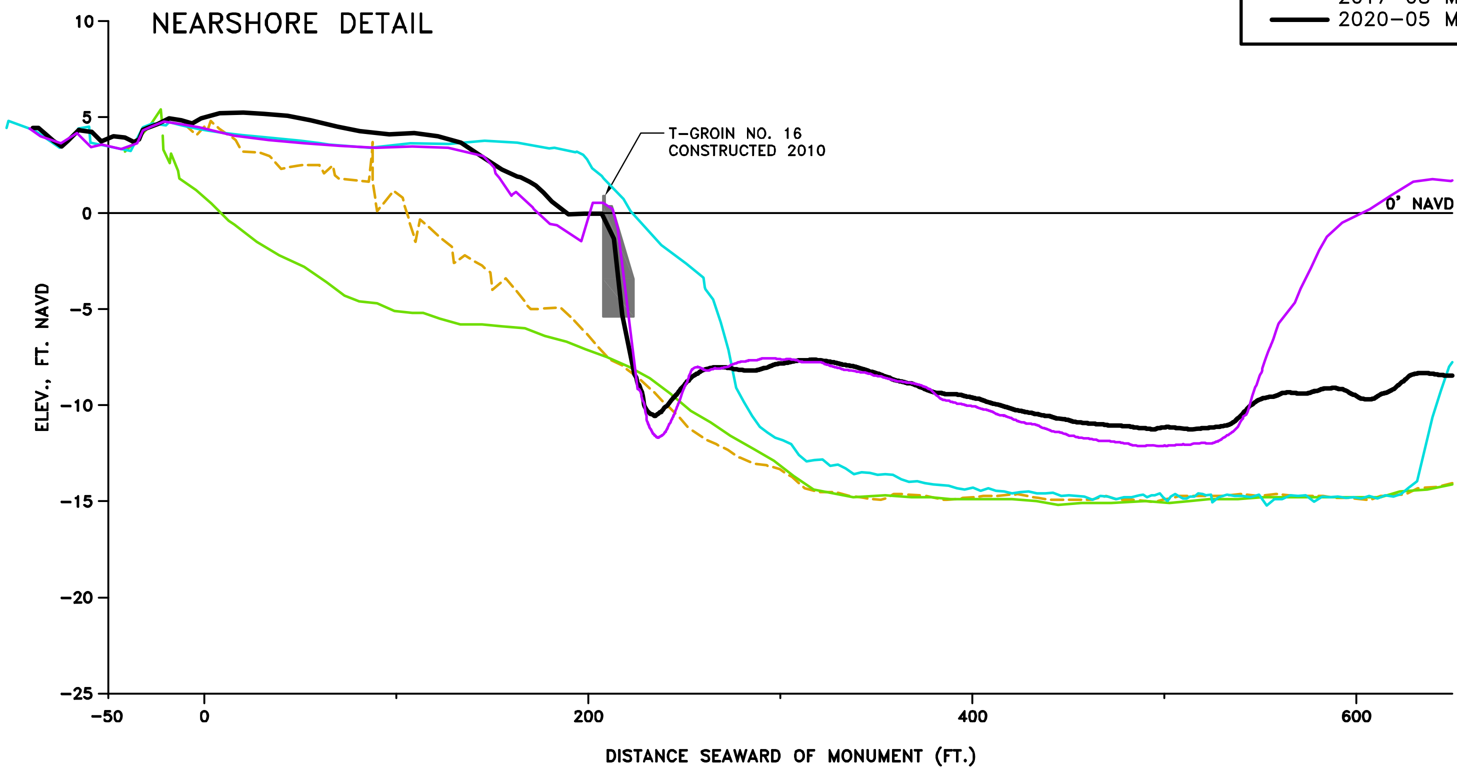
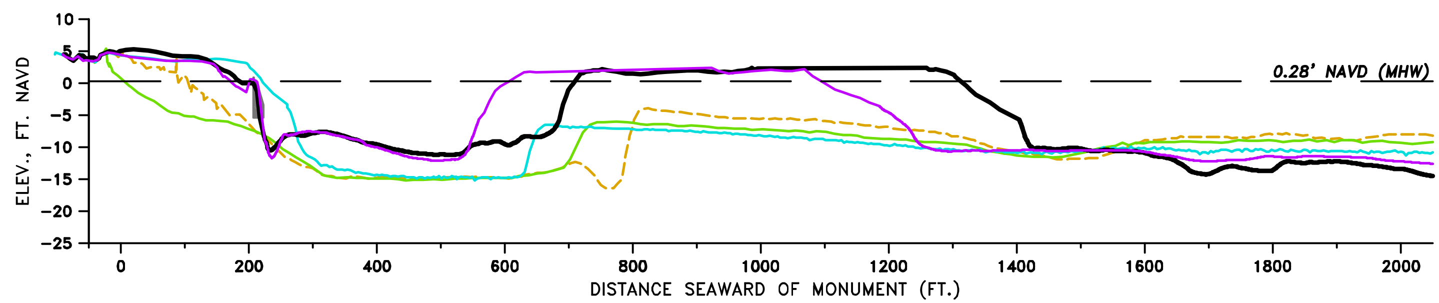
BEACH PROFILE: H-8

LEGEND
- 2005-12 POST CONSTRUCTION
- 2009-12 MONITORING CP&E
- 2013-8-24 MONITORING/32 MO CEC
- 2017-08 MONITORING CEC
- 2020-05 MONITORING CEC





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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ECOSYSTEM RESTORATION – CROSS SECTIONS

FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 9

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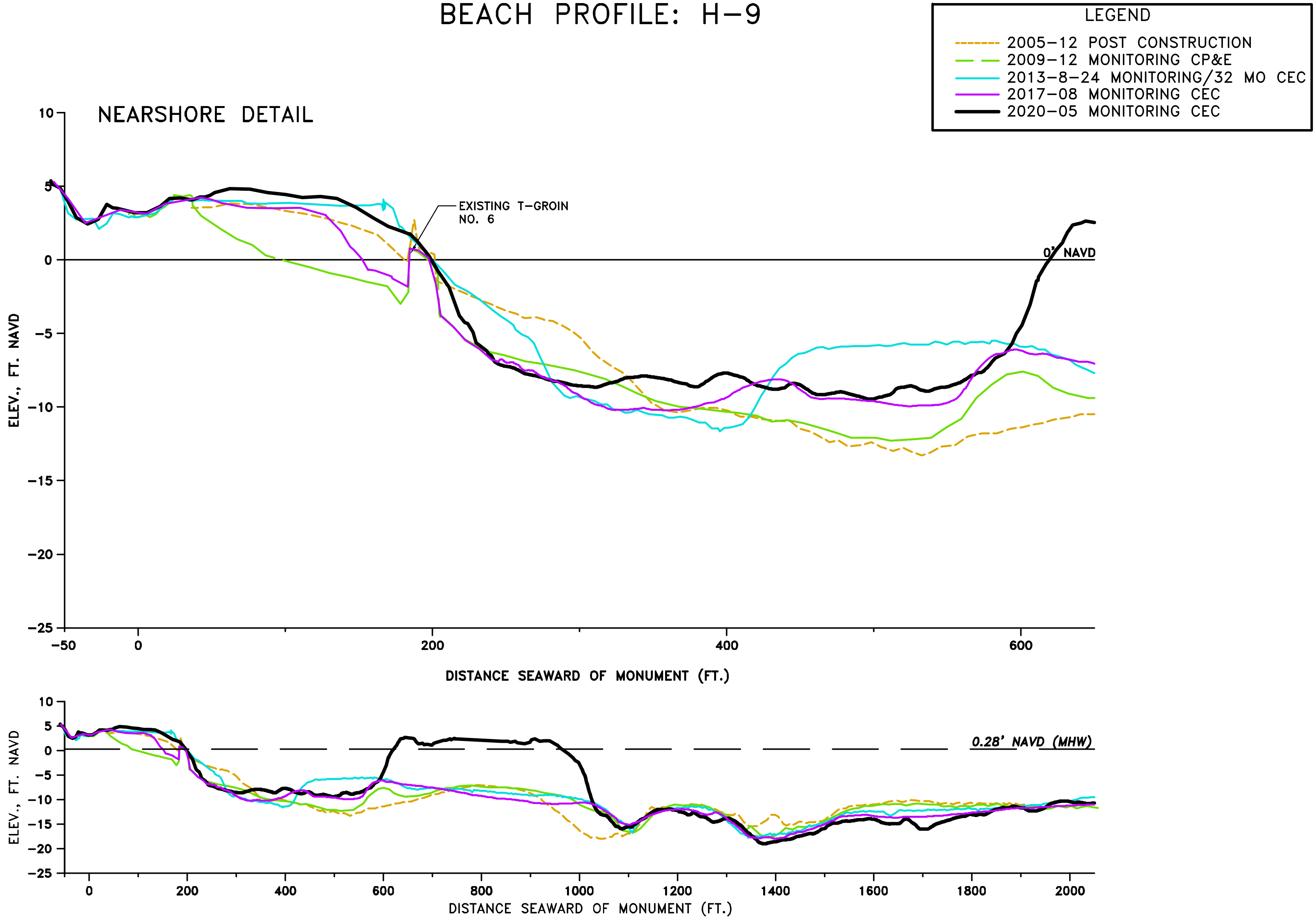
BEACH PROFILE: H-9



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	FOR: CITY OF MARCO ISLAND		
	DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
	JOB: 27-002	DATUM: NONE	FIGURE: 10

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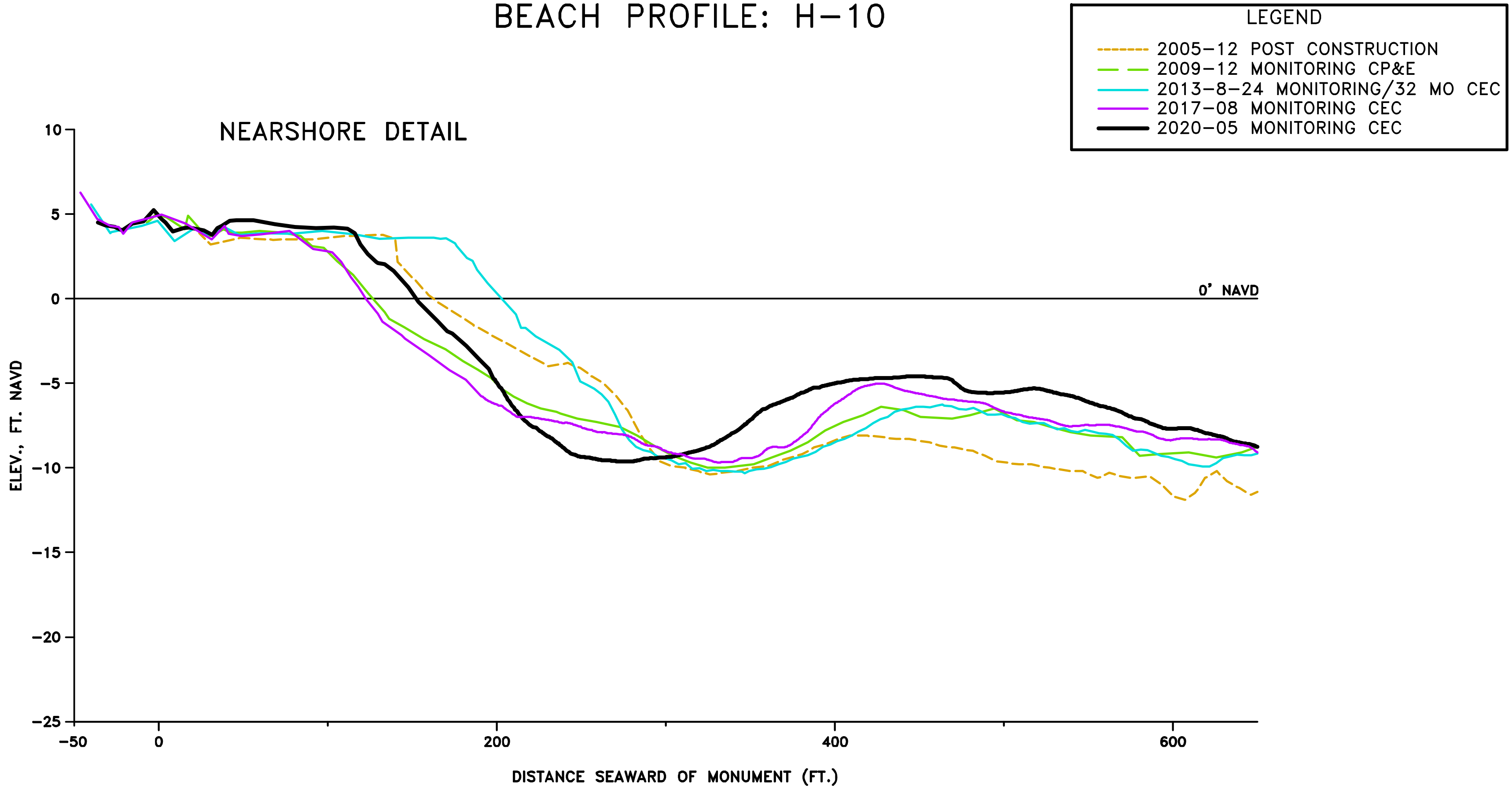
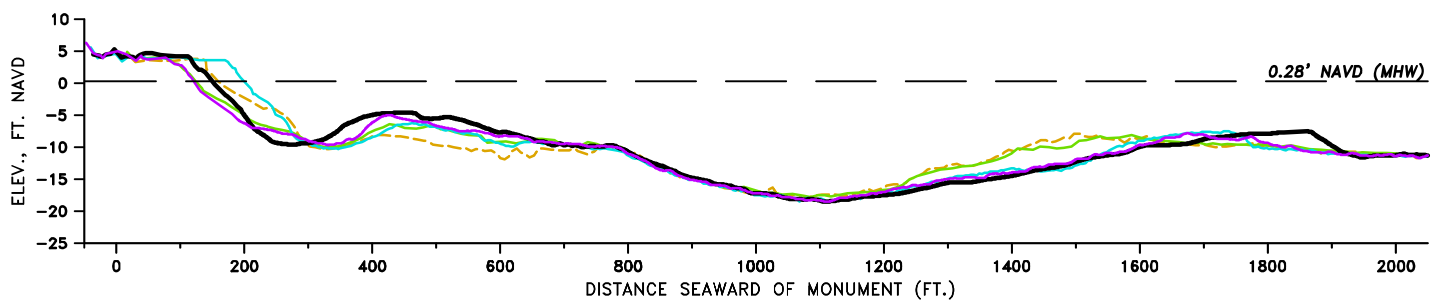
BEACH PROFILE: H-10





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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 11

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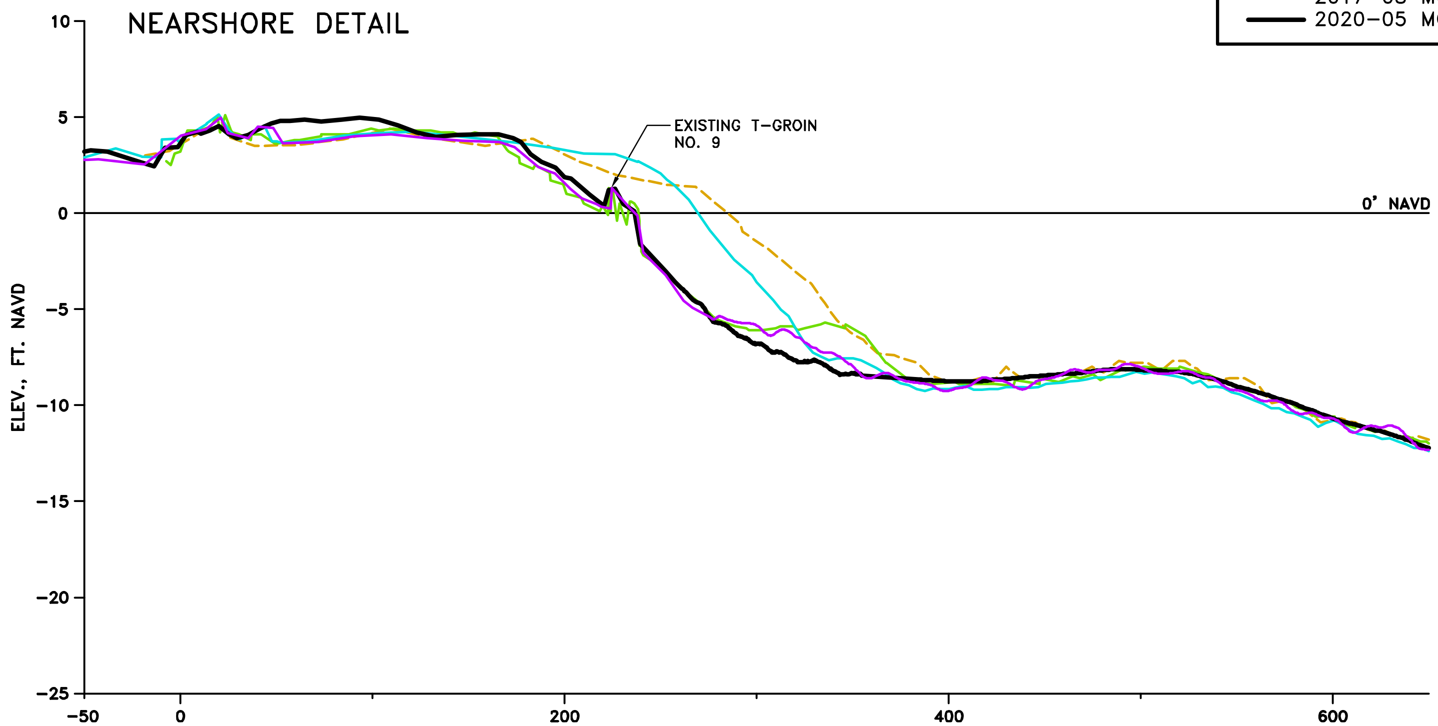
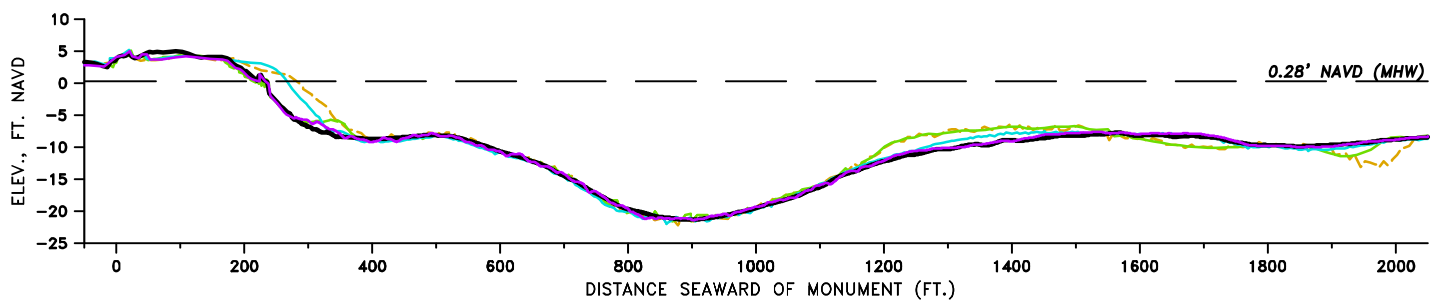
BEACH PROFILE: H-11

LEGEND
- 2005-12 POST CONSTRUCTION
- 2009-12 MONITORING CP&E
- 2013-8-24 MONITORING/32 MO CEC
- 2017-08 MONITORING CEC
- 2020-05 MONITORING CEC





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COASTAL ENGINEERING DESIGN AND PERMITTING

TIGERTAIL LAGOON / SAND DOLLAR ISLAND
ECOSYSTEM RESTORATION - CROSS SECTIONS

FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 12

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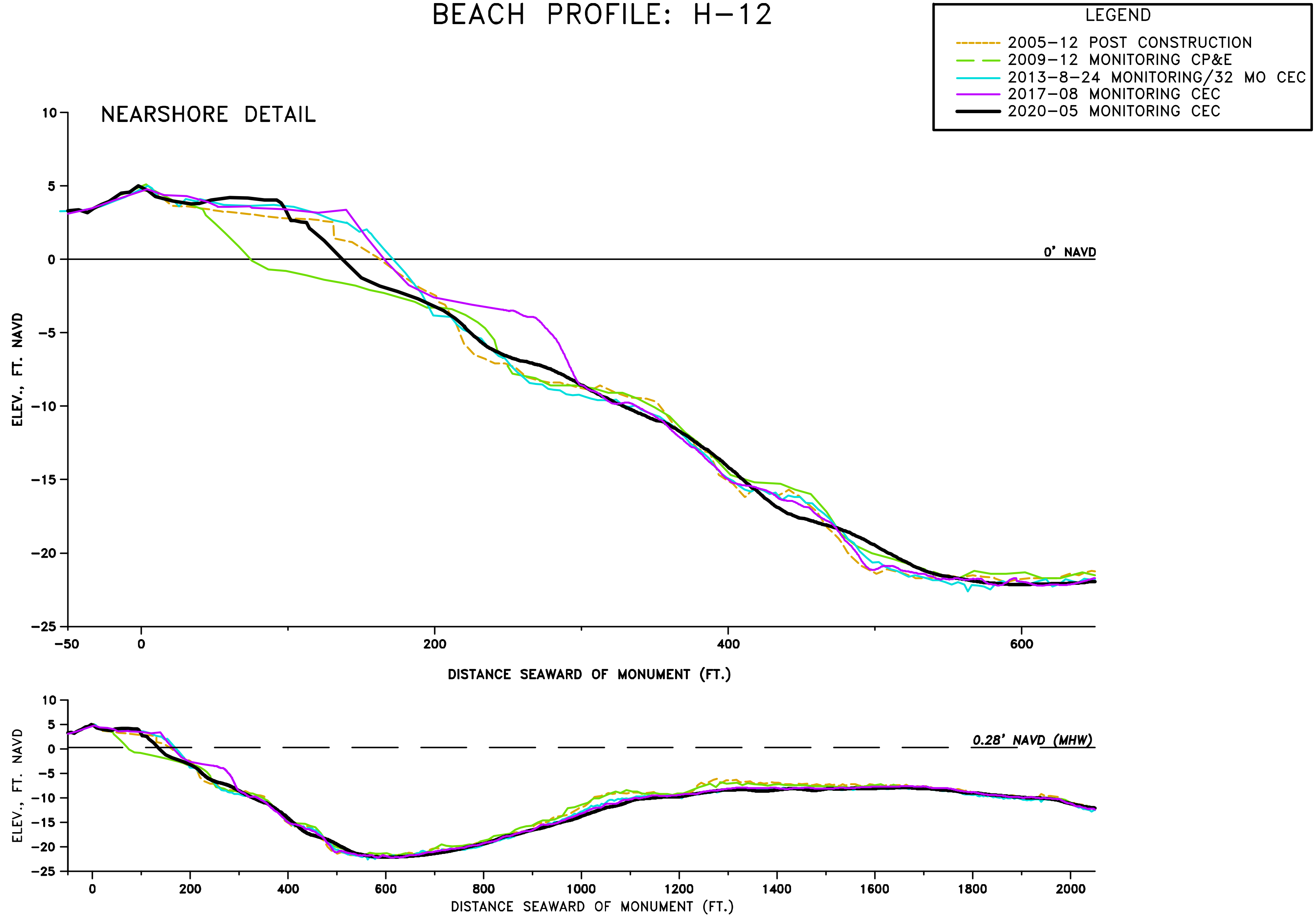
BEACH PROFILE: H-12



HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
	FOR: CITY OF MARCO ISLAND		
	DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
	JOB: 27-002	DATUM: NONE	FIGURE: 13

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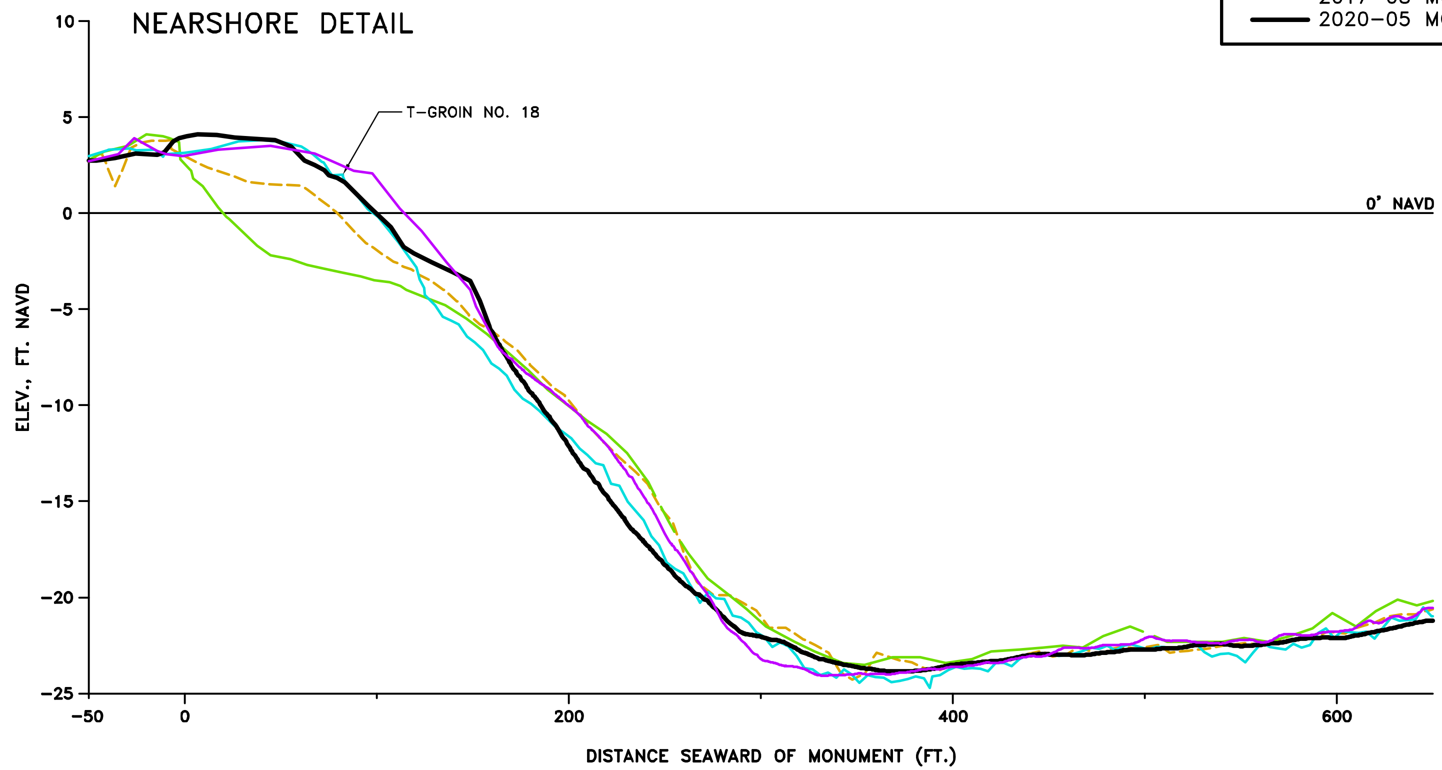
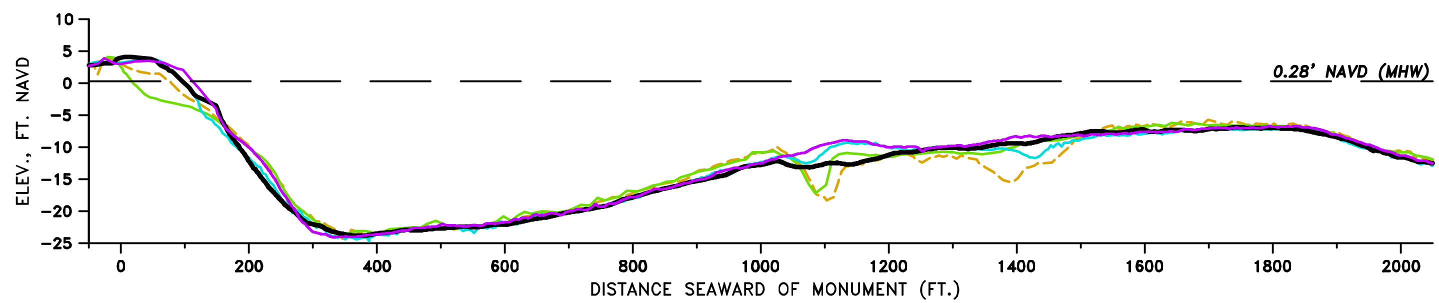
BEACH PROFILE: H-13

LEGEND
2005-12 POST CONSTRUCTION
2009-12 MONITORING CP&E
2013-8-24 MONITORING/32 MO CEC
2017-08 MONITORING CEC
2020-05 MONITORING CEC





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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION - CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 14

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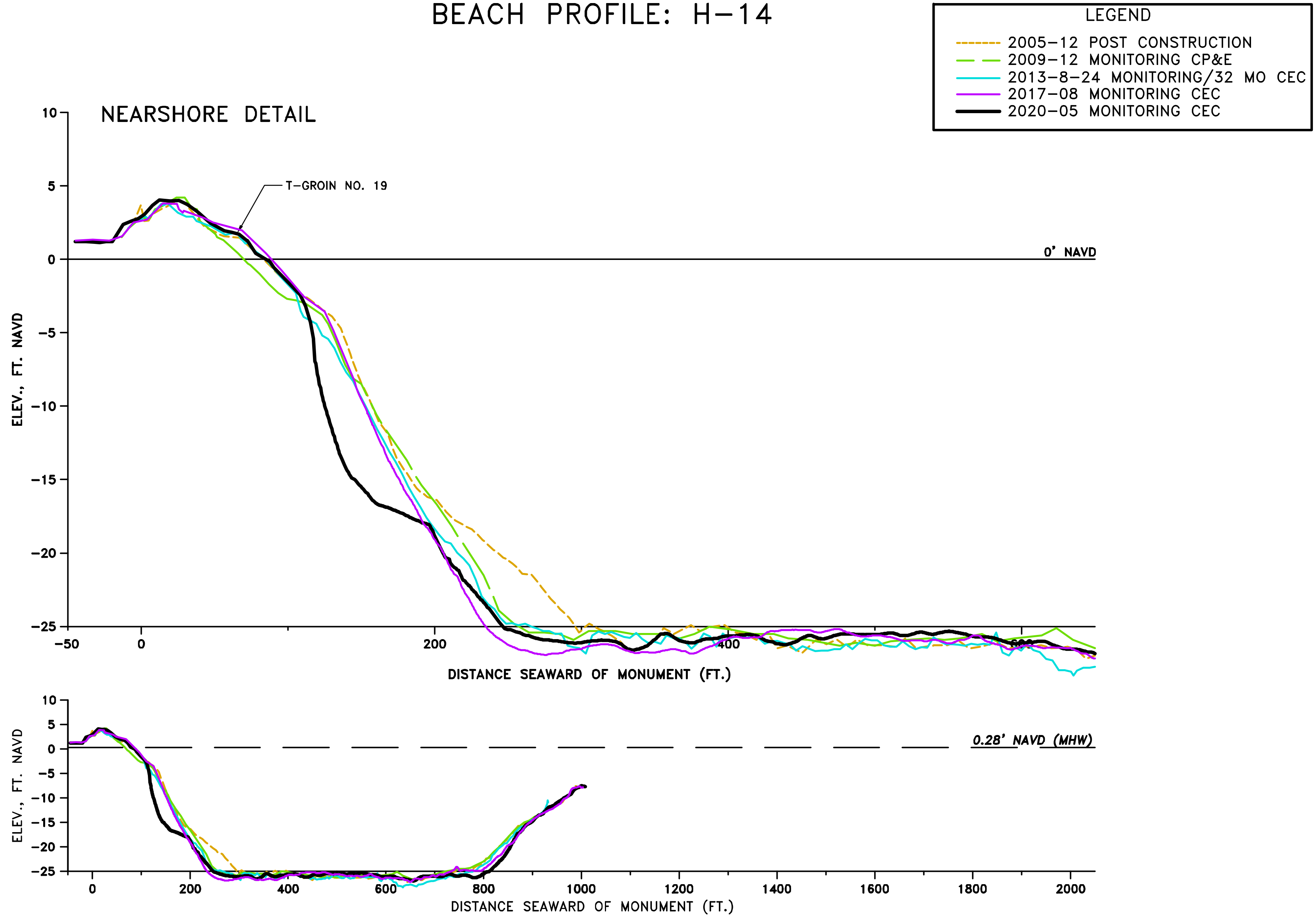
BEACH PROFILE: H-14



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	FOR: CITY OF MARCO ISLAND	
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 15

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BEACH PROFILE: H-15

LEGEND
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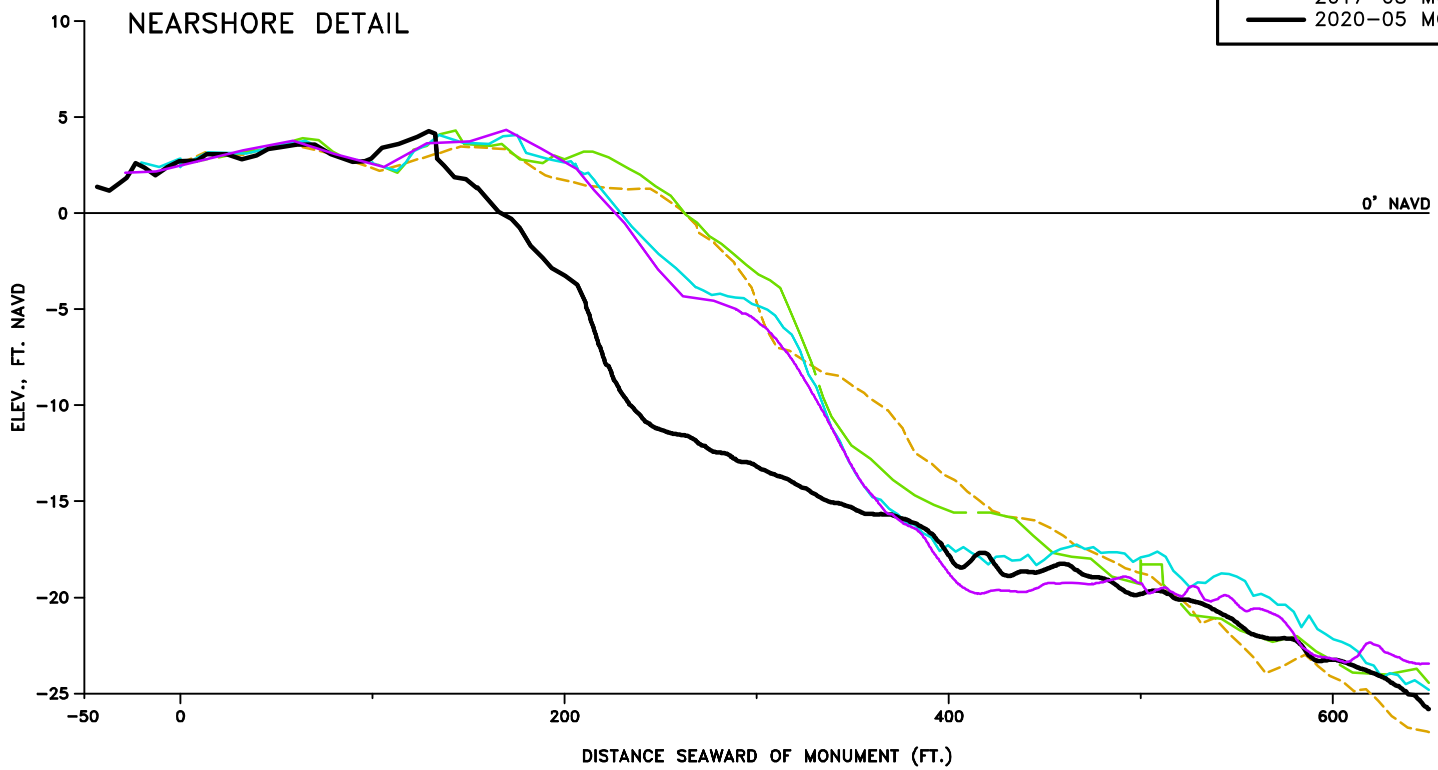
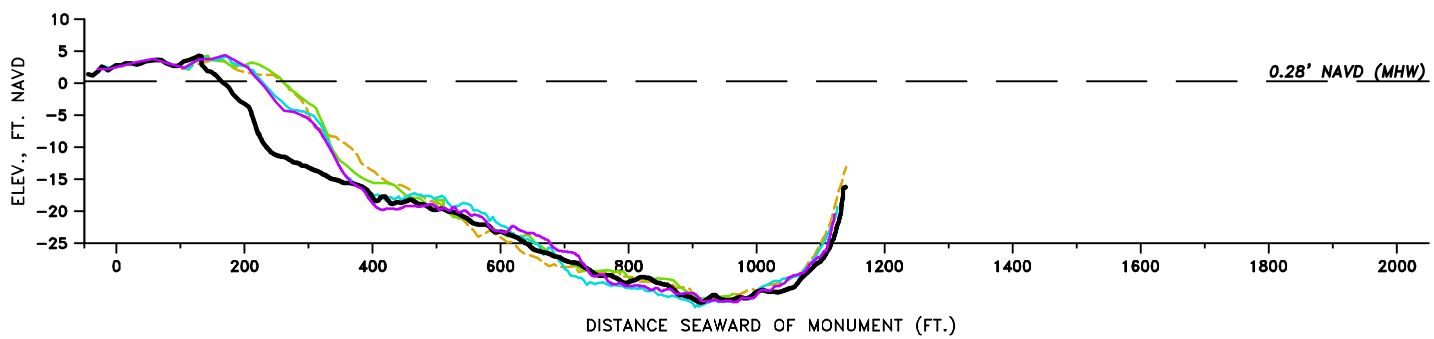
- 2013-8-24 MONITORING/32 MO CEC
- 2017-08 MONITORING CEC
- 2020-05 MONITORING CEC





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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 16

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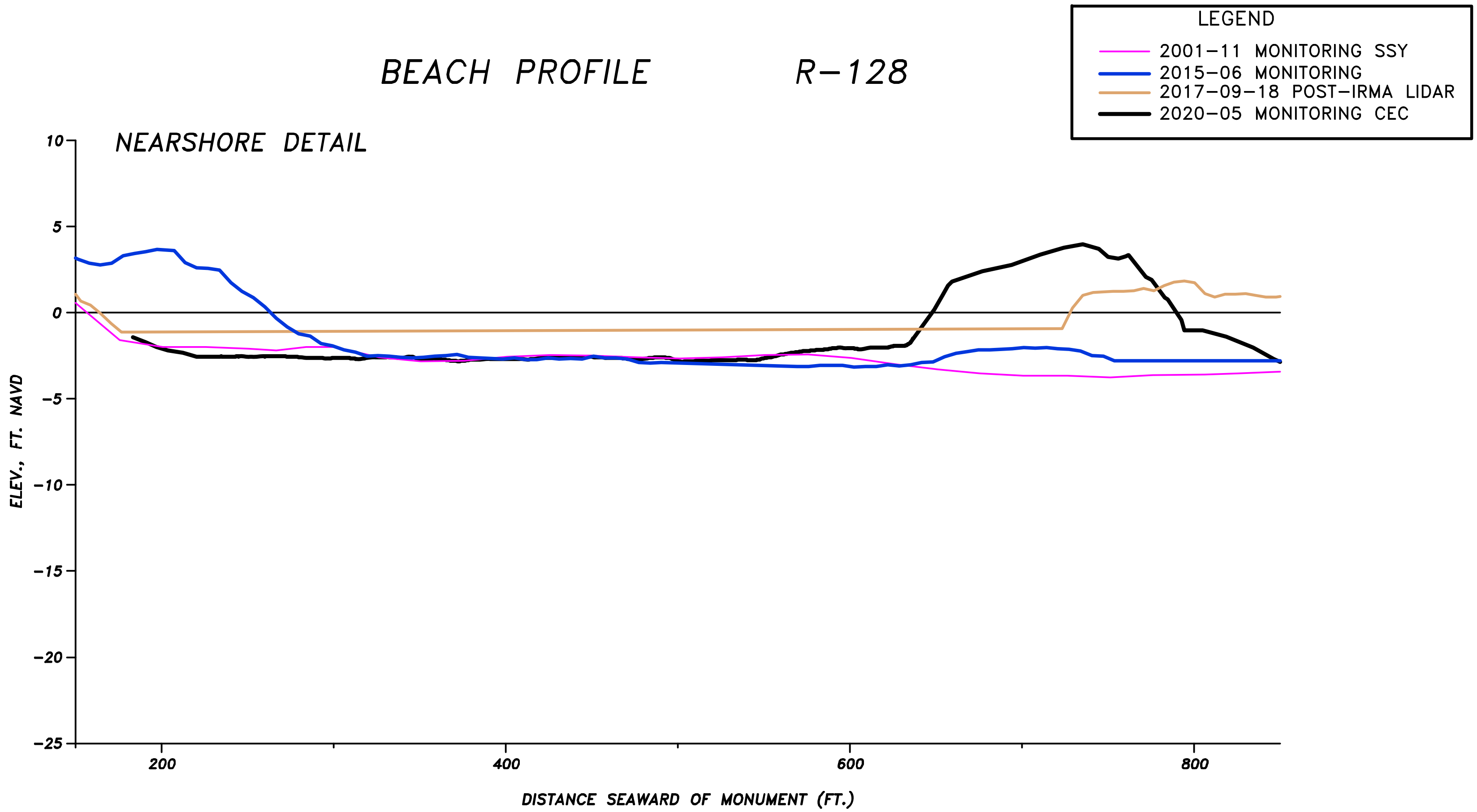
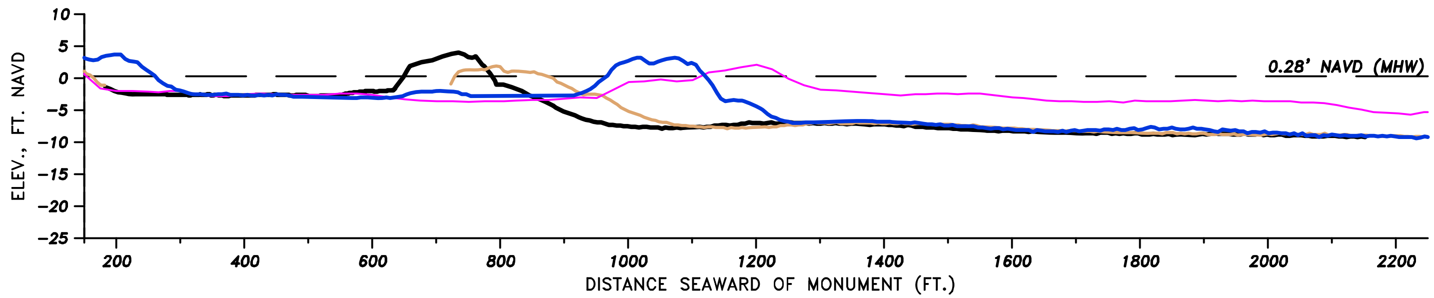
BEACH PROFILE R-128





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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 17

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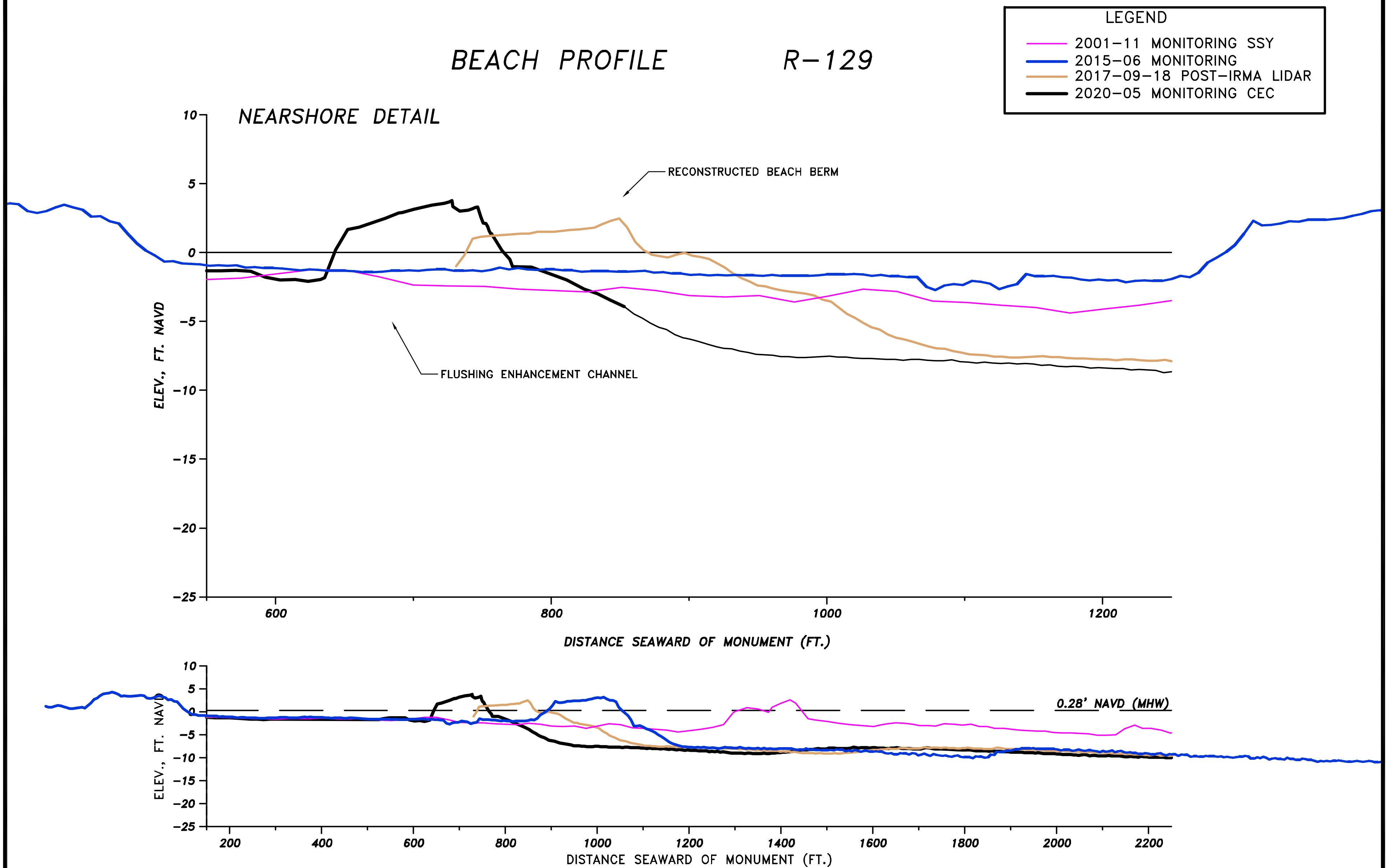

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS

FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 18

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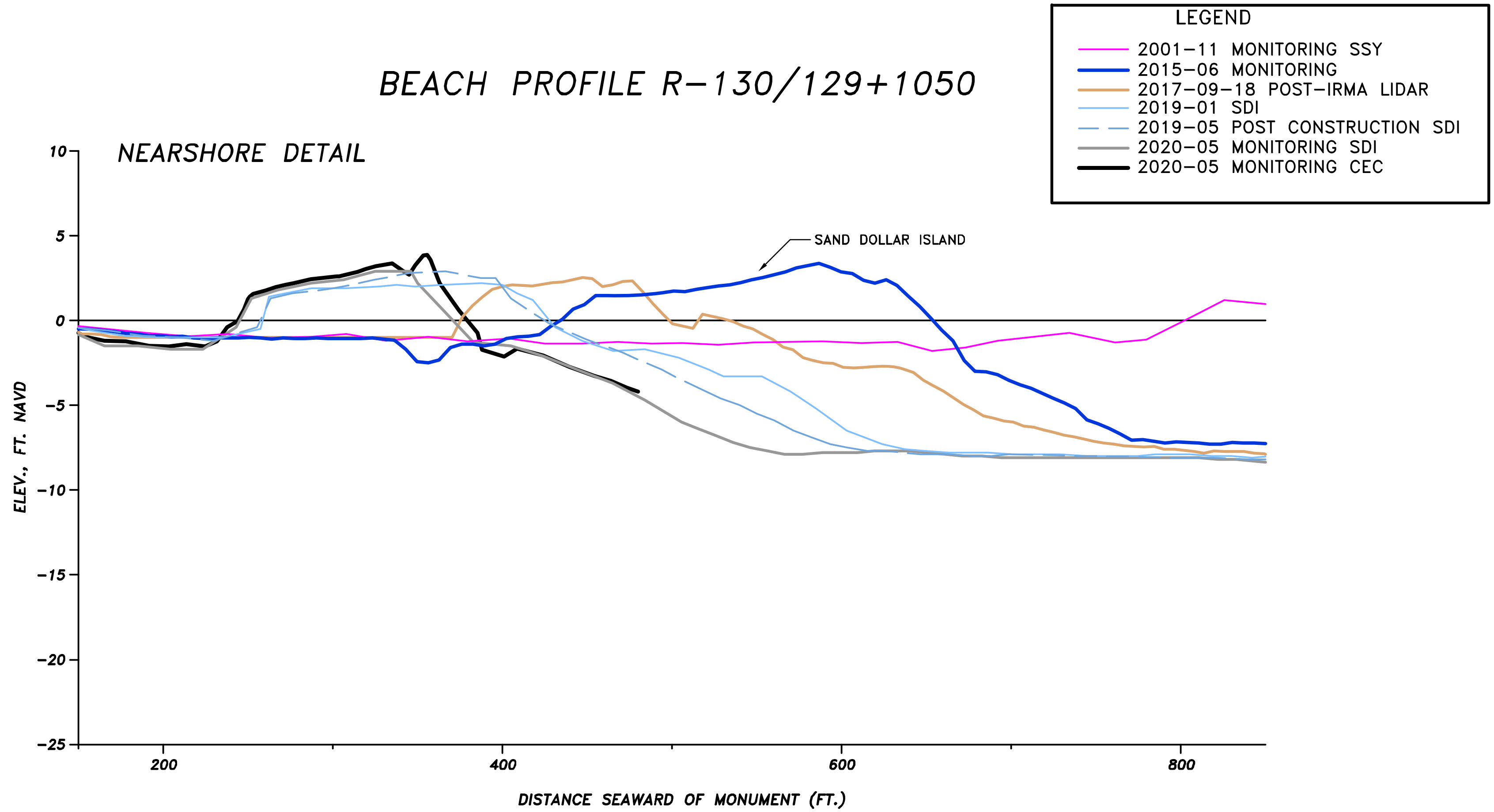

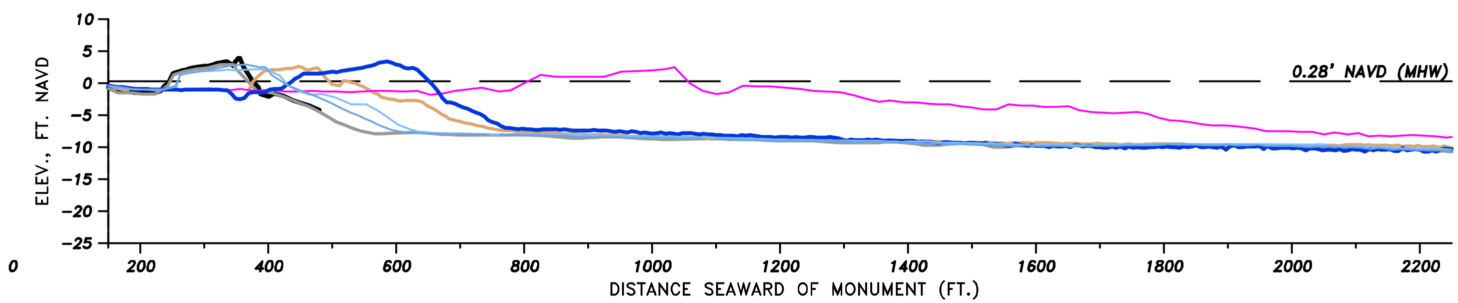

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	FOR: CITY OF MARCO ISLAND		
	DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
	JOB: 27-002	DATUM: NONE	FIGURE: 19

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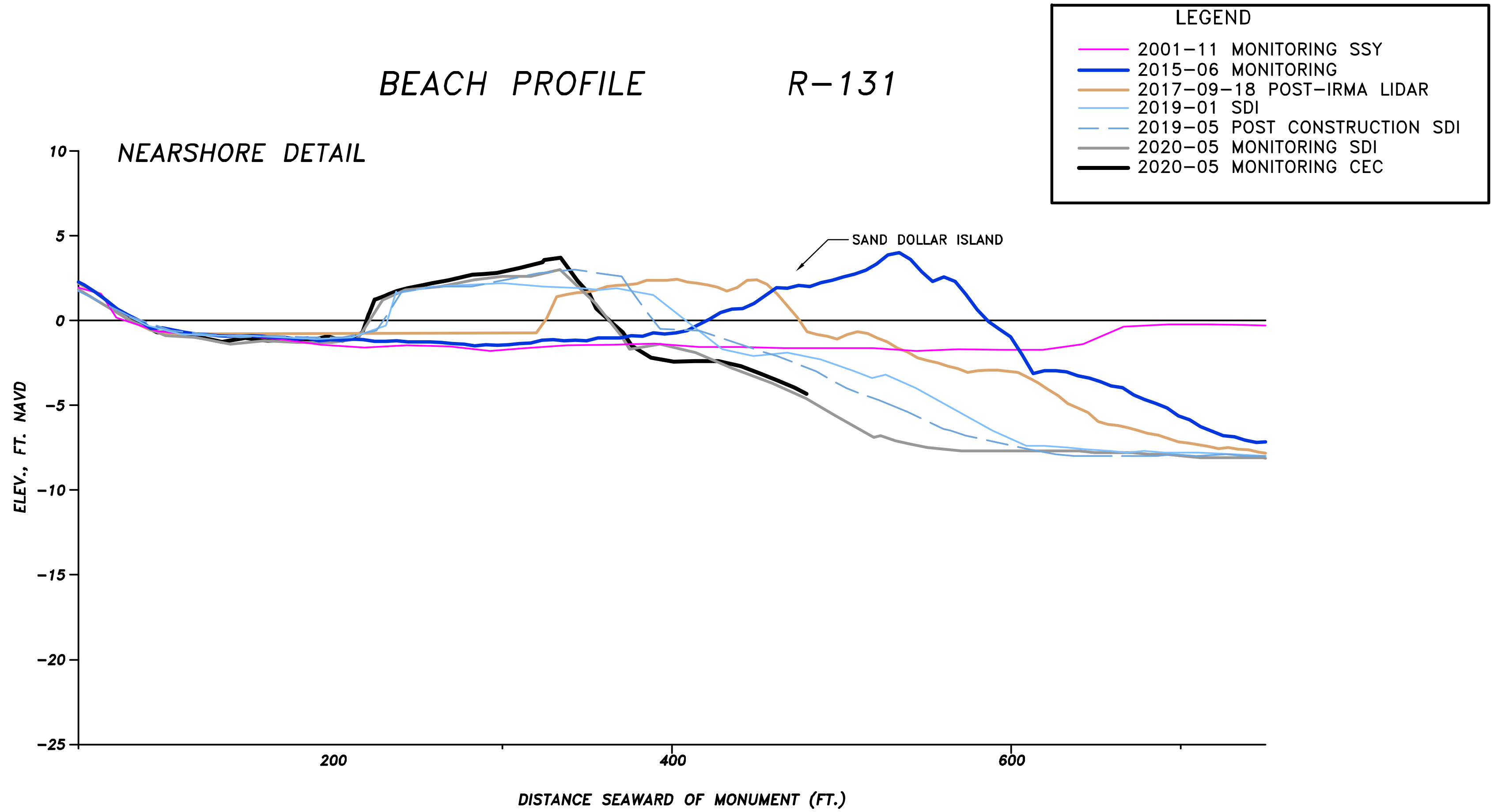

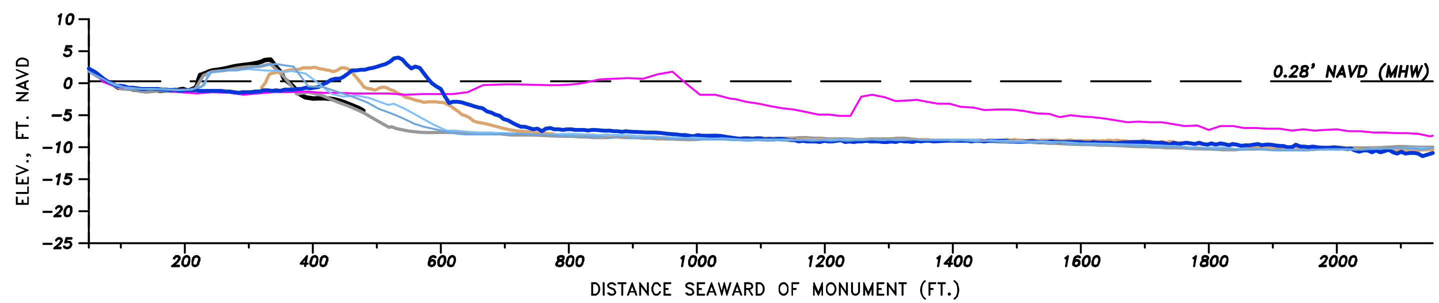

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TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27–002	DATUM: NONE	FIGURE: 20

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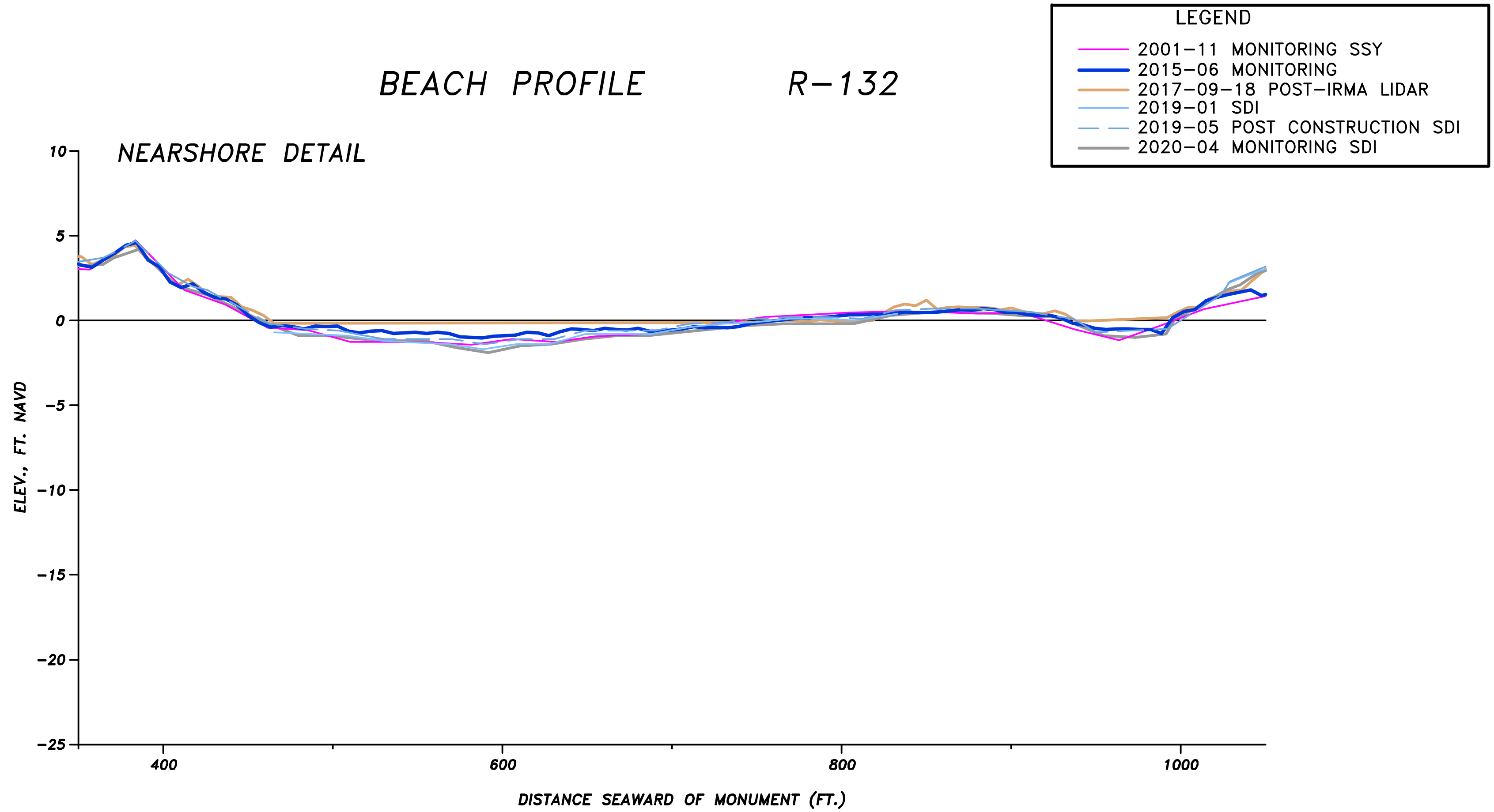

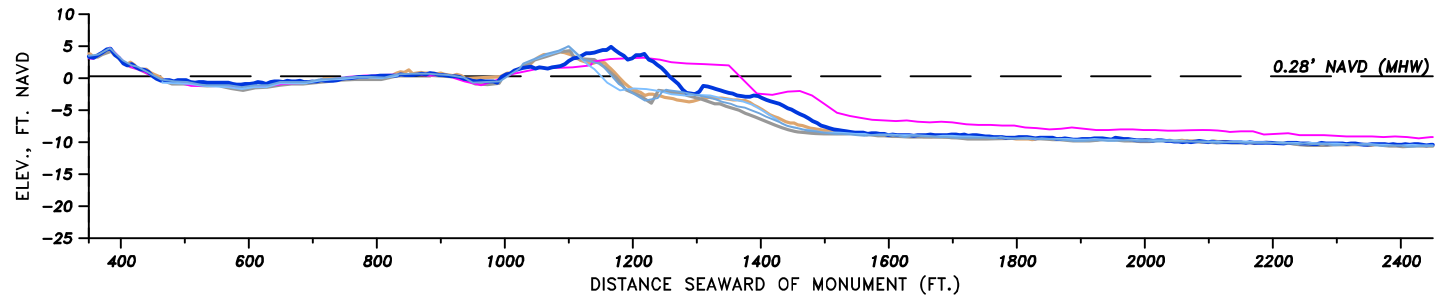

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DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 21

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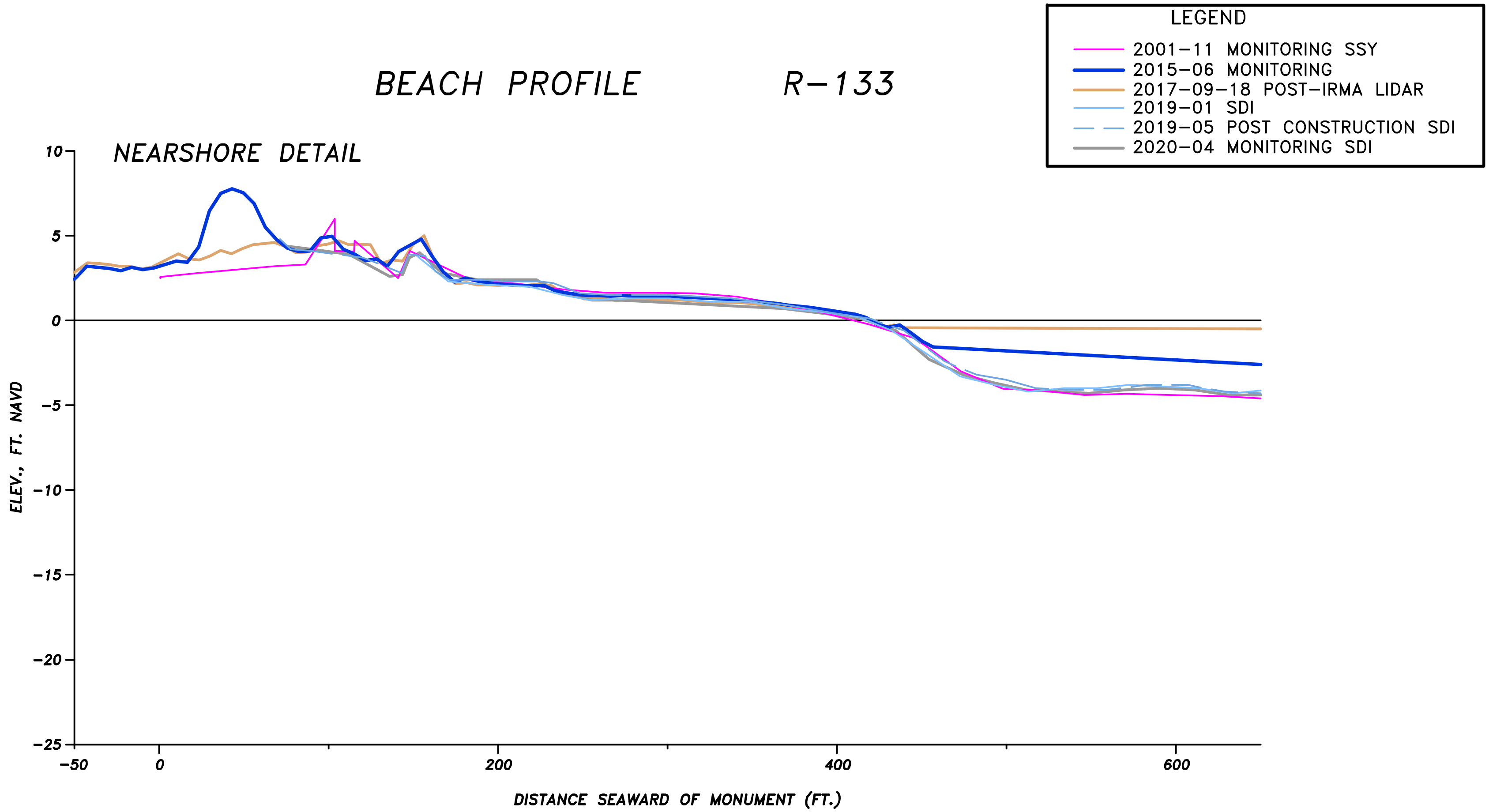
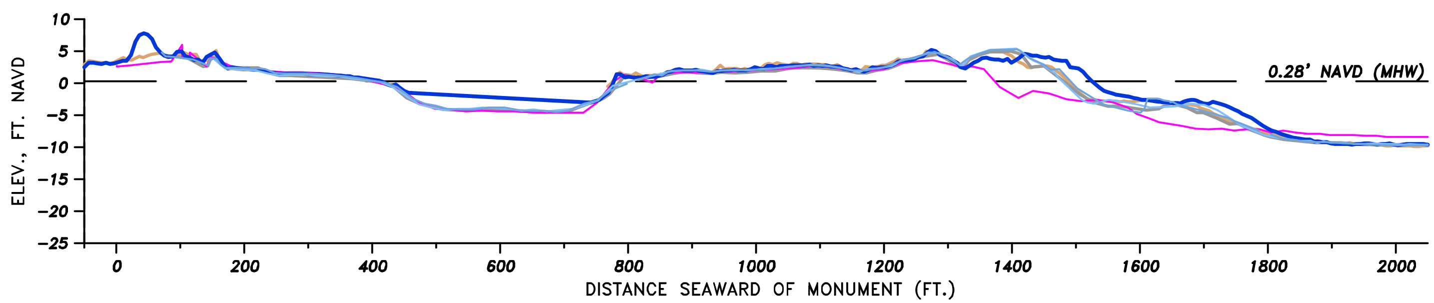
BEACH PROFILE R-133





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FOR: CITY OF MARCO ISLAND		
DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
JOB: 27-002	DATUM: NONE	FIGURE: 22

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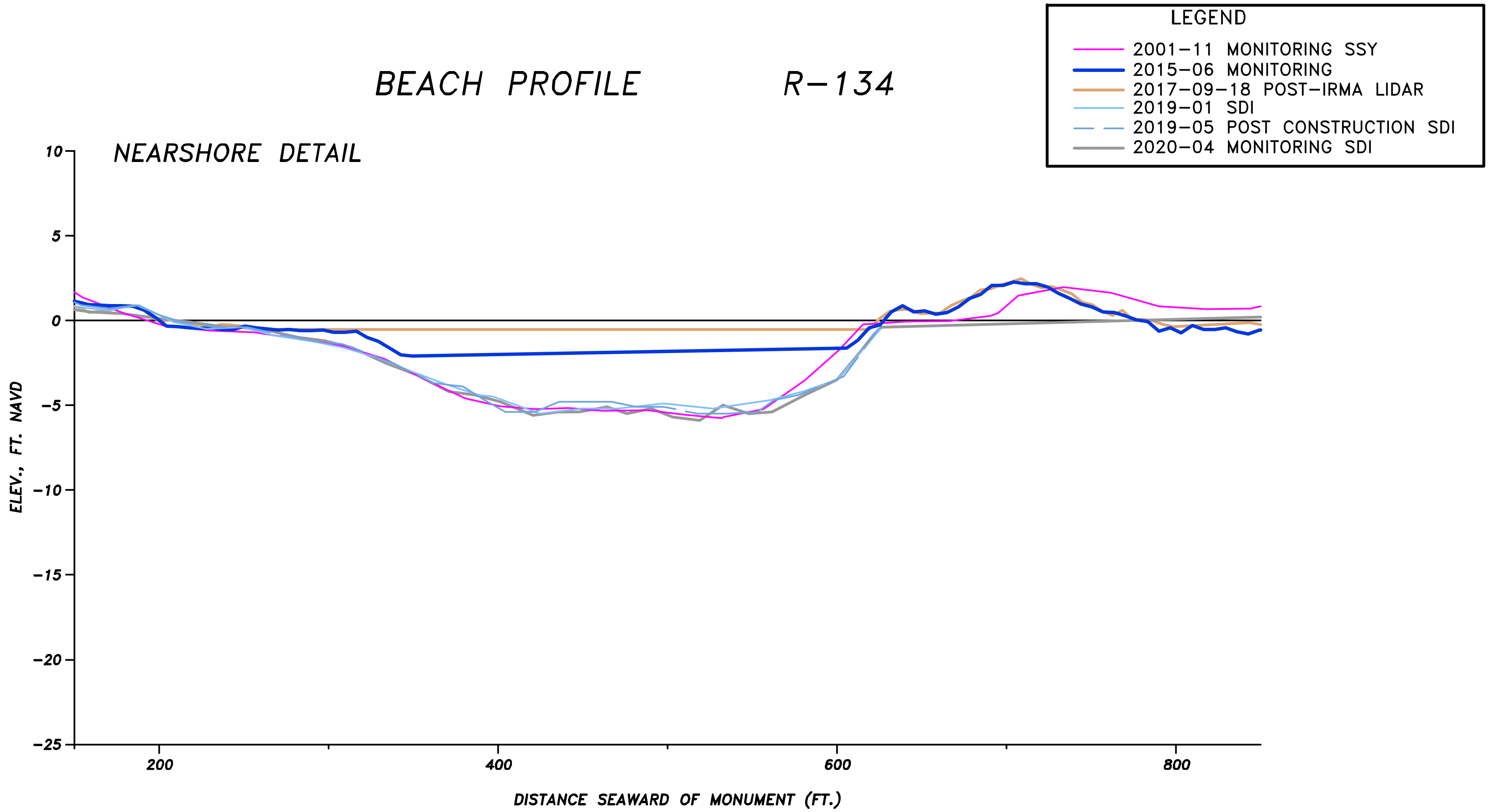
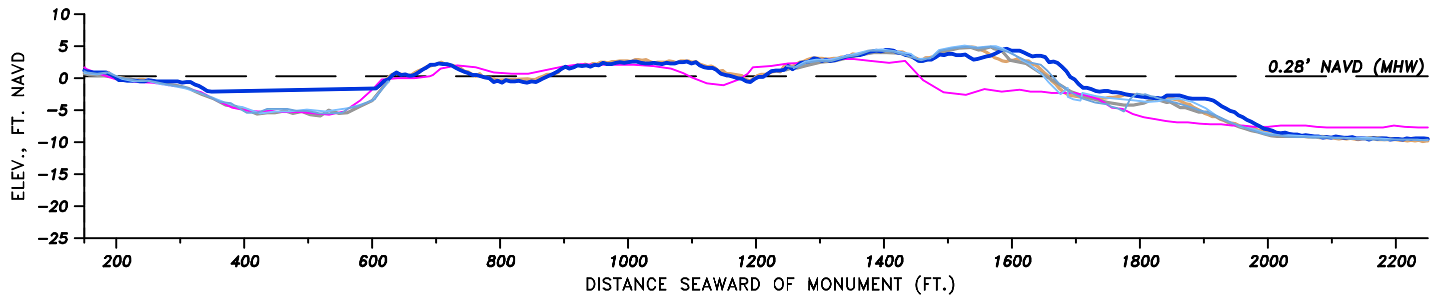
BEACH PROFILE R-134





HUMISTON & MOORE ENGINEERS COASTAL ENGINEERING DESIGN AND PERMITTING	TIGERTAIL LAGOON / SAND DOLLAR ISLAND ECOSYSTEM RESTORATION – CROSS SECTIONS		
	FOR: CITY OF MARCO ISLAND		
	DATE: 4/06/21	FILE: PLAN	SCALE: SHOWN
	JOB: 27-002	DATUM: NONE	FIGURE: 23

5679 STRAND COURT
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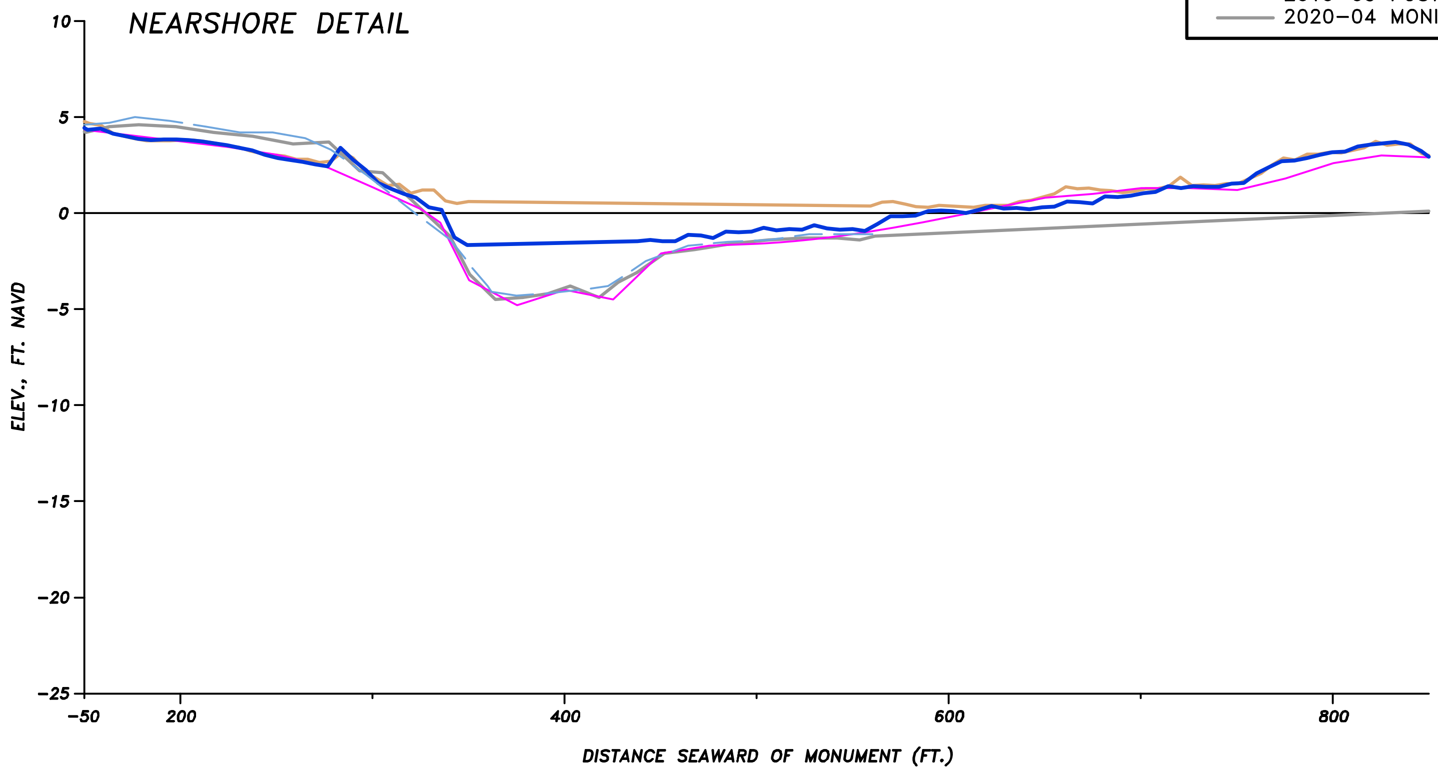
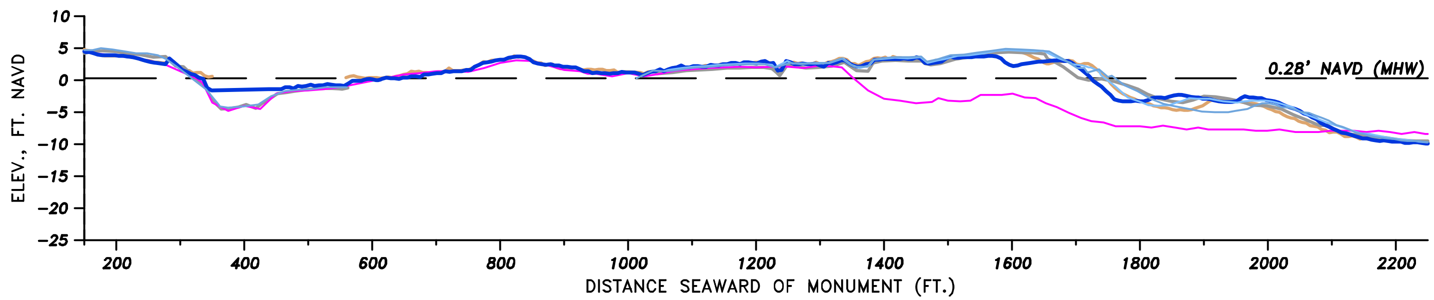
BEACH PROFILE R-135

LEGEND

- 2001-11 MONITORING SSY
- 2015-06 MONITORING
- 2017-09-18 POST-IRMA LIDAR
- 2019-01 SDI
- 2019-05 POST CONSTRUCTION SDI
- 2020-04 MONITORING SDI





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COASTAL ENGINEERING DESIGN AND PERMITTING

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