FINAL REPORT

Study of Summer Haven River and Surrounding Areas

St. Johns County, Florida

Prepared for: St. Johns County Board of County Commissioners

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EXECUTIVE SUMMARY

The Summer Haven River (SHR) lies within the unincorporated community of Summer Haven in the southeast corner of St. Johns County, FL. The naturally occurring SHR winds approximately two miles from Matanzas Inlet at its north end to the Intracoastal Waterway/Matanzas River at its south end. A one-mile-long section of the SHR lies immediately behind a narrow barrier island historically susceptible to dune erosion, overwash, and breaches during severe storms. In recent years, named and unnamed storms have periodically overwashed the Summer Haven beaches and breached the dunes causing beach sand to deposit within, and block the natural flow of, the SHR. Since 2016, repeated efforts to restore the river's flow by excavating the overwash sediment and rebuilding the adjacent berm and/or dunes have been necessary due to repeated breaching of the barrier island. Realizing only partial and temporary success from these repeated small-scale efforts, St. Johns County (County) commissioned this study to identify an array of environmentally and financially sustainable long-term solutions to maintain flow through the SHR. The study area's Atlantic shoreline extends from approximately two miles north of Matanzas Inlet to the St. Johns County/Flagler County line approximately 2.5 miles south of the inlet.

Study Overview

Developing environmentally and financially sustainable long-term solutions that will provide adequate protection to the Summer Haven shoreline and minimize the potential for storm-induced sediment transport to infill the SHR requires a thorough understanding of the area's existing conditions, coastal processes, and the dominant processes that continuously lead to the persistent erosion, dune overtopping (overwash), and repeated ocean breaches. To achieve the understanding required to effectively identify and evaluate potential solutions, this study conducted a comprehensive topographic and bathymetric survey, developed a sediment budget of the Matanzas Inlet system, and analyzed the waves and hydrodynamics throughout the study area. Results of this costal processes analysis led to development of an array of potential solutions, and further evaluation identified the solutions that could potentially achieve the study goals and qualify for state and federal authorization (i.e., environmental permits). Finally, this study also identifies potential funding sources and partners.

Benefits of a Flowing Summer Haven River

As documented in numerous reports and letters provided by Summer Haven residents, engineers and scientists, and other users of the river, the Summer Haven River historically — prior to 2008 when the first recent major breach occurred that stopped the river's flow — has provided numerous benefits, summarized as follows:

- Ecosystem Services — Provides critical habitat and foraging grounds for numerous marine species (e.g., marine turtles, manatee, dolphin); nursery grounds for commercial and recreational fisheries; ecologically sensitive habitats including salt marsh, mangroves, and oyster and clam beds; prime wading and foraging habitat for numerous bird species.
- Economics — Protects property values and provides commercial opportunities. Two hundred seventy-five (275) Summer Haven property owners pay more than $1.5M annually in County property taxes. Commercial opportunities include ecotourism, boating charters, professional fishing guides, kayak and paddle boarding classes, and clam and oyster harvesting.
- Education — Used as an "outdoor classroom" for St. Johns County School District Marine Science Program.

- Hydrology — During outgoing tides, the river flow provides a "steering current" in Matanzas Inlet that pushes against the primary tidal flow directed towards the inlet's southern shoreline. Additionally, the existing breach of the SHR (based on 2022 conditions) reduces the inlet's tidal prism by approximately 7-8%; a reduced prism when the river does not flow can lead to inlet shoaling. The SHR is the most direct route for water exchange between the Atlantic Ocean and Pellicer Creek.
- Recreation — Provides public opportunities for boating, fishing, kayaking, paddle boarding, and swimming; supports usable public boat launch areas within Helen Mellon Schmidt Park; facilitates access to Matanzas Inlet; and provides excellent wildlife viewing of dolphins, sea turtles, manatees, and birds.

Since the river stopped flowing and began filling with sediment, anecdotal evidence points to significant declines in water quality and the abundance and diversity of wildlife, including marine species and bird species. For example, a retired research scientist and aquatic biologist noted, in public comments on this study, a dramatic decline in the health of the surrounding estuary resulting from the reduced flushing and decrease in salinity; observations include a decline in oyster beds near Marineland and Pellicer Creek and biological diversity including commercially harvested species leading to a loss of ecosystem services. As another example, a charter boat captain notes that multitudes of bait fish inhabited the river when it flowed, drawing in abundant larger predator fish which have since dramatically decreased in number. Residents also commented on dangerous shoaling and flow patterns in the inlet and severe erosion of Barratarria properties along the inlet's southern shoreline in recent years. The readily apparent shallower water depths resulting directly from sand overwashed into the river through the breaches as well as subsequent siltation from the reduced flows have significantly impacted recreational opportunities, including the use of the previously usable boat launches at Helen Mellon Schmidt Public Park. Shoaling in the ICWW at the south end of SHR near the mouth of Pellicer Creek has also created navigation hazards.

Prior Projects

Numerous beach fill placement events have occurred in the study area, including large-scale projects conducted by USACE and FIND via beach placement of beach quality dredge materials, smaller scale FEMA-sponsored emergency fill projects conducted by the County, and emergency efforts to close storm-induced breaches. These prior actions to stabilize the shoreline have failed to provide long-term protection because (1) the fine grain size of the dredged material is too small to endure the wave action and tends to wash away quickly and (2) the FEMA-funded projects and other emergency efforts are too small-scale to provide lasting protection. The St. Augustine Port, Waterway and Beach District's Summer Haven River Restoration Project constructed a substantial dune along the northern segment of Summer Haven; the dune performed well during several strong nor'easters and minor hurricanes but, following significant erosion from Hurricane Ian, did not endure Hurricane Nicole. The fate of these prior projects demonstrates, to maintain the SHR's flow, the need to identify a sustainable long-term robust solution to prevent breaches and overwash of sand into the river.

Matanzas Inlet Conditions

As mentioned above, several residents have expressed concern regarding erosion of the inlet's south shoreline west of the SR A1A bridge. While this erosion has been an issue for decades, prompting property owners to harden the shoreline with bulkheads and revetments along the affected areas, the erosion has recently increased and spread westward, causing expensive property damage, because of the high inlet flow velocities that currently concentrate along the shoreline — to such a degree that the inlet channel depths exceed 30 ft a very short distance from the shoreline. To investigate the evolution of the inlet's channel and shoreline positions and possible correlation with the lack of SHR flow since 2008, this study analyzed aerial imagery from 1995 – 2022 and digitized the primary channel edges and inlet shoreline positions.

Recognizing that each aerial photograph is a snapshot in time of a very dynamic inlet and few hydrographic surveys of the inlet are available to quantitatively evaluate flood shoal and channel conditions, this study commented only on observed trends within the western, southern, and eastern/northern portions of the inlet. While clear trends are evident, the timing of the various trends do not point to a clear correlation with the SHR's closure beginning in 2008. Rather, storm activity appears to play the dominant role, particularly given the quiet period of storm activity preceding Hurricane Sandy (October 2012) and the dramatic increase in severe storm activity in recent years.

Before 2012, the western edge of the primary inlet channel (i.e., just north of the SHR's mouth) did not change significantly; however, since 2016, the position of the channel's west edge has clearly shifted westwardly. The inlet's western shoreline, north of the armored portion of the west bank, has predominantly experienced slight recession since 1999 but most notably in 2019 and 2022, coinciding with the channels westward shift. Just east of the SHR's mouth, along the southern portion of the inlet, the channel began migrating southerly into the shoal during the 2000's, as compared to conditions in the 1990's. A consistent trend of the channel behavior is not evident from 2008–2019, but the 2022 channel position has clearly eroded further towards the southern shoreline, which agrees with residents' reports of increased erosion.

The eastern edge of the primary inlet channel has varied widely, driven by the ever-changing flood shoals. Similarly, the inlet's northern/eastern shoreline has experienced dynamic reshaping with significant swings of shoreline advance and recession. From 1995–2012, the inlet's northern shoreline advanced southward into the inlet, narrowing the inlet's opening. However, the 2016–2022 shoreline positions reveal a general trend of recession northward, widening the inlet's opening. The shoreline recession in the latter period is not surprising given the severe storm activity and water levels the inlet has experienced during that time, as opposed to the calmer period of storm activity preceding Hurricane Sandy in 2012. Interestingly, the widening of the inlet's opening after 2012 coincides with the southern inlet channel migrating southwestward after 2012 (i.e., beginning with the 2016 channel position). As shoaling at the inlet entrance peaked in 2012, the flood shoal also seems to have peaked in size along the northern portion of the inlet, possibly forcing a greater proportion of flow through the inlet's southern channel. As the inlet reopened post-2012, it is possible that increased flow through the southern channel, particularly during the severe storm events, predominantly caused the channel to begin its westwardly migration.

Overall, the inlet flow appears spread across the inlet in earlier years, particularly in 1999 where the channel occupied primarily the center and northern portions of the inlet, but the more recent channel migration does not appear to coincide with the SHR's closure beginning in 2008.

Inlet Hydrodynamics and Sediment Transport Potential

To evaluate the complex flow conditions of Matanzas Inlet and surrounding waterways and the effects of the SHR on inlet and waterways hydrodynamics, this study applied Advanced Circulation Model for Coastal Ocean Hydrodynamics (ADCIRC) to simulate the complex flow regime. This study evaluated four scenarios: (1) existing conditions (i.e., no flow through SHR), (2) deepening SHR to -6 ft NAVD88 (approximately 3.5 ft deep at low tide) to reestablish flow, (3) deepening SHR to -10 ft NAVD88 (approximately 7.5 ft deep at low tide), and (4) dredging of the inlet flood shoal to alleviate the damaging high flows near the southern shoreline of Matanzas Inlet. Of note, Scenario 2 is a simplified representation of the currently authorized SHR dredging elevations (the actual elevations range from -4 to -6 ft NAVD88), and Scenario 3 represents a preferred river condition (per public comments) and serves to test the sensitivity of the SHR depth on the river's effect on inlet hydrodynamics. The model simulations sought to determine whether flow through SHR has a measurable effect on the inlet currents, as well as the hydrodynamics near Pellicer Creek, and how reconfiguring the inlet flow by dredging through the northern portion of the flood shoal could alleviate erosion of inlet's southern shoreline.

To understand how the modeled velocity changes from scenarios 2–4 affect sediment transport and, hence, the erosion concerns along the southern shoreline, this study evaluated sediment transport potential through comparison of the model simulation velocities with the critical velocity required to initiate sediment movement. Plots of flow velocity changes, compared to existing conditions, for scenarios 2-3 (SHR dredged to -6 ft and -10 ft NAVD88) reveal slight velocity changes within the inlet, generally on the order of 0.5 ft/s or less. These magnitudes combined with the pattern of reduced flow along the southern/western side of the inlet and increased flow along the northern side demonstrates a slight "steering current" effect of the SHR flow pushing the inlet's main flow away from the southern shoreline. Evaluation of sediment transport potential, however, reveals both scenarios have minimal effect on the sediment transport potential (i.e., erosion) along the southern shoreline. The steering current appears to only affect the edge of the shoal at the SHR mouth; this may alleviate erosion during peak ebb tide for only the properties within this area but not along the southern shoreline in general. During peak flood tide, the tidal currents enter the SHR with velocities greater than the critical velocity, which would likely reduce the shoal elevations at the mouth of the river. Scenario 3, with the river deepened to -10 ft NAVD88, does not have much more effect than Scenario 2, with only minor differences near the mouth of the river.

For Scenario 4, with a new inlet channel dredged, the velocities increase significantly throughout the dredged channel as expected and decrease significantly in the southern channel. Scenario 4 drastically alters the sediment transport potential patterns within the inlet. During peak ebb flow, expansive areas throughout the southern and western portions of the inlet no longer exceed critical velocity and, therefore, would experience accretion. During flood flow, a narrow strip along the western bank and a wide strip along the southern bank no longer exceed critical velocity. Thus, dredging a deeper channel across the northern portion of the inlet would alleviate the erosion pressures along the west bank and along the entire southern shoreline.

Discussion of Existing Beach Conditions

Most authors think sediment moves along both the Anastasia Island and Summer Haven shorelines from north to south. The sediment budgets presented herein indicate a net longshore transport gradient of north to south. As such, Matanzas Inlet generally wants to migrate to the south. Historical aerials bear this out. This southward migration of the inlet threatened the south shoreline of the SR A1A Bridge over Matanzas Inlet, first constructed in the early 1920's and last replaced in 1993. Hurricane Dora (1964) prompted additional armoring of this shoreline. Over the long-term, stronger flood tidal flows, because of the inlet's location relative to St. Augustine and Ponce de Leon inlets, likely deposit more sediments inside the inlet than the ebb tidal flows remove. This net imbalance allows the flood shoals inside the inlet to grow with sand that otherwise, without the inlet's sand-trapping effect, would reach Summer Haven and other downdrift beaches.

With lesser amounts of sand reaching the Summer Haven beaches, they become more susceptible to storm-induced erosion as the beach is generally narrower and lower over time in the presence of storms. Overwash occurs when the minimum combination of elevated water levels and wave runup is exceeded. Upon happening in natural areas (unaffected by man), overwash deposits would remain in place, naturally recruit vegetation, and receive aeolian (sand transported by wind) sand deposits to allow a barrier island to build up. While putting overwash deposits back onto the beach, as done on Summer Haven many times, helps the beaches recover after a storm event, this practice does not allow the barrier island to increase in elevation to naturally build more resiliency in the face of rising sea levels. Therefore, the frequency of future storms causing overwash (and breaches) may increase. This phenomenon may be bearing out given the recent breaches occurring in 2008 (Tropical Storm Fay), 2016 (Hurricane Matthew), 2017 (Hurricane Irma), 2019 (Hurricane Dorian), 2021 (nor'easter), and 2022 (hurricanes Ian and Nicole).

The lack of a wide dry beach can also contribute to the lack of or relatively small post-storm dune recovery in the Summer Haven area. Elevated water levels and high waves erode sand from the beach and dune during a storm. They transport the sand seaward into a bar (and potentially landward as overwash). During calmer sea states, the seaward-directed sand gradually moves from the bar shoreward into the dry beach berm. Depending on the width of the berm, winds may pick up the dry fraction of the sand and transport (termed aeolian transport) it landward where vegetation can trap the sand. This trapped sand will recruit vegetation and help the dune recover. A narrow beach does not provide enough source material to allow for this process to fully realize. As such dune rebuilding on narrow beaches typically requires intervention.

Identification and Evaluation of Potential Actions

This study followed a two-phase approach to evaluating potential alternatives — an initial screening followed by conceptual-level design assessment. The first phase identifies and summarizes possible solutions — including seawall, revetment, dune restoration, beach and dune restoration, T-head groins, breakwaters, artificial reefs, and structural dune core alternatives — and evaluates their potential for achieving the study goals and receiving regulatory approvals. The second phase further evaluates only those approaches that both may achieve the study goals and receive regulatory approval. Additionally, this study considered the costs of taking no action and continuing a policy of managed retreat.

Initial Screening Results

Table ES.1 summarizes the initial screening results. Overall, a seawall, revetment, beach and dune nourishment, and dune restoration with a structural core meet the principal objective of preventing breaches and minimizing dune overtopping to keep beach sediments from infilling the river. However, from a regulatory perspective, beach and dune nourishment is the most viable alternative, with some allowance for groins and breakwaters only should they prove necessary to improve beach nourishment performance (following a minimum of three years or performance monitoring). Seawall and revetment alternatives may potentially receive regulatory approval, without beach restoration, if sited landward of the Coastal Construction Control Line (CCCL). Because of the limited area between the eastern shoreline of the SHR and the CCCL and the larger footprint of a revetment, a seawall is the more feasible option. Similarly, a restored dune with a structural core may receive regulatory approval if located landward of the CCCL. Therefore, the seawall and beach and dune nourishment alternatives moved to the next phase of study. As discussed below, dune restoration with a structural core and the seawall alternative are very similar such that this study merges the two concepts into a single alternative for further analysis.

Table ES.1 Initial Screening of Alternatives

Alternative[1]	Prevents Breaches/ Minimizes Dune Overtopping	Potentially Meets Regulatory Approval
Seawall	✓	X / ✓ [2]
Revetment	✓	X / ✓ [2]
Dune Restoration	X	✓
Beach and Dune Nourishment	✓	✓ [3]
T-head Groins	X	✓ [4]
Breakwaters (incl. Artificial Reefs)	X	✓ [4]
Dune Restoration with Core	✓	X / ✓ [2]

[1]Includes engineering solutions only; Section 5.3 discusses the non-engineering alternatives of taking no action and managed retreat.

[2]Seawalls, revetments, and structured dune cores do not meet the eligibility criteria under 161.085(2)(a) and 161.085(2)(c), FS if sited seaward of the CCCL. They may potentially receive authorization only if situated landward of the CCCL.

[3]Beach nourishment is Florida's state-wide preferred solution for shoreline stabilization.

[4]Construction and performance monitoring of a beach and dune nourishment project is a pre-requisite (per Florida rules) for shoreline stabilization structures, which Florida will only authorize to improve the longevity of beach nourishment projects.

Of note, implementation of a long-term beach and dune nourishment plan will require identification of a suitable sand source. Future ICWW maintenance dredging materials, existing dredge material stored in

FIND's upland DMMA's, and sand overwashed into the SHR remain available for summer haven beach management activities; however, these fine-grained materials eroded quickly and do not provide lasting storm protection. Additionally, though these materials are an inexpensive source of beach compatible material, the available volume is insufficient for any long-term storm protection solution. Private, commercial inland mines have proven a reliable source of beach compatible sand for County beaches and can produce more desirable coarse fill material more resistant to erosion; however, the costs to purchase the material and haul it long distances — the closest, largest-producing mines locate 40-50 miles inland — are often relatively high. Dredging of the flood shoal could possibly supplement other sources, with an added benefit of relieving the erosional pressures along the southern shoreline of the inlet where property owners are suffering property loss from increased ebb flow-induced erosion.

Offshore sand sources, typically excavated and pumped directly onto the beach via dredge, often prove the most economical sand source for large-scale and long-term beach and dune restoration efforts. However, as documented in USACE's Sand Availability and Needs Determination (SAND) study, which quantified 50-year sand needs and available sand resources for all current (at the time of the study) federal and non-federal beach nourishment projects in the USACE South Atlantic Division (SAD), no currently proven offshore borrow area exists to solely provide beach fill for Summer Haven projects. Should the County pursue identification of an offshore sand source, Given the long-term sand needs for the currently authorized federal projects, coordination with USACE is necessary to identify the most suitable areas for further exploration given the currently authorized federal beach restoration projects north and south of summer Haven in St. Augustine Beach and Flagler County.

Conceptual Design – Seawall Landward of the CCCL

This alternative consists of locating a seawall approximately five feet landward of the CCCL. The seawall concept consists of two concrete-capped steel sheet piles (spaced 20 feet apart) tied together with tie rods. The seawalls reach an elevation of +14 feet NAVD88 to mimic the historical dune elevations in the area. The dune, fronting the seawall has a crest elevation of +12 feet NAVD88, a crest width of 20 feet, and a 3H:1V seaward slope. The seawall would extend from approximately R-200 to R-205.5 (approximately 5,500 feet long).

An engineering analysis performed with U.S. Army Corps of Engineers' SBEACH cross-shore erosion model helped assess the adequacy of the dune template to future, synthetic storms. The modeled storms included the 15-, 25-, 50-, and 100-year events. The less frequent but more severe events expose an additional three or more feet than originally exposed such that the exposed wall height increases from three feet to at least six feet. Given the large distance between the two walls and their elevations, overwashing of the double wall system is unlikely to occur.

Sheeting from the splash zone and up could prove vulnerable to corrosion and may require additional maintenance such as recoating, inspections, and repairs. For storms larger than design event, repairs may include replacing portions of wall, anchors, and backfill. Dune fill repairs would likely reoccur more frequently. Construction of this alternative requires the County to obtain easements, which are often difficult to obtain, from private property owners.

Conceptual Design – Beach and Dune Nourishment

This alternative consists of placing a small dune seaward of the line of coastal construction such that the landward edge of the dune crest lies approximately 40 feet east from the edge of the five isolated houses. The dune crest reaches an elevation of +14 feet NAVD88 to match the peak historical dune conditions. The beach consists of a 150-feet wide beach crest at elevation +10 feet NAVD88 with a 10H:1V seaward slope until matching existing grade. Overall, the beach and dune nourishment project, with an approximate fill density of 150 cubic yards per linear foot, has a total initial nourishment volume of approximately 1.5 million cubic yards when extending from R-200 to R-209 (approximately 9,000 feet).

An engineering analysis performed with U.S. Army Corps of Engineers' SBEACH cross-shore erosion model helped assess the adequacy of the beach and dune template to future, synthetic storms. The modeled storms included the 25-, 50-, and 100-year events. The analysis considered 0.28- and 0.35-mm sand. Erosion caused by the 25- and 50-year events encroaches the dune toe but the beach and dune prevent overwashing of the dune. For the 100-yr event, overwash of the dune occurs. Application of a beach fill diffusion analysis indicates that 50% of the fill remains after approximately five years. To determine beach maintenance costs, this study assumes that the beach fill requires renourishment every five years, like the County's beach nourishment project in St. Augustine Beach and other large-scale projects along Florida's east coast. Both analyses confirm the adequacy of the conceptual design to meet the engineering objectives.

Conceptual Costs

After conceptually designing the range of alternatives, the next step in the evaluation process included developing conceptual level estimates of initial (construction) and maintenance costs. **Table ES.2** summarizes the initial and maintenance costs associated with the four alternatives. All initial construction cost estimates include mobilization costs associated with contractor's operations to move personnel, equipment, supplies, and incidentals to the project site and establish temporary facilities. Item costs originate from a variety of sources including previous similar Florida jobs. All costs include 5% of the initial costs for engineering design, permitting, and construction phase services as well as 20% contingency on costs.

Note that assigning costs to maintenance activities proves difficult, as doing so requires, for example, making many assumptions regarding frequency and severity of storms over the design life. Recognizing this challenge, this study assigned simple maintenance costs to provide some rough order-of-magnitude estimates for County planning purposes. For the beach and dune nourishment alternative, conceptual analyses have shown that replacing 50% of the initial fill every five years is a reasonable estimate. For seawalls, experience suggests that they require much less maintenance; for calculation purposes, a maintenance cost of 10% of the initial cost every 10 yrs over the 50-yr design life seems appropriate.

In addition to the above engineering solutions, this study also compared the costs to the no action and managed retreat options. No financial costs arise for the no action alternative. Developing a cost for managed retreat occurred as follows. For simplicity in this feasibility-level study, the 2023 just (market) value for each property, obtained from the St. Johns County Property Appraiser website (https://www.sjcpa.gov/), serves as the basis for estimating the cost of managed retreat. The market value of the 20 properties north of R-205 (Figure 5.8) total $3,130,362. This cost represents a potential additional cost to the alternatives should acquisition of the properties prove necessary to construct a seawall and/or place fill on the private property.

Table ES.2 Conceptual Level Initial and Maintenance Costs

Alternative	Initial Construction Cost (in millions)	50-year Maintenance Cost (in millions)[1]	50-year Total Cost (in millions)[1]
Seawall[2]	$47.1	$11.9	$59.0
Beach and Dune Nourishment[3,4]	$34.3	$87.6	$121.9
No Action	$0	$0	$0
Managed Retreat	$3.13	$0	$0

[1]Dollar values represent present worth equivalents at the beginning of 2023 with a 4.75% discount rate and annual 2.2% inflation rate.

[2]Assumes seawall and/or dune maintenance every 10 years at 10% of initial construction cost (i.e., $4.71 million every 10 years).

[3]Assumes nourishment occurs every 5 years at half the initial construction cost (i.e., $17.15 million every 5 years).

[4]Structures like T-head groins and breakwaters could decrease renourishment quantities and frequency and therefore, the beach nourishment maintenance costs. If constructed, the cost of groins or breakwaters could vary widely depending on the need to protect the entire length of beach fill or just an erosional hot spot. Protecting the entire 9,700-ft length project area may require over 25 T-head groins or numerous breakwaters and initially cost over $80 million. Protecting a 1,000-ft hotspot may require 3 T-head groins or 1-3 breakwaters and initially cost over $10 million. Only after first constructing and monitoring the fill over three years will the need for structures possibly prove evident and cost worthy. If structures can extend the beach nourishment interval from 5 years to 10 years, the 50-year Beach and Dune Nourishment cost decreases to $83.5 million, a savings of $38.4 million that could help offset the cost of structures.

Alternatives Analysis Summary

Based on an understanding of the Matanzas Inlet and surrounding areas, this study identified two, potentially permissible (from an environmental regulatory standpoint), engineering solutions. They include:

- Seawall with small dune. This alternative consists of locating a seawall approximately five feet landward of the CCCL. The seawall concept consists of two concrete-capped steel sheet piles tied together with tie rods. The seawalls reach an elevation of +14 feet NAVD88 to mimic the historical dune elevations in the area. The dune, fronting the seawall has a crest elevation of +12 feet NAVD88, a crest width of 20 feet, and a 3H:1V seaward slope. The seawall would extend from approximately R-200 to R-205.5 (approximately 5,500 linear feet). Conceptual initial and maintenance costs (over a 50-year project life), in 2023 present worth equivalents, equal approximately $47.1 million and $11.9 million, for a total of $59.0 million.

- Large-scale beach and dune nourishment. This alternative consists of placing a small dune seaward of the line of coastal construction such that the landward edge of the dune crest lies approximately 40 feet east from the edge of the five isolated houses. The dune crest reaches an elevation of +14 feet NAVD88 to match the peak historical dune conditions. The beach consists of a 150-feet wide beach crest at elevation +10 feet NAVD88 with a 10H:1V seaward slope until matching existing grade. Overall, the beach and dune nourishment project, with an approximate fill density of 150 cubic yards per linear foot, has a total initial nourishment volume of approximately 1.5 million cubic yards. The beach fill would extend from approximately R-200 to R-209 (approximately 9,000 linear feet). Conceptual initial and 50-year maintenance costs, in 2023 present worth equivalents, equal approximately $34.3 million and $87.6 million, for a total of $121.9 million.

Non-engineering alternatives examined included no action and managed retreat. Neither keep the SHR open but the latter could prove necessary when implementing an engineered solution.

- No action. Continued beach erosion, overtopping, and breaching of the existing dune/berm will allow the beach to naturally migrate westward, eventually completely filling in the portions of the Summer Haven River lying adjacent to the beach.

- Managed retreat. A coastal management strategy that allows (1) the beach to naturally migrate landward, as opposed to attempting to stabilize the beach with engineering solutions, and (2) restoration of developed properties back to their natural ecosystems. Managed retreat has occurred to a limited degree since 2009 along the stretch of property fronting Summer Haven River. County acquisition of the private parcels north of R-205 could facilitate construction of any engineering solutions on these parcels. Buying out the 20 properties north of R-205 could cost $3.13 million.

Given the large costs associated with the engineering alternatives, the County will likely have to leverage funds from various local, state, and possibly federal sources to implement them. Sources may include raising local revenues through special purpose taxes and seeking state programmatic funds and grants and federal grants. While the state supports a grant program for funding beach management activities, the most likely funding option includes seeking monies for a project as part of the state of Florida's annual budget appropriations process. Note that the previous Summer Haven River restoration project received such an appropriation that fully funded its original construction budget. Other possibilities include supplemental funding through the Florida Inland Navigation District's Waterway Assistance Program. The federal funding options include seeking a National Oceanic and Atmospheric Administration grant through its National Coastal Resilience Fund for initial design or construction and through the Federal Emergency Management Agency for post-storm repairs after initial construction. If qualified, the former grant amounts would only provide supplemental funds for green infrastructure project components.

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Acronyms and Abbreviations

BMFA	Beach Management Funding Assistance
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
CCCL	Coastal Construction Control Line
County	St. Johns County
CSRM	Coastal Storm Risk Management
cy	cubic yards
cy/ft	cubic yards per linear foot
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FIND	Florida Inland Navigation District
FNAI	Florida Natural Areas Inventory
FS	Florida Statutes
ft	feet
ft/s	feet per second
GTMNERR	Guana Tolomato Matanzas National Estuarine Research Reserve
INTERA	INTERA Incorporated
INTERA-GEC	INTERA-GEC, LLC
ICWW	Intracoastal Waterway
JCP	Joint Coastal Permit
m	meters
m/s	meters per second
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
SAPWBD	St. Augustine Port, Waterway, and Beach District
SHR	Summer Haven River
SHRRP	Summer Haven River Restoration Project
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WAP	Waterway Assistance Program
WIS	Wave Information Study

1.0 Introduction

As part of a task order issued under RFQ No: 22-01; Continuing Contracts for As Needed Professional Services, Master Contract No: 22-PSA-INT-16053, St. Johns County (County) requested INTERA-GEC conduct studies to develop (1) an environmentally and financially sustainable long-term solution to maintain the flow of the Summer Haven River (SHR) and (2) a list of potential projects to address beach erosion threatening the Summerhouse Complex north of Fort Matanzas. This report covers a study of the Summer Haven River. A separate report addresses the Summerhouse property.

1.1 Study Purpose and Scope

The SHR lies within the unincorporated community of Summer Haven in the southeast corner of St. Johns County, FL. The naturally occurring SHR winds approximately two miles from Matanzas Inlet at its north end to the Intracoastal Waterway/Matanzas River at its south end. A one-mile-long section of the SHR lies immediately behind a narrow barrier island historically susceptible to dune erosion, overwash, and breaches during severe storms. Since the 1990s, federal, state, and local governments have taken action to mitigate the shoreline erosion, primarily through beach placement of beach quality sediment derived from Intracoastal Waterway (ICWW) maintenance dredging. However, a breach created and enlarged by back-to-back storms in 2008 caused over 300,000 cubic yards (cy) of sand to eventually infill the river and completely block its tidal flow. Since 2016, repeated efforts (in 2016, 2017, 2019, and 2021) to partially restore the river’s flow by excavating the overwash sediment and rebuilding the adjacent berm and/or dunes have been necessary due to repeated breaching of the barrier island. Realizing only partial and temporary success from these repeated small-scale efforts, St. Johns County commissioned this study to identify a long-term feasible solution to maintaining flow through the SHR.

Developing environmentally and financially sustainable long-term solutions that will provide adequate protection to the Summer Haven shoreline and minimize the potential for storm-induced sediment transport to infill the SHR requires a thorough understanding of the area’s existing conditions, coastal processes, and the dominant processes that continuously lead to the persistent erosion, dune overtopping (overwash), and repeated ocean breaches. To achieve that understanding, this study conducted a comprehensive topographic and bathymetric survey, developed a sediment budget of the Matanzas Inlet system, and analyzed the waves and hydrodynamics throughout the study area. Results of this coastal processes analysis led to development of an array of potential solutions, and further evaluation identified the solutions that could potentially achieve the study goals and qualify for state and federal authorization. Finally, this study also identifies potential funding sources and partners to possibly implement feasible solutions.

1.2 Study Area

The study area’s Atlantic shoreline extends from approximately two miles north of Matanzas Inlet to the St. Johns County/Flagler County, line approximately 2.5 miles south of the inlet — between Florida Department of Environmental Protection (FDEP) reference monuments R-187 and R-209.5. The study area waterways include Matanzas Inlet, SHR, and the ICWW. **Figure 1.1** provides a study area map.

Figure 1.1 Study Area Map

1.3 Report Participants and Coordination

The information presented herein derives from a collaborative data collection effort. To outline the scope of the study and solicit input from the community, INTERA-GEC and the County held a town hall meeting on December 6, 2022 and created a public portal to allow stakeholders to submit written comments and other information pertinent to the study. Appendix A provides minutes of the town hall meeting.

In addition to the public outreach, INTERA-GEC contacted or met with various government entities and organizations to directly solicit available literature and data, including:

- Florida Department of Environmental Protection (FDEP)
- U.S. Army Corps of Engineers (USACE)
- Florida Inland Navigation District (FIND)
- National Park Service (NPS)
- National Oceanic and Atmospheric Administration (NOAA)
- Federal Emergency Management Agency (FEMA)
- Florida Department of Transportation (FDOT)
- St. Augustine Port, Waterway, and Beach District (SAPWBD)
- University of Florida
- Friends of the Summer Haven River
- Summerhouse Beach & Racquet Club
- St. Johns County

2.0 Beach, River, and Inlet Management History

Prior to the 1930s, when the Matanzas Inlet system remained in its natural state, the SHR provided the only navigable waterway southward from Matanzas Inlet and tidally connected Pellicer Creek and surrounding areas to the inlet's southern shoreline (**Figure 2.1**). Matanzas Inlet and its adjacent beaches (including Summer Haven to the south) have historically been highly dynamic areas experiencing drastic geomorphologic changes including inlet migration, beach erosion, dune overtopping (overwash), and natural breach/inlet openings and closings. For example, Mehta and Jones (1977) and others have reported on the formation of Peńon Inlet south of Matanzas Inlet in the late 1800s. Beginning with the construction of the ICWW in the 1930's, man's efforts and severe erosion have reshaped Matanzas Inlet and adjacent beaches. **Figure 2.2** depicts an inventory of coastal structures in the area; Appendix B lists the structures numbered in the figure. Appendix C presents a timeline of events in/around the Matanzas Inlet since the 1800s. The following paragraphs highlight some of the major events.

As described in Mehta and Jones (1977), private funds supported construction of the first bridge over Matanzas Inlet in mid-1920s. Now known for carrying SR A1A, the FDOT later replaced this bridge in the mid-1950s and again in the early 1990s. Other work associated with SR A1A included constructing a 415-ft-long concrete sheet pile wall in Summer Haven in the late 1950's and completing a bridge over the Summer Haven River in 1960. Note that damage caused by a northeaster in 1962 and Hurricane Dora in 1964 necessitated repairs to the sheet pile including adding a granite rock revetment. Dean and O'Brien (1987) state that the concrete bridge abutments prevent the inlet from naturally migrating south.

The USACE completed the Matanzas Relocation Cut in early 1932 to move the ICWW west of present-day Rattlesnake Island (**Figure 2.1**), away from incoming Atlantic Ocean waves, and discontinue use of the SHR. By 1935, the USACE also constructed a steel sheet pile dike with revetment to separate the SHR from the ICWW. Hurricane Dora also breached Rattlesnake Island near the dike. This breach remained open for approximately 12 years until 1976, when the USACE closed the breach based on recommendations from the NPS (which was responsible for Fort Matanzas). This breach contributed to channel shoaling in both the north and south arms of the Matanzas River as most of the tidal flow went through the breach. Notably, the ICWW near the north arm remains one of the most frequent shoaling areas. FIND commissioned a study of this area in the late 2000s. Taylor Engineering (2009), the study authors, found that a sediment basin to trap sand before reaching the ICWW as the most promising solution to reduce shoaling.

Several unnamed (e.g., northeasters) and named storms have significantly affected the Matanzas Inlet and surrounding areas. These include the ones mentioned above as well as the Thanksgiving Day storm (1984), hurricanes Floyd and Irene (1999), hurricanes Frances and Jeanne (2004), Tropical Storm Fay (2008), Hurricane Matthew (2016), Hurricane Irma (2017), Hurricane Dorian (2019), and hurricanes Ian and Nicole (2022). Notably, Tropical Storm Fay and Hurricane Matthew breached the Summer Haven beaches, and subsequent storms continue to breach the vulnerable areas. Due to the severe beach erosion, the FDEP designated the beach from R-200 to R-209 (i.e., from the northern Old A1A revetment to the St. Johns County/Flagler County line) in 1999 as critically eroded, defined in part as, "a segment of the shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost."

Source: Friends of the Summer Haven River

Figure 2.1 **Matanzas Inlet System before and after the Matanzas Relocation Cut**

Figure 2.2 Inventory of Coastal Structures in Fort Matanzas Area (NPS, 2013)

Prior to 2008 when the first recent major breach occurred, the SHR provided a diverse mix of estuarine, marsh, mangrove and oyster habitat supporting recreational and commercial fisheries. Additionally, with navigable water depths and usable public boat launch areas within Helen Mellon Schmidt Park, the river provided public recreational opportunities. Since then, local efforts have attempted to restore the historic benefits of the river and partially mitigate beach erosion.

The following sections summarize beach fill placement and waterways dredging records in the area, prior SHR restoration efforts, related state and federal permits, and survey data available to support the coastal analyses.

2.1 Beach Fill Placement Records

Numerous beach fill placement events have occurred in the study area, predominantly conducted by USACE and the FIND via beach placement of beach quality dredge materials, whether conducted concurrently with ICWW maintenance dredging events or via offloading of stored dredge material from FIND's dredge material management area (DMMA) SJ-1. The County has also conducted emergency fill projects via truck haul of material from SJ-1 or other upland sources and, most recently, from dredging of overwash sediment from the southern end of the SHR. Finally, the Summer Haven River Restoration Project (SHRRP) (discussed below) placed a significant volume of fill along the northern segment of Summer Haven.

Table 2.1 summarizes the beach fill placement records since 1990, when USACE/FIND began placing ICWW maintenance dredging materials on the Summer Haven shoreline. The information presented in the table originates from several sources including ATM (2021), FDEP (2020), and FIND's ICWW maintenance dredging records (Appendix D). Where discrepancies in reported values (years and/or volumes) appear between the different sources, this study selected values based on the maintenance dredging records. **Figure 2.3** provides an overview of Summer Haven beach fill placement areas. Annualizing the total placement volume from 1990-2021 yields approximately 115,000 cy/yr.

These prior actions to stabilize the shoreline have failed to provide long-term protection for a variety of reasons. For example, beach fill placed during USACE's ICWW maintenance dredging projects tends to wash away quickly, because the grain size is too small to endure the wave action. Emergency efforts to close breaches following storms have funding limitations that prevent construction of berms and dunes of sufficient height and width to completely mitigate the storm-induced erosion. Similarly, FEMA-funded emergency berms are typically too small-scale to provide lasting protection.

2.2 Waterways' Dredging Records

The beach fill records discussed above capture the dredging records since 1990 when USACE/FIND began placing materials on the Summer Haven shoreline as opposed to spoil islands or DMMA SJ-1. **Table 2.2** reorganizes the data to summarize the SHR and ICWW dredging events and includes prior maintenance dredging records from 1958–1990 (Appendix D provides detailed records). The confluence of the Matanzas River north arm and the ICWW represents one of the highest shoaling areas along the entire ICWW (Taylor Engineering, 2009). The USACE and FIND dredge the ICWW approximately every three years, on average, to maintain navigation. The long-term (1958–2017), mid-term (1990–2017), and short-term (2003–2017) ICWW shoaling volumes are similar, averaging approximately 60,000 cy/yr, 58,000 cy/yr, and 61,000 cy/yr). However, the immediate short-term period characterized by frequent Summer Haven breaches has increased to approximately 72,000 cy/yr from 2011–2017 (affected by the Hurricane Matthew breach) and 147,000 cy/yr from 2017-2019 (affected by Hurricane Irma and subsequent storms re-opening the breach).

Table 2.1 Summer Haven Beach Fill Placement History

Year	Volume (cy)	Approximate Fill Location	Sand Source	Sponsor
1990	191,502	R-200 – R-208	ICWW	FIND/USACE
1994	197,370	not available	ICWW	FIND/USACE
1999	211,615	R-200 – R-208	ICWW	FIND/USACE
1999	765,000	R-198 – R-209	SJ-1 OFFLOADING	FIND
2002	21,300	R-203 – R-208	UPLAND SITE	SJC/FEMA
2003	29,000	R-200 – R-208	UPLAND SITE	SJC/FEMA
2003	286,529	R-200 – R-208	UPLAND SITE	FIND/USACE
2005	not available	not available	UPLAND SITE	SJC
2007	186,524	R-200 – R-208	ICWW	FIND/USACE
2007	not available	not available	UPLAND SITE	SJC
2011	33,700	R-202 – R-208	SJ-1	SJC/FEMA
2011	238,977	R-205 – R-208	ICWW	FIND/USACE
2016	78,000	R-204 – R-205	SHR NORTH	SAPWBD/SJC
2017	23,180	R-205 – R-208	SHR SOUTH	SJC/PRIVATE
2017	432,486	R-204 – R-207.5	ICWW	FIND/USACE
2017	317,150	R-200 – R-204	SHR NORTH	SAPWBD/FDEP
2018	20,640	R-200 – R-202	SHR NORTH	SAPWBD/FDEP
2019	47,100	R-200 – R-202	SHR NORTH	SAPWBD/FDEP/FIND/PRIVATE
2019	394,028	R-200 – R-208	ICWW	FIND/USACE
2019	22,100	not available	SHR SOUTH	SJC
2021	53,330	R-203.5 – R-208	SHR SOUTH	SJC/FEMA
Total	3,549,531	-	-	-

Note: Annualized placement volume corresponds to approximately 115,000 cy/yr

Figure 2.3 Overview of Summer Haven Beach Fill Placement Areas

Table 2.2 Summer Haven Vicinity Waterways' Dredging History

Year	Volume (cy)	Location	Sponsor
Summer Haven River			
2016	78,000	SHR North	SAPWBD/FDEP
2017	23,180	SHR South	SJC/Private
2017	317,150	SHR North	SAPWBD/FDEP
2018	20,640	SHR North	SAPWBD/FDEP
2019	47,100	SHR North	SAPWBD/FDEP/FIND/Private
2019	22,100	SHR South	SJC
2021	53,330	SHR South	SJC/FEMA
Total	561,500	---	---
Intracoastal Waterway			
1958	149,911	ICWW	FIND/USACE
1960	159,308	ICWW	FIND/USACE
1962	139,413	ICWW	FIND/USACE
1963	117,869	ICWW	FIND/USACE
1964	80,280	ICWW	FIND/USACE
1966	32,965	ICWW	FIND/USACE
1967	29,681	ICWW	FIND/USACE
1968	59,542	ICWW	FIND/USACE
1970	150,169	ICWW	FIND/USACE
1973	188,713	ICWW	FIND/USACE
1978	597,815	ICWW	FIND/USACE
1983	287,560	ICWW	FIND/USACE
1987	225,600	ICWW	FIND/USACE
1992	191,502	ICWW	FIND/USACE
1994	197,370	ICWW	FIND/USACE
1999	211,615	ICWW	FIND/USACE
2001	218,000	ICWW	FIND/USACE
2007	187,862	ICWW	FIND/USACE
2011	272,915	ICWW	FIND/USACE
2017	432,487	ICWW	FIND/USACE
2019	394,028	ICWW	FIND/USACE
Total	4,257,857	---	---

2.3 Summer Haven River Restoration

The following narrative briefly summarizes prior efforts conducted by stakeholders to restore the SHR. **Figures 2.4–2.21** support the narrative with SHR and beach photos before and after select storms; they show conditions along the north and south ends of the R-200 to R-205 stretch.

As mentioned, a breach located at R-200 initially created by Tropical Storm Fay in 2008 caused over 300,000 cy of sand to eventually infill the river and completely block its tidal flow (**Figures 2.4 and 2.5**). With the goal of restoring the river, Friends of the Summer Haven River formed and — with the SAPWBD as the local government sponsor — successfully obtained funding through a special appropriation from FDEP for construction of the SHRRP. In 2016, with state and federal permits issued and a construction contractor under contract with SAPWBD, the SHRRP was set to commence November 1, the first day after turtle nesting season.

In early October 2016, prior to construction commencement, Hurricane Matthew impacted the project area and created small breaches towards the north end (**Figure 2.6**) and a large breach near R-204.5 (**Figure 2.13**) that transported a large quantity of sediment into the south end of the river (i.e., south of the SHRRP dredging template) and into the ICWW near Pellicer Creek. After much coordination among federal, state, and local government representatives, SAPWBD was able to direct the SHRRP contractor to close the breach. With elevated water levels and extreme tides persisting until mid- to late-November, the contractor closed the breach on November 30, 2016 with sand excavated from the SHRRP template. Closure of the breach allowed the SHRRP to move forward and USACE/FIND to continue with a planned ICWW maintenance dredging project.

In early September 2017, with the SHRRP just a few weeks away from completion (**Figure 2.7**), Hurricane Irma severely impacted the SHRRP and reopened the breach near R-204.5. The elevated water levels and waves destroyed the berm and dunes created by the SHRRP from R-200 to R-202 (**Figure 2.8**) and overwashed a substantial volume of sand back into the river. With construction funds nearly depleted, SAPWBD was able to direct the contractor to re-excavate only a portion of the river in 2017-2018 (**Figure 2.9**). Subsequent reimbursement from the County for expenditures related to closing the Hurricane Matthew breach, a grant from FIND, and private contributions allowed SAPWBD to perform additional re-excavation activities in 2019. The substantial dune constructed post-Irma remained intact after Hurricane Dorian in 2019 and a severe nor'easter in late 2021 (**Figure 2.10**). However, Hurricane Ian in September 2022 created overwash areas through the dune (**Figure 2.11**), and Hurricane Nicole in November 2022 further eroded the dune and created a breach at R-200 (**Figure 2.12**).

The south end (i.e., R-203 to R-205 vicinity) has experienced a similar fate as the north end, with breach closure efforts constantly undone by storms. Following closure of the breach caused by Hurricane Matthew (**Figure 2.13**), USACE/FIND placed approximately 433,000 cy of maintenance dredging materials on the beach fronting the breach (**Figure 2.14**). The beach fill likely lessened the impacts from Hurricane Irma; however, the storm reopened the breach (**Figure 2.15**), just south of the Hurricane Matthew breach location, and lowered the dune/beach elevations across the region. Closure of the breach occurred promptly by scraping overwash materials back across the breach. However, frequent overtopping during high tides continued. Hurricane Dorian produced a similar effect in 2019 (**Figures 2.16 and 2.17**). During summer 2021, the County constructed a FEMA dune along Summer Haven (R-203 to R-208.5) with the overwash material in the south end of the river serving as a borrow source; the project removed approximately 53,000 cy from the river, reestablishing its flow in the process (**Figure 2.18**). However, one month after project completion, a severe nor'easter re-opened the breach and almost completely cutoff the river's flow (**Figure 2.19**). In September and November 2022, hurricanes Ian and Nicole shifted the breach to the south, flowing under the houses near R-205 (**Figures 2.20 and 2.21**).

Figure 2.4 North End - 2008 Tropical Storm Fay Breach (Taylor Engineering, 2018)

Figure 2.5 North End - May 2016 Pre-Hurricane Matthew (Taylor Engineering, 2018)

Figure 2.6 North End - October 2016 Post-Hurricane Matthew (Taylor Engineering, 2018)

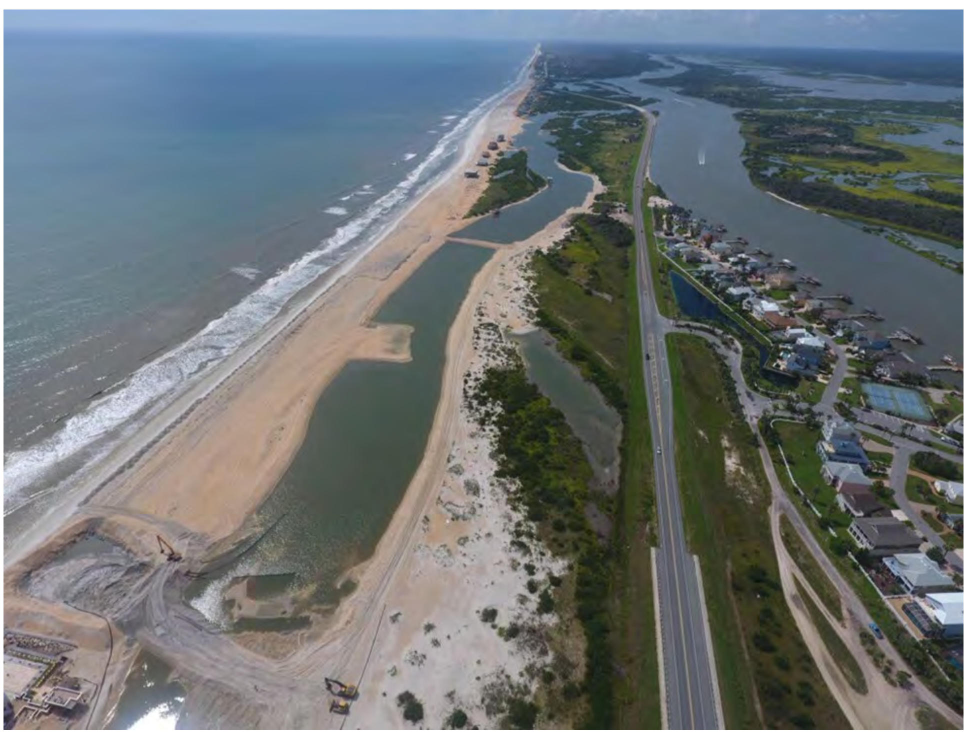

Figure 2.7 North End - September 2017 Pre-Hurricane Irma (Taylor Engineering, 2018)

Figure 2.8 North End - September 2017 Post-Hurricane Irma (Taylor Engineering, 2018)

Figure 2.9 North End - Post-Hurricane Irma Re-construction (Taylor Engineering, 2018)

Figure 2.10 North-End - March 2022 Post-Nor'easter (source: St. Johns County)

Figure 2.11 North End - September 2022 Post-Hurricane Ian (source: St. Johns County)

Figure 2.12 North End - November 2022 Post-Hurricane Nicole (source: St. Johns County)

Figure 2.13 South End - October 2016 Breach Post-Hurricane Matthew (source: St. Johns County)

Figure 2.14 South End – March 2017 USACE/FIND Dredge Material Placement (source: Google Earth)

Figure 2.15 South End – September 2017 Post-Hurricane Irma Breach (source: St. Johns County)

Figure 2.16 South End - August 2019 Pre-Hurricane Dorian (source: St. Johns County)

Figure 2.17 South End – October 2019 Post-Hurricane Dorian (source: St. Johns County)

Figure 2.18 South End – October 2021 Post-FEMA Project, Pre-Nor'easter (source: St. Johns County)

Figure 2.19 South End – November 2021 Post-Nor'easter (source: St. Johns County)

Figure 2.20 South End – September 2022 Post-Hurricane Ian (source: St. Johns County)

Figure 2.21 South End - November 2022 Post-Hurricane Nicole (source: St. Johns County)

2.4 Active State and Federal Permits

2.4.1 FDEP Joint Coastal Permits

2.4.1.1 Permit No. 0313002-001-JC, Summer Haven River Restoration - Expires February 6, 2029

On February 6, 2014, the FDEP issued Permit No. 0313002-001-JC to the SAPWBD to excavate approximately 216,000 cy (at the time of the permit application submittal) of sand from the SHR and place the sand on the adjacent beach and dune between R-200 and R-208. FDEP approved various permit modifications as follows:

- No. 0313002-002-JN, 8/17/2016 — Authorized dredging of the shoal located at the confluence of the Summer Haven River and Matanzas Inlet, adjusted the excavation template within the Summer River, and increased the berm width for beach placement between R-200 to R202.5.
- No. 0313002-003-JN, 10/14/2016 — Authorized placement of material within the Hurricane Matthew breach.
- No. 0313002-004-JN, 9/26/2017 – Authorized the leveling of shoals in the south end of the Summer Haven River that increased in size due to the Hurricane Matthew breach.
- No. 0313002-005-JN, 4/6/2018 — Allowed the planting of the constructed dune and installation of signage educating the public on dune vegetation and restoration.
- No. 0313002-006-JN, 4/10/2019 — Modified the dune fill template, extended the permit expiration date an additional ten years to February 6, 2029, and authorized beach maintenance for future emergency events.
- No. 0313002-007-JN, 6/28/2019 — Revised the special conditions provided in the previous modification regarding required dune vegetation management.
- No. 0313002-008-JN, 2/2/2021 — Authorized a one-time extension of the excavation template further south to remove overwash sediments and provide the estimated 70,000 cubic yards needed to construct the FEMA berm project and reestablished flow in the Summer Haven River.

2.4.1.2 Permit No. 0289228-001-JC, Summer Haven Dune and Beach Placement – Expires July 26, 2027

On July 26, 2012, FDEP issued Permit No. 0289228-001-JC to St. Johns County to place beach compatible sand, sourced from FIND's DMMA SJ-1, along the critically eroded beach between R-202 and R-208.5. FDEP approved various permit modifications as follows:

- No. 0289228-002-JN, 10/26/2017 — Extended the fill placement area to include R-200 to R-202 and R-208.5 to R-209.
- No. 0289228-003-JN, 12/18/2017 — Authorized a one-time excavation template of a portion of the Summer Haven River to remove overwash sediments.
- No. 0289228-004-JN, 1/14/2020 — authorize another one-time excavation template of the overwash deposits within the full dredge template of the Summer Haven River Restoration Project (permit # 0313002-001-JC) with placement of beach compatible material within the authorized fill template.
- No. 0289228-005-JN, 3/10/2020 — Authorized FIND DMMA FL-3 as a borrow source.
- Permit No. 0289228-005-JN 5/31/2022 — Extended the permit expiration date by 5 years to July 26, 2027.

2.4.2 Department of the Army Dredge and Fill Permits

2.4.2.1 SAJ-2012-02400, Summer Haven River Restoration Project – expires November 24, 2026

USACE issued Permit No. SAJ-2012-02400 to SAPWBD for the SHRRP on November 24, 2014. In 2020, USACE modified the permit to extend the expiration date, expand the dredging boundary southwards to include the breach area, and authorize maintenance dredging of the river to return overwash to the beach. The permit currently expires November 24, 2026.

2.4.2.2 SAJ-2010-03050, for Summer Haven Dune and Beach Placement – expires September 19, 2027

USACE issued Permit No. SAJ-2010-03050 to St. Johns County for Summer Haven Dune and Beach Placement on September 19, 2012.

2.5 Topographic and Bathymetric Survey Data

Arc Surveying and Mapping, Inc (Arc) performed a bathymetric and topographic survey and aerial LiDAR mapping for this study (LiDAR survey date: October 20, 2022, Topographic survey date: October 17 to December 16, 2022, Hydrographic survey date: October 11 to November 29, 2022). The survey utilized a combination of data acquisition procedures including conventional survey collection, hydrographic single beam, drone-based LiDAR and photogrammetry, and Real Time Kinematic (RTK) GPS. The procedures utilized result in high-resolution spatial data, which provide accurate control and feature data acquisition. **Figure 2.22** provides a contour map of the survey.

Historic beach profile surveys spanning 1972 – 2020 along the St. Johns County coastline are available on the FDEP website: http://publicfiles.dep.state.fl.us/DWRM/Beaches/HSSD/ProfileData/prof839088/. The surveyed profiles coincide with FDEP reference monuments spaced approximately 1,000 ft apart along the shoreline. **Table 2.3** shows a summary of the data available for the study area. As noted in the table, not every survey included all profiles from R-187 to R-209, and not every survey extended far enough seaward to allow an accurate and realistic measurement of offshore contour changes, and hence volume changes, to the estimated depth of closure (approximately at -30 ft NAVD88).

The NOAA digital coast database provides historical hydrographic surveys. The database mostly comprises surveys performed by the USACE (2004, 2009, 2010, 2016, and 2017) and the County through its Countywide Digital Contour Mapping Project (2004, 2008, and 2013). Three full inlet surveys — 2016 pre- and post-Hurricane Matthew and 2017 post-Hurricane Irma — including the flood and ebb shoals are available from NOAA; the surveys prior to 2016 did not capture the full inlet. **Table 2.4** shows the date and extent of the available surveys near the study area, including the 2022 survey performed for this study.

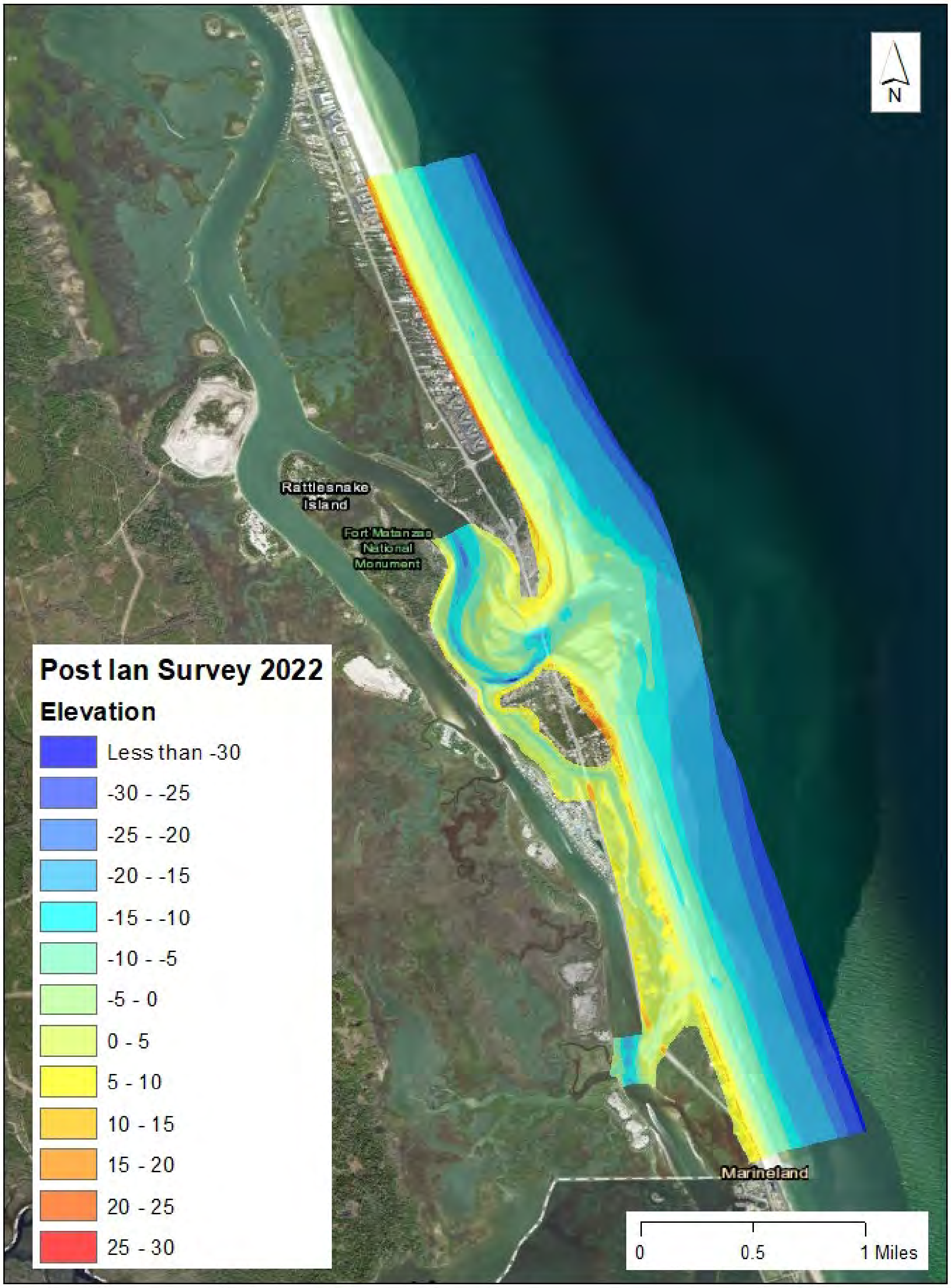

Figure 2.22 Survey Contour Map

Table 2.3 Available Beach Profile Survey Data

Filename	Source[1]	Survey Date		Survey Extents	Includes R-187 to 209
		Month	Year		
SJ7209_CCC_1.PRF	FDEP	09	1972	Entire Profile/ Wading Depth[2]	Yes
SJ8405_CON_1.PRF	FDEP	05	1984	Entire Profile/ Wading Depth[2]	Yes (except R-198)
SJ8409_PST_1.PRF	FDEP	09	1984	No data	No
SJ8412_PST_1.PRF	FDEP	12	1984	Wading Depth	Yes (except R-196, R-198)
SJ8607_CCC_1.PRF	FDEP	07	1986	Entire Profile/ Wading Depth[2]	Yes
SJ9210_CON_1.PRF	FDEP	10	1992	No data	No
SJ9307_CON_1.PRF	FDEP	07	1993	Wading Depth	Yes (except R-208, R-209)
SJ9509_CON_1.PRF	FDEP	09	1995	No data	No
SJ9604_CON_1.PRF	FDEP	04	1996	Wading Depth	No (R-200 - R-209 only)
SJ9702_CON_1.PRF	FDEP	02	1997	Wading Depth	No (R-200 - R-209 only)
SJ9902_CON_1.PRF	FDEP	02	1999	Entire Profile	Yes (except R-208, R-209)
SJ0306_CON_1.PRF	FDEP	06	2003	Entire Profile	Yes
SJ0306_OFF_1.PRF	FDEP	06	2003	Entire Profile	Yes
SJ0703_SPE_1.PRF	FDEP	03	2007	No data	No
SJ0709_CON_1.PRF	FDEP	09	2007	Entire Profile	Yes
SJ1105_CON_1.PRF	FDEP	05	2011	Entire Profile	Yes
SJ1405_COE_1.PRF	USACE	05	2014	No data	No
SJ1407_CON_1.PRF	FDEP	07	2014	Wading Depth	Yes
SJ1606_COE_1.LID	USACE	06	2016	Entire Profile[3]	Yes
SJ1611_COE_1.LID	USACE	11	2016	Entire Profile[3]	Yes
SJ1706_CON_1.PRF	FDEP	06	2017	Wading Depth	Yes
SJ1709_COE_1.LID	USACE	0	2017	Wading Depth	Yes (except R-200 - R-204)
SJ1803_OLS_1.PRF	OLS	03	2018	No data	No
SJ1911_CON_1.PRF	FDEP	11	2019	Wading Depth	Yes
SJ1912_ARC_1.PRF	ARC	12	2019	No data	No
SJ2011_DRM_1.PRF	n/a	11	'2020	Wading Depth	Yes (except R-187 - R-193)

[1]FDEP=Florida Department of Environmental Protection; USACE=U.S. Army Corps of Engineers; OLS=Olsen and Associates; ARC=ARC Surveying and Mapping, Inc.
[2] Survey every third profile extends offshore (-35 to -40 ft) and the others are wading depth (-2 to-8 ft)
[3] Profile extends offshore (-12 to -18 ft)

Table 2.4 Available Beach Hydrographic Data

Survey Start	Survey End	Source[1]	Description[2]	Survey Coverage
2004-11-01	2004-12-31	USACE	Post-Hurricane Ivan	Beach, Partial Channel
2004-01-17	2004-02-07	SJC	CDCM	Beach (Topo only)
2005-12-11	2006-02-05	USACE	NCMP	Beach, Fort Matanzas (Topo only)
2008-02-14	2008-02-25	SJC	CDCM	Beach (Topo only)
2009-09-27	---	USACE	NCMP	Beach, Partial Channel, Rattlesnake Island
2010-05-04	2010-06-16	USACE	NCMP	Beach
2013-01-11	2013-01-25	SJC	CDCM	Beach (Topo only)
2016-05-19	2016-07-20	USACE	NCMP	Beach, Ebb Shoal, Flood Shoal, Summer Haven River
2016-10	2016-12	USACE	Post-Hurricane Matthew	Beach, Ebb Shoal, Flood Shoal, Summer Haven River
2017-09-18	2017-10-25	USACE	Post-Hurricane Irma	Beach, Ebb Shoal, Flood Shoal, Summer Haven River
2022-10-11	2022-11-29	ARC	Post-Hurricane Ian	Beach, Ebb Shoal, Flood Shoal, Summer Haven River

[1]SJC=St. Johns County; ARC= Arc Surveying and Mapping, Inc.

[2]CDCM=Countywide Digital Contour Mapping; NCMP=National Coastal Mapping Program

3.0 Site Characteristics

Any efforts undertaken to restore the SHR or mitigate coastal erosion must consider the effects of or on the natural and physical environments of the study area. This section discusses these environments as they pertain to Summer Haven beach and river management.

3.1 Natural Environment

The following sections briefly discuss the natural resources, threatened and endangered species, Essential Fish Habitat (EFH), and coastal barrier resources of the study area.

3.2 Natural Resources

Florida Natural Areas Inventory (FNAI) presents a standardized classification of Florida's natural communities (FNAI, 2010). In accordance with this classification, the SHR and adjacent beach contain the following natural communities, as described in FNAI (2010):

- Beach dune — A predominantly herbaceous community of wide-ranging coastal specialist plants on the vegetated upper beach and first dune above the beach (foredune).
- Coastal grassland — A predominantly herbaceous community occupying the drier portions of the transition zone between beach dunes on the immediate coast and communities dominated by woody species, such as coastal strand or maritime hammock, further inland.
- Coastal strand — An evergreen shrub community growing on stabilized coastal dunes in the peninsula of Florida, often with a smooth canopy due to pruning by salt spray.
- Unconsolidated substrate — Mineral Based Natural Communities of unsolidified material — including coralgal, marl, mud, mud/sand, sand or shell — generally characterized as expansive, relatively open areas of subtidal, intertidal, and supratidal zones which lack dense populations of sessile plant and animal species.
- Salt marsh — A largely herbaceous community that occurs in the portion of the coastal zone affected by tides and seawater and protected from large waves, either by the broad, gently sloping topography of the shore, by a barrier island, or by location along a bay or estuary.
- Mangrove swamp — A dense forest occurring along relatively flat, low wave energy, marine and estuarine shorelines.

Several prior studies/reports have further described the current and historic (i.e., prior to the effects of the 2008 breach of the Summer Haven beaches) natural resources of the study area. The scope of this study — focused on an engineering solution to maintain flow through the SHR — excludes an updated mapping and characterization of the natural resources. For reference, Appendix E includes a more detailed natural resources narrative prepared for the state and federal permit applications for the SHRRP (Taylor Engineering, 2012), and Appendix F contains a *Biological Summary of the Summer Haven River* (Steinmetz, 2022), which describes the historic river ecosystem.

The following sections address permitting and funding considerations related to natural resources.

3.2.1 Threatened and Endangered Species

Table 3.1, prepared by USACE in 2020 in review of a modification request to Department of the Army Permit No. SAJ-2012-02400 for the SHRRP, identifies effects that Summer Haven dredging and beach fill projects may have on endangered and threatened species or their critical habitats. Issuance of any future Department of the Army permits will require USACE to update this list and request U.S. Fish and Wildlife (USFWS)/National Marine Fisheries Service (NMFS) concurrence with the determinations pursuant to Section 7 of the Endangered Species Act (ESA).

Table 3.1 Endangered Species Designations in the Study Area

Species/Critical Habitat	Status*	Agency	Biological Opinion (BO)*	Covered under BO	USACE Initial Determination*
Manatee (*Trichechus manatus*)	T	USFWS	SPBO	Yes	MANLAA
Eastern Indigo Snake (*Drymarchon couperi*)	T	USFWS	Eastern Indigo Snake Key	Yes	NLAA
Florida Scrub Jay (*Aphelocoma coerulescens*)	T	USFWS	N/A	N/A	NE
Piping Plover (*Charadrius melodus*)	T	USFWS	P3BO	Yes	MANLAA
Rufa Red knot (*Calidris canutus rufa*)	T	USFWS	P3BO	Yes	MANLAA
North Atlantic Right Whale	E	NMFS	SARBO	Yes	NE
North Atlantic Right Whale Critical Habitat Unit 2	-	-	-	-	NLAM
Atlantic sturgeon (*Acipenser oxyrinchus oyrinchus*)	E	NMFS	SARBO/JAXBO	No	MANLAA
Shortnose sturgeon (*Acipenser brevirostrum*)	E	NMFS	SARBO/JAXBO	Yes	MANLAA
Smalltooth Sawfish (*Pristis pectinata*)	E	NMFS	SARBO/JAXBO	No	MANLAA
Sea Turtles Nesting					
Loggerhead (*Caretta caretta*)	T	USFWS	SPBO	Yes	MANLAA
Green (*Chelonia mydas*)	T	USFWS	SPBO	Yes	MANLAA
Kemp’s Ridley (*Lepidochelys kempii*)	E	USFWS	SPBO	Yes	MANLAA

Species/Critical Habitat	Status*	Agency	Biological Opinion (BO)*	Covered under BO	USACE Initial Determination*
Leatherback (*Dermochelys coriacea*)	E	USFWS	SPBO	Yes	MANLAA
Hawksbill (*Eretmochelys imbricata*)	E	USFWS	SPBO	Yes	MANLAA
Loggerhead Sea Turtle Critical Terrestrial Habitat Unit LOGG-T-FL-03	-	USFWS	SPBO	Yes	NLAM
Sea Turtles Swimming					
Green (*Chelonia mydas*);	T	NMFS	SARBO/JAXBO	Yes	MANLAA
Kemp's Ridley (*Lepidochelys kempii*);	E	NMFS	SARBO/JAXBO	Yes	MANLAA
Leatherback (*Dermochelys coriacea*);	E	NMFS	SARBO/JAXBO	Yes	MANLAA
Loggerhead (*Caretta caretta*);	T	NMFS	SARBO/JAXBO	Yes	MANLAA
Hawksbill (*Eretmochelys imbricata*)	E	NMFS	SARBO/JAXBO	Yes	MANLAA
Loggerhead Sea Turtle Neritic Habitat Unit LOGG-N-15	-	NMFS	SARBO/JAXBO	Yes	NLAM

*Key:
NMFS: National Marine Fisheries Service
USFWS: United States Fish and Wildlife Service
T: Federal Listing Status Threatened
E: Federal Listing Status Endangered
SPBO: Statewide Programmatic Biological Opinion 2015
SARBO: South Atlantic Region Biological Opinion 1997
P^3BO: Piping Plover Programmatic Biological Opinion
MANLAA: May Affect, Not Likely to Adversely Affect
MALAA: May Affect, Likely to Adversely Affect
NLAM: Not Likely to Adversely Modify
NE: No Effect
Source: https://www.saj.usace.army.mil/Missions/Regulatory/Public-Notices/Article/2118800/saj-2012-02400-mod-2-tmm/

3.2.2 Essential Fish Habitat (EFH)

During processing of Department of the Army permit applications, USACE must consult with NMFS regarding potential effects on EFH as required by the Magnuson-Stevens Fishery Conservation and Management Act 1996. During prior consultations for Summer Haven dredging and beach fill projects, USACE has identified impacts to specific acreage of estuarine habitats utilized by various life stages of shrimp (*Farfantepenaeus* spp., *Penaeus* spp., and/or *Litopenaeus* spp.), snapper (*Lutjanus* spp.), and grouper (*Mycteroperca* spp. and/or *Epinephelus* spp.) as well as specified miles of nearshore habitat within the Atlantic Ocean. USACE has previously determined, with NMFS concurrence, that proposed projects would not have a substantial adverse impact on EFH or federally managed fisheries in the Summer Haven River. For future permit applications, USACE must update their determination relative to proposed project impacts and the need for mitigation measures and coordinate with NMFS.

3.2.3 Coastal Barrier Resources

The Coastal Barrier Resources Act of 1982 (Public Law 97-348; CBRA) established the John H. Chafee Coastal Barrier Resources System (CBRS) to promote conservation of certain costal barrier resources along the Atlantic, Gulf of Mexico, Great Lakes, U.S. Virgin Islands, and Puerto Rico coasts by restricting federal expenditures that encourage development of the resources. The CBRS includes System Units consisting of relatively undeveloped coastal areas at the time of their designation and Otherwise Protected Areas (OPAs) held primarily for wildlife refuge, sanctuary, recreational, or conservation purposes. Currently, 588 System Units encompass nearly 1.4 million acres of land and aquatic habitat, and 282 OPAs encompass 2.1 million acres (https://www.fws.gov/program/coastal-barrier-resources-act/maps-and-data). CBRA prohibits most new federal expenditures and financial assistance, including flood insurance, within System Units. However, it only prohibits federal spending on flood insurance within OPAs. CBRA does not prohibit or impose restrictions on development using non-federal funds.

The Summer Haven study area lies completely within CBRS Unit P05A, Matanzas River and OPA P05AP lies within Fort Matanzas National Monument (**Figure 3.1**). The CBRA may prohibit federal funding but not authorization of projects implemented by local or state sponsors.

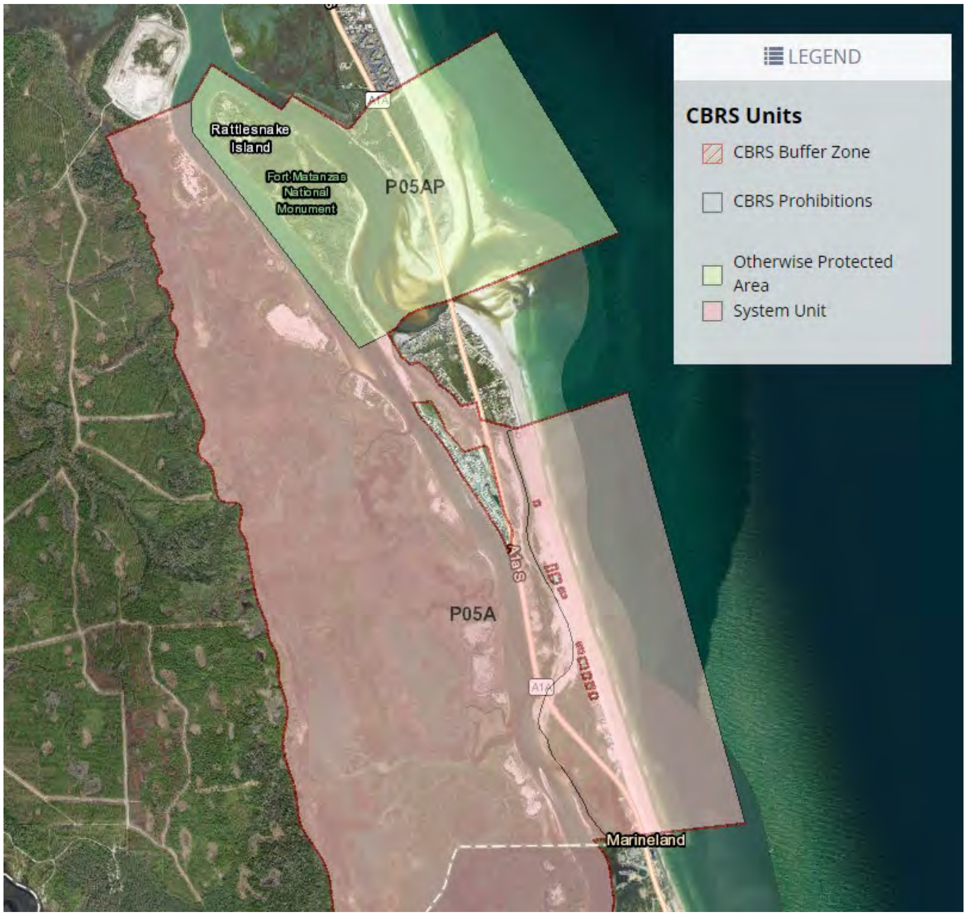

Figure 3.1 Coastal Barrier Resources (https://fwsprimary.wim.usgs.gov/CBRSMapper-v2/)

3.2.4 Guana Tolomato Matanzas National Estuarine Research Reserve

The Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR), a collaboration between the FDEP and NOAA for the purposes of research, education, and stewardship), covers the Summer Haven area and adjacent waterways (**Figure 3.2**; green shading). Note that the boundaries include some of the dune north of the inlet at the Ft. Matanzas National Monument Park and falls landward of the line of construction on the south side of the inlet.

Figure 3.2 GTMNERR Boundaries near the Study Area

3.3 Physical Environment

Many natural factors influence the coastal processes in and around Summer Haven, including winds, waves, tides, currents, storms, and sea level rise. Anthropogenic factors include shoreline stabilization structures, beach management projects, dredging projects, and development. Florida statutes requiring preservation of native beach sand characteristics place restrictions on beach fill and borrow areas. The following sections briefly discuss these factors.

3.3.1 Winds

The USACE Wave Information Study (WIS) hindcast provides wind (and wave) information offshore the study area for the period January 1980 through December 2020. Numerical models driven by climatological wind fields overlaid on grids of the estimated bathymetry generate the WIS, hourly hindcast data. The WIS numerical hindcasts supply long-term wave climate information at locations (stations) of U.S. coastal waters. Station 63419 (29.75° N, 81.00° W; 20 meters water depth) lies nearest to the study area (**Figure 3.3**). **Figure 3.4** presents the wind rose for the hindcast data. Winds predominantly originate from the southwest. The largest wind speeds generally originate from the west to northeast directions. Onshore winds originate from the north-northwest through south-southeast directions.

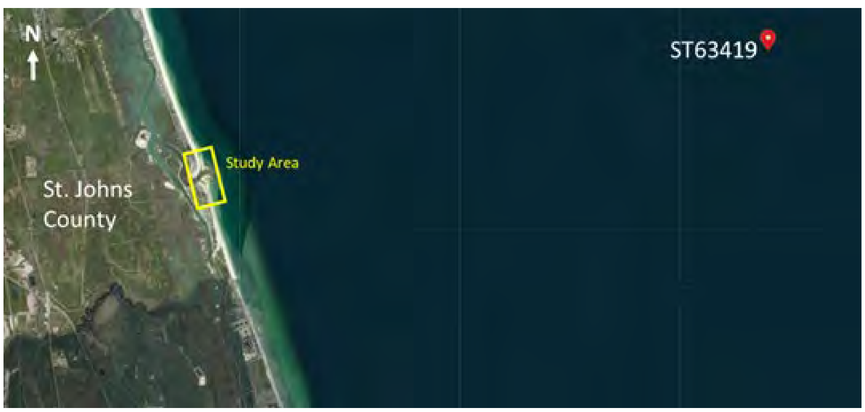

Figure 3.3 Location of Nearest WIS Station

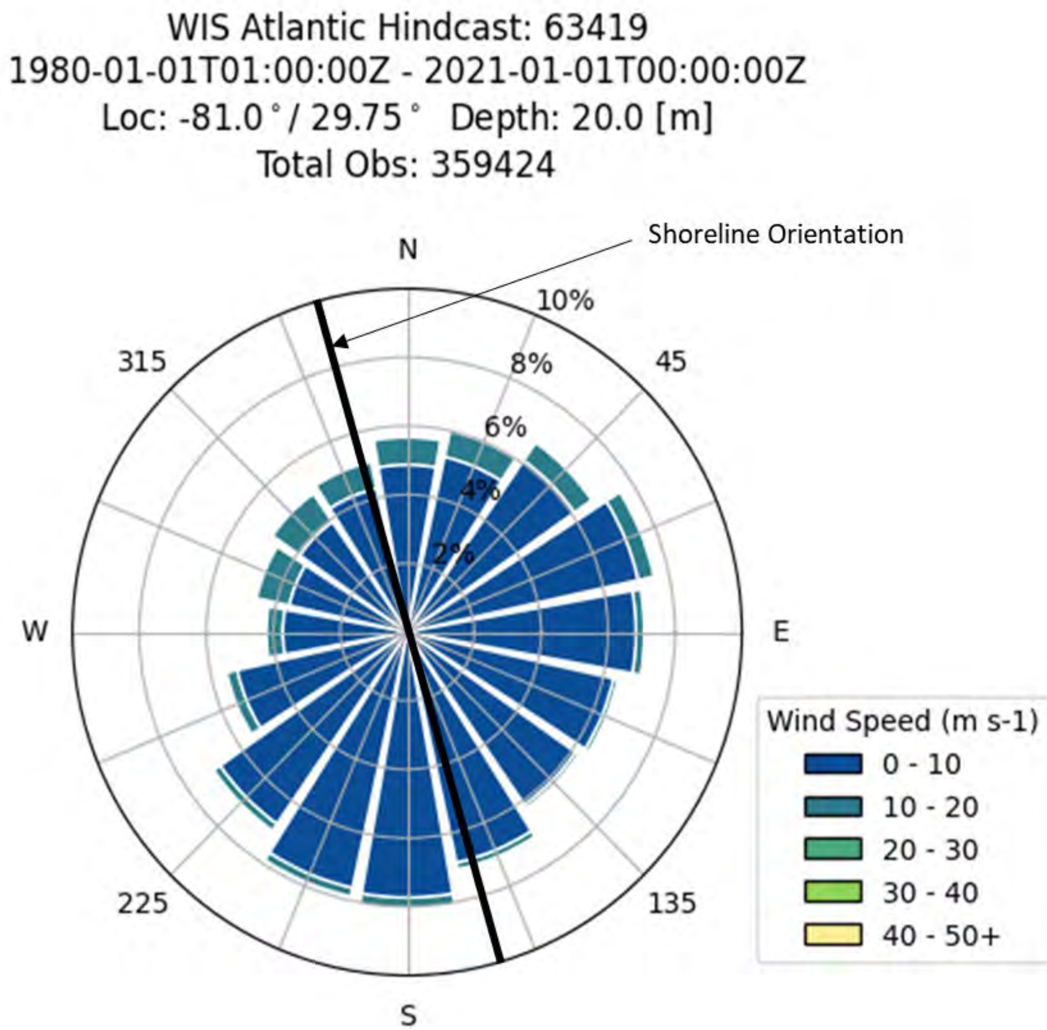

Figure 3.4 Wind Rose at Station No. 63419 (https://wis.erdc.dren.mil/)

3.3.2 Waves

The USACE WIS hindcast also provides the wave climate offshore the study area. **Figure 3.5** presents the wind rose for the hindcast data. The data suggest that waves primarily originate from the northeast to east-southeast directions. Further, the data shows that nearly 95% of the waves move onshore.

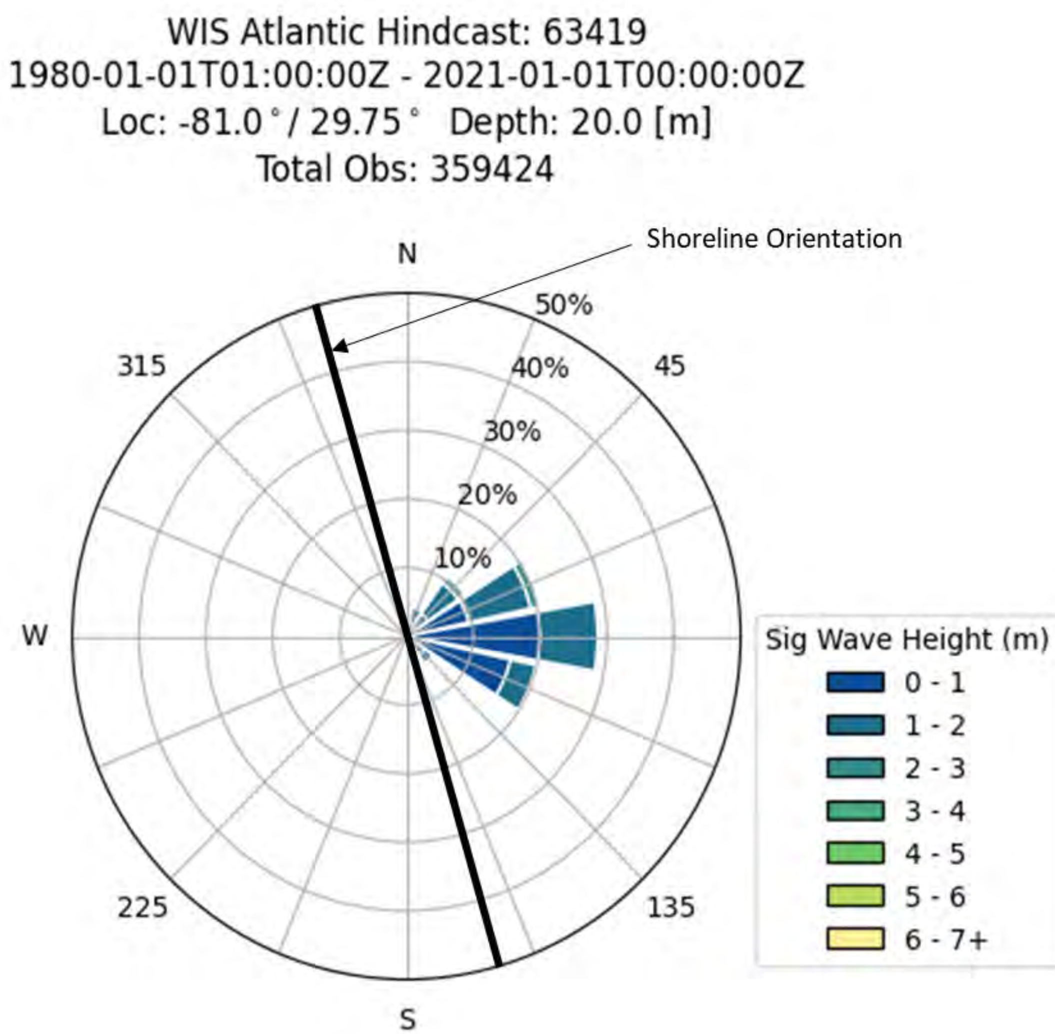

Figure 3.5 **Wave Rose at Station No. 63419 (https://wis.erdc.dren.mil/)**

3.3.3 Water Levels

Water levels, a function of astronomical tide and other non-tidal components, significantly affect shoreline behavior and inlet dynamics. This section describes the water levels in the study area.

3.3.3.1 Astronomical Tides

NOAA has a free software tool called VDATUM (https://vdatum.noaa.gov/welcome.html) that transforms heights among different vertical datums. **Table 3.2** presents tidal datums at the center of the bridge that crosses the inlet channel produced by NOAA's VDATUM tool V. 4.5.1. Semidiurnal tides with two highs and two lows per day characterize the astronomical tides in the study area. The mean tidal range in the area equals approximately 4.1 feet (ft).

To permit some projects, the FDEP requires projecting the Seasonal High Water Line (SHWL), defined in Section 161.053(5)(a)2, Florida Statutes (FS), as "...the line formed by the intersection of the rising shore and the elevation of 150 percent of the local mean tidal range above local mean high water." In the study area, this elevation corresponds to approximately +7.8 ft NAVD88.

Table 3.2 Tidal Datums in the Study Area

Tidal Datum	Elevation (ft NAVD88)
Mean Higher High Water (MHHW)	2.004
Mean High Water (MHW)	1.660
Mean Tide Level (MTL)	-0.382
Mean Sea Level (MSL)	-0.383
Mean Low Water (MLW)	-2.424
Mean Lower Low Water (MLLW)	-2.601
Seasonal High Water Line (SHWL)	7.786

3.3.3.2 Sea Level Rise

Future sea level rise in the study area could adversely affect shoreline erosion and shore protection structure performance by increasing flood inundation levels, increasing depth-limited waves, and reducing structure freeboard. Most recording stations around the world have indicated that MSL has steadily risen over the past century. The predicted values of sea level rise vary depending on the predicted value of anticipated temperature rise.

Figure 3.6 depicts the historic sea level rise (2.78 +/- 0.25 mm/yr) measured at Mayport, FL and **Figure 3.7** shows the historic sea level rise (3.00 +/- 0.21 mm/yr) measured at Virginia Key, FL. These gages correspond to the closest, long-term NOAA gages to the study area. These two rates suggest an historic sea level rise of approximately 2.81 mm/yr near the study area.

Based on EC 1165-2-212 (USACE, 2011) and ER 1100-2-8162 (USACE, 2019), the USACE provides a method for estimating sea level rise curves for low, intermediate, and high sea level rate scenarios for incorporation into federal projects. The “low” scenario corresponds to the historical estimate from NOAA tide gages; the “intermediate” scenario corresponds to the National Research Council (NRC) Curve I where global eustatic sea level rises 0.5 meters by 2100; the “high” scenario corresponds to the NRC Curve III where global eustatic sea level rises 1.5 meters by 2100.

Figure 3.8 presents these sea level rise projection curves from 1992 until 2077 for the study area. Current NOAA gages reference the 1983-2001 tidal epoch, and the year 1992 represents the midway point within that timeframe. Therefore, sea level rise projections should begin with a relative sea level rise value of zero in 1992. Assuming the county will implement a project/program in 2027 with a design service life of 50 years (i.e., 2027 – 2077), which coincides with a typical federal project design life, **Figure 3.8** suggests that sea level rise may range from 0.78 to 3.46 ft by the end of 2077 depending on the sea level rise scenario.

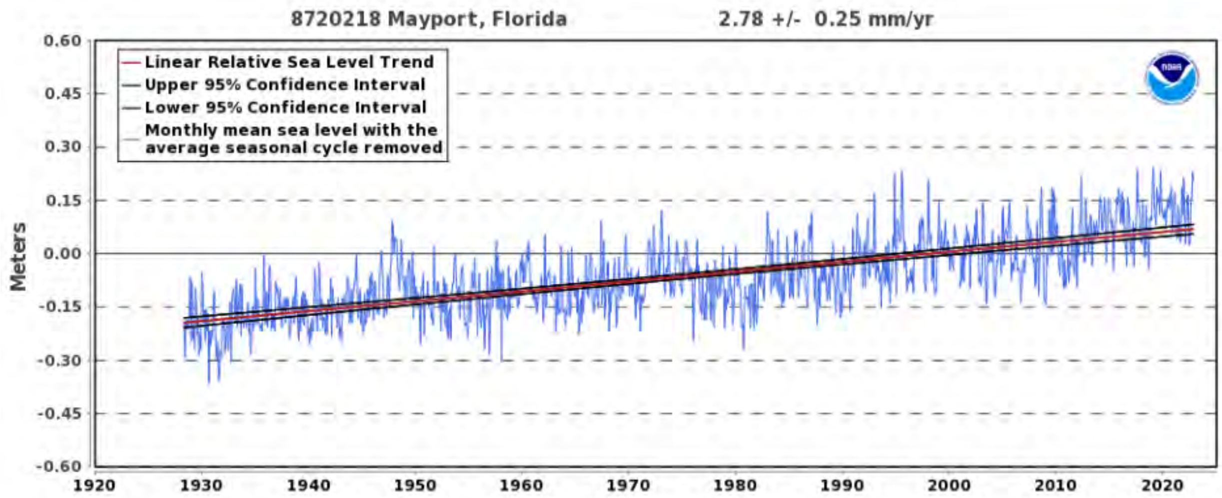

Figure 3.6 Historic Sea Level Rise Trend at Mayport, FL (https://tidesandcurrents.noaa.gov/)

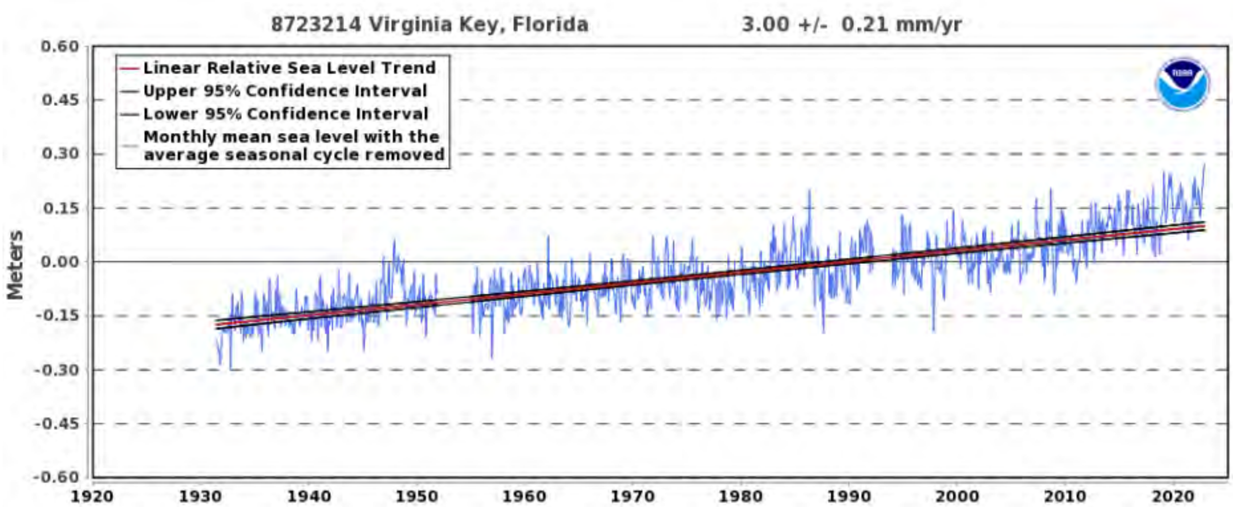

Figure 3.7 Historic Sea Level Rise Trend at Virginia Key, FL (https://tidesandcurrents.noaa.gov/)

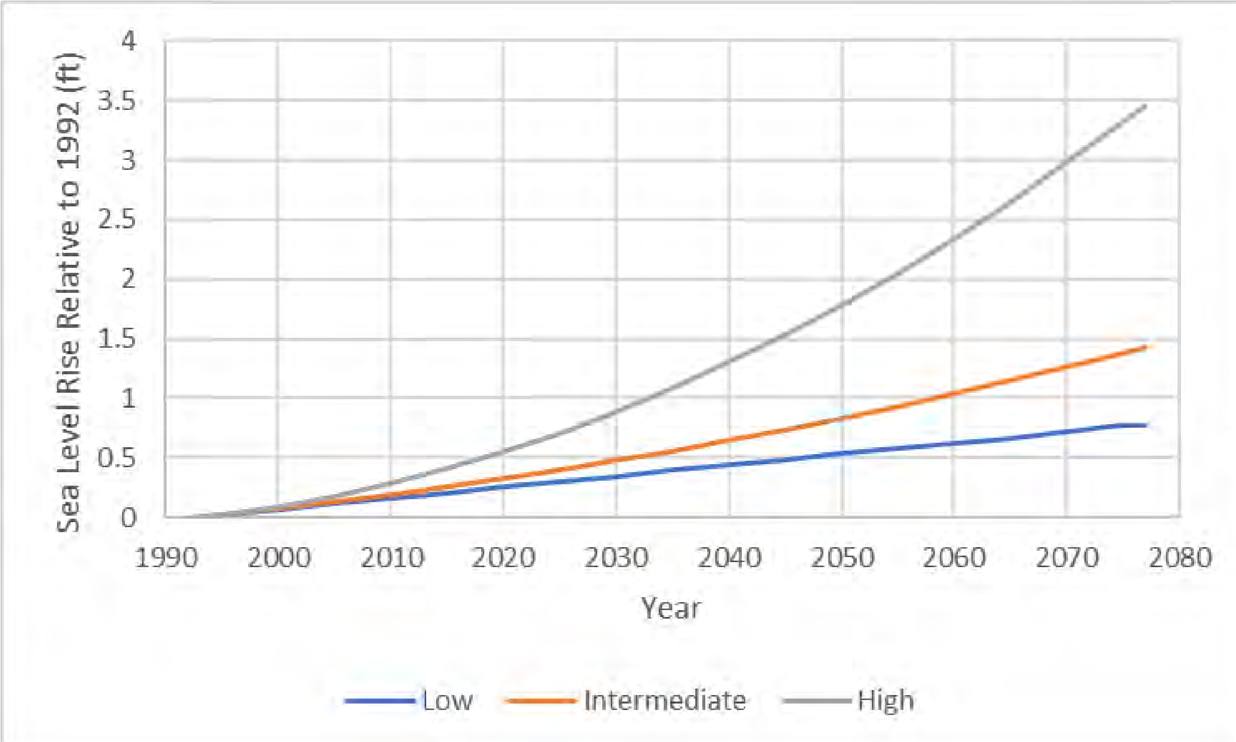

Figure 3.8 Projected Relative Sea Level Rise based on USACE Curves

Notably, Section 161.551, FS, requires state agencies, among others, which "commission or manage a construction project within the coastal building zone using funds appropriated from the state", conduct a sea level impact projection (SLIP) study. Section 161.54, FS defines the coastal building zone as "the land area from the seasonal high-water line landward to a line 1,500 feet landward from the coastal construction control line as established pursuant to s. 161.053, and, for those coastal areas fronting on the Gulf of Mexico, Atlantic Ocean, Florida Bay, or Straits of Florida and not included under s. 161.053, the land area seaward of the most landward velocity zone (V-zone) line as established by the Federal Emergency Management Agency and shown on flood insurance rate maps." The study area lies within a coastal construction control line and fronts the Atlantic Ocean. Therefore, the County may be required to conduct a SLIP study for a project should state funds support the project.

3.3.4 Currents

Nearshore hydrodynamics include the forces of waves, tides, and currents. Nearshore currents play a significant role in coastal sediment transport. Nearshore currents consist of two components, longshore and cross-shore. Longshore currents are parallel to the shoreline and are associated with either rip currents or oblique wave energy. Longshore currents generally determine the long-term direction and magnitude of littoral transport. Cross-shore currents are perpendicular to the shore and are caused by undertow, rip currents and breaking waves. Undertow and rip currents are responsible for offshore-directed currents while the forces of breaking waves are responsible for onshore-directed transport. Cross-shore currents may have a shorter-term effect but can result in both temporary and permanent erosion. Although reversals may occur, the net sediment transport for the study area is generally from north to south due to the dominant wave activity from the northeast during the fall and winter months.

Longshore and tidal currents converge at the mouth of Matanzas Inlet producing a complex pattern, which depends on the ebb and flood tidal flow through the inlet. Due to the inlet channel's 90-degree bend pressing the inlet currents against the throat's southern shoreline, particularly during ebb flows (i.e., outgoing tides), erosion of the inlet's south shoreline west of the bridge has long been a concern and has prompted property owners to harden the shoreline with bulkheads and revetments. Section 4.6 provides additional details regarding inlet currents.

3.3.5 Rainfall

The National Weather Service (NWS) (https://www.weather.gov/) reports historical and current climatological data, including precipitation, at many locations in Florida. **Figure 3.9** presents the annual rainfall means, minimums, and maximums at the St. Augustine Lighthouse from 1973 – 2016. On average, the wettest weather occurs in June, July, August, and September. These four months account for nearly one-half of the mean annual precipitation. The maximum rainfall totals during these months have occurred since 2007 except for the month of July, which the NWS recorded in 1991.

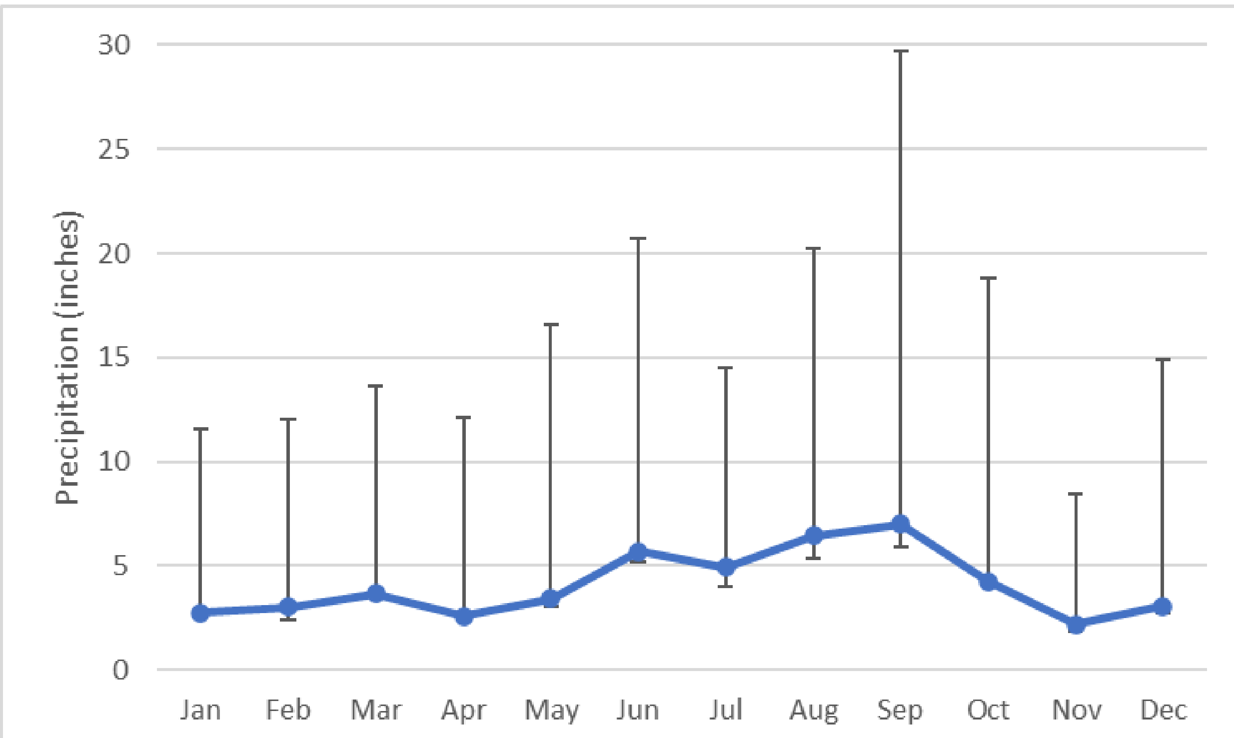

Figure 3.9 Monthly Precipitation at St. Augustine Lighthouse (1973-2016)

3.3.6 Storm Climatology

3.3.6.1 Tropical Storms and Hurricanes

As discussed, tropical storms and hurricanes have significantly affected the project area. Hurricane season typically runs from June – October. Investigation of NOAA's HURDAT database (https://coast.noaa.gov/hurricanes) reveals that from the 1840s through 2021, 84 cyclonic storms of tropical storm minimal intensity, including 29 hurricanes, have passed within 60 nautical miles (nmi) of Matanzas Inlet. **Figure 3.10** shows the paths of these storms. Only two hurricanes made landfall very near the site (Hurricane Dora in 1964 and an unnamed storm in 1926) while many moved parallel to the coast without making landfall or moved across the state and exited into the Atlantic Ocean near the study area.

The most devastating storm event to date was Hurricane Dora (September 1964), which passed through the study area and affected most of northeast Florida. Hurricane Dora made landfall in St. Augustine as a Category 2 storm with associated wind speeds near 110 mph and 12-ft-high surge (Mehta and Jones, 1977). Hurricanes Dora triggered the expansion of the revetment north of R-200 and relocation of SR A1A in the 1970s to its present location.

During large storm events, Summer Haven has experienced wash-over of the beach. A nor'easter in March 1989 overwashed the dune immediately south of the Summer Haven revetment and established a short-lived inlet connecting the Atlantic Ocean to the Summer Haven River (Taylor and McFetridge, 1989). Since then, many storms have significantly affected the project area, including Matthew (2016), Irma (2017), Dorian (2019), Ian (2022), and Nicole (2022).

Hurricane Matthew approached the east coast of Florida on October 6, 2016. The storm eye's center came within 30 miles of Summer Haven. The storm brought strong winds and storm surge throughout the county. The storm created a breach and water flowed over the sand that covered the SHR. The 0.25-mile-wide breach located just south of R-204 connecting the ocean to the SHR. The storm destroyed a vegetated engineered dune that existed along the seaward side of Summer Haven South and damaged portions of Old A1A. Reports stated severe structural damage occurred with many houses and businesses inundated by saltwater that was at least three feet high.

Hurricane Irma did not make landfall in the county but brought floodwaters that did not peak in some Florida rivers until two to three days later. Significant flooding occurred along the banks of the St. Johns River, likely due to a combination of storm surge and rainfall runoff into the river. The hurricane caused substantial erosion and damage to the beach and dune system in the county resulting in the designation of additional critical erosion areas in the county. Within the study area, the storm caused erosion of the newly placed beach sand south of R-204 and moved that sand offshore.

In early September 2019, Hurricane Dorian made landfall in Abaco Island as a Category 5 storm and then later made a second landfall on Grand Bahama Island. Hurricane Dorian then approached the east coast of Florida as a tropical storm. The storm brought winds, rain, and storm surge to the northeast Florida coast pushing beach sand between R-204 and 205 into the river.

A nor'easter storm in November 2021 caused a breach in the berm connecting the Atlantic Ocean to the Summer Haven River at R-205.

Hurricane Ian made landfall on September 28, 2022, at Cayo Costa, Lee County, in southwest Florida as a strong Category 4 hurricane. Ian reached the Atlantic coast as a tropical storm before strengthening to a Category 1 hurricane on September 30. Ian impacted the northeast coast of Florida with wind and storm surge resulting in major dune and beach erosion and extensive seawall failures.

Nicole made landfall on the east coast of Florida as a tropical storm. Nicole was a particularly large and slow-moving storm. As a result, the storm created waves over 30 ft, which are in general associated with major hurricanes. Nicole occurred a few weeks after Hurricane Ian and further exacerbated the severe beach and dune erosion within the study area.

Figure 3.11 shows the path of Hurricane Ian and **Figure 3.12** shows the path of Hurricane Nicole. The former storm exited the coast south of the study area while the latter storm made landfall along the Florida coast south of the study area. Given these paths, both storms produced some period of onshore waves and high surge conditions in the area.

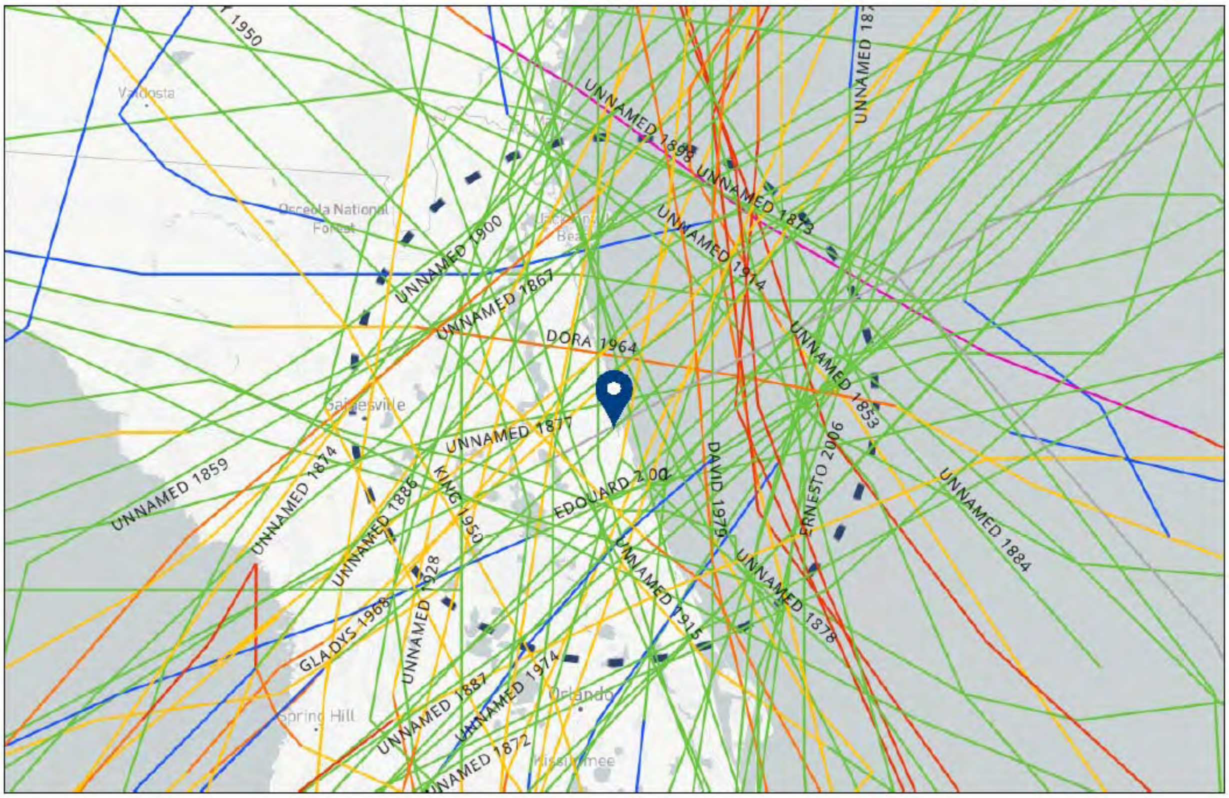

Figure 3.10 Tropical Storms and Hurricanes Passing within 60 nmi of the Study Area

Figure 3.11 Path of Hurricane Ian (https://www.wunderground.com/article/storms/hurricane/news/2022-09-30-hurricane-ian-forecast-landfall-south-north-carolina-virginia)

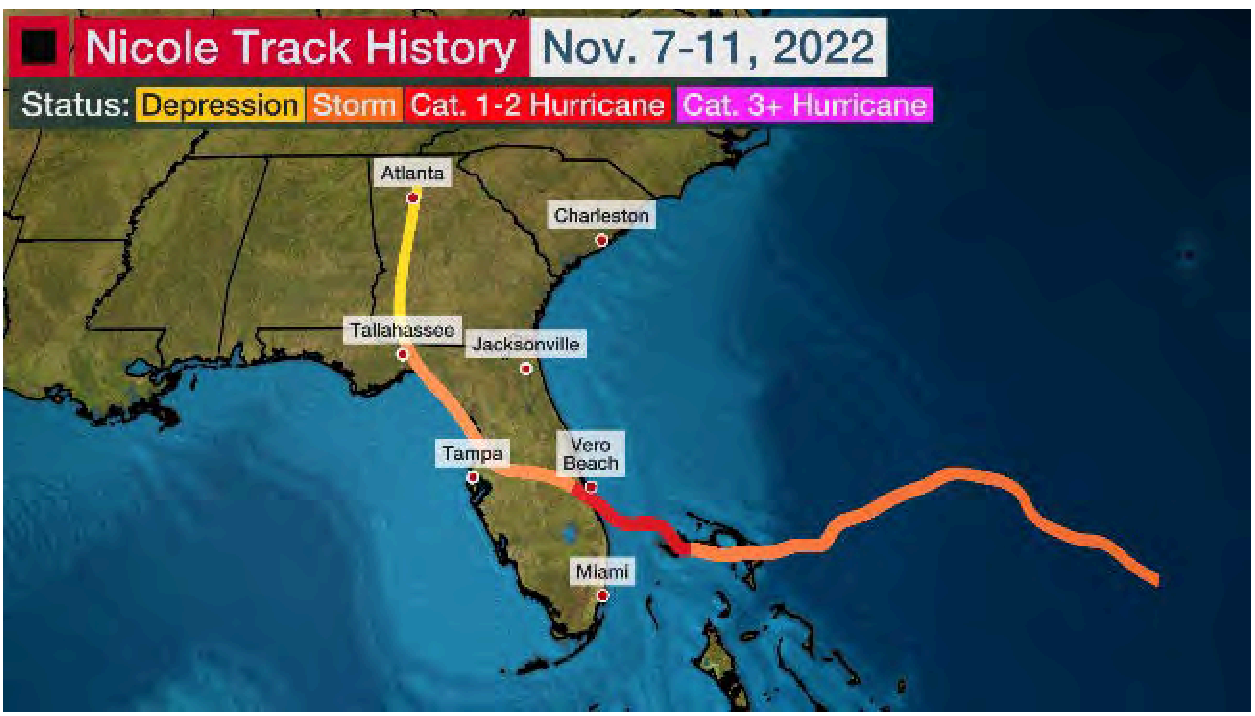

Figure 3.12 Path of Hurricane Nicole (https://www.wunderground.com/article/storms/hurricane/news/2022-11-11-hurricane-nicole-recap-florida-southeast)

Figure 3.13 presents a cumulative frequency distribution of tropical storms and hurricanes since 1850. One may draw best-fit lines through the data to estimate storm frequency trends. Except for two periods, the study area has averaged approximately one storm every two years. From 1876 – 1889, the study area averaged one storm per year. For a 12-yr period from 1989 – 2001, no storm eyes came within 60 nmi of the study area. Notably, Hurricane Floyd (1999), an especially large storm, did affect most of Florida's east coast but its eye did not come within 60 nmi of the Matanzas Inlet area.

Table 3.3 presents the Saffir-Simpson scale associated with these events. **Figure 3.14** sorts the storms by Saffir-Simpson category and 19-yr periods, coinciding with different tidal epochs, since 1903. Note that *TS* corresponds to tropical storms, *H1* refers to Category 1 hurricanes, *H2* refers to Category 2 hurricanes, and so on. The figure suggests that the number of storms since 2002 is not appreciably different from other periods of record. The 1983-2001 period was a period of low activity relative to the other periods.

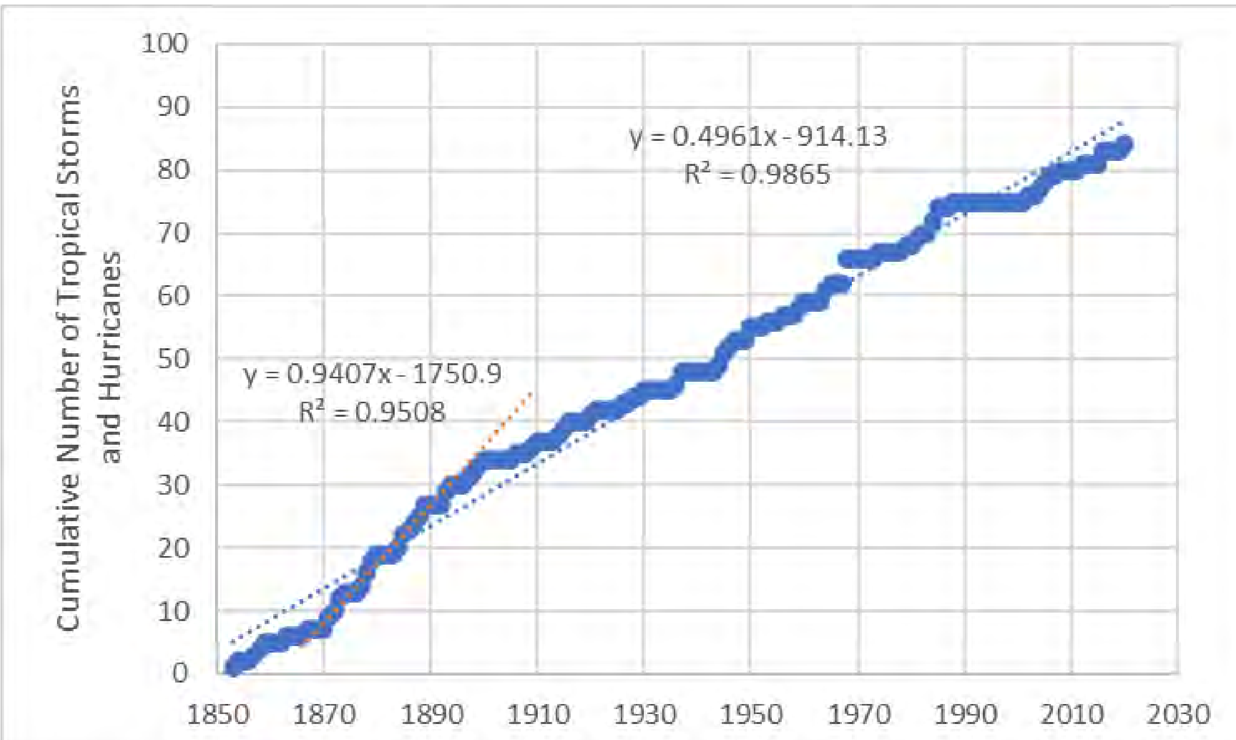

Figure 3.13 Cumulative Number of Tropical Storms and Hurricanes since 1850

Table 3.3 Saffir-Simpson Scale for Tropical Events

Scale	Maximum Sustained Wind Speeds (mph)
Tropical Storm	39-73
Category 1	74-95
Category 2	96-110
Category 3	111-130
Category 4	131-155
Category 5	>155

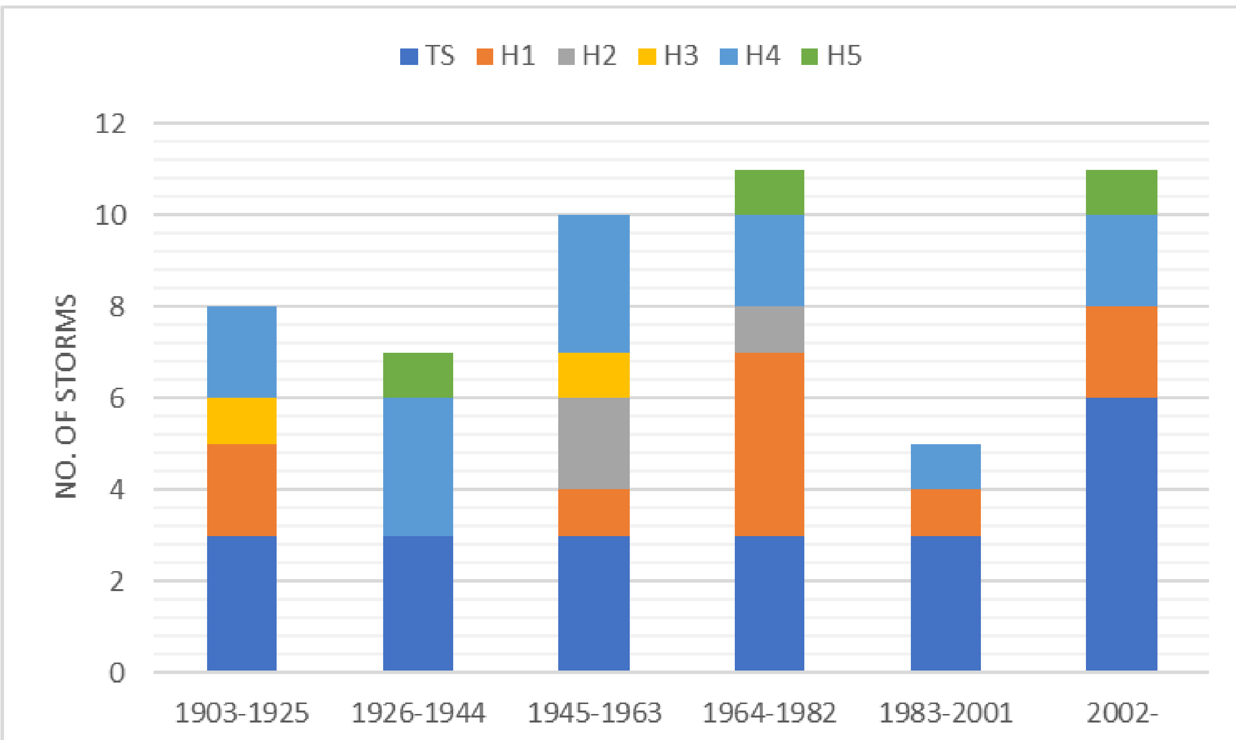

Figure 3.14 Tropical Storms and Hurricanes since 1903

These tropical storms and hurricanes produce storm surge, an increase in normal water levels resulting from barometric tide (rise in water associated with low barometric pressure of storm), wind setup, Coriolis force, and wave setup. Many authors typically ascribe return periods to storms based on their total storm tide elevations, which include storm surge and astronomical tide. **Figure 3.15** presents total storm tide as a function of return period for the study area based on Dean et al. (1987) and FDEP (2009). Notably, the FDEP includes tropical storms whereas Dean et al. does not. The curves allow for estimating the return period of recent storms — Hurricane Matthew (2016), Hurricane Irma (2017), Hurricane Dorian (2019), Hurricane Ian (2022), and Hurricane Nicole (2022). Water levels from NOAA storm reports (Stewart, 2017; Cangialosi et al., 2018; and Avila et al., 2020), United States Geological Survey (USGS) gages (https://stn.wim.usgs.gov/FEV/#2022Ian), and NOAA observed water levels (https://tidesandcurrents.noaa.gov/) informed where to enter **Figure 3.15**. **Table 3.4** summarizes the return period range for the five storms listed above. As a conservative measure, this study adopts the FDEP curve, extrapolated to Dean et al.'s 100-yr value, for evaluating potential solutions as this curve predicts lower return periods than Dean et al. for the same water levels.

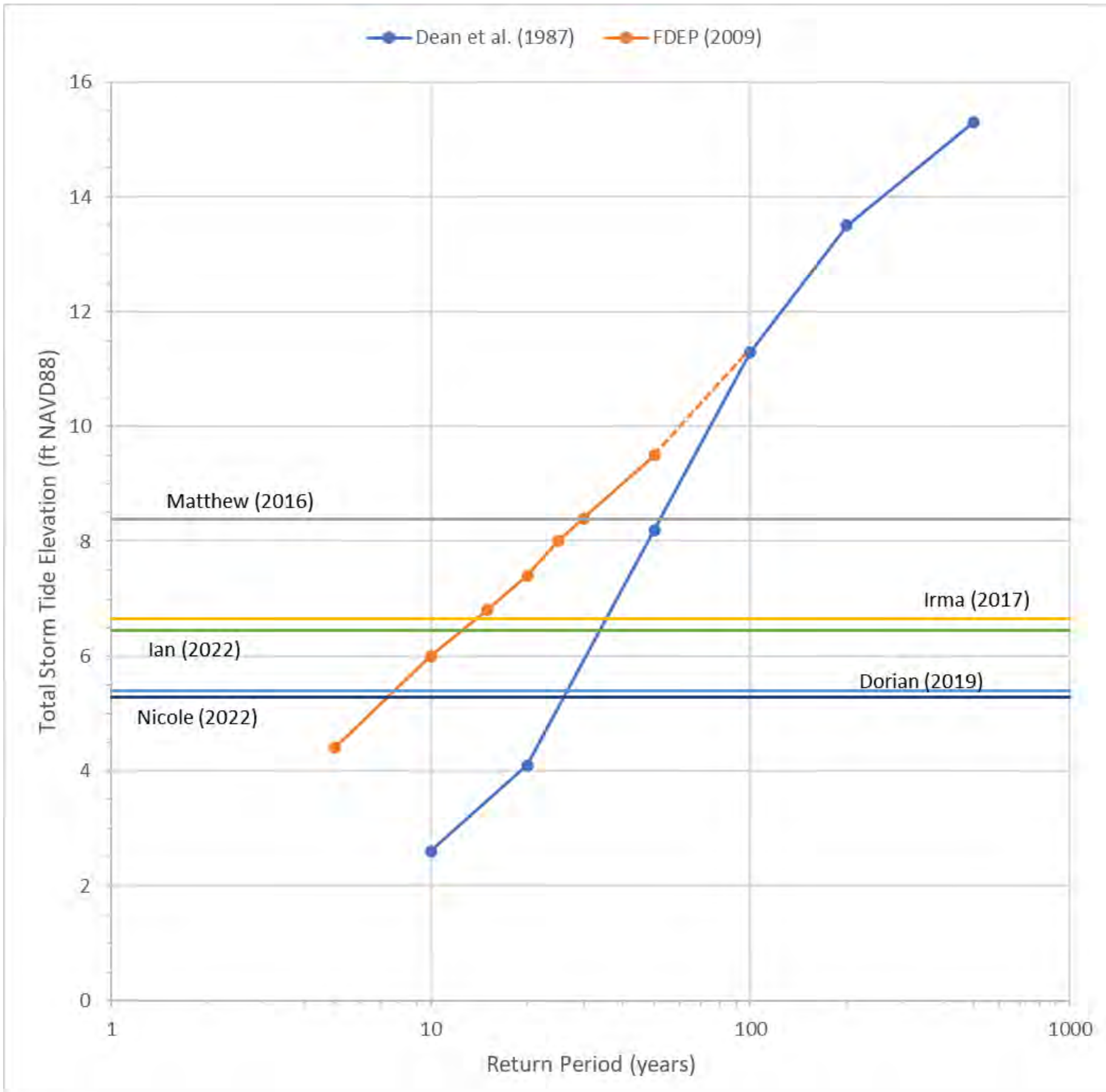

Figure 3.15 Total Storm Tide Return Periods

Table 3.4 Return Periods of Five Recent Hurricanes in the Study Area

Hurricane	Return Period Range (yrs)
Matthew (2016)	30-53
Irma (2017)	14-39
Dorian (2019)	8-29
Ian (2022)	13-37
Nicole (2022)	8-29

3.3.6.2 Nor'easters

During the late fall, winter, and spring, northeasters ("nor'easters"), with winds from the northeast, can erode the beaches. A nor'easter forms when a high-pressure system and a low-pressure system form near the Carolinas and offshore in the Caribbean. The clockwise circulation around the high pressure and the counterclockwise circulation around the low pressure set up a pressure gradient, producing strong northeast winds. Given their more frequent nature and longer duration, these storms can erode the beaches similar or greater levels than tropical events. A notable nor'easter includes the Thanksgiving Day Storm of 1984 that caused more than 30 ft of shoreline recession and 7.5 cy/ft of sand loss on average north and south of Matanzas Inlet (Florida Department of Natural Resources, 1985). More recently, a nor'easter in November 2021 caused erosion in much of the county. The USACE (2017) reports that nor'easters historically affect St. Johns County beaches approximately 1.75 times per year.

3.3.7 Native Beach Sediment

In 2010, in support of the permit application for FDEP Permit No. 0289228-001-JC, Taylor Engineering compiled, collected, and analyzed existing beach sediment data to determine the representative characteristics. Gradation test results previously prepared in 2008 by Universal Engineering Services, Inc. (UES) — who collected and sieved 23 beach sand samples at the top of the dune, in the County right-of-way, and on the berm along profile lines R-200 to R-208 — characterized the grain size distribution. To determine the carbonate content, Ellis & Associates, Inc. tested five beach sediment samples (collected by Taylor Engineering) representing the vegetated dune, dune toe, mid-berm, intertidal, and wading depth regions along the R-205 profile. Appendix G contains the test results and gradation curves for the above samples.

Based on results of the above analysis, FDEP incorporated the sediment compliance parameters into the Sediment Quality Control/Quality Assurance Plan for Permit Number 0289228-001-JC (**Table 3.5**), as well as subsequent permits, to ensure that borrow material remains compatible with the existing beach sand. Of note, given the several beach placements of ICWW maintenance dredging material along the Summer Haven shoreline prior to UES' and Taylor Engineering's beach sediment sampling, the values in in the table represent the existing beach at the time but not necessarily the true native beach sand that existed prior to any beach fill events.

Table 3.5 Sediment Parameter Guidelines for Summer Haven Beaches

Sediment Parameter	Parameter Definition	Compliance Value
Max Silt Content	Passing #230 Sieve	2%
Max. Shell Content*	Retained on #4 Sieve	10%
Munsell Color Value	Moist Value (chroma=1)	6 or lighter
Mean Grain Size	Moments Method	0.15 mm – 0.35 mm
*Shell Content is used as the indicator of fine gravel content for the implementation of quality control/quality assurance procedures.		

3.3.8 Sand Sources

As mentioned, prior beach management efforts have involved beneficial use of dredge materials from the ICWW, excavated overwash deposits from the SHR, stored dredge materials from FIND's DMMA SJ-1, and other upland sites (documentation unavailable for projects from 2002-2007 per **Table 2.1**). The following paragraphs summarize the borrow sources available to support the potential alternatives discussed in Chapter 5.

3.3.8.1 Intracoastal Waterway

Since 1992, FIND/USACE has predominantly placed the beach compatible dredged materials from the nearby ICWW reaches on the Summer Haven shoreline. This sediment, composed of fine sand that strong inlet and river currents can transport to the ICWW, is similar in size to native beach dune sand but finer than the native beach berm. Based on samples collected in late 2008, the USACE (2010) reports the ICWW material consists of mean grain sizes ranging from 0.13 to 0.24 mm (with a composite mean of 0.16 mm), silt content of 3.2%. The smaller sand size proves unstable when subject to the ocean waves and typically erodes quickly, providing short-lived storm protection benefits. This beneficial use of dredge material practice, however, is valuable due to its high frequency, typically substantial fill volume, and costs borne by the federal government. Federal spending restrictions typically prevent USACE from shaping a dune with the fill material or significantly altering its fill placemen template. However, dune construction or template modifications to improve project benefits may remain an option should a non-federal partner cover the incremental cost (as St. Johns County has done previously). Beach placement of dredged materials represents a valuable supplement to any long-term solution to maintain flow through the SHR but is not alone suitable for any large-scale beach restoration efforts designed for long-term storm protection.

3.3.8.2 Florida Inland Navigation District Dredge Material Management Areas

The County's existing state and federal permits — 0289228-001-JC and SAJ-2012-02400(SP-SCW) — for Summer Haven Dune and Beach Placement authorize DMMAs SJ-1 and FL-3 as borrow sites containing beach quality sand (**Figure 3.16**). Taylor Engineering (2010 and 2020) report composite statistics for each of the DMMAs (**Table 3.6**). The County has placed SJ-1 material on the beach for two significant projects:

(1) the County's 2011 FEMA emergency berm project and (2) FIND's 1999 large-scale offloading of SJ-1 (**Table 2.1**). Recently authorized by FDEP in 2020, no entity has yet utilized FL-3 material for Summer Haven projects. Both sites contain sand derived from ICWW maintenance dredging — SJ-1 for reaches near Matanzas Inlet and SHR and FL-3 for ICWW reaches in Palm Coast — which are not ideal for beach nourishment as mentioned above. Recent estimates suggest approximately 86,000 cy remain in SJ-1 and 280,000 cy in FL-3 (ATM, 2021). However, not all the material may prove beach compatible. To access sand in the DMMAs, FIND requires execution of a Use Agreement, approval from its Executive Director for any removal less than 50,000 cy, and approval from its Board of Commissioners for any removal that exceeds 50,000 cy. The DMMAs are suitable for smaller-scale dune restoration or emergency berm efforts; however, the available volume and small grain size of the material is not suitable for any large-scale beach restoration efforts designed for long-term storm protection. FIND typically does not charge for sand from DMMAs. Finally, note that Flagler County is currently utilizing an unknown portion of the FL-3 material to restore some of its dunes north of Flagler Beach.

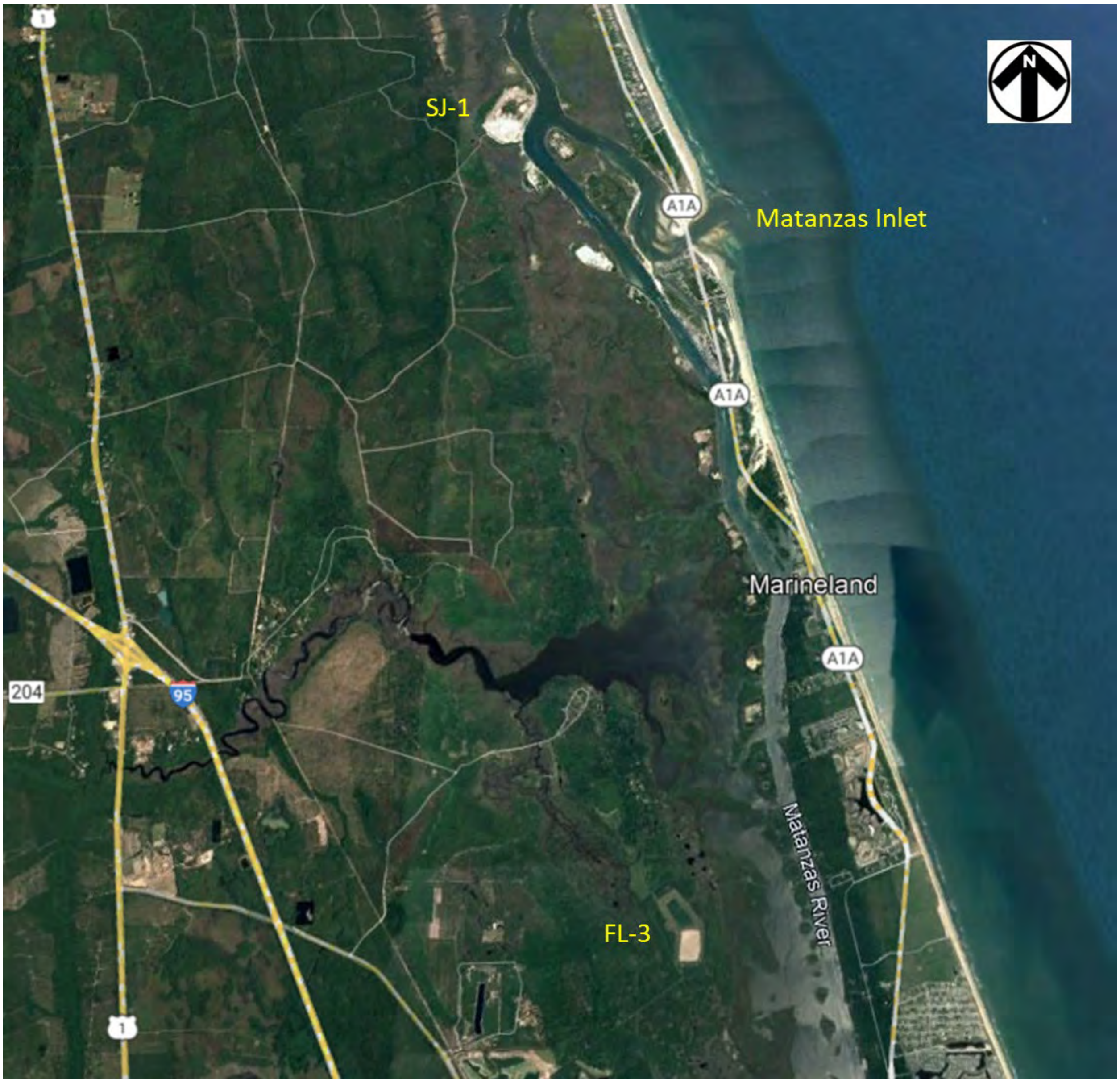

Figure 3.16 Location Map of Nearby FIND DMMAs

Table 3.6 SJ-1 and FL-3 Composite Sediment Characteristics

Parameter	SJ-1	FL-3
Mean Grain Size (mm)	0.18	0.28
Sorting (phi)	0.85	1.13
Silt (%)	0.4	0.68
Carbonate Content (%)	6.2	6.7 – 33.5
Munsell Color	2.5YR 7/2 – 5Y 7/2	5Y 6/1 – 5Y 8/1

3.3.8.3 Inland Commercial Mines

Private, commercial inland mines have proven a reliable source of beach compatible sand for County beaches. These commercial sources, many of which the FDEP has pre-approved, can produce more desirable coarse fill material (generally ranging up to 0.45 mm mean grain size); however, the costs to purchase the material and haul it long distances — the closest, largest-producing mines locate in Grandin, Interlachen, and Keystone Heights between Gainesville and Palatka (**Figure 3.17**) — are often relatively high. Many entities prefer importing sand from offshore, with typically higher production rates and avoidance of traffic and road use impacts, and less expensive unit costs for large-scale beach nourishment projects. However, with dredging costs continuously increasing and close offshore sources becoming scarcer in Florida, several large-scale beach restoration projects in Florida have sourced the beach fill from upland mines. For ongoing dune restoration work in north Flagler County, the winning bidder provided 71,343 tons (approximately 49,544 cy) of sand from mines near Interlachen and Keystone Heights for a cost of $44.39/ton ($30.83/cy) (inclusive of material, transportation, and placement costs) for an 8,300-ft-long project area.

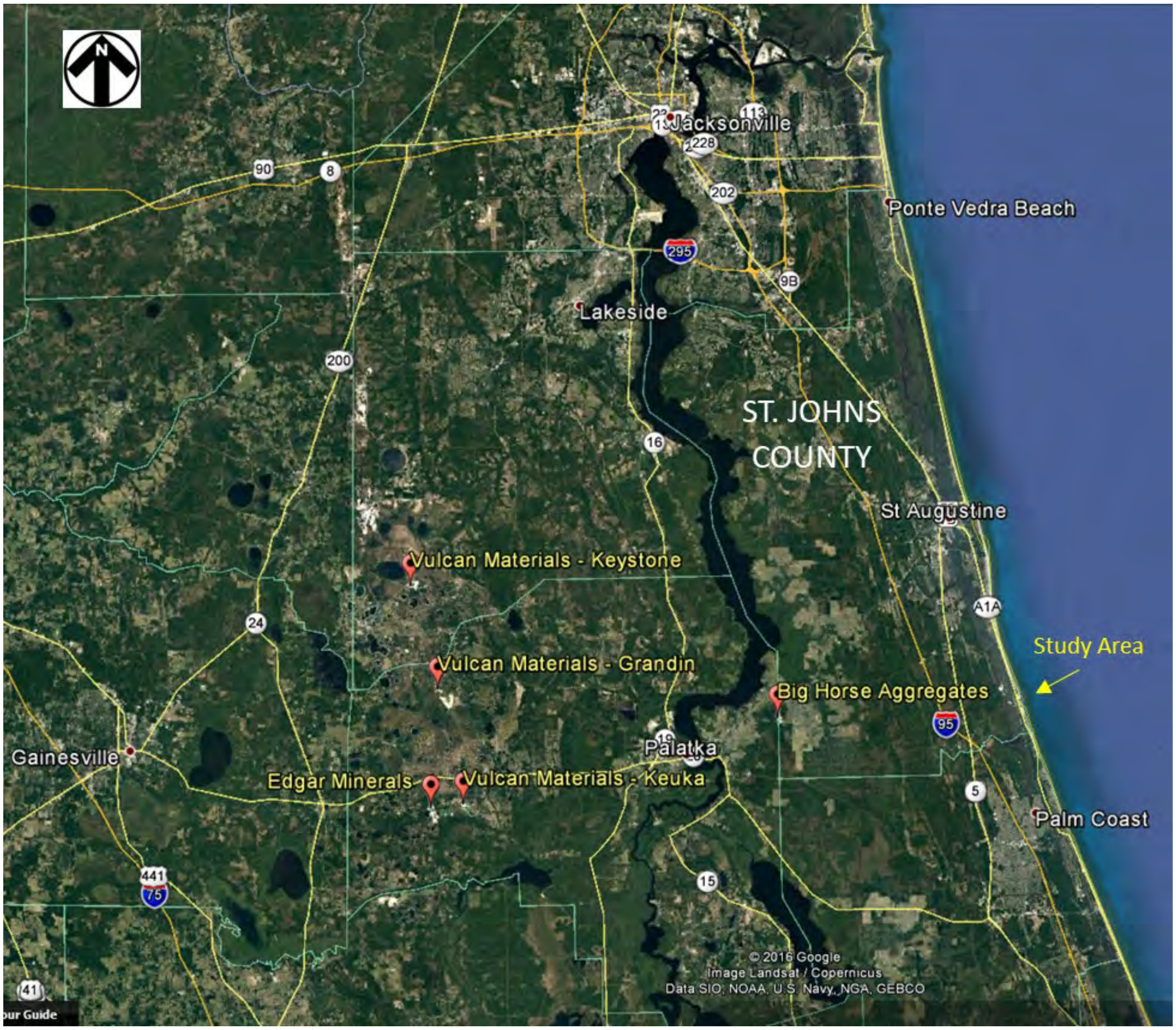

Figure 3.17 Location Map of Nearby Commercial Sand Mines (INTERA, 2017)

3.3.8.4 Summer Haven River

The authorized dredging templates at the north end of the river, authorized for the SHRRP, and the south end, authorized in 2021 as an extension of the SHRRP template, define the vertical and horizontal extends of beach compatible sand (existing at the time of the permit applications) that could feasibly be removed to restore flow through the river from the inlet to the ICWW. Following the impacts of hurricanes Ian and Nicole, any future efforts to restore the river with a long-term solution should re-examine the dredging templates and river shoaling to capture any additional overwash deposits.

Since 2017, FDEP has authorized excavation of overwash in the southern portion of the river to allow stakeholders to return the material to the beach to manage closure of the recurring breaches and rebuild the dunes. FDEP has only authorized each event as a one-time occurrence, requiring permit modifications for each subsequent or any future event. The river deposits represent an inexpensive source of beach compatible material. However, the available volume is insufficient for any large-scale beach restoration efforts designed for long-term storm protection.

3.3.8.5 Matanzas Inlet Flood Shoal

Figure 3.18 shows the location of the inlet's flood shoal complex. No known dredging of this complex has occurred. INTERA-GEC collected six grab samples from 0-1 ft below top of ground at different areas of the shoal to characterize the material. The median grain sizes of the samples vary from 0.19 to 1.36 mm (composite mean of 0.60 mm) depending on shell content, which varies from 0 to 20%. Of note, the Florida Department of State Bureau of Historic Preservation has confirmed the presence of cultural resources nearby but not within the flood shoal complex (see Appendix H); however, future findings of any significant cultural resources within the shoal (e.g., shipwrecks) may affect use of the shoal as a borrow source.

Figure 3.18 Matanzas Inlet Flood Shoal Complex and Location of Sediment Grab Samples

3.3.8.6 Offshore Sources

Figure 3.19 shows known sand sources spanning southern St. Johns County – northern Volusia County as identified in USACE's Sand Availability and Needs Determination (SAND) study — part of the South Atlantic Coastal Study (SACS) authorized by Section 1204 of the Water Resources Development Act of 2016 — which quantified 50-year sand needs and available sand resources for all current (at the time of the study) federal and non-federal beach nourishment projects in the USACE South Atlantic Division (SAD). USACE organized sand sources into the following categories.

- Proven — Resource areas with beach-quality sand whose thickness and lateral extent have been fully determined through design-level geotechnical data and in most cases are permitted.
- Potential — Resource areas with beach-quality sand whose existence has been verified through preliminary geotechnical and geophysical data (with vibracores approximately one mile apart). Thickness and/or lateral extent has been preliminarily determined.
- Unverified Plus — Resource areas hypothesized to exist on the basis of geophysical evidence (seismic profiles, bathymetry, or side scan sonar) and at least one geotechnical core or surficial samples verifying beach-quality sand.
- Unverified — Resource areas hypothesized to exist based on indirect evidence for the presence of beach-quality sand.
- Unusable — Unusable because (1) all beach-compatible material has been removed from the area prior to the SAND Study, (2) the sand source is inaccessible due to current conditions, or (3) the area was investigated and the presence of non-beach quality material throughout the area was verified.

The closest proven and potential sources offshore Butler Beach (approximately 10 miles northeast) and Flagler Beach (approximately 15 miles southeast) correspond to those investigated for the federal St. Johns County Shore Protection Project and Flagler County Coastal Storm Risk Management Project. **Figure 3.20**, which zooms into the Summer Haven vicinity, shows only unverified sources closer to the study area.

Currently, no proven offshore borrow area exists to solely provide beach fill for Summer Haven projects. Given the long-term sand needs for the currently authorized federal projects, coordination with USACE is necessary to identify the most suitable areas for further exploration should the County pursue identification of an offshore sand source. State and federal agencies do not charge for sand dredged from offshore.

Figure 3.19 Classification of Sand Sources Offshore Southern St. Johns County – Northern Volusia County (https://sacs.maps.arcgis.com/apps/dashboards/46d59434896a464a89d1f3b54d43d0d5)

Figure 3.20 Classification of Sand Sources Offshore Summer Haven (https://sacs.maps.arcgis.com/apps/dashboards/46d59434896a464a89d1f3b54d43d0d5)

4.0 Beach, Dune, and Waterway Conditions

The following section examines Matanzas Inlet and its surrounding areas to determine the historical trend of beach and shoreline erosion. It includes details of a longshore sediment transport analysis and presents a sediment budget.

4.1 MHW Shoreline Changes

This analysis assessed shoreline movement using historic MHW shoreline positions. MHW data along the County coastline originated from the FDEP's Public Files website (https://floridadep.gov/rcp/beaches-inlets-ports/content/historic-shoreline-database). MHW data, spanning 1867–2020, represent the distance between each FDEP reference monument to the MHW elevation contour for each year. **Table 4.1** shows a summary of the MHW data available within the project area. A comparison of the historic shoreline positions can suggest erosive or accretive trends. Undergoing both advancement and recession of the MHW position, shoreline changes fluctuate over time along the study area. The shoreline is dynamic and changing due to waves, winds, sea level change, storm events and erosion control measures.

Table 4.1 Available MHW Shoreline Data in the Study Area

Survey Year	Includes R-187 to 209	Survey Year	Includes R-187 to 209
1867-1872	Yes	1996	No (only R-200 to R-209)
1923	Yes	1997	Yes (except R-187 to R-189)
1952-1956	Yes	1999	Yes (except R-208, R-209)
1956-1957	Yes	2003	Yes
1970	No (only R-197 to R-200)	2007	Yes
1972	Yes	2011	Yes
1973-1975	Yes	2014	Yes
1979-1980	Yes	2016	Yes
1984	Yes	2017	Yes
1986	Yes	2019	Yes (except R-206)
1993	No (only R-192, R-195,R- 198, R-201, R-205, R-207)	2020	Yes (except R-195 to R-209)

Table 4.2 summarizes shoreline change rates in feet per year (ft/yr) for various periods determined via three different methods:

- End Point Method – determined simply by difference in the shoreline position at the beginning and end years of the period;

- Least Squares Method – based on the slope of a trend line fit by least square methods to all the data points within the period; and
- Average - a simple average of the End Point and Least Squares Methods.

Figure 4.1–**Figure 4.3** and **Table 4.2** show the shoreline change rates calculated via the end point method along the Atlantic beaches for the periods 1984–2022, 2007–2022, and 2016–2022. Appendix I contains historical (1867–2022) shoreline trend plots at each reference monument.

The shoreline change data indicate the following:

- The beaches in the study area historically fluctuate — with both recession and seaward advance.
- The beaches at R-196 to R-199 appear to be within the shadow and direct influence of the ebb shoal; the beach in this region predominantly experienced shoreline advance (except for recession at R-196 and R-197 from 1984 – 2022), likely associated with episodic transport of ebb shoal sediments onto the downdrift beach during storm event.
- The shoreline at R-199 remained relatively stable due to the existing revetment fixing the shoreline position.
- From 1984 – 2022, the shoreline predominantly receded both north and south of the inlet, with shoreline advance occurring only at the far north end and at R-197 and R-198. North of the inlet, the recession magnitudes generally increased towards the inlet, with a notable increase beginning at R-194 at the south end of Summerhouse. South of the inlet, the greatest shoreline recession occurred from R-200 to R-205, the beach fronting the SHR.
- From 2007 – 2022, a mix of shoreline recession and advance occurred both north and south of the inlet. North of the inlet, shoreline changes ranged from moderate shoreline advance to minor shoreline recession, except for the significant recession at R-195 reflecting the dynamic nature of the beach near the inlet. South of the inlet, the beach fronting the SHR (R-200 to R-205) experienced significant shoreline recession, while the beach further south experienced only minor shoreline recession or advance.
- From 2016– 2022, shoreline recession occurred north and south of the inlet primarily due to Hurricane Matthew and subsequent storms. North of the inlet, the shoreline recession magnitudes generally increased with distance away from the inlet, peaking at R-191 and then diminishing northward. South of the inlet, the shoreline recession magnitudes also increased with distance away from the inlet, peaking at R-205 in the current breach vicinity; minor shoreline recession predominantly occurred further south. The post-storm recovery activities in Summer Haven (i.e., beach placement of ICWW maintenance dredging material and overwash sediments excavated from SHR) likely partially offset the storm-induced shoreline recession.

Table 4.2 Historic MHW Change for Matanzas Inlet

FDEP Reference Monument	End Point Method			Least Squares Method			Average		
	1984 – 2022	2007 – 2022	2016 – 2022	1984 – 2022	2007 – 2022	2016 – 2022	1984 – 2022	2007 – 2022	2016 – 2022
R-187	1.4	3.8	-5.1	1.0	-2.6	-10.1	1.2	0.6	-7.6
R-188	0.7	1.4	-10.6	0.3	-4.2	-15.2	0.5	-1.4	-12.9
R-189	0.2	1.2	-11.2	-0.2	-4.2	-17.8	0.0	-1.5	-14.5
R-190	-0.6	-0.4	-15.1	-0.2	-4.1	-20.9	-0.4	-2.2	-18.0
R-191	-0.6	-2.0	-13.2	-1.1	-8.3	-18.8	-0.9	-5.1	-16.0
R-192	-1.0	0.4	-9.0	-2.0	-5.2	-13.0	-1.5	-2.4	-11.0
R-193	-0.8	0.1	-5.2	-2.2	-8.8	-11.4	-1.5	-4.4	-8.3
R-194	-3.2	-0.2	-10.1	-3.4	-9.3	-19.5	-3.3	-4.8	-14.8
R-195	-4.3	-6.3	-3.9	-4.8	-11.2	-6.1	-4.6	-8.7	-5.0
R-196	-4.7	2.1	1.0	-3.8	-1.8	3.7	-4.3	0.2	2.4
Inlet									
R-197	-1.3	4.1	6.6	-2.0	2.2	7.6	-1.7	3.2	7.1
R-198	5.3	6.2	19.3	1.7	4.7	5.9	3.5	5.5	12.6
R-199	-0.2	0.0	0.4	-0.3	-0.3	-2.1	-0.3	-0.1	-0.8
R-200	-2.2	-2.3	-0.9	-1.6	-1.7	-7.0	-1.9	-2.0	-3.9
R-201	-2.8	-6.1	-2.7	-2.1	-3.4	-1.5	-2.5	-4.7	-2.1
R-202	-2.3	-5.9	-5.2	-2.2	-7.1	-2.5	-2.2	-6.5	-3.9
R-203	-2.3	-4.1	-8.3	-2.1	-5.0	-4.6	-2.2	-4.5	-6.5
R-204	-2.0	-5.6	-9.1	-1.7	-6.8	-7.7	-1.8	-6.2	-8.4
R-205	-3.1	-7.6	-13.9	-0.9	-7.1	-24.9	-2.0	-7.4	-19.4
R-206	-0.8	-0.3	-1.2	0.4	0.2	-8.9	-0.2	0.0	-5.1
R-207	0.2	2.1	0.5	0.2	1.5	-4.3	0.2	1.8	-1.9
R-208	-1.3	-1.0	-3.5	-0.4	-2.1	-6.6	-0.9	-1.5	-5.0
R-209	-0.8	0.6	-1.6	-0.4	-1.4	-3.0	-0.6	-0.4	-2.3

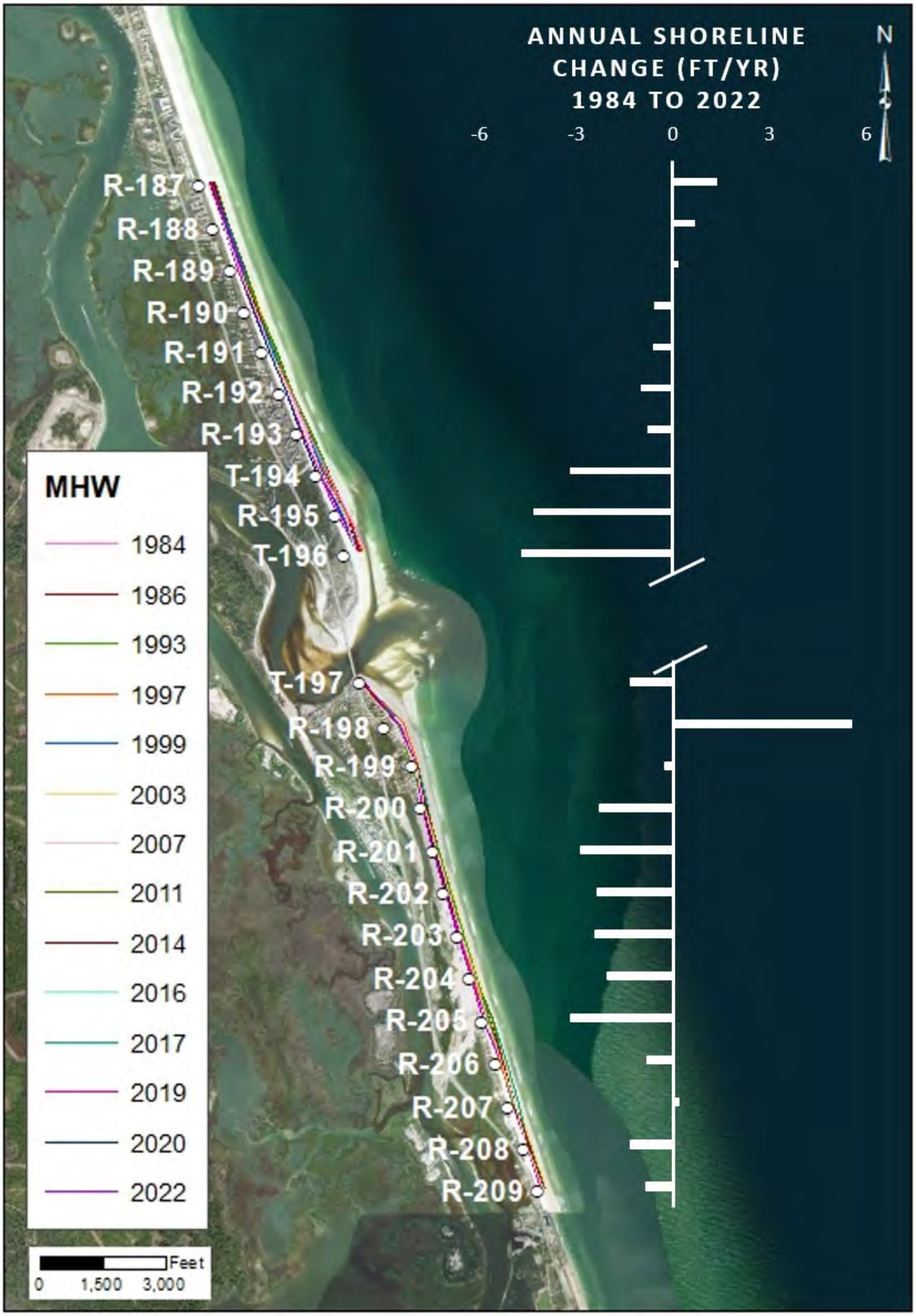

Figure 4.1 Shoreline Change Rates 1984 – 2022

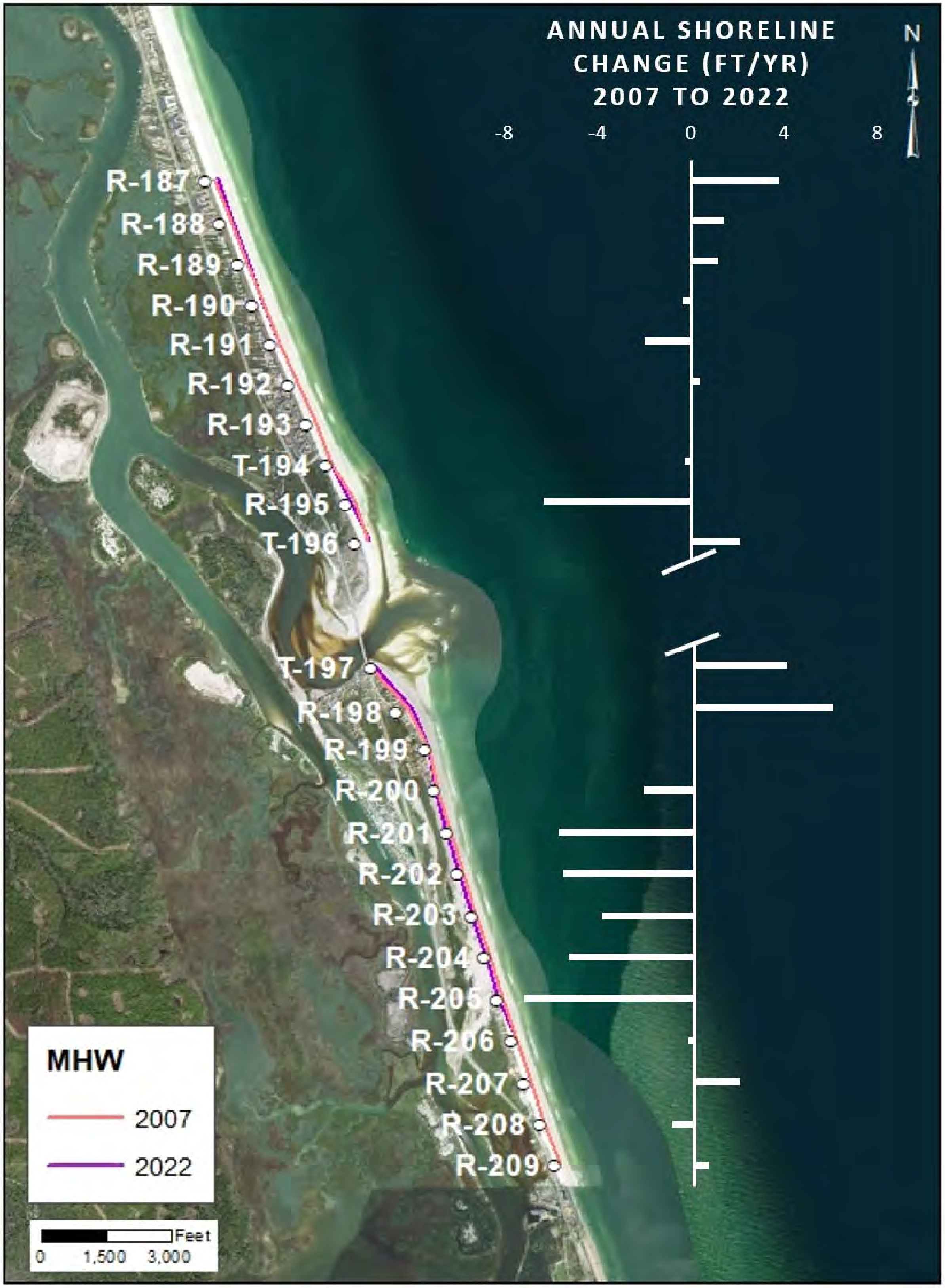

Figure 4.2 Shoreline Change Rates 2007 – 2022

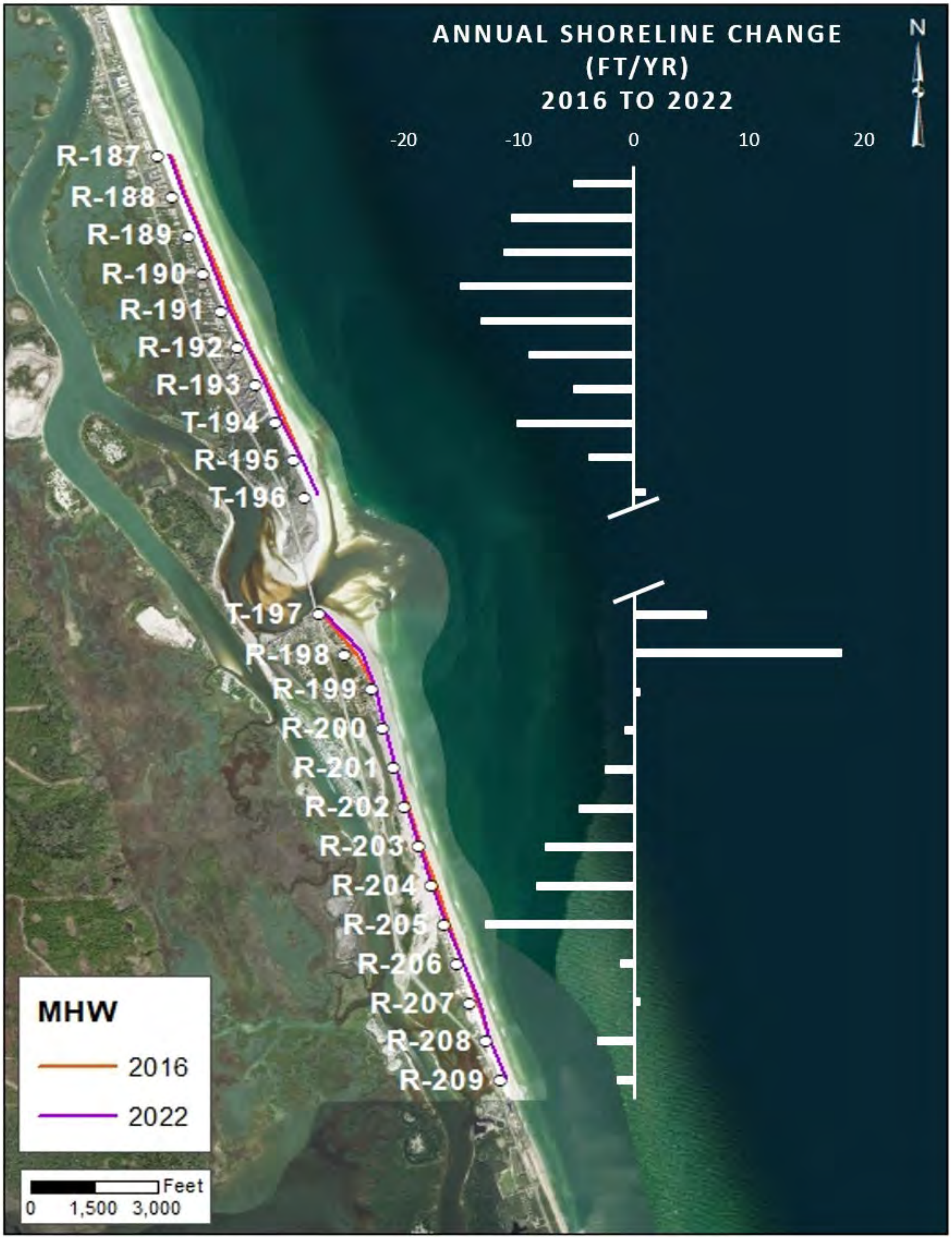

Figure 4.3 Shoreline Change Rates 2016 – 2022

4.2 Beach Volume Changes

Beach profile surveys along the St. Johns County coastline — available on FDEP's website (http://publicfiles.dep.state.fl.us/DWRM/Beaches/HSSD/ProfileData/prof839088/) — span the years 1972–2020 (**Table 2.3**). In concert with formulation of the sediment budget, data for years 2007, 2016 (pre-Hurricane Matthew), and 2022 were selected for quantitative analysis based on the completeness of the data. Appendix J shows the representative beach profiles for these years.

Volume change analysis was performed within a GIS framework using ArcMap 10.8.1. The analysis subdivided the study area into cells (**Figure 4.4**) used in the sediment budget (Section 4.5) as follows:

- Cells N1, N2, and N3 – corresponding to the beach north of the Inlet;
- Cell ES – corresponding to the ebb shoal;
- Cell FS – corresponding to the flood shoal – including the Summer Haven River; and
- Cells S1, S2, and S3 – corresponding to the beach south of the inlet.

Figure 4.5 shows the volume changes above and below MHW as well as the above the depth of closure from R-187 to R-209 for the period 2007-2022. **Figure 4.6** shows these volume changes for the period 2016–2022. **Figure 4.7** shows the volume changes for the period 2007-2022 within the sediment budget cells. **Figure 4.8** show the volume changes for the period 2016-2022 in the sediment budget cells. The data indicate:

- Between 2007 and 2022, the study area predominately gained sand — except near the north side of the inlet (N3) and the Summer Haven beaches (S1 and S2). Interestingly, the beaches generally accreted just south of the inlet and eroded just north of the inlet. This pattern suggests a possible longshore sediment transport gradient from south to north near the south side of the inlet.
- Between 2016 and 2022:
    - The study area predominately lost sand – likely attributable to heightened storm activity over this period, including hurricanes Matthew (2016), Irma (2017), Dorian (2019), Ian (2022), and Nicole (2022) and multiple northeasters.
    - Beaches north of the inlet lost sand primarily above MHW — likely attributable to storm-induced wave action driving sand from the beach and dune southwards toward the inlet (i.e., reflecting the net southward littoral drift).
    - Beaches south of the inlet lost sand predominately below MHW — likely attributable to an inlet-induced downdrift longshore sediment transport deficit created by the inlet's sand trapping effect (i.e., net accretion of sand in the flood shoal and interior waterways).

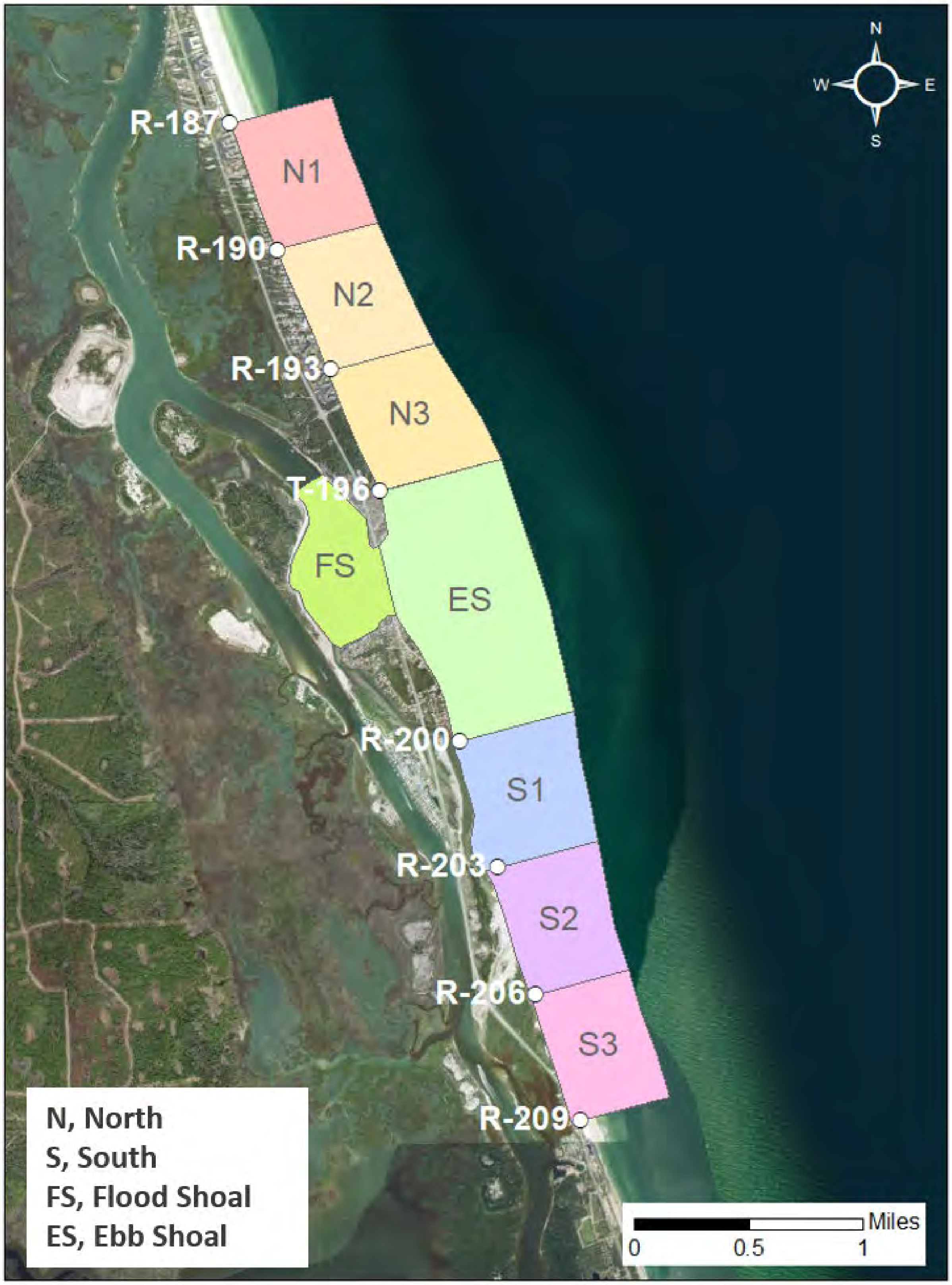

Figure 4.4 Sediment Budget Cells

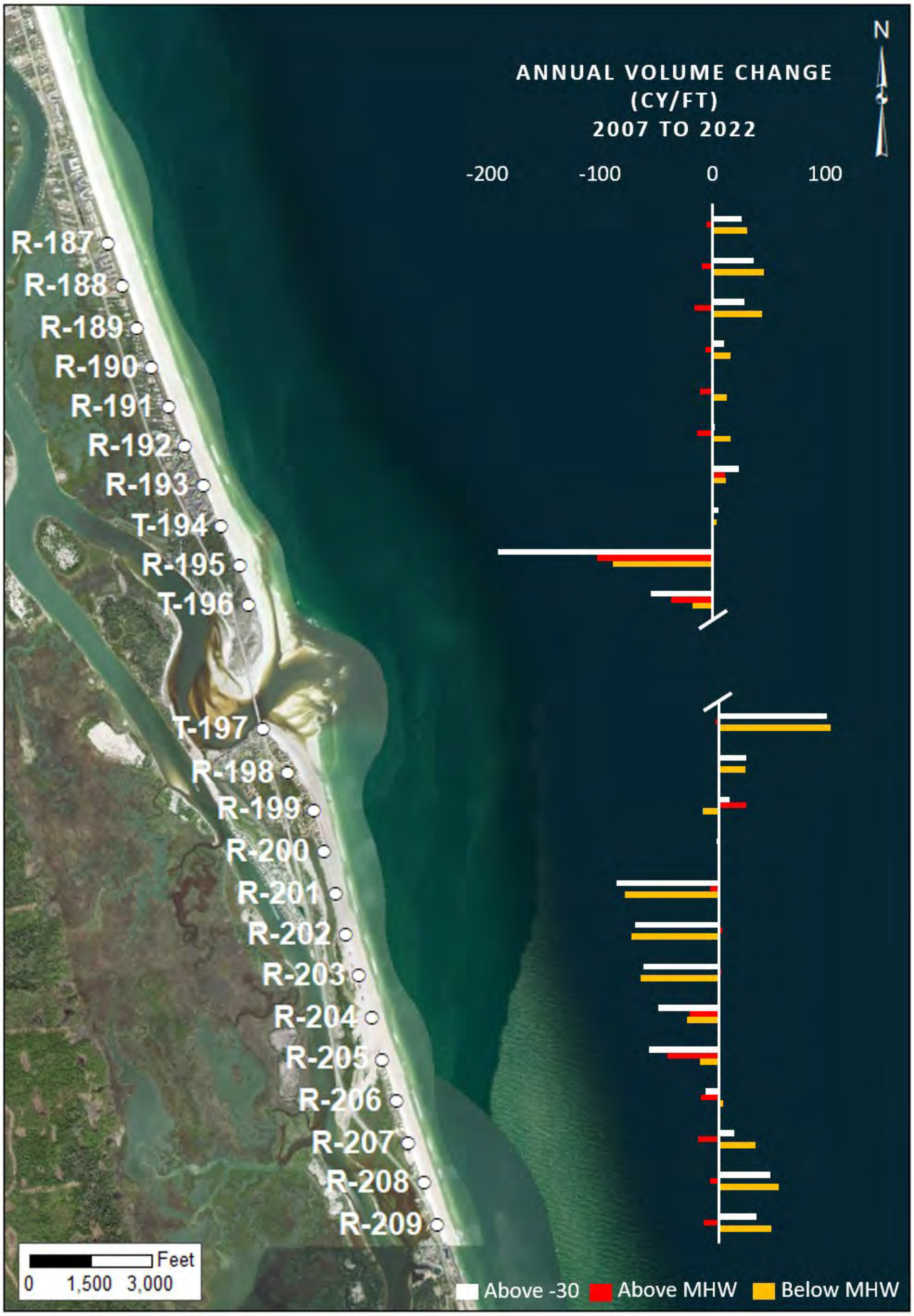

Figure 4.5 2007–2022 Volume Changes by Monument

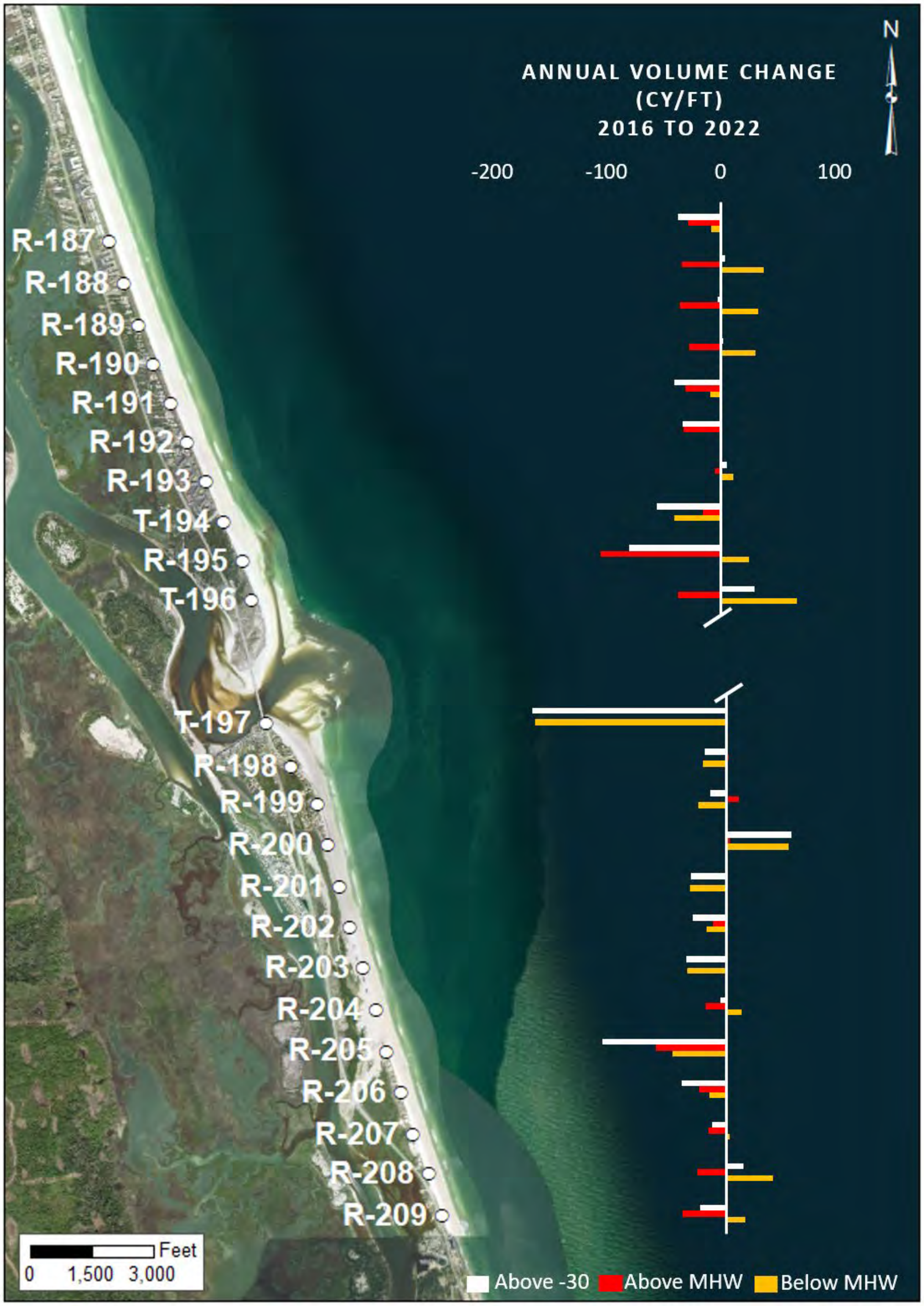

Figure 4.6 2016–2022 Volume Changes by Monument

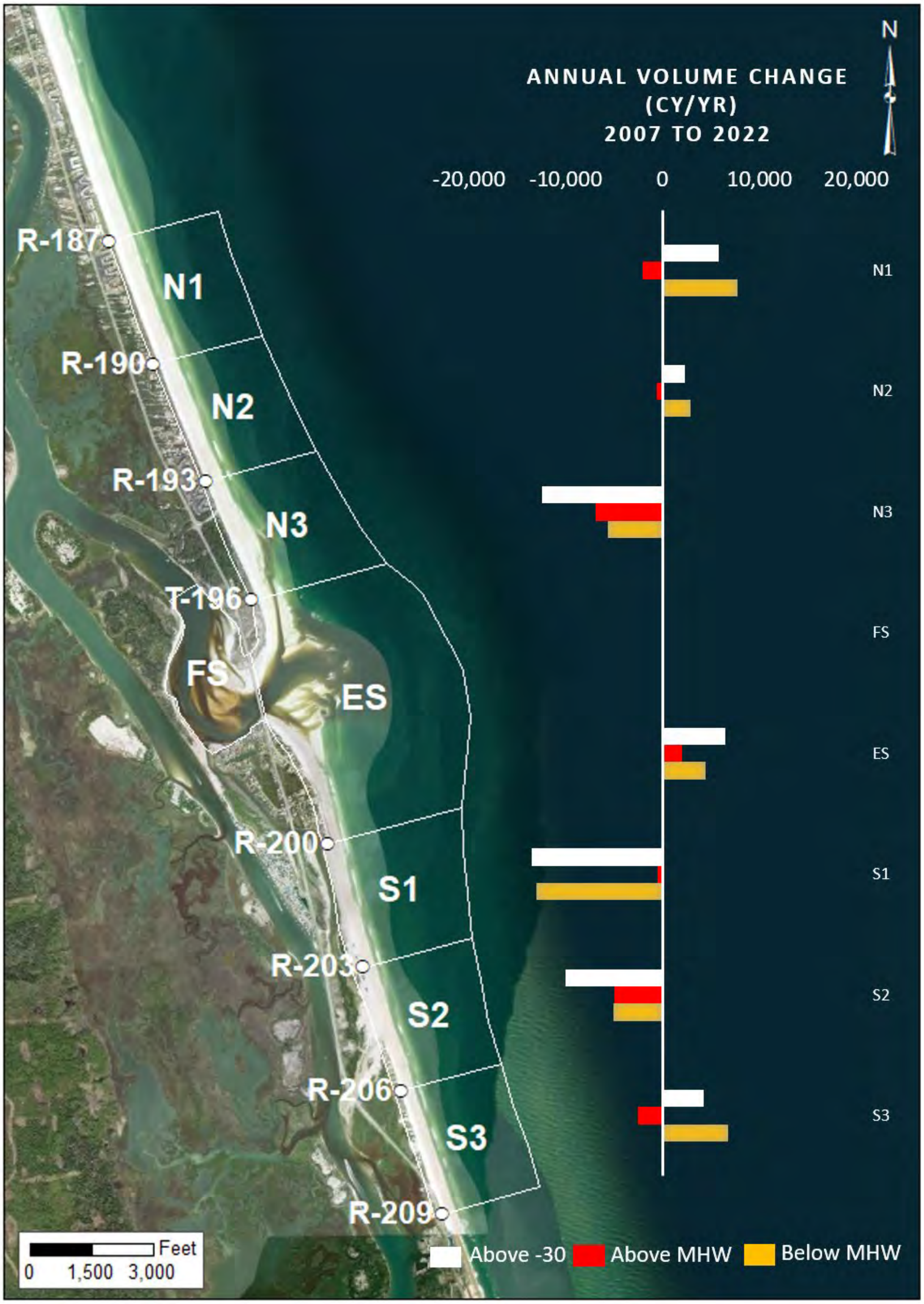

Figure 4.7 2007–2022 Beach Volume Changes in the Sediment Budget Cells

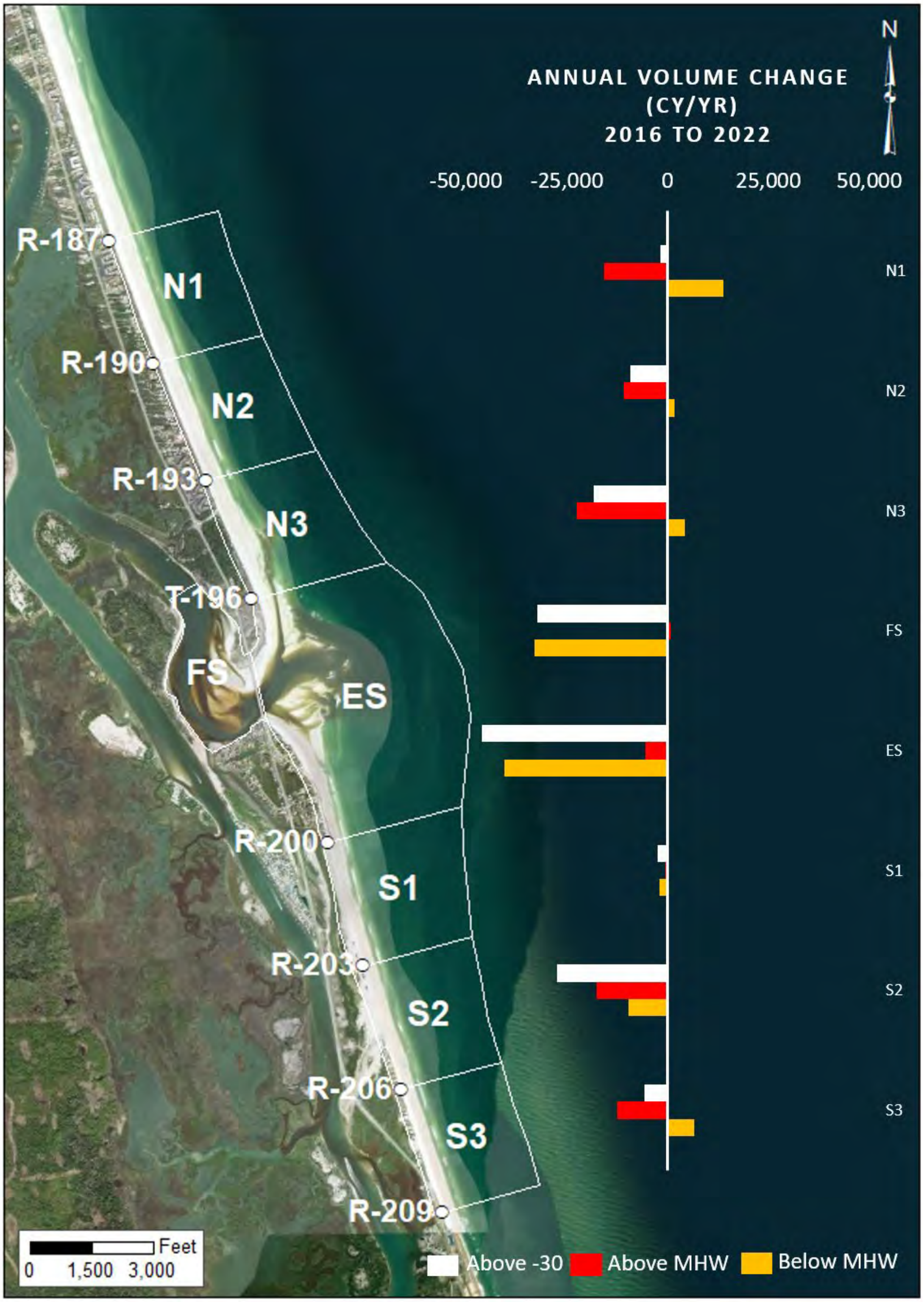

Figure 4.8 2016–2022 Beach Volume Changes in the Sediment Budget Cells

4.3 Longshore Sediment Transport Potential

Wave-driven longshore sediment transport occurs in the nearshore zone when waves break at oblique angles resulting in energy dissipation and momentum flux transfer to the water column. Wave breaking energy dissipation primarily drives sediment mobilization, while the longshore component of wave momentum flux generates surf zone currents that also transport sediments alongshore. Numerous authors have derived several formulas to determine bulk longshore sediment transport rates, primarily from wave energy flux considerations (e.g. USACE, 1984; Van Hijum et al., 1989), dimensional analyses (e.g. Kamphuis, 1991), or empirical relationships (e.g., van der Meer, 1990). Input parameters generally range from deepwater wave height, period, and direction to several nearshore wave, sediment, and beach profile characteristics. Each formula, rigorously tested and verified by field data or laboratory experiments, has proven reliable under various wave and nearshore conditions. The accuracy of each formula generally reflects the level of input parameters required. This section discusses application of the CERC formula (USACE, 1984) and presents longshore sediment transport rates.

To quantify bulk sediment transport rates, many coastal engineers apply the CERC formula, presented in the *Shore Protection Manual* (SPM) (USACE, 1984) and subsequent USACE manuals. The form in the SPM appears as

$$Q = \frac{K H_b^2 C_{gb} \sin(2\alpha_b)}{16(s-1)a'} \tag{1}$$

where H_b is the breaking significant wave height, C_{gb} is the wave group velocity at breaking, α_b is the wave ray direction (measured from shore normal), a' is the sediment volume fraction of the bed, s is the specific gravity of the sediment, and K is an empirical constant.

Numerous authors (e.g., Bodge and Kraus [1991] and Kamphuis and Sayao [1982] as cited in Kamphuis [1991]) have devoted much attention to the K coefficient value. Notably, the K value, a tunable parameter, requires calibration for every application. For this project, the authors set K equal to 0.81 to ideally match previously published rate magnitudes in the study area.

Notably, the above formula calculates longshore sediment transport potential (LSTP), which may or may not differ from actual longshore sediment transport occurring in the area. Actual longshore transport is a function of sediment availability, site-specific grain size, and nearshore characteristics.

Waves propagating over a complex bathymetry change in height and direction due to the interaction of many processes. These processes include wave shoaling, refraction, diffraction, and energy dissipation from depth-induced wave breaking. Simulating the effects of these complex processes and interactions requires the application of a wave propagation model, in this case SWAN. Numerical modeling of different incident wave conditions provides a means to assess resultant nearshore wave height patterns.

SWAN (Simulating Waves Nearshore) (https://swanmodel.sourceforge.io/) simulates wave transformation patterns from an offshore boundary to the shoreline. Developed at the Delft University of Technology in the Netherlands, SWAN is a one- and two-dimensional numerical model for estimating wave parameters in coastal areas, lakes, and estuaries from given wind, bathymetric, and current conditions. The wave action balance equation with sources and sinks forms the basis of the model. Wave propagation processes represented include propagation through geographic space, refraction due to spatial variations in bottom and current, shoaling due to spatial variations in bottom and current, blocking and reflections by opposing currents, and transmission through, blockage by, or reflection against obstacles. Wave generation and dissipation processes represented include generation by wind; dissipation by white-capping, depth-induced wave breaking, and bottom friction; and wave-wave interactions. The model contains both stationary and nonstationary operational modes formulated for Cartesian, curvilinear, or spherical coordinate systems. Extensive refinement and verification over the past decade have resulted in a robust, state-of-the-art model for wave propagation applications.

Determining the direction of sediment transport (i.e., north or south) requires referencing the direction of approaching waves with respect to shore-normal, defined as a direction perpendicular to the local shoreline. With the shore-normal direction taken as 0°, one assumes a positive wave direction for waves approaching counter-clockwise from shore-normal and a negative wave direction for waves approaching clockwise from shore-normal. Positive sediment transport reflects a positive wave direction whereas negative sediment transport reflects a negative wave direction. For example, for an observer standing onshore and looking at the water, positive transport represents transport to the right of the observer. Note that waves traveling directly onshore (i.e., 0° wave direction) do not contribute to any longshore sediment transport. The study area from north to south generally orients along the 345°-165° from North axis.

Because of the complex bathymetry, SWAN provided breaking wave heights as input for the longshore sediment transport calculations. Eight wave cases represented the waves propagating toward the shoreline in this analysis. Derived from the WIS data at station 63419, **Table 4.3** presents the azimuths of the eight wave angle band limits, the percent occurrence, average wave height, average peak period, and median direction of each band. Onshore waves occur about 95% of the time.

SWAN model input requires (1) a bathymetric mesh and (2) the incident wave energy spectrum specified at the offshore mesh boundary. The bathymetry collected by Arc Surveying and Mapping in fall 2022 represented nearshore conditions (40-ft and shallower water depths) while bathymetry obtained from NOAA's Digital Coast represented offshore conditions. **Figure 4.9** shows the SWAN model mesh. The mesh contains more than 26,200 triangular elements with more than 13,400 nodes at the corners of these elements. Note that SWAN requires inputs in metric units.

Each angle band in **Table 4.3** represents an incident wave condition. Typically, one applies a JONSWAP parametric spectral shape, together with a directional spreading function, at the offshore boundary as a two-dimensional incident wave spectrum. **Table 4.3** lists the input for wave height, peak period, and mean direction at an offshore boundary depth of nearly 22 meters (m). SWAN provides the wave height and angle at each node from the offshore boundary toward the shoreline for each wave condition and the location of the depth-limited breaking location. For locations where the waves did not break, the authors calculated the breaking depth one node offshore the shoreline by applying linear wave shoaling.

Table 4.3 Representative Wave Cases for SWAN Simulations

Case	Angle Band (deg)	Mean Angle (deg)	Mean Wave Height (m)	Mean Wave Height (ft)	Average Peak Wave Period (sec)	Percent Occurrence
1	345-7.5	356.25	1.23	4.0	6.0	2.8%
2	7.5-30	18.75	1.23	4.0	6.8	4.3%
3	30-52.5	41.25	1.30	4.3	7.9	9.2%
4	52.5-75	63.75	1.18	3.9	8.8	19.4%
5	75-97.5	86.25	0.93	3.0	8.5	26.6%
6	97.5-120	108.75	0.79	2.6	7.9	24.6%
7	120-142.5	131.25	0.90	3.0	7.2	5.9%
8	142.5-165	153.75	0.94	3.1	6.7	2.0%

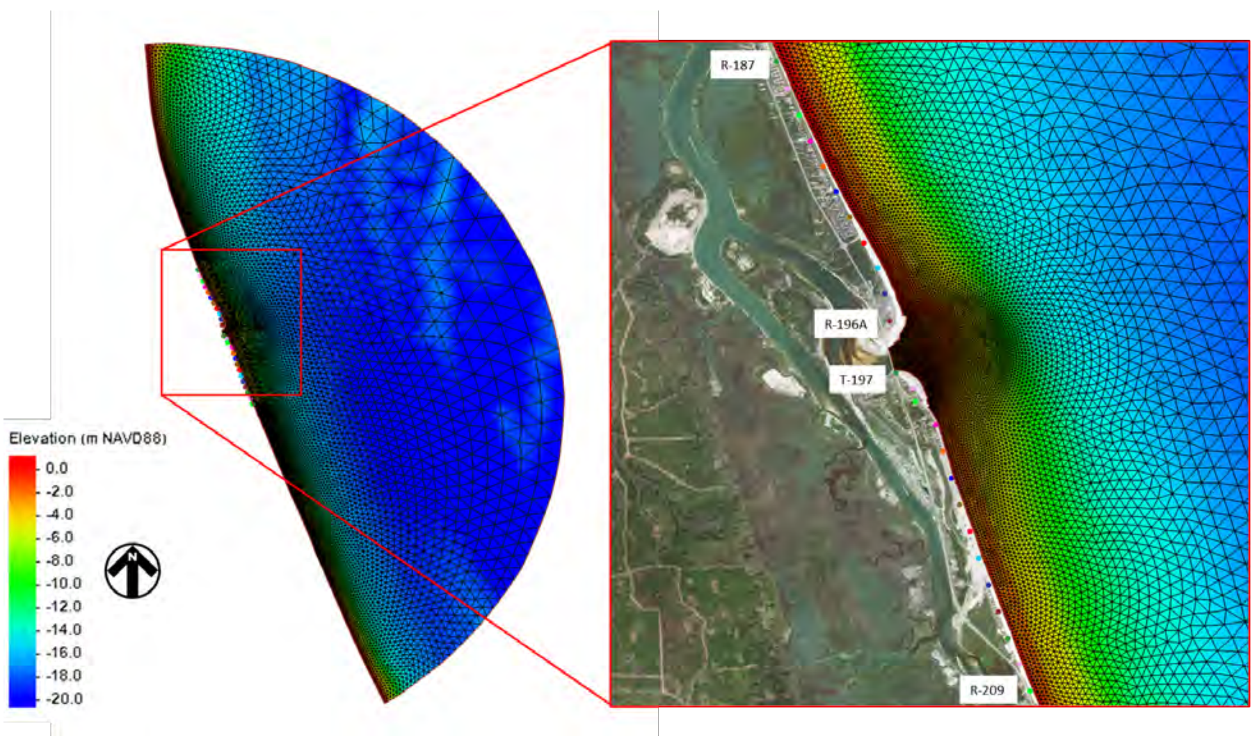

Figure 4.9 SWAN Model Mesh

By way of example, **Figure 4.10** shows the normalized wave height contours and wave direction vectors for waves originating from 108.75 degrees from North (Case 6). A normalized wave height at each node equals a ratio of the computed wave height and the wave height at the offshore boundary. A map of normalized wave heights allows for visualizing areas of wave growth (warmer colors) and decay (cooler colors). Waves from the east-southeast increase in height at the outer ebb shoal to approximately 1.1

times the incident wave heights before breaking. The sharp color contrast from red/orange to blue/green indicates the breaker line. Interestingly, waves break closer to the shoreline south of the inlet than north of the inlet. Except near the inlet, waves approach the shoreline within 10 degrees from shore normal along the breaker line.

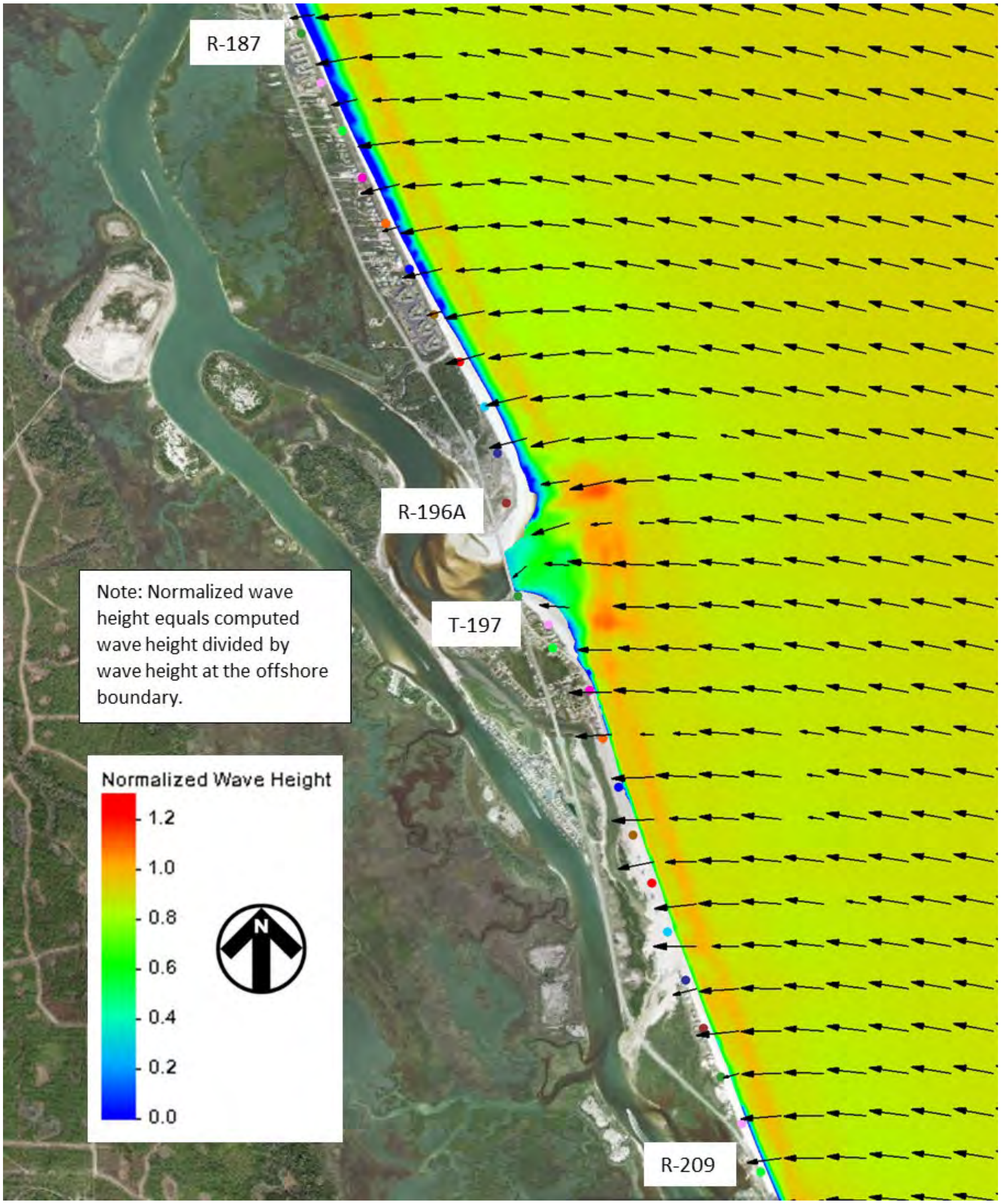

Figure 4.10 Normalized Modeled Wave Heights and Wave Vectors (Case 6)

To estimate the net LSTP rate patterns, one combines the results of each individual model case to provide representative or effective LSTP rates alongshore for each model case. Determining the effective LSTP occurs by weighing each model case calculation by its associated percentage of occurrence (**Table 4.3**) as follows:

$$Q_{LSTP,eff,j} = \frac{\sum_{m=1}^{8} p_m Q_{LSTP,j,m}}{100\%} \quad (2)$$

where $Q_{LSTP,eff,j}$ is the effective annual LSTP for longshore model node, j, p_m is the percentage of occurrence for wave case number, m, $Q_{LSTP,j,m}$ is the LSTP for longshore model node, j, and wave case number, m. A normalizing factor of 100% represents the total percentage of waves from all directions. **Figure 4.11** presents net and gross LSTP patterns along the study area calculated with the CERC formula. Positive transport occurs north to south; negative transport occurs south to north.

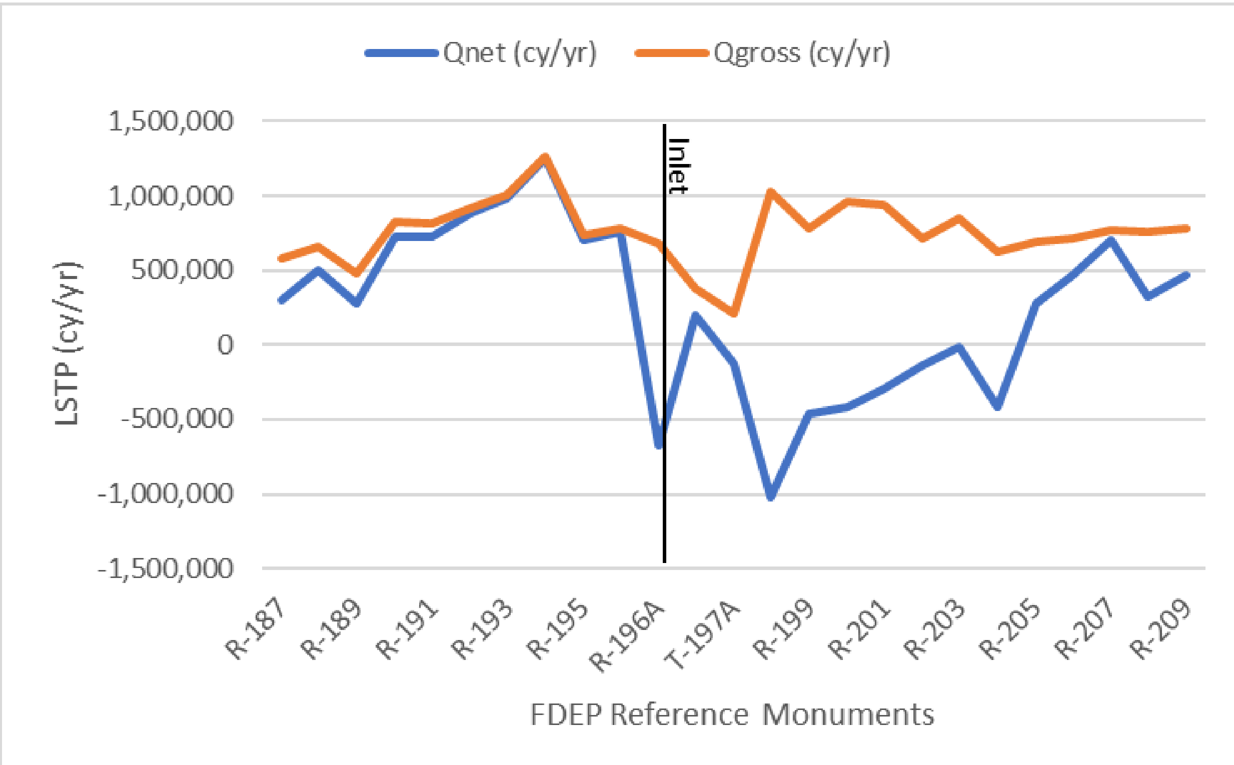

Figure 4.11 **Longshore Sediment Transport Potential along Study Area**

Taylor and McFetridge (1991) report on various historical estimates of LSTP rates north and south of the inlet. For a shore normal of 74 degrees (very near the shore normal of 75 degrees applied by the FDEP in this area except at R-196A with 90-degree shore normal), they report net and gross rates of 242,000-389,000 cy/yr (southward) and 860,000-995,000 cy/yr. Taylor Engineering (2009) also developed a sediment budget including the area from R-174 to R-15 (Flagler County). For the period 1986-2003, the sediment budget shows a net transport rate south on both sides of the inlet of approximately 400,000-500,000 cy/yr. This study matches Taylor and McFetridge's gross rate well. It matches the net rate less so relative to the other two studies. Application of different wave climates plays a large role in net transport rates given net rates are sensitive to wave direction.

For the period 1980-2020, the analysis shows that net transport north of the inlet is from north to south at an increasing rate until near T-194, the middle of the Summerhouse property, after which transport still is from north to south but at lesser rates. South of the inlet, the net transport is from south to north with a transition point at R-205, where the net transport direction reverses.

The above net LSTP curve will serve as an input into developing a sediment budget for the study area discussed later in this chapter.

4.4 Matanzas Inlet Conditions

Over the years, many have expressed concern regarding erosion of the inlet's south shoreline west of the bridge. This erosion has prompted property owners to harden the shoreline with bulkheads and revetments along the affected areas. Recently, the erosion has increased and spread westward because of the high inlet flow velocities that currently concentrate along the shoreline (see Section 4.6) — to such a degree that the inlet channel depths exceed 30 ft a very short distance off the bank.

To investigate the evolution of the inlet's channel and shoreline positions, this study analyzed Google Earth high-resolution satellite images — for years 1995, 1999, 2004, 2007, 2008, 2010, 2012, 2016, 2019, and 2022. **Table 4.4** lists the acquisition date of the images and their sources. To facilitate geo-referencing the aerial imagery, INTERA-GEC established nine ground control points in Google Earth, saved the points in KML file format, converted the KML file to a layer file using ArcMap 10.8.1, and then geometrically rectified the images (to NAD 1983 State Plane Florida East FIPS 0901 datum) applying second order polynomial transformation algorithms. The ArcMap reclassification tool helped detect the channel bank. Identification of the shoreline boundary occurred by computing RGB based vegetation indices (RGBVI and GLI) to differentiate land from water.

Table 4.4 Google Earth Historical Image Metadata

Acquisition Date	Year	Image Source
01/17/2022	2022	Maxar Technologies
11/19/2019	2019	Maxar Technologies
02/16/2016	2016	Maxar Technologies
01/19/2012	2012	Maxar Technologies
12/06/2010	2010	USDA/FPAC/GEO
12/31/2007	2008	USDA/FPAC/GEO
05/07/2007	2007	USDA/FPAC/GEO
12/31/2003	2004	FDEP
01/25/1999	1999	US Geological Survey
02/06/1995	1995	US Geological Survey

Figures 4.12 and 4.13 show the channel edges over the periods 1995-2008 and 2008-2022. **Figures 4.14 and 4.15** show the shoreline positions for the periods 1995-2008 and 2008-2022, representing the periods before and after the 2008 breach that curtailed the river flow (Note that the 2008 data appear in all figures as a reference point). Appendix K contains the aerial imagery from each year with the digitized channels and shoreline. Recognizing that each aerial photograph is a snapshot in time of a very dynamic inlet and few hydrographic surveys of the inlet are available to quantitatively evaluate flood shoal and channel conditions, the following paragraphs comment on general observed trends only.

Evident in **figures 4.12 and 4.13**, the inlet flow appears spread across the inlet more in earlier years, particularly in 1999 where the channel occupied primarily the center and northern portions of the inlet. In more recent years, the channel along the southern half of the inlet seems to have become more dominant. Before 2012, the western edge of the channel (i.e., just north of the SHR's mouth) did not change significantly. In 2016 (pre-Hurricane Matthew), a slight westward shift occurs in the southern portion of the west bank and an eastern shift in the northern portion. Since 2016, the position of the channel's west edge has clearly shifted westwardly. Just east of the SHR's mouth, the channel began migrating southerly into the shoal during the 2000's, as compared to conditions in the 1990's. However, a consistent trend of the channel behavior is not evident from 2008–2019. The 2022 channel position has clearly eroded further into the flood shoal, which agrees with residents' reports of increased erosion. The eastern edge of the channel has varied widely, driven by the ever-changing flood shoals.

Figures 4.14 and 4.15 show the inlet's western shoreline, north of the armored portion of the west bank, has predominantly experienced slight recession since 1999 but most notably in 2019 and 2022, coinciding with the channels westward shift described above. The inlet's northern/eastern shoreline has experienced dynamic reshaping with significant swings of shoreline advance and recession. From 1995–2012, the inlet's northern shoreline advanced southward into the inlet, restricting the inlet opening. However, the 2016–2022 shoreline positions reveal a general trend of recession northward, reopening the inlet. The shoreline recession in the latter period is unsurprising given the severe storm activity and water levels the inlet has experienced during that time.

Interestingly, the opening of the inlet entrance after 2012 coincides with the southern inlet channel migrating southwestward after 2012 (i.e., beginning with the 2016 channel position). As shoaling at the inlet entrance peaked in 2012, the flood shoal also seems to have peaked in size along the northern portion of the inlet, possibly forcing a greater proportion of flow through the inlet's southern channel. As the inlet reopened post-2012, it is possible that increased flow through the southern channel, particularly during the severe storm events, predominantly caused the channel to begin its westwardly migration. Of note, the channel migration does not appear to coincide with the SHR's closure beginning in 2008 (see Section 4.6 for more detailed information on the SHR's effects on the surrounding waterways).

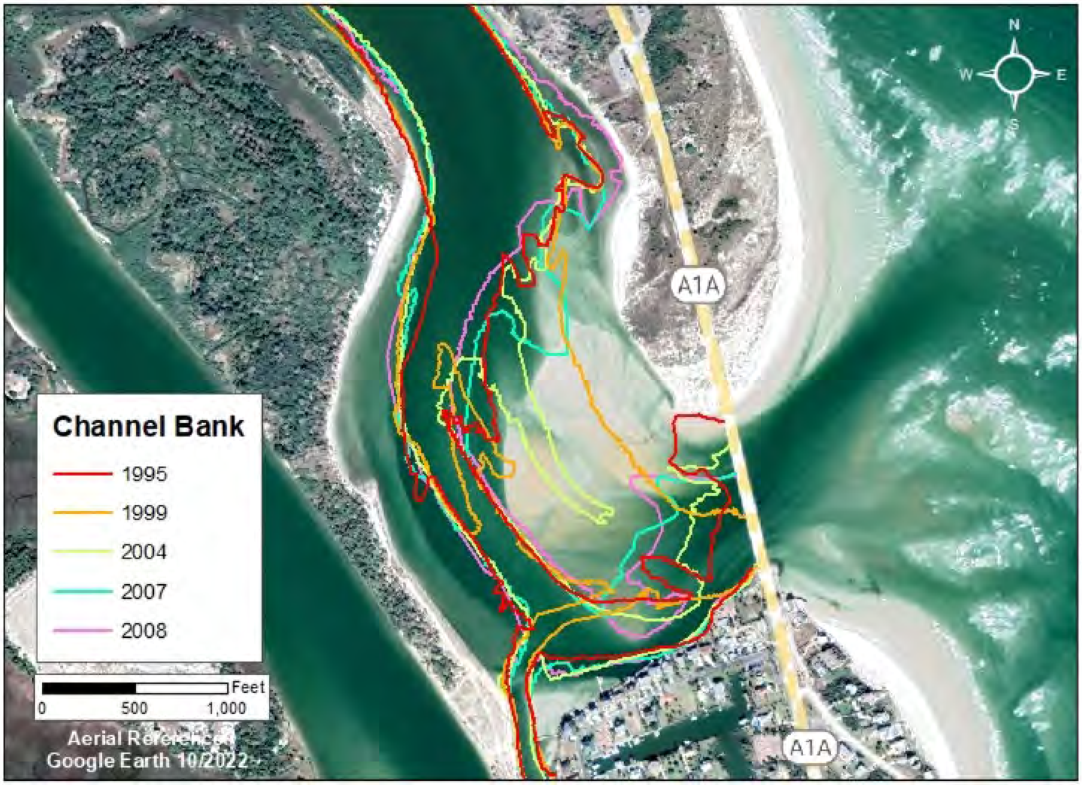

Figure 4.12 Matanzas Inlet Primary Channel Positions from 1995–2008

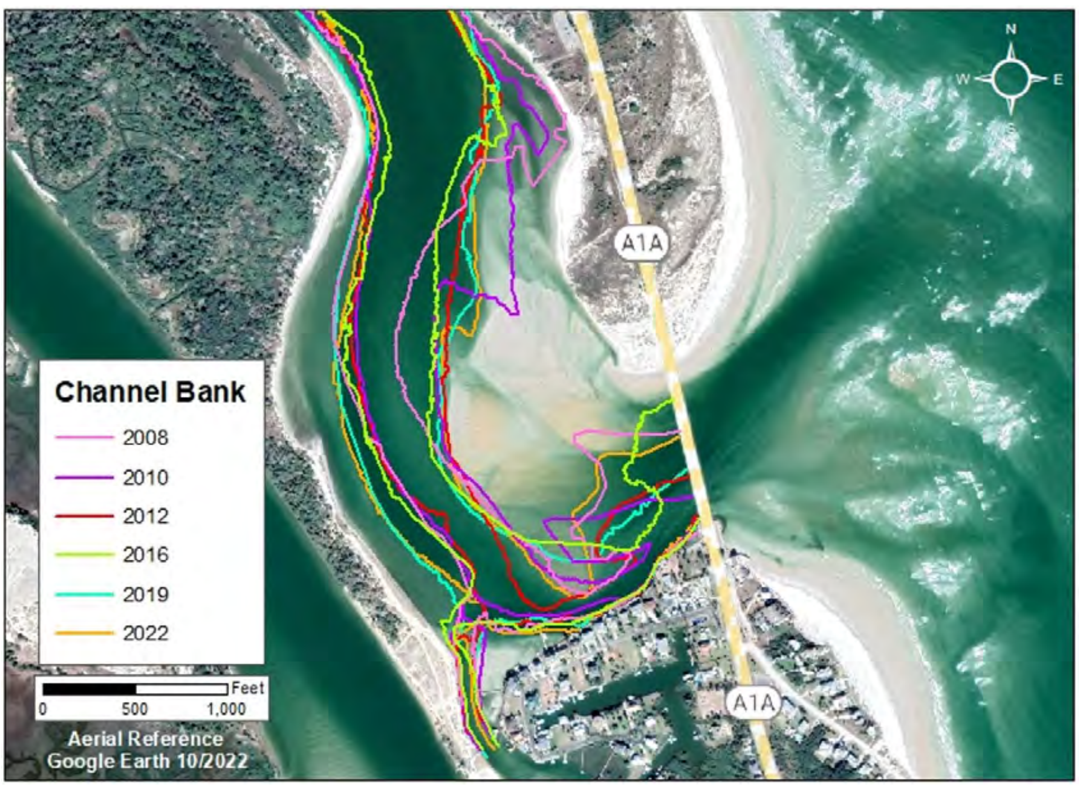

Figure 4.13 Matanzas Inlet Primary Channel Positions from 2008–2022

Figure 4.14 Matanzas Inlet Shoreline Positions from 1995–2008

Figure 4.15 Matanzas Inlet Shoreline Positions from 2008–2022

4.5 Sediment Budget

A sediment budget uses the conservation of mass to quantify sediment sources, sinks, and pathways in a littoral cell environment. It is a tool used to quantify the effects of a changing sediment supply on the coastal system and to understand the large-scale morphological responses of the coastal system. The sediment budget equation is expressed as:

$$\sum Q_{source} + \sum Q_{sink} + \Delta V + P - R = Residual \quad (3)$$

The sources (Q_{source}) and sinks (Q_{sink}) in the sediment budget together with net volume change within the cell (ΔV) per the surveys and the amounts of material placed in (P) and removed from (R) the cell are calculated to determine the residual volume — ideally equal to zero for a completely balanced cell (Rosati and Kraus, 1999). **Figure 4.16** schematically illustrates the factors within each cell of the sediment budget model.

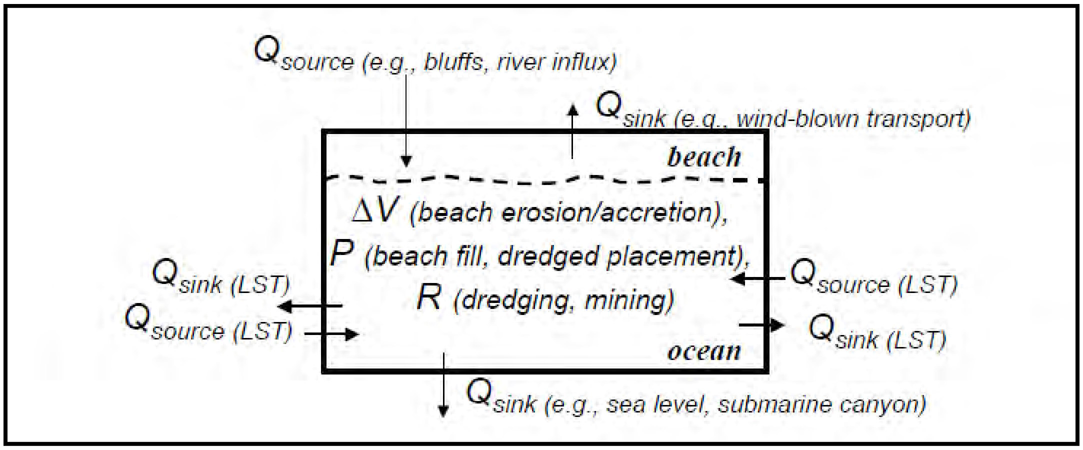

Figure 4.16 Sediment Budget Schematic Diagram

In general, a sediment budget is expected to reflect the trends of sediment processes over the time period considered consistent with:

- The calculated net sediment transport
- Historical shoreline changes
- Comparison and assessment of aerial photography
- Storm history
- Prior inlet projects
- A qualitative description of the sediment processes in the project area.

4.5.1 Previous Sediment Budgets

The sediment budget surrounding Matanzas Inlet was previously assessed by Taylor and McFetridge (1991) for the period 1972–1986 who found the Inlet functioned as a sediment sink – trapping on the order of 64,000 cy/yr. Taylor Engineering (2009) calculated a sediment budget for 1986–2003 extending from R-174 north of the inlet to R-15 in Flagler County to the south. This budget indicates the inlet traps 71,000 cy/yr.

4.5.2 Development

The availability of comprehensive survey coverage of the study area dictated the time periods selected for the current sediment budget. As mentioned in Section 2.5, only three comprehensive full inlet surveys — 2016 pre- and post-Hurricane Matthew and 2017 post-Hurricane Irma — including the flood and ebb shoals are available in addition to the new 2022 survey conducted for this study. To evaluate the longest period possible based on comprehensive survey data, this study selected 2016 (pre-Hurricane Matthew)–2022. Severe storm activity characterized this period; thus, the sediment budget is not necessarily representative of the Matanzas Inlet vicinity over the long-term. Therefore, this study also calculated a sediment budget for 2007–2022 to evaluate the inlet and beach behavior over a longer period. Lacking 2007 inlet hydrographic surveys, the 2007–2022 sediment budget assumed the inlet trapped 71,000 cy/yr as estimated by Taylor Engineering (2009).

Figure 4.4 (Section 4.2) illustrates the cells identified over the study area including:

- Cells N1, N2, and N3 – corresponding to the beach north of the Inlet;
- Cell ES – corresponding to the ebb shoal;
- Cell FS – corresponding to the flood shoal and interior waterways, including the Summer Haven River; and
- Cells S1, S2, and S3 – corresponding to the beach south of the inlet.

To formulate the sediment budget, volume changes discussed in Section 4.2 defined the beach and offshore changes within cells. Dredge and fill placement records (**Table 2.1** and **Table 2.2**) were reviewed and used to account for inlet losses and artificial bypassing to the Summer Haven beach. The longshore transport rate entering the northern boundary of the sediment budget equals 122,643 cy/yr based on long term (1980–2020) assessment of the wave climate and longshore transport (Section 4.3).

The longshore transport magnitudes at the southern boundary of each cell balances the transport at the cell's northern boundary and the volume change within the cell. This analysis assumes no cross-shore transport occurs beyond the cells' offshore boundary. For the cells south of the inlet, the manual placement of fill from ICWW maintenance dredging projects represents an influx of sand or bypassing of sand from the inlet interior to the downdrift beach. The fill typically erodes quickly above MHW, but the fate of the fill offshore is not well-documented. Taylor Engineering (2009) suggests (based on a 1986–2003 sediment budget) that 52% of the placed fill deposited offshore within five miles south of the inlet. To account for the uncertainty regarding the transport directions and magnitudes of the fill placements, this study developed sediments budgets for two cases for each analysis period.

Case 1 assumes all fill remains within the cells south of the inlet, perhaps in a thin layer spread offshore but within the volume computational cells. For this case, the volume changes completely capture the effect of the fill placement. Therefore, the actual placement volumes do not constitute an additional input. In effect, had the placements not occurred, the calculated erosion volumes would have been much more severe, by an amount equal to the placement volume. For example, a calculated cell volume of -10,000 cy with placement of 20,000 cy would have eroded -30,000 cy had the placement not occurred; the placed material remains in the cell and does not contribute to longshore transport between the cells. Case 2 assumes none of the fill remains within the cells such that the placement volumes constitute an influx of sand. In this case, all placed fill served as a sacrificial volume of sand that protected the existing contours until the fill completely eroded and transported away. Applying the same example as above, a placement volume of 20,000 cy prevented -20,000 cy of erosion before it "washed away", and then -10,000 cy of erosion occurred; the longshore transport calculations must account for 20,000 cy placement volume. Actual behavior likely lies somewhere in the middle of these cases.

Figure 4.17 shows the 2007–2022 sediment budget for Case 1. The numbers adjacent to each cell (e.g., N1) indicate the volume changes (∆V) above MHW (designated with the subscript "beach") and below MHW (designated by the subscript "nearshore"). Adding these two volumes corresponds to the volume change within that cell. For example, take N1. The volume change above MHW equals -2,007 cy/yr and the volume change below MHW equals 7,773 cy/yr. Adding the two values yields 5,767 cy/yr. A positive value indicates that the area represented by cell N1 gained nearly 5,800 cy/yr over this period. The white arrows indicate the net longshore transport direction with the white numbers designated as Q correspond to the net longshore transport magnitude. The net transport rate represents a larger rate directed south and a smaller rate directed north. Finally, the warm colors correspond to areas of erosion and the cold colors correspond to areas of accretion. From the figure, erosion occurred everywhere except within the northernmost cells (N1 and N2) and the ebb shoal. The inlet trapping approximately 71,000 cy/yr (assumed) within its interior waterways and 6,469 cy/yr within the ebb shoal creates a longshore sediment transport deficit just to the north of the inlet and the Summer Haven beaches represented by cells S1 and S2 (R-200 to R-206). The sediment transport magnitudes generally increase toward the inlet from the north, reduce across the inlet, and generally increase away from the inlet toward the south.

Figure 4.18 illustrates the 2007–2022 sediment budget for Case 2. With the placement volumes constituting an additional input, the net longshore transport magnitudes increase south of the inlet such that they more closely match the input magnitude north of the inlet. Instead of showing an accreting to stable area south of R-206, the net longshore transport magnitude further increases.

Figure 4.19 shows the 2016–2022 sediment budget for Case 1. Erosion predominantly occurred throughout the study area except across the inlet. The erosion trend is expected given the numerous strong storms that occurred during this period. Including bypassing dredged material and SHR restoration, the ICWW, flood shoal, and ebb shoal lost material. Significant erosion above MHW occurred north and south of the inlet. That erosion was not offset by accretion below MHW.

Figure 4.20 illustrates the 2016–2022 sediment budget for Case 2. With the placement volumes constituting an additional input, the net longshore transport magnitudes increase significantly south of the inlet such that they double the input magnitude north of the inlet.

In all cases, the Summer Haven beaches experience net longshore transport erosion.

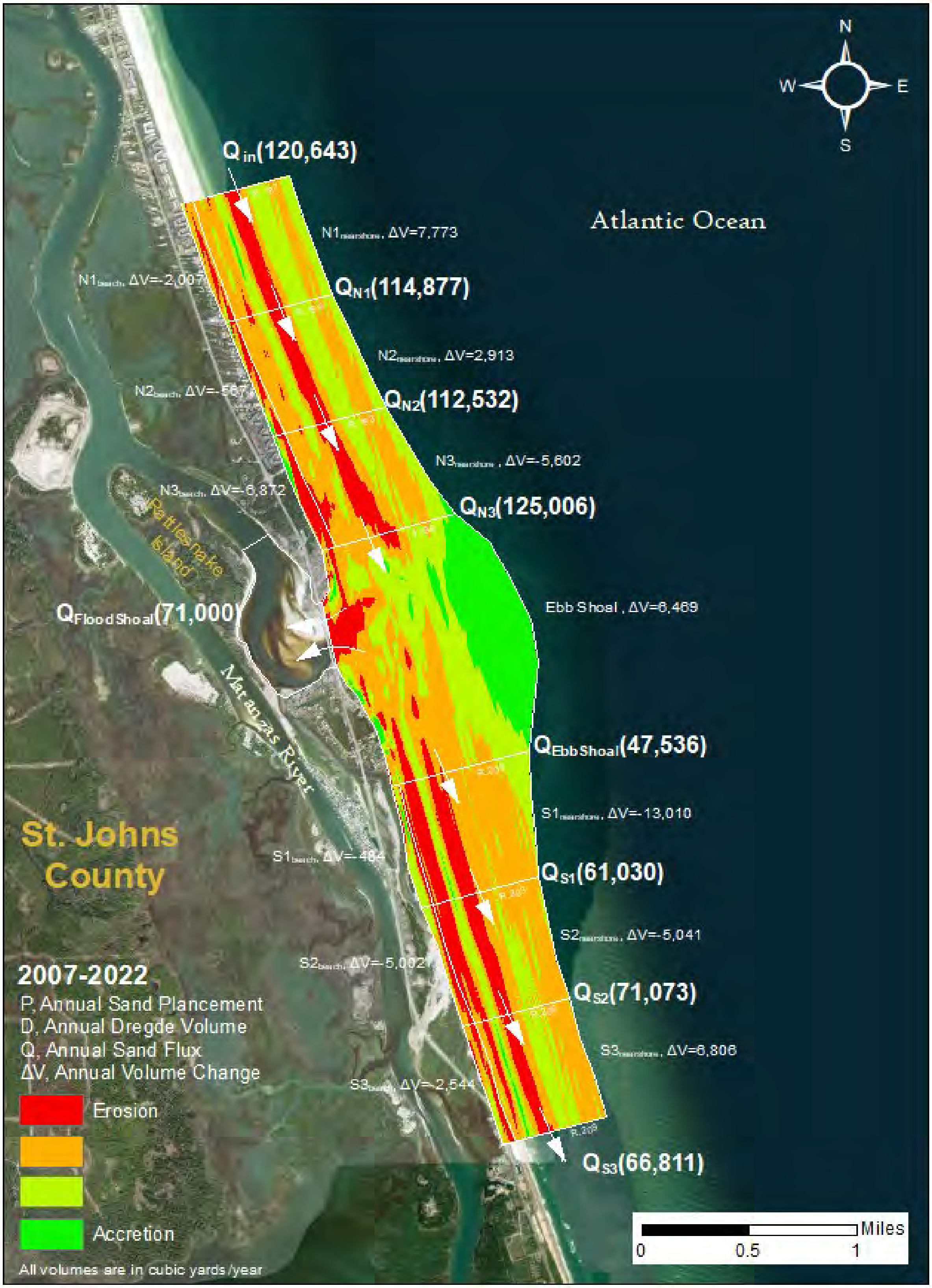

Figure 4.17 2007–2022 Sediment Budget — Case 1

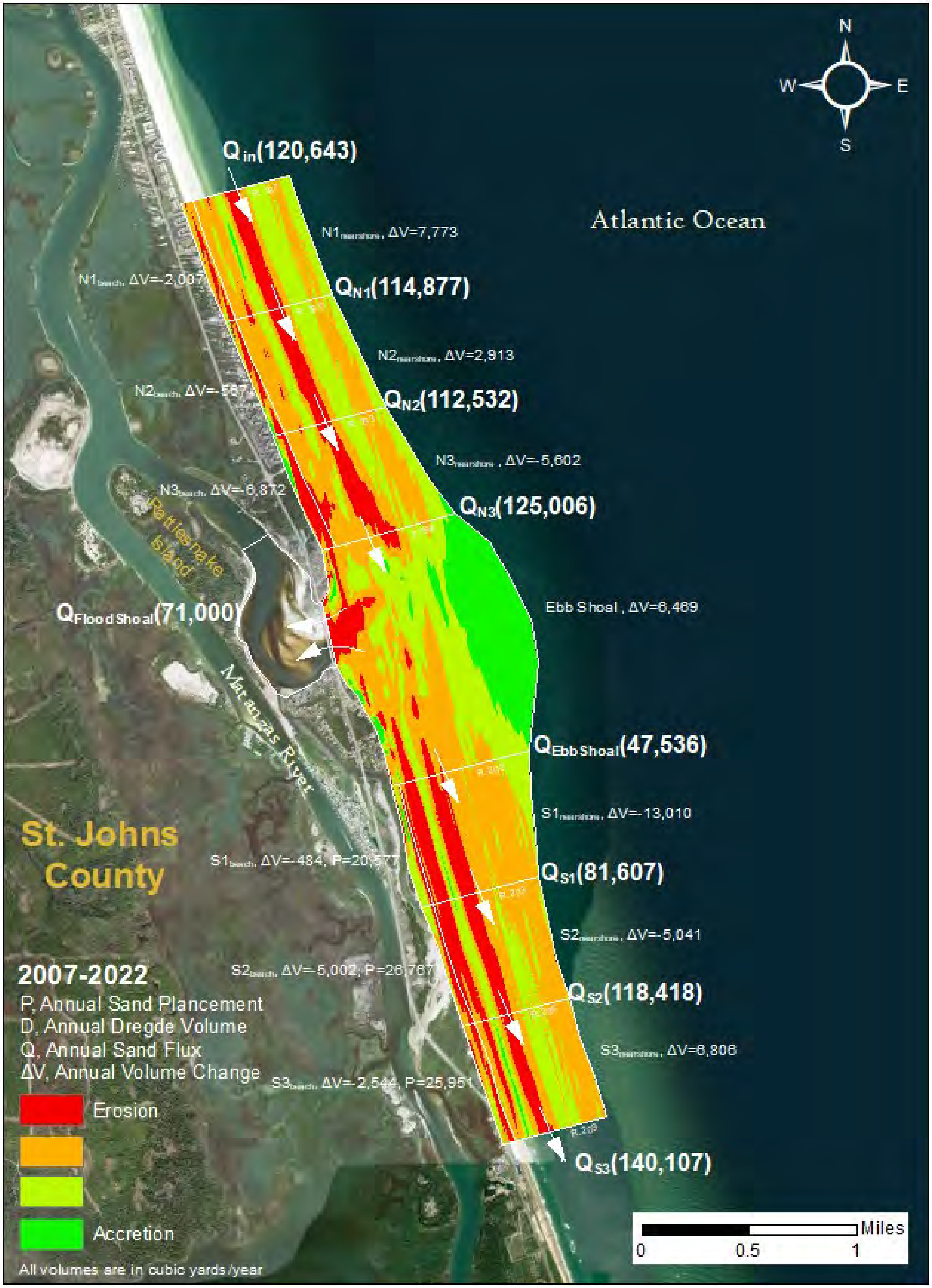

Figure 4.18 2007–2022 Sediment Budget — Case 2

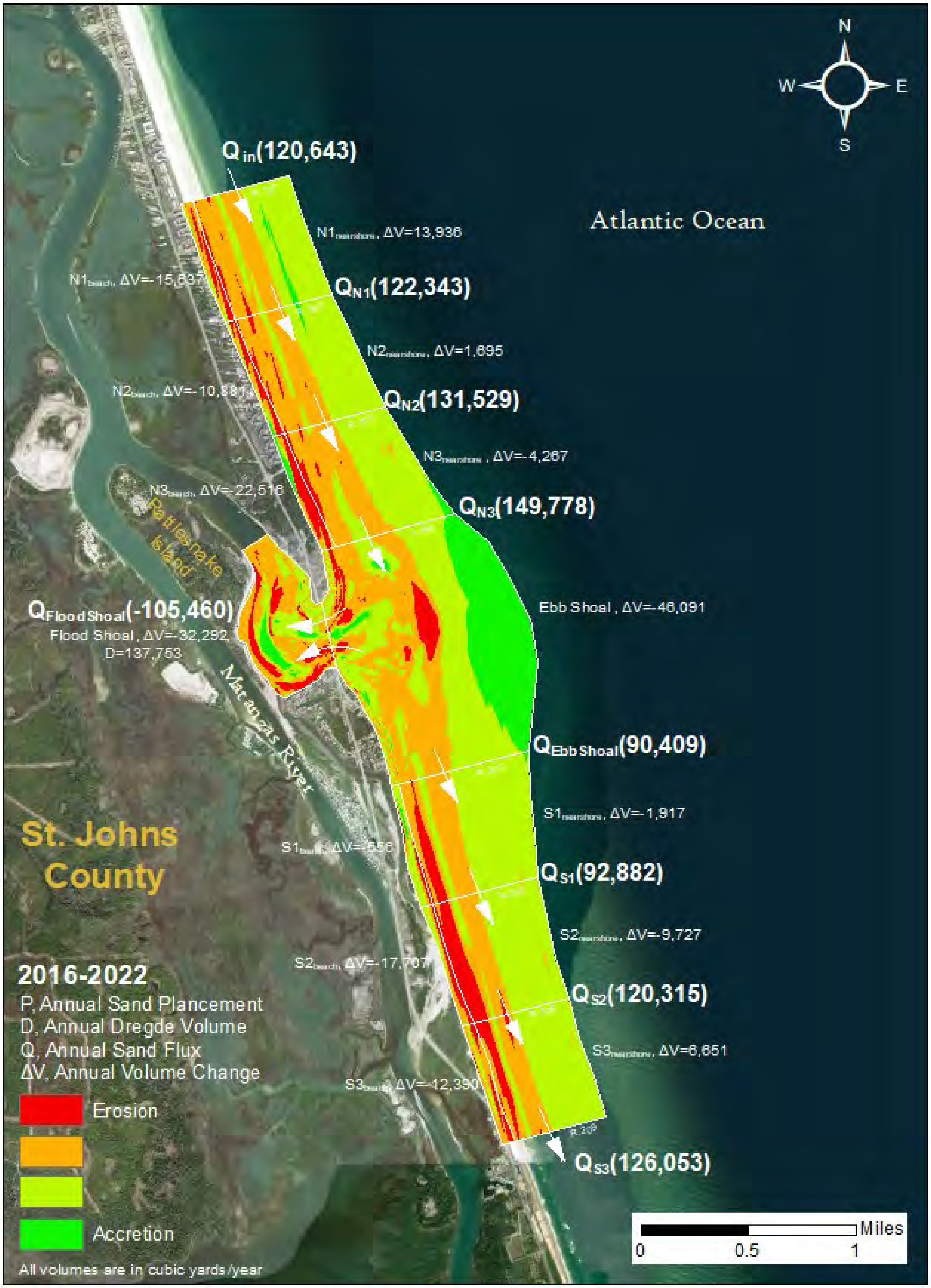

Figure 4.19 2016–2022 Sediment Budget – Case 1

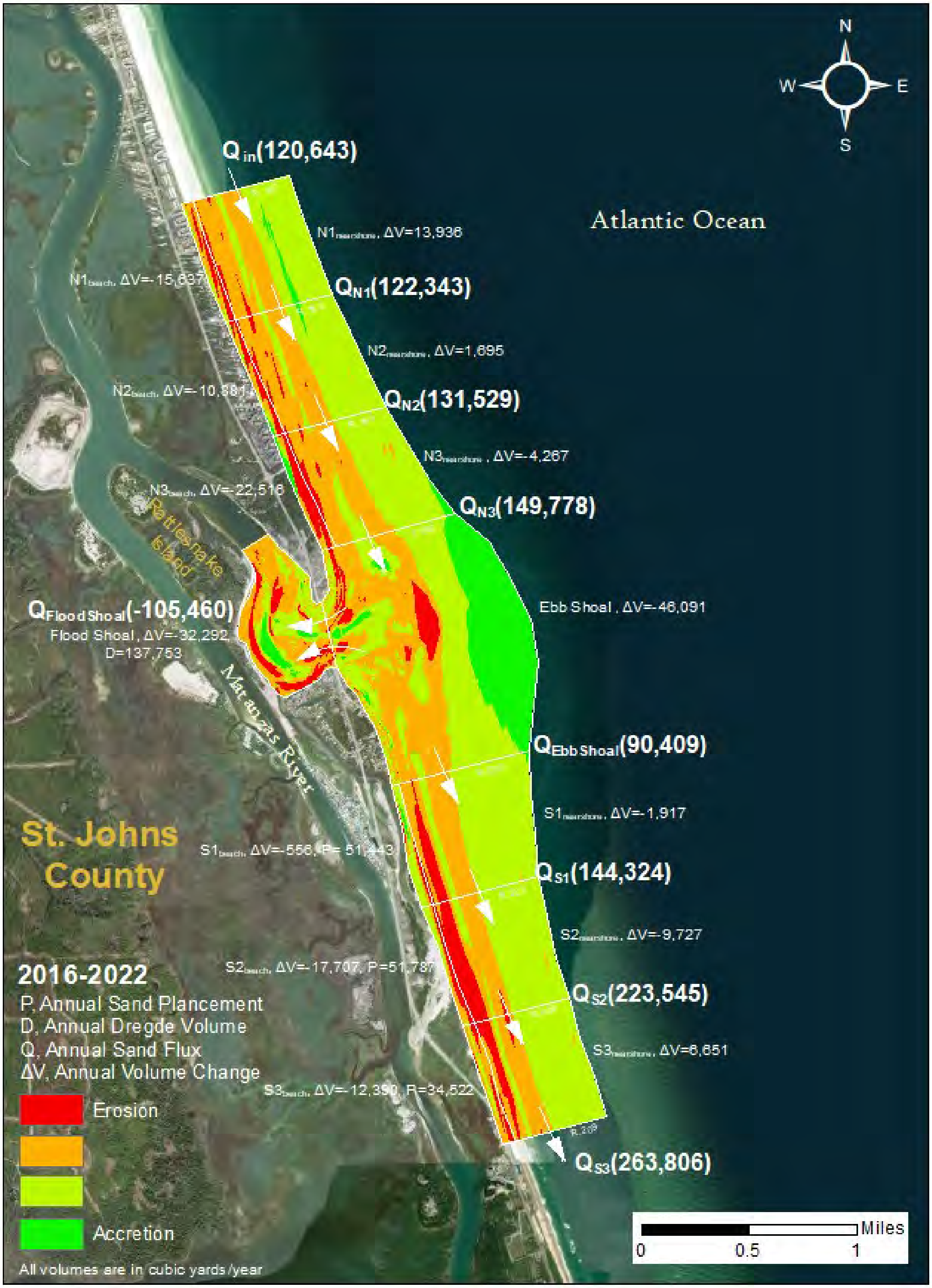

Figure 4.20 2016–2022 Sediment Budget — Case 2

4.6 Hydrodynamics

To evaluate the complex flow conditions of Matanzas Inlet and the surrounding waterways and the effects of the Summer Haven River (SHR) on inlet and waterways hydrodynamics, this study applied Advanced Circulation Model for Coastal Ocean Hydrodynamics (ADCIRC), a time-dependent, two-dimensional model to simulate the complex flow regime over a 30-day period from January 1-30, 2022. Appendix L provides details of the numerical modeling analysis. This section provides a summary of the results.

This study evaluated four scenarios: (1) existing conditions (i.e., no flow through SHR), (2) deepening SHR to -6 ft NAVD88 (approximately 3.5 ft deep at low tide) to reestablish flow, (3) deepening SHR to -10 ft NAVD88 (approximately 7.5 ft deep at low tide), and (4) dredging of the inlet flood shoal to alleviate the damaging high flows near the southern shoreline of Matanzas Inlet. Of note, scenario 2 is a simplified representation of the currently authorized dredging elevations (the actual elevations range from -4 to -6 ft NAVD88), and scenario 3 represents a preferred river condition (per public comments) and also serves to test the sensitivity of the Summer Haven River depth on the river's effect on inlet hydrodynamics.

The model simulations sought to determine whether flow through Summer Haven River has a measurable effect on the inlet currents, as well as the hydrodynamics near Pellicer Creek, and how reconfiguring the inlet flow by dredging through the northern portion of the flood shoal could alleviate erosion of inlet's southern shoreline. Private property along the southern shoreline, west of the bridge crossing, has experienced damage and property loss from the inlet flow velocities that are currently concentrated against the shoreline. The erosion of the waterway in front of these homes is apparent in the contours of the existing conditions (**Figure 4.21**), where channel depths exceed 30 ft a very short distance away from the shoreline. Scenarios 2 and 3 only modified the bathymetry in the SHR. Scenario 4 only modified the inlet bathymetry within the new dredge channel near the northern shoreline of the inlet (**Figure 4.22**).

Figure 4.23–**Figure 4.24** show the flow velocities at peak ebb flow (i.e., outgoing tide) and peak flood flow (i.e., incoming tide) at the inlet under scenario 1 — existing conditions. The following sections discuss the general effects of each scenario — as evident in contour plots of the changes in flow velocity magnitudes as compared to exiting conditions — followed by an evaluation of their effects on sediment transport.

Of note, **Table 4.5** provides the calculated flood and ebb tidal prisms for Matanzas Inlet for scenarios 1–4. The third column indicates the percentage increase in tidal prism relative to existing conditions. For comparison purposes, Mehta and Jones (1977) show the inlet is flood dominant (with the flood tidal prism exceeding the ebb tidal prism) with reported flood and ebb tidal prisms of $5.84 * 10^8$ and $4.15 * 10^8$ cubic feet (ft^3) calculated from discharge data collected on July 18, 1974. The tidal prisms are unequal given the inlet's proximity to St. Augustine and Ponce de Leon inlets. Taylor Engineering (2009) showed that the Tropical Storm Fay (2008) breach would likely reduce the tidal prism at the inlet by less than 7%, which is like the 7.8% reduction calculated between scenarios 2 (restored river condition) and 1 (breached condition) (i.e., [4.90-4.52]/4.90 * 100%).

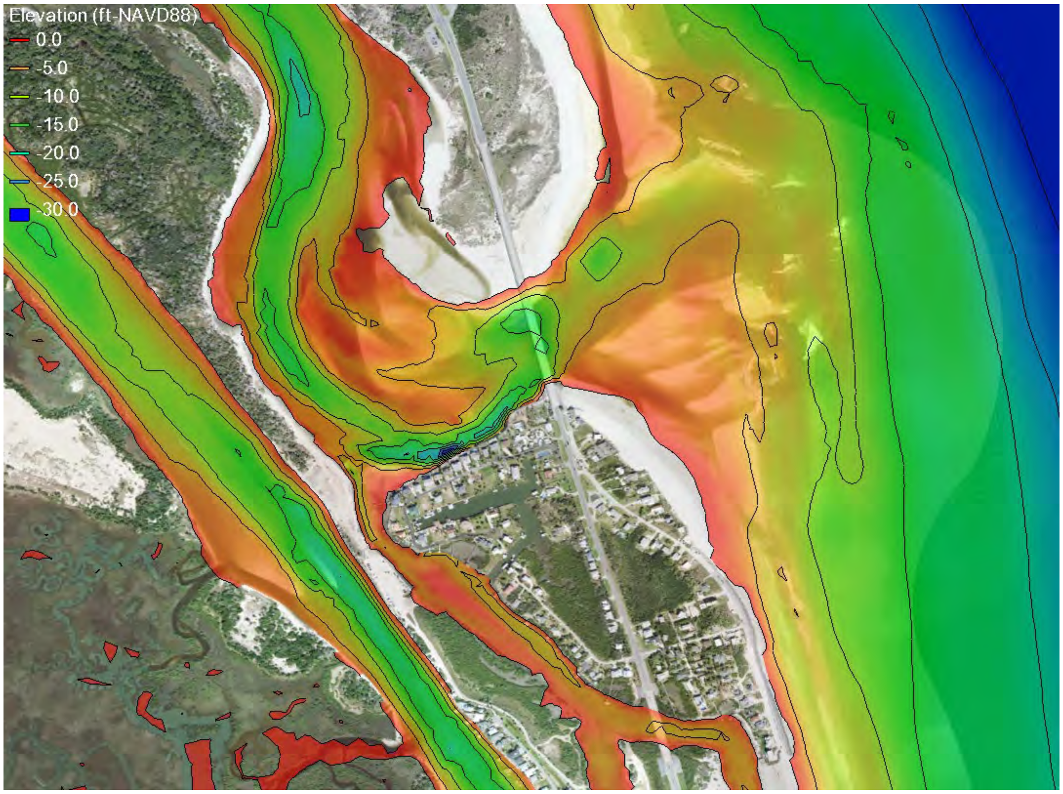

Figure 4.21 Scenario 1 Existing Bathymetry Contours at the Inlet

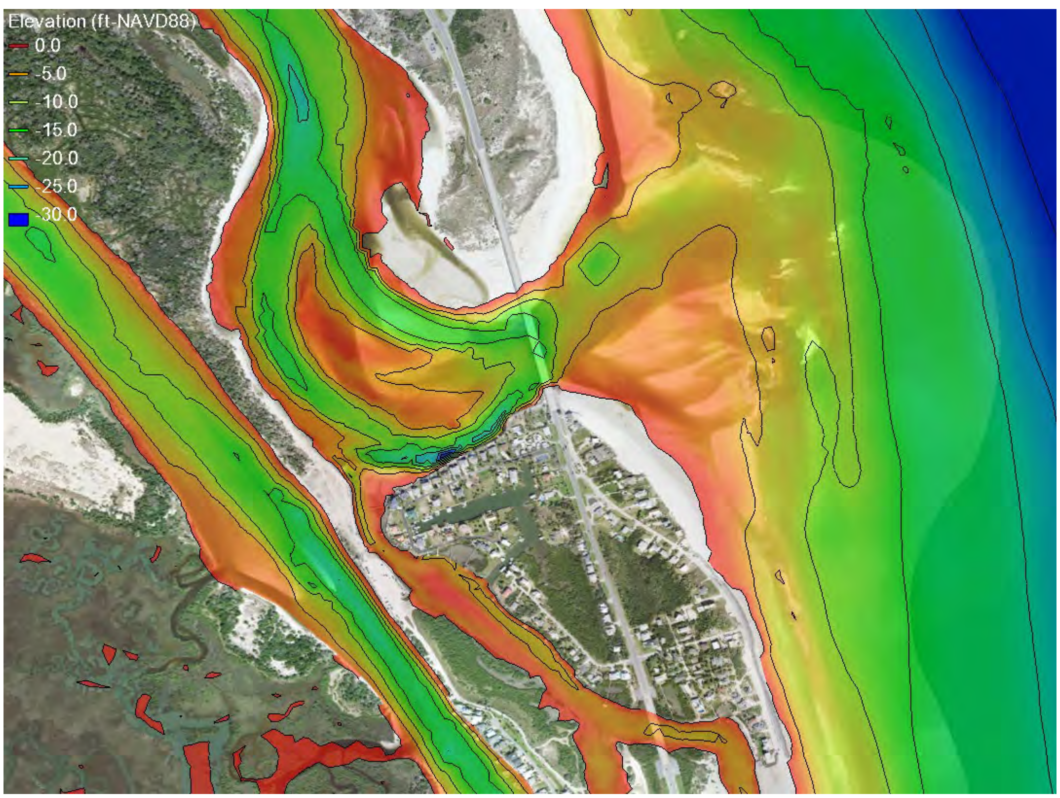

Figure 4.22 Scenario 4 Dredged Inlet Channel Bathymetry Contours at the Inlet

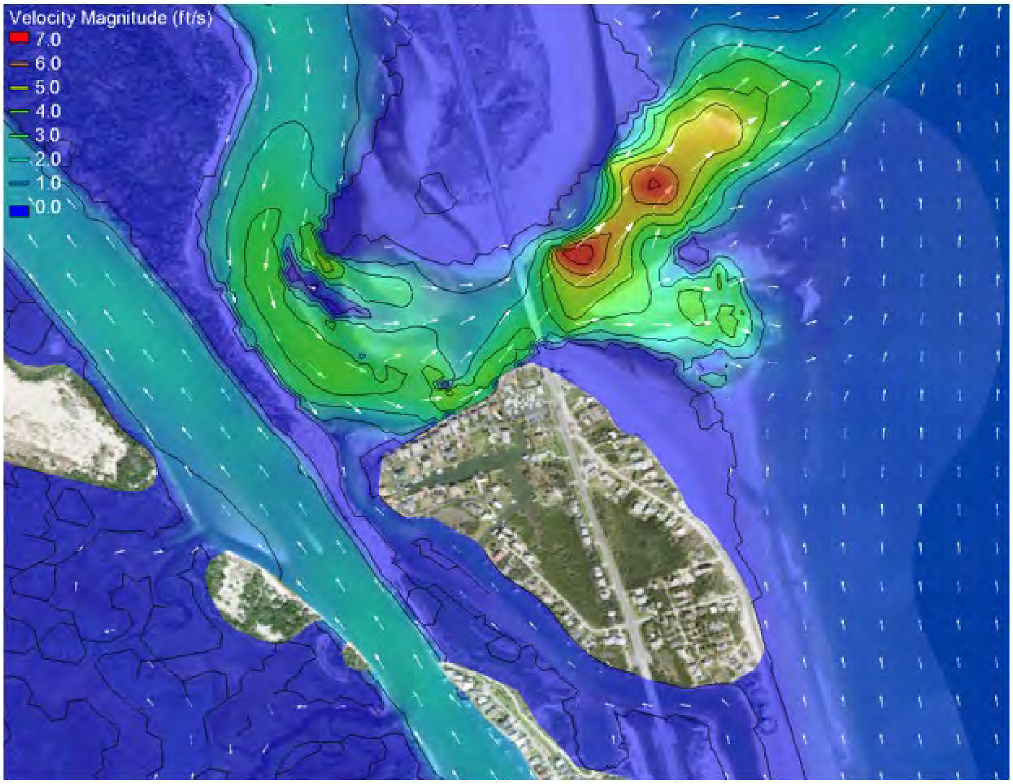

Figure 4.23 Peak Ebb Flow Velocities under Existing Conditions

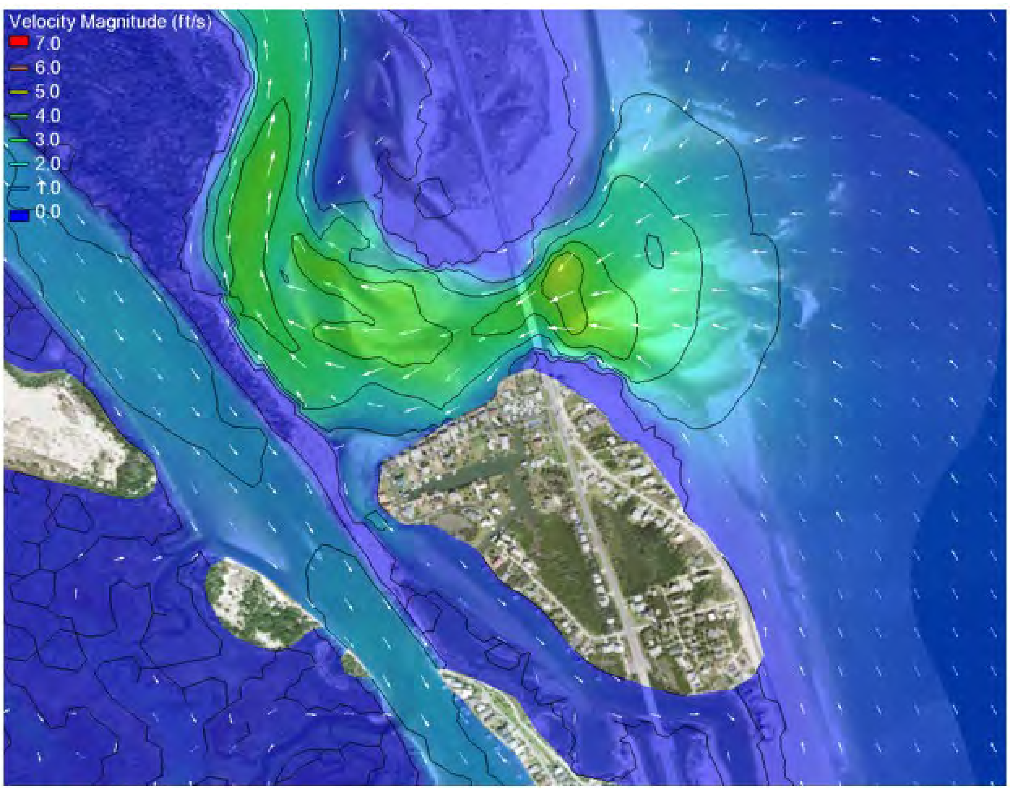

Figure 4.24 Peak Flood Flow Velocities under Existing Conditions

Table 4.5 Tidal Prisms for Scenarios 1–4

Scenario	Flood Tidal Prism ($10^8 ft^3$)	Ebb Tidal Prism ($10^8 ft^3$)	Flood Tidal Prism Change from Existing (%)
1 — Existing Conditions	4.52	4.13	-
2 — SHR Deepened to -6 ft NAVD88	4.90	4.43	8.4
3 — SHR Deepened to -10 ft NAVD88	5.19	4.61	14.8
4 — Dredged Inlet Channel	4.97	4.47	10.0

4.6.1 General Effects within Matanzas Inlet

Appendix L includes plots of scenario results for both ebb and flood flows. For brevity, this section includes sample plots for ebb flow only.

Figure 4.25–**Figure 4.27** show the changes in flow velocity, compared to existing conditions, at peak ebb flow within the inlet for scenarios 2–4. Negative values correspond to a reduction in velocity and positive values indicate an increase in velocity. Note the black contour lines surrounded by green shading represents the zero-change contour; the occurrence of this contour throughout the waterways and marsh demonstrates the sensitivity of the hydrodynamics to Summer Haven River changes, yet the changes are minimal beyond the north and south ends of the river.

For scenarios 2 and 3, the zero-change contour extends slightly beyond the mouth of the river and into the inlet channel indicating the currents from the river have a minor effect on the inlet currents (the effects of the river are even less pronounced during flood flow). Slight orange and blue shading within the inlet channel reflect small velocity changes — generally on the order of 0.5 ft/sec or less. These magnitudes combined with the pattern of reduced flow along the southern/western side of the inlet and increased flow along the northern side demonstrates a weak “steering current” effect of the SHR flow pushing the inlet’s main flow away from the southern shoreline. For scenario 4, the velocities increase significantly throughout the dredged channel as expected and decrease significantly in the southern channel (the effects during flood flow are similar but lesser in magnitude). The following section discusses the effects of these velocity changes on the inlet.

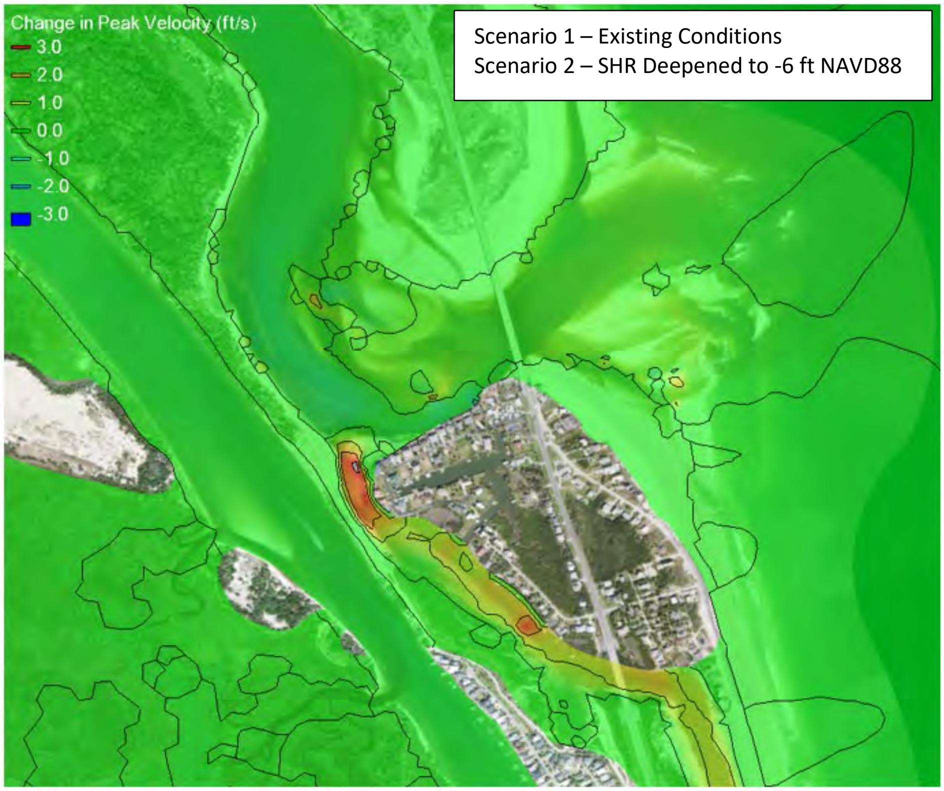

Figure 4.25 Change in Velocity within Inlet at Peak Ebb Flow – Scenario 2 vs. Existing Conditions

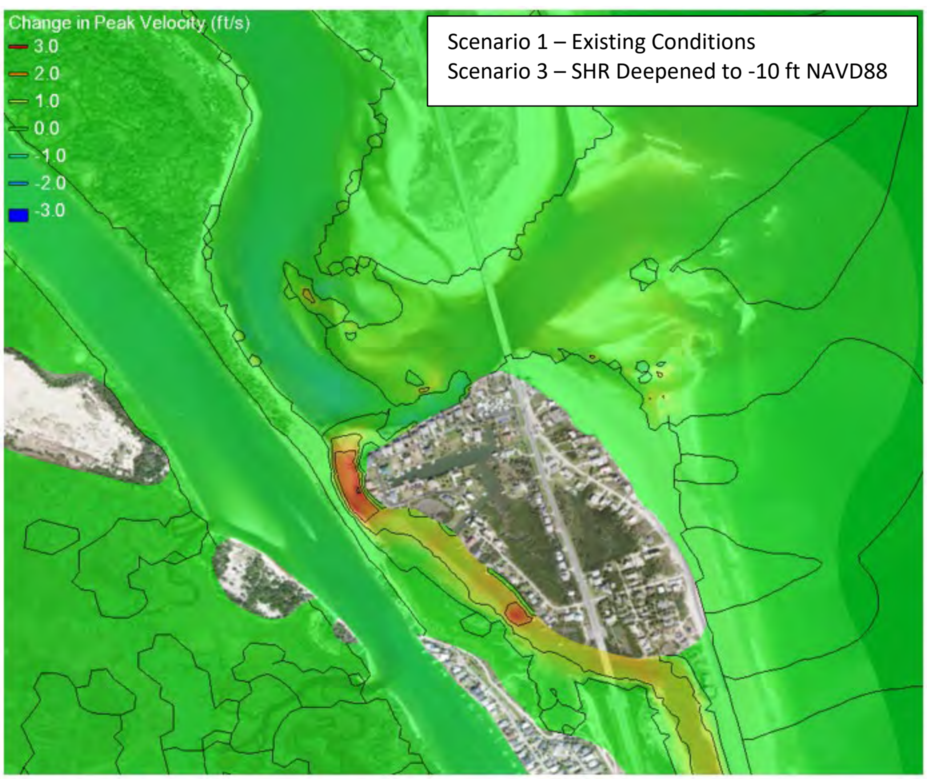

Figure 4.26 Change in Velocity within Inlet at Peak Ebb Flow – Scenario 3 vs. Existing Conditions

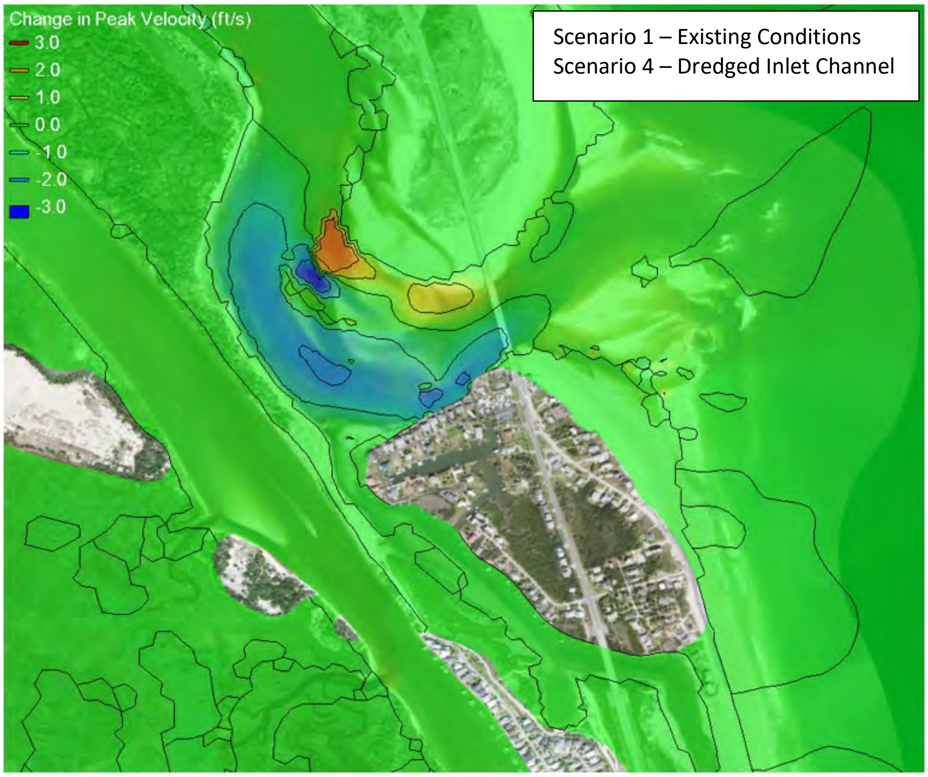

Figure 4.27 Change in Velocity within Inlet at Peak Ebb Flow — Scenario 4 vs. Existing Conditions

4.6.2 Effects on Sediment Transport Potential

To understand how the above velocity changes from scenarios 2–4 affect sediment transport and, hence, the erosion concerns along the southern shoreline, this study evaluated sediment transport potential through comparison of the model simulation velocities with the critical velocity for the sediment. The critical velocity is the velocity required to initiate sediment movement. It is a function of the sediment size, density of the sediment, density of the water, depth of the water column and bed roughness. When the depth averaged velocity exceeds the critical velocity, sediment transport occurs at the bed. Conversely, when existing velocities are reduced to below the critical velocity, sediment deposition may occur.

Figure 4.28–**Figure 4.35** plot contours of the velocity exceedance over the critical velocity for scenarios 1–4 for the peak ebb and flood flows. In these plots, sediment transport (i.e., erosion of the seabed) may occur anywhere the velocities exceed the critical velocity (i.e., any place within the colored contours). Accretion may occur any place where the velocities are less than the critical velocity (i.e., any place void of contours).

For scenario 1 (existing conditions), the ebb flow velocities exceed the critical velocity (**Figure 4.27**) throughout the inlet except along the north bank, along the shoal fronting the Summer Haven River, and along the most elevated portions of the flood shoal towards the center of the inlet. Note the high exceedance along the center of the southern shoreline where the ebb flow runs against the shoreline before completing its turn seaward; this explains the concerning erosion along the shoreline. During incoming tide (**Figure 4.29**), the flood flow runs against the west bank before completing its turn northward, while the southern shoreline is largely unaffected by the currents.

For scenario 2, with the river deepened to -6 ft NAVD88, the steering current has minimal effect on the sediment transport potential (i.e., erosion) along the southern shoreline during ebb flow (**Figure 4.30**), where the velocities remain above the critical velocity. The steering current appears to only affect the edge of the shoal at the SHR mouth; this may alleviate erosion during peak ebb tide for only the properties within this area but not along the southern shoreline in general. During peak flood tide (**Figure 4.31**), the tidal currents enter the SHR with velocities greater than the critical velocity, which would likely reduce the shoal elevations at the mouth of the river.

Scenario 3, with the river deepened to -10 ft NAVD88, does not have much more effect than scenario 2, with only minor differences near the mouth of the river. At peak ebb flow (**Figure 4.32**), the tidal flow through the river that exceeds critical velocity connects to the inlet, which would likely reduce the shoal elevations and help maintain the river's channel depths. During peak flood flow (**Figure 4.33**), the flow exceeding critical velocity covers a larger area over the shoal at the mouth of the river.

Scenario 4 drastically alters the sediment transport potential patterns within the inlet. During peak ebb flow (**Figure 4.34**), expansive areas throughout the southern and western portions of the inlet no longer exceed critical velocity. During flood flow (**Figure 4.35**), a narrow strip along the western bank and a wide strip along the southern bank no longer exceed critical velocity. Thus, dredging a deeper channel across the northern portion of the inlet would alleviate the erosion pressures along the west bank and along the entire southern shoreline.

The minor changes observed for scenarios 2 and 3 are difficult to discern in the above-mentioned figures. To more clearly illustrate the effects, **Figure 4.36**–**Figure 4.39** identify (1) areas currently experiencing erosion (i.e., existing velocities exceed critical velocities) that no longer do in the model simulations (i.e., model velocities drop below critical velocities) and (2) areas currently stable (i.e., existing velocities are below critical velocities) that do experience erosion in the model simulations (i.e., velocities increase above critical velocities). The figures focus on the southern shoreline of the inlet. The results for scenarios 2 and 3 are similar, with erosion potentially abating (blue hatched polygons) along the edge of the shoal at the mouth of the river during ebb tide and erosion potentially increasing (red hatched polygons) over a larger area across the shoal during flood tide. Unlike scenario 4, scenarios 2 and 3 do not reduce erosion along the southern shoreline eastward of the shoal.

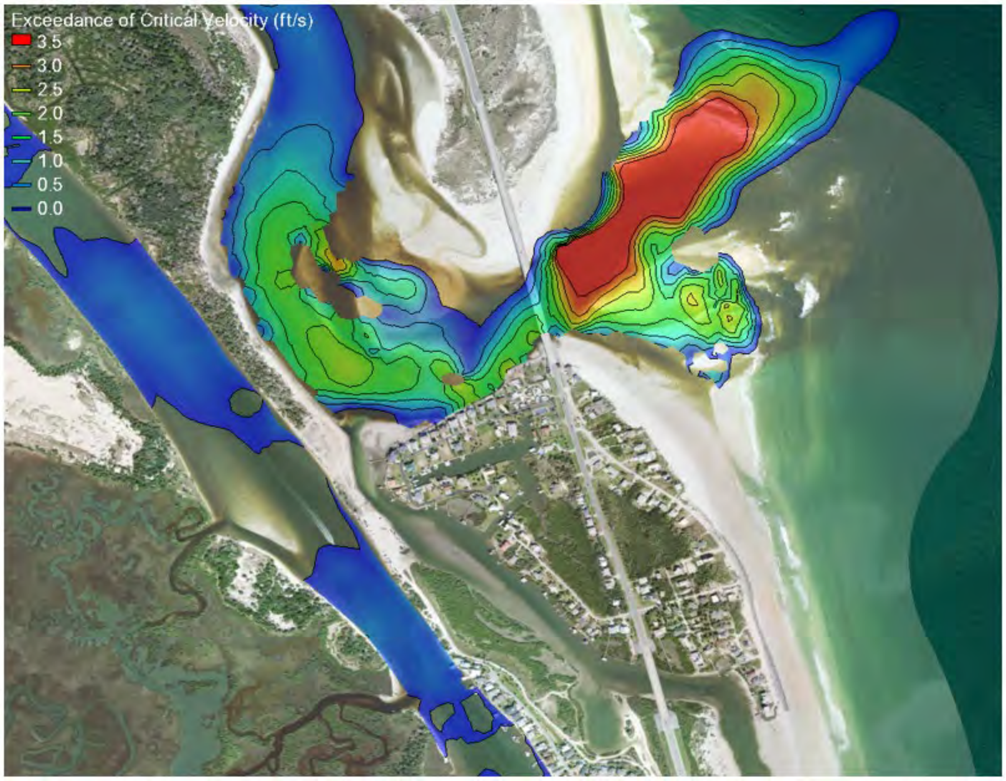

Figure 4.28 Exceedance of Critical Velocity at Peak Ebb Flow — Existing Conditions

Figure 4.29 Exceedance of Critical Velocity at Peak Flood Flow — Existing Conditions

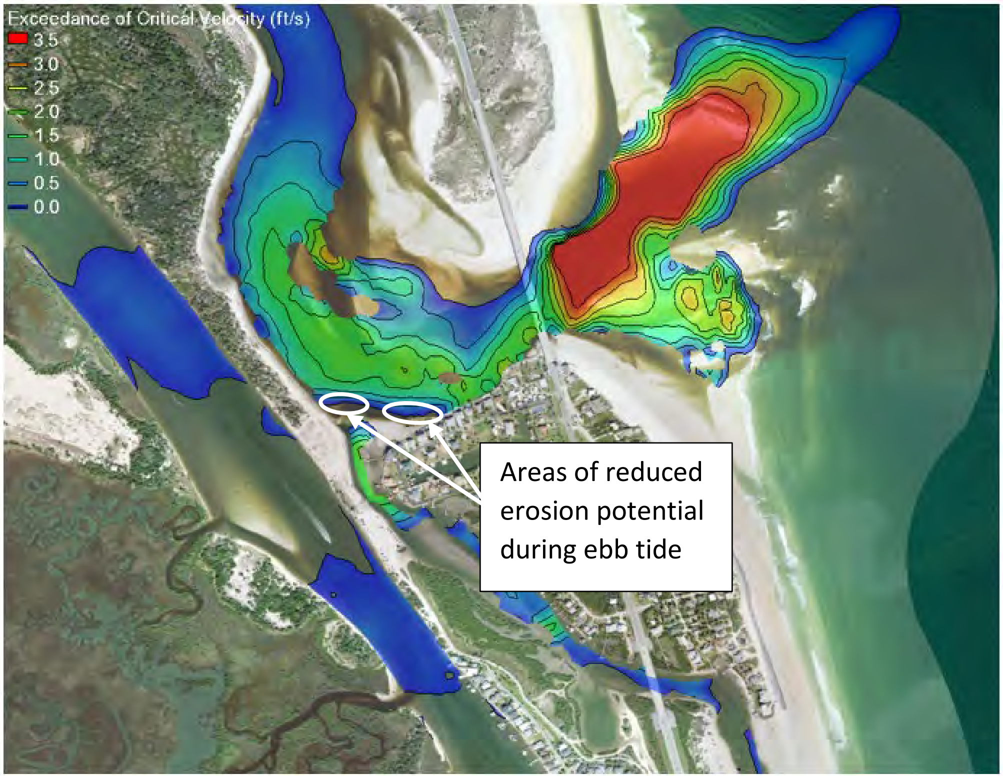

Figure 4.30 Exceedance of Critical Velocity at Peak Ebb Flow – Scenario 2 (SHR Deepened to -6 ft NAVD88)

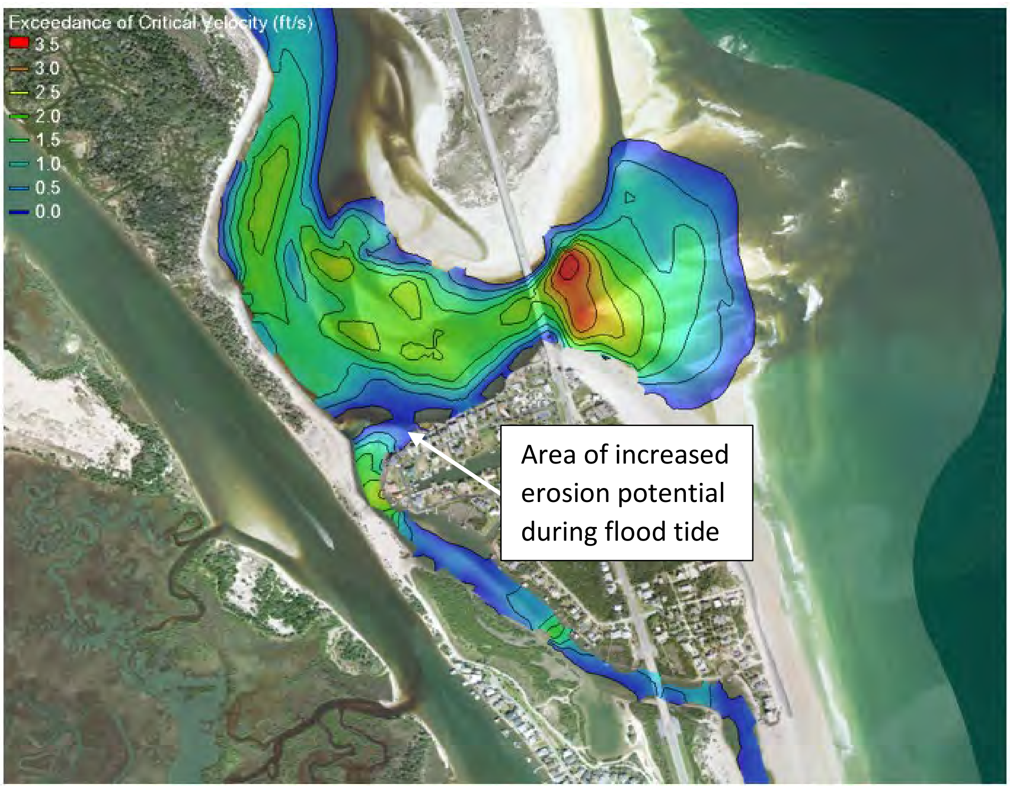

Figure 4.31 Exceedance of Critical Velocity at Peak Flood Flow – Scenario 2 (SHR Deepened to -6 ft NAVD88)

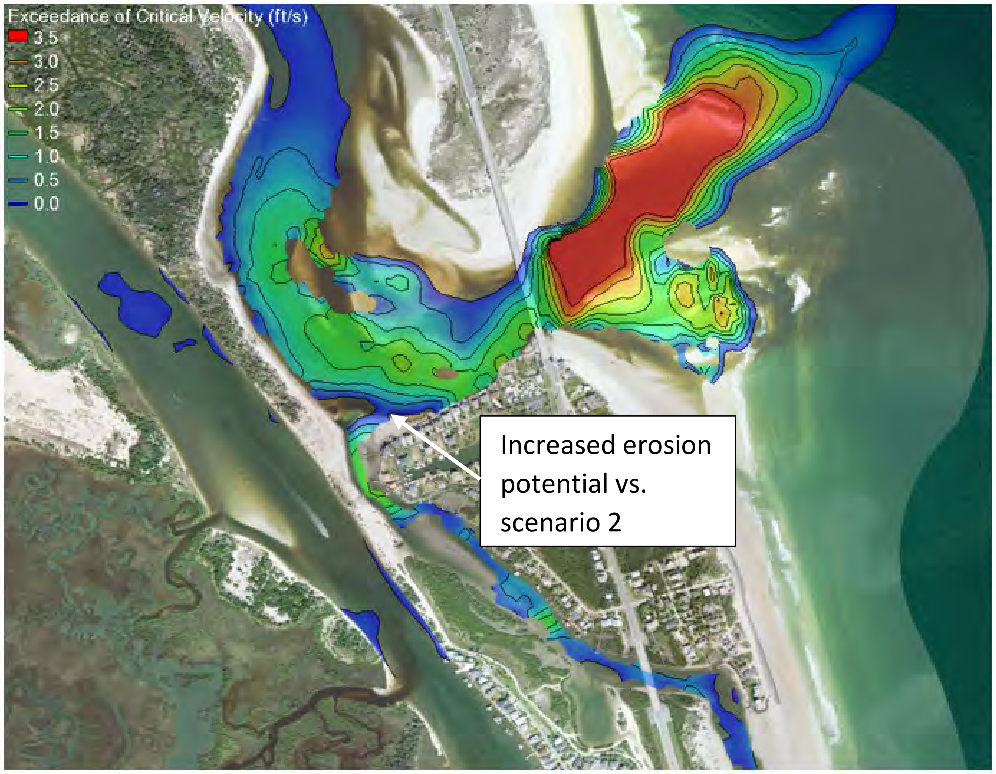

Figure 4.32 Exceedance of Critical Velocity at Peak Ebb Flow – Scenario 3 (SHR Deepened to -10 ft NAVD88)

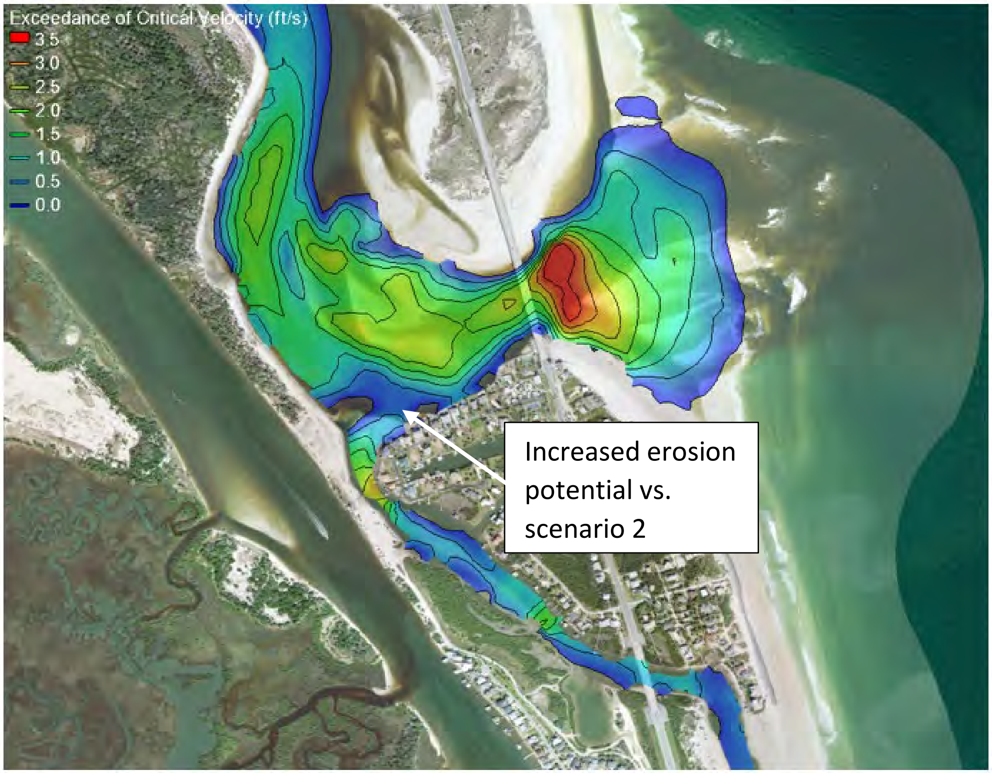

Figure 4.33 Exceedance of Critical Velocity at Peak Flood Flow – Scenario 3 (SHR Deepened to -10 ft NAVD88)

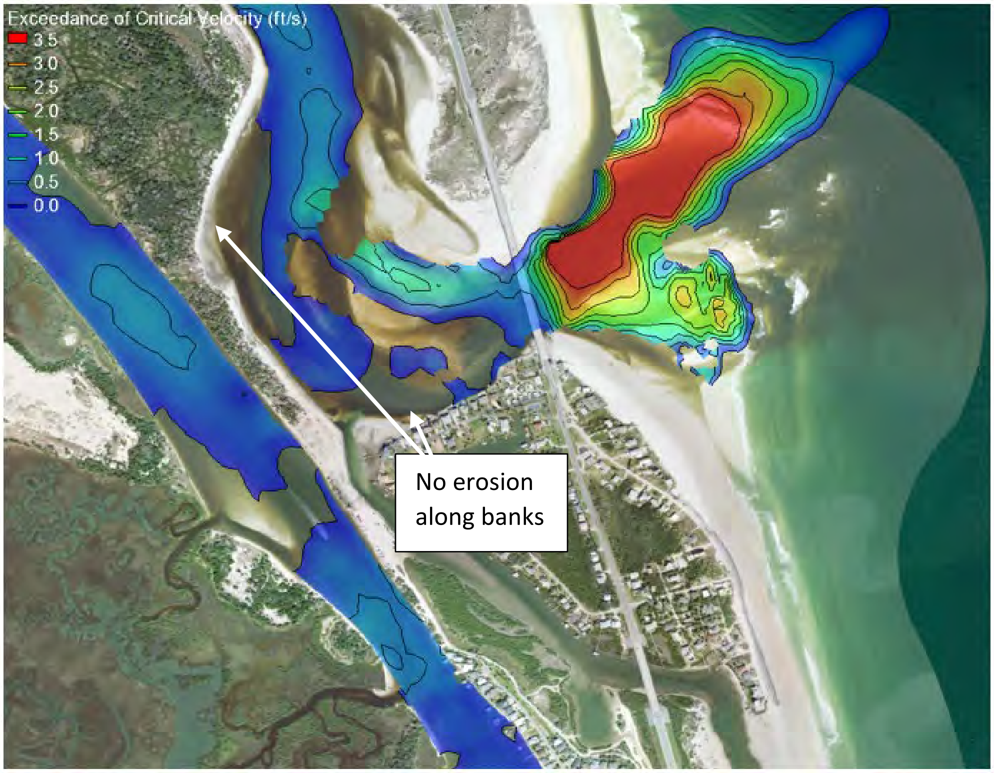

Figure 4.34 Exceedance of Critical Velocity at Peak Ebb Flow – Scenario 4 (Dredged Inlet Channel)

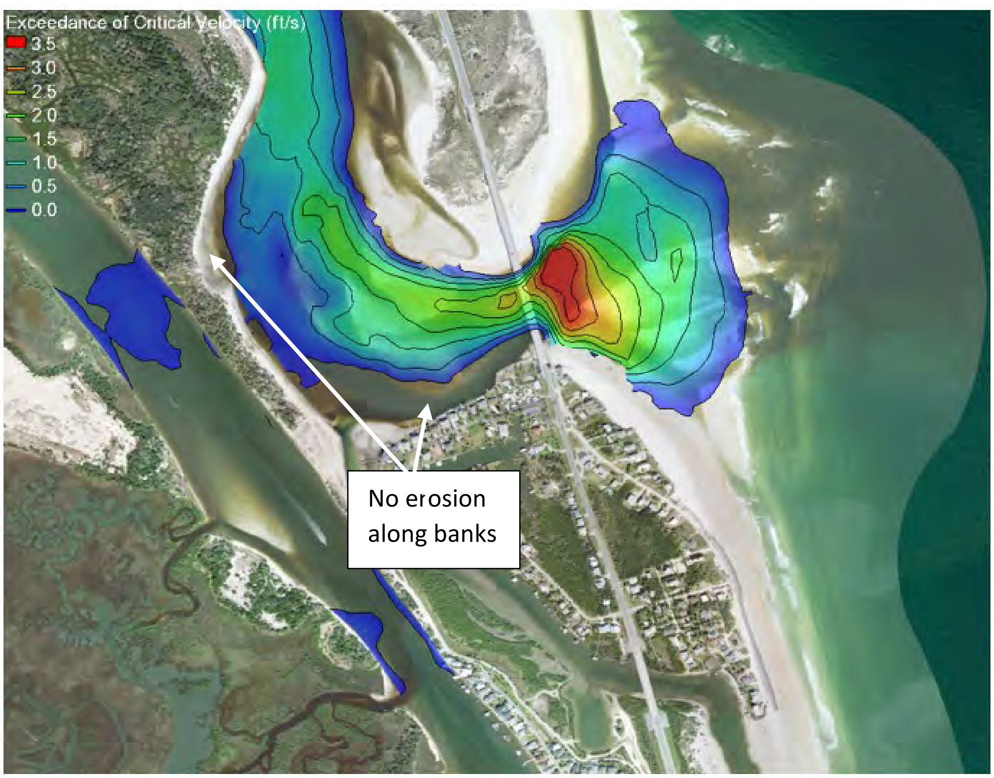

Figure 4.35 Exceedance of Critical Velocity at Peak Flood Flow – Scenario 4 (Dredged Inlet Channel)

Figure 4.36 Scenario 2 (SHR Deepened to -6 ft NAVD88) Effects on Erosion during Ebb Flow

Figure 4.37 Scenario 2 (SHR Deepened to -6 ft NAVD88) Effects on Erosion during Flood Flow

Figure 4.38 Scenario 3 (SHR Deepened to -10 ft NAVD88) Effects on Erosion during Ebb Flow

Figure 4.39 Scenario 3 (SHR Deepened to -10 ft NAVD88) Effects on Erosion during Flood Flow

4.6.3 General Effects near Pellicer Creek

Appendix L includes plots of scenario results for both ebb and flood flows. For brevity, this section includes sample plots for ebb flow only.

Figure 4.40 shows the flow velocities at peak ebb flow under existing conditions at the south end of SHR near Pellicer Creek. **Figure 4.41**–**Figure 4.43** show the changes in flow velocity, compared to existing conditions, at peak ebb flow for scenarios 2–4. Like the prior figures focused on the inlet, negative values correspond to a reduction in velocity, positive values indicate an increase in velocity, and the black contour lines surrounded by green shading represents the zero-change contour. Note the plots indicate velocity changes at 0.5-ft/s contour intervals. The increased flow through the SHR is evident for scenarios 2 and 3, with slightly greater change for Scenario 3 as expected with a deeper river and larger flow volume. For scenarios 2 and 3, a slight increase in flow velocity is evident in the ICWW south of the SHR, and a slight decrease in flow velocity occurs in the ICWW north of the SHR. For Scenario 2, the corresponding maximum ebb flow velocity increase and decrease in the ICWW equals 0.2 ft/s and -0.2 ft/s (0.2 ft/s and -0.25 ft/s for peak flood flow); For Scenario 3, the magnitudes increase slightly to 0.3 ft/s and -0.5 ft/s (0.45 ft/s and -0.4 ft/s for peak flood flow). Scenario 4 has negligible effect.

Further analysis of the model output indicates the flow velocity changes extend further into the primary marsh channel across from the SHR and further up and down the ICWW; however, the velocity change magnitudes are minor. The maximum flow velocity changes in the marsh creek for Scenario 2 ebb and flood flows are 0.1 ft/s and 0.2 ft/s; the maximum changes increase to 0.15 ft/s and 0.4 ft/s for Scenario 3 ebb and flood flows. These results suggest the SHR affects the flow velocities near the confluence of the SHR and ICWW as expected, but the broad reaching effects are minor in magnitude. Note, the model results pertain to flow velocities only and do not extend to salinity levels or other measures of water quality.

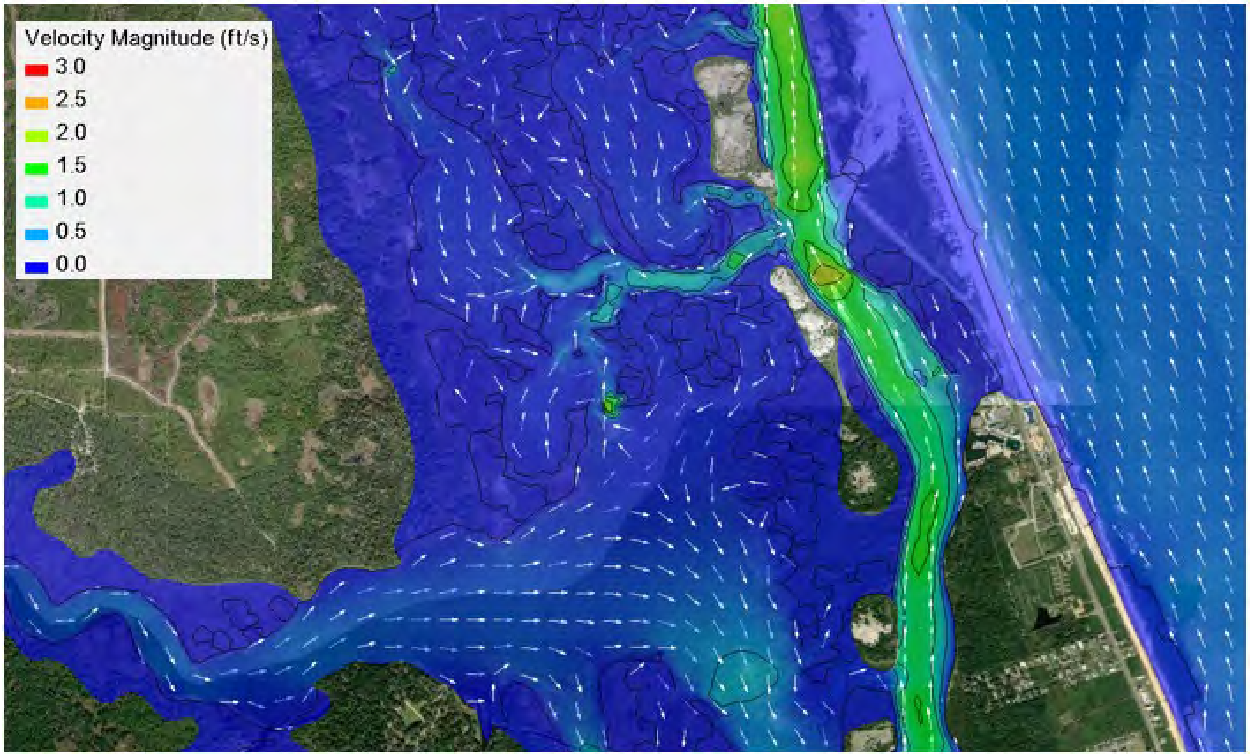

Figure 4.40 Velocities at Peak Ebb Flow under Existing Conditions

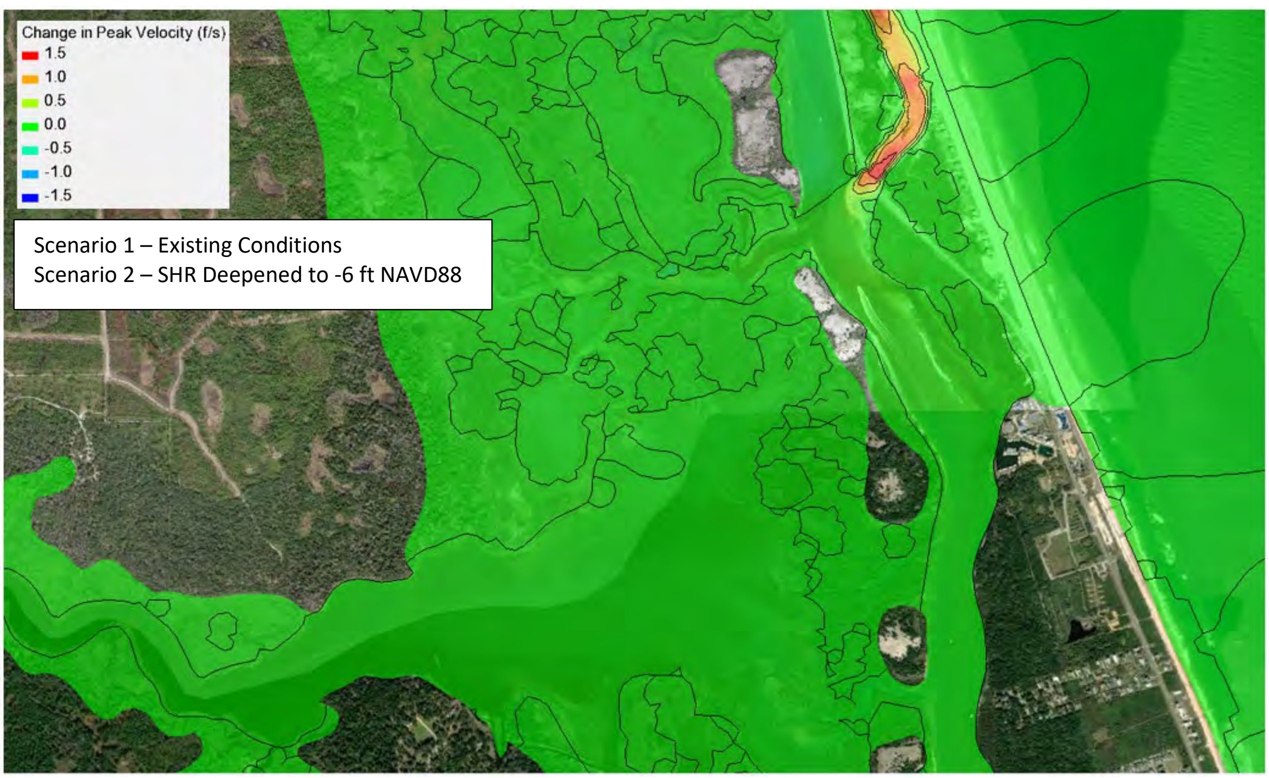

Figure 4.41 Change in Velocity within Inlet at Peak Ebb Flow – Scenario 2 vs. Existing Conditions

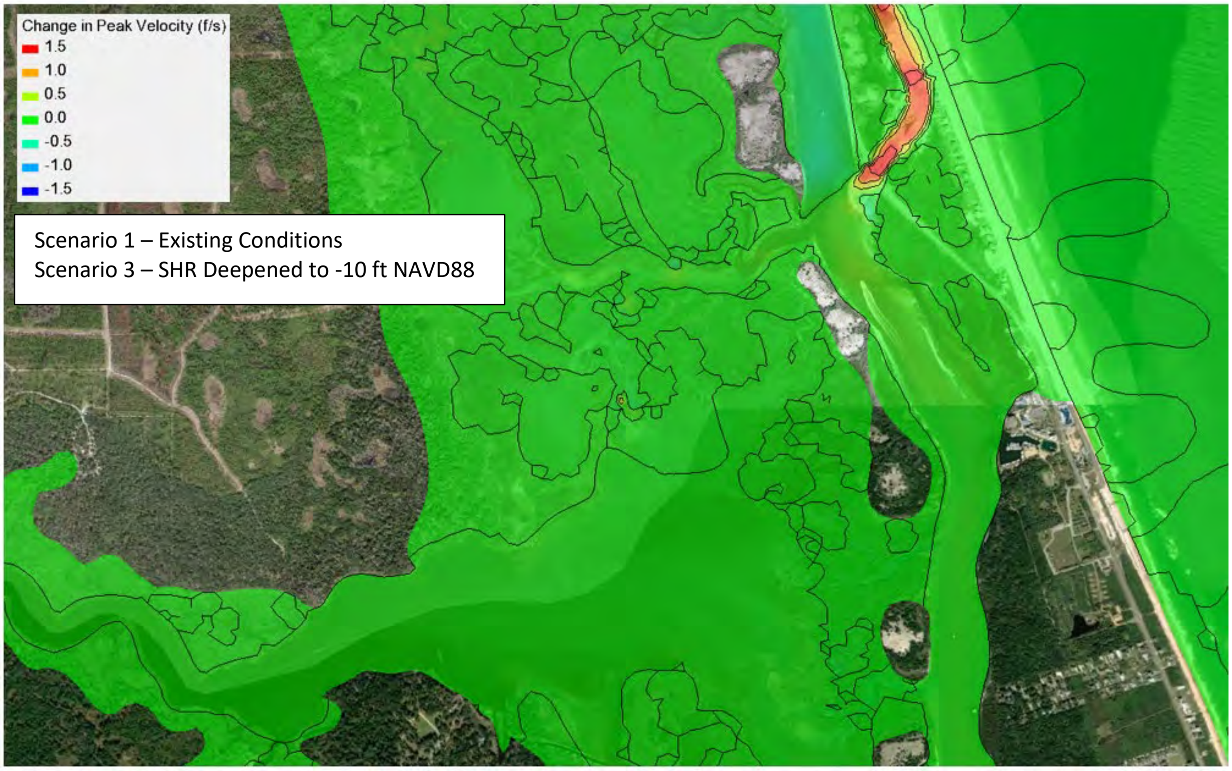

Figure 4.42 Change in Velocity within Inlet at Peak Ebb Flow – Scenario 3 vs. Existing Conditions

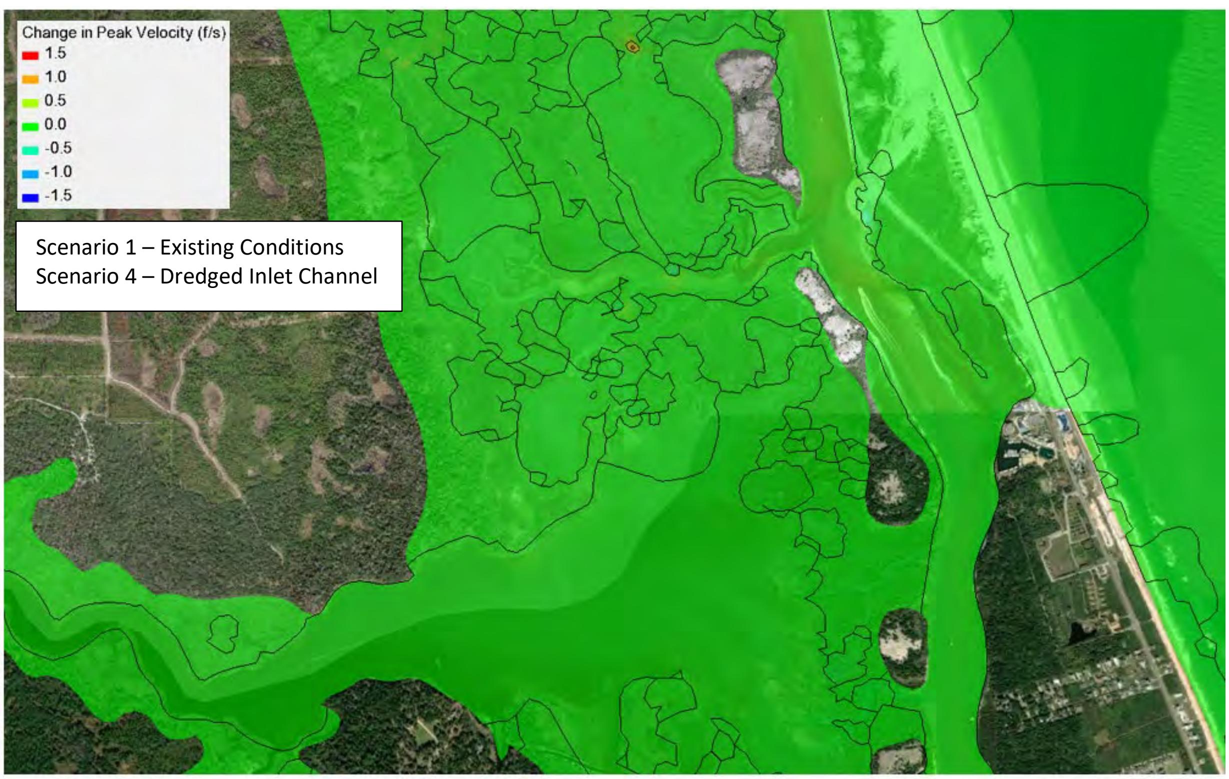

Figure 4.43 Change in Velocity within Inlet at Peak Ebb Flow – Scenario 4 vs. Existing Conditions

4.7 Discussion

Most authors think sediment moves along both the Anastasia Island and Summer Haven shorelines from north to south. The sediment budgets presented herein indicate a net longshore transport gradient of north to south. As such, Matanzas Inlet generally wants to migrate to the south. Historical aerials bear this out. This southward migration of the inlet threatened the south shoreline of the SR A1A Bridge over Matanzas Inlet, first constructed in the early 1920’s and last replaced in 1993. Hurricane Dora (1964) prompted additional armoring of this shoreline. Over the long-term, stronger flood tidal flows, because of the inlet’s location relative to St. Augustine and Ponce de Leon inlets, likely deposit more sediments inside the inlet than the ebb tidal flows remove. This net imbalance allows the flood shoals inside the inlet to grow with sand that otherwise, without the inlet’s sand-trapping effect, would reach Summer Haven and other downdrift beaches.

With lesser amounts of sand reaching the Summer Haven beaches, they become more susceptible to storm-induced erosion as the beach is generally narrower and lower over time in the presence of storms. Overwash occurs when the minimum combination of elevated water levels and wave runup is exceeded. Upon happening in natural areas (unaffected by man), overwash deposits would remain in place, naturally recruit vegetation, and receive aeolian (sand transported by wind) sand deposits to allow a barrier island to build up. While putting overwash deposits back onto the beach, as done on Summer Haven many times, helps the beaches recover after a storm event, this practice does not allow the barrier island to increase in elevation to naturally build more resiliency in the face of rising sea levels. Therefore, the frequency of future storms causing overwash (and breaches) may increase. This phenomenon may be bearing out given the recent breaches occurring in 2008 (Tropical Storm Fay), 2016 (Hurricane Matthew), 2017 (Hurricane Irma), 2019 (Hurricane Dorian), 2021 (nor’easter), and 2022 (hurricane Ian and Nicole). Overwashes also create low spots in the barrier island. These low spots are susceptible to future overwash and potential breaches as waves and elevated water levels continue to scour the low spots.

The lack of a wide dry beach can also contribute to the lack of or relatively small post-storm dune recovery in the Summer Haven area. Elevated water levels and high waves erode sand from the beach and dune during a storm. They transport the sand seaward into a bar (and potentially landward as overwash). During calmer sea states, the seaward-directed sand gradually moves from the bar shoreward into the dry beach berm. Depending on the width of the berm, winds may pick up the dry fraction of the sand and transport (termed aeolian transport) it landward where vegetation can trap the sand. This trapped sand will recruit vegetation and help the dune recover. A narrow beach does not provide enough source material to allow for this process to fully realize. As such dune rebuilding on narrow beaches typically requires intervention.

5.0 Identification and Evaluation of Potential Actions

This study followed a two-phase approach to evaluating potential alternatives — an initial screening followed by conceptual-level design assessment. The first phase identifies and summarizes possible solutions — including seawall, revetment, dune restoration, beach and dune restoration, T-head groins, breakwaters, artificial reefs, and structural dune core alternatives — and evaluates their potential for achieving the study goals and receiving regulatory approvals. The second phase further evaluates only those approaches that both may achieve the study goals and receive regulatory approval. Additionally, this study considered the costs of taking no action and continuing a policy of managed retreat.

5.1 Initial Screening of Potential Engineering Alternatives

The following sections describe the considered alternatives and their potential for meeting the project objectives.

5.1.1 Seawall

Construction of a sheet pile seawall for shoreline stabilization intents could fix the shoreline position and, if constructed high enough, prevent overtopping. However, once exposed to wave forces, seawalls tend to reflect wave energy seaward, which leads to exacerbated erosion and lowering of the beach profile, allowing larger waves to break closer to shore. Without replenishment of sand fronting a seawall, a significant reduction or elimination of the recreational beach, turtle nesting habitat, and shorebird habitat would likely occur. Given such adverse environmental impacts, the FDEP permits seawall construction only for protection of private property and public infrastructure under certain conditions.

One condition includes when seawalls (or other coastal armoring) locate seaward of the state's Coastal Construction Control Line (CCCL). The CCCL lies just seaward of the east bank of the SHR (**Figure 5.1**), potentially providing sufficient space for installation of a seawall. Regulatory approval for a seawall landward of the CCCL at Summer Haven would fall under the jurisdiction of the FDEP Beaches, Inlets and Ports Program as a Joint Coastal Permit (JCP). Obtaining authorization for such a wall may prove difficult. Permitting would address such items as surface water and wetland impacts.

Pursuant to Section 161.085(2)(a), FS, Florida may issue permits for rigid coastal armoring structures only for protection of private structures or public infrastructure (i.e., public evacuation routes, public emergency facilities, bridges, power facilities, water or wastewater facilities, other utilities, hospitals, or structures of local governmental, state, or national significance) proven vulnerable to damage from frequent coastal storms. Per Section 161.085(2)(c), FS, absent such private structures or public infrastructure, Florida may only permit rigid costal armoring to protect private and public property if the proposed installation is between and adjoins at both ends existing rigid coastal armoring structures, follows a continuous and uniform armoring structure construction line with existing coastal armoring structures, and is no more than 250 ft in length.

Given the long expanses of shoreline without vulnerable private structures or public infrastructure between R-200 and R-205, a seawall does not meet Florida's eligibility criteria for rigid coastal structures sited seaward of the CCCL. Therefore, a seawall located there is not a viable solution. However, a seawall located landward of the CCCL could prove viable under authorization of a JCP.

Figure 5.1 Location of the Coastal Construction Control Line

5.1.2 Revetment

Revetments currently exist at the northern and southern boundaries of the Summer Haven shoreline, protecting Old A1A north of R-200 and Marineland south of R-209. These structures have successfully fixed the shoreline position, but no dry beach exists seaward of these structures. Construction of a revetment along the Summer Haven shoreline between the existing revetments could fix the shoreline position and, if constructed high enough, prevent overtopping. However, like seawalls, revetments typically lead to depletion of the beach fronting the structure and are difficult to permit.

Revetments fall under the restrictions of Section 161.085(2)(a), FS and Section 161.085(2)(c), FS discussed above for seawalls. Like a seawall, a revetment is not a viable solution seaward of the CCCL but could prove viable under authorization of a JCP. When considering the side slopes of a revetment, its footprint can far exceed the footprint of a seawall. Given the small space available to place a revetment between a restored riverbank and the CCCL and the need for minimizing the footprint to lessen potential environmental impacts, this alternative will not likely prove viable.

5.1.3 Dune Restoration

This alternative consists of placing a small dune seaward of the line of coastal construction such that the landward edge of the dune crest lies approximately 40 ft east from the edge of the five isolated houses. A typical dune consists of a landward 3H:1V slope up to elevation +14 ft NAVD88 (to match historical dune elevations), a flat dune crest of 25 ft, and a seaward dune slope of 3H:1V. As borne out by experience in the area and confirmed by cross-shore erosion modeling (see Appendix M), a 25-yr event overwashes the dune. Therefore, dune only restoration does not meet the performance criteria set forth herein.

5.1.4 Beach and Dune Nourishment

This alternative would construct a large-scale beach and dune project to provide natural storm damage reduction benefits while enhancing the recreational and environmental beach functions. In theory, the initial project would include construction of a minimum design template — engineered to provide protection against selected storm conditions (e.g., 25-yr storm surge levels) — plus placement of advance fill at the seaward edge of the berm. When natural coastal processes erode the advance fill and the shoreline recedes back to the design template shoreline position, a nourishment project will occur to rebuild the advance fill template. Periodic nourishments will occur as necessary to maintain the design template and its intended level of storm protection. A fully funded long-term beach nourishment program can maintain sufficient dune characteristics and protective berm width to minimize the risk of dune overtopping and breach development.

In general, FDEP supports beach nourishment pursuant to Section 161.161, FS and 161.091, FS, which require FDEP to develop and maintain a comprehensive long-term beach management plan for the restoration and maintenance of the state's critically eroded beaches that:

(a) Encourages regional approaches to ensure the geographic coordination and sequencing of prioritized projects;
(b) Reduces equipment mobilization and demobilization costs;
(c) Maximizes the infusion of beach-quality sand into the system;
(d) Extends the life of beach nourishment projects and reduces the frequency of nourishment; and
(e) Promotes inlet sand bypassing to replicate the natural flow of sand interrupted by improved, modified, or altered inlets and ports.

The FDEP's Strategic Beach Management Plan for the northeast Atlantic coast region (FDEP, 2020) identifies beach nourishment as the approved beach management strategy and, therefore, necessitates further evaluation.

5.1.5 T-head Groins

Traditional shore-perpendicular groins can help stabilize the shoreline by trapping longshore-directed sand along their updrift side; however, such groins have little effect on cross-shore-directed sand transport and are prone to forming rip currents. T-head groins consist of a traditional shore-perpendicular groin section ("stem") combined with a shore-parallel "head" section designed to diffract waves and form a crenulate beach between groins. Structures with heads at their seaward ends appear less susceptible to offshore losses and tend to create a more stable beach between groins, even in storms with high cross-shore transport potential (Bodge, 1998). Use of the head also allows for a shorter stem than a traditional groin, keeping the groin footprint in shallower water closer to shore, which typically reduces materials (typically rock) quantities and lowers construction costs. The heads can be angled (deviating from a strict "T" shape), oriented to align the gap between adjacent heads with the design wave angle to improve the performance of the T-head groin field. A combination of traditional groins, T-head groins, and detached breakwaters (i.e., the T-head without the stem) may also provide an improved solution.

Both traditional and T-head groins diminish the longshore sand transport and, thus, have the potential to cause downdrift beach erosion. The erosion potential can be avoided or minimized by locating the terminal groin at the end of a littoral cell (i.e., where no downdrift beach exists), in a region of decelerating longshore transport gradients (i.e., an area that tends to naturally accrete), or pre-filling the groin field with sand so, theoretically, the groins will not trap sand but rather allow longshore sand transport to bypass the groin field. At Summer Haven, an extension of the groin field, or another solution permittable by regulatory agencies, would have to continue along the south end of Summer Haven (i.e., from R-205 to the Marineland revetment) to avoid adversely affecting the private property along this stretch.

T-head groin maintenance requirements may consist of periodic replacement of rock following extreme storms. T-head groins, like other rock structures, are designed to withstand certain design water level and wave conditions (e.g., a 50-year storm surge). If an extreme event that exceeds the design conditions occurs, the excess wave forces may displace some of the rock to varying degrees depending on the severity of the storm. Maintenance would entail reconstructing the structure to design parameters.

T-head groins could help stabilize the Summer Haven shoreline. However, extreme water levels during powerful storms could overtop the structures and subject the dunes to wave-induced erosion, potentially leading to overwash of the beach and/or dune sand into the river. Thus, this alternative, as a stand-alone solution, does not meet the goals of the study yet could help achieve the goals if implemented in combination with beach and dune nourishment.

Furthermore, per discussions with FDEP staff, FDEP could potentially permit construction of T-head groins only after construction and three years of performance monitoring of a beach nourishment project. The structures would have to prove necessary to extend the life of the beach nourishment project and reduce the frequency of nourishment per Section 161.091(2)(d), FS.

The T-head groin alternative is potentially viable, if needed, in combination with a beach nourishment project discussed above.

5.1.6 Breakwaters

Breakwaters consist of detached shore-parallel structures that protect a shoreline by dissipating wave energy, reduce the littoral transport landward of the structure, and promote sediment deposition if sited correctly. Breakwaters often lead to formation of a salient (i.e., a shoreline bulge) along the sheltered area landward of the breakwater. With no shore-perpendicular stem attached to the shoreline, longshore sediment transport may continue to some degree along the coast behind the breakwater. However, certain design parameters may lead to formation of a tombolo, a spit of sand that connects the beach to the breakwater, and elimination of any bypassing of sand behind the breakwater.

Protection of long sections of shoreline requires multiple breakwaters constructed in a row, referred to as segmented breakwaters. One must carefully consider breakwater lengths, gap lengths, and distances from shore for optimal project performance and avoiding dangerous currents or poor water circulation. Crest elevation (emergent, submergent or low-crested) is also vital to breakwater design. Emergent breakwaters provide the most shoreline protection by preventing transmission of wave energy under design conditions. However, emergent breakwaters are more expensive and may have more pronounced adverse effects on aesthetics, water quality, and downdrift erosion. Submerged or low crested breakwaters allow some degree of overtopping, depending on design conditions, and only partially attenuate the wave energy, thus lessening the degree of shoreline protection.

Like T-head groins, per discussions with FDEP staff, FDEP could potentially permit construction of breakwaters only after construction and a minimum of three years of performance monitoring of a beach nourishment project. The structures would have to prove necessary to extend the life of the beach nourishment project and reduce the frequency of nourishment per Section 161.091(2)(d), FS. The breakwater alternative is potentially viable in combination with a beach nourishment project.

5.1.7 Artificial Reefs

Artificial reefs, or living breakwaters, are a type of breakwater designed to incorporate natural habitat by providing a hard substrate for colonization by oysters or hard corals or by creating shelter and habitat for marine species. Artificial reefs may consist of various materials, such as limestone boulders or re-purposed bridge and highway materials, as well as manufactured concrete reef modules offered in numerous shapes and sizes by a variety of manufacturers. One well-known example of a manufactured concrete reef module is a Reef Ball, a hemispherical shape characterized by a rough surface that promotes quick colonization by marine species and plants and many holes specifically designed to dissipate wave energy. The artificial reef alternative falls under the broader category of breakwaters. Therefore, it potentially viable, if needed, in combination with a beach nourishment project.

5.1.8 Structural Dune Core

Construction of a dune with a structural core maintains the natural beach environment during normal conditions but can minimize erosion under severe conditions when significant dune erosion occurs. Many have applied sand-filled geotextile products (typically tubes or bags) but with mixed results. To maintain sufficient turtle nesting habitat, a three-foot deep layer of sand must remain above the geotextile forms in perpetuity. This can lead to expensive beach fill maintenance projects should chronic dune erosion occur. When exposed, geotextile tubes are also subject to vandalism, as they are easily susceptible to knife punctures. A buried seawall offers an alternative with a smaller footprint and, hence, less maintenance requirements.

Like the seawall and revetment alternatives discussed above, a structural dune core (whether composed of sand-filled geotextile products, seawall, or revetment) falls under the restrictions of Section 161.085(2)(a), FS and Section 161.085(2)(c), FS. Given the long expanses of shoreline without vulnerable private structures or public infrastructure between R-200 and R-205, a structural dune core does not meet Florida’s eligibility criteria for rigid coastal structures seaward of the CCCL. When sited landward of the CCCL, this alternative acts like a seawall or revetment sited in a similar location.

5.1.9 Screening Results

Table 5.1 summarizes the initial screening results. Overall, a seawall, revetment, beach and dune nourishment, and dune restoration with a structural core meet the principal objective of preventing breaches and minimizing dune overtopping to keep beach sediments from infilling the river. From a regulatory perspective, beach and dune nourishment is the most viable alternative with some allowance for groins and breakwaters should they prove necessary to improve beach performance. Seawall and revetment alternatives may receive regulatory approval if sited landward of the CCCL. Because of the limited area between a restored riverbank and the CCCL and the larger footprint of a revetment, a seawall is preferrable. Similarly, a restored dune with a structural core may receive regulatory approval if located landward of the CCCL. Therefore, the seawall and beach and dune nourishment alternatives move to the next phase of study. As discussed below, dune restoration with a structural core and the seawall alternative are very similar such that this study merges the two concepts into a single alternative for further analysis.

Table 5.1 Initial Screening of Alternatives

Alternative[1]	Prevents Breaches/ Minimizes Dune Overtopping	Potentially Meets Regulatory Approval
Seawall	✓	X / ✓ [2]
Revetment	✓	X / ✓ [2]
Dune Restoration	X	✓
Beach and Dune Nourishment	✓	✓ [3]
T-head Groins	X	✓ [4]
Breakwaters (incl. Artificial Reefs)	X	✓ [4]
Dune Restoration with Core	✓	X / ✓ [2]

[1]Includes engineering solutions only; Section 5.3 discusses the non-engineering alternatives of taking no action and managed retreat.
[2]Seawalls, revetments, and structured dune cores do not meet the eligibility criteria under 161.085(2)(a) and 161.085(2)(c), FS if sited seaward of the CCCL. They may potentially receive authorization only if situated landward of the CCCL.
[3]Beach nourishment is Florida's state-wide preferred solution for shoreline stabilization.
[4]Construction and performance monitoring of a beach and dune nourishment project is a pre-requisite (per Florida rules) for shoreline stabilization structures, which Florida will only authorize to improve the longevity of beach nourishment projects.

5.2 Conceptual Design of Viable Alternatives

The following sections discuss conceptual designs of the two alternatives initially screened as meeting the project objectives and potentially meeting regulatory approval — seawall and beach and dune nourishment.

5.2.1 Seawall

Figure 5.2 shows a conceptual cross section and plan view for a seawall project along the Summer Haven beaches from approximately R-200 to R-205.5. This alternative consists of locating a seawall approximately five feet landward of the CCCL. The dune, fronting the seawall and extending seaward into the CCCL, consists of 0.28-mm material, a crest elevation of +12 ft NAVD88, a crest width of 20 ft, and a 3H:1V seaward slope. The seawall concept consists of two steel sheet piles tied together with tie rods and concrete caps. The seawalls reach an elevation of +14 ft NAVD88 to mimic the historical dune elevations in the area.

An engineering analysis performed with USACE's SBEACH cross-shore erosion model helped assess the adequacy of the dune template to future, synthetic storms. Appendix M presents more details regarding model setup, calibration, and future storm simulations. Briefly, model setup included specifying a pre-storm profile, storm parameters, and sediment transport parameters. This study calibrated the model to

Hurricane Matthew (2016) conditions given the availability of pre- and post-storm profiles and storm information.

For the with-project simulations, storm data derived from Dean et al. (1987) and FDEP (2009) and USACE Wave Information Study (WIS). The former provides total storm tide elevations and corresponding 36-hr hydrographs while the latter provides historical offshore wave data for the period 1980-2020. The SWAN wave model (described previously) transformed the waves from deepwater to an approximate 40-ft water depth, the most seaward extent of the beach profiles. The modeled storms included the 15-, 25-, 50-, and 100-yr events. **Figure 5.3** presents the simulation results. While the 15- and 25-yr events erode some of the dune, they do not expose the dune below its original crest elevation. The less frequent events expose an additional three or more feet than originally exposed such that the exposed wall height increases from three feet to at least six feet. Given the large distance (20 ft) between the two walls and their elevations, overwashing of the double wall system is unlikely to occur.

Sheeting from the splash zone and up could prove vulnerable to corrosion and may require additional maintenance such as recoating, inspections, and repairs. For storms larger than design event, repairs may include replacing portions of wall, anchors, and backfill. Dune fill repairs would likely reoccur more frequently.

Of note, construction of this alternative requires the County to obtain easements, which are often difficult to obtain, from private property owners.

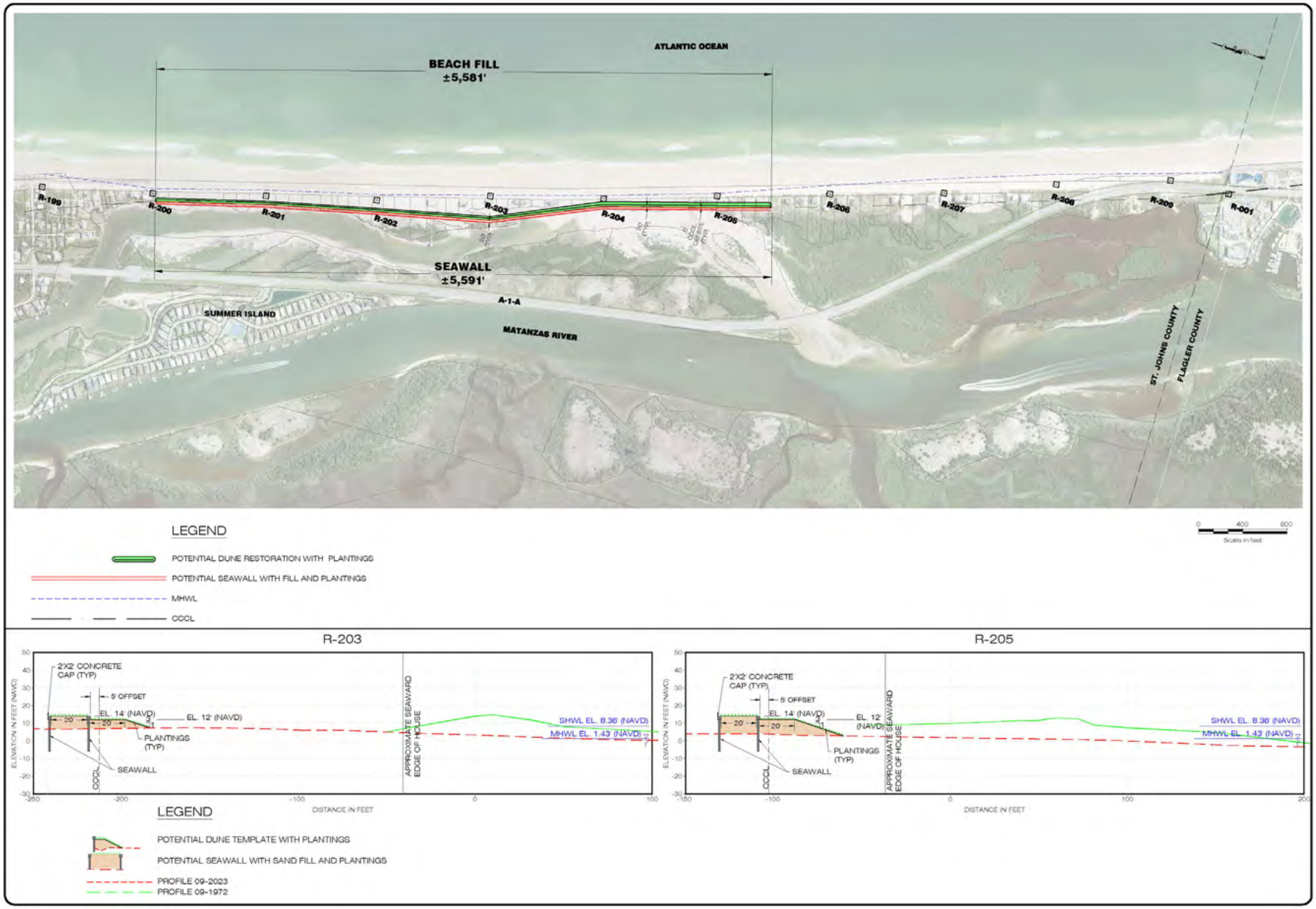

Figure 5.2 Concept Sketch – Seawall

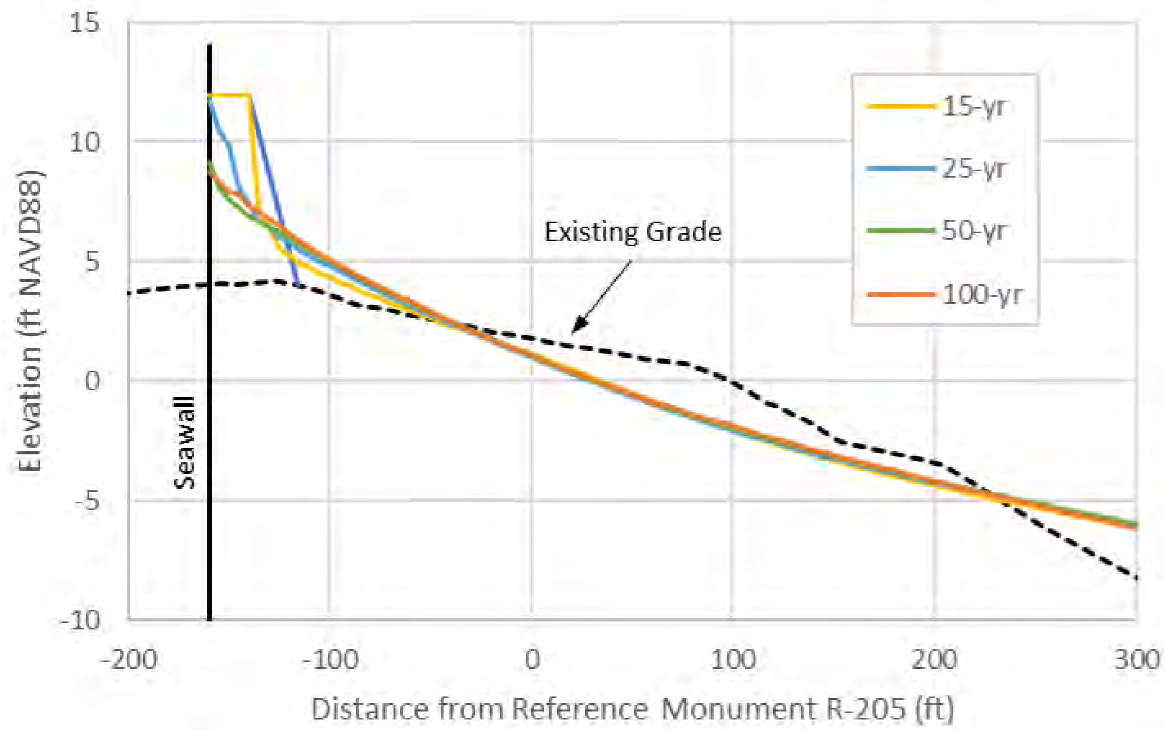

Figure 5.3 **SBEACH Simulations for Seawall Alternative**

5.2.2 Beach and Dune Nourishment

Figure 5.4 shows a conceptual cross section and plan view for a beach and dune nourishment project along the Summer Haven beaches from approximately R-200 to R-209. This alternative consists of placing a small dune seaward of the line of coastal construction such that the landward edge of the dune crest lies approximately 40 ft east from the edge of the five isolated houses. The dune crest reaches an elevation of +14 ft NAVD88 to match the peak historical dune conditions. The beach consists of a 150-ft wide beach crest at elevation +10 ft NAVD88 with a 10H:1V seaward slope until matching existing grade. Overall, the beach and dune nourishment project has an approximate fill density of 150 cy/ft for a total initial nourishment volume of approximately 1.5 million cubic yards.

An engineering analysis performed with USACE's SBEACH cross-shore erosion model helped assess the adequacy of the beach and dune template to future, synthetic storms. Appendix M presents more details regarding model setup, calibration, and future storm simulations. Briefly, model setup included specifying a pre-storm profile, storm parameters, and sediment transport parameters. This study calibrated the model to Hurricane Matthew (2016) conditions given the availability of pre- and post-storm profiles and storm information.

For the with-project simulations, storm data derived from Dean et al. (1987) and FDEP (2009) and USACE Wave Information Study (WIS). The former provides total storm tide elevations and corresponding 36-hr hydrographs while the latter provides historical offshore wave data for the period 1980-2020. The SWAN wave model (described previously) transformed the waves from deepwater to an approximate 40-ft water depth, the most seaward extent of the beach profiles. The modeled storms included the 25-, 50-, and 100-yr events. **Figure 5.5** shows the SBEACH results for the beach and dune template immediately after construction using a mean sediment size of 0.28 mm (equivalent to sand identified in FL-3). The 25- and 50-yr events erode much of the berm but do not encroach the dune toe, whereas the 100-yr event completely erodes the dune, severely lowers the profile elevations, and causes overwash. Results presented in Appendix M for a mean sediment size of 0.35 mm show the improved performance offered by a larger grain size (**Figure 5.6**). To represent the effect of back-to-back storms, this analysis re-ran SBEACH using the 25-yr post-storm profile to represent existing conditions with the coarser sand. The results, plotted in **Figure 5.7**, shows the second storm erodes nearly all the remaining berm but still does not erode into the dune, whereas the 100-yr storm again causes severe erosion.

From a longevity perspective, many coastal engineers apply a diffusion analysis based on the theory of Pelnard-Considere (e.g., see Dean and Dalrymple, 2002). Following this theory, a beach fill represents a perturbation or a planform anomaly to the local uninterrupted shoreline, which over time, longshore sediment transport smooths. This smoothing or diffusion of the beach fill by longshore sediment transport acts in conjunction with any background erosion present without the beach fill. Appendix N presents the details of the diffusion analysis.

Based on site-specific parameters, including a representative background shoreline erosion rate of -2 ft/yr, **Figure 5.8** presents the predicted amount of the beach fill remaining over time for the concept project. The figure shows that 50% of the fill remains after approximately five years. To determine beach maintenance costs, this study assumes that the beach fill requires renourishment every five years, which is like the County’s beach nourishment project in St. Augustine Beach. Of note, a major storm could prompt the need for nourishment sooner than five years, as is the case for the federal project in Vilano Beach that lost more than 75% of the authorized fill from a severe nor’easter within six months following construction. Unfortunately, funding availability rather than project need often dictates the nourishment schedule. For this study’s conceptual level cost estimate over a 50-yr project life, the assumed long-term average nourishment interval of five years is reasonable.

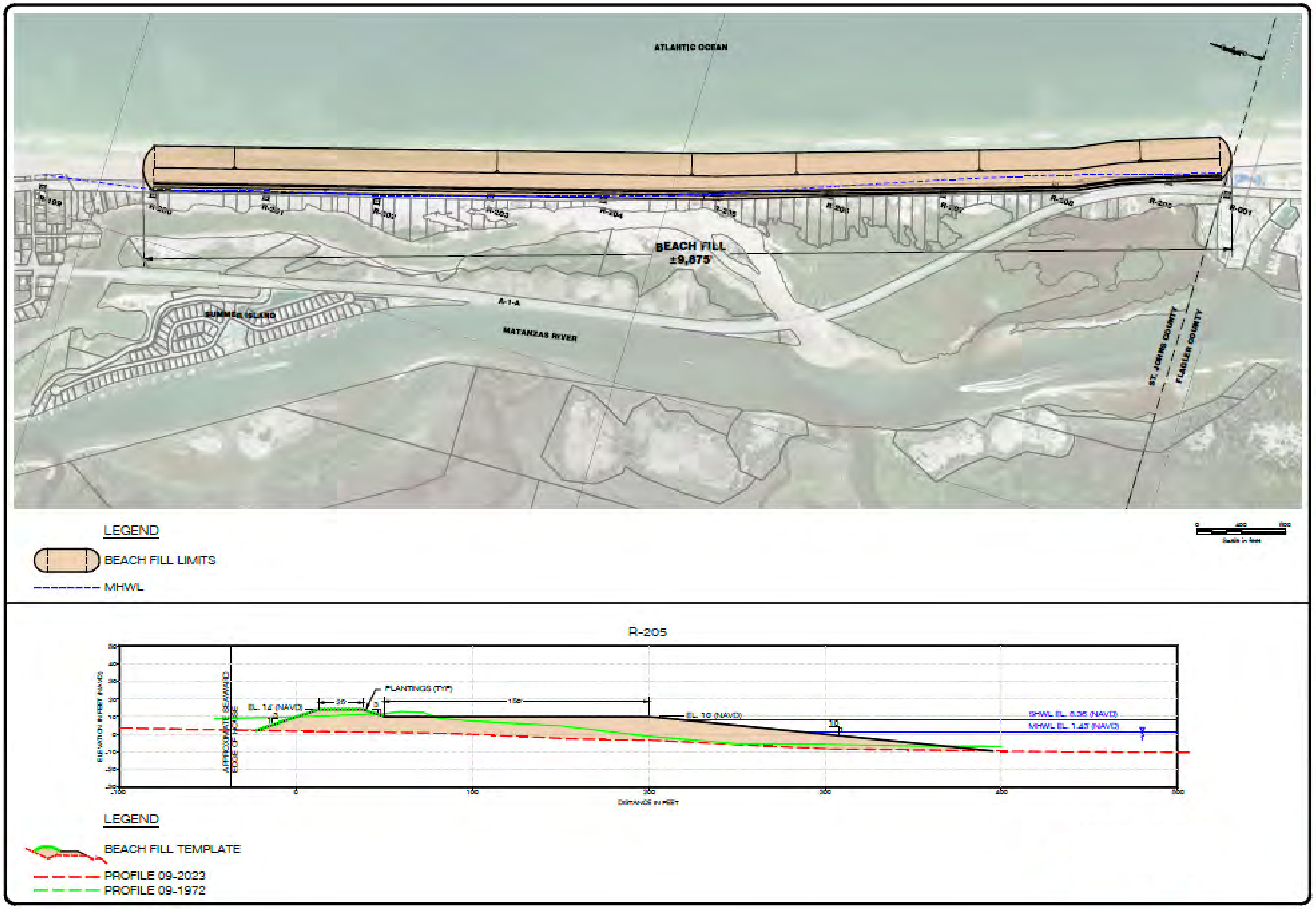

Figure 5.4 Concept Sketch – Beach and Dune Nourishment

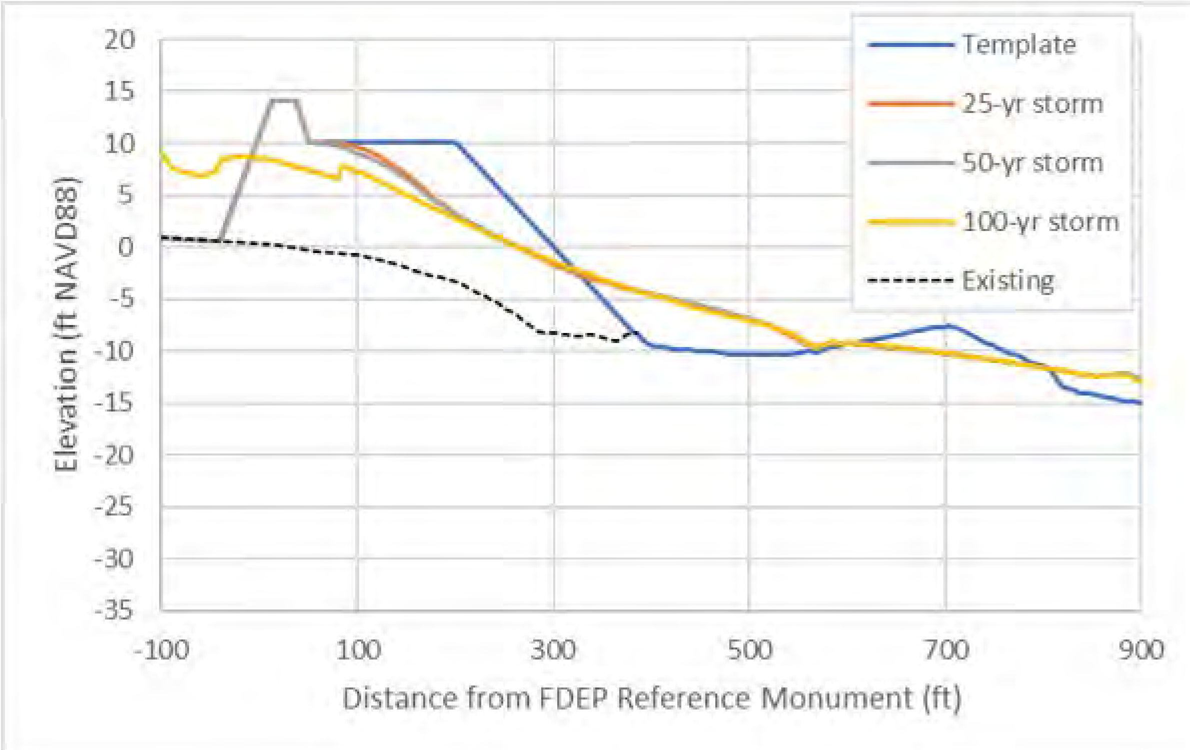

Figure 5.5 SBEACH Simulations for Beach and Dune Nourishment Alternative (D50 = 0.28 mm)

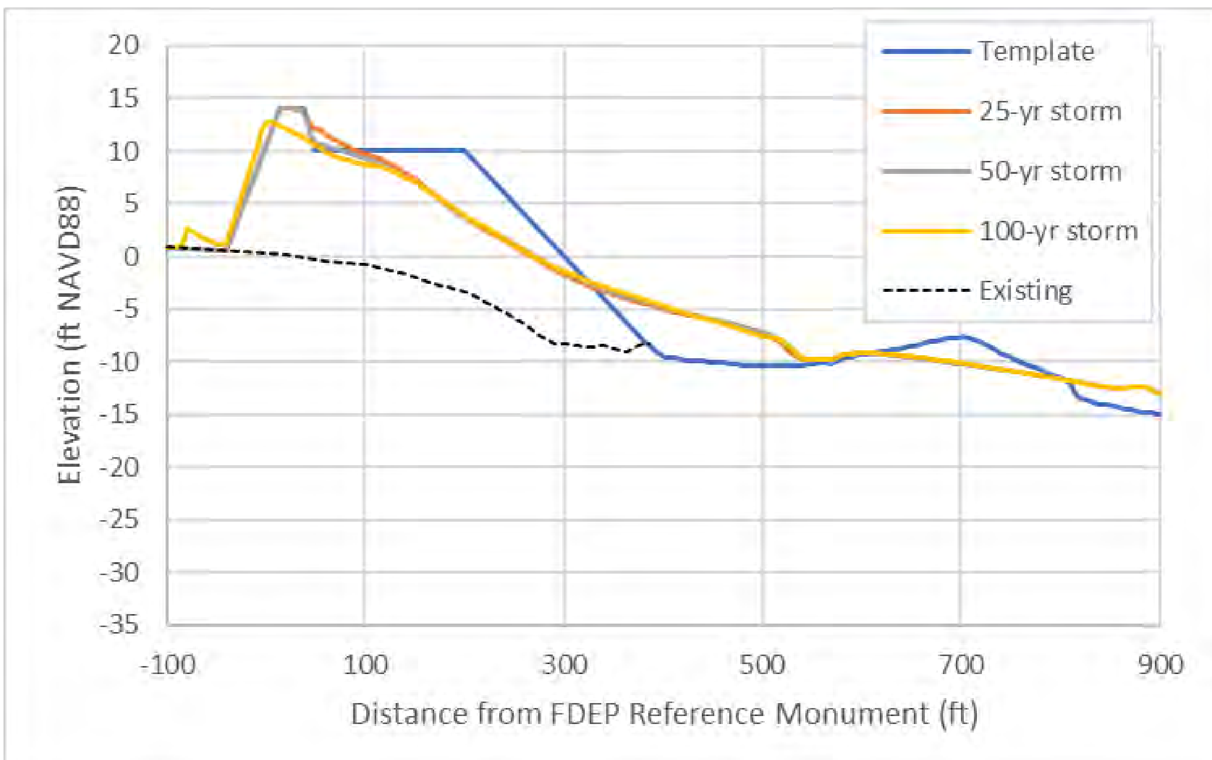

Figure 5.6 SBEACH Simulations for Beach and Dune Nourishment Alternative (D50 = 0.35 mm)

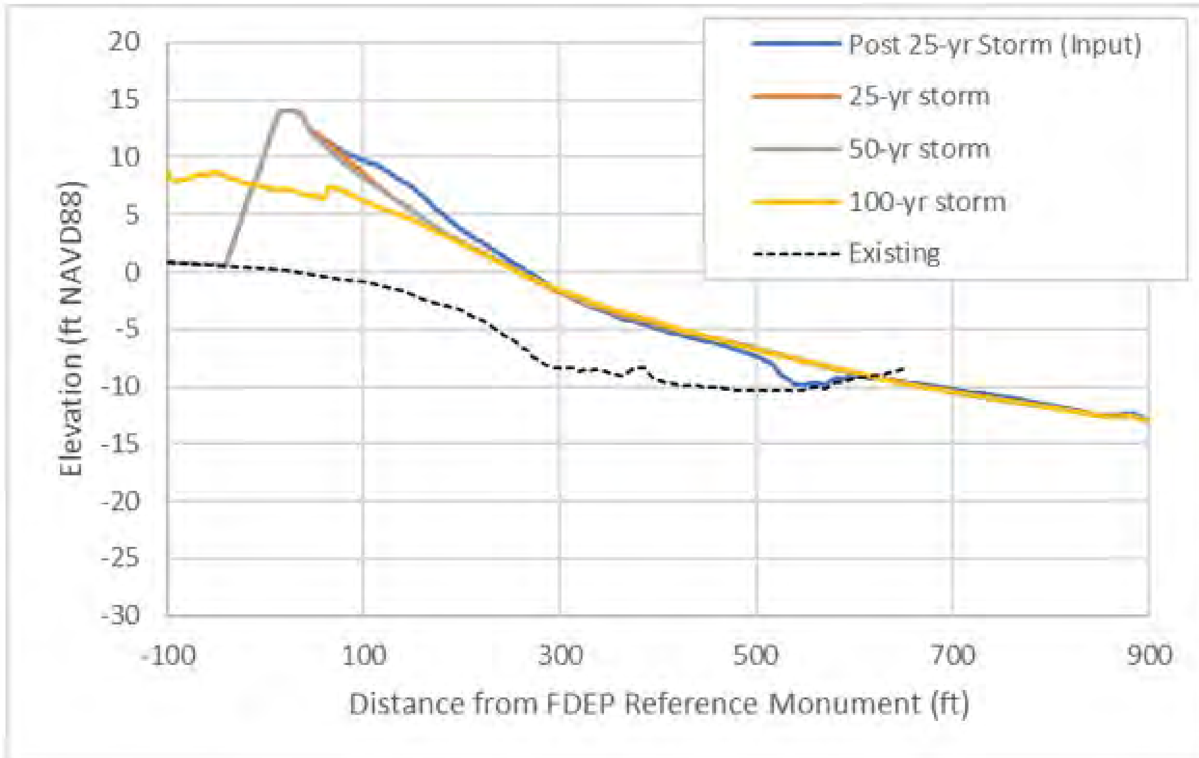

Figure 5.7 SBEACH Simulations for Beach and Dune Nourishment Alternative with Back-to-Back Storms

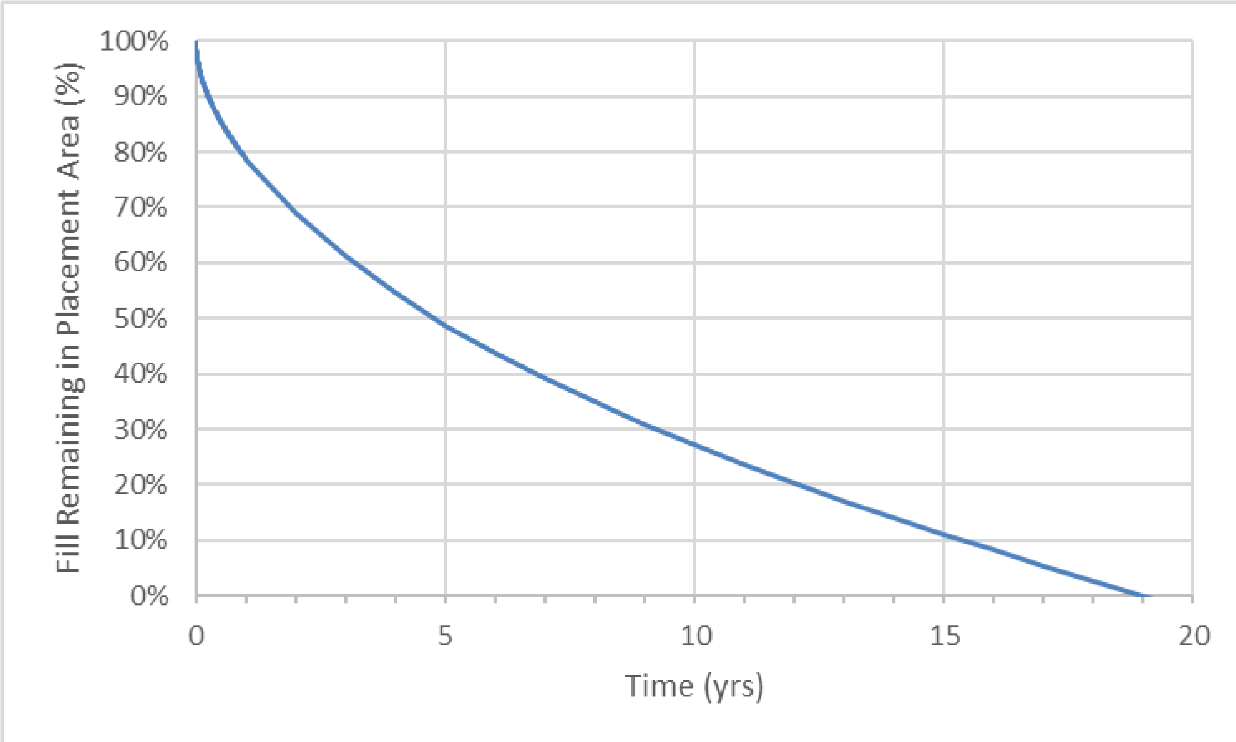

Figure 5.8 **Prediction of Sand Remaining over Time**

As discussed in Section 3.3.8, no proven offshore borrow area exists to solely provide beach fill for Summer Haven projects. Thus, a sand source investigation must identify a source of beach compatible sand to support a long-term beach nourishment plan in this area. The investigation's initial steps should include coordination with USACE to discuss existing knowledge (previously collected data, available sand volume, etc.) of the proven sources offshore Butler Beach and Flagler Beach and the unverified sources offshore Summer Haven. Exploration of the unverified sources would likely follow the typical protocol of conducting reconnaissance phase geophysical and geotechnical data collection over several potential sites followed by detailed phase geophysical, geotechnical, and cultural resources surveys targeting the most promising site(s). The initial reconnaissance and detail phases may take 6–12 months or longer and typically identify sufficient sand quantities for the first few nourishments; subsequent phases are typically required for further delineation and permitting of borrow areas for longer-term nourishment projects. The Matanzas Inlet flood shoal could serve as a supplemental borrow source after undergoing a similar investigation. Alone, however, it likely could not satisfy the needs of this type of beach and dune fill project. After initial construction, approximate long-term needs could equal 750,000 cy or more every five years depending on storm activity and material quality.

5.2.2.1 Beach and Dune Nourishment with Shore Stabilization Structures

As mentioned above, structures like groins and breakwaters could help lessen the quantity and frequency of sand needed for subsequent beach renourishments. However, the determination of that need cannot occur until at least three years of monitoring of the initial nourishment has occurred. Typical Florida structures usually locate downdrift of inlets where the inlet's sediment bypass bar reconnects to the downdrift shoreline south of them.

Given the location of the Summer Haven beaches relative to Matanzas Inlet, a strong possibility exists that structures may prove warranted in improving beach nourishment performance.

Conceptually, a single T-head groin may have the following characteristics.

- Trunk and stem elevations: MHW
- Crest widths: 20 ft
- Side and seaward slopes: 2H:1V
- Bottom elevation: -5 ft NAVD88
- At least two layers of armor stone over geotextile

A submerged breakwater might have the following characteristics.

- Crest elevation: -5 ft NAVD88
- Crest width: 20 ft
- Side slopes: 2H:1V
- Bottom elevation: -10 ft NAVD88
- At least two layers of armor stone over core material and geotextile

In most instances when needed to improve beach fill performance, usually three or more groins or breakwaters prove necessary to stabilize the target shoreline and smoothly transition the shoreline to adjacent areas. **Figure 5.9** shows a conceptual a conceptual cross section and plan view for a beach and dune nourishment project with submerged breakwaters from approximately R-200 to R-209.

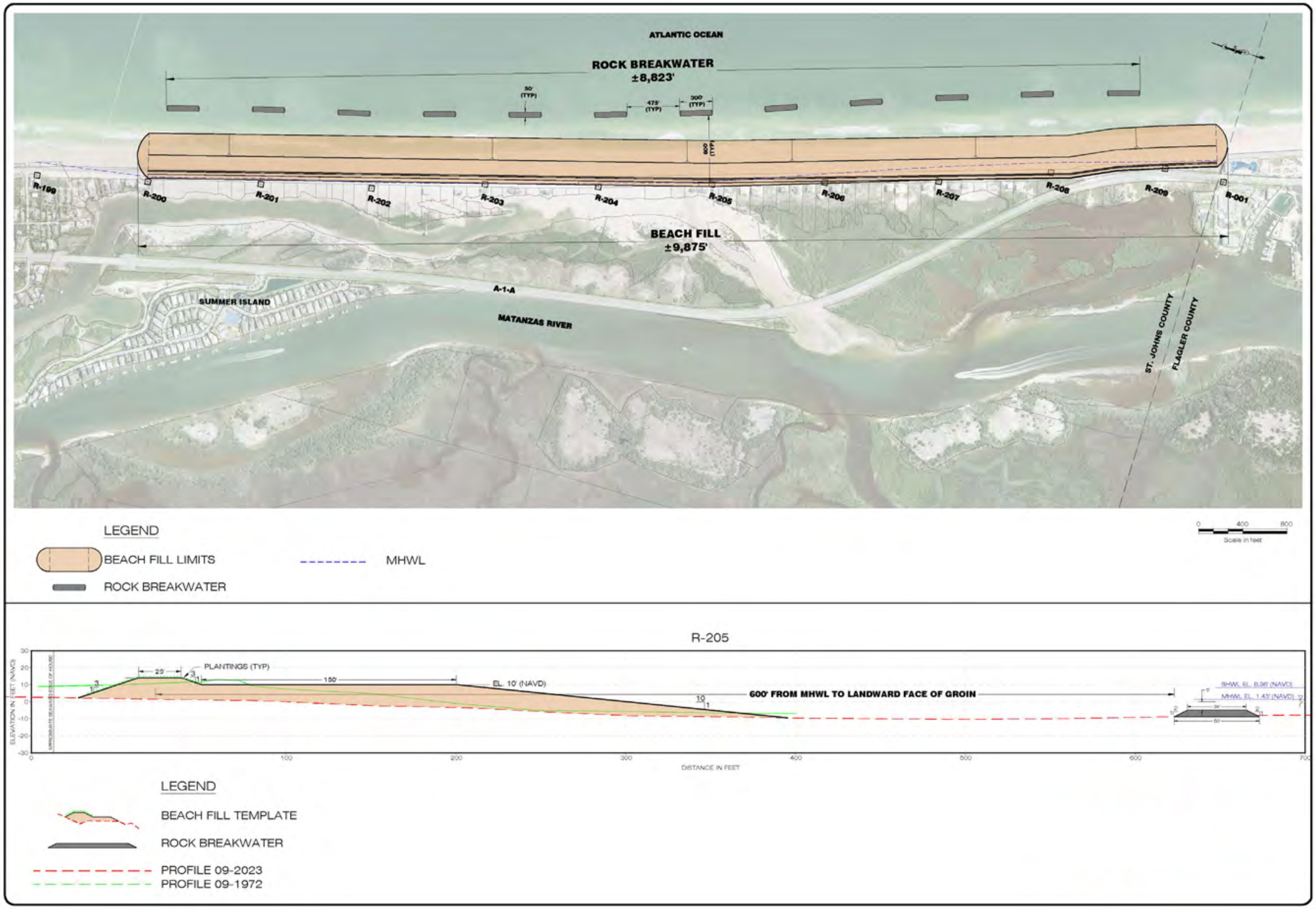

Figure 5.9 Concept Sketch – Beach and Dune Nourishment with Submerged Breakwaters

Groin and breakwater maintenance requirements may consist of periodic replacement of rock following extreme storms. Groins and breakwaters, like other coastal structures, are designed to withstand certain design water level and wave conditions (e.g., a 50-yr storm event). If an extreme event that exceeds the design conditions occurs, the excess wave forces may displace some of the rock to varying degrees depending on the severity of the storm. Typical formulas used to calculate required rock size assume the design wave height may cause 0-5% damage to the structure. However, repairs would likely not be initiated until perhaps 10-15% damage occurs, which would require multiple design level storms or waves 14% greater than the design wave height (USACE, 2014). Maintenance repairs, likely amounting to 10% of the initial construction cost (see **Table 5.2**) over a 50-yr project life, would entail reconstructing the structure to design parameters when needed or possibly adding rock in response to structure settlement over time.

5.3 Non-engineering Alternatives

In addition to the engineering alternatives presented above, this study considered the costs of taking no action and continuing a policy of managed retreat along the Summer Haven shoreline, particularly as the latter may relate to implementation of an engineering alternative.

5.3.1 No-Action

The no-action alternative provides no solution to maintaining flow through the SHR and allows natural coastal processes to shape the conditions of the SHR and the adjacent beach. Continued beach erosion, overtopping, and breaching of the existing dune/berm will allow the beach to naturally migrate westward, eventually completely filling in the portions of the SHR lying adjacent to the beach. Vegetated dunes will naturally develop over time and beach dune habitat will eventually replace the wetland habitat provided by the river. The conditions that developed from 2008 – 2016 (prior to commencement of the SHRRP) near R-200 to R-203 following the breach caused by Tropical Storm Fay provide an example of probable future conditions with the no-action alternative (**Figure 5.10**). With no flow through the river, remaining portions of the river at the south and north ends connected to the ICWW and Matanzas Inlet will continue to shoal as flood tidal currents and aeolian processes transport and deposit sediment into these areas. Homeowners would likely abandon existing shorefront homes along the Summer Haven shoreline once they become inaccessible.

Of note, until the river infills with sediment and dunes naturally develop into a continuous feature of sufficient height and width that provides a barrier to storm surge, the area between the shoreline and S.R A1A will remain susceptible to direct impacts from elevated water levels and waves during storm events. If the river is not sufficiently infilled, breaches can continue to develop and create strong tidal connections between the ocean and ICWW or inlet. Once the river infills sufficiently to prohibit such breaches, the topography of the infilled river should limit wave size to depth-limited breaking waves heights. That is, the water depth will only support waves up to a certain size. Under this condition, the no-action alternative should not affect the vulnerability of SR A1A given (1) the significant distance from shoreline to the roadway that would still exist and (2) the new, larger areas for dune vegetation that would act to further dissipate waves. However, ocean flooding could still affect the roadway.

The no-action alternative avoids the expense and any unfavorable effects associated with other alternatives. However, this alternative would affect the recreational benefits associated with an accessible river and may affect property values (e.g., loss of boating access). Additionally, the conversion of wetlands to beach dune habitat generally represents a net environmental loss. Existing literature qualitatively documents the benefits provided by the SHR but does not quantify the benefits. Performing the necessary analyses and calculations exceeds the scope of this study.

Figure 5.10 Conditions Approximately Eight Years after the T.S. Fay (2008) Breach

5.3.2 Managed Retreat

Managed retreat is a coastal management strategy that allows (1) the beach to naturally migrate landward, as opposed to attempting to stabilize the beach with engineering solutions, and (2) restoration of developed properties back to their natural ecosystems. Managed retreat typically involves relocating shorefront structures further landward and/or buy-out programs where local, state, or federal governments purchase private property. Relocating structures is not viable at Summer Haven due to lack of suitable upland property; thus, the managed retreat alternative for Summer Haven would entail the County purchasing private shorefront property, which would then become public property, and demolishing the structures to restore the natural habitat.

Managed retreat on a large scale is often a contentious undertaking requiring complex coordination between the government and property owners. Managed retreat has occurred to a limited degree since 2009 along the stretch of property fronting the SHR. As of January 2022, the County has acquired Blocks 3–15 and Blocks 28–32 (**Figure 5.11**) at a total cost of approximately $400,000, with $208,265 of that amount grant-funded. The 20 remaining private parcels north of R-205 (i.e., within and north of the current breach area) include 13 vacant parcels and 7 parcels with structures. The County has not acquired any of the 28 parcels from R-205 to R-208.5.

Like the no-action alternative, managed retreat provides no solution to maintaining flow through the SHR and would allow similar recreational, environmental, and property value effects from the river infilling with sand. However, environmental and/or recreational enhancement of the purchased property could help offset adverse effects. Applied in conjunction with an engineering solution to protect the SHR, County acquisition of the private parcels north of R-205 could negate the need to obtain private easements and facilitate project construction.

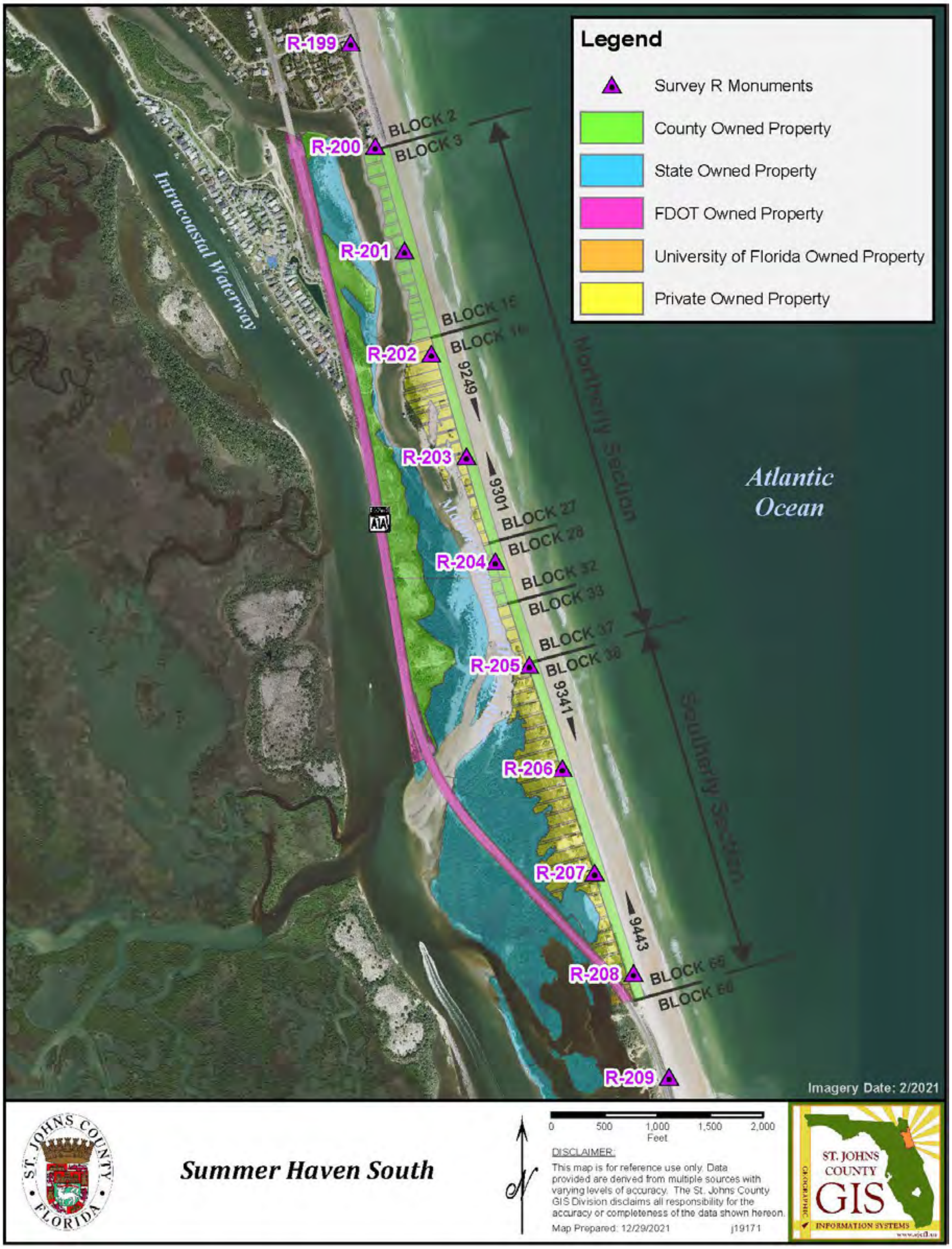

Figure 5.11 Summer Haven Parcel Map

5.4 Conceptual Costs

After conceptually designing the range of alternatives, the next step in the evaluation process included developing conceptual level estimates of initial (construction) and maintenance costs. **Table 5.2** summarizes the initial and maintenance costs associated with the four alternatives over a typical 50-yr project life. All initial construction cost estimates include mobilization costs associated with contractor’s operations to move personnel, equipment, supplies, and incidentals to the project site and establish temporary facilities. Item costs originate from a variety of sources including previous similar Florida jobs. All costs include 5% of the construction cost for engineering design, permitting, and construction phase services as well as 20% contingency on total costs.

Note that assigning costs to maintenance activities proves difficult as doing so requires, for example, making many assumptions regarding frequency and severity of storms over the design life. Recognizing this challenge, this study assigned simple maintenance costs to provide some rough order-of-magnitude estimates for County planning purposes. For the beach and dune nourishment alternative, conceptual analyses have shown that replacing 50% of the initial fill every five years is a reasonable estimate. For seawalls, experience suggests that they require much less maintenance. For calculation purposes, this study assumes a maintenance cost of 10% of the initial cost every 10 yrs over the 50-yr design life.

For simplicity in this feasibility-level study, the 2023 just (market) value for each property, obtained from the St. Johns County Property Appraiser website (https://www.sjcpa.gov/), serves as the basis for estimating the cost of managed retreat. The market value of the 20 properties north of R-205 (**Figure 5.11**) totals $3,130,362. This cost represents a potential additional cost to the alternatives should acquisition of the properties prove necessary to construct a seawall and/or place fill on the private property.

Table 5.2 Conceptual Level Initial and Maintenance Costs

Alternative	Initial Construction Cost (in millions)	50-year Maintenance Cost (in millions)[1]	50-year Total Cost (in millions)[1]
Seawall[2]	$47.1	$11.9	$59.0
Beach and Dune Nourishment[3,4]	$34.3	$87.6	$121.9
No Action	$0	$0	$0
Managed Retreat	$3.13	$0	$0

[1]Dollar values represent present worth equivalents at the beginning of 2023 with a 4.75% discount rate and annual 2.2% inflation rate.
[2]Assumes seawall and/or dune maintenance every 10 years at 10% of initial construction cost (i.e., $4.71 million every 10 years).
[3]Assumes nourishment occurs every 5 years at half the initial construction cost (i.e., $17.15 million every 5 years).
[4]Structures like T-head groins and breakwaters could decrease renourishment quantities and frequency and therefore, the beach nourishment maintenance costs. If constructed, the cost of groins or breakwaters could vary widely depending on the need to protect the entire length of beach fill or just an erosional hot spot. Protecting the entire 9,700-ft length project area may require over 25 T-head groins or numerous breakwaters and initially cost over $80 million. Protecting a 1,000-ft hotspot may require 3 T-head groins or 1-3 breakwaters and initially cost over $10 million. Only after first constructing and monitoring the fill over three years will the need for structures possibly prove evident and cost worthy. If structures can extend the beach nourishment interval from 5 years to 10 years, the 50-year Beach and Dune Nourishment cost decreases to $83.5 million, a savings of $38.4 million that could help offset the cost of structures.

5.5 Potential Funding Sources

Implementing the dune and beach nourishment or seawall alternatives will require significant funding to cover initial construction, maintenance, and monitoring. The following sections introduce state and federal funding sources to support these projects. Of note, this analysis excludes discussing local funding sources (e.g., municipal services benefit or taxing units, local option sales tax, tourist development tax, and special taxing district) of which the County is fully aware.

5.5.1 Federal

As mentioned, Summer Haven lies within a Coastal Barrier Resources Act (CBRA) zone, which will prohibit the federal government from funding a shore stabilization project under certain funding sources. These sources include the Continuing Authorities Program (CAP), which otherwise would authorize the USACE to implement eligible water resources projects without project specific congregational authorization, as well as funding under a federally authorized Coastal Storm Risk Management (CSRM) Project. Additionally, without a federal CSRM Project, Summer Haven will not be eligible for the Flood Control and Coastal Emergencies (FCCE) Program (PL 84-99), which, for authorized and constructed federal projects by the USACE, will cover 100% of the costs to repair storm-related damages.

Regarding the CSRM Project, under request by St. Johns County, USACE has already included Summer Haven in the St. Johns County CRSM study that included South Ponte Vedra Beach, Vilano Beach, and Summer Haven reaches. The study, completed in 2017, excluded Summer Haven before developing a solution for the following reasons (USACE, 2017):

- Summer Haven is a geographically separate reach from the other two reaches (South Ponte Vedra and Vilano Beach) and has extremely limited public access/parking.
- The FDOT has already relocated SR A1A landward.
- Only a minimal number of structures lie within the southern portion of the reach.
- Structures in the northern portion of the reach have a revetment fronting them; thereby reducing the damage risk.
- Rebuilding of damaged structures is questionable given limited road access and damage susceptibility.
- The County is purchasing properties when able and not allowing future development of the acquired properties.
- With the existing structural inventory growing smaller, it is highly likely that damages would not justify a 50-yr CSRM project anywhere in the reach.
- Alternatives are also limited by the presence of a CBRS unit in three-quarters of the reach.

Given the situation has not changed since 2017, developing a CRSM project at Summer Haven seems unlikely.

As discussed below, a Summer Haven project may qualify for funding from NOAA, National Fish and Wildlife Foundation (NFWF) or FEMA.

5.5.1.1 NOAA and NFWF Grant Programs

Among others, NOAA and NFWF offer grants for enhancing the resilience of coastal communities and improving habitat for fish and wildlife to nonprofit 501(c) organizations, state and territorial government agencies, local governments, municipal governments, Tribal governments and organizations, educational institutions, or commercial (for-profit) organizations. In 2023, NOAA and NFWF, through its National Coastal Resilience Fund (NCRF) established in 2018, will award approximately $140 million in grants. Last summer, it offered grants of over $7.7 million for projects related to restoring and enhancing, for example, wetlands, dunes, and tidal rivers in seven states (https://www.noaa.gov/news-release/). One of the awardees included a project in Hawai'i restoring dunes along one mile of shoreline to reduce impacts of erosion, sea level rise, and high wave flooding and enhance habitat for native plants and animals (including sea turtles). The awardee received over $1 million in grant money with a $417,000 match.

This fund, funded by Congress, provides competitive grants ranging from $100,000 to over $3 million for coastal projects that improve a community's resilience while also helping support or restore fish and wildlife habitat. While grants like these do not serve as long-term funding sources, they can provide supplemental funding. The grant only supports nature-based solutions that provide the dual benefits of reducing risks to communities from coastal hazards and enhancing habitats for fish and wildlife. In 2022, the NCRF received 455 pre-proposals and invited 200 of those to submit full proposals. Of those 200, 96 received funding. This equates to a success rate of 21% (96/455).

All proposals must address the following priorities.

- Nature-based solutions. Use of natural solutions like rebuilding dunes or installing living shorelines.
- Community resilience benefit. Reduction of natural hazard threats like storms and SLR.
- Fish and wildlife benefit. Must improve fish and wildlife habitat.
- Community impact and engagement. Priority for risk reduction or job creation benefits to underserved communities.
- Innovation, transferability, and sustainability

The NCRF funds projects in four categories including

- Community capacity and building and planning
- Site assessment and preliminary design
- Final design and permitting
- Restoration implementation

The NCRF will release its request for proposals for 2024 funding in February with pre-proposals due in April. It would send out full proposal invitations in May with a due date of the end of June. Awards usually take place in November.

To have a high chance of success in receiving an award, the project must address the grant's primary focus of resilience in terms of protecting vulnerable community infrastructure such as houses, public buildings like fire or police stations, roads, and utilities. The project must address making this infrastructure more resilient to coastal flooding and erosion. As noted above, it can only fund so-called green infrastructure portions of a project like living shorelines or dunes and not gray infrastructure like seawalls or groins. Given this information, the County would likely have to show that SR A1A is made more resilient to coastal storms through implementation of the project. As noted previously, waves would not likely affect the vulnerability of the roadway after breaching because of sand infilling. A model developed for assessing the US-1 bridge over Pellicer Creek (INTERA, 2022) suggests that floodwaters entering breaches through the barrier island could inundate part of SR A1A during extreme events. However, additional modeling, beyond the scope of this study, must address this possibility more definitively.

Based on preliminary discussions with NCRF fund staff (Sarah Whitehouse, personal communication, May 11 and June 12, 2023; Courtney Greene, personal communication, May 10, 2023), the beach and dune restoration and seawall projects both could prove eligible for funding with some "tweaking". However, possible hurdles could include community demographics and uncertainties related to spending federal funds in CBRA zones.

5.5.1.2 FEMA Public Assistance Grants

FEMA grants are ineligible to fund the initial construction of a project but may become available for post-storm recovery and repair efforts required after initial construction.

FEMA provides post-disaster public assistance following a federal disaster declaration. FEMA provides public assistance as a cost share with the requesting state or local government. The federal share is 75% of eligible costs with possible increases to 90%. FEMA divides public assistance eligibility into two groups: (1) Emergency work and (2) Permanent work. FEMA (2020) states emergency work includes:

- Debris removal
- Private property demolition
- Emergency response activities
- Emergency protective measures
- Individual temporary facilities
- All donated resources for emergency work

Permanent work includes damaged facilities consisting of the following infrastructure categories:

- Transportation
- Flood control
- Education
- Housing
- Health
- Emergency service facilities
- Other governmental facilities
- Energy
- Water/Wastewater
- Communications/information technology
- Natural and cultural resources

Beaches may fall under either work. If a natural or engineered beach could incur damage from a five-year storm event, then that beach is eligible for emergency protective measures under FEMA's emergency work classification or so-called Category B funding. In this case, FEMA provides funding for the construction of emergency sand berms with up to 6 cy/ft to protect against additional damage from a five-year storm.

If the County incurs storm-related damage to an engineered and maintained beach, then the beach sand lost during the storm is eligible for replacement funding under the permanent work classification (so-called Category G funding, natural and cultural resources). This funding source only applies after a project is constructed; FEMA will not assist with initial construction. Notably, a federally funded beach nourishment project is ineligible for FEMA public assistance. Pre- and post-storm profiles determine the eligible volume of sand for replacement. FEMA typically only considers funding the volume of sand lost offshore the depth of closure (see Chapter 4) or beyond the longshore limits of the beach.

A compromised seawall could prove eligible for post-disaster public assistance under FEMA's permanent work classification (so-called Category D funding) if it provides flood control (or in this case, a coastal shoreline protection) in protecting improved property and lives.

5.5.2 State

5.5.2.1 General Appropriation

As part of the state of Florida's annual budget appropriations process, the governor submits a plan to the legislature that recommends funding levels for each of the state's departments. Each house of the legislature prepares its own budget based on the governor's recommendation to develop and pass a general appropriations act to fund the state government. The County could seek monies for a project by advocating for that project's inclusion in the governor's budget or through local elected state representatives or senators to include funding for the project in the legislature's budgets. The SHRRP received such an appropriation that fully funded its original construction budget.

5.5.2.2 FDEP Beach Management Funding Assistance Program

The FDEP manages the Beach Management Funding Assistance (BMFA) Program, which provides funds to local, state, and federal governmental agencies for protecting, preserving, and restoring Florida's sand beaches along the Gulf of Mexico, Atlantic Ocean, and Straits of Florida. Financial assistance includes up to 50% of beach and up to 75% of inlet project costs. Section 161.101, FS, and rules of Chapter 62B-36, Florida Administrative Code (FAC) authorize the BMFA program.

Eligible activities include:

- Beach restoration and nourishment
- Project design and engineering studies
- Environmental studies and monitoring
- Inlet management planning
- Inlet management activities to reduce adjacent beach erosion (e.g., sand transfer)
- Dune restoration and protection
- Other beach erosion prevention related activities consistent with the adopted Strategic Beach Management Plan

The public must have access to the beach management projects. Additionally, the FDEP must have designated the shoreline as a critically eroded beach. The FDEP, as per Chapter 62B-36.002(5), FAC, defines a critically eroded beach as

"…a segment of the shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost. Critically eroded shorelines may also include peripheral segments or gaps between identified critically eroded areas which, although they may be stable or slightly erosional now, their inclusion is necessary for continuity of management of the coastal system or for the design integrity of adjacent beach management projects."

The FDEP solicits formal funding requests from local governments and agencies. Given the proposed activity is eligible, improving funding priorities includes scoring high in the following criteria:

- Tourism-related impacts
- Federal involvement

- Storm damage reduction benefits
- Cost effectiveness
- Previous state commitment
- Recreational benefits
- Mitigation of inlets
- Sand placement volumes
- Successive unfunded requests
- Environmental habitat enhancement
- Overall readiness to proceed

The first four criteria correspond to 65% of the total ranking points.

Notably, the program explicitly excludes seawalls and revetments as eligible activities. Furthermore, the program only covers structures, such as T-heads groins and breakwaters, only if they enhance the longevity of a beach nourishment project. The FDEP does not usually fund groins and breakwaters until at least three years of beach monitoring data suggest their need to improve beach nourishment performance (Robert Brantly, FDEP, personal communication, March 1, 2023).

The FDEP's draft Strategic Beach Management Plan for the Summer Haven beaches includes monitoring. However, the draft plan also includes conducting a feasibility study to investigate alternatives to mitigate inlet impacts, developing a sediment budget, and adopting an inlet management plan to address the adjacent eroding beaches (Guy Weeks, FDEP, personal communication, January 27, 2023).

Funding requests for Fiscal Year 2022/2023 consisted of 20 different beach nourishment projects totaling $50.7 million (excluding annual post-construction physical monitoring funding requests). Of the top 10 ranked projects, nine have federal involvement and all span highly developed shorefronts, demonstrating the importance of the first four criteria listed above. Given the lack of federal involvement and upland development, Summer Haven beach nourishment likely would not receive a top 10 ranking but would remain eligible for funding (eight of the bottom 10 ranked projects did not have federal involvement). Of note, FDEP typically funds post-construction monitoring of projects that it contributes construction funds towards; thus, Summer Haven would likely qualify for a 50% state cost share of post-construction physical monitoring.

5.5.2.3 FIND Waterway Assistance Program

FIND and the Florida Legislature (authorized by Section 374.976, FS, and administered under Chapter 66B-2, FAC) established the Waterway Assistance Program (WAP) to annually support increases in public access associated with the ICWW and associated waterways within the FIND's 12 eastern Florida counties, including St. Johns County. Local governmental agencies — municipalities, counties, port authorities and special taxing districts located within the 12 counties — can seek support for waterway projects located on natural, navigable waterways. Projects may include navigation channel dredging and activities associated with channel markers, navigation signs or buoys, boat ramps, docking facilities, fishing and viewing piers, waterfront boardwalks, inlet management, environmental education, law enforcement equipment, boating safety programs, beach renourishment, dredge material management, environmental mitigation, and shoreline stabilization. FIND can provide up to 75% funding for public navigation projects and up to 50% funding for all other eligible projects.

FIND allocates approximately $10-12 million dollars annually for the program, and the legislative limit on project funding is equal to the tax revenue that FIND receives from the county in which the applicant locates. Grant applications are due toward the end of March with funding for those projects approved by the FIND Board of Commissioners becoming available on October 1. FIND previously provided a $50,000 grant to SAPWBD for the SHRRP, suggesting FIND may potentially continue to support restoration of the river. However, given the above-mentioned annual funding availability and funding limitation as well as the number of counties along the Florida east coast eligible for grant funding, WAP grants will likely remain relatively small in comparison to the conceptual cost estimates presented in Section 5.4.

6.0 Summary

Named and unnamed storms have periodically overwashed the Summer Haven beaches and breached the dunes causing infilling of the SHR. Since 2016, repeated efforts to restore the river's flow by excavating the overwash sediment and rebuilding the adjacent berm and/or dunes have been necessary due to repeated breaching of the barrier island. Realizing only partial and temporary success from these repeated small-scale efforts, St. Johns County BOCC commissioned this study to identify an array of long-term feasible, engineering solution to maintaining flow through the SHR. Developing environmentally and financially sustainable long-term solutions that will provide adequate protection to the Summer Haven shoreline and minimize the potential for storm-induced sediment transport to infill the SHR requires a thorough understanding of the area's existing conditions, coastal processes, and the dominant processes that continuously lead to the persistent erosion, dune overtopping (overwash), and repeated ocean breaches.

Over the long-term, stronger flood tidal flows, because of the Matanzas inlet's location relative to St. Augustine and Ponce de Leon inlets, will likely deposit more sediments inside the inlet than the ebb tidal flows remove. This net imbalance allows the flood shoals inside the inlet to grow with sand intended for the Summer Haven and other downdrift beaches. With lesser amounts of sand reaching the Summer Haven beaches, they become more susceptible to storm-induced erosion as the beach is generally narrower and lower over time in the presence of storms. Overwash occurs when the minimum combination of elevated water levels and wave runup is exceeded. While putting overwash deposits back onto the beach, as done on Summer Haven many times, helps the beaches recover after a storm event, this practice does not allow the barrier island to increase in elevation to naturally build more resiliency in the face of rising sea levels. The lack of a wide dry beach can also contribute to the lack of or relatively small post-storm dune recovery in the Summer Haven area.

Based on an understanding of the Matanzas Inlet and surrounding areas, this study identified two, potentially permissible (from an environmental regulatory standpoint), engineering solutions. They include:

- Seawall with small dune. This alternative consists of locating a seawall approximately five feet landward of the CCCL. The seawall concept consists of two concrete-capped steel sheet piles tied together with tie rods. The seawalls reach an elevation of +14 ft NAVD88 to mimic the historical dune elevations in the area. The dune, fronting the seawall has a crest elevation of +12 ft NAVD88, a crest width of 20 ft, and a 3H:1V seaward slope. The seawall would extend from approximately R-200 to R-205.5. Conceptual initial and maintenance costs (over a 50-yr project life), in 2023 present worth equivalents, equal approximately $47.1 million and $11.9 million, for a total of $59.0 million.
- Large-scale beach and dune nourishment. This alternative consists of placing a small dune seaward of the line of coastal construction such that the landward edge of the dune crest lies approximately 40 ft east from the edge of the five isolated houses. The dune crest reaches an elevation of +14 ft NAVD88 to match the peak historical dune conditions. The beach consists of a 150-ft wide beach crest at elevation +10 ft NAVD88 with a 10H:1V seaward slope until matching existing grade. Overall, the beach and dune nourishment project, with an approximate

fill density of 150 cy/ft, has a total initial nourishment volume of approximately 1.5 million cubic yards. The beach fill would extend from approximately R-200 to R-209. Conceptual initial and 50-yr maintenance costs, in 2023 present worth equivalents, equal approximately $34.3 million and $87.6 million, for a total of $121.9 million.

In addition to engineering alternatives, this study also considered the beach management alternatives of taking no action and continuing a policy of managed retreat along the Summer Haven shoreline. These alternatives do not address the issue of keeping the river flowing, but the latter may prove necessary to implement an engineering alternative.

- No action. Continued beach erosion, overtopping, and breaching of the existing dune/berm will allow the beach to naturally migrate westward, eventually completely filling in the portions of the Summer Haven River lying adjacent to the beach; and
- Managed retreat. A coastal management strategy that allows (1) the beach to naturally migrate landward, as opposed to attempting to stabilize the beach with engineering solutions, and (2) restoration of developed properties back to their natural ecosystems. Managed retreat has occurred to a limited degree since 2009 along the stretch of property fronting SHR. County acquisition of the private parcels north of R-205 could facilitate construction of any engineering solutions that must traverse these parcels to keep the SHR flowing. Buying out the 20 properties north of R-205 could cost $3.13 million.

Implementation of a long-term beach and dune nourishment plan will require identification of sand source. Private, commercial inland mines have proven a reliable source of beach compatible sand for County beaches, and these commercial sources can produce more desirable coarse fill material. However, the costs to purchase the material and haul it long distances are often relatively high. Many entities prefer importing sand from offshore, with typically higher production rates and avoidance of traffic and road use impacts, and less expensive unit costs for large-scale beach nourishment projects. Currently, no proven offshore borrow area exists to solely provide beach fill for Summer Haven. Should the County pursue identification of an offshore sand source, the investigation's initial steps should include coordination with USACE to discuss existing knowledge (previously collected data, available sand volume, etc.) of the proven sources offshore Butler Beach and Flagler Beach and the unverified sources offshore Summer Haven. Continued placement of ICWW maintenance dredging materials by USACE/FIND could supplement beach nourishment, but the material characteristics and available volume are insufficient to fully support a successful beach nourishment program.

Dredging of the flood shoal could possibly supplement beach nourishment as well, with an added benefit of relieving the erosional pressures along the southern shoreline of the inlet where property owners are suffering property loss from increased ebb flow-induced erosion. Hydrodynamic modeling showed that dredging a channel through the flood shoal in the northern half of the inlet would drastically alter the inlet flow patterns and curtail erosion along the southern and the western shorelines. The modeling also revealed that the SHR, when flow is re-established, has a weak steering current effect on the inlet currents, slightly pushing the ebb flow away from the southern shoreline. The steering current potentially provides benefits to a few properties close to the river mouth; however, the effect is not strong enough to alleviate erosion along most of the southern shoreline.

Given the large costs associated with the engineering alternatives, the County will likely have to leverage funds from various local, state, and possibly federal sources to implement them. Sources may include raising local revenues through special purpose taxes and seeking state programmatic funds and grants and federal grants.

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Appendix A

Public Comments

1) December 6, 2022 Town Hall Meeting Notes
2) Questions and Comments Uploaded to the Public Portal Following the Town Hall Meeting
3) Questions and Comments Uploaded to the Public Portal Following September 21, 2023 Public Meeting

December 6, 2022 Town Hall Meeting Notes

- Linda Ginn from Friends of the Summer Haven River gave a presentation
  - Spoke on the animals in the water in the Summer Haven River
  - Recreational benefits
  - Professor from local lab gave a speech
  - Man who works for children's marine program spoke
- Lorena gave acknowledgments to visiting officials
- Mike Trudnak gave Intera-GEC presentation
- Public Comment Summary:
  - Is the focal point of the project the river? *Answer: Yes*
  - We can't put the river back we are wasting our money. Only way to save the river is by putting rocks on the beach. *Answer: The study evaluates rock structures as potential alternatives.*
  - We need to focus on the erosion on the beach. *Answer: The study will evaluate alternatives to stabilize the shoreline.*
  - What would happen if we did nothing? *Answer: The report addresses this topic to a limited extent.*
  - How much money was spent on this area?
  - This study is very large. We need to rebrand the study from the river study to the estuary study due to how big the project area is. *Answer: The study remains focused on identifying feasible solutions for maintaining flow through the river.*
  - We keep putting sand on the beach over and over again and it keeps washing away. What other options are there instead of sand?
    - Mike said that is the point of the study to find out what the best solution is.
  - The more people build the more problems we are having. Back in the 70s we did not have these issues. What caused this change? *Answer: the erosion problems have been ongoing for decades.*
  - Man spoke on the history of when the revetment was added and when Rattlesnake Island was added moving the ICWW to the west and making it not flow into the SH river.
  - Are you looking into the cost and benefits of the future project? *Answer: The study will present costs but will not include a cost-benefit analysis.*
  - How did you decide how much sand to put on the beach during the past Summer Haven beach project? *Answer: Prior projects have typically been limited by available sand (e.g., SHR Restoration Project, ICWW maintenance dredging projects) or FEMA limitations (e.g., 2011 and 2021 projects)*
  - When the USACE built Rattlesnake Island they anticipated Summer Haven River open. Did the Corps do a report? *Answer: We are unaware of any such available report.*
  - A1A used to run on the beach there. Please incorporate sea level rise and climate change in the report. *Answer: The report discusses sea level rise.*
  - You need to be able to say to the commissioners that it might not be feasible to keep the river open.
  - Homeowner claims the river is closing in on itself.

- Man spoke to the crowd saying that the whole reason everyone moved to Summer Haven is because of the river and the beauty of the area.
- Where is the USACE? Why are they not here helping with this project. *Answer: The report addresses USACE's prior involvement studying Summer Haven.*
- Man gave full breakdown of the history of every coastal construction event that has happened since the early 1900s (information from the "Matanzas Inlet glossary" by UF?)
- The Corps shares some of the responsibility for these issues.
- Why can't we just place rocks the whole way. Are turtles the actual reason we can't get anything done? *Answer: The report discusses the permitting limitations.*
- Please look at the long-term effects of going with one solution. *Answer: The study will evaluate long-term solutions.*
- If we don't save the river, A1A is next.
- Why do the seawalls work so well south in Marineland? Who paid for it? Government needs to let the homeowners work on their own. *Answer: Revetments, evaluated in the report, can be an effective shore stabilization solution. We're unaware of the funding source.*
- The river will eventually come back as long as it doesn't get filled back in with sand. *Answer: The river is filled with sand and likely will not come back without dredging/excavation and a shoreline stabilization solution.*
- We want a solution that will work for generations to come. *Answer: The goal of the study is to identify potential long-term solutions.*

- Damon Douglas gave closing statements:
  - There is a website for everyone to submit their information.
  - There are a few other studies going on in this area with the FDEP and USACE.
  - Please bring up your ideas and comments to the board.

Questions and Comments Uploaded to the Public Portal Following the Town Hall Meeting

The following summarizes the documents uploaded to the public portal.

Summer Haven River PDF.pdf

- Commented on the degradation of water quality and reduction in wildlife in the north section of the river, shoaling at the mouth of Pellicer Creek, and the public benefits associated with use of Helen Mellon Schmidt Public Park.

  Answer: The Executive Summary acknowledges the above effects and benefits.

- Commented on changing shoals and flow patterns since flow of the SHR has been reduce/stopped and the erosion along Barratarria.

  Answer: Sections 4.4 and 4.6 of the report address this concern.

- "Is it possible to construct a dune line somewhat further to the west of where it has been previously? Could this sand dune line be bolstered on the Westerly side with some sort of groins or revetment that would act as a sand "backstop" preventing over wash of sand into the river? The westerly revetment/groin would be covered with sand and vegetated."

  Answer: The design alternative discussed in Section 5.2.1 positions the dune westward and has a dual-seawall design as a "backstop". Due to permitting limitations and associated lack of space, seawalls rather than a revetment would be required.

- "Perhaps the river width could be reduced while the depth is increased. Keep in mind that the protection of the river also protects the wetlands west of the river."

  Answer: Permitting restrictions would likely prohibit reducing the river width.

- "The area just south of where the rock revetment at Summer Haven ends, presents a point of accelerated flow from the ocean in a storm event. At the south end of the existing rock revetment appears to accelerate surge (to the south) in a storm event. Could some sort of T-groin or near shore reef be positioned at this critical area?"

  Answer: Erosion often occurs downdrift of a structure due to the structure's interruption of natural longshore sand transport as well as the effect of waves bending around the end of the structure. Adding a structure could help alleviate erosion at the "critical area" but would generally shift the erosional hot spot southwards. Note that Section 5.1 discusses major permitting obstacles for coastal structures.

- Expressed support for construction of a robust, maintained dune system (with sand from the river) and an artificial near shore (rather than off-shore) reef to break up wave action.

  Answer: The report discusses such alternatives.

Integra Submission.pdf 2/13/2023

- "The study contemplates that Intera will provide alternative solutions and the related costs of each. The study does not request an analysis of the financial consequences of not selecting one of the solutions identified by the study. Therefore, the county commissioners will not have a cost/benefit analysis to help them determine whether it is more economical to pursue one of the proposed solutions or to do nothing. The study should be expanded to show the potential financial consequences of not restoring the river."

Answer: An economic evaluation of the SHR benefits would have to be performed under a separate future study.

- Recommended excavating the entire river to 7 feet below dead low tide, using the sand to construct a robust dune from the existing revetment southwards to approximately the County line, vegetating the new dune and maintaining it with ICWW maintenance dredging materials and other sources as necessary.

  Answer: Chapter 5 of the report includes a dune restoration alternative and discusses potential sand sources and their limitations.

- "Potential sources for financing this solution should include entities of the county, state, and federal governments because the greater costs of failing to implement a solution will fall on each of them and their constituents."

  Answer: Section 5.5 addresses local, state, and federal funding.

- Commented on numerous benefits of the SHR.

  Answer: The Executive Summary acknowledges the stated benefits.

Comments_SummerHavenStudy_Intera-GEC_ASteinmetz.pdf 1/24/2023

- Expressed support for restoring the SHR flow and reconstructing, more robustly and resiliently, the barrier dune system.

  Answer: Chapter 5 of the report includes a dune restoration alternative and discusses potential sand sources and their limitations.

- Expressed concern that the current state of the demolished barrier dune and extent of sand deposition within the Summer Haven River is too vast of a project for a local entity to solely assume. Suggested the formation of a technical advisory committee comprised of local, state, and federal agencies along with scientists, residents, and other interested stakeholders as a collaborative initiative.
- Expressed concern that the significant negative consequences of the current dune and river conditions are not clearly understood by the community and provided the following consequences: A1A and the Summer Island neighborhood are directly vulnerable to the Atlantic Ocean, significant shoaling in the ICWW at the south end of the river, shoaling within Matanzas Inlet posing a navigational hazard for boaters and search and rescue efforts that use the inlet to gain direct access to the Atlantic Ocean, significant erosion of private property along the southern shoreline of Matanzas Inlet, and negative ecological impacts in the SHR and adjacent aquatic areas.
- Discussed potential negative impacts to Pellicer Creek and noted that St. Johns River Water Management District has spent approximately $100 million in taxpayer dollars to purchase large tracts of contiguous forested lands in the Matanzas River watershed, which encompasses Pellicer Creek, to protect water quality.
- Commented that this segment of the Matanzas River has been recognized as an environmentally sensitive area by state environmental agencies.
- Noted the Summer Haven River is one of the most populated waterways in St. Johns County used by the public for recreation and commercial fishing and by the St. Johns County Marine Science Program as a living classroom.

Answer: The report acknowledges many of the above comments.

Audubon Florida recommendations for engineering study of Summer Haven.pdf 1/24/2023

- "It is important to provide the appropriate context necessary to evaluate potential solutions. Specifically, sea level rise (~8" to 12" over the last century, plus anticipated future rise) and anthropogenic changes to the surrounding landscape have undoubtedly changed system function. Past and future changes should be detailed to the extent necessary to explain why certain configurations of the system may or may not produce desired outcomes."

  Answer: The study addresses sea level rise and takes into account prior beach/river system behavior in evaluating potential alternatives.

- "Sediment transport in the area (including areas of expected loss or accretion) should be examined for a variety of scenarios that maintain the Summer Haven River or have all or portions of the river fill back in, and scenarios that plug the new inlet or allow its morphology fluctuate more naturally. This examination should include anticipated effects on the land and shoreline within the Fort Matanzas National Monument and downstream areas bordering A1A and Marineland."

  Answer: The study's focus is to develop an array of potential solutions for maintaining flow through the SHR. The study addresses the above comments as they pertain to the study's focus.

- "Given the many negative impacts of hardened shorelines (changes in sediment transport, loss of recreational opportunities, impacts to turtles, shorebirds, and other beach-dependent wildlife, among others), we suggest the study prioritize natural solutions and those that interfere least with the natural function of the system."

  Answer: The study evaluates beach and dune restoration as a natural solution.

- "A managed retreat option should be considered, primarily for the houses on the southern end of Summer Haven. It may no longer be feasible to provide services to these homes given the changes in the system combined with future sea level rise and increased probability of high energy tropical systems. Retreat costs should be compared with costs required to maintain these houses (immediate projects plus ongoing repair and maintenance)."

  Answer: The study addresses managed retreat for the five isolated houses; the south end is beyond the scope of this study. A separate study conducted by FDEP addresses the south end.

- "Proposed solutions should consider the county's Habitat Conservation Plan and the on-site mitigation requirements for Least Terns included in the Summer Haven River dredging permits, as well as the needs of wildlife that require access to a natural shoreline (turtles and shorebirds in particular that are known to use this site)."

  Answer: The evaluation of potential alternatives considers environmental/regulatory constraints.

Recicar - Letter regarding Summer Haven River restoration 2023.docx 1/18/2023

- Commented on the southern migration of the inlet channel and erosion along the southern shoreline.

  Answer: Sections 4.4 and 4.6 of the report address this concern.

- "An additional item to be considered for the study is the revetment/bulkhead under the South end of the bridge going over the Matanzas Inlet and how it controls the hydrologic processes. One question to consider is that if this bulkhead/revetment is to be extended further North under the bridge, will it help to assist in protecting the Northern shoreline of Summer Haven/Baritarria or will it have deleterious effects to other portions of flow in that area?”

Answer: Studying the effects of repositioning that bulkhead is beyond the scope of this study. Extending the bulkhead northward into the channel would likely have no positive effect on the ebb tidal currents that erode the southern shoreline.

- Commented that the study should consider structural reinforcement of the Summer Haven shoreline in a manner that provides as close to a natural look as possible, possibly by integrating with dunes and vegetation.

  Answer: The study considers such a solution.

Intera Study Submittal Rev.pdf 1/24/2023

- Commented on the need to protect A1A, Barrataria shoreline erosion, shoaling at the mouth of Pellicer Creek, public benefits of Helen Mellon Schmidt Public Park, observed decline in water quality and wildlife with river closed.

  Answer: The report acknowledges the expressed concerns.

- Expressed support for “construction of a robust, maintained dune system (with sand from the river) and an artificial near shore (rather than off-shore) reef to break up wave action.”

  Answer: The study addresses dune restoration and artificial reefs as alternatives.

Summer Haven Study- Resident Input.pdf 1/18/2023 (also submitted as Ara Klidjian.msg 1/19/2023)

- Presented the following proposal: “…dig a channel along the southern property line of the Fort Matanzas National Park and the St. John’s County park abutting it. The channel would connect the Matanzas Inlet bay to the ICW with revetment on both sides of the channel.”

  Answer: The proposed solution would dramatically increase shoaling in the ICWW and most likely be unacceptable to USACE, FIND, and regulatory agencies. The cut is located where Hurricane Dora (1964) breached Rattlesnake Island. This breach remained open for approximately 12 years until 1976, when the USACE closed the breach based on recommendations from the NPS (which was responsible for Fort Matanzas). This breach contributed to channel shoaling in both the north and south arms of the Matanzas River as most of the tidal flow went through the breach.

Summer Haven Feasibility Study Recommendation- L Monahan 1.18.23.pdf 1/18/2013

- Presented potential solutions including a rock revetment spanning the entire Summer Haven shoreline to connect the existing revetments, a Summer Haven Nature Trail and Bike Path along the top of the revetment (and continued throughout the beach area and various parks in Summer Haven and Matanzas National Park), and offshore breakwaters (ideally living breakwaters), regular maintenance dredging of the Summer Haven River.

  Answer: The study evaluates the revetment and breakwater solutions. The seawall alternative discussed in Section 5.2.1 could potentially incorporate a nature trail.

Summer haven River Letter.pdf 1/10/2023

- Damaged file. Could not open.

Inventory of Coastal Engineering Projects in Fort Matanzas National Monument nrtr-2013-703.pdf 1/9/2023

- A report produced by the National Park Service.

  Answer: This report is referenced in the study.

2022 12 06 Town Hall Presentation - prepared by Tatoul.pdf 1/5/2023

- Overall expressed support for mainting flow through the river. Expressed concerns regarding reduced SHR flow negatively affecting Pellicer Creek.

  Answer: The study focused on developing an array of potential solutions for maintaining flow through the SHR, not quantifying the benefits of a flowing SHR. The numerical modeling documented effects of the SHR on current velocities near Pellicer Creek.

- Provided a history of Matanzas Inlet and a discussion on the inability to allow the river "to return to its natural state" given the numerous modifications by USACE.

  Answer: The study does not propose returning the area to its natural state.

- Proposed a revetment on the backside of the dune near the river's eastern edge.

  Answer: The design alternative discussed in Section 5.2.1 positions the dune westward and has a dual-seawall design along the river's eastern edge. Due to permitting limitations and associated lack of space, seawalls rather than a revetment would be required.

- Included letter from a retired biologist anecdotally stating a dramatic decline in the health of the surrounding estuary, including a decline in oyster beds and biological diversity leading to a loss of ecosystem services.

  Answer: The Executive Summary acknowledges the stated effects of the river.

12/21/2023 Don Hammons 8965 Old A1A.pdf

- Expressed the government should "focus on the most important priorities and plan for the future instead of the band-aid approach." The top priorities listed involved improvements to the A1A bridges and roadway to protect the evacuation route. Other suggestions involved closing old A1A to public traffic and parking, building a seawall along the coast rather than repeatedly trucking in sand, seeking funding from the state and federal governments, and protecting properties and home values.

  Answer: The County does not have authorization to modify the A1A bridges and roadway; FDOT is responsible for this infrastructure. The study's focus is to develop an array of potential solutions to maintaining flow through the SHR. Analysis of roadway closures, parking, and protection of properties and home values is beyond the scope of this study. The study discusses seawall alternatives for protecting the SHR and funding options.

12/7/2023 Summer Haven Overview Deck 12.21.21 SJC BCC Meeting.pdf

- Presentation by Summer Haven representatives to BOCC (1) discussing the importance of repairing the breach and maintaining flow through the SHR and (2) requesting BOCC sponsorship and commitment to protect Summer Haven homes and tax base, environmental resources and habitat, recreation opportunities, and the evacuation route.

12/7/2023 Summer Haven Vulnerability Assessment- Resident Input 4.11.22.pdf

- Presented risk factors (storm surge, king tide flooding, shoaling in waterways, breaches, beach erosion, insufficient dunes, rainfall flooding, and extreme heat/drought) and vulnerable systems (recreational assets [specific assets listed]; transportation infrastructure, SHR navigation and loss of significant ecosystem; businesses, economic drivers, and tourism; public and private residential and non-residential properties; seawalls and other water retention infrastructure; existing dune; old A1A revetment; historic structures; emergency response plans).
- Suggested the study (1) create a steering committee to include scientists from a local research institution, public officials, business owners, environmental organizations, technical experts, and community representatives from Friends of Summer Haven River and neighborhood associations (Summer Island and Barritaria); (2) perform a literature search and review of water quality reports, biological studies, and hydrodynamic modeling for Summer Haven River and the vicinity (i.e., Pellicer Creek, Marineland area, and Fort Matanzas/Matanzas Inlet); (3) consider local knowledge and documentation offered by the community; and (4) collect data related to previous studies, public usage of recreational assets, 5-10 year economic review, public and private property values; and (5) community engagement via public meetings.
- Presented benefits of SHR biology, ecology, and hydrology.

  Answer: The study has incorporated many of the above suggestions and background information.

12/7/2023 WHITE PAPER - Summer Haven 1.7.22.pdf

Note this documented was submitted in draft form with missing information.

- The purpose of this paper is to provide the BCC the case for action to address areas of concern including, shoreline erosion in Matanzas Inlet, vital dune maintenance, protection of SR A1A, and preserving the essential Summer Haven River.
- The report identified the need for a long-term solution due to an insufficient dune, the effects of unresolved breaches, and dangerous inlet conditions and inlet erosion; acknowledged the challenges caused by sea level rise; listed recreation, environmental, and education benefits of the SHR, and provided historical highlights.
- Provided “best” practice “sustainable solutions including breakwaters to protect the breach area, regular maintenance dredging to restore the SHR to its original depth and condition, apply for FIND grant applications for waterway access improvement projects, pursue partnership with USACE, construct and maintain a proper dune, create a county emergency fund for beach erosion issues, pursue state & federal funding for coastal flooding initiatives, leverage FIND projects to direct sand to Summer Haven dunes, utilize County owned lots to store sand to regularly elevate low dune areas.
- Provided reasons for the county to invest in Summer Haven including tourism, property taxes, community parks and recreational open space, and being an ideal example for the SJC County “Branding” Initiative.
- Provided supporting quotes from local business owners, scientists and residents.

- Provided a “path forward”, requesting BOCC sponsorship and commitment primarily with the above-mentioned “best-practices” as well as another study to investigate the short- and long-term impacts of managed retreat.

  Answer: The study acknowledges many of the above suggestions.

12/1/2023 DJI_0646.jpg

- Post-Ian (presumably) photo of over was areas at Summer Haven’s north end.

11/23/2022 Gittelmacher Letter Submission.pdf

- Commented that the inlet has had a varying, but stable tidal flow up until the last 5-7 years or so and the instability has since increased causing “dangerous currents, terrible beach erosion, sand bar shifts, and shoaling.”

  Answer: Sections 4.4 and 4.6 of the report address this concern.

- Commented “the community at large is burdened with real danger to the boating community from dangerous currents and shifting sand bars, and danger of injury to the many people and families that visit the inlet for swimming, fishing, kayaking and the like.”

  Answer. The report acknowledges this safety concern.

Questions and Comments Uploaded to the Public Portal Following September 21, 2023 Public Meeting

The following summarizes the documents uploaded to the public portal.

Summer Haven River Project (1).pdf

- Presented comments slandering Michael Trudnak and addressing USACE studies and funds.

  Response: The submitted comments, containing an abundance of false statements and misinformation, do not warrant a response.

Summer Haven River.pdf

- Requested that all references to the UF Whitney Laboratory be removed from this report. Our institution has not had the opportunity to study this issue and, as such, has not taken a position on the appropriate course of action.

  Response: As requested, all such references have been removed.

Summer Haven River project.docx

- Commented that (1) the study needs to be part of a broader effort to address and find coordinated solutions to the entire Matanzas Inlet and Summer Haven coastal problem; (2) the project needs the attention of our Governor's office, our U.S. Congressmen and U.S. Senators to proceed constructively and successfully; (3) the County must figure out how to gain financial support from state and federal agencies; and (4) the County should convince the FDOT to abort their $9.9 million SR A1A Trail project from Marineland to Matanzas Inlet and direct the funds to the SHR project.

  Response: Comment Acknowledged.

SHR Study PubComLet.pdf

Commented that (1) the study mentions the No Action and Managed Retreat alternatives but "gives little or no predictions of the future of Matanzas Inlet and the remaining piece of the SHR"; (2) these alternatives are not a desirable or workable solution as they do no protect the numerous benefits provided by the SHR; and (3) St. Johns County officials should reject these alternatives and choose one of the options that will maintain the SHR.

Response: Comment Acknowledged.

Surfrider_Summer Haven River Study Draft Report Comments.pdf

- Expressed strong support for the managed retreat alternative, provided numerous suggestions and considerations for a thorough managed retreat plan, and requested inclusion of such information in the final report. Expressed opposition to (1) any coastal armoring, specifically the seawall option, based on the potential adverse impacts to the beach and dune ecosystems typical of such structures; (2) the "economically unfeasible" seawall alternative due to the high construction costs and high long-term maintenance costs (suggested the report likely underestimates such costs); (3) the no-action alternative, which "presents the greatest risk to the environment and private property"; and (4) beach nourishment, which, while preferable to hard structures, is "not fiscally responsible or sustainable".

Response: Managed retreat, while a viable beach management option, will not protect the SHR and, thus, does not meet the study objective to identify alternatives to maintain flow through the SHR. Therefore, the final report does not include the managed retreat details suggested by Surfrider. Should the County choose to pursue further development of a managed retreat plan, Surfrider's comments should be considered.

SUMMER HAVEN RIVER STUDY PUBLIC COMMENT.docx

- Submitted numerous questions, as addressed below, and personal commentary regarding the questions.
- Why would Mr. Trudnak recommend an erosion control alternative (i.e., partial seawall) that, by his own admission, serves to possibly resolve one problem while definitely creating another? Why would Mr. Trudnak offer an alternative for consideration by the County Commission that is counter to a stated goal of the study (i.e., stabilize the Summer Haven shoreline)?

  Response: For clarity, the seawall alternative presented is the only potentially feasible/permittable structural solution — aside from large-scale beach restoration with groins or nearshore breakwaters as stated in the report — that may prevent breaches and dune overtopping and, hence, protect the SHR, meeting the stated goal of the study. The seawall, as illustrated in the report, would lie along the east bank of the SHR, set as far back from the ocean as possible, has a restored dune in front of it, and would have to terminate landward of the existing houses in an area not prone to historic dune overwash. Accordingly, the potential downdrift impacts typical of shoreline stabilization structures (i.e., seawalls or revetments constructed near the shoreline to protect shorefront development) is substantially reduced — only a potential concern if extreme storm surge completely overtops the dunes in the southern area of Summer Haven, areas that have not been historically overtopped.

- What was the result of the 2007 Summer Haven Study referenced above? What is the current status of Commissioner Dean's request seeking expertise from the USACE in identifying a solution to protect the Summer Haven community? What is the status of Michael Waltz's letter? Why did you spend general revenue monies to fund a study focusing on erosion control in the face of a similar request to the USACE? Why did the County Commission wait until prompted by a stakeholder to suggest contacting representatives Waltz and Rutherford?

  Response: These questions do not pertain to the methodology or results of the current study.

- Why did the County fail to recognize/investigate the exceptions to federal funding as delineated in the 2017 feasibility study at the time of the study? Why did Mr. Trudnak fail to investigate the exceptions to prohibition of federal funding per the CBRA? Why did Mr. Trudnak fail to recognize the situation at Summer Haven has changed dramatically since 2017?

  Response: The conclusion stated in the current study (page 122) that "developing a CRSM project at Summer Haven seems unlikely" remains valid. The U.S. Fish and Wildlife Service has confirmed that "the portions of the project that are within the boundaries of FL Unit P05A [the Summer Haven area south of the existing Old A1A revetment], a full system unit, do not appear to meet any of the General or Specific exceptions." Note, the CBRA exemption granted in Vilano

Beach was based, in part, on an unusual project situation that does not apply to Summer Haven (the fill material was dredged from a CBRA zone and placed in another CBRA zone).

- Why was a letter of exception not written to exempt the southern end of Summer Haven from the funding restrictions of a CBRA.

  Response: See above response.

- Did the hiring committee engage in due diligence. Why was Mr. Trudnak hired when he was personally known to members of the hiring committee?

  Response: This question is not relevant to the methodology or results of the current study. Note, the commentary slandering Mr. Trudnak is based on false statements and does not warrant acknowledgment or a response.

- Why did the County suggest public comment could not ensue without permission from FDEP when FDEP prepared the study for consideration and review by the County? Why was it stated the SHR study did not address managed retreat on the south end of Summer Haven as that was under the jurisdiction of the FDEP study?

  Response: The County's statement is correct — FDEP, not the County, is responsible for soliciting public comment for their own study. The County's statement is correct — FDEP's study included the south end, while the SHR study focused on identifying solutions to protect the SHR, not manage the south end.

Several empty folders were uploaded to the portal.

Appendix B

Coastal Structure Data (NPS, 2013)

The following table from NPS (2013) includes the structures referenced in Figure 2.2.

ID	Location	Structure	Material	Year Built	Year Maint.	Length (m)	In FOMA	[2]Source
1	Fort Matanzas	Revetment	Rock	1936	2007	88	Yes	1
2	Fort Matanzas	Pier	Concrete	1935	1956, 1978–79, 2007	39	Yes	1,2
3	Fort Matanzas	Groin	Rock	1940	2007	13	Yes	1,3
4	Fort Matanzas	Groin	Rock	1940	2007	9	Yes	1,3
5	Fort Matanzas	Bulkhead	Steel and cement	1936	2007	55	Yes	1, 2,4
6	Fort Matanzas	Seawall	Rock	1940	1966	23	Yes	3,4
7	Fort Matanzas	Groin	Wood and rock	1948–49	1966, 2007	66	Yes	2,3
8	Visitor Center	Groin	Rock	1934–1935	2007	16	Yes	1,5
9	Visitor Center	Groin	Rock	1934–1935	2007	14	Yes	1,5
10	Visitor Center	Groin	Rock	1934–1935	2007	13	Yes	1,5
11	Visitor Center	Groin	Rock	1934–1935	2007	14	Yes	1,5
12	Visitor Center	Pier	Concrete	1935	2000	66	Yes	1
13	Visitor Center	Groin	Rock	1934–1935	2007	18	Yes	1,5
14	S. Rattlesnake Island	Revetment	Rock	1977		781	Yes	6
15	S. Rattlesnake Island	Dike	Steel	1977		[1]143	Yes	5,6
16	S. Rattlesnake Island	Revetment	Rock	1977		127	Yes	6
17	S. Rattlesnake Island	Dike	Steel	1936		[1]533	Yes	7
18	Summer Haven	Revetment	Rock			[1]749	No	
19	Summer Haven	Bulkhead		pre 1995		[1]825	No	8
20	Summer Haven	Revetment	Rock	1963		816	No	9
21	Summer Haven	Seawall				149	No	
22	Summer Haven	Seawall	Concrete	1957–58		104	No	5

[1] Length for these structures is approximate.
[2] Source: 1: EA Engineering (2006), 2: NPS (1980), 3: Kidd (2004), 4: USACE (1987), 5: Mehta and Jones (1977), 6: USACE (1976), 7: Freeland (1940), 8: Google Earth, 9: FDEP (2000).

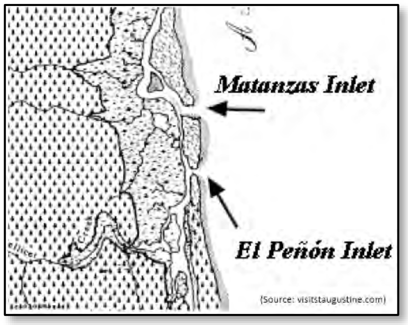
Appendix C

Timeline of Major Historic Matanzas Inlet Area Events

Peńon Inlet

1857

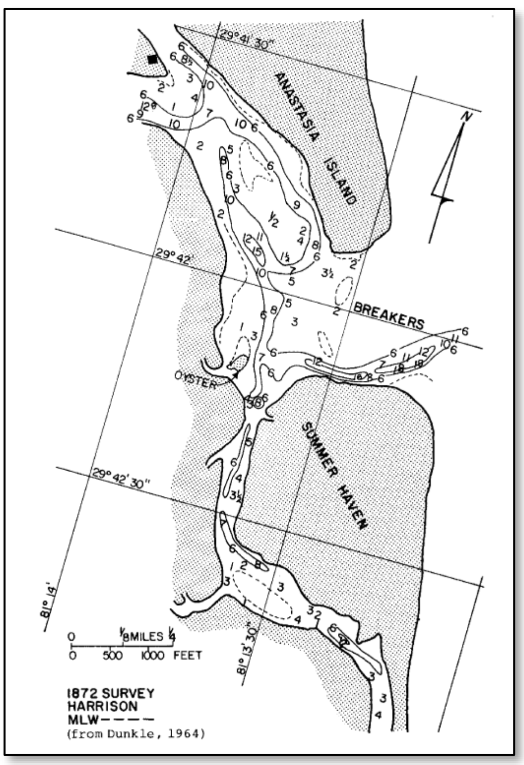
Gabriel P. Perpall's field notes indicate Summer Haven area separated from adjacent land south by small amount of water at high tide. Mehta and Jones (1977) speculate it was Peńon Inlet that closed in the early 1800's.



Harrison Survey

1872

As per Brunson (1972), Harrison indicates Matanzas Inlet widened 300 meters between 1869 and 1872. Mehta and Jones note the shoal in the inlet is approximately 500 yards wide and that a 10-18-foot-deep inlet channel lies immediately north of Summer Haven.



East Coast Canal

1883

Canal construction begins after Florida East Coast Canal Company receives one million acres of state-owned land (Mehta and Jones, 1977).

Canal near Inlet

1885

Canal construction near Matanzas Inlet begins (Mehta and Jones, 1977).

Canal Complete

1912

Construction of the canal completed with five-foot-project water depths and 40-to-50-foot-project widths. The canal deteriorated over time because of lack of maintenance (Mehta and Jones, 1977).

Fort Protection

1916

The War Department stabilizes the Fort Matanzas property by constructing a retaining wall around the north, east, and south sides of the fort (Mehta and Jones, 1977).

Inlet Survey

1923

The U.S. Coast and Geodetic Survey finds water depths ranging from 12 to 30 feet offshore Matanzas Inlet (Mehta and Jones, 1977).

Ft. Matanzas

1924

Fort Matanzas named a National Monument (Mehta and Jones, 1977).

Bridge over Inlet

1925

1926

Private funds support construction of the first bridge over Matanzas Inlet that connects the north and south sides of the inlet (Mehta and Jones, 1977).

FIND Established

1927

The Florida legislature creates the Florida Inland Navigation District (FIND) to maintain the state's inland waterways (Mehta and Jones, 1977).

Canal Surrender

1928

St. Johns County, along with 10 others, vote to bond purchase of the East Coast Canal and right-of-way to give to the federal government (Mehta and Jones, 1977).

Canal Depth

1929

The controlling depth increases from five to eight feet (Mehta and Jones, 1977).

Shoal Dredging

1930

U.S. Army Corps of Engineers (USACE) removes more than 58,000 cubic yards of shoal material from the north and south sides of the inlet (Mehta and Jones, 1977).

Relocation Cut

1932

The USACE completes Matanzas Relocation Cut, a 9,450-foot-long bypass channel through the marsh west of the inlet, by removing over 500,000 cubic yards of material. This cut relocates the Intracoastal Waterway (ICWW) to the west of present-day Rattlesnake Island (Mehta and Jones, 1977).

Fort Protection

1934

1935

Continuing protection efforts of the fort include installing a seawall and three short groins around the Fort's shoreline. Additionally, the placement of another 11 rock groins along west Anastasia Island (across from the Fort) attempts to help eroding shoreline (Mehta and Jones, 1977).

Intracoastal Dike

1935

The USACE installs 2,100-foot-long steel sheet pile dike and rock revetment to separate the Intracoastal Waterway from the south arm of the Matanzas River at Rattlesnake Island (Mehta and Jones, 1977). Mehta and Jones report the top of the dike reached 10 feet mean low water.

Field Survey

1938

A USACE survey shows four-to-five-foot water depths below mean low water in the Matanzas River south arm and 10-to-20-foot water depths in the inlet channel, which lies immediately against the Summer Haven north shoreline (Mehta and Jones, 1977).

Field Survey

1939

A USACE survey of the Matanzas Relocation Cut shows a controlling depth of 4.7 feet (Mehta and Jones, 1977).

Field Survey

1943

A USACE survey shows water depths of 15 to 20 feet through the north arm of the Matanzas River (from the inlet to the ICWW) and maximum ebb and flood currents of 2.50 and 2.17 feet per second (Mehta and Jones, 1977).

ICWW Depth

1945

Congress passes the River and Harbor Act that authorizes increasing the controlling Intracoastal Waterway depth and width to 12 and 125 feet between Jacksonville and Ft. Pierce (Mehta and Jones, 1977). Mehta and Jones also report that the USACE removed a shoal in the waterway near Pellicer Creek.

Cut Dredging

1947

Emergency dredging removes “critical” shoals located in the Matanzas Relocation Cut (Mehta and Jones, 1977).

ICWW Depth

1951

Authorized in 1945, ICWW improvements completed (Mehta and Jones, 1977).

Bridge Replaced

1956

The Florida Department of Transportation (FDOT) replaces the original 1925/26 bridge over Matanzas Inlet (Mehta and Jones, 1977).

SR A1A Protection

1957

1958

Protecting SR A1A necessitates constructing a 415-foot-long concrete sheet pile wall in Summer Haven (Mehta and Jones, 1977).

River Bridge

1960

The completion of a bridge across the Matanzas River south of Summer Haven to allow for rerouting SR A1A inland (Mehta and Jones, 1977).

Nor'easter

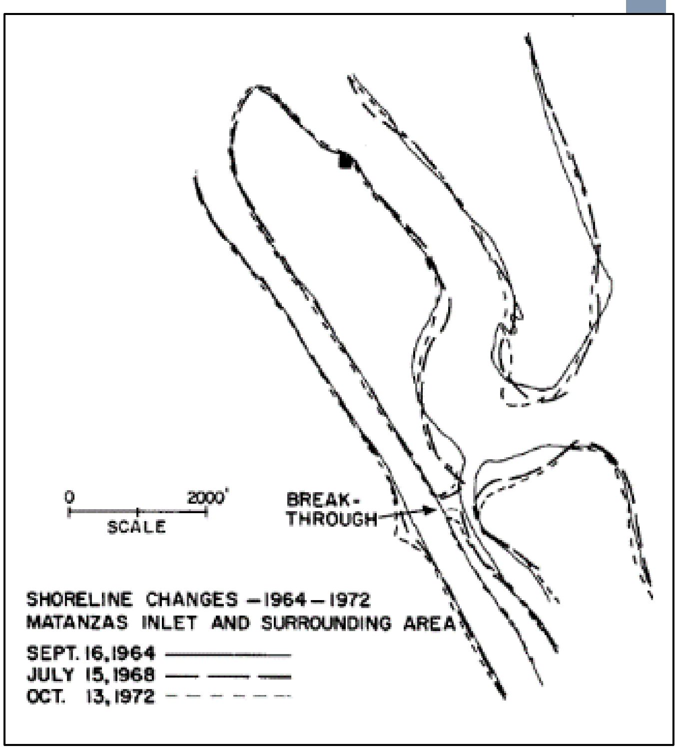
1962

A late year nor'easter damages to SR A1A in Summer Haven necessitating repairs to 1,130 feet of roadway pavement and 1,800 feet of granite rock revetment on the oceanside of SR A1A (Mehta and Jones, 1977).

Hurricane Dora

1964

Hurricane Dora, which struck northeast Florida, prompts repairs including adding a 430-foot-long splash apron adjacent to existing SR A1A revetment and an extension of the splash apron and revetment south another 1,070 feet. Roadway repairs also occurred. A breach in Rattlesnake Island also occurred (Mehta and Jones, 1977).



Field Data

1970

The University of Florida measures tides and currents at the inlet and southward in the Matanzas River and ICWW as part of a Flagler County study. Measured salinities decrease by approximately 25%, on average, every five miles south of the inlet (Mehta and Jones, 1977).

Inlet Bridge Scour

1971

Hopkins (1971), cited by Mehta and Jones (1977), indicates general and local scour at the inlet bridge's piers equal approximately five feet.

Section 107 Study

1971

At request of FIND, USACE prepares reconnaissance report (under Section 107 of Rivers and Harbors Act of 1960) on closing breach to reduce shoaling in Matanzas River and provide small boat navigational channel. No federal interest found because of benefit-cost ratios less than one and reduced shoaling may not occur (USACE, 1971).

Breach Widens

1972

The breach at Rattlesnake Island widens to 250 feet. The Summer Haven area experiences more erosion than north side of inlet. The National Park Service (NPS) recommends closing the breach because of observed erosion along government-owned property (Mehta and Jones, 1977).

Sediment Study

1972

As part of a sedimentological study, Burnson (1972) notes the inlet migrating south until the 1964 breach and a depositional bar forming between Rattlesnake Island and Anastasia Island.

CCCL

1973

The state completes the Coastal Construction Control Line (CCCL) for St. Johns County (Mehta and Jones, 1977).

Field Survey

1973 1974

A USACE survey shows an inlet channel depth of 12 feet at the bridge and 30 feet at the breach. In the Intracoastal Waterway west of the breach, the water depths reach 40 to 45 feet. The north arm of the Matanzas River shows significant shoaling (Mehta and Jones, 1977).

Field Data

1974

The University of Florida measures tides and currents at the inlet and Intracoastal Waterway. The USACE also measures current velocities and computes discharges at the inlet, breach, and north arm of the Matanzas River (Mehta and Jones, 1977).

Public Notice

1975

The USACE, per a public notice, proposes to (1) construct a steel sheet pile dike at the breach, (2) dredge a relief channel through the shoal in the north arm of the river, and (3) nourish 3,200 feet of the beach south of the inlet (Mehta and Jones, 1977).

Breach Closure

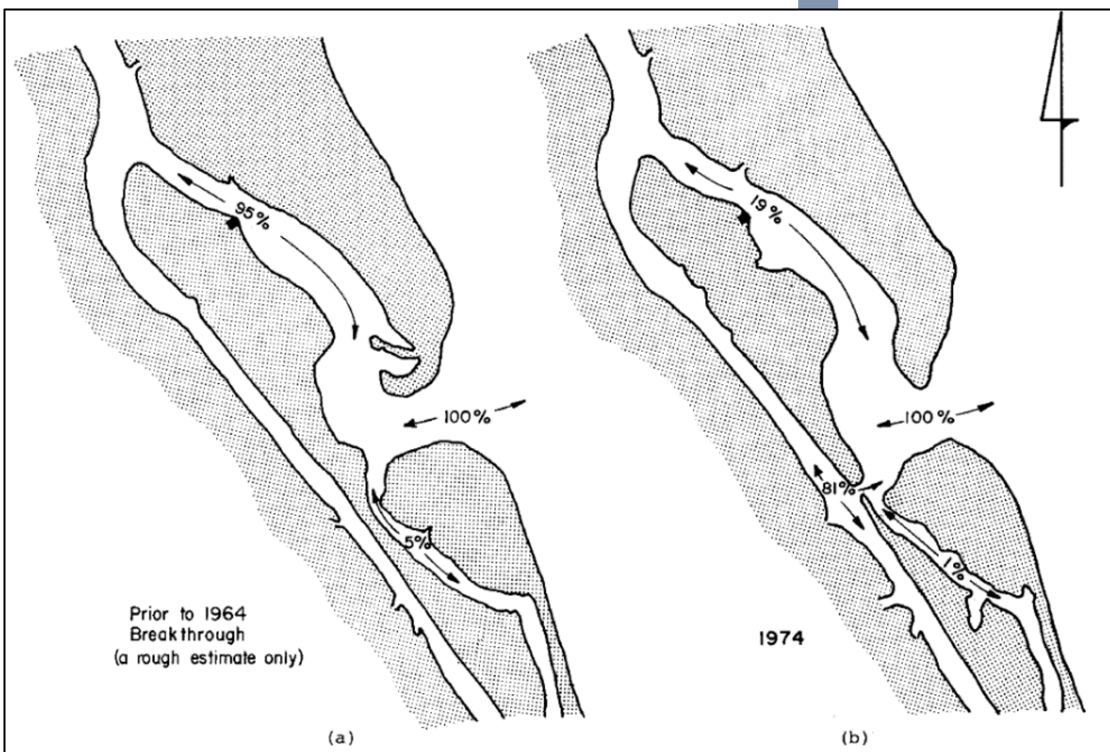
1976 1977

Work begins to close the breach in October 1976 and ends in March 1977. The breach at the time of the work was 310 feet wide (Mehta and Jones, 1977). As per USACE (1982), a rock dike backed with approximately 127,500 cubic yards of sand fill dredged from the north arm relief channel closed the breach.

Inlet Glossary

1977

Mehta and Jones (1977) publish an inlet glossary for Matanzas Inlet. In addition to a history of the activities around the inlet and surrounding areas, Mehta and Jones assess the pre-breach and post-breach changes in the inlet system. Based on previously collected data, they show that the tidal prism flows dropped in the north and south arms of the river after the project. This result helps qualitatively support the observed shoaling in both areas after the breach.



Monitoring Study

1977

Mehta and Sheppard (1977), in addition to other analyses, determined that the after closing the 1964 breach in Rattlesnake Island, the tidal prism distributions through the north and south arms of the Matanzas River equal 80% and 20% based on April 1977 conditions. The authors acknowledge the difference between its and the Mehta and Jones study, which is just an estimate.

Section 14 Study — 1982

USACE (1982), per St. Johns County request, examined beach fill and revetment alternatives to protect Old A1A in Summer Haven. Revetment alternative was selected. However, the benefit-cost ratio was less than 1. Therefore, no federal government interest in project under Section 14 of Flood Control Act of 1946.

Thanksgiving Day — 1984

Thanksgiving Day storm affects the Florida east coast from November 21-24. Near Matanzas Inlet, the storm eroded over 10 cy/ft above MSL north of the inlet (R-187 to R-196) and over 5 cy/ft above MSL south of the inlet (R-197 to R-209). The shoreline retreated by approx. 44 and 20 feet north and south of the inlet (DNR, 1985).

1986 Beaches Bill — 1987

In response to the 1986 Beaches Bill, Dean and O'Brien (1987) address east coast inlets including Matanzas Inlet. They state that the concrete bridge abutments prevent the inlet from migrating south. They also recommend bypassing sand to prevent flood shoal growth.

FIND Plan — 1989

FIND developed a long-term dredged material management plan for ICWW sediments. Because of rapid and extensive shoaling at the confluence with the Matanzas River north arm and limited 50-yr storage capacity, Taylor and McFetridge (1989) recommend placing dredged material on Summer Haven.

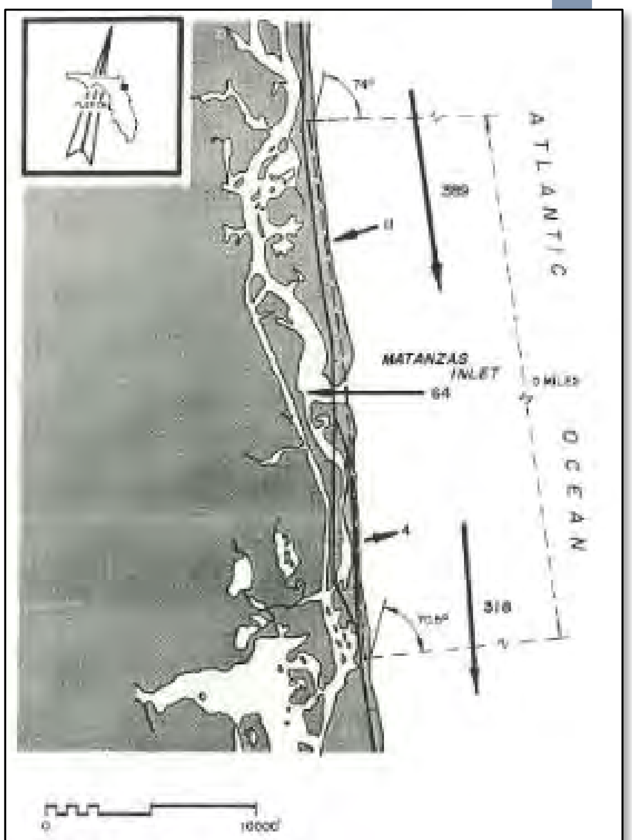
Crit. Erosion Area — 1989

The Florida Department of Environmental Protection (FDEP) classifies R-197 to R-200 as critical erosion area (Guy Weeks, FDEP, personal communication with Tim Mason, ATM, dated January 21, 2021).

FIND SJ-MB

1991

Taylor and McFetridge (1991) develop a beach disposal area plan for ICWW sediments dredged near the inlet. As part of the plan, they developed a sediment budget that showed an approx. 71,000 cy/yr difference across the inlet with average ICWW dredging of 63,840 cy/yr. The difference represents net gain of material on beach north of inlet. Beach disposal area extends 7,800 ft south from 3,000 ft south of the inlet (R-200 to R-208).



Beach Disposal

1992

USACE/FIND place 191,052 cy from ICWW on Summer Haven beach from R-200 to R-208 (FDEP, 2020)

Beach Disposal

1994

USACE/FIND place 197,370 cy from ICWW on Summer Haven beach (unknown locations) (Taylor Engineering, 2009)

Beach Disposal

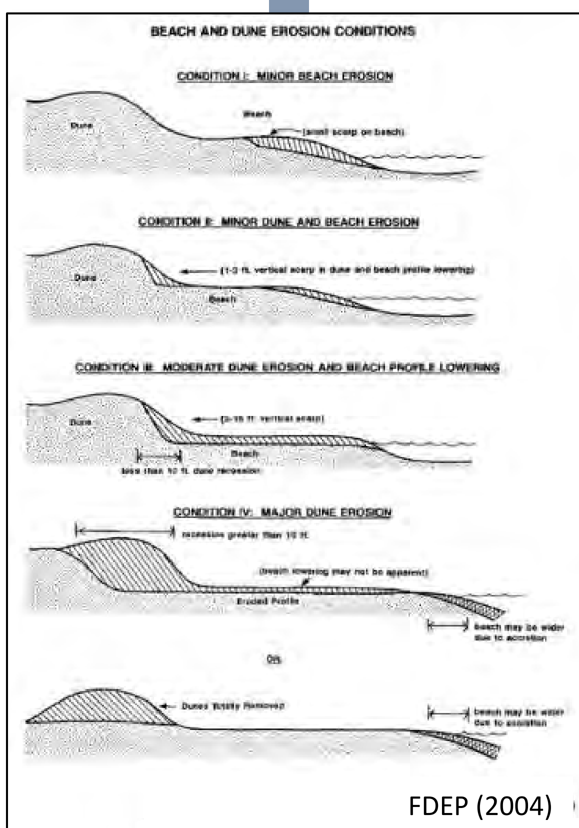
1999

FIND place 765,000 cy from SJ-1 on Summer Haven beach from R-200 to R-208. (FDEP, 2020); USACE/FIND also place 211,615 cy from ICWW on Summer Haven beach from R-198 to R-209 (Taylor Engineering, 2009).

Hur. Floyd & Irene

1999

Hurricane Floyd did not make landfall but went up the east coast of Florida. Hurricane Irene made landfall in the Keys and exited the coast at Jupiter. Generally, Hurricane Floyd produced worst erosion along Florida east since 1984 Thanksgiving storm. Near Matanzas Inlet, the FDEP observed severe erosion (Condition IV) north and south of the inlet including Summerhouse and Summer Haven beaches. Several storm surge breaches occurred in Summer Haven as well as Old A1A becoming buried with sand and dunes completely leveled. Hurricane Irene caused some additional erosion but to a much lesser extent than Hurricane Floyd (FDEP, 2000).



FDEP (2004)

Crit. Erosion Area

1999

FDEP declares R-200 to R-209 as critical erosion area (Email from Guy Weeks, FDEP, to Tim Mason, ATM, dated Jan 21, 2021)

Beach Disposal

2001

USACE/FIND place 218,000 cy from ICWW on Summer Haven beach (R-200 to R-208) (Taylor Engineering, 2009).

T.S. Gabrielle

2001

Tropical Storm Gabrielle made landfall at Venice and exited the Florida coast near Cape Canaveral in September (https://www.nhc.noaa.gov/)

FEMA Beach Fill

2002

St. Johns County utilized FEMA funds to place truck-hauled sand from FIND’s SJ-1 dredged material management area (DMMA) to construct small emergency protective berms and partially restore sand lost during Tropical Storm Gabrielle and Hurricane Floyd. Placed 21,300 cy between R-203 and R-208 (FDEP, 2020).

FEMA Beach Fill

2003

St. Johns County utilized FEMA funds to place truck-hauled sand from FIND’s SJ-1 DMMA to construct small emergency protective berms and partially restore sand lost during Tropical Storm Gabrielle and Hurricane Floyd. Placed 29,000 cy between R-200 and R-208 (FDEP, 2020).

Frances & Jeanne

2004

Hurricanes Frances and Jeanne made landfall very near the same location and occurred within three weeks of each other. Hurricane Frances made landfall as a Category 2 hurricane on September 5 in northern Martin County. Hurricane Jeanne made landfall as a Category 3 storm in northern Martin County, an unprecedented two miles from the landfall location of Hurricane Frances. The FDEP (2004) states that

"…much of Anastasia Island (R154-R197) from St. Augustine Beach through Crescent Beach to Matanzas Inlet sustained major beach and dune erosion (Condition IV) (Photo 1). South of Matanzas Inlet, in Summer Haven (R197-R208) Condition III erosion was observed, and south of the revetment (R201.2 and R201.5) the narrow barrier breached once again."

"At Summer Haven about 2000 feet of the old U.S. Highway A1A asphalt roadway was undermined and collapsed, generally between R205.5 and R207.5 (Photo 2). In addition, about 200 feet of a sandbag sill was destroyed south of R205."

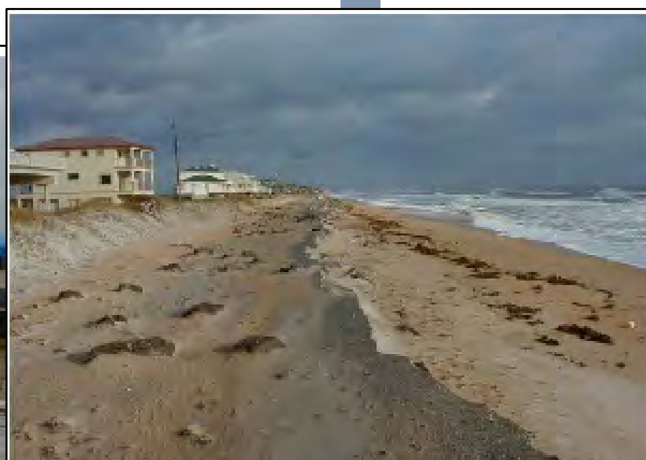


Photo 2 Summer Haven Road Damage

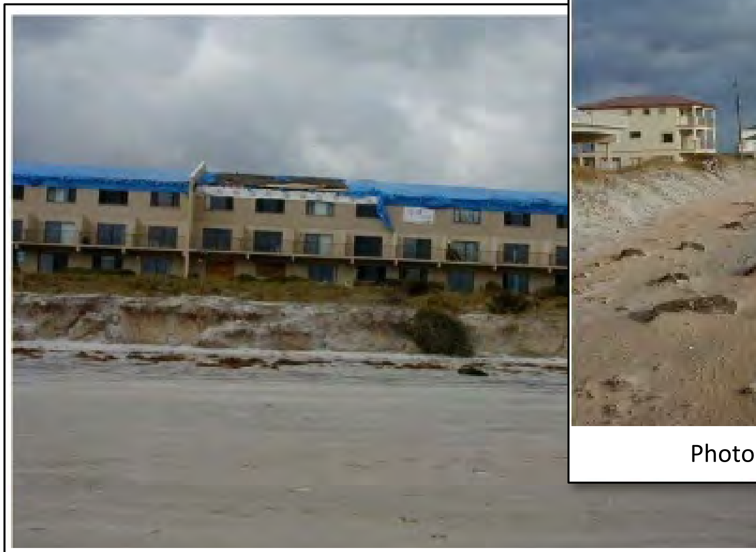


Photo 1 Anastasia Island Erosion at R-193

Recon. Study

2004

USACE Reconnaissance Report (905 (b) Analysis (USACE, 2017) focuses on erosion control projects at Vilano Beach and Summer Haven.

Beach Disposal

2004

USACE/FIND place 214,475 cy from ICWW on Summer Haven beach (R-200 to R-208) (FDEP, 2020).

Beach Disposal

2007

USACE/FIND place 187,862 cy from ICWW on Summer Haven beach (R-200 to R-208) (FDEP, 2020).

County Study

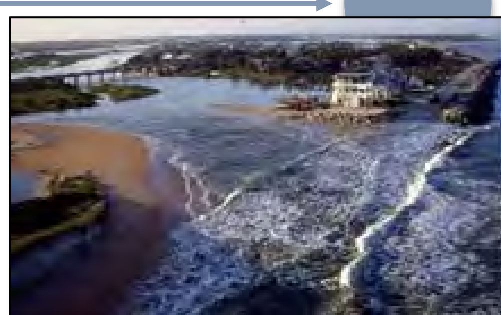
2007

PBS&J (2007) develops an "opportunity and constraints study of alternatives for providing a protected driving surface in the Summer Haven area." Study examined hard and soft solutions. Study suggested that the most expensive alternative (beach fill) is also the likeliest to receive environmental permit authorizations.

T.S. Fay

2008

In August, Tropical Storm Fay breached Summer Haven beach near R-200 (FDEP, 2020). Breach eventually closed on its own. Northeast Florida generally experienced two to four feet of storm surge (https://www.weather.gov/tae/event-200808_fay).



FIND Sed. Study

2009

Because the rate of shoaling is very high (every 2.7 years with average volume of over 175,000 cy) at the confluence of the Matanzas River north arm and the ICWW, FIND (Taylor Engineering, 2009) studied alternatives to reduce the frequency and costs (quantity) of dredging the ICWW channel while also preserving the environmental values and existing recreational use of the associated waterways. Alternatives consisted of construction of sediment basin in Matanzas River north arm, construction of a spur dike off the northern tip of Rattlesnake Island, and extension of the existing settling basin in the ICWW. A variation of the first alternative proved the most promising.

FEMA Beach Fill

2011

St. Johns County utilized FEMA funds to place 33,700 cy of truck-hauled sand from FIND's SJ-1 DMMA to construct a small emergency protective berm and partially restore lost sand from R-202 to R-208 (ATM, 2021).

Beach Disposal

2011

USACE/FIND place 272,915 cy from ICWW on Summer Haven beach (R-200 to R-208) (ATM, 2021).

NPS Inventory

2013

The NPS (Dallas et al., 2013) documented the coastal engineering projects in and around Fort Matanzas. The inventory identified 29 distinct projects, including revetments, dikes, and seawalls on Rattlesnake Island and Summer Haven and one major beach nourishment project at the time. The NPS offered that the Relocation Cut dramatically changed the area's flow patterns.

Hur. Matthew

2016

Hurricane Matthew skirted the Atlantic coast of Florida in early October. In northeast Florida, the storm caused the most damage since Hurricane Dora (1964) (FDEP, 2017). NOAA (Stewart, 2017) reports a peak Hurricane Matthew storm tide elevation of +8.39 ft NAVD88 at Fort Matanzas Beach, just north of Matanzas Inlet. The hurricane breached the beach again and severely damaged the rock revetment and Old A1A in Summer Haven. The most seaward dune of the three-dune system at Summerhouse eroded.

USGS (10/13/2016)

Close Breach

2016

As part of Summer Haven River Restoration Project, sponsored by the St. Augustine Port, Waterways, and Beach District (SAPWBD), St. Johns County closes breach between R-204 and R-205 with 78,000 cy from the Summer Haven River (ATM, 2021).

Sand Source Study

2017

INTERA (2017) Identified, assessed compatibility of, and developed cost estimates for potential upland (commercial sand mines and DMMAs) and offshore and inlet sand sources for dune nourishment after Hurricane Matthew (2016) for use along all county shorelines.

Beach Disposal

2017

USACE/FIND place 432,487 cy from ICWW on Summer Haven beach (R-200 to R-208) (ATM, 2021). Notably, the Summer Haven Restoration Project was also still ongoing.

Hurricane Irma

2017

Hurricane Irma made landfall in the Florida Keys as a Category 4 storm and made another landfall at Marco Island in September 2017. It continued traversing north along Florida's western inland counties. The hurricane's wind field spread up to 360 nautical miles from its center when over Florida (Cangialosi et al., 2018). In St. Johns County, the USGS measured a storm tide near Matanzas Inlet of +7.6 ft NAVD88. The beaches adjacent to Matanzas Inlet (including Summerhouse and Summer Haven) experienced Condition IV erosion (FDEP, 2018). Summer Haven Restoration Project sand was lost offshore and transported back into the river via overwash fans. A tornado embedded in a rain band destroyed the roofs of several buildings within Summerhouse.

USACE Feas. Study

2017

This Coastal Storm Risk Management (CSRM) study (USACE, 2017) examines whether federal interest exists in protecting three reaches — South Ponte Vedra Beach, Vilano Beach, and Summer Haven. This study suggests Summer Haven "…may require abandonment and retreat in order to protect lives and property. Continued erosion, breaching, and overwash of Summer Haven may eventually impact the Intracoastal Waterway (IWW)…" The presence of CBRS units may limit federal alternatives. The USACE screened out the Summer Haven reach from further analysis based on the relatively small number and value of structures to protect (e.g., SR A1A already relocated west and a rock revetment protects part of Old A1A) and CBRS unit limits federal alternatives.

River Restoration

2017

The Summer Haven River Restoration Project places 275,000 cy from the Summer Haven River onto beach between R-200 to R-204 (FDEP, 2020).

River Restoration

2018

The Summer Haven River Restoration Project places 67,000 cy from the Summer Haven River onto beach between R-200 to R-202 (FDEP, 2020).

River Restoration

2019

The Summer Haven River Restoration Project places 47,000 cy from the Summer Haven River onto beach between R-200 to R-202 (FDEP, 2020).

Beach Disposal

2019

USACE/FIND place 394,028 cy from ICWW on Summer Haven beach (R-200 to R-208) (FDEP, 2020).

Hurricane Dorian

2019

Remaining well offshore, Hurricane Dorian paralleled Florida's Atlantic coast in September. Inundation heights reached one to three feet in northeast Florida (Avilla et al., 2020). It "caused tidal over-topping between R203.5 and R204.5" in St. Johns County (FDEP, 2020).

Close Breach

2019

St. Johns County closes breach with 22,100 cy from Summer Haven River. Location of placement area unknown (ATM, 2021).

Summerhouse

2020

INTERA (2020) helped the Summerhouse board assess the permissibility of placing coastal armoring in front of its oceanfront buildings through an FDEP-approved coastal vulnerability study. Study showed three southernmost ocean-facing buildings (15, 16, and 20) were vulnerable to a 15-yr storm.

SHR Dredging

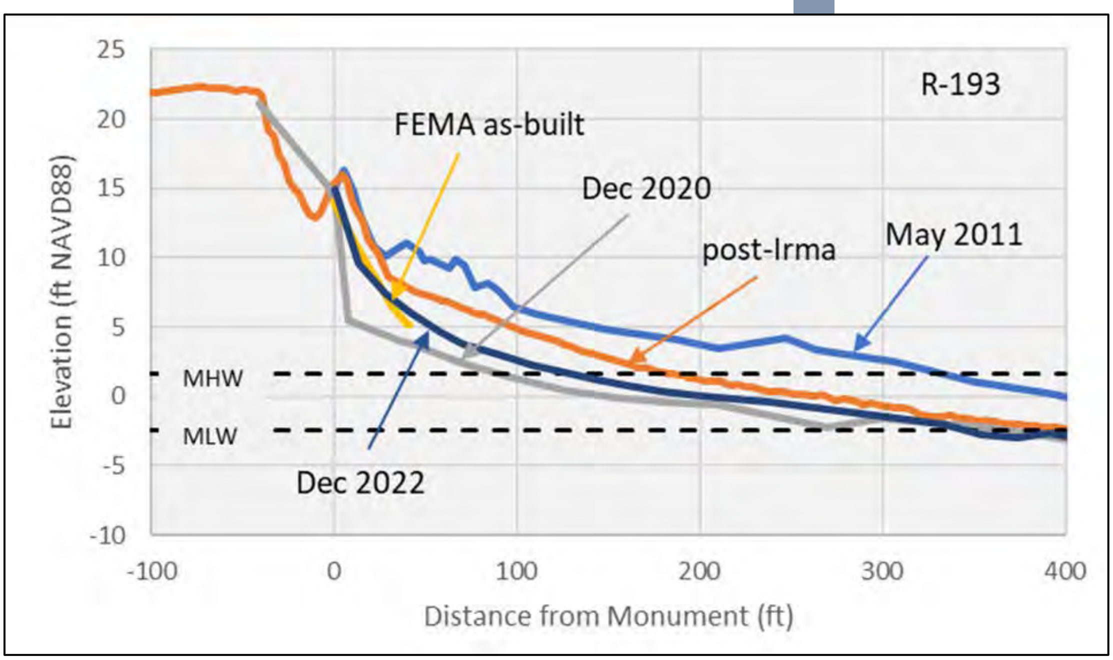
2021

The Summer Haven South FEMA Dune Project, authorized to mitigate Hurricane Matthew damages, placed 53,330 cy along 5,630 ft from R-203 to R-208.5 using overwash sediments in the south end of the Summer Haven River as the borrow source. The borrow area dredging re-established flow through the river, though the water depths in the northern portions associated with the Summer Haven River Restoration Project remained shallower than the authorized depths. Construction ended September 30, 2021.

FEMA Dune

2021

Utilizing FEMA funds, the county placed sand north of the inlet in front of the Summerhouse complex in addition to other areas along the county's shoreline. A contractor placed sand in September/October at Summerhouse. The approximate volume density at Summerhouse equals approx. 7.6 cy/ft. (Bill Chenevert, Summerhouse, personal communication, May 17, 2021). Placed sand showed buildings no longer vulnerable.



Nor’easter

2021

In November 2021, a powerful nor’easter with over 40 mph winds re-opened the Summer Haven breach, eventually infilling the south end of the Summer Haven River and severely restricting the river’s flow.

Hur. Ian & Nicole

2022

Hurricanes Ian (September) and Nicole (November) affected the Matanzas Inlet area. Hurricane Ian produced storm surge levels like Hurricane Irma and Hurricane Nicole produced levels like Hurricane Dorian. Hurricane Ian eroded most of the FEMA dune on the north side of the inlet and caused another breach of the Summer Haven beaches near R-205.

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Appendix D

Intracoastal Waterway Maintenance Dredging Records

Intracoastal Waterway Maintenance Dredging Records

Year	From		To		Length (mile)	Design Volume (cy)	Pay Volume (cy)
	Cut	Sta	Cut	Sta			
1958	60	6+00	61	7+00	0.64	53,372	63,538
1958	61	45+00	61	58+00	0.25	20,849	24,820
1958	62	25+00	62	32+00	0.13	10,841	12,906
1958	63	2+00	63	28+00	0.49	40,863	48,647
1960	60	7+00	61	5+00	0.47	102,000	87,727
1960	61	44+00	61	57+00	0.25	16,000	46,664
1960	63	4+00	63	31+00	0.51	19,000	18,967
1960	63	39+00	64	6+00	0.16	4,000	5,950
1962	60	6+00	61	5+00	0.49	105,000	103,504
1962	61	47+00	61	56+00	0.17	14,000	35,909
1963	60	10+50	61	36+50	1	99,010	117,869
1964	60	0+00	60	60+00	0.49	66,900	80280
1966	61	36+50				5,974	7,112
1966	62	45+50				21,717	25,853
1967	60	9+50	60	15+00	0.1	15,700	20,240
1967	64	34+50	F1	8+00	0.19	14,000	9,441
1968	60	18+50	60	25+75	0.14	21,400	59,542
1970	61	40+00	61	61+00	0.4	52,500	56,668
1970	61	64+50	62	7+00	0.24	31,500	34,000
1970	63	3+80	63	26+00	0.42	39,700	59,501
1973	60	10+50	61	10+50	0.51	86,000	112,447
1973	61	40+50	62	2+50	0.61	46,000	76,266
1978	59	23+00	61	11+00	0.73	260,000	312,776
1978	61	40+00	62	35+00	1.23	174,000	185,632
1978	63	8+00	63	31+00	0.44	52,000	62207
1978	64	31+00	F1	6+00	0.22	31,000	37200
1983	59	19+00	61	14+00	0.87	288,000	287,560
1987	60	6+00	61	58+00	1.50	188,000	225,600
1990	60	8+50	61	16+00	0.65	170,000	191,502
1994	60	4+00	61	15+00	0.72	180,000	197,370
1999	59	20+00	61	22+00	1.00	222,000	211,615
2003	60	5+00	60	12+003	0.13	15,013	24,732
2003	60	12+00	60	17+00	0.09	36,536	48,787
2003	60	17+00	60	24+00	0.14	45,224	65,838
2003	60	24+00	60	26+83	0.05	28,386	37,703
2003	61	0+00	61	5+00	0.10	37,035	52.360
2003	61	5+00	61	13+00	0.15	23,808	44,837
2003	61	46+00	61	55+00	0.17	1,737	9,029
2003	61	55+00	61	65+00	0.19	355	3,243
2007	60	8+00	60	26+83	0.36	81,434	124,064
2007	61	00+00	61	13+00	0.25	37,026	62,460

Year	From		To		Length (mile)	Design Volume (cy)	Pay Volume (cy)
	Cut	Sta	Cut	Sta			
2011	60	5+00	60	23+90	0.36	85,396	123,990
2011	60	23+90	61	13+00	0.68	79,950	114,163
2011	60	25+50	61	0+50	0.03	127	824
2017	59	20+00	60	1+56	0.10	6,346	7,659
2017	60	1+56	60	26+86.34	0.48	223,164	265,565
2017	61	0+00	61	18+00	0.34	133,834	159,262
						Total	3,963,829

Appendix E

Summer Haven River Restoration Natural Resources and Protected Species (Taylor Engineering, 2012)

Attachment G

Summer Haven River Restoration
Natural Resources and Protected Species

Prepared for

Florida Department of Environmental Protection

U.S. Army Corps of Engineers

By

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July 2012

Summer Haven River Restoration

Natural Resources and Protected Species

This narrative provides information for the Summer Haven River Restoration Joint Coastal Permit application items 28 and 29.

Item 28. Existing Natural Communities Description

On May 3, 2012 Taylor Engineering environmental staff visited the project site to characterize and map existing natural communities within and immediately adjacent to the project area. Prior to the field investigation, environmental staff reviewed existing, readily available information including recent and historical aerial photographs, Florida Natural Areas Inventory endangered species and natural community descriptions, St. Johns County Habitat Conservation Plan, and other publications that contain pertinent natural resource information.

Applying the classifications described by the Florida Natural Areas Inventory (FNAI) in its publication *Guide to the Natural Communities of Florida* (2010 edition), natural communities within the project vicinity generally comprise beach dune, coastal grassland, coastal strand, unconsolidated substrate, salt marsh, and mangrove swamp.

The FNAI (2010) defines beach dune as "a predominantly herbaceous community of wide-ranging coastal specialist plants on the vegetated upper beach and first dune above the beach (foredune)." In the project area, severe coastal erosion and overwash has decimated a significant fraction of the beach dune habitat. This habitat now only occurs near the southern portion of the project area forming a narrow (approximately 100-ft wide), eroded, and severely scarped strip of vegetated habitat between the upper beach and estuarine wetlands to the west (Figure 1-4). Herbaceous species such as sea oats (*Uniola paniculata*), bitter panicum (*Panicum amarum*), saltmeadow cordgrass (*Spartina patens*), dune sunflower (*Helianthus debilis*), seashore dropseed (*Sporobolous virginicus*), and dune elder (*Iva imbricata*) compose the majority of the plant community. The harsh and dynamic conditions characteristic of the beach dune community limit the diversity of wildlife using this habitat. Wildlife typically associated with the beach dune community includes invertebrates such as the ghost crab (*Ocypode quadrata*), various small mammals, shorebirds, and sea turtles for nesting. However, in its current eroded condition, beach dune habitat within the project area provides very limited wildlife habitat value.

The FNAI (2010) defines coastal grassland as "a predominantly herbaceous community occupying the drier portions of the transition zone between beach dunes on the immediate coast and communities dominated by woody species." In the assessment area, a small community that exhibits characteristics of coastal grasslands occurs behind the beach dune community (Figure 1-4). This area eventually transitions into salt marsh/mangrove estuarine wetlands. The coastal grassland community contains a mix of beach dune and transitional high saltwater marsh vegetation. Dominant species include sea oats, saltmeadow cordgrass, sea oxeye daisy (*Borrichia frutescens*), seashore dropseed, aster (*Aster sp.*), beach pennywort (*Hydrocotyle bonariensis*), sandbur (*Cenchrus sp.*), and prickly pear cactus (*Opuntia stricta*).

The FNAI (2010) describes coastal strand as "an evergreen shrub community growing on stabilized coastal dunes in the peninsula of Florida, often with a smooth canopy due to pruning by salt spray." In an undisturbed environment, the coastal strand community generally lies between stabilized coastal dunes and maritime hammock. In the project area, coastal strand habitat occurs in two small, isolated areas. Less than a quarter acre in size, the first area situates just west of the southern end of the AIA bridge crossing the Summer Haven River (Figure 1-2). The second area covers approximately one acre and occurs as an elevated stand within a high saltwater marsh community just east of AIA (Figure 1-4). Typical plant species occupying these coastal strand habitats include Southern red cedar (*Juniperus silicicola*), red bay (*Persea borbonia*), cabbage palm (*Sabal palmetto*), saw palmetto (*Serenoa repens*), and yaupon holly (*Illex vomitoria*). Coastal strand may provide valuable habitat for a wide variety of wildlife including birds, reptiles, and small mammals; however, due to its small size and isolated condition, coastal strand within the project area provides marginal habitat value.

The FNAI defines the marine and estuarine unconsolidated substrate communities as "mineral-based natural communities generally characterized as expansive, relatively open areas of subtidal, intertidal, and supratidal zones which lack dense populations of sessile plant and animal species." Unconsolidated substrate composes the majority of the project area and serves as the primary focus of the proposed restoration effort (Figure 1-1 – Figure 1-5). The majority of this community comprises fine to medium-grained white to light brown sandy material that overwashed from the beach and dune and filled a large portion of the Summer Haven River and adjacent estuarine wetlands. The overwash has resulted in substantial loss of estuarine wetland and open water habitat. Although mostly buried with only the crowns exposed, some black mangroves (*Avecennia germinans*) survived the overwash filling and intermittently occur in some portions of the unconsolidated substrate community. In addition, pioneer dune species, such as sea oats, have begun to recruit into some isolated sections of the overwash area. The clean sandy material deposited by the overwash created suitable habitat for nesting shorebirds, particularly least terns (*Sterna antillarum*). A relatively large least tern nesting colony has developed within the overwash area adjacent to the main breach in the beach and dune system (Figure 1-3 and Figure 1-4). This area may become less suitable tern habitat as pioneer vegetation becomes established.

The FNAI describes the salt marsh community as a “largely herbaceous community that occurs in the portion of the coastal zone affected by tides and seawater and protected from large waves, either by the broad, gently sloping topography of the shore, by a barrier island, or by location along a bay or estuary.” In the project area, the salt marsh community is largely intermixed with the mangrove community, which the FNAI describes as “dense forest occurring along relatively flat, low wave energy, marine and estuarine shorelines.” The salt marsh/mangrove community is present along the length of the project area (Figure 1-1 – Figure 1-5). Dominant vegetation within the lower elevations of the salt marsh/mangrove community generally consists of smooth cordgrass (*Spartina alterniflora*) while the higher elevations contain black mangrove (*Avicennia germinans*), saltwort (*Batis maritima*), glasswort (*Salicornia sp.*), sea oxeye daisy, and saltmeadow cordgrass. Some portions of the salt marsh/mangrove community contain fringing oyster assembledges. Saltmarsh/mangrove communities provide valuable habitat for a myriad of fish and wildlife and serve as important nursery areas for commercially important finfish, shellfish, and crustaceans. Overwash occurring over the past several years has resulted in significant loss of salt marsh/mangrove habitat within the project area. The proposed project aims to restore these important estuarine communities.

Submitted as a separate attachment to this permit application, the report entitled “Biological Summary of the Summer Haven River” provides additional information regarding the Summer Haven ecosystem prior to the breach and fill.

Item 29. Threatened and Endangered Species Information

A number of federally and state listed species may occur in the project area include (**Table 1**). Among those listed in Table 1, a few of the species are of particular interest in the project area.

Table 1. Federally and State Listed Species Potentially found in the Project Area (http://www.fws.gov/northflorida/CountyList/Johns.htm, http://www.fnai.org/)

Category	Species Common Name	Species Scientific Name	Federal Code	State Code
Mammals	West Indian (Florida) Manatee	*Trichechus manatus latirostris*	E/CH	E
Birds	Piping Plover	*Charadrius melodus*	E	E
	Little blue heron	*Egretta caerulea*		SSC
	Snowy egret	*Egretta thula*		SSC
	Tricolored heron	*Egretta tricolor*		SSC
	White Ibis	*Eudocimus albus*		SSC
	Southeastern American kestrel	*Falco sparverius paulus*		ST
	American oystercatcher	*Haematopus palliatus*	C	SSC
	Wood stork	*Mucteria americana*	E	E
	Osprey	*Pandion haliaetus*	E	SSC
	Brown pelican	*Pelecanus occidentalis*	E	SSC
	Roseate spoonbill	*Platalea ajaja*	T	SSC
	Black skimmer	*Rynchops niger*		SSC
	Least tern	*Sterna antillarum*		ST
Reptiles	Gopher Tortoise	*Gopherus polyphemus*		
	Green Sea Turtle	*Chelonia mydas*		
	Hawksbill Sea Turtle	*Eremochelys imbricata*		
	Leatherback Sea Turtle	*Dermochelys coriacea*		
	Loggerhead Sea Turtle	*Caretta caretta*		
Fish	Atlantic Sturgeon	*Acipenser oxyrinchus*		SSC
	Shortnose Sturgeon	*Acipenser brevirostrum*	E	E

CH Critical Habitat
E Federally Endangered
T Federally Threatened
SSC Species of Special Concern
ST State Threatened

The (approximately) forty miles of Atlantic Ocean beaches in St. Johns County provides potential nesting habitat for four species of marine turtles the loggerhead *(Caretta caretta),* green *(Chelonia mydas),* leatherback *(Dermochelys coriacea),* and hawksbill *(Eretmochelys imbricata)* sea turtles. Of the four, loggerhead nests are most commonly found on county beaches (3-6 nests per km/year[1]), while less than two green turtle or leatherback turtle nests are located annually within county borders[2]. Readily available data provide no reports of hawksbill nests within the county borders. Thus, between two and

[1] http://myfwc.com/research/wildlife/sea-turtles/nesting/loggerhead/
[2] http://myfwc.com/research/wildlife/sea-turtles/nesting

fifteen loggerhead nests may occur annually within the 8,000 ft sand placement and two or less green and leatherback turtle nests. The federal and state governments have not defined any period when construction may not occur on the beaches in St. Johns County.

A 2001 Environmental Assessment provided the basis for a Finding of No Significant Impact (FONSI) to marine turtles and manatees associated with dredging of the IWW near Matanzas Inlet and placement of dredged sand on the Summer Haven Beach between FDEP Monuments R-200 and R-208 (USACE 2001), the same location proposed for use in this project.

The 2010 Habitat Conservation Plan Assessment Annual Report 2010 (Dodson 2010) included the following information on least tern nesting within the area proposed for excavation.

> On Wednesday, October 10, 2008, during an extreme high tide and storm event, a complete breach in the dune system occurred on the northern end of Summer Haven forming a new inlet (Object 9). This breach prevented homeowners from accessing their homes from the northern end of old A1A forcing homeowners to access their homes from the south using a trail that runs parallel to the beach on the western side of the small fore dune. The breach has since filled in with sand…and is now mostly dry with pioneering vegetation and several different types of animals including gopher tortoise and least terns utilizing the area. On May 28 [2010] the FWC staff contacted the County to report that a small least tern colony and two pairs of Wilson's plovers had been observed in the dry barren sand where the old Summer Haven river once flowed during high and low tides. County staff responded by marking the area with posts, flagging, and signage. FWC documented over 100 nests and determined the site to be a successful nesting site with multiple chicks becoming flight capable. The colony had all but diminished just after the July 4th holiday and the postings were removed in early August.

Least terns were also reported using the same area for nesting in 2011 by Florida Shorebird Alliance[3], and anecdotal reports of least tern nesting in the same location during the current 2012 season are common, although no written reports were readily available for the current nesting period.

Manatees use the Matanzas Inlet frequently, and were common visitors to the waters of the Summer Haven River (e.g. see information in Attachment I) prior to the breach and filling of the open waters of the river. Anecdotal information from local residents indicates that since the breach event and subsequent filling of the river, manatees have been seen on a much less frequent basis in the remaining open water portions of the river.

References

USACE 2010. Environmental Assessment on Maintenance Dredging Intracoastal Waterway-Matanzas Inlet Vicinity St. Johns County, Florida. US Army Corps of Engineers, Jacksonville District.

Dodson, Tara. 2001. Habitat Conservation Plan Assessment St. Johns County, Florida 2010 Annual Report. Section 11 Beach Driving at Summer Haven pp. 50-52. Prepared for: U.S. Fish and Wildlife Service North Florida Ecological Services Office Attn: HCP Program 7915 Baymeadows Way Suite 200 Jacksonville, FL 32256-7517. Prepared by: Tara Dodson Environmental Coordinator St. Johns County Growth Management-Environmental Division Habitat Conservation Section 901 Pope Road St. Augustine, FL 32080 available at: http://www.co.st-johns.fl.us/HCP/Report.aspx

[3] http://www.flshorebirdalliance.org/pdf/Wrack_Line_0911.pdf

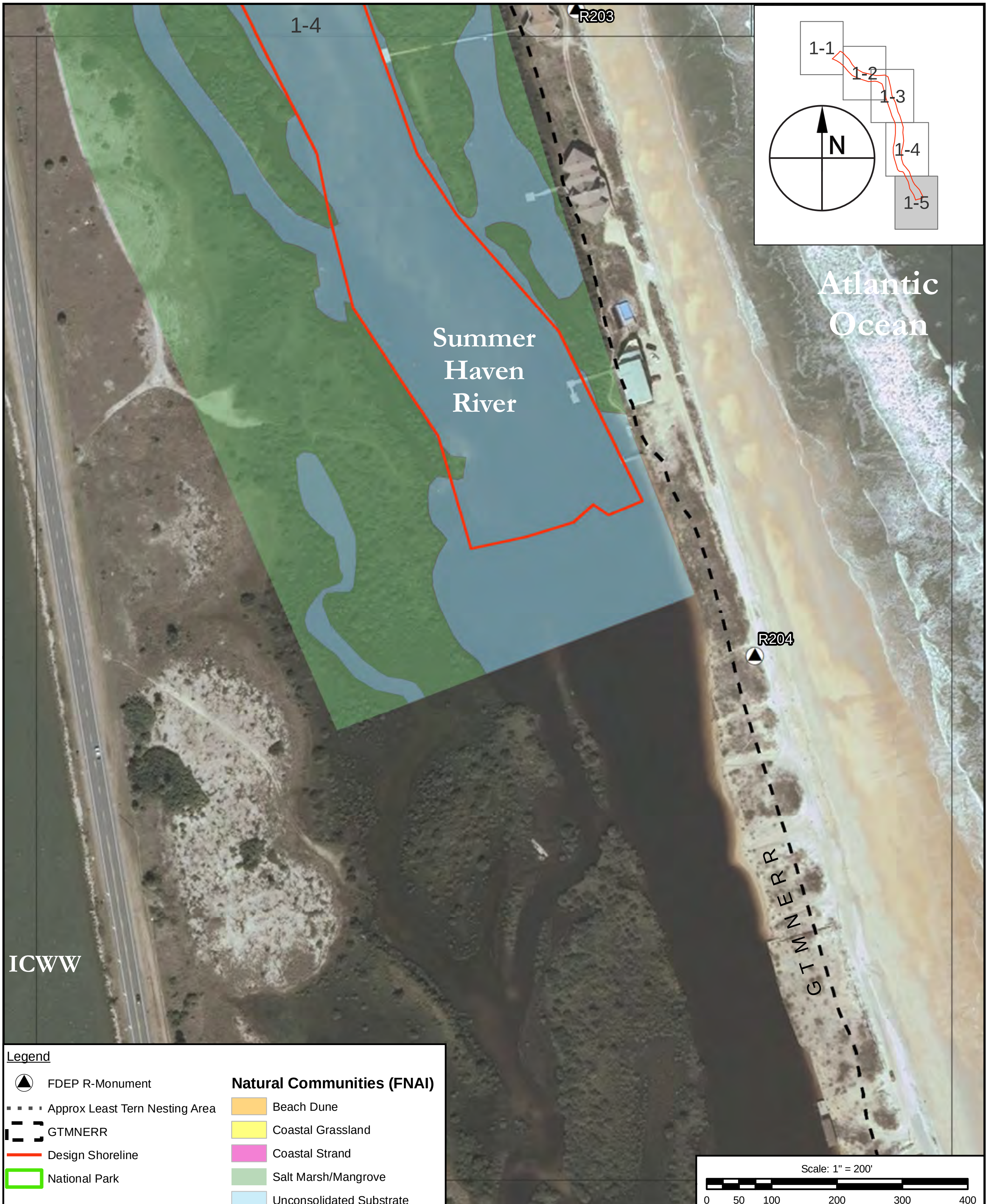

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Figure 1-5
Site Features and Natural Communities
Summer Haven River Restoration Project
St. Johns County, FL

PROJECT	C2012-023
DRAWN BY	RC
SHEET	
DATE	JUNE 2012

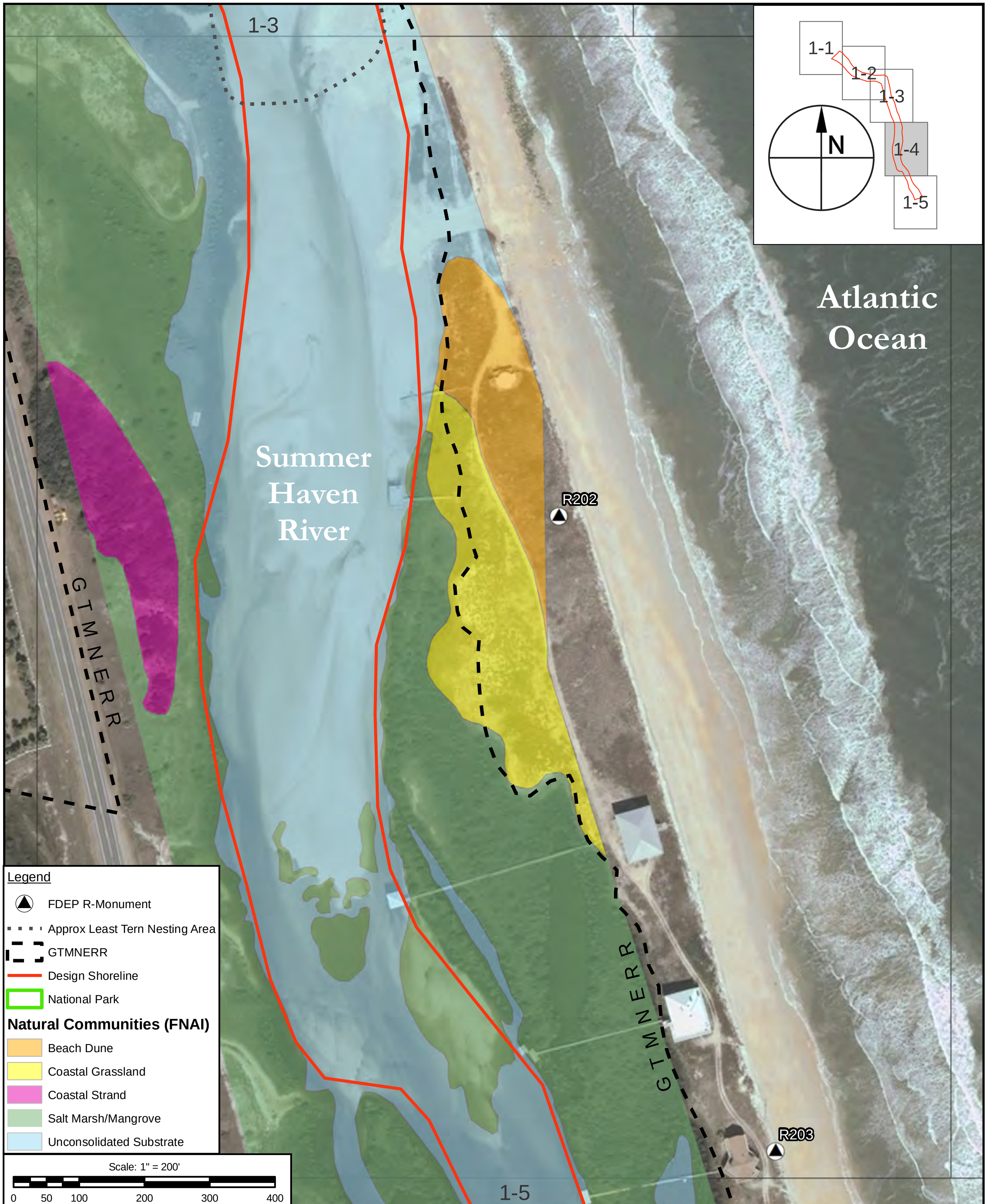

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Figure 1-4
Site Features and Natural Communities
Summer Haven River Restoration Project
St. Johns County, FL

PROJECT	C2012-023
DRAWN BY	RC
SHEET	
DATE	JUNE 2012

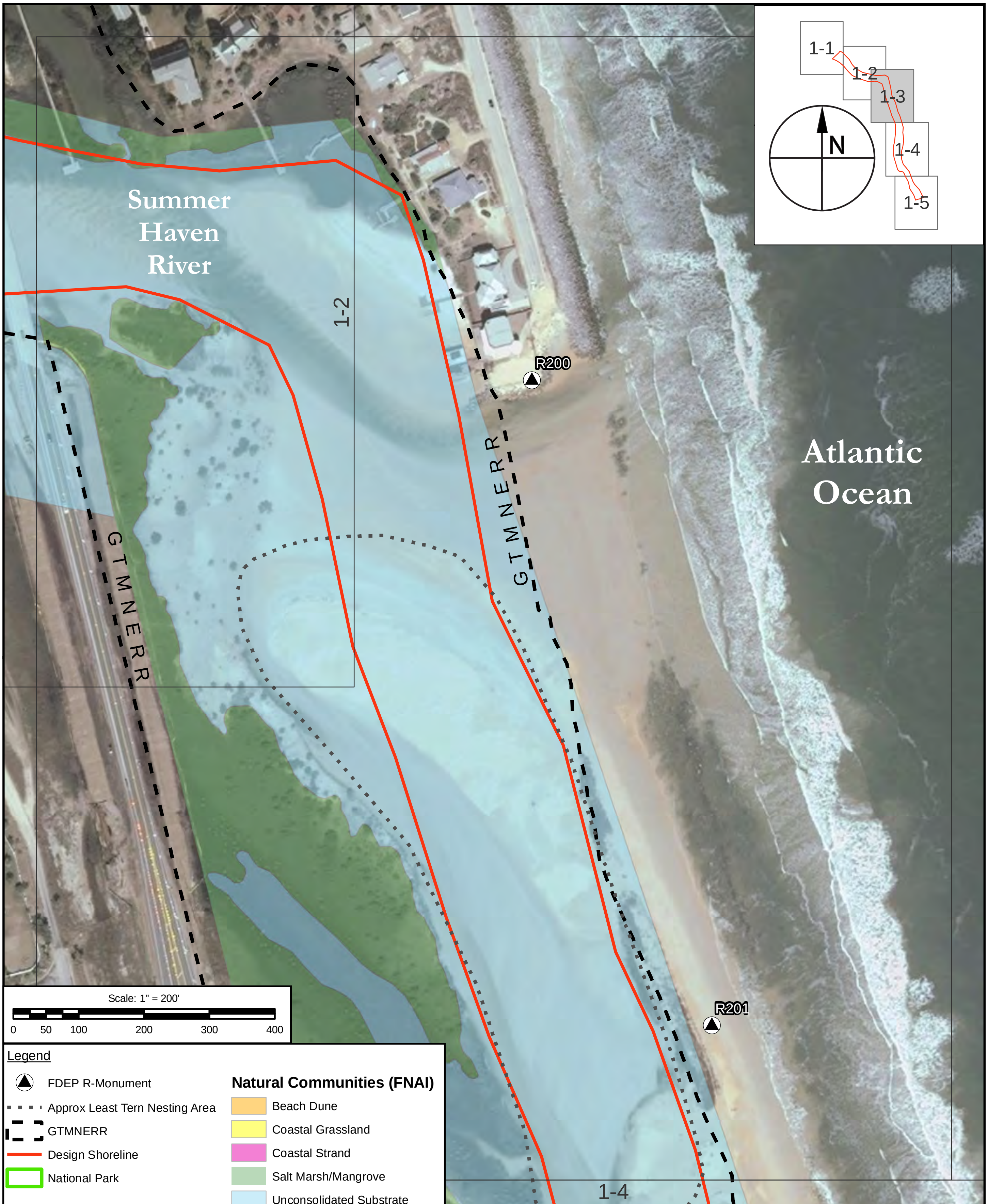

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Figure 1-3
Site Features and Natural Communities
Summer Haven River Restoration Project
St. Johns County, FL

PROJECT	C2012-023
DRAWN BY	RC
SHEET	
DATE	JUNE 2012

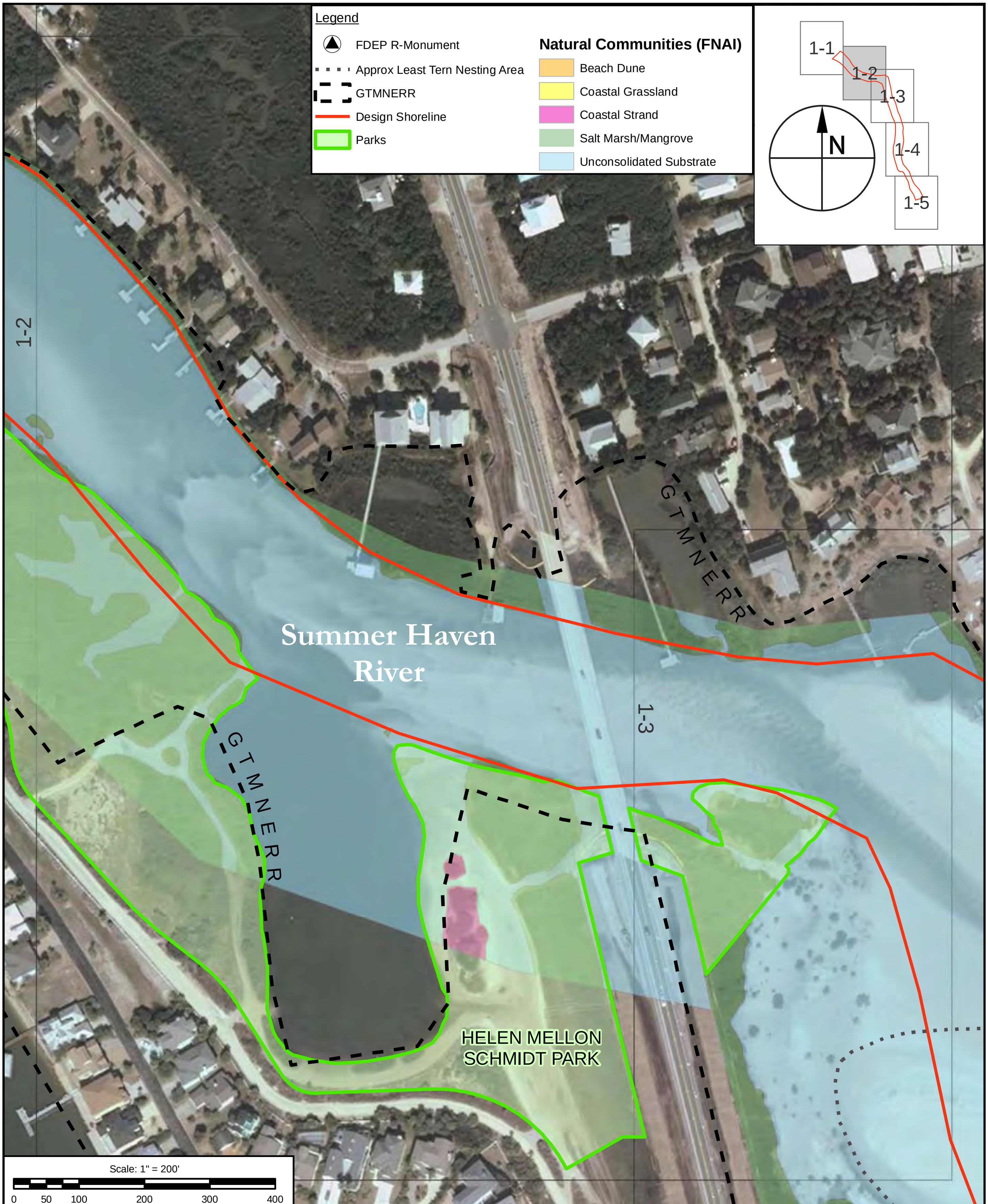

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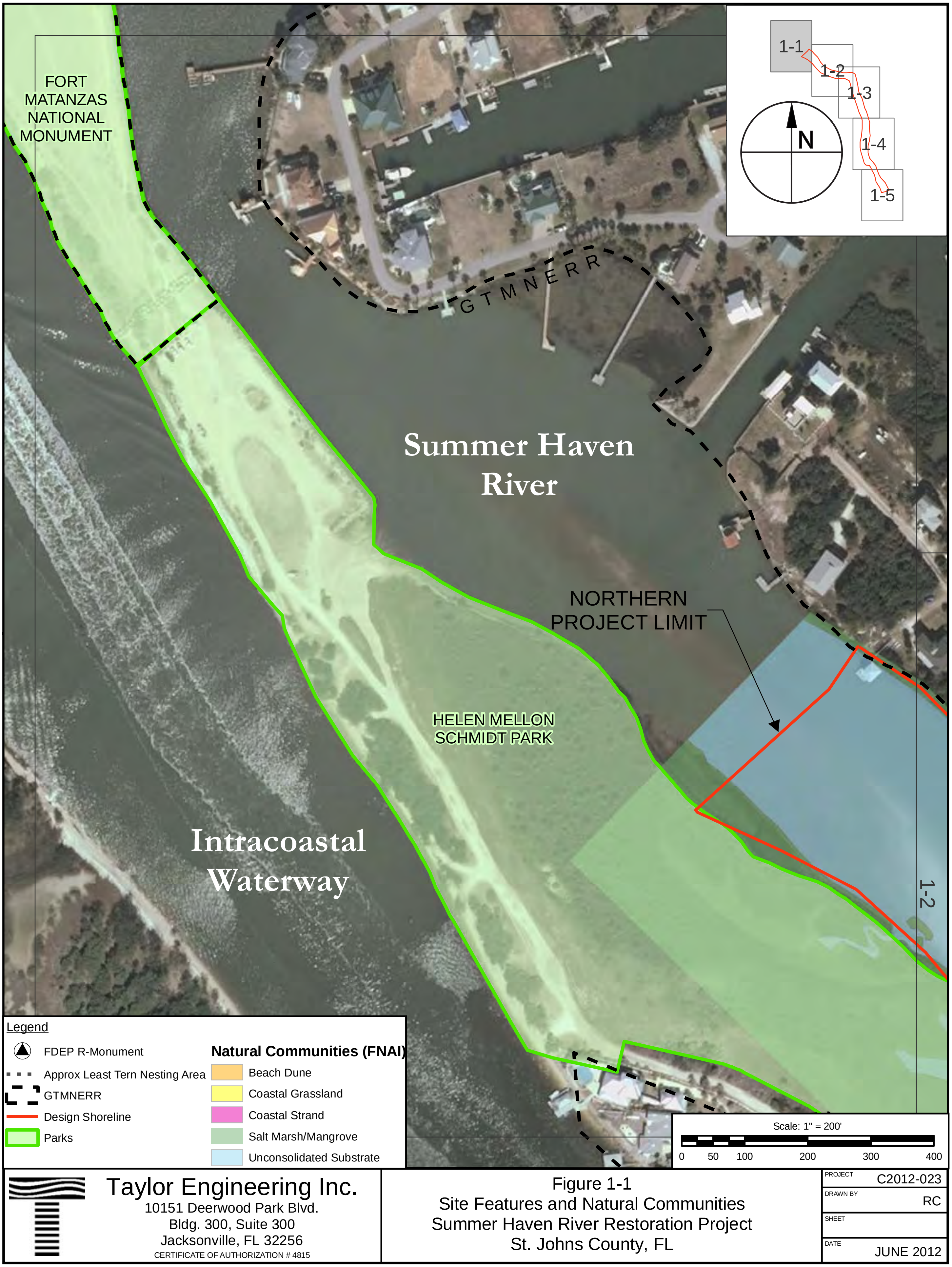
Figure 1-2
Site Features and Natural Communities
Summer Haven River Restoration Project
St. Johns County, FL

PROJECT	C2012-023
DRAWN BY	RC
SHEET	
DATE	JUNE 2012


FORT MATANZAS NATIONAL MONUMENT
GTMNERR
Summer Haven River
NORTHERN PROJECT LIMIT
HELEN MELLON SCHMIDT PARK
Intracoastal Waterway
1-2
1-1
1-2
1-3
1-4
1-5
N
Legend
FDEP R-Monument
Approx Least Tern Nesting Area
GTMNERR
Design Shoreline
Parks
Natural Communities (FNAI)
Beach Dune
Coastal Grassland
Coastal Strand
Salt Marsh/Mangrove
Unconsolidated Substrate
Scale: 1" = 200'
0
50
100
200
300
400
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CERTIFICATE OF AUTHORIZATION # 4815
Figure 1-1
Site Features and Natural Communities
Summer Haven River Restoration Project
St. Johns County, FL
PROJECT C2012-023
DRAWN BY RC
SHEET
DATE JUNE 2012

Appendix F

Biological Summary of the Summer Haven River (Steinmetz, 2022)

Biological Summary of the Summer Haven River

St. Johns County, FL

Prepared For:

Friends of the Summer Haven River
9051 Gene Johnson Rd.
St. Augustine, FL 32080

By:

Alicia McKinney Steinmetz

Revised April 2022

Original June 2012

Introduction

The Summer Haven River (SHR) is located in St. Augustine, FL at the southernmost end of St. Johns County within the Matanzas River Basin. It is a naturally occurring waterway, approximately 2.3 miles in length, extending directly from Matanzas Inlet at the north end to its confluence with the Matanzas River (Atlantic Intracoastal Waterway) at the south end. The Summer Haven River was the only navigation route south from Matanzas Inlet before the construction of the Atlantic Intracoastal Waterway (ICW) in the 1930s. Prior to the 1930s, the Summer Haven River functioned as the headwaters to Pellicer Creek. The river also served as one of the arteries which directed fresh sea water into Pellicer Creek with each flood tide.

The Summer Haven River has been recognized as a historical, recreational, and ecologically vital region in St. Johns County, providing many ecosystem services. The SHR is surrounded by state and federally protected areas. Located directly across from the confluence of the Summer Haven River and the Matanzas River is the entrance to Pellicer Creek. Faver-Dykes State Park is located adjacent to Pellicer Creek Aquatic Preserve. The Summer Haven River is located just a few miles north of Marineland and The River to Sea Preserve at Marineland. The river is bordered on the west by the St. Johns County Helen Mellon Schmidt Park and the federally-owned Rattlesnake Island where Fort Matanzas River National Monument is located. Several residential communities are positioned along the east side of the river. A barrier beach dune exists approximately mid-river on the east side separating the Atlantic Ocean from the SHR. Over the years, rock revetments were placed in the vicinity of the river along portions of Rattlesnake Island/Ft. Matanzas, along a section of beach south of Matanzas Inlet, and at Marineland.

Historically, the Summer Haven community has existed since the late 1800s. The homes along the river and beach are recorded as the oldest beach homes on state record dating back to the 1890s. Thomas A. Mellon of Pittsburgh, entrepreneur, lawyer, judge, and founder of Mellon Bank, built several homes in the area and began vacationing with his family in Summer Haven in the late 1800s, establishing Summer Haven. Eventually the community attracted other well-known folks, including Cornelius Vanderbilt Whitney, Owen D. Young, and author Marjorie Kinnan Rawlings. Gene Johnson, famed African-American oysterman living on the Summer Haven River, entertained and hosted oyster dinners for the elite vacationers.

The SHR has evolved through the decades as an ecotourism destination. The river is utilized daily year-round by numerous visitors kayaking, paddle boarding, boating, jet skiing, fishing, swimming, and wildlife viewing. Most of the public accesses the river for ecotourism at Helen Mellon Schmidt Park, adjacent to the entrance of the Summer Island neighborhood to the west. Others access the river from its headwaters at Matanzas Inlet. The river also provides a living classroom for the St. Johns County Marine Science Program and by scientists at the University of Florida Whitney Laboratory.

This segment of the Matanzas River has been recognized as an environmentally sensitive area by state environmental agencies. According to a report by the St. Johns River Water Management District (SJRWMD), submitted to the Florida Department of Environmental

Protection (FDEP), the portion of the Matanzas River Basin extending from St. Augustine Inlet south to Palm Coast is ecologically valuable. Matanzas Inlet, the headwaters of the Summer Haven River, was described as "…one of the most natural inlets on Florida's Atlantic coast, which connects the ocean with the estuary nursery areas that are vital to commercially and recreationally important fishery species" (SJRWMD 2009). Specifically, the Summer Haven River has been recognized as a "…vital component of one of the most pristine estuarine environments left in the state of Florida. As a research scientist and aquatic biologist who has lived in St. Johns County and worked at the University of Florida's Whitney Laboratory for Marine Biosciences since 1994 (retired in 2021), I can attest to the significant impact that the closure of the Summer Haven River has had on the ecology of the Matanzas River Estuary." (Jose Nunez, personal communication, December 20, 2021)

The purpose of this paper is to provide a documented summary of the ecological significance of the Summer Haven River and the critical habitat it previously provided for many species of fish, birds, mammals and reptiles. Moreover, the water quality in the Summer Haven River was such that oysters and clams were abundant and commercially harvested.

Background

The Summer Haven River was once a free-flowing water body which received seawater from Matanzas Inlet at the north end and exchanged water with the Matanzas River (ICW) at the south end across from Pellicer Creek. The entire length of the river was once navigable by motorboats, kayaks, canoes and jet skis. There are two public boat launch areas within the St. Johns County Helen Mellon Schmidt Park that are used by the public daily. The river encompasses several naturally occurring sandbars, salt marsh and mangrove swamp habitat, and oyster bars. Since 2008, the river has suffered substantial damage from a series of extreme weather events.

In 2008, following several sequential storm events (Tropical Storm Faye on August 21, 2008; Hurricane Hanna on September 5, 2008; and Hurricane Kyle on September 27, 2008), the ocean breached a small section of the sand dune system approximately mid-river. Over time, the breach closed naturally and sand from the beach was deposited into the river, eventually impeding the flow of water between its headwaters north at Matanzas Inlet and its confluence with the Matanzas River (ICW) at the south end. Consequently, a significant expanse of estuarine marsh, mangrove and oyster habitat was lost resulting in a concomitant decline in fisheries, bird, mammal, and reptile populations.

Several years after the ocean breach, the Friends of the Summer Haven River partnered with the St. Augustine Port, Waterway and Beach District to restore water flow in the SHR by dredging the sand that was deposited into the river from the ocean breach of the dune, and rebuilding that section of beach dune (Port dune – R200-R202). Through several years of campaigning for project support, planning, and permitting, the State of Florida recognized the ecosystem services the river provided and granted $3 million for the Summer Haven River

Restoration Project. River flow began to increase as restoration work progressed, but the area was devastated yet again by unprecedented storms - Hurricanes Matthew (2016) and Irma (2017). Like all other areas of St. Johns County beaches, Summer Haven dune was severely damaged. The ocean completely flattened and destroyed the barrier dune further south from the original breach of 2008, causing extensive damage to homes along that area of beach. The ocean free flowed into the river filling the river with vast amounts of beach sand, obstructing river flow and smothering marsh habitat and oyster beds. Fortunately, however, most of the Port dune that was under construction remained intact. The Summer Haven River Restoration Project was completed in mid-September 2017. In April 2018, the Friends of the Summer Haven River coordinated over 100 volunteers to install vegetation on the dune as natural reinforcement. And in January 2022, the Friends of the Summer Haven River coordinated the installation of sand fencing and additional habitat signage on the Port dune. Meanwhile, St. Johns County utilized FEMA funds to engineer and contract reconstruction of the barrier beach dune which was destroyed during the 2016 and 2017 hurricanes, and excavated the sand from the SHR to reconstruct the barrier dune.

As both the Summer Haven River Restoration Project conducted by the Port and the Friends of the Summer Haven River, and the barrier beach dune construction project conducted by St. Johns County were completed, the Summer Haven River began flowing, creating tidal exchange with the ICW at the south end and Matanzas Inlet at the north end of the river. Wildlife and fisheries returned to their habitat and foraging grounds in the river, and the river was navigable the entire length. Nonetheless, a powerful nor'easter occurring during a king tide in November 2021 destroyed the recently constructed St. Johns County barrier dune, consequently causing extensive infilling of sand in the Summer Haven River and sand encroachment into the ICW navigable channel. Fortunately, the Port dune, which was engineered and constructed differently than the St. Johns County FEMA barrier beach dune, withstood both Hurricane Dorian in September 2019 and the severe November 2021 king tide nor'easter.

Ecosystem Services

The Summer Haven River was a highly valuable, coastal ecosystem providing a variety of ecosystem services, including critical habitat and foraging grounds for threatened and endangered species, nursery grounds for commercial and recreational fisheries, and phenomenal wildlife viewing of dolphins, sea turtles, manatees, and birds. Ecologically sensitive habitats included salt marsh, mangroves, and oyster and clam beds. Since the ocean breach and damming of the river, the vast majority of the oyster beds were decimated from sand deposition. According to a Wetland Evaluation Report prepared for the Florida Department of Transportation (FDOT) in 2003, there were 2.11 acres of commercial shellfish lease adjacent to the South Bridge and a 9.6 acre non-commercial oyster and clam lease east of the North Bridge.

As stated in the FDOT Wetland Evaluation Report (2003b), an analysis of the U.S. Fish and Wildlife Service's (USFWS) National Wetlands Inventory (NWI) map for the Matanzas Inlet quadrangle indicated the salt marsh was classified as "an estuarine, intertidal, emergent, persistent, regularly flooded (E2EM1N) wetland system, while the mangrove swamp was considered an estuarine intertidal, scrub-shrub, broad-leaved evergreen, regularly flooded (E2SS3N) wetland with both of the wetland systems regularly flooded with each tidal cycle. Additionally, there was a shrubby transitional zone located at the upland-wetland interface described as an estuarine, intertidal, scrub-shrub, broad-leaved deciduous, irregularly-flooded (E2SS1P) wetland. In the salt marsh, smooth cordgrass (*Spartina alterniflora),* saltwort (*Batis maritima)* and glasswort (*Salicornia virginica)* were identified as the dominant species on the lower elevations of the marsh, whereas saltmeadow cordgrass (*Spartina patens)*, coastal dropseed (*Sporobolus virginicus),* sea oxeye daisy (*Borrichia frutescens)*, marsh elder (*Iva frutescens),* sea purslane *(Sesuvium portulacastrum*) and salt marsh aster *(Aster tenuifolius).* Black mangrove (*Aviecennia germinans)* was the dominant species of the mangrove swamp as well as some smooth cordgrass. Saltbush *(Baccharis halimifolia*), marsh elder, sea oxeye daisy, southern red cedar *(Juniperus virginiana*) and wax myrtle *(Myrica cerifera*) were identified as dominant species at the shrub fringe in the area east of the South Bridge.

Oyster and Clams

As aforementioned, there were 2.11 acres of commercial shellfish lease adjacent to the South Bridge and a 9.6 acre non-commercial oyster and clam lease east of the North Bridge in the Summer Haven River (FDOT 2003b). In addition to the leased beds, oysters and clams were present along the length of the Summer Haven River, but most have been destroyed due to the sand deposition from the ocean breach. As stated in Guana-Tolomato-Matanzas National Estuarine Research Reserve (2012), "The Eastern oyster, *Crassostrea virginica*, is a keystone species because of its critical role in maintaining a healthy coastal ecosystem. Oysters are important to the environment and the many organisms that share the same habitat. One of the most impressive benefits of oysters is that they significantly improve water quality. As filter-feeders, they function much like a home filtration system. A full grown adult oyster filters approximately 50 gallons of water in a single day. Oysters provide food for other animals and are an important shelter and nursery habitat for many fish and invertebrate species. They are also crucial to the commercial and recreational fisheries. The frequency and density of oyster reefs in Florida are declining at a significant rate, which is caused primarily by habitat destruction and habitat fragmentation brought on by coastal development, water pollution, and wave energy from boat traffic."

The Guana-Tolomato-Matanzas National Estuarine Research Reserve spearheaded a project to recycle oyster shells in an effort to reconstruct an eroded shoreline in Northeast Florida, as well as restore historic oyster beds that will be a foundation for a living reef along the Tolomato River shoreline in the Guana Peninsula in St. Johns County (Guana-Tolomato-Matanzas National Estuarine Research Reserve 2012).

Fisheries

Concomitant with the Wetland Evaluation Report FDOT 2003b, an Essential Fish Habitat (EFH) Report FDOT 2003a was drafted to determine if the reconstruction of the two SR A1A bridges over the Summer Haven River would impact critical fisheries habitat. The EFH FDOT 2003a report utilized the Magnuson-Stevens Fishery Conservation and Management Act of 1976 and the 1996 Sustainable Fisheries Act, and the FDOT Project Development and Environment Study. As stated in the EFH FDOT 2003a report, an EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." According to the EFH FDOT 2003a report, the following describes the determination of an essential fish habitat: "W*aters* include aquatic areas and their associated physical, chemical, and biological properties that are used by fishes and may include areas historically used by fishes. *Substrate* includes sediment, hard bottom, structures underlying the waters, and any associated biological communities. *Necessary* means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. *Spawning, breeding, feeding, or growth to maturity* covers all habitat types used by a species throughout its life cycle. Only species managed under a federal fishery management plan (FMP) are covered (50 C.F.R. 600). The act requires federal agencies to consult on activities that may adversely influence EFH designated in the FMPS. The activities may have direct (e.g., physical disruption) or indirect (e.g., loss of prey species) effects on EFH and may be site-specific or habitat wide. The adverse result(s) must be evaluated individually and cumulatively."

For purposes of the EFH FDOT 2003a report, the report only focused on those areas that would be impacted by the bridge reconstruction over the SHR which extended 0.46 miles from the North Bridge to 0.50 miles south of the South Bridge. Salt marsh and mangrove habitat reportedly occurred within the project boundaries and thus were considered "habitats of concern." In the EFH FDOT 2003a report, a list of species that likely occurred within the project area was generated from review of the Affected Fishery Management Plans and Fish Stocks of the Comprehensive EFH Amendment (SAFMC 1998). The EFH FDOT 2003a report focused only on those species that were covered under a federal fishery management plan (FMP). Below are the results of the managed species assessment for species likely occurring within the bridge reconstruction project area according to the EFH FDOT 2003a report which could have been potentially impacted by the bridge replacements (Table 1).

Table 1. Managed Species Identified by the South Atlantic Fishery Management Council That Are Known to Occur in St. Johns County, Florida (from Essential Fish Habitat Report FDOT, 2003)

Taxa	Common Name
Carangidae	
Caranx hippos	Crevalle jack
Haemulidae	
Haemulon sciurus	Blue stripe grunt
Lutjanidae	
Lutjanus analis	Mutton snapper
Lutjanus cyanopterus	Cubera snapper
Lutjanus griseus	Gray snapper
Lutjanus jocu	Dog snapper
Lutjanus synagris	Lane snapper
Ocyurus chrysurus	Yellowtail snapper
Serranidae	
Mycteroperca bonaci	Black grouper
Mycteroperca microlepis	Gag grouper
Mycteroperca phenax	Scamp
Drum	
Scaienops ocellatus	Red drum
Sparidae	
Archosargus probatocephalus	Sheepshead
Invertebrates	
Penaeus aztecus	Brown shrimp
Penaeus duorarum	Pink shrimp
Penaeus setiferus	White shrimp

Additionally, SJRWMD 2009 presented a list of species that were considered to be "…important for ecological, recreational, aesthetic, or commercial purposes…". Those species and associated descriptions from SJRWMD 2009 are listed below.

"The American oyster *(Crassostrea virginica)* is found throughout the Matanzas River, with large reefs extending south from Moses Creek Conservation Area to the Matanzas Inlet. In addition to their economic importance, oyster reefs also provide important habitat for many estuarine fish and invertebrate species. Recreational and commercial oyster harvesting occurs within delineated shellfish harvesting areas south of the State Road 206 bridge."

"White shrimp *(Penaeus setiferus)* and brown shrimp *(Penaeus aztecus)* are harvested commercially in northeast Florida and spend part of their life cycles in the Matanzas River estuary. Both species are important in estuarine and saltmarsh environments as they convert detritus, plant material, microorganisms, macroinvertebrates, and fish parts into useful protein for higher trophic level organisms."

"Blue crabs *(Callinectes sapidus)* are harvested recreationally and commercially in the Matanzas River estuary using crab traps or pots as the primary method of harvest. Blue crabs spend most of their life cycle within estuarine habitats, although the larval stages develop in the open ocean. Young crabs move within estuaries to mid and low salinity waters and grow quickly. Blue crabs reach maturity and the five-inch legal harvest size in one to two years. Blue crabs play an important role in the marine and estuarine trophic system, as prey and predators."

"Red drum *(Sciaenops ocellatus)* is a popular recreational game and food fish found in the Matanzas River estuary. These fish are also commonly found around oyster reefs and in the tidal channels of the saltmarsh. During cold spells, large numbers of red drum can be found in tidal creeks and rivers. They can live in freshwater and have been found well up Pellicer Creek and Moses Creek."

"Striped mullet *(Mugil cephalus)* occurs in both the estuary and open water of the Matanzas River. The fish is an ecologically important component in the flow of energy through estuarine communities."

"Mummichog *(Fundulus heteroc/itus)* or killifish are an abundant Atlantic Coast fish ranging from the Matanzas River to Newfoundland, Canada. They are particularly important in marsh food chains because of their distribution and abundance. Mummichogs are instrumental in the movement of organic material within and out of saltmarsh ecosystems (FNAI 1991). Mummichogs from the Matanzas River have been used extensively as a model organism for reproductive and other physiological studies by researchers at the University of Florida's Whitney Marine Laboratory in Marineland. There are at least three additional species of *Fundulus* in the basin."

Anecdotal information on the fisheries of the Summer Haven River and Matanzas Inlet was obtained from area residents who are in contact with the Summer Haven River on a consistent basis. Matt Valliere, USCG Licensed Captain, a local charter captain, has observed a significant decline in the abundance and diversity of fish species in Matanzas Inlet and the Summer Haven River since the ocean breach occurred in 2008. Specifically, Valliere has witnessed the decimation of flounder, redfish, snook, trout, mullet, sheepshead, black drum, grouper, tarpon, and shark which were once plentiful in the Summer Haven River and Matanzas Inlet. Prior to the breach, when the Summer Haven River was a flowing river, the river was inhabited by multitudes of bait fish. As a result, predator fish were abundant in Matanzas Inlet and Summer Haven River (Matt Valliere, pers. comm.). Fingerling mullet traveled through the SHR in schools of millions, especially during the fall months.

According to area residents, tarpon, snook, trout and bottlenose dolphin were observed on numerous occasions foraging on the fingerling mullet, which created quite a display of water splashing as the predatory fish feasted on the mullet schools within the narrow confines of the SHR river and in the private canal located in Barrataria Island (Stephen Steinmetz; Bill McKenna; Mark Dement; Jason Leverett; Jeff Berry; John Watson; Eric Pope, Roy Campbell pers. comm.). Moreover, blue crabs and stone crabs were once plentiful in the Summer Haven River (Stephen Steinmetz; Eric Pope, Peggy Saz; Terry Parker pers. comm.). Commercial fishing for flounder in the Summer Haven River has also ceased.

West Indian (Florida) Manatee

The West Indian (Florida) manatee (*Trichechus manatus latirostris*) is protected by the Florida Manatee Sanctuary Act and federally protected by the Marine Mammal Protection Act and Endangered Species Act (FFWCC 2012). Manatees inhabitat coastal waters, estuaries, and major rivers in Florida when water temperatures exceed 20°C (March/April through October/November) with some manatees migrating north to southeastern Georgia, as far north as Massachusetts, or west to Texas (FFWCC 2007). In the absence of seagrasses in the Matanzas River, it is presumed that manatees in the Matanzas River prefer to forage on *Spartina alterniflora* (cordgrass), which is in abundance along the shorelines of the Matanzas River (ATM 2005). As stated in ATM 2005, “The shoreline vegetation that is present along most of this stretch of the river may be browsed upon by manatees, and therefore the entire Matanzas River and Atlantic Intracoastal Waterway including various embayments and tributaries where water depths are adequate, are prime habitat for manatees.” Moreover, there have been numerous accounts from local residents, boaters, and fisherman that manatees frequent the Summer Haven River, often in groups of two or more. Manatee sitings are so frequent, in fact, that several residents commented that the river should be designated as a “no wake zone” to protect the manatees. Some residents even display a “manatee zone” sign on their docks.

Bottlenose Dolphin

Bottlenose dolphin were frequently observed in the Summer Haven River. As stated in SJRWMD 2009, “An active population of bottlenose dolphin *(Tursiops truncatus)* ranges throughout the Matanzas River, including the portion of the river proposed for OFW designation. These animals move in and out of both the Matanzas Inlet and the St. Augustine Inlet feeding on mullet, menhaden, and hardhead catfish. Several St. Augustine ecotourism businesses specialize in boating excursions directed specifically toward dolphin watching.” As mentioned previously, dolphin were routinely observed feeding on bait fish in the Summer Haven River.

Sea Turtles

The loggerhead *(Caretta caretta),* leatherback *(Dermochelys coriacea),* and green *(Chelonia mydas)* sea turtles are known to exist within the Matanzas River Basin (SJRWMD 2009; St. Johns County Sea Turtle Patrol 2012). Specifically, the area of beach that was breached in 2008 is used as a sea turtle nesting site. There were 51 loggerhead nests and 1 green turtle nest in 2010 and in 2011 there were 25 loggerhead nests and 7 rare leatherback nests on a 2 mile stretch of beach. The Sea Turtle Patrol of St. Johns County is in favor of restoring the beach dunes at the breach site and restoring water flow in the Summer Haven River (Libert 2012). As stated in Libert 2012, "Restoring the dune system provides nesting habitat for sea turtles; restoring the dune system forms a barrier between the Atlantic Ocean and A1A so that turtles do not inadvertently come close to the highway; creating and maintaining a continuous dune system in the breach area (R201-202) fortifies and prevents further erosion of the remaining dune system which supports turtle nesting; the Summer Haven River provided estuarine habitat and foraging grounds for sea turtles; and opening the Summer Haven River will increase the biodiversity of the area."

Birds

When the Summer Haven River was a free-flowing system, it provided prime wading and foraging habitat for many bird species. As a resident on the north end of the Summer Haven River since 2002, and as an environmental scientist by training, the author began maintaining a log book in 2003 of the bird species that were observed foraging in the river. The log book contained many entries including species, date, time and numbers of birds observed. Below is a bird species list compiled from those records; however, the list should not be considered an absolute list of bird species of the Summer Haven River. The species list below is merely an indication of species that were observed by one individual at random times from 2003 to 2007. According to anecdotal accounts, the diversity and abundance of bird species observed in the Summer Haven River have declined dramatically since the river stopped flowing from Matanzas Inlet at the north end to its confluence with the ICW at the south end of the river.

Bird species observed in the Summer Haven River from 2003 to 2007:

1. Cormorant
2. Purple Martin
3. Kingfisher
4. Reddish Egret
5. Great Egret
6. Snowy Egret

7. Great Blue Heron
8. Little Blue Heron
9. Green Heron
10. Black-Crowned Night Heron
11. Tri-Colored Heron
12. Hooded Merganser
13. Red-Breasted Merganser
14. Common Loon
15. Roseate Spoonbill
16. Least Tern
17. Royal Tern
18. Black Tern (following Hurricane Francis)
19. Sooty Tern (following Hurricane Francis and Tropical Storm Faye)
20. Gulls (various species)
21. Spotted Sandpiper
22. Wood Stork
23. White Ibis
24. Black Skimmer
25. Clapper Rail (heard)
26. Ruddy Turnstone
27. American Oystercatcher
28. Willet
29. Short-billed Dowitcher
30. Black-bellied Plover
31. Wilson’s Plover
32. Dunlin

33. Sanderling
34. Bald Eagle
35. Osprey
36. Brown Pelican
37. Magnificent Frigatebird (one occurrence)

Many of the bird species observed in the Summer Haven River were regarded as "important species" as indicated in SJRWMD 2009, which presented the following descriptions from USFWS 2008 and FFWCC 2008. Each species' current protective status was verified from FFWCC 2021.

"Brown pelicans *(Pelecanus occidentalis)* can be seen in the estuary as well as along the Atlantic shoreline. Pelicans are primarily fish-eaters, requiring up to four pounds of fish a day. Their diet consists mainly of small fish such as menhaden and silversides." They are no longer listed, but are part of the Imperiled Species Management Plan (FFWCC 2021).

"Little blue herons *(Egretta caerulea)* stand roughly 2 feet tall and appear dark bluish overall. They feed in the estuaries and saltwater and freshwater marshes throughout the petition area. Herons feed on small amphibians, small fish, crustaceans, and insects." Little blue herons are listed as State Threatened (FFWCC 2021).

"Tricolored herons *(Egretta tricolor)* prefer wetlands with low vegetation and shallow water, as deep as seven inches, suitable for wading up to their chests. They feed on small fish like top minnows, which together comprise almost 90 percent of the diet. They breed within the areas proposed for OFW designation." Tricolored herons are designated as State Threatened (FFWCC 2021).

"Snowy egrets *(Egretta thula)* are one of the most familiar herons, delicately built, with snowy white feathers, black legs, and bright yellow feet. The snowy egret's diet is composed primarily of fish and crustaceans but also includes snails, snakes, and aquatic and terrestrial insects." Snowy egrets are no longer listed but are part of the Imperiled Species Management Plan (FFWCC 2021).

"The reddish egret *(Egretta rufescens)* is the rarest and least well-known of the North American herons and is seen in the petition area rarely. Small fish make up the bulk of this wading bird's diet." The reddish egret is listed as State Threatened (FFWCC 2021).

"The American oystercatcher *(Haematopus palliatus)* is one of the largest and heaviest of American shorebirds, easily identified by dark-brown wings, a black head, and a bright red bill. Oystercatchers get their name from their habit of snatching oysters from slightly open shells. They also use their powerful bills to open mollusks and to sort through heavy shells in search of food. They breed within the areas proposed for OFW designation." The American oystercatcher is listed as State Threatened (FFWCC 2021).

"The least tern *(Stema antillarum),* listed by the state as threatened, is a migratory seabird that returns to the Matanzas River area during April and May from wintering grounds in Latin America. The least tern has long, pointed wings and a deeply forked tail and can be seen feeding throughout the tidal flats and marshes of the area. There is a large nesting colony in the dunes of the Fort Matanzas National Monument." The least tern continues to be listed as State Threatened (FFWCC 2021).

"Bald eagles *(Haliaeetus leucocephalus),* officially declared the National Emblem of the United States by the Second Continental Congress in 1782, are distinctive, large, dark brown birds with a white head and tail, and yellow eyes, bill, and feet. The principal food for bald eagles is fish, which the birds seize by using their strong talons to take their prey from the water. There are at least five bald eagle nests within the areas proposed for OFW designation, and several more close by." The bald eagle is no longer listed by the federal or state governments, but it is protected by the Migratory Bird Treaty Act, the Bald and Golden Eagle Protection Act, and the state's newly enacted bald eagle rule in Chapter 68A, F.A.C."

"The wood stork *(Mycteria americana)* is the largest wading bird native to America and can be found throughout the proposed OFW area. Storks are birds of freshwater and estuarine wetlands, nesting primarily in cypress or mangrove swamps. They feed in freshwater marshes, narrow tidal creeks, or flooded tidal pools generally within 16 miles of their colony. Particularly attractive feeding sites are depressions in marshes or swamps where fish become concentrated during periods of falling water levels. The Matanzas State Forest has a nesting colony of wood storks." The wood stork is federally designated threatened (FFWCC 2021).

"Roseate spoonbills *(Ajaja ajaja)* are easily identified by luminous pale pink plumage with red highlights and a long bill with a spoon shaped tip. As it sweeps the bill from side to side through shallow water, the spoonbill encounters, captures, and swallows small fish, shrimp, crayfish, fiddler crabs, and aquatic insects." Roseate spoonbills are state designated as threatened (FFWCC 2021).

"The American kestrel *(Falco sparverius)* is the smallest and most common of the falcons. Two subspecies of American kestrel occur in Florida: a northern subspecies *(Falco sparverius sparverius)* that winters here between September and April, and a resident, non-migratory subspecies, the southeastern American kestrel *(Falco sparverius paulus)."* The Southeastern American kestrel continues to be designated as State Threatened (FFWCC 2021).

"The piping plover *(Charadrius melodus)* is a small migratory shorebird that forages for food around the high tide line and along the water's edge throughout the proposed OFW area. They also use beaches as resting and foraging areas."   The piping plover is considered Federally Threatened (FFWCC 2021).

"The white ibis *(Eudocimus albus)* is a medium-sized wading bird with a long downward-curving bill. White ibis are found in awide variety of habitats, including freshwater and brackish marshes, salt flats and salt marsh meadows, many types of forested wetlands, wet prairies, swales, seasonally inundated fields, and man-made ditches. White ibis may be found throughout the proposed OFWs during all seasons." The white ibis was formerly listed as a State Species of Special Concern but is no longer listed. It is part of the Imperiled Species Management Plan (FFWCC 2021).

"The black skimmer *(Rynchops niger)* is a coastal waterbird with a red, blacktipped bill and red legs. It has a distinctive bill with the lower mandible much longer than the upper mandible. They skim food (mostly small fishes) from the surface of water while flying with their *lower* mandible in water. Skimmers inhabit coastal waters, including beaches, bays, estuaries, sandbars, and tidal creeks (foraging), and also inland waters of large lakes, phosphate pits, and flooded agricultural fields." The black skimmer is designated as State Threatened (FFWCC 2021).

Black-crowned night herons have been observed nesting in trees along the Summer Haven River and foraging at night in dock lights and along the banks of the river.

Conclusions

Similar to most estuarine tidal waterbodies, the Summer Haven River is a complex and dynamic coastal ecosystem consisting of open water, estuarine marsh, black mangrove and oyster habitat. The Summer Haven River, prior to the barrier beach dune devastation, exhibited invaluable ecosystem services including historical, cultural, recreational and commercial value for the citizens and visitors of St. Johns County. The SHR provided a contiguous prime estuarine habitat for many recreational and commercial fish species, foraging grounds for the previously endangered Florida manatee and bottlenose dolphin, as well as wading and foraging opportunities for a diverse and abundant population of bird species, including the federally threatened (formerly endangered) wood stork and other rare bird species. Likewise, sea turtles foraged in the river and used the adjacent beach area as nesting grounds. Most importantly, the Summer Haven River as a flowing river had a profound ecological significance and synergistic correlation to the Matanzas Inlet ecosystem and hydrodynamics.

Like all coastal St. Johns County areas, erosion has affected the beach at Summer Haven. It is undeniable that the ocean breach which initially occurred in 2008, followed by more severe and continuing damage to the dune system in 2016, 2017, and 2021, has had a deleterious effect on the ecology of the Summer Haven River, Matanzas Inlet, and presumably adjacent estuarine habitats. Loss of the barrier beach dune, subsequent infilling of sand in the river, and the absence of water flow from the SHR have inadvertently exacerbated shoaling and receding shoreline along the southside of Matanzas Inlet.   It is imperative that the unintended negative consequences and cumulative long-term negative impacts be thoroughly considered by resource managers. Complete restoration of the Summer Haven River and replacement of a more robust barrier beach dune is vital to re-establish ecosystem services the river once provided, including biological, historical, recreational, safety and commercial services for the citizens and visitors to St. Johns County.

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Appendix G

Summer Haven Beach Sand Gradation Tables and Curves

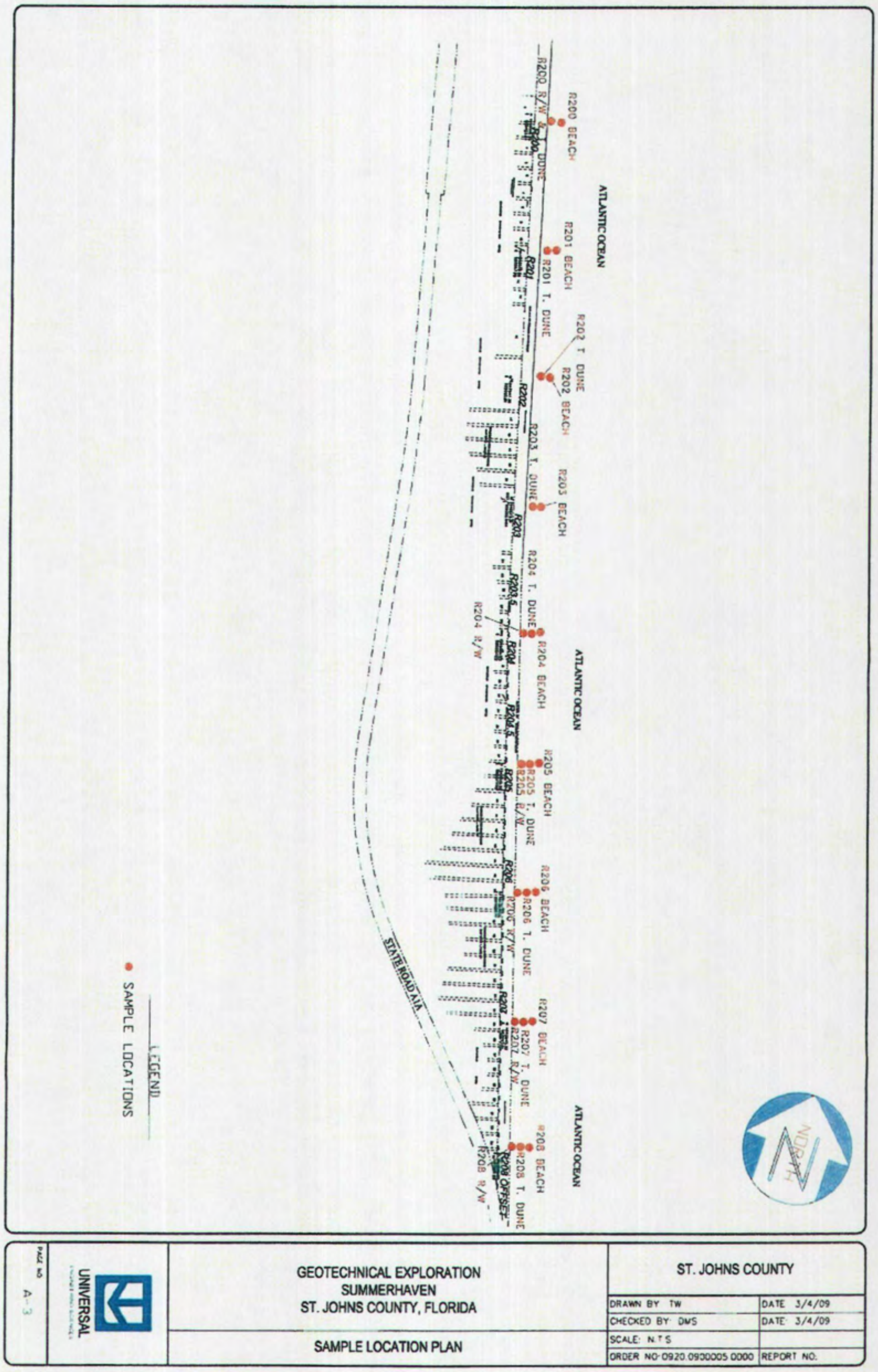


Figure 2.1 Summer Haven Beach Sampling Locations (Source: [UES, 2009])

APPENDIX A

Geotechnical Analysis Summary Tables

Table A.1 Summer Haven Beach Sediment Grain Size Data Table[1]

FDEP Monument	Location	Mean Grain Size		Median (d50)		St Dev (Sorting)		Moist Munsell Color	Silt Content	Carbonate Content
		(phi)	(mm)	(phi)	(mm)	(phi)	(mm)			
R-200	Beach	1.71	0.31	1.82	0.28	0.78	0.58	10YR 7/2	0.22%	*Not Tested*
	R/W & T Dune	0.61	0.66	0.53	0.69	1.35	0.39	10YR 7/3	0.81%	*Not Tested*
R-201	Beach	1.48	0.36	1.58	0.33	0.89	0.54	10YR 7/1	0.10%	*Not Tested*
	T Dune	1.82	0.28	1.99	0.25	0.79	0.58	10YR 7/2	0.03%	*Not Tested*
R-202	Beach	1.81	0.29	2.16	0.22	1.06	0.48	10YR 8/1	0.24%	*Not Tested*
	T Dune	1.97	0.26	1.87	0.27	0.60	0.66	10YR 8/1	0.10%	*Not Tested*
R-203	Beach	2.30	0.20	2.30	0.20	0.39	0.76	10YR 7/1	0.02%	*Not Tested*
	T Dune	2.47	0.18	2.56	0.17	0.48	0.72	10YR 7/2	0.10%	*Not Tested*
R-204	Beach	2.36	0.19	2.37	0.19	0.41	0.75	10YR 7/1	0.02%	*Not Tested*
	R/W	2.13	0.23	2.47	0.18	1.09	0.47	10YR 7/2	0.22%	*Not Tested*
	T Dune	1.65	0.32	2.17	0.22	1.38	0.38	10YR 7/3	0.90%	*Not Tested*
R-205	Beach	1.44	0.37	1.52	0.35	0.95	0.52	10YR 7/2	0.01%	*Not Tested*
	R/W	1.65	0.32	2.08	0.24	1.32	0.40	10YR 7/2	0.14%	*Not Tested*
	T Dune	1.63	0.32	2.52	0.17	1.86	0.28	10YR 7/1	0.17%	*Not Tested*
R-206	Beach	1.84	0.28	1.92	0.26	0.64	0.64	10YR 7/2	0.02%	*Not Tested*
	R/W	1.57	0.34	1.65	0.32	0.79	0.58	10YR 7/2	0.02%	*Not Tested*
	T Dune	1.19	0.44	1.41	0.38	1.47	0.36	10YR 5/3	0.80%	*Not Tested*
R-207	Beach	1.86	0.28	1.93	0.26	0.61	0.66	10YR 7/2	0.02%	*Not Tested*
	R/W	1.70	0.31	1.90	0.27	0.99	0.50	10YR 7/2	0.05%	*Not Tested*
	T Dune	1.95	0.26	2.14	0.23	0.90	0.54	10YR 8/2	0.11%	*Not Tested*
R-208	Beach	1.19	0.44	1.20	0.44	0.83	0.56	10YR 7/2	0.01%	*Not Tested*
	R/W	1.22	0.43	1.21	0.43	0.79	0.58	10YR 7/2	0.02%	*Not Tested*
	T Dune	2.15	0.23	2.27	0.21	0.66	0.63	10YR 8/1	0.04%	*Not Tested*
Minimum		2.47	0.18	2.56	0.17	1.86	0.28	-	0.01%	-
Maximum		0.61	0.66	0.53	0.69	0.39	0.76	-	0.90%	-
Average		1.73	0.30	1.89	0.27	0.91	0.53	-	0.18%	-

[1]Samples tested by Universal Engineering Services

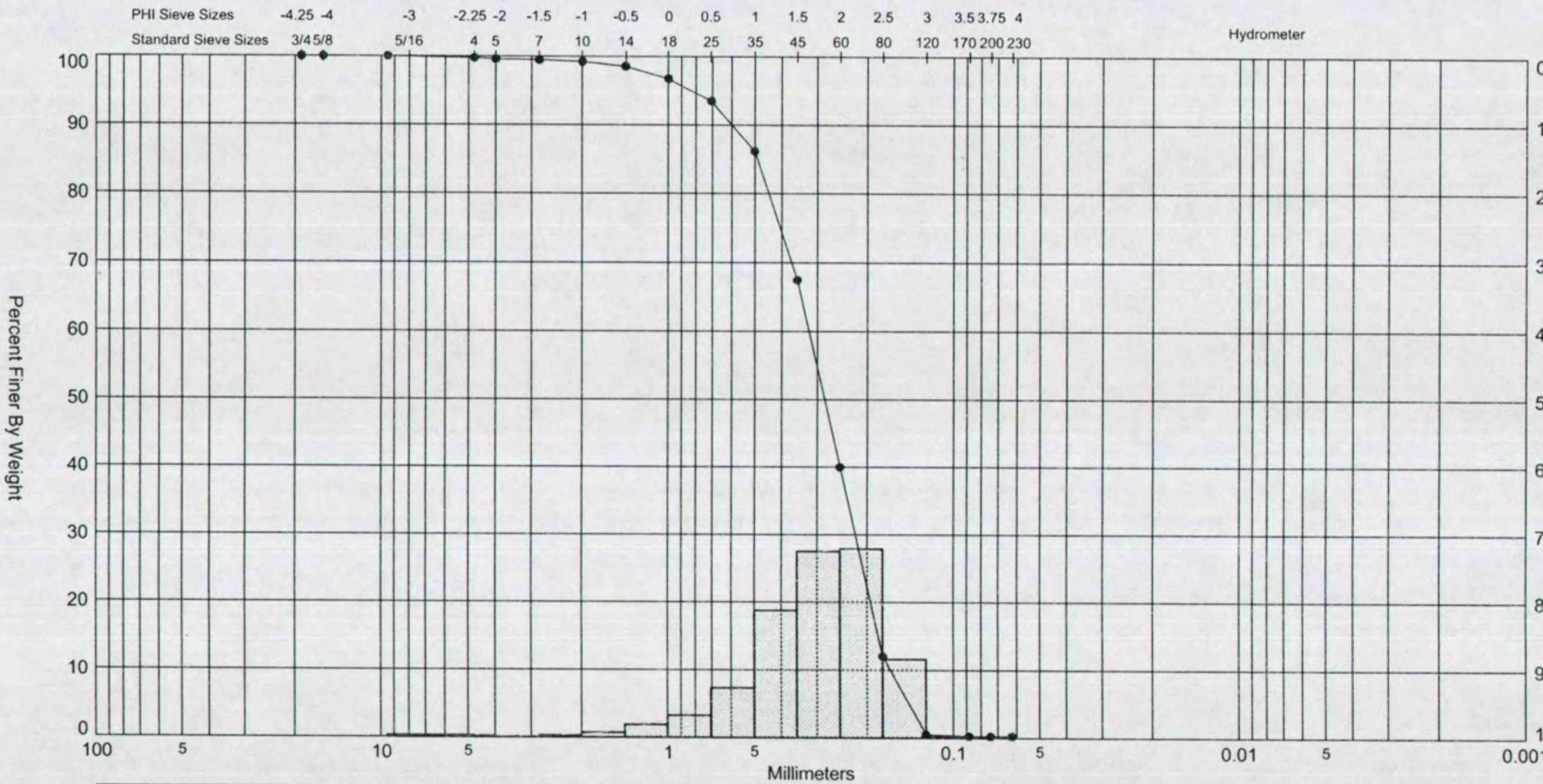
Table A.2 Summer Haven Beach Sediment Pre- and Post-Carbonate Removal Analysis[1]

FDEP Monument	Location	Mean Grain Size (phi)	Mean Grain Size (mm)	Median (d50) (phi)	Median (d50) (mm)	St Dev (Sorting) (phi)	St Dev (Sorting) (mm)	Silt Content	Carbonate Content
R-205	**Pre-Calcium Carbonate Removal**								
	Dune Toe	1.98	0.25	2.11	0.23	0.71	0.61	0.00%	11.1%
	Dune Veg	1.96	0.26	2.15	0.23	0.81	0.57	0.05%	12.9%
	Intertidal Zone	1.38	0.38	1.74	0.30	1.05	0.48	0.01%	24.7%
	Mid Berm	1.56	0.34	1.70	0.31	0.82	0.57	0.19%	22.6%
	Wading Depth	1.11	0.46	1.50	0.35	1.10	0.47	0.02%	29.8%
	Minimum	1.98	0.25	2.15	0.23	1.10	0.47	0.00%	11.1%
	Maximum	1.11	0.46	1.50	0.35	0.71	0.61	0.19%	29.8%
	Average	1.60	0.34	1.84	0.28	0.90	0.54	0.05%	20.2%
	Post-Calcium Carbonate Removal								
	Dune Toe	2.19	0.22	2.25	0.21	0.55	0.68	0.17%	0.00%
	Dune Veg	2.20	0.22	2.26	0.21	0.54	0.69	0.09%	0.00%
	Intertidal Zone	1.99	0.25	2.04	0.24	0.54	0.69	0.08%	0.00%
	Mid Berm	2.21	0.22	2.27	0.21	0.51	0.70	0.14%	0.00%
	Wading Depth	2.18	0.22	2.27	0.21	0.58	0.67	0.11%	0.00%
	Minimum	2.21	0.22	2.27	0.21	0.58	0.67	0.08%	0.00%
	Maximum	1.99	0.25	2.04	0.24	0.51	0.70	0.17%	0.00%
	Average	2.15	0.22	2.22	0.21	0.54	0.69	0.12%	0.00%

[1]Samples tested by Ellis & Associates

APPENDIX B

Summer Haven Grain Size Tables and Curves (UES Data)



Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-200 Beach	—●—	0.0	SP	#200 - 0.22 #230 - 0.22			1.82	1.71	-1.37	6.84	0.78

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	585,424
Northing (Y, ft):	1,949,506
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

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fax (904) 731-9847

Project Name: Summer Haven Beach Sand

Sample Name: R-200 Beach

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
585,424	1,949,506	Florida State Plane East	0.0 NAVD 88

USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/2	

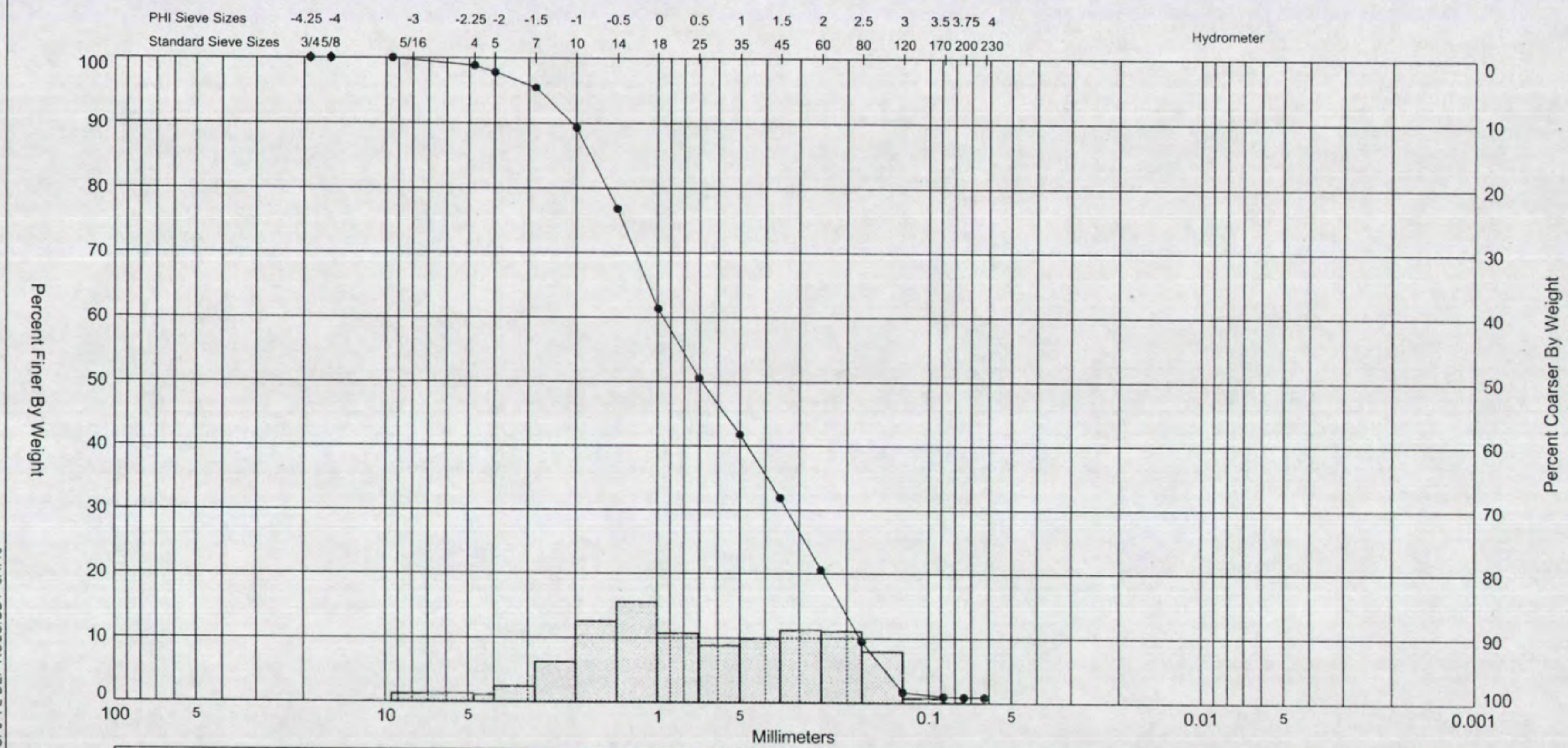
Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
328.18	327.60	0.00	0.04	#200 - 0.22 #230 - 0.22			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.75	0.23	0.75	0.23
5	-2.00	4.00	0.49	0.15	1.24	0.38
7	-1.50	2.83	0.36	0.11	1.60	0.49
10	-1.00	2.00	0.84	0.26	2.44	0.74
14	-0.50	1.41	2.19	0.67	4.63	1.41
18	0.00	1.00	5.93	1.81	10.56	3.22
25	0.50	0.71	10.74	3.27	21.30	6.49
35	1.00	0.50	24.01	7.32	45.31	13.81
45	1.50	0.35	61.48	18.73	106.79	32.54
60	2.00	0.25	90.17	27.48	196.96	60.02
80	2.50	0.18	91.69	27.94	288.65	87.95
120	3.00	0.13	37.96	11.57	326.61	99.52
170	3.50	0.09	0.83	0.25	327.44	99.77
200	3.75	0.07	0.02	0.01	327.46	99.78
230	4.00	0.06	0.00	0.00	327.46	99.78

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.80	2.43	2.27	1.82	1.30	1.06	0.27

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.71	0.31	0.78	-1.37	6.84

GRANULARMETRIC REPORT SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/2/10



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-200 R/W & T Dune	—●—	0.0	SW	#200 - 0.83 #230 - 0.81			0.53	0.61	-0.06	2.14	1.35

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	585,424
Northing (Y, ft):	1,949,506
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

Project Name: Summer Haven Beach Sand

Sample Name: R-200 R/W & T Dune

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

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Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
585,424	1,949,506	Florida State Plane East	0.0 NAVD 88

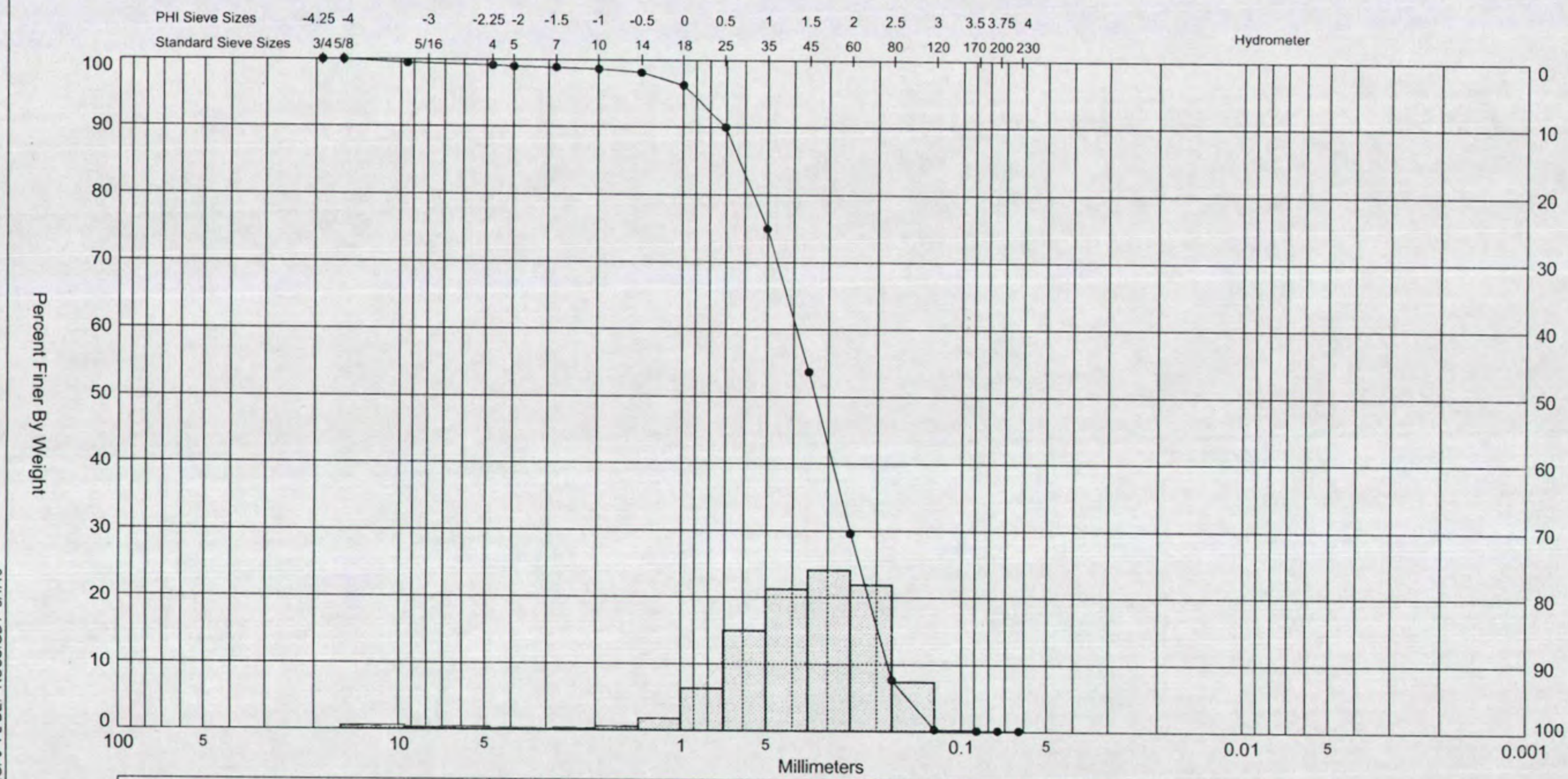
USCS:	Munsell:	Comments:
SW	Wet - 10YR-7/3	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
332.73	330.02	0.00	0.00	#200 - 0.83 #230 - 0.81			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	3.88	1.17	3.88	1.17
5	-2.00	4.00	3.41	1.02	7.29	2.19
7	-1.50	2.83	7.73	2.32	15.02	4.51
10	-1.00	2.00	20.50	6.16	35.52	10.68
14	-0.50	1.41	41.60	12.50	77.12	23.18
18	0.00	1.00	51.50	15.48	128.62	38.66
25	0.50	0.71	35.81	10.76	164.43	49.42
35	1.00	0.50	29.37	8.83	193.80	58.25
45	1.50	0.35	33.03	9.93	226.83	68.17
60	2.00	0.25	37.36	11.23	264.19	79.40
80	2.50	0.18	36.84	11.07	301.03	90.47
120	3.00	0.13	26.30	7.90	327.33	98.38
170	3.50	0.09	2.24	0.67	329.57	99.05
200	3.75	0.07	0.39	0.12	329.96	99.17
230	4.00	0.06	0.06	0.02	330.02	99.19

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.79	2.21	1.80	0.53	-0.44	-0.79	-1.46

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	0.61	0.66	1.35	-0.06	2.14



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-201 Beach	—●—	0.0	SW	#200 - 0.10 #230 - 0.10			1.58	1.48	-1.67	9.59	0.89

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	585,699
Northing (Y, ft):	1,948,519
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

Project Name: Summer Haven Beach Sand	TAYLOR ENGINEERING, INC.
Sample Name: R-201 Beach	Taylor Engineering, Inc. 10151 Deerwood Park Blvd., Bldg. 300, Suite 300 Jacksonville, FL 32256 ph (904) 731-7040 fax (904) 731-9847
Analysis Date: 12-31-08	
Analyzed By: Universal Engineering Sciences	

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
585,699	1,948,519	Florida State Plane East	0.0 NAVD 88

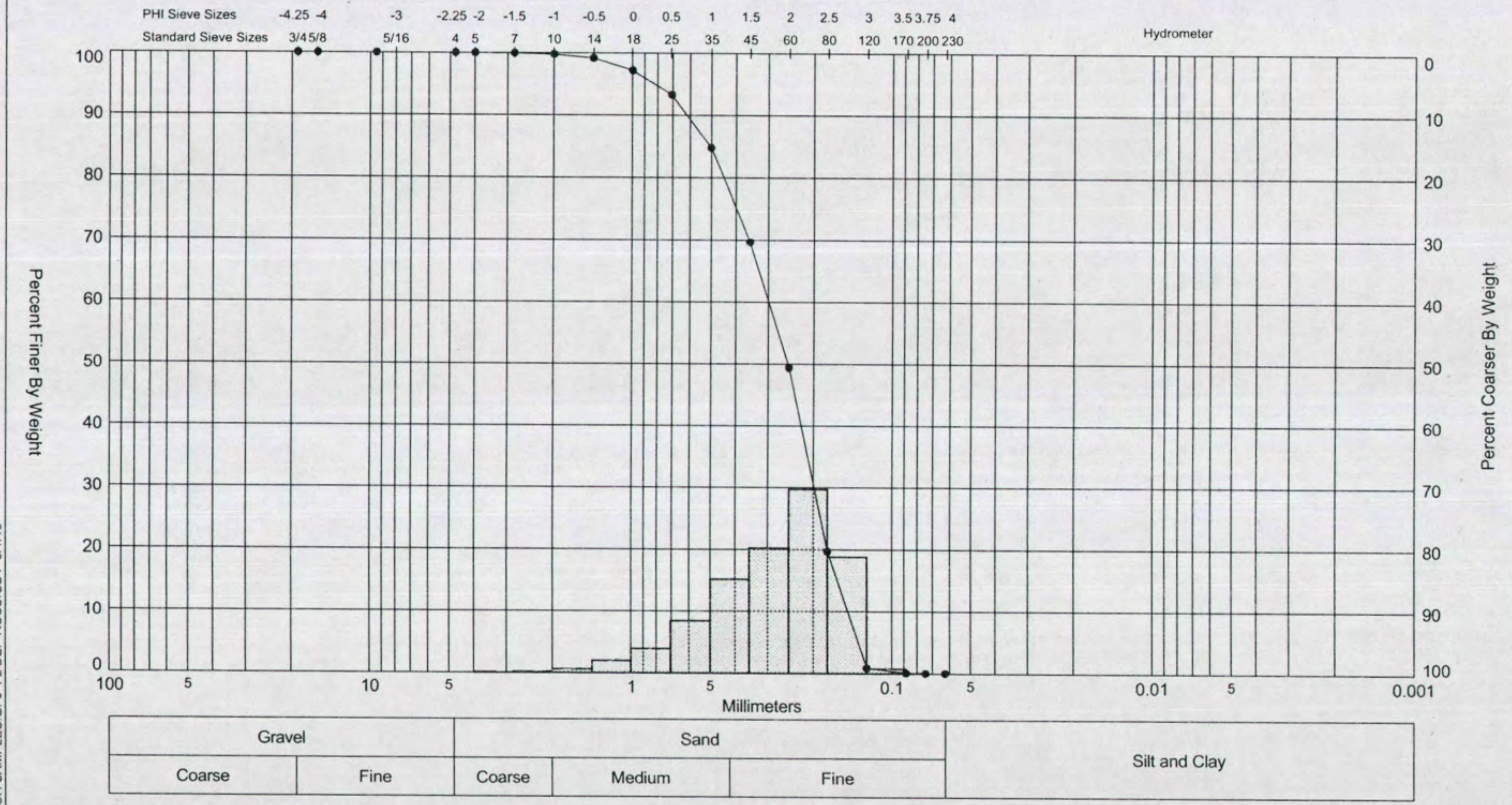
USCS:	Munsell:	Comments:
SW	Wet - 10YR-7/1	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
329.52	329.23	0.00	0.01	#200 - 0.10 #230 - 0.10			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	1.77	0.54	1.77	0.54
4	-2.25	4.76	1.02	0.31	2.79	0.85
5	-2.00	4.00	0.50	0.15	3.29	1.00
7	-1.50	2.83	0.45	0.14	3.74	1.13
10	-1.00	2.00	0.72	0.22	4.46	1.35
14	-0.50	1.41	1.70	0.52	6.16	1.87
18	0.00	1.00	5.91	1.79	12.07	3.66
25	0.50	0.71	20.82	6.32	32.89	9.98
35	1.00	0.50	49.52	15.03	82.41	25.01
45	1.50	0.35	70.12	21.28	152.53	46.29
60	2.00	0.25	79.31	24.07	231.84	70.36
80	2.50	0.18	72.30	21.94	304.14	92.30
120	3.00	0.13	24.49	7.43	328.63	99.73
170	3.50	0.09	0.53	0.16	329.16	99.89
200	3.75	0.07	0.03	0.01	329.19	99.90
230	4.00	0.06	0.00	0.00	329.19	99.90

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.68	2.31	2.11	1.58	1.00	0.70	0.11

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.48	0.36	0.89	-1.67	9.59



Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-201 T Dune	—●—	0.0	SP	#200 - 0.03 #230 - 0.03			1.99	1.82	-0.87	3.59	0.79

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	585,699
Northing (Y, ft):	1,948,519
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

TAYLOR ENGINEERING, INC.

Taylor Engineering, Inc.
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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand

Sample Name: R-201 T Dune

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
585,699	1,948,519	Florida State Plane East	0.0 NAVD 88

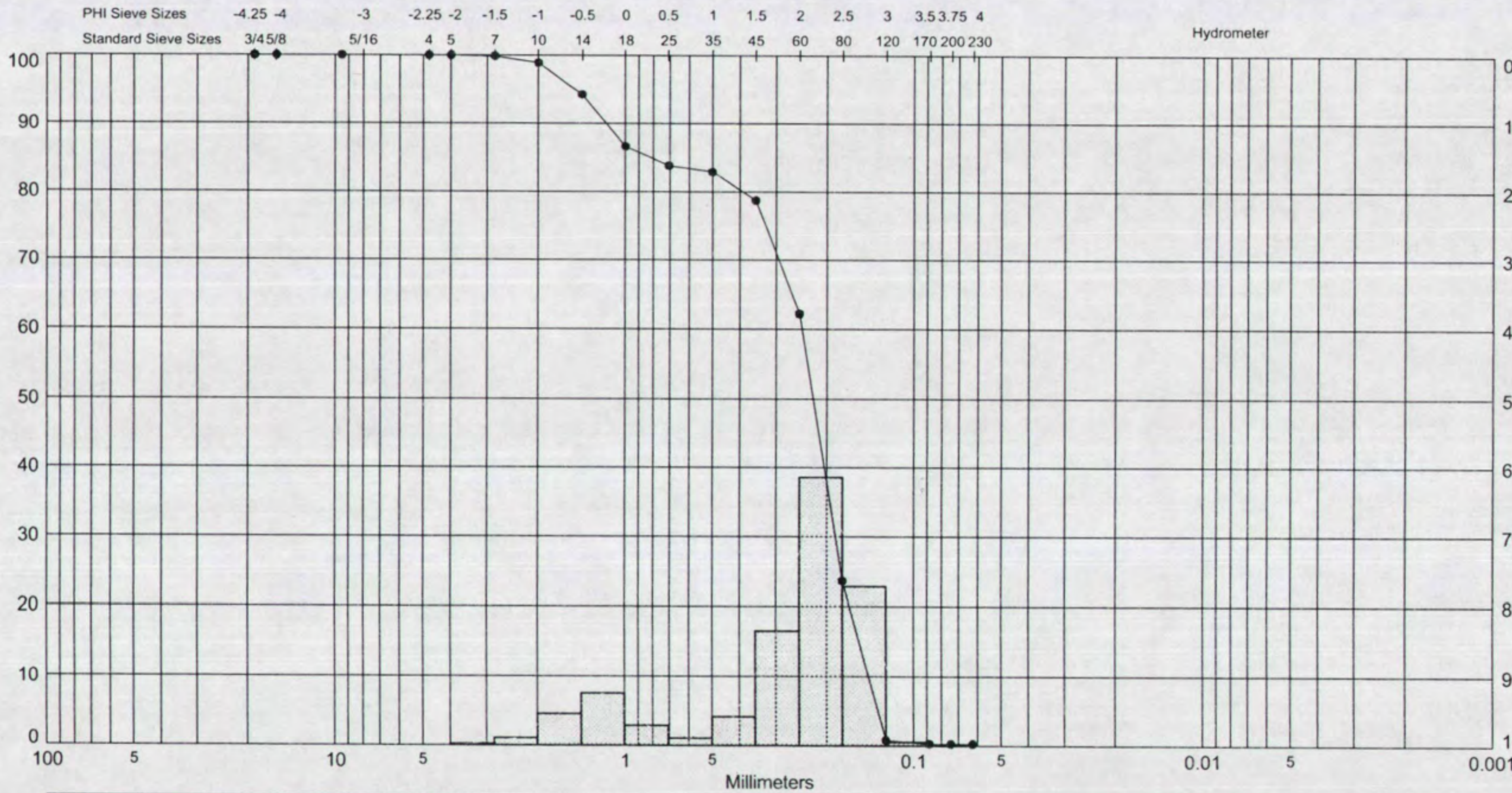
USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
344.97	344.86	0.00	0.00	#200 - 0.03 #230 - 0.03			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.00	0.00	0.00	0.00
5	-2.00	4.00	0.00	0.00	0.00	0.00
7	-1.50	2.83	0.17	0.05	0.17	0.05
10	-1.00	2.00	0.57	0.17	0.74	0.21
14	-0.50	1.41	2.12	0.61	2.86	0.83
18	0.00	1.00	6.69	1.94	9.55	2.77
25	0.50	0.71	13.61	3.95	23.16	6.71
35	1.00	0.50	29.11	8.44	52.27	15.15
45	1.50	0.35	52.26	15.15	104.53	30.30
60	2.00	0.25	69.94	20.27	174.47	50.58
80	2.50	0.18	102.40	29.68	276.87	80.26
120	3.00	0.13	65.08	18.87	341.95	99.12
170	3.50	0.09	2.70	0.78	344.65	99.91
200	3.75	0.07	0.20	0.06	344.85	99.97
230	4.00	0.06	0.01	0.00	344.86	99.97

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.89	2.60	2.41	1.99	1.33	1.03	0.28

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.82	0.28	0.79	-0.87	3.59



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-202 Beach	—●—	0.0	SW	#200 - 0.26 #230 - 0.24			2.16	1.81	-1.4	3.85	1.06

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	585,951
Northing (Y, ft):	1,947,547
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

TAYLOR ENGINEERING, INC.

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand
Sample Name: R-202 Beach
Analysis Date: 12-31-08
Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
585,951	1,947,547	Florida State Plane East	0.0 NAVD 88

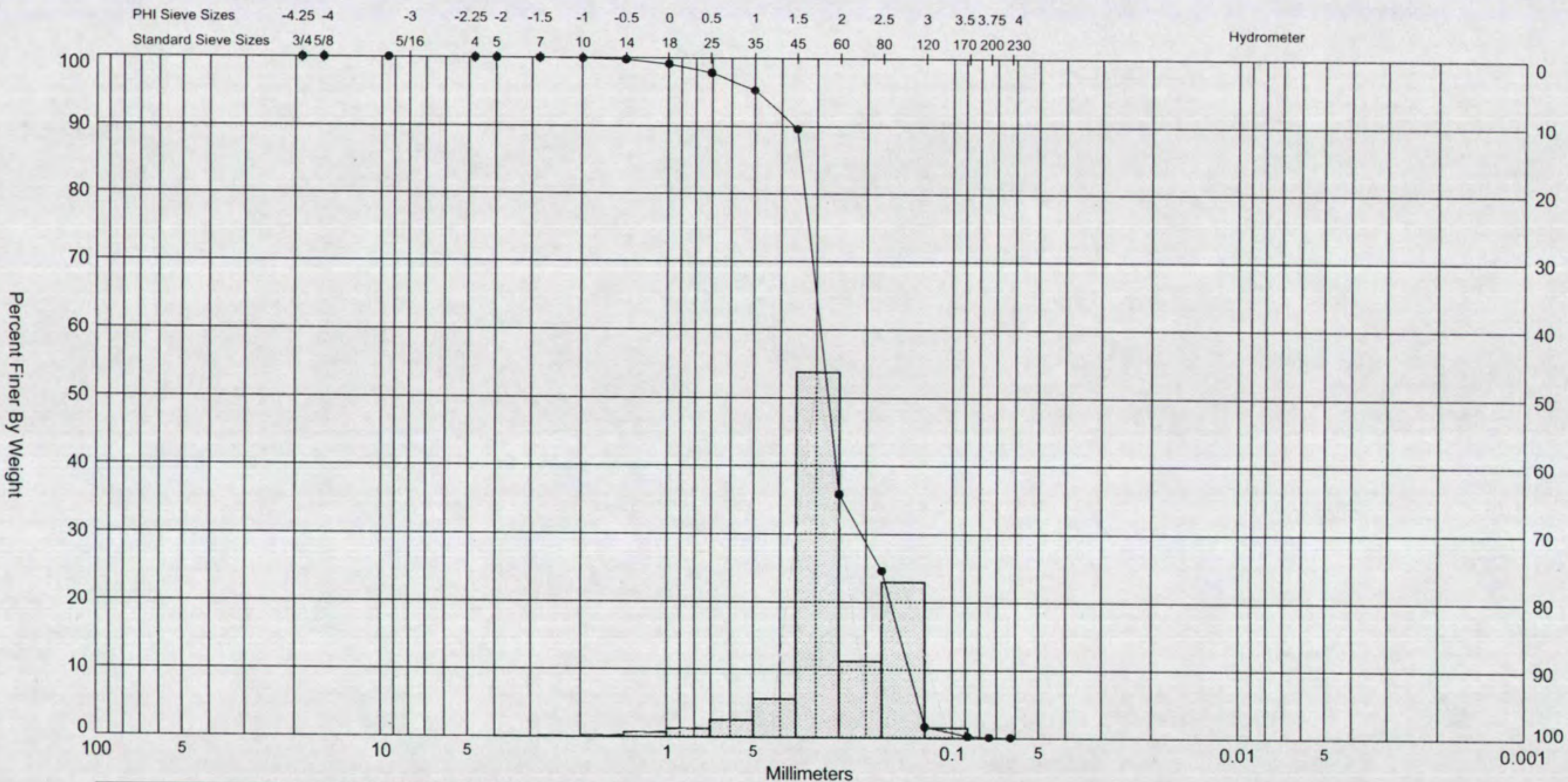
USCS:	Munsell:	Comments:
SW	Wet - 10YR-8/1	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
337.73	336.95	0.04	0.00	#200 - 0.26 #230 - 0.24			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.00	0.00	0.00	0.00
5	-2.00	4.00	0.00	0.00	0.00	0.00
7	-1.50	2.83	0.45	0.13	0.45	0.13
10	-1.00	2.00	3.32	0.98	3.77	1.12
14	-0.50	1.41	15.57	4.61	19.34	5.73
18	0.00	1.00	25.65	7.59	44.99	13.32
25	0.50	0.71	9.60	2.84	54.59	16.16
35	1.00	0.50	3.22	0.95	57.81	17.12
45	1.50	0.35	13.99	4.14	71.80	21.26
60	2.00	0.25	55.80	16.52	127.60	37.78
80	2.50	0.18	130.26	38.57	257.86	76.35
120	3.00	0.13	77.20	22.86	335.06	99.21
170	3.50	0.09	1.75	0.52	336.81	99.73
200	3.75	0.07	0.04	0.01	336.85	99.74
230	4.00	0.06	0.06	0.02	336.91	99.76

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.91	2.67	2.48	2.16	1.61	0.47	-0.58

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.81	0.29	1.06	-1.4	3.85



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-202 T Dune	—●—	0.0	SP	#200 - 0.12 #230 - 0.10			1.87	1.97	-0.56	5.11	0.6

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	585,951
Northing (Y, ft):	1,947,547
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand

Sample Name: R-202 T Dune

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
585,951	1,947,547	Florida State Plane East	0.0 NAVD 88

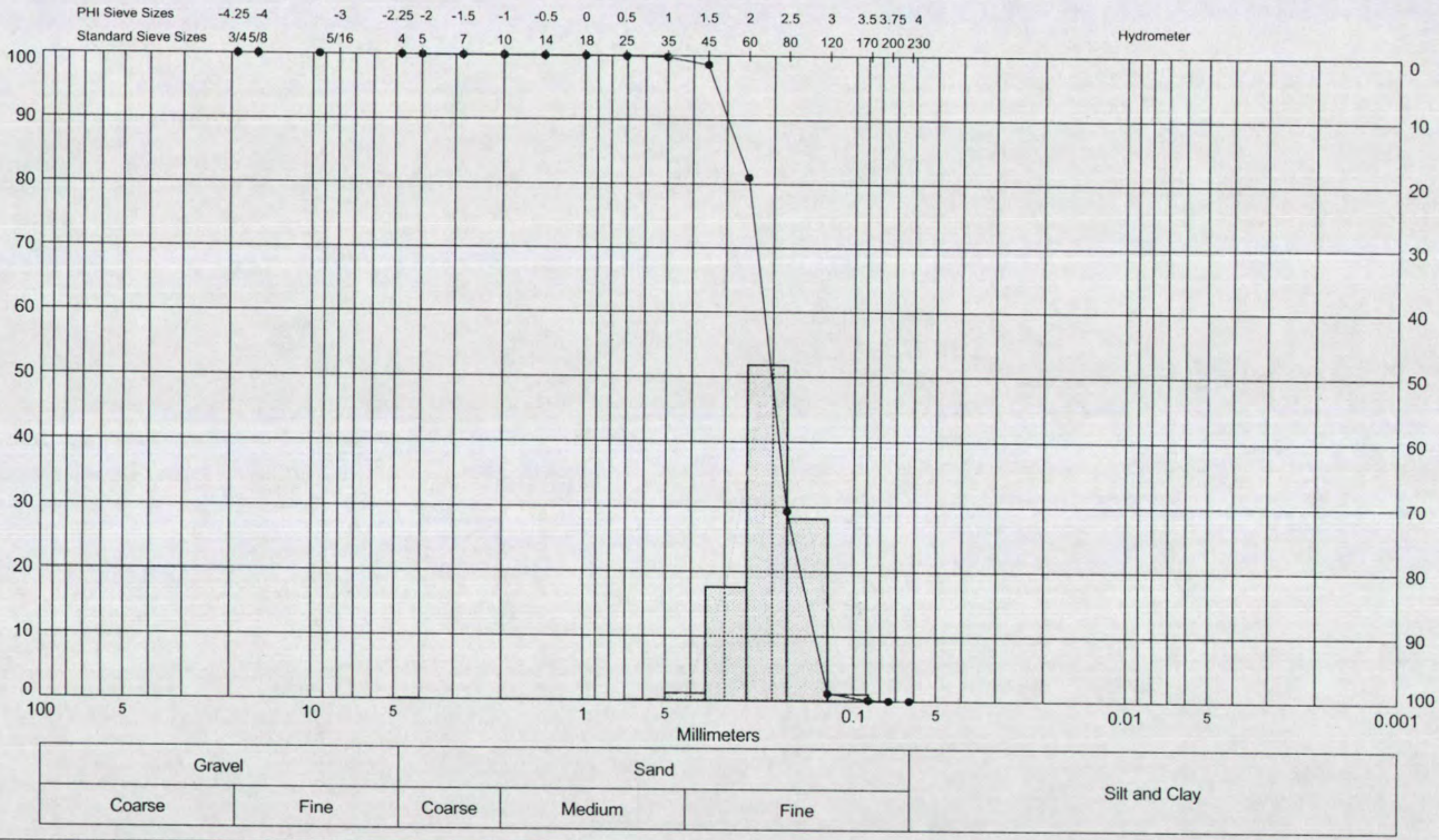
USCS:	Munsell:	Comments:
SP	Wet - 10YR-8/1	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
331.08	330.77	0.03	0.00	#200 - 0.12 #230 - 0.10			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.00	0.00	0.00	0.00
5	-2.00	4.00	0.00	0.00	0.00	0.00
7	-1.50	2.83	0.05	0.02	0.05	0.02
10	-1.00	2.00	0.19	0.06	0.24	0.07
14	-0.50	1.41	0.56	0.17	0.80	0.24
18	0.00	1.00	2.14	0.65	2.94	0.89
25	0.50	0.71	4.25	1.28	7.19	2.17
35	1.00	0.50	8.29	2.50	15.48	4.68
45	1.50	0.35	18.81	5.68	34.29	10.36
60	2.00	0.25	178.02	53.77	212.31	64.13
80	2.50	0.18	37.38	11.29	249.69	75.42
120	3.00	0.13	75.86	22.91	325.55	98.33
170	3.50	0.09	4.83	1.46	330.38	99.79
200	3.75	0.07	0.29	0.09	330.67	99.88
230	4.00	0.06	0.07	0.02	330.74	99.90

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.93	2.69	2.48	1.87	1.64	1.55	1.03

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.97	0.26	0.6	-0.56	5.11



SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-203 Beach	—●—	0.0	SP	#200 - 0.02 #230 - 0.02			2.3	2.3	-1.06	11.99	0.39

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	586,284
Northing (Y, ft):	1,946,573
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand

Sample Name: R-203 Beach

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
586,284	1,946,573	Florida State Plane East	0.0 NAVD 88

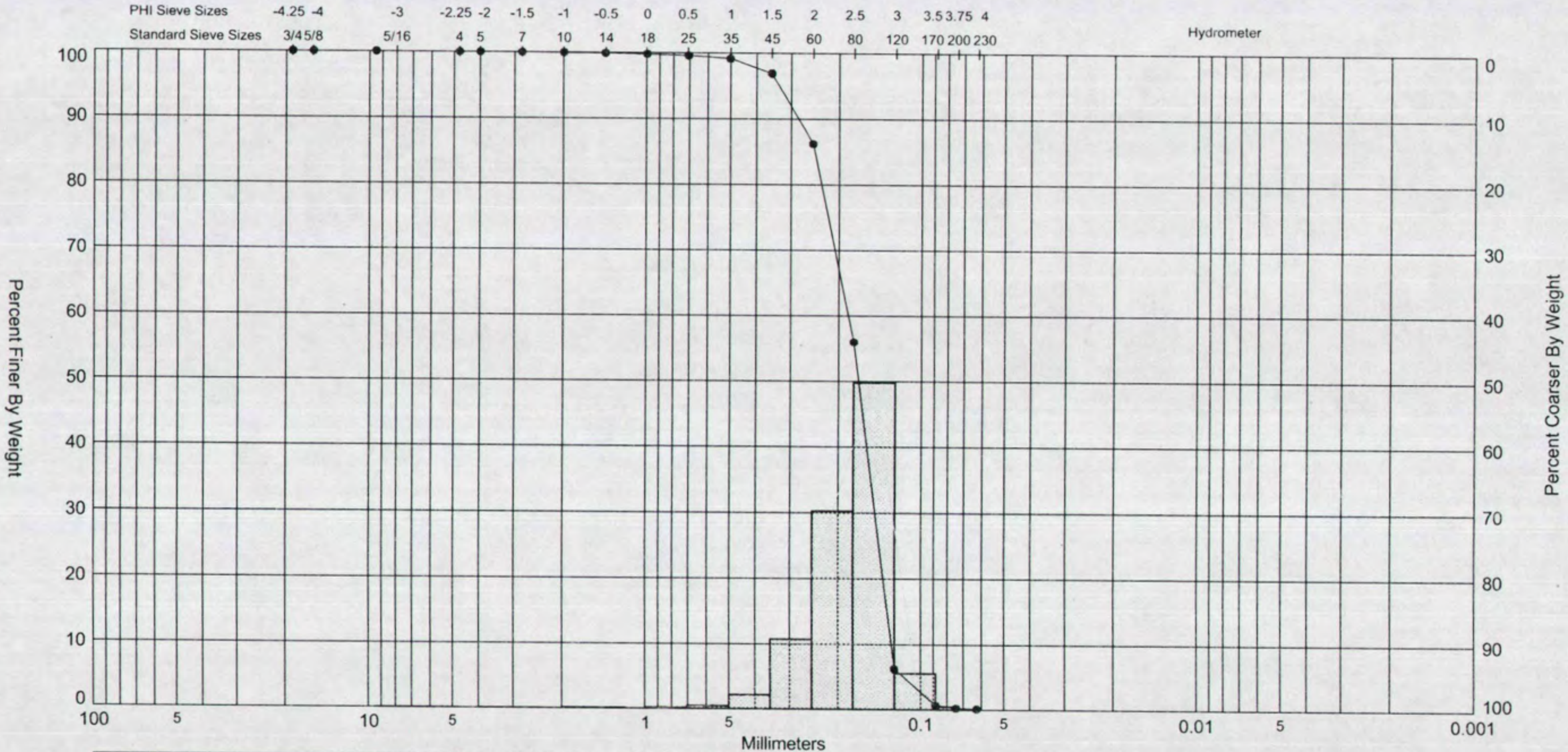
USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/1	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
328.96	328.91	0.00	0.01	#200 - 0.02 #230 - 0.02			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.00	0.00	0.00	0.00
5	-2.00	4.00	0.16	0.05	0.16	0.05
7	-1.50	2.83	0.00	0.00	0.16	0.05
10	-1.00	2.00	0.02	0.01	0.18	0.05
14	-0.50	1.41	0.01	0.00	0.19	0.06
18	0.00	1.00	0.10	0.03	0.29	0.09
25	0.50	0.71	0.12	0.04	0.41	0.12
35	1.00	0.50	0.32	0.10	0.73	0.22
45	1.50	0.35	3.86	1.17	4.59	1.40
60	2.00	0.25	57.83	17.58	62.42	18.97
80	2.50	0.18	170.20	51.74	232.62	70.71
120	3.00	0.13	92.56	28.14	325.18	98.85
170	3.50	0.09	3.45	1.05	328.63	99.90
200	3.75	0.07	0.26	0.08	328.89	99.98
230	4.00	0.06	0.00	0.00	328.89	99.98

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.93	2.74	2.58	2.30	2.06	1.92	1.60

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	2.3	0.20	0.39	-1.06	11.99



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-203 T Dune	—●—	0.0	SP	#200 - 0.21 #230 - 0.10			2.56	2.47	-1.53	10.46	0.48

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	586,284
Northing (Y, ft):	1,946,573
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

TAYLOR ENGINEERING, INC.

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Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand

Sample Name: R-203 T Dune

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
586,284	1,946,573	Florida State Plane East	0.0 NAVD 88

USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/2	

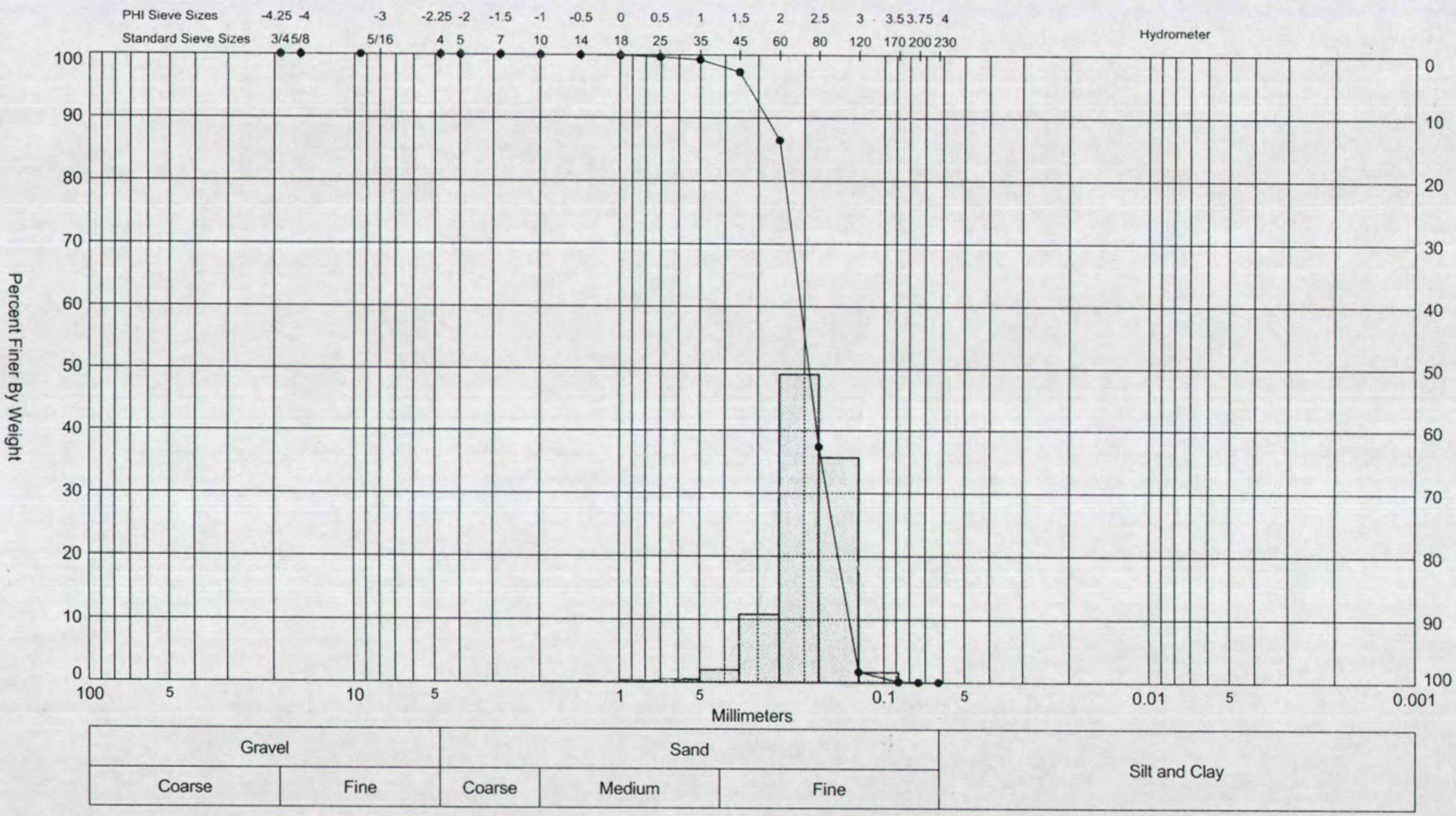
Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
324.71	324.39	0.00	0.01	#200 - 0.21 #230 - 0.10			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.08	0.02	0.08	0.02
5	-2.00	4.00	0.00	0.00	0.08	0.02
7	-1.50	2.83	0.02	0.01	0.10	0.03
10	-1.00	2.00	0.06	0.02	0.16	0.05
14	-0.50	1.41	0.19	0.06	0.35	0.11
18	0.00	1.00	0.33	0.10	0.68	0.21
25	0.50	0.71	0.65	0.20	1.33	0.41
35	1.00	0.50	1.46	0.45	2.79	0.86
45	1.50	0.35	7.12	2.19	9.91	3.05
60	2.00	0.25	34.84	10.73	44.75	13.78
80	2.50	0.18	98.26	30.26	143.01	44.04
120	3.00	0.13	161.48	49.73	304.49	93.77
170	3.50	0.09	18.15	5.59	322.64	99.36
200	3.75	0.07	1.40	0.43	324.04	99.79
230	4.00	0.06	0.33	0.10	324.37	99.90

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
3.11	2.90	2.81	2.56	2.19	2.04	1.59

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	2.47	0.18	0.48	-1.53	10.46

SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10



Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-204 Beach	—●—	0.0	SP	#200 - 0.03 #230 - 0.02			2.37	2.36	-1.2	7.79	0.41

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	586,557
Northing (Y, ft):	1,945,584
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

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fax (904) 731-9847

Project Name: Summer Haven Beach Sand

Sample Name: R-204 Beach

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
586,557	1,945,584	Florida State Plane East	0.0 NAVD 88

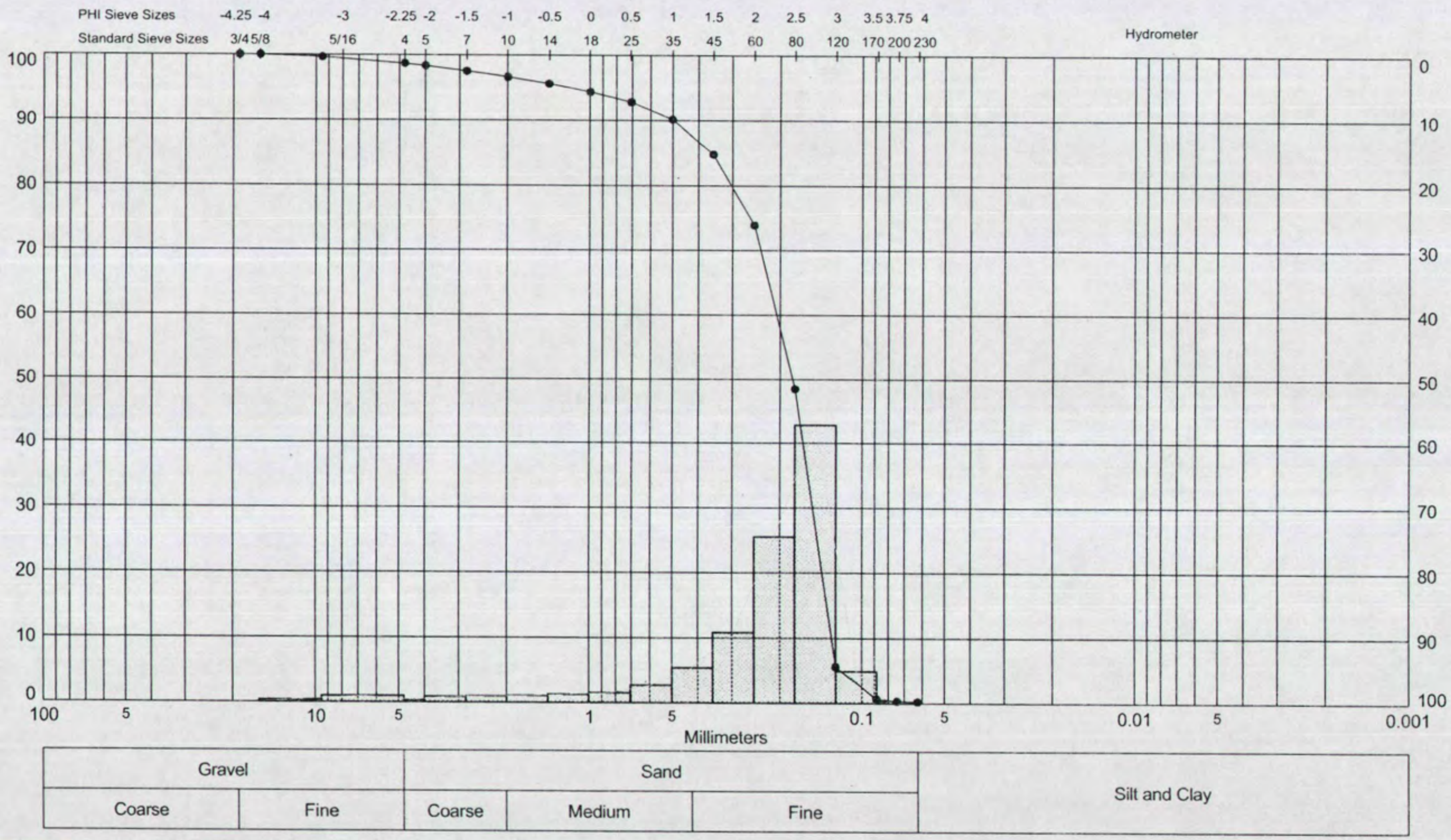
USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/1	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
330.74	330.67	0.00	0.00	#200 - 0.03 #230 - 0.02			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.00	0.00	0.00	0.00
5	-2.00	4.00	0.00	0.00	0.00	0.00
7	-1.50	2.83	0.00	0.00	0.00	0.00
10	-1.00	2.00	0.06	0.02	0.06	0.02
14	-0.50	1.41	0.07	0.02	0.13	0.04
18	0.00	1.00	0.25	0.08	0.38	0.11
25	0.50	0.71	0.68	0.21	1.06	0.32
35	1.00	0.50	1.48	0.45	2.54	0.77
45	1.50	0.35	6.31	1.91	8.85	2.68
60	2.00	0.25	35.81	10.83	44.66	13.50
80	2.50	0.18	162.46	49.12	207.12	62.62
120	3.00	0.13	118.07	35.70	325.19	98.32
170	3.50	0.09	5.24	1.58	330.43	99.91
200	3.75	0.07	0.22	0.07	330.65	99.97
230	4.00	0.06	0.02	0.01	330.67	99.98

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.95	2.80	2.67	2.37	2.12	2.03	1.61

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	2.36	0.19	0.41	-1.2	7.79



Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-204 R/W	—●—	0.0	SW	#200 - 0.34 #230 - 0.22			2.47	2.13	-2.55	10.59	1.09

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	586,557
Northing (Y, ft):	1,945,584
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand
Sample Name: R-204 R/W
Analysis Date: 12-31-08
Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
586,557	1,945,584	Florida State Plane East	0.0 NAVD 88

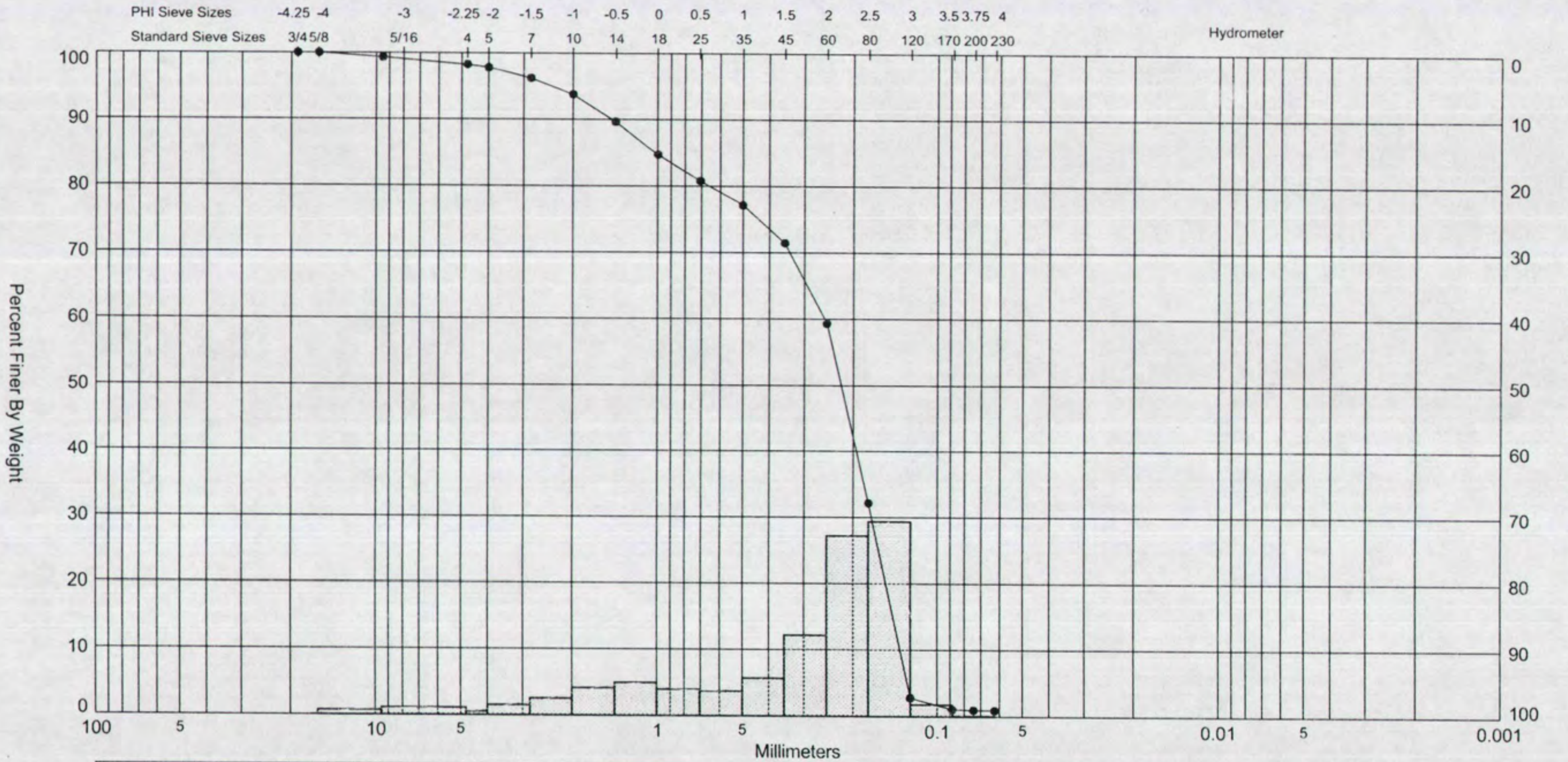
USCS:	Munsell:	Comments:
SW	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
327.34	326.71	0.09	0.00	#200 - 0.34 #230 - 0.22			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	1.15	0.35	1.15	0.35
4	-2.25	4.76	3.11	0.95	4.26	1.30
5	-2.00	4.00	1.21	0.37	5.47	1.67
7	-1.50	2.83	2.64	0.81	8.11	2.48
10	-1.00	2.00	2.89	0.88	11.00	3.36
14	-0.50	1.41	3.27	1.00	14.27	4.36
18	0.00	1.00	4.14	1.26	18.41	5.62
25	0.50	0.71	5.03	1.54	23.44	7.16
35	1.00	0.50	8.72	2.66	32.16	9.82
45	1.50	0.35	17.70	5.41	49.86	15.23
60	2.00	0.25	35.42	10.82	85.28	26.05
80	2.50	0.18	83.36	25.47	168.64	51.52
120	3.00	0.13	140.32	42.87	308.96	94.39
170	3.50	0.09	16.13	4.93	325.09	99.31
200	3.75	0.07	1.14	0.35	326.23	99.66
230	4.00	0.06	0.38	0.12	326.61	99.78

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
3.06	2.88	2.77	2.47	1.95	1.54	-0.25

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	2.13	0.23	1.09	-2.55	10.59



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-204 T Dune	—●—	0.0	SW	#200 - 0.95 #230 - 0.90			2.17	1.65	-1.49	4.68	1.38

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	586,557
Northing (Y, ft):	1,945,584
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand
Sample Name: R-204 T Dune
Analysis Date: 12-31-08
Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
586,557	1,945,584	Florida State Plane East	0.0 NAVD 88

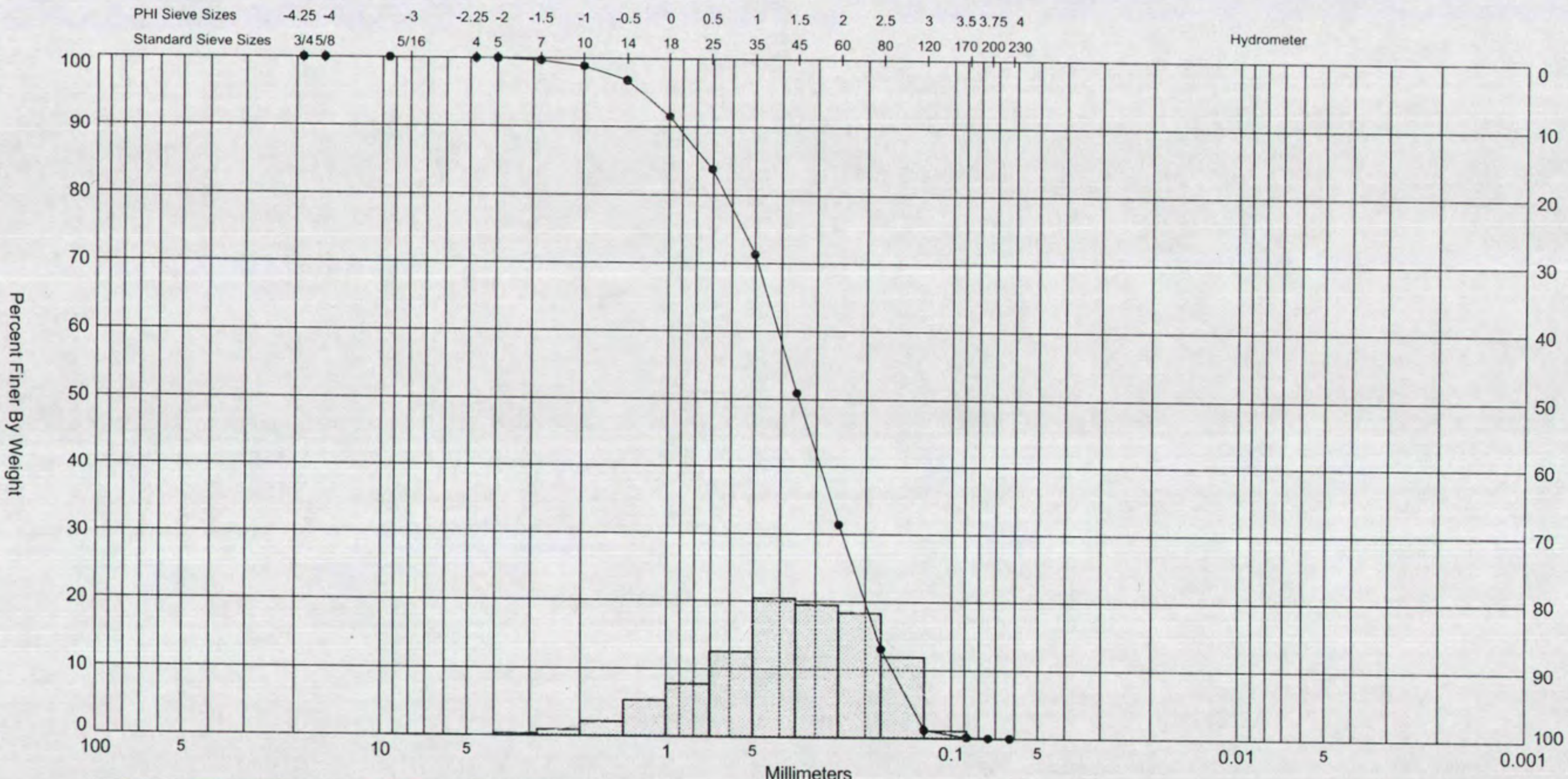
USCS:	Munsell:	Comments:
SW	Wet - 10YR-7/3	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
330.98	328.06	0.07	0.00	#200 - 0.95 #230 - 0.90			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	2.20	0.66	2.20	0.66
4	-2.25	4.76	3.50	1.06	5.70	1.72
5	-2.00	4.00	1.57	0.47	7.27	2.20
7	-1.50	2.83	5.09	1.54	12.36	3.73
10	-1.00	2.00	8.19	2.47	20.55	6.21
14	-0.50	1.41	13.63	4.12	34.18	10.33
18	0.00	1.00	16.33	4.93	50.51	15.26
25	0.50	0.71	13.08	3.95	63.59	19.21
35	1.00	0.50	12.07	3.65	75.66	22.86
45	1.50	0.35	18.84	5.69	94.50	28.55
60	2.00	0.25	40.18	12.14	134.68	40.69
80	2.50	0.18	90.01	27.19	224.69	67.89
120	3.00	0.13	97.05	29.32	321.74	97.21
170	3.50	0.09	5.77	1.74	327.51	98.95
200	3.75	0.07	0.32	0.10	327.83	99.05
230	4.00	0.06	0.16	0.05	327.99	99.10

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.96	2.77	2.62	2.17	1.19	0.09	-1.24

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.65	0.32	1.38	-1.49	4.68



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-205 Beach	—●—	0.0	SW	#200 - 0.02 #230 - 0.01			1.52	1.44	-0.56	3.04	0.95

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	586,876
Northing (Y, ft):	1,944,606
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand

Sample Name: R-205 Beach

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
586,876	1,944,606	Florida State Plane East	0.0 NAVD 88

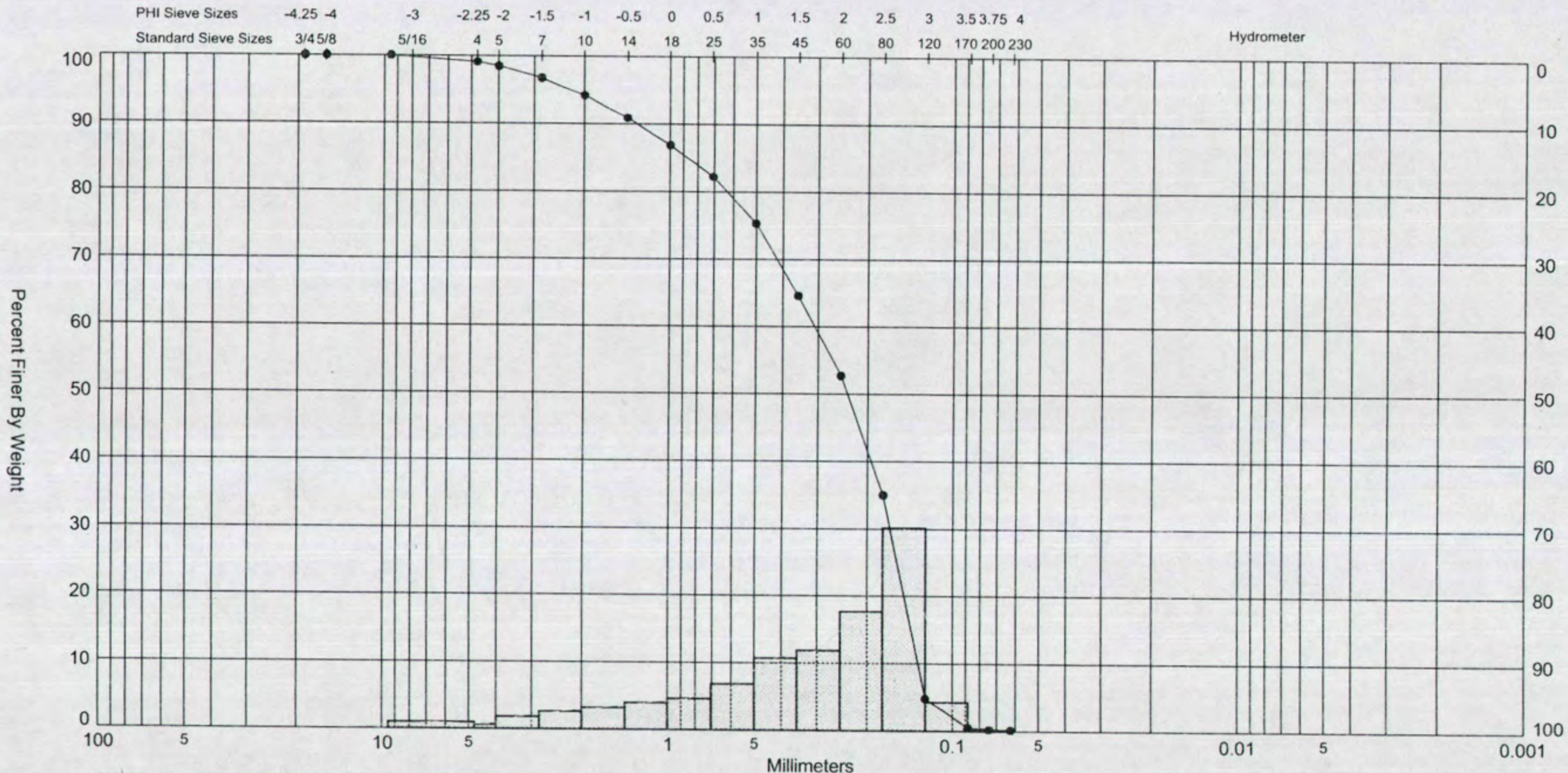
USCS:	Munsell:	Comments:
SW	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
334.41	334.37	0.00	0.00	#200 - 0.02 #230 - 0.01			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.09	0.03	0.09	0.03
5	-2.00	4.00	0.01	0.00	0.10	0.03
7	-1.50	2.83	0.90	0.27	1.00	0.30
10	-1.00	2.00	2.78	0.83	3.78	1.13
14	-0.50	1.41	6.87	2.05	10.65	3.18
18	0.00	1.00	17.57	5.25	28.22	8.44
25	0.50	0.71	25.80	7.72	54.02	16.15
35	1.00	0.50	41.88	12.52	95.90	28.68
45	1.50	0.35	68.37	20.44	164.27	49.12
60	2.00	0.25	65.07	19.46	229.34	68.58
80	2.50	0.18	61.43	18.37	290.77	86.95
120	3.00	0.13	39.74	11.88	330.51	98.83
170	3.50	0.09	3.50	1.05	334.01	99.88
200	3.75	0.07	0.34	0.10	334.35	99.98
230	4.00	0.06	0.02	0.01	334.37	99.99

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.84	2.42	2.17	1.52	0.85	0.49	-0.33

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.44	0.37	0.95	-0.56	3.04



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-205 R/W	—●—	0.0	SW	#200 - 0.21 #230 - 0.14			2.08	1.65	-1.19	3.83	1.32

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	586,876
Northing (Y, ft):	1,944,606
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand

Sample Name: R-205 R/W

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
586,876	1,944,606	Florida State Plane East	0.0 NAVD 88

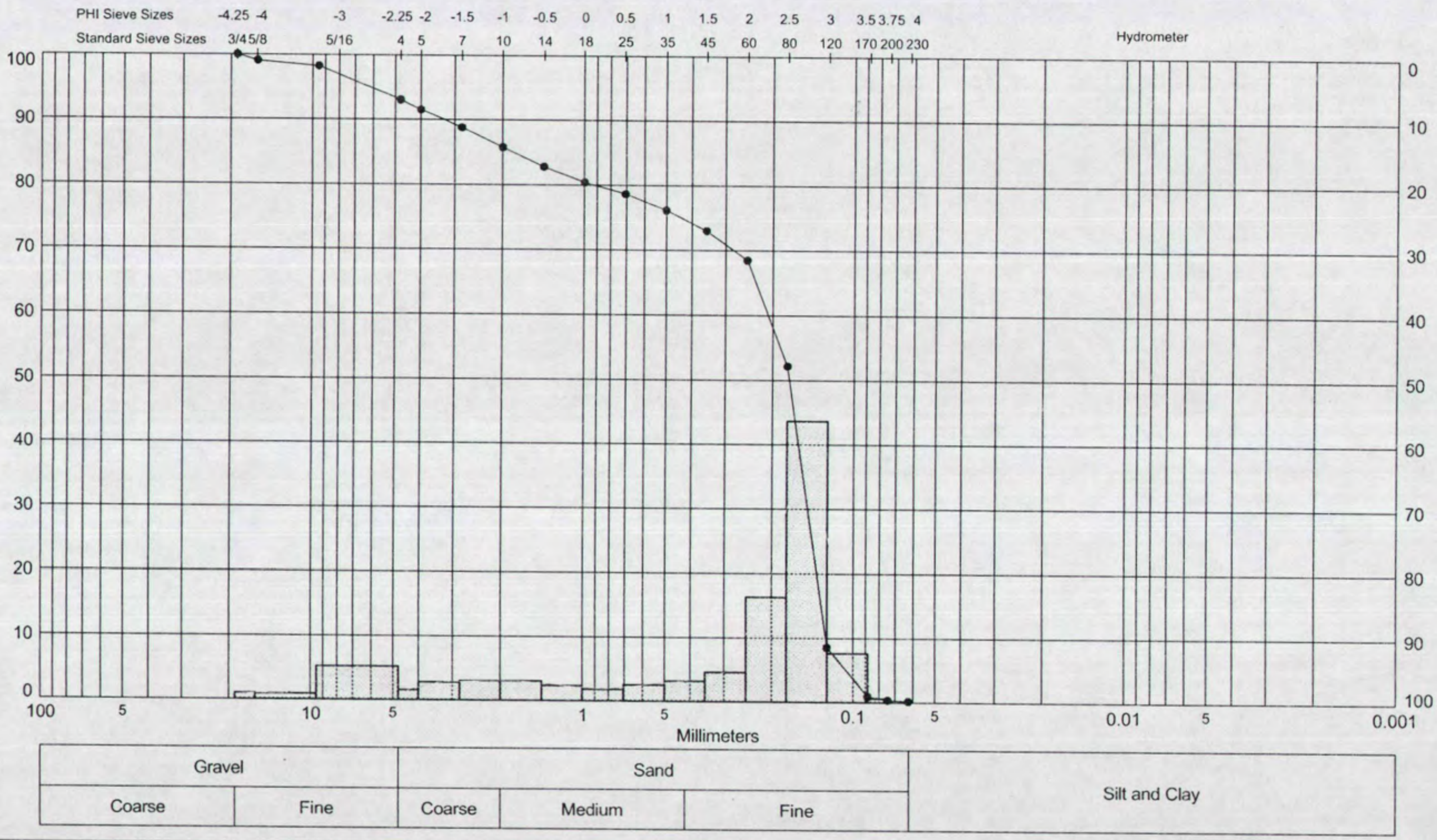
USCS:	Munsell:	Comments:
SW	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
330.37	330.06	0.13	0.01	#200 - 0.21 #230 - 0.14			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	3.12	0.94	3.12	0.94
5	-2.00	4.00	1.94	0.59	5.06	1.53
7	-1.50	2.83	5.65	1.71	10.71	3.24
10	-1.00	2.00	8.60	2.60	19.31	5.84
14	-0.50	1.41	10.75	3.25	30.06	9.10
18	0.00	1.00	13.18	3.99	43.24	13.09
25	0.50	0.71	15.49	4.69	58.73	17.78
35	1.00	0.50	22.71	6.87	81.44	24.65
45	1.50	0.35	35.57	10.77	117.01	35.42
60	2.00	0.25	39.38	11.92	156.39	47.34
80	2.50	0.18	58.35	17.66	214.74	65.00
120	3.00	0.13	99.61	30.15	314.35	95.15
170	3.50	0.09	14.33	4.34	328.68	99.49
200	3.75	0.07	0.99	0.30	329.67	99.79
230	4.00	0.06	0.23	0.07	329.90	99.86

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
3.00	2.82	2.67	2.08	1.02	0.31	-1.16

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.65	0.32	1.32	-1.19	3.83



SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-205 T Dune	—●—	0.0	SW	#200 - 0.34 #230 - 0.17			2.52	1.63	-1.47	3.91	1.86

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	586,876
Northing (Y, ft):	1,944,606
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand

Sample Name: R-205 T Dune

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
586,876	1,944,606	Florida State Plane East	0.0 NAVD 88

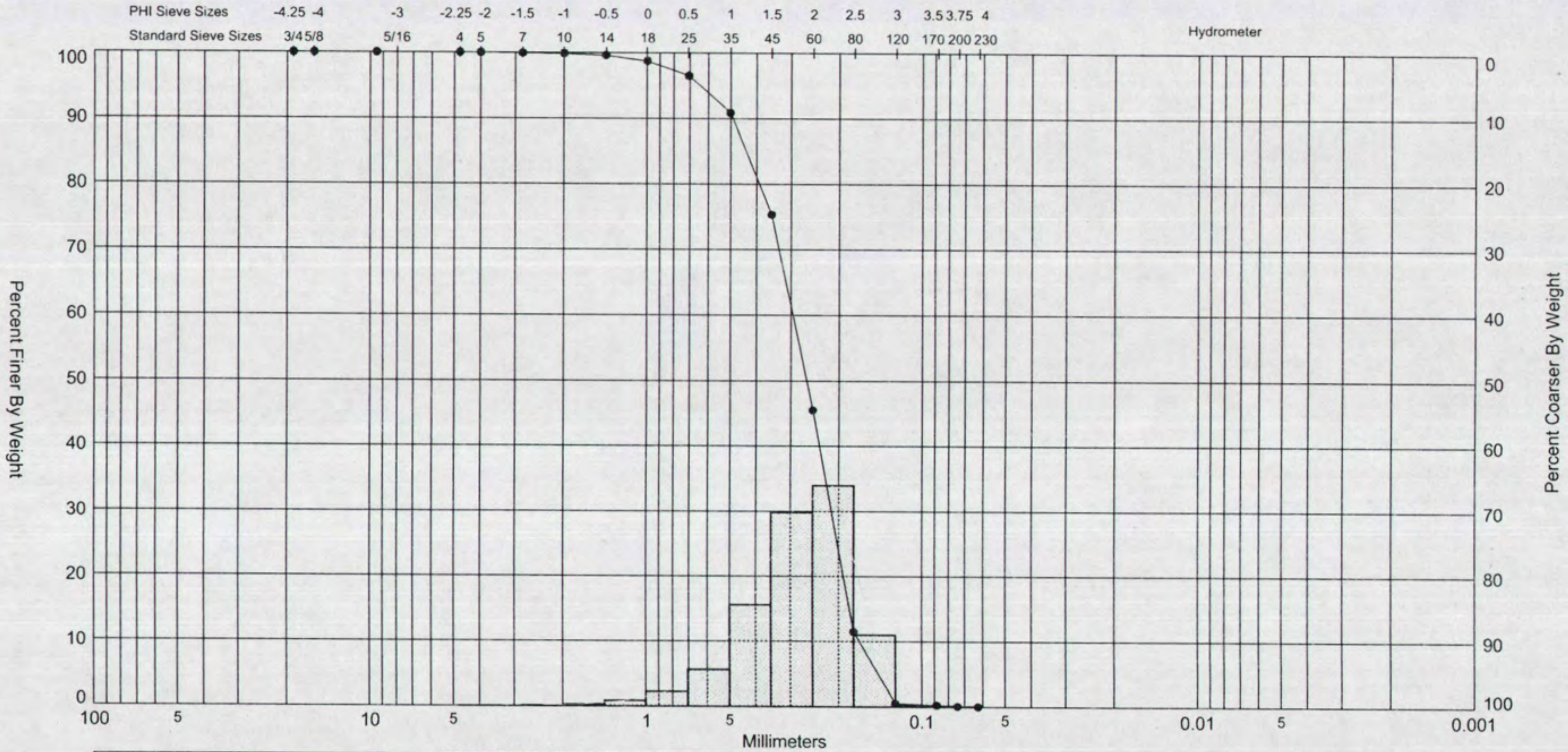
USCS:	Munsell:	Comments:
SW	Wet - 10YR-7/1	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
334.82	334.26	0.02	0.00	#200 - 0.34 #230 - 0.17			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	3.06	0.91	3.06	0.91
3/8"	-3.25	9.51	2.71	0.81	5.77	1.72
4	-2.25	4.76	17.41	5.20	23.18	6.92
5	-2.00	4.00	5.11	1.53	28.29	8.45
7	-1.50	2.83	9.18	2.74	37.47	11.19
10	-1.00	2.00	10.07	3.01	47.54	14.20
14	-0.50	1.41	10.14	3.03	57.68	17.23
18	0.00	1.00	7.88	2.35	65.56	19.58
25	0.50	0.71	6.00	1.79	71.56	21.37
35	1.00	0.50	8.23	2.46	79.79	23.83
45	1.50	0.35	10.50	3.14	90.29	26.97
60	2.00	0.25	15.24	4.55	105.53	31.52
80	2.50	0.18	54.58	16.30	160.11	47.82
120	3.00	0.13	146.08	43.63	306.19	91.45
170	3.50	0.09	25.56	7.63	331.75	99.08
200	3.75	0.07	1.94	0.58	333.69	99.66
230	4.00	0.06	0.55	0.16	334.24	99.83

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
3.23	2.91	2.81	2.52	1.19	-0.70	-2.62

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.63	0.32	1.86	-1.47	3.91



SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-206 Beach	—●—	0.0	SP	#200 - 0.07 #230 - 0.02			1.92	1.84	-0.93	4.92	0.64

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	587,188
Northing (Y, ft):	1,943,631
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand
Sample Name: R-206 Beach
Analysis Date: 12-31-08
Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
587,188	1,943,631	Florida State Plane East	0.0 NAVD 88

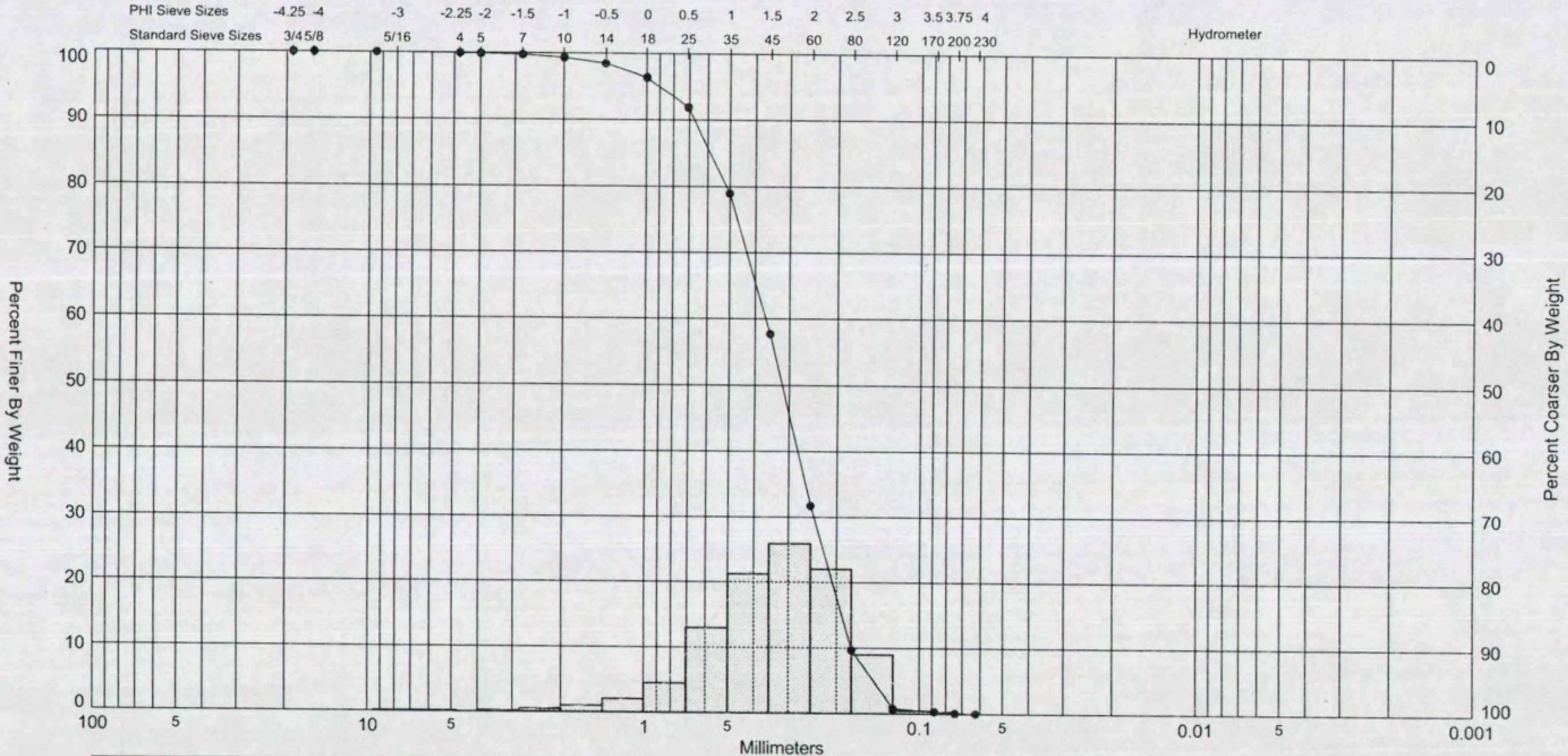
USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
326.74	326.72	0.03	0.00	#200 - 0.07 #230 - 0.02			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.00	0.00	0.00	0.00
5	-2.00	4.00	0.09	0.03	0.09	0.03
7	-1.50	2.83	0.10	0.03	0.19	0.06
10	-1.00	2.00	0.25	0.08	0.44	0.13
14	-0.50	1.41	0.80	0.24	1.24	0.38
18	0.00	1.00	2.73	0.84	3.97	1.22
25	0.50	0.71	7.23	2.21	11.20	3.43
35	1.00	0.50	18.46	5.65	29.66	9.08
45	1.50	0.35	50.88	15.57	80.54	24.65
60	2.00	0.25	97.57	29.86	178.11	54.51
80	2.50	0.18	111.04	33.98	289.15	88.50
120	3.00	0.13	36.07	11.04	325.22	99.53
170	3.50	0.09	0.77	0.24	325.99	99.77
200	3.75	0.07	0.52	0.16	326.51	99.93
230	4.00	0.06	0.18	0.06	326.69	99.98

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.79	2.43	2.30	1.92	1.51	1.22	0.64

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.84	0.28	0.64	-0.93	4.92



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-206 R/W	—•—	0.0	SP	#200 - 0.05 #230 - 0.02			1.65	1.57	-0.76	4.41	0.79

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	587,188
Northing (Y, ft):	1,943,631
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

Project Name: Summer Haven Beach Sand

Sample Name: R-206 R/W

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

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Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
587,188	1,943,631	Florida State Plane East	0.0 NAVD 88

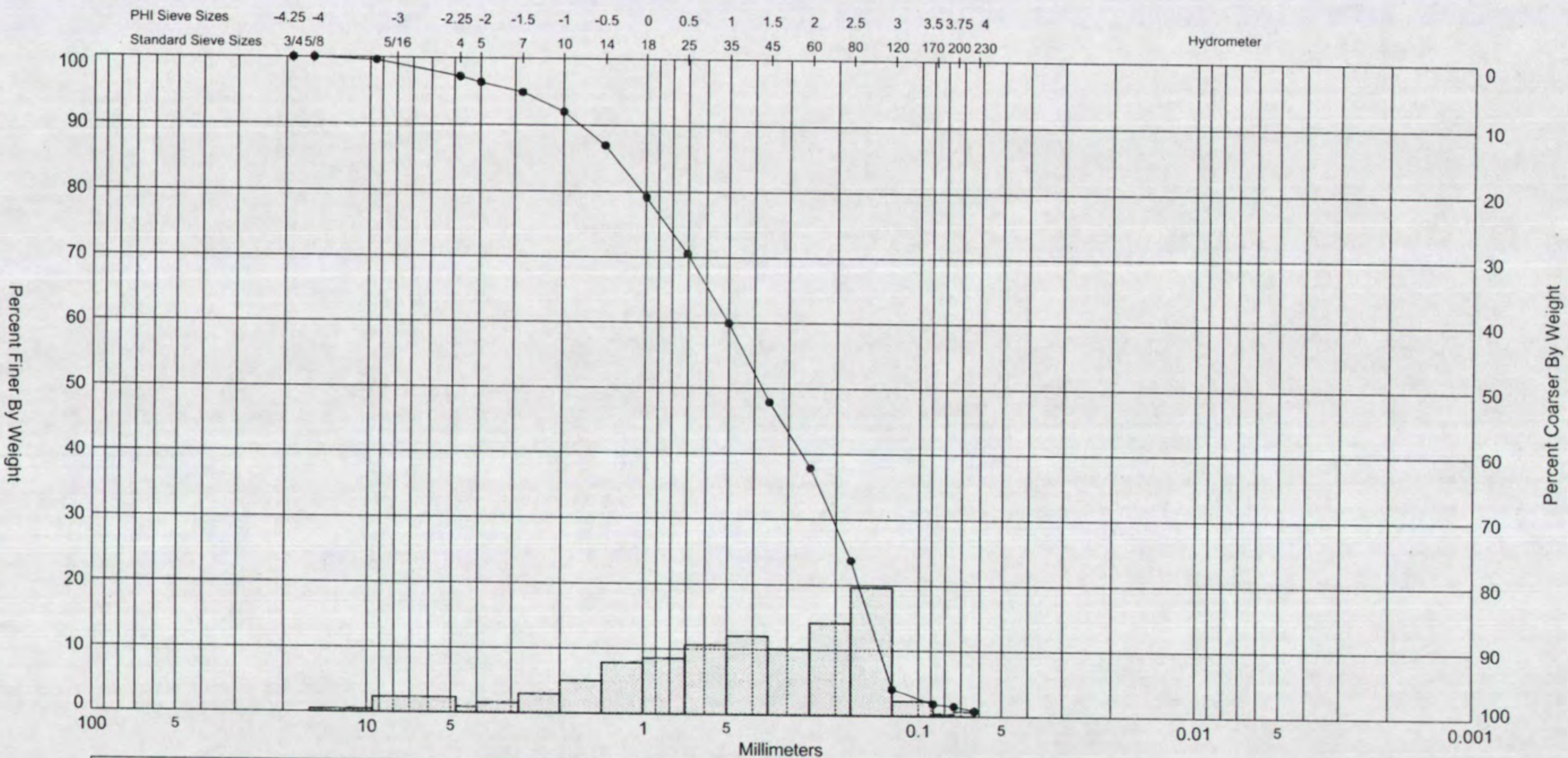
USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
324.89	324.87	0.04	0.00	#200 - 0.05 #230 - 0.02			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.23	0.07	0.23	0.07
5	-2.00	4.00	0.14	0.04	0.37	0.11
7	-1.50	2.83	0.47	0.14	0.84	0.26
10	-1.00	2.00	1.29	0.40	2.13	0.66
14	-0.50	1.41	2.86	0.88	4.99	1.54
18	0.00	1.00	6.64	2.04	11.63	3.58
25	0.50	0.71	14.63	4.50	26.26	8.08
35	1.00	0.50	42.25	13.00	68.51	21.09
45	1.50	0.35	68.93	21.22	137.44	42.30
60	2.00	0.25	84.30	25.95	221.74	68.25
80	2.50	0.18	71.58	22.03	293.32	90.28
120	3.00	0.13	29.25	9.00	322.57	99.29
170	3.50	0.09	1.37	0.42	323.94	99.71
200	3.75	0.07	0.80	0.25	324.74	99.95
230	4.00	0.06	0.08	0.02	324.82	99.98

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.76	2.36	2.15	1.65	1.09	0.80	0.16

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.57	0.34	0.79	-0.76	4.41



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-206 T Dune	—●—	0.0	SW	#200 - 1.49 #230 - 0.80			1.41	1.19	-0.75	3.12	1.47

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	587,188
Northing (Y, ft):	1,943,631
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report
Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand

Sample Name: R-206 T Dune

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
587,188	1,943,631	Florida State Plane East	0.0 NAVD 88

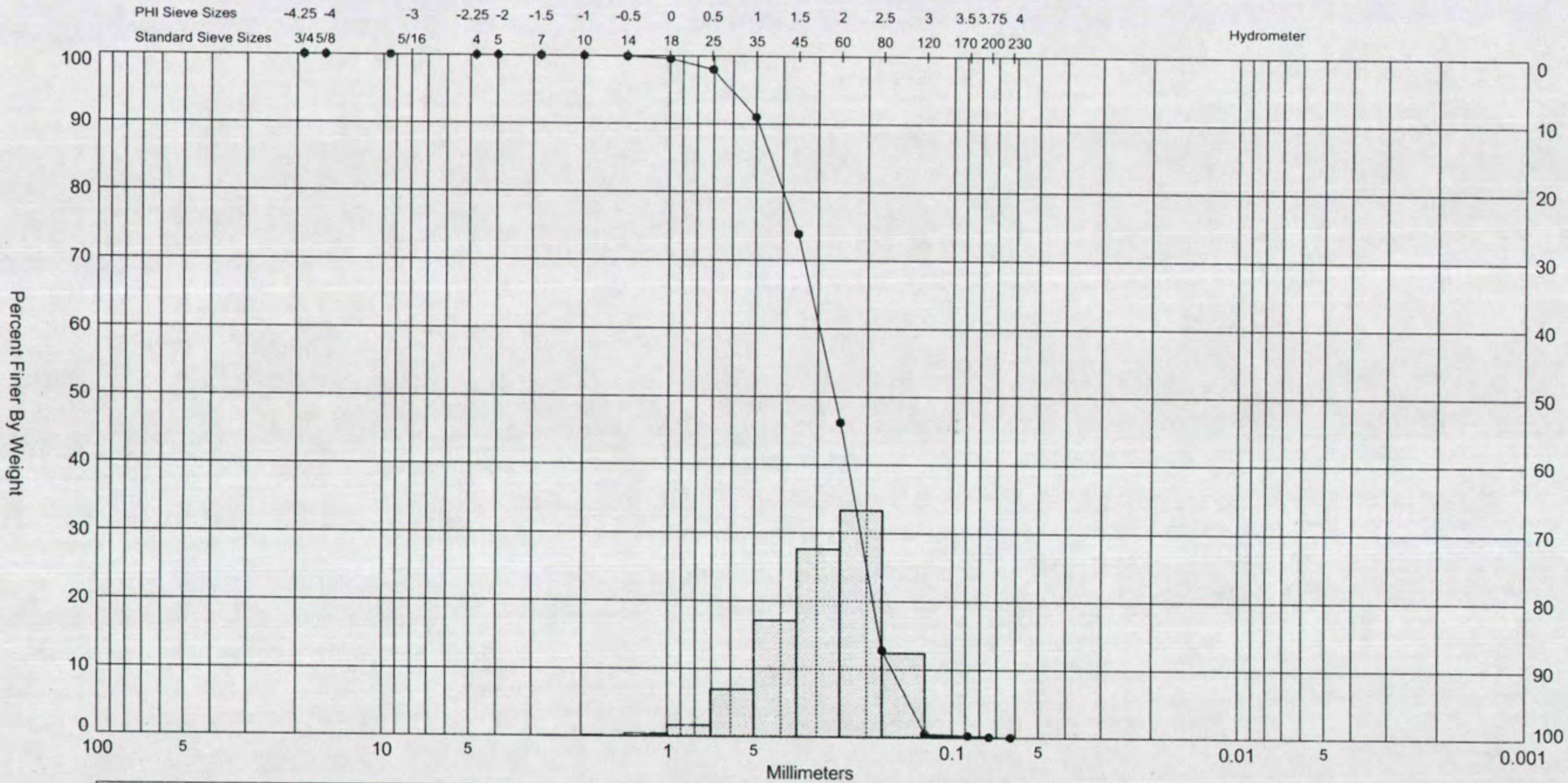
USCS:	Munsell:	Comments:
SW	Wet - 10YR-5/3	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
327.56	325.32	0.37	0.00	#200 - 1.49 #230 - 0.80			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	1.26	0.38	1.26	0.38
4	-2.25	4.76	7.69	2.35	8.95	2.73
5	-2.00	4.00	2.71	0.83	11.66	3.56
7	-1.50	2.83	5.05	1.54	16.71	5.10
10	-1.00	2.00	9.44	2.88	26.15	7.98
14	-0.50	1.41	16.36	4.99	42.51	12.98
18	0.00	1.00	25.73	7.86	68.24	20.83
25	0.50	0.71	28.06	8.57	96.30	29.40
35	1.00	0.50	34.90	10.65	131.20	40.05
45	1.50	0.35	39.48	12.05	170.68	52.11
60	2.00	0.25	32.96	10.06	203.64	62.17
80	2.50	0.18	46.29	14.13	249.93	76.30
120	3.00	0.13	64.31	19.63	314.24	95.93
170	3.50	0.09	7.23	2.21	321.47	98.14
200	3.75	0.07	1.22	0.37	322.69	98.51
230	4.00	0.06	2.26	0.69	324.95	99.20

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.98	2.70	2.45	1.41	0.24	-0.31	-1.53

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.19	0.44	1.47	-0.75	3.12



Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-207 Beach	—●—	0.0	SP	#200 - 0.05 #230 - 0.02			1.93	1.86	-0.55	3.34	0.61

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	587,494
Northing (Y, ft):	1,942,645
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand
Sample Name: R-207 Beach
Analysis Date: 12-31-08
Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
587,494	1,942,645	Florida State Plane East	0.0 NAVD 88

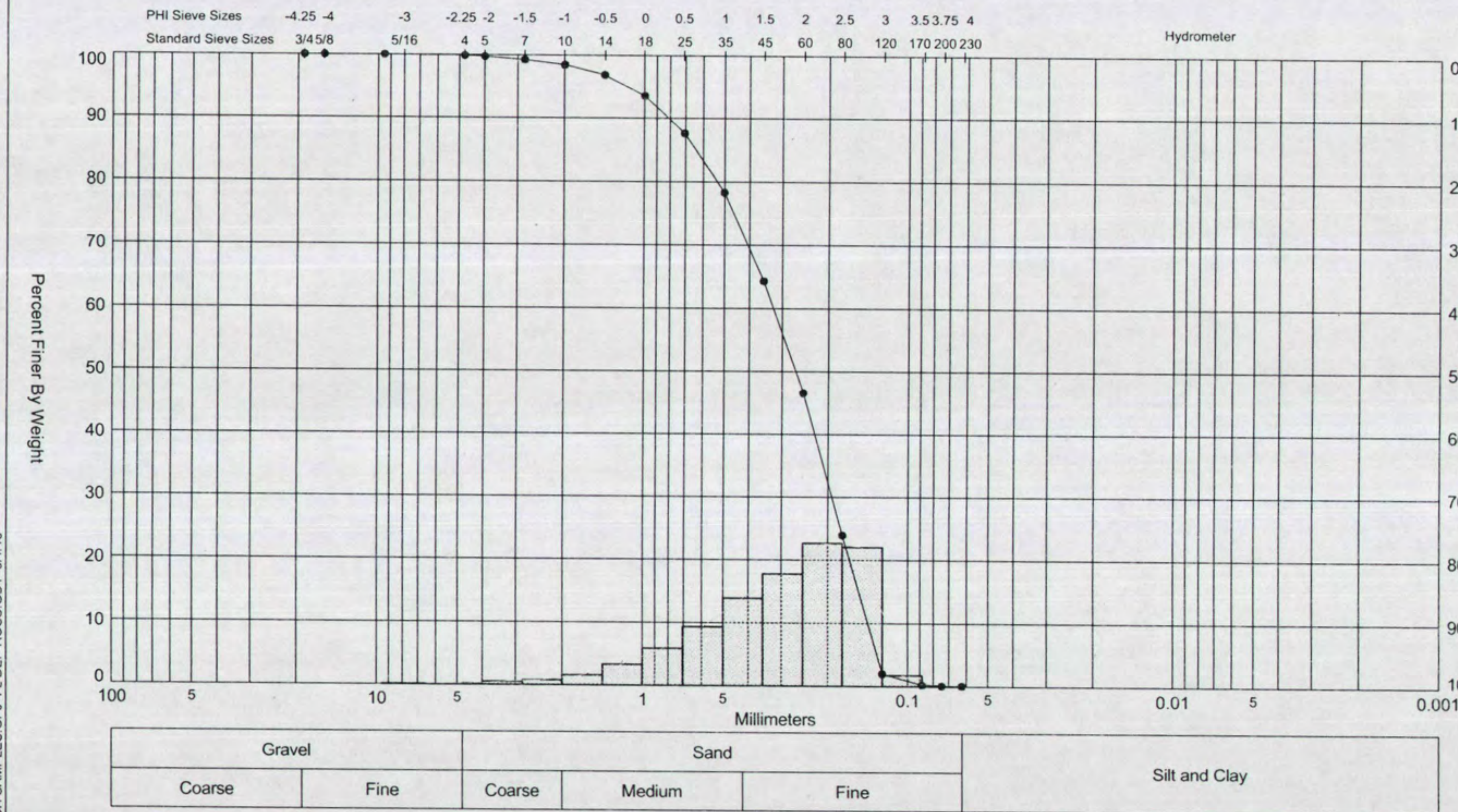
USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
341.66	341.58	0.00	0.00	#200 - 0.05 #230 - 0.02			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.00	0.00	0.00	0.00
5	-2.00	4.00	0.00	0.00	0.00	0.00
7	-1.50	2.83	0.00	0.00	0.00	0.00
10	-1.00	2.00	0.09	0.03	0.09	0.03
14	-0.50	1.41	0.18	0.05	0.27	0.08
18	0.00	1.00	1.26	0.37	1.53	0.45
25	0.50	0.71	5.35	1.57	6.88	2.01
35	1.00	0.50	23.74	6.95	30.62	8.96
45	1.50	0.35	58.57	17.14	89.19	26.10
60	2.00	0.25	94.62	27.69	183.81	53.80
80	2.50	0.18	113.90	33.34	297.71	87.14
120	3.00	0.13	42.38	12.40	340.09	99.54
170	3.50	0.09	0.80	0.23	340.89	99.77
200	3.75	0.07	0.59	0.17	341.48	99.95
230	4.00	0.06	0.10	0.03	341.58	99.98

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.82	2.45	2.32	1.93	1.47	1.21	0.72

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.86	0.28	0.61	-0.55	3.34



SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-207 R/W	—●—	0.0	SW	#200 - 0.08 #230 - 0.05			1.9	1.7	-1	3.97	0.99

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	587,494
Northing (Y, ft):	1,942,645
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand

Sample Name: R-207 R/W

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
587,494	1,942,645	Florida State Plane East	0.0 NAVD 88

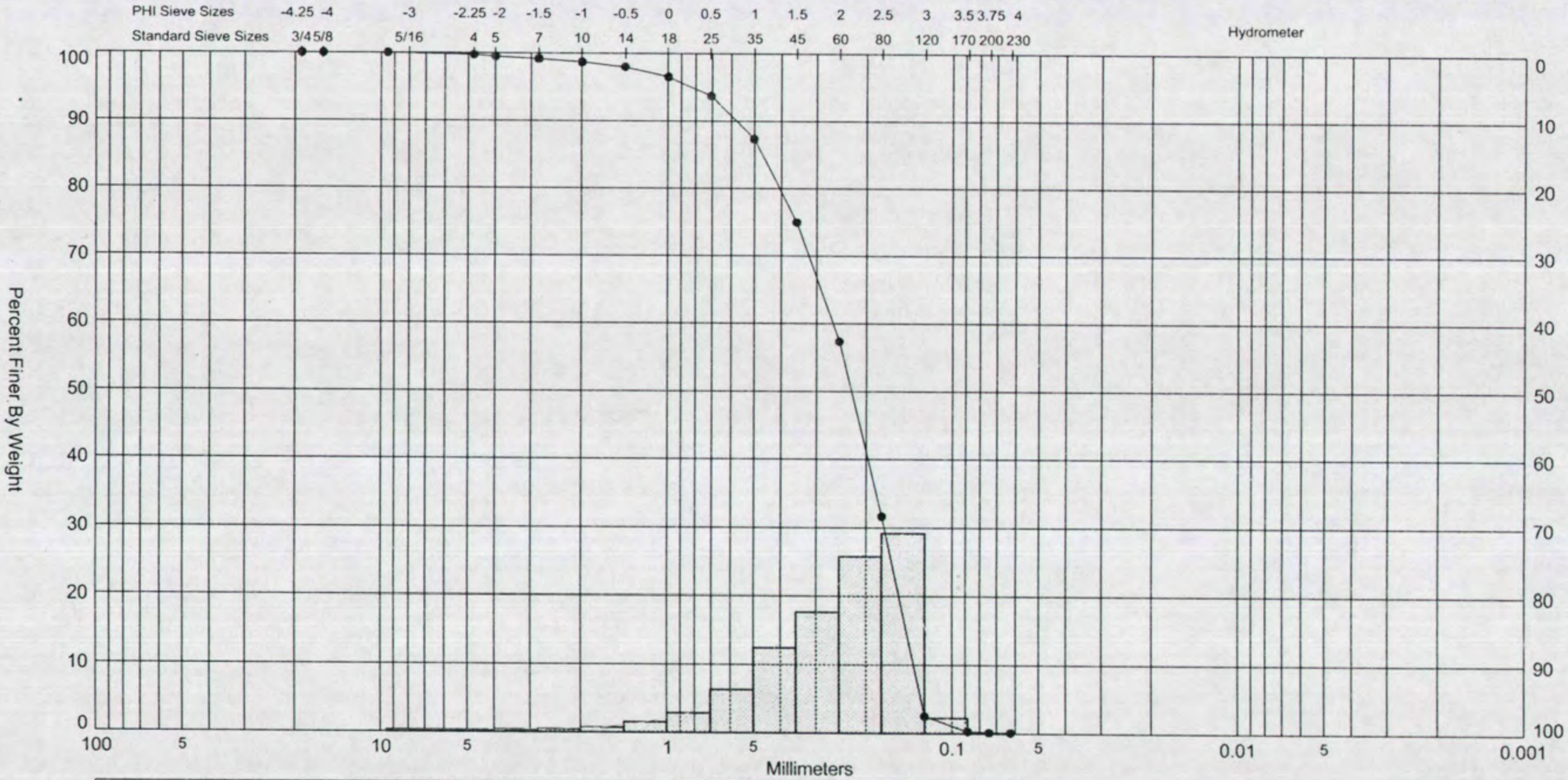
USCS:	Munsell:	Comments:
SW	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
327.98	327.86	0.04	0.00	#200 - 0.08 #230 - 0.05			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.39	0.12	0.39	0.12
5	-2.00	4.00	0.50	0.15	0.89	0.27
7	-1.50	2.83	1.60	0.49	2.49	0.76
10	-1.00	2.00	2.57	0.78	5.06	1.54
14	-0.50	1.41	5.11	1.56	10.17	3.10
18	0.00	1.00	10.97	3.34	21.14	6.45
25	0.50	0.71	19.35	5.90	40.49	12.35
35	1.00	0.50	30.75	9.38	71.24	21.72
45	1.50	0.35	45.70	13.93	116.94	35.65
60	2.00	0.25	58.30	17.78	175.24	53.43
80	2.50	0.18	74.21	22.63	249.45	76.06
120	3.00	0.13	72.04	21.96	321.49	98.02
170	3.50	0.09	5.81	1.77	327.30	99.79
200	3.75	0.07	0.41	0.13	327.71	99.92
230	4.00	0.06	0.10	0.03	327.81	99.95

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.93	2.68	2.48	1.90	1.12	0.69	-0.22

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.7	0.31	0.99	-1	3.97



Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-207 T Dune	—●—	0.0	SW	#200 - 0.13 #230 - 0.11			2.14	1.95	-1.55	6.71	0.9

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	587,494
Northing (Y, ft):	1,942,645
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand
Sample Name: R-207 T Dune
Analysis Date: 12-31-08
Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
587,494	1,942,645	Florida State Plane East	0.0 NAVD 88

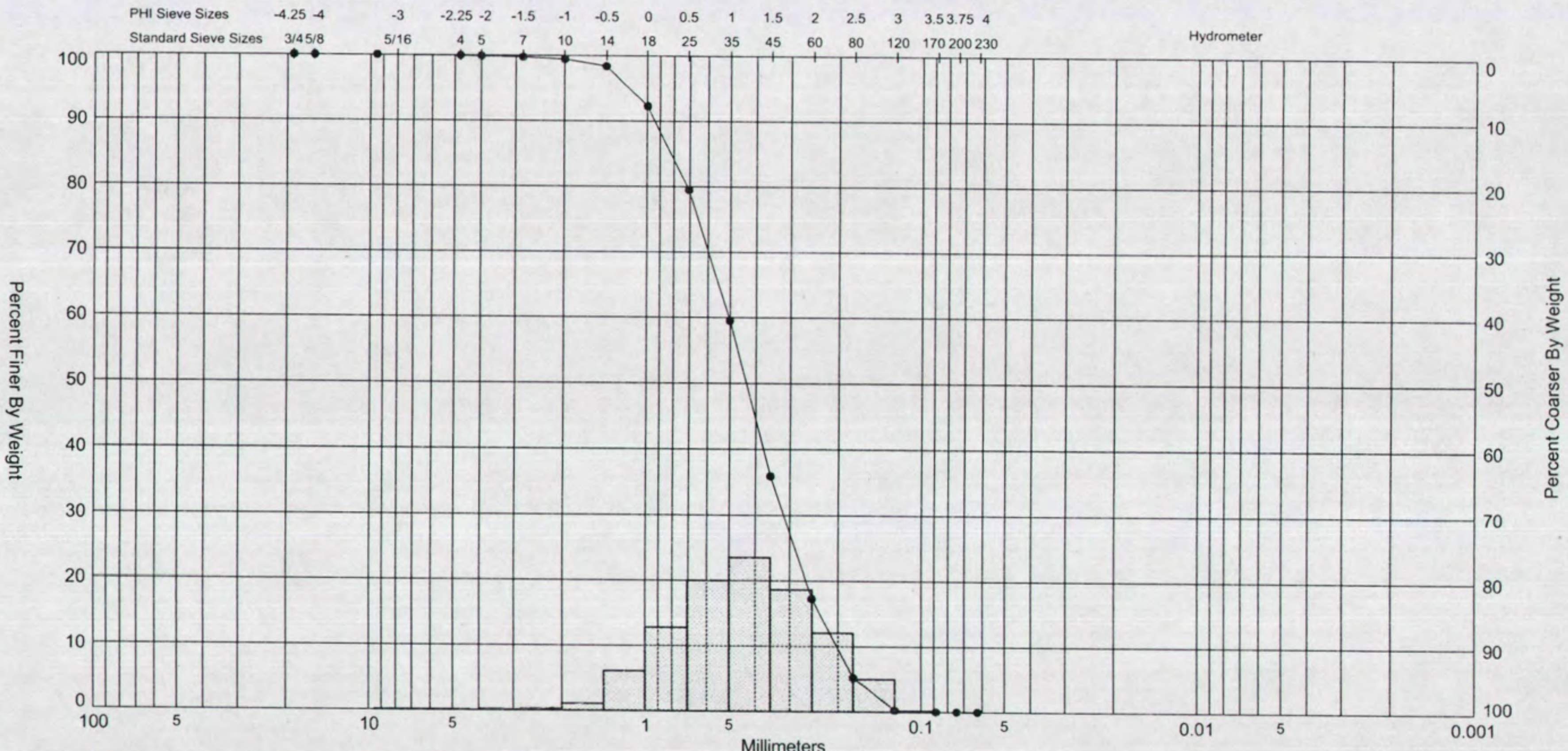
USCS:	Munsell:	Comments:
SW	Wet - 10YR-8/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
352.92	352.71	0.18	0.00	#200 - 0.13 #230 - 0.11			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.97	0.27	0.97	0.27
5	-2.00	4.00	0.75	0.21	1.72	0.49
7	-1.50	2.83	1.23	0.35	2.95	0.84
10	-1.00	2.00	1.56	0.44	4.51	1.28
14	-0.50	1.41	2.43	0.69	6.94	1.97
18	0.00	1.00	5.20	1.47	12.14	3.44
25	0.50	0.71	10.04	2.84	22.18	6.28
35	1.00	0.50	22.34	6.33	44.52	12.61
45	1.50	0.35	43.69	12.38	88.21	24.99
60	2.00	0.25	62.30	17.65	150.51	42.65
80	2.50	0.18	90.73	25.71	241.24	68.36
120	3.00	0.13	102.94	29.17	344.18	97.52
170	3.50	0.09	7.80	2.21	351.98	99.73
200	3.75	0.07	0.49	0.14	352.47	99.87
230	4.00	0.06	0.06	0.02	352.53	99.89

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.96	2.77	2.61	2.14	1.50	1.14	0.27

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.95	0.26	0.9	-1.55	6.71



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-208 Beach	—•—	0.0	SP	#200 - 0.02 #230 - 0.01			1.2	1.19	-0.22	3.06	0.83

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	587,863
Northing (Y, ft):	1,941,694
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

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Project Name: Summer Haven Beach Sand
Sample Name: R-208 Beach
Analysis Date: 12-31-08
Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
587,863	1,941,694	Florida State Plane East	0.0 NAVD 88

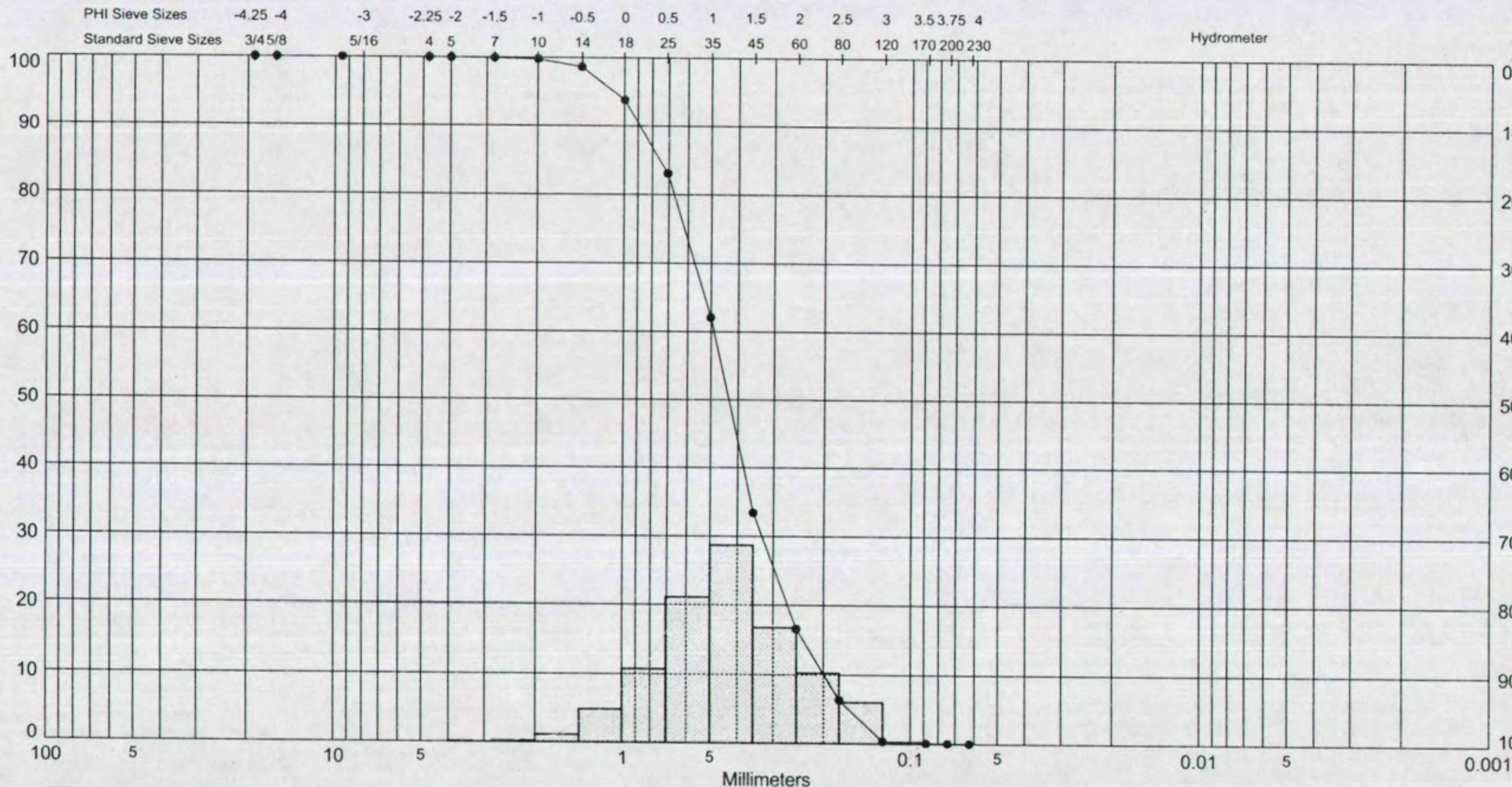
USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
331.84	331.81	0.00	0.00	#200 - 0.02 #230 - 0.01			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.17	0.05	0.17	0.05
5	-2.00	4.00	0.28	0.08	0.45	0.14
7	-1.50	2.83	0.44	0.13	0.89	0.27
10	-1.00	2.00	0.97	0.29	1.86	0.56
14	-0.50	1.41	3.53	1.06	5.39	1.62
18	0.00	1.00	20.15	6.07	25.54	7.70
25	0.50	0.71	42.48	12.80	68.02	20.50
35	1.00	0.50	66.47	20.03	134.49	40.53
45	1.50	0.35	78.12	23.54	212.61	64.07
60	2.00	0.25	61.88	18.65	274.49	82.72
80	2.50	0.18	40.06	12.07	314.55	94.79
120	3.00	0.13	16.56	4.99	331.11	99.78
170	3.50	0.09	0.65	0.20	331.76	99.98
200	3.75	0.07	0.03	0.01	331.79	99.98
230	4.00	0.06	0.02	0.01	331.81	99.99

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.52	2.05	1.79	1.20	0.61	0.32	-0.22

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.19	0.44	0.83	-0.22	3.06



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-208 R/W	—●—	0.0	SP	#200 - 0.04 #230 - 0.02			1.21	1.22	-0.03	2.9	0.79

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	587,863
Northing (Y, ft):	1,941,694
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

TAYLOR ENGINEERING, INC.

Taylor Engineering, Inc.
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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

TAYLOR ENGINEERING, INC.

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10151 Deerwood Park Blvd., Bldg. 300, Suite 300
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ph (904) 731-7040
fax (904) 731-9847

Project Name: Summer Haven Beach Sand

Sample Name: R-208 R/W

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
587,863	1,941,694	Florida State Plane East	0.0 NAVD 88

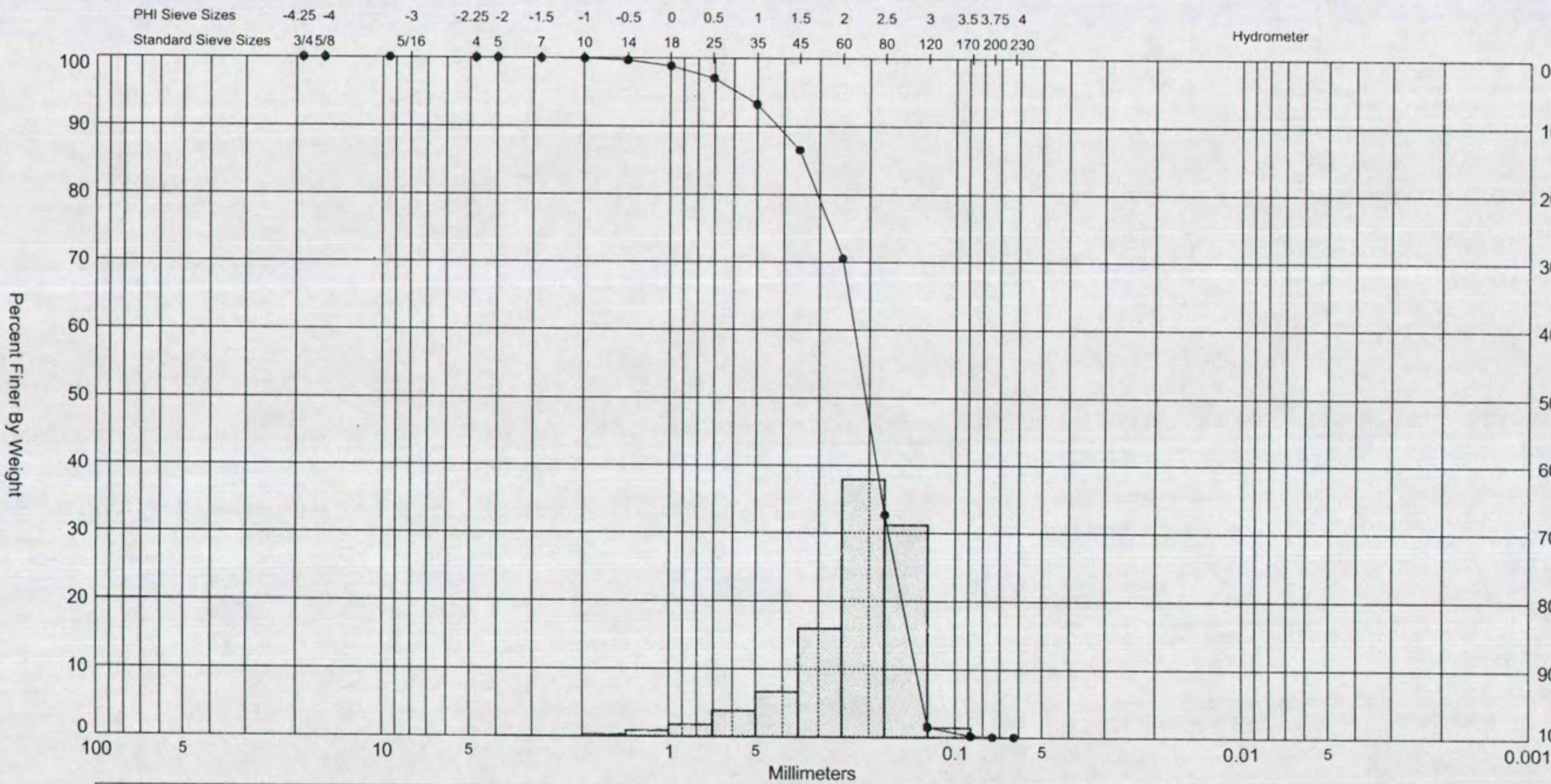
USCS:	Munsell:	Comments:
SP	Wet - 10YR-7/2	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
309.62	309.57	0.00	0.00	#200 - 0.04 #230 - 0.02			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.00	0.00	0.00	0.00
5	-2.00	4.00	0.00	0.00	0.00	0.00
7	-1.50	2.83	0.14	0.05	0.14	0.05
10	-1.00	2.00	0.52	0.17	0.66	0.21
14	-0.50	1.41	3.45	1.11	4.11	1.33
18	0.00	1.00	15.04	4.86	19.15	6.19
25	0.50	0.71	33.26	10.74	52.41	16.93
35	1.00	0.50	64.98	20.99	117.39	37.91
45	1.50	0.35	88.86	28.70	206.25	66.61
60	2.00	0.25	51.95	16.78	258.20	83.39
80	2.50	0.18	31.81	10.27	290.01	93.67
120	3.00	0.13	18.71	6.04	308.72	99.71
170	3.50	0.09	0.76	0.25	309.48	99.95
200	3.75	0.07	0.03	0.01	309.51	99.96
230	4.00	0.06	0.06	0.02	309.57	99.98

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.61	2.03	1.75	1.21	0.69	0.46	-0.12

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	1.22	0.43	0.79	-0.03	2.9



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
R-208 T Dune	—●—	0.0	SP	#200 - 0.05 #230 - 0.04			2.27	2.15	-1.44	5.82	0.66

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	Summer Haven Beach Sand
Analysis Date:	12-31-08
Analyzed By:	Universal Engineering Sciences
Easting (X, ft):	587,863
Northing (Y, ft):	1,941,694
Horizontal System:	NAD 1983
Vertical System:	NAVD 88

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SIEVE ANALYSIS SUMMER HAVEN BEACH SAMPLES.GPJ FL DEP ROSS.GDT 3/1/10

Granularmetric Report

Depths and elevations based on measured values

TAYLOR ENGINEERING, INC.

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fax (904) 731-9847

Project Name: Summer Haven Beach Sand

Sample Name: R-208 T Dune

Analysis Date: 12-31-08

Analyzed By: Universal Engineering Sciences

Easting (ft):	Northing (ft):	Coordinate System:	Elevation (ft):
587,863	1,941,694	Florida State Plane East	0.0 NAVD 88

USCS:	Munsell:	Comments:
SP	Wet - 10YR-8/1	

Dry Weight (g):	Wash Weight (g):	Pan Retained (g):	Sieve Loss (%):	Fines (%):	Organics (%):	Carbonates (%):	Shells (%):
320.78	320.70	0.05	0.00	#200 - 0.05 #230 - 0.04			

Sieve Number	Sieve Size (Phi)	Sieve Size (Millimeters)	Grams Retained	% Weight Retained	Cum. Grams Retained	C. % Weight Retained
3/4"	-4.25	19.03	0.00	0.00	0.00	0.00
5/8"	-4.00	16.00	0.00	0.00	0.00	0.00
3/8"	-3.25	9.51	0.00	0.00	0.00	0.00
4	-2.25	4.76	0.00	0.00	0.00	0.00
5	-2.00	4.00	0.00	0.00	0.00	0.00
7	-1.50	2.83	0.13	0.04	0.13	0.04
10	-1.00	2.00	0.13	0.04	0.26	0.08
14	-0.50	1.41	0.79	0.25	1.05	0.33
18	0.00	1.00	2.66	0.83	3.71	1.16
25	0.50	0.71	5.63	1.76	9.34	2.91
35	1.00	0.50	12.30	3.83	21.64	6.75
45	1.50	0.35	21.32	6.65	42.96	13.39
60	2.00	0.25	51.46	16.04	94.42	29.43
80	2.50	0.18	121.56	37.90	215.98	67.33
120	3.00	0.13	99.89	31.14	315.87	98.47
170	3.50	0.09	4.47	1.39	320.34	99.86
200	3.75	0.07	0.28	0.09	320.62	99.95
230	4.00	0.06	0.03	0.01	320.65	99.96

Phi 5	Phi 16	Phi 25	Phi 50	Phi 75	Phi 84	Phi 95
2.94	2.77	2.62	2.27	1.86	1.58	0.77

Moment	Mean Phi	Mean mm	Sorting	Skewness	Kurtosis
Statistics	2.15	0.23	0.66	-1.44	5.82

APPENDIX D

Beach and Borrow Area Pre and Post Carbonate Removal Tables and Curves (Ellis & Associates)

Ellis & Associates Inc.

SUMMARY OF GRADATION TEST RESULTS
(Pre-Calcium Carbonate Removed)

Project: Summer Haven
Client: Taylor Engineering, Inc.
Project No.: 0405-0020

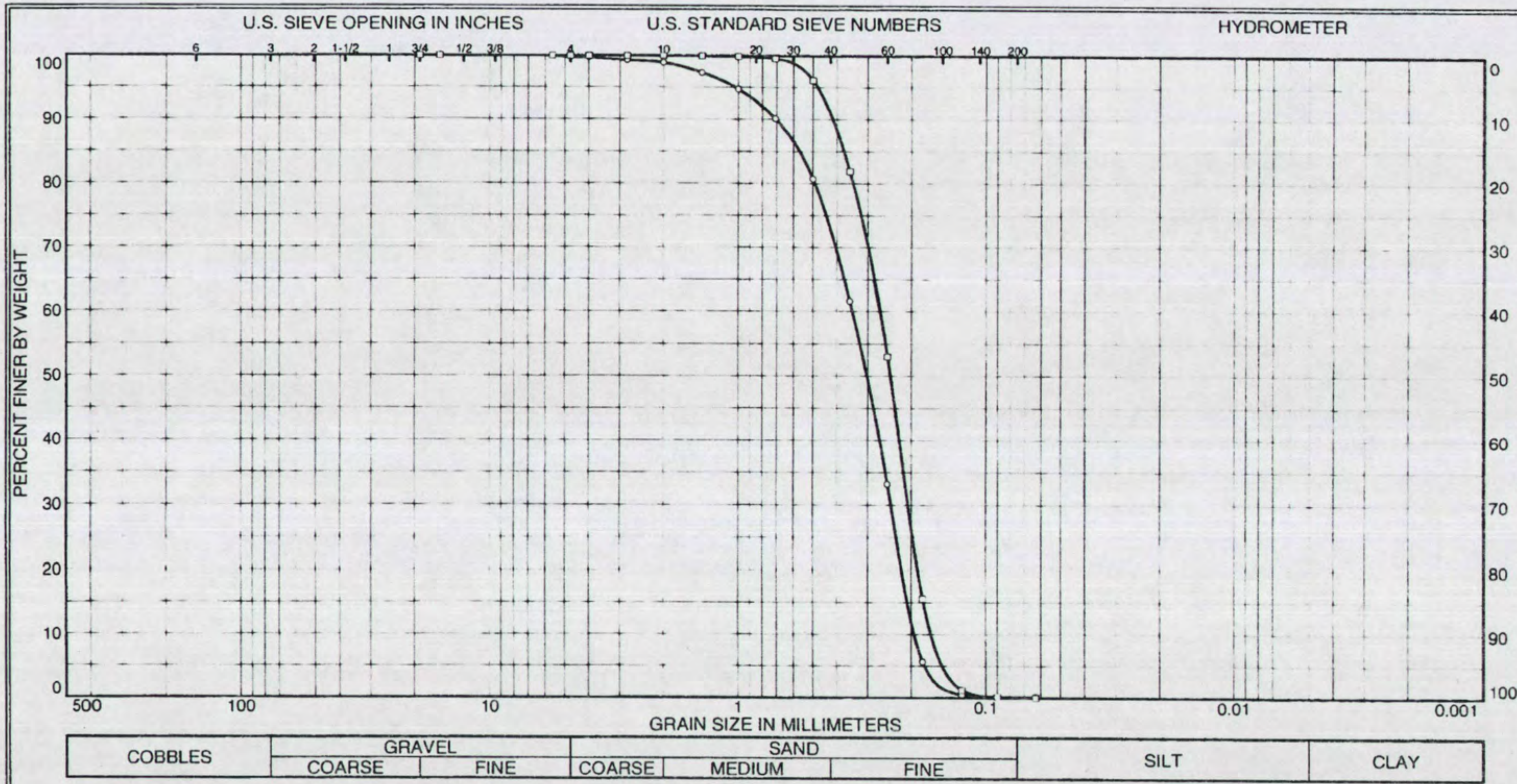
Sample No.	GRADATION TESTS Percent Passing , %																	Calcium Carbonate Content, %
	3/4"	5/8"	No. 3.5	No. 4	No. 5	No. 7	No. 10	No. 14	No. 18	No. 25	No. 35	No. 45	No. 60	No. 80	No. 120	No. 170	No. 230	
R205 Mid Berm	100.0	100.0	100.0	99.8	99.7	99.3	98.9	97.3	94.7	90.1	80.7	61.6	33.2	5.7	0.47	0.19	0.19	22.6
R205 Dune Toe	100.0	100.0	100.0	100.0	100.0	99.9	99.7	99.1	98.0	95.9	91.2	80.5	58.2	21.5	1.5	0.01	0.00	11.1
R205 Dune Veg	100.0	100.0	99.8	99.8	99.7	99.6	99.3	98.7	97.1	94.4	88.6	78.4	61.5	22.5	2.2	0.19	0.05	12.9
R205 Intertidal Zone	100.0	100.0	99.7	99.5	99.2	98.4	96.4	92.3	86.6	80.1	73.9	67.5	30.6	2.0	0.14	0.02	0.01	24.7
R205 Wading Depth	100.0	100.0	98.5	98.5	98.1	97.4	95.2	90.5	83.8	76.1	68.2	50.3	14.9	1.2	0.07	0.04	0.02	29.8
S01	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1.9
S11	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	18.3
B2	100.0	100.0	99.7	99.4	99.2	98.5	97.6	96.7	96.2	95.6	95.0	94.4	92.2	55.4	12.4	1.6	0.40	7.2
S05	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.4	97.6	47.3	10.5	0.7	0.09	1.6
S07	100.0	100.0	100.0	100.0	99.9	99.8	99.6	99.4	99.3	99.1	99.0	98.9	98.3	76.4	13.7	0.9	0.13	1.8

Ellis & Associates Inc.

SUMMARY OF GRADATION TEST RESULTS
(Post-Calcium Carbonate Removed)

Project: Summer Haven
Client: Taylor Engineering, Inc.
Project No.: 0405-0020

	GRADATION TESTS Percent Passing , %																
Sample No.	3/4"	5/8"	No. 3.5	No. 4	No. 5	No. 7	No. 10	No. 14	No. 18	No. 25	No. 35	No. 45	No. 60	No. 80	No. 120	No. 170	No. 230
R205 Mid Berm	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.6	96.1	81.9	53.0	15.6	1.23	0.18	0.08
R205 Dune Toe	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.9	99.6	97.5	89.5	70.4	31.0	2.8	0.18	0.09
R205 Dune Veg	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.5	96.8	88.2	70.4	30.3	2.5	0.28	0.17
R205 Intertidal Zone	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	99.0	96.1	91.5	78.9	25.3	1.67	0.26	0.14
R205 Wading Depth	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.0	94.9	87.5	73.3	30.1	2.24	0.13	0.11
B2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7	99.3	97.5	73.5	13.9	1.45	0.24
S05	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.7	97.9	58.2	10.8	0.62	0.05
S07	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.8	99.0	82.5	13.2	0.75	0.01



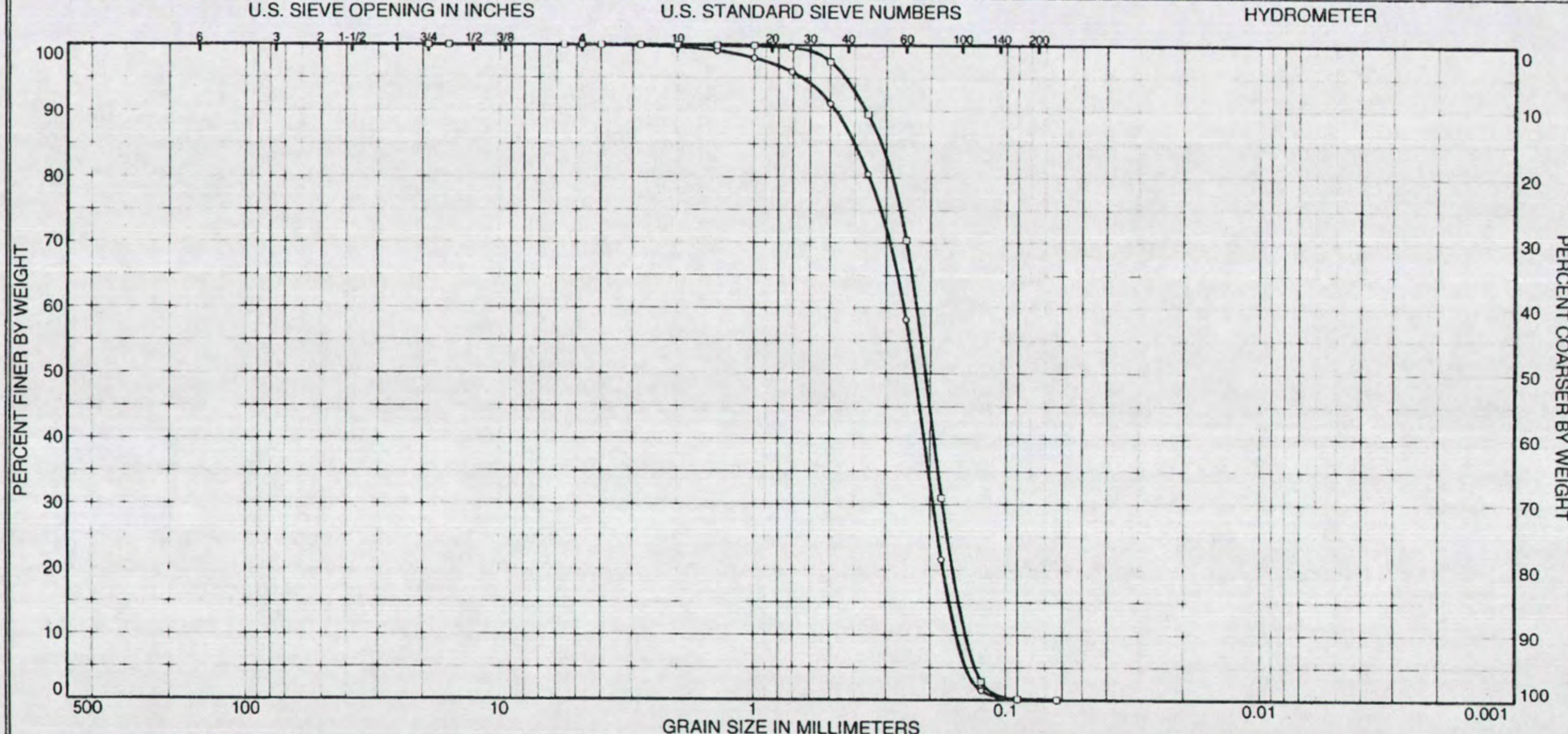
	LOCATION	SOURCE	SAMPLE #	DEPTH/ELEV.	MATERIAL DESCRIPTION
○	R205 Mid Berm, Pre-Calcium Carbonate Removed				Calcium Carbonate Content = 22.6%
□	R205 Mid Berm, Post-Calcium Carbonate Removed				

Project No. 0405-0020 **Client** Taylor Engineering, Inc.

Particle Size Distribution Report

Summer Haven

Ellis & Associates, Inc.



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

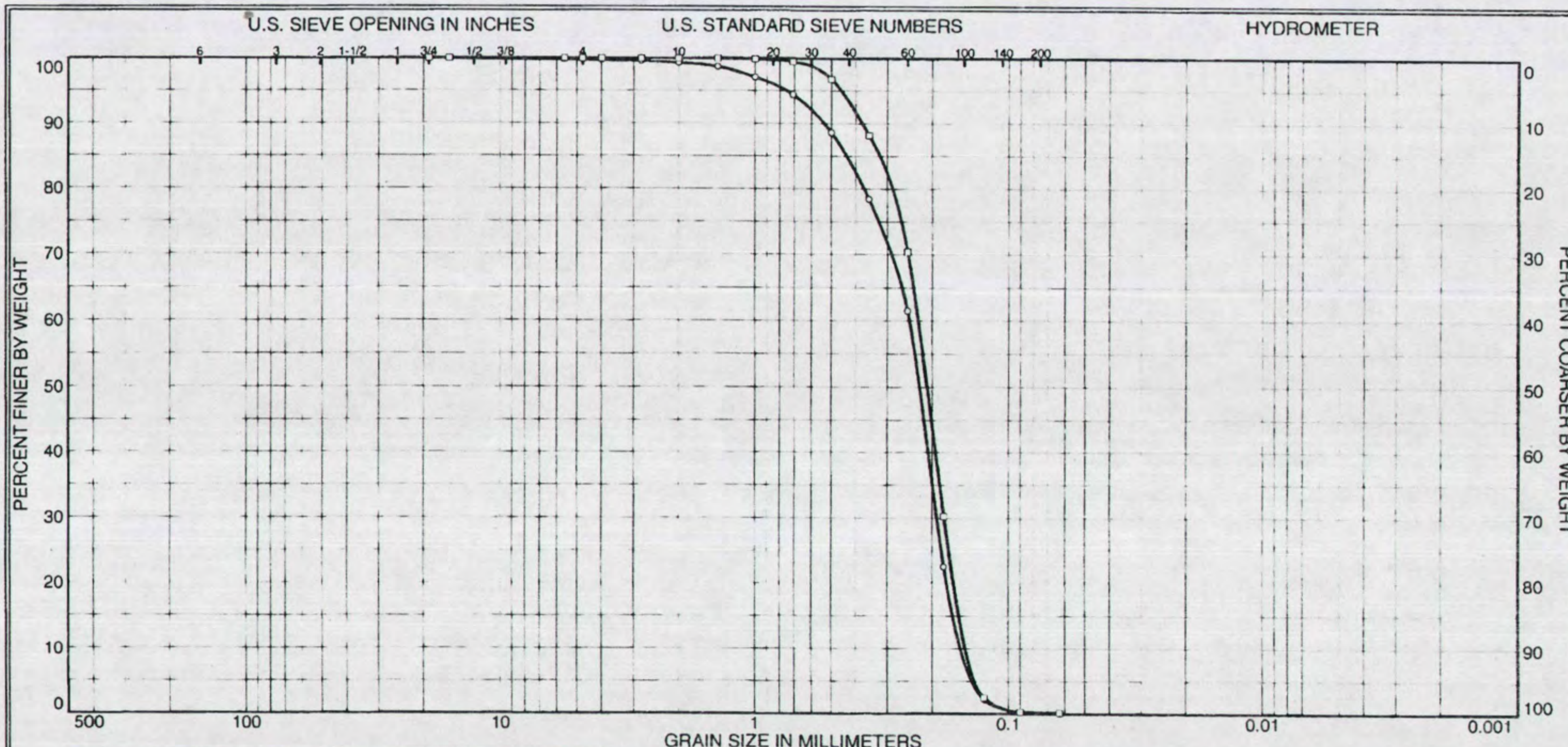
	LOCATION	SOURCE	SAMPLE #	DEPTH/ELEV.	MATERIAL DESCRIPTION
○	R205 Dune Toe, Pre-Calcium Carbonate Removed				Calcium Carbonate Content = 11.1%
□	R205 Dune Toe, Post-Calcium Carbonate Removed				

Project No. 0405-0020 **Client** Taylor Engineering, Inc.

Particle Size Distribution Report

Summer Haven

Ellis & Associates, Inc.



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

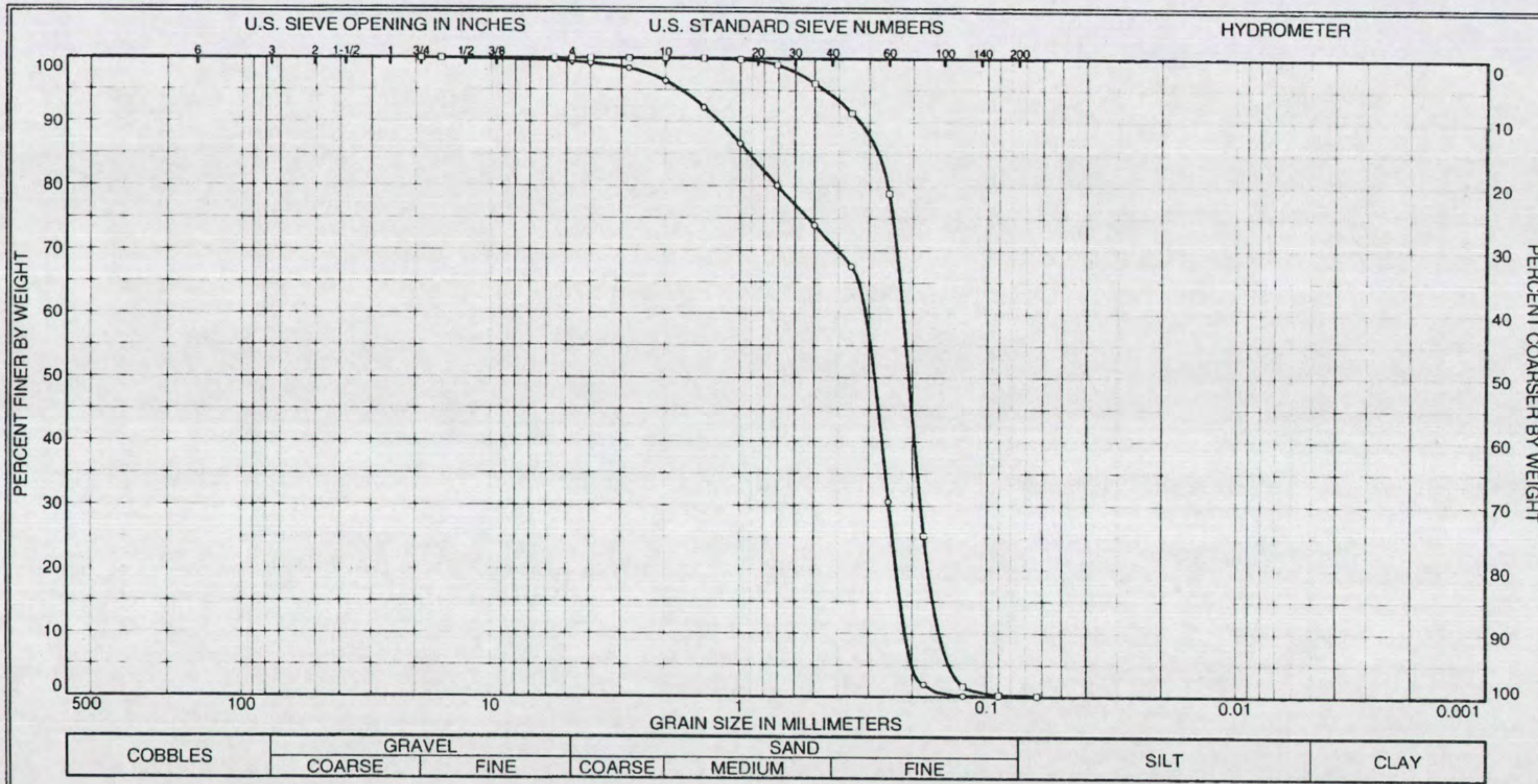
	LOCATION	SOURCE	SAMPLE #	DEPTH/ELEV.	MATERIAL DESCRIPTION
○	R205 Dune Veg, Pre-Calcium Carbonate Removed				Calcium Carbonate Content = 12.9%
□	R205 Dune Veg, Post-Calcium Carbonate Removed				

Project No. 0405-0020 **Client** Taylor Engineering, Inc.

Particle Size Distribution Report

Summer Haven

Ellis & Associates, Inc.



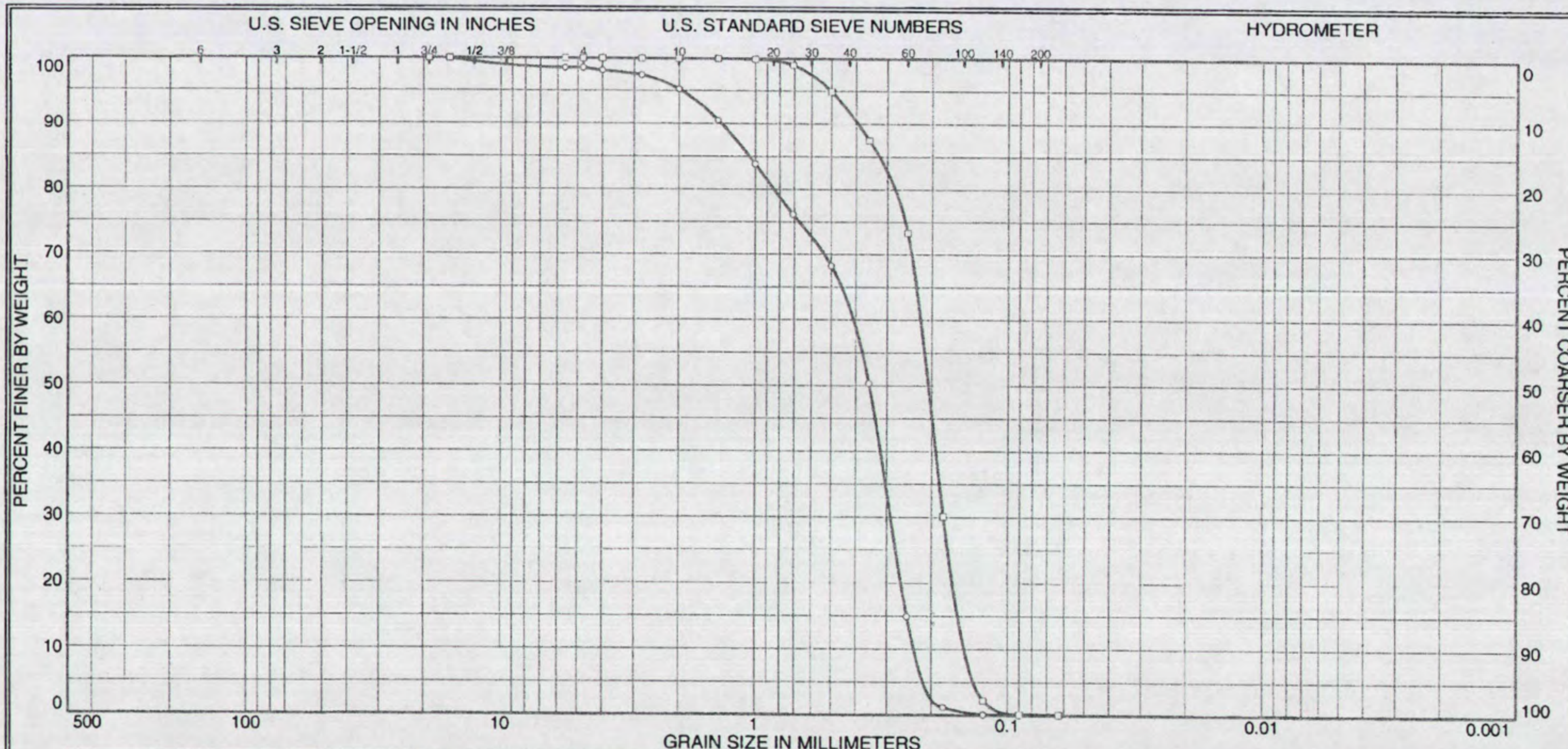
	LOCATION	SOURCE	SAMPLE #	DEPTH/ELEV.	MATERIAL DESCRIPTION
○	R205 Intertidal Zone, Pre-Calcium Carbonate				Calcium Carbonate Content = 24.7%
□	R205 Intertidal Zone, Post-Calcium Carbonate				

Project No. 0405-0020 **Client** Taylor Engineering, Inc.

Particle Size Distribution Report

Summer Haven

Ellis & Associates, Inc.



COBBLES	GRAVEL		SAND			SILT	CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE		

	LOCATION	SOURCE	SAMPLE #	DEPTH/ELEV.	MATERIAL DESCRIPTION
○	R205 Wading Depth, Pre-Calcium Carbonate				Calcium Carbonate Content = 29.8%
□	R205 Wading Depth, Post-Calcium Carbonate				

Project No. 0405-0020 **Client** Taylor Engineering, Inc.

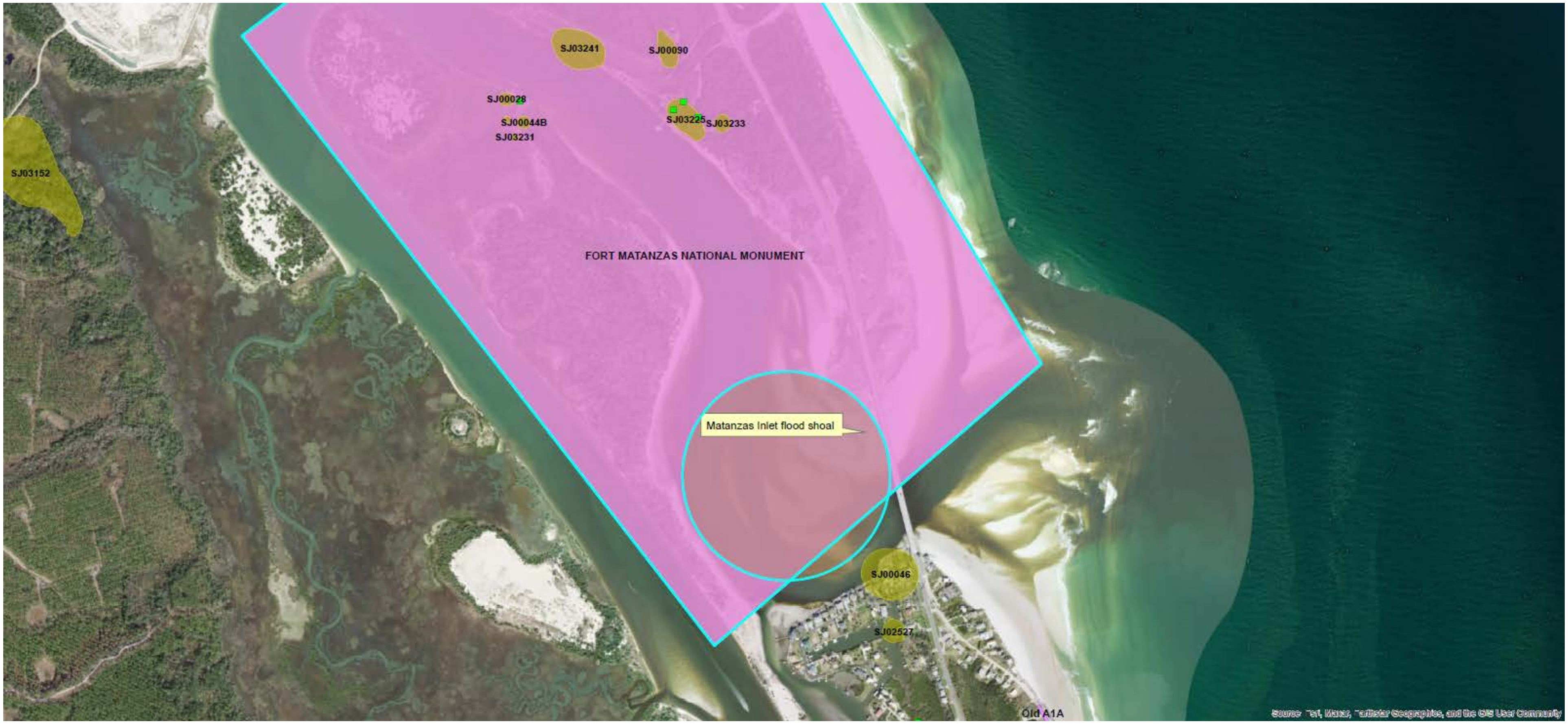
Particle Size Distribution Report

Summer Haven

Ellis & Associates, Inc.

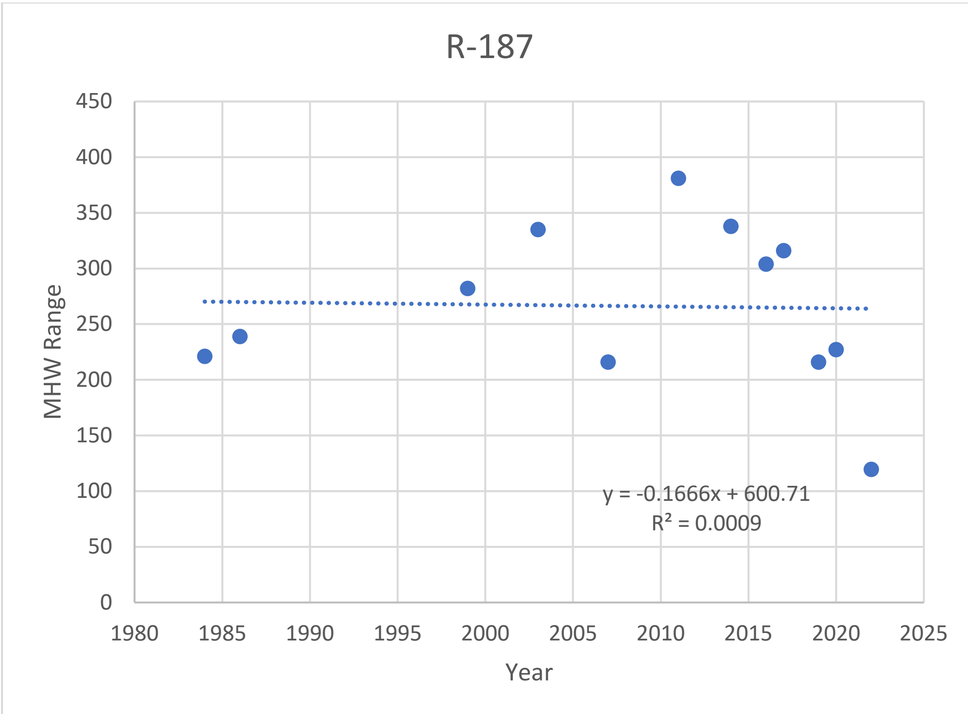
Appendix H

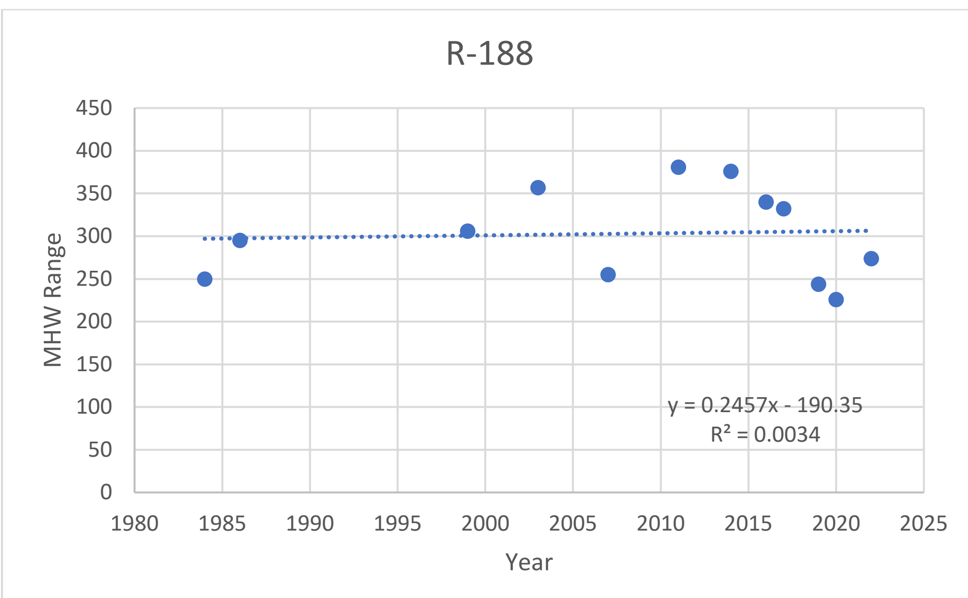
Existing Cultural Resources

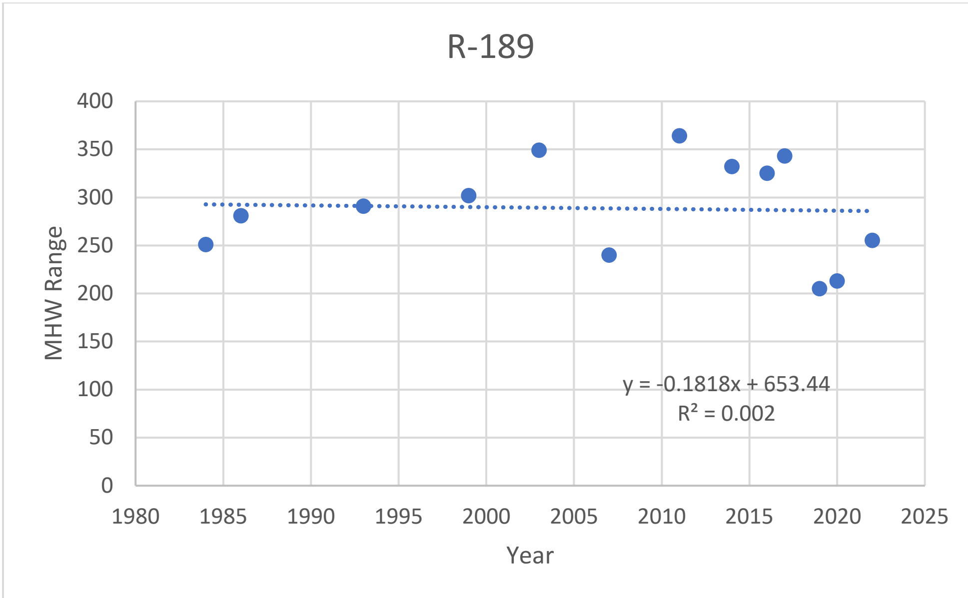

SJ03241
SJ00090
SJ00028
SJ00044B
SJ03231
SJ03225
SJ03233
SJ03152
FORT MATANZAS NATIONAL MONUMENT
Matanzas Inlet flood shoal
SJ00046
SJ02527
Old A1A

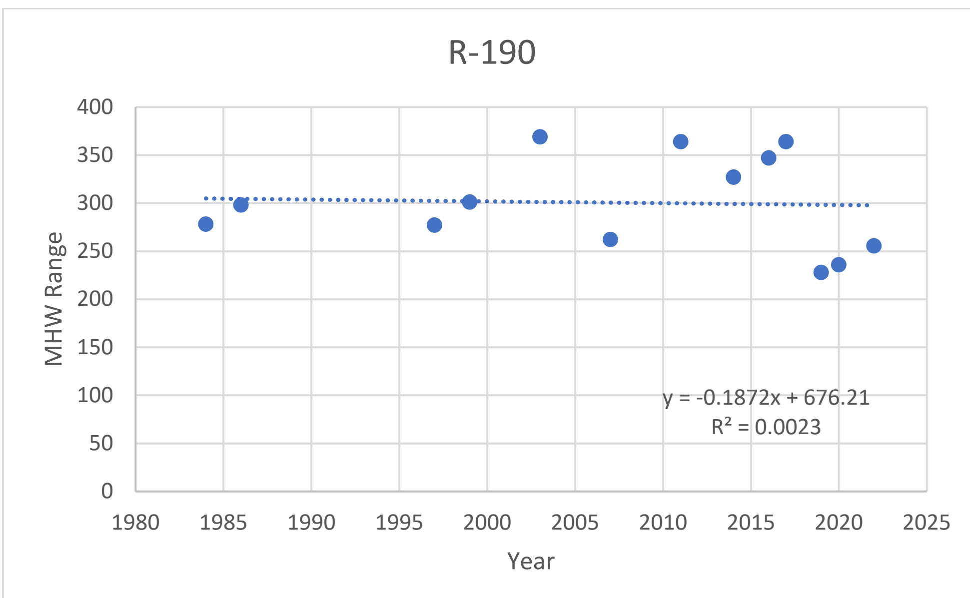
Appendix I

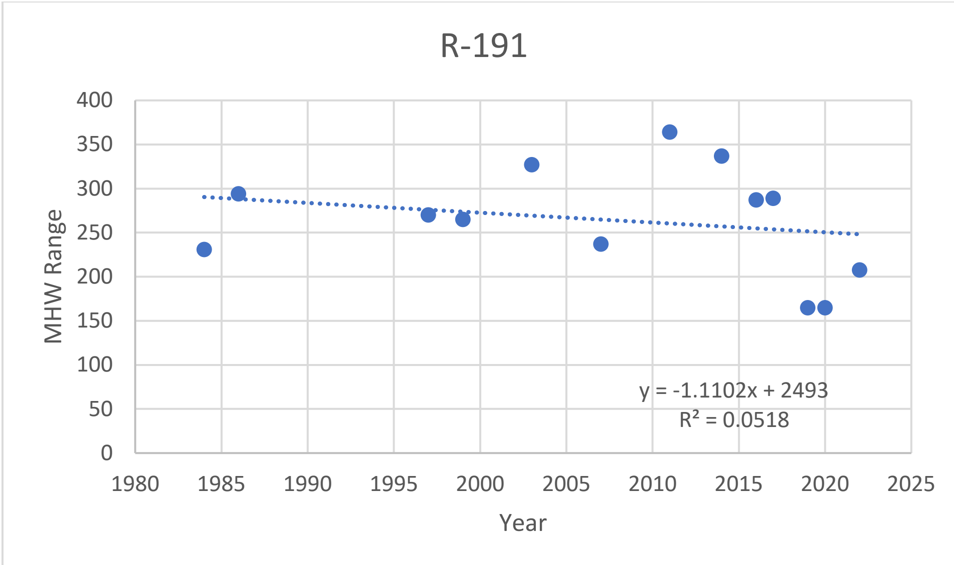
Historical Shoreline Change Trend Plots

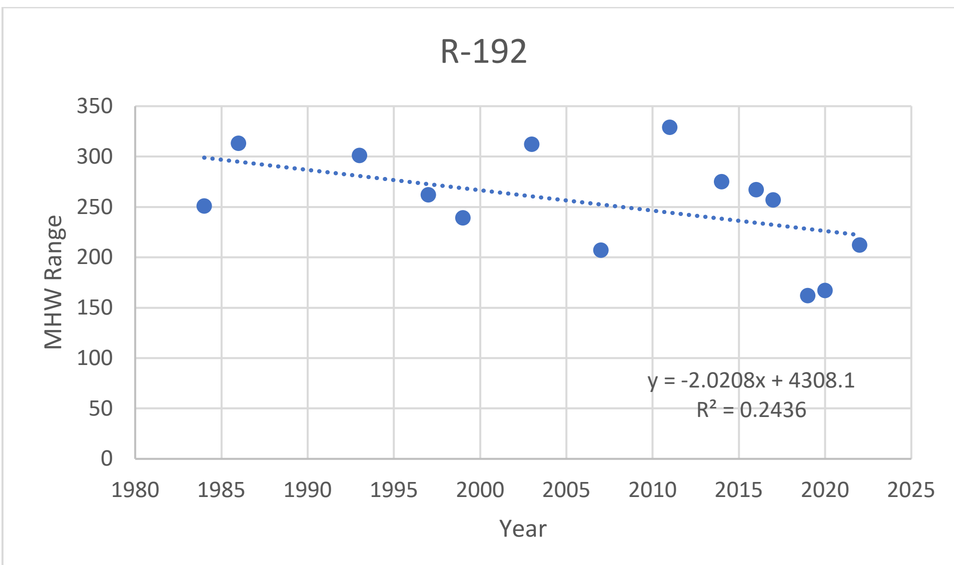

R-187
MHW Range
450
400
350
300
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
y = -0.1666x + 600.71
R² = 0.0009

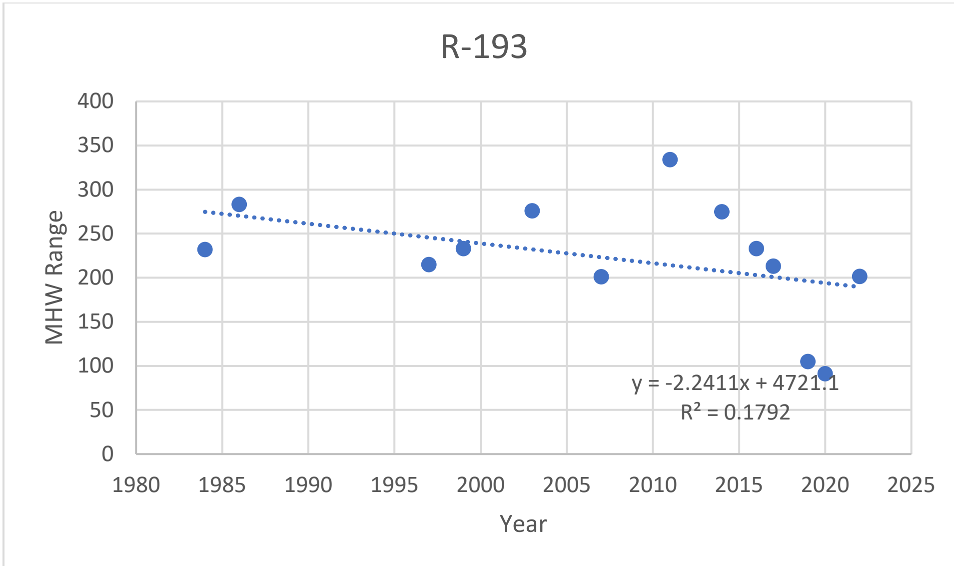

R-188
MHW Range
450
400
350
300
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
y = 0.2457x - 190.35
R² = 0.0034

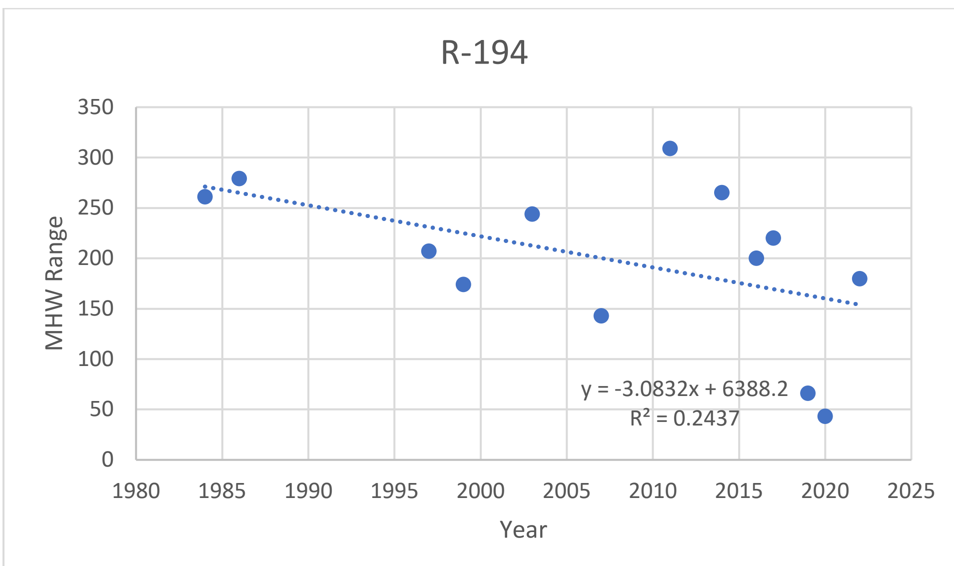

R-189
MHW Range
400
350
300
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
y = -0.1818x + 653.44
R² = 0.002

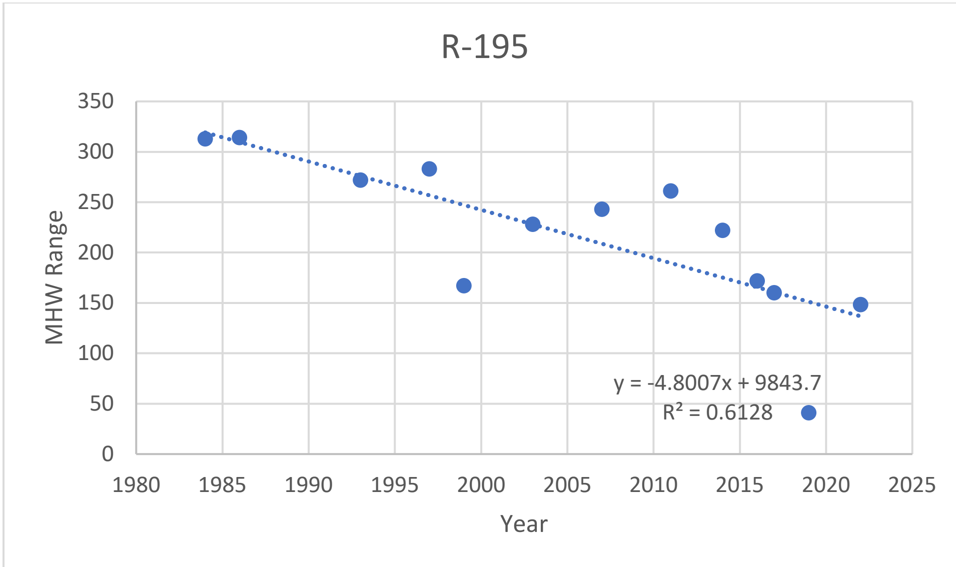

R-190
MHW Range
400
350
300
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
y = -0.1872x + 676.21
R² = 0.0023

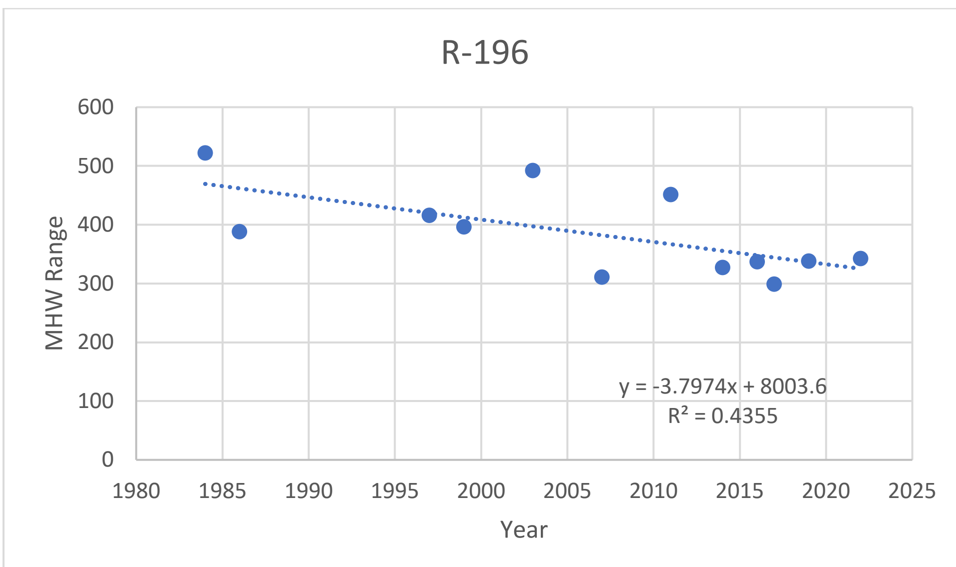

R-191
400
350
300
250
200
150
100
50
0
MHW Range
y = -1.1102x + 2493
R² = 0.0518
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

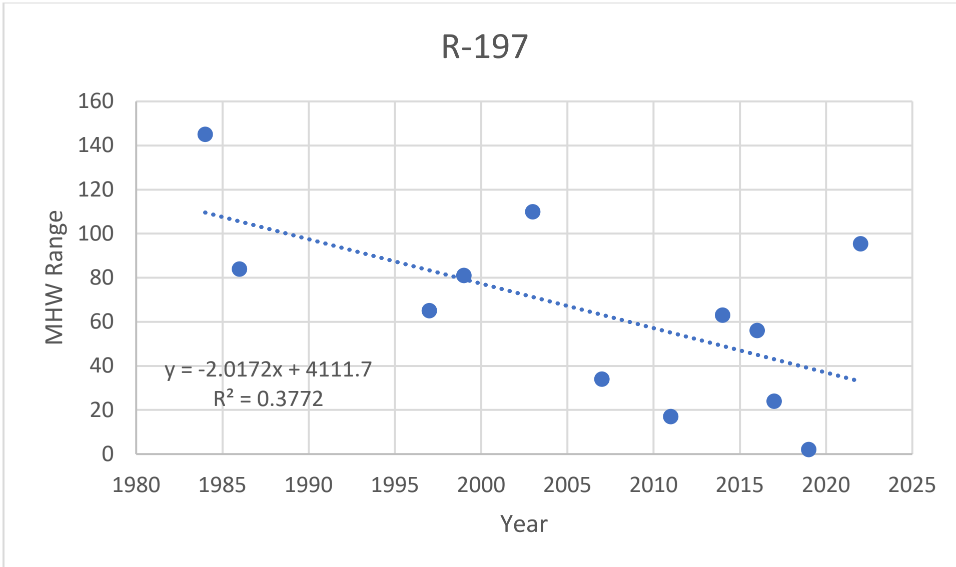

R-192
350
300
250
200
150
100
50
0
MHW Range
y = -2.0208x + 4308.1
R² = 0.2436
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

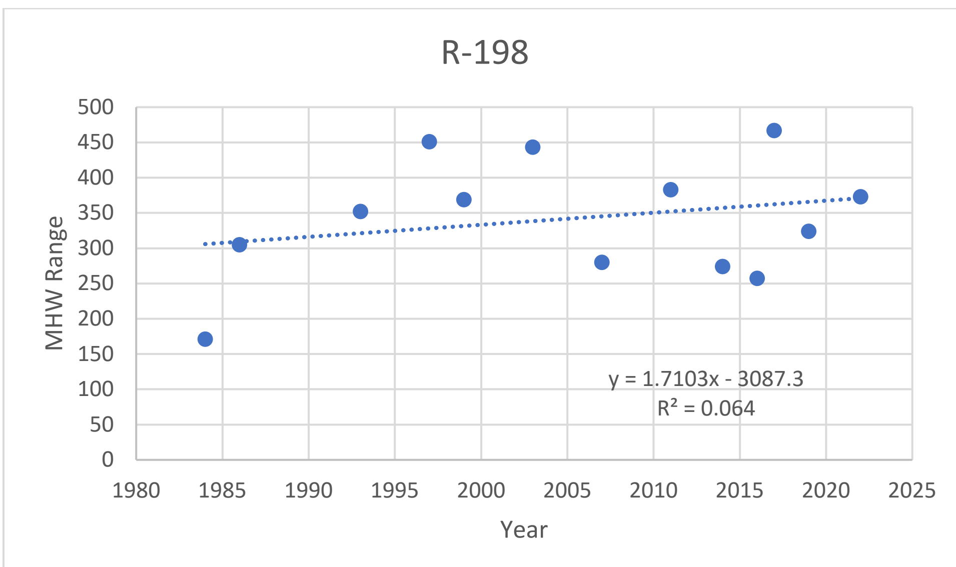

R-193
400
350
300
250
200
150
100
50
0
MHW Range
y = -2.2411x + 4721.1
R² = 0.1792
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

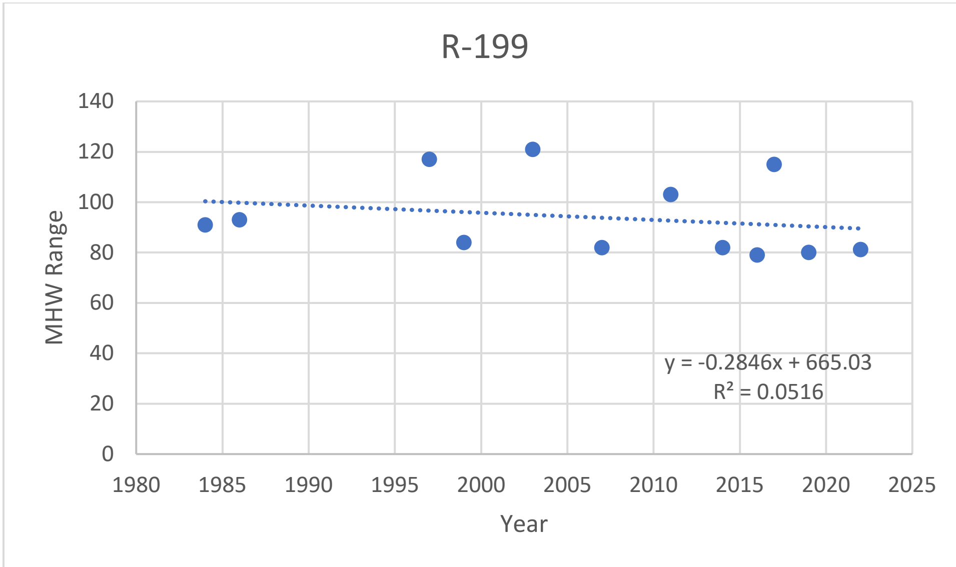

R-194
350
300
250
200
150
100
50
0
MHW Range
y = -3.0832x + 6388.2
R² = 0.2437
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

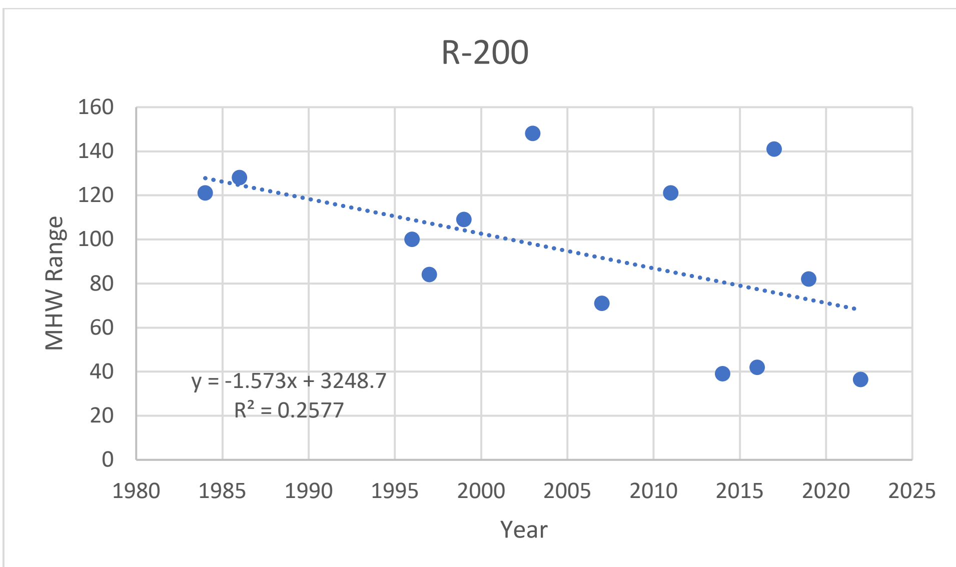

R-195
350
300
250
200
150
100
50
0
MHW Range
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
y = -4.8007x + 9843.7
R² = 0.6128

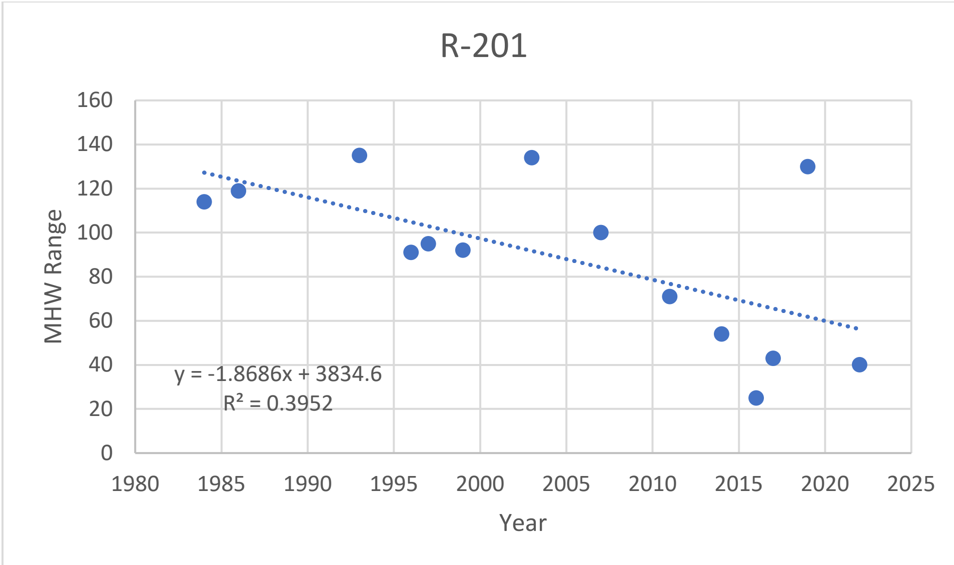

R-196
600
500
400
300
200
100
0
MHW Range
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
y = -3.7974x + 8003.6
R² = 0.4355

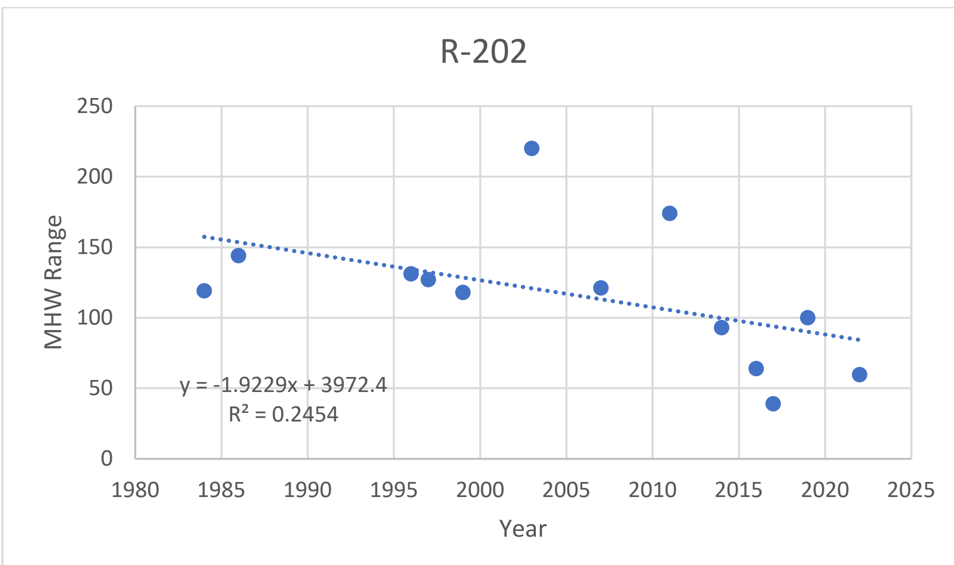

R-197
160
140
120
100
80
60
40
20
0
MHW Range
y = -2.0172x + 4111.7
R² = 0.3772
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

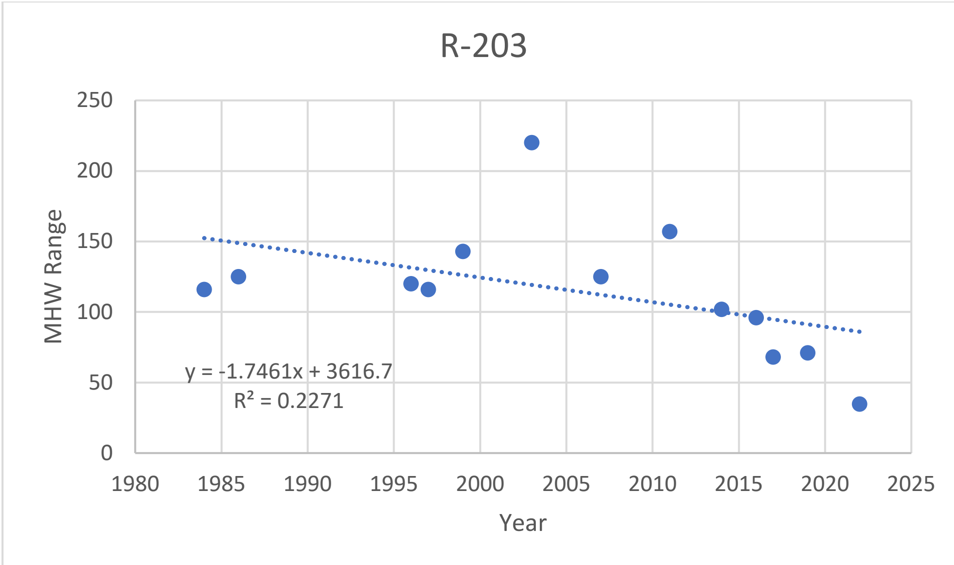

R-198
500
450
400
350
300
250
200
150
100
50
0
MHW Range
y = 1.7103x - 3087.3
R² = 0.064
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

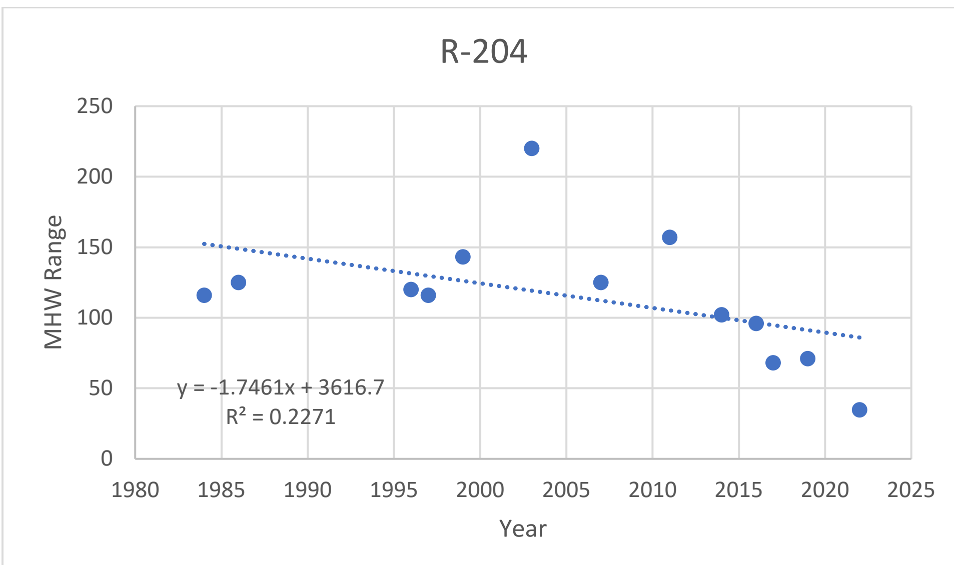

R-199
140
120
100
80
60
40
20
0
MHW Range
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
y = -0.2846x + 665.03
R² = 0.0516

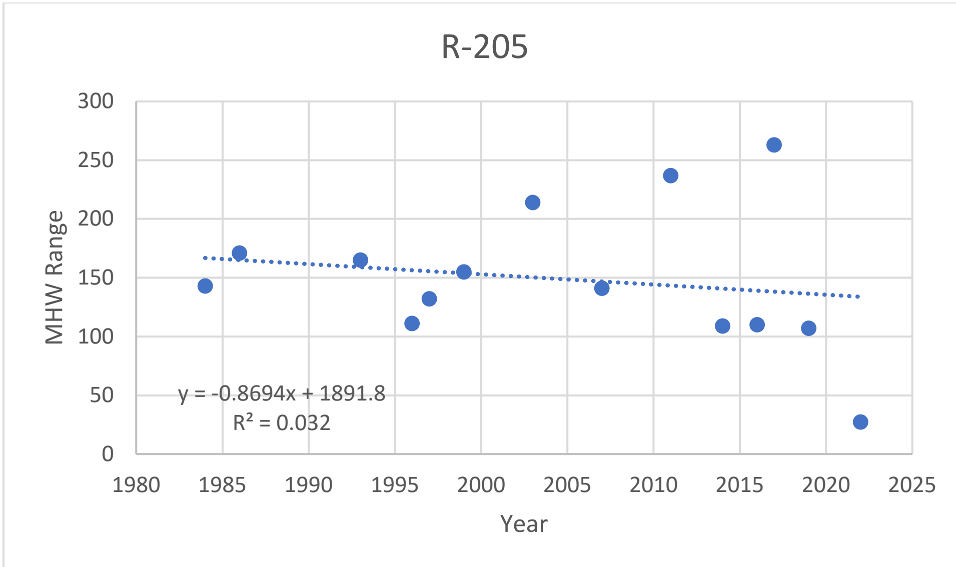

R-200
160
140
120
100
80
60
40
20
0
MHW Range
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year
y = -1.573x + 3248.7
R² = 0.2577

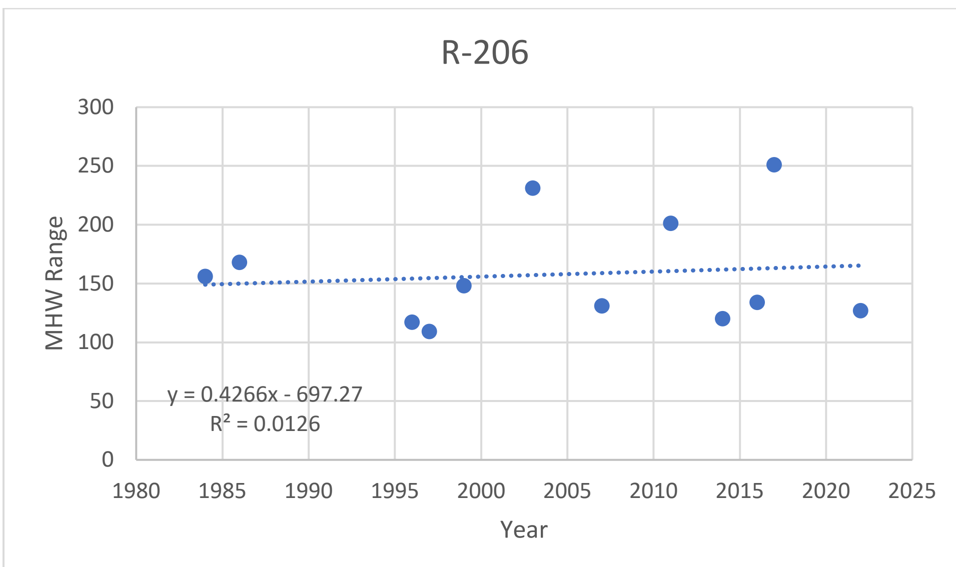

R-201
MHW Range
Year
y = -1.8686x + 3834.6
R² = 0.3952
160
140
120
100
80
60
40
20
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025

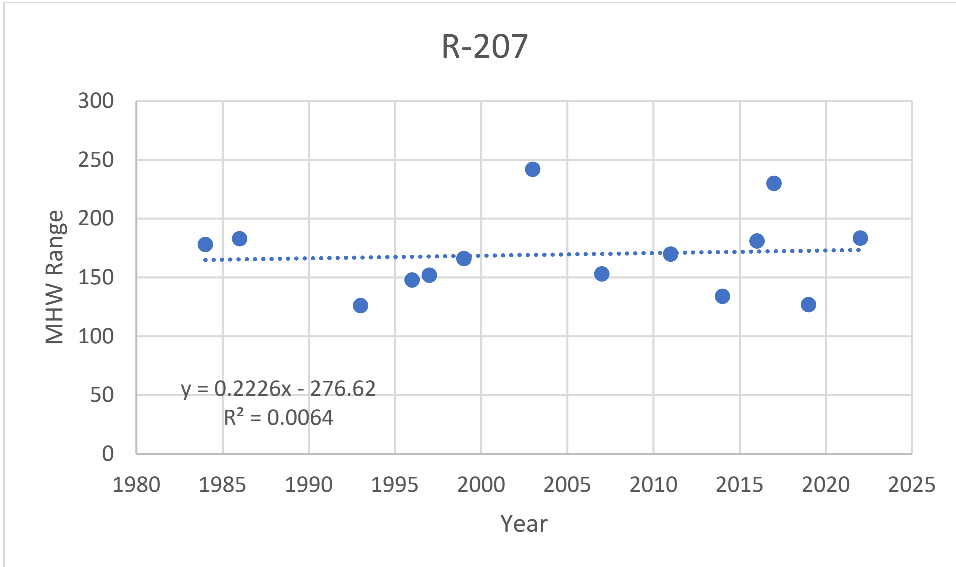

R-202
MHW Range
Year
y = -1.9229x + 3972.4
R² = 0.2454
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025

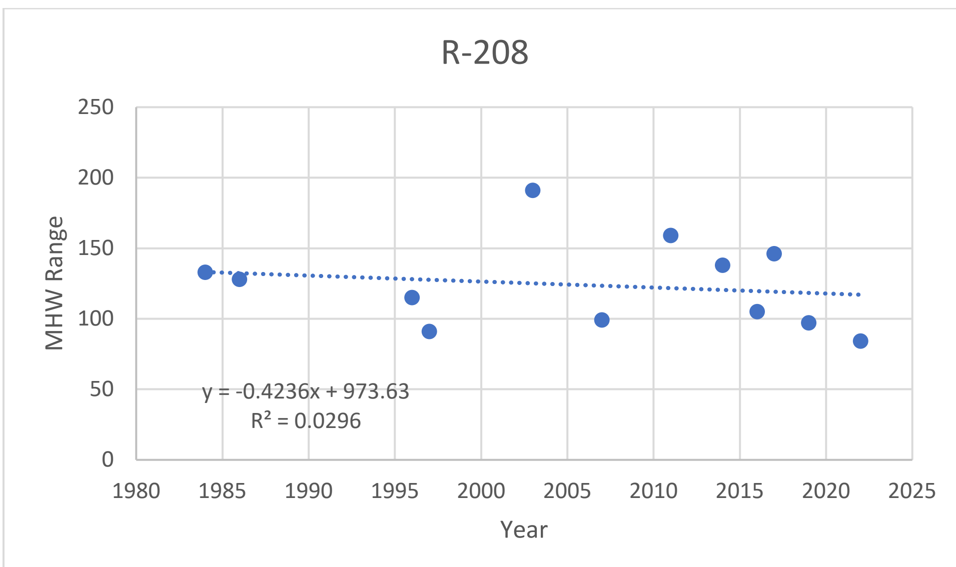

R-203
250
200
150
100
50
0
MHW Range
y = -1.7461x + 3616.7
R² = 0.2271
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

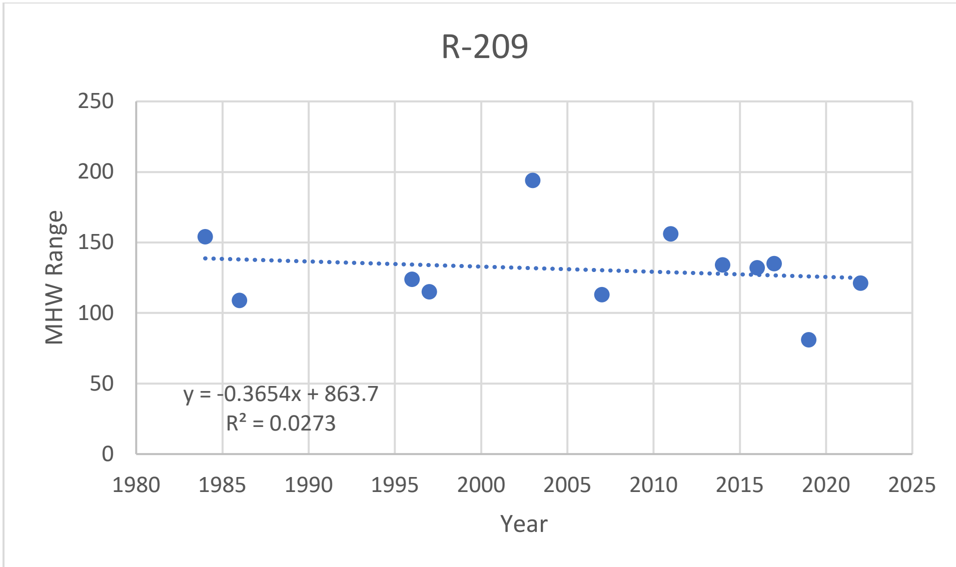

R-204
250
200
150
100
50
0
MHW Range
y = -1.7461x + 3616.7
R² = 0.2271
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year


R-205
300
250
200
150
100
50
0
MHW Range
y = -0.8694x + 1891.8
R² = 0.032
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year


R-206
300
250
200
150
100
50
0
MHW Range
y = 0.4266x - 697.27
R² = 0.0126
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

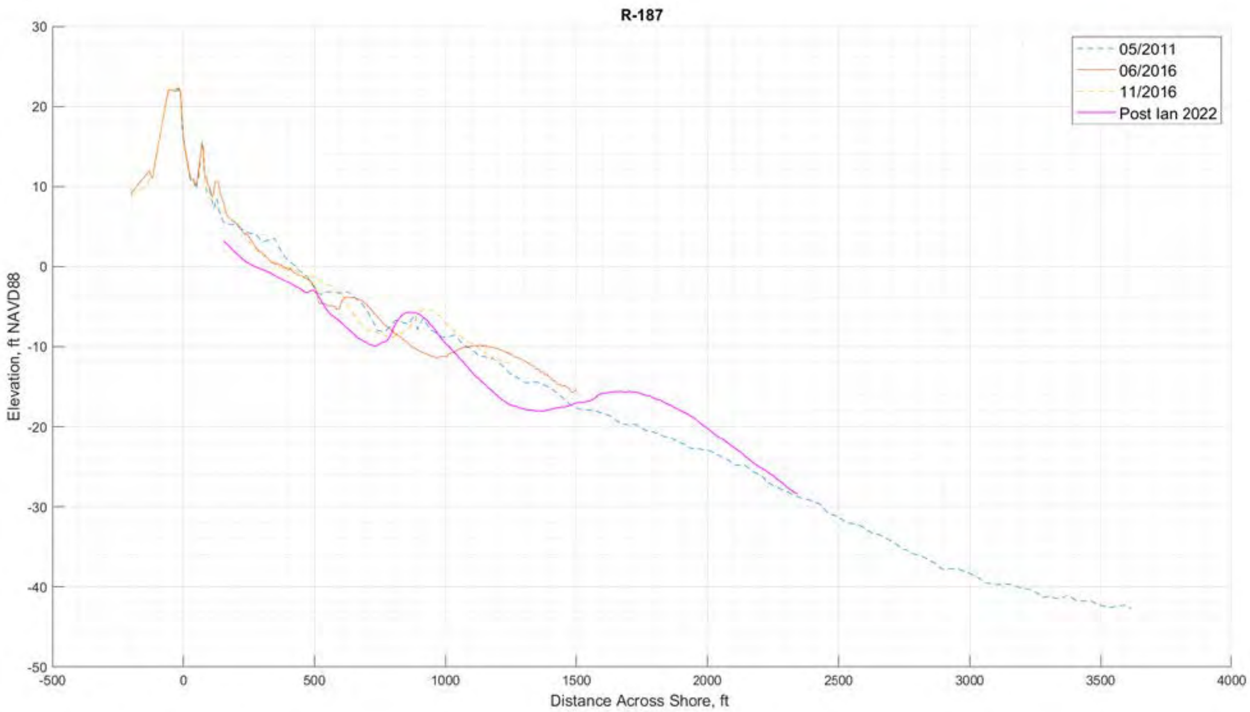

R-207
MHW Range
Year
300
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
y = 0.2226x - 276.62
R² = 0.0064

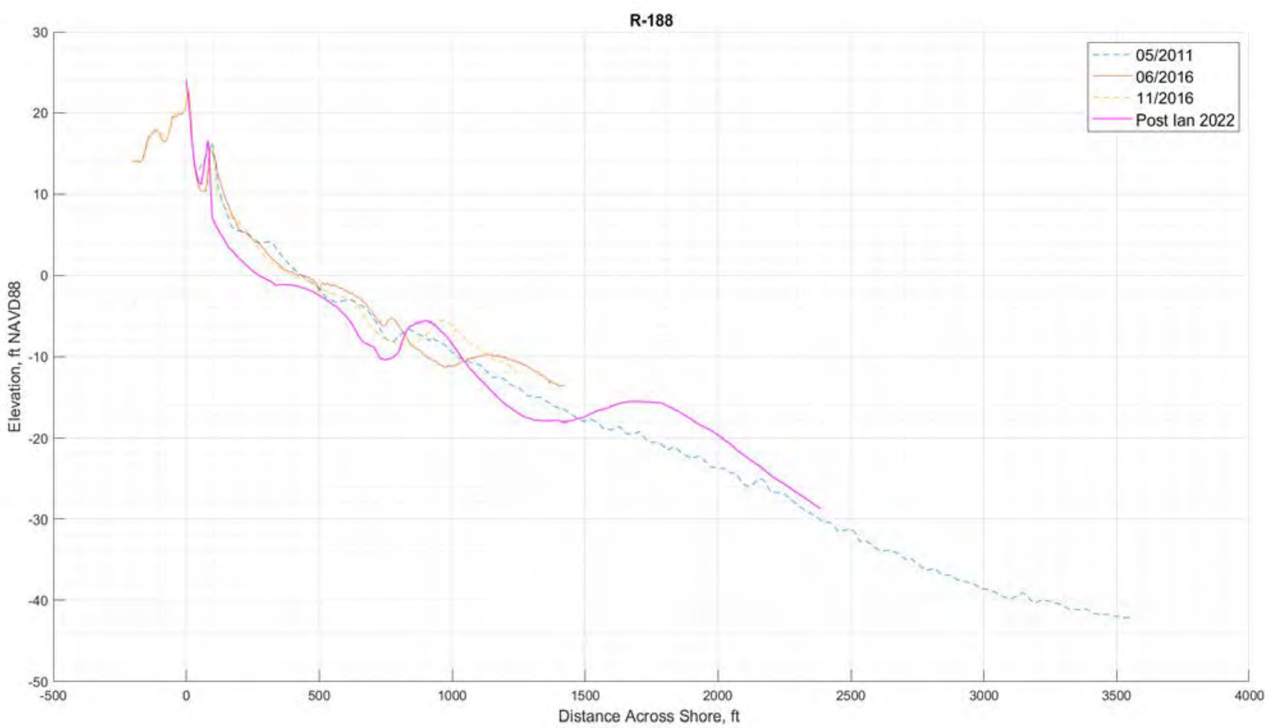

R-208
MHW Range
Year
250
200
150
100
50
0
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
y = -0.4236x + 973.63
R² = 0.0296

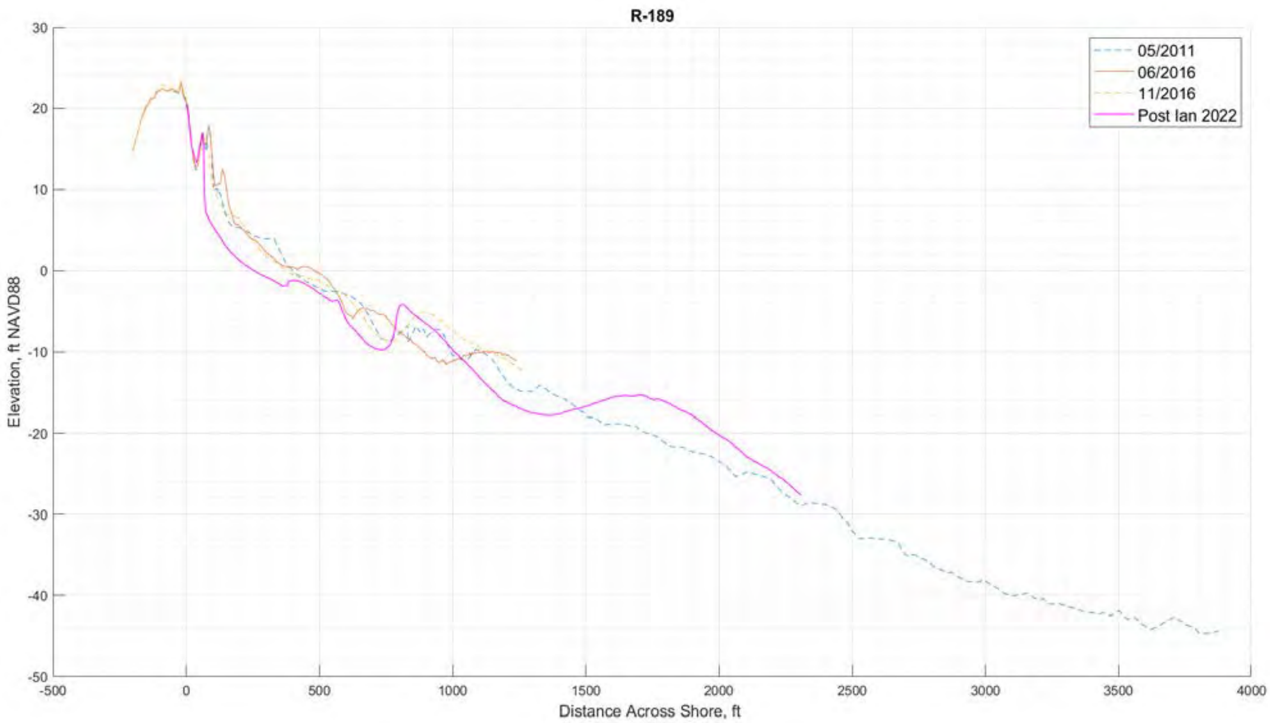

R-209
MHW Range
250
200
150
100
50
0
y = -0.3654x + 863.7
R² = 0.0273
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
Year

Appendix J

Representative Beach Profiles


R-187
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft


R-188
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft


R-189
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
30
20
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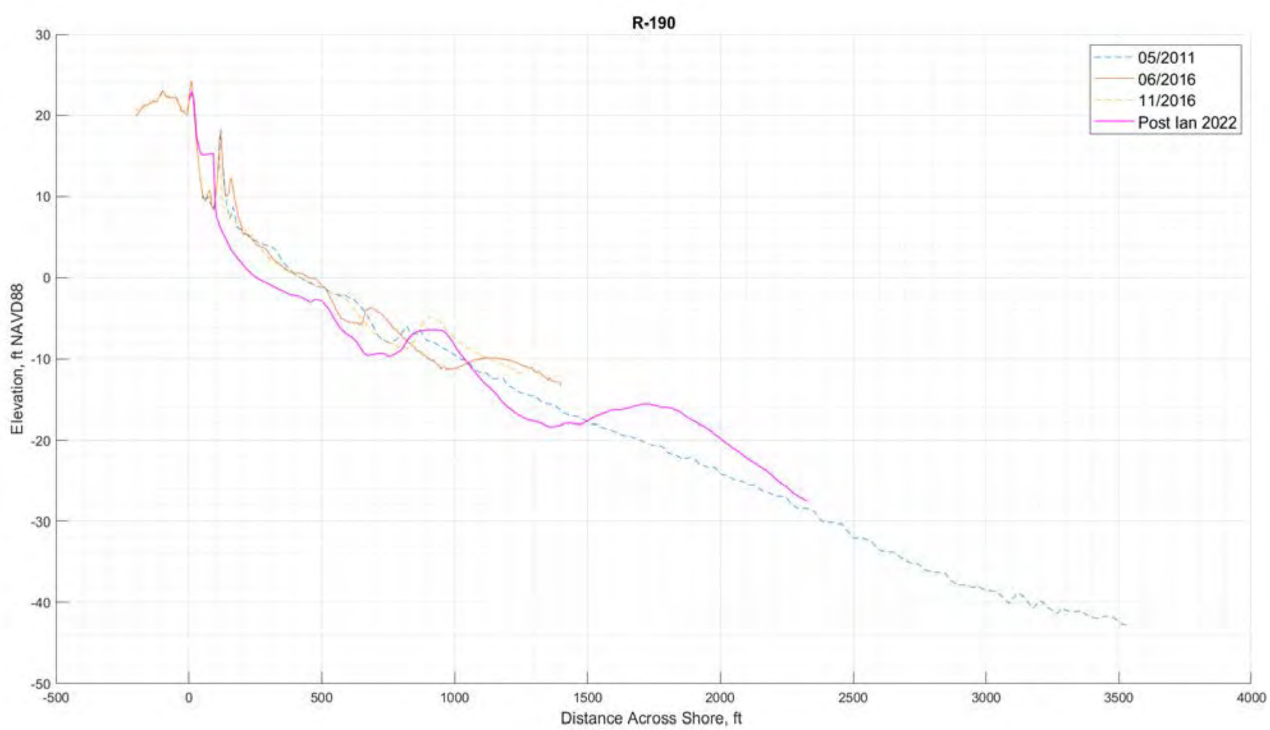
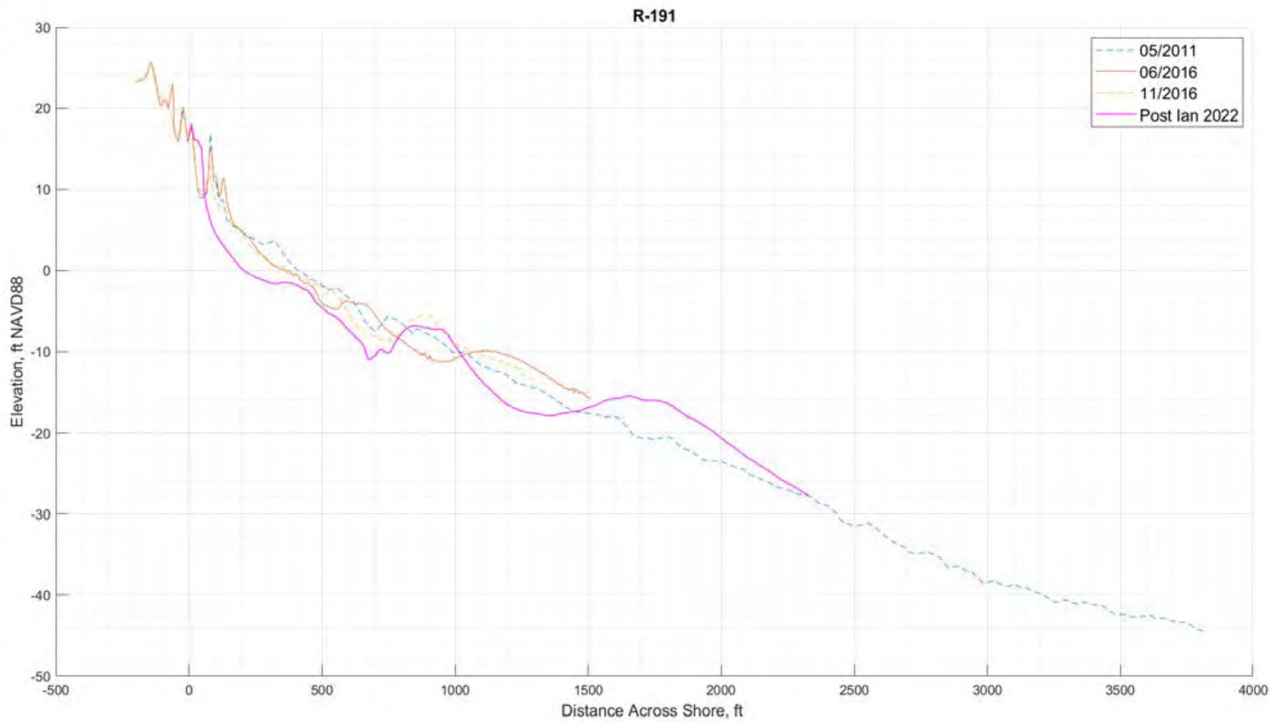
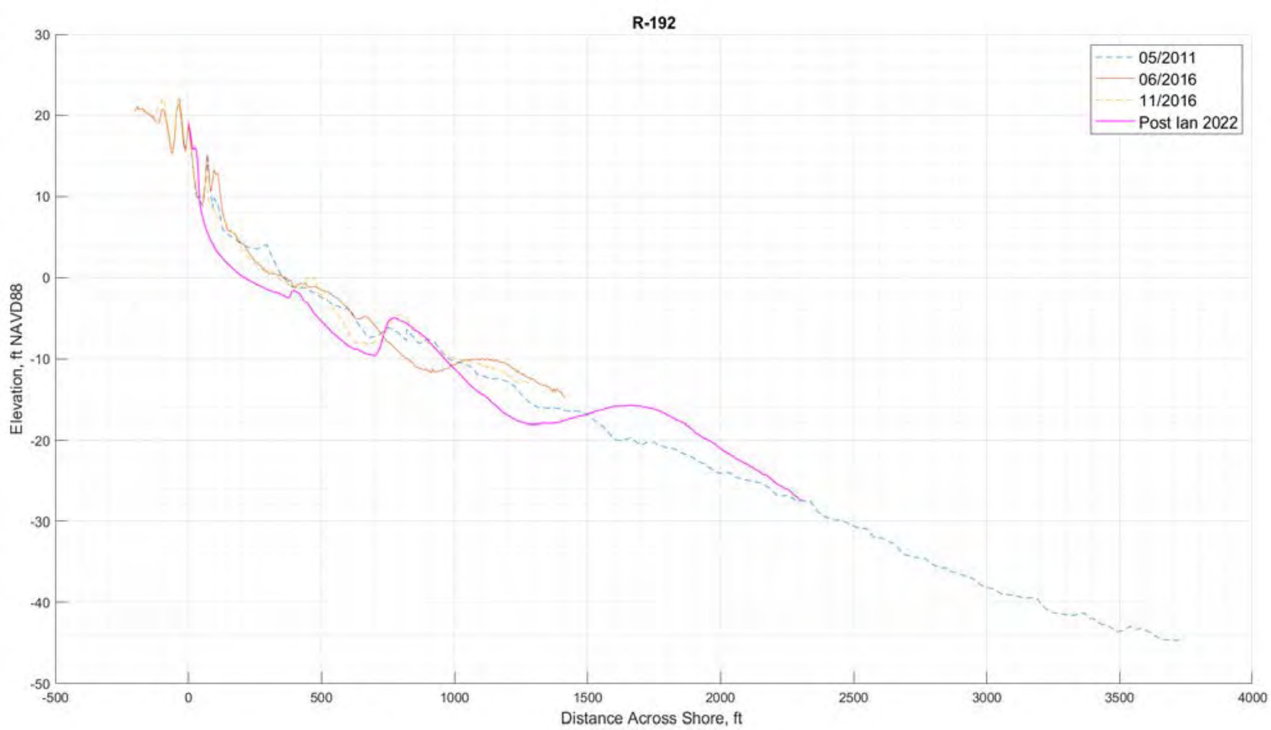
0
-10
-20
-30
-40
-50
-500
0
500
1000
1500
2000
2500
3000
3500
4000


R-190
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
30
20
10
0
-10
-20
-30
-40
-50
-500
0
500
1000
1500
2000
2500
3000
3500
4000


R-191
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
30
20
10
0
-10
-20
-30
-40
-50
-500
0
500
1000
1500
2000
2500
3000
3500
4000


R-192
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
30
20
10
0
-10
-20
-30
-40
-50
-500
0
500
1000
1500
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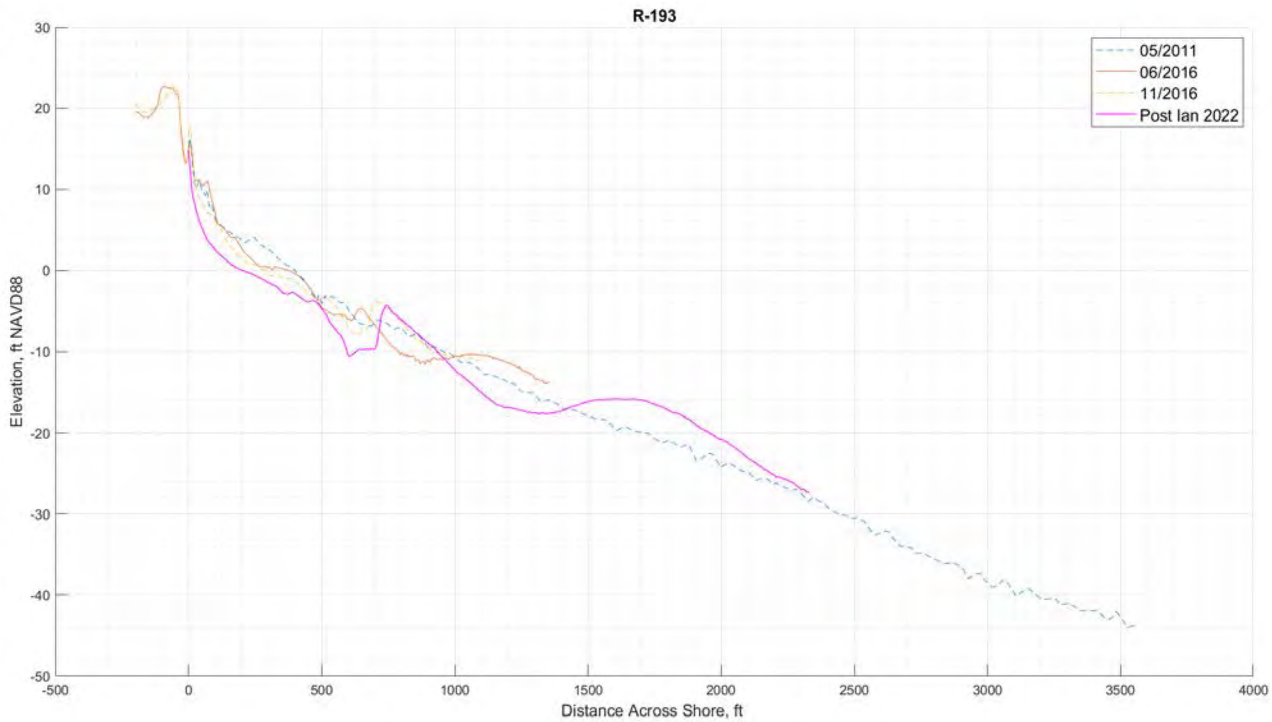
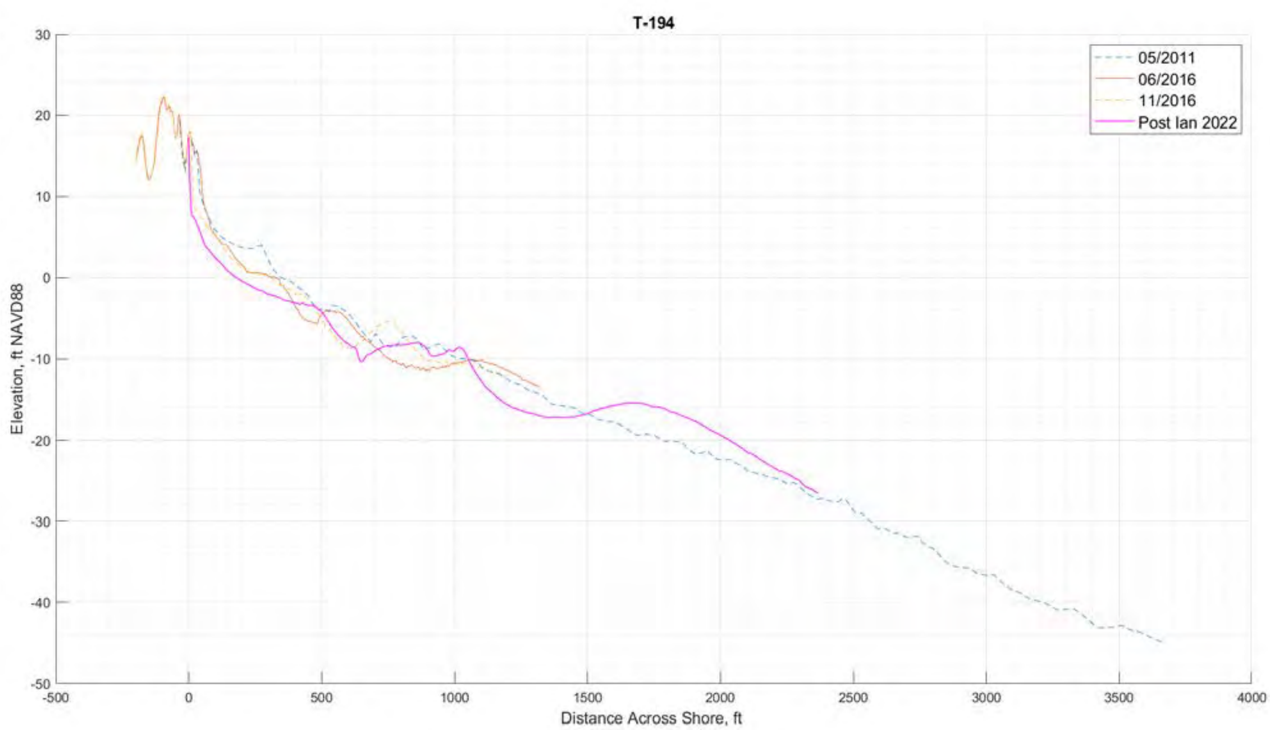
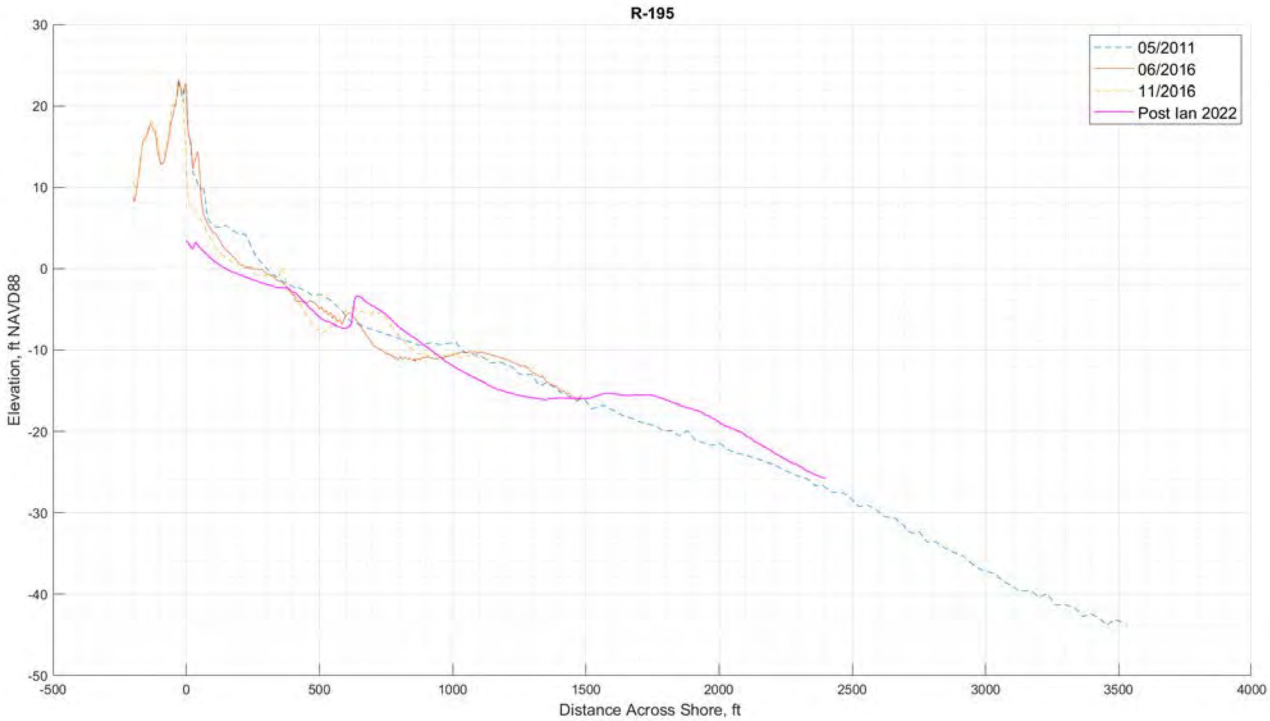
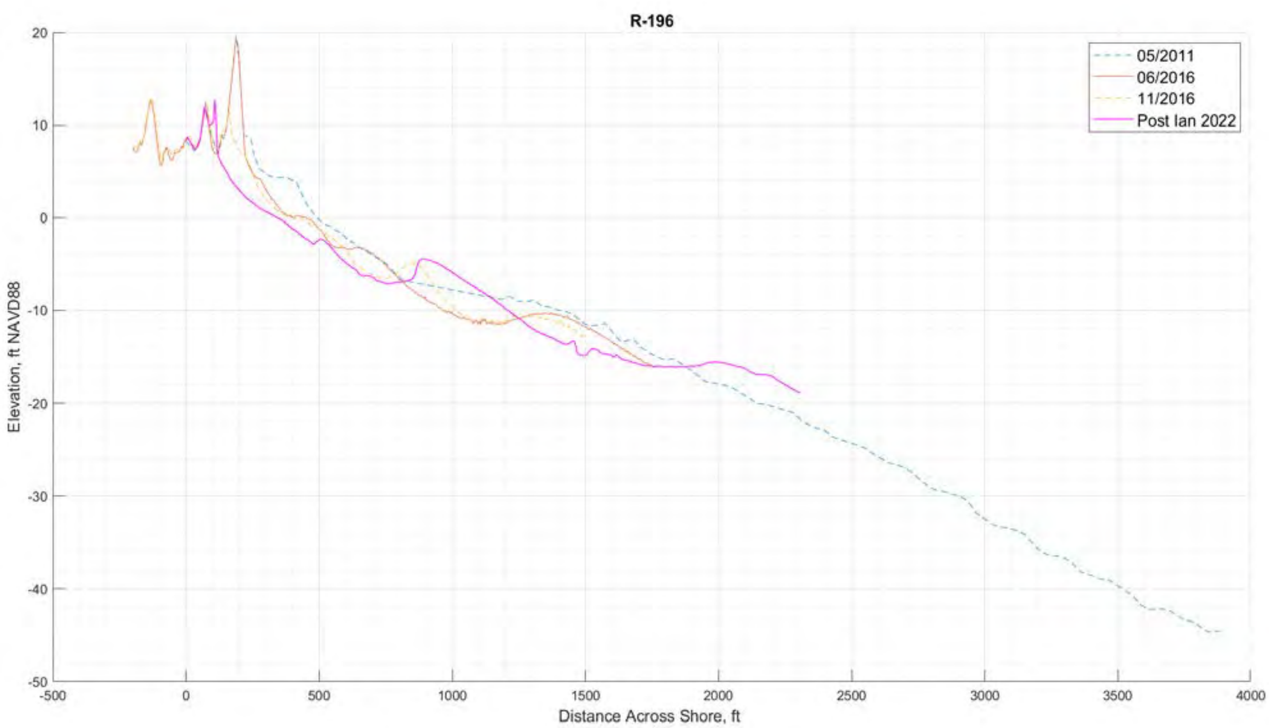
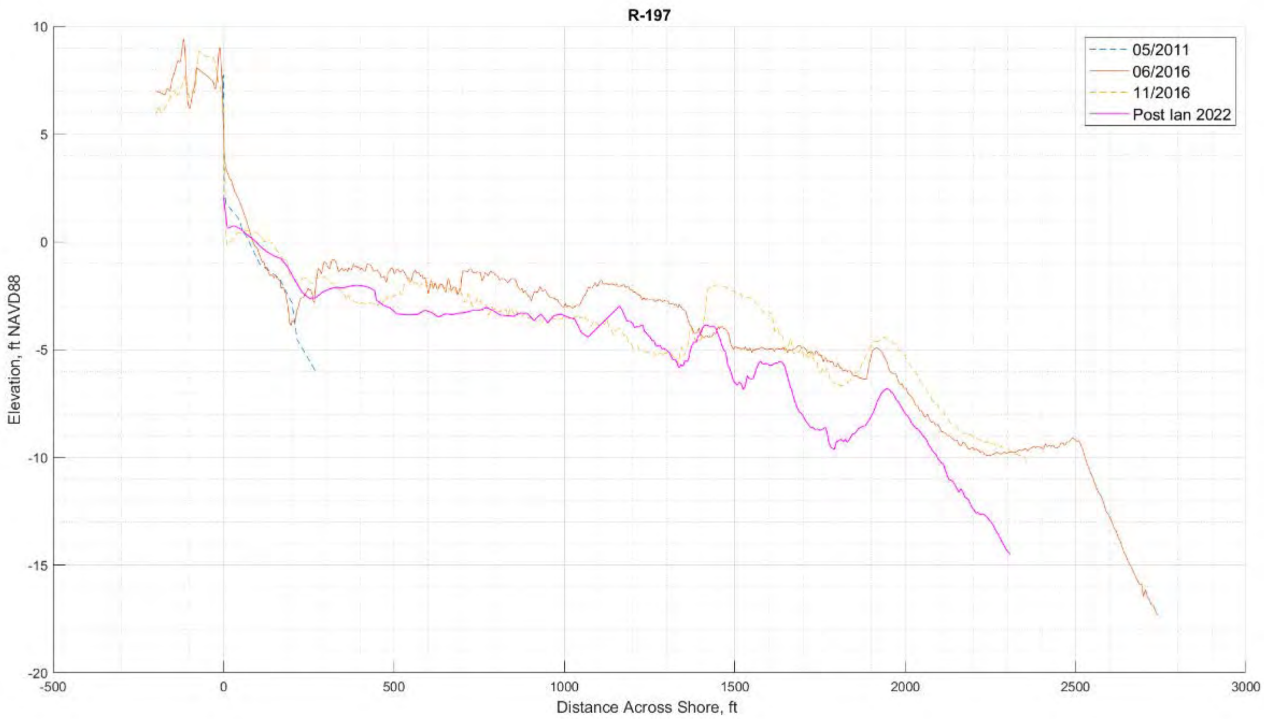
2500
3000
3500
4000


R-193
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft


T-194
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft


R-195
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
30
20
10
0
-10
-20
-30
-40
-50
-500
0
500
1000
1500
2000
2500
3000
3500
4000


R-196
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
20
10
0
-10
-20
-30
-40
-50
-500
0
500
1000
1500
2000
2500
3000
3500
4000


R-197
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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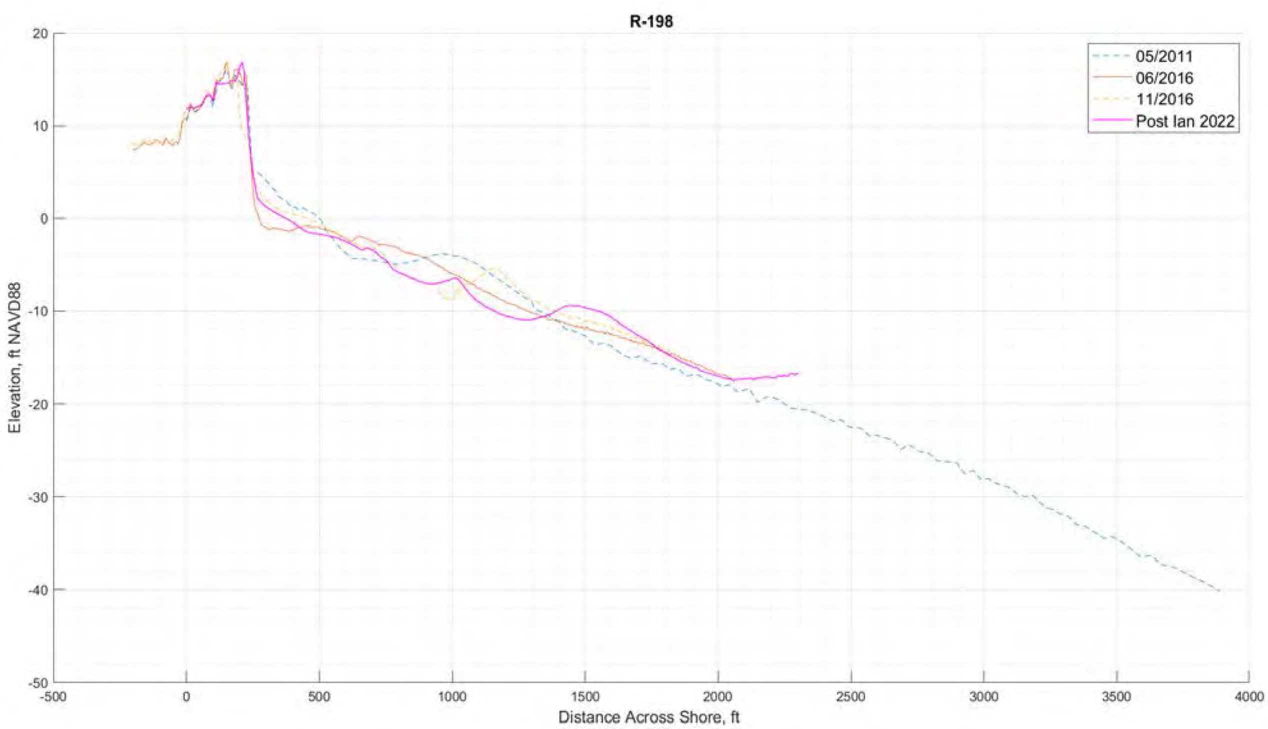
5
0
-5
-10
-15
-20
-500
0
500
1000
1500
2000
2500
3000


R-198
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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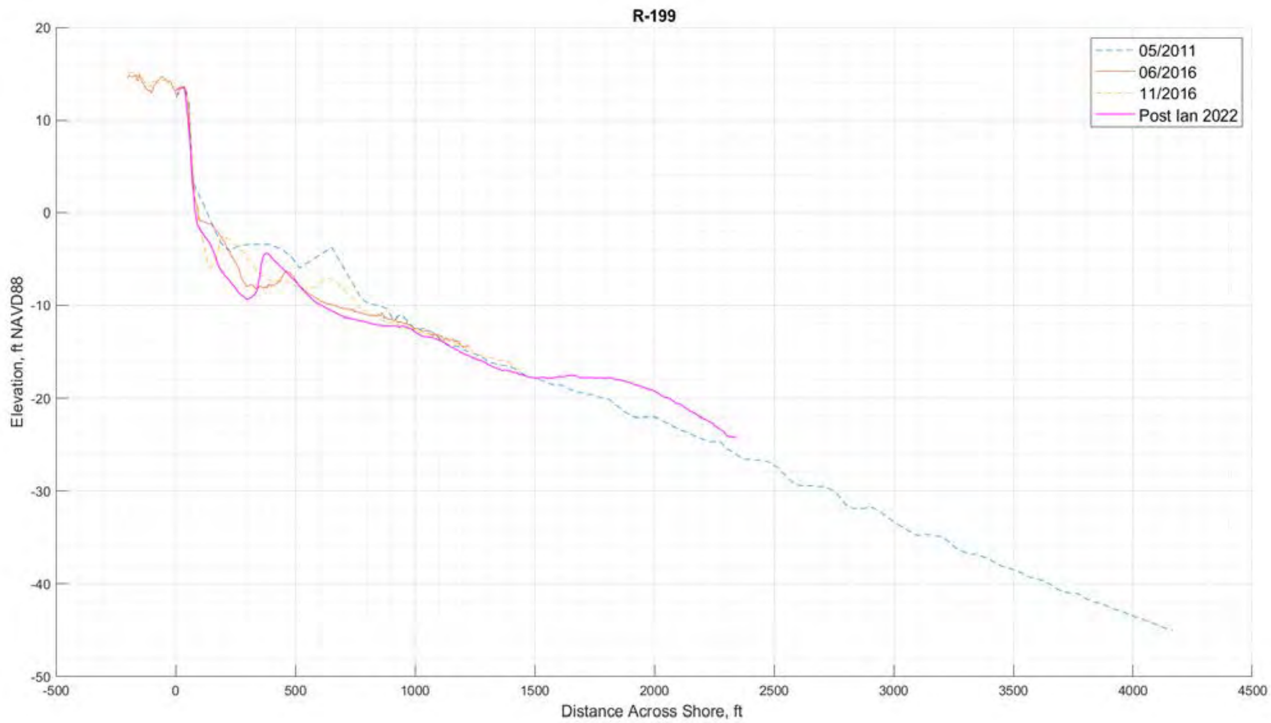
-10
-20
-30
-40
-50
-500
0
500
1000
1500
2000
2500
3000
3500
4000


R-199
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
20
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-10
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-30
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-500
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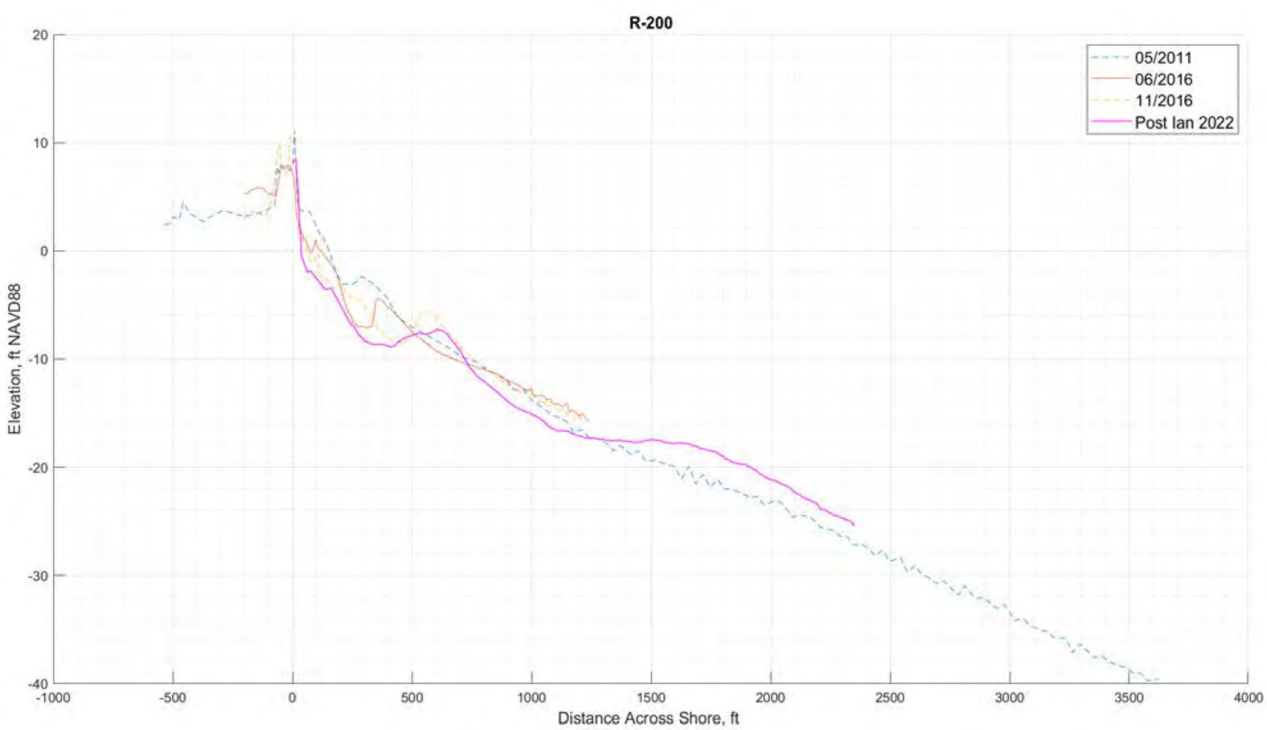
4500


R-200
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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3500
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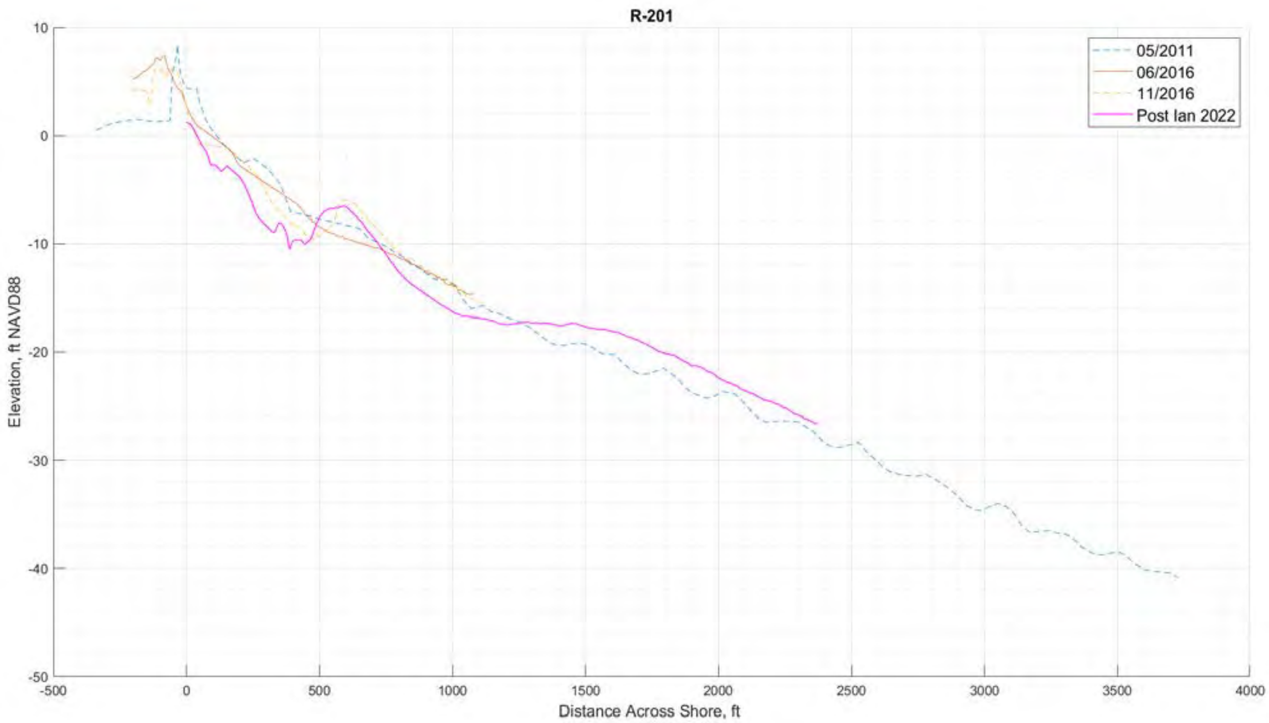
R-201
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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3500
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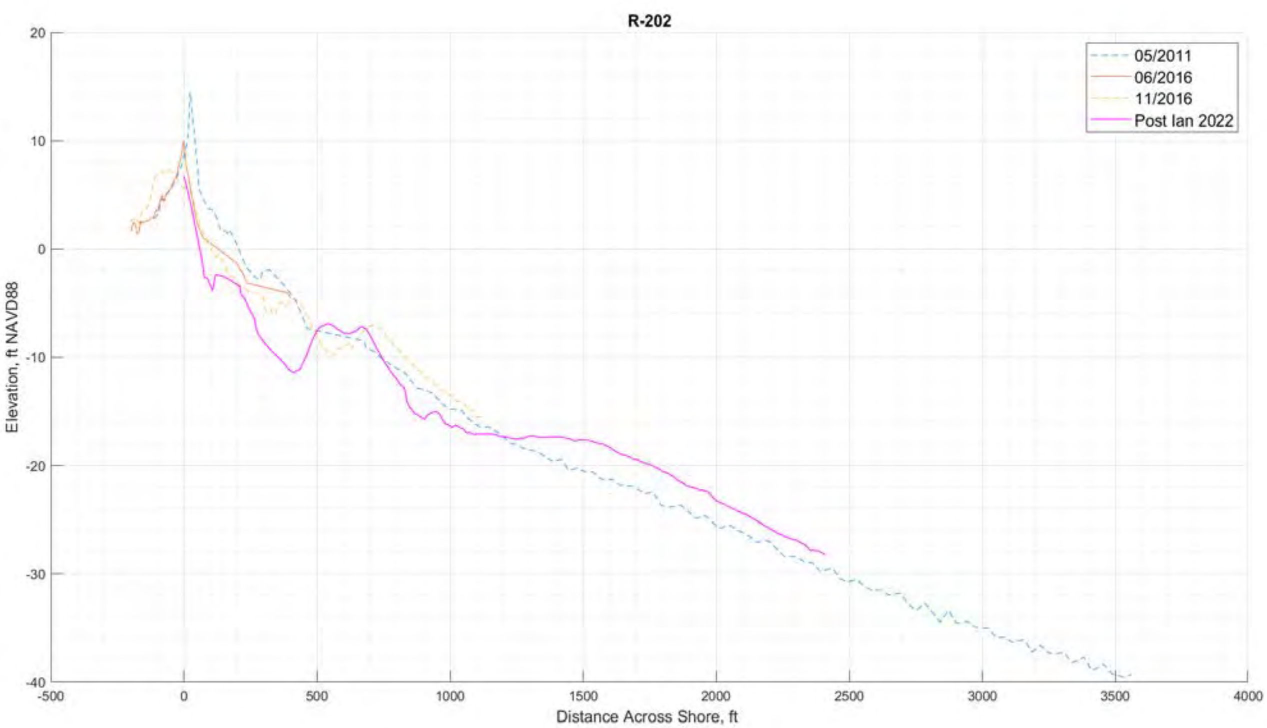
R-202
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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0
500
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2500
3000
3500
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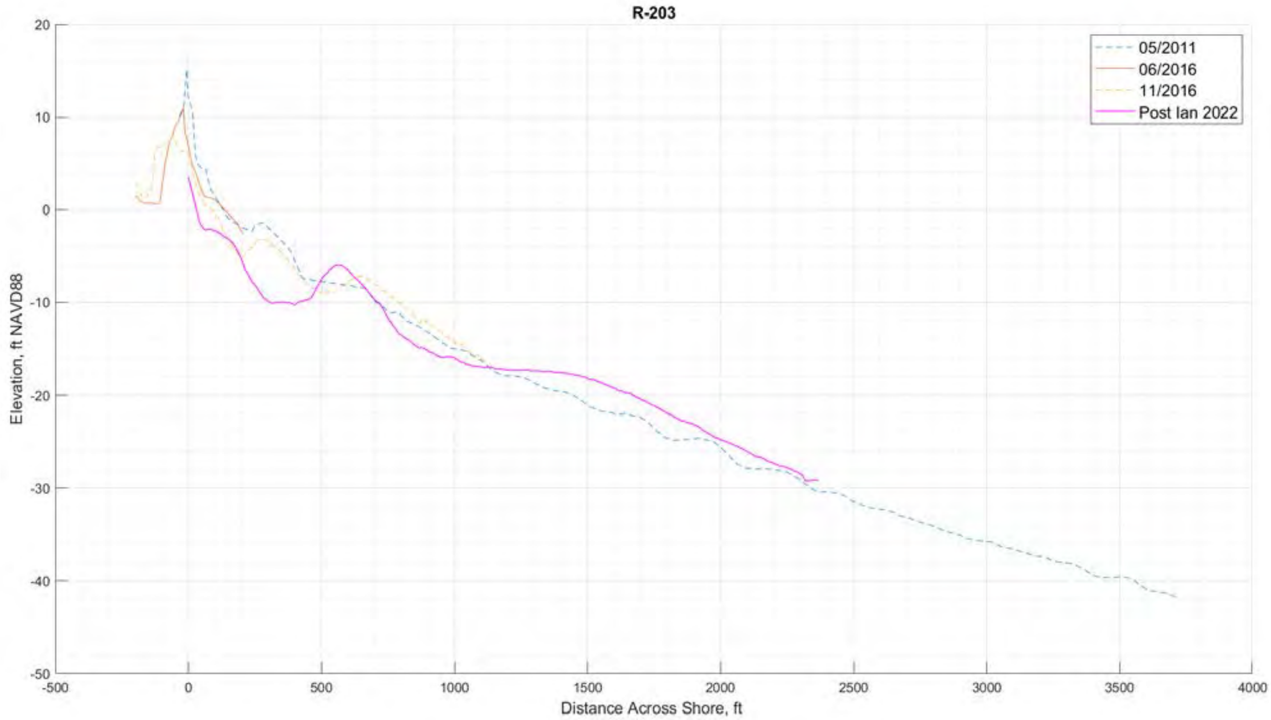
R-203
05/2011
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Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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-500
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1000
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3500
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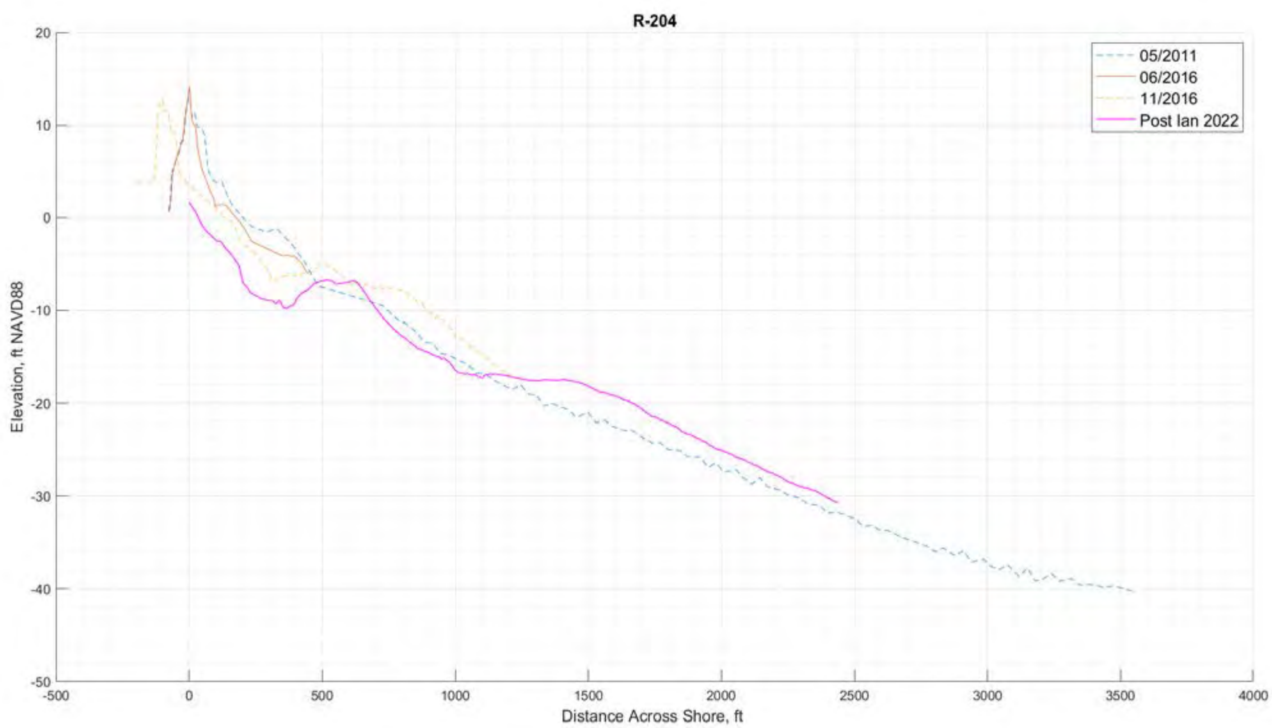
R-204
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06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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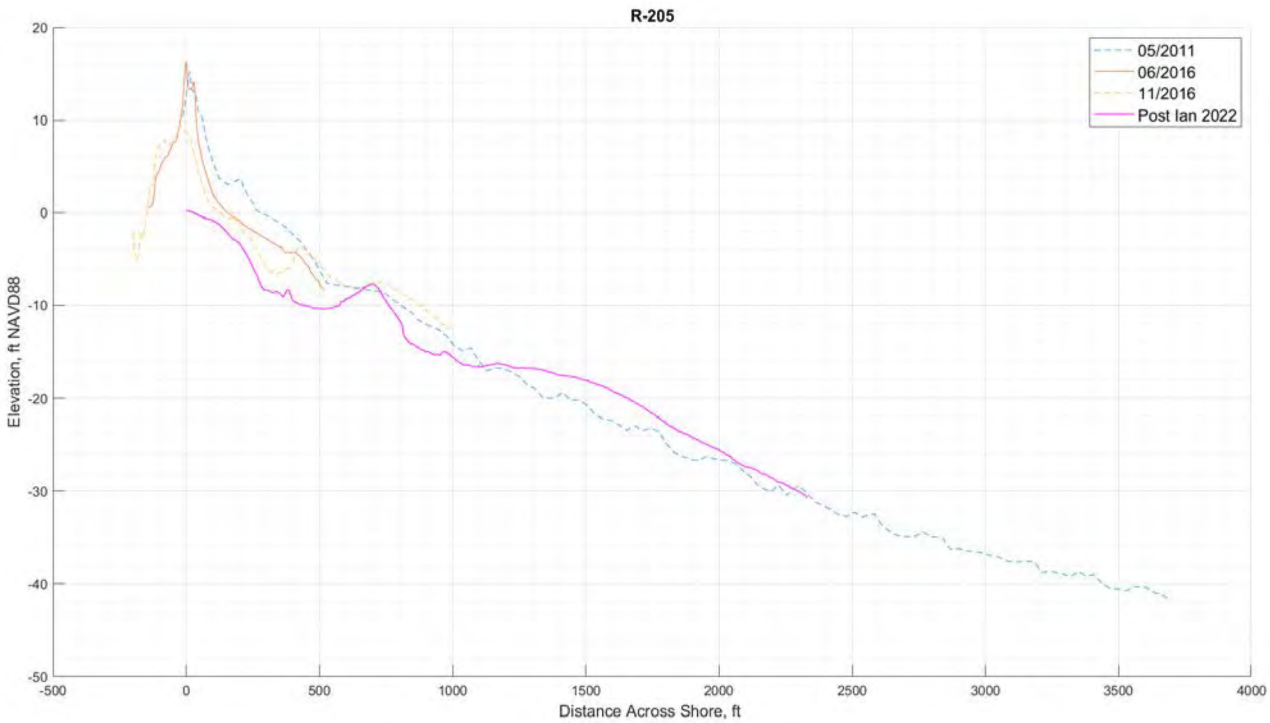
R-205
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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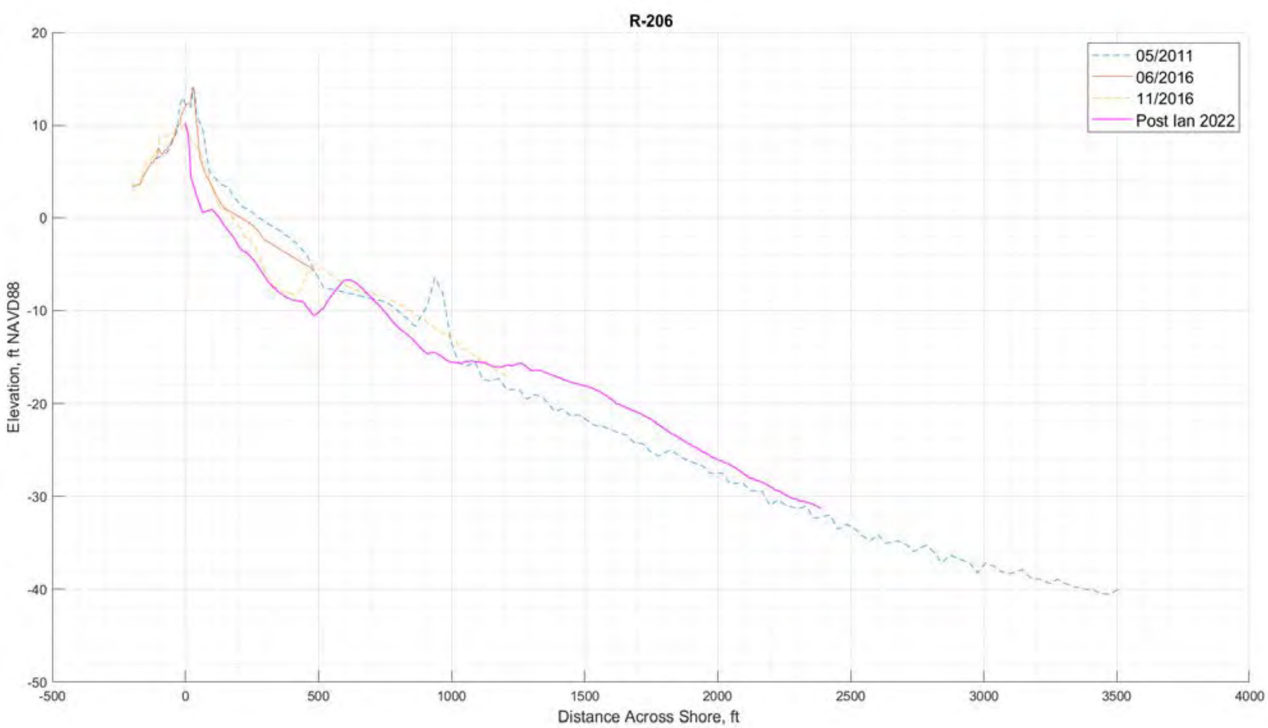
R-206
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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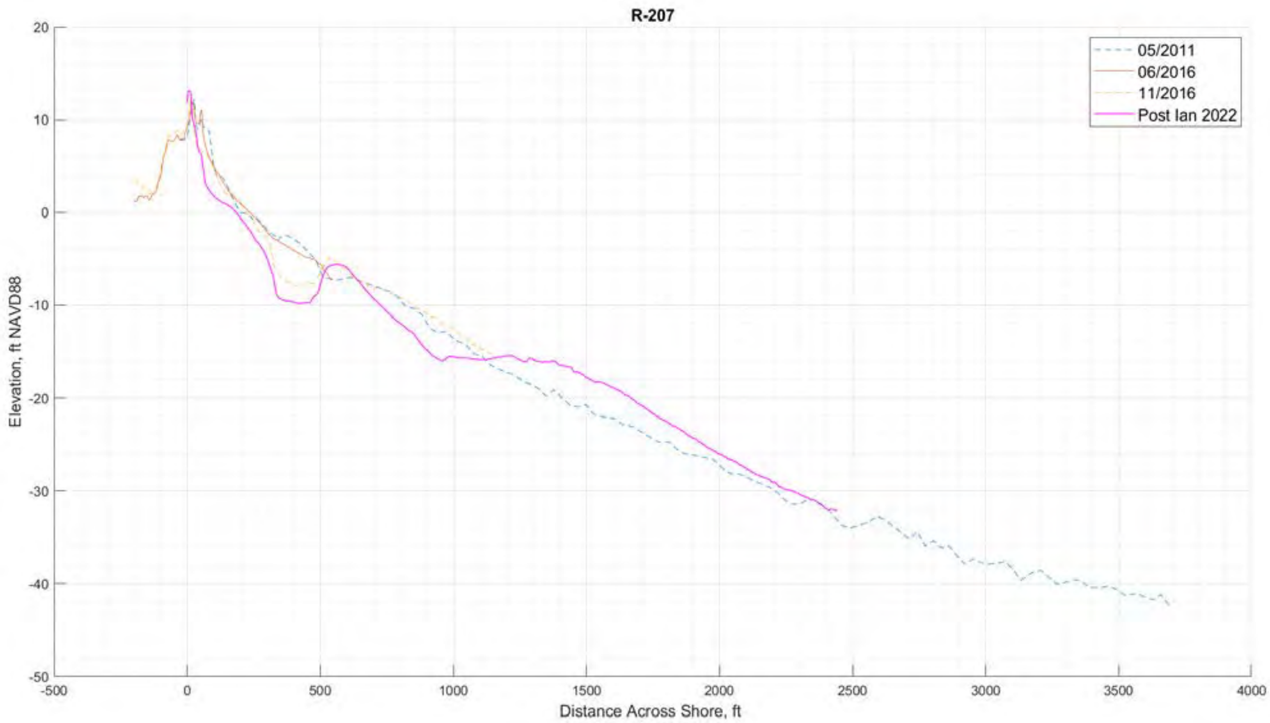

R-207
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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-500
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500
1000
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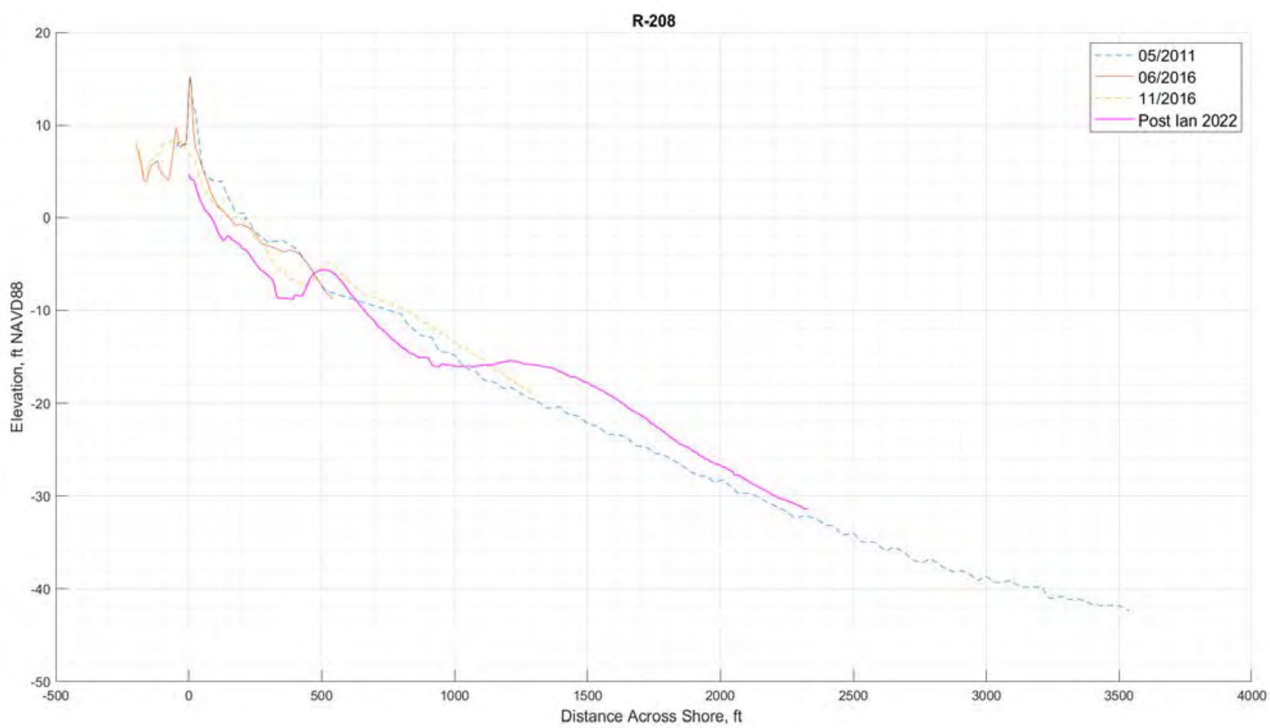

R-208
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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-500
0
500
1000
1500
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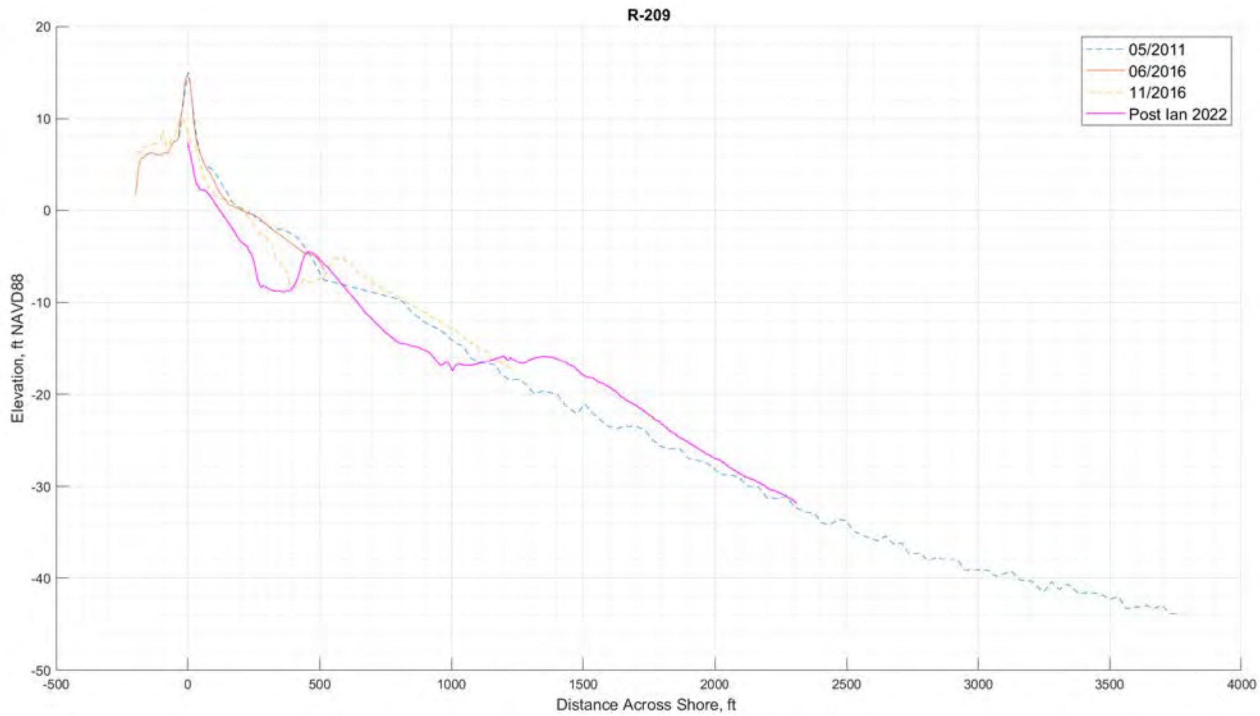
2500
3000
3500
4000


R-209
05/2011
06/2016
11/2016
Post Ian 2022
Elevation, ft NAVD88
Distance Across Shore, ft
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-30
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-500
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500
1000
1500
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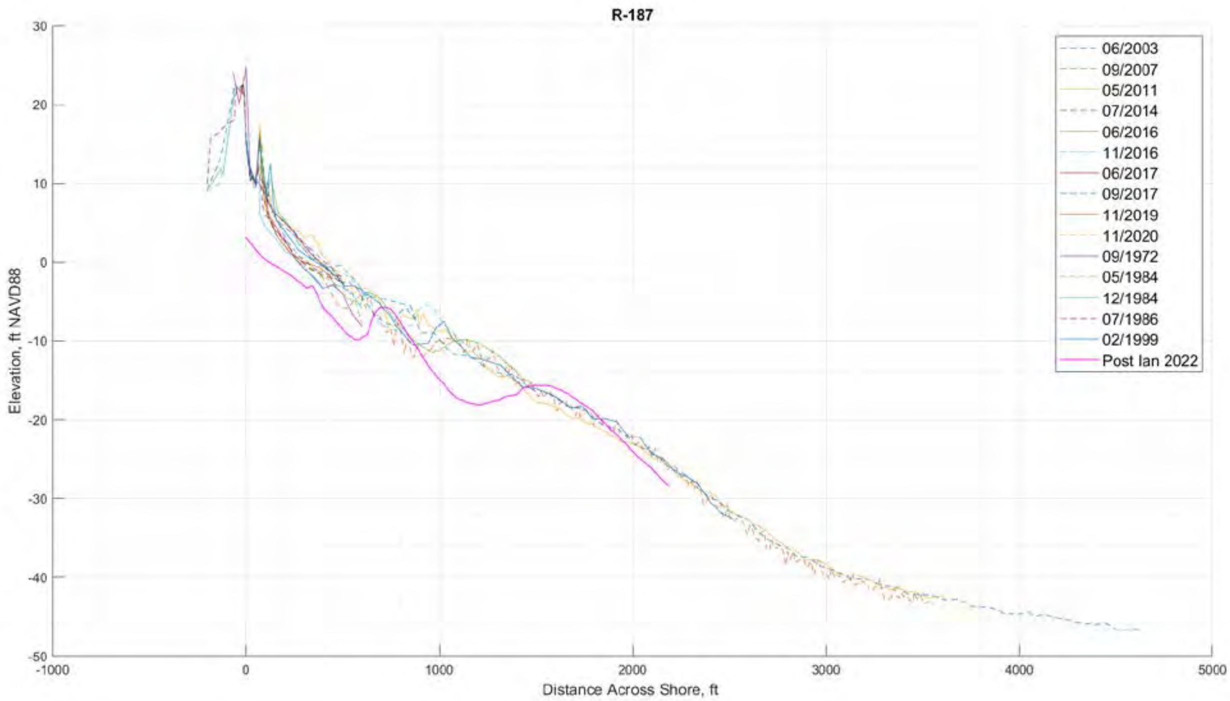
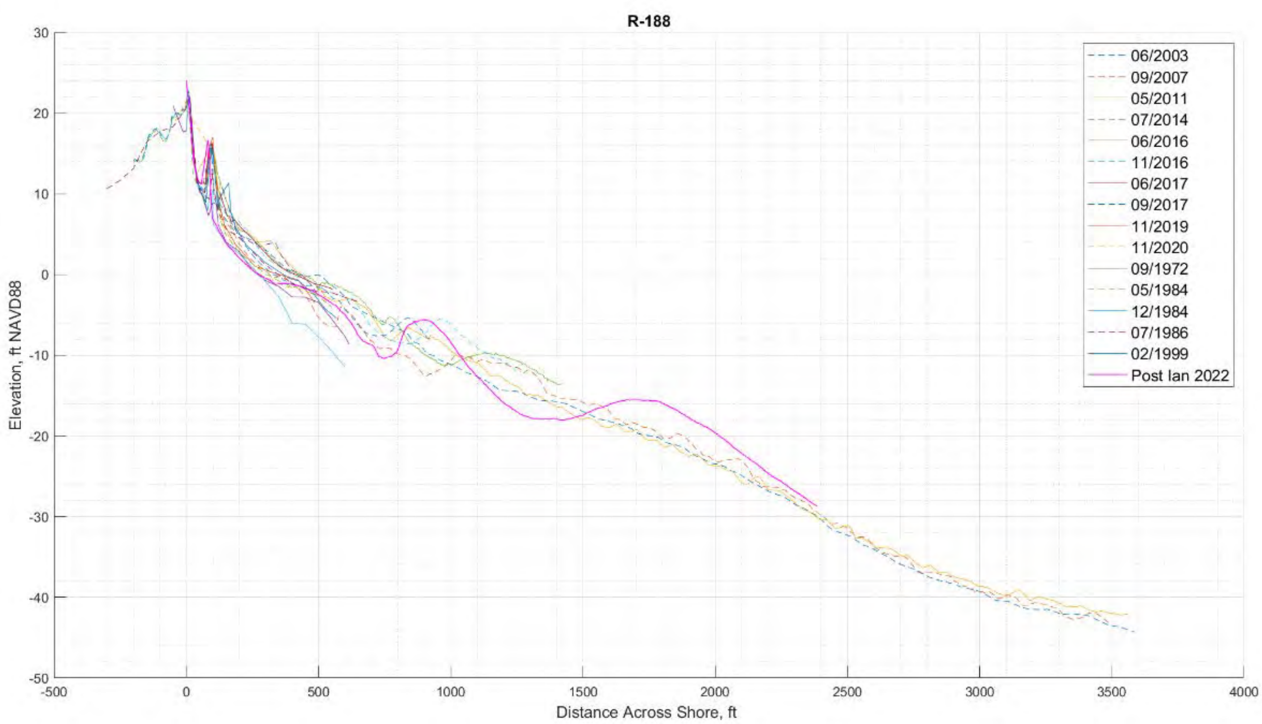
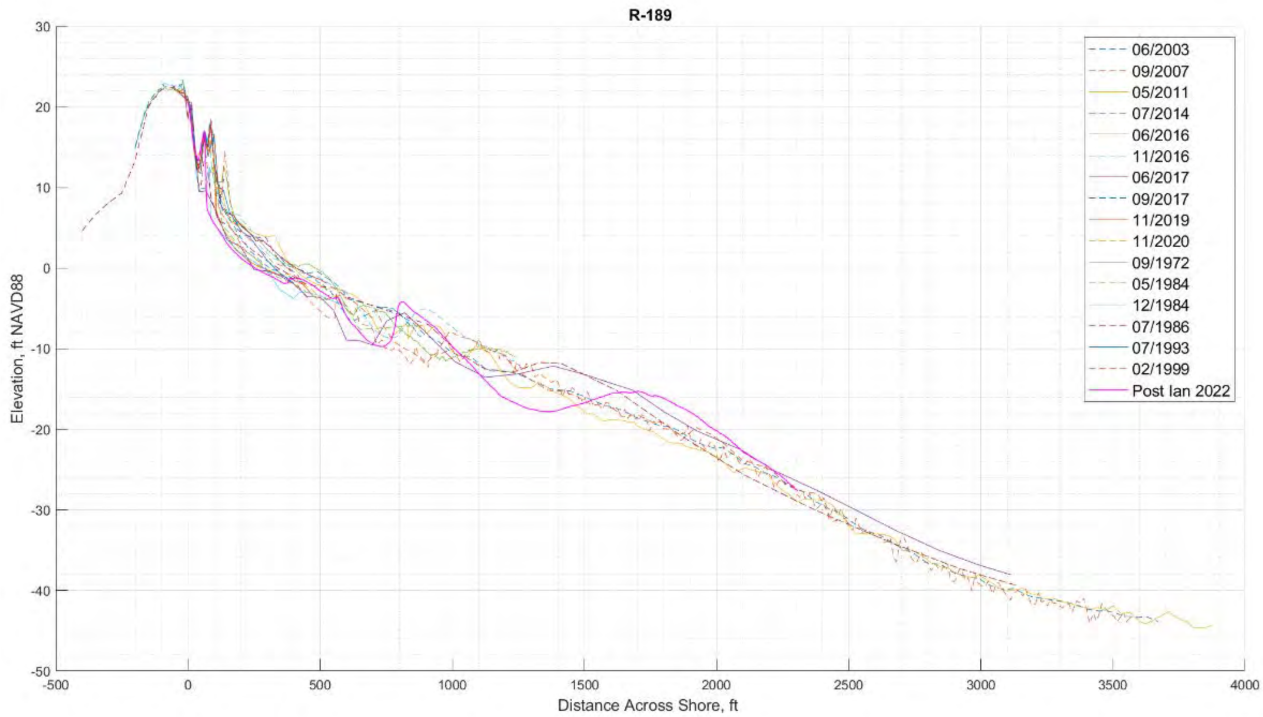
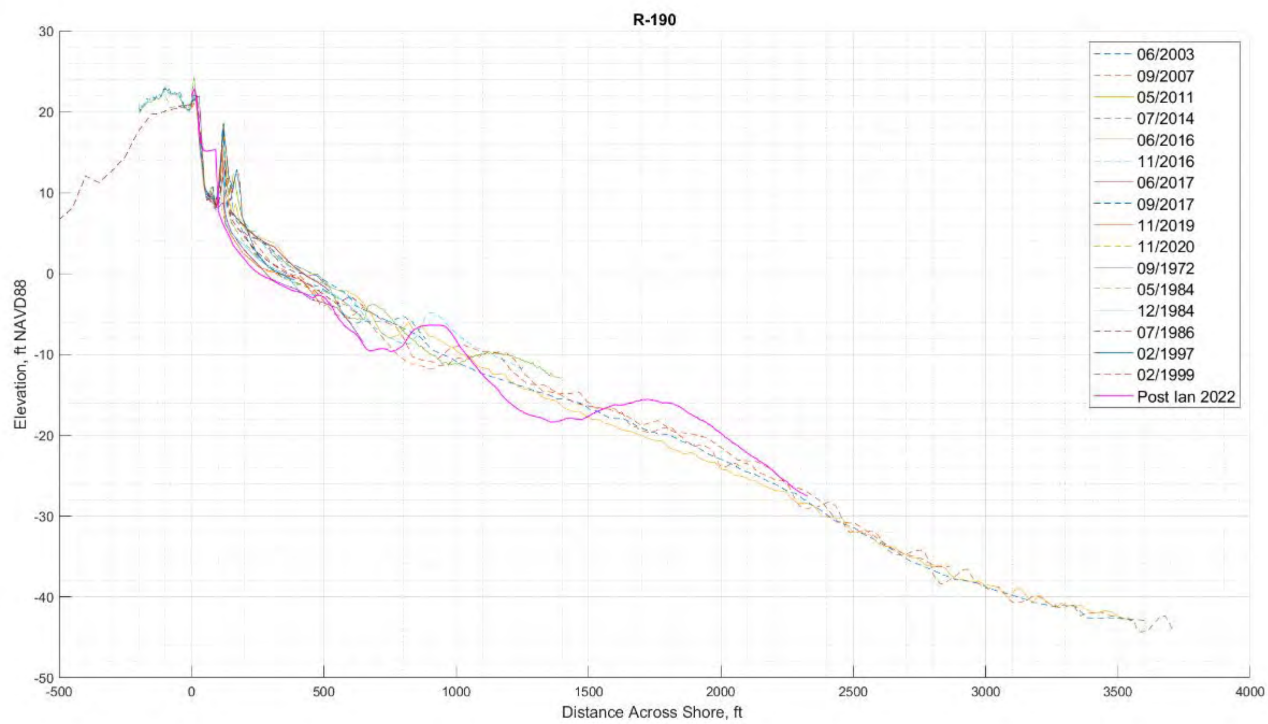
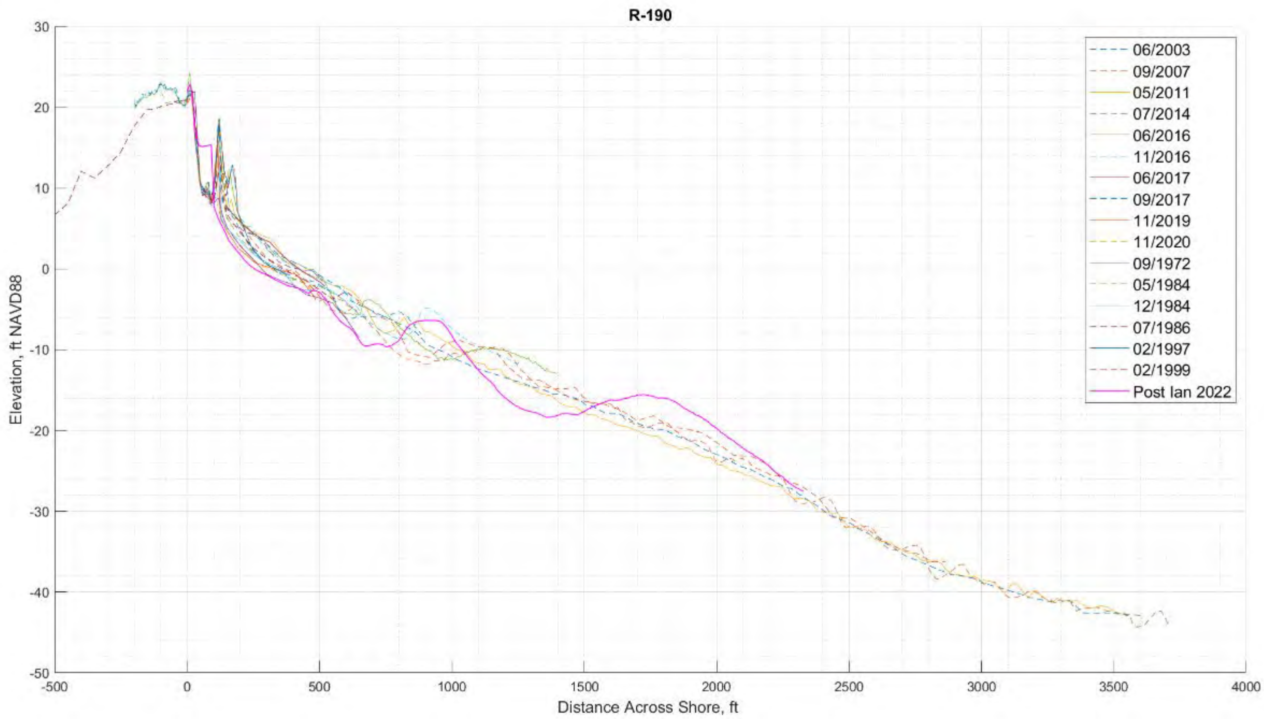

R-187
Elevation, ft NAVD88
Distance Across Shore, ft
06/2003
09/2007
05/2011
07/2014
06/2016
11/2016
06/2017
09/2017
11/2019
11/2020
09/1972
05/1984
12/1984
07/1986
02/1999
Post Ian 2022


R-188
Elevation, ft NAVD88
Distance Across Shore, ft
06/2003
09/2007
05/2011
07/2014
06/2016
11/2016
06/2017
09/2017
11/2019
11/2020
09/1972
05/1984
12/1984
07/1986
02/1999
Post Ian 2022


R-189
Elevation, ft NAVD88
Distance Across Shore, ft
06/2003
09/2007
05/2011
07/2014
06/2016
11/2016
06/2017
09/2017
11/2019
11/2020
09/1972
05/1984
12/1984
07/1986
07/1993
02/1999
Post Ian 2022


R-190
Elevation, ft NAVD88
Distance Across Shore, ft
06/2003
09/2007
05/2011
07/2014
06/2016
11/2016
06/2017
09/2017
11/2019
11/2020
09/1972
05/1984
12/1984
07/1986
02/1997
02/1999
Post Ian 2022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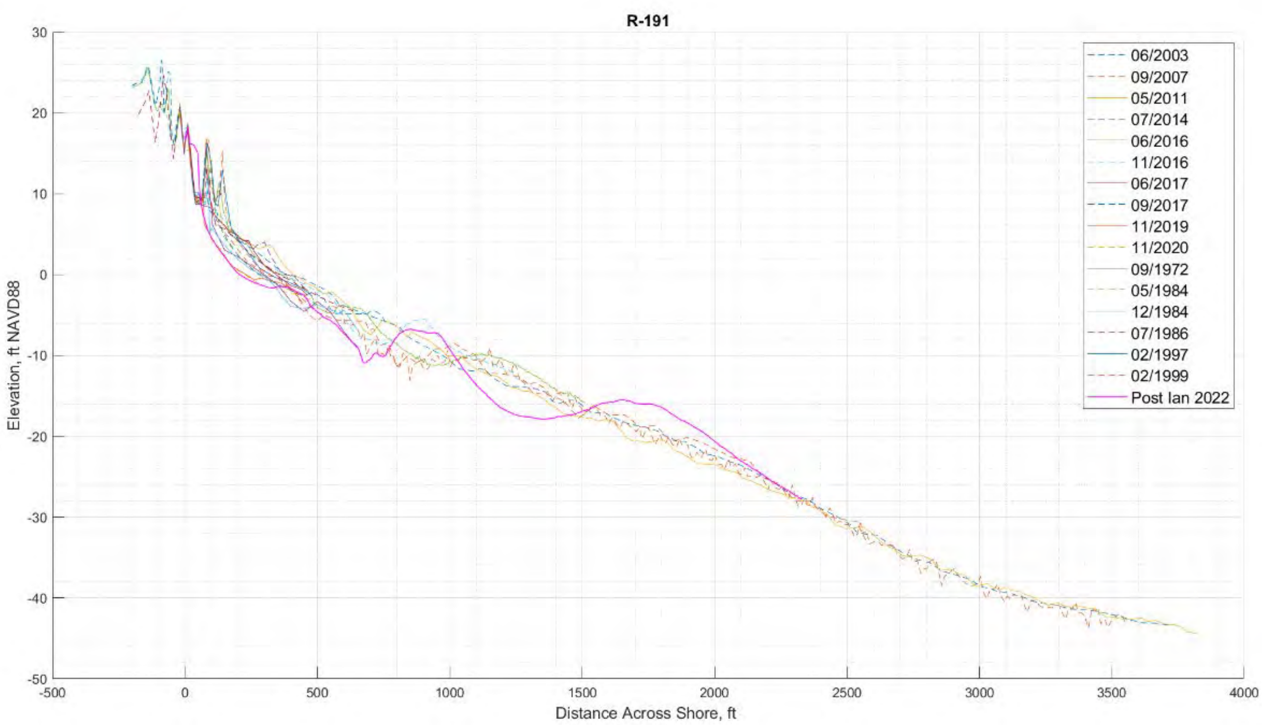
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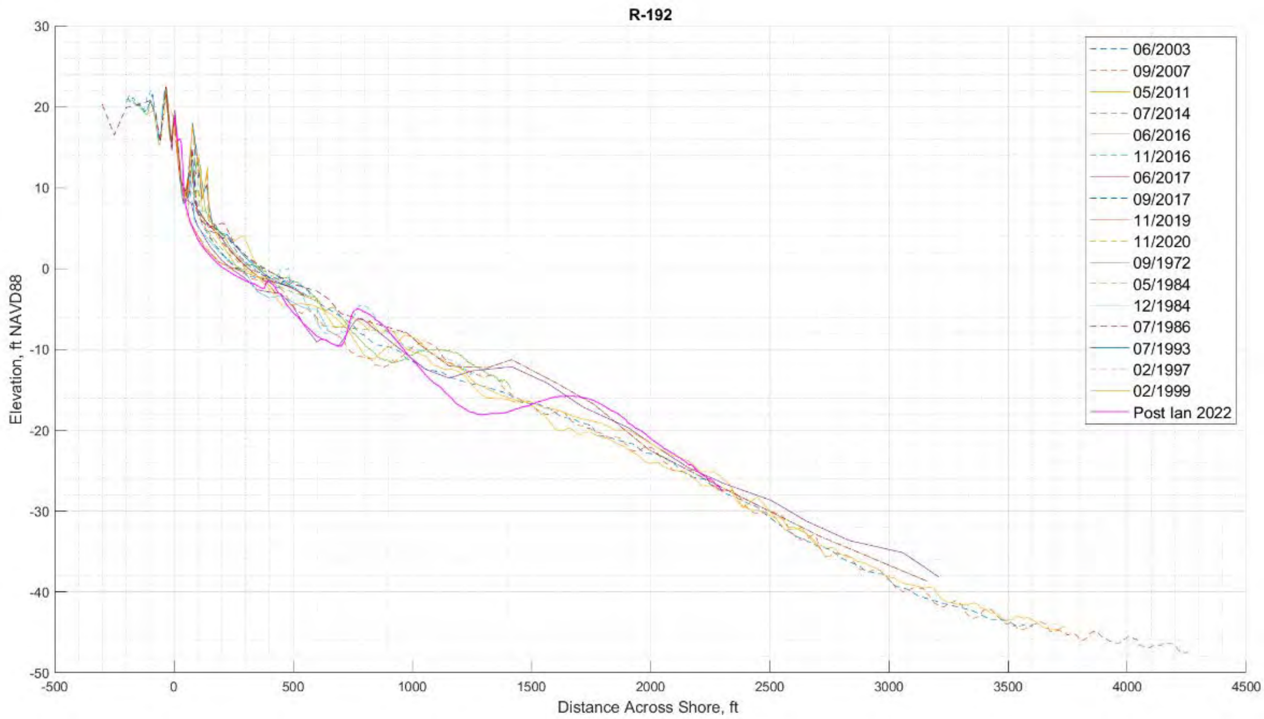
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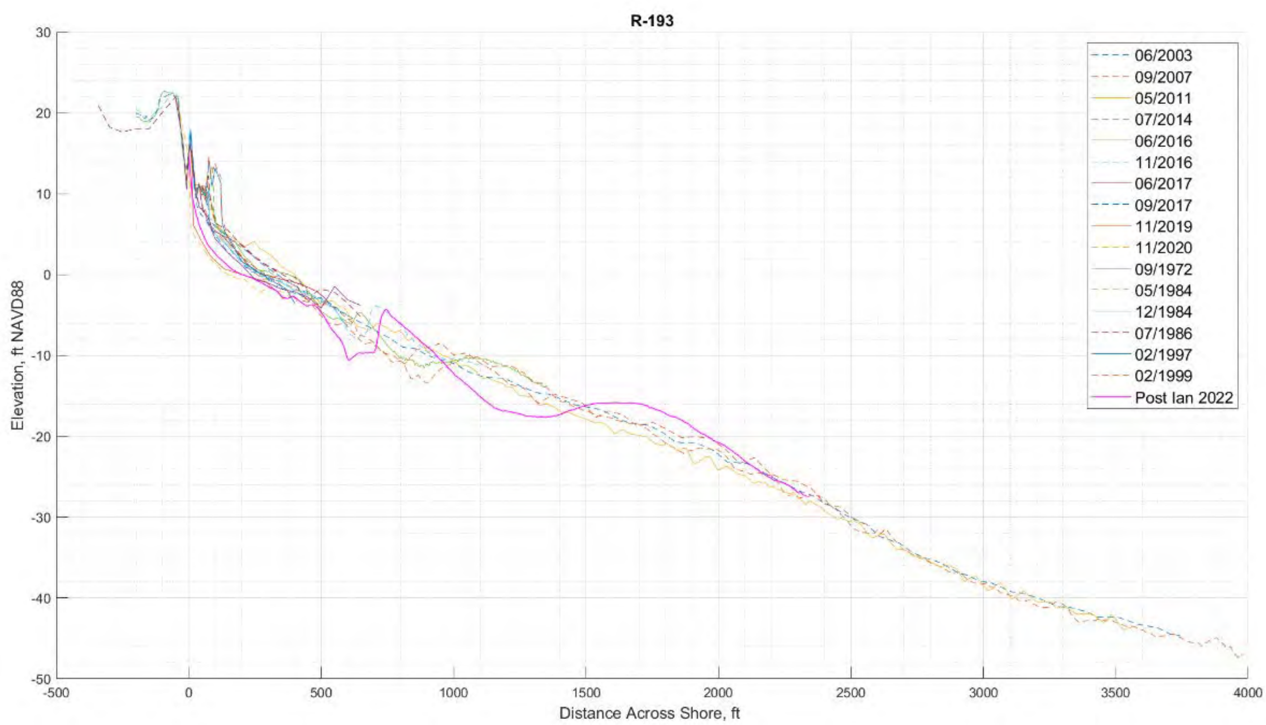
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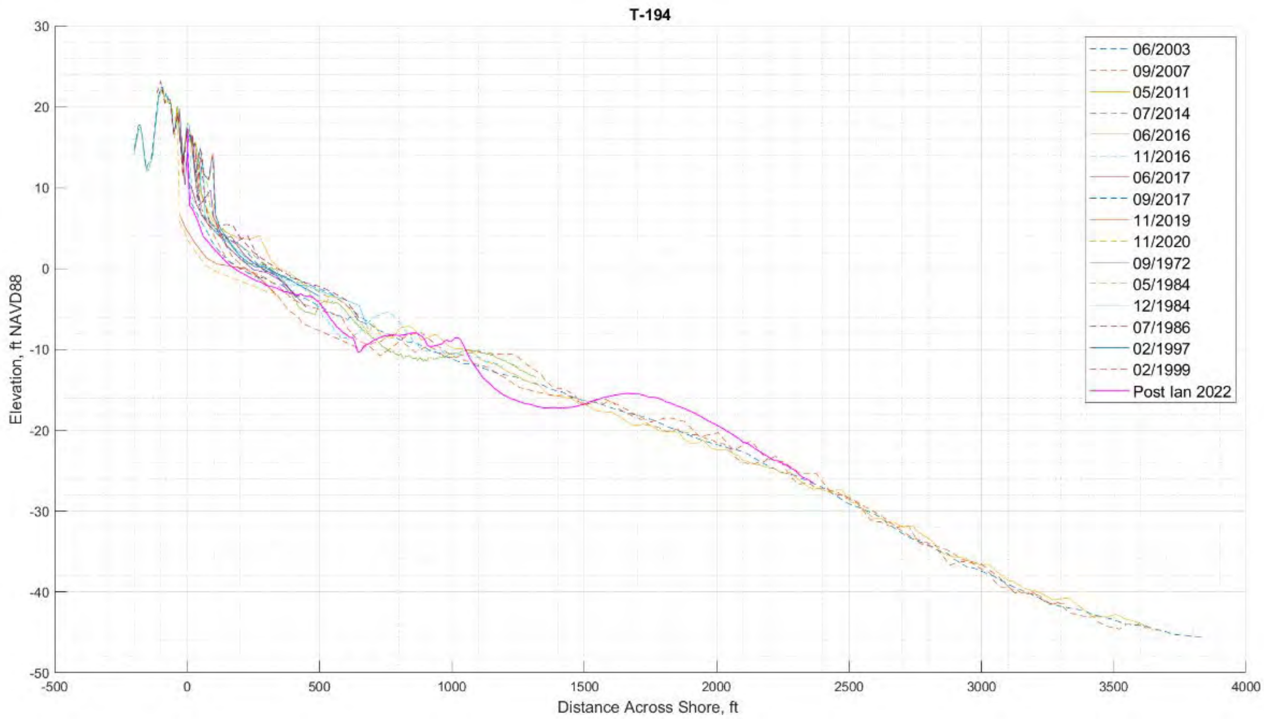
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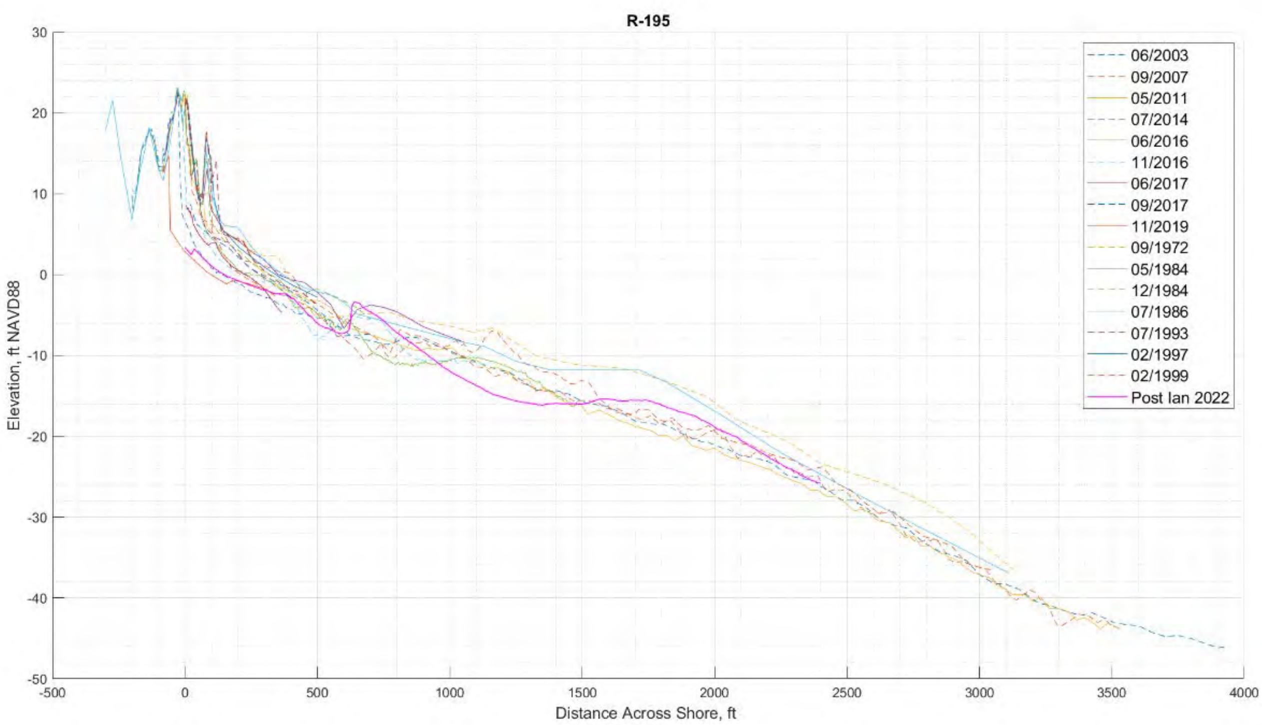
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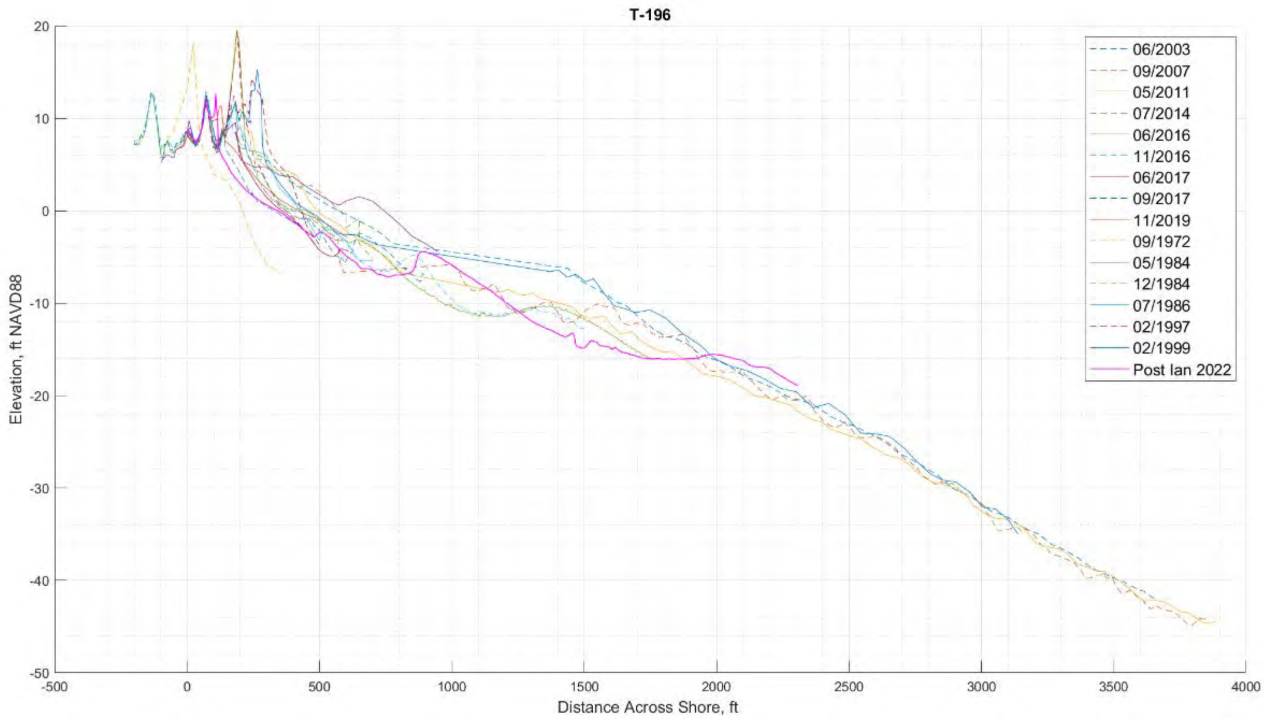
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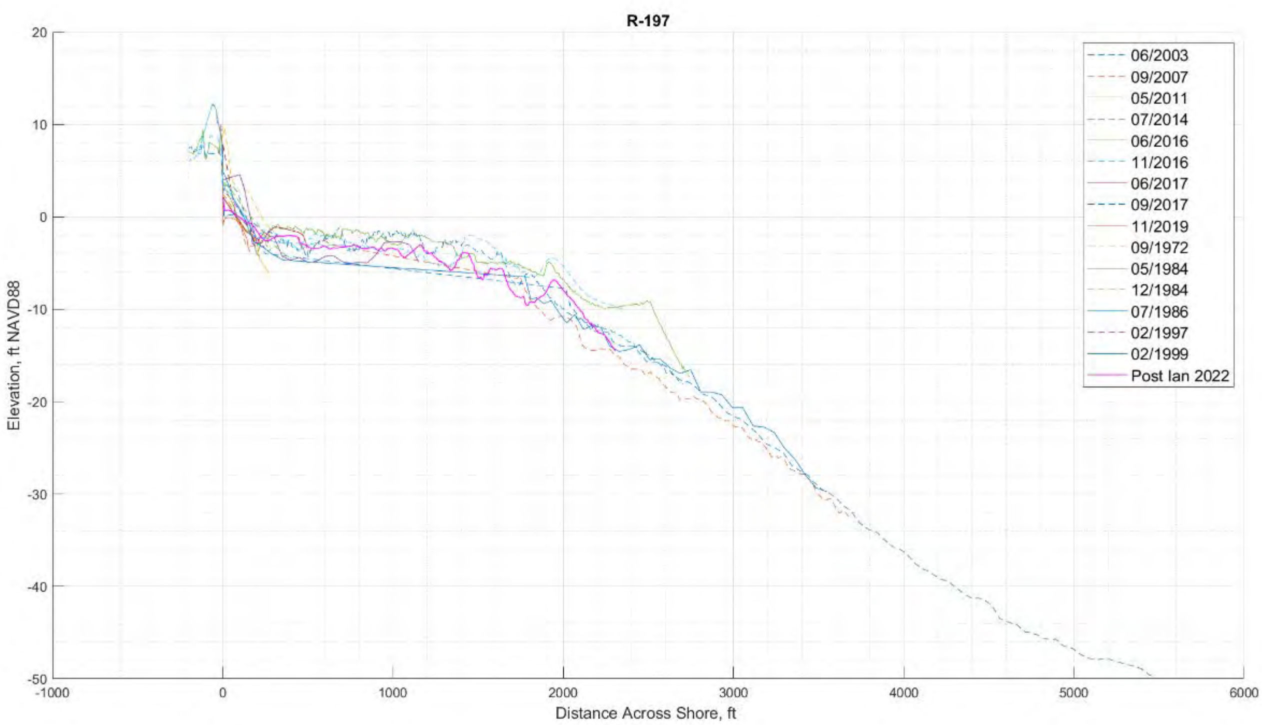
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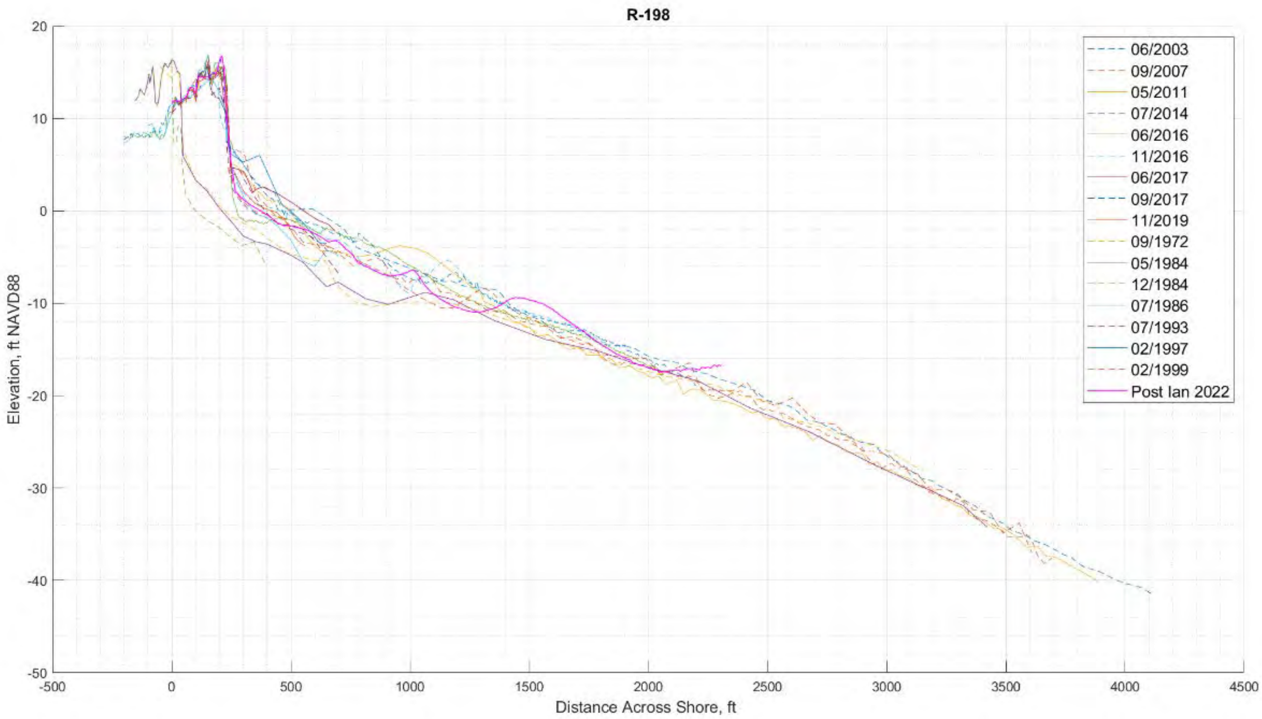
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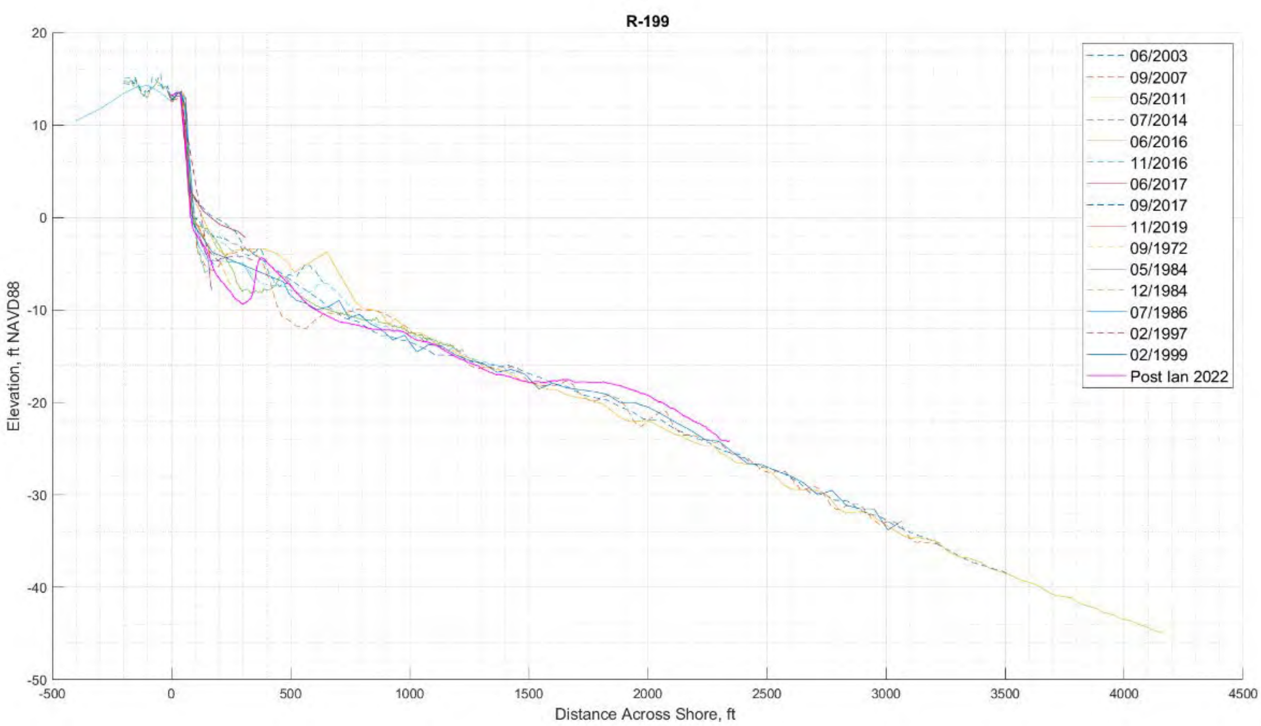
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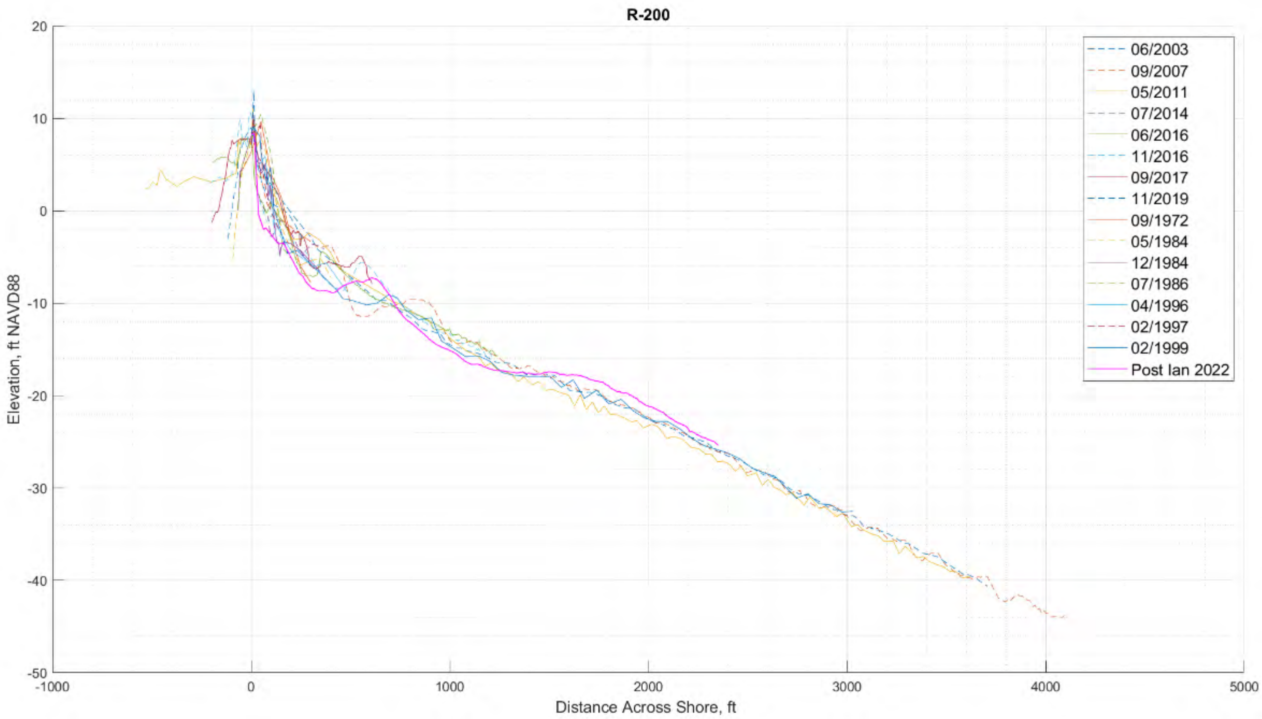

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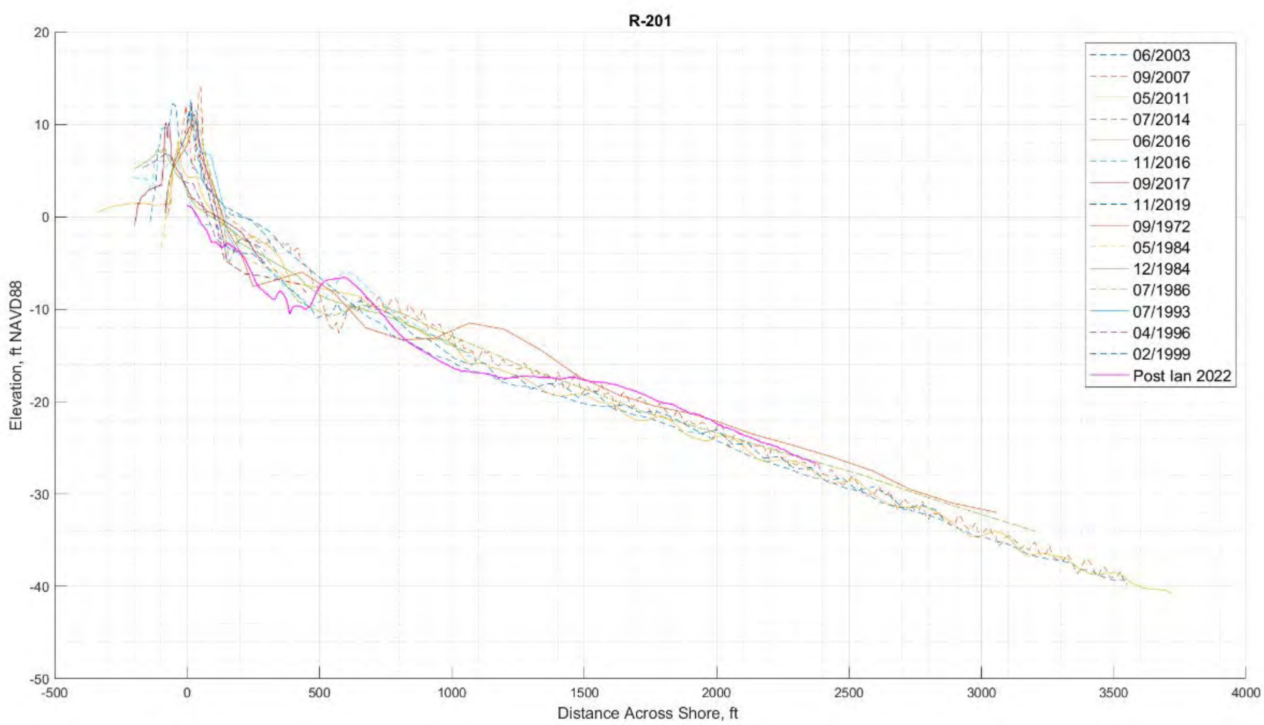

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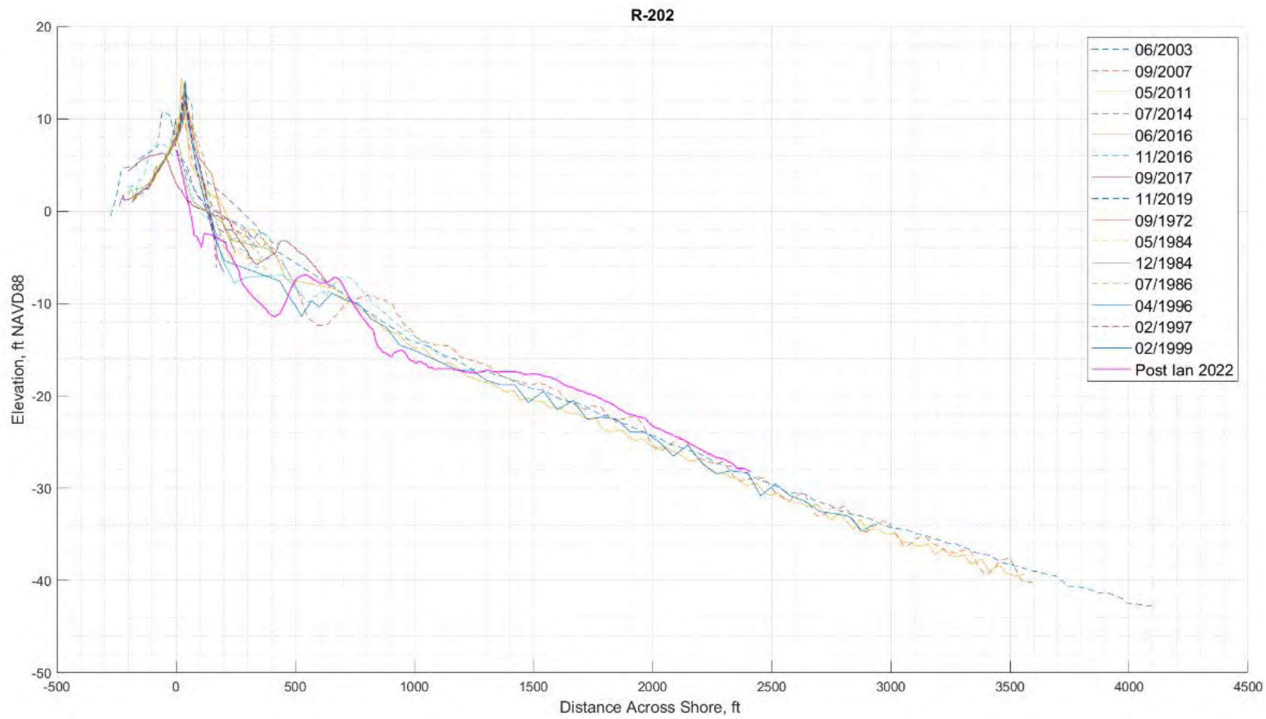
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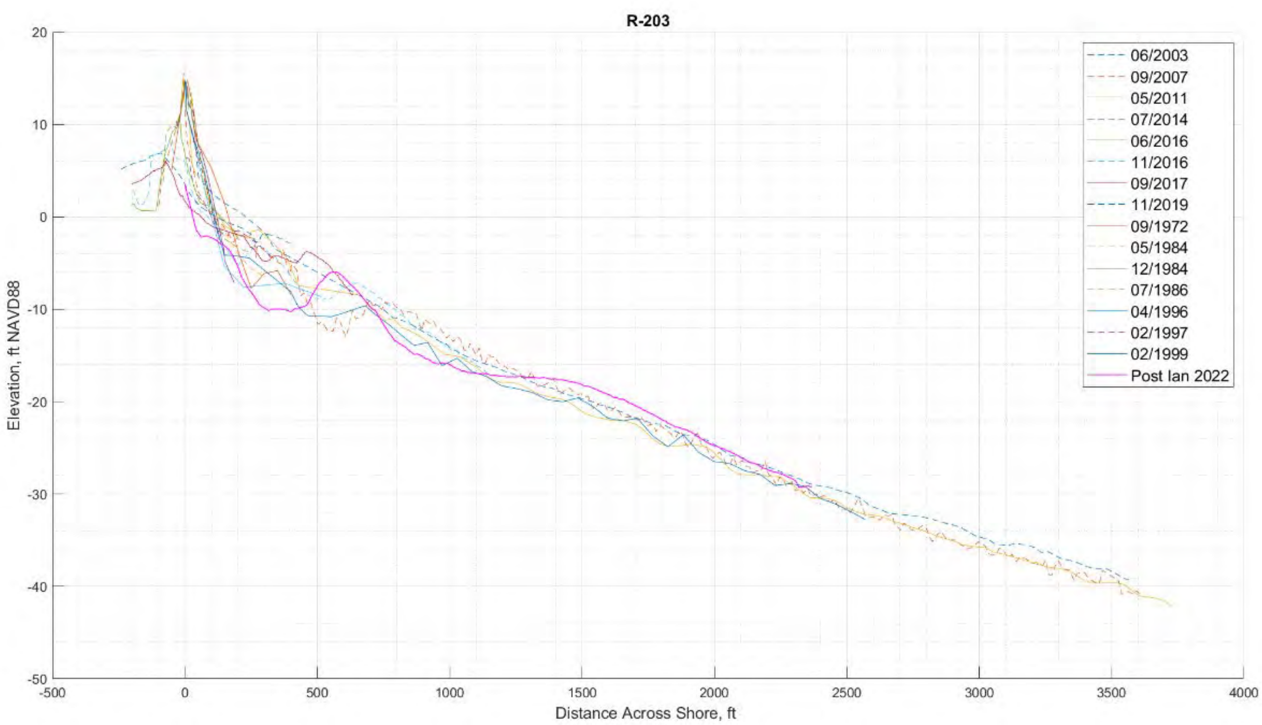
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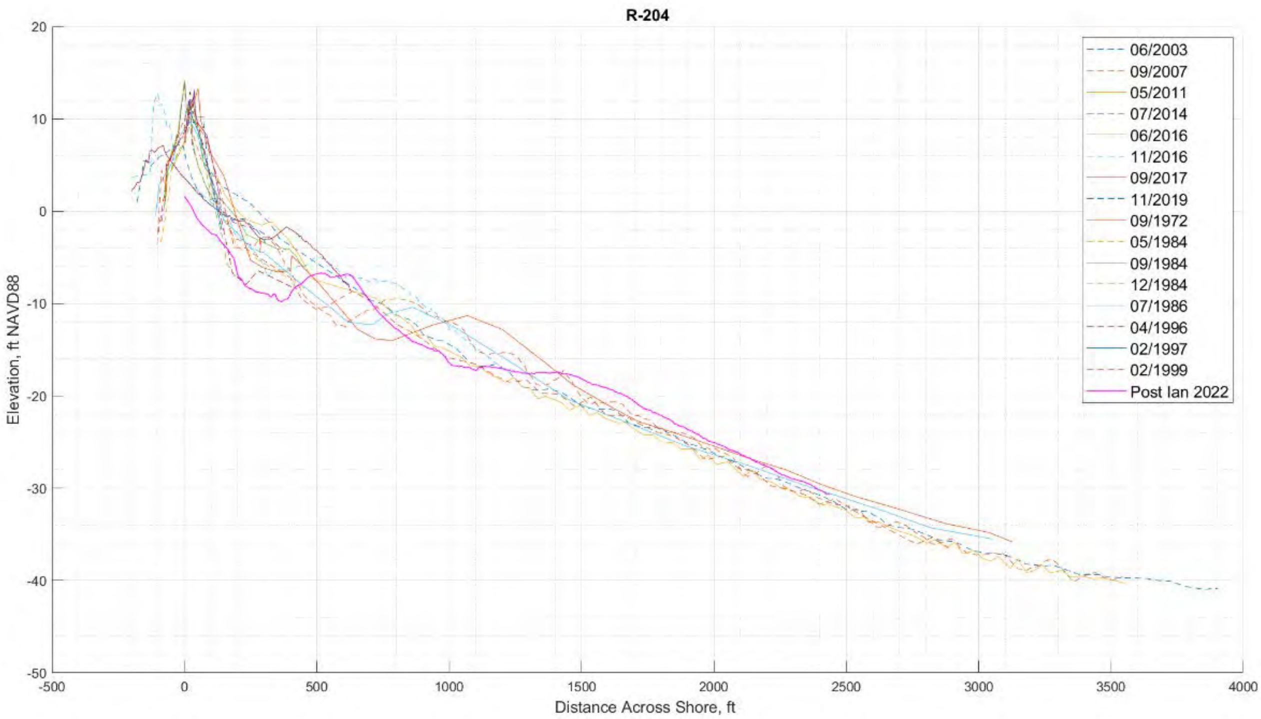
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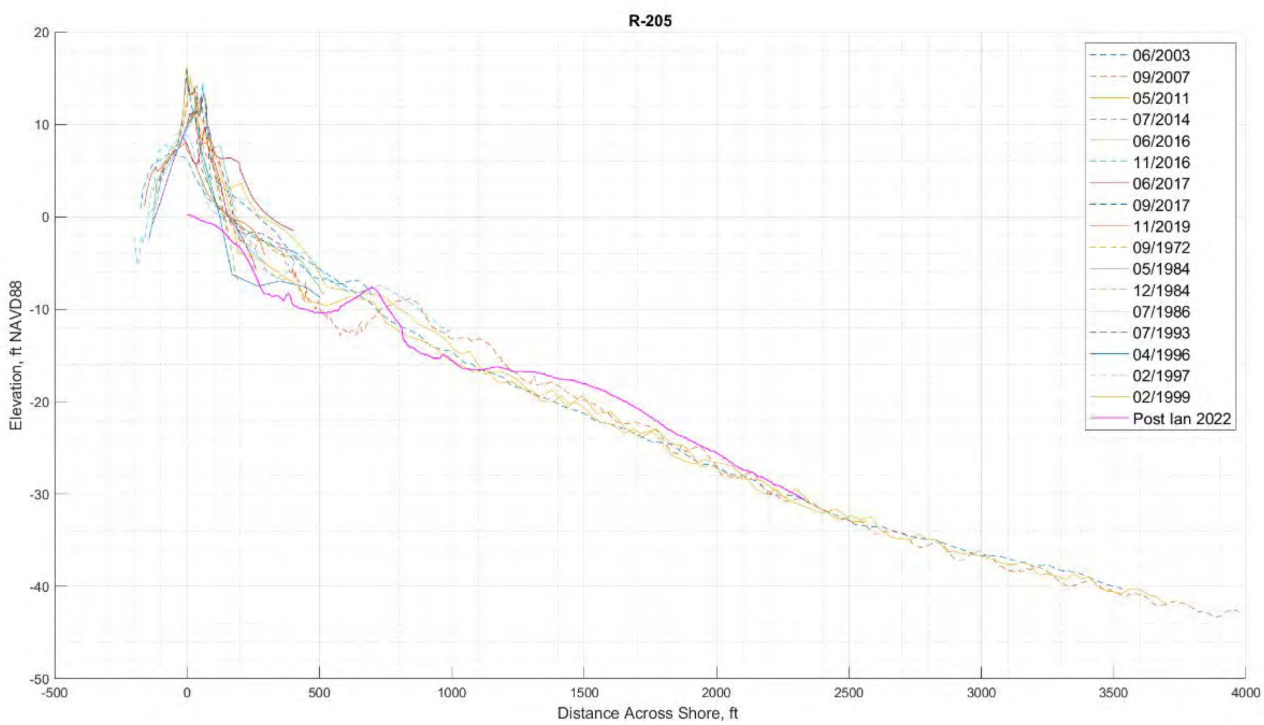
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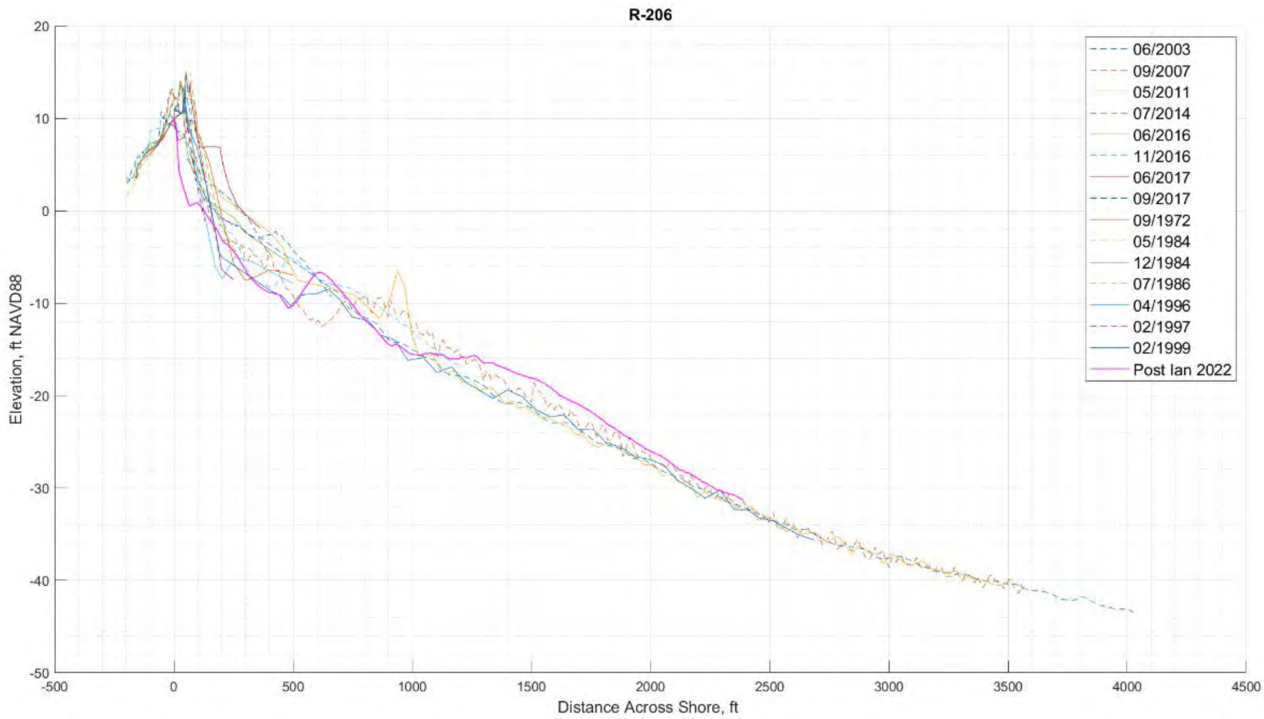

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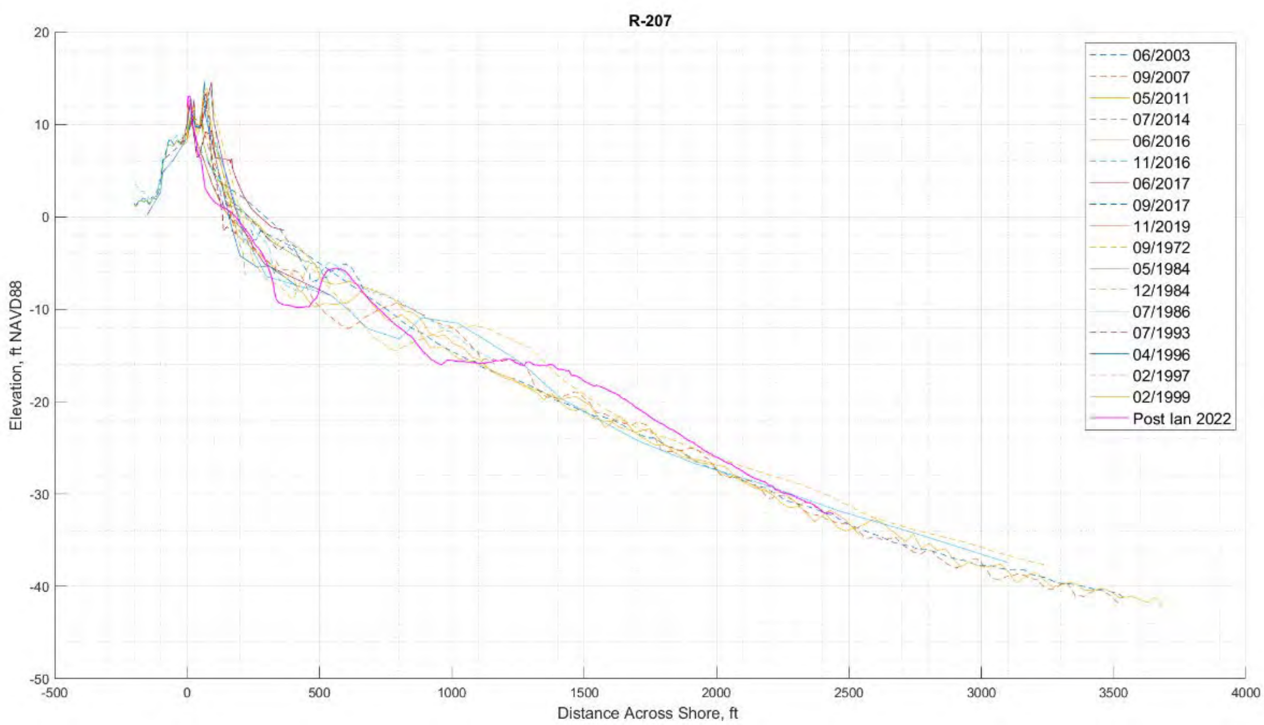

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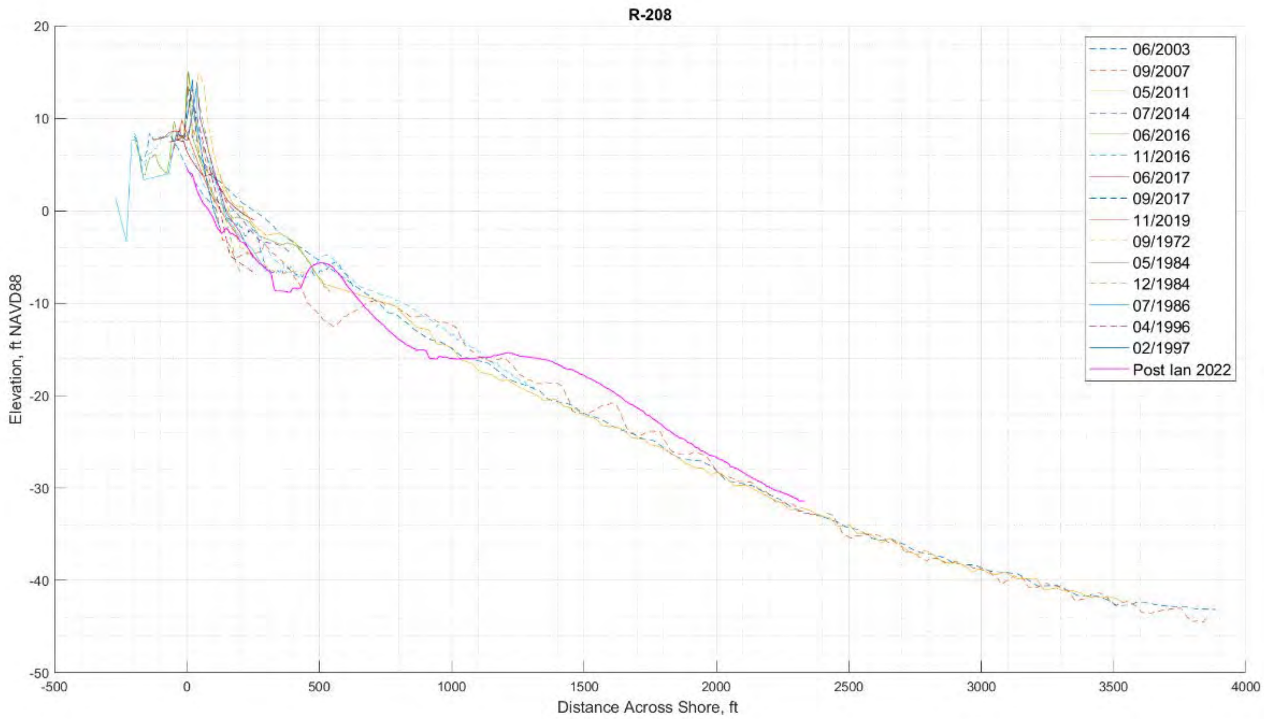
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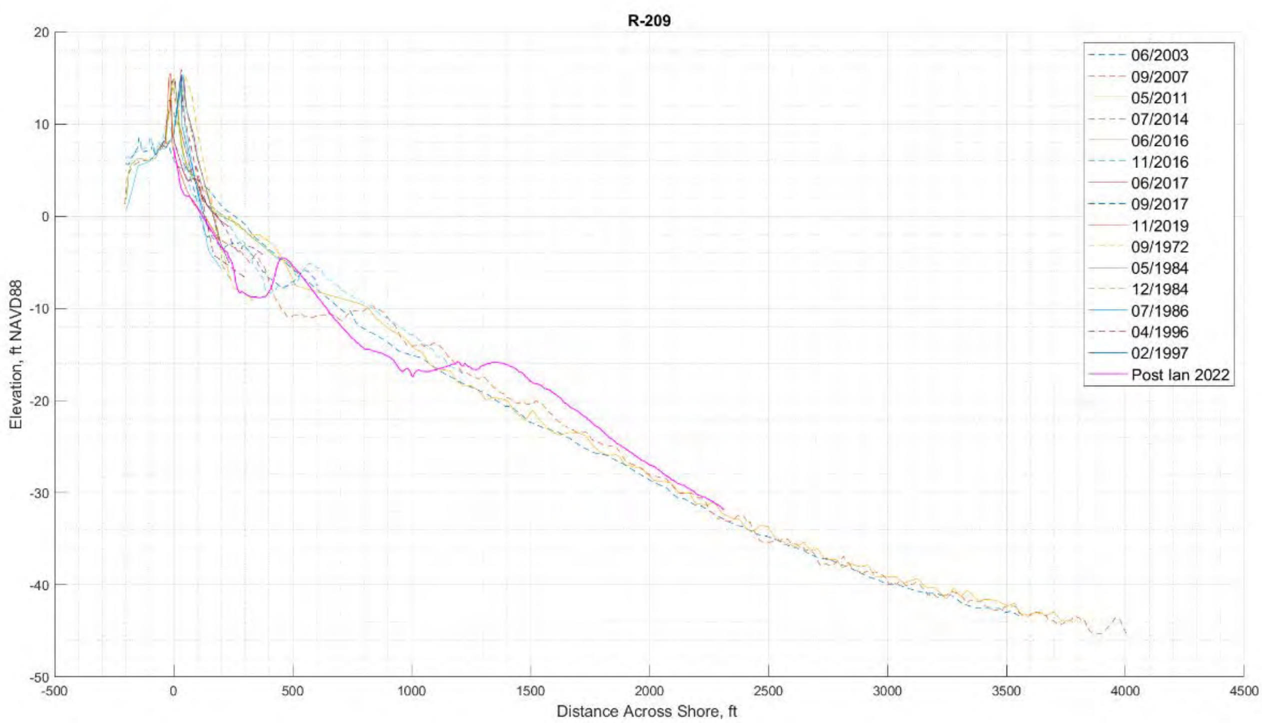
Post Ian 2022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Elevation, ft NAVD88
Distance Across Shore, ft
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3500
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Post Ian 2022

Appendix K

Google Earth Aerial Imagery

Figure 1 1995 Matanzas Inlet Shoreline and Primary Channel Bank Positions

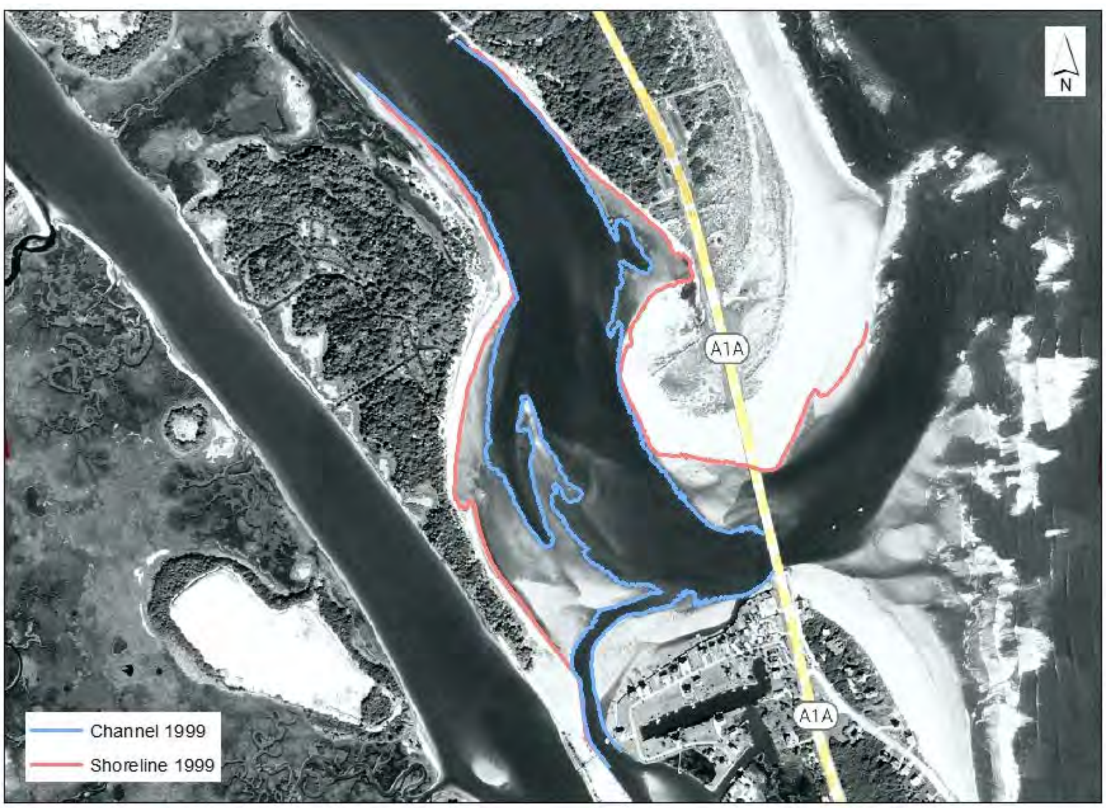

Figure 2 1999 Matanzas Inlet Shoreline and Primary Channel Bank Positions

Figure 3 2004 Matanzas Inlet Shoreline and Primary Channel Bank Positions

Figure 4 2007 Matanzas Inlet Shoreline and Primary Channel Bank Positions

Figure 5 2008 Matanzas Inlet Shoreline and Primary Channel Bank Positions

Figure 6 2010 Matanzas Inlet Shoreline and Primary Channel Bank Positions

Figure 7 2012 Matanzas Inlet Shoreline and Primary Channel Bank Positions

Figure 8 2016 Matanzas Inlet Shoreline and Primary Channel Bank Positions

Figure 9 2019 Matanzas Inlet Shoreline and Primary Channel Bank Positions

Figure 10 2022 Matanzas Inlet Shoreline and Primary Channel Bank Positions

Appendix L

ADCIRC Hydrodynamic Modeling Summary

1.0 Hydrodynamic Modeling

Hydrodynamic models provide engineers a means to evaluate tidal and storm surge circulation in and around inlets, rivers, and bays. Hydrodynamic models simulate flow by solving the fluid dynamic governing equations for the physical processes at any given geographic location under specific water level and flow boundary conditions and consider channel shape, depth, and bed material. Evaluation of the complex flow conditions of Matanzas Inlet and the surrounding waterways and the effects of the Summer Haven River (SHR) on inlet and waterways hydrodynamics requires a time-dependent, 2-dimensional hydrodynamic model.

For this study, the Advanced Circulation Model for Coastal Ocean Hydrodynamics (ADCIRC) code provides a time-dependent, two-dimensional model to simulate the complex flow regime. ADCIRC, a numerical model developed specifically for generating long duration hydrodynamic circulation along shelves, coasts, and within estuaries, intends to produce numerical simulations for very large computational domains in a unified and systematic manner. The collaboration of many researchers, including investigators at the University of Notre Dame (J.J. Westerink), the University of North Carolina at Chapel Hill (R.A. Luettich), the University of Texas at Austin (M.F. Wheeler and C. Dawson), the University of Oklahoma (R. Kolar), the State of Texas (Jurji), and the Waterways Experiment Station (N. Scheffner) (Luettich and Westerink, 2000), have led to the development of the ADCIRC model. Both the U.S. Army and Navy have extensively applied ADCIRC for a wide range of tidal and hurricane storm surge predictions in regions including the western North Atlantic, Gulf of Mexico and Caribbean Sea, the Eastern Pacific Ocean, the North Sea, the Mediterranean Sea, the Persian Gulf, and the South China Sea. ADCIRC employs computational models of flow and transport in continental margin waters to predict free surface elevation and currents for a wide range of applications including evaluating coastal inundation, defining navigable depths and currents in near shore regions, and assessing pollutant and/or sediment movement on the continental shelf.

The following sections focus on the model mesh description, model verification, and the application of alternate bathymetry contours corresponding to four scenarios: (1) existing conditions (i.e., no flow through SHR), (2) deepening SHR to -6 ft NAVD to re-establish flow, (3) deepening SHR to -10 ft NAVD, and (4) dredging of the inlet flood shoal to alleviate the damaging high flows near the southern shoreline of Matanzas Inlet. Comparison of the model results for scenarios 2 and 3 to scenario 1 identified the effects of the SHR on the surrounding waterways. Comparison of scenario 4 versus scenario 1 revealed the effects of re-configuring the inlet channels. Of note, scenario 2 is a simplified representation of the currently authorized dredging depths (the actual depths range from -4 to -6 ft NAVD), and scenario 3 represents a preferred river condition (per public comments) and also serves to test the sensitivity of the SHR depth on the river's effect on inlet hydrodynamics.

1.1 Model Development

This study modified and recalibrated a model previously developed for flow through Matanzas Inlet (INTERA, 2022). The model mesh covers coastlines of St. Johns County and Flagler County extending from State Road 206 at the north end of the mesh boundary to Beverly Beach at the south end of the mesh boundary. The mesh includes 58,664 nodes and 113,812 elements (**Figure 1.1**). The resolution is increased at channels, inlets and barrier islands that are subject to overtopping. The element size changes from 4600 feet offshore to 25 feet in narrow parts of Pellicer Creek. The bathymetric data is a combination of USGS bathymetric survey data, USACE bathymetric survey data, 2022 LiDAR data, and

2022 hydrographic survey data. The model applies tidal forcings at its offshore boundary for a 30-day simulation to produce the existing hydraulic conditions in the study area. **Figure 1.2** shows the existing bathymetric conditions (scenario 1), and **Figure 1.3**–**Figure 1.5** present the modified bathymetric contours associated with scenarios 2–4 described above.

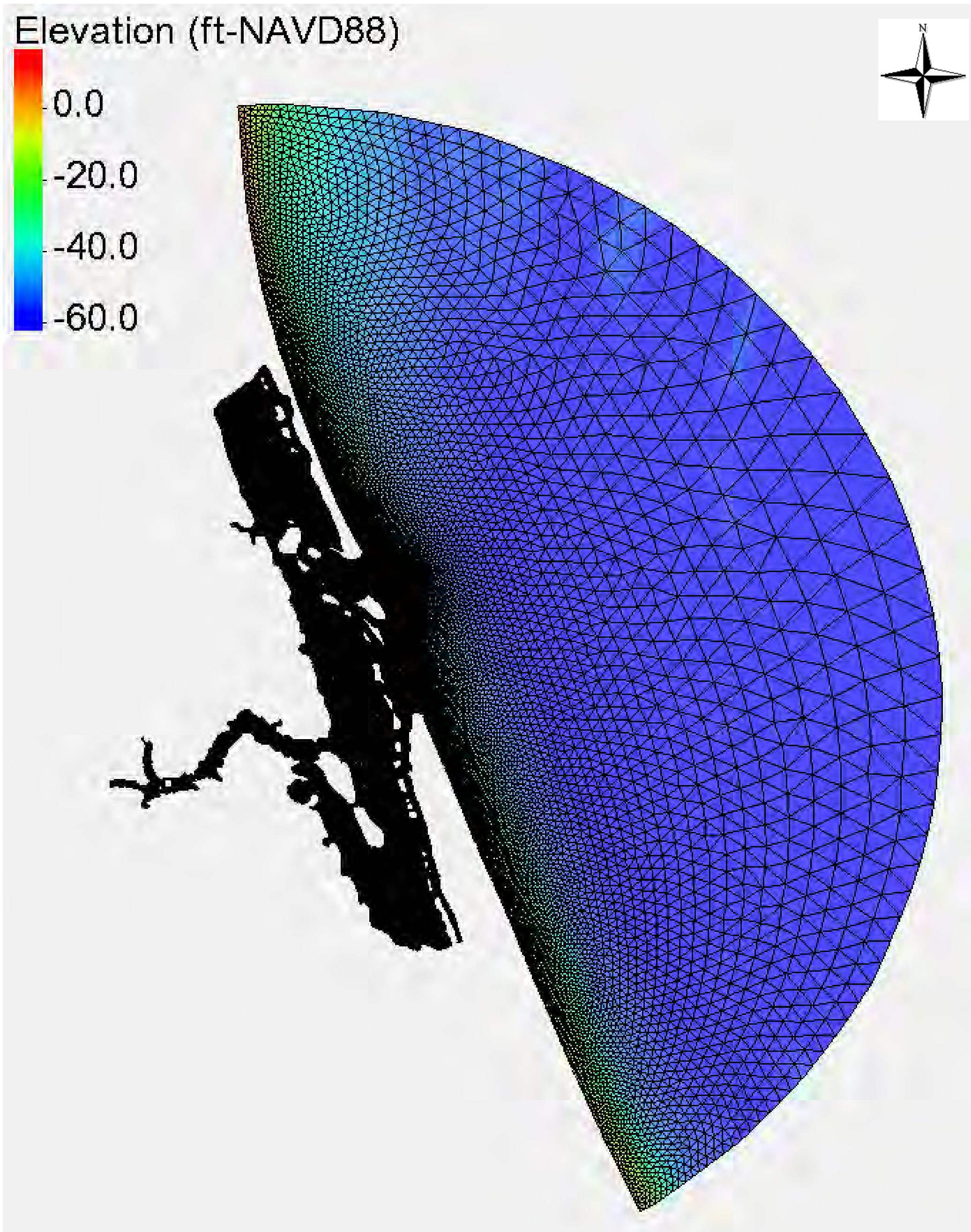

Figure 1.1 ADCIRC Model Mesh Extent and Elevation Contours

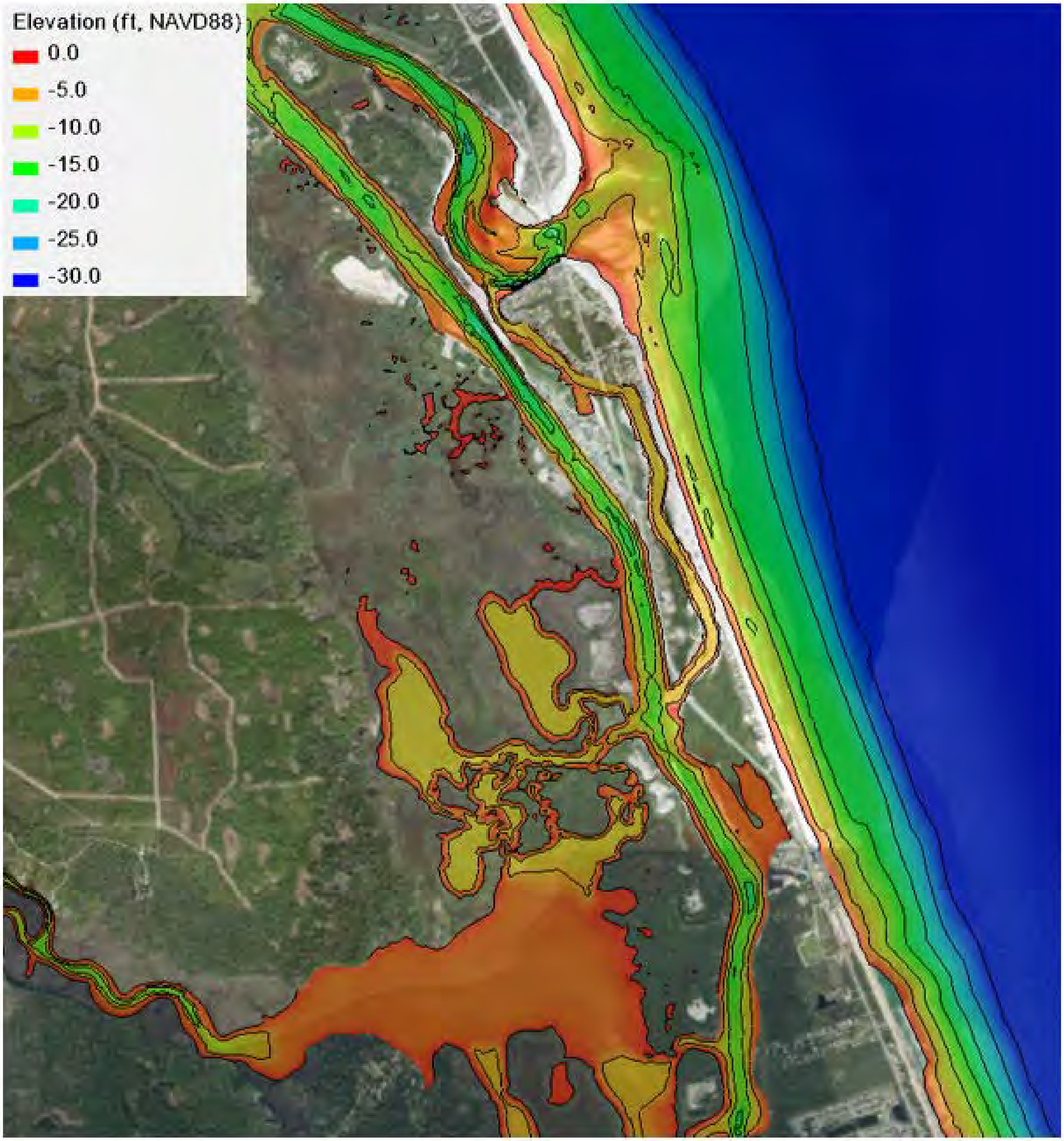

Figure 1.2 Scenario 1 Existing Bathymetry Contours

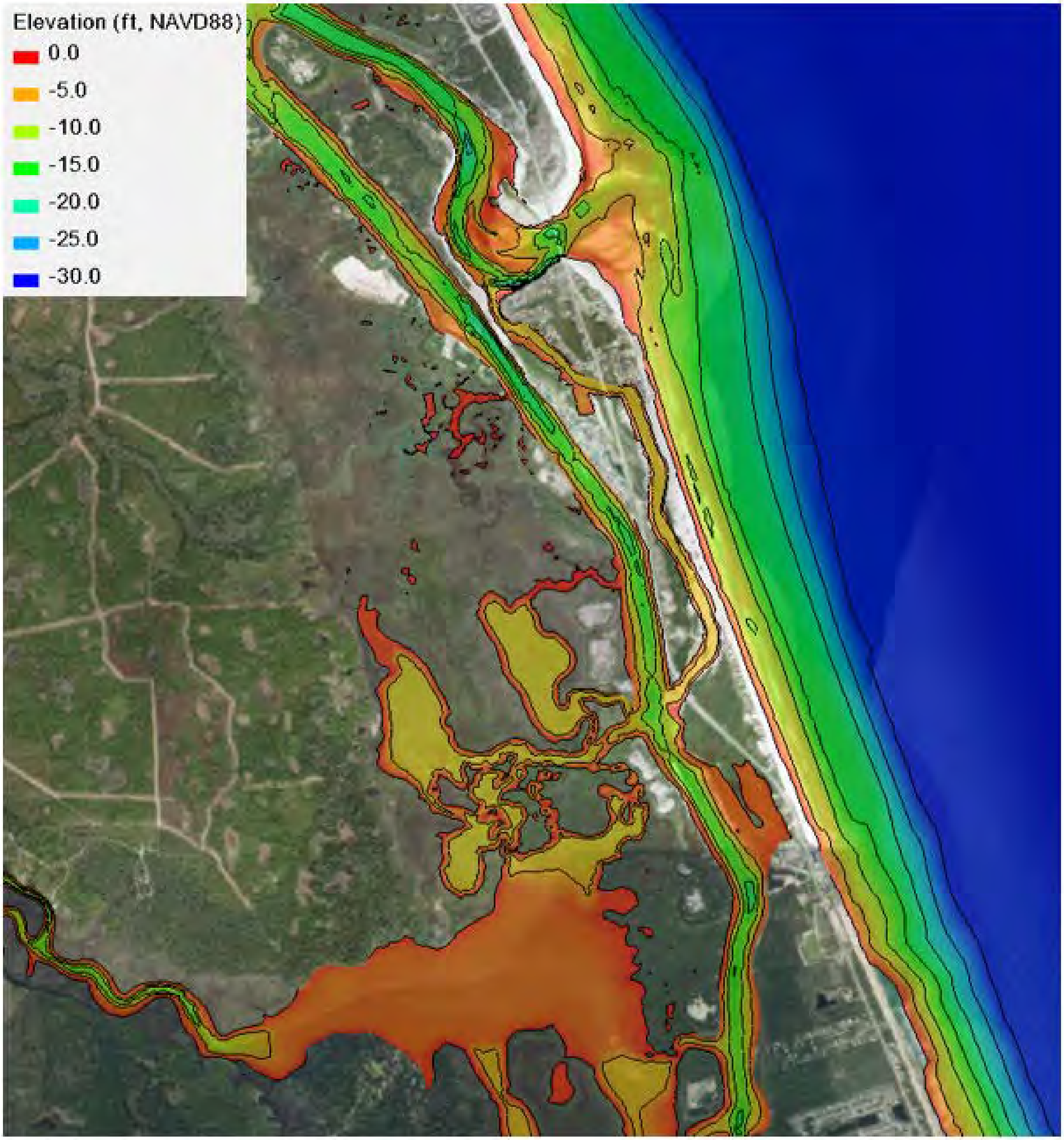

Figure 1.3 Scenario 2 Bathymetry Contours (SHR Deepened to -6 ft NAVD)

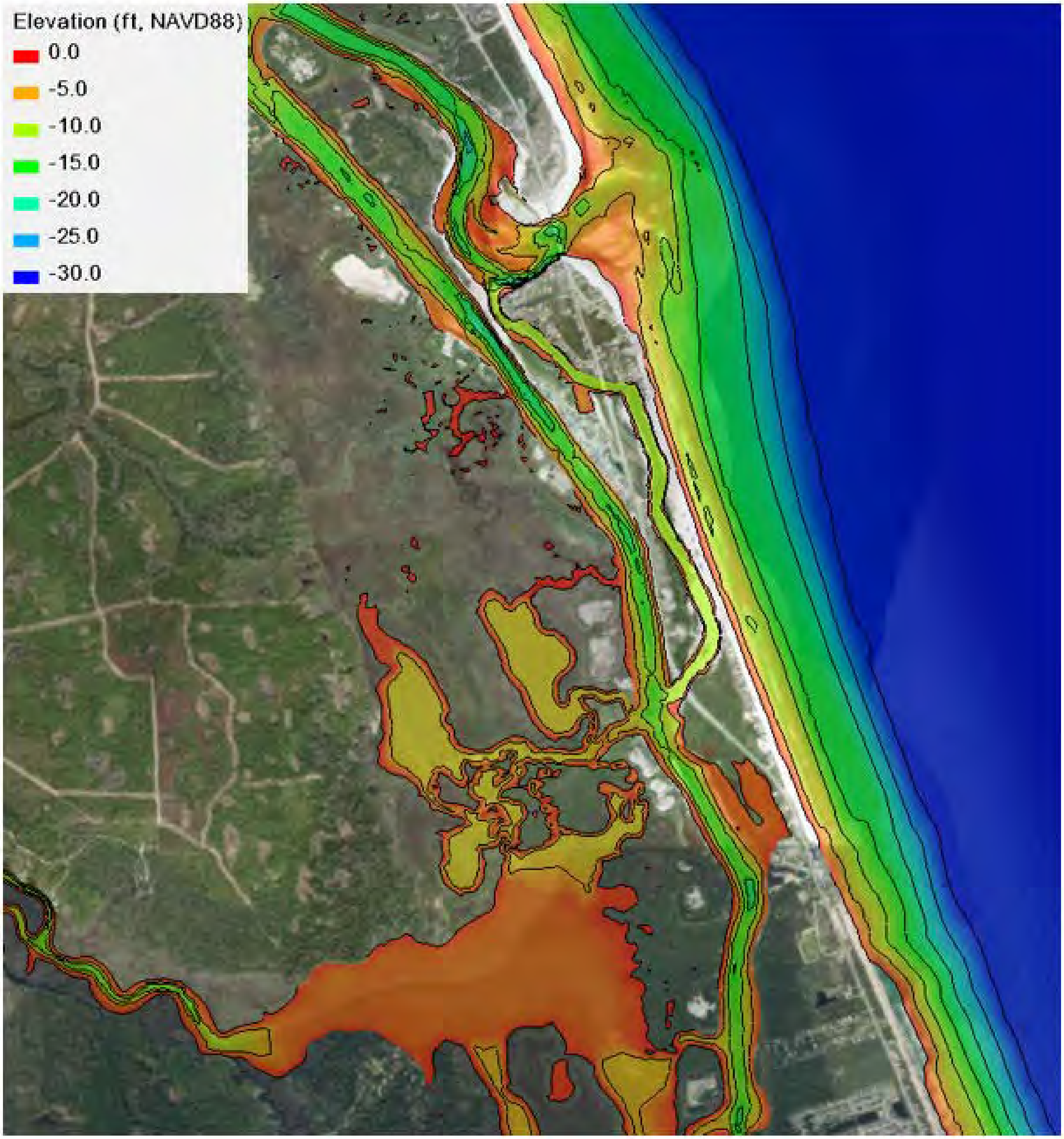

Figure 1.4 Scenario 3 Bathymetry Contours (SHR Deepened to -10 ft NAVD)

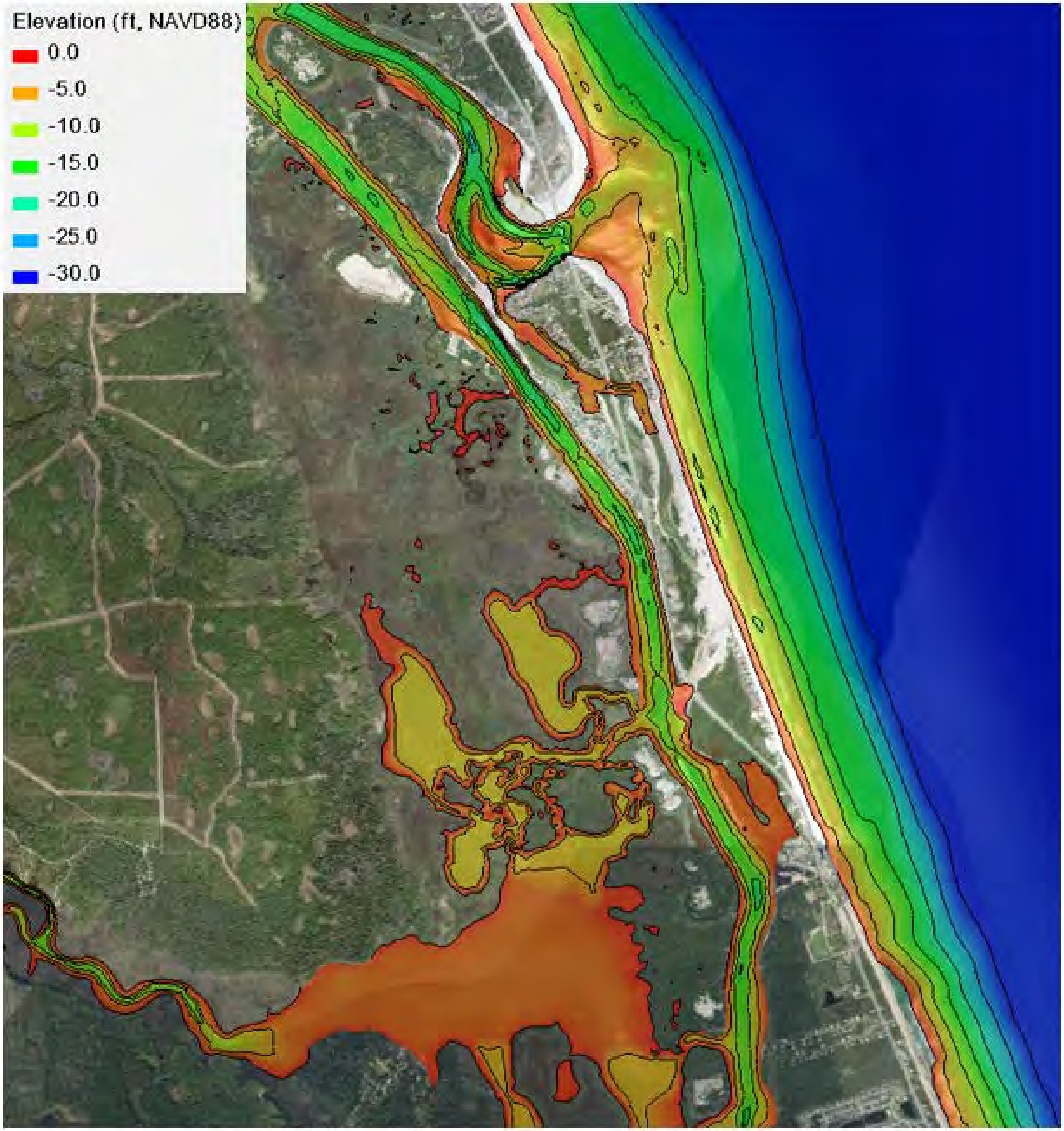

Figure 1.5 Scenario 4 Bathymetry Contours (Dredged Inlet Channel)

1.2 Model Calibration

Model calibration involves an iterative process of adjusting model parameters until the model results at a set location closely match measured data at that location. Unfortunately, time and budget constraints for this project excluded the prospect of collecting field data for model calibration. Fortunately, NOAA maintains a series of stations that collect meteorological and oceanographic data, including a station at the bridge spanning Matanzas Inlet (Station 8720692) and at Fort Matanzas (Station 8720686), approximately 1.3 miles inside the inlet (**Figure 1.6**). NOAA's tidal prediction and measurements data are available at the Center for Oceanographic Products and Services (CO-OPS) web site (http://tidesandcurrents.noaa.gov/). This study calibrated the ADCIRC model by forcing it with tidal constituents and comparing the simulated data to NOAA predictions during a typical tidal cycle.

Calibration of the model applies the following error estimations as a quantitative method to judge their ability to reproduce measured events. The first equation provides an estimate of the mean error (E), the average of the deviation of the calculated from the measured values defined as

$$E = \frac{\sum_{i=1}^{N} (\chi_c - \chi_m)_i}{N}$$

where χ_c is the calculated value, χ_m is the measured value, and N is the total number of data points. A positive value for the mean error would indicate that the model overestimates the event, while a negative value would indicate the model underestimates the event. The root-mean square error (E_{rms}), given by the following equation, indicates the absolute error of the comparison. The variables remain the same as indicated above.

$$E_{rms} = \sqrt{\frac{\sum_{i=1}^{N} \left(\chi_c - \chi_m\right)_i^2}{N}}$$

The final error estimator (E_{pct}), represents the percent error. This variable gives an indication of the degree to which the calculated values misrepresent the measured values. Percent error is given as

$$E_{pct} = \frac{E_{rms}}{R}$$

where R is a representative range of the variable χ.

The mean of predictions from ADCIRC are expected to be zero since it consists of tidal constituents all with zero means. A feature of the tide at this location is the strong seasonal signal. This is due to riverine runoff and change in the water density caused by radiational heating. Interestingly, NOAA tidal predictions also have these seasonal signals, even though they are not tidal in origin. These signals are captured as solar annual constituent (SA) and solar semiannual constituent (SSA), because they have the same frequency as the seasonal effects. This is a known and documented effect for NOAA tidal predictions. The ADCIRC calibration run only uses tidal forcing as its boundary condition and cannot capture these seasonal non-tidal effects. For a month-long simulation, simply removing the means eliminates most of the seasonal signal and allows for a more direct comparison.

Calibration resulted from iterative adjustments to the Manning's n, within the range 0.018 to 0.02, until differences between NOAA tidal predictions and ADCIRC estimated water surface elevations fall within an acceptable range. **Figure 1.7** compares those predictions with model simulations of water surface elevation. As the figure demonstrates, the model predicts the tide within an acceptable error. **Table 1** summarizes the results of the calibration. From the table, the average percent error at each location is within FEMA's acceptable error range; as such, the model is considered calibrated. The calibrated model has a horizontal eddy viscosity (ESLM) of 3.75 m2/s and Manning's n value of 0.02 for water, 0.05 for marsh, and 0.1 for land (shown in **Table 2**). **Table 2** presents the final values of the spatially variable Manning's Friction Factor.

Figure 1.6 Location of NOAA Tide Prediction Data Used for Model Calibration

Table 1 Summary of the Calibration Results

Location	RMS Error	Average % Error
Matanzas Inlet (8720692)	0.10	6.58%
Fort Matanzas (8720686)	0.09	6.54%

Table 2 Summary of Spatially Variable Manning's Friction Factors

Area	Manning's Friction Factor (*n*)
Waterways	0.02
Marsh	0.05
Land	0.1

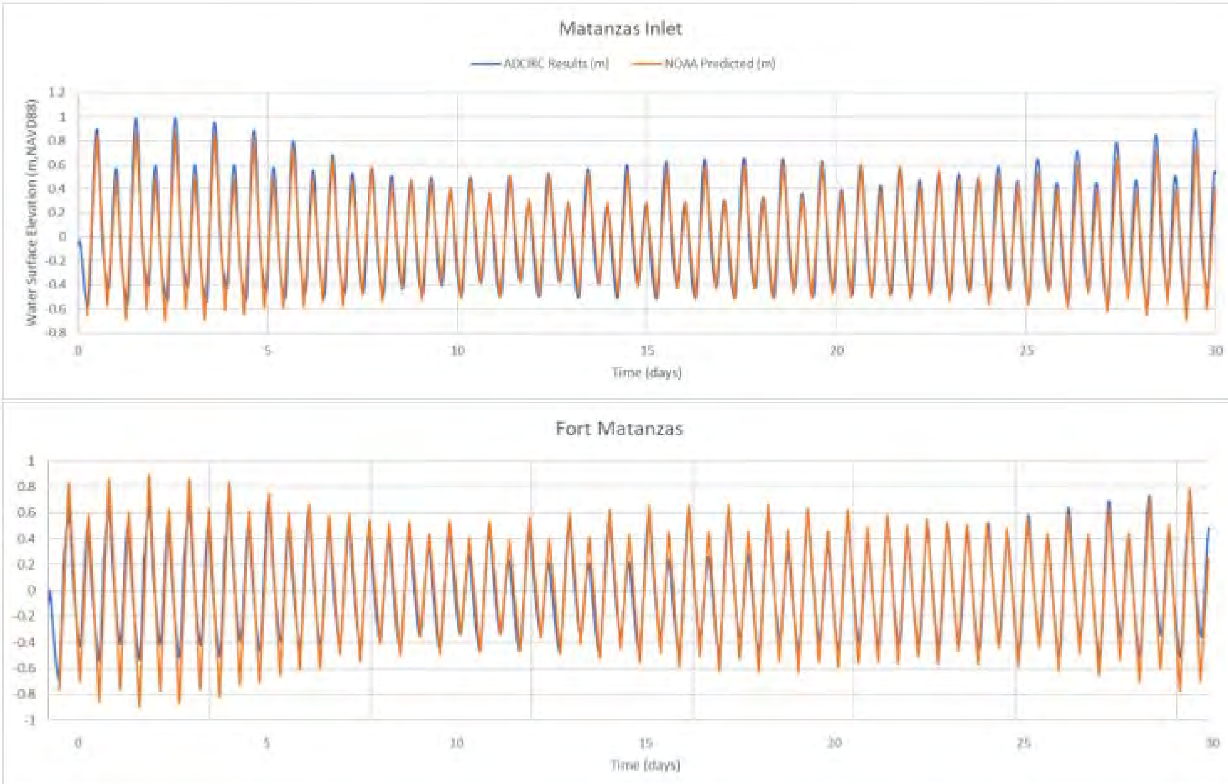

Figure 1.7 Calibration Comparison Plot at Matanzas Inlet (top) and Fort Matanzas (bottom)

Of note, **Table 3** provides the calculated flood and ebb tidal prisms for Matanzas Inlet for scenarios 1–4. The third column indicates the percentage increase in tidal prism relative to existing conditions. For comparison purposes, Mehta and Jones (1977) show the inlet is flood dominant (with the flood tidal prism exceeding the ebb tidal prism) with reported flood and ebb tidal prisms of 5.84 * 10^8 and 4.15 * 10^8 cubic feet (ft^3) calculated from discharge data collected on July 18, 1974. The tidal prisms are unequal given the inlet's proximity to St. Augustine and Ponce de Leon inlets. Taylor Engineering (2009) showed that the Tropical Storm Fay (2008) breach would likely reduce the tidal prism at the inlet by less than 7%, which is like the 7.8% reduction calculated between scenarios 2 (restored river condition) and 1 (breached condition) (i.e., [4.90-4.52]/4.90 * 100%).

Table 3 Tidal Prisms for Scenarios 1–4

Scenario	Flood Tidal Prism ($10^8 ft^3$)	Ebb Tidal Prism ($10^8 ft^3$)	Flood Tidal Prism Change from Existing (%)
1 — Existing Conditions	4.52	4.13	-
2 — SHR Deepened to -6 ft NAVD88	4.90	4.43	8.4
3 — SHR Deepened to -10 ft NAVD88	5.19	4.61	14.8
4 —Dredged Inlet Channel	4.97	4.47	10.0

1.3 Simulation Results

The model simulations sought to determine whether flow through the SHR has a measurable effect on the inlet currents, as well as the hydrodynamics near Pellicer Creek, and how reconfiguring the inlet flow by dredging through the northern portion of the flood shoal could alleviate erosion of inlet's southern shoreline. Private property along the southern shoreline, west of the bridge crossing, has experienced damage and property loss from the inlet flow velocities that are currently concentrated against the shoreline. The erosion of the waterway in front of these homes is apparent in the contours of the existing conditions (**Figure 1.8**), where channel depths exceed 30 ft a very short distance away from the shoreline. **Figure 1.9**–**Figure 1.11** show the modified contours at the inlet for scenarios 2–4. Scenarios 2 and 3 only modified the bathymetry in the Summer Haven River, and Scenario 4 only modified the inlet bathymetry within the new dredge channel near the northern shoreline of the inlet.

Figure 1.12 and **Figure 1.13** show the flow velocities at peak ebb flow (i.e., outgoing tide) and peak flood flow (i.e., incoming tide) at the inlet under scenario 1 — existing conditions. Attachment 1 contains additional plots of flow velocity for the study for each scenario. The following sections discuss the general effects of each scenario —as evident in contour plots of the changes in flow velocity magnitudes as compared to exiting conditions — followed by an evaluation of their effects on sediment transport. Of note, the velocity change plots in the following section use the same scale (+3.0 ft/sec to -3 ft/sec) for all scenarios to demonstrate their relative effects.

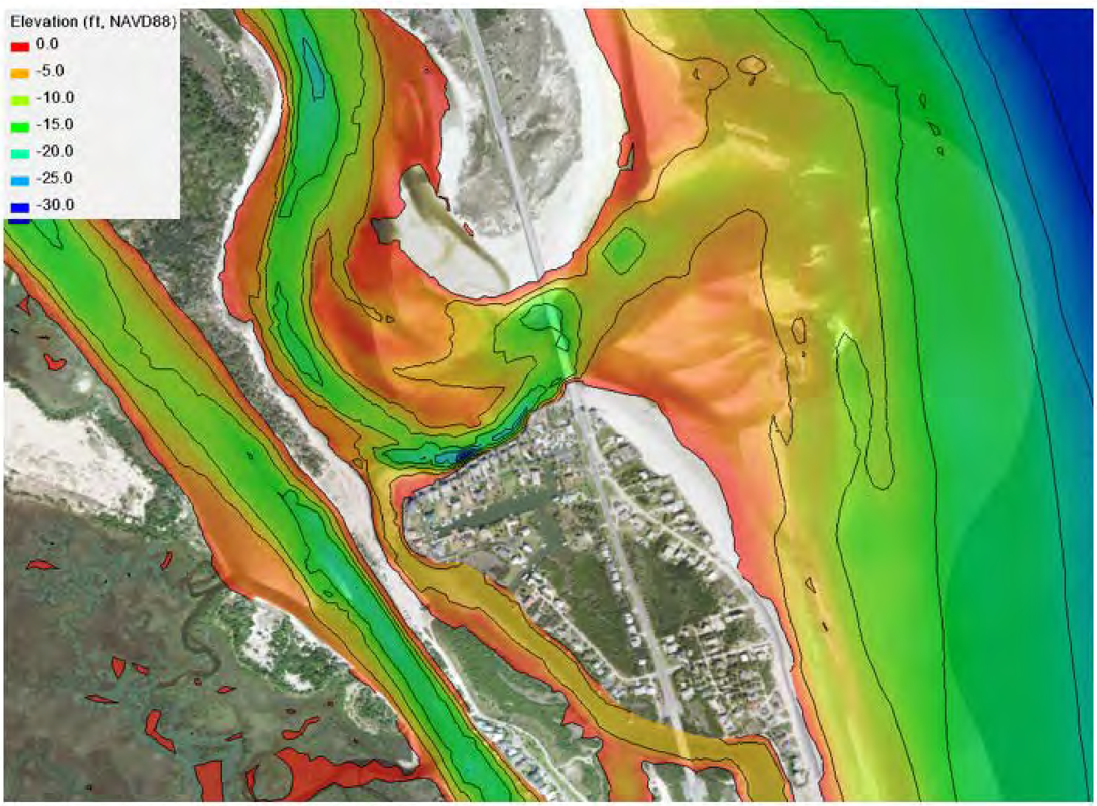

Figure 1.8 Scenario 1 Existing Bathymetry Contours at the Inlet

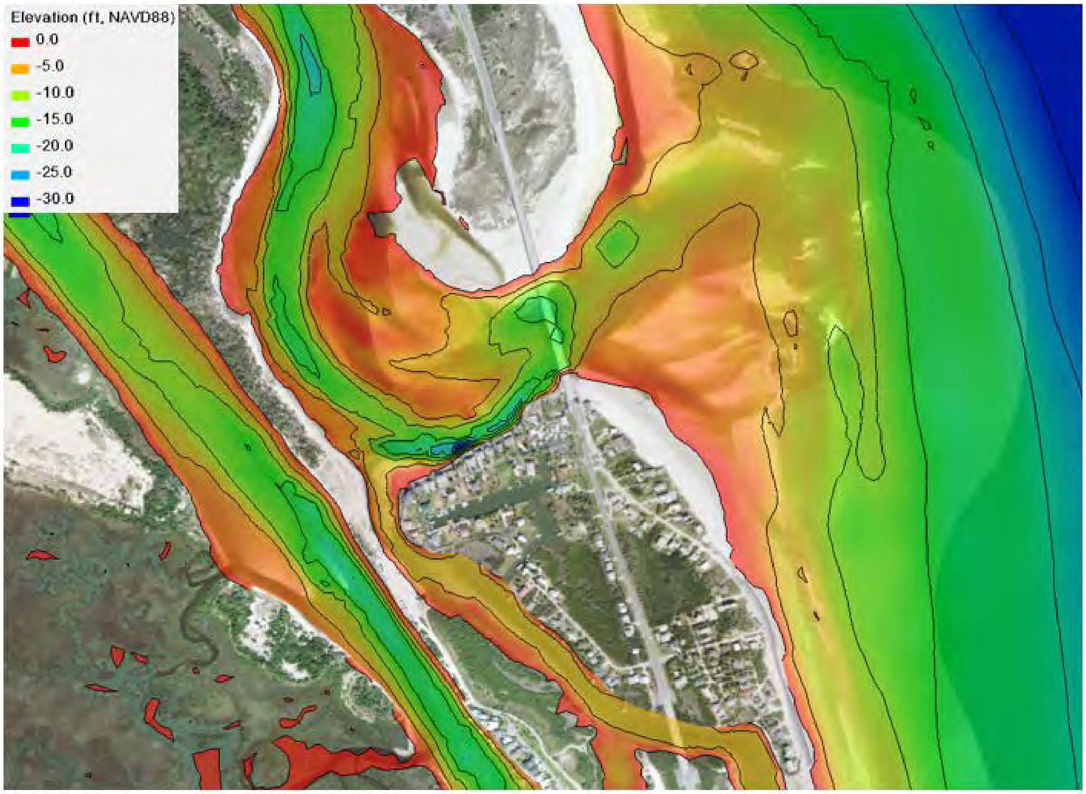

Figure 1.9 Scenario 2 Bathymetry Contours at the Inlet (SHR deepened to -6 ft NAVD)

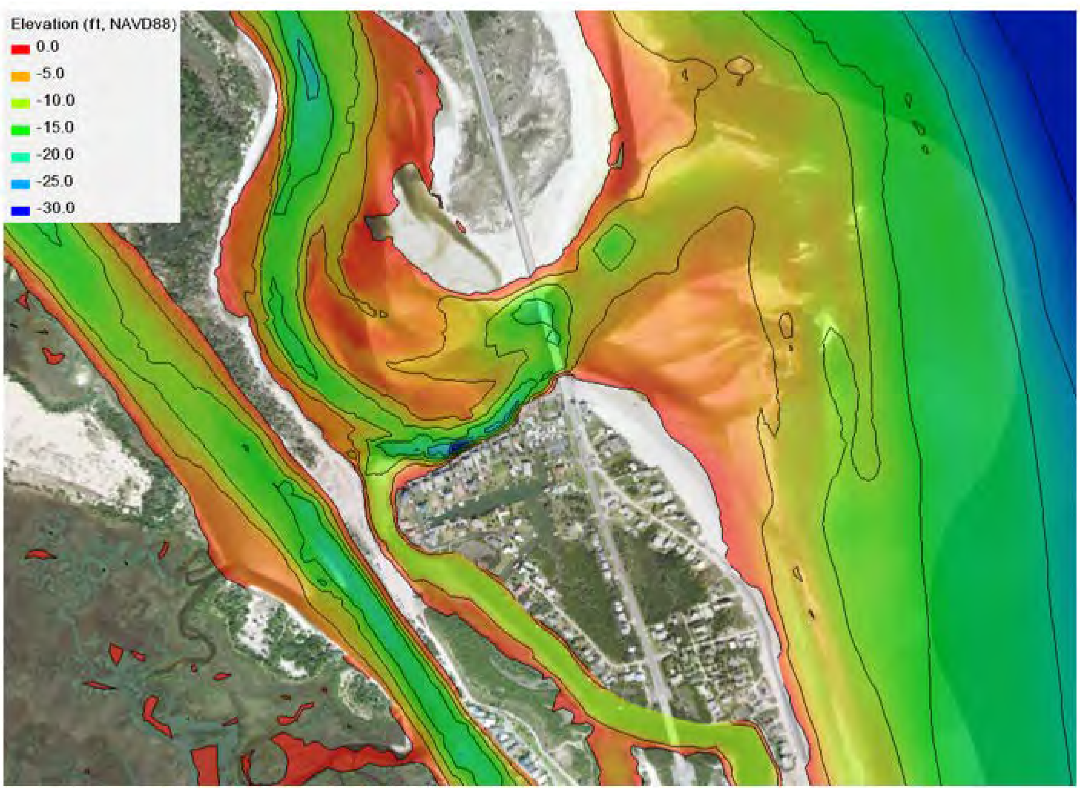

Figure 1.10 Scenario 3 Bathymetry Contours at the Inlet (SHR deepened to -10 ft NAVD)

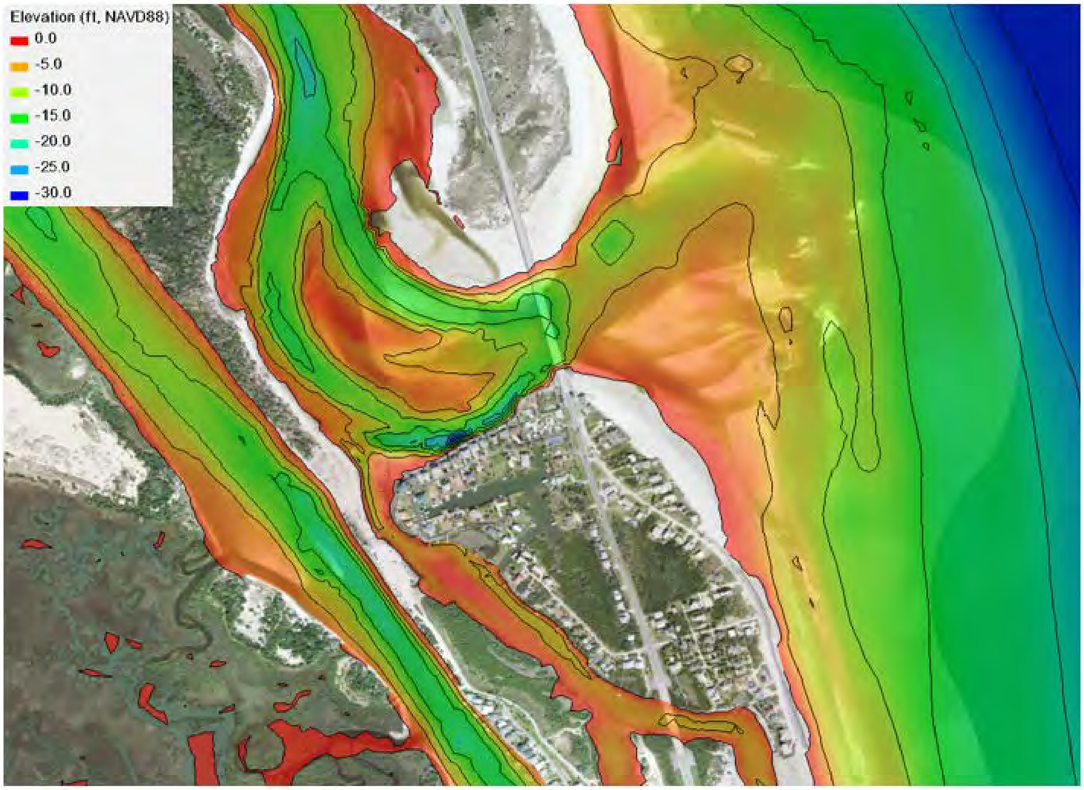

Figure 1.11 Scenario 4 Bathymetry Contours at the Inlet (Dredged Inlet Channel)

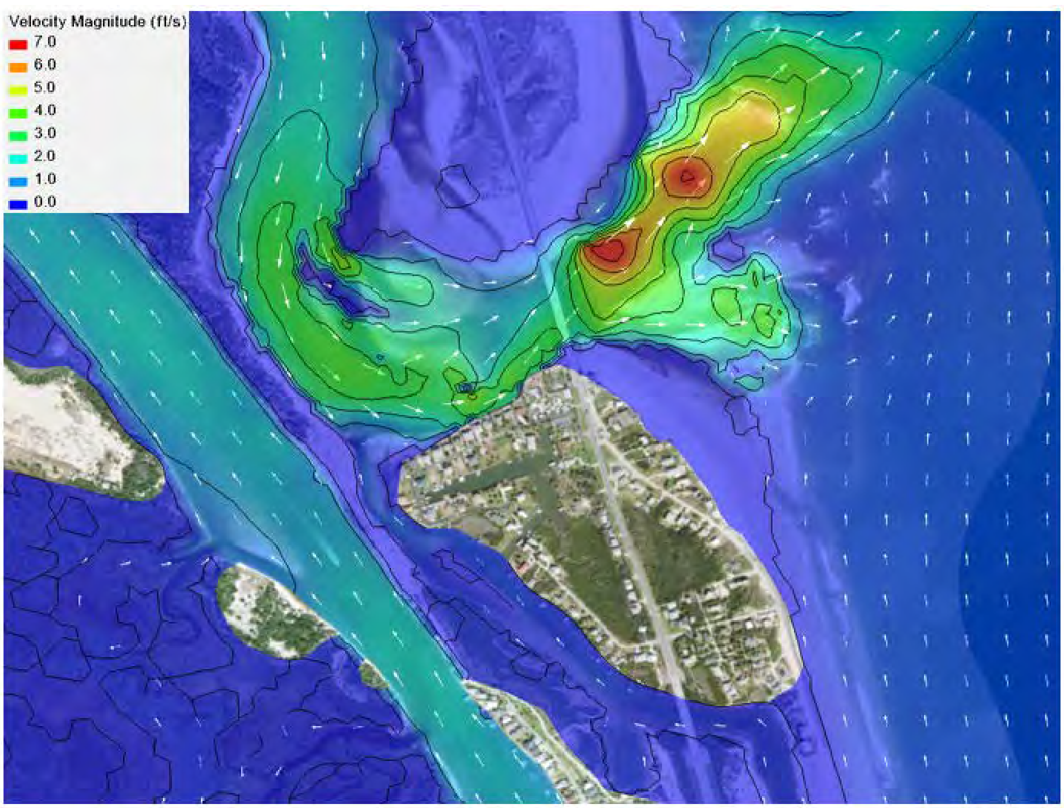

Figure 1.12 Peak Ebb Flow Velocities under Existing Conditions

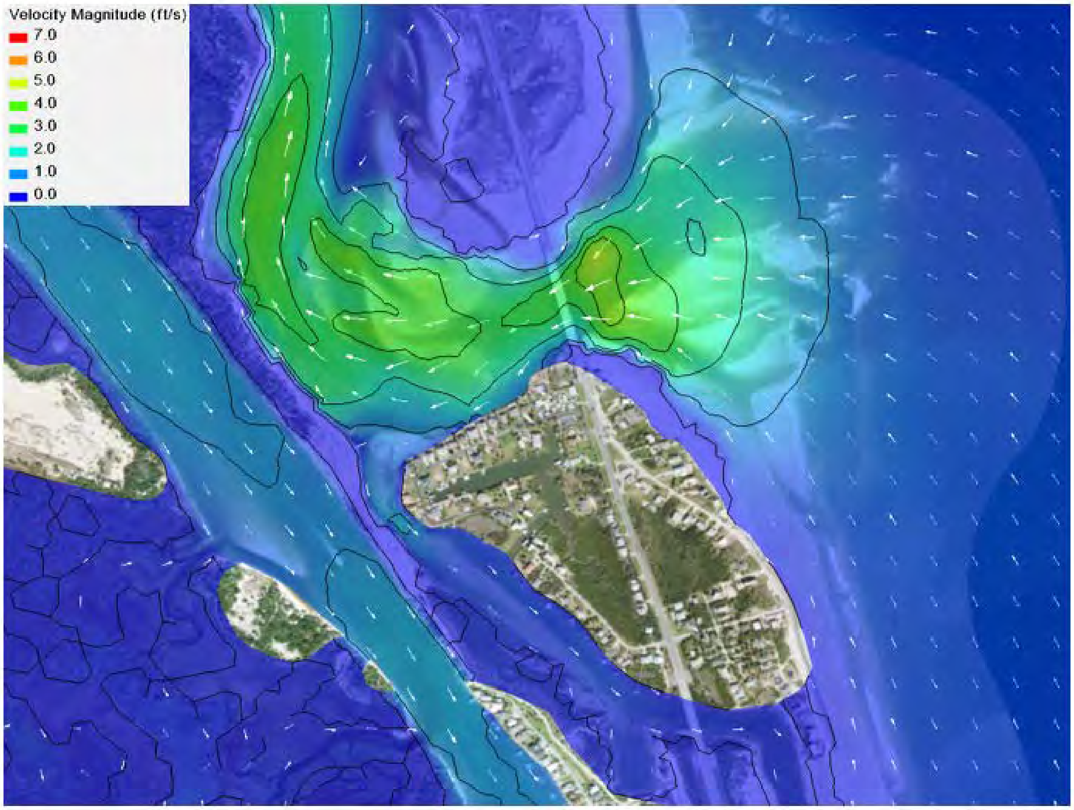

Figure 1.13 Peak Flood Flow Velocities under Existing Conditions

1.3.1 General Effects within Matanzas Inlet

For scenario 2, **Figure 1.14** and **Figure 1.15** show the changes in flow velocity, compared to existing conditions, at peak ebb flow and peak flood flow after re-establishing flow through SHR with a channel depth of -6 ft NAVD; **Figure 1.16** and **Figure 1.17** show the same results zoomed into the inlet. Negative values correspond to a reduction in velocity and positive values indicate an increase in velocity. Note the black contour lines surrounded by green shading represents the zero-change contour; the occurrence of this contour throughout the waterways and marsh demonstrates the sensitivity of the hydrodynamics to Summer Haven River changes, yet the changes are minimal beyond the north and south ends of the river. During ebb flow, the zero-change contour extends slightly beyond the mouth of the river and into the inlet channel; during flood flow, the effects of the river are even less pronounced.

Slight orange and blue shading is apparent within the inlet channel in **Figure 1.16** and **Figure 1.17** for ebb and flood flow, indicating slight effects of the Summer Haven River flow on the inlet currents. The velocity changes are small, generally less than 0.5 ft/sec, yet the pattern of reduced flow along the southern/western side of the inlet and increased flow along the northern side demonstrates a weak “steering current” effect of the Summer Haven River flow pushing the inlet’s main flow away from the southern shoreline. The steering current effect is greatest during ebb flow when the inlet currents travel directly towards the southern shoreline as opposed to flood flow when the current travels towards the western shoreline. Section 1.3.2 further discusses the effects of the steering current on the inlet.

For scenario 3, **Figure 1.18** and **Figure 1.19** show the changes in flow velocity, compared to existing conditions, at peak ebb flow and peak flood flow after re-establishing flow through SHR with a channel depth of -10 ft NAVD; **Figure 1.20** and **Figure 1.21** show the same results zoomed into the inlet. Overall, the increased depth of the Summer Haven River as compared to scenario 2 seems to make only a slight difference. During ebb flow, the zero-change contour extends slightly further northeastward into the inlet channel than scenario 2; the river's effects on inlet currents still appear minor but slightly more pronounced than scenario 2. During flood flow, the zero contour extends just slightly further eastward than scenario 2. The above-mentioned steering current effect is slightly stronger for scenario 3, given the deeper river depths and increased flow through the river; however, the velocity changes are still generally 0.5 ft/sec or less.

For scenario 4, **Figure 1.22** and **Figure 1.23** show the changes in flow velocity, compared to existing conditions, at peak ebb flow and peak flood flow after dredging the northern inlet channel; **Figure 1.24** and **Figure 1.25** zoom into the inlet. During ebb flow, the velocities increase significantly throughout the dredged channel as expected and decrease significantly in the southern channel. Like scenarios 2–3, the effects during flood flow are similar to those during ebb flow but lesser in magnitude. The significant changes in velocity would have a significant effect on the erosion along the southern shoreline, as discussed in more detail in Section 1.3.2.

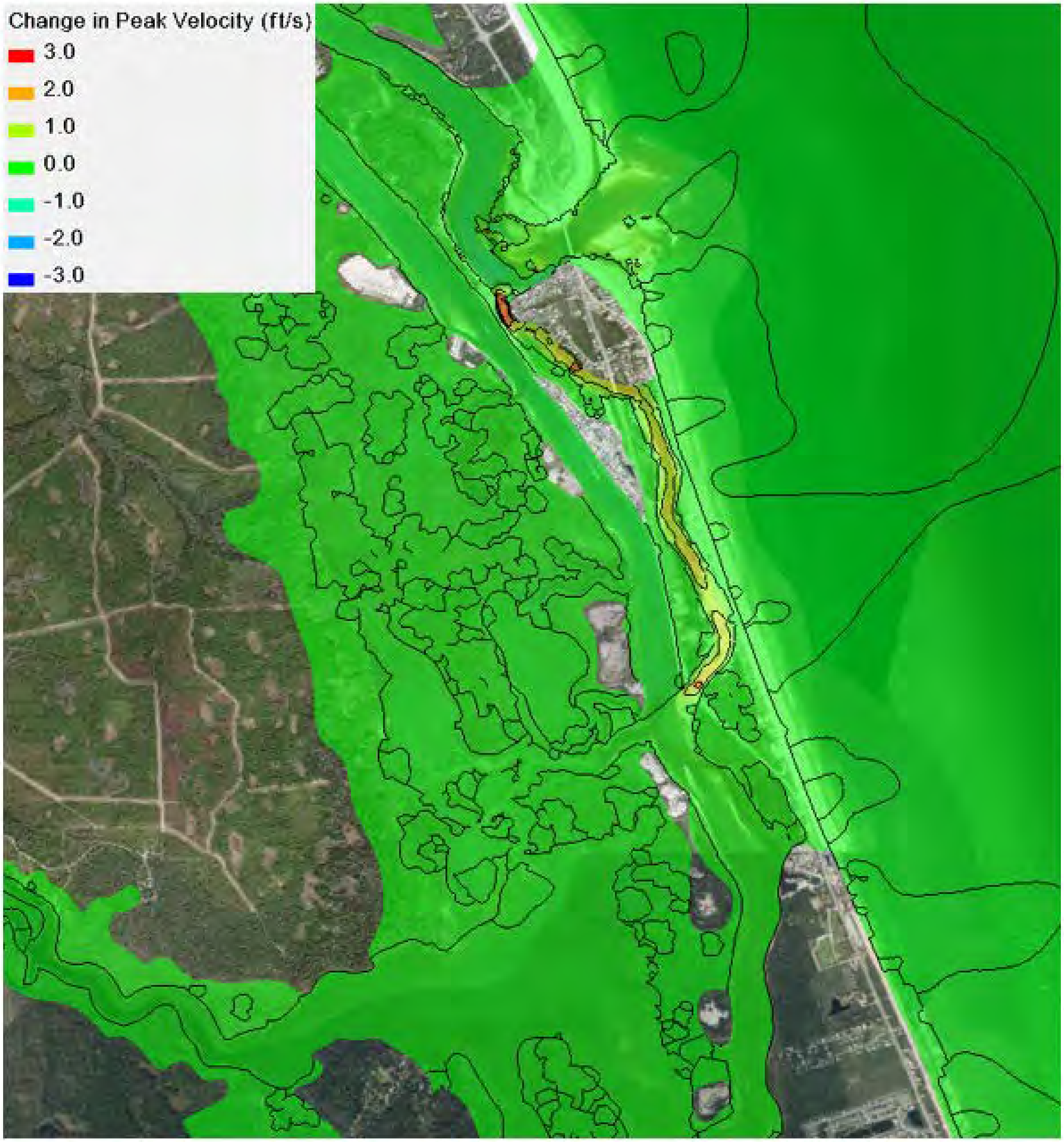

Figure 1.14 Change in Velocity at Peak Ebb Flow — Scenario 2 (SHR at -6 ft NAVD 88) vs. Existing Conditions

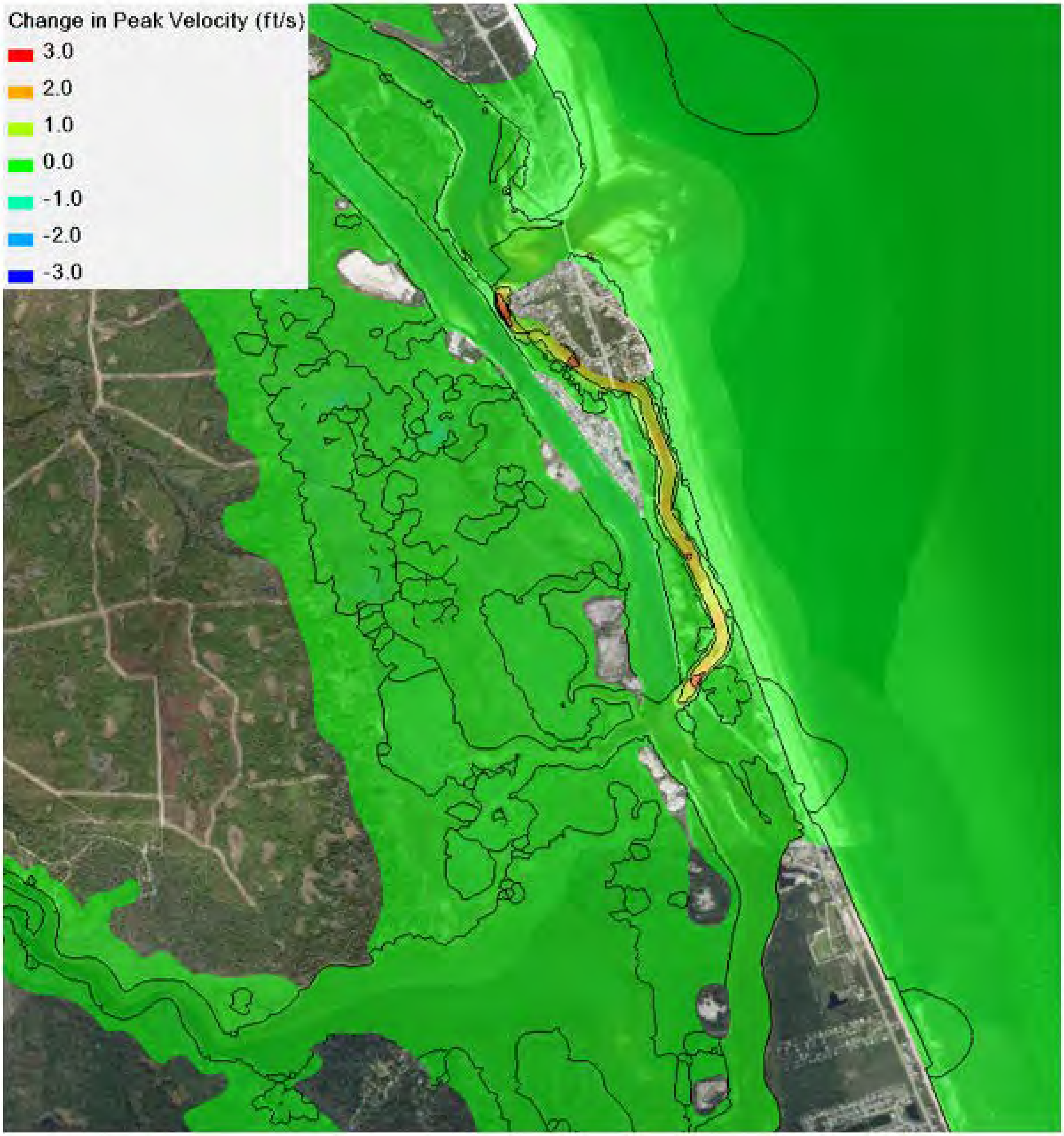

Figure 1.15 Change in Velocity at Peak Flood Flow — Scenario 2 (SHR at -6 ft NAVD 88) vs. Existing Conditions

Figure 1.16 Change in Velocity within Inlet at Peak Ebb Flow — Scenario 2 vs. Existing Conditions

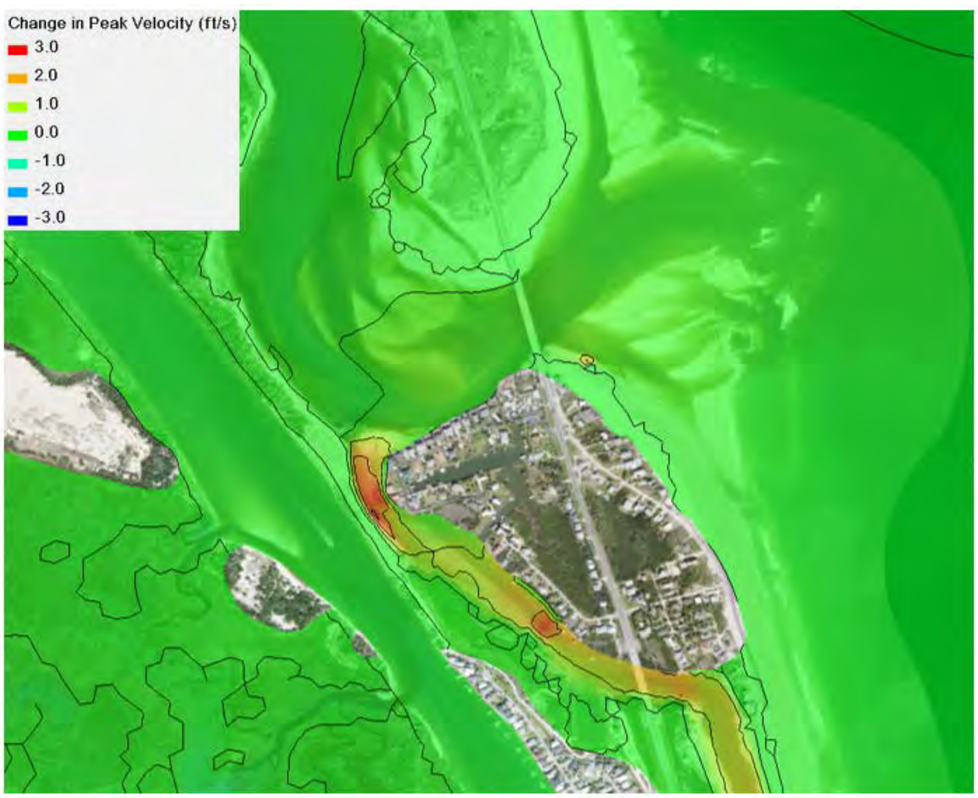

Figure 1.17 Change in Velocity within Inlet at Peak Flood Flow — Scenario 2 vs. Existing Conditions

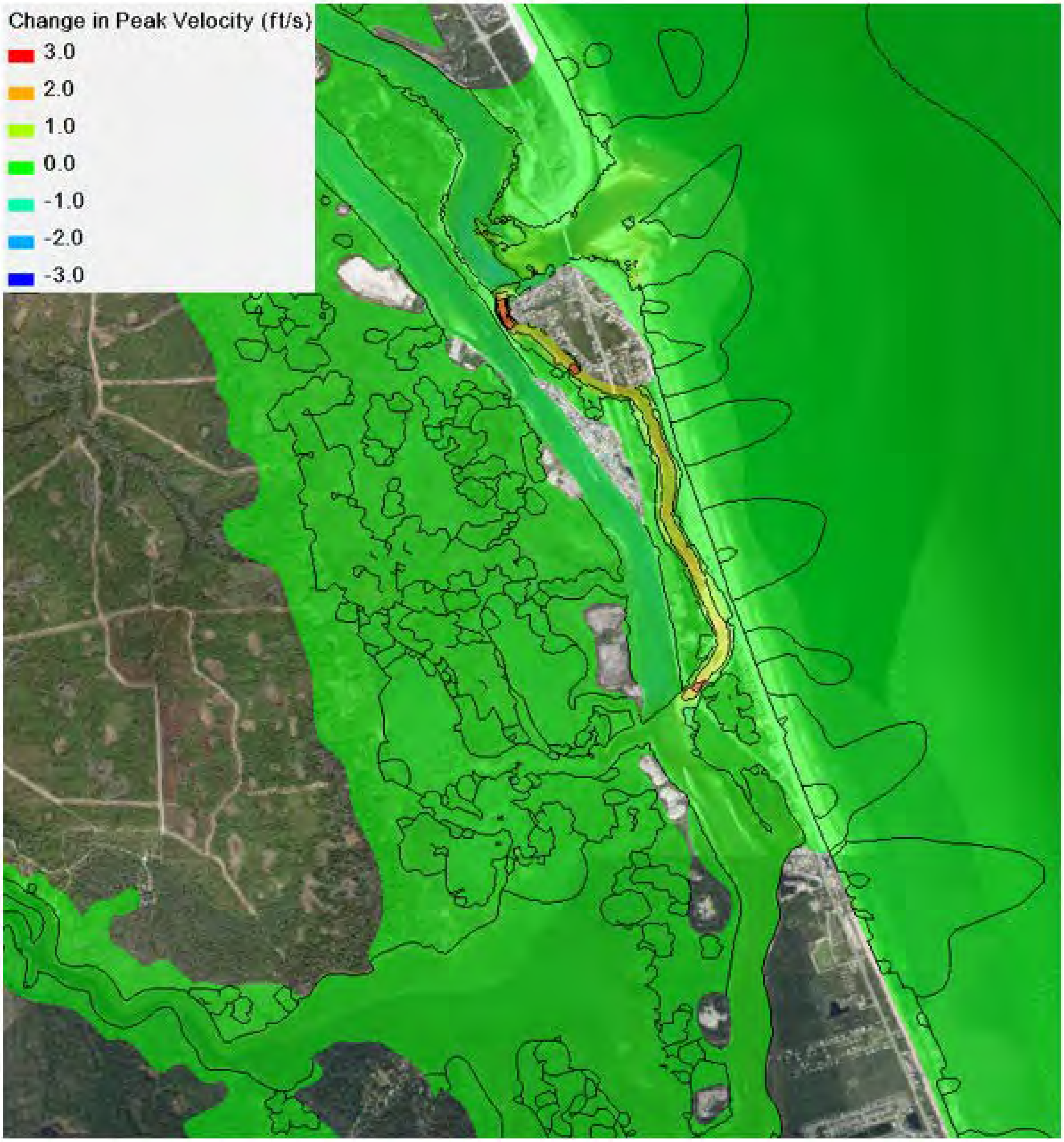

Figure 1.18 Change in Velocity at Peak Ebb Flow — Scenario 3 (SHR at -10 ft NAVD 88) vs. Existing Conditions

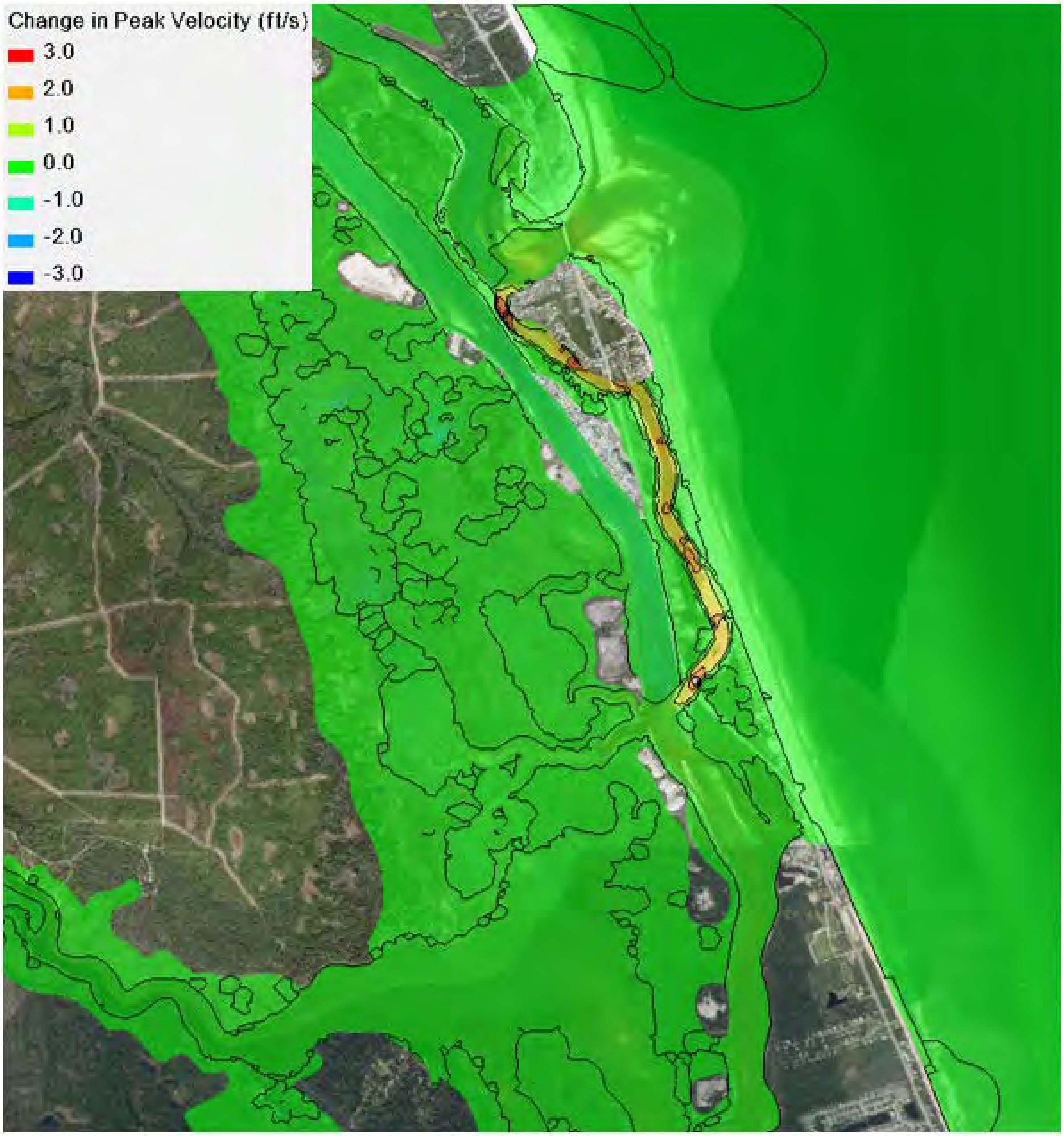

Figure 1.19 Change in Velocity at Peak Flood Flow — Scenario 3 (SHR at -10 ft NAVD 88) vs. Existing Conditions

Figure 1.20 Change in Velocity within Inlet at Peak Ebb Flow — Scenario 3 vs. Existing Conditions

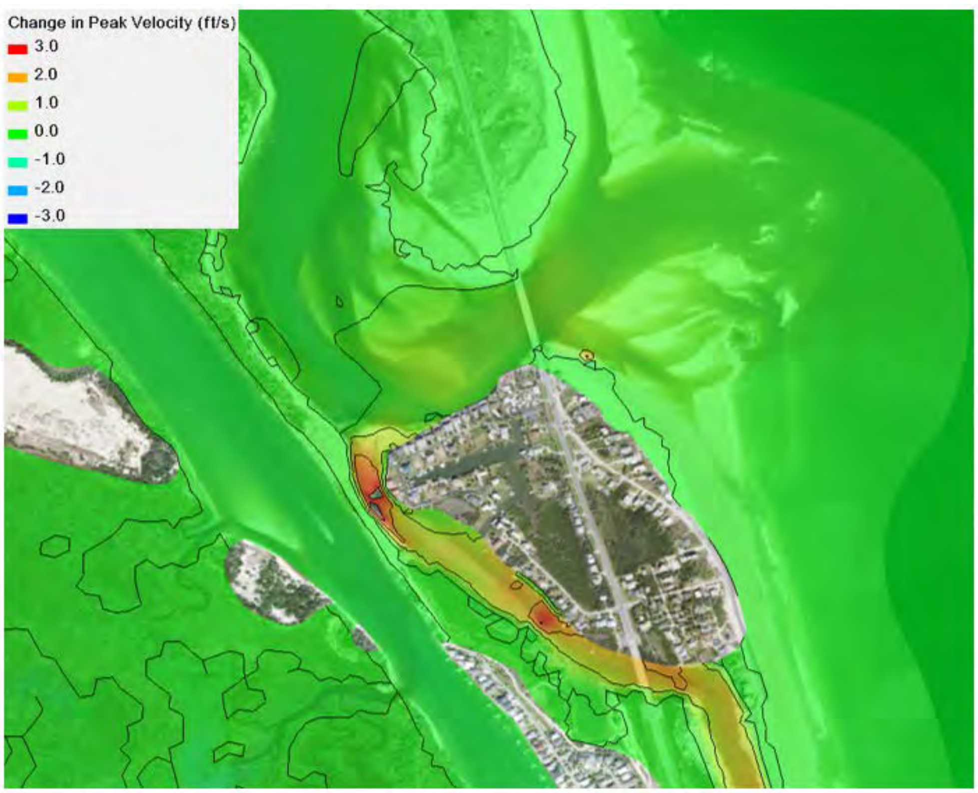

Figure 1.21 Change in Velocity within Inlet at Peak Flood Flow — Scenario 3 vs. Existing Conditions

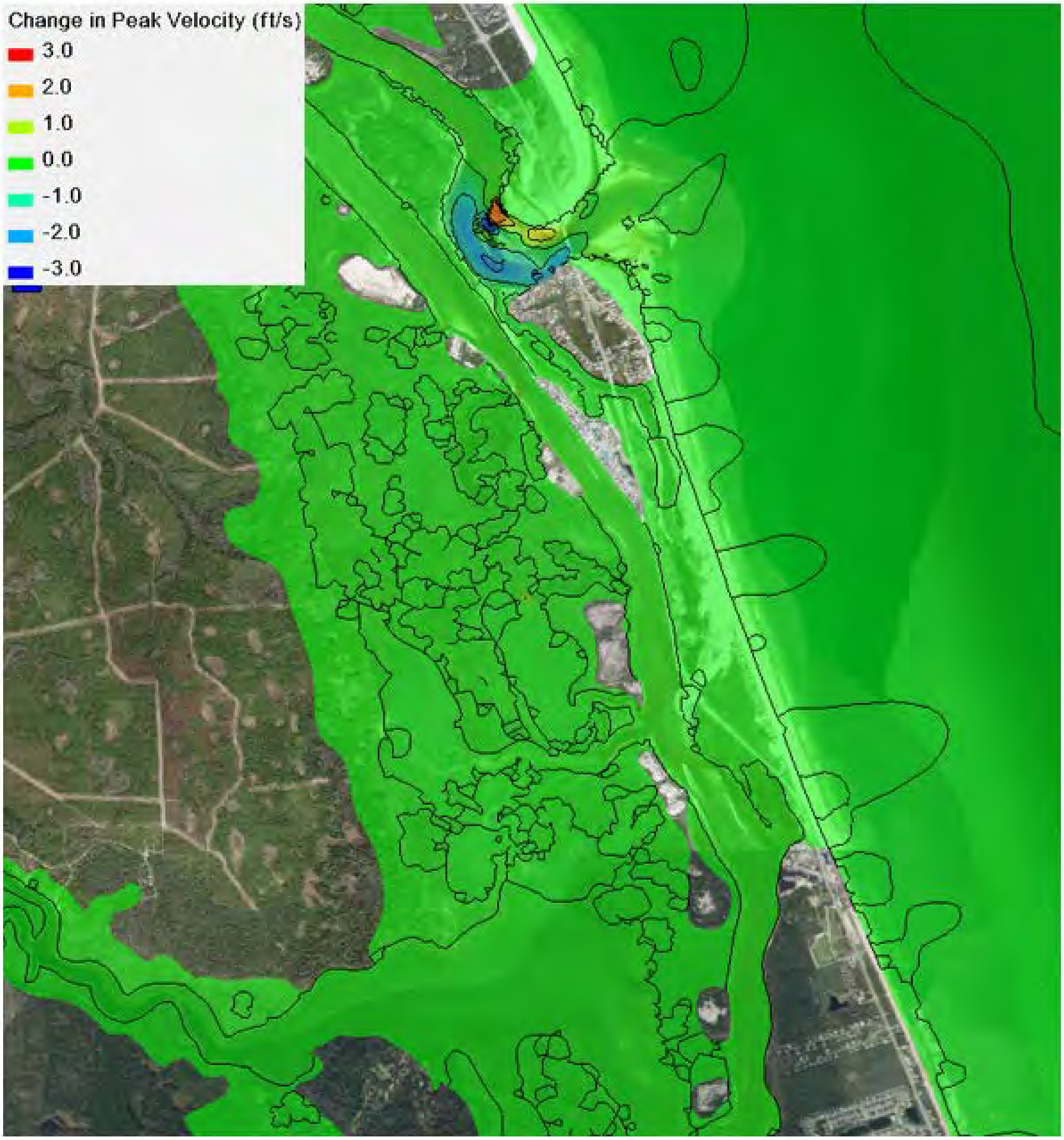

Figure 1.22 Change in Velocity at Peak Ebb Flow — Scenario 4 (Dredged Inlet Channel) vs. Existing Conditions

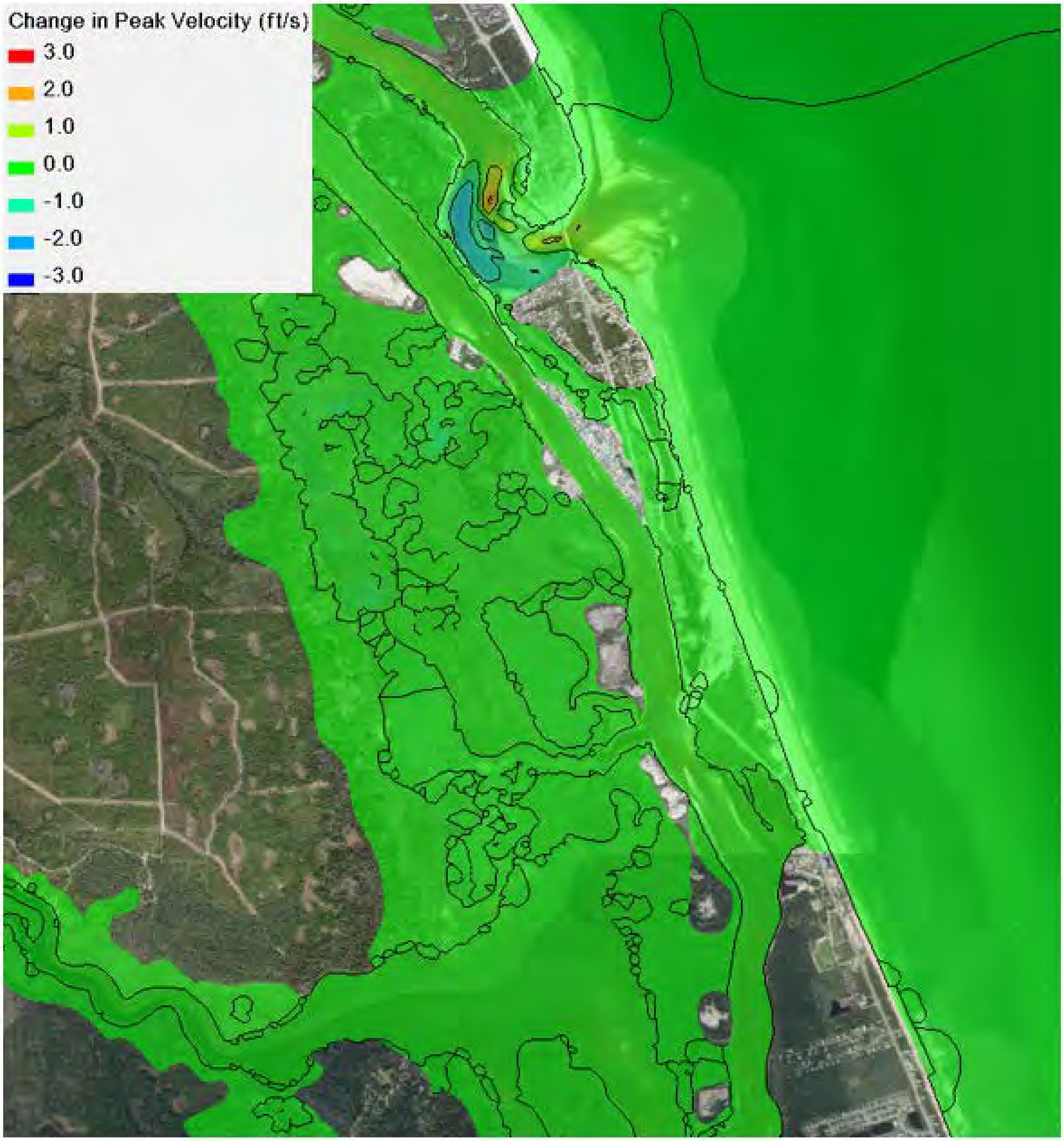

Figure 1.23 Change in Velocity at Peak Flood Flow — Scenario 4 (Dredged Inlet Channel) vs. Existing Conditions

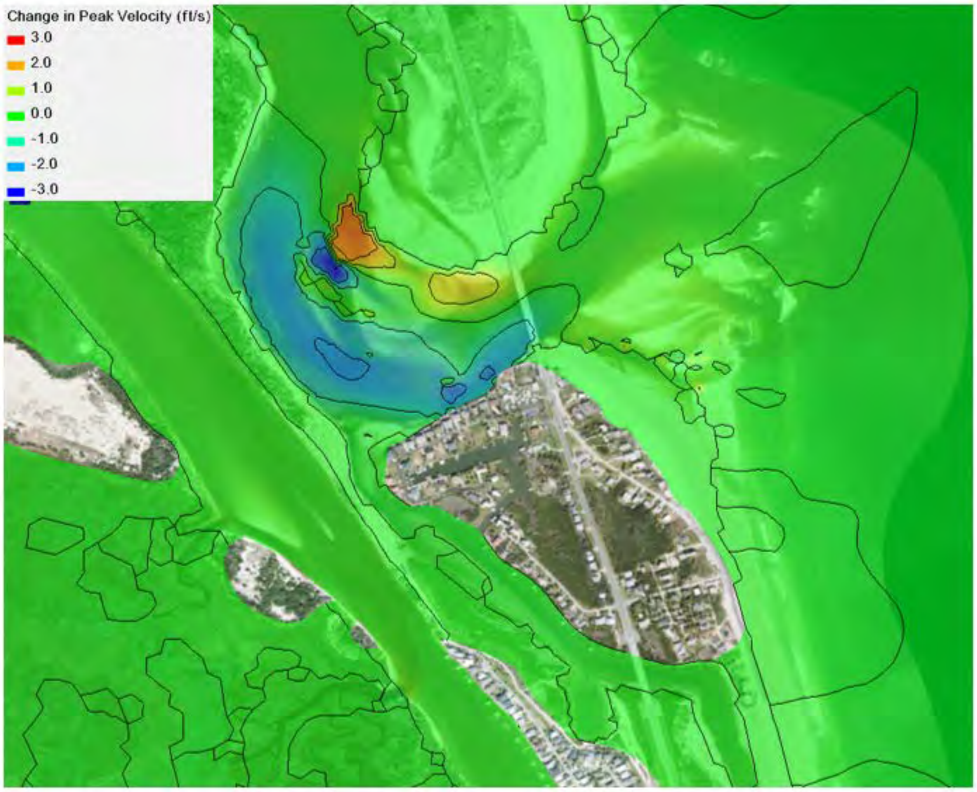

Figure 1.24 Change in Velocity within Inlet at Peak Ebb Flow – Scenario 4 vs. Existing Conditions

Figure 1.25 Change in Velocity within Inlet at Peak Flood Flow – Scenario 4 vs. Existing Conditions

1.3.2 Effects on Sediment Transport Potential

To understand how the previously discussed velocity changes from scenarios 2–4 affect sediment transport and, hence, the erosion concerns along the southern shoreline, this study evaluated sediment transport potential through comparison of the simulation velocities with the critical velocity for the sediment. The critical velocity is the velocity required to initiate sediment movement. It is a function of the sediment size, density of the sediment, density of the water, depth of the water column and bed roughness. When the depth averaged velocity exceeds the critical velocity, sediment transport occurs at the bed. Conversely, when existing velocities are reduced to below the critical velocity, sediment deposition may occur.

Figure 1.26–**Figure 1.33** plot contours of the velocity exceedance over the critical velocity for scenarios 1–4 for the peak ebb and flood flows. In these plots, sediment transport (i.e., erosion of the sea bed) may occur anywhere the velocities exceed the critical velocity (i.e., any place within the colored contours). Accretion may occur any place where the velocities are less than the critical velocity (i.e., any place void of contours).

For scenario 1 (existing conditions), the ebb flow velocities exceed the critical velocity (**Figure 1.26**) throughout the inlet except along the north bank, along the shoal fronting the Summer Haven River, and along the most elevated portions of the flood shoal towards the center of the inlet. Note the high exceedance along the center of the southern shoreline where the ebb flow runs against the shoreline before completing its turn seaward; this explains the concerning erosion along the shoreline. During incoming tide (**Figure 1.27**), the flood flow runs against the west bank before completing its turn northward, while the southern shoreline is largely unaffected by the currents.

For scenario 2, with the river deepened to -6 ft NAVD, the steering current has minimal effect on the erosion along the southern shoreline during ebb flow (**Figure 1.28**), where the velocities remain above the critical velocity. The steering current appears to only affect the edge of the shoal at the SHR mouth; this may alleviate erosion during peak ebb tide for only the properties within this area but not along the southern shoreline in general. During peak flood tide (**Figure 1.29**), the tidal currents enter the SHR with velocities greater than the critical velocity, which would likely reduce the shoal elevations at the mouth of the river.

Scenario 3, with the river deepened to -10 ft NAVD, doesn’t have much more effect than scenario 2, with only minor differences near the mouth of the river. At peak ebb flow (**Figure 1.30**), the tidal flow through the river that exceeds critical velocity connects to the inlet, which would likely reduce the shoal elevations and help maintain the river’s channel depths. During peak flood flow (**Figure 1.31**), the flood flow exceeding critical velocity covers a larger area over the shoal at the mouth of the river.

Scenario 4 drastically alters the sediment transport patterns within the inlet. During peak ebb flow (**Figure 1.32**), expansive areas throughout the southern and western portions of the inlet no longer exceed critical velocity. During flood flow (**Figure 1.33**), a narrow strip along the western bank and a wide strip along the southern bank no longer exceed critical velocity. Thus, dredging a deeper channel across the northern portion of the inlet would alleviate the erosion pressures along the west bank and along the entire southern shoreline.

The minor changes observed for scenarios 2 and 3 are difficult to discern in the above-mentioned figures. To more clearly illustrate the effects, **Figure 1.34**–**Figure 1.39** identify (1) areas currently experiencing erosion (i.e., existing velocities exceed critical velocities) that no longer do in the model simulations (i.e., model velocities drop below critical velocities) and (2) areas currently stable (i.e., existing velocities are below critical velocities) that do experience erosion in the model simulations (i.e., velocities increase above critical velocities). The figures focus on the southern shoreline of the inlet. The results for scenarios 2 and 3 are similar, with erosion potentially abating (blue hatched polygons) along the edge of the shoal at the mouth of the river during ebb tide and erosion potentially increasing (red hatched polygons) over a larger area across the shoal during flood tide. Unlike Scenario 4, Scenarios 2 and 3 do not reduce erosion along the southern shoreline eastward of the shoal. Of note, in **Figure 1.38,** the gap between the blue hatched polygons along the southern shoreline represents an area where the Scenario 4 ebb flow velocity only very slightly exceeds the critical velocity (see **Figure 1.32**); the magnitude of the exceedance also decreased dramatically as compared to existing conditions (see **Figure 1.26**) in this area, indicating greatly reduced erosion potential.

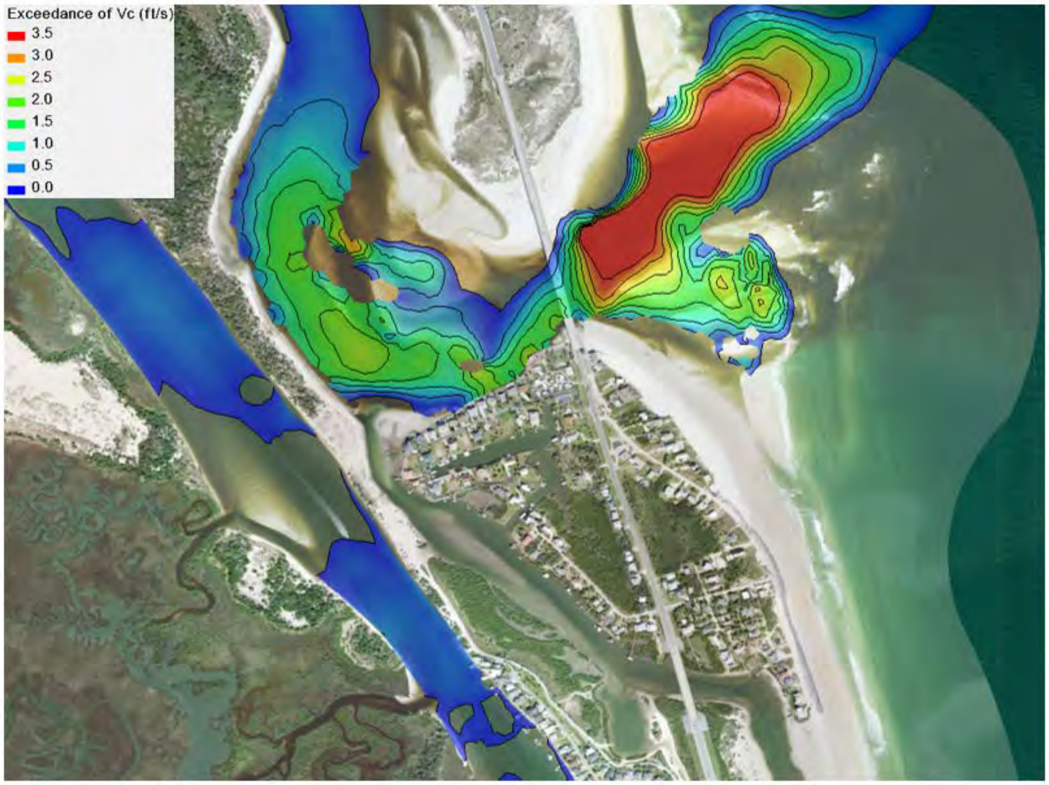

Figure 1.26 Exceedance of Critical Velocity at Peak Ebb Flow — Existing Conditions

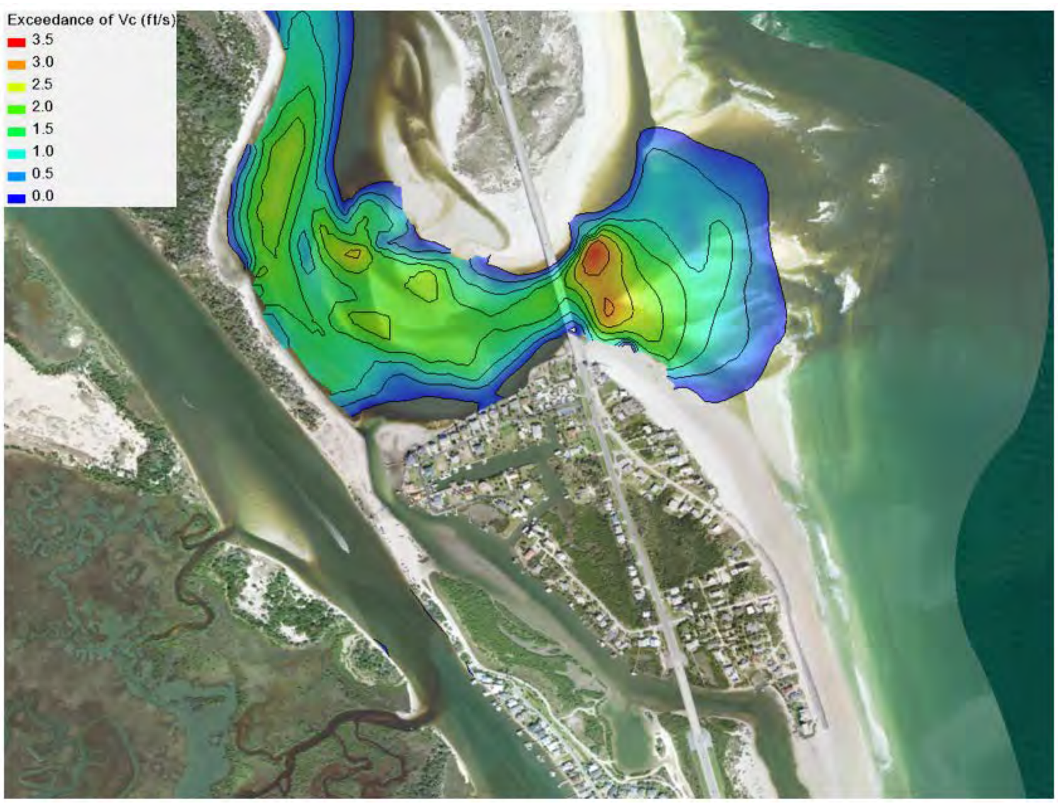

Figure 1.27 Exceedance of Critical Velocity at Peak Flood Flow — Existing Conditions

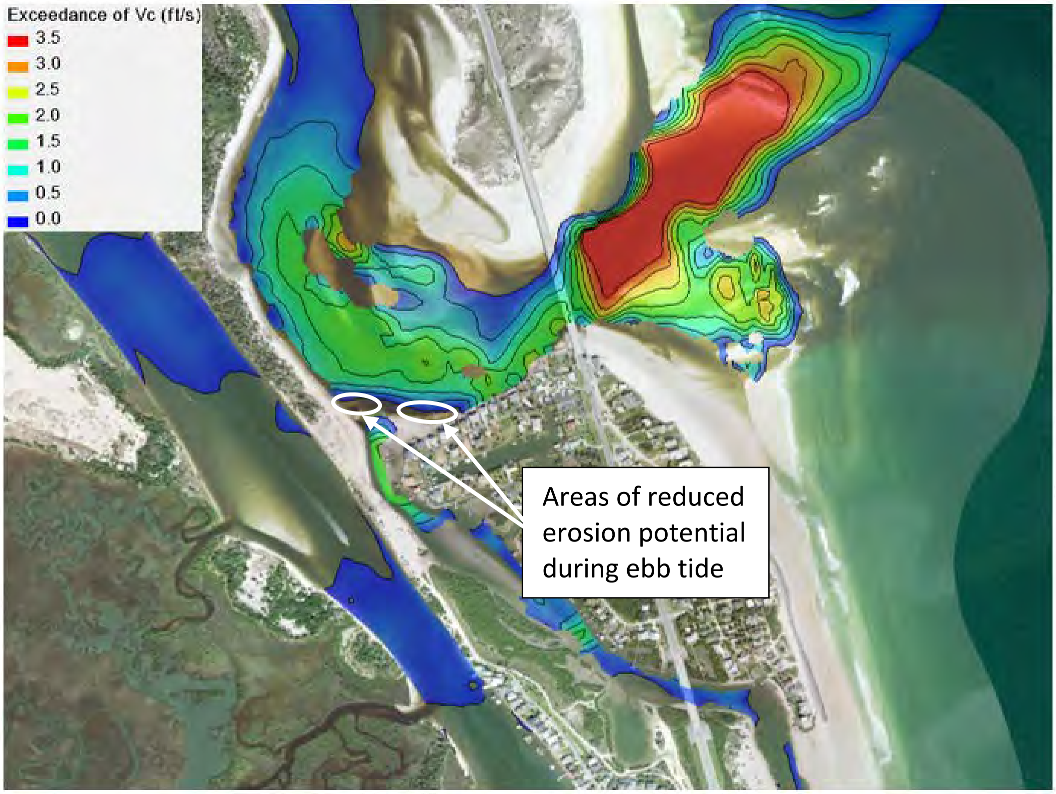

Figure 1.28 Exceedance of Critical Velocity at Peak Ebb Flow – Scenario 2 (SHR at -6 ft NAVD 88)

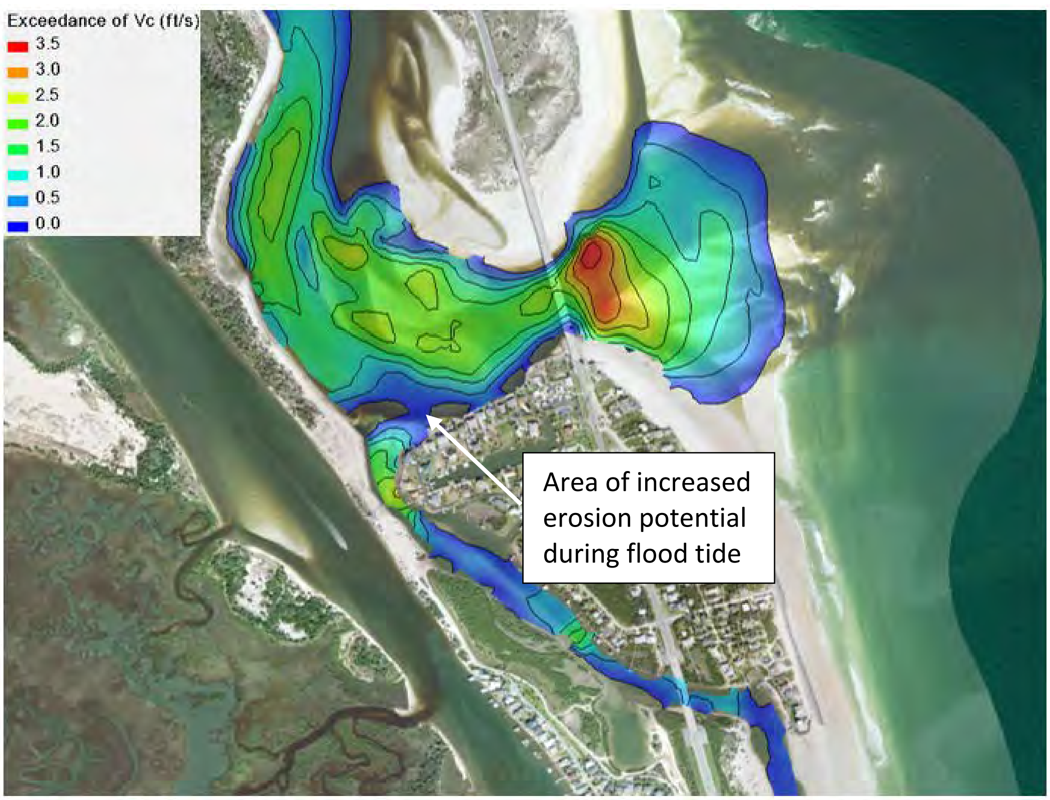

Figure 1.29 Exceedance of Critical Velocity at Peak Flood Flow – Scenario 2 (SHR at -6 ft NAVD 88)

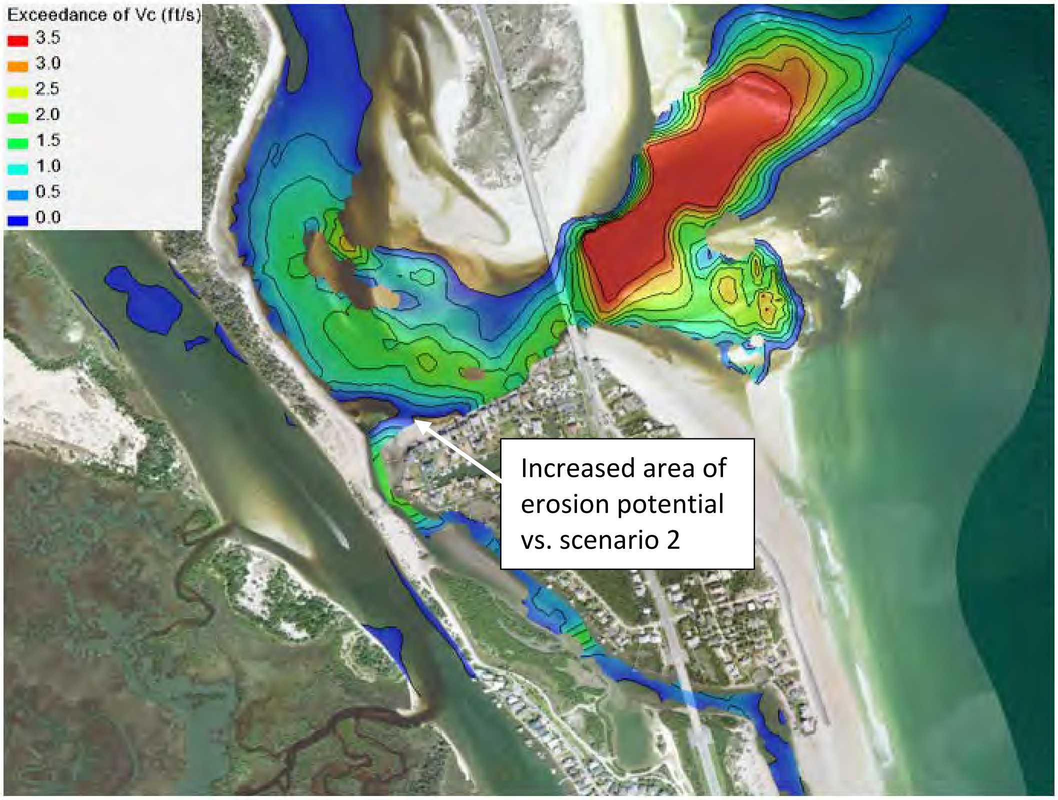

Figure 1.30 Exceedance of Critical Velocity at Peak Ebb Flow – Scenario 3 (SHR at -10 ft NAVD 88)

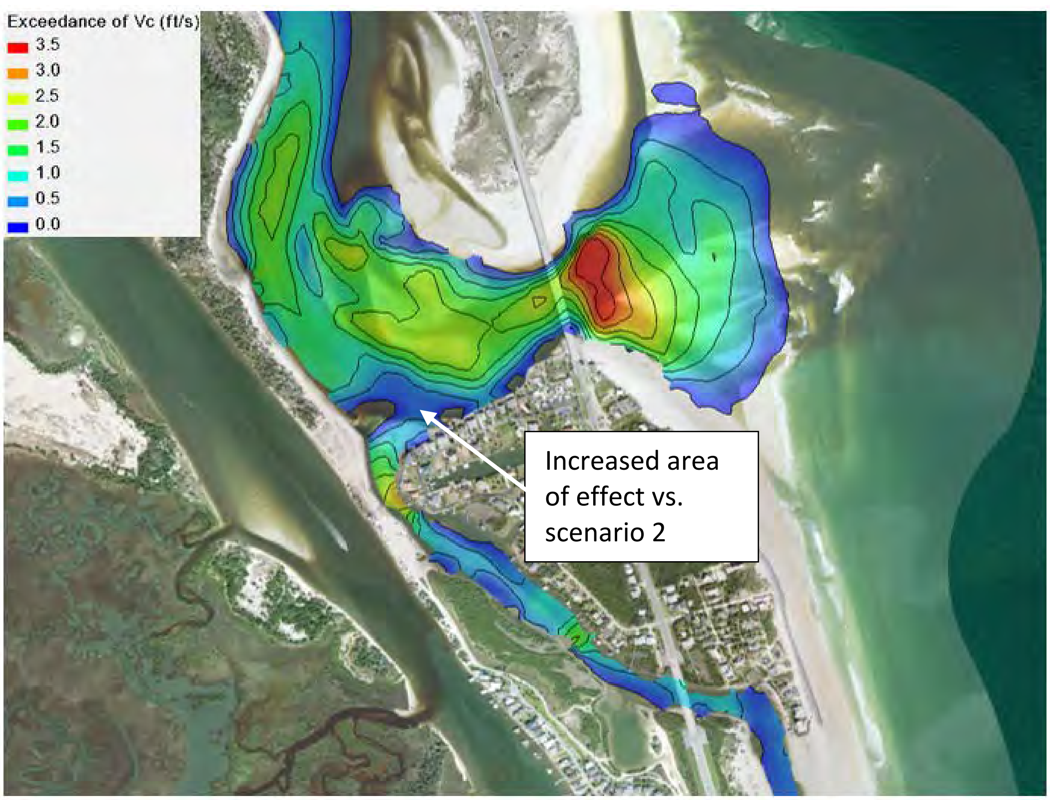

Figure 1.31 Exceedance of Critical Velocity at Peak Flood Flow – Scenario 3 (SHR at -10 ft NAVD 88)

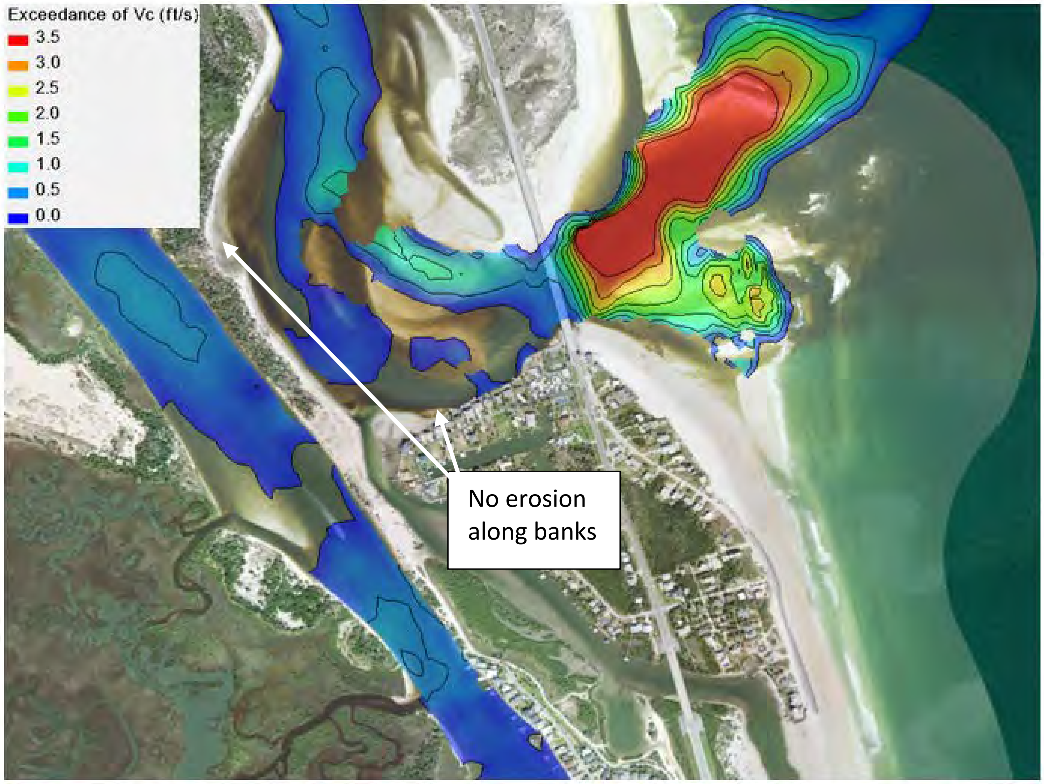

Figure 1.32 Exceedance of Critical Velocity at Peak Ebb Flow — Scenario 4 (Dredged Inlet Channel)

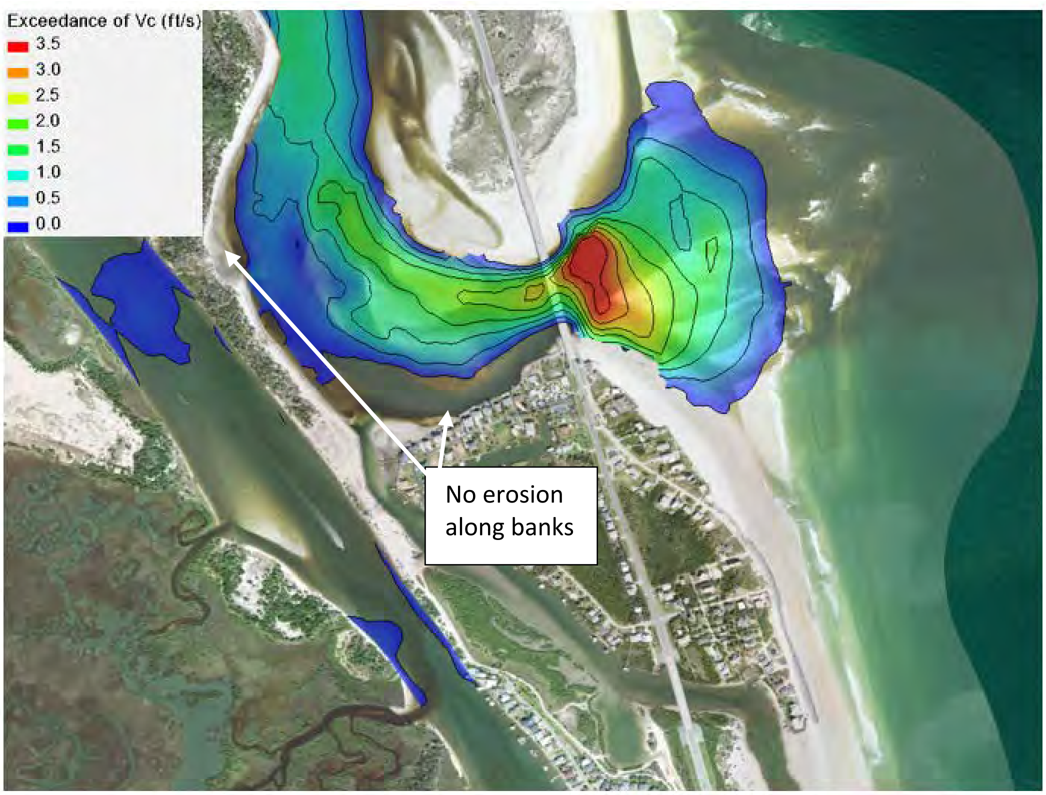

Figure 1.33 Exceedance of Critical Velocity at Peak Flood Flow — Scenario 4 (Dredged Inlet Channel)

Figure 1.34 Scenario 2 (SHR Deepened to -6 ft NAVD 88) Effects on Erosion during Ebb Flow

Figure 1.35 Scenario 2 (SHR Deepened to -6 ft NAVD 88) Effects on Erosion during Flood Flow

Figure 1.36 Scenario 3 (SHR Deepened to -10 ft NAVD 88) Effects on Erosion during Ebb Flow

Figure 1.37 Scenario 3 (SHR Deepened to -10 ft NAVD 88) Effects on Erosion during Flood Flow

Figure 1.38 Scenario 4 (Dredged Inlet Channel) Effects on Erosion during Ebb Flow

Figure 1.39 Scenario 4 (Dredged Inlet Channel) Effects on Erosion during Flood Flow

1.3.3 General Effects near Pellicer Creek

Figure 1.40 and **Figure 1.41** show the flow velocities at peak ebb and flow under existing conditions at the south end of SHR near Pellicer Creek. **Figure 1.42**–**Figure 1.47** show the changes in flow velocity, compared to existing conditions, at peak ebb and flood flow for scenarios 2–4. Like the prior figures focused on the inlet, negative values correspond to a reduction in velocity, positive values indicate an increase in velocity, and the black contour lines surrounded by green shading represents the zero-change contour. Note the plots indicate velocity changes at 0.5-ft contour intervals. The increased flow through the SHR is evident for scenarios 2 and 3, with slightly greater change for Scenario 3 as expected with a deeper river and larger flow volume. For scenarios 2 and 3, a slight increase in flow velocity is evident in the ICWW south of the SHR, and a slight decrease in flow velocity occurs in the ICWW north of the SHR. For Scenario 2, the maximum ebb flow velocity increase and decrease in the ICWW equals 0.2 ft/sec and -0.2 ft/sec, and the corresponding flood flow increase and decrease equal 0.25 ft/sec and -0.2 ft/sec. for Scenario 3, the maximum ebb flow velocity increase and decrease in the ICWW equals 0.3 ft/sec and -0.5 ft/sec, and the corresponding flood flow increase and decrease equal 0.45 ft/sec and -0.4 ft/sec. Scenario 4 has negligible effect.

Further analysis of the model output indicates the flow velocity changes extend further into the primary marsh channel across from the SHR and further up and down the ICWW; however, the velocity change magnitudes are minor. The maximum flow velocity changes in the marsh creek for Scenario 2 ebb and flood flows are 0.1 ft/sec and 0.2 ft/sec; the maximum changes increase to 0.15 ft/sec and 0.4 ft/sec for Scenario 3 ebb and flood flows. These results suggest the SHR affects the flow velocities near the confluence of the SHR and ICWW as expected, but the broad reaching effects are minor in magnitude. Note, the model results pertain to flow velocities only and do not extend to salinity levels or other measures of water quality.

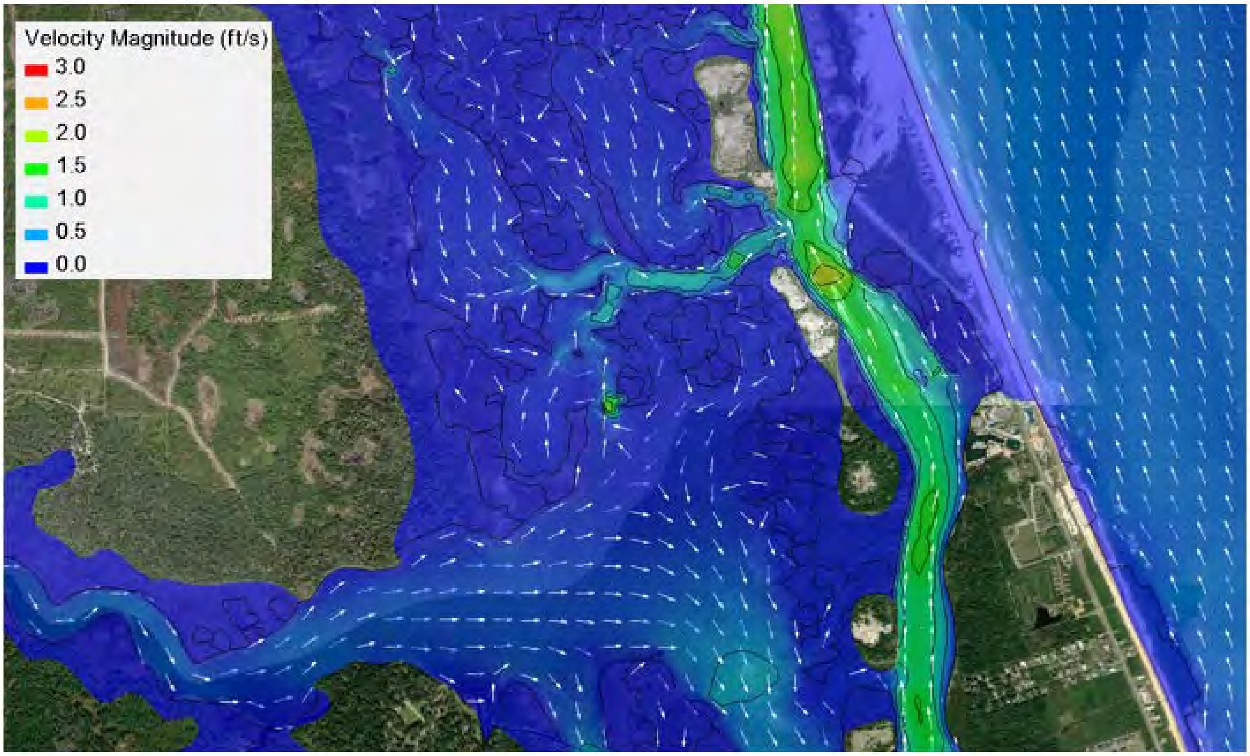

Figure 1.40 Velocities at Peak Ebb Flow under Existing Conditions near Pellicer Creek

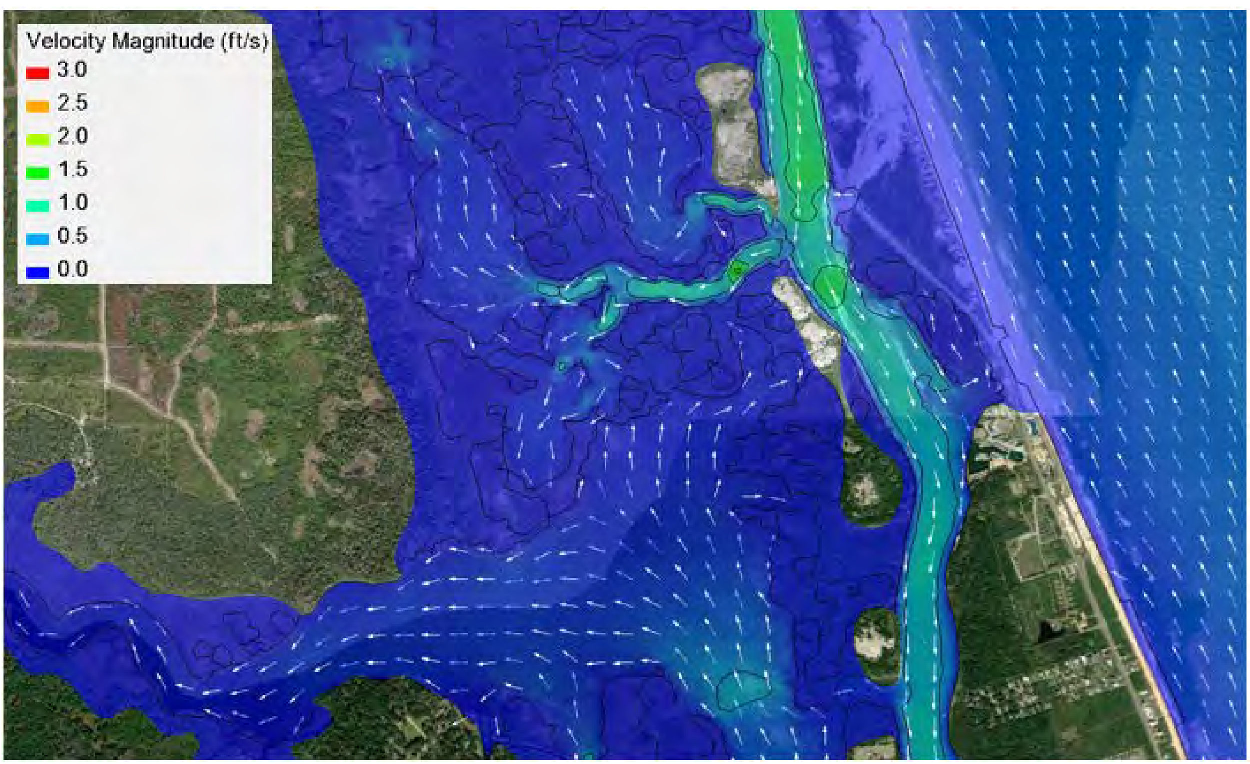

Figure 1.41 Velocities at Peak Flood Flow under Existing Conditions near Pellicer Creek

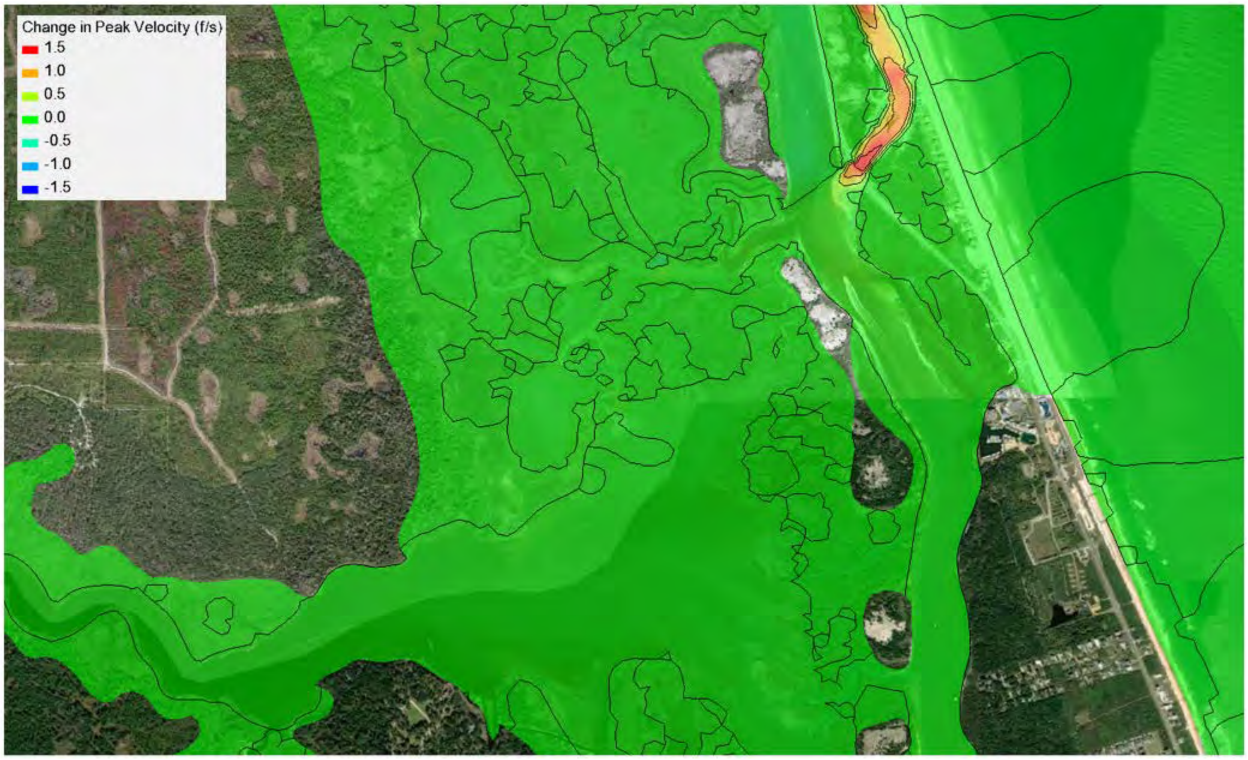

Figure 1.42 Change in Velocity within Inlet at Peak Ebb Flow — Scenario 2 vs. Existing Conditions

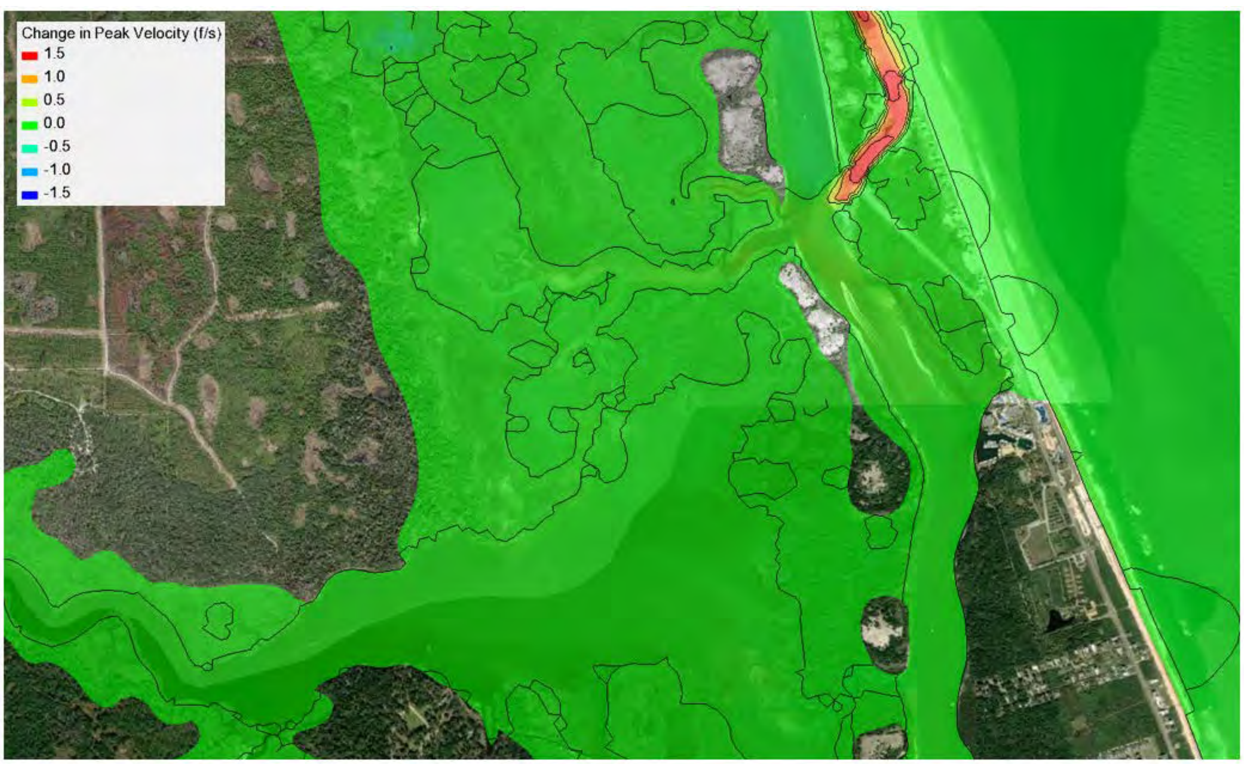

Figure 1.43 Change in Velocity within Inlet at Peak Flood Flow — Scenario 2 vs. Existing Conditions

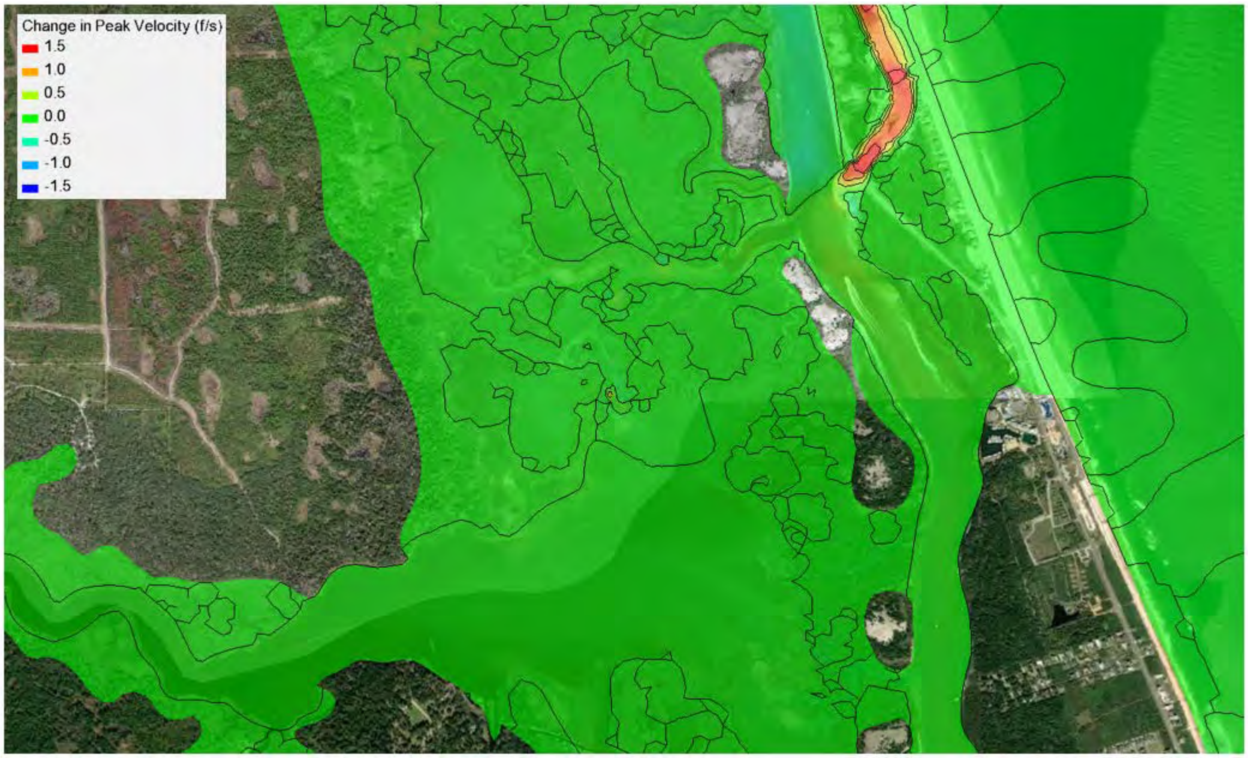

Figure 1.44 Change in Velocity within Inlet at Peak Ebb Flow — Scenario 3 vs. Existing Conditions

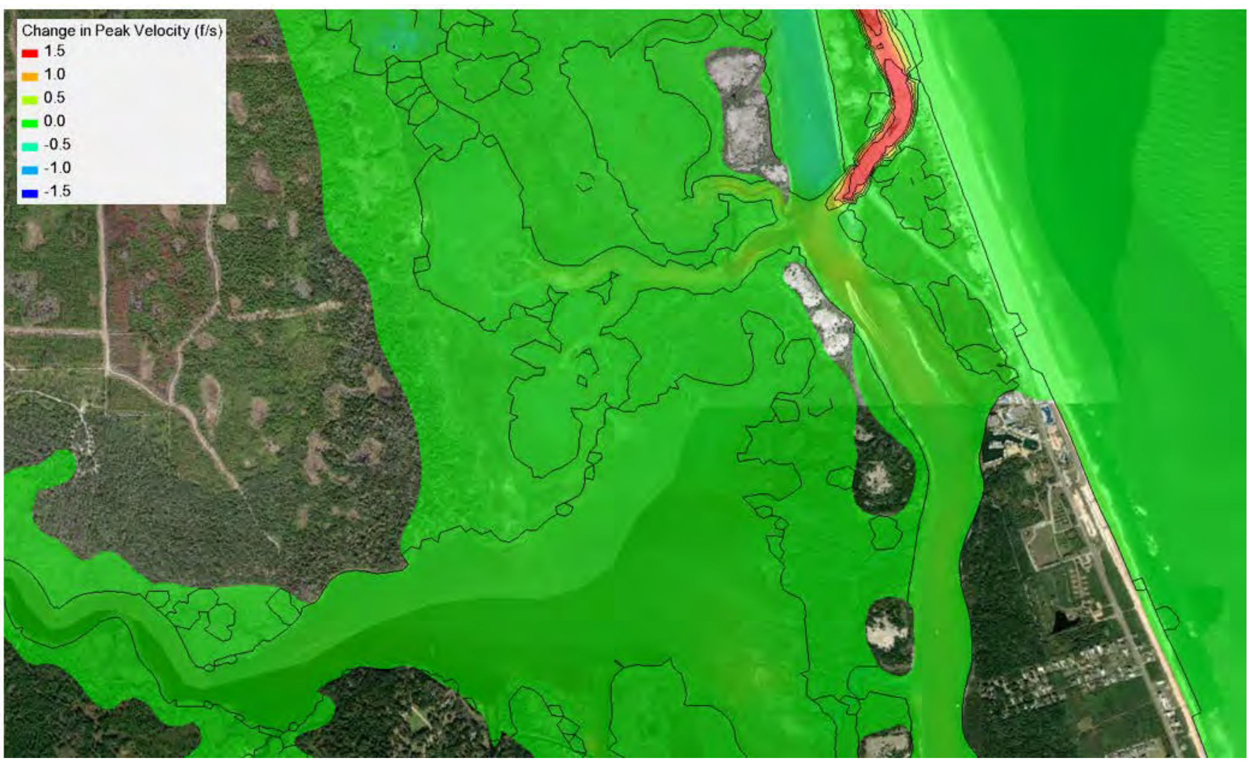

Figure 1.45 Change in Velocity within Inlet at Peak Flood Flow — Scenario 3 vs. Existing Conditions

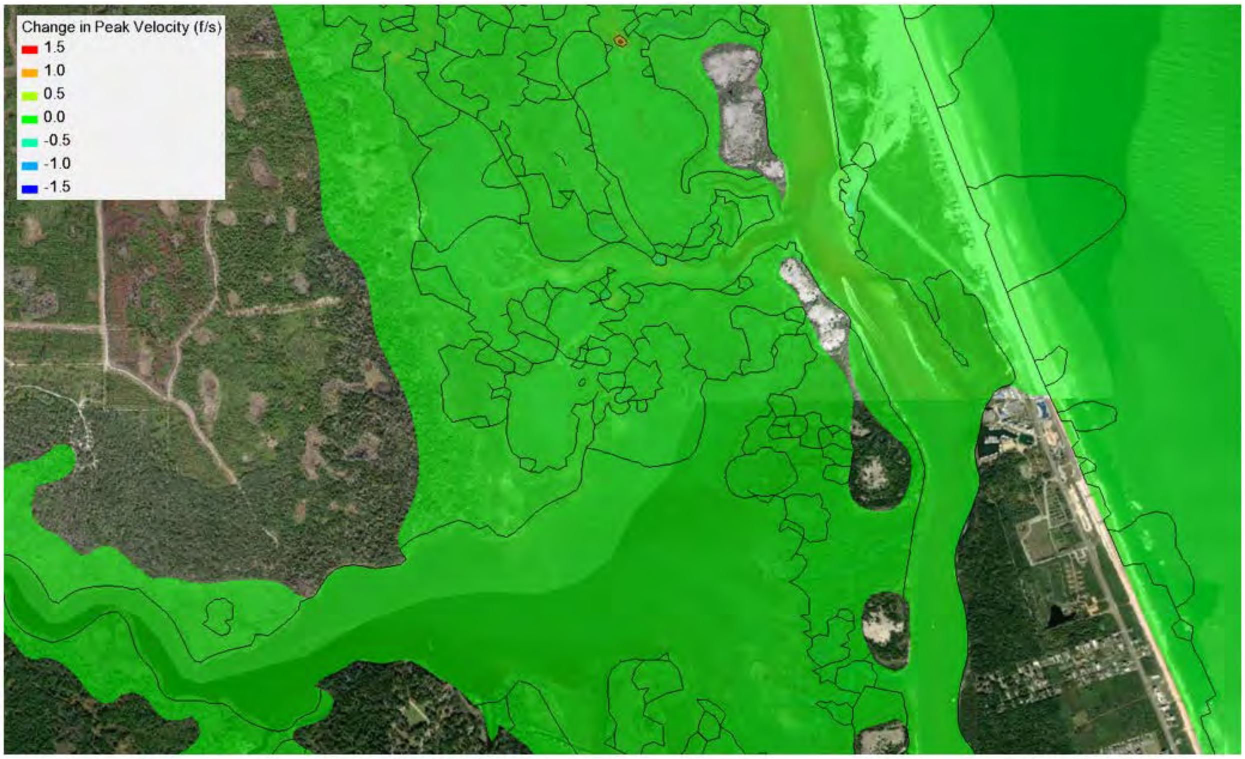

Figure 1.46 Change in Velocity within Inlet at Peak Ebb Flow — Scenario 4 vs. Existing Conditions

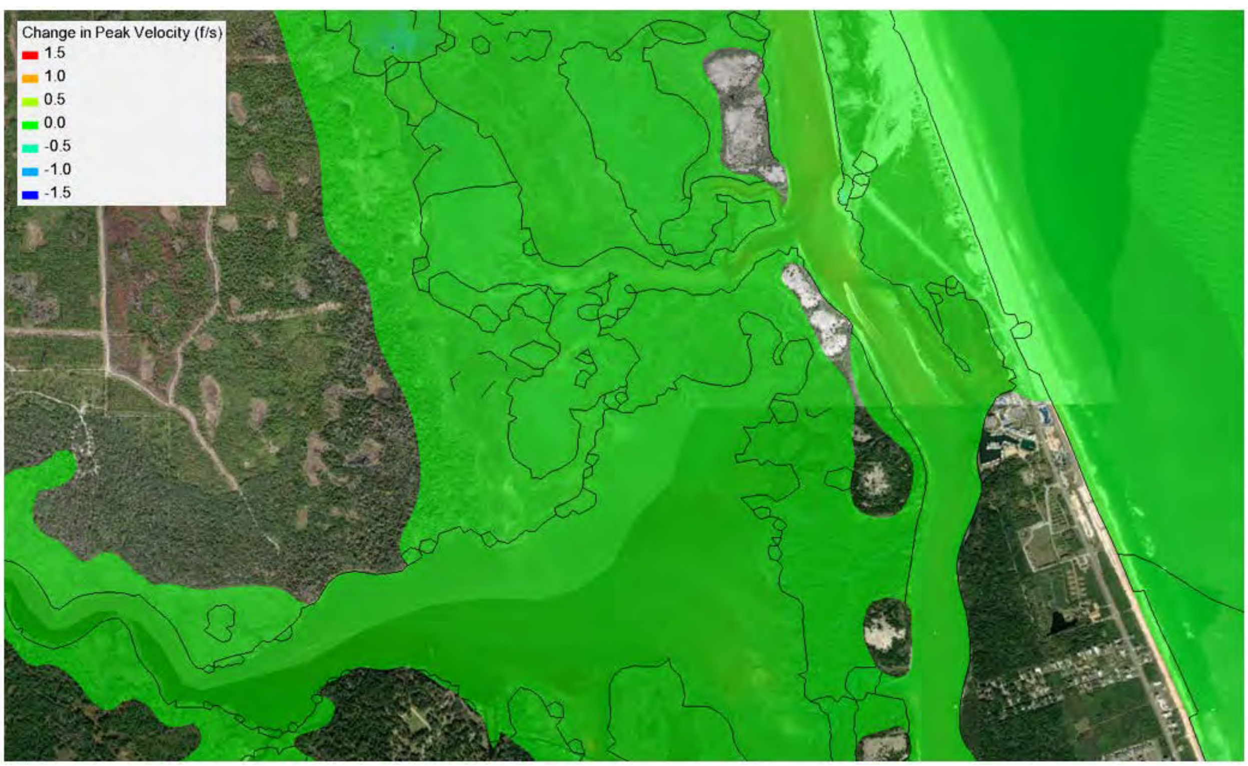

Figure 1.47 Change in Velocity within Inlet at Peak Flood Flow — Scenario 4 vs. Existing Conditions

Attachment A

Plots of Maximum Velocities for Scenarios 1–4

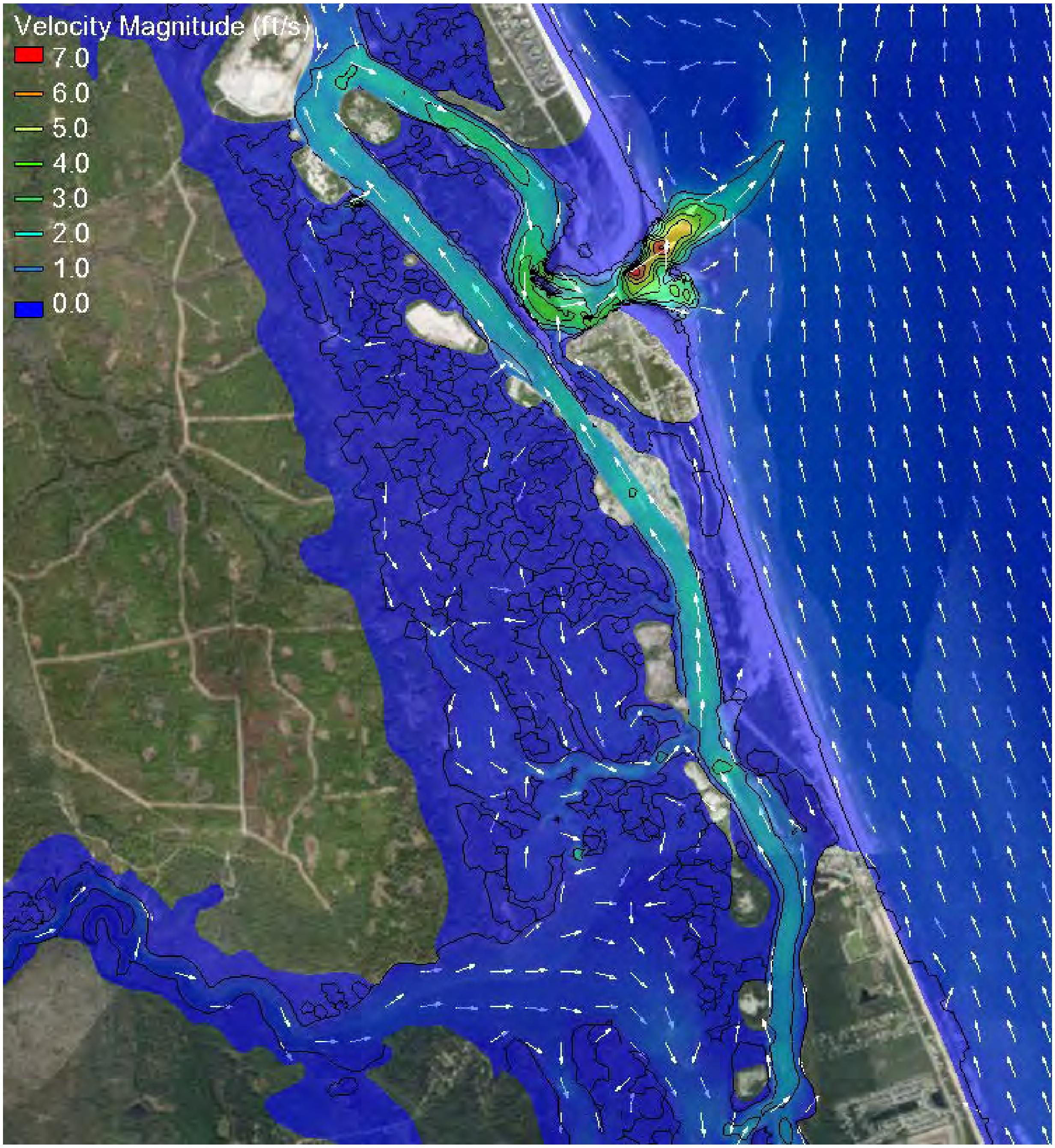

Figure A.1 Peak Ebb Flow Velocities under Scenario 1 (Existing Conditions)

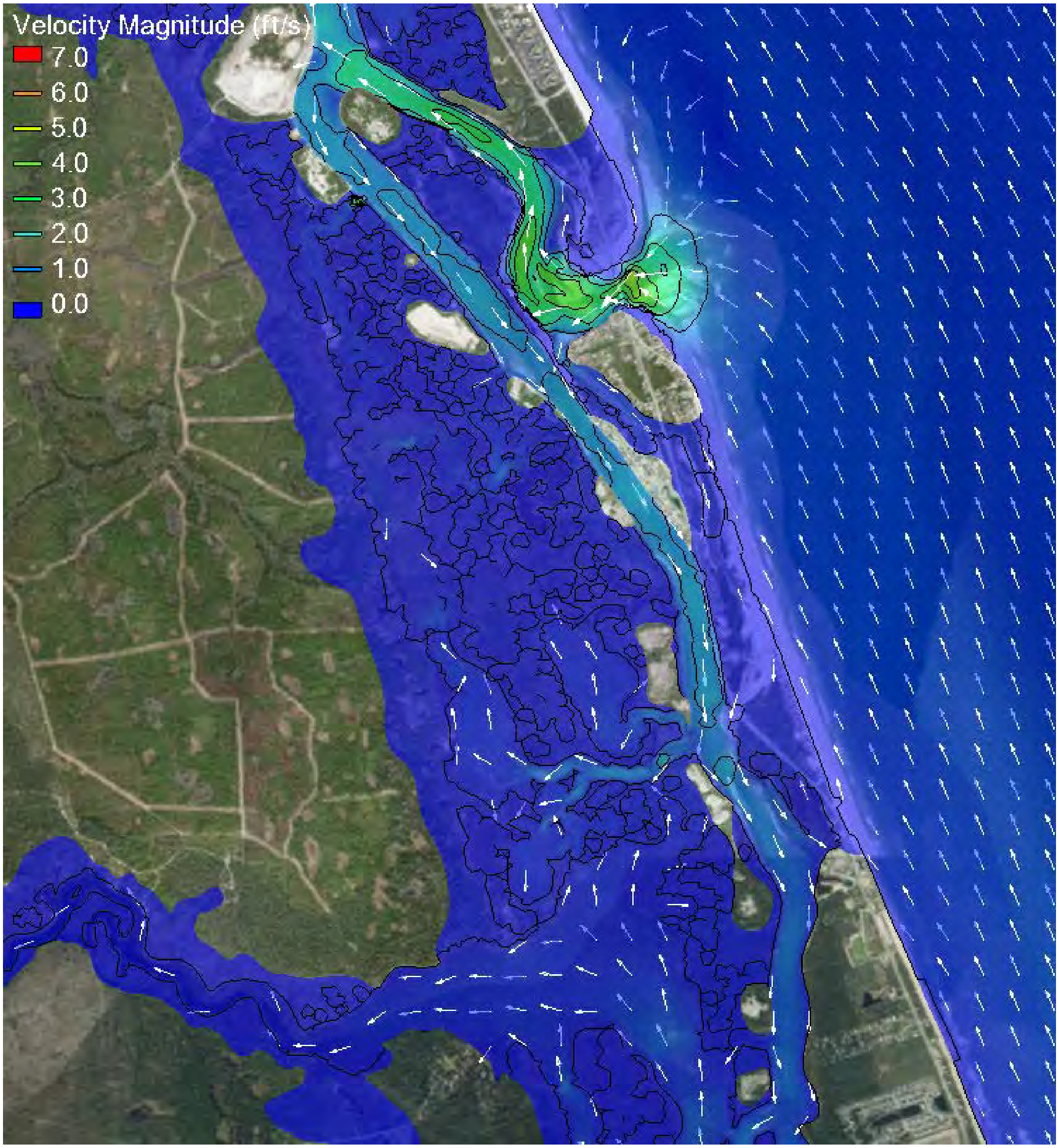

Figure A.2 Peak Flood Flow Velocities under Scenario 1 (Existing Conditions)

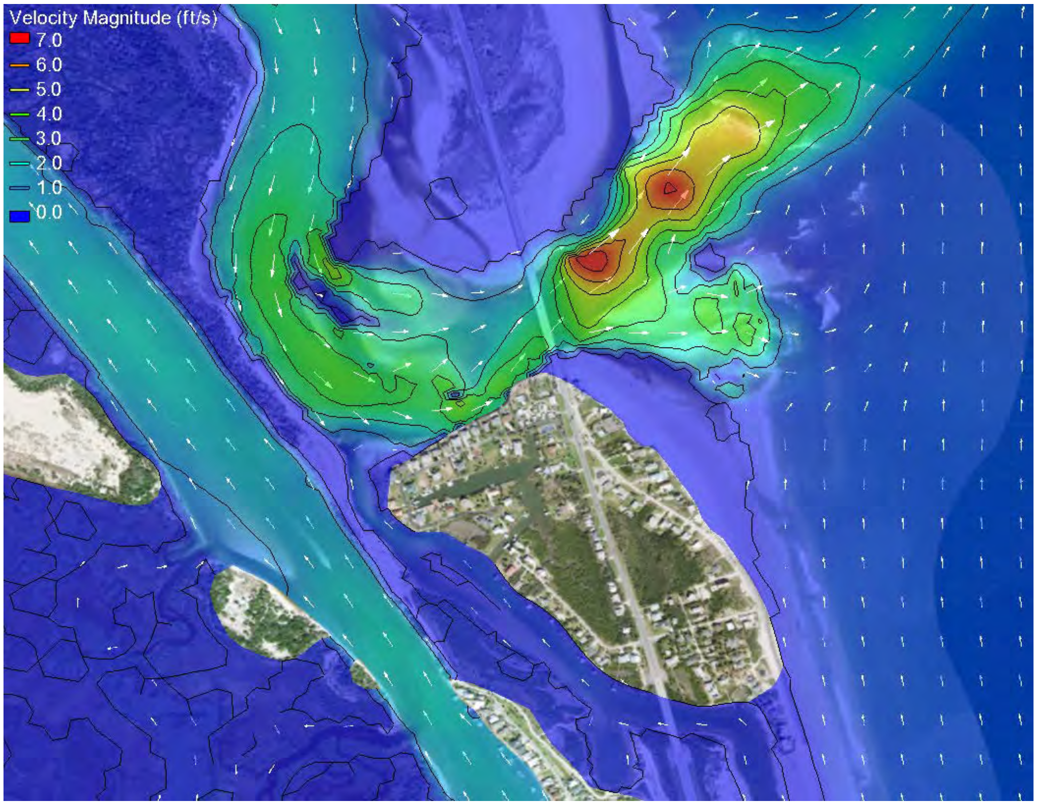

Figure A.3 Peak Ebb Flow Velocities within Inlet under Scenario 1 (Existing Conditions)

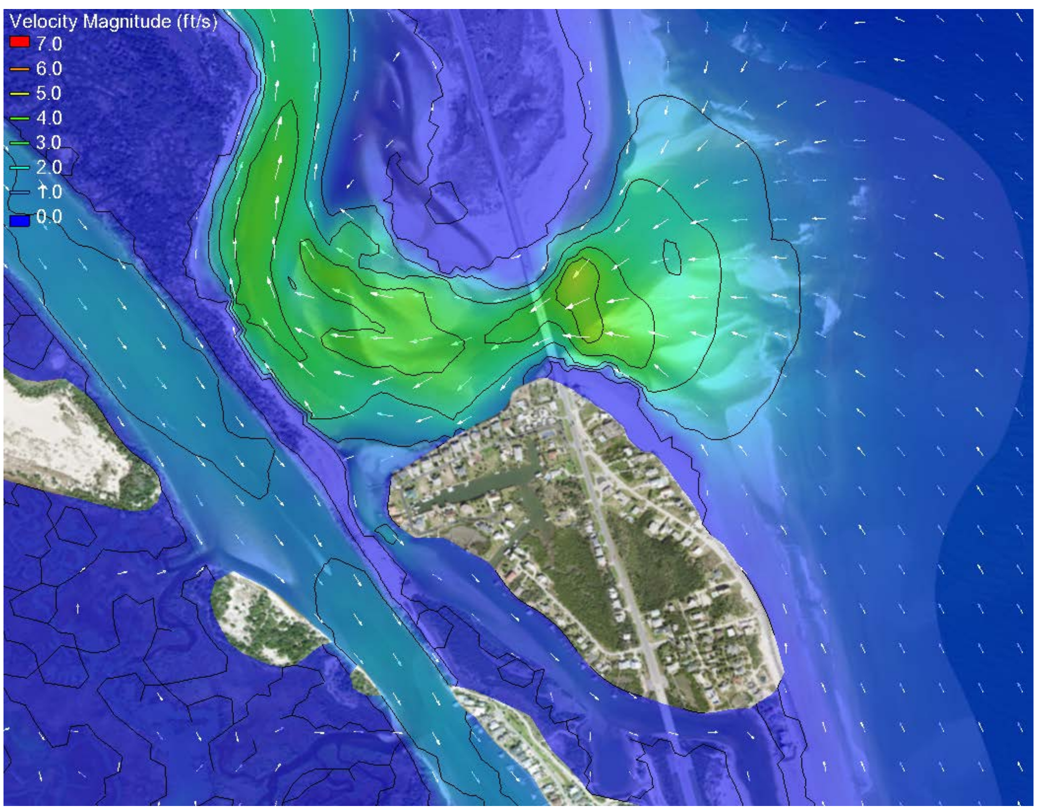

Figure A.4 Peak Flood Flow Velocities within Inlet under Scenario 1 (Existing Conditions)

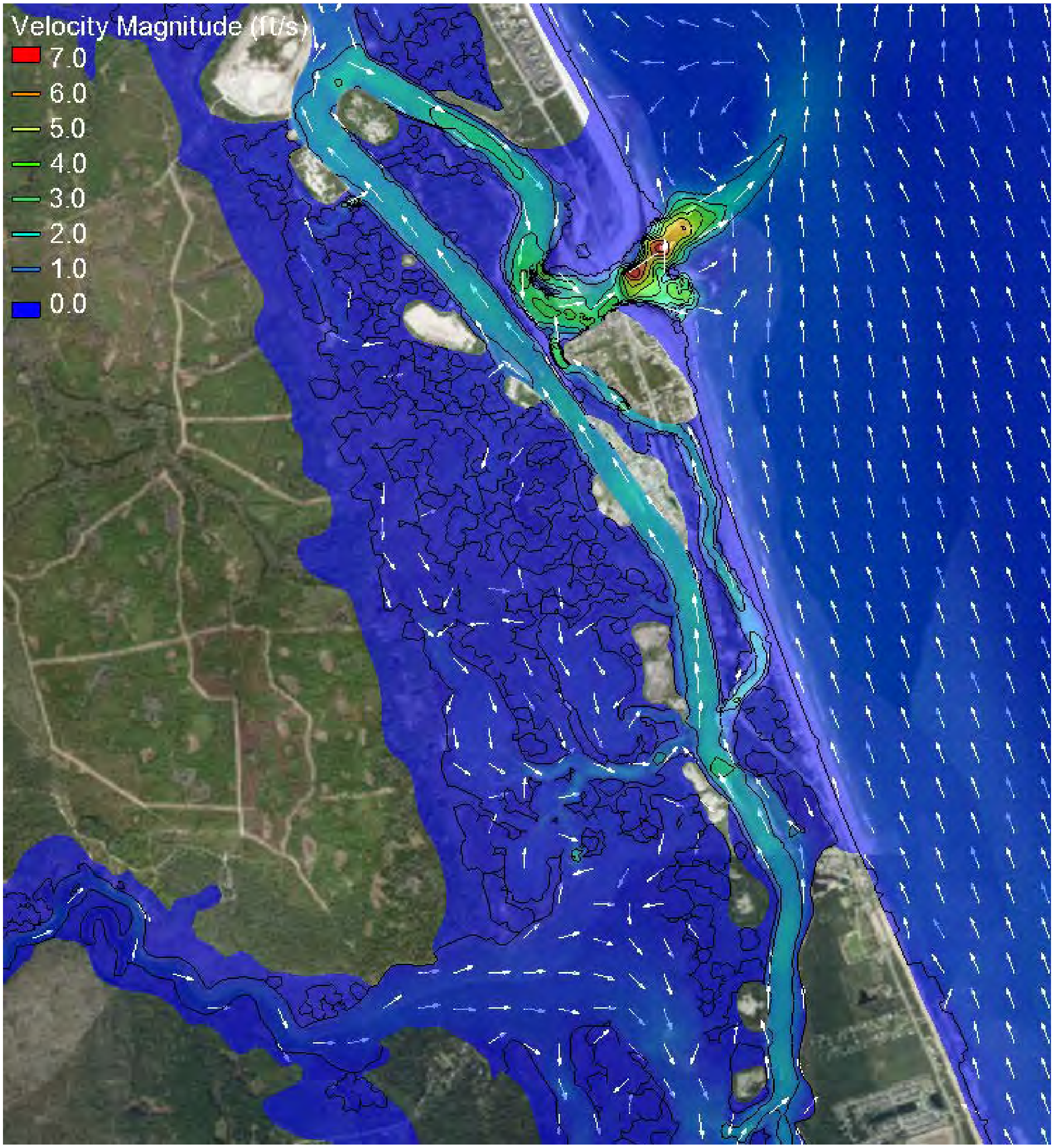

Figure A.5 Peak Ebb Flow Velocities under Scenario 2 (SHR Deepened to -6 ft NAVD)

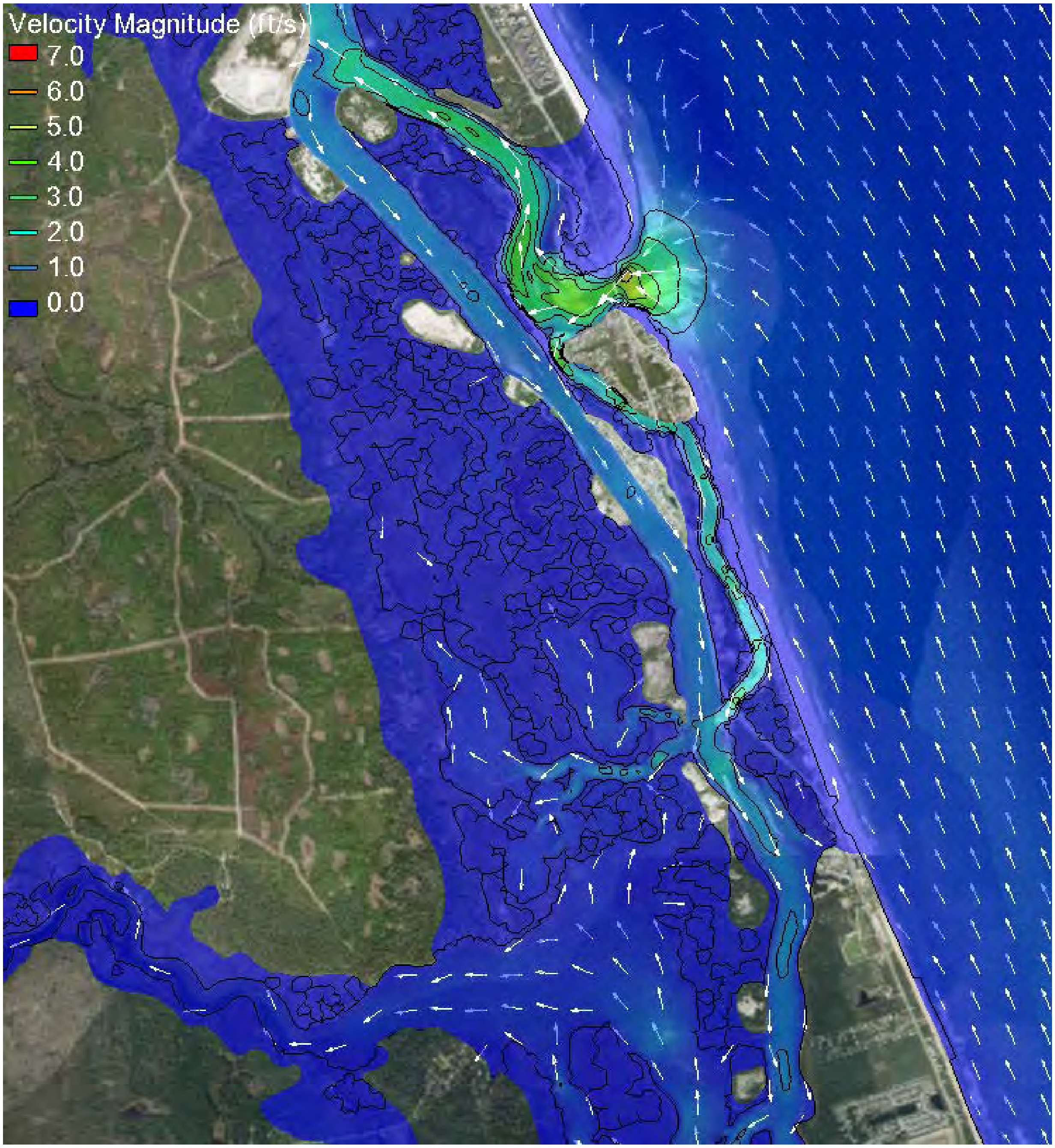

Figure A.6 Peak Flood Flow Velocities under Scenario 2 (SHR Deepened to -6 ft NAVD)

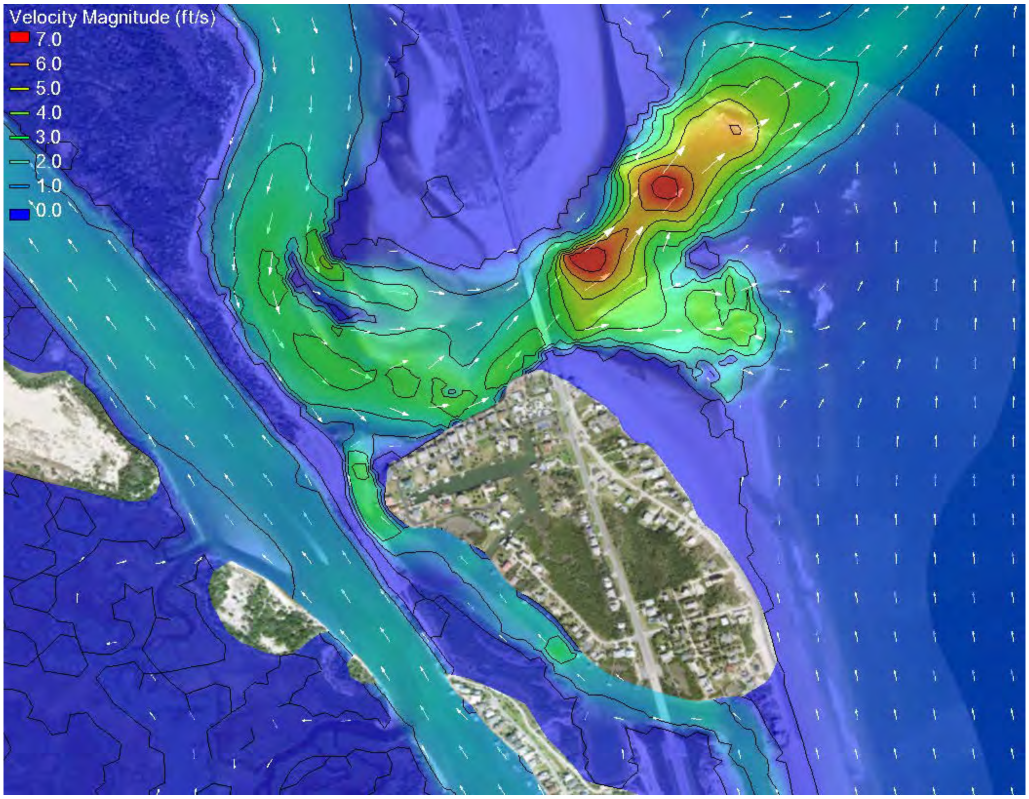

Figure A.7 Peak Ebb Flow Velocities within Inlet under Scenario 2 (SHR Deepened to -6 ft NAVD)

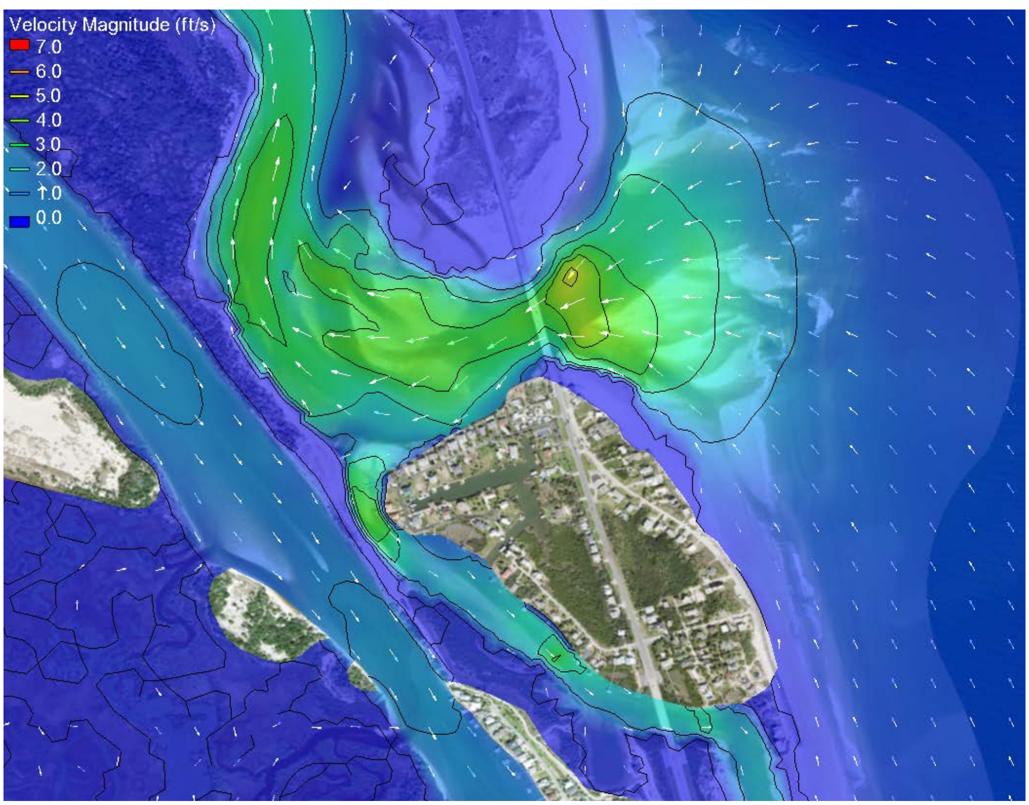

Figure A.8 Peak Flood Flow Velocities within Inlet under Scenario 2 (SHR Deepened to -6 ft NAVD)

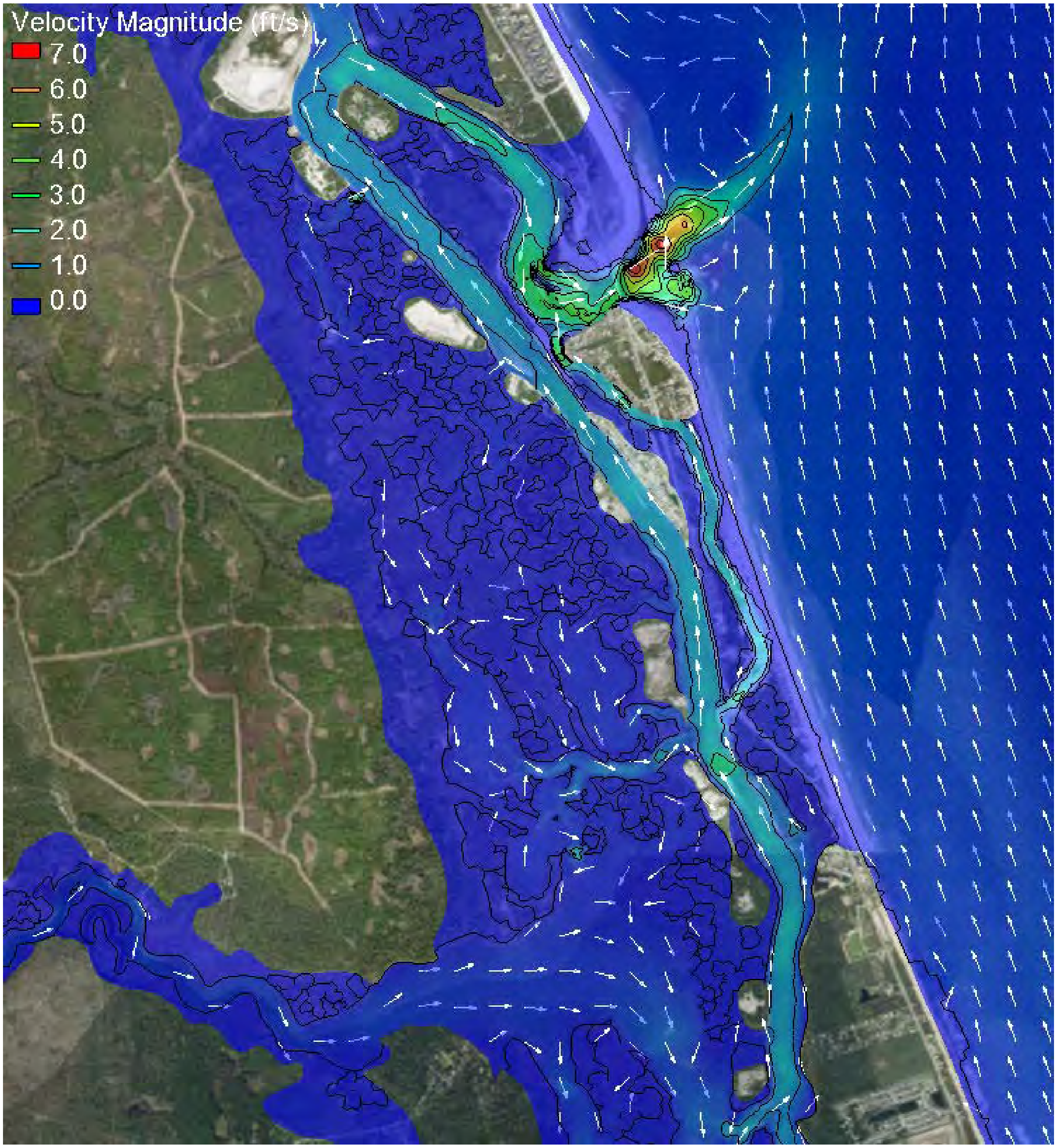

Figure A.9 Peak Ebb Flow Velocities under Scenario 3 (SHR Deepened to -10 ft NAVD)

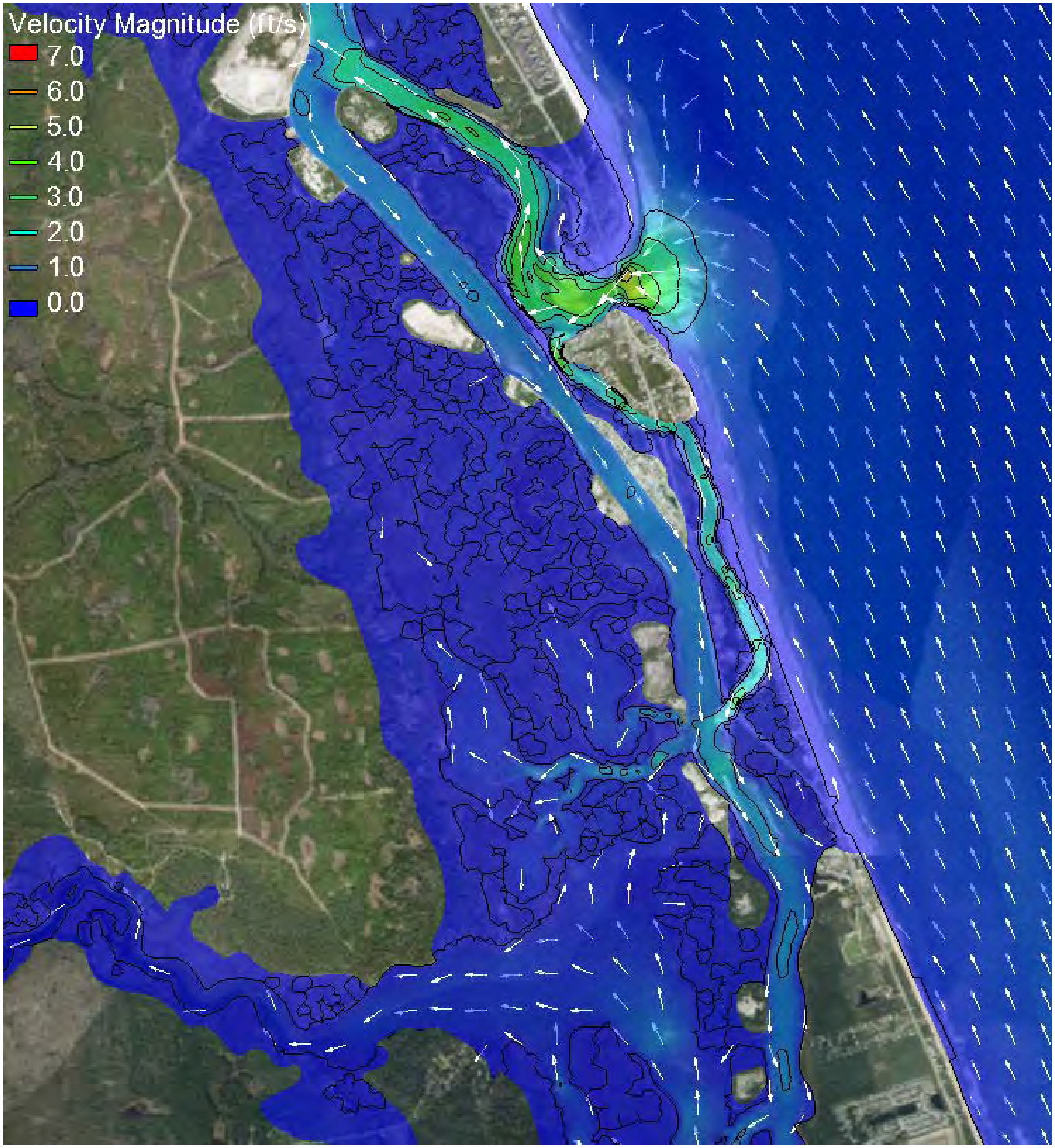

Figure A.10 Peak Flood Flow Velocities under Scenario 3 (SHR Deepened to -10 ft NAVD)

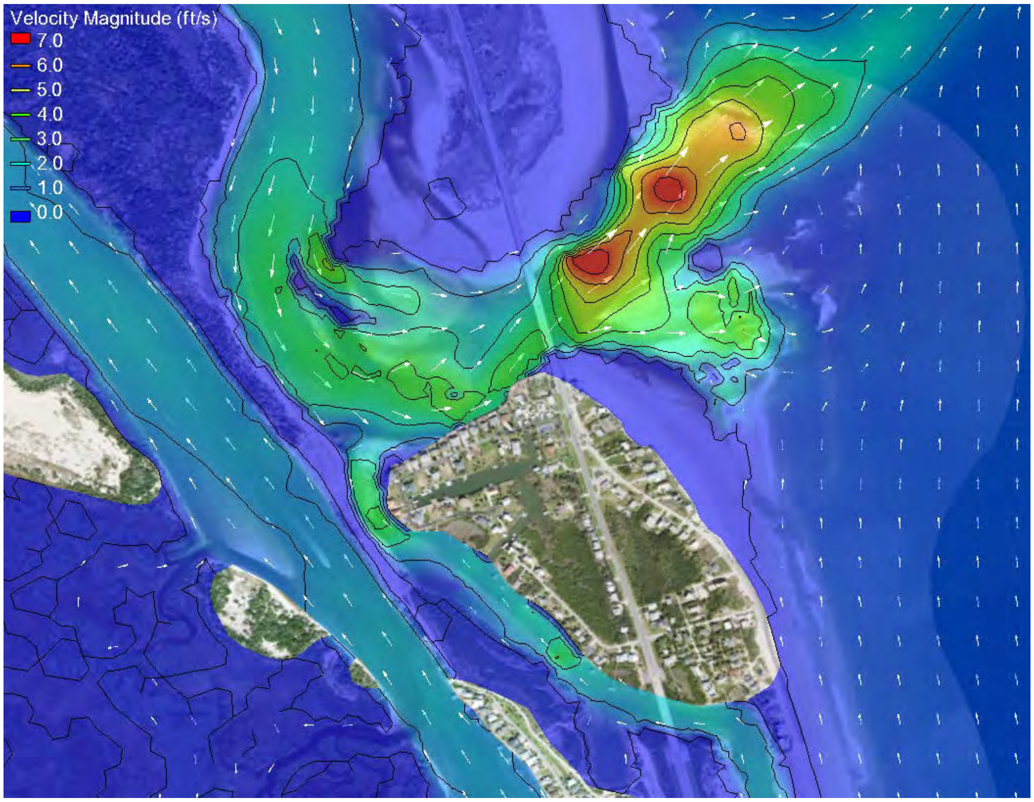

Figure A.11 Peak Ebb Flow Velocities within Inlet under Scenario 3 (SHR Deepened to -10 ft NAVD)

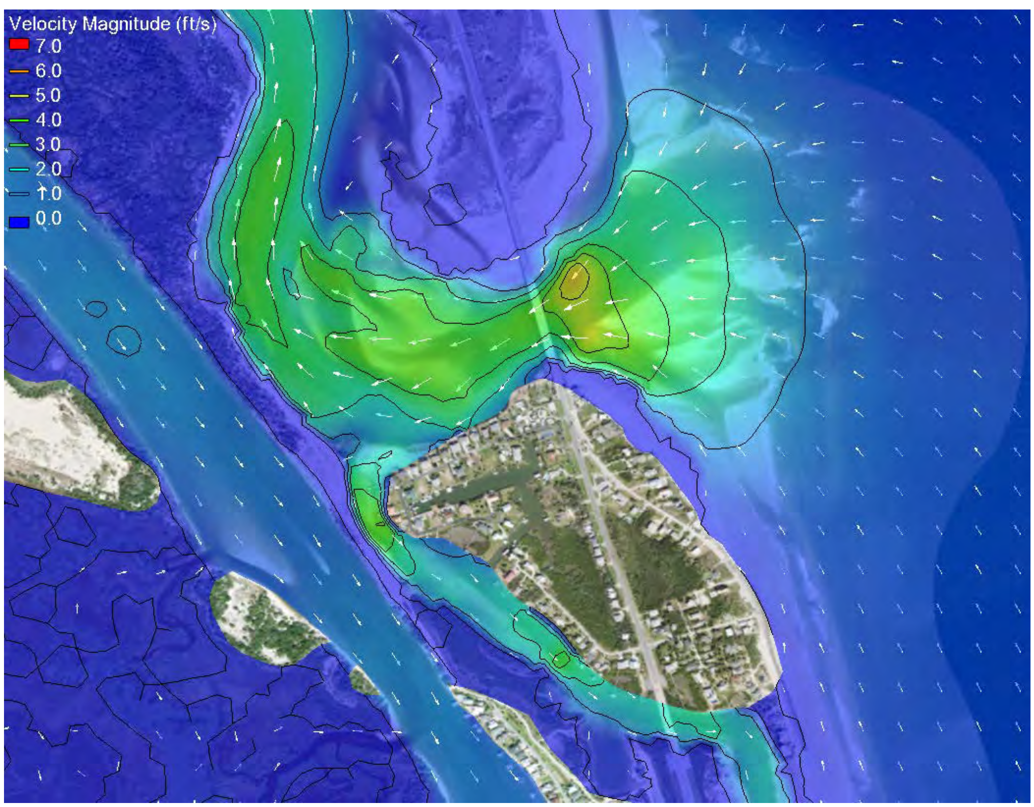

Figure A.12 Peak Flood Flow Velocities within Inlet under Scenario 3 (SHR Deepened to -10 ft NAVD)

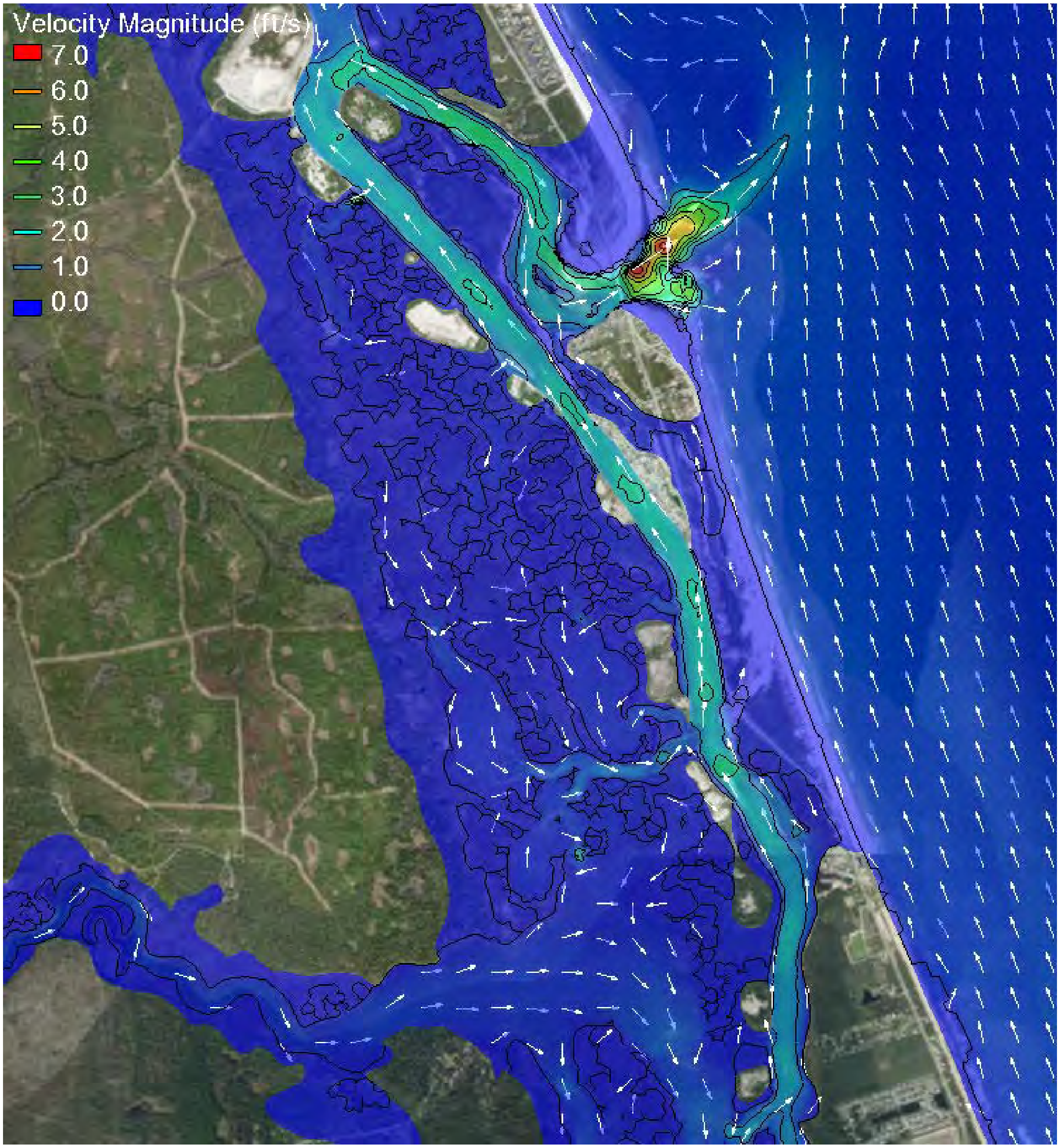

Figure A.13 Peak Ebb Flow Velocities under Scenario 4 (Dredged Inlet Channel)

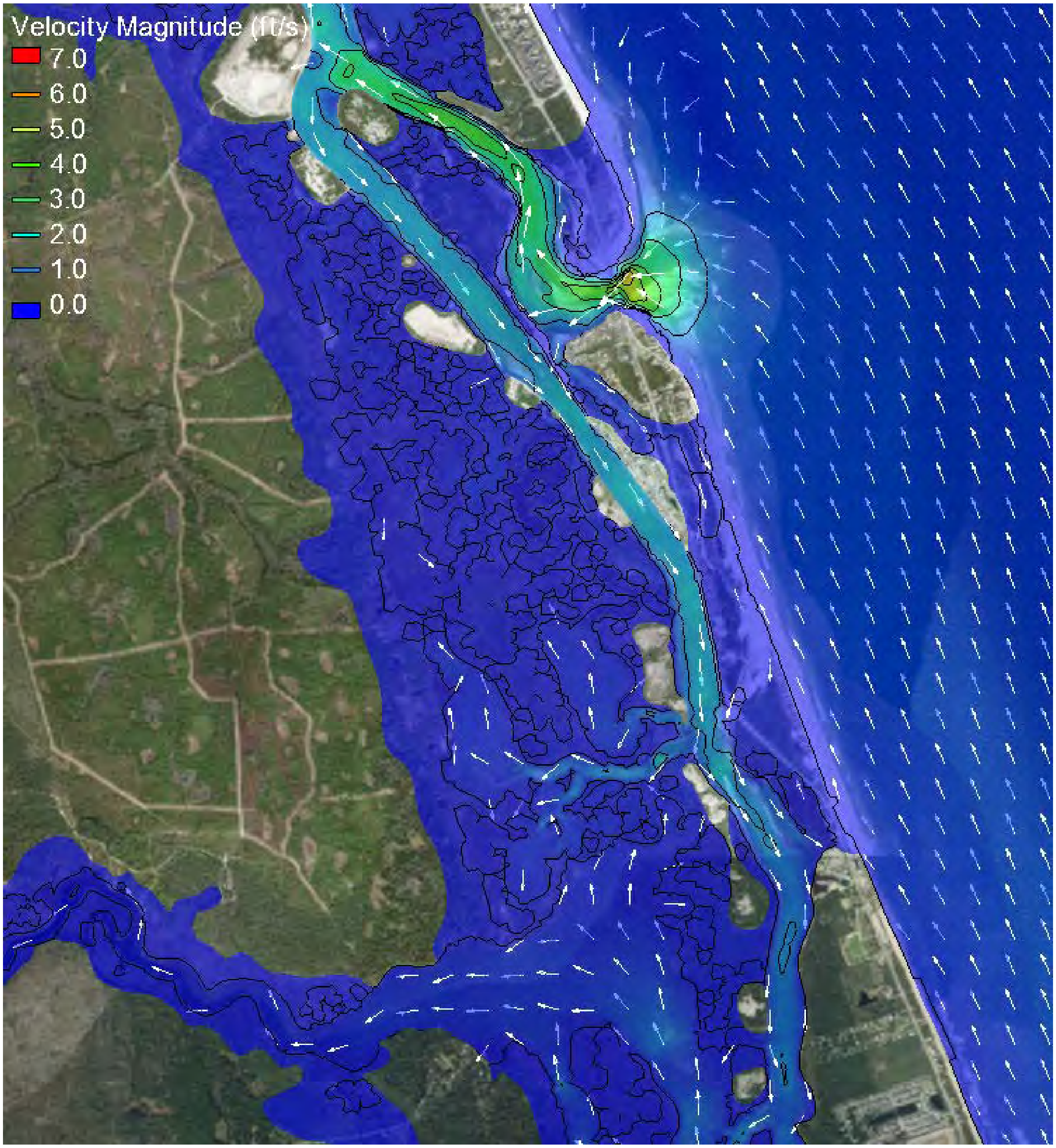

Figure A.14 Peak Flood Flow Velocities under Scenario 4 (Dredged Inlet Channel)

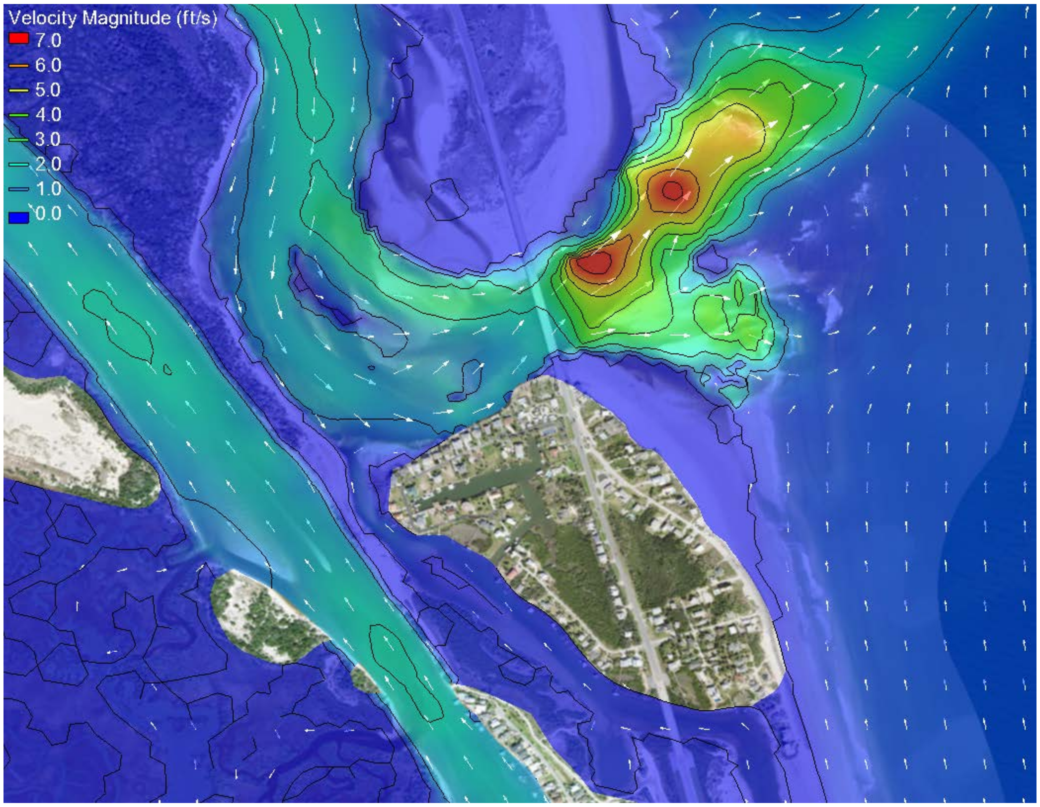

Figure A.15 Peak Ebb Flow Velocities within Inlet under Scenario 4 (Dredged Inlet Channel)

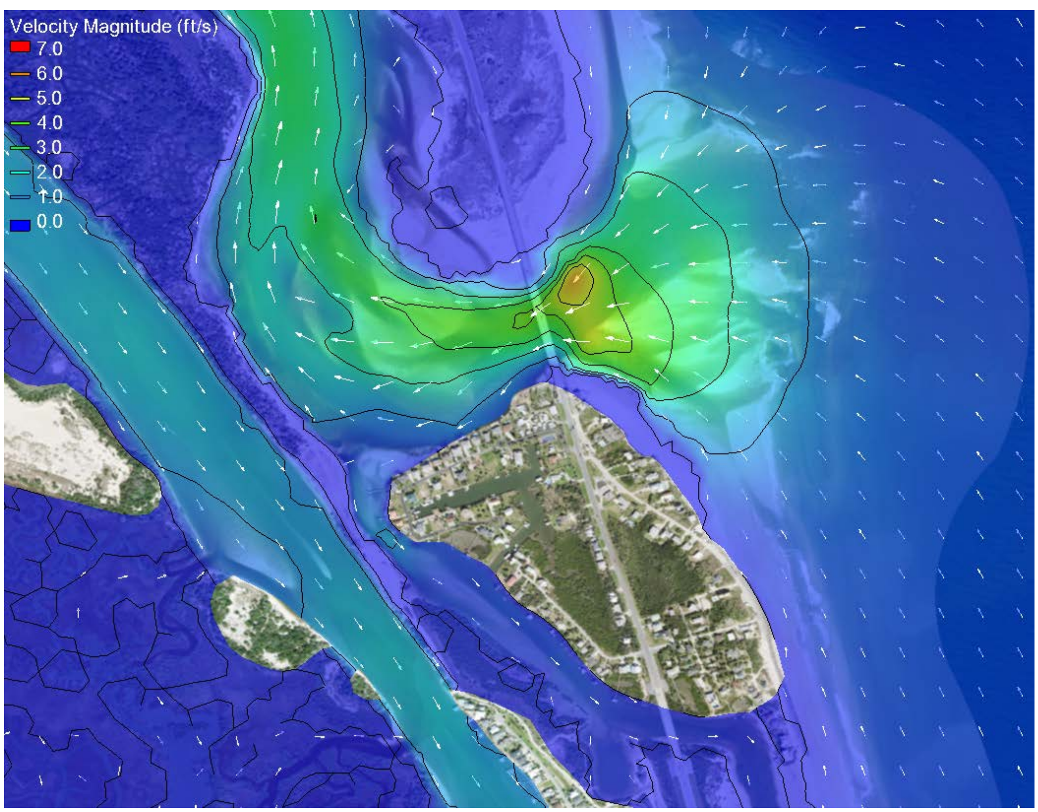

Figure A.16 Peak Flood Flow Velocities within Inlet under Scenario 4 (Dredged Inlet Channel)

Appendix K

SBEACH Cross-shore Erosion Modeling Summary

Introduction

This study employed the USACE Storm Induced Beach Change (SBEACH) cross-shore sediment transport model (Larson and Kraus, 1989a; Larson and Kraus, 1989b; Rosati et al., 1993) to predict beach profile change due to cross-shore transport of sediment under changing water levels and breaking waves. For present purposes, the model simulates potential storm-related dune and beach erosion for 25-, 50- and 100-yr storms for the dune only and dune and beach nourishment alternatives.

SBEACH, a two-dimensional cross-shore model, applies input parameters describing the physical characteristics of a storm event to predict the adjustment of a pre-storm to a post-storm beach profile. SBEACH simulates wave-induced erosion as well as formation and movement of offshore bars and troughs and accounts for hardbottom or seawall effects on dune and beach erosion. The model accommodates variable grid spaces, time-dependent water levels and wave characteristics, wave refraction and runup, water level setup due to breaking waves (wave setup) and wind (wind setup), and sediment overwash. As SBEACH only simulates beach erosion due to short-term events (storms), model results provide no indication of long-term trends of cross-shore sediment transport. The model neglects simulation of any longshore sediment transport processes.

Model simulations require a pre-storm beach profile, storm information for the duration of a storm event, and sediment transport parameters. The pre-storm beach profile input requirements include a pre-storm beach profile and sediment grain size. The storm information includes wave height and period and water level (storm surge) hydrographs for the duration of the storm event. Simulations did not apply the optional model input of wave direction and wind direction and speed. Additionally, input beach profiles for the SBEACH simulations excluded application of the hardbottom location feature.

Model Calibration

To calibrate the model, this study assessed pre- and post-Hurricane Matthew (2016) profiles at R-193 near Summerhouse Beach & Racquet Club on the north side of Matanzas Inlet. Hurricane Matthew produced measurable beach profile changes captured by the June and November 2016 beach profiles (Figure 1). The figure shows some placement of sand at the secondary dune near elevation +15 ft NAVD88 that SBEACH excludes. Wave and water level conditions originate from INTERA's SWAN+ADCIRC hindcast of Hurricane Matthew completed for multiple Florida clients. Figure 2 shows the wave heights and periods offshore the study area and the water levels during Hurricane Matthew.

The SBEACH model allows for calibration of four main parameters: the transport rate parameter (K), the slope-related sand transport rate parameter (ε), the spatial decay coefficient (λ), and the avalanching angle (Φ). The transport rate parameter governs the magnitude of sediment transport directly and influences the response time of the beach profile. Smaller values of K lead to longer time scales for equilibrium whereas larger K values result in faster response times and more beach erosion and larger offshore bars. The slope-related transport rate parameter mainly influences the bar volume with larger values of ε resulting in more subdued bars. The spatial decay coefficient influences the rate of decay of transport seaward of the break point with smaller values of λ resulting in slower rates of decay. The avalanching angle influences the steepness of the eroded profile with larger values causing steeper profiles. The first two parameters discussed above represent the main calibration parameters (Rosati et al., 1993). Table 1 presents the range of these and other adjustable parameters.

Figure 1 Pre- and Post-Storm Profiles at R-193 for Hurricane Matthew

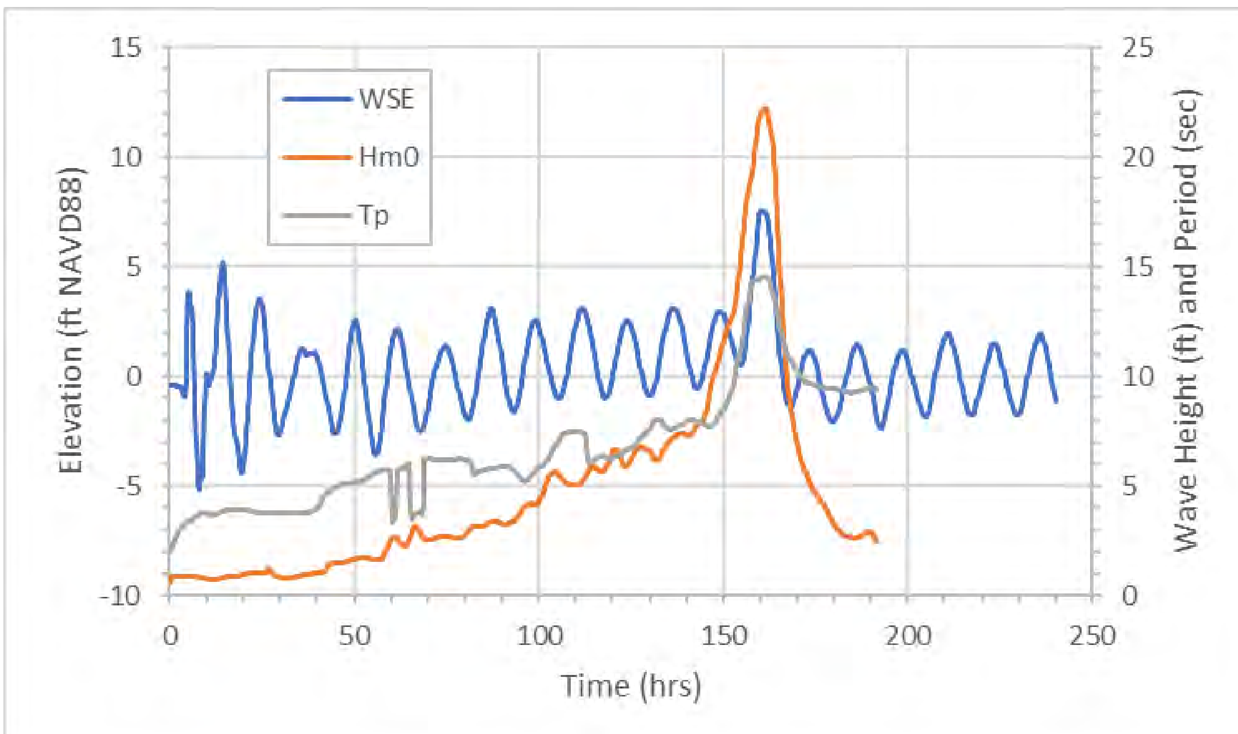

Figure 2 Hindcasted Waves and Water Levels for Hurricane Matthew

Table 1 SBEACH Parameters

Parameter	Symbol	Units	Default Value	Suggested Parameter Range	R1	R2	R3	R4
Transport Rate Coefficient	K	m^4/N	1.75 * 10^{-6}	0.25 * 10^{-6} – 2.5 * 10^{-6}	2.50 * 10^{-6}	2.50 * 10^{-6}	2.50 * 10^{-6}	2.50 * 10^{-6}
Slope Dependent Term	ε	m^2/s	0.002	0.001 – 0.005	0.005	0.005	0.005	0.005
Transport Rate Decay Coefficient	λ	1/m	0.5	0.1 – 0.5	0.5	0.5	0.5	0.1
Overwash Transport Parameter	Over	---	0.005	0.002 – 0.008	0.005	0.005	0.005	0.005
Avalanching Angle	Φ	deg	45	15 – 90	45	45	45	45
Cross-shore Spacing	DXc	ft	---**	---	5 – 20	5 – 20	5 – 20	5 – 20
Median Grain Size	D50	mm	---	0.15 – 1.0	0.25	0.25	0.23	0.23
Water Temperature	Temp	deg C	20	0 – 40	27	27	27	27
Landward Surfzone Depth	---	ft	1	0.05 – 1.6	1	1.6	1.6	1.6

**Applied 0.25 mm

FDEP (2009) provides SBEACH calibration parameters for high frequency storms around the state including on both sides of Matanzas Inlet (Table 2). These parameters generally served as starting points for this study's calibration effort.

The model setup included inputting the pre-Matthew beach profile from the back beach/dune offshore to an elevation of approximately -40 ft NAVD88, approximately 3,500 ft offshore. A variable grid spaced five feet across the active beach profile and 20 ft across the deeper beach profile represented the beach profile at R-193.

Figure 3 shows the measured and predicted contour changes from the pre-Matthew condition for the SBEACH simulations with default parameters and parameters indicated by columns R1-R4 in Table 1. This figure shows that all tested parameters produce results that underestimate the measured contour changes. However, the parameters represented by R4 best match the measured contour changes after Hurricane Matthew. Therefore, this study adopted those parameters for modeling hypothetical storms. Figure 4 shows the SBEACH results with the R4 parameters and the measured post-Matthew profile.

Table 2 FDEP (2009) SBEACH Calibration Parameters

Parameter	Symbol	Units	R-187 to R-195	R-198 to R-209
Transport Rate Coefficient	K	m^4/N	2.50 * 10^{-6}	5.00 * 10^{-7}
Slope Dependent Term	ε	m^2/s	0.005	0.002
Transport Rate Decay Coefficient	λ	1/m	0.5	0.5
Overwash Transport Parameter	Over	---	0.005	0.005
Avalanching Angle	Φ	deg	45	20
Cross-shore Spacing	DXc	ft	---	---
Median Grain Size	D50	mm	0.15	0.45
Water Temperature	Temp	deg C	27	27
Landward Surfzone Depth	---	ft	---	---

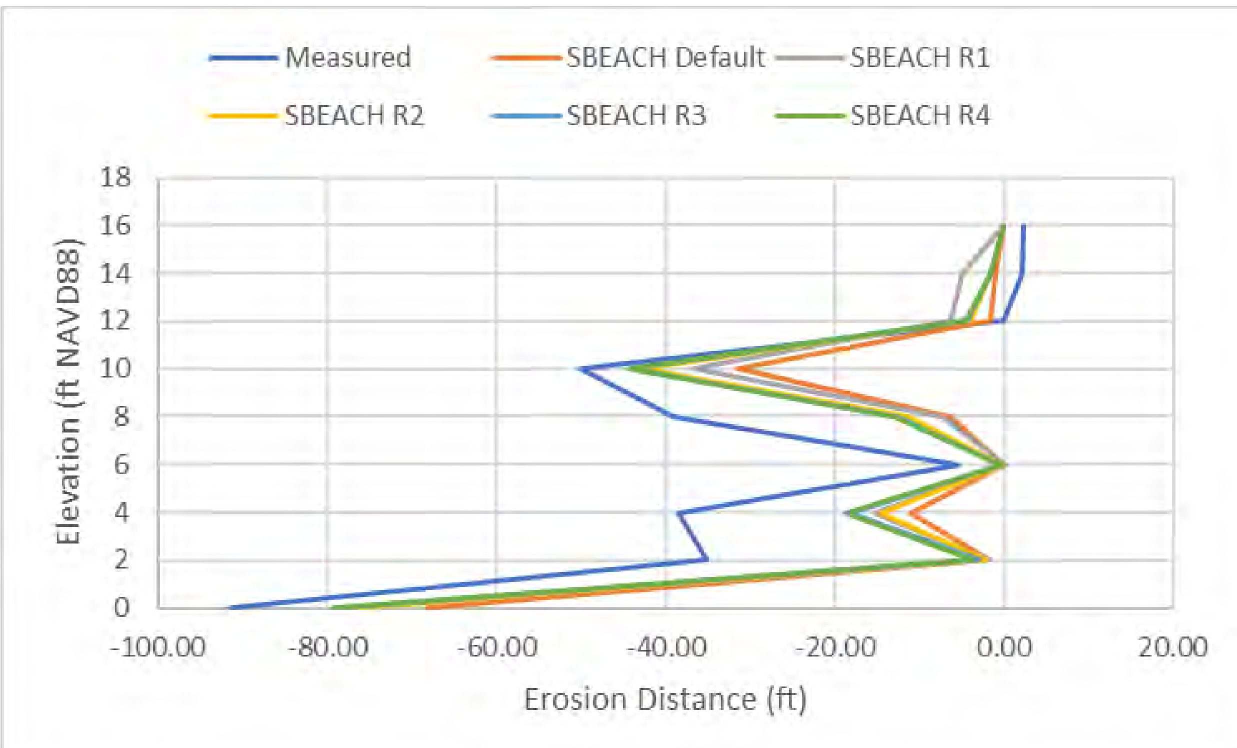

Figure 3 Measured and Predicted Contour Changes for Hurricane Matthew

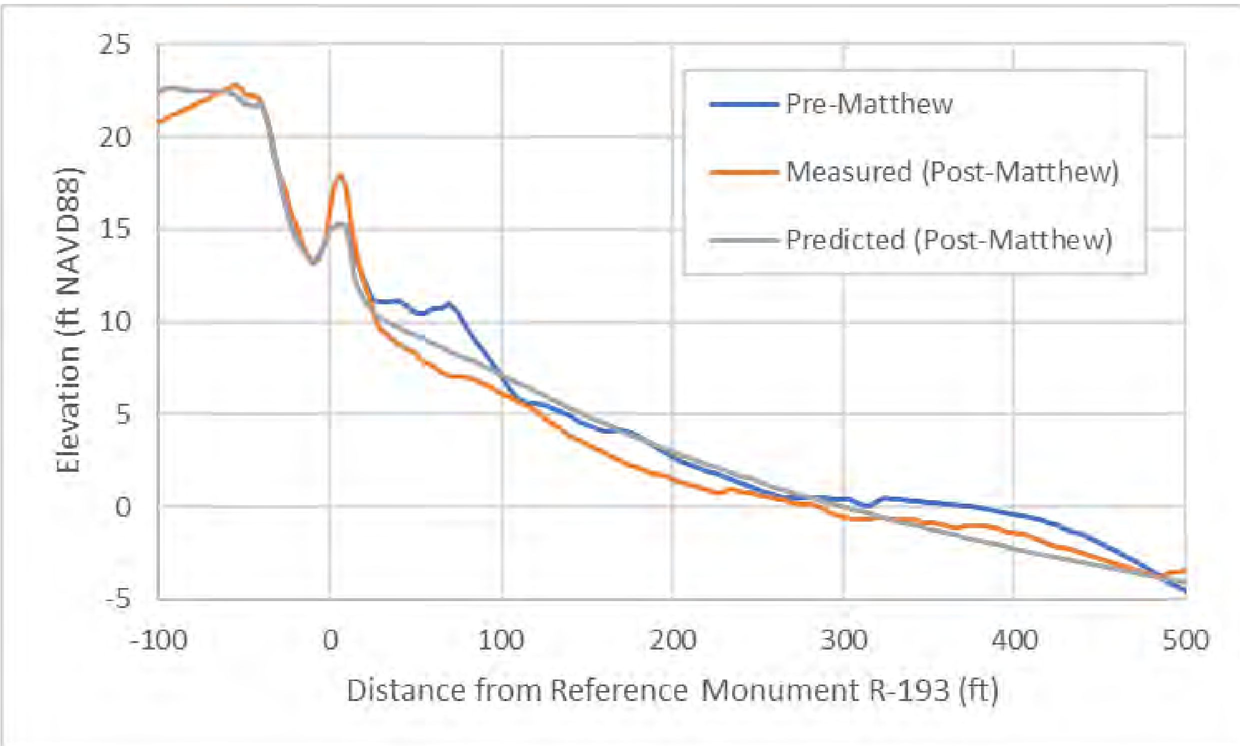

Figure 4 SBEACH Results with R4 Calibration Parameters and Measured Post-Matthew Profile

<u>Return Period Storm Simulations</u>

Determining the adequacy of an alternative required assessing its performance under 15-, 25-, 50-, and 100-yr storm events. Dean et al. (1987) and FDEP (2009) provide total storm tide elevations and 36-hr hydrographs including hurricanes only (Dean et al.) and hurricanes and tropical storms (FDEP) for the study area (Table 3). While both sources provide peak 50-yr storm tide values, this study adopts the higher (more conservative) value published by the FDEP.

Table 3 Peak Total Storm Tide Elevations near the Study Area

Return Period (yrs)	**Total Storm Tide Elevation (ft NAVD88)**	
	Dean et al.*	**FDEP**
5	---	4.4
10	2.6	6.0
15	---	6.8
20	4.1	7.4
25	---	***8.0***
30	---	8.4
50	8.2	***9.5***
100	***11.3***	---
200	13.5	---
500	15.3	---

*Converted from ft NGVD29 to ft NAVD88 by subtracting 1.037 ft

Both studies provide storm tide hydrographs, which this study adjusted so that the peak elevation matched the return period of the published peak storm tide elevation. Because both the hydrographs and SBEACH account for the effects of dynamic wave setup, the adjusted storm tide hydrographs underwent further iterative adjustment until the SBEACH-predicted water level matched the corresponding peak storm tide elevation. Despite FDEP providing all SBEACH calibration parameters, storm tide hydrograph, and constant wave height and period conditions, this study adopted the above approach for consistency in the development of the SBEACH inputs across the different return period events assessed.

The USACE Wave Information Study (WIS) (https://wis.erdc.dren.mil/) provides offshore wave conditions (wave height, period, and direction) for the period 1980-2020 for the SBEACH model. The WIS numerical hindcasts supply long-term wave climate information at locations (stations) of U.S. coastal waters. Station 63419 (29.75° N, 81.00° W; 20 meters water depth) represents conditions near the study area. Because extreme statistics were unavailable from USACE at the time of this writing, a peak-over-threshold analysis determined the deepwater wave heights associated with different return periods (Table 4). A best-fit curve of the largest wave heights at station 63419 with the form $y = \alpha * x^{\beta}$ determined the wave periods associated with the different return period wave heights. The SWAN wave model (described in the main report) transformed the waves from deepwater to an approximate 40-ft water depth, the most seaward extent of the beach profiles. The transformation of these waves from deepwater to 40-ft water depth provided storm wave conditions nearer to the study area.

Table 4 Peak Wave Heights and Periods

Return Period (yrs)	Deepwater Wave Height (ft)	Associated Deepwater Wave Period (sec)	Wave Height at 40-ft Water Depth (ft)	Associated Wave Period at 40-ft Water Depth (ft)
15	16.9	13.5	16.2	14.0
25	18.3	14.2	17.6	14.0
50	20.3	15.2	19.7	15.4
100	22.4	16.2	21.6	15.4

Developing wave height and period hydrographs from the peak wave characteristics required making some assumptions regarding their shape. With a typical storm event lasting about 36 hrs, distributing the peak storm characteristics over a 36-hr period simulated the passage of a storm and provided a realistic storm model. A sine squared distribution approximated the storm wave heights and periods over the 36-hr period. This distribution corresponds to

$$X(t) = (X_p - X_{min}) sin^2 \left(\pi \frac{t - 36}{36} \right) + X_{min}$$

where X is the wave height or period, X_p is the peak wave height or period, X_{min} is the minimum wave height or period before and after the storm, and t is time. For the hydrographs, storm wave heights begin and end with three-foot waves and storm wave periods begin and end with eight-second waves.

Figures 5-8 show the 15-, 25-, 50-, and 100-yr adjusted storm tide, wave height, and wave period hydrographs applied in SBEACH. The SBEACH model did not apply wave height randomization. This study applied a one-minute time step and variable grid spacing from 5 to 20 ft.

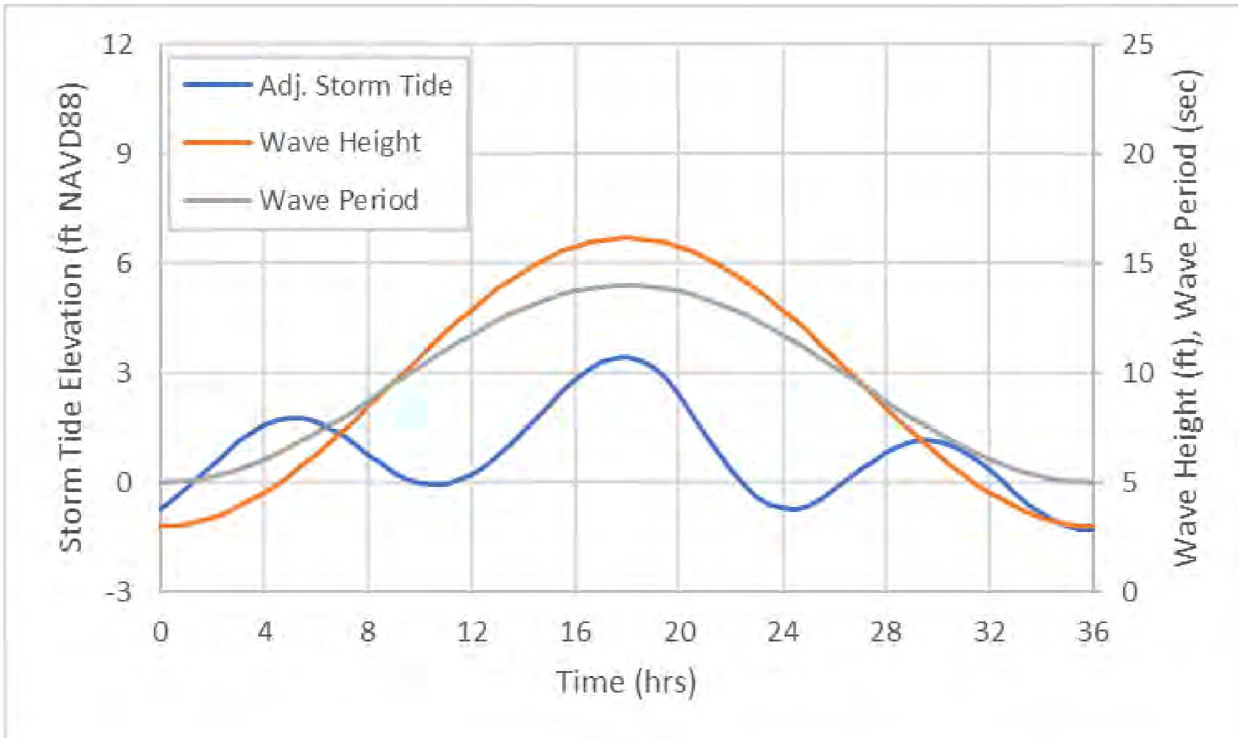

Figure 5 15-Yr Adjusted Storm Tide, Wave Height, and Wave Period Hydrographs

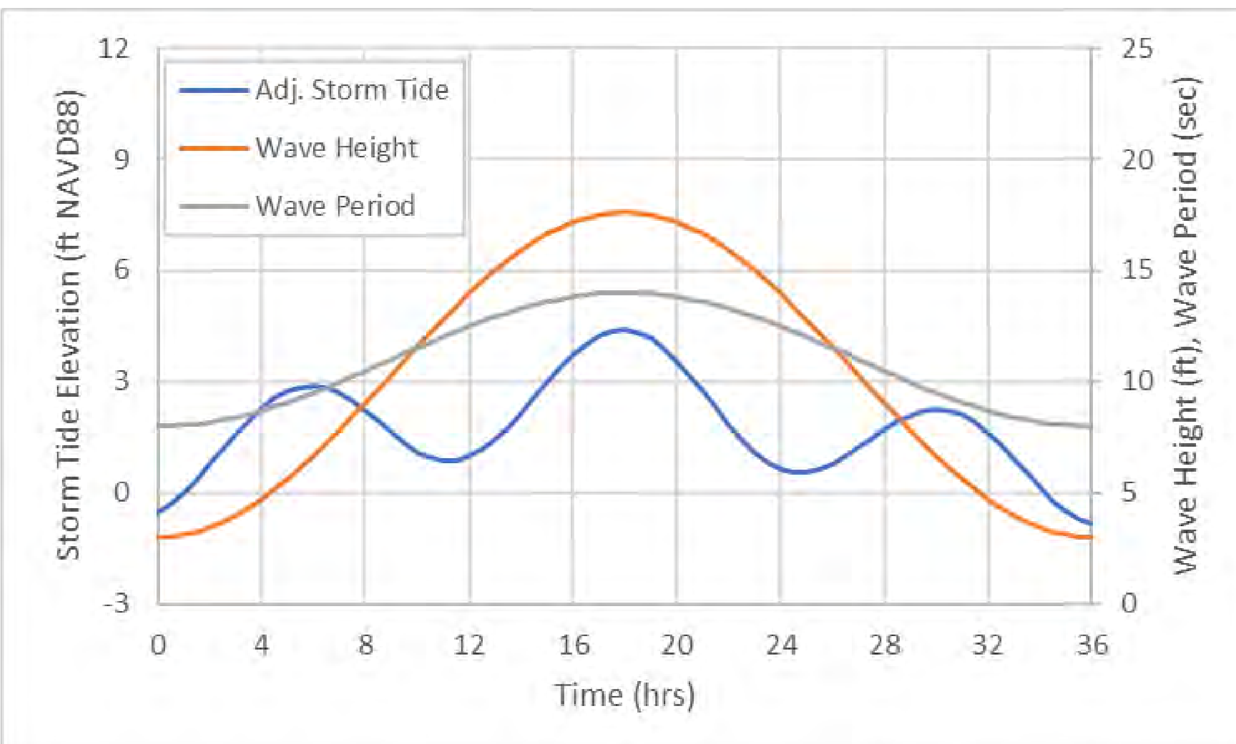

Figure 6 25-Yr Adjusted Storm Tide, Wave Height, and Wave Period Hydrographs

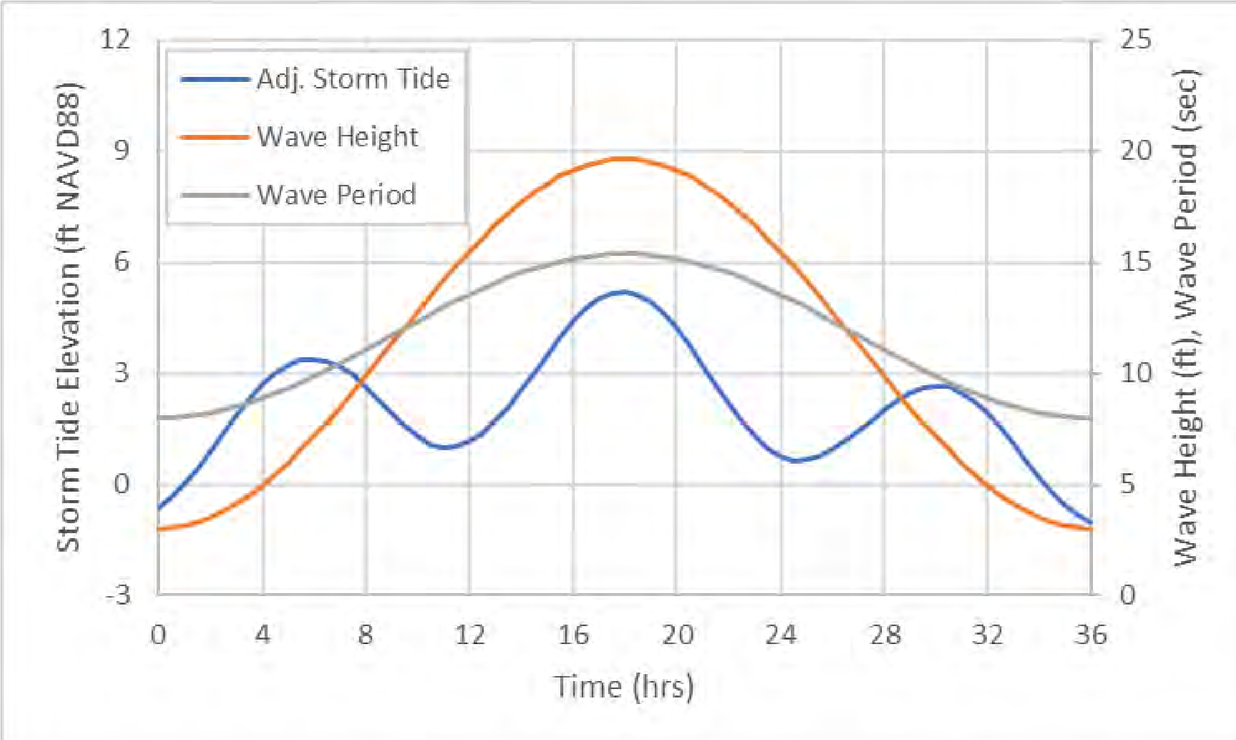

Figure 7 50-Yr Adjusted Storm Tide, Wave Height, and Wave Period Hydrographs

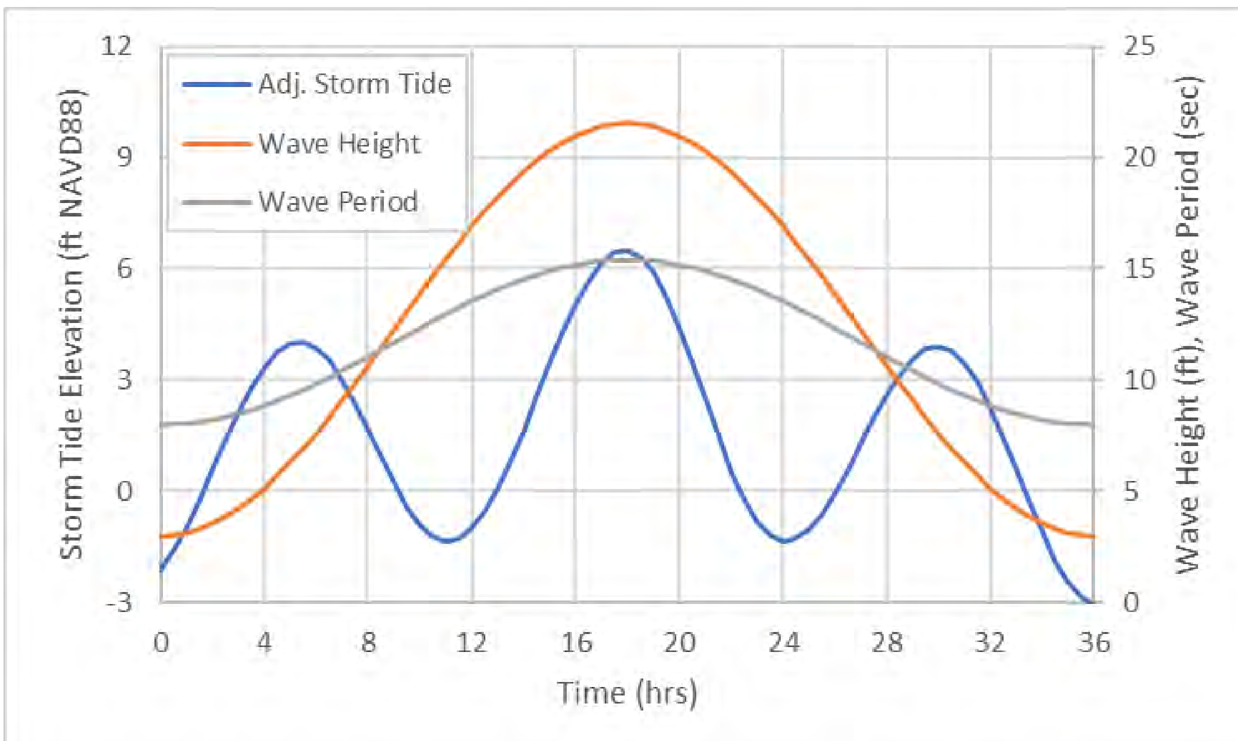

Figure 8 100-Yr Adjusted Storm Tide, Wave Height, and Wave Period Hydrographs

The following sections present the SBEACH modeling results for the dune only and dune and beach nourishment alternatives.

Dune Only

This alternative consists of placing a small dune seaward of the line of coastal construction such that the landward edge of the dune crest lies approximately 40 ft from the edge of "orphaned" houses. Figure 8 shows the typical dune concept. Figure 9 shows that a 25-yr event nearly completely erodes and overwashes the dune. The SBEACH simulation applied a median sediment size of 0.28 mm based on currently identified sand sources.

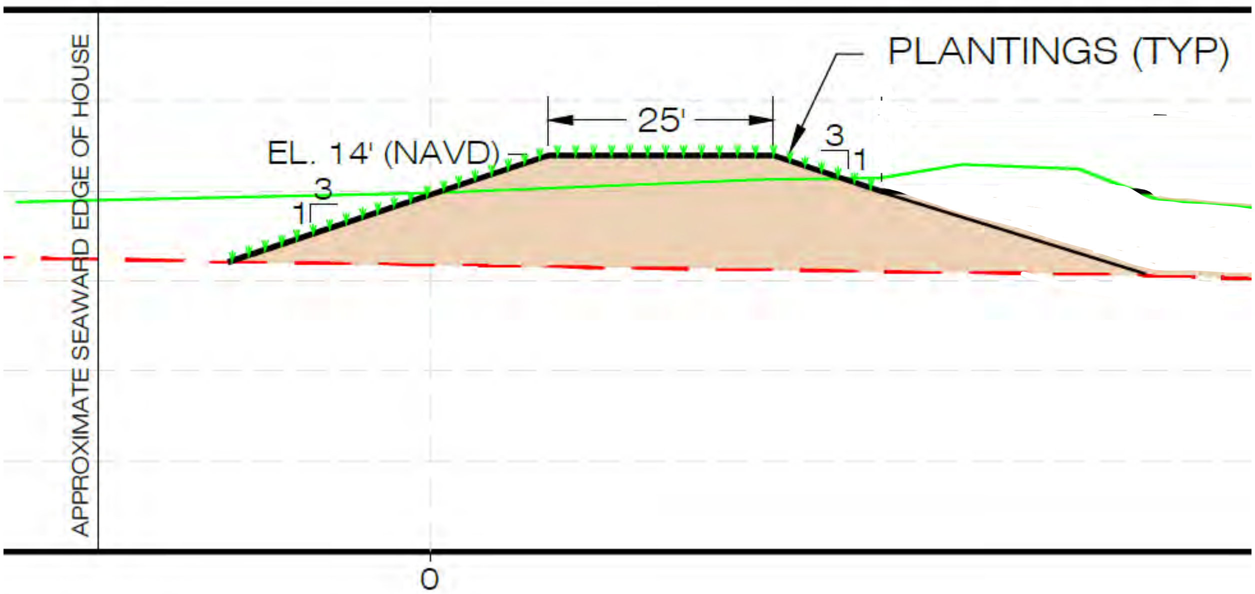

Figure 8 Typical Dune Only Concept Sketch

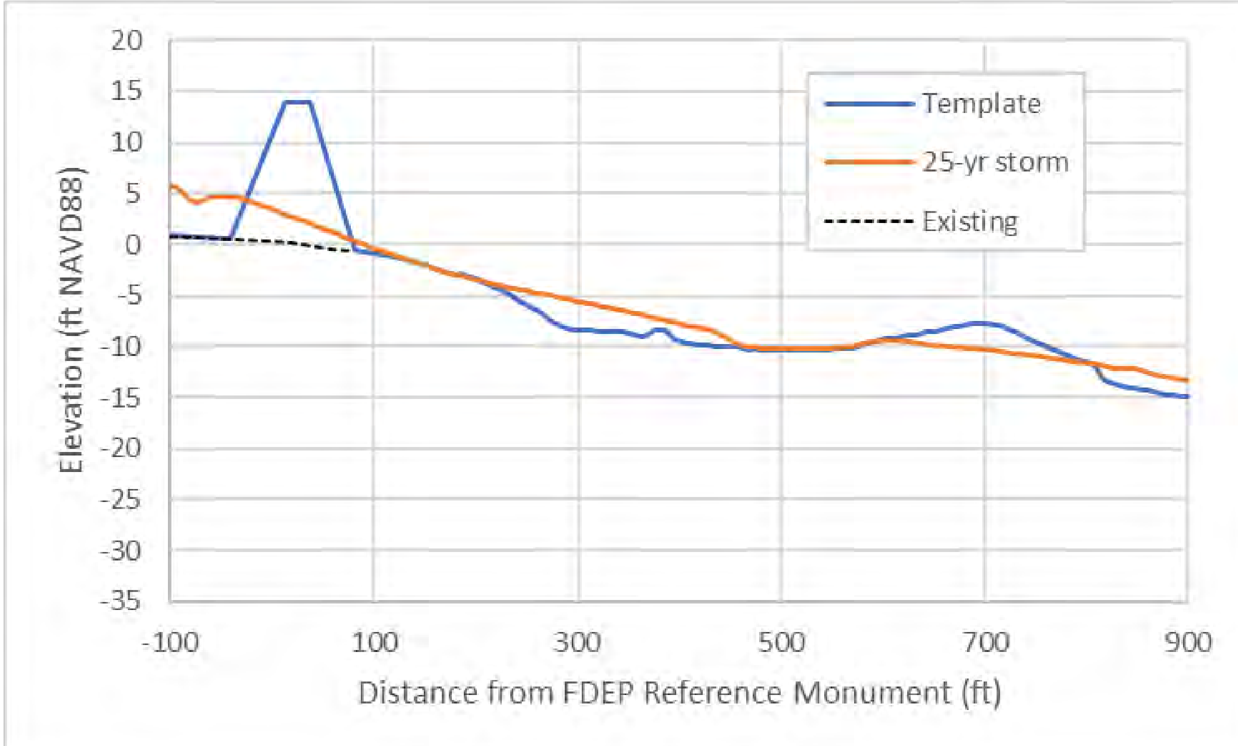

Figure 9 SBEACH Results – Dune Only, 25-yr Event

Dune and Beach Nourishment

This alternative consists of the same sized dune as presented above and a 150-ft wide beach crest at elevation +10 ft NAVD88 with a 10H:1V seaward slope (Figure 10). This study investigated use of median sand sizes of 0.28 and 0.35 mm to assess the variation in potentially available sand sources.

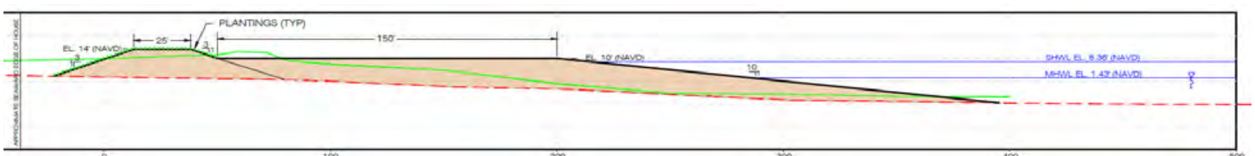

Figure 10 Dune and Beach Nourishment Concept

Before inputting the beach template into SBEACH, a profile equilibration assessment occurred to mimic the beach adjustments that occur after construction as normal waves and currents move and spread the sediment offshore (into a milder slope) and alongshore. Equilibrium profiles assumed an above mean high water (MHW) slope and Dean's equilibrium profile shape below MHW based on the sand size. Note that for the 0.28-mm option, profile equilibration results in eroding part of the dune. Therefore, this study did not run SBEACH for this option. Figure 11 shows the erosion resulting from 25-, 50-, and 100-yr events for the dune and beach concept with the slightly coarser material. Erosion caused from the 25- and 50-yr events encroaches the dune toe but the beach and dune prevent overwashing of the dune. For the 100-yr event, overwash of the dune occurs.

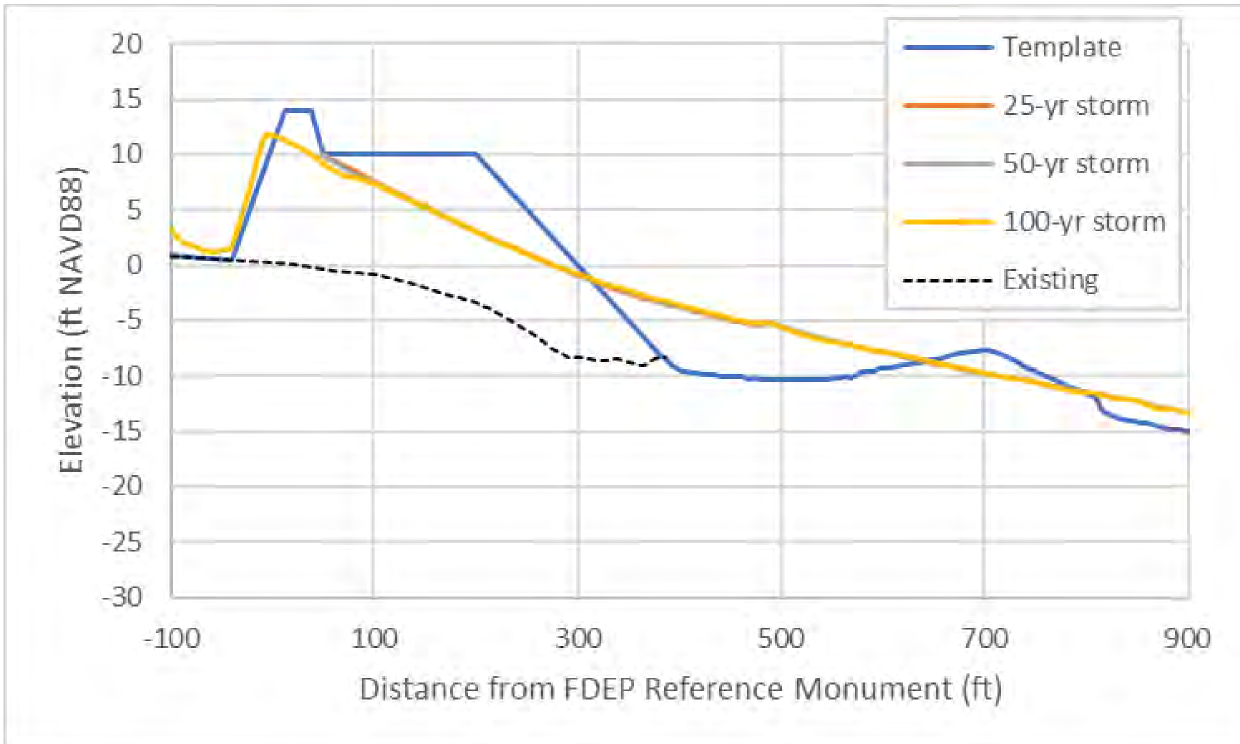

Figure 11 SBEACH Results – Dune and Beach Nourishment, 0.35 mm Sediment

Seawall with Small Dune

This alternative consists of locating a seawall approximately 125 ft landward of the line of construction of the orphaned houses and landward of the CCCL. Figure 12 shows the concept. The wall extends to elevation +14 ft NAVD88. The dune consists of 0.28-mm material, a crest elevation of +12 ft NAVD88, a crest width of 20 ft, and a 3H:1V seaward slope. The authors utilized SBEACH to determine how much dune loss might occur during various return period storms. Notably, the simulations assumed the wall would not fail.

Figure 13 presents the SBEACH simulation results. While the 15- and 25-yr events erode some of the dune, they do not expose the dune below its original crest elevation. The less frequent events expose an additional three or more feet than originally exposed such that the exposed wall height increases from three feet to at least six feet.

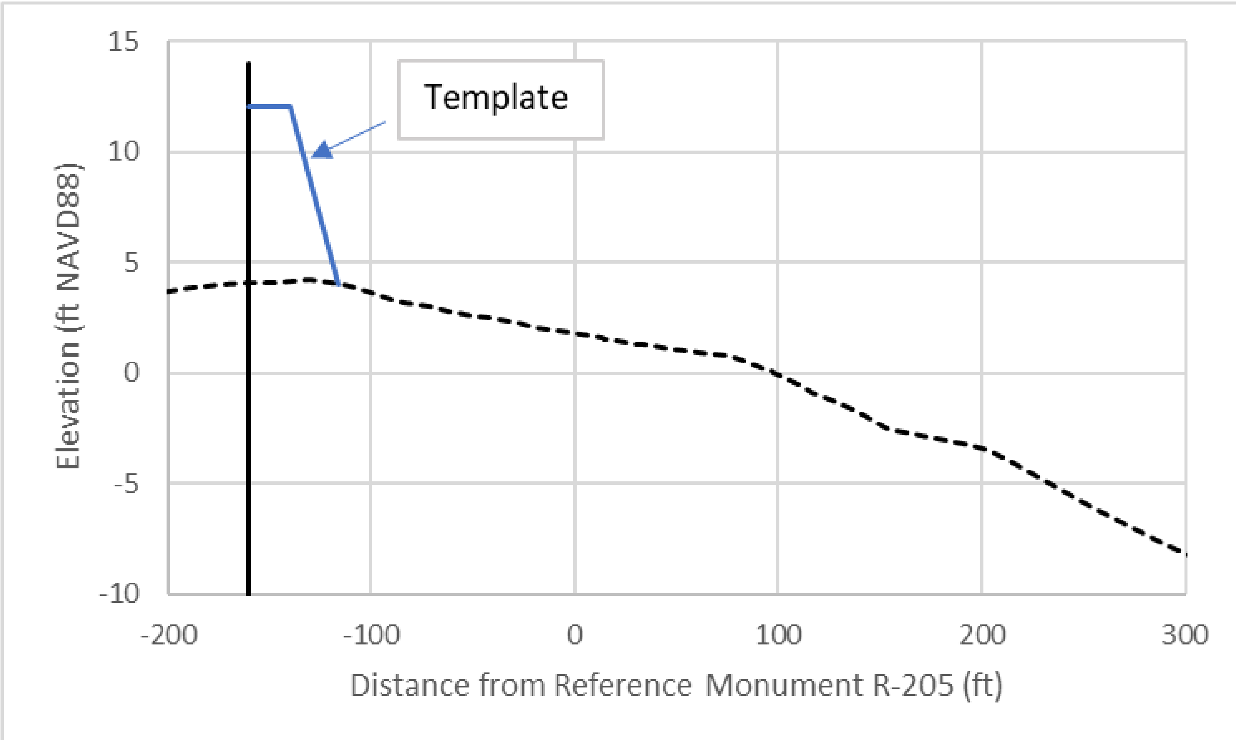

Figure 12 Seawall with Small Dune Concept

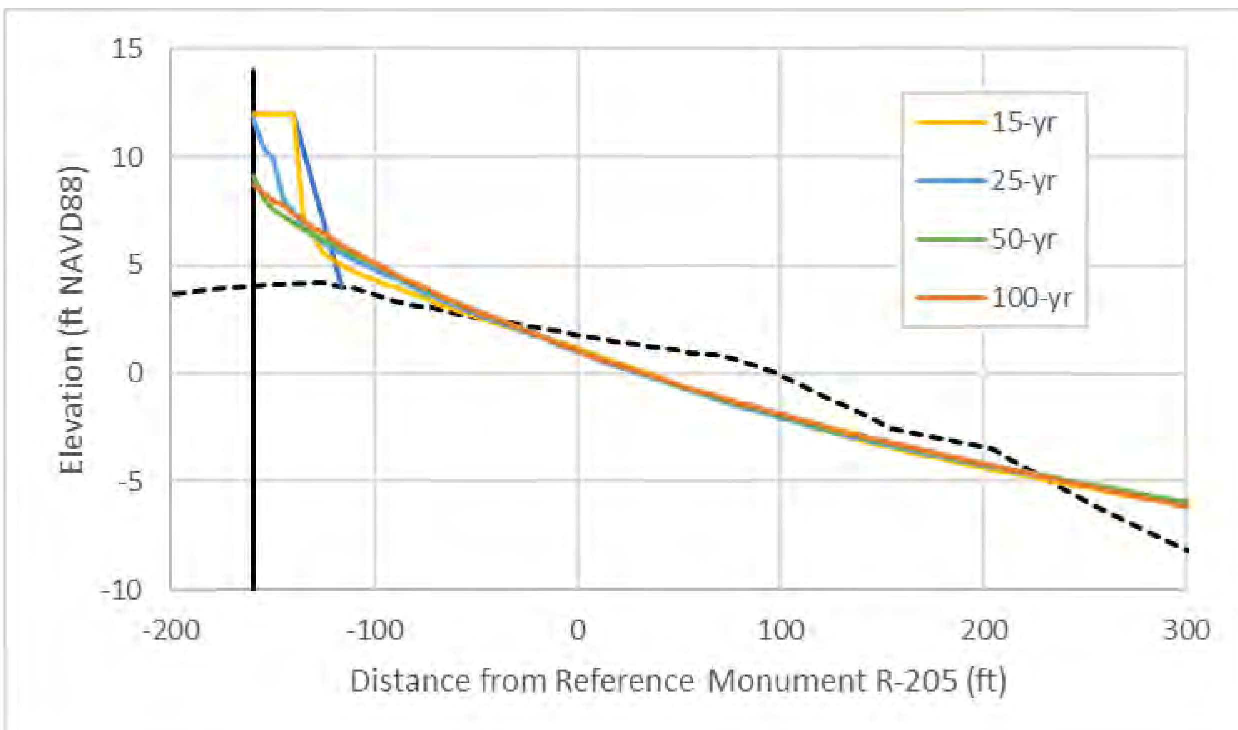

Figure 13 SBEACH Results – Seawall with Small Dune, 0.28 mm Sediment

References

Dean, R.G., Chiu, T.Y., and Wang, S.Y. 1987. *Combined Total Storm Tide Frequency Analysis for St. Johns County, Florida*. Beaches and Shores Resources Center, Florida State University, Tallahassee, FL.

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Rosati, J.D., Wise, R.A., Kraus, N.C. and Larson, M. 1993. *SBEACH: Numerical Model for Simulating Storm-Induced Beach Change, Report 3, Users Manual*. U.S. Army Waterways Experiment Station, Vicksburg, MS.

Appendix N

Beach Fill Diffusion Analysis

Analysis

This study estimated a renourishment interval of five years for a beach fill project shown below. The next several paragraphs detail the basis for this interval.

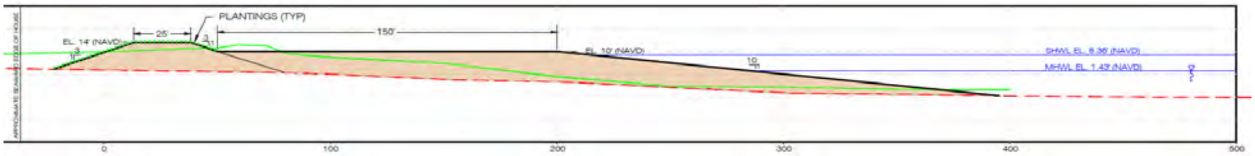

Figure 1 Dune and Beach Nourishment Concept

Following a theory based on Pelnard-Considere (1956), as cited in e.g., Dean and Dalrymple (2002), a beach fill represents a perturbation or a planform anomaly to the local uninterrupted shoreline, which over time, longshore sediment transport smooths. The present project acts as such an anomaly. A linearized approximation of the Pelnard-Considere "diffusion" equation that describes this process corresponds to

$$\frac{\partial y}{\partial t} = G\frac{\partial^2 y}{\partial x^2} \qquad (1)$$

where *y* is the cross-shore position of the shoreline at time *t*, and *x* is the alongshore distance. This equation (a form of the well-known heat conduction equation) contains several possible analytical solutions; the boundary conditions (at the lateral ends) specify the solution. The longshore diffusivity parameter (*G*) governs the rate of evolution of the project. In this linearized treatment,

$$G = K\frac{H_0^{2.4}C_{G0}^{1.2}g^{0.4}}{8(s-1)(1-p)C_*\kappa^{0.4}(h_*+B)}\left[\frac{cos^{1.2}(\beta_0-\alpha_0)cos2(\beta_0-\alpha_*)}{\cos(\beta_0-\alpha_*)}\right] \qquad (2)$$

where *K* is an empirical nondimensional constant, *H* is the wave height, C_G is the wave group velocity, *g* is the acceleration due to gravity, *s* is the specific gravity of sand (2.65), *p* is the sediment porosity (0.35), *C* is the wave velocity, *κ* is the ratio of the breaking wave height to the breaking water depth (0.78), h_* is the water depth of limiting sediment motion (depth of closure), *B* is the height of the berm above the water level, *β* is the shoreline azimuth, and *α* is the direction of the waves. The subscripts *0* and *** denote conditions in deep water and at the depth of limiting motion.

Given an initial shoreline like a rectangular planform, engineers may describe the evolution of the shoreline by

$$y(x,t) = \frac{Y}{2}\left\{erf\left[\frac{\gamma}{4}\left(\frac{2x}{L}+1\right)\right] - erf\left[\frac{\gamma}{4}\left(\frac{2x}{L}-1\right)\right]\right\} \qquad (3)$$

where *Y* is the initial width of the planform beach fill, *L* is the project length, *erf[ ]* is the error function defined as

$$\mathrm{erf}(x) = \frac{2}{\sqrt{\pi}}\int_0^x e^{-u^2}du \qquad (4)$$

and

$$\gamma = \frac{L}{\sqrt{Gt}} \tag{5}$$

governs the shoreline evolution rate. The fraction of the placed sand remaining within the placement area at time *t* is

$$M(t) = \frac{1}{YL}\int_{-\frac{L}{2}}^{\frac{L}{2}} y(x,t)dx = \frac{2}{\gamma\sqrt{\pi}}\left(e^{-\left(\frac{\gamma}{2}\right)^2} - 1\right) + \text{erf}\left(\frac{\gamma}{2}\right) - \frac{Et}{\Delta y_0} \tag{6}$$

where E is the background erosion rate and Δy_0 is the initial beach width, defined as

$$\Delta y_0 = \frac{V_0}{(h_* + B)l} \tag{7}$$

where V_0 is the total initial volume of placed sand.

This smoothing or diffusion of the beach fill by longshore sediment transport acts in conjunction with any background erosion (E) present without the beach fill.

With parameters shown in Table 1, Equation 2 yields a longshore diffusivity factor of 0.09 ft^2/s for the Marineland, FL area. Given this and the beach fill parameters provided in Table 2, the theory predicts the curve shown in Figure 1.

Table 1 Longshore Diffusivity Calculation Summary

Parameter	**Value**
Mean sand size (D50)	0.35 mm
Specific gravity (s)	2.65
Porosity (p)	0.35
Breaking parameter (κ)	0.78
Sediment transport coefficient (K)	1.05
Depth of closure (h_*)	30 ft
Effective wave height (H_0)	2 ft
Effective wave period (T)	7 sec
Wavelength at h_*	200 ft
Wave celerity in deep water (C_0)	35.9 ft/s
Deepwater wave group velocity (C_{G0})	17.9 ft/s
Wave celerity at h_* (C_*)	26.4 ft/s
Longshore Diffusivity (G)	0.09 ft^2/s

Table 2 Beach Fill Characteristics

Parameter	Value
Project length (l)	9,875 ft
Beach fill volume (V_0)	1,500,000 cy
Background erosion (E)	2 ft/yr
Depth of closure (h_*)	30 ft
Berm height (B)	8 ft

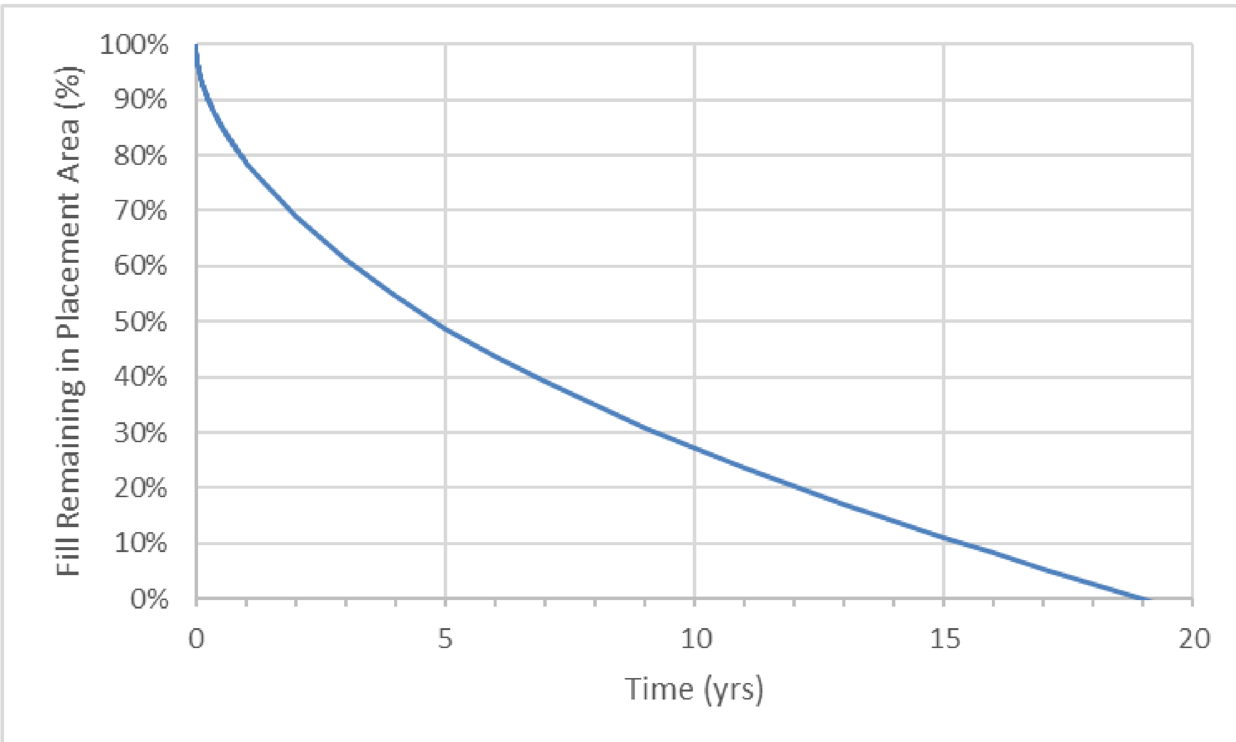

Figure 1 Prediction of Sand Remaining

SBEACH modeling suggests that the critical design berm volume represents approximately 80% of the total placed initial volume. However, experience has shown that subsequent renourishments perform better than the initial nourishment — especially given the beach is currently in a very sand starved condition. As such, this analysis assumes renourishment is necessary when 50% of the fill remains. Figure 1 shows that 50% of the fill remains after approximately five years. Therefore, the beach needs renourishing every five years.

<u>References</u>

Dean, R.G. and Dalrymple, R.A. 2002. *Coastal Processes with Engineering Applications*. Cambridge University Press, New York.