Fort Myers Beach Management & Planning Session

Council Chambers
2525 Estero Blvd.
Fort Myers Beach, FL 33931

Agenda **Thursday, February 4, 2021** **9:00 AM**

ORDER OF BUSINESS

I. CALL TO ORDER

II. PLEDGE OF ALLEGIANCE

III. ITEMS FOR DISCUSSION

A. Times Square and Bayside Park update
Presentation by DRMP Inc. of the design status for Times Square and Bayside Park.

B. Review of Laguna Shores Channel Dredge STA #002
Review of Laguna Shores Channel Dredge STA #002

C. Beach Renourishment Project
Review Beach Renourishment Project Scope

D. Annual Special Event Pass
Annual On-site Special Event Permit for Non-profits properties in excess of 1.2+ acres ($1,200.00/year)

IV. AGENDA MANAGEMENT

A.
Agenda Management

V. ADJOURNMENT

NOTE: THIS MEETING IS TELEVISED LIVE ON COMCAST CHANNEL 98.

IF A PERSON DECIDES TO APPEAL A DECISION MADE BY THE COUNCIL IN ANY MATTER CONSIDERED AT THIS MEETING/HEARING, SUCH PERSONS MAY NEED TO ENSURE THAT A VERBATIM RECORD OF THE PROCEEDING IS MADE, TO INCLUDE THE TESTIMONY AND EVIDENCE UPON WHICH ANY SUCH APPEAL IS TO BE BASED.

	For special accommodations, please notify the Town Clerk's Office at least 72 hours in advance. (239) 765-0202		**Help for the hearing impaired is available through the Assistive Listening System. Receivers can be obtained from the Town Clerk's Office.**

In accordance with the Americans with Disabilities Act (ADA), persons needing a special accommodation to participate in the Board's proceedings should contact the Town Clerk's Office not later than three days prior to the proceedings.

Town of Fort Myers Beach
Agenda Item Summary

Blue Sheet Number: **2021-145**

1. **Requested Motion:**

Meeting Date: February 4, 2021

Presentation by DRMP Inc. of the design status for Times Square and Bayside Park.

Why the action is necessary:
Provides an update to Town Council and the public as to the current design status of Times Square and Bayside Park.

What the action accomplishes:
Provides an update to Town Council for the design of Times Square and Bayside Park.

2. **Agenda:**
ITEMS FOR DISCUSSION

3. **Requirement/Purpose:**
Other

---

5. **Background:**
DRMP Inc. was contracted to design Times Square, Bay Oaks and Bayside Park. To date, DRMP Inc. has completed 90% design of Times Square and Bayside Park. This presentation will provide an update as to the current design status of each project. This provides the Town Council with the last opportunity for public input on the project without the cost associated with rework.

Attachments:

Financial Impact:
Council will determine whether to continue design by funding 100% design for these projects.

6. **Alternative Action**

7. **Staff Recommendations:**

8. **Recommended Approval:**

______________________ Chelsea O'Riley, Public Works Director	Date: January 27, 2021
______________________ John R Herin Jr, Town Attorney	Date: January 27, 2021
______________________ Amy Baker, Town Clerk	Date: January 27, 2021
______________________ Roger Hernstadt, Town Manager	Date: January 28, 2021

Town of Fort Myers Beach
Agenda Item Summary

Blue Sheet Number: **2021-88**

1. **Requested Motion:**

Meeting Date: February 4, 2021

Review of Laguna Shores Channel Dredge STA #002

Why the action is necessary:
Infill into channel is inhibiting boating access to residents and visitors in and around Buccaneer Lagoon.

What the action accomplishes:
Permitting and design of Laguna Shores Channel Dredge.

2. **Agenda:**
ITEMS FOR DISCUSSION

3. **Requirement/Purpose:**

---

5. **Background:**
Recent bathymetric survey of Laguna Shores Channel observed significant infill along the entire length of the channel limiting boating access. It was estimated (N.B. pre- Storm Eta) that approximately 5,500 cubic yards of material is required to be removed in order to restore the channel to the original design template of -7' MLW. Project history attached.

Attachments:
1. Fmb10Sta2HwaExeToCChustz1-26-21
2. Construction Cost Estimate
3. Engineering Services Cost Estimate Summary
4. Engineering Proposal
5. Fmb3Recap2-11-20

Financial Impact:
Permitting & Design Engineering Services $10,000 NTE (STA attached).
Construction Phase Engineering Services $12,850 NTE
Dredge Construction Cost Estimate $130/cy to $206/cy ($700,000 to $1,200,000) depending on method (see Construction Costs Estimate attached)
Monitoring Phase Engineering Services $11,000

6. **Alternative Action**
Postpone the permitting and design of Laguna Shores Channel Dredge.

7. **Staff Recommendations:**
Town Council to set a financial policy regarding the cost of the dredge project prior to commencement. The previous Laguna Shores Channel Dredge project was funded by an assessment to Benefitting Properties by the Town (Resolution 08-44). Town Council to appropriate budget and authorize the Town Manager to execute the attached Task Order.

8. **Recommended Approval:**

Date: January 27, 2021

Daphnie Bercher, Community Services Administrator

Date: January 27, 2021

John R Herin Jr, Town Attorney

Date: January 27, 2021

Amy Baker, Town Clerk

Date: January 28, 2021

Roger Hernstadt, Town Manager

TOWN OF FORT MYERS BEACH SERVICE AGREEMENT

SUPPLEMENTAL TASK AUTHORIZATION

_X_ Supplemental Task Authorization NO.: 002

CONTRACT/PROJECT NAME: Laguna Shores Channel Dredge

CONSULTANT: Hans Wilson & Associates, Inc. PROJECT NO.: ____________

SOLICIT NO.: RFQ-20-06-AD CONTRACT NO.: ________

REQUESTED BY: Chadd Chustz, Env Project Mgr DATE OF REQUEST: January 22, 2021

Upon the completion and execution of this Supplemental Task Authorization by both parties, the Consultant/Provider is authorized to and shall proceed with the following:

EXHIBIT "A"	SCOPE OF PROFESSIONAL SERVICE:	DATED: January 22, 2021
EXHIBIT "B"	COMPENSATION & METHOD OF PAYMENT:	DATED: January 22, 2021
EXHIBIT "C"	TIME AND SCHEDULE OF PERFORMANCE:	DATED: January 22, 2021
EXHIBIT "D"	CONSULTANT'S/PROVIDER'S ASSOCIATED SUB-CONSULTANT(S)/SUB-CONTRACTORS:	DATED: January 22, 2021

It is understood and agreed that the acceptance of this modification by the CONSULTANT/PROVIDER constitutes an accord and satisfaction.

RECOMMENDED:

By: ____________________
Department Director Date

By: ____________________
Contracts Manager Date

ACCEPTED: Hans Wilson & Associates, Inc

By: Robin M. Nixon 1/26/21
Consultant/Provider Date

TOWN APPROVAL:

By: ____________________
Town Manager Date

Cost of STA: $10,000

Date: January 22, 2021

EXHIBIT A

SCOPE OF PROFESSIONAL SERVICES

Laguna Shores Channel Dredge – January 2021

Overview

STA NO. 2: Laguna Shores Channel Dredge

The following services will be provided by Hans Wilson & Associates, Inc:

Environmental Consulting and Marine Engineering services in conjunction with restoration of the Laguna Shores Access Channel connecting Buccaneer Lagoon to Big Carlos Pass located at the east end of Estero Island, Section 3, Township 47 South, Range 24 East, Lee County, Florida.

1: **Permitting** – Provide technical support to Town staff upon request to permit the dredge project with the Florida Department of Environmental Protection (DEP) and U.S. Army Corps of Engineers (COE) including drawings, management plans, and supporting documentation necessary for a complete application submittal to State and Federal regulatory agencies. This does not include any response to requests for additional information that may require additional field work, survey services, or similar specific tasks.
Time and Materials Not To Exceed Budget @ $7,500

3: **Plans and Specifications** – Update the existing construction plans and specifications for dredging the existing channel alignment per the last bathymetric survey. Review options for the dredged material handling location and identify a suitable upland site for dredge material placement. Notify the regulatory agencies of pending construction, either as exempted from the DEP permit process and under COE Nationwide permit #3 or per final permits issued for the maintenance dredging. Prepare information and materials sufficient for signed and sealed drawings to be used for construction permitting with the Town.
Fixed Fee @ $2,500

Hourly Breakdown:

Total Cost (of Job): $10,000.00

EXHIBIT B

Date: January 22, 2021

COMPENSATION AND METHOD OF PAYMENT FOR

Laguna Shores Dredge

Section 1. BASIC SERVICES/TASK(S)

The TOWN shall compensate the CONSULTANT for providing and performing the Task(s) set forth and enumerated in EXHIBIT "A", entitled "SCOPE OF PROFESSIONAL SERVICES", as follows:

NOTE: A Lump Sum (L.S.) or Not-to-Exceed (N.T.E.) amount of compensation to be paid the CONSULTANT should be established and set forth below for each task or sub-task described and authorized in Exhibit "A". In accordance with Agreement Article 5.02(2) "Method of Payment", tasks to be paid on a Work-in-Progress payment basis should be identified (WIPP).

Task Number	Task Title	Amount of Compensation	Indicate Basis of Compensation LS or NTE	If Applicable Indicate (W.I.P.P.)
#1	Permitting	$7,500	NTE	
#2	Plans & Specifications	$2,500	LS	
TOTAL (Unless list is continued on next page)		$10,000.00	LS	

Section 2. ADDITIONAL SERVICES

The TOWN shall compensate the CONSULTANT for such ADDITIONAL SERVICES as are requested and authorized in writing for such amounts or on such a basis as may be mutually agreed to in writing by both parties to this Agreement. The basis and/or amount of compensation to be paid the CONSULTANT for ADDITIONAL SERVICES requested and authorized in writing by the TOWN shall be as set forth in Article 4 of this Agreement.

Should it be mutually agreed to base compensation for ADDITIONAL SERVICES on an hourly rate charge basis for each involved professional and technical employee's wage rate classification, the applicable hourly rates to be charged are as set forth and contained in ATTACHMENT NO. 1 hereto dated March 16, 2020 (as included in RFQ-20-06-AD), entitled "CONSULTANT'S PERSONNEL HOURLY RATE SCHEDULE".

Section 3. REIMBURSABLE EXPENSES AND COSTS

When the CONSULTANT'S compensation and method of payment is based on an hourly rate for professional and/or technical personnel, the CONSULTANT shall, in addition to such hourly rates as are set forth in Attachment No. 1 hereto, be entitled to reimbursement of out-of-pocket, non-personnel expenses and costs as set forth in ATTACHMENT NO. 2 hereto March 16, 2020 (as included in RFQ-20-06-AD) entitled "NON-PERSONNEL REIMBURSABLE EXPENSES AND COSTS".

ATTACHMENT NO. 1 TO EXHIBIT B

Date: January 22, 2021

CONSULTANT'S PERSONNEL HOURLY RATE SCHEDULE FOR Laguna Shores Channel Dredge

Consultant or Sub-consultant Name: Hans Wilson & Associates, Inc
(A separate Attachment No. 1 should be included for each Sub-Consultant)

(1) Project Position or Classification (Function to be Performed)	(2) Current Direct* Payroll Average Hourly Rate	(3) Multiplier**	(4) Hourly Rate To Be Charged (Column 2x3)
Standard Rate Schedule As Included with Proposal			

*NOTE: Direct Payroll hourly rate means the actual gross hourly wage paid.
**NOTE: Indicate applicable multiplier for indirect personnel costs, general administrative & overhead costs, and profit.
***NOTE: A separate personnel hourly rate schedule should also be attached for each Sub-Consultant listed in Exhibit "D".

ATTACHMENT NO. 2 TO EXHIBIT B

Date: January 22, 2021

NON-PERSONNEL REIMBURSABLE EXPENSES AND COSTS FOR
Laguna Shores Channel Dredge

CONSULTANT OR SUB-CONSULTANT NAME: Hans Wilson & Associates, Inc
(A separate Attachment No. 2 should be included for each Sub-Consultant)

ITEM	BASIS OF CHARGE
NOTE: Receipts or in-house logs are required for all non-personnel reimbursable expenses unless exempt (such as meals).	
Administrative Services Fee – Applicable only when specifically authorized by the Town, for administering the procurement of special additional services, equipment, reimbursables etc. not covered under the costs and/or changes established in the Agreement.	

NOTE: N.T.E. indicates Not-To-Exceed

EXHIBIT C

Date: January 22, 2021

TIME AND SCHEDULE OF PERFORMANCE FOR

Laguna Shores Channel Dredge – January 2021

This EXHIBIT "C" establishes times of completion for the various phases and tasks required to provide and perform the services and work set forth in EXHIBIT "A" of this Agreement. The times and schedule of performance set forth hereinafter is established pursuant to this Agreement.

Phase and/or Task Reference As Enumerated in EXHIBIT "A"	NAME OR TITLE Of Phase and/Task	Number Of Calendar Days For Completion Of Each Phase And/or Task	Cumulative Number Of Calendar Days For Completion From Date of Notice to Proceed
#1	Permitting	90 days	90 days
#2	Plans and Specifications	120 days	120 days

EXHIBIT D

Date: January 22, 2021

CONSULTANT'S ASSOCIATED SUB-CONSULTANT(S) AND SUBCONTRACTOR(S) FOR

Laguna Shores Channel Dredge – January 2021

CONSULTANT has identified the following Sub-Consultant(s) and/or Subcontractor(s) which may be engaged to assist the CONSULTANT in providing and performing services and work on this Project:

(If none, enter the word "none" in the space below.)

Service and/or Work to be Provided or Performed	Name and Address of Individual or Firm				Sub-Consultant Services are Exempted from Prime Consultant's Insurance Coverage	
					Yes	No
	NONE					

Chadd Chustz

From: Hans Wilson <hans@hanswilson.com>
Sent: Monday, January 25, 2021 12:09 PM
To: Chadd Chustz
Subject: Fmb10Chadd CostEst 1-25-21

Chadd – Here is a quick breakdown on a potential construction cost. I don't have the cost numbers for the last work that Kelly Brothers did in 2012, it was for 6,460 cy. The mechanical dredging option, which we did last time, is less costly but will require a mixing zone variance and turbidity monitoring. The DEP didn't ask for that last time but they are under more scrutiny now, nine years later. Turbidity controls are tough at this location because of the current. It is more expensive if you go with hydraulic but less likely to have a turbidity violation. I hope this helps. – Hans

Hydraulic Dredging (no mixing zone variance)			
Scope	**Unit**	**Unit $**	**Total Pricing**
Mobilization	Lump Sum	$16,000	$16,000
Dredging and Material Handling	5,500 CY (estimated)	$180 per CY	$990,000
Severance Fee	5,500 CY (estimated)	$2.25 per CY	$12,375
De-Mobilization	Lump Sum	$12,000	$12,000
Project Sub Total		**$1,030,375**	
Contingency (10%)			$103,038
Estimated Total Project Pricing w/ contingency		**$1,133,413**	
Estimated Total Cost per CY		**$206**	

Mechanical Dredging (mixing zone variance required)			
Scope	**Unit**	**Unit $**	**Total Pricing**
Mobilization	Lump Sum	$16,000	$16,000
Dredging and Material Handling	5,500 CY (estimated)	$90 per CY	$577,500
Severance Fee	5,500 CY (estimated)	$2.25 per CY	$12,375
Mixing Zone Authorization	Lump Sum	$15,000	$15,000
3rd Party Turbidity Monitoring	Lump Sum	$15,000	$15,000
De-Mobilization	Lump Sum	$12,000	$12,000
Project Sub Total		**$647,875**	
Contingency (10%)			$64,788
Estimated Total Project Pricing w/ contingency		**$712,663**	
Estimated Total Cost per CY		**$130**	

Hans Wilson, P.E.
1938 Hill Ave.
Ft. Myers, FL 33901
239.334.6870
hans@hanswilson.com
Marine Engineers &
Environmental Consultants
Celebrating 20 Years of Excellence

Knowledge, Quality, Service.

From: Chadd Chustz <Chadd@fmbgov.com>
Sent: Monday, January 25, 2021 11:53 AM
To: Hans Wilson <hans@hanswilson.com>
Cc: Robin Mixon <robin@hanswilson.com>; 'Tina Cesarino' <tina@hanswilson.com>
Subject: Laguna Dredge STA

GM, please see attached STA for permitting phase of dredge. If we need to make adjustments, please let me know.

Thank you,

Chadd Chustz
Environmental Project Manager
Town of Fort Myers Beach
chadd@fmbgov.com
(239) 765-0202 Ext. 1312

From: Hans Wilson <hans@hanswilson.com>
Sent: Wednesday, November 11, 2020 3:46 PM
To: Chadd Chustz <Chadd@fmbgov.com>
Cc: Robin Mixon <robin@hanswilson.com>; 'Tina Cesarino' <tina@hanswilson.com>
Subject: Fmb10Chadd Scope 11-11-20

Chadd – I am sure your hands are full today but I finally put a scope together. I gave you the full tilt boogey for this project. In this scope there is the permit phase, the construction phase, and the monitoring phase. I just wanted you to have the full package for budgeting purposes. Call me if you have any questions. - Hans

Hans Wilson, P.E.
1938 Hill Ave.
Ft. Myers, FL 33901
239.334.6870

hans@hanswilson.com
Marine Engineers &
Environmental Consultants
Celebrating 20 Years of Excellence

Knowledge, Quality, Service.

From: Chadd Chustz <Chadd@fmbgov.com>
Sent: Friday, November 06, 2020 9:09 AM
To: Hans Wilson <hans@hanswilson.com>
Subject: RE: Laguna Shores Dredge

Thanks, I was just about to call you :)
I was trying to include it in my monthly report to TC (due this morning)
Ready when you are.
Happy Friday,

Chadd Chustz
Environmental Project Manager
Town of Fort Myers Beach
chadd@fmbgov.com
(239) 765-0202 Ext. 1312

From: Hans Wilson [mailto:hans@hanswilson.com]
Sent: Friday, November 6, 2020 8:38 AM
To: Chadd Chustz <Chadd@fmbgov.com>
Subject: RE: Laguna Shores Dredge

Got your reminder. I will try to get that to you today or Monday.

Hans Wilson, P.E.
1938 Hill Ave.
Ft. Myers, FL 33901
239.334.6870
hans@hanswilson.com
Marine Engineers &
Environmental Consultants
Celebrating 20 Years of Excellence

Knowledge, Quality, Service.

From: Chadd Chustz <Chadd@fmbgov.com>
Sent: Thursday, November 05, 2020 12:02 PM
To: hans@hanswilson.com
Subject: Laguna Shores Dredge

Good Morning Mr. Hans,

I am following up on the Laguna Shores re: cost estimate/proposal for obtaining an exemption from ERP from FDEP and a Nationwide 35 from the USACE on the Town's behalf.

Also if you can provide a brief narrative for the remaining steps, timeline and associated costs for implementing the project, that would be greatly appreciated.

Thank you,

Chadd Chustz
Environmental Project Manager
Town of Fort Myers Beach
chadd@fmbgov.com
(239) 765-0202 Ext. 1312

Note: Florida has a very broad public records law. Most communication(s) to or from Fort Myers Beach officials regarding Town business are public records available to the public and media upon request. Your email communications and email address may be subject to public disclosure.

Note: Florida has a very broad public records law. Most communication(s) to or from Fort Myers Beach officials regarding Town business are public records available to the public and media upon request. Your email communications and email address may be subject to public disclosure.

Note: Florida has a very broad public records law. Most communication(s) to or from Fort Myers Beach officials regarding Town business are public records available to the public and media upon request. Your email communications and email address may be subject to public disclosure.

Note: Florida has a very broad public records law. Most communication(s) to or from Fort Myers Beach officials regarding Town business are public records available to the public and media upon request. Your email communications and email address may be subject to public disclosure.

Note: Florida has a very broad public records law. Most communication(s) to or from Fort Myers Beach officials regarding Town business are public records available to the public and media upon request. Your email communications and email address may be subject to public disclosure.

Laguna Shores Channel Drdge Project
Engineering Services Cost Estimate Summary

Permit Application	$4,300	LS		
RAI	$3,200	NTE		
Plans & Specs	$2,500	LS	**Permitting & Design Phase**	$10,000
Bid Coordination	$2,300	LS		
Permit Coordination	$2,500	LS		
Pre Dredge Survey	$2,800	LS		
Construction Administration	$3,500	NTE		
Site Visit (5)	$1,750	NTE	**Construction Phase**	$12,850
Post Dredge Survey	$4,400	LS		
2 Year Monitoring	$3,300	LS		
5 Year Monitoring	$3,300	LS	**Monitoring Phase**	$11,000

November 11, 2020

Roger Hernstadt, Town Manager
Town of Ft. Myers Beach
2523 Estero Blvd.
Ft. Myers Beach, FL 33931

Subject: Proposal for Services - Laguna Shores Channel Restoration

I. PROJECT DESCRIPTION - Environmental Consulting and Marine Engineering services in conjunction with restoration of the Laguna Shores Access Channel connecting Buccaneer Lagoon to Big Carlos Pass located at the east end of Estero Island, Section 3, Township 47 South, Range 24 East, Lee County, Florida.

II. SCOPE OF SERVICES

B. Permit Applications - Prepare a dredged material handling site plan showing the general turbidity controls and related management items. Prepare representative cross-sections and plan views of the site suitable for permit application submittal and processing. Prepare a general project description, including details regarding dredging and dredged material handling operations, for permit application submittal. Meet with Town staff to discuss the proposed plan and secure approval to move forward on permit application submittal. Prepare and submit an Environmental Resource Permit application package to the Florida Department of Environmental Protection (DEP) and a separate U.S. Army Corps of Engineers (COE) application in the form required by each agency, including supporting documentation, maps locating the project site, dredge and fill volumetric calculations, completion of critical habitat impact assessments for manatee and Smalltooth sawfish, etc. **Fixed Fee @ $4,300**

C. Permit Application Coordination – It is anticipated that the project will qualify for an exemption verification with the DEP and a federal Nationwide Permit so processing of the applications should not be extensive. However recent changes in agency policy has caused the state and federal regulators to look at maintenance projects as if they were new projects. This task fund work associated with preparing and submitting responses to any Requests for Additional Information (RAI) received from the COE and/or DEP. This includes revisions to the existing drawings, modifying ERP application submittal pages, clarifying the proposed project description, or other revisions to the submitted documents as necessary to clarify the project intent. This does not include any response to requests for additional information that may require additional field work, creation of new drawings, survey services, or similar specific tasks.
Time and Materials, Not To Exceed Budget @ $3,200

D. Plans and Specifications – Update the existing construction plans and specifications for dredging the existing channel alignment per the last bathymetric survey. Review options for the dredged material handling location and identify a suitable upland site for dredge material placement. Notify the regulatory agencies of pending construction, either as exempted from the DEP permit process and under COE Nationwide permit #3 or per final permits issued for the maintenance dredging. Prepare information and materials sufficient for signed and sealed drawings to be used for construction permitting with the Town. **Fixed Fee @ $2,500**

E. Bid Coordination – Update the existing General Conditions and Technical Specifications, include the revised construction drawings and submit to staff for preparation of a standard Town of Ft. Myers Beach bid package. Bid documents will include a per cubic yard price for variations in volumes between the date of the last survey conducted for maintenance dredging and the time of construction start up. Coordinate with bidding contractors on project details, answer questions, coordinate bid revisions/addendums with Town staff, as appropriate. Review proposals, compare cost estimates, and make a recommendation to the Town regarding selection of a contractor.

Fixed Fee @ $2,300

F. Permit Coordination - Coordinate between all parties during construction to ensure that all permit conditions are being observed. Coordinate with on site staff regarding compliance of all general and specific permit conditions at the project site. This task does not include daily monitoring of the contractor during construction. If the regulatory agencies require Environmental Compliance Monitoring on a daily basis, a contract addendum will be provided to the Town to provide this service.

Fixed Fee @ $2,500

G. Field Work – Set horizontal and vertical control for staking and monitoring the dredging areas. Complete a bathymetric survey of the proposed dredging area immediately prior to construction to confirm excavation volumes and modify the contract for any changes. Dependent upon contractor progress, there will be one progress survey and a final post construction survey (minimum). Reduce field survey data and plot onto a plan necessary to evaluate dredging completion and pay quantities. Any subsequent surveys of the same area after initial clearance survey will be at the cost of the contractor. (**Pre dredge survey) Fixed Fee @ $2,800**

(One incremental, one post dredge survey) Fixed Fee @ $4,400

H. Construction Administration – Conduct a pre-construction on-site meeting to discuss the proposed construction, permits, and operating conditions. Conduct twice weekly observations of the construction in progress to include turbidity monitoring compliance verification. Coordinate progress payment requests from the contractor. Confirm substantial completion, punch list items for final completion and payment. Prepare a post construction plan with as built depth information and submit to the regulatory agencies to convert the project from a construction permit to an operating permit.

Time and Materials Budget Not To Exceed $3,500 plus $350 per site visit maximum five week construction period.

M. Post Construction Monitoring – Complete two post construction bathymetric surveys of the project site ($3,300 per survey) and calculate infilling rates and volumes relative to future maintenance needs. Surveys will take place two years and five years from the Final Completion date.

Additional Services: Any additional services not covered under Tasks B - M may be requested at an hourly rate, upon approval by the Client. HWA will not perform such services without consent from the Client. The hourly rates listed in this scope will remain in effect for any additional engineering services.

III. ACCEPTANCE - To initiate our services, please sign and return this proposal to our office. We will complete a Supplemental Task Agreement and submit to the Town under our existing continuing services contract. The General Conditions and Method of Compensation for the contract remain in effect. We look forward to working with you and if you have any questions, please give me a call or stop by our office.

Sincerely,

Hans Wilson

Hans Wilson, P.E.

AUTHORIZED BY:___________________________________ **DATE:**_________

Print Name:____

2001 – HWA contracts with the Town of Ft. Myers Beach to assess three waterfront communities for improvements to navigational access. They included Marina Towers, the connection between Big Carlos Pass and Bucaneer Lagoon (Laguna Shores Channel), and placement of the dredged material in front of the Carlos Point Condominium to ameliorate erosion conditions. Results precipitate in interest by the Town on how to evaluate and fund dredging projects around the island.

2002 – An Environmental Resource Permit application was submitted to the Dept. of Environmental Protection (DEP) and the U.S. Army Corps of Engineers (COE) for the Marina Towers and Carlos Point project as well as applications submitted for creating a connecting channel between Big Carlos Pass and Buccaneer Lagoon (Laguna Shores Channel).

2003 – Permits issued for Marina Towers dredging and material placement in front of Carlos Point Condominium. HWA contracts with the Town of Ft. Myers Beach to develop an assessment methodology for the canals on Estero Island. Public workshop held in January to allow for public input on canal maintenance priorities on Estero Island. Final methodology and petition notebook submitted for Town use in April.

2004 – Worked through public interest issues with DEP regarding Laguna Shores Channel. Collaboration with Town staff on funding methodology. Hurricane Charley impacts Canal 15 (Yachtsmans Cove) requiring emergency dredging and associated permits. December Town staff makes funding recommendation to Town Council.

2005 – Permits issued for dredging of Canal 15 (Yachtsmans Cove) with cost share between residents and Town per policy. Project completed by Stemic Enterprises, Inc. Permit applications to the DEP and COE for Laguna Shores modified for southern alignment (least preferred/most likely to fail) per direction from DEP and agreement by Town Council.

2006 – Ongoing negotiations on public interest associated with Laguna Shores channel. DEP and COE permits issued for dredging Laguna Shore channel.

2007 – Received USCG channel marker permits, FWCC seagrass and manatee sign permits.

2008 – HWA authorized to move forward with construction plans and technical specifications for dredging Laguna Shores Channel. Bids received from marine contractors. Florida Marine Construction hired to excavate the channel. Construction begins end of December.

2009 - Construction completed in February. The channel had filled in and became non-navigable by the end of the year (see attached Town staff memo).

2010 – Work begins on re-permitting the northern alignment option direct to Bucaneer Lagoon channel. Channel alignment mapped for resources.

2011 – Continued to provide technical support to Town staff in re-designing the access channel, collecting core borings, WCIND funding application, and relocation of channel markers. HWA contracted to prepare construction plans and specifications for the alternative alignment. DEP permit issued for new channel location.

2012 – COE permit issued for new channel location. Contractor bids received, ZEP Construction, Inc. contracted to construct the new channel with Kelly Brothers sub-contracted by ZEP to perform the work. Work completed by year end.

2013 – Construction final certifications completed. One year post dredging monitoring completed 12-28-13.

2015 – Second annual monitoring competed (1-15-15).

Town of Fort Myers Beach
Agenda Item Summary

Blue Sheet Number: **2021-143**

1. **Requested Motion:**

Meeting Date: February 4, 2021

Review Beach Renourishment Project Scope

Why the action is necessary:

Including additional reach into the permitting of the project will give the Town the ability to renourish more readily should the need arise. Another benefit is that the additional reach gives the project a higher ranking to qualify for State funding per 61B-36.006 FAC.

What the action accomplishes:

2. **Agenda:**
ITEMS FOR DISCUSSION

3. **Requirement/Purpose:**

---

5. **Background:**

The project scope is to renourish beach from R-175 (Bowditch Park) to R-182 (~Canal St) with sand dredged from offshore burrow area (Due Diligence Report Attached). The current scope only includes 2.2 miles of the 5.8 miles of beach that is designated as Critically Eroded by FDEP (map attached).

Both FDEP & USACE issue beach renourishment permits for 15 year increments. Permitting the entire 5.8 mile reach of critically eroded beach would give the Town the ability to renourish more readily as the need arises. Another benefit is that the additional reach gives the project a higher ranking to qualify for State funding per 61B-36.006 FAC.

Current Status
Staff is soliciting an RFQ for Engineering Services for feasibility, planning, stakeholder coordination, design, permitting, funding and grant support, bid phase, construction phase, and monitoring services. TDC granted the Town $300,000 in FY20/21 for the permitting and design of the project. The Town has also submitted an application to the State for 50% cost sharing, which is expected to go to the State Legislature for a decision in March 2021.

Attachments:

1. 19504 Letter Report 20200210 - final
2. Map of Current Project Scope and Additional Critically Eroded Beach
3. Timeline and Cost Share
4. Estero Island Coastal Management Plan
5. Project Probable Cost Estimate

Financial Impact:

Current Probable Project Cost Attached.

Additional Considerations If Increasing Project Scope:
Economist - $10,000
Determine public beach accessibility for State project cost sharing per 62B-36.007 FAC.
Develop funding strategies (e.g. MSBU) for properties that do not meet public accessibility criteria.
Engineering Design - $20,000

Design fill templates for additional reach.
Erosion Control Line Survey - $25,000
Establish ECL for R-203 (Creciente) to R-207 (Sun Caper).

6. **Alternative Action**

7. **Staff Recommendations**:
Town Council provide policy direction to include additional reach of critically eroded beach in the permit applications to FDEP & USACE. If additional reach included, then direct Staff apply to TDC for grant to conduct engineering due diligence study on additional reach, and conduct ECL survey on R-203 to R-207.

8. **Recommended Approval**:

______________________________ Daphnie Bercher, Community Services Administrator	Date: January 27, 2021
______________________________ John R Herin Jr, Town Attorney	Date: January 27, 2021
______________________________ Amy Baker, Town Clerk	Date: January 27, 2021
______________________________ Roger Hernstadt, Town Manager	Date: January 27, 2021

COASTAL ENGINEERING CONSULTANTS INC.

CECI Group Services
Coastal and Marine Engineering
Environmental and Geological Services
Land and Marine Survey and Mapping
Website: www.coastalengineering.com

A CECI GROUP COMPANY

MEMORANDUM

TO:	**Chadd Chustz**
FROM:	**Michael Poff**
DATE:	**February 10, 2020**
SUBJECT:	**Estero Island Beach Renourishment Project Due Diligence**
CEC FILE NO.	**19.504**

1 INTRODUCTION

The Town of Fort Myers Beach (Town) is pursuing the next renourishment project for Estero Island (Figure 1). Coastal Engineering Consultants (CEC) was hired to assist the Town establish beach fill design criteria, review results of past renourishment projects, outline a path forward for design and permitting, and assist the Town with funding and grant pursuits.

This Technical Memorandum presents the history of Estero Island Beach nourishment and results of CEC's project performance analysis, and presents the design criteria for the next renourishment project. Included herein are Project details to support the Town's Fiscal Year (FY) 2020-21 Beach and Shoreline Funding Request to the Lee County Visitor and Convention Bureau for design and permitting costs.

Figure 1. Estero Island Location Map.

2 Scope of Work

CEC's contracted scope of work with the Town included the following:

- Develop Beach Project Design Criteria by utilizing the 2019 annual monitoring survey of Estero Island and the 2011 nourishment project's permitted fill template between the Florida Department of Environmental Protection (FDEP) reference monuments C-174A.5 and R-181.5 and computing the design volume for the renourishment project to summer 2019 conditions;
- Compute the background erosion rate within the 2011 project limits by utilizing the volume change analyses published in the annual monitoring reports;
- Apply the design volume and two years of background erosion to estimate the fill volume required for renourishment;
- Compute the volume available within the 2011 permitted borrow area limits by utilizing the 2019 annual monitoring survey of the nearshore borrow area;
- Compute the background infill rate of the borrow area by utilizing the borrow area volume change analyses published in the annual monitoring reports. Apply the available volume and two years of background infill to estimate the borrow area volume available for construction;
- Review the 2011 project permits for application to the next renourishment project. Review the special permit conditions and proffer an opinion if the project is in compliance or identify if there are outstanding issues. Prepare a summary of the permits required for the renourishment project;
- Review the shoreline change and volume change analyses published in the 2011 to 2019 annual monitoring reports and compare them to the 2011 beach project design documents. Proffer an opinion on the performance of the project compared to the design criteria. Identify areas along the prior project limits that underperformed;
- Conduct a constructability review specific to the renourishment project fill volume, potential borrow area volume, permit status, and performance assessment. Develop preliminary recommendations for advancing the project to the design and permit stage and address shoreline segments that underperformed;
- Prepare an order of magnitude construction budget for the renourishment project. Prepare a project schedule and timeline;
- Conduct one meeting with Town staff to review the design criteria, permit status, constructability review, and preliminary recommendations and obtain input. Update the recommendations and order of magnitude budget;
- Prepare and submit to the Town a draft letter report summarizing the beach project design criteria, permit status, and constructability review; and present the recommendations, schedule, and budget for the next renourishment project. Address comments and finalize and submit the report to the Town;
- Prepare a presentation and attend one Town Council meeting to present the findings.

3 ESTERO ISLAND BEACH RESTORATION HISTORY

3.1 2011 Initial Nourishment Project

In December 2011, Lee County completed construction of the Estero Island Beach Restoration Project including sand placement along the north-central segment of the island and the addition of a terminal groin on the northern end of the beach fill.

The 2011 Project was constructed between April 2011 and December 2011. Approximately 403,000 cubic yards (CY) of sand were excavated and placed in the beach fill area between FDEP reference monuments (R-monuments) C-174A.5 and R-181.5 (Figure 1). The beach was constructed to a berm height of 2.9 feet NAVD88 over a shoreline distance of approximately 6,700 feet (1.3 miles). The design berm extended seaward at the 2.9 feet NAVD88 elevation an average of 236 feet and then sloped to the -1.2 feet NAVD88 elevation at a 15H:1V slope. The design then adjusted to a 20H:1V slope seaward until it connected with existing grade. All dredging was conducted in the Primary Borrow Area. The terminal groin was constructed with approximately 3,630 tons of limestone rock for a length of 240 feet with a maximum crest width of approximately 12.7 feet. A single vinyl sheetpile row was installed along the centerline of the structure to make it sand tight. FDEP raised concerns that the groin would slow down sediment transport below a rate that will maintain the area north of project in a stable position. As a result Lee County is required to monitor this area and report on the trends observed (Lee County, 2003).

3.2 2016 Maintenance Dredging and Beneficial Use Project

In 2016, the U.S. Army Corps of Engineers (USACE) dredged Matanzas Pass (Figure 2) and placed dredge material (estimated quantity was 130,000 CY based on USACE Project Plans) in the nearshore area between R-182 and R-187. This USACE project is reflected in the analysis presented in this Report.

3.3 2017 Truck Haul Project

In 2017, Lee County imported approximately 2,100 CY via truck haul to address erosion due to Hurricane Irma along the Crescent Beach shoreline in the vicinity of R-181.

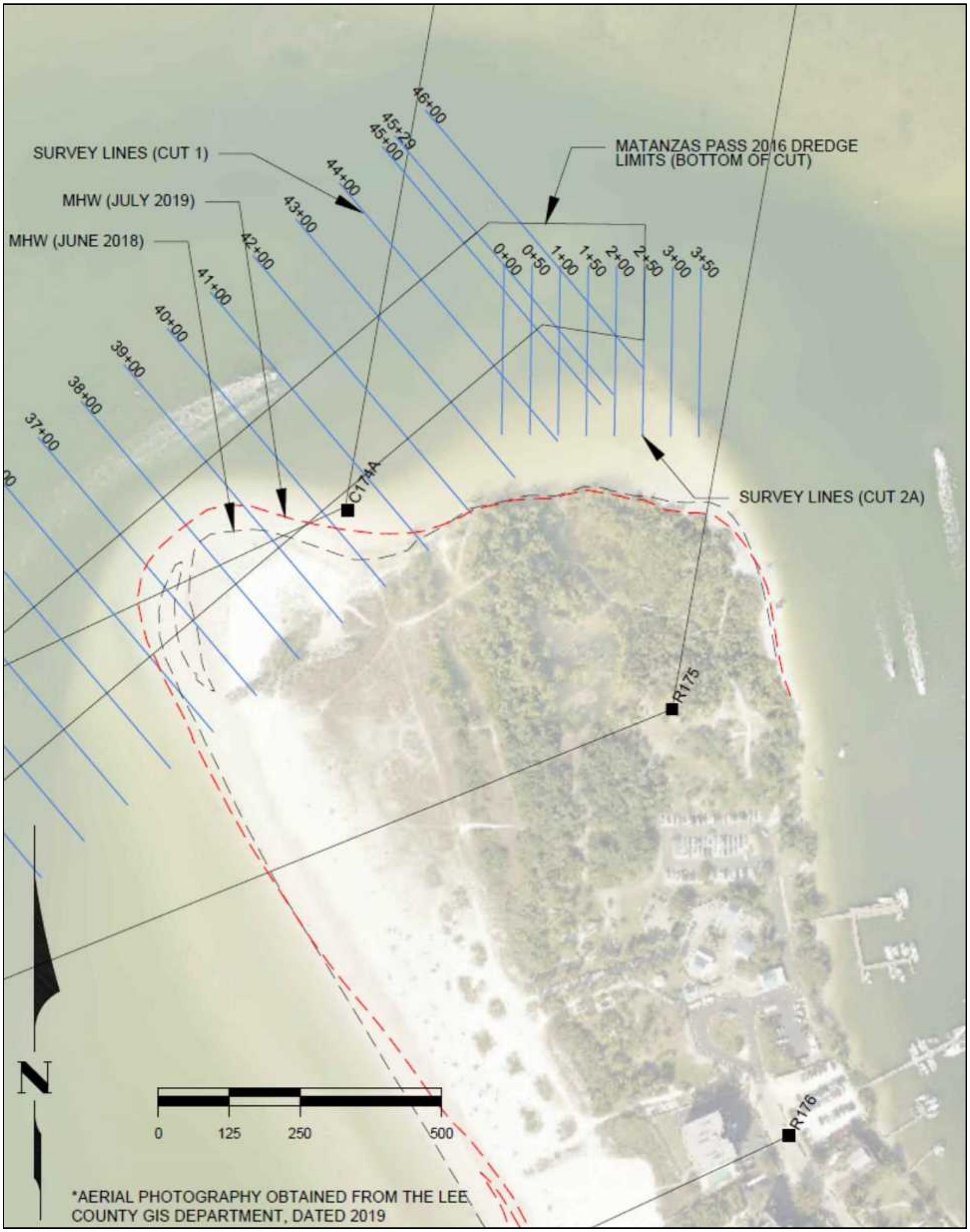


Figure 2. Plan View of North Adjacent Shoreline and 2016 USACE Dredging Project.

4 Beach Project Design Criteria

4.1 Fill Area Background Erosion

Table 1 presents the 2012 post-construction and 2019 monitoring survey shoreline positions at MHW between R-174A and R-186. In addition to the positions, the table includes shoreline change rates calculated for the 2012-2019 time period representing the seven-year post-construction monitoring period. Between 2012 and 2019, the Project Area shoreline experienced an average recession of 14.5 feet. The areas adjacent to the Project Area experienced 0.3 feet of recession north of the Project and 12.3 feet of advancement south of the Project.

Table 2 presents the volumetric changes that occurred from the 2012 post-construction survey to the 2019 monitoring survey within the fill footprint and north and south adjacent areas. The net volume change between 2012 and 2019 within the fill footprint was approximately 148,150 CY of erosion which equated to approximately 19,750 CY of erosion per year. The areas adjacent to the Project Area experienced approximately 290 CY of accretion per year north of the Project and approximately 14,440 CY of accretion per year south of the Project.

Table 1. Summary of 2012-2019 Shoreline Changes.

MONUMENT (AZIMUTH)	POSITION (FT)		2012-2019 SHORELINE CHANGE RATE (FT/YR)	2012-2019 AVERAGE SHORELINE CHANGE RATE (FT/YR)	
	POST-CON JAN. 2012	MONITORING JUL. 2019			
R-175 (az=10)	352.8	350.6	-0.3	-0.3	North Adjacent Shoreline
C-174A (az=10)	N/A	-40.3	N/A		
C-174A (az=245)	N/A	405.0	N/A		
R-175 (az=248)*	759.7	774.1	1.9	-14.5	Project Area
R-176 (az=245)	673.0	526.0	-19.6		
R-177 (az=220)*	739.8	580.2	-21.3		
R-178 (az=227)*	656.2	560.0	-12.8		
R-179 (az=230)*	564.7	439.8	-16.6		
R-180 (az=210)*	332.1	163.8	-22.4		
C-180.5 (az=205)	323.9	153.1	-22.8		
R-181 (az=205)	331.9	162.0	-22.6		
R-182 (az=204)*	394.8	440.8	6.1		
R-183 (az=205)	449.6	510.1	8.1	12.3	South Adjacent Shoreline
R-184 (az=205)	469.5	563.7	12.5		
R-185 (az=200)*	229.1	383.4	20.6		
R-186 (az=205)	296.9	358.3	8.2		

* 2012 Line was shifted from adjacent azimuth
N/A = profile below MHW

Table 2. 2012-2019 Volumetric Changes within Project Area Fill Footprint.

MON (AZIMUTH)	2012 to 2019 CELL AREA (CY)	AVE CELL AREA (CY/FT)	LENGTH (FT)	VOLUME (CY)	2012 to 2019 TOTAL VOLUME CHANGE (CY)	2012 to 2019 ANNUALIZED VOLUME CHANGE RATE (CY/YR)	2012 to 2019 TOTAL ANNUALIZED VOLUME CHANGE RATE (CY/YR)	
R-174 (az=245)	0.0				2,142		286	North Adjacent Shoreline
		4.0	531	2,142		286		
R-175 (az=248)*	8.1				-148,153		-19,750	Project Area
		-7.9	817	-6,441		-859		
R-176 (az=245)	-23.8							
		-27.5	1,160	-31,856		-4,247		
R-177 (az=220)*	-31.1							
		-19.8	1,033	-20,456		-2,727		
R-178 (az=227)*	-8.5							
		-14.3	790	-11,320		-1,509		
R-179 (az=230)*	-20.1							
		-30.0	1,244	-37,295		-4,972		
R-180 (az=210)*	-39.8							
		-39.6	500	-19,789		-2,638		
C-180.5 (az=205)	-39.4							
		-36.5	508	-18,545		-2,472		
R-181 (az=205)	-33.6							
		-2.4	1,005	-2,449		-327		
R-182 (az=204)*	28.7							
		31.4	856	26,921	108,329	3,589	14,441	South Adjacent Shoreline
R-183 (az=205)	34.2							
		26.9	1,070	28,770		3,835		
R-184 (az=205)	19.6							
		30.1	980	29,491		3,931		
R-185 (az=200)	40.6							
		24.4	948	23,147		3,086		
R-186 (az=205)	8.3							

* 2012 Line was shifted from adjacent azimuth

4.2 Beach Fill Design Criteria

CEC utilized the 2011 permitted fill template (Permit # 0173059-001-JC, Modification 0173059-004-EM dated April 20, 2005) and the 2019 survey profiles to compute the volume required to fill the template. The permitted fill template has a berm crest elevation at +2.9 feet NAVD88 with a seaward slope of 1V:15H to elevation -1.2 feet NAVD88 where there is a change in the slope of 1V:20H. To restore the beach between R-175 and R-182 to the 2011 beach nourishment project condition, approximately 189,000 CY would be required (Table 3).

Table 3. Fill Volume Quantities.

MON (AZIMUTH)	CELL AREA (CY)	AVE CELL AREA (CY/FT)	LENGTH (FT)	VOLUME (CY)
R-175 (az=248)*	0.0			
		16.0	817	13,030
R-176 (az=245)	31.9			
		29.5	1,160	34,254
R-177 (az=220)*	27.2			
		24.3	1,033	25,099
R-178 (az=227)*	21.4			
		23.2	790	18,360
R-179 (az=230)*	25.1			
		30.8	1,244	38,375
R-180 (az=210)*	36.6			
		39.0	1,003	39,076
R-181 (az=205)	41.3			
		20.6	1,005	20,737
R-182 (az=204)*	0.0			
Total				**188,931**

* 2012 Line was shifted from adjacent azimuth

To account for background erosion losses that may occur between 2019 and the projected construction period of FY2021-22, 2.5 years of background erosion were applied. The total design volume for the Project equates to 189,000 CY plus 19,750 CY/YR * 2.5 years equal to 238,375 CY. Rounding up, the recommended design criteria for the beach fill volume for the next renourishment event is 250,000 CY.

4.3 Borrow Area: Available Volume

Figure 3 presents a plan view of the Borrow Area including the survey lines with corresponding station numbers. Table 4 presents the volume available within the permitted Borrow Area limits based on the 2019 survey totaling approximately 1 million cubic yards (MCY).

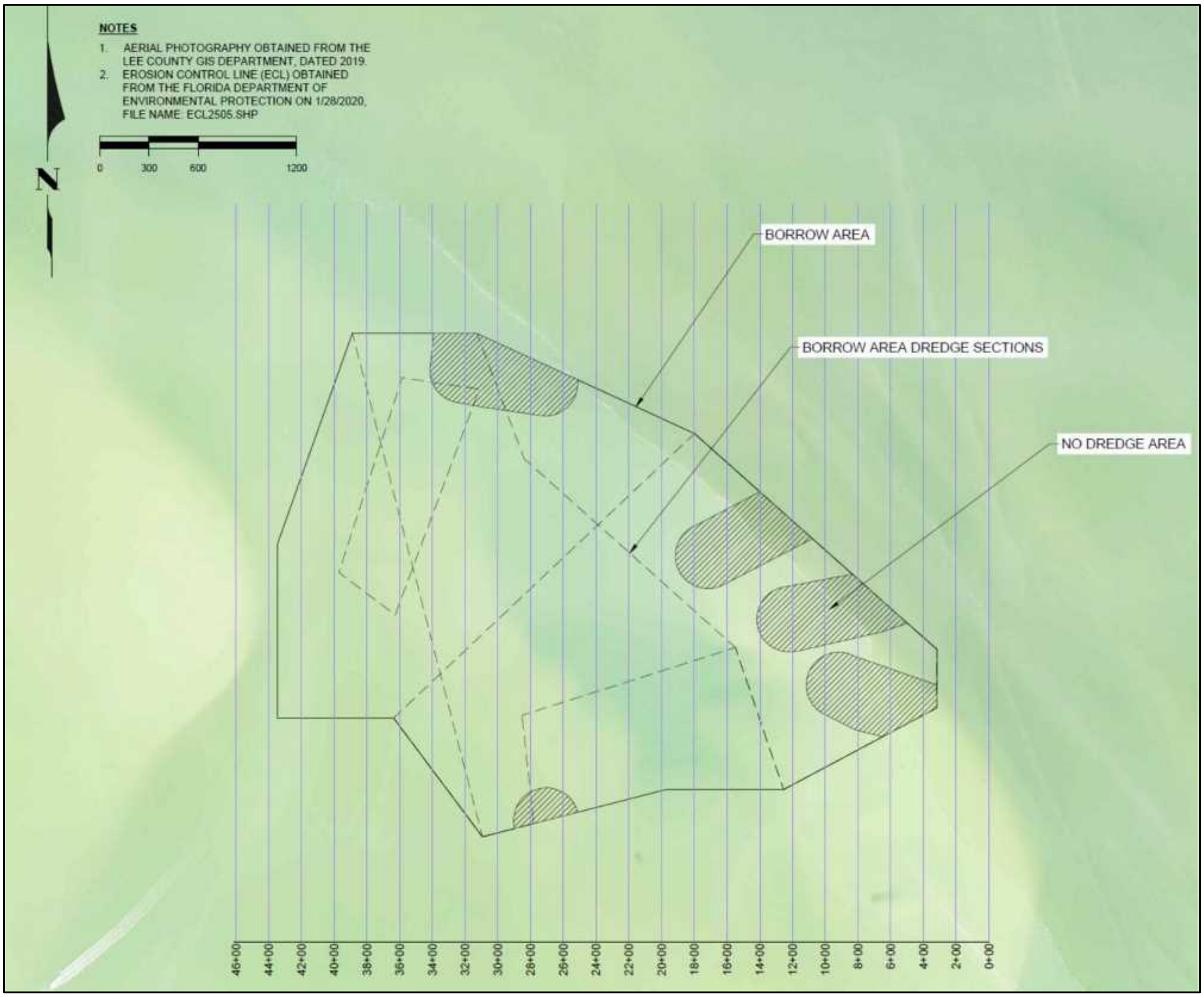


Figure 3. Borrow Area Plan.

Table 4. Borrow Area Available Volume Based on July 2019 Survey.

STATION	CELL AREA (CY/FT)	AVE CELL AREA (CY/FT)	LENGTH (FT)	AVAILABLE VOLUME (CY)
3+17*	3.3			
		4.9	83	408
4+00	6.5			
		18.9	200	3,778
6+00	31.3			
		42.9	200	8,572
8+00	54.4			
		72.0	200	14,404
10+00	89.6			
		142.4	200	28,480
12+00	195.2			
		213.1	200	42,629
14+00	231.1			
		223.6	200	44,712
16+00	216.0			
		169.5	200	33,892
18+00	122.9			
		118.5	200	23,698
20+00	114.1			
		142.2	200	28,431
22+00	170.2			
		203.0	200	40,605
24+00	235.8			
		257.9	200	51,582
26+00	280.0			
		299.9	200	59,971
28+00	319.7			
		369.3	200	73,857
30+00	418.9			
		448.2	200	89,641
32+00	477.6			
		478.9	200	95,777
34+00	480.2			
		480.5	200	96,105
36+00	480.8			
		464.0	200	92,810
38+00	447.3			
		411.0	200	82,196
40+00	374.7			
		324.7	200	64,947
42+00	274.8			
		206.1	146	30,087
43+46*	137.4			
Total				**1,006,581**

*Borrow Area end stations were not surveyed, the assumed volume was half the volume of the nearest surveyed station

4.4 Borrow Area Volume Changes

Table 5 presents the infilling rate of the Borrow Area which occurred between the 2012 post-construction and 2019 monitoring surveys. It indicates that the Borrow Area experienced scouring of approximately 15,230 CY which equated to approximately 2,030 CY per year. Based on these negligible changes, the recommended design criteria for the available borrow area volume for future renourishment is 1.0 MCY.

Table 5. 2012-2019 Borrow Area Volume Changes.

STATION	CELL AREA (CY/FT)	AVE CELL AREA (CY/FT)	LENGTH (FT)	2012-2019 VOLUME CHANGE (CY)	2012-2019 INFILLING RATE(CY/YR)
3+17*	2.4				
		3.6	83	296	40
4+00	4.7				
		9.1	200	1,824	243
6+00	13.5				
		5.7	200	1,145	153
8+00	-2.1				
		-10.5	200	-2,105	-281
10+00	-19.0				
		-38.0	200	-7,594	-1,012
12+00	-56.9				
		-78.8	200	-15,754	-2,100
14+00	-100.6				
		-82.5	200	-16,493	-2,199
16+00	-64.3				
		-42.6	200	-8,520	-1,136
18+00	-20.9				
		-12.5	200	-2,504	-334
20+00	-4.2				
		27.7	200	5,531	737
22+00	59.5				
		29.8	200	5,960	795
24+00	0.1				
		3.0	200	603	80
26+00	5.9				
		25.3	200	5,067	675
28+00	44.8				
		49.6	200	9,913	1,322
30+00	54.4				
		54.2	200	10,849	1,446
32+00	54.1				
		14.0	200	2,796	373
34+00	-26.2				
		-16.6	200	-3,316	-442
36+00	-7.0				
		-6.3	200	-1,267	-169

STATION	CELL AREA (CY/FT)	AVE CELL AREA (CY/FT)	LENGTH (FT)	2012-2019 VOLUME CHANGE (CY)	2012-2019 INFILLING RATE(CY/YR)
38+00	-5.7				
		-5.9	200	-1,183	-158
40+00	-6.2				
		-2.8	200	-551	-73
42+00	0.6				
		0.5	146	71	9
43+46*	0.3				
Total				**-15,232**	**-2,031**

*Borrow Area end stations were not surveyed, the assumed volume was half the volume of the nearest surveyed station

5 Permitting and Constructability Review

5.1 2011 Project Permits

5.1.1 FDEP Permit

CEC reviewed the permit related files available on the FDEP website. Below is a list of the issued permit and all permit modifications. In summary, a 10-year permit to nourish the northern segment of Estero Island was issued on March 5, 2002 with permit expiration date of March 5, 2012. In December 2012, FDEP extended the permit to March 5, 2014. The permit's physical monitoring plan (PMP) included seven years of post-construction monitoring which ended in 2019.

Date of Issue: March 5, 2002

Permit/Authorization No.: 0173059-001-JC
Expiration Date/Construction Phase: March 5, 2012
County: Lee
Project: Estero Island and Lovers Key Beach Restoration Project
Description: The Estero Island and Lovers' Key Beach Restoration project is to be divided into three reaches. Reach 1 is located in north Estero Island and extends approximately 4.6 miles and begins 300 feet north of R-175 and continues south to R-198. This project includes the construction of a terminal groin on Estero Island 300 feet north of R-175 to prevent losses of beach sand into Matanzas Pass, which is a Federal navigation project. Reach 2 is located at the southern tip of Estero Island and extends approximately 0.51 miles beginning at R-208 adjacent to the sand spit (Little Estero Island) and extending south to a point 500 feet east of R-210. No sand will be placed within the sand spit region. Reach 3 is located on Lovers' Key, and extends approximately 1.1 miles commencing 500 feet north of R-215 and proceeding to a point 500 feet south of R-220. Borrow Site I is located 1.6 miles offshore of Estero Island. Borrow Site II is located 0.5 miles southwest of south Estero Island.

Date of Issue: March 5, 2002

Permit Variance No.: 0173059-002-EV
Description: Establish a temporary mixing zone greater than 150 meters within an area of Class III Waters of the Gulf of Mexico.

Date of Issue: April 5, 2002

Permit Modification No.: 0173059-002-JC
Description: Applies to Lovers Key

Date of Issue: April 26, 2004

Permit Modification No. 0173059-003-JC
Description: Applies to Bonita Beach

Date of Issue: April 20, 2005

Permit Modification No. 0173059-004-EM

Description: Replace the previously accepted permit plans and drawings for Reach 1 (Estero Island) of the Estero Island and Lovers Key Beach Restoration Project with the updated and revised project plans and drawings that were submitted to the Department in March of 2005 in preparation for Notice to Proceed approval. In addition, the language of the permit will be corrected to reflect the updated plans and drawings. In the previously accepted permit drawings and specifications for the Reach 1 portion of the project, the profile slopes on the design berm had a 1V:10H slope that broke at -0.9' NGVD to a 1V:15H slope, whereas the final construction plans show a 1V:15H slope that breaks at 0.0' NGVD to a 1V:20H slope. These were adjusted based on a suggestion form a contractor, who indicated that sand with a mean grain size in the range of the borrow area creates a flatter slope. This slope was used previously and is the most likely outcome. About half of Lovers Key (Reach 3) slopes corresponded to this slope. In addition, the revised plans show the southern limit of fill of the project extending just south of R-196.5, whereas the previously accepted plans have the project extending south to R-198. There are also other small discrepancies between the previously permitted drawings and the final submitted construction plans, such as the angle at which the profile toe of fill tapers to an end on either side of the fill area, and the dimensions of the terminal groin.

Date of Issue: December 19, 2012

Permit Modification No.: 0173059-005-JN

Original Expiration Date: March 5, 2012

New Expiration Date: March 5, 2014

5.1.2 Permit Summary

Both the FDEP and the USACE permits have expired. New permits will be required for the next renourishment project. The agencies have authority to issue 15-year permits to include the initial project and two subsequent renourishment projects. CEC recommends the Town pursue new 15-year permits for the long-term beach management of Estero Island including one initial event and two subsequent renourishment events on a ten year cycle noting the permits can be extended to allow for the second renourishment event.

5.2 2011 Project Performance

The 2011 Project was monitored for 7 years according to the PMP which included:

1) Beach profiles surveys: pre-, post-, 1st-year, 2nd-year, 3rd-year, 5th-year, and 7th-year
2) Borrow Area surveys: pre-, post-, 2nd-year, 5th-year, and 7th-year
3) Aerial Photography: post-, 1st-year, 2nd-year, 3rd-year, 5th-year, and 7th-year
4) Analysis and Reporting: post-, 1st-year, 2nd-year, 3rd-year, 5th-year, and 7th-year

5) Special Monitoring od Groin and Borrow Area effects: post-, 1st-year, 2nd-year, 3rd-year, 5th-year, and 7th-year

Analysis of the 1st-year monitoring results was performed by Lee County (Lee County, 2013) and indicated the shoreline within the Project Area between R-175 and R-182 responded as anticipated, adjacent shoreline south of R-182 was accreting and there were no downdrift impacts due to the groin near C-174A.

The 2nd-year, 3rd-year, 5th-year, and 7th-year analyses were performed by CEC (CEC, 2014; CEC, 2015; CEC, 2018; and CEC, 2019). All reports indicated shoreline erosion within the Project Area, shoreline advancement in the adjacent area to the south and no adverse impacts due to the terminal groin.

Based on the analysis of the beach fill and adjacent shorelines, the dredging of the Borrow Area in 2011 did not have measurable effects on the shoreline.

6 Cost Analysis

6.1 Methodology

The Tri-Services Automated Cost Engineering System, Micro-Computer Aided Cost Estimating System, Second Generation (MCACES MII Version 3.01) software was used to develop the unit cost for the beach fill. MII is the second generation of the TRACES software used as a costing tool by the USACE. The dredge production rate, equipment daily cost, and sediment dredging and transport duration were developed utilizing a variation of the Cutter Suction Dredge Cost Estimating Program (CSDCEP) developed by the Center for Dredging Studies, Zachary Department of Civil Engineering, Texas A&M University (TAMU). The CSDCEP incorporates costing and production rate tools for dredges. The CSDCEP was customized for current inflation values, specific dredge parameters relating to fuel consumption and various equipment parameters. Shore-based construction and survey crews were eliminated from the derived daily cost equations because these were found to be best computed in the MII. The customized CSDCEP shall hereafter be referred to as the CEC-TAMU costing spreadsheets for dredging.

6.2 Basis

The basis of the Preliminary Opinion of Probable Project Cost is comprised of the following items.

6.2.1 Design and Permitting

Costs for Design and Permitting were based on professional experience and judgment on similar beach fill projects completed in the Project area. The cost includes detailed geophysical survey of a pipeline corridor from the Borrow Area to the Island which was not included in the prior project but it a key item that is being required of current projects and permit processes.

6.2.2 Mobilization/Demobilization

The mobilization/demobilization costs included the anticipated plant and equipment to be used in the excavation, transportation, and placement of beach fill. The derived cost was then compared to historic contract bids from projects of a similar nature.

6.2.3 Beach Fill

The equipment cost was computed by considering the daily rate for dredges, booster pump(s), fuel, per foot sediment pipeline cost, and supporting equipment cost derived from the CEC-TAMU costing spreadsheets for dredging. The fill unit cost was computed by considering the daily rates for the plant, equipment and personnel. The unit cost per CY was based on the required fill volume, anticipated cut-to-fill ratio losses, pumping distance, dredge pumping/transport capacity, total dredging equipment daily cost, construction crews, and shore equipment. This total was then divided by the required fill volume to derive a unit cost inclusive of excavation, transport, and placement. The unit cost was entered into the MII cost analysis as in-place cost for fill and multiplied by the required volume to derive the total cost for the fill escalated to the anticipated year of construction.

6.2.4 Environmental Protection, Turbidity Monitoring and Shorebird Abatement

Costs for environmental protection, turbidity monitoring and shorebird abatement were based on professional experience and judgment on recent beach fill projects completed in the Project area.

6.2.5 Construction Management

Costs for Construction Management were based on professional experience and judgment on recent beach fill projects completed in the Project area and the computed construction duration.

6.2.6 Monitoring and Maintenance Costs

Costs for Long-Term Monitoring were based on professional experience and judgment on similar beach fill projects completed in the Project area. The Project permits will require biological (sea turtle and shorebird) and physical (surveys, performance analyses) monitoring as well as beach tilling for three years after completion of construction.

6.3 Preliminary Opinion of Probable Project Cost

The Preliminary Opinion of Probable Project Cost is presented in Table 6. It was developed as described above and escalated from the base price year used in the MII and CEC-TAMU costing spreadsheets to the projected construction year. A 10% contingency was applied to account for uncertainties to formulate the project costs for the funding application.

Table 6. Preliminary Opinion of Probable Project Cost

ESTERO ISLAND BEACH RENOURISHMENT PRELIMINARY OPINION OF PROBABLE PROJECT COSTS ANTICIPATED YEAR OF CONSTRUCTION: 2021-22					
Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Extended Price [1]**
1	Design and Permitting	LS	1	$190,000	$190,000
2	Mobilization/Demobilization	LS	1	$2,150,000	$2,150,000
3	Beach Fill	CY	250,000	$10.92	$2,730,000
4	Environmental Protection	LS	1	$30,000	$30,000
5	Turbidity Monitoring	Days	100	$500	$50,000
6	Shorebird Abatement	Days	110	$500	$55,000
7	Construction Management	LS	1	$300,000	$300,000
8	Biological Monitoring	Years	3	$30,000	$90,000
9	Physical Monitoring	Years	3	$50,000	$150,000
10	Beach Tilling	Years	3	$6,000	$18,000
[1] Values rounded to the nearest $1,000				**Subtotal**	**$5,763,000**
				10% Contingency	**$576,000**
				Grand Total	**$6,339,000**

19

7 RECOMMENDATIONS

Based on the seven years of monitoring results, the 2011 beach nourishment project has performed well. The background erosion rate was measured equal to approximately 20,000 CY/YR. The updrift and downdrift beach segments adjacent to the beach fill limits were generally accretional due to the spreading of the beach fill alongshore as well as the beneficial use of the maintenance dredging of Matanzas Pass. There were no documented adverse impacts from the terminal groin or from dredging the Borrow Area.

It is anticipated that re-building the 2011 project to its original design template will address the continuing beach erosion between R-175 and R-182 and will not result in impacts to the adjacent shorelines. Based on the 2019 survey, the volume to fill the 2011 fill template was computed equal to 189,000 CY. Applying 2.5 years of background erosion, the recommended design criteria for the next renourishment event is 250,000 CY.

The Borrow Area has over 1 MCY of available volume which is sufficient for the next renourishment event and future projects within a 15-year time frame assuming a renourishment cycle of ten years.

CEC recommends the Town pursue new 15-year permits for the long-term beach management of Estero Island. The Preliminary Opinion of Probable Project Cost for the next renourishment and three years of post-construction monitoring and beach tilling was developed equal to $6,339,000.

8 REFERENCES

Coastal Engineering Consultants. (2014). Estero Island Restoration 2nd Year Annual Monitoring Report.

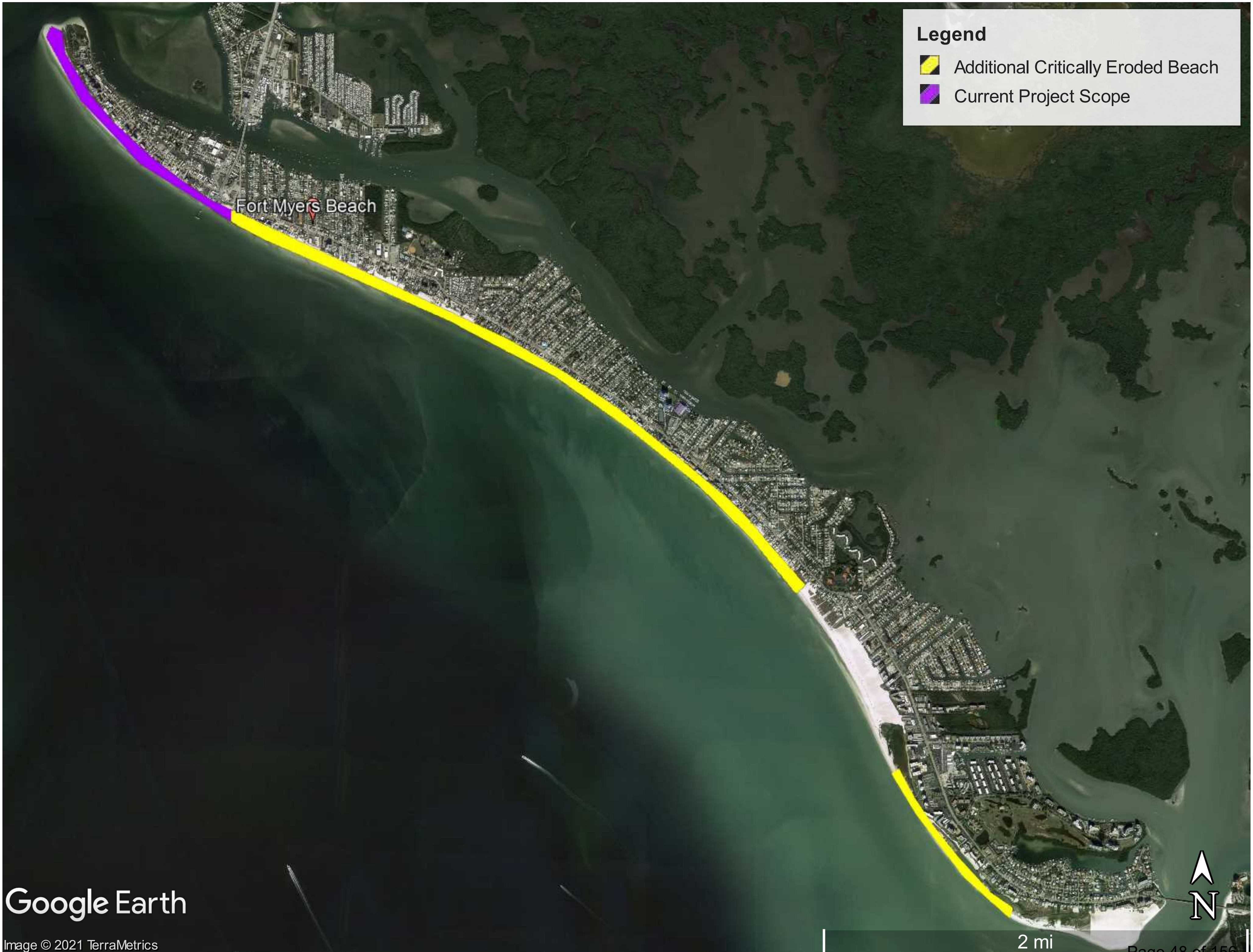
Coastal Engineering Consultants. (2015). Estero Island Restoration 2015 Annual Monitoring Report.

Coastal Engineering Consultants. (2018). Estero Island Restoration 2017 Annual Monitoring Report.

Coastal Engineering Consultants. (2019). Estero Island Restoration 2019 Annual Monitoring Report.

Lee County. (2003). Estero Island, Lovers Key and Bonita Beach Restoration; Contingency Plan. DEP Permit 0173059-JC and 0200803-JC. Fort Myers.

Lee County Division of Natural Resources. (2013). Estero Island Restoration 1st Year Annual Monitoring Report.


Legend
Additional Critically Eroded Beach
Current Project Scope
Fort Myers Beach
Google Earth
Image © 2021 TerraMetrics
2 mi
N

Beach Renourishment Project Timeline:

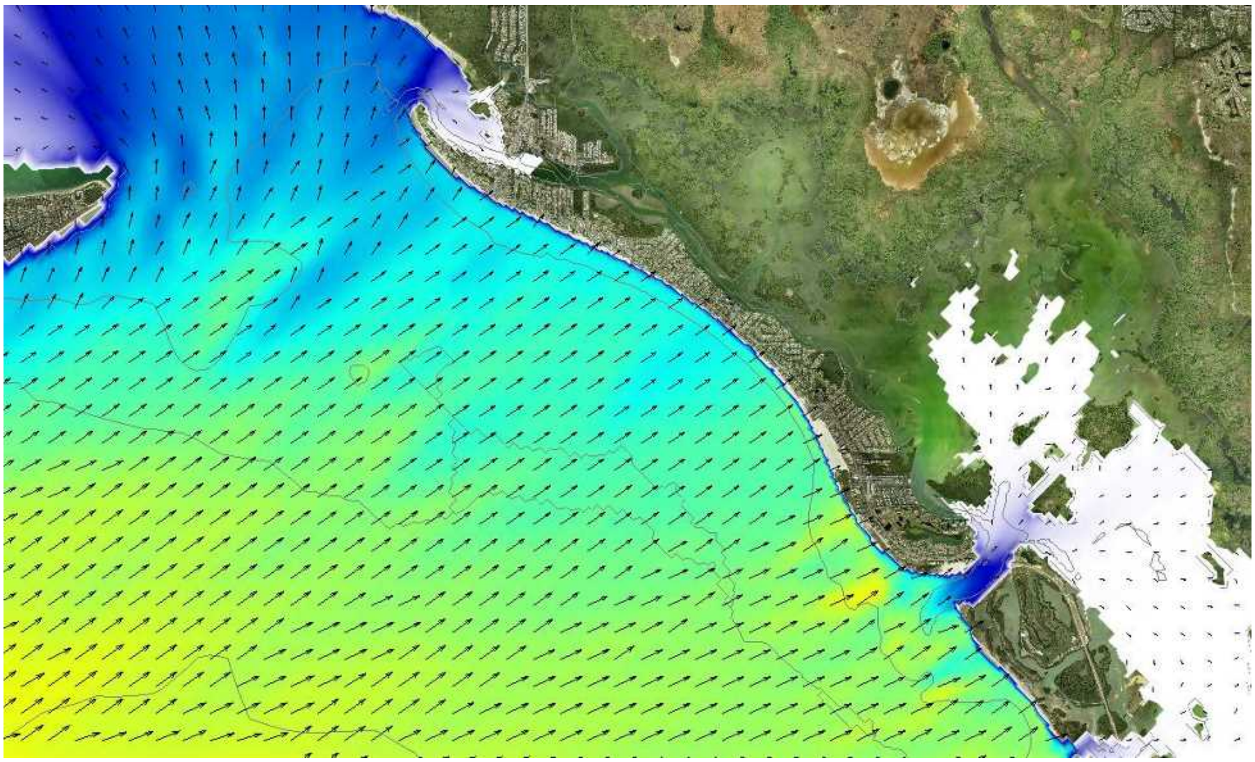
- **October 2020-March 2022** Design and Permitting (18 Months)
- **April 2022-July 2022** Bid Process (4 Months)
- **October 2022-February 2023** Construction (5 Months)

Beach Renourishment Project Cost Share:

Entity	Cost Share	Cost Allocation
FDEP	50.0%	$3,169,500
Lee County	45.6%	$2,890,584
Ft. Myers Beach	4.4%	$278,916
Total	100%	$6,339,000

*based on previous renourishment ILA with Lee County

Estero Island Coastal Management Plan



Final Report

August 27, 2014

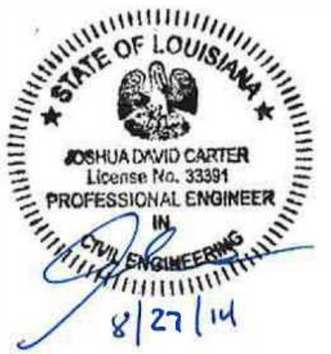
Submitted To:
Town of Ft. Myers Beach

Prepared for:

The Town of Ft. Myers Beach, FL

This document is intended for planning purposes only in support of future design efforts. It should not be used in lieu of permitting, final design, or construction documents developed specifically for those purposes.

Respectfully Submitted,



Josh Carter, P.E.
Project Manager
Coast & Harbor Engineering,
A Division of Hatch Mott MacDonald
650 Poydras St, Ste 2025
New Orleans, LA 70130
504.383.9785

Shane Phillips, P.E.
Project Director
Coast & Harbor Engineering,
A Division of Hatch Mott MacDonald
110 Main Street, Ste. 103
Edmonds, WA 98020
425.778.6042

Contributing Authors:
Arpit Agarwal
Matt Campbell
Casey Connor
Scott Fenical

Rev.	Date of Issue	Reason for Issue	Lead Author	QC Review	Submitted by
2	8/27/2014	Final	J. Carter	S. Fenical	J. Carter
1	4/28/2014	DRAFT Final	J. Carter	S. Fenical	J. Carter
0	1/13/2014	Draft for 1st review	J. Carter	M. Campbell	J. Carter

\1046.B - FMB2\4 - Technical Docs\3 - CMP - final report\20140827 CHE – FMB CMP report.pdf

EXECUTIVE SUMMARY

The Estero Island Coastal Management Development project has two objectives: (1) Develop an understanding of coastal processes and anthropogenic factors that control short and long term shoreline morphology of Estero Island and (2) Develop and evaluate a set of long-term engineering solution(s) that maximize coastal stability for the Estero Island Gulf shoreline.

To develop an understanding of coastal processes controlling shoreline erosion, CHE collected and analyzed literature as well as historical and new data and performed a coastal processes analysis with analytical and numerical modeling tools. Then based on the understanding of coastal processes, CHE developed a suite of 10 alternative over three reaches of the Island. These alternatives were evaluated for the performance in meeting the project goals and cost while also weighing environmental impacts and impacts to adjacent shorelines.

Existing data collected includes historical bathymetric and topographic data, new bathymetric and topographic data, historical literature, historical geotechnical data, aerial photos and shoreline positions from 1953 to 2011, and coastal processes data including wind, waves, and water surface elevations in the project vicinity. Previous coastal engineering projects were also summarized. The most notable projects are: 8 beach nourishments on the north end of the island beneficially using maintenance material dredged from Matanzas Pass that average approximately 200,000 cy every 5 years on average; nearshore placement of dredged material on the northern portion of the island in 2009; and the 2011 beach nourishment project that placed approximately 400,000 cy of material on the northernmost reach of the island at a cost of $3.65 million.

The coastal processes analysis reviewed important processes that impact the morphology of Estero Island vicinity. Relative sea level rise in the project vicinity is occurring at a rate of 2.4 mm/yr, which results in 0.4 ft/yr of shoreline retreat along Estero Island. An evaluation of the wind and wave climate showed that the project site receive relatively little wave energy, and that its geographic setting play a large role in sheltering the island from day-to-day wave energy. Extreme storms less frequently make landfall in the project site when compared to much of the rest of the Gulf coast or the Florida coast. However, due to the low topography and relatively low energy environment, when storms do make landfall their impact on morphology and infrastructure is dramatic.

Numerical modeling was conducted to develop a better understanding of tidal circulation and inlet processes, the wave climate, longshore transport, and shoreline morphology. Modeling efforts included the MORPHO circulation model, SWAN wave model, analytical longshore transport modeling driven by the wave model results, and GENCADE shoreline morphology model.

Island morphology was investigated by examining historical shoreline positions and shoreline change patterns over time. The morphology of the southern end of the island is dominated by the attachment of the ebb shoal bar in the late 1960s. This bar formed a series of lagoons between the main island and the shoreline, and also provided a source of sediment for the immediate and adjacent areas. The central portion of the island has remained relatively stable from 1953 to 2011. Moderate accretion has occurred up to approximately R-194, likely from sediment being transported in from the attachment of the ebb shoal bar further south. The reach from approximately R-193 to R-187 has experienced moderate shoreline retreat on the order of 1 to 3 ft/yr, very close to the expected retreat rate associated with relative sea level rise. The northernmost reach from R-187 to R-175 at Matanzas Pass has experienced high shoreline retreat rates, up to -25 ft/year. Management of the erosion in this area has primarily been accomplished by beneficially using the material dredged from the federally maintained Matanzas Pass navigation channel immediately adjacent to Bodwitch Point north of R-175.

The morphology of Big Carlos pass was investigated by analyzing bathymetry and LIDAR data sets from 2006, 2010, and 2013. Because these data sets do not extend the full extents of the ebb shoal, estimating volume and volume change rates has high uncertainties. The ebb shoal is estimated to have between 7.5 and 10 million cy. It is likely that in fact the shoal varies by as much as several million cubic yards over decadal time scales due to episodic morphological processes such as the welding of a bypassing bar to the downdrift shoreline, or attachment of a bar to the updrift shoreline as occurred in the early 1970s. Measured volume change rates indicate between 2006 and 2010, on the order of 40k cy was deposited on the ebb shoal, and then between 2010 and 2013 75% of that material was eroded off the shoal, potentially as a bypassing event.

Based on the results of the morphology analysis a hypothesis on the long-term morphology patterns along the island was developed. The general trend is northerly transport on the north, a divergent node that occurs in the north 1/3 of the island and any given year can vary in location as much as almost two miles. Similarly, a convergent node exists between a range of R-198 and R-202. Sediment is transport into and across Big Carlos Pass and bypassed to Lovers Key. On the extreme northern end of Lover's Key, sediment is transported into the pass, and near R-215 another divergent node occurs. From R-215, transport is generally to the south along Lover's Key.

Gencade morphology modeling was calibrated and validated, and used to compute the future without project conditions. This modeling confirmed the hypothesis on the long-term morphology. The northern beach nourishment was shown to have a lifetime of approximately 8 years. The central region is stable but localized erosion is expected impact infrastructure in 2-3 years. The southern end of the island at the Critical Wildlife Area will erode to infrastructure at R-204 within 4 years.

Estero Island was separated into 3 reaches, Reach 1 on the north, Reach 2 in the center, and Reach 3 on the south. 10 alternatives were developed based on the understanding of coastal processes and morphology. The alternatives are:

- Alt 1.1 - 400,000 cy beach nourishment on Reach 1
- Alt 1.2 - Short Groins on Reach 1
- Alt 1.3 - Breakwaters on Reach 1
- Alt 2.1 - 200,000 cy Onshore Beach Nourishment on Reach 2
- Alt 2.2 - 200,000 cy Nearshore Placement on Reach 2
- Alt 2.3 - 200,000 cy Offshore Placementt on Reach 2
- Alt 3.1 - Nearshore Detached Breakwaters on Reach 3
- Alt 3.2 - 250,000 cy Onshore Beach Nourishment on Reach 3

- Alt 3.3 - 250,000 cy Onshore Beach Nourishment and Breakwaters on Reach 3
- Alt 3.4 - 250,000 cy Nearshore nourishment

Each alternative was evaluated for performance in stabilizing the shoreline, cost, environmental impacts, and impacts to adjacent shorelines.

The best performing alternative in Reach 1 is Alt 1.2, the short groin field, to supplement future beach nourishments. The short groin field has almost twice the life compared to beach nourishment and is half the cost of the breakwaters.

For Reach 2, while Alternative 2.1 outperforms nearshore placement in terms of beach stabilization, the source identified for the nourishment is Matanzas Pass maintenance dredging which will likely result in unfavorable material quality, which may completely preclude the ability to construct onshore beach nourishment. Alternative 2.2 is selected as the recommend alternative for Reach 2.

The best overall performing alternative in Reach 3 is Alt 3.2 onshore beach nourishment. The ability of beach nourishment to stabilize the shoreline is nearly the same as breakwaters at a fourth of the cost. A potentially large hurdle with onshore beach nourishment is regulatory compliance in the Critical Wildlife Area; careful construction practices may help pass this hurdle.

The presence of a dune was analyzed through cross-shore modeling to determine its ability to protect inland infrastructure. It was determined that dunes of approximately 6 CY/ft of material above the 5 year water level were effective in protecting up to a 5-year event. When the dune was combined with beach nourishment, the dune was effective up to a 10-year event.

Finally a series of recommended actions to be taken by the town are discussed, including implementing these alternatives, constructing or growing a dune where moderate storm damage protection is desired, securing borrow sites for long-term use on the Island, and developing and implementing a long-term monitoring plan with a focus on Big Carlos Pass with a goal to determine if it is in fact a long-term sustainable borrow site, and to determine what is the best location for the borrow site.

Table of Contents

1 Introduction 1
2 Review of Existing Data 2
3 Data Collection 2
3.1 Tides and Vertical Datum 2
3.2 Bathymetric and Topographic Data 3
3.3 Geotechnical Data 5
3.4 Aerial Photos 6
3.5 Shoreline Data 7
3.6 Coastal Processes Data 7
3.7 Previous Coastal Engineering Projects and Construction 8
4 Coastal Processes Analysis 12
4.1 Geologic Setting 12
4.2 Relative Sea Level Rise 12
4.3 Meteorological Climate - Winds and Waves 13
4.4 Extreme Events (storms) 14
4.5 Inlets and Tidal Currents 15
4.6 Littoral Transport 15
4.7 Summary of Coastal Setting 16
5 Estero Island Vicinity Morphology 16
5.1 Island 16
5.2 Inlets 21
6 Numerical Modeling of Coastal Processes 24
6.1 Bathymetric Surface Model Development 24
6.2 Wave Modeling 26
6.3 Circulation Modeling 30
6.4 Longshore Transport Modeling 32
6.5 Shoreline Morphology Modeling 36
6.6 Cross-Shore Morphology Modeling 42
7 Alternatives Development 43
7.1 Reach 1: Northernmost end of Estero Island 43
7.2 Reach 2: North-central Estero Island 45
7.3 Reach 3: Southern Estero Island 46
7.4 Beach Nourishment Considerations 47
7.5 Conceptual Design of Alternatives 47
8 Alternatives Analysis 55
8.1 Development of Evaluation criteria 55

8.2 Beach Response ... 56
8.3 Dune Component ... 71
8.4 Cost ... 75
8.5 Environmental Impact and Permitability ... 75
8.6 Alternatives Evaluation ... 78
8.7 Recommendations ... 81
9 Conclusions ... 83
10 References ... 85

Appendix A: Detailed Cost Estimates

Attachment 1 [as separate document]: Response to Comments on DRAFT Report

Estero Island Coastal Management Plan
Final Report
August 27, 2014

1 INTRODUCTION

This report discusses the results of work conducted by Coast & Harbor Engineering, Inc. (CHE) under the Scope of Work in accordance with the Town of Fort Myers Beach (TFMB) Professional Services Agreement dated February 6, 2013 for PSA-13-03-CD for the Estero Island Coastal Management Plan Phase 2 - Coastal Management Plan Development. The specific objectives of this project are:

- Develop an understanding of coastal processes and anthropogenic factors that control short and long term shoreline morphology of Estero Island
- Develop and evaluate a set of long-term engineering solution(s) that maximize coastal stability for the Estero Island Gulf shoreline.

An aerial photo of the project area is shown in Figure 1. Figure 2 shows Estero Island and Lover's Key along with the layout of R-monuments in the region, which are frequently used as reference points in discussion below.

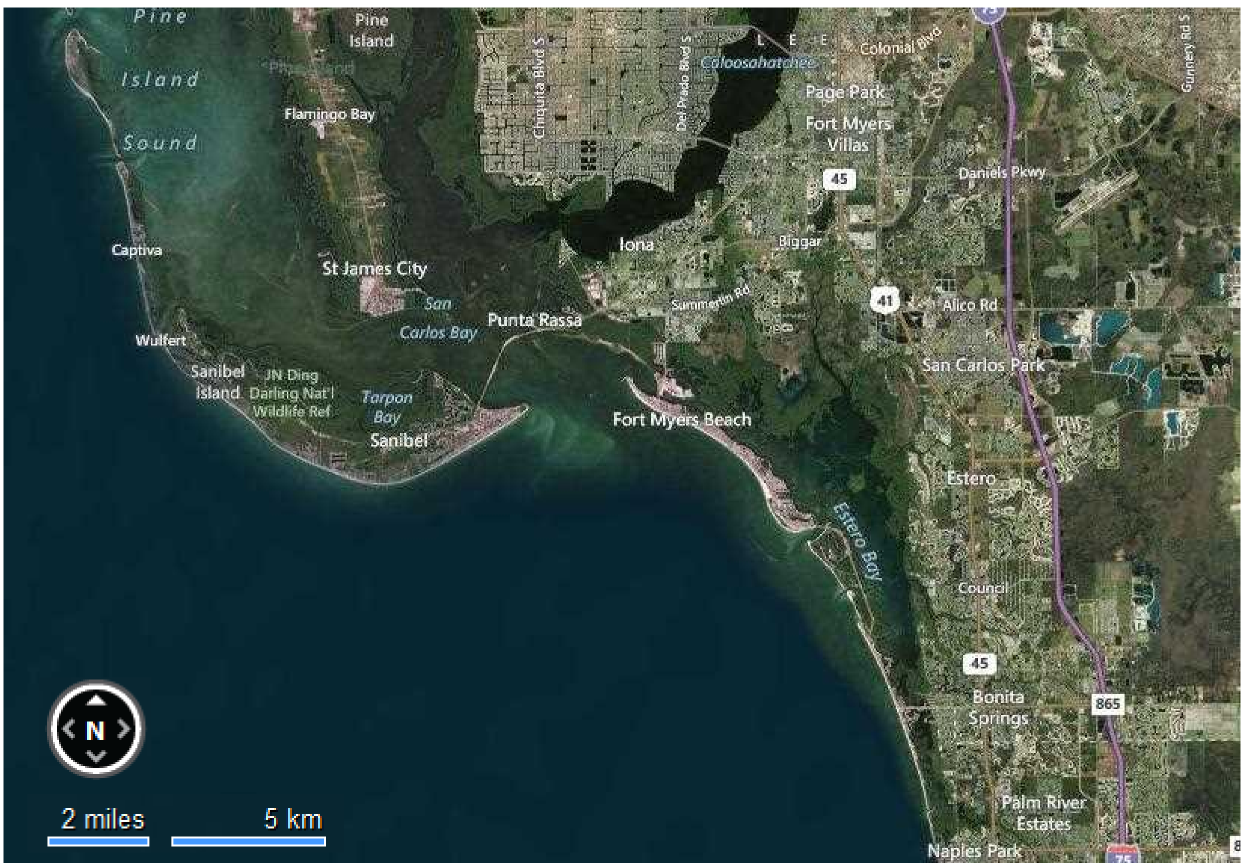


Figure 1. Estero Island, Town of Fort Myers Beach, Project Vicinity.

Figure 2. Estero Island and location of R-monuments.

2 REVIEW OF EXISTING DATA

A review of existing data and literature was conducted to identify all available data, reports, design, and publications from previous studies and designs relevant to Estero Island. Sources investigated include TFMB, Lee County Archives, US Army Corps of Engineers (USACE), Florida Department of Environmental Protection, and scholarly journals and conference proceedings. Three primary studies capture the majority of the understanding of coastal processes available on Estero Island and vicinity: (1) the USACE 1969 Beach Erosion Control Study, which first authorized beach nourishment by USACE on Estero Island (EI) (USACE, 1969), (2) a study conducted by Godshalk and Associates for Lee County in 1988 (primarily the subsection of Volume II titled "Evaluation of the Lee County Barrier-Island Coastline: Dominant Processes, Shoreline Trends, Past Stabilization Efforts, and Recommendations for Beach Management" by Albert C. Hine of the University of South Florida (Godshalk and Assoc., 1988), and (3) the USACE Lee County Shore Protection Project General Re-evaluation Report prepared in 2001 with several technical appendices prepared by consultants (USACE, 2001). Numerous other studies and reports have been prepared, but all rely heavily on these three primary documents for technical information. The full bibliography of the literature reviewed is provided in Section 10. A detailed review of this data was prepared by CHE in Phase 1 of this project (see CHE, 2012) which summarizes the technical information on coastal processes, regional morphology, and coastal construction projects in the EI vicinity. This information is used in the following analysis and discussions.

3 DATA COLLECTION

3.1 Tides and Vertical Datum

USACE (1969) stated the tides at EI are mixed semidiurnal and diurnal, with a mean range of 2 ft to 2.9 ft. Highest annual tide (not storm-induced) estimated at +3.3 ft. Tide elevations at the nearest vertically controlled tide gage located in Naples (NOAA Tide Gage 8725110) are shown in Table 1 relative to NAVD88. In addition, vertical datums at Estero Island were derived from the NOAA VDATUM database (NOAA, 2013b). The vertical datum and tide reference from VDATUM will be used for all analysis and design.

Table 1. Tide Elevations relative to NAVD88 at Estero Island from VDATUM database and at Naples FL NOAA Tide Gage 8725110.

	Estero Island NAVD88 [ft]	Naples NAVD88 [ft]
Mean Higher High Water (MHHW)	0.50	0.58
Mean High Water (MHW)	0.23	0.33
Mean Sea Level (MSL)	-0.64	-0.64
Mean Low Water (MLW)	-1.57	-1.68
Mean Lower Low Water (MLLW)	-2.10	-2.29

3.2 Bathymetric and Topographic Data

Numerous bathymetric and topographic surveys have been conducted in the Estero Island vicinity since the initial USACE 1969 study. In 1974, the Florida DNR established a baseline monument system along the shoreline spaced approximately 1,000 ft apart. Since establishment, beach profile survey data has been collected intermittently at these monuments. Surveys in 1974 and 1989 were conducted as part of a county-wide study by the FDNR for the establishment and subsequent re-establishment of a coastal construction control line. Corresponding offshore profiles were taken by sonar from beach to approximately 3000 ft offshore at every third monument for the 1974 survey. The 1989 survey included offshore soundings at every monument from the beach to approx. 3,000 to 9,000 ft offshore.

More recent bathymetry was collected for the USACE 2001, 2005, pre-construction in 2011 and post-construction in 2012. No comprehensive detailed survey data has been identified for the passes adjacent to Estero Island (Matanzas, Big Carlos, and other passes connected to the Estero Bay System). Bathymetry is available in Matanzas Pass but typically only covers the navigation channel. Recent bathymetry data is available for Big Carlos pass but only over areas needed to identify a sand borrow source. In addition, bathymetric data is generally unavailable for Estero Bay.

Bathymetric data is available in the form of navigation charts and through the NOAA National Ocean Service’s GEODAS data clearinghouse (NOAA, 2013a). Comprehensive coverage is available and shown in Figure 3, but the data is typically old and not adequate for use in hydrodynamic modeling in inlets and along active shorelines due to their dynamic nature. In addition, 2010 LIDAR data is available for the project vicinity, shown in Figure 4 (USACE 2010). The LIDAR data provides a surface model of the subaerial land and to a limited depth by the subaqueous bottom. However, the LIDAR data has gaps, and is typically accurate to ± 30 cm (NOAA, 2013b).

New topographic and bathymetric data was collected to complete single realization of the conditions of Estero Island, Matanzas Pass, portions of Estero Bay, and Big Carlos Pass between February 25th and March 22nd of 2013 by Sea Diversified of Delray Beach, FL. Figure 5 shows the new survey data.

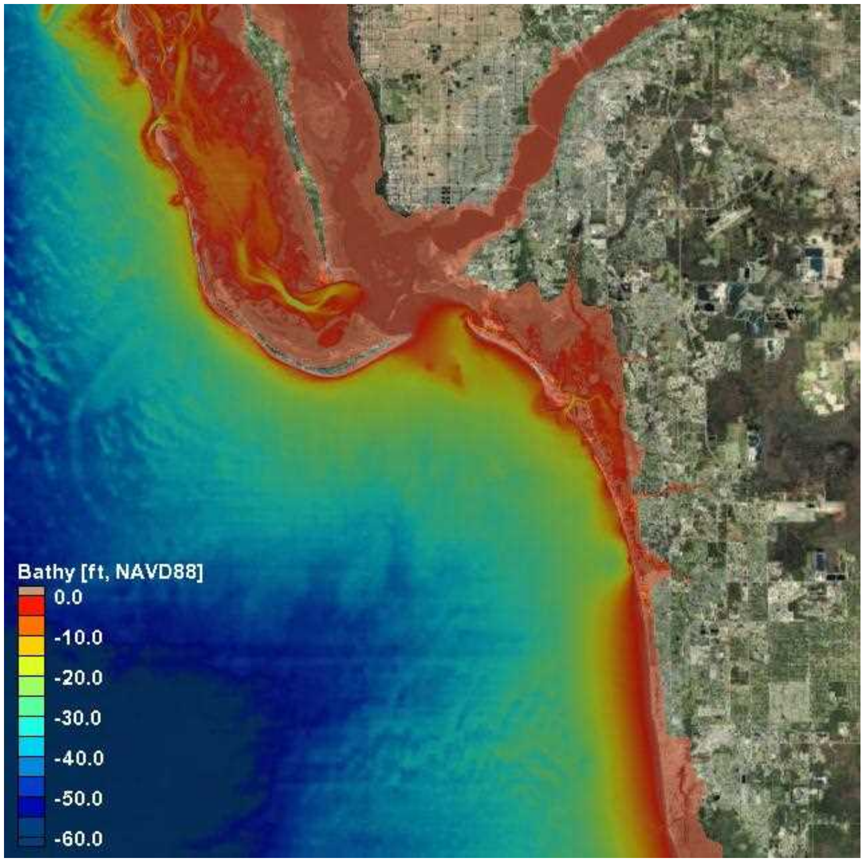


Figure 3. Bathymetric surface of project vicinity developed by NOAA (NOAA 2013).

Figure 4. Bathymetric and topographic surface of project vicinity from 2010 LIDAR data set.

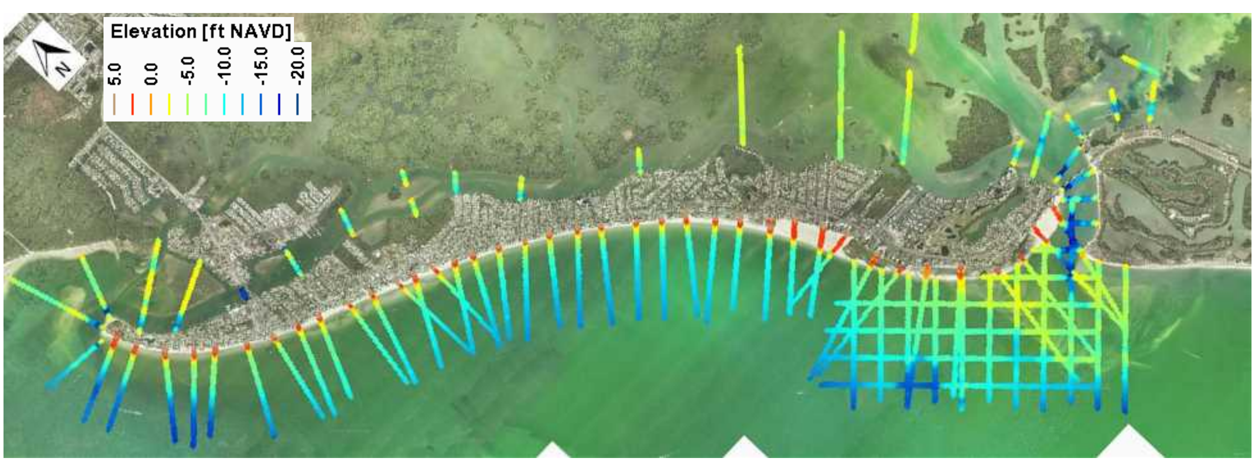


Figure 5. New bathymetric transects collected in spring 2013 (elevations in feet, NAVD88).

3.3 Geotechnical Data

Extensive geotechnical data has been collected in the vicinity of Estero Island for beach nourishment material in support of the USACE 1969 and 2001 studies. No new geotechnical data was collected for the current study. Sediments along the project reach are primarily quartz sand and shell in varying mixtures. During the USACE (1969) study, sediment samples at the backshore, foreshore, and elevation of -3, -6, -12 and -18 ft MLW were obtained on 12 profiles across EI. The median diameter ranged from 0.07 to 1.4 mm, with the average median diameter on backshore of 0.38 mm, foreshore of 0.26 mm, and at the -18 ft contour of 0.09 mm. Geotechnical data collected on Estero Island beach in 1990 showed a mean grain size of 0.15 mm, a phi sorting of 1.02 and approximately 5% passing the #200 sieve, the ASTM definition of silt (USACE, 2001).

Several possible borrow sources have been identified for future nourishment efforts during the USACE 1969 and 2001 studies. A total of 3.5 million cy were identified in the Estero Borrow Area B-1 offshore of Sanibel Island shown in Figure 6. This site was not utilized for the 2012 beach nourishment and likely remains available for future use. Further borrow site investigation in 2001 identified an additional 2,645,100 cy closer to Estero Island in two sites, BA-1 and BA-2, as shown in Figure 6. BA-1 was utilized for the 2012 beach nourishment project and some material remains. BA-2 was used in a 2004 beach nourishment of Lover's Key. Table 2 provides the characteristics of the native Estero Island sand and sediment available in the three borrow sites.

Unless the identified borrow sites become financially or environmentally unfeasible to dredge, they appear to be sufficient for future nourishment activities for several renourishment cycles. If in the future a new nourishment project is to be constructed, a detailed geotechnical investigation should be conducted to delineate the exact borrow site and volumes.

Table 2. Native and borrow area sediment characteristics for Estero Island (from USACE 2001).

Native Beach Sand	North Estero Is	South Estero Is	Lovers Key
mean (mm)	0.13	0.20	0.20
mean (phi)	2.90	2.35	2.31
sorting (phi)	0.50	1.04	0.87
silt (%)	6.96%	2.46%	2.48%
color	5Y-8/1 to -6/1	5Y-8/1 to -7/1	5Y-8/1 to -7/1

Fill Sand	Borrow Area B-1	Borrow Area BA-1	Borrow Area BA-2
mean (mm)	0.15	0.15	0.16
mean (phi)	2.73	2.73	2.60
sorting (phi)	0.97	0.97	1.12
silt (%)	3.82%	3.82%	4.81%
insitu color	5Y-7/1 to -5/1	5Y-7/1 to -5/1	5Y-7/1 to -5/1
washed color	5Y-8/1 to -6/1	5Y-8/1 to -6/1	5Y-8/1 to -7/1
Volume Available	3,500,000	1,841,700*	803,400*

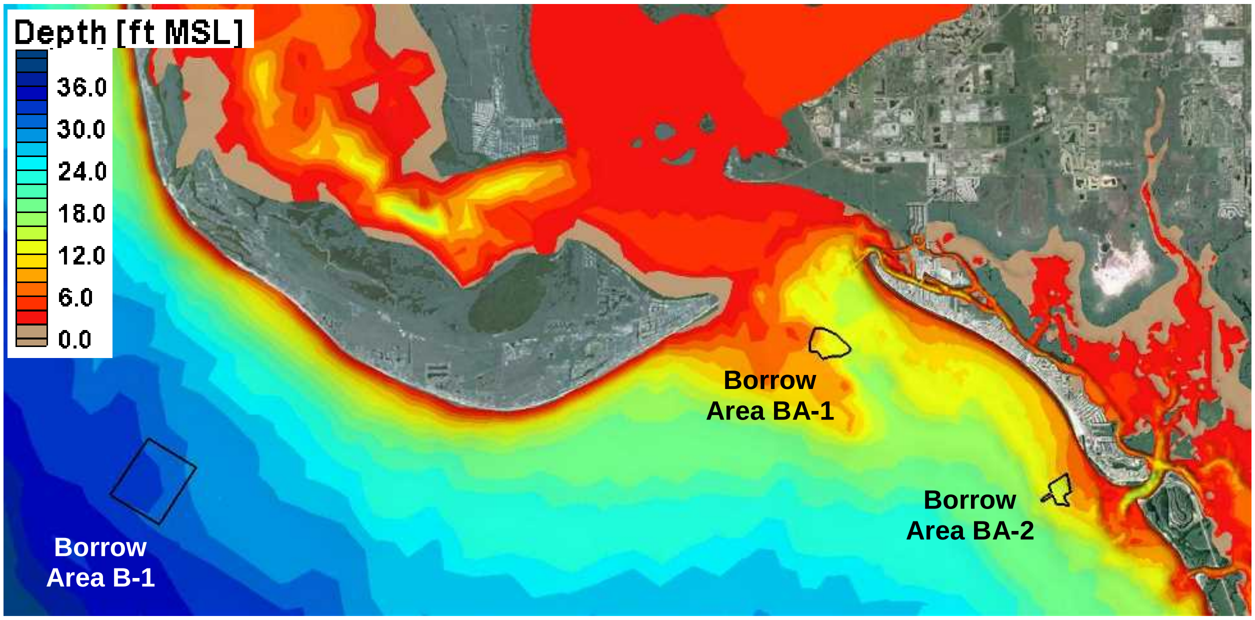


Figure 6. Borrow sites evaluated for the 2012 beach nourishment (elevations in feet, NAVD88).

3.4 Aerial Photos

Aerial photos are important data sources as they provide a means of extracting the shoreline position over time, and also provide visual evidence of morphology. Humiston and Moore (1997) identified available aerial photos from the USDA and FDOT. Lee County provided CHE with a copy of all available digitized aerial photos in their database. Table 3 summarizes all identified aerial photos of the vicinity.

It should be noted that while aerial photography is an important tool in establishing and analyzing morphological trends, using aerial photographs requires careful attention to reduce subjectivity of visual interpretation of the photos, and a detailed error analysis must be performed on the results as any position data (such as shoreline location) obtained from photos can be high. The error associated using aerial photography to define the shoreline position is a function of errors in rectification, seasonal variability, hydrodynamic conditions at the time of photography (water surface elevation), the subjectivity of the interpretation of the high water line, and photograph quality. It is common to have an error in shoreline position from a single photo in the range of ± 30 ft (Crowell *et al*., 1991; Moore, 2000). This error typically increases as photo quality decreases and photo age increases.

Table 3. Aerial photographs identified for the Estero Island area.

Year	Exact Date	Source	Coverage
1944	4/13/1944	NARA	ALL
1953	unknown	Lee County	ALL
1953	2/9/1953	NARA	ALL
1958	1/18/1958	USDA	north and south
1958	3/15/1958	USDA	central
1968	11/22/1968	Lee County	ALL
1968	3/18/1968	FDOT	ALL
1970	2/14/1970	USDA	north
1970	2/26/1970	USDA	South
1972	3/9/1972	Lee County	ALL
1972	3/3/1972	FDOT	ALL
1975	10/22/1975	Lee County	ALL
1975	10/22/1975	FDOT	South
1975	10/24/1975	FDOT	North and Central
1977	4/9/1977	USDA	ALL
1979	3/7/1979	Lee County	ALL
1979	3/7/1979	FDOT	Central and South
1979	3/13/1979	FDOT	North
1980	12/13/1980	USDA	ALL
1985	3/3/1985	USDA	ALL
1986	2/26/1986	Lee County	ALL
1986	2/25/1986	FDOT	ALL
1990	1/14/1990	Lee County	ALL
1990	1/14/1990	FDOT	ALL
1994	3/15/1994	USDA	North
1995	1/27/1995	USDA	South
1996	2/5/1996	Lee County	ALL
1996	2/5/1996	FDOT	North and Central
1996	3/13/1996	FDOT	Central and South
2002	4/1/2002	Lee County	ALL
2004	unknown	Lee County	Partial (Estero)
2005	1/18/2005	Lee County	ALL
2007	8/22/07 - 11/11/07	Lee County	ALL
2008	1/1/2008	Lee County	ALL
2011	unknown	Lee County	ALL

3.5 Shoreline Data

Shoreline data is used to determine shoreline change rates and can be a means of estimating volume change rates, both of which are important in developing a quantitative understanding of morphology. Shorelines can be derived from either digitization of aerial photography or from direct surveying. Humiston and Moore (1997) summarized available shoreline from 1858 to 1982. More recent shoreline data is available from the USACE 2001 and subsequent reanalysis studies (CEC 2005; ATM 2007). In addition the aerial photos in Table 3 were rectified and the shoreline position from all photos were digitized for use in a shoreline change analysis, discussed in Section 5.

3.6 Coastal Processes Data

The wave, wind and water level data was collected at locations in the vicinity of the project site to develop an understanding of the coastal processes impacting the project site. The locations where the coastal processes data was collected from are shown in Figure 7. Water level data (hourly) was collected from the NOAA's Naples Station # 8725110 (NOAA, 2012) station for the period 1/1/1996 to 1/31/2013. Wind and hindcast wave data was collected from the Coastal and Hydraulics Laboratory WIS (Wave Information Studies) (WIS, 2013). Station 73295. WIS is a result of numerical hindcasting of wind and waves; it is not actual measured wave data. However, WIS information has been shown to reproduce measured conditions with reasonable accuracy (Tracy, undated). The hindcast wave conditions provide an hourly significant wave height, spectral peak wave period, wave direction, and wind speed and wind direction at 10 m above the ocean surface for the time recorded between January, 1980 and December, 2012 at a water depth of 5 m. Hindcast wave data was also collected at an ECMWF station (ECMWF, 2013) from January, 1979 to December, 2012.

Figure 7. Data Stations used in the coastal processes analysis near Estero Island.

3.7 Previous Coastal Engineering Projects and Construction

3.7.1 Coastal Structures

Various privately sponsored coastal structures have been constructed along the Gulf Beach of EI since the 1950s, including 87 stone groins, 4 timber groins, 2 combined stone/timber groins, and approximately 3800 ft of mostly concrete seawall (USACE, 1969). Godshalk and Assoc. (1988) state that generally these structures have failed to provide protection to the beach and reduce erosion. Groins have been temporarily effective. Seawalls and bulkheads have been effective at protecting infrastructure, but not at maintaining a beach fronting them.

In 1988 Godshalk and Assoc. observed that a low, continuous seawall approximately 14,000 ft in length 2-3 ft high exists approximately between R-180 and R-198. The beach width in front of the seawall varies but in some areas it is quite narrow. Low rock and woodpile groins have been placed in a few areas but are ineffective. A seawall exists at the very southern end of the island facing Big Carlos Pass and no coastal structures are at the northern tip of San Carlos Island. Recent construction in 2011 constructed a terminal groin on north end of island at Matanzas pass, details of the terminal groin are discussed in Section 3.7.6.

Table 4. Summary of structures along Estero Island as of 1988; reproduced from Godshalk and Assoc. (1988b). Note: teminal groin from 2012 construction is added.

Extent	Structure Type	Approx Length [ft]
R175	Terminal Groin	260
R180 to R194	Seawall / Bulkhead	14,000
R194	Groin (remnants)	n/a
R195 to R198	Bulkhead	3,020
R197	Nine rock groins	500
R198 to R199	Groins (remnants)	1,000
R208 to R210	Bulkhead and groins	1,480

3.7.2 Matanzas Dredging and Placement

Matanzas Pass captures the northward transport from the northern end of EI. Because of this the pass is been dredged frequently to maintain navigation and to provide a source for beach nourishment. A summary of dredging of Matanzas Pass is provided in Table 5. In 1959, USACE recommended dredging Matanzas Pass (House Document 183, 86th congress, 1st session 1959), and recommended the channel be dredged at 12 ft x 150 ft transitioning to 11 ft deep and 125 ft wide inside the pass. The same document estimated northerly transport of sand into Matanzas Pass at 22,000 cy/yr.

Since then, Matanzas Pass has been dredged at least 6 times between 1961 and 1986 by the USACE, in 1996 by Lee County, and in 2001 where 180,000 cy of material were removed and nourished (Humiston and Moore, 2008). Historical disposal for the maintenance dredging has been approximately 200 ft north of R-178 to approx. 500 ft south of R-180 on Estero Island. In 2009 the USACE dredged Matanzas and placed approximately 229,000 cy of material in the nearshore zone (not on the dry beach) a bit further south between R-182 to R-187A. Lee County estimates that Matanzas Pass requires maintenance dredging every 5 years.

Table 5. Summary of dredging of Matanzas Pass (from Humiston and Moore, 1997 and Boutelle 2012).

Date	Volume [cy]	Project	Placement	Borrow Source
2/1961 to 3/1961	265,000	Dredge & Beach Nourishment	Beach; Unknown location	Matanzas
8/1961 to 11/1961	52,000	Dredge & Beach Nourishment	Beach; Unknown location	Matanzas
1972	110,000	Dredge & Beach Nourishment	Beach; Unknown location	Matanzas
11/1979 to 4/1980	192,000	Dredge & Beach Nourishment	R-178.2 to R-180.5	Matanzas
10/1982 to 10/1983	71,000	Dredge & Beach Nourishment	R-178.2 to R-180.5	Matanzas
11/1985 to 6/1986	96,000	Dredge & Beach Nourishment	R-178.2 to R-180.5	Matanzas
4/1996 to 5/1996	188,712	Dredge & Beach Nourishment	R-179.1 to R-183.7	Matanzas
2001	187,800	Dredge & Beach Nourishment	R-178.2 to R-185.5	Matanzas
2009	229,313	Dredge & Nearshore Placement	R-182 to R-187A	Matanzas

3.7.3 Nearshore placement

In October 2009, Matanzas Pass was dredged and the material composed primarily of fine sand was placed approximately 600 ft offshore of EI 1.5 miles southeast of Matanzas Pass in the form of an artificial berm designed to be 6,000 ft long, 400 ft wide, 3 ft high with slopes of 20H:1V composed of 229,313 cy. The nearshore placement was conducted in part due to the fact that DEP determined that the material was not beach compatible due to high amounts of fines. Researchers from the University of South Florida have monitored the morphology of the berm; two years of monitoring results are available in Brutsche (2011), Brutsche et al (2011a; 2011b), Brutsche and Wang (2012), and Wang et al. (2013).

Over the first two years of monitoring, this material moved onshore an average of 300 ft and increase in elevation. In addition, sediment sampling over time observed coarser material moving onshore while finer and muddy sediment tended to move offshore.

Recent, unpublished results by the same researchers have developed conclusions on the performance of the nearshore placement. Brutsche (2013) indicated that the nearshore placement resulting in a stable beach landward of the nearshore placement from 2009 to 2013, and that approximately 10% of the berm volume has attached to the subaerial beach. The remainder of the material has been distributed to nearby areas, acting as the source for littoral transport that otherwise would have resulted in erosion of the beach in the nearshore placement area. The estimated lifetime of the berm is 6 years. The remainder of the berm material that attached to the shoreline is expected to behave as a traditional subaerial beach nourishment.

3.7.4 Lover's Key

A beach nourishment was conducted in the fall of 2004 along 1.2 miles of Lovers Key, which consisted of placing 590,000 cy of sand between approximately R215 and R220 (FDEP, 2008). The borrow source was an offshore site; the exact location was not able to be determined.

3.7.5 Big Carlos Pass

Big Carlos Pass ebb shoal was utilized as a borrow source for a beach nourishment along Bonita Beach in June 2004, where approximately 143,000 cy of sand was placed between R226 to R230 (FDEP, 2008). See Figure 6, BA-2 for location of site. The impacts of this dredging should be carefully studied, and the future use of Big Carlos Pass ebb shoal as a sand source must be analyzed in detail considering the possible implications to adjacent shorelines as improper dredging of ebb shoals can lead to erosion on adjacent shorelines and/or unintended morphology of the pass itself. Sufficient data to determine impacts of the dredging were not available.

3.7.6 2011 Beach Nourishment

A large-scale beach nourishment was recently constructed on the north end of EI funded by the DEP, Town of FMB, Lee County, and West Coast Inland Navigation District (WCIND). The WCIND specifically funded the terminal groin. This construction is the result of the USACE (1969) Beach Erosion Control Study, the follow-up USACE 2001 General Reevaluation Report, and subsequent updates to the design. The design and modification over time are briefly summarized here.

The 1969 design criteria included berm widths of at least 50 ft at +4 ft MLW (+4 ft is reached with 5 yr return storm); 15:1 slope subaqueous, 35:1 MLW to dunes, adding a 5-yr advance supply of sand to berm; 4.6 mi of nourishment from north; a total volume of 325,000 cy, and renourishment at 120k cy/yr with a renourishment cycle at 3 years. They also proposed a terminal groin at Matanzas Pass with a crest elevation of +4 ft and stone sized to be stable for a wave height of 6 ft.

Olsen (1987) estimated nourishment for EI (in reaches R180-185, R192-198, R207.5-210) for a volume of 1.2 million cy at a cost of $5,000,000, with maintenance (renourishment) at 600,000 cy every 6.1 years, annualized to 98,000 cy/yr at $761,000 per yr.

Humiston and Moore (1997) reviewed island wide beach restoration history and considered a new beach nourishment from R177-199 (4.2 mi) and R207-210 (0.6 mi), with a volume of 1.4 million cy, two 200 ft terminal groins at north end of EI and one at the south end of the island. The total cost was estimated at $9,000,000 with maintenance at 10 yr intervals for an annualized maintenance cost of $546,000 per yr.

CEC (1998) recommended 1.4 million cy of nourishment from R175-199 (4.8 mi) and R207-210 (0.6 mi) with groins at north and south end of island for a total cost of $12,800,000.

The USACE 2001 re-evaluation design recommended the following design features: 4.7 miles of beach nourishment (4.6 was originally authorized), berm elevation of +5 ft MLW and 40 ft wide (at MHW), construction slope of 10H:1V, existing beach slope estimated as 25H:1V above MLW and 35H:1V below MLW, limits from R-175 to R-198 with 1800 ft tapers that connect the beach fill to the existing shoreline. The nourishment volume is 790,800 cy including 244,400 cy of advance fill volume (546,400 cy design volume). The renourishment cycle is 3 years with 81,500 cy/yr annually required. An update described in CPE (2001a) modified the renourishment cycle to 8 yr intervals due to reduced erosion rate (attributed primarily to erroneous survey data) and due to a closer borrow site that reduced the sand cost resulting in increased possible volume of fill.

The terminal groin was proposed in vicinity of R-175. The optimum effective length of groin was 150 ft with an additional 90 ft necessary to link structure to existing berm crest (240 ft total). The design criteria resulted in a continuous groin height of +6 ft MLW (capable of sustaining a 4 ft wave with no overtopping and a 6 ft wave with minimal overtopping). The groin structure design specified 4000 tons of armor stone, 1,600 square yd of geotextile fabric, and 2,500 sf of vinyl sheet pile (for 230 ft linear ft of wall).

ATM (2007) analyzed changes from 2000 to 2005 to reassess the USACE 2001 plan. Between April 2000 and October 2005 the project area shoreline on the whole advanced 0.92 ft and gained 272,000 cy above depth of closure. Analysis indicated that these volumetric gains occurred primarily within the nearshore as the upper beach above MLW exhibited a net gain on the order of 2,000 cy. Overall the beach has remained stable or accretionary, but significant erosion areas are present within the project area. Erosion/accretion trends remained consistent with shoreline observations and consistent with shoreline trends for the area dating back to at least 1974. Historically, placement of dredged material within the vicinity of the pier has helped address the impacts of the northern hotspot. This placement however, has occurred over a localized area and the constructed shoreline has receded at an above average rate due to diffusion losses of material to adjacent (non-nourished) areas. Shoreline data collected since the USACE 2001 study suggests that the volume of material required to meet the project's goals may be less than projected within the current plan, but any major modifications to USACE plans are not warranted. ATM recommended minor modifications to reduce volume by 124,000 cy (12% reduction)

Based on reports from Lee County, sand placement and terminal groin construction was completed on 12/19/2011. Approximately 402,805 cy were placed within the project area (Boutelle, 2012). Sand was placed from approximately 400 ft north of R-175 to R-181.5. The total cost for the construction was $3,652,469.30.

4 Coastal Processes Analysis

4.1 Geologic Setting

Understanding the geological setting is important in gaining insight into the larger morphodynamic processes at work in the project vicinity, as they often drive smaller and local processes that influence project-scale processes. USACE (1969), Godshalk and Assoc., (1988), and USACE (2001) have discussed the geologic setting of the project vicinity.

Florida occupies a larger geologic unit the Floridian Plateau. During geological time the plateau has been dry or shallow seas. Each retreat of the sea left marine deposits which, during subsequent advances of the sea, were moved by waves to form beaches, offshore bars, islands, and similar features. Each sea advance left shorelines successively lower above the present sea level. The last sea advance, the Pamlico, may have produced Pine Island - it appears that Pine Island was an offshore barrier bar of the Pamlico age. The current Lee County bars (islands) are younger post-Pleistocene deposits related to the present emerging shoreline. The shoreline consists of a series of barriers and inlets. The two largest inlets are Boca Grande and San Carlos Bay; they are larger and deeper as rivers empty to the Gulf through them (the Caloosahatchee River empties through San Carlos Bay).

Godshalk and Assoc. (1988) noted that no new quartz sands are being introduced into the present coastal system as it is a closed sand budget. The contribution of carbonate sand from shell and shell fragments are not considered a dominant factor considering the total quantity of sand (although it is significant at some local sites); this is a factor that is poorly understood.

4.2 Relative Sea Level Rise

Sea level rise was not addressed at the project site until the USACE (2001) study. Relative sea level rise is the sum of the eustatic sea level change and local land elevation change. Historic relative sea level rise is measured at tide gages which are carefully controlled relative to a vertical datum. Future sea level rise can be estimated by extrapolating measured historic sea level rise from local tide gages.

The closest long term sea level records was from Key West from 1850-present and was estimated at 2.24 mm/yr ± 0.16 mm/yr. Recent data from NOAA (2012) at Naples (approximately 20 miles south) computes the sea level rise from 1965 to 2012 at 2.02 ± 0.6 mm/yr, and for nearby St. Petersburg (approximately 100 miles north) sea level rise rate is computed as 2.36 ± 0.29 mm/yr from 1948 to 2012. Measurements at Ft. Myers, FL (inland from Estero Island) from 1965 to 2012 are 2.40 ± 0.65 mm/yr. Plots of measured long term sea level rise at these stations are shown in Figure 8. Based on this data, the most conservative measure of relative sea level rise is from the Ft. Myers tide gage. Using this data to extrapolate into the future, in 25 years sea level would be expected to be 60 ± 16 mm (0.19 ± 0.05 ft) higher than today.

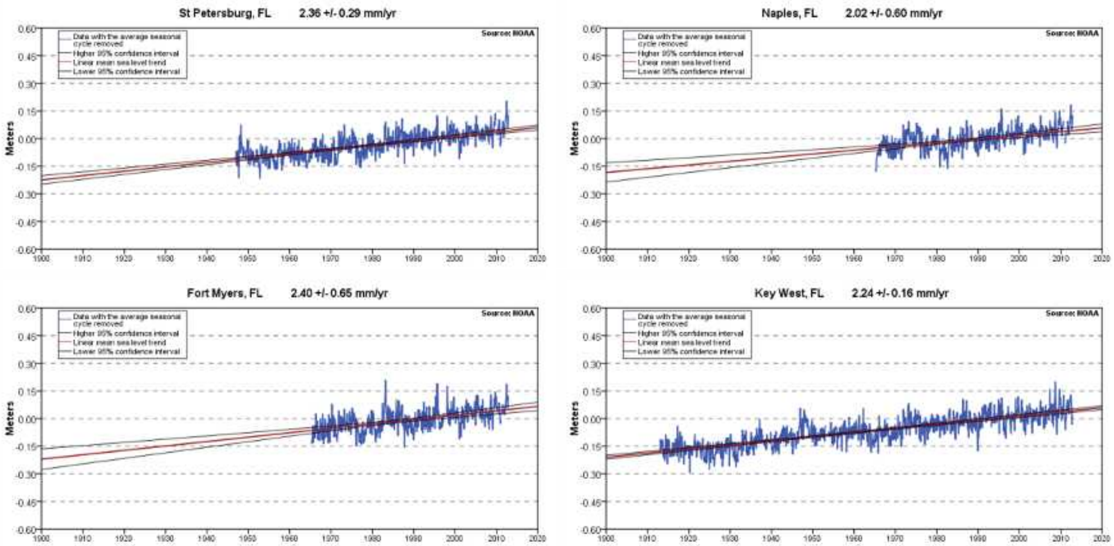


Figure 8. Long term sea level trends in project vicinity.

Relative sea level rise results in shoreline recession as the beach profile adjusts to the increasing water elevation. This adjustment is explained by Bruun (1962), who proposed a formula for estimating shoreline recession based on the local rate of relative sea level rise. This method assumes that the local beach profile shape will remain constant to sea level by translating landward and upward. If no additional sand is added to the system, as is indicated by the geological setting, the shoreline will recede landward as a result.

Using the Bruun formula and a relative sea level rise of 0.19 ft over 25 years, the shoreline is expected to recede approximately 10.5 ft due to the relative sea level rise, or approximately 0.4 ft/yr in that time period. Note that in the GRR (USACE 2001), the shoreline retreat due to relative sea level rise was estimated at between 0.8 and 1.6 ft/yr. The difference is from a different estimate of expected future relative sea level rise. In any case, this shoreline retreat rate is a relatively minor component of the shoreline morphology along the project vicinity.

4.3 Meteorological Climate - Winds and Waves

The meteorological climate in the project vicinity is important in that wind-waves are the primary driver of sediment transport and therefore morphology along barrier beaches. USACE (1969) and Hubertz and Brooks (1989) stated that during the winter, winds are from the northeast to the north, and that during the remainder of the year winds are predominantly from the east and south. USACE (2001) noted that diurnal sea-breeze (onshore-offshore) are present but are not an appreciable cause of sediment transport.

Waves are generally from the northwest to southeast, with a mean wave height and period of 1.3 ft and 4 seconds, resulting in a mild wave climate. Only light swell waves 1 to 6 ft high move toward Lee County from the northwest and south. A summary of the wave climate is shown in Table 6.

Rose plots were developed for the wave and wind data from WIS Station 73295 from 1980 to 2012. Rose plots illustrate the frequency of occurrence of events for 16 directional bins for various magnitudes. Majority of the winds come from north-east to south-east directions. The location is relatively sheltered from strong winds as approximately only 5% of the winds exceed 25 mph speeds. Due to the orientation of Sanibel Island in the north and southern Florida shoreline in the south, the project site receives waves (about 70%) primarily between south-southeast and west-northwest directions.

Table 6. Percent occurrence of wave height and wave period offshore Lee County computed by WIS wave hindcast from 1980-2012.

Wave Height [ft]	Wave Period [seconds] <3.0	-4 4.9	-5 5.9	-6 6.9	-7 7.9	-8 8.9	-9 9.9	-10 10.9	-12 12.9	-14 LONGER	Total
0-0.3	28.0	--	--	--	--	--	--	--	--	--	28.0
0.3-1.6	25.6	9.9	4.1	2.3	1.5	0.8	0.5	0.3	--	0.008	45.1
1.7-3.2	5.9	15.9	1.3	0.5	0.3	0.3	0.9	0.6	--	0.005	25.9
3.3-4.9	--	0.05	0.15	0.12	0.13	0.09	0.24	0.09	--	0.007	0.9
5.0-6.5	--	--	0.01	0.02	0.01	0.02	0.06	0.02	--	0.001	0.1
6.6-8.2	--	--	--	--	--	--	--	--	--	--	--
8.2+	--	--	--	--	--	--	--	--	--	--	--
Total	31.5	25.9	5.6	2.9	2.0	1.2	1.8	1.0	0.0	0.021	100.0

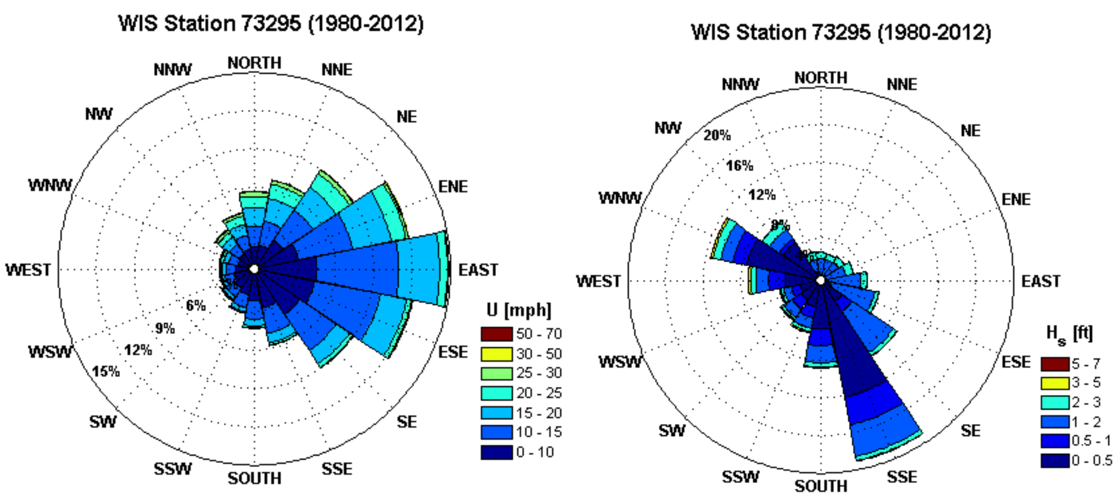


Figure 9. Wind rose (left) and wave rose (right) from the WIS Station 73295 near the project site.

4.4 Extreme Events (storms)

EI is subject to extratropical storms (cold fronts), tropical storms and hurricanes. Extratropical storms associated with easterly moving low pressure cold fronts can cause beach erosion and shorefront damage, and are the major contributor to sediment transport and morphology on EI outside of individual tropical events (Godshalk and Assoc., 1988). The USACE (1969) estimated that based on the record from 1830 to 1968, hurricanes occur at a frequency of 1 every 6 years while some tropical event (a hurricane or tropical storm) occurs at a frequency of 1 storm every 3 years.

Godshalk and Assoc. (1988) computed that the storm surge at EI is 5.2 ft for a 10 yr event, 8.3 ft for a 25 yr event, and 13.2 ft for a 100 yr event. During the 1929 Hurricane, surge was estimated at +12 ft MLW on Sanibel Island, and during the 1935 Hurricane surge was measured at +15 ft MLW.

Neal (2005) provided an assessment of Hurricane Charley on EI in 2004. The storm made landfall with winds of 145 mph and a surge estimated at +8 ft on EI. Shoreline losses were on average 28 ft along EI, with more significant impacts on the north end of the Island; erosion in this area exceeded 100 feet in some cases. The sand spit at the southern tip of EI protected the infrastructure in its lee. Seawalls and rock revetments protected infrastructure in many other areas. Scour occurred at the base of some of these shoreline armaments.

An extreme value analysis was performed on water levels at the Naples tide gage and on wind speeds and wave heights at the WIS gage; results are shown in Table 7. Note that the water levels are slightly smaller than those reported by Godshalk and Assoc. (1988). These water levels were based on the measured data at the Naples tide gage from 1996 through 2013, and estimates of water levels during Hurricane Charley (used +7 ft NAVD) and Katrina (used +4 ft NAVD) were manually added to the record, as the gage did not record those events.

Table 7. Extreme values of water levels, wind speed, and wave heights near the project site.

Return Period [yrs]	Water Level at Naples [ft NAVD88]	Wind Speed [mph]	Wave Height [ft]
1	2.1	34	5.0
2	2.4	38	5.4
5	3.2	84 (Cat1)	5.9
10	4.1	103 (Cat2)	6.2
20	5.3	126 (Cat3)	6.4
25	5.7	133	6.5
50	7.2	148 (Cat4)	6.8

4.5 Inlets and Tidal Currents

EI is bounded by two inlets, Matanzas Pass to the north and Big Carlos Pass to the south. The USACE 1969 study indicated that currents in the larger passes are generally 3 to 3.7 ft/sec and that currents in Matanzas Pass were minimal. However, modeling of tidal circulation (see Section) indicates that currents in Matanzas Pass often reach 2-3 ft/sec. Godshalk and Assoc. (1988) determined that Big Carlos Pass tidal prism is 8.10 x 10^8 ft^3. The tidal prism for Matanzas Pass was not provided and literature references of the tidal prism were not identified.

4.6 Littoral Transport

The littoral transport along EI is complex due primarily to the low-energy environment which leads to a mixed transport signal. The USACE (1969) concluded that littoral transport is to the north on the north end of the Island and to the south on remainder of the Island. Reversals in trends occur, and are modified by the influence of passes. A previous study on Matanzas Pass dredging estimated the northerly transport on northern 2 mi on north end of EI at 22,000 cy/yr. Estimates from dredging at Gordon Pass (15 mi south of south Lee County) put littoral transport on southern Lee County at 66,000 cy/yr to the south, and USACE suggested that this rate applies on the south end of EI as well.

Olsen (1987) stated that littoral transport is to the north on the northern part of island and to the south on the southern part of the Island. The northward transport is caused by sheltering from northern waves by Sanibel Island and San Carlos Bay. Godshalk and Assoc. (1988) provided and estimate of transport rates and directions shown in Figure 10. Their values 33,000 cy/yr transported into Matanzas Pass and 66,000 cy/yr transported south.

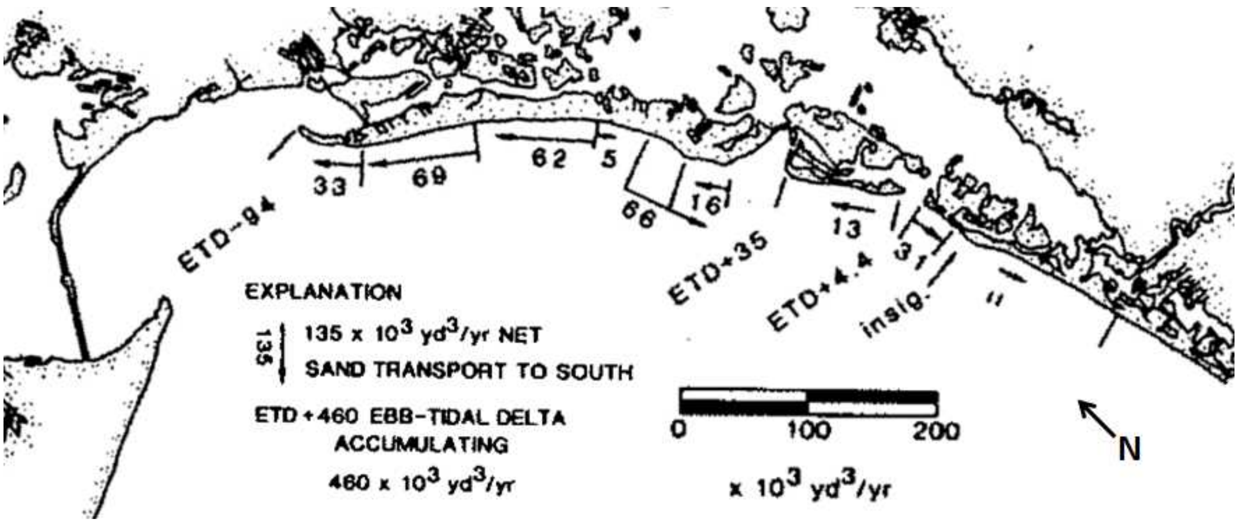


Figure 10. Littoral sand transport along the EI shoreline, excerpt from Godshalk and Assoc., 1988b.

USACE in 2001 stated that for a variety of reasons the longshore transport rate for EI Island ranges from near zero to a maximum of 69,000 cy/yr, while estimates from Poff and Stephen (1998) indicate a lower value of 29,000 cy/yr. GENESIS simulations conducted during the USACE 2001 study had a maximum transport rate of 59,000 cy/yr within the design runs.

In Section 6.4 of this report, wave modeling is used to develop a longshore transport model of the Island. This is further refined in Section 6.5 through a GENCADE shoreline morphology model of the project area.

4.7 Summary of Coastal Setting

Godshalk and Assoc. (1988) summarized the coastal settings of Estero Island best: Estero Island is a low energy environment, has low ground elevations, a low tide range, and has a low frequency of major storms. These conditions make EI susceptible to large damage and dramatic morphology from rare but large events (hurricanes).

5 Estero Island Vicinity Morphology

5.1 Island

The EI shoreline is a low, gently sloping mixed quartz and carbonate shell beach. The average EI berm elevation is +4 ft, average slope above MLW 20H:1V and below MLW 50H:1V (USACE, 1969). Godshalk and Assoc. (1988) noted that dunes and fore-dune ridge are discontinuous and low in relief. Few dunes are present along developed sections. None exist where seawalls have been installed.

The morphology of the Island is a function of the wave climate; Sanibel Island shelters EI from the dominant northwesterly waves, which is a major factor in morphology and littoral transport on EI. It is commonly thought to be the cause of a nodal point in the littoral drift near the center of the island, which results in northward transport on the north of the island and southward transport on the south of the island (USACE, 1969; Godshalk and Assoc., 1988; Humiston and Moore, 1997; CEC, 1998; USACE 2001). CEC (1998) proposed structures such as groins or breakwaters be installed at the nodal point to hold sand in place longer. This would result in erosion rates near the center of the island and also on the north of the island higher than adjacent areas; this does not completely hold true after a detailed review of shoreline morphology.

Shoreline change rates were determined in the USACE 1969 study to be 24 ft of recession between 1885 to 1967, and 100 ft of recession from 1957 to 1967. Offshore of the island, the 6 and 12 ft contours generally receded offshore during the same time frame. From 1867 to 1967, USACE estimated that the island eroded approximately 138,000 cy/yr.

Big Carlos Pass is the dominant morphologic influence on the southern end of the island. In 1997, Humiston and Moore described the Little Estero Island Critical Wildlife area (Critical Wildlife Area). Local reports suggest these bars formed during Hurricane Donna in 1960 and have since created an extensive region of vegetated dunes and bars (USACE, 2001). The area is thought to be a result of portions of the ebb shoal from Big Carlos Pass migrating onshore and becoming emergent. In 1992 the areas was established as a Critical Wildlife Area. Shoals are prevalent in the area due to the confluence of wave induced littoral transport southward along Estero Island with the tidal current induced transport at Big Carlos Pass. In 1997, the southern end of Estero Island experienced erosion primarily as a result of the southern sediment transport by the emergent shoals (Humiston and Moore, 1997).

USACE (2001) computed historical volume change rates using sequential surveys of the region. Discrepancies exist in volume change rate calculations, and quantities should therefore be treated with some skepticism. Depth of closure was estimated at 13.25 ft using the Hallermeier method, but observations of survey transects indicate a depth of 8 ft may be more appropriate; 8 ft was used in volume calculations. From 1982 and 1989, estimates suggest Estero Island gained 245,400 cy, however, 190,000 cy of fill was placed in 1986 resulting in a net gain of 55,400 cy, which equates to annual accretion rate of 7,900 cy/yr. No hypothesis was stated for the source of this accretion. From 1989 to 1995 the region had a net loss of 340,000 cy or 56,700 cy/yr.

USACE (2001) also estimated the influence of sea level rise of shoreline change. Based on National Research Council’s 1987 estimate, sea level rise by 2043 is estimated to be 0.7 to 1.5 ft. This translates into a shoreline recession of 0.78 ft/yr and 1.7 ft/yr, respectively based on Bruun rule and using the surveys collected for the 2001 study. As discussed in Section 4.2, using measured, conservative historical sea level rise rates results in approximately 0.4 ft/yr of shoreline retreat due to relative sea level rise.

In 2000, Applied Technology and Management, Inc. (ATM) computed the shoreline change associated with storm events using the SBEACH model. They computed that for a 15-yr storm the shoreline would erode an average of 6.8 cy/ft of beach or approximately 44.2 ft of beach width at the MHW line, and for the 25-yr storm, the shoreline would erode an average of 7.8 cy/ft of beach or approximately 42.3 ft of beach width at MHW.

CHE collected and processed aerial photos from 1953 to 2011, and digitized the shoreline on each photo as discussed in Section 3.4. These shorelines were compiled together to provide a current analysis of historical and recent shoreline change along the entire Estero Island.

Figure 11 shows the envelope of all shoreline positions from 1953 to 2011 plotted relative to the average shoreline position. In the figure, Matanzas Pass is on the left and Big Carlos Pass is on the right; an aerial photo showing the R-monuments is also provided for reference. This figure illustrates that the south end of the island from approximately R-199 to R-210 has experienced the most dramatic changes, primarily as a result of interaction with Big Carlos Pass and the welding of a portion of the ebb shoal to the shoreline near R-203 in the 1960's. In this reach, the overall shoreline position has varied by up to 500 ft in places, with an average variation of approximately 100 ft.

The central region of the island from R-196 to R-185 has remained remarkably stable, with shoreline position variations within approximately 30 ft (within the accuracy of the delineation of the shoreline on aerial photos). The stability of the central region of the Island is aided by the presence of bulkheads which preclude further shoreline retreat. From R-185 north to R-175 at Matanzas Pass, the shoreline variability gradually increases to an envelope of approximately 100 ft on the northernmost reach. This variation is a result of the erosion due to northern longshore transport and subsequent beach nourishment activities that have occurred from dredging of Matanzas Pass and placement in this reach.

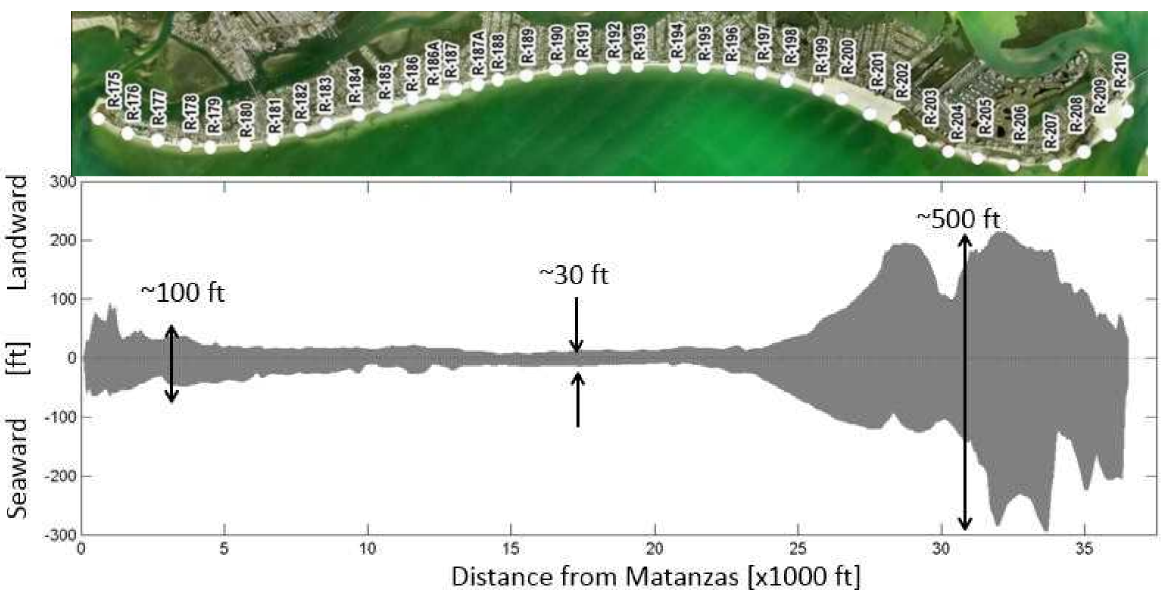


Figure 11. Estero Island Shoreline positions envelope from 1953 to 2011.

The individual delineated shorelines are presented in Figure 12. In this figure, Matanzas Pass is on the left and Big Carlos Pass is on the right. For each year where a shoreline is available, the shoreline position is shown relative to the average shoreline positions from 1953 to 2011. Due to the extremely dynamic nature of the southern end of the island and relatively stable central portion of the island, the shorelines are shown on two different vertical scales, where the top figure is plotted with the y-axis scale of 300 ft (the grey box represents a 300 ft distance) to illustrate the variability of the south end, while the bottom figure is plotted with the y-axis scale of 50 ft to illustrate the variability of the central and north end of the island. In addition, in regions and times where beach nourishment occurred, the volume is shown as text.

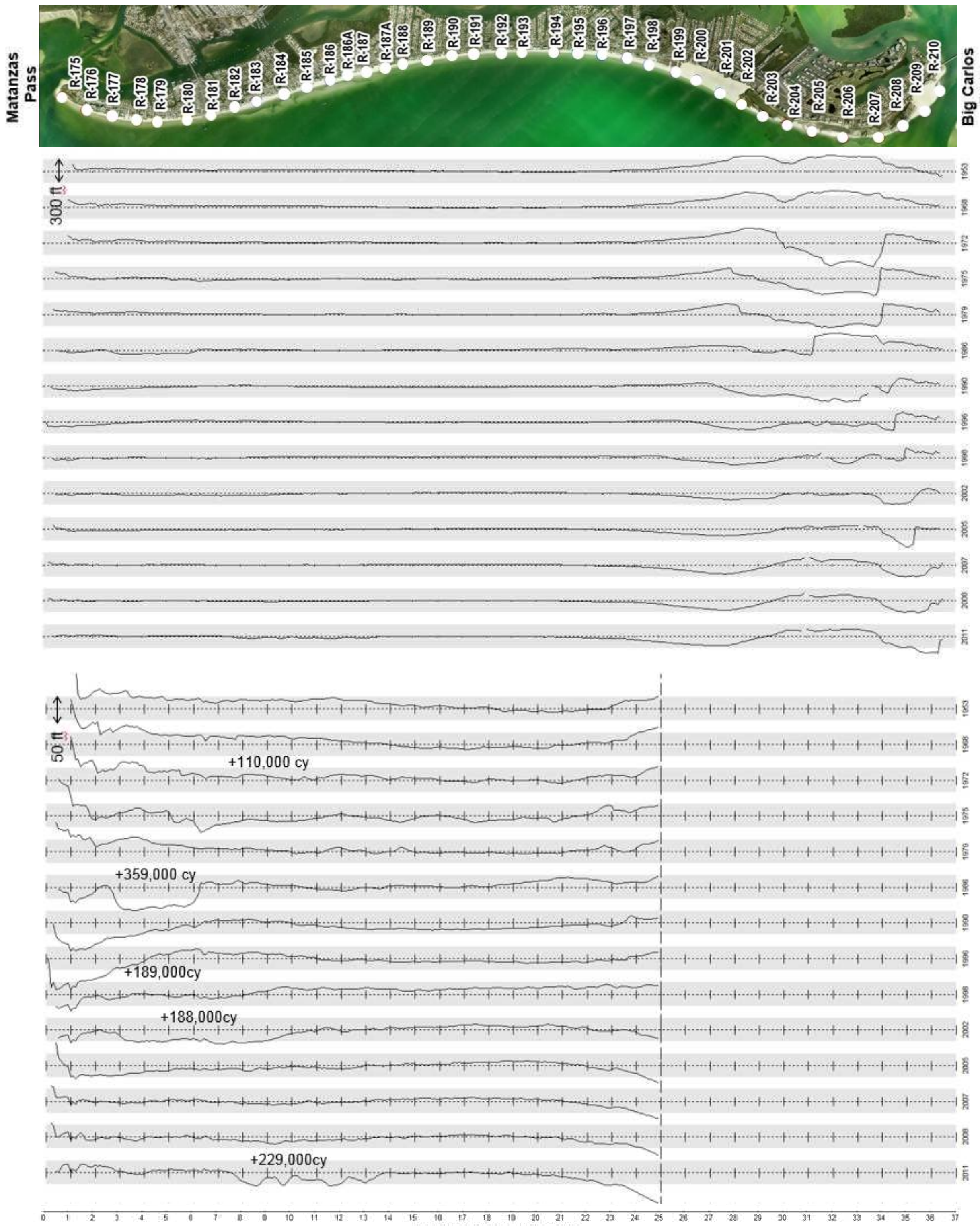


Figure 12. Estero Island shoreline position (solid line) deviation from the mean shoreline position (dotted line) from 1953 to 2011. For each year, the grey bar shows +/- 150 ft from the mean position on the top image, and +/- 25 ft from the mean position on the bottom image. For each year, the shoreline is seaward of the mean position when the shoreline is below the mean, and landward when the shoreline is above the mean. Top image shows entire EI reach from Matanzas Pass on left side to Big Carlos Pass on the right side. Bottom figure shows only reach from Matanzas to approximately R-198, to show the shoreline position on an appropriate scale.

Figure 13 shows the shoreline change rates from 1999 to 2012 derived from the shoreline positions shown in Figure 12. Cool colors represent shoreline advance while red colors indicated shoreline retreat. Values of shoreline change corresponding to Figure 13 are provided in Table 8.

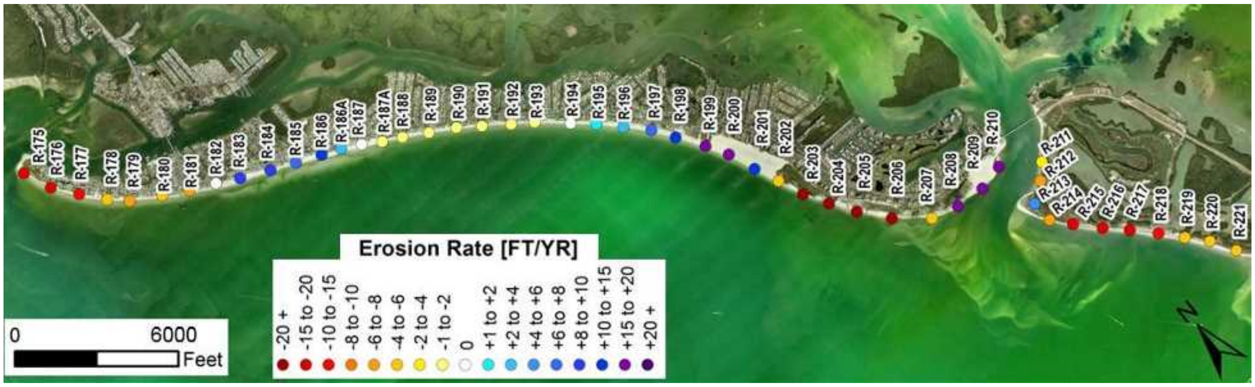


Figure 13. Estero Island Shoreline Change Rates from 1999 to 2012 (before 2012 beach nourishment).

Figure 12 and Figure 13 can be used to understand the historical shoreline morphology of EI over time. This in turn can help lead to a better understanding of sediment transport patterns and pathways. The morphology of the southern end of the island is dominated by the attachment of the ebb shoal bar in the 1960s; it is first seen in the shoreline from 1972. After that time, the sand in the shoal bar diffuses both to the north into the reach from R-202 to R-195 and to the south, rapidly advancing the shoreline from R-208 to R-210. The ebb shoal bar attachment lead to a large source of sediment for the entire southern reach of the Island. The area where the bar attachment occurred, between R-202 and R-207, has receded since the time of attachment, and receded at a high rate. The area landward of the bar attachment is primarily shallow lagoons. Therefore, when storm events of even moderately elevated water and wave energy occur, the attachment bar rolls landward and sand is overwashed from the beach face and deposited into the lagoon. This morphological process leads to rapid shoreline retreat, but typically has a smaller volume loss per foot of retreat that a similar retreat would on a typical beach face.

The central portion of the island from R-196 to R-182 has remained relatively stable from 1953 to 2011. Moderate accretion has occurred up to approximately R-194, likely from sediment being transported in from the attachment of the ebb shoal bar further south. The reach from approximately R-193 to R-187 has experienced moderate shoreline retreat on the order of 1 to 3 ft/yr. These rates are similar to those calculated for the expected retreat rate associated with relative sea level rise discussed in Section 4.2. The reach between R-187 to R-182 has recently been the site of the nearshore berm construction in 2009; recent shoreline positions show accretion reflecting the nearshore berm's impact on the shoreline. Prior to placement of the nearshore berm, this reach experienced somewhat higher rates of erosion than the adjacent reach to the south.

The northernmost reach from R-187 to R-175 at Matanzas Pass has experienced high shoreline retreat rates, up to -25 ft/year. Management of the erosion in this area has primarily been accomplished by beneficially using the material dredged from the federally maintained Matanzas Pass navigation channel immediately adjacent to Bodwitch Point north of R-175. This is reflected in the bottom portion of Figure 12; the impact of beach nourishments can be detected in the shoreline locations. The nourishments tend to diffuse both to the north and south, and translate as a body to the north, indicating a net northward transport.

Table 8. Shoreline change rates from 1999 to 2011 at R-monuments.

R-mon	Shoreline Change [ft/yr]	R-mon	Shoreline Change [ft/yr]	R-mon	Shoreline Change [ft/yr]	R-mon	Shoreline Change [ft/yr]
R-175	-15.3	R-187	0.6	R-199	16.6	R-212	-6.1
R-176	-17.8	R-187A	-1.2	R-200	21.6	R-213	4.3
R-177	-14.9	R-188	-1.3	R-201	12.3	R-214	-6.5
R-178	-5.8	R-189	-1.9	R-202	-4.9	R-215	-15.8
R-179	-8	R-190	-1.8	R-203	-20.4	R-216	-17.1
R-180	-5.4	R-191	-1.8	R-204	-29.7	R-217	-18.9
R-181	-6.2	R-192	-1.4	R-205	-35.9	R-218	-11.5
R-182	0.8	R-193	-1	R-206	-44.6	R-219	-5.2
R-183	9.4	R-194	0.4	R-207	-4.6	R-220	-4.2
R-184	8.5	R-195	1.7	R-208	35.6	R-221	-4.7
R-185	6.4	R-196	3.5	R-209	41.3		
R-186	10.5	R-197	6.2	R-210	28.8		
R-186A	3.6	R-198	10.7	R-211	-3.4		

5.2 Inlets

EI is bounded by two inlets, Matanzas Pass to the North and Big Carlos Pass to the south. USACE (1969) stated that tidal currents appear to have little effect on the littoral transport of material on Estero Island. Olsen (1987) provided a summary of Matanzas Pass and the entrance to San Carlos Bay. They stated that the Matanzas Pass entrance to San Carlos Bay has never been improved, is more than 3 mi in width, and is the main tidal outlet for Caloosahatchee River. Historic trends indicate that the majority of sand eroded from eastern Sanibel was deposited in the vicinity of this entrance. The ebb tidal shoal was estimated at 26.1 million cy, indicating that eroded material from Sanibel likely remains in the area. Matanzas Pass captures much of the littoral drift transported to the north from EI. Between 1961 to 2009, more than 1.39 M cy was dredged from Matanzas Pass and placed on northern EI, an annualized rate of approximately 30,000 cy/yr.

USACE (2001) noted that significant tidal currents in the Big Carlos Pass affect littoral processes on the southern portion of EI. USACE estimate that the flood and ebb shoals contain about 4.2 and 8.0 million cy of material, respectively. Generally, coastal inlet shoals intercept and store littoral material proportionally to the magnitude of the flow rate through the shoals, where higher flow rates result in higher littoral sediment storage (Walton and Adams, 1976). A noticeable widening and deepening of the pass occurred in 1965 immediately following the construction of the causeway between Ft Myers and Bonita Beach. This resulted in an increase in the total sediment volume retained in the inlet flood and ebb shoal system. USACE noted that material from periodic dredging of the pass has been placed on the adjacent beaches of EI on Lover’s Key in 2004. Little information is available on New Pass to the south of Lover’s Key. Olsen estimated in 1987 that the New Pass flood shoal contains 300,000 cy, and the ebb shoal contains 420,000 cy. They also stated that the construction of Estero Blvd Causeway construction has led to enlargement of the shoals. It should be noted that Big Carlos Pass has not been dredged for navigation or as a borrow source; the ebb shoals were used as a borrow source for nourishment.

Bathymetry from the 2006 LIDAR, 2010 LIDAR and from the recent survey data collected in spring 2013 were compared to develop an estimate of the Big Carlos ebb shoal volume and volume change rate. No two data sets completely cover the extents of the shoal, so complete estimates are not possible. Future monitoring should be conducted using similar methodologies and survey areas to facility more accurate calculation of shoal volumes and shoal volume changes. The available data was used to provide some estimates, but as they do not cover the entire shoal, conclusions are limited in completeness.

Figure 14 shows color contour maps of the 2006 LIDAR, 2010 LIDAR (USACE 2010), and surface developed from the 2013 survey. The extents of the contours represent the extents of the data collected. Difference maps in Figure 14 show the elevation changes between data sets (2010-2006; 2013-2010; and 2013-2006). The differences can only be computed over areas where the data sets overlap. The difference maps show similar trends. The outer extents of the shoal offshore EI (to the northwest of the inlet) are accreting over time. Also, the main channel area, while not well represented in the data, appears to be deepening. This indicates a potentially growing tidal prism, as the inlet entrance grows to allow for more flow into and out of the bay. This is an expected morphological process in estuaries with relatively gently sloping bathymetry experiencing relative sea level rise. This pattern may also simply indicated migration of the main thalweg of the channel which would tend to modify the morphologic patterns. Positive conclusions on this cannot be made without a longer-term and better defined data set.

These inlet bathymetry data sets were used to estimate the volume of the sand in the ebb shoal. The definition of the shoal is challenging to determine. Reasonable estimates would include all the volume above the depth of closure, or volume above the adjacent active beach profile, or possibly some other metric. CHE computed the volume represented in the surveys above three elevations: -8 ft NAVD, -11 ft NAVD, and -14 ft NAVD. The first two, -8 ft and -11ft, reflect what appears to be the possible range of extents of the shoal based on visual observation. Without larger spatial extents and a few more realizations of the bathymetry, it is difficult to determine. The -14 ft represents the depth of closure determined as discussed below in Section 6.5.

The ebb shoal volume calculations, and the volume changes, are shown in Table 9. Based on these results and engineering judgment, we estimate the ebb shoal volume to be between 7.5 and 10 million cy. It is likely that in fact the shoal varies by as much as several million cubic yards over decadal time scales due to episodic morphological processes such as the welding of a bypassing bar to the downdrift shoreline, or attachment of a bar to the updrift shoreline as occurred in the early 1970s.

The measured change rates range from +42,000 cy/yr to -33,000 cy/yr. These values are relatively small compared to the total volume, and are likely within the error bounds of our ability to accurately estimate the volumes and therefore any volume change conclusions have limited value. However, these changes may indicate between 2006 and 2010, on the order of 40k cy was deposited on the ebb shoal, and then between 2010 and 2013 75% of that material was transported off the shoal and on to Lover's Key as a bypassing event.

Circulation modeling was conducted of the project vicinity; results are discussed in Section 6.3 and illustrate tidal circulation patterns and magnitudes in the inlets. Results also provide a measure of the tidal prism and from that an estimate of the ebb shoal volume of Big Carlos Pass.

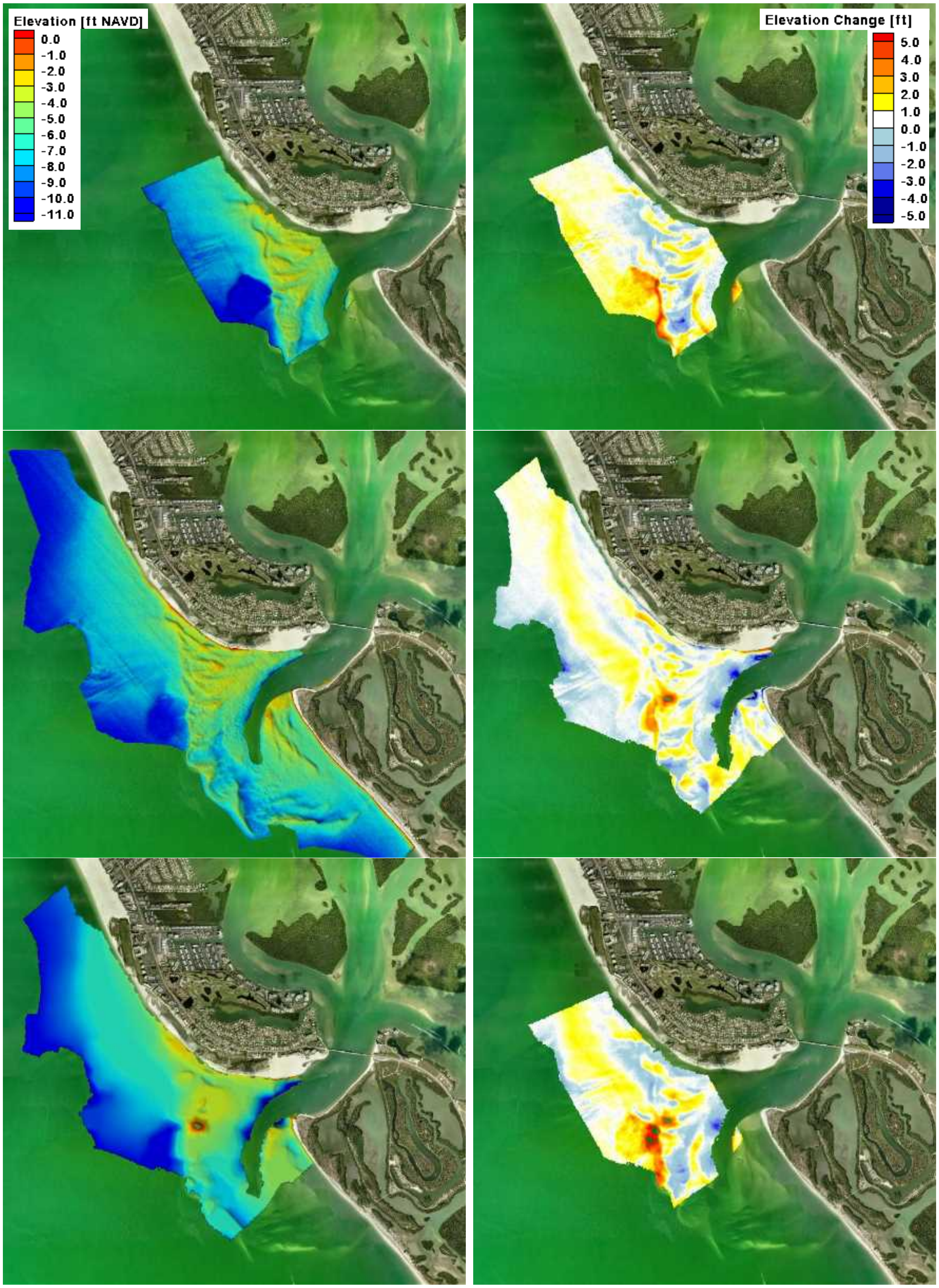


Figure 14. Big Carlos Flood Shoal elevation data from 2006 LIDAR (top left), 2010 LIDAR (middle left) and 2013 survey (bottom left). Big Carlos Flood Shoal elevation changes: 2010 - 2006 (top right), 2013 - 2010 (middle right) and 2013 – 2006 (bottom right). Hot colors (positive) indicate accretion while cool colors (negative) indicated erosion.

Table 9. Big Carlos Pass ebb shoal volume and volume changes computed on bathymetry data from 2006, 2010, and 2013.

	total volume in available data extents	volume in 2006 extents	volume in 2013 extents
Volume above -8 ft NAVD [cy]			
2006	1,053,000	1,043,000	--
2010	2,243,000	1,040,000	1,784,000
2013	1,843,000	1,092,000	1,809,000
Volume Changes above -8 ft NAVD [cy/yr]			
2010-2006	--	-750	--
2013-2010	--	17,333	8,333
2013-2006	--	7,000	--
Volume above -11 ft NAVD [cy]			
2006	3,100,000	3,070,000	-
2010	7,190,000	3,240,000	5,530,000
2013	5,500,000	3,220,000	5,420,000
Volume Changes above -11 ft NAVD [cy/yr]			
2010-2006	--	42,500	--
2013-2010	--	-6,667	-36,667
2013-2006	--	21,429	--
Volume above -14 ft NAVD [cy]			
2006	9,550,000	5,550,000	-
2010	13,890,000	5,720,000	9,920,000
2013	11,930,000	5,700,000	9,820,000
Volume Changes above -14 ft NAVD [cy/yr]			
2010-2006	--	42,500	--
2013-2010	--	-6,667	-33,333
2013-2006	--	21,429	--

6 Numerical Modeling of Coastal Processes

6.1 Bathymetric Surface Model Development

A bathymetric surface model was developed to obtain a consistent bathymetry set covering a wide region required for wave and circulation modeling. Three different bathymetry sets used to develop the bathymetric surface model in the order of preference were: 2013 topography and bathymetry data, 2010 LIDAR bathy data, and NOAA's GEODAS bathy data. The developed bathymetric surface model in the project vicinity and the EI surface model are shown in Figure 15 and Figure 16 respectively.

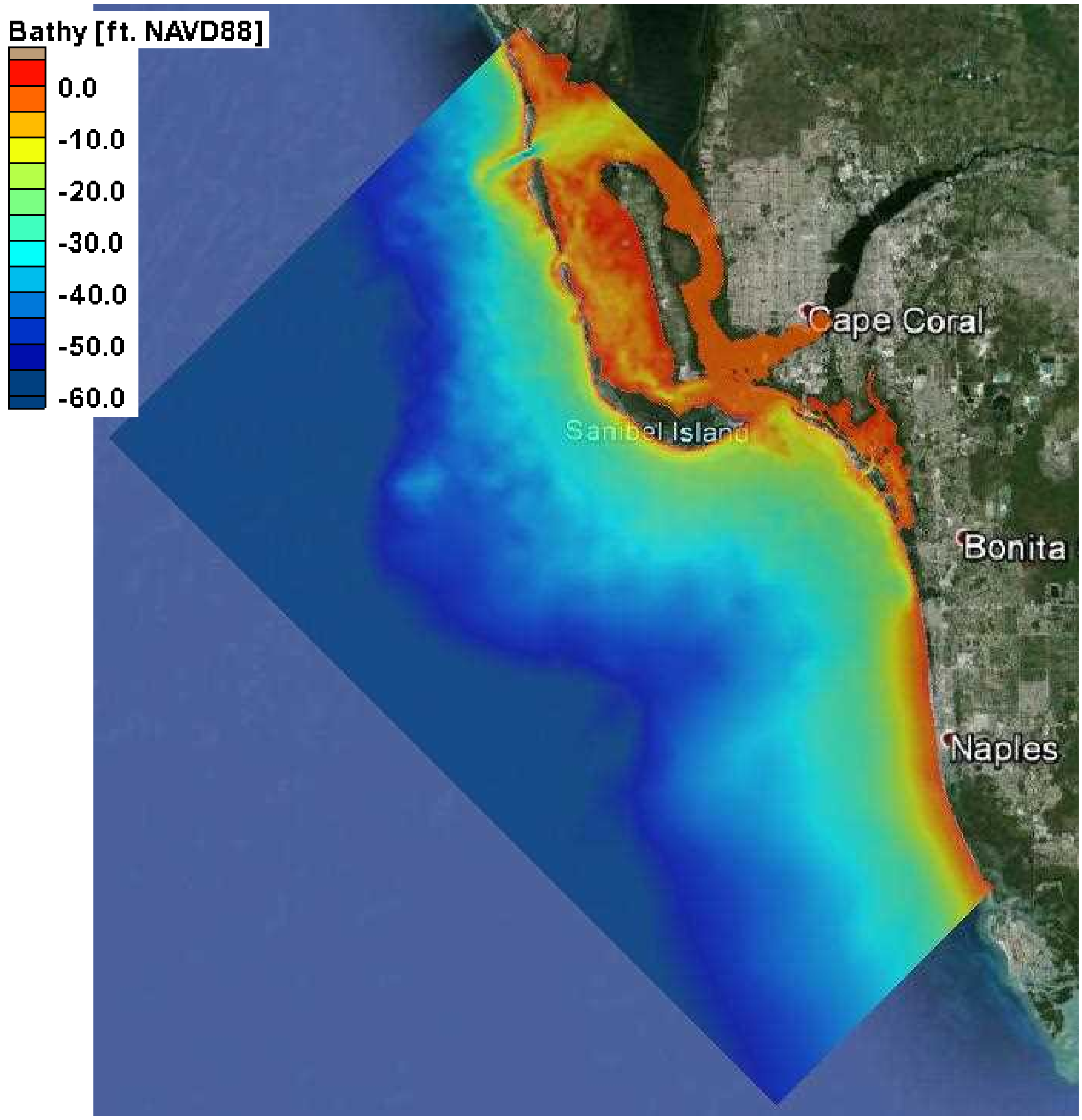


Figure 15. Project vicinity surface model.

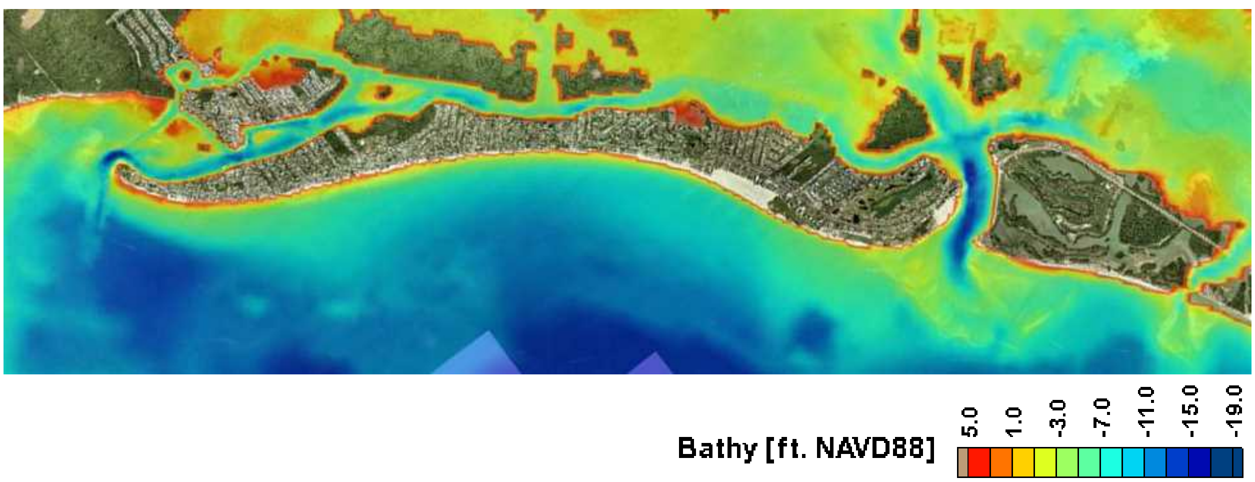


Figure 16. EI surface model.

6.2 Wave Modeling

Wave modeling was conducted to transform waves at the available WIS and ECMFW locations near the project to the shoreline. The nearshore wave modeling is used to develop an understanding of the local wave climate, which is used to drive longshore transport and shoreline morphology models, and is used in conceptual design calculations for structures to determine hydraulic stability.

Wave modeling was conducted using the SWAN model. SWAN (Delft, 2012) is a 2-D, spectral (phase-averaged) wave transformation model that can be used to generate wind-waves and transform wave conditions to the nearshore project area. SWAN simulates wind-wave generation, transformation on the current, refraction, shoaling, nonlinear wave-wave interactions and energy dissipation through white-capping and breaking.

A wave modeling grid was developed using the bathymetry surface model developed in Section 6.1. The grid domain and resolution is illustrated in Figure 17. The grid extends 103 km parallel to the shore and 65 km perpendicular to the shore, and uses variable spacing where larger grid cells are used in the offshore, deeper water and on areas that do not influence waves at the site, and resolution is increased in the nearshore and at the project site.

To understand the wave transformation to the project site, a series of wave model runs were conducted using the same wind speed and input wave conditions, but with direction varied around the 16 points of the compass. The input wave conditions were a height of 1 m (3.3 ft) and a period of 5 sec. Results are shown in Figure 18 and Figure 19. These figures show the wave height as color contours and wave direction as the arrows. The input wave direction is indicated with an inset white arrow in the top right of each panel of the figure. Some observations from these model results are that waves are generally smaller on the northern end of the island than the central and southern end. Also, waves are nearly shore normal for waves coming from the northwest, west, and southwest, a result of the wide, very flat Gulf bottom fronting the island. Finally, the waves on the north end of the island tend to be less shore normal and at an angle that would drive more northerly longshore transport than on other parts of the island.

This model setup was used to transform waves from the WIS station to the nearshore region where wave height, period, and direction were extracted for use in the longshore transport and shoreline morphology modeling applications. A dynamic downscaling method was used to sort the wave inputs from the WIS gage into bins designed to capture the relevant combination of conditions to be representative of the input wave climate. SWAN was used to transform those representative cases (3566 cases) to the nearshore. Then, a transfer function was developed between the WIS input and the nearshore results to generate a time series along the island shoreline. These results were used in longshore transport calculations (Section 6.4) and in shoreline morphology modeling (Section 6.5).

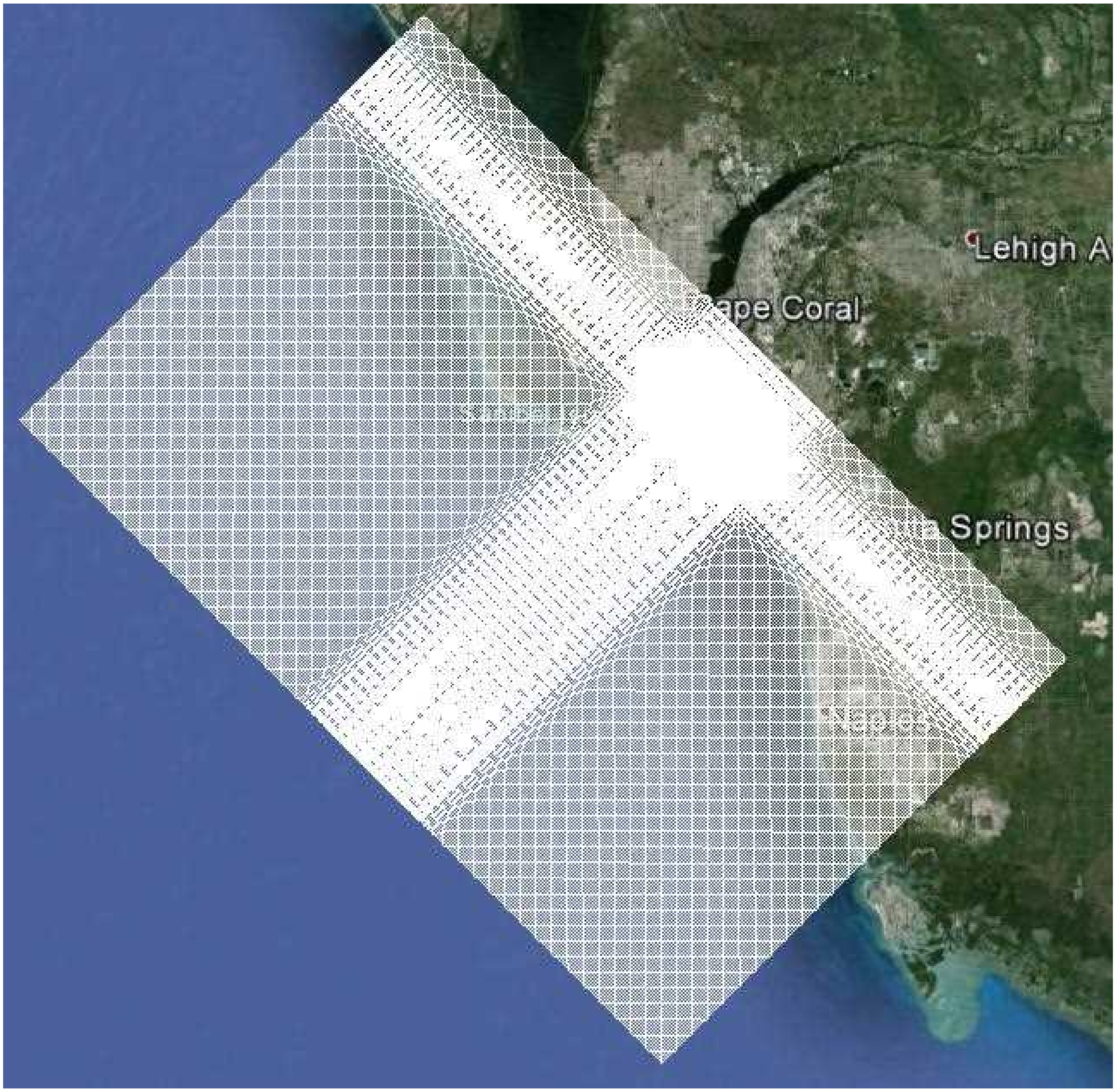


Figure 17. EI wave model domain and variable resolution grid**.**

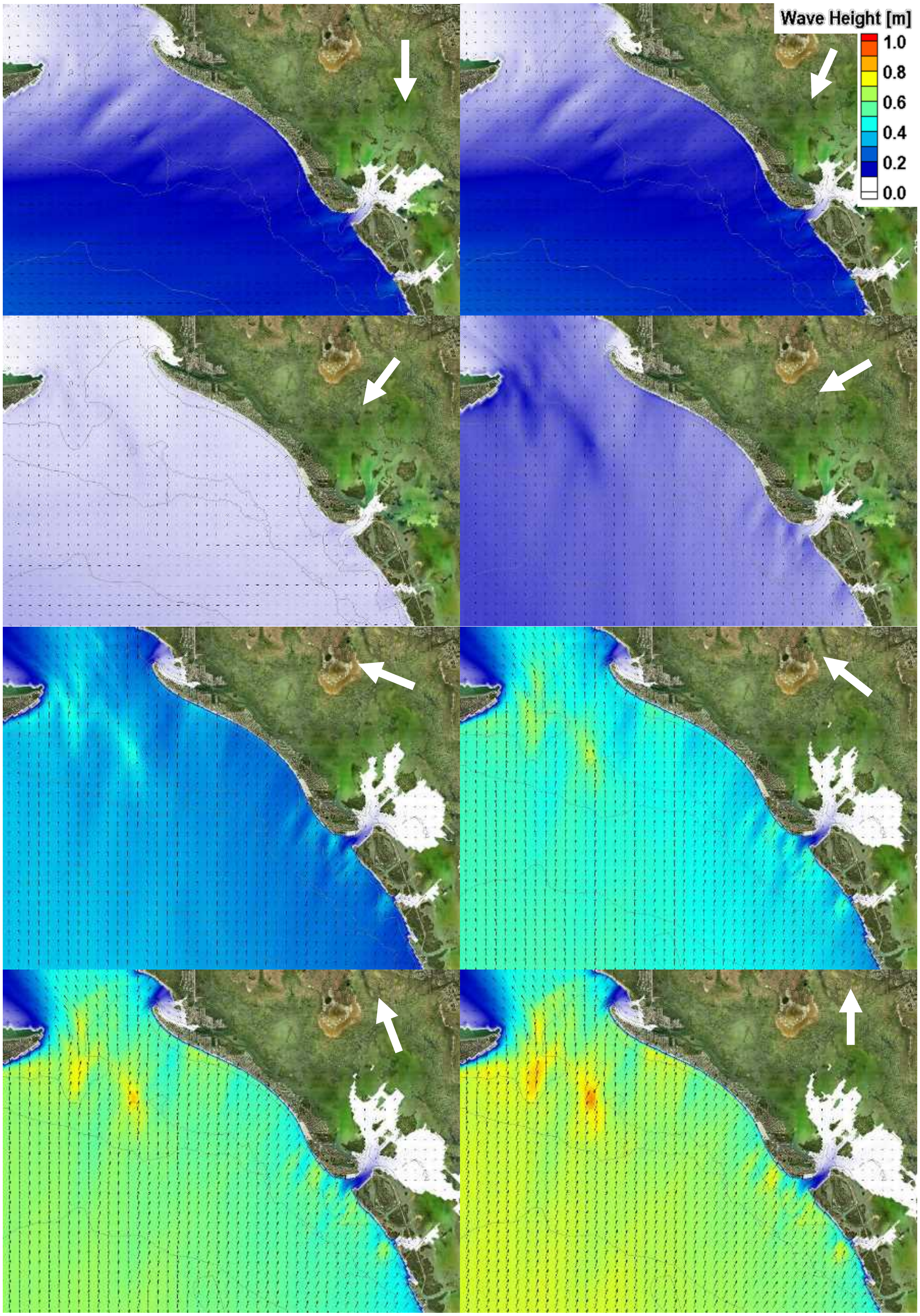


Figure 18. EI wave model results for wind and waves from various points of the compass. Input wave direction indicated by white arrow in top right of each figure.

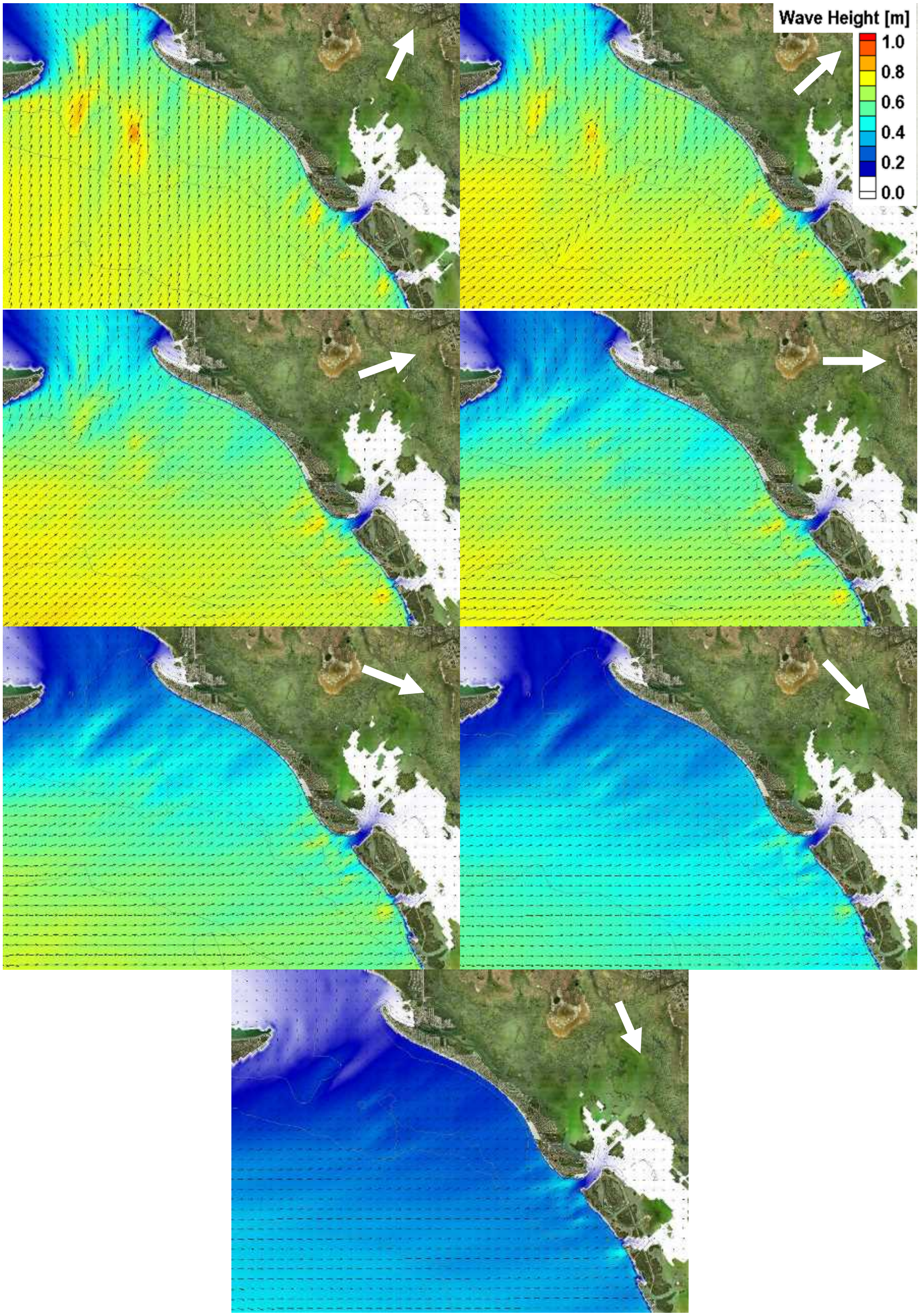


Figure 19. EI wave model results for wind and waves from various points of the compass. Input wave direction indicated by white arrow in top right of each figure.

6.3 Circulation Modeling

Circulation modeling was conducted to develop an understanding of the circulation patterns and magnitudes in the project vicinity. The circulation modeling used the model MORPHO. MORPHO-UNS (Kivva et al., 2006) is an unstructured finite volume fully nonlinear 2-D model that simulates depth-averaged surface water flow, sediment transport, and bottom-change morphology in the near-shore zone. MORPHO-UNS has significant other capabilities, including a built-in hurricane wind model, wave modeling coupling, rainfall, evaporation, constituent transport, and can be used to simulate salinity in the absence of density effects.

Morpho uses an unstructured finite element mesh (grid) for modeling. The modeling domain and grid are shown in Figure 20. Elevations were interpolated from the bathymetry surface developed in Section 6.1. The grid resolution is approximately 1 km on the offshore boundary and less than 5 m in areas near the project site.

Figure 20. EI circulation model domain – entire grid (left) and EI project area (right).

Little data was available to calibrate the model. In 2002, USGS installed two flow gages near the site, one on the bridge over Big Carlos Pass and one on the bridge across Matanzas Pass. Both gages measured flow rates through the channels; the gage at Matanzas measured water surface elevation (Byrne and Gabaldon, 2008). The circulation model was develop and run during the time period over which the gages were installed, and results were compared as shown in Figure 21.

Results of the circulation modeling are shown in Figure 22, Figure 23, and Figure 24 for flood and ebb currents for the entire project domain (Figure 22), Matanzas Pass (Figure 23), and Big Carlos Pass (Figure 24). Observations from these results indicate that flow through Big Carlos Pass is 3-4 times larger than flow through Matanzas. Velocities in Big Carlos reach 1 m/sec (3.3 ft/sec) and in Matanzas reach about 0.7 m/sec (2.3 ft/sec). Also, there is a non-negligible tidal influence on the shorelines adjacent to both passes, especially on flood tide, which tends to increase sediment transport off the island and into the passes.

The measured flow data was also used to compute an estimate of the tidal prism of Big Carlos Pass. Both measured flow data and modeled results yield a tidal prism of approximately 10^8 ft^3. Other means are available to compute the tidal prism. Simply using the bathymetry and the estimated water elevation change due to tides, the tidal prism is approximately 7.2 x 10^8 ft^3, while Godshalk and Associates (1988) estimated the tidal prism at 8.2 x 10^8 ft^3. Walton and Adams (1976) developed a relationship between the tidal prism of inlets and the ebb shoal volume based on measured inlets across the United States shorelines. Using this relationship, shown in Figure 25, and a tidal prism range of 7 to 10 x 10^8 ft^3, the ebb shoal volume is between 8 to 15 million cy, reasonably within the range computed based on available surveys.

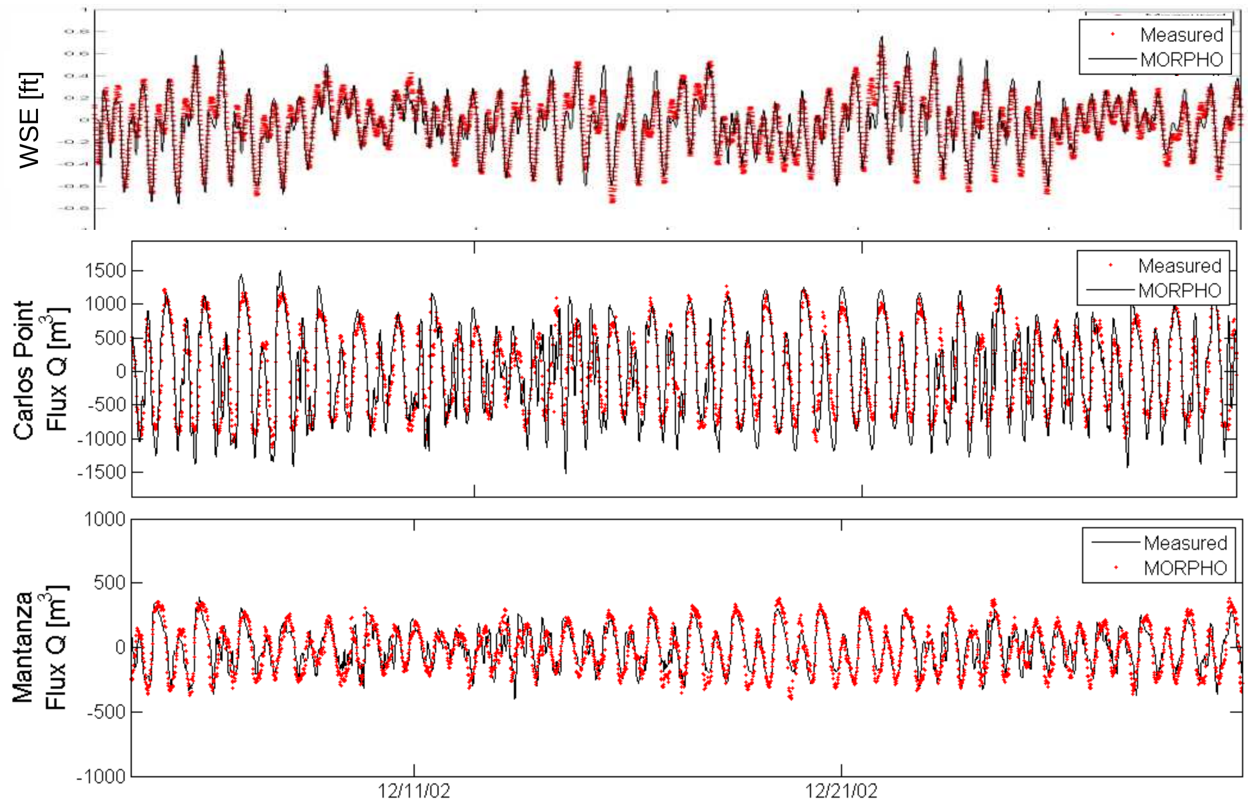


Figure 21. EI circulation model calibration -water surface elevation at Big Carlos Pass (top), flow rate at Big Carlos Pass (middle), and flow rate at Matanzas Pass (bottom).

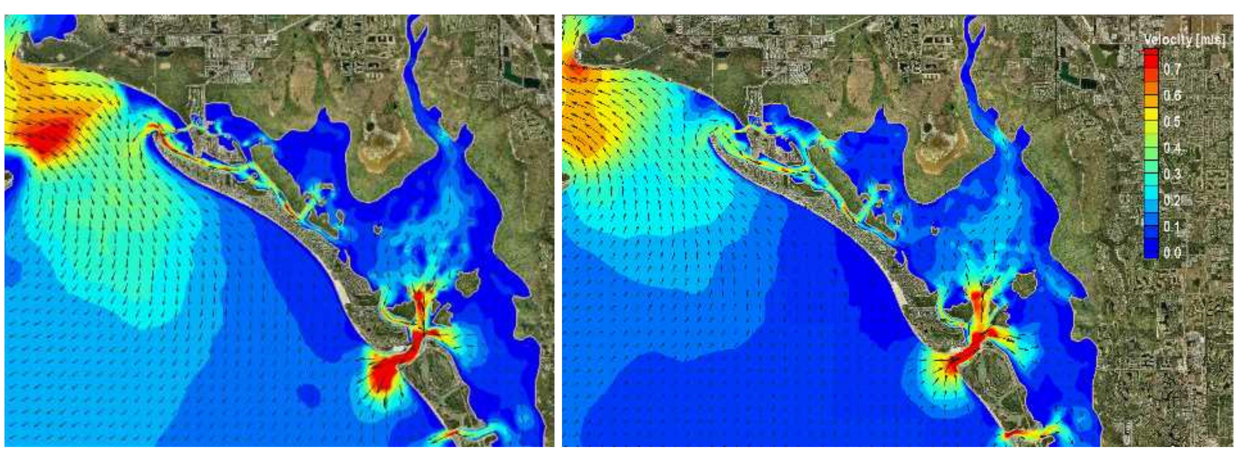


Figure 22. Tidal current velocities computed by the MORPHO circulation model for the project vicinity at max ebb flow (left) and max flood flow (right)

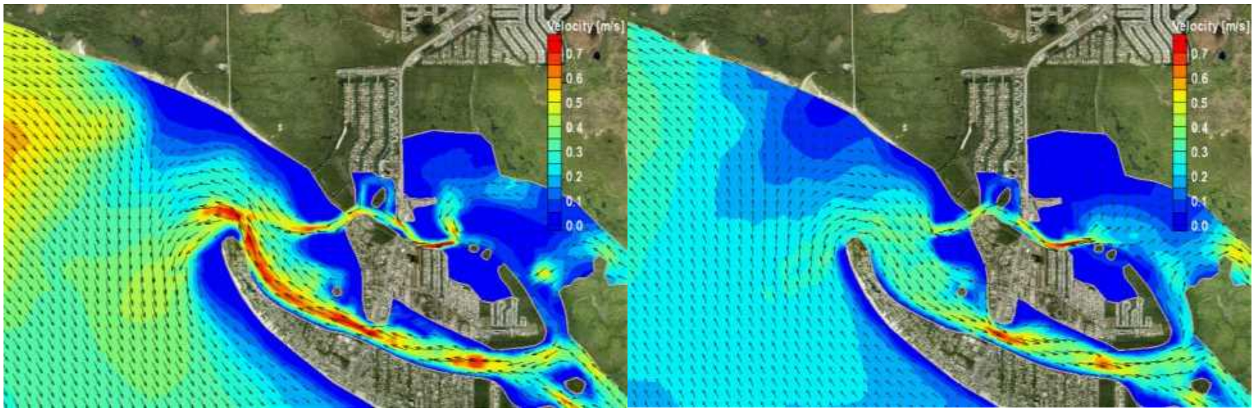


Figure 23. Tidal current velocities computed by the MORPHO circulation model at Matanzas Pass at max ebb flow (left) and max flood flow (right)

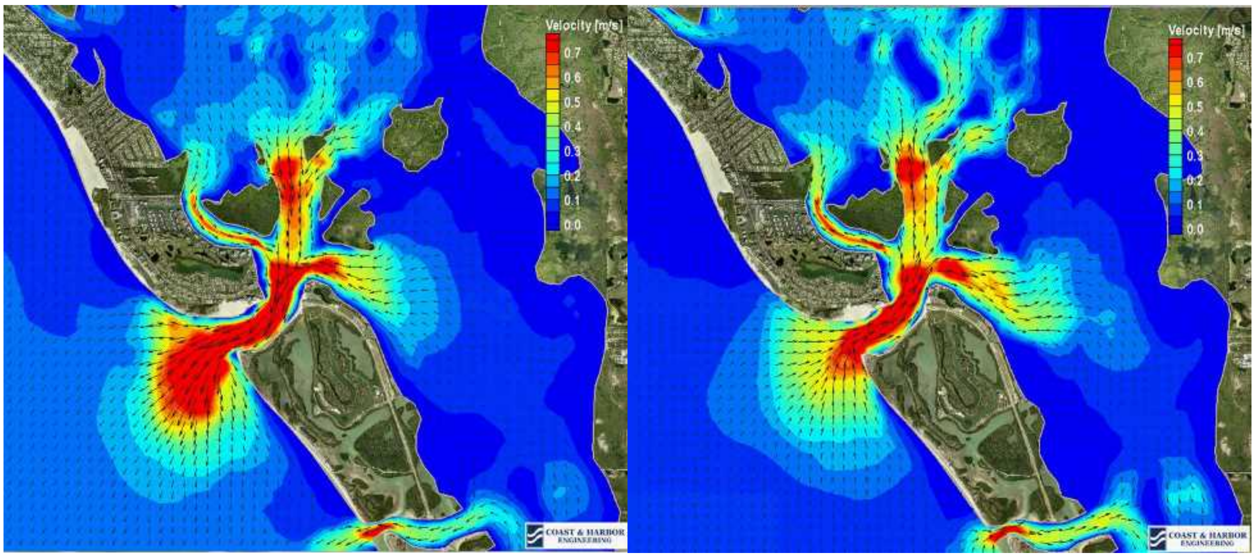


Figure 24. Tidal current velocities computed by the MORPHO circulation model at Big Carlos Pass at max ebb flow (left) and max flood flow (right)

6.4 Longshore Transport Modeling

In order to develop an understanding of longshore transport processes along the project shoreline, the wave modeling results developed in section 6.2 were used to drive longshore transport calculations. Wave parameters (Hs, Tp, and direction) were extracted at the 2 m (6.6 ft) contour along the shoreline to use the SWAN model from 1979 to 2011 to properly compute wave transformation while still capturing 95% of waves prior to breaking.

These wave parameters were then used to compute the longshore transport rates through the CERC equation (USACE, 2002). The CERC equation is a well-established tool to compute longshore transport, and requires calibration of a free parameter 'K'. Using the default value of K=0.39 recommended by USACE, longshore transport into Matanzas Pass matched well with estimated sedimentation in Matanzas Pass determined through dredging rates of approximately 30,000 cy/yr. Therefore, it was determined that the default K value is sufficient to model longshore transport rates. Results of the longshore transport calculations are shown in Figure 26 to Figure 28.

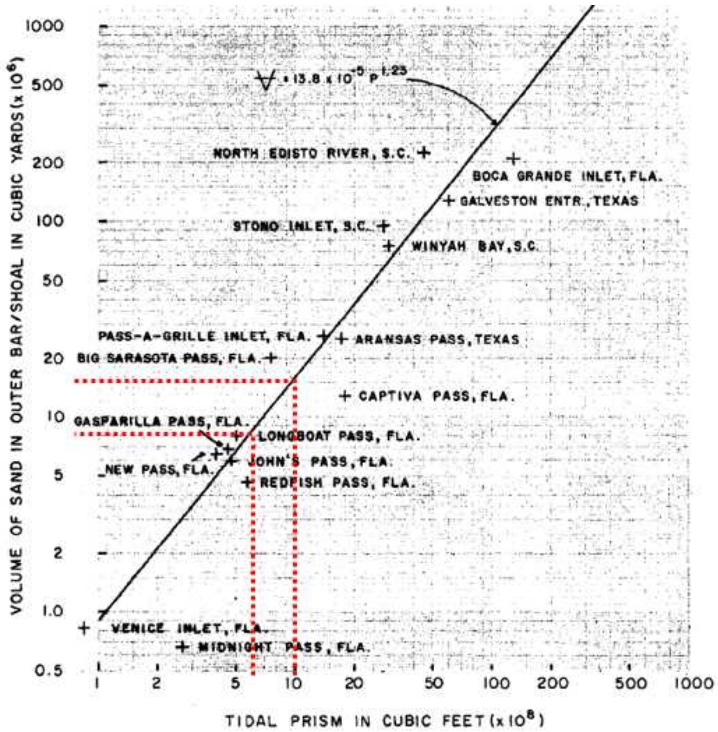


Figure 25. Tidal prism and ebb shoal volume relationship developed by Walton and Adams (1976). Range of estimates of tidal prism at Big Carlos Pass is shown between red dashed lines.

Figure 26 shows the long-term gross and net transport rates for the project site. Red bars show gross transport north, blue bars show gross transport south, the solid black line shows the net transport (positive values are northward transport; negative values are southward transport), and the dotted black lines show the envelope of maximum and minimum transport. These results show that on the northern end of the island from R-180 north, the transport is always to the north, and that the divergent nodal point in transport on net is in a range from R-186 to R-188. However, year to year, the exact location of the nodal point varies over the range of R-185 to R-194. Generally, between R-188 and R-200, transport is slightly to the south on net, but is very bi-directional and the southern transport more or less balances the northern transport. A convergent nodal point exist around R-200 to R-201. This area corresponds to a region that has experienced accretion over the past 30 years, as the historical shoreline records indicate. R-204, has the largest transport rates, which are directed northward. A second divergent node point occurs at R-206 near the Leonardo Arms condominium. Divergent nodal points typically have high erosion rates as all sediment along the shoreline is directed away from that point. This also reflects observed historical shoreline change rates. Maximum net transport into Big Carlos Pass is on the order of 50,000 cy/yr, but ranges from 0 to as much as 130,000 cy/yr.

Figure 27 shows monthly ensemble longshore transport rates at select locations along the project site. Monthly ensembles consist of all longshore transport values that occurred during each month of the year averaged for that month; the figure shows the gross northerly, gross southerly, and net transport rates. These results show a clear seasonal trend of much higher transport rates during winter months than summer months. The net direction of transport reflects the trends shown in Figure 26: northerly transport on the north of the site, bi-directional transport through the middle reach of the island, and strong northerly and southerly transport at R-204 and R-208.5 respectively on the south of the Island.

Figure 28 shows the variation in gross and net annual transport rates at the same monuments as shown in Figure 27. Here the trends remain the same as shown in the monthly ensemble rates. Also these results show that the annual transport can vary by more than a factor of two from year to year.

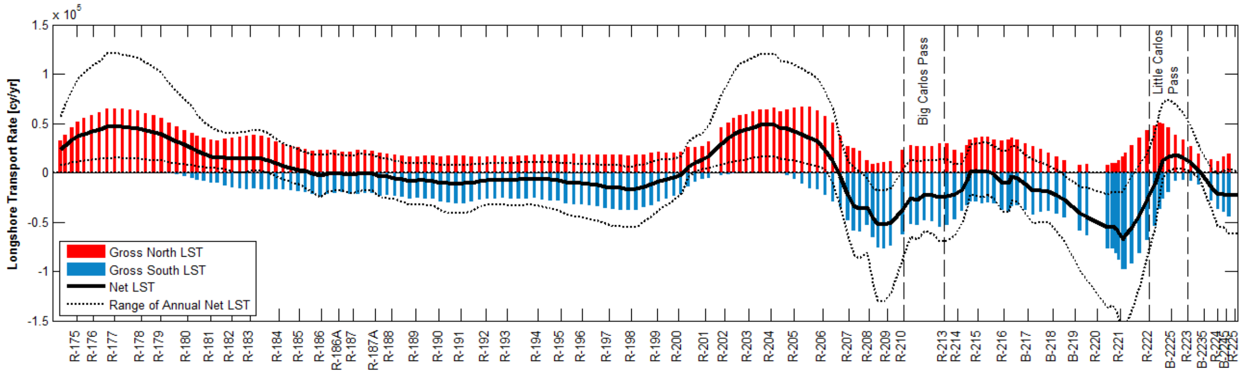


Figure 26. Computed LST rates along EI from 1979 to 2011. Gross northern transport is shown with red bars, gross southern transport is shown in blue bars, the thick black line shows the net longshore transport rate, and the dotted lines show the range of net longshore transport

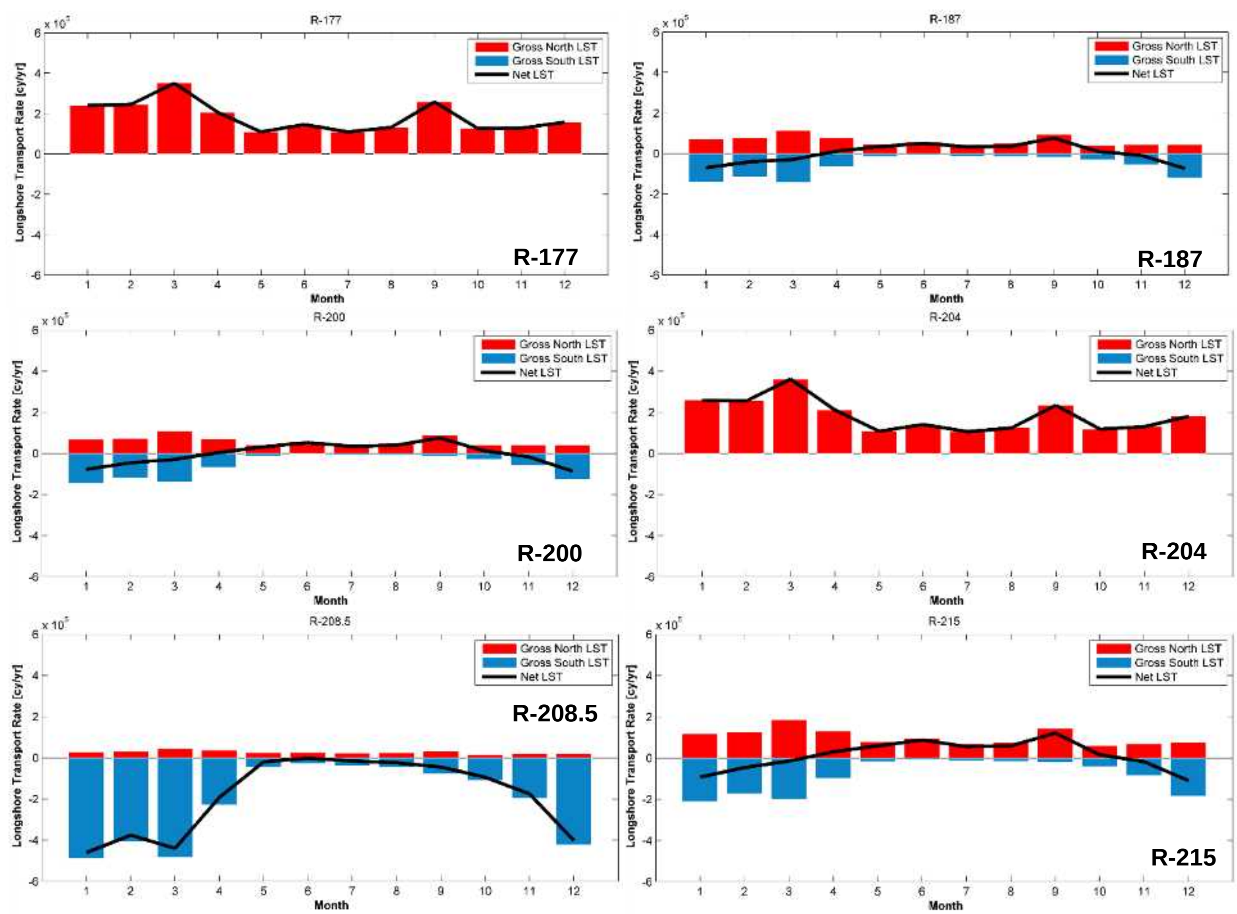


Figure 27. Monthly ensemble average computed LST rates along EI from 1979 to 2011. Gross northern transport is shown with red bars, gross southern transport is shown in blue bars, and the thick black line shows the net longshore transport rate.

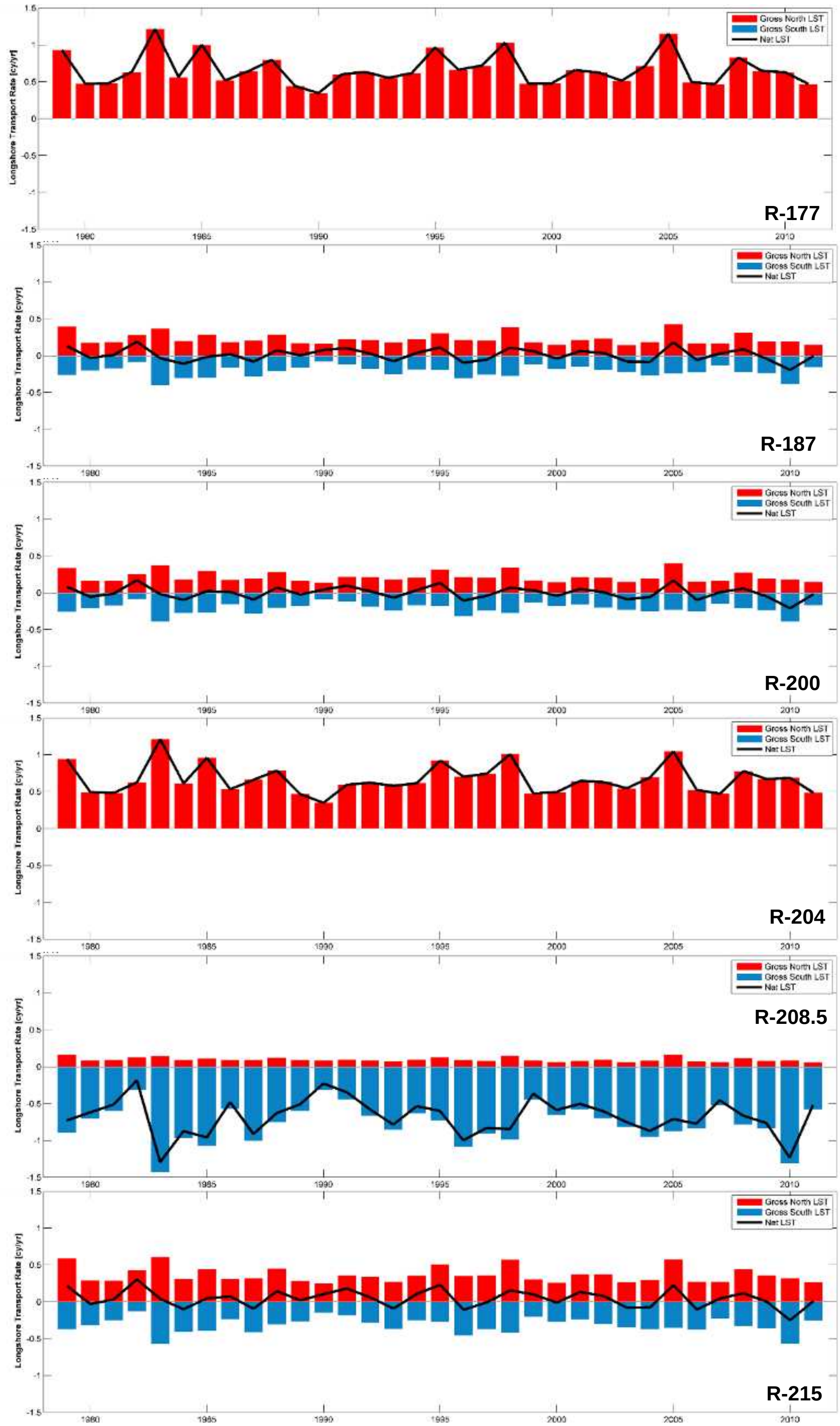


Figure 28. Computed LST rates along EI from 1979 to 2011 at individual stations. Gross northern transport is shown with red bars, gross southern transport is shown in blue bars, and the thick black line shows the net longshore transport rate.

Based on the results of the morphology analysis discussed in Section 5 and these longshore transport rates, a hypothesis on the long-term morphology patterns along the island was developed and is presented in Figure 29. This figure shows the expected transport direction by arrows, and relative magnitude by color, where cool colors show less transport and warm colors reflect more transport. The general trend is northerly transport on the north, a divergent node that occurs in the north 1/3 of the island and any given year can vary in location as much as almost two miles. Similarly, a convergent node exists between a range of R-198 and R-202. Sediment is transport into and across Big Carlos Pass and bypassed to Lovers Key. On the extreme northern end of Lover's Key, sediment is transported into the pass, and near R-215 another divergent node occurs. From R-215, transport is generally to the south along Lover's Key.

Figure 29. Estero Island morphology patterns.

6.5 Shoreline Morphology Modeling

Shoreline morphology modeling was conducted to qualitatively predict on a planning-level the beach response of future with and without alternatives. GenCade (Frey et. al., 2012), a 1-D shoreline morphology numerical model based on the synthesis of the GENESIS model (Hanson and Kraus, 1989) and the Cascade model (Larson et. al., 2003) was used. GenCade calculates shoreline change and wave-induced long-shore sand transport.

GenCade model setup requires defining the initial shoreline, wave forcing conditions, boundary conditions, time step and duration for model run and beach characteristics (effective grain size, average berm height, depth of closure, longshore sand transport calibration coefficients) as the primary parameters for model execution. The model setup also provides the capability to define other natural and structural features such as inlets, breakwaters, groins, seawalls, and beach nourishment events.

The GenCade grid extended from the Big Hickory Island in the south to the end of Estero Island in the north and included the Big Carlos Pass. For simplicity and due to lack of data the New Pass was included as a continuous shoreline connecting the Lovers Key in the north to Big Hickory Island in the south. Based on results discussed in Section 5.2, the initial and equilibrium ebb shoal volumes for the Big Carlos Pass were set at 8.0 and 9.5 million cy.

The wave time series developed from the SWAN modeling were used as the wave forcing to drive the model. Based on the review of available geotechnical data and surveyed beach profiles the effective grain size, average berm height and depth of closure were set as 0.14 mm, 5.5 ft NAVD88, and 14 ft NAVD88 respectively. The longshore sand transport calibration coefficients were calibrated and finalized during the calibration run and are discussed in Section 6.5.1. The model setup was calibrated (Section 6.5.1) and validated (Section 6.5.2) before using it for

FWOP (Future With-out Project) conditions (Section 6.5.3) and testing different FWP (Future With Project) or Alternatives (Section 8) on the existing shoreline.

GenCade is a one-line model which has certain limitations. It assumes a uniform cross-sectional beach profile (essentially uniform shore parallel contours) for the modeling domain. This assumptions is not valid in areas with large variations in cross-shore morphology, and especially in areas near inlets. Also, for simplicity it assumes a constant grain size, berm height and depth of closure for the entire model domain and therefore detail level variations along the beach cannot be included in the model setup. Considering these limitations, the GenCade model for the project shoreline will be sufficient to capture overall trends for shoreline morphology but the model will not resolve detailed morphology, especially near the inlets, with a high level of certainty. Therefore, caution should be used in interpreting results, especially detailed variations in results and should focus on the larger scale patterns and trends identified.

6.5.1 Calibration Run

Model calibration was conducted for the period between 4/2002 and 1/2005. This period was chosen for calibration run because of the availability of shoreline data and because this period has no beach nourishment events on the Estero Island. The beach nourishment event on the Lover's Key in 2004 was included in the model.

The longshore sand transport calibration coefficient K1 that gave the best calibration results was found to be 1.04. The second calibration coefficient K2 only effects the evolution in areas influenced by wave diffraction near structures. Due to the lack of any structures in the modeling domain during the calibration period run, guidance from available literature (Frey et. al., 2012, USACE, 2001) was used to fix the value of K2 to 0.52 (K2 ~ K1/2).

The results of the calibration run are shown in Figure 30 and Figure 31. Figure 30 shows the starting (2002), measured (2005) and modeled (2005) shorelines. It shows that the calibrated model is able to predict the future shorelines with good levels of accuracy. To quantify the accuracy levels of the calibrated model, difference between the modeled and measured 2005 shorelines is plotted in Figure 31. The error (approximately +/- 40 ft) in shoreline delineation due to wet/dry line is also plotted on the figure to give a sense of the accuracy level. Brier Skill Score (BSS) was used as a quantification measure for the accuracy of calibrated model. BSS is a statistical measure of the accuracy of forecast predictions and ranges from less than 0 to a maximum of 1.0. Higher the BSS, more accurate is the prediction. A BSS above 0.8 is classified as excellent, while a BSS between 0.6 and 0.8 is classified as good. The BSS for the calibration run was computed as 0.9 which indicates that an excellent match is produced between the modeled and measured shoreline positions. The average calibration error (average absolute change between modeled and measured shoreline for the calibration period) was also computed and is 22 ft.

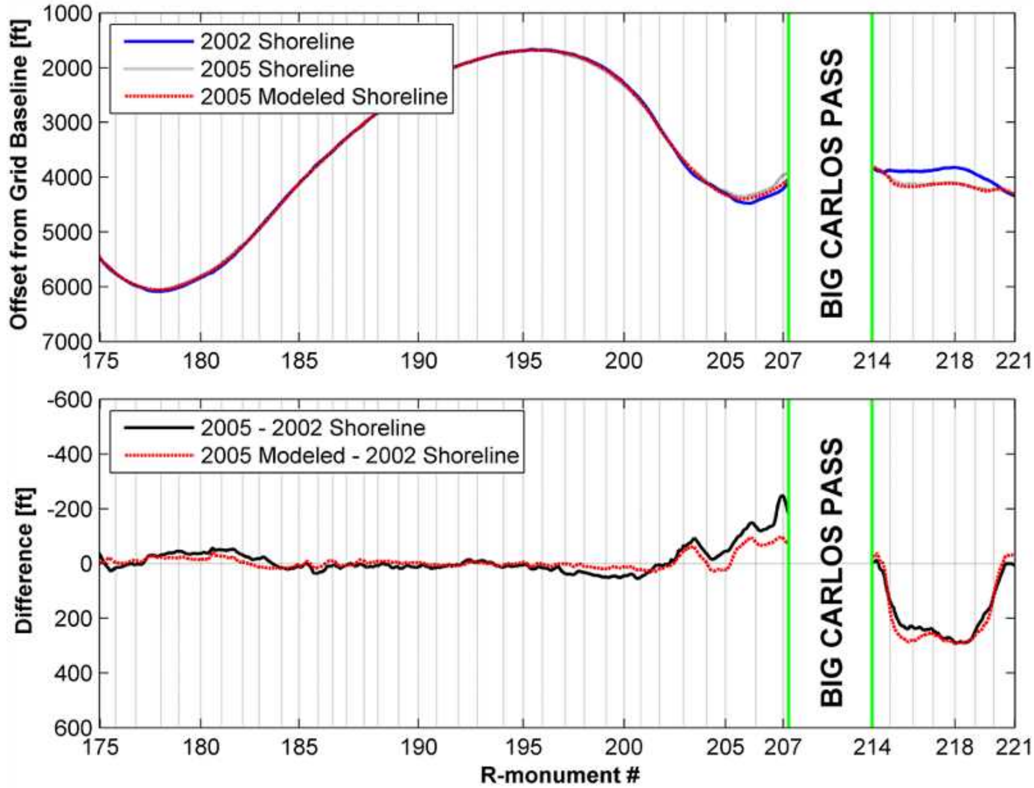
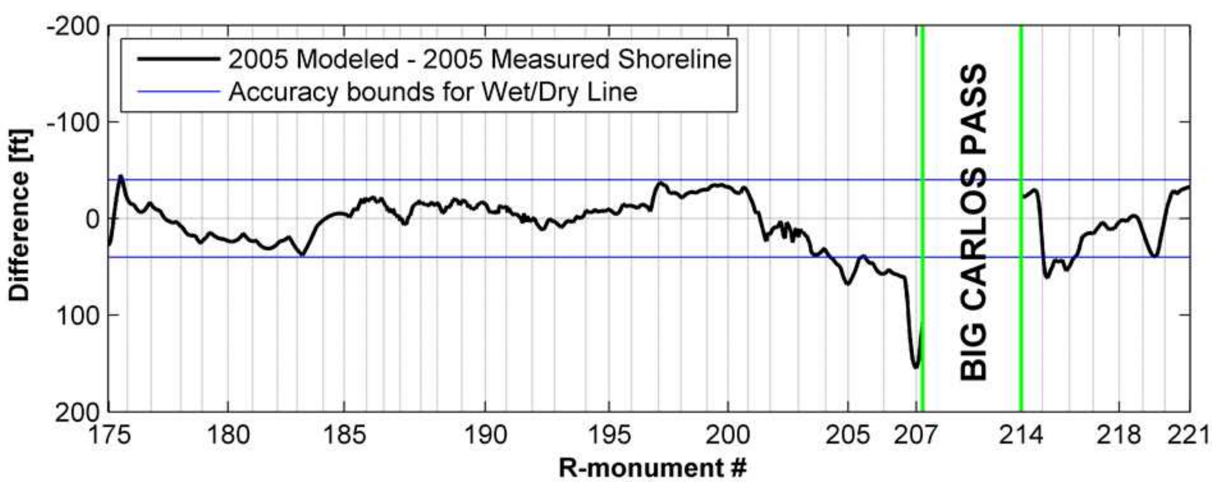


Figure 30. (top) Initial (2002), Measured (2005) and Modeled (2005 Modeled) shorelines for the project shoreline and (bottom) Difference of the measured (2005) and modeled (2005 modeled) shoreline from the initial (2002) shoreline for the calibration run.



s

Figure 31. Difference between the modeled (2005 modeled) and measured (2005) shoreline for the calibration run.

6.5.2 Validation Run

Model validation was conducted for a period from 4/2002 to 8/2007. The beach nourishment event on the Lover's Key in 2004 was included in the model. Results for the validation run were plotted in a similar fashion as the calibration run and are shown in Figure 32 and Figure 33. The computed BSS for the validation run is 0.85 which falls under the excellent classification for the BSS. The average validation error was computed as 26 ft. The calibration and validation runs suggests that the model setup can be used with fair level of accuracy for qualitative analysis of the project shoreline with and without proposed alternatives.

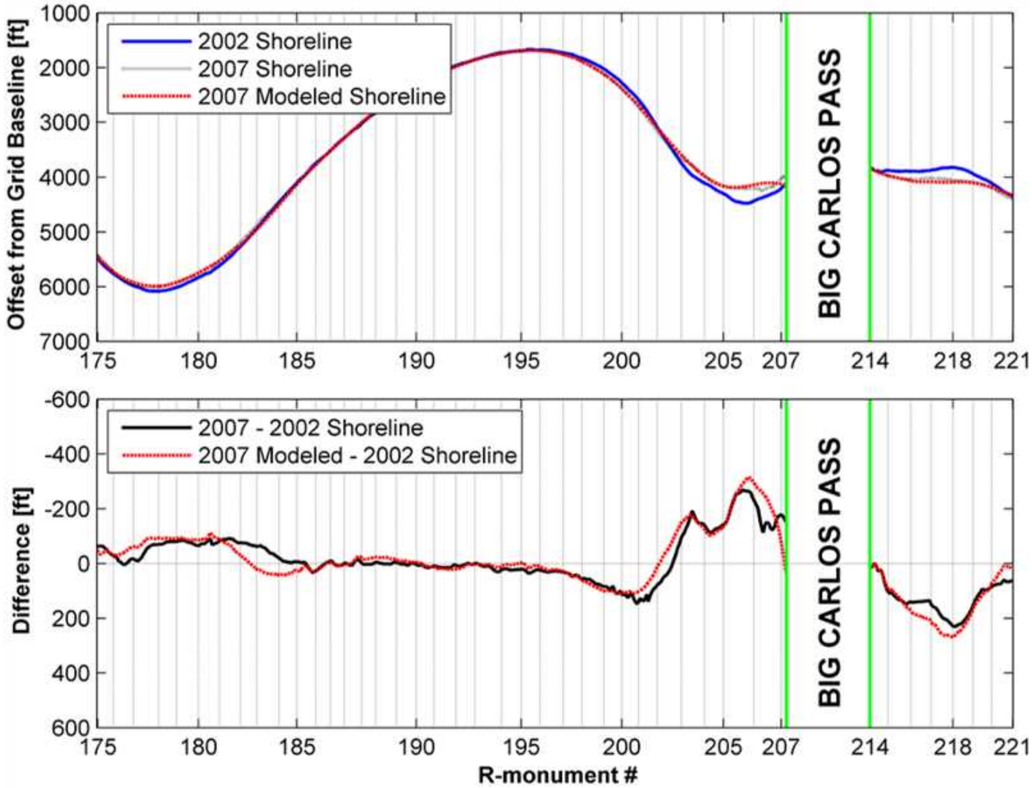


Figure 32. (a) Initial (2002), Measured (2007) and Modeled (2007 Modeled) shorelines for the whole project shoreline and (b) Difference of the measured (2007) and modeled (2007 modeled) shoreline from the initial (2002) shoreline for the validation run.

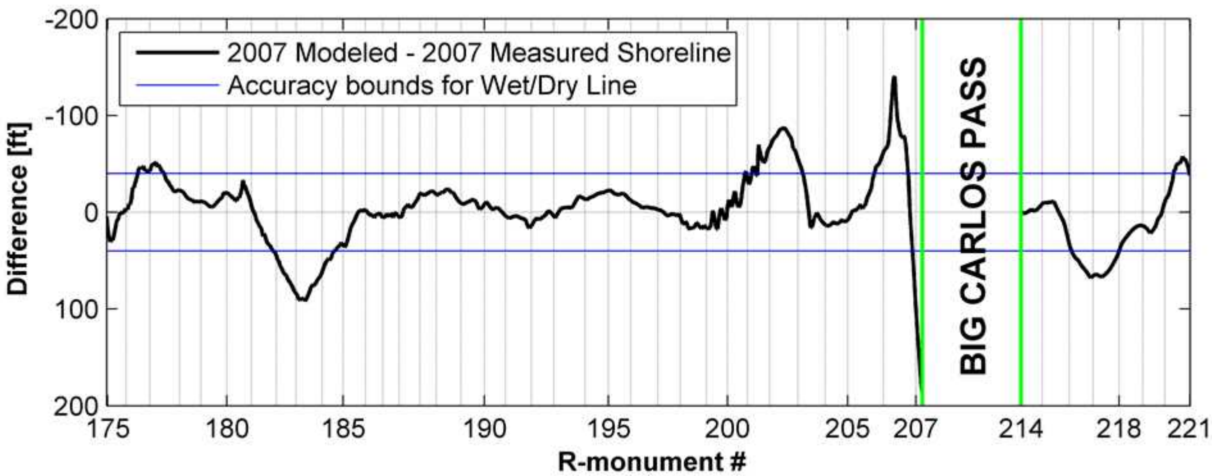


Figure 33. Difference between the modeled (2007 modeled) and measured (2007) shoreline for the validation run.

6.5.3 Future without Project Model

Future without Project (FWOP), the same as existing conditions projected into the future, scenario was computed to determine the shoreline morphology over the next several years and to develop an understanding of the sand transport pathways to be able to effectively design shoreline protection alternatives.

Post-beach nourishment (2012) shoreline was used as the starting point for the FWOP run as that incorporates the base beach fill on the northern Estero Island. The historic 20 years of hindcast wave conditions (1991 to 2010) was assumed to sufficiently replicate the future conditions (2012 to 2032). The existing groin on the northern end of EI was included into the model. FWOP model run results are shown for an 8 year period from 2012 to 2020, as that is the estimated re-nourishment cycle period (CPE, 2001a) of the beach nourishment on Reach 1. Figure 34 shows the beach response for the northern and central shoreline on Estero Island and Figure 35 shows the beach response for the southern shoreline of Estero Island near Big Carlos Pass and the adjacent shoreline at Lover’s Key. For FWOP conditions, after approximately 8 years, the shoreline on the northern end of island shoreline retreats to the infrastructure just southeast of the pier at R-181.

The central shoreline from R-182 to R-201 does not vary much from the starting shoreline after 8 years, reflecting historical morphological trends. However between R-187 and R-188, the shoreline recedes just landward of the existing vegetation line after 2-3 years. At 8 years, the total recession at that location is less than 20 ft, well within the ability of the model’s accuracy.

The southernmost section of the Estero Island’s shoreline from R-202 to R-209 experiences large shoreline retreat varying from 50 to almost 350 ft in 8 years. After approximately 4 years, the shoreline has receded to the existing vegetation and infrastructure at R-204. The adjacent shoreline on Lover’s Key also suffers mild shoreline retreat on the order of about 100 ft in 8 years. These trends correspond well to the morphological trends presented in Figure 29 in Section 6.4.

Figure 34. Beach response for FWOP conditions for (a) Reach 1 and (b) Reach 2 shoreline after 8 years.

Figure 35. Beach response for FWOP conditions for (a) Reach 3 and (b) Lover's Key shoreline after 8 years

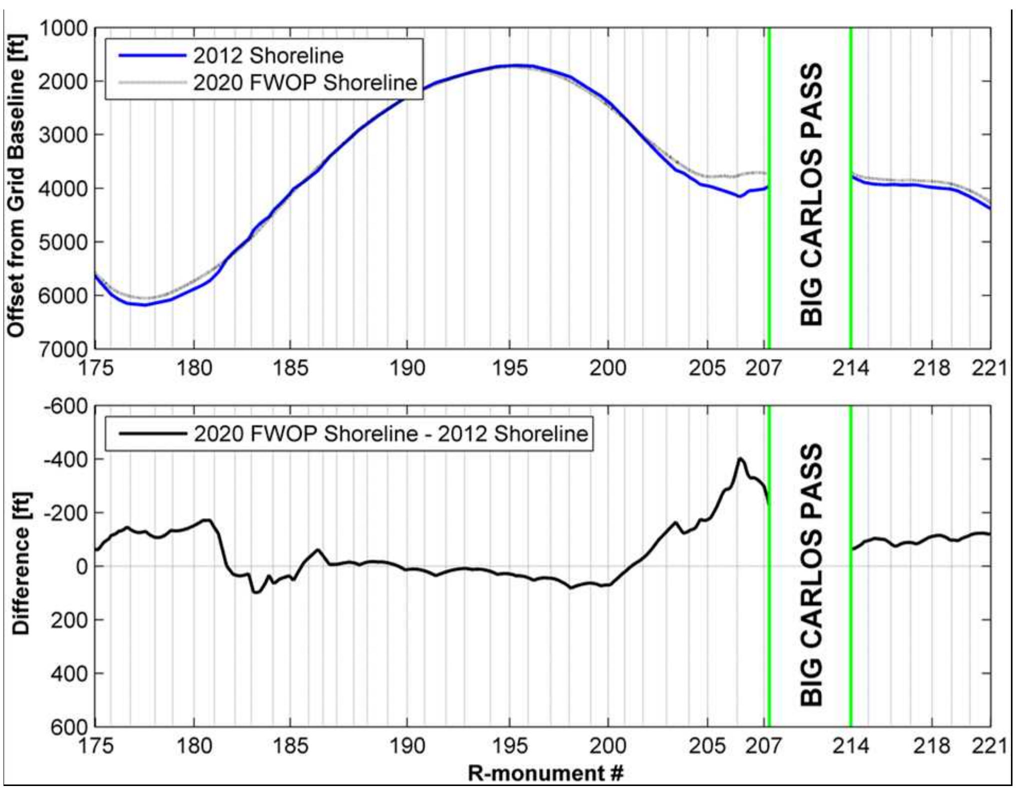


Figure 36. Difference between the predicted (2024) and current (2012) shorelines for FWOP conditions

6.6 Cross-Shore Morphology Modeling

Cross-shore morphological modeling was conducted to analyze and evaluate benefit a dune provides in storm damage reduction to private property. The cross-shore morphology during a storm event was simulated using the numerical model SBEACH (Storm-induced BEAch CHange). SBEACH is a 2-D numerical model that simulates cross-shore beach profile changes during storm events. The model assumes all transport is in the cross-shore direction and does not take into account downdrift transport or localized effects. SBEACH was modified in Version 4.0 and calibrated to incorporate overwash processes (Larson *et al.*, 2004). The SBEACH modeling procedure consisted of model setup, model calibration, modeling of existing conditions, and modeling of alternative dune scenarios.

An SBEACH model was previously calibrated in the project area by the USACE in the General Reevaluation Report for Lee County (USACE, 2001). The model incorporated profiles from Gasparilla Island. The storm used for calibration was the subtropical storm of June 1982. The calibration parameters were established as follows: a transport rate coefficient (K) of 0.0000025 m^4/N, a slope dependent coefficient (EPS) of $0.004m^2/s$, and a transport rate decay factor (LAMM) of $0.5m^{-1}$. The similar location and environmental conditions of our project area to the USACE model justify the use of these previously calibrated model parameters.

The model setup consists of developing a cross-shore profile, establishing storm input data, effective grain size, and transport coefficients. The transport coefficients described above were used in the model. The effective grain size was assumed to have a D50 of 0.15 mm, which corresponds to the upper end of the range determined by the USACE (2001). The cross-shore profile used in the analysis was located at monument R-187 in Reach 2, which is shown in Figure 37. This profile has a nearshore slope of approximately 35H:1V. There is a foreshore berm present at approximately 2.5 ft NAVD and a backshore berm of approximately 5.7 ft NAVD. Analysis of proposed beach nourishment and dune alternatives will be discussed further in Section 8.3.

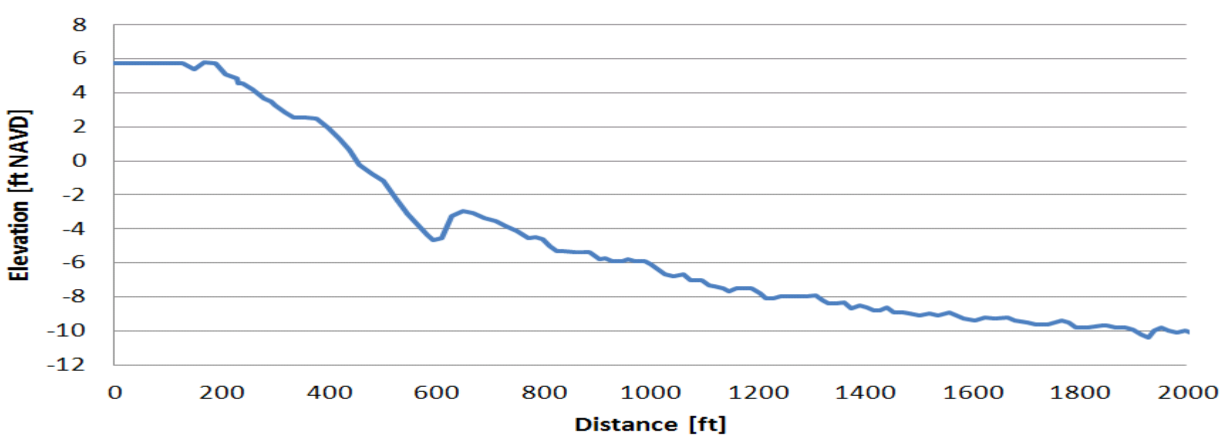


Figure 37. Profile at monument R-187 in Reach 2.

The representative storm was developed based on the storm Gabrielle (September 2001), which passed north of the project area and made landfall in Venice, FL. The storm surge during TS Gabrielle had a peak surge elevation of 3.63 ft NAVD88 at the Naples tide station, which is approximately a 5 year water level. The peak wind speed was approximately 41 mph, which occurred approximately at the same time as the peak surge. The peak wave height during the storm was 5.6 ft and the corresponding wave period was approximately 10 seconds. The storm water level, wind speed, wave height and period were also scaled to the 5and 10 year extreme values discussed in Section 4.

The existing profile at monument R-187 in Reach 2 was subjected to the three storm conditions described above (i.e. TS Gabrielle, 5 year, and 10 year storm conditions). The results of the cross-shore morphology modeling are shown in Figure 38. The maximum water levels due to surge and wave setup are also shown on the profiles. The shoreline receded at mean sea level (MSL) by an average of approximately 7.4 m (24 ft) in all of the storm conditions. The maximum water level approached within 0.2m (0.7 ft) and 0.14 m (0.5 ft) of the backshore berm crest during the TS Gabrielle and 5 year storm conditions, respectively. It would be expected that waves would be overtopping this backshore berm during these storm conditions. The maximum water level exceeds the backshore berm crest by 0.3m (0.9 ft) during the 10 year storm conditions, which would also have substantial waves propagating inland. These conditions are expected to cause damage to infrastructure.

7 ALTERNATIVES DEVELOPMENT

Results of the coastal engineering analysis indicate that three reaches of the island should be considered for action: Reach 1, the northernmost end of the island between R-175 at Bowditch Point and R-181 near the pier; Reach 2, the north-central portion of the island between approximately R-182 and R-191; and Reach 3, the southern end of the island along the Little Estero Island Critical Wildlife Area generally between R-202 and R-209 with a focus within approximately a mile centered at R-204. Potential solutions developed will be numbered Alternatives 1, 2, and 3, referring to the Reaches 1, 2, and 3 as stated above, respectively. The individual alternative concepts for each reach will be labeled 1.1, 1.2, 1.3, etc. for Reach 1 and 2.1, 2.2, 2.3, etc. for Reach 2, and similar for Reach 3. Variations on each alternative concept (i.e. structure length, gap length, distance from beach, etc.) will be assigned a letter, e.g. 1.1a, 1.1b, etc.

7.1 Reach 1: Northernmost end of Estero Island

Reach 1, the northernmost end of Estero Island between R-175 at Bowditch Point and R-181 near the pier, is dominated by gross and net northward sediment transport year-round. For all but extremely rare events, the transport is directed 100% of the time northward from R-181. A nodal point in the net longshore transport located on average at R-186 results in less sediment entering the northernmost reach than is transported north off the Island, which has led to long-term erosion. Therefore, alternatives for this reach should either add sand to the system or help retain sand in the system for a longer period of time. Lee County Natural Resources completed construction of a 402,805 cy nourishment project in this reach in early 2012; the project is expected to have an 8 year lifetime (CPE, 2001a). Therefore, nourishment in the short term in this region is not needed, although future renourishment will certainly be required, and therefore, it is assumed that beach nourishment will be in consideration as an alternative. The renourishment rate could be reduced through construction of coastal structures such as groins and breakwaters. This could lead to a long-term savings in beach maintenance costs through increasing the nourishment lifetime. In addition, coastal structures in this region will have no down-drift impacts as longshore transport is dominantly to the north. Three alternatives are proposed for evaluation in Reach 1: 1.1 Beach nourishment alone, 1.2 Beach nourishment with low-crested groins, and 1.3 Beach nourishment with detached nearshore breakwaters. Sketches of proposed alternatives for Reach 1 are shown in Figure 39.

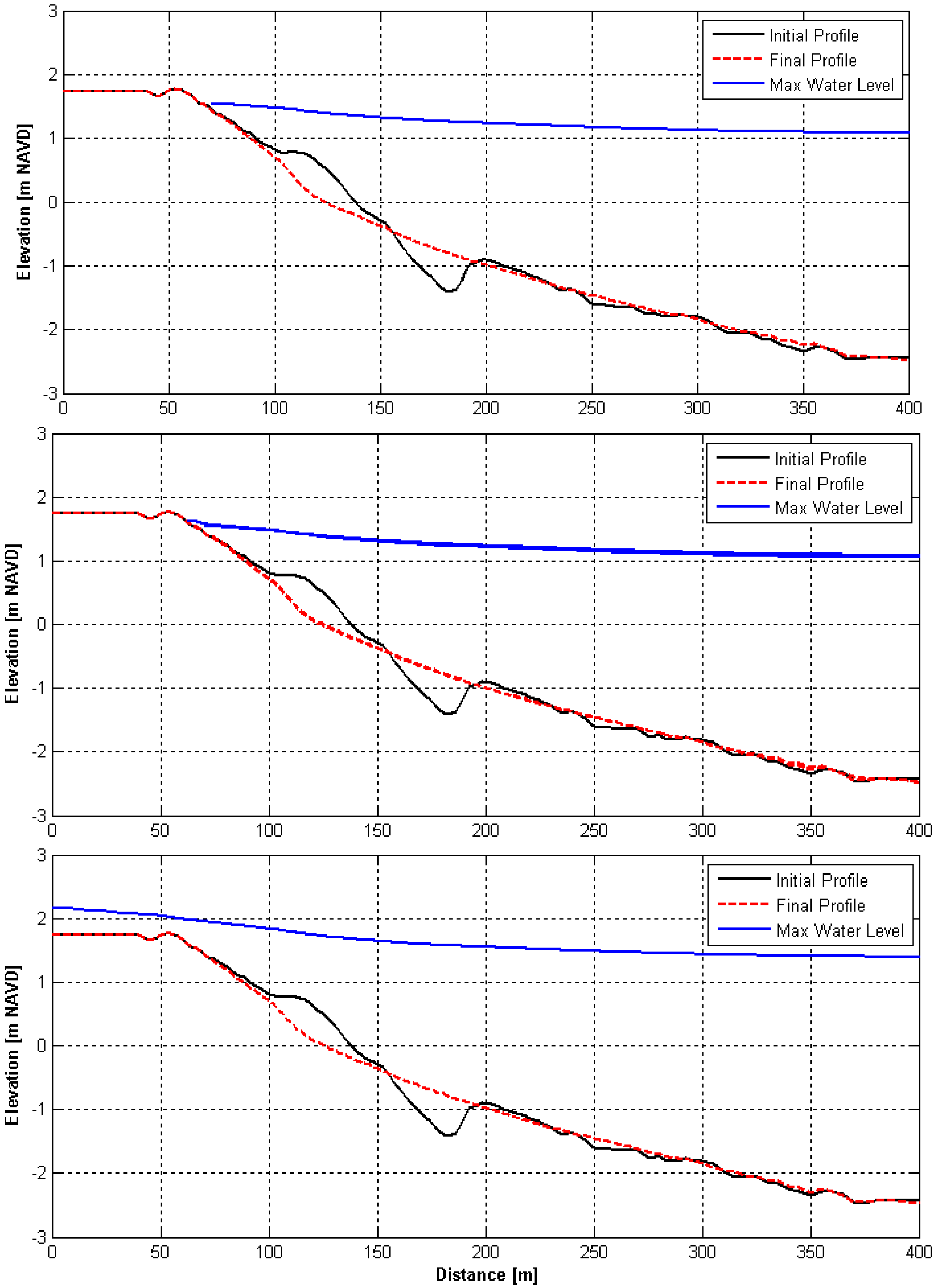


Figure 38. SBEACH results showing existing (solid black line), post storm profile (dotted red line), and maximum water level due to surge and wave setup (solid blue line) for TS Gabrielle storm conditions (top), 5 year storm conditions (middle), and for 10 year storm conditions.

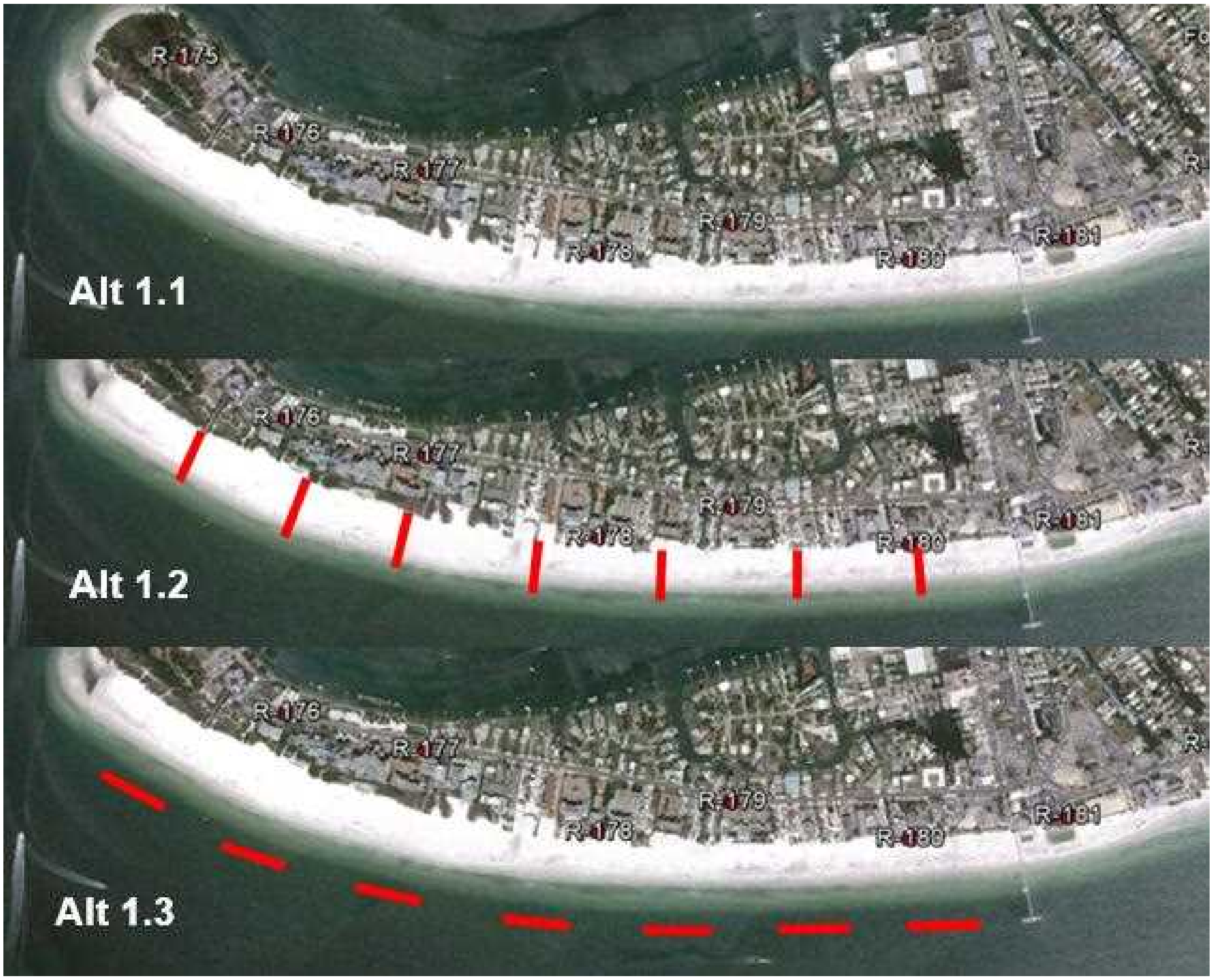


Figure 39. Proposed alternatives for Reach 1.

7.2 Reach 2: North-central Estero Island

The north-central portion of Estero Island between approximately R-182 and R-191 is a relatively stable portion of the island characterized by a narrow beach and primarily bi-directional longshore transport. Long term shoreline change rates indicate that erosion will continue along the more central portion of this region. Therefore this reach would benefit from a beach nourishment program. With the recent construction of the beach nourishment in Reach 1, material dredged from Matanzas pass in the future will need a new disposal area as most historical disposal from the dredging of the pass was placed in Reach 1. Placing that material in Reach 2 is expected to provide for a wider beach platform in the Reach, offset for expected future erosion, and act as a feeder beach to Reach 1 as transport is net north for much of this reach about half the time. Three alternatives are proposed for evaluation in Reach 2: 2.1 On-shore beach nourishment, 2.2 Nearshore placement beach nourishment, 2.3 Off-shore placement beach nourishment. Sketches of proposed alternatives for Reach 2 are shown in Figure 40

Figure 40. Proposed alternatives for Reach 2.

7.3 Reach 3: Southern Estero Island

The southern portion of Estero Island between R-202 and R-209, the Island's Critical Wildlife Area, is currently experiencing rapid shoreline retreat, which is focused around R-204 and approximately a half mile north and south of that point. This reach is extremely dynamic due to the strong influence of Big Carlos Pass and the fact that the shoreline is exposed to the highest wave energy on the island. The majority of this reach is characterized by an ebb shoal bar that attached itself to the shoreline in the 1970s. Since then, the shoal has acted as a barrier separating the main island shoreline from the Gulf, with the barrier migrating landward through the barrier rollover process. Within a few years, the condominium property located at R-204 will be exposed to the Gulf forces and act as a natural headland, blocking the longshore transport leading to strong downdrift erosion (north of R-204). Locations south of R-204 will continue to be protected by the barrier for at least 5 to 8 years until the barrier migrates and welds itself to the main island shoreline. Without action, serious erosion concerns may exists for properties between R-202 and R-204. Any action with hard structures is likely to adversely impact adjacent shorelines. Shorelines at the ends of this reach are characterized currently as accretional with wide beaches, and moderate downdrift erosion at these regions may be sustainable. However, extending the protection to these ends may require more stabilization structures than may otherwise would be necessary. Finally, beach nourishment may be the safest option, but any nourishment here except large volume efforts would erode within a relatively short time frame. Considering these challenges, four alternatives are proposed for evaluation in Reach 3: 3.1. Nearshore breakwaters; 3.2 On-shore placement of beach nourishment, 3.3 On-shore placement of beach nourishment with nearshore breakwaters, and 3.4 Off-shore placement beach nourishment. Sketches of proposed alternatives for Reach 3 are shown in Figure 41.

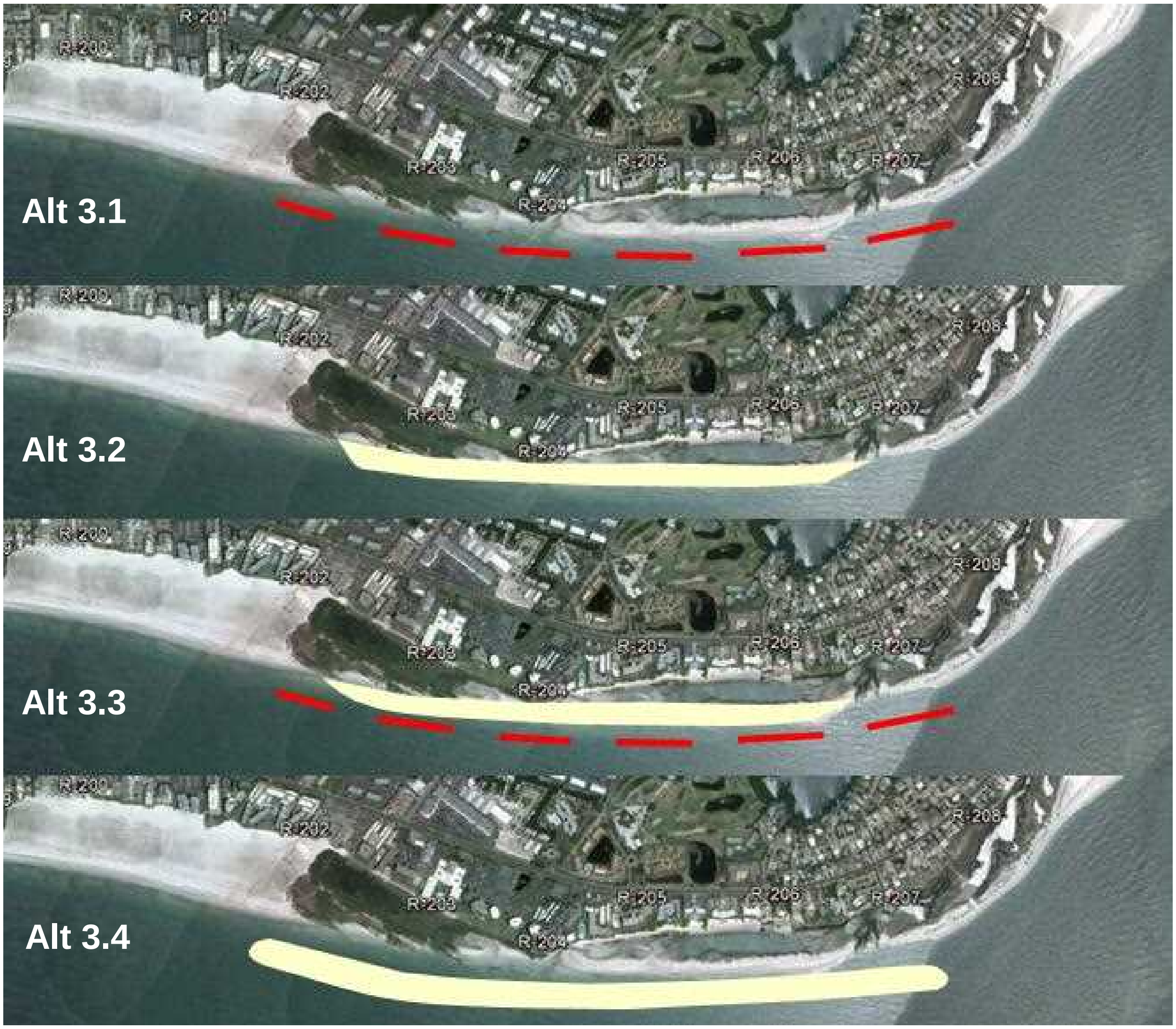


Figure 41. Proposed alternatives for Reach 3.

7.4 Beach Nourishment Considerations

Any proposed onshore beach nourishment will consider the use of a dune in order to provide additional storm damage reduction to infrastructure landward of the beach. The dune will be considered to add sand to the beach littoral system and added into the evaluation of the alternative in that manner, so performance for beach nourishment will be identical for a beach with and without a dune in terms of the beach nourishment lifetime. The dune feature will be evaluated for its ability to reduce storm damage to infrastructure for smaller storm events that do not overtop or completely erode the dune through empirical or analytical methods.

7.5 Conceptual Design of Alternatives

Conceptual design of alternatives was performed in order to develop a reasonable baseline for comparison of the alternatives ability to meet project goals. Note that these alternatives are only designed to the conceptual level (i.e. 10% design), and therefore all aspects of the design require refinement during later phases of design.

7.5.1 Design Criteria and Assumptions

The structural alternatives such as breakwaters and groins were assumed to have a design life of 25 years. The design life is directly associated with the design storm (i.e. 25 year return period), which was used to determine the rock size. The 25 year return period of wind, water level, and wave height discussed in Section 4 were used to determine the storm parameters. The stone was assumed to have a density of 2650 kg/m^3 (166 lbs/ft^3). This density may not be obtainable from local quarries; impacts to stone size are expected to be negligible to small and should be evaluated in greater detail during preliminary design. The slopes of the structures were assumed to be 2H:1V.

The stable rock size for the breakwaters and groins was estimated to have a median diameter (D_{50}) of approximately 1.6 ft and a corresponding weight (W_{50}) of approximately 630 lbs using methodologies proposed in The Rock Manual (CIRIA, 2007) and in the Coastal Engineering Manual (Burcharth and Hughes, 2002).

7.5.2 Breakwaters

Breakwaters retain beach sand and reduce erosion rates by decreasing the wave energy in the lee of the structures. They also modify sediment transport along the beach by causing diffraction of waves around the ends of the breakwater. This causes shoreline formations in the lee of the structures, such as salients and tombolos. Salients are accretional formations that do not reach the breakwater, where tombolos attach to the breakwaters. The modification of the wave field and resulting features work to reduce the rate of longshore transport in the vicinity in the lee of the breakwaters. The generalized functional design parameters used in breakwater design are shown in Figure 42. These parameters can be optimized to generate the desired shoreline response.

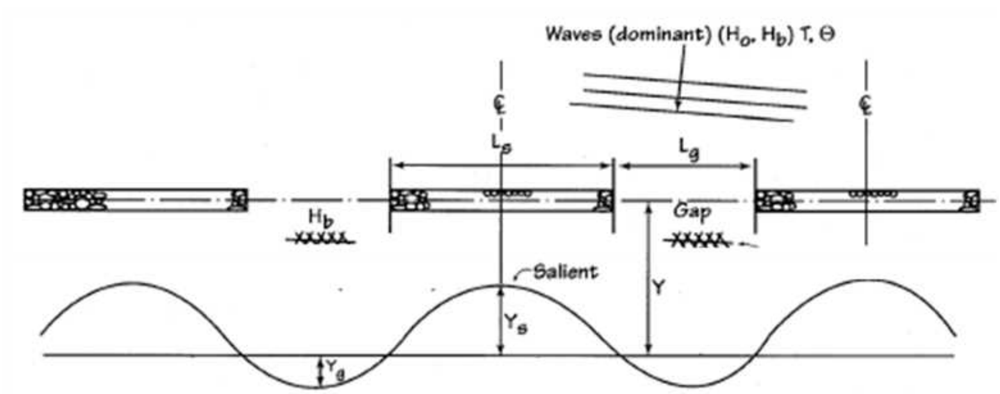


Figure 42. Breakwater planform design parameters (adapted from Basco 2002).

The breakwater planform, shown in Figure 43 and Figure 44 for Reach 1 and Reach 3, respectively, was designed to produce salients. Salients are the more desired shoreline response since they do not completely obstruct longshore sediment transport, like tombolos and therefore have less risk of a dramatic downdrift erosion impact. They also provide more shorefront area for beach users. The breakwaters alternatives in Reach 1 and Reach 3 where designed at the -6 ft NAVD and -4 ft NAVD contours, respectively. These contours are approximately 225 feet offshore in both reaches. Using methodology in the Coastal Engineering Manual on functional design of breakwaters (Basco, 2002), the ratio of breakwater length (Ls) to distance offshore (Y) to produce salients in the Gulf of Mexico is ideal between 0.7 and 0.95. The proposed breakwater length was 200 feet, which gives an Ls/Y ratio of 0.89.

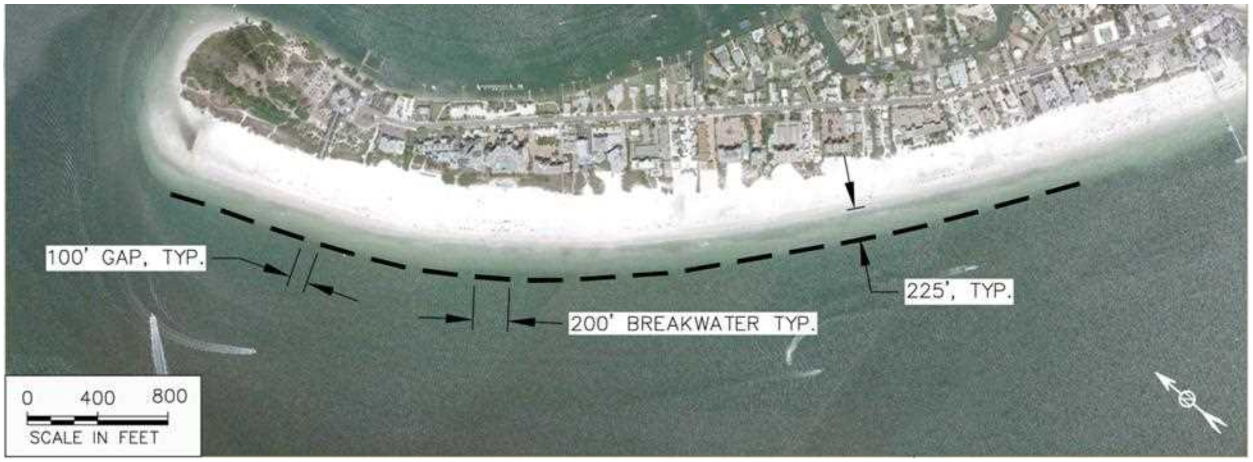


Figure 43. Planform of breakwater alternative in Reach 1 (Alternative 1.3).

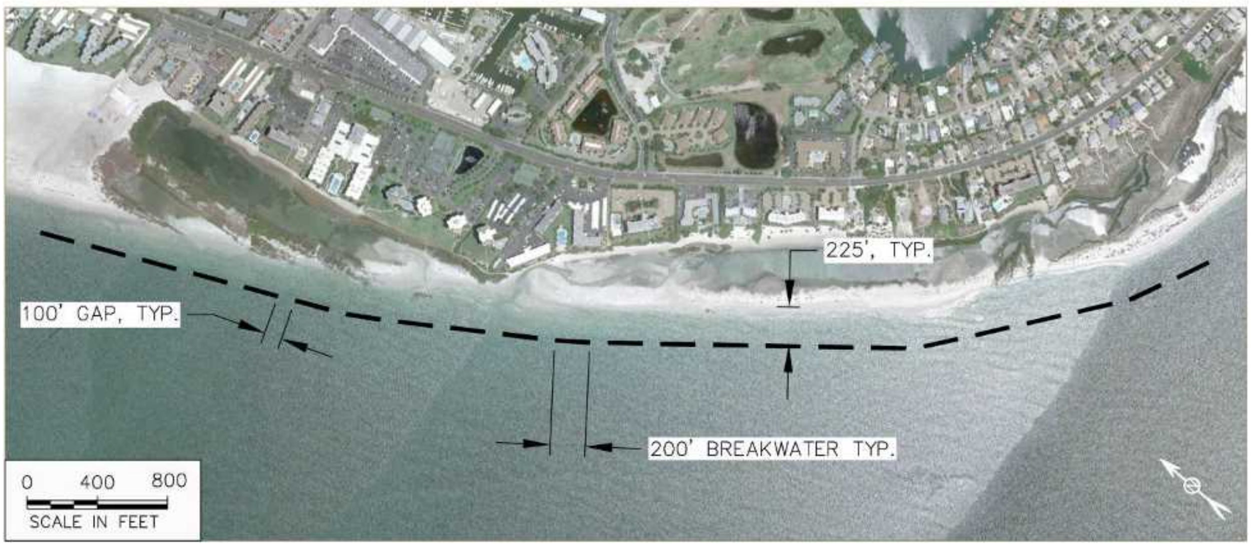


Figure 44. Planform of breakwater alternative in Reach 3 (Alternative 3.1).

The gaps were also determined by methodologies presented in the Coastal Engineering Manual, see Figure 45. The slope of the profile was correlated to the ratio of structure length (Ls) to gap width (Lg). Reach 1 has a slope of approximately 37.5H:1 V and Reach 3 has a slope of approximately 56H:1V. The maximum gap width allowable to produce salients in Reach 1 and Reach 3 was approximately 285 ft and 100 ft, respectively, due to variation in nearshore slopes between the two sites. This value indicates the maximum gap that would produce desired shoreline response results; smaller gaps widths will also provide shoreline response. The design gap for both reaches was designed to be 100 ft. The Reach 1 benefits from this gap width by producing a strong shoreline response. The south end breakwater spacing should not be reduced further as the potential for ponding on the landward side of the breakwater resulting from with narrower gap widths could lead to detrimental effects (potentially increasing shoreline erosion or formation of strong cross-shore currents in gaps).

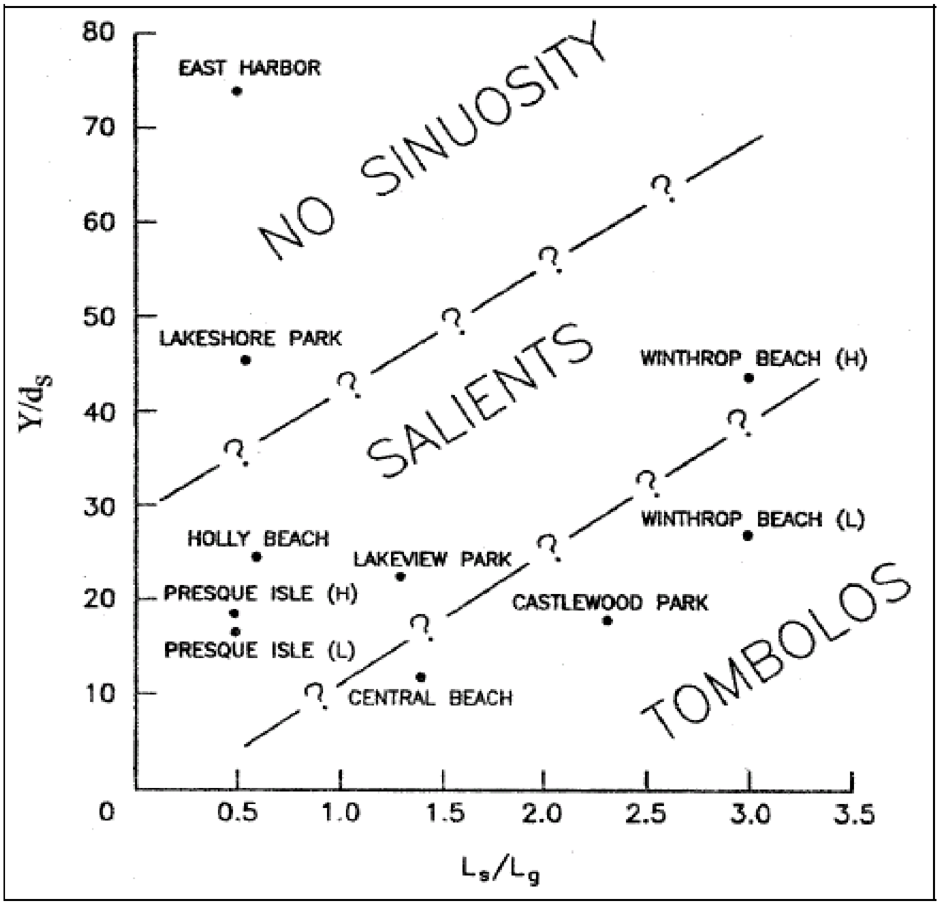


Figure 45. Dimensionless plot of nearshore breakwater projects for Y/ds, versus Ls/Lg (from Pope and Dean 1986 and adapted from Basco 2002).

The cross-section of the breakwater was designed using the stable rock size and acceptable transmission during storms. The crest width was assumed to have 3 stone widths, which would be approximately 5 ft, per recommendations of the Rock Manual (CIRIA, 2007). The elevation of the breakwater crest was assumed to be at or above the dry beach (i.e. approximately +4 ft NAVD). Transmission (Kt) of the breakwater during 1 year storm conditions, as described in Section 4.4, was determined to be 0.37 using van der Meer's (2005) formula for low-crested structures. The transmission during average conditions was assumed to be zero (Kt=0). The cross section of the breakwater is shown on profiles for Reach 1 and 3 in and Figure 46, respectively.

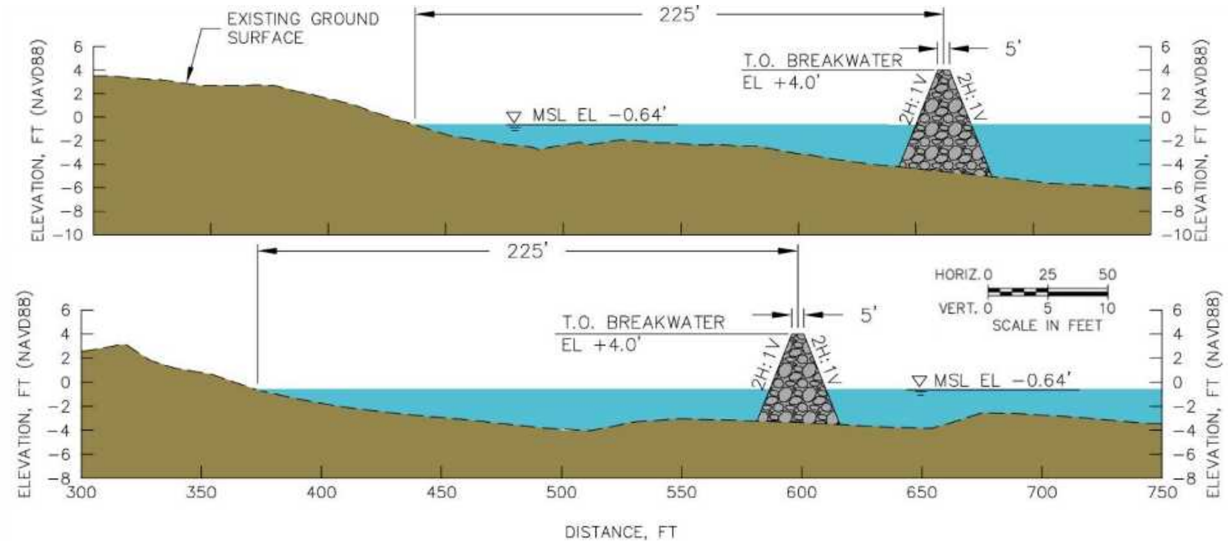


Figure 46. Cross-section of breakwater in Reach 1 on profile near monument R-178 (top) and Reach 3 on profile near monument R-206 (bottom).

7.5.3 Groins

Groins are shoreline normal structures that capture longshore sediment transport proportional to the depth that they extend into the active nearshore transport zone. Groin alternatives were considered in Reach 1 due to the dominant sediment transport to the north and the proximity to Matanzas Pass. The rule of thumb for proper function of a groin field is a ratio of groin spacing (X) to groin length (Ys) of 2 to 3 (Basco, 2002). As erosion occurs, the effective length of the groin increases, and the more efficient the groins become in holding sediment (assuming sediment continues to remain and be transported in the region). The groins were designed to extend from the existing backshore berm (approximate +4 ft contour) to the design length.

Two groin alternatives evaluated, which were composed of short and long groin fields with groins that were 350 ft (Alt 1.2a) and 645 ft (Alt 1.2b), respectively. The spacing of the groins was designed to be approximately three (3) times the effective length after the beach was eroded halfway from the existing position (i.e. approximately 175 ft from the +4 ft contour). This yielded an effective length of the groin of 175 ft and 470 ft for the short and long groins, respectively. When the spacing requirement is applied, this yields a required spacing for the short and long groins of 525 and 1,410 ft, respectively. The planform design of these alternatives in Reach 1 are shown in Figure 47 and Figure 48. It was determined that the Long Groins (Alt 1.2b) would likely result in too much shoreline retreat between groins that would impact existing properties, while costing much more than the short groins due to the geometric growth in volume requirements of stone in deeper depths of water. Therefore, the long groins are excluded from further evaluation.

Figure 47. Planform of short groin alternative in Reach 1 (Alternative 1.2a).

Figure 48. Planform of long groin alternative in Reach 1 (Alternative 1.2b).

The groin cross-section design was determined from rock size, existing contours, and water levels. The longitudinal cross-sections for the short and long groins are shown in Figure 49. The same rock size used for the breakwaters was used on the groin, which was designed to have a 5 ft crest width. The crest height was +4 ft at the landward extent to match the dry beach elevation. The seaward extent was designed to minimize overtopping during average conditions (i.e. MSL, mean wave height =1.3 ft). The wave run up was calculated using methods presented by van der Meer (1992). The 2% exceedance height of wave run up during average conditions was calculated to be +2.9 ft. During average conditions the water level (including wave setup) at the groin is expected to be approximately 0 NAVD, therefore the crest height of the seaward extent of the groins was designed to be +3 ft NAVD.

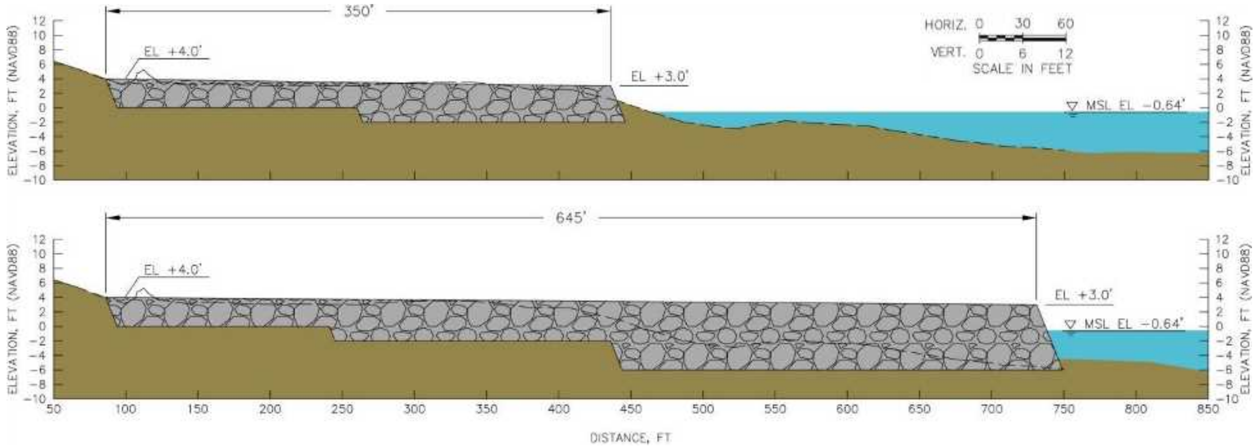


Figure 49. Cross-section of short groin (top) and long groin (bottom) alternative in Reach 1.

7.5.4 Beach nourishment

The beach nourishment alternatives were designed considering the existing nourishment profiles, existing beach slopes, available sand volumes, and area of protection. The elevation of the beach nourishment crest was designed to +3 ft NAVD to match the existing foreshore berm. The approximate equilibrium slope for each reach was determined from the existing contours and grain size. The crest width for both the Reach 2 and Reach 3 beach nourishment alternatives was designed to be 150 ft. The volumes available for placement were used in conjunction with the assumed equilibrium slopes to optimize the design elevation, extents of beach nourishment, and crest width. It was assumed that the source for Reach 1 and 2 for future beach nourishments would likely come from Matanzas Pass. Based on historical dredging records and previous beach nourishment events, it is assumed that the available volume would be approximately 200,000 CY. The borrow source for beach nourishment of Reach 3 was assumed to have approximately 250,000 CY available from Big Carlos Pass and/or the fillet that has formed on the east end of Estero Island. The fillet on the east end has between 100,000 CY and 170,000 CY depending on the configuration of the cut; this source is likely recyclable. Figure 50 shows typical beach nourishment sections for Reach 1 and 3. The size (volume) and configuration of nourishments should be revisited during a final design based on detailed performance criteria. In general, larger volumes will provide a longer renourishment interval. If used in conjunction with breakwaters, the nourishment width and breakwater location must be designed and optimized to work together as a system.

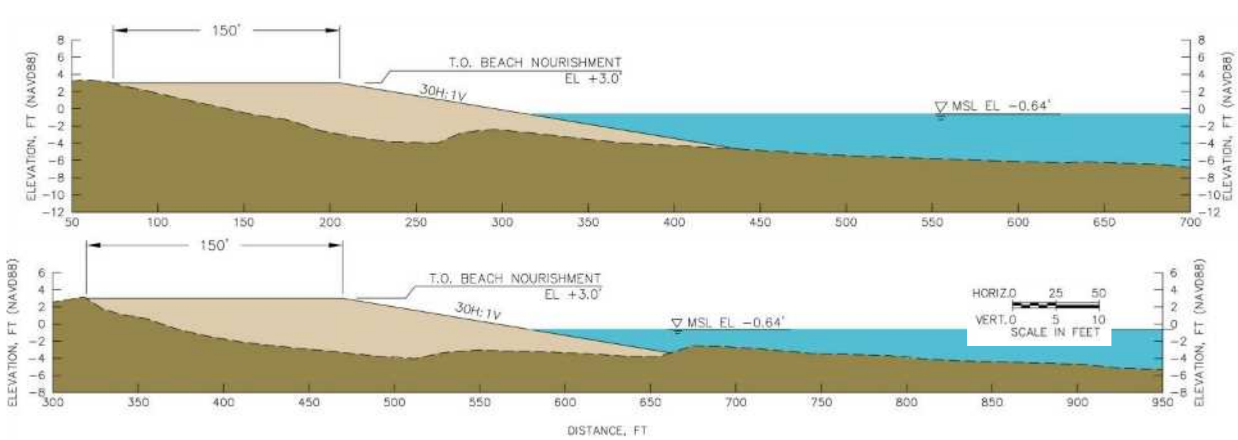


Figure 50. Cross-section of beach nourishment alternative for Alternative 1.1 in Reach 2 (top) and Alternatives 3.1 and 3.3 in Reach 3 (bottom).

The extents of beach nourishment were located in areas that have been identified as erosional hotspots or would maximize the benefits of beach nourishment events. The extents of beach nourishment alternatives for Reach 2 and Reach 3 are shown in Figure 51 and Figure 52, respectively. The beach nourishment in Reach 2 extends 6,000 ft approximately from R-185 to R-190. The beach nourishment in Reach 3 extends 6,700 ft approximately from monument R-202 to R-208.

The nearshore placement of beach nourishment was also considered for Reaches 2 and 3 (Alternatives 2.2 and 3.4). The layout of this placement was designed to be similar to the nearshore placement constructed in 2009, and correspond to the onshore placement alternatives in length and volume. The cross section of the nearshore placement design at Reach 2 is shown in Figure 53. The centerline of the placement was designed to be approximately 600 ft offshore, which the depth would be approximately -7 ft NAVD. The maximum elevation of the placement would be approximately -3 ft NAVD and the width was designed to be 220 ft. The design for nearshore placement in Reach 3 would be similar but would be placed approximately 1,200 ft offshore. The extents of this placement would be the same as those described above for the beach nourishment in Reaches 2 and 3.

Offshore placement was also considered for beach nourishment as Alternative 2.3. The offshore placement would be consist of a similar placement configuration, volume, and extents as the nearshore placement, but placed in an elevation of -12 ft NAVD. The maximum elevation of the placement would be approximately -8 ft NAVD width of 220 ft.

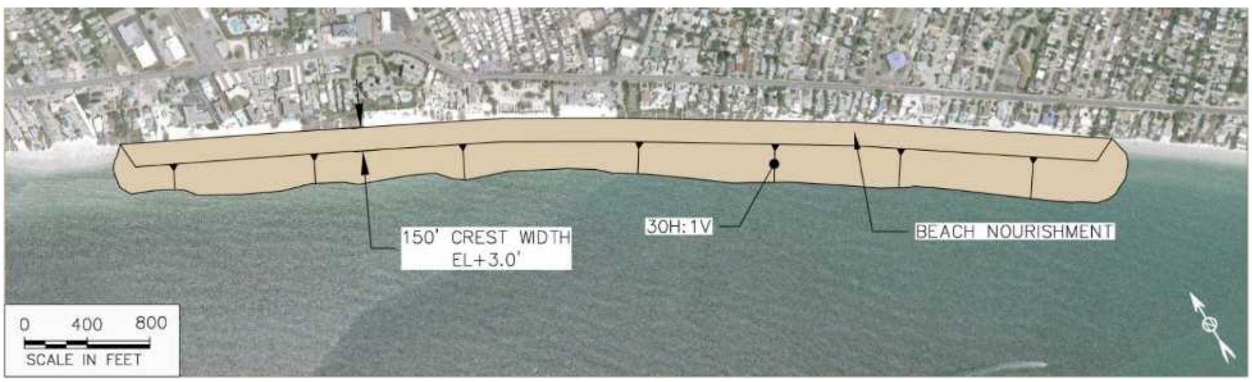


Figure 51. Planview of beach nourishment alternative in Reach 2.

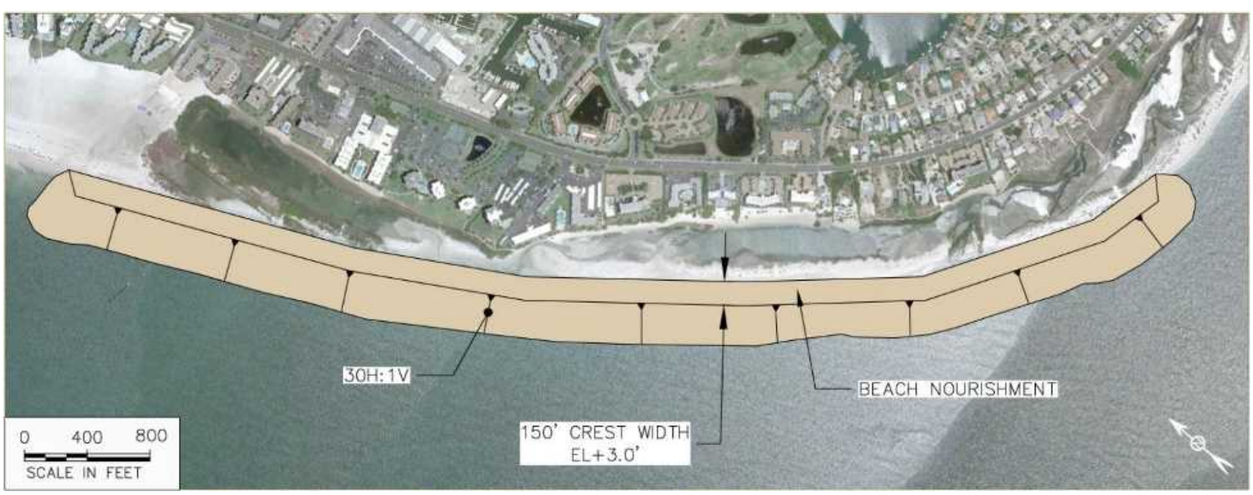


Figure 52. Plan view of beach nourishment alternative in Reach 3.

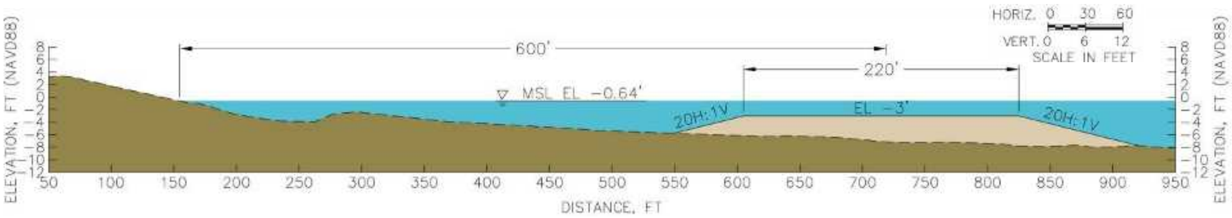


Figure 53. Cross-section of nearshore placement of beach nourishment in Reach 2 (Alternative 2.2).

8 ALTERNATIVES ANALYSIS

8.1 Development of Evaluation criteria

To determine the best performing alternative, a direct comparison between the concepts will be made. For the purpose of this evaluation, two categories of criteria are presented: design criteria and performance criteria.

Design criteria are used to test for the alternatives' ability to meet the design life of the project; i.e. the minimum length of time the alternative is expected to perform as designed. Assumed project design lifetime is 25 years. If the alternative includes beach nourishment, the design life will consider the expected nourishment lifetime and renourishment cycle required to meet the design life. If the alternative includes a structure, the structure should be able to withstand the design storm (the maximum storm expected to occur during the design life) during which minor damage (0 to 15%) occurs to the structure. In addition, material used should be designed to withstand the environment where they are deployed for at least this time period, or consider maintenance required to ensure that the alternative performs for that time period.

The performance criteria will be used as a basis to analyze how the alternatives' perform in meeting the project goals. For example, the primary project goal is to stabilize shoreline change (i.e. reduce erosion). Therefore, the ability of each alternative to reduce erosion will be evaluated as a performance criteria. The performance criteria will be used as a basis to analyze the alternatives' performance (how well the alternative meets the project goal), and to directly compare the performance of each alternative relative to the other. Erosion reduction will be determined by evaluating the modeled shoreline morphology as a result of the alternative.

Evaluation criteria that will be included in the alternatives' analysis are summarized below:

1. Project performance (reduce shoreline erosion)
2. Hydrodynamic stability (i.e. stone size; for structures only)
3. Cost (construction and maintenance; renourishment cycle)
4. Impacts to adjacent shoreline
5. Environmental impact and permitability

8.2 Beach Response

The alternatives was evaluated for their ability to increase the time the shoreline remains landward of the existing vegetation line and/or impacting infrastructure. The alternatives that were tested for these reaches are:

- Alt 1.1 400,000 cy beach nourishment on Reach 1 (also FWOP)
- Alt 1.2 Short Groins on Reach 1
- Alt 1.3 Breakwaters on Reach 1
- Alt 2.1 200,000 cy Onshore Beach Nourishment on Reach 2
- Alt 2.2 200,000 cy Nearshore Placement on Reach 2
- Alt 2.3 200,000 cy Offshore Placementt on Reach 2
- Alt 3.1 Nearshore Detached Breakwaters on Reach 3
- Alt 3.2 250,000 cy Onshore Beach Nourishment on Reach 3
- Alt 3.3 250,000 cy Onshore Beach Nourishment and Breakwaters on Reach 3
- Alt 3.4 250,000 cy Nearshore nourishment

The Alt 2.3 and 3.4 the offshore nourishments, were not evaluated with Gencade. Instead, Gencade results for onshore nourishment were adjusted to reflect expected morphology based on recent observations of nearshore berm placement. The beach response, lifetime of FWP conditions, change in lifetime for FWP over FWOP conditions and impacts to adjacent shorelines for various alternatives are discussed in Section 8.2.1 to 8.2.10 below. Lifetime of an alternative is defined as the time in years by when the shoreline breaches a critical point (existing vegetation line or infrastructure) on the beach.

The various alternatives are incorporated in the GenCade model to provide a conceptual level performance and expected beach response resulting from these alternatives. The configuration and structural parameters for the chosen alternatives should be developed in more detail and optimized for the best performance at future stages of design.

8.2.1 Beach Nourishment on Reach 1

This alternative is essentially FWOP conditions discussed in Section 6.5.3 as the starting point for that was the post 400,000 cy beach nourishment on Reach 1. On Reach 1, the lifetime for this alternative is approximately 8 years when the shoreline retreats to the structure just southeast of the existing jetty at R-181. Since the longshore transport direction on Reach 1 is primarily northwest, Reach 2 receives negligible to minor amounts of sand from the beach nourishment on Reach 1. Reach 3 and the adjacent shoreline on Lover's Key show severe to moderate erosion, consistent with FWOP conditions.

For this alternative the shoreline recession reaches the existing vegetation line and infrastructure at year 8. At that time, approximately 50% of the beach volume remains within the template.

8.2.2 Alt 1.2 Short Groins on Reach 1

Groins were incorporated into GenCade model. The permeability of the groins were set as 0.3 for this conceptual level study as these groins slope down from a crest height of +4 to +3 ft NAVD88 seaward and therefore will allow overtopping and passing of material through and over them.

Figure 54. Beach response for FWOP conditions for the whole project shoreline after 8 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 8.

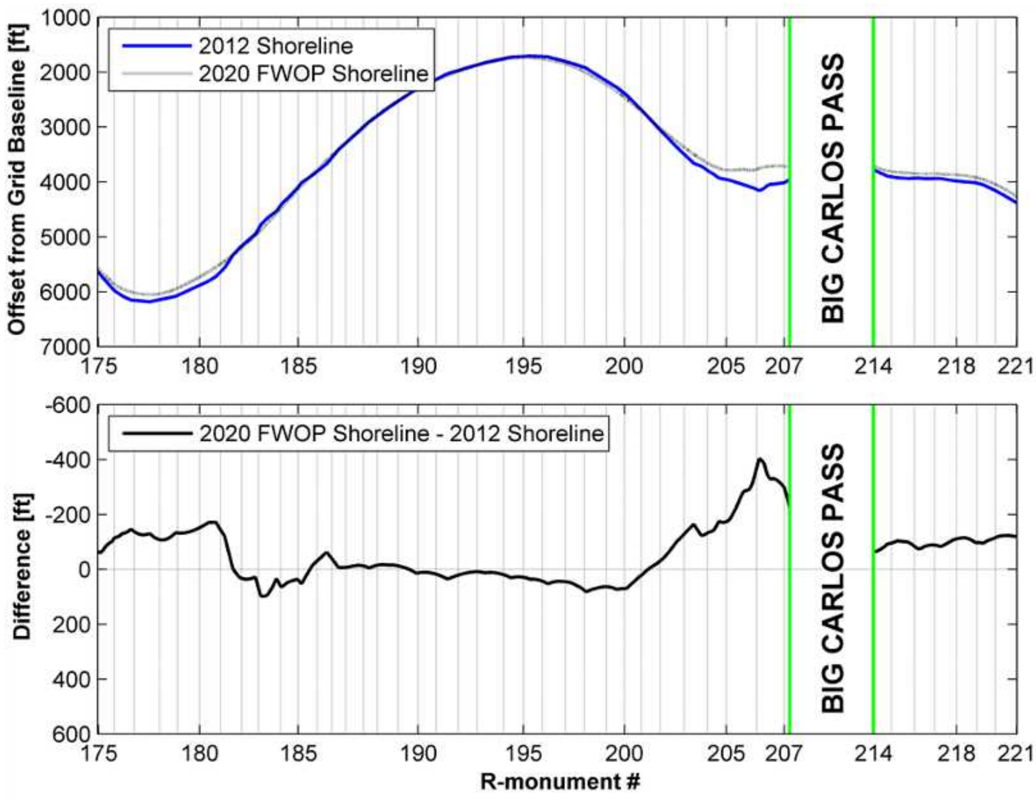


Figure 55. (top) Beach response for FWOP conditions for the whole project shoreline after 8 years and (bottom) Change in shoreline for FWOP after 8 years.

The beach response for this alternative after 8 years is shown in Figure 56 for Reach 1 and for the entire project shoreline in Figure 58. Results indicate that the beach response northwest of R-181 for this alternative is better than FWOP conditions as the beach erosion is reduced by 50 to 100 ft over FWOP conditions at year 8. As the groin field ends at R-180, the shoreline response southeast of R-181 is identical to FWOP conditions, confirming the dominant northward transport in this reach.

For this alternative the shoreline recession reaches the existing vegetation line and infrastructure near R-175 at year 12 as shown in Figure 57. At that time, approximately 50% of the beach volume remains within the template. The northward moving sediment transport along Reach 1 of EI shoreline is gradually trapped by the groin field between R-176 to R-180, which reduces the sediment reaching the northern end of the EI shoreline and therefore this section of shoreline shows localized higher erosion than FWOP conditions. The groin field in this region could be modified to a tapered groin system (groins of varying length) for more optimal performance of the beach response on Reach 1. Additionally, it appears the shoreline near the pier needs additional protection not provided by the conceptual design presented here. Therefore, 2-4 more groins added to the south end of the field are expected to improve performance in above the 12 years presented here. This should be evaluated in later stages of design of this concept.

Figure 56. Beach response for Reach 1 for (left) FWOP conditions and (right) Alt 1.2 after 8 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 8.

Figure 57. Beach response for Reach 1 for (left) FWOP conditions and (right) Alt 1.2 after 14 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 14.

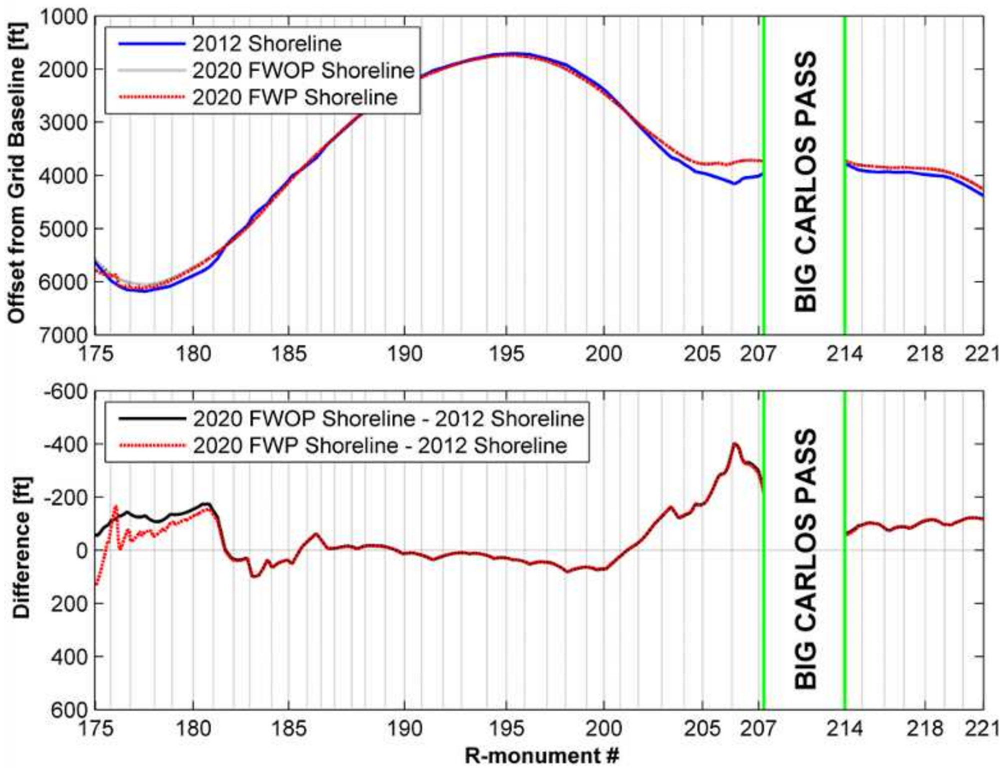


Figure 58. (top) Beach response for FWOP conditions and Alt 1.2 for the whole project shoreline after 8 years and (bottom) Change in shoreline for FWOP conditions and Alt 1.2 after 8 years.

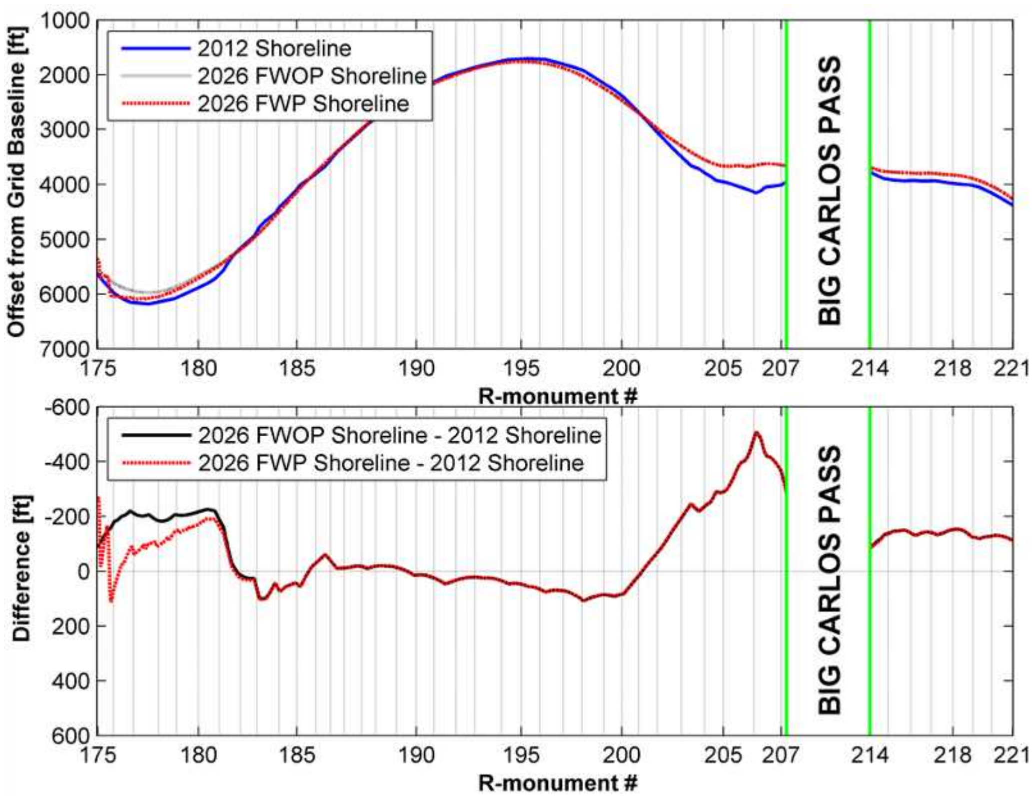


Figure 59. (top) Beach response for FWOP conditions and Alt 1.2 for the whole project shoreline after 14 years and (bottom) Change in shoreline for FWOP conditions and Alt 1.2 after 14 years.

8.2.3 Alt 1.3 Detached Breakwaters on Reach 1

Breakwaters are incorporated into GenCade to simulate Alternative 1.3. A transmission coefficient was determined using appropriate analytical expressions (CIRIA, 2007 and Buccino & Calabrese, 2007); for the designed breakwaters the transmission coefficient was computed as 0.2 outside and input as a constant value in the model.

The beach response for this alternative on Reach 1 after 8 years is shown in Figure 60 and for the whole project shoreline in Figure 62. The nearshore breakwater alternative is effective in producing salients and damping the shoreline retreat rate when compared to the FWOP conditions. For this alternative the shoreline recession reaches the existing vegetation line and infrastructure near R-176 at year 15 with approximately 70% of the volume remaining in the template as shown in Figure 61 compared to the FWOP conditions where the shoreline from R-177 to R-180 has already reached the existing vegetation and infrastructure. Therefore, an estimated increase of 7 years in lifetime is achieved over FWOP conditions alternative.

The beach response south of the breakwater field is similar to that of FWOP conditions. As observed with the groin field, trapping of the northward moving sediment by the structures, result in a deficit of sediment reaching the northern end of EI shoreline and therefore increased erosion from FWOP conditions is observed between R-175 to R-176. This region is also highly influenced by Matanzas Pass, and structures in the last 1000 ft of the pass should be carefully evaluated during a final design to account for this interaction. The planar arrangement of the detached breakwaters may be able to be altered to produce a more desirable response on the northern EI shoreline.

Figure 60. Beach response for Reach 1 for (left) FWOP conditions and (right) Alt 1.3 after 8 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 8.

Figure 61. Beach response for Reach 1 for (left) FWOP conditions and (right) Alt 1.3 after 15 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 15.

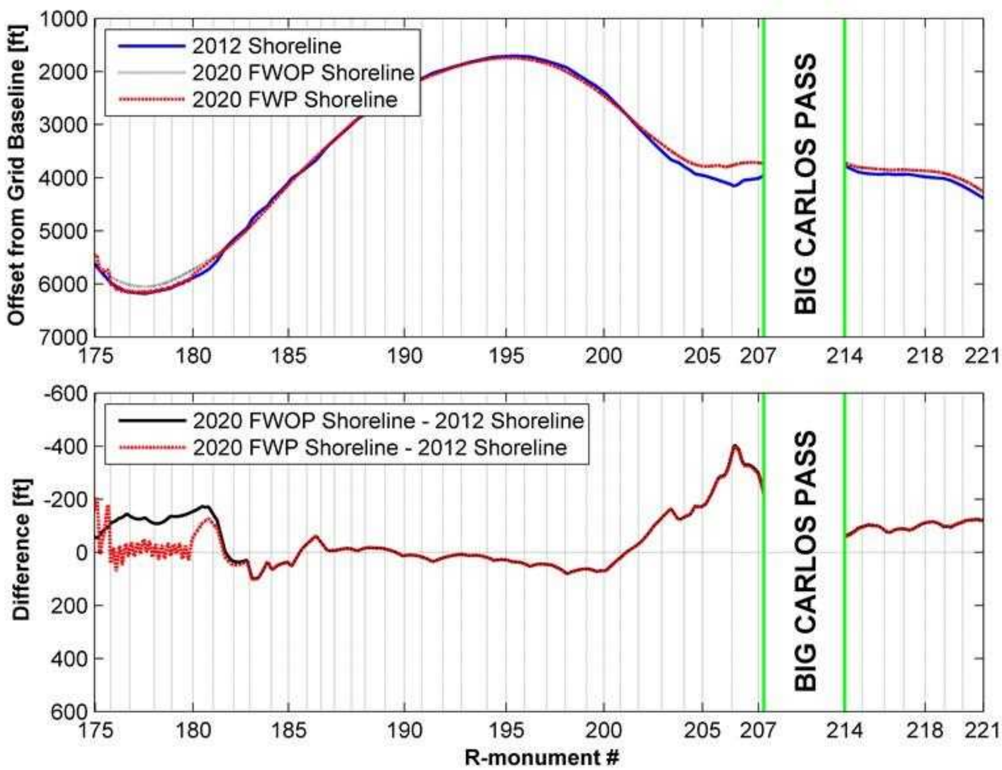


Figure 62. (top) Beach response for FWOP conditions and Alt 1.3 for the whole project shoreline after 8 years and (bottom) Change in shoreline for FWOP conditions and Alt 1.3 after 8 years

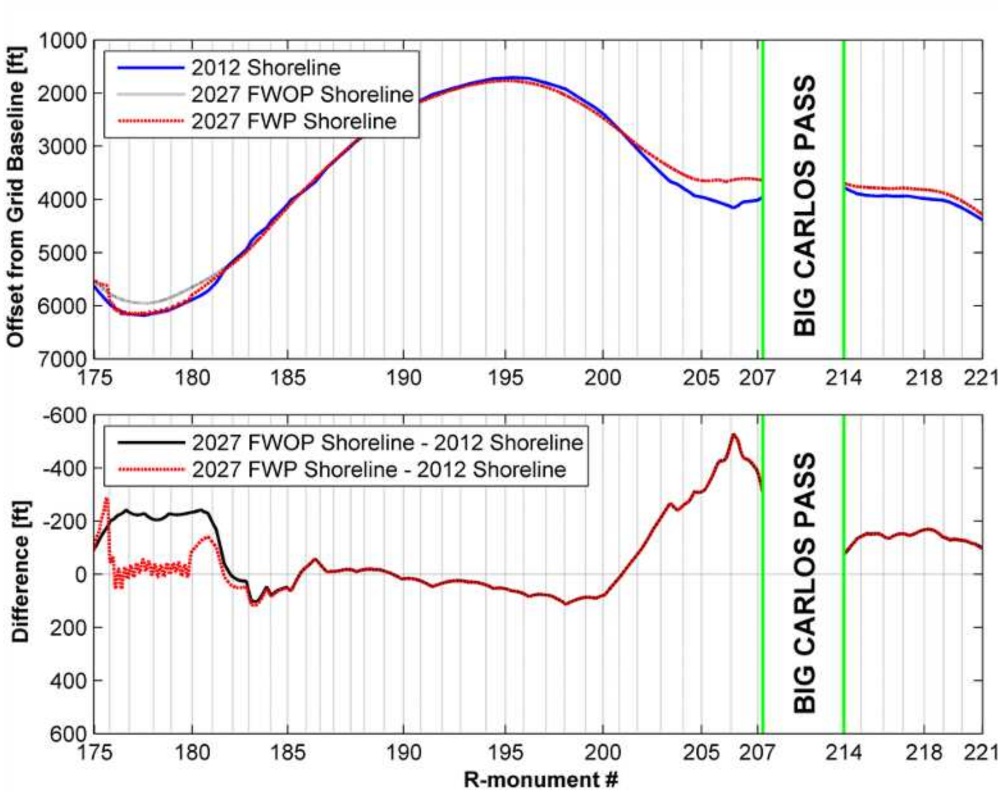


Figure 63. (top) Beach response for FWOP conditions and Alt 1.3 for the whole project shoreline after 15 years and (bottom) Change in shoreline for FWOP conditions and Alt 1.3 after 15 years

8.2.4 Alt 2.1 Onshore Beach Nourishment on Reach 2

The GenCade model incorporates a beach nourishment alternative as an onshore beach fill by defining the beach nourishment extents between R-185 and R-190 and the crest width of the fill. A total of 200,000 cy of material was placed as described in Section 7.

The Reach 2 shoreline is relatively stable, as transport is bi-directional (approximately equally balanced northward and southward gross transport). The existing shoreline change rates in this region are also relatively small. Because of this, the nourishment remains relatively stable after 8 years compared to the 2012 shoreline as shown in Figure 64 and Figure 65. Reach 1 and Reach 3 are only fed a small amount of material from the nourishment spreading 1000 to 2000 ft from the end of the template as the added beach material is primarily retained within the Reach 2. After 8 years (the estimate lifetime of the Alt 1.1 alternative), the beach nourishment has lost less than 30% of the material from the template, and the shoreline recession has not yet reached the vegetation line and infrastructure in the R-187 to R-188 region as occurs during the FWOP conditions. The expected lifetime of a beach nourishment in this region is more than 20 years due to the low erosion rates.

Figure 64. Beach response for Reach 2 for (left) FWOP conditions and (right) Alt 2.1 after 8 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 8.

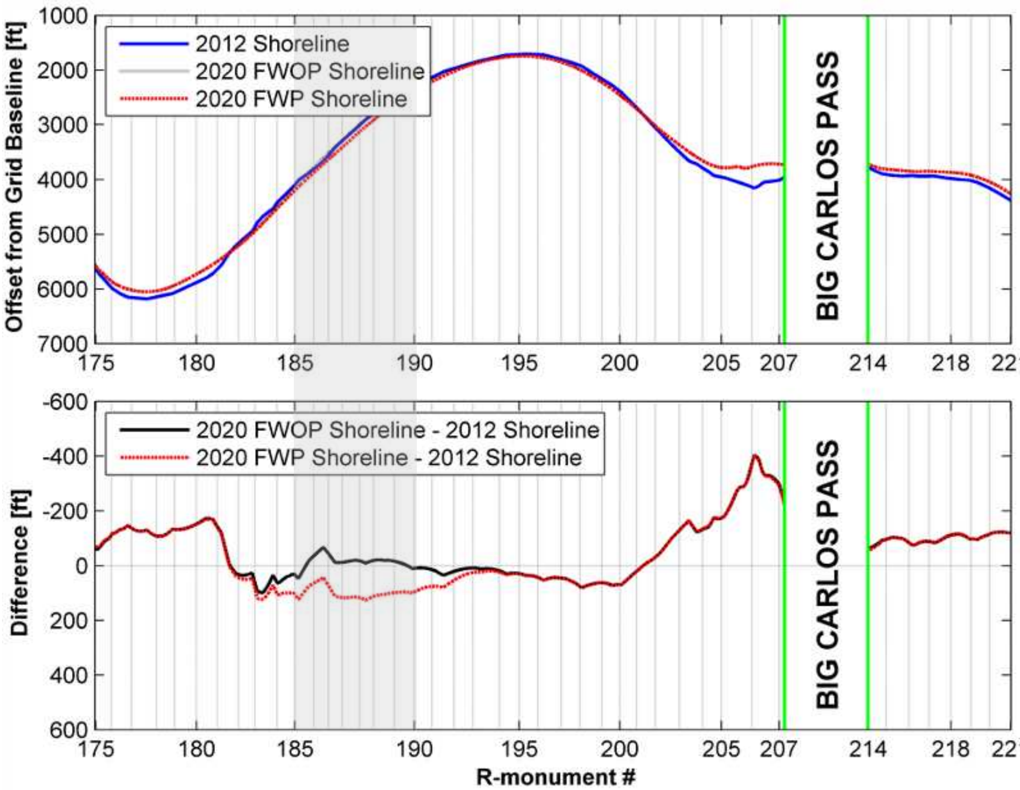


Figure 65. (top) Beach response for FWOP conditions and Alt 2.1 for the whole project shoreline after 8 years and (bottom) Change in shoreline for FWOP conditions and Alt 2.1 after 8 years.

8.2.5 Alt 2.2 Nearshore Placement on Reach 2

Evaluation of nearshore placement of beach nourishment is challenging, as little is known about the performance of such a nourishment, and no predictive tools exist (outside of complicated 3-dimensional morphological models) with ability to simulate proper morphology. The best indication of the performance of the nearshore placement is results of monitoring from the 2009 nearshore placement on EI. Monitoring and evaluation of the berm was conducted from 2009 to 2012. Several interim reports have been published (Brutsche et al, 2011a; Brutsche et al, 2011b; Brutsche, 2011; Brutsche and Wang, 2012) and the results of 2 years of monitoring are documented in their final report Wang et al. (2013) as discussed in Section 3.7.3.

Wang et al.'s monitoring yielded interesting findings: the nearshore placement resulted in a stable beach landward of the nearshore placement from 2009 to 2013. Also, Brutsche (2013) noted that approximately 10% of the berm volume attached to the subaerial beach at year 6, and that the remaining material was primarily distributed across the cross-shore areas. It is hypothesized that this material will act as the source for littoral transport that otherwise would have resulted in erosion of the beach in the nearshore placement area. The estimated lifetime of the berm is 6 years. The remainder of the berm material that attached to the shoreline is expected to behave as a traditional subaerial beach nourishment.

The proposed Alternative 2.2 is nearly identical to the 2009 nearshore placement in extents, volume and geometry, except that the location of placement is shifted south. The extents of the proposed nearshore placement remain in a region with nearly identical wave climate and longshore transport patterns. Finally, the material for fill will be from a very similar source – maintenance dredging of Matanzas Pass. Therefore, we assume that the Alternative 2.2 nearshore placement performance will be similar to that of the 2009 nearshore placement. The shoreline within the placement reach (R-185 to R-190) would remain stable for approximately 6 years after which approximately 20,000 cy would attach to the shoreline. Then this material would erode at a rate similar to the Alternative 2.1 onshore nourishment. Using this methodology, the lifetime of this alternative is estimated to be approximately 10 years.

8.2.6 Alt 2.3 Offshore Placement on Reach 2

If evaluation of nearshore beach nourishment is challenging, the evaluation of the offshore placement is even more challenging, and even less is known about the performance of such a nourishment. Therefore, a simple estimate was used to provide an indication of the performance of the offshore placement. We assume that the sediment transport that occurs on the nearshore bar is the best indication of its mobility and therefore ability to nourish the beach, and therefore it is reasonable to assume the same sediment transport rate that occurs on the offshore placement would indicate the same performance. From this, if the sediment transport rate on the offshore placement is less, the performance would be proportionally less than the nearshore placement as the material in the alternative would not be mobile and available to the littoral system.

Following this reasoning, we computed the sediment transport rate caused by waves on a cross-section for existing conditions, for Alternative 2.2 conditions, and Alternative 2.3 conditions. Waves developed in the SWAN and longshore transport modeling were used as input in order to capture a long-term record of wave energy, and the waves were linearly transformed across the cross-section. Sediment transport was computed by the Engelund-Hansen (1967) and the van Rijn (1994) methods. The relative transport rate is plotted on the representative cross-sections for existing, Alt 2.2, and Alt 2.3 cases in Figure 66. These results indicate that the total sediment transport rate on the offshore placement site is approximately 80% less than the transport rate on the nearshore placement site. Based on these results, the impact of the offshore placement on shoreline stability and reducing shoreline retreat is assumed to be negligible.

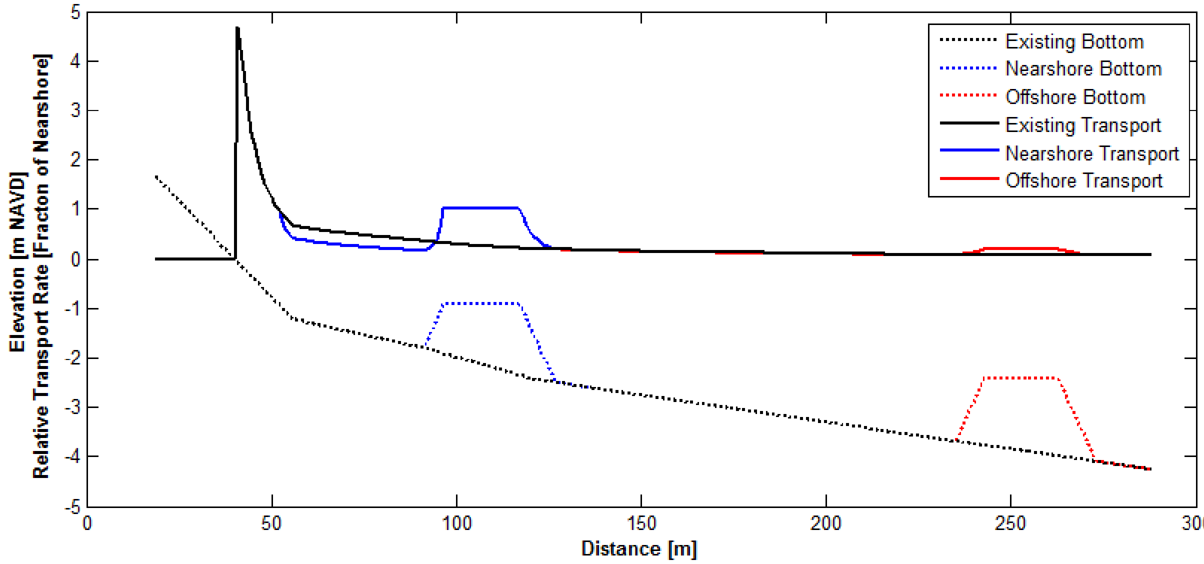


Figure 66. Sediment transport for existing conditions, the nearshore placement (Alt 2.2), and the offshore placement (Alt 2.3). The transport rate is scaled relative to the maximum transport rate that occurs over the nearshore placement bar. The dotted lines are the bottom profiles of the existing conditions, Alt 2.2 nearshore placement, and Alt 2.3 offshore placement in Reach 2.

8.2.7 Alt 3.1 Nearshore Detached Breakwaters on Reach 3

The nearshore detached breakwaters on Reach 3 were incorporated in GenCade by defining the parameters discussed previously in Section 8.2.3. As discussed in Section due to the high level of uncertainty in predicting shoreline response near the inlets by the GenCade model, the shorelines between R-208 to R-213 (shoreline adjacent to Big Carlos Pass) are excluded in the results (for all alternatives in Reach 3).

The shorelines for the Alternative with breakwaters compared with FWOP conditions on Reach 3 are shown in Figure 67. The beach response shows formation of salients behind the breakwaters and reduction in shoreline erosion by almost as high as 50% compared to FWOP conditions. As the primary sediment transport along Reach 3 is to the south it is expected that the shoreline erosion with the breakwaters will gradually increase towards the southern breakwaters. Also, since the sediment transport direction is bidirectional around R-201 (the wide beach section), because of the breakwaters it experiences an increase in downdrift erosion ranging from 25 to 125 ft compared to the FWOP conditions. The lifetime for this alternative is computed as approximately 11 years when the shoreline recedes to the existing vegetation line and infrastructure at R-204.

Figure 68 shows the impact to the adjacent shoreline on Lover’s Key due to the alternative. Approximately 50% of the sediment moving south along Reach 3 currently gets transported into the Big Carlos ebb shoal and bypassed to Lover’s Key. If the breakwater alternative is implemented, the breakwaters retain the material on the beach on Estero Island, and do not allow it to transport into the Big Carlos ebb shoal, leading to a potential deficit in transport onto Lover’s Key. This would cause an increase in shoreline recession on the Lover’s Key shoreline. The shoreline recession increases southeast along the Lover’s Key; the shoreline recession reaches 30 ft/yr after 12 years for Alt 3.1 while FWOP shows 22 ft/yr after 12 years.

Figure 67. Beach response for Reach 3 for (left) FWOP conditions and (right) Alt 3.1 after 12 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 12.

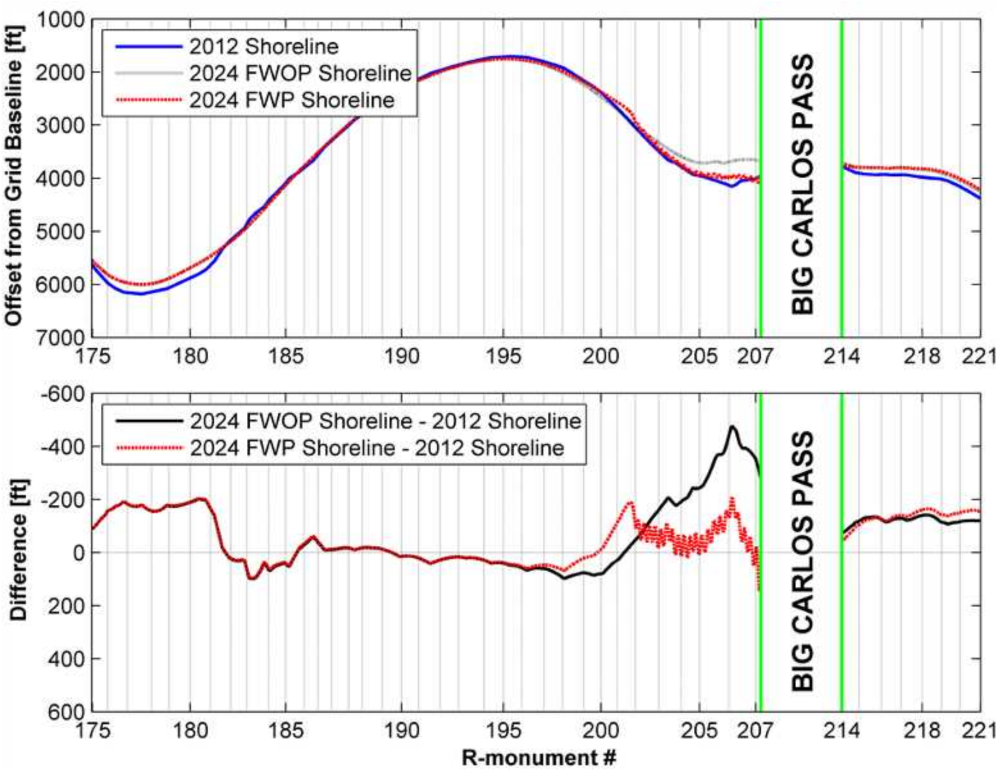


Figure 68. (top) Beach response for FWOP conditions and Alt 3.1 for the whole project shoreline after 8 years and (bottom) Change in shoreline for FWOP conditions and Alt 3.1 after 12 years.

8.2.8 Alt 3.2 Onshore Beach Nourishment on Reach 3

The onshore beach nourishment with crest width of 150 ft was incorporated in the GenCade grid over Reach 3 similar to how it was incorporated for in Reach 2. The beach nourishment increased the lifetime of the critical wildlife area over FWOP conditions. Results show that the shoreline recedes landward from the 2012 shoreline position, but the lagoons remain even when the first structure is impacted at R-204. Also, the downdrift erosion observed for the breakwaters alternative around R-201 is not observed for the beach nourishment alternative.

The lifetime for this alternative is computed as approximately 12 years, corresponding to the time when the shoreline recedes to the vegetation line abutting the seaward structure at R-204. The modeling results show a slight reduction (10 to 25 ft) in shoreline retreat over the 12 years on the Lover's Key as some of the added beach fill for this alternative bypasses the ebb shoal and attaches to the western end of the island.

Figure 69. Beach response for Reach 3 for (left) FWOP conditions and (right) Alt 3-2 after 12 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 12.

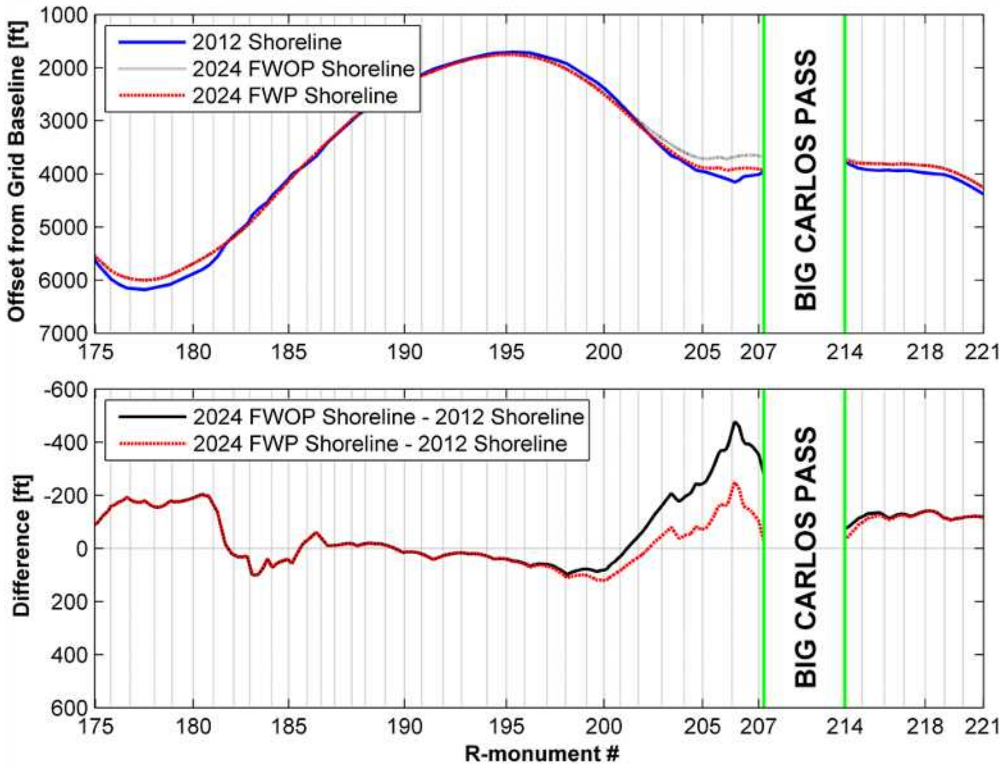


Figure 70. (top) Beach response for FWOP conditions and Alt 3.2 for the whole project shoreline after 8 years and (bottom) Change in shoreline for FWOP conditions and Alt 3.2 after 12 years.

8.2.9 Alt 3.3 Onshore Beach Nourishment and Breakwaters on Reach 3

The final alternative tested for Reach 3 was a combination of onshore beach nourishment with a crest width of 150 ft along with breakwaters placed seaward. The beach response for this alternative on Reach 3 and for the entire project shoreline is shown in Figure 71 and Figure 73 respectively. Due to the added beach fill component the beach response is better as compared to the Alt 3.1 (breakwaters only alternative) on this reach; in fact the shoreline is seaward of the existing 2012 shoreline position at the end of 8 years. The downdrift erosion around R-201 is reduced slightly compared to Alt 3-1 due to transport of some beach fill material northward along the beach on Reach 3, but still exists.

Due to the addition of the beach fill material behind the breakwaters for this alternative, the bypassing of material occurs and no increase in erosion on the adjacent shoreline of Lover's Key is observed. The lifetime of this alternative is approximated as 15 years when the shoreline just starts to recede to the existing vegetation between R-206 and R-207.

Figure 71. Beach response for Reach 3 for (left) FWOP conditions and (right) Alt 3.3 after 8 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 8.

Figure 72. Beach response for Reach 3 for (left) FWOP conditions and (right) Alt 3.3 after 15 years. Green line represents the shoreline at year 0, and the brown line is the shoreline at year 15.

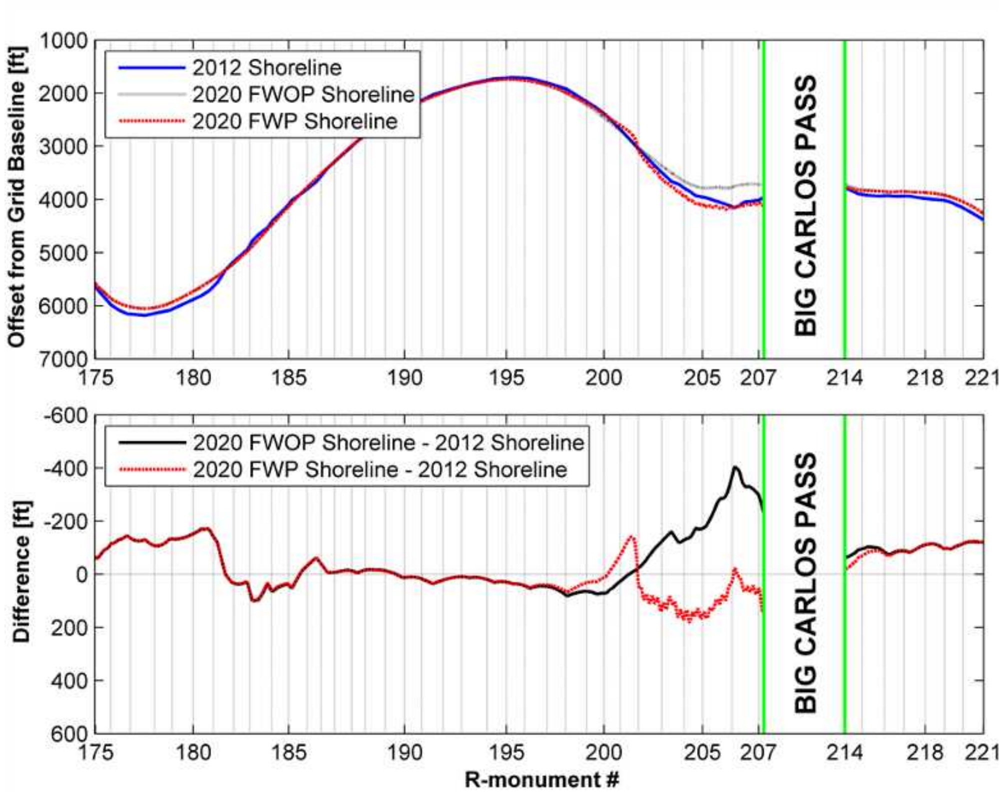


Figure 73. (top) Beach response for FWOP conditions and Alt 3.3 for the whole project shoreline after 8 years and (bottom) Change in shoreline for FWOP conditions and Alt 3.3 after 8 years.

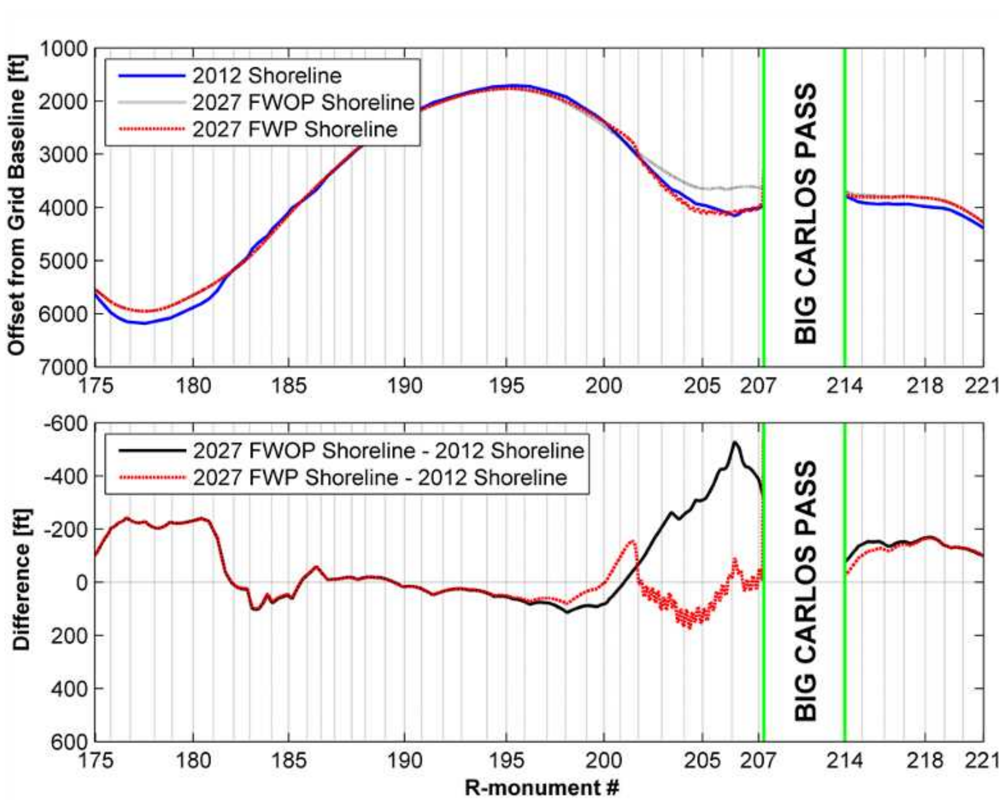


Figure 74. (top) Beach response for FWOP conditions and Alt 3.3 for the whole project shoreline after 15 years and (bottom) Change in shoreline for FWOP conditions and Alt 3.3 after 15 years.

8.2.10 Alt 3.4 Nearshore Placement on Reach 3

Proper evaluation of nearshore placement on Reach 3 has complexities beyond the nearshore placement Alt 2.2 in Reach 2 due to the proximity to Big Carlos Pass. In fact, the nearshore placement could be considered ebb shoal nourishment. No predictive tools exist outside of complicated 3-dimensional morphological models with ability to simulate proper morphology. Therefore as a means of comparison, we assume that in Reach 3 the nearshore placement will contribute half as much material to the beach as the nearshore placement in reach 2, with the other half being transported into the ebb delta. This would translate into a lifetime of half of that of Alternative 3.2, or approximately 6 years. Note that this estimate is highly uncertain.

8.2.11 Summary of Beach Response for Alternatives

The alternatives beach response can be evaluated in terms of lifetime, or the time the alternative keeps the shoreline seaward of the existing vegetation or infrastructure. The estimated performance lifetime in terms of beach response is summarized in Table 10.

Table 10. Summary Alternative's lifetime in terms of beach response.

Alternative	Description	Lifetime
1.1	Beach Nourishment	8
1.2	Short Groin Field	12
1.3	Breakwater Field	14
2.1	Onshore Beach Nourishment	>20
2.2	Nearshore Nourishment	10
2.3	Offshore Nourishment	n/a
3.1	Breakwater Field	11
3.2	Onshore Beach Nourishment	12
3.3	Onshore Beach Nourishment and Breakwater	15
3.4	Nearshore Beach Nourishment	6

8.3 Dune Component

The cross-shore modeling for the existing conditions in Reach 2 showed that overtopping was likely to occur during 5 year storm conditions. The overtopping of the backshore berm crest could pose threats to existing infrastructure. The presence of a dune feature was explored to determine if it would be effective in minimizing this overtopping and thus reducing the potential for damage to existing infrastructure.

The FEMA National Flood Insurance Program developed a 5 year protection criterion for emergency dune replacement (FEMA, 1988). Their study developed a relationship for expected erosion during a 5 year storm above the 5 year water level, and that expected erosion would be 6 CY/LF above the 5 year still water level.

The dune was designed to be located landward of the existing foreshore berm (which is approximately at the 5 year still water level). The dune was designed to have a volume of approximately 6 CY/LF resulting in a crest elevation of +6 ft NAVD (2-3 ft above existing beach elevation at the location of the dune) and a crest width of 46 ft and side slopes of 3H:1V. The existing profile at Reach 2 was modified to include a dune only and beach nourishment and dune alternatives. The beach nourishment was designed to have the same beach width as described in Section 7.5.4.

These alternatives were subjected to TS Gabrielle, 5 year, and 10 year storm conditions in the SBEACH model to evaluate the dune erosion and the maximum water level due to surge and wave setup. The results of these model runs are shown in Figure 75. A summary of the dune erosion is shown in Table 11.

Table 11. Percentage erosion of dune after storm conditions.

	TS Gabrielle	5 year	10 year
Dune only	-52%	-35%	-76%
Beach and Dune	-2%	-3%	-14%

The profile results of the dune only alternative model runs are shown in Figure 75. The dune only alternative shoreline receded at mean sea level (MSL) by an average of approximately 5.9 m (19 ft) in all of the storm conditions, which is less than the existing profile. The maximum water level for the dune only alternative was approximately the same as for the existing profile. Due to the presence of the dune, the maximum water level in the TS Gabrielle and 5 year storm conditions did not reach the backshore berm. The dune was eroded (24 % remaining) in the 10 year storm conditions. Therefore, the dune is expected to provide storm damage protection for up to at least a 5 year storm event.

The profile results of the dune and beach alternative model runs are shown in Figure 76. The dune and beach nourishment alternative shoreline receded at mean sea level (MSL) by an average of approximately 10.2 m (33ft) in all of the storm conditions, which is more than the existing profile primarily due to equilibration of nourishment slope. The maximum water level for the alternative was approximately the same as for the existing profile. Due to the presence of the dune, the maximum water level in all storm conditions did not reach the backshore berm. The dune and beach nourishment alternative was eroded substantially less than the dune only alternative. When the dune component is added to the beach nourishment, storm damage protection for is provided for at least a 10 year event.

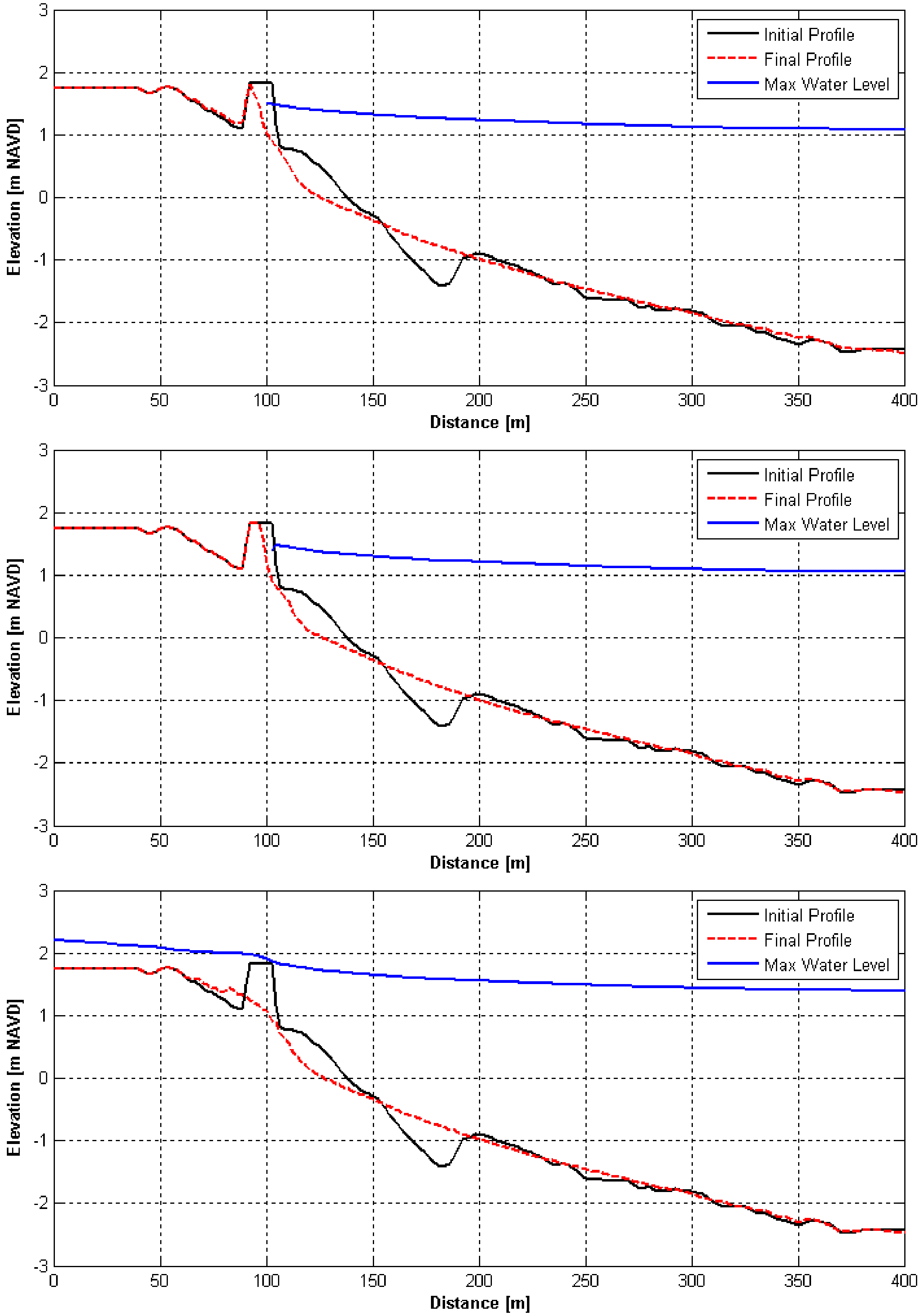


Figure 75. SBEACH results showing dune only profile (solid black line), post storm profile (dotted red line), and maximum water level due to surge and wave setup (solid blue line) for TS Gabrielle storm conditions (top), for 5 year storm conditions (middle), and for 10 year storm conditions.

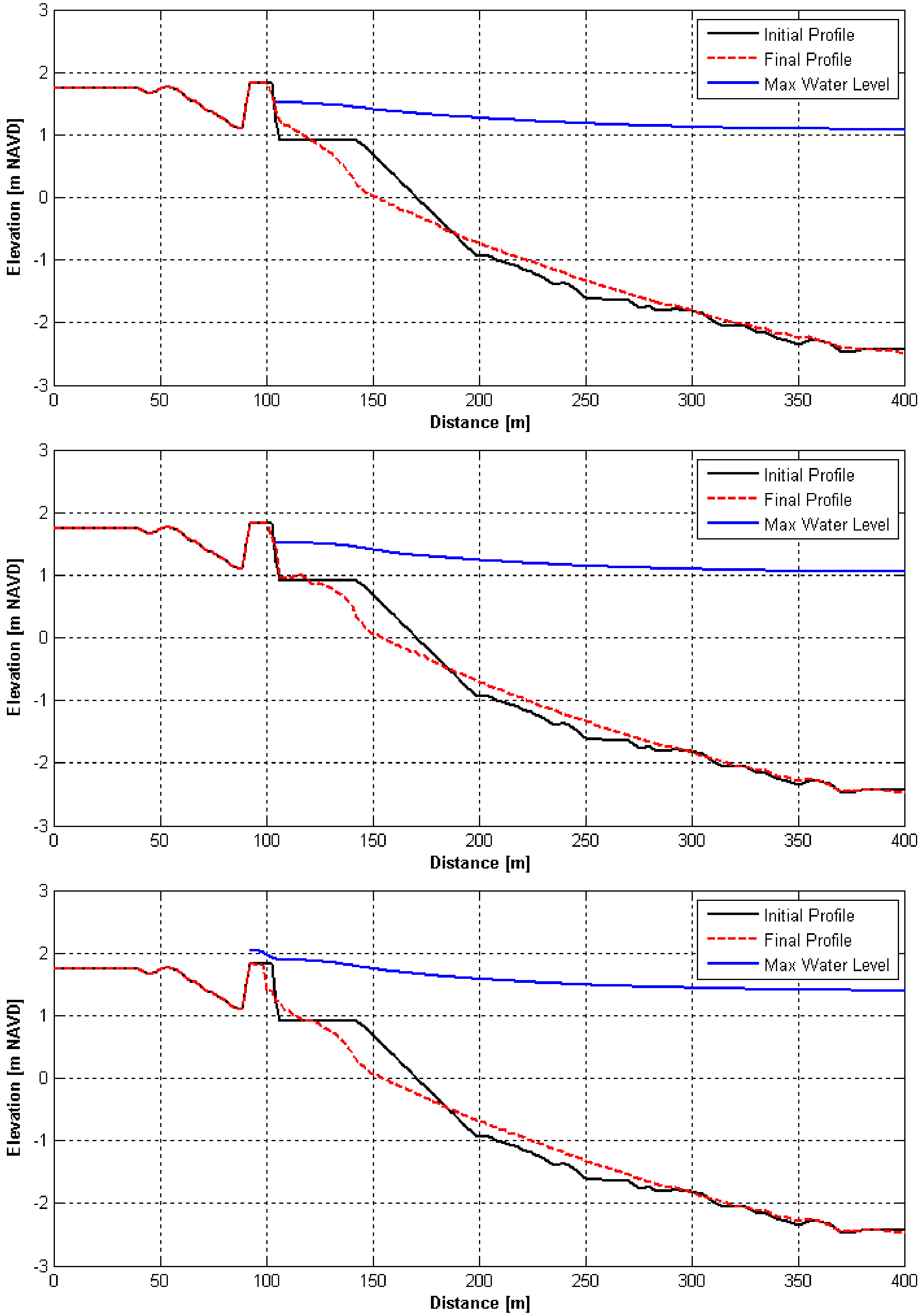


Figure 76. SBEACH results showing dune and beach nourishment profile (solid black line), post storm profile (dotted red line), and maximum water level due to surge and wave setup (solid blue line) for TS Gabrielle storm conditions (top), for 5 year storm conditions (middle), and for 10 year storm conditions.

8.4 Cost

Estimates of probable construction cost was developed for each of the alternatives. The costs were developed from information gathered from local contractors, previously bid projects in the area, and existing market conditions. A 30% contingency was added to the cost to account for the level of design and any unknowns that would be expected to come up during the final design phase. This cost estimate was primarily developed to compare the various alternatives. The mobilization was determined for beach nourishment and rock alternatives based on equipment types and expected effort. The surveying was similarly determined for each alternative type. The volumes of materials were estimated and unit cost were applied to each alternative based on expected methodologies.

Construction of the 2011 beach nourishment was $3,652,469. We assume future renourishments will place a similar volume with a similar methodology. Therefore, accounting for inflation, the next nourishment in 8 years is expected to be $4,630,000.

The construction items and probable costs for each alternative are shown in Appendix A, Table 17 through Table 24. A summary of all the alternatives total cost are shown in Table 12. The most expensive alternative in Reach 1 is the breakwater field alternative at approximately $1.0M. The most expensive alternative in Reach 3 is the onshore beach nourishment and breakwater field combination alternative at approximately $14.7M (note that this alternative Alt 3.3 onshore beach nourishment and breakwater field combination, is more expensive than their component parts added together, ie Alt 3.1 + Alt 3.2, due to the fact that building the two to work together properly requires placing the breakwaters in deeper water, resulting in more cost for the structures). The least expensive alternative in Reach 1 is short groin field at $4.4M. The least expensive alternative in Reach 3 is the nearshore beach nourishment at $2.6M. The nearshore beach nourishment is less expensive than the onshore beach nourishment, in general, due to the reduced amount of equipment needed, especially on the beach. Note that offshore beach nourishment is assumed to be the same as nearshore beach nourishment due to the similar requirements of volume and equipment required to construct the alternative.

Table 12. Summary of Alternatives Cost Estimates.

Alt	Alternative Description	Total Estimated Cost
1.1	Beach Nourishment	$ 4,630,000
1.2	Short Groin Field	$ 4,431,000
1.3	Breakwater Field	$ 9,994,400
2.1	Onshore Beach Nourishment	$ 2,548,000
2.2	Nearshore Placement	$ 2,314,000
2.3	Offshore Placement	$ 2,314,000
3.1	Breakwater Field	$ 8,623,000
3.2	Onshore Beach Nourishment	$ 2,775,500
3.3	Onshore Beach Nourishment and Breakwater	$ 14,724,000
3.4	Nearshore Placement	$ 2,636,000

8.5 Environmental Impact and Permitability

The alternatives have different impacts on the environment and therefore have different levels of effort in terms of permitting. Impacts can occur only during construction or as a result of a feature being built. Some areas of concern for environmental and other regulated impacts include:

1. Impacts to adjacent shorelines
2. Impacts to Endangered Species and other wildlife of concern, including Sea Turtles, Piping Plover, Snowy Plover, other migratory birds, sturgeon, and manatees. This includes direct harm or harassment of these species as well as impacts or harm to their habitat.
3. Impacts to important habitat, such as sea grasses, marsh/wetlands, hard bottom, coral, dunes, and beaches
4. Impacts to beach use and activity
5. Aesthetic impact

A summary of potential impacts are provided below. The discussion is not comprehensive and other unforeseen issue may arise during regulatory compliance.

8.5.1 Alt 1.1 Beach Nourishment

Beach nourishment has environmental impacts during construction both at the borrow site and at the placement site. Borrow site impacts include disturbance of essential fish habitat, potential impacts to hardbottom or coral if nearby due to turbidity, impacts to sea turtles, sturgeon, and possibly manatees (if in a region where manatees frequent), general water quality during dredging, and impacts to shoreline through direct or indirect modification of littoral drift and sediment supply.

Impacts on the beach are primarily a concern during construction. They include disturbance to piping plover habitat, direct harassment of piping plover, disturbance of birds nesting on the beach, disturbance of sea turtle nesting, direct harassment of sea turtles during nesting process, and impacts on nearshore water quality during dredging that may impact essential fish habitat, hard bottom, and aquatic vegetation. In addition, the character of the beach fill material must match that of the native beach. This is a major source of concern with using the borrow site of Matanzas Pass maintenance material. However, as stated in Section 3.3, other, higher quality borrow site exist that would alleviate this concern, for a slightly higher price. The cost estimate provided in Section 8.4 assumes using the higher quality borrow site.

During construction the immediate area around the construction site is unusable to the public, which can also be of concern in terms of timing of the construction activities with high season.

8.5.2 Alt 1.2 Short Groin Field

The short groin field impacts are primarily on the beach, as construction would be from land. They include disturbance to piping plover habitat, direct harassment of piping plover, disturbance of birds nesting on the beach, disturbance of sea turtle nesting, and direct harassment of sea turtles during nesting process. In addition, the groin field will result in hard structures made of rip-rap stone on the beach, which limits the accessibility of the beach and use by the public. Downdrift impacts are not a concern as longshore transport is unidirectional to the north.

8.5.3 Alt 1.3 Breakwater Field

The breakwater field does not directly impact the beach, and therefore has potentially fewer issue to endangered species (plover). However, there is some potential concern of impact to sea turtles from breakwaters. The major impacts from breakwater construction are filling essential fish habitat with stone, and dredging an access channel for construction (which may not be required based on geometry and breakwater layout); all of these can be considerable hurdles. Breakwaters may reduce the aesthetics of the beach and may cause issues with ingress/egress for jet ski vendors due the obstruction; this is subjective.

8.5.4 Alt 2.1 Onshore Beach Nourishment

The onshore beach nourishment here has the identical issues as discussed in Section 8.5.1. The cost estimate provided in Section 8.4 assumes the borrow site is Matanzas Pass, which may prove to contain poor quality material depending on the location of dredging.

8.5.5 Alt 2.2 Nearshore Beach Nourishment

The nearshore beach nourishment does not directly impact the beach, so all issues with onshore beach nourishment on the beach are removed. Borrow site impacts and impact to nearshore water quality are still a concern as discussed in Section 8.5.1. Possibly the biggest advantage of the nearshore placement is that the material quality can be much lower than the onshore placement, which opens nearshore placement up for beneficially using almost all material dredged from Matanzas Pass. Overall the nearshore placement alternative has less impacts than onshore placement.

8.5.6 Alt 2.3 Offshore Beach Nourishment

The offshore beach nourishment has identical issues as the nearshore beach nourishment discussed in Section 8.5.5.

8.5.7 Alt 3.1 Breakwater Field

The breakwater field in Reach 3 has the same impacts and concerns as the breakwaters in Reach 1 discussed in 8.5.3. Reach 3 contains additional concerns of impacts to adjacent shorelines. The breakwaters are shown to effectively reduce longshore transport, and therefore will cause some downdrift erosion both north and south of the breakwater field. Additionally, trapping more sand on the shoreline will likely reduce the amount of material available to be transported into Big Carlos Pass, thereby potentially impacting Lover’s Key.

8.5.8 Alt 3.2 Onshore Beach Nourishment

The onshore beach nourishment here has the identical issues as discussed in Section 8.5.1. The cost estimate provided in Section 8.4 assumes using the borrow site is from Big Carlos Pass, which add additional concerns to impact downdrift beaches of Lover’s Key. It appears that the impact to Lover’s Key would be temporary as sand from the beach nourishment would make it to Lover’s Key. If the borrow site is in a less active portion of the ebb shoal (in deeper water on the more distal end of the shoal), the impacts to Lover’s Key may offset with the benefits of the beach nourishment.

Additionally, disturbing the beach in the Little Estero Island Critical Wildlife Area may not be feasible depending on the regulations governing actions in the CWA.

8.5.9 Alt 3.3 Onshore Beach Nourishment and Breakwater

The onshore beach nourishment here has the identical issues as discussed in Section 8.5.8, and the breakwaters will have the same issues as discussed in Section 8.2.3. In addition, the breakwater placement in a very dynamic area in essentially an active ebb shoal requires caution. This dynamic area may hinder the ability of the breakwaters to function correctly, and will likely have a more complicated morphological response than the Gencade simulations were able to reflect. We recommend investigating the morphological response to these structures with more detailed 3-dimensional morphological models prior to moving forward with design and implementation.

8.5.10 Alternative 3.4 Nearshore Beach Nourishment

The nearshore beach nourishment does not directly impact the beach, so all issues with onshore beach nourishment on the beach are removed. Borrow site impacts and impact to nearshore water quality are still a concern as discussed in Section 8.5.1. Possibly the biggest advantage of the nearshore placement is that there is no direct impact to the Critical Wildlife Area. A major uncertainty is project performance. However, outside of the impacts at the borrow site, the impacts of placing this material are thought to be very small.

8.5.11 Summary of Environmental impacts and permitability.

The alternatives were scored based on their environmental impacts and permitability based on a subjective evaluation of the above criteria; results are shown in Table 13.

Table 13. Summary of evaluation of alternatives environmental impact and permitabilty. A rank of 5 is the best (least impact) and a value of 1 is the worst (highest impacts).

Alternative	Alternative Description	Ranking [5 - best, 1 - worst]
1.1	Beach Nourishment	3
1.2	Short Groin Field	2
1.3	Breakwater Field	2
2.1	Onshore Beach Nourishment	2
2.2	Nearshore Beach Nourishment	4
2.3	Offshore Beach Nourishment	4
3.1	Breakwater Field	2
3.2	Onshore Beach Nourishment	1
3.3	Onshore Beach Nourishment and Breakwater Field	1
3.4	Nearshore Beach Nourishment	3

8.6 Alternatives Evaluation

To determine the best performing alternatives, the alternatives are compared relative to their design and performance criteria established in 8.1. The design criteria control the development of structure geometric parameter; all stone structures therefore are designed with stones that are stable under the design criteria conditions (25 year storm).

The performance criteria include beach response, cost, cost/benefit, environmental impacts, and impacts to adjacent shorelines. The beach response was evaluated in Section 8.2, the costs were determined in Section 8.4, and the environmental impacts were discussed in Section 8.5.

For Reach 1, a state beach nourishment project has been constructed, and is expected to require renourishment at least every 8 years. The Alt 1.2 and 1.3 include structures that reduce sediment transport of the beach nourishment, and therefore will increase the beach nourishment lifetime. However, the structures cost as much as or more than a beach nourishment event. Therefore, the structures should increase the lifetime sufficiently to reduce the overall cost of stabilizing the shoreline over the lifetime of the structures. The structures have been designed for a 25 year event, and therefore, the structures should at least pay for themselves in 25 years, meaning they should reduce the number of nourishments sufficiently to offset the cost of construction of the structures.

Table 14 shows a breakdown of the number of nourishments expected to be required under alternatives 1.1, 1.2 and 1.3, the beach nourishment costs over 25 years, the structure cost, and the total Reach 1 cost in 25 years, all for inflation rates of 0%, 3%, and 4%. If inflation is not included (i.e. is 0%), the Groin Field is approximately equal in cost to only performing beach nourishments, while constructing the breakwaters would cost $4.5 million more than the beach nourishment only. When inflation is set at a long-term average rate of 3%, the short groin field results in $3 million in savings over beach nourishment alone, while the breakwater field still costs $1.8 million more than beach nourishment alone. If inflation is slightly higher at 4%, the savings for the groin field reach $4.2 million over 25 years and the breakwater field costs approximately the same as nourishment only. Based on these results, the groin field is the most cost-effective choice. It should be noted that while the structure design life is 25 years, rubble mound structures typically perform at only a slightly reduced function well past their lifetime. This means that the savings achieved with the groin field will continue to compound well past the 25 year lifetime. To achieve continual performance at the same level past the 25 year event, some periodic maintenance of the structure will be required.

Table 14. Total cost of nourishment and structures in 25 years for Reach 1 for inflation of 0%, 3% and 4%.

	Alternative	number of nourishments in 25 years	nourishment cost after 25 years	structure cost	total cost in 25 years
inflation = 0					
1.1	Beach Nourishment	3.1	$11,870,000	$0	$11,870,000
1.2	Short Groin Field	1.8	$6,780,000	$4,430,000	$11,210,000
1.3	Breakwater Field	1.7	$6,330,000	$9,990,000	$16,330,000
inflation = 3%					
1.1	Beach Nourishment	3.1	$17,600,000	$0	$17,600,000
1.2	Short Groin Field	1.8	$10,060,000	$4,430,000	$14,490,000
1.3	Breakwater Field	1.7	$9,390,000	$9,990,000	$19,380,000
inflation = 4%					
1.1	Beach Nourishment	3.1	$20,230,000	$0	$20,230,000
1.2	Short Groin Field	1.8	$11,560,000	$4,430,000	$15,990,000
1.3	Breakwater Field	1.7	$10,790,000	$9,990,000	$20,780,000

Reach 2 and 3 do not allow for a similar cost/benefit analysis over time as they do not improve the performance of a nourishment project. However, the alternatives in Reach 2 and 3 provide shoreline stabilization for those reaches, and can be evaluated in terms of the cost per year of stabilizing the alternative provides. Table 15 shows the total cost, the expected lifetime of beach stabilization performance, and the cost per year of performance for each alternative in Reach 2 and 3. Alt 2.1 has the best cost for performance in Reach 2, and Alt 3.2 has the best cost for performance in Reach 3 by a factor of at least 2.

Table 15. Cost, lifetime, and cost per year of nourishment and structures for Reach 3.

	Alternative	Total Cost	lifetime [yrs]	Cost/year
2.1	Onshore Beach Nourishment	$2,548,000	>20	$127,400
2.2	Nearshore Placement	$2,314,000	10	$231,400
2.3	Offshore Placement	$2,314,000	n/a	n/a
3.1	Breakwater Field	$8,623,441	11	$783,949.18
3.2	Onshore Beach Nourishment	$2,775,500	12	$231,291.67
3.3	Onshore Beach Nourishment and Breakwater	$14,724,255	15	$981,617.00
3.4	Nearshore Placement	$2,635,750	6	$439,291.67

To select the best performing alternative, all the performance evaluation criteria should be considered together. Table 16 shows each alternative and each of the evaluation criteria: beach performance, cost/benefit, environmental impact, and impact to adjacent shoreline. The performance of each alternative is ranked for each criteria 1 to 5, where 1 is worst and 5 is best. Results are summed without weight, and for each reach, the alternatives are ranked best to worst, where 1 is best.

The best performing alternative in Reach 1 is Alt 1.2, the short groin field, to supplement future beach nourishments. The short groin field has almost twice the life compared to beach nourishment alone, and only slightly lower life than the breakwater field. At the same time, the groins were almost half the cost of the breakwaters. Environmental impacts of placing stone on the beach are not small, but not impossible to overcome with due care. While adjacent shorelines will only be benefitted from a beach nourishment, there will be little to no impact to adjacent shorelines from constructing structures as longshore transport is dominantly to the north in Reach 1. However, some erosion may occur on the north and bay side of Bowditch Point due to reduction in transport.

For Reach 2, Alternative 2.1 clearly outperforms nearshore placement in terms of beach stabilization. However, the source for material for beach nourishment identified for Reach 2 is Matanzas Pass maintenance dredging which will likely result in unfavorable material quality, which may completely preclude the ability to construct onshore beach nourishment. Therefore, as the overall performance of Alternative 2.2 is the same as Alternative 2.1, Alternative 2.2 is selected as the recommend alternative for Reach 2. It should be noted that Alternative 2.3 is essentially a no-action alternative as it has no benefits for beach stabilization.

The best overall performing alternative in Reach 3 is Alt 3.2 onshore beach nourishment. The ability of beach nourishment to stabilize the shoreline is nearly the same as breakwaters at a fourth of the cost. However, a potentially large hurdle with onshore beach nourishment is regulatory compliance in the Critical Wildlife Area. While placement of sand directly on the beach has the potential to interfere with many important habitat types and directly displace or disturb protected species, the long term benefit of sand for the continued existence of the habitat is likely to outweigh the short-term impacts, as long as the short term impacts are carefully managed during construction. The onshore nourishment will only help adjacent shorelines, even if the borrow source is located in Big Carlos Pass (and is carefully located after proper evaluation). However any structures will cause large downdrift impacts on both the northern and southern ends of the proposed structures. Therefore Alt 3.2 was selected as the best cost, best performance least impacting alternative in Reach 3.

Table 16. Evaluation matrix for different alternatives. 5 is best, 1 is worst. In rank, 1 is best.

	Alternative	Beach Performance	cost/ benefit	envir. impact	Adjacent Shoreline	total	Rank per Reach
1.1	Beach Nourishment	2	2	3	5	12	2
1.2	**Short Groin Field**	**4**	**5**	**2**	**4**	**15**	**1**
1.3	Breakwater	5	1	2	4	12	3
2.1	Onshore Nourishment	5	4	2	5	16	2
2.2	**Nearshore Nourishment**	**4**	**2**	**5**	**5**	**16**	**1**
2.3	Offshore Beach Nourishment	1	1	5	3	10	3
3.1	Breakwater	4	2	2	1	9	3
3.2	**Onshore Nourishment**	**4**	**4**	**1**	**5**	**14**	**1**
3.3	Onshore Nourishment and Breakwater	5	2	1	3	11	2
3.4	Nearshore Nourishment	2	2	3	4	11	2

8.7 Recommendations

Based on the findings discussed in this report, CHE's recommendation to the Town of Ft. Myer's Beach are:

8.7.1 Reach 1

A. In Reach 1 continue to support and construct beach re-nourishment projects.
B. Construct the Alt 1.2 short groin field in conjunction with the renourishment program. During preliminary design, explore the benefits of adding 2-4 additional groins further south.

8.7.2 Reach 2

A. Beneficially utilize maintenance dredging of Matanzas Pass as nearshore placement Alt 2.2.
B. The entire placement extents benefit from the nearshore placement, but priority areas are in the region of R-185 to R-188 which experiences the most erosion. Therefore, in the event of smaller quantities of material, place the material in the northern reaches.

8.7.3 Reach 3

A. Construct Alt 3.2 onshore nourishment utilizing sediment dredged from Big Carlos Pass.
B. If permitting challenges arise, utilize nearshore nourishment as an interim measure and closely monitor results to better understand behavior in order to more effectively design future action in the region
C. Consider immediate action (or permitting immediate action) at R-204. This may be in the form of beach nourishment or upland property protection.

8.7.4 General beach nourishment and borrow sites

A. Secure the use of identified borrow sources B-1, BA-1 and BA-2 (> 5.75 M cy) for future re-nourishments of north end.

B. Perform a study to evaluate use of Big Carlos Pass as long-term borrow site for southern end of island. Wait to perform the study until at least two to four more years of monitoring can be performed on the morphology of Big Carlos Pass.
C. Dunes are effective at reducing storm damage from minor to moderate storms. When constructed using approximately 6 cy/ft of material, a dune alone is effective at protecting against up to a 5-yr event, and when a dune is combine with beach nourishment, is effective at protecting for up to a 10-yr event.
D. Dunes need maintenance to continue to be effective as a storm damage defense. Use vegetation and sand fencing to help stabilize dunes.
E. Natural dunes may form through the use of sand fences and vegetation. If the goal is dune building, the town should establish and enforcement regulation to minimize disturbance of dune vegetation.

8.7.5 Monitoring

A. In general, better coastal and beach management will result from an effective, consistent, and long-term monitoring program. We recommend developing, funding, and performing monitoring into the future.
B. Any monitoring program should include data collection along with ongoing analysis of the data relative to specified metrics in order to develop an understanding from the data collected.
C. Perform consistent monitoring of the Island shoreline through regular topographic and bathymetric survey transects at island R-monuments. The more frequent the better; if frequency is annual or longer, then the surveys should be conducted in the same time of year.
D. Perform a long-term monitoring study of Big Carlos Pass, with a goal to determine if it is in fact a long-term sustainable borrow site, and to determine what is the best location for the borrow site. The study should consist of a data collection campaign and an analysis to determine morphology and sediment budget of pass and adjacent shorelines.
    a. The data collection should include a multibeam survey (the best) or comprehensive water-penetrating LIDAR data (next best).
    b. Either should include topography of the beach up to at least the vegetation line (can be done through topographic transects).
    c. It is very important that the extents of the monitoring surveying are sufficient to encompass the entire shoal. The 2010 LIDAR survey is close to capturing the extents and are a good first estimate.
    d. Several realizations of the shoal are needed.
    e. Recommend the first monitoring survey begin immediately after the completion of the dredging of the shoal as a borrow source for the Lover's Key beach nourishment.
E. Recommend performing a beach nourishment, perhaps of Reach 3 as Alt 3.2, using Big Carlos Pass as the borrow site, and monitor the morphology results of the beach

nourishment and borrow site. This will help guide further long-term management of Big Carlos Pass.

9 CONCLUSIONS

The Estero Island Coastal Management Plan project has two objectives: (1) Develop an understanding of coastal processes and anthropogenic factors that control short and long term shoreline morphology of Estero Island and (2) Develop and evaluate a set of long-term engineering solution(s) that maximize coastal stability for the Estero Island Gulf shoreline.

To develop an understanding of coastal processes controlling shoreline erosion, CHE collected and analyzed literature as well as historical and new data and performed a coastal processes analysis with analytical and numerical modeling tools. Then based on the understanding of coastal processes, CHE developed a suite of 10 alternative over three reaches of the Island. These alternatives were evaluated for the performance in meeting the project goals and cost while also weighing environmental impacts and impacts to adjacent shorelines.

The morphology of the southern end of the island is dominated by the attachment of the ebb shoal bar in the late 1960s which formed a series of lagoons between the main island and the shoreline, and also provided a source of sediment for the immediate and adjacent areas. The central portion of the island has remained relatively stable from 1953 to 2011 with localized areas of minor accretion and erosion. The northernmost reach from R-187 to R-175 at Matanzas Pass has experienced high shoreline retreat rates, up to -25 ft/year, which has been managed by beneficially using the material dredged from the federally maintained Matanzas Pass navigation channel immediately adjacent to Bodwitch Point.

The morphology of Big Carlos pass was investigated by analyzing available bathymetry data sets. Because these data sets do not extend the full extents of the ebb shoal, estimating volume and volume change rates has high uncertainties. The ebb shoal is estimated to have between 7.5 and 10 million cy. Measured volume change rates indicate between 2006 and 2010, on the order of 40k cy was deposited on the ebb shoal, and then between 2010 and 2013 75% of that material was eroded off the shoal, potentially as a bypassing event.

Based on the results of the morphology analysis a hypothesis on the long-term morphology patterns along the island was developed. The general trend is northerly transport on the north, a divergent node that occurs in the north 1/3 of the island and any given year can vary in location as much as almost two miles. Similarly, a convergent node exists between a range of R-198 and R-202. Sediment is transport into and across Big Carlos Pass and bypassed to Lovers Key. On the extreme northern end of Lover's Key, sediment is transported into the pass, and near R-215 another divergent node occurs. From R-215, transport is generally to the south along Lover's Key.

Numerical modeling was conducted to develop a better understanding of tidal circulation and inlet processes, the wave climate, longshore transport, and shoreline morphology. Modeling efforts included the MORPHO circulation model, SWAN wave model, analytical longshore transport modeling driven by the wave model results, and GENCADE shoreline morphology model.

Gencade morphology modeling was calibrated and validated, and used to compute the future without project conditions. This modeling confirmed the hypothesis on the long-term morphology. The northern beach nourishment was shown to have a lifetime of approximately 8 years. The central region is stable but localized erosion is expected impact infrastructure in 2-3 years. The southern end of the island at the Critical Wildlife Area will erode to infrastructure at R-204 within 4 years.

Estero Island was separated into 3 reaches, Reach 1 on the north, Reach 2 in the center, and Reach 3 on the south. 10 alternatives were developed based on the understanding of coastal processes and morphology. The alternatives are:

- Alt 1.1 - 400,000 cy beach nourishment on Reach 1
- Alt 1.2 - Short Groins on Reach 1
- Alt 1.3 - Breakwaters on Reach 1
- Alt 2.1 - 200,000 cy Onshore Beach Nourishment on Reach 2
- Alt 2.2 - 200,000 cy Nearshore Placement on Reach 2
- Alt 2.3 - 200,000 cy Offshore Placementt on Reach 2
- Alt 3.1 - Nearshore Detached Breakwaters on Reach 3
- Alt 3.2 - 250,000 cy Onshore Beach Nourishment on Reach 3
- Alt 3.3 - 250,000 cy Onshore Beach Nourishment and Breakwaters on Reach 3
- Alt 3.4 - 250,000 cy Nearshore nourishment

Each alternative was evaluated for performance in stabilizing the shoreline, cost, environmental impacts, and impacts to adjacent shorelines.

The best performing alternative in Reach 1 is Alt 1.2, the short groin field, to supplement future beach nourishments. The short groin field has almost twice the life compared to beach nourishment and is half the cost of the breakwaters.

For Reach 2, while Alternative 2.1 outperforms nearshore placement in terms of beach stabilization, the source identified for the nourishment is Matanzas Pass maintenance dredging which will likely result in unfavorable material quality, which may completely preclude the ability to construct onshore beach nourishment. Alternative 2.2 is selected as the recommend alternative for Reach 2.

The best overall performing alternative in Reach 3 is Alt 3.2 onshore beach nourishment. The ability of beach nourishment to stabilize the shoreline is nearly the same as breakwaters at a fourth of the cost. A potentially large hurdle with onshore beach nourishment is regulatory compliance in the Critical Wildlife Area; careful construction practices may help pass this hurdle.

The presence of a dune was analyzed through cross-shore modeling to determine its ability to protect inland infrastructure. It was determined that dunes of approximately 6 CY/ft of material above the 5 year water level were effective in protecting up to a 5-year event. When the dune was combined with beach nourishment, the dune was effective up to a 10-year event.

Recommended actions to be taken by the town include implementing the recommended alternatives, constructing or growing a dune where moderate storm damage protection is desired, securing borrow sites for long-term use on the Island, and developing and implementing a long-term monitoring plan with a focus on Big Carlos Pass with a goal to determine if it is in fact a long-term sustainable borrow site, and to determine what is the best location for the borrow site.

10 REFERENCES

Applied Technology and Management (1997) Lee County Long Range Erosion Control Budget Plan. Prepared for Lee County Department of Public Works, Division of Environmental Services. March 1997.

Applied Technology and Management (2000) Estero Island Beach Restoration Project Economic Analysis. Prepared for Lee County Environmental Services Division. July 2000.

Applied Technology and Management (2007) Beach Renourishment Plan Review: Summary of Study Results. Prepared For Town of Fort Myers Beach. August 2007.

Basco, D. (2002). Shore Protection Projects. In: Pope, J., Coastal Engineering Manual, Part V , Coastal Project Planning and Design Chapter V-3, Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, DC.

Beck, Tanya, M., Rosati, Julie D., Rosati, James (2012) An Update on Nearshore Berms in the Corps of Engineers: Recent Projects and Future Needs. January 2012.

Brutsche, Katherine (2011) First Year Sedimentological Characteristics and Morphological Evolution of an Artificial Berm at Fort Myers Beach, Florida. Theses and Dissertations University of South Florida. January 2011.

Brutsche, Katherine E., Wang, Ping (2012) First Year Morphological Evolution of an Artificial Berm at Fort Myers Beach, Florida. January 2012.

Brutsche, Katherine E., Wang, Ping, Rosati, Julie D., Beck, Tanya, M (2011) Sedimentological Characteristics and Evolution of an Artificial Nearshore Berm, Fort Myers Beach, Florida. Presentation at American Shore & Beach Preservation Association Conference.

Brutsche, Katherine E., Wang, Ping, Rosati, Julie D., Beck, Tanya, M. (2011) Two-Year Morphological Evolution of an Artificial Berm at Fort Myers Beach, Florida. PowerPoint Presentation.

Brutsche, Katherine E., (2013) Personal Communication, October 2013.

Boutelle, S. (2012) Lee County - Natural Resources Division. Personal Communication, September 2012.

Burcharth, H.F., Hughes, S. (2002). Fundamentals of Design. In: Hughes, S., Coastal Engineering Manual, Part VI , Design of Coastal Project Elements Chapter VI-5 , Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, DC.

Byrne, M.J., Gabaldon, J.N., 2008, Hydrodynamic Characteristics and Salinity Patterns in Estero Bay, Lee County, Florida: U.S. Geological Survey Scientific Investigations Report 2007-5217, 33 p.

CIRIA (2007). The Rock Manual. The use of rock in hydraulic engineering. 2nd Edition. C683, CIRIA, London.

Coastal Engineering Consultants (1998) Preliminary Beach Restoration Implementation and Funding Plan. Prepared for the Town of Fort Myers Beach April 28, 1998. CEC Job No. 97.466.

Coastal Engineering Consultants (2005) Plan Sheets for Estero Island Shoreline Change Rates (1974, 2001, 2004) and Historical MHW Positions. Prepared for the Town of Fort Myers Beach.

Coastal Planning and Engineering (1999) Appendix A: Engineering Design and Cost Estimate Lee County, Florida Shore Protection Project General Reevaluation Report. Prepared for US Army Corps of Engineers Jacksonville District. July 1999.

Coastal Planning and Engineering (2001a) Supplemental Engineering Report: Lee County, Florida Shore Protection Project. General Reevaluation Report with Draft Environmental Impact Statement, Estero Island Segment. Prepared for the U.S. Army Corps of Engineers, Jacksonville District. January 2001.

Coast & Harbor Engineering (2012) Estero Island Coastal Management Plan – Plan Approach and Review of Existing Data and Studies. Prepared for the Town of Ft Myers Beach under RFQ-11-01-CD, October 8, 2012.

Coastal Planning and Engineering (2001b) Borrow Area Impact Analysis: Refraction, Diffraction, and Cross-Shore Modeling, Estero Island and Lovers Key Beach Restoration Project. Prepared for Lee County, March 2001.

Coastal Planning and Engineering (2001c) Estero Island Sand Search Investigation, Phase 1. January 2001.

Coastal Planning and Engineering (2001d) Estero Island Sand Search Investigation, Phase 2. January 2001.

Coastal Planning and Engineering (2005) Permit Drawings for Estero Island Beach Restoration Project, Lee County, Florida. April 2005.

Coastal Planning and Engineering (2012) 2012 Estero Island Post-Construction Topographic and Hydrographic Survey Report. Prepared for Florida Department of Environmental Protection Bureau of Beaches and Coastal Systems, Submitted by Lee County February 2012.

Crowell, M., Leatherman, S.P., Buckley, M.K. (1991) Historical Shoreline Change: Error Analysis and Mapping Accuracy. Journal of Coastal Research, 7(3), 839 -852. Ft Lauderdale (Florida). ISSN 079-0208.

Davis, R.A. and Gibeaut, J.C. (1990) Historical Morphodynamics of Inlets in Florida - Models for Coastal Zone Planning. Sea Grant Project No. R/C-S-23, Technical Paper 55, Florida Sea Grant College.

Dean, R.G., Cheng, J., Subarna, M. (1998) Characteristics of Shoreline Change along the Sandy Beaches of the State of Florida: An Atlas. Prepared by the Coastal and Oceanographic Engineering Department, University of Florida, sponsored by the Florida Sea Grant Program. UFL/COEL-98/015.

Dean, R.G., Chiu, T.Y., Wang, S.Y., (1990) Combined Total Storm Tide Frequency Analysis for Lee County. July 1990.

Delft University of Technology, Environmental Fluid Mechanics Section. 2012. SWAN – User Manual, Version 40.91, April 2012.

Doyle, Larry J., Sharma, Dinesh C., Hine, Albert C., Pilkey, Orrin H. Jr., Neal, William J., Pilkey, Orrin H. Sr., Martin, David, Belknap, Daniel F. (1984) Living with the West Florida Shore. Duke University Press.

Engelund, F., and E. Hansen (1972). A Monograph on Sediment Transport in Alluvial Streams, Teknisk Forlag, Copenhagen.

Godshalk and Associates (1988a) Lee County Coastal Study, A report to the Lee County, Florida Department of Community Development. Volume 1: Findings and Recommendations. February 1988.

Godshalk and Associates (1988b) Lee County Coastal Study, A report to the Lee County, Florida Department of Community Development. Volume 2: Technical Reports and Appendices. February 1988.

Federal Emergency Management Agency (1988), Basis of Erosion Assessment Procedures for Coastal Flood Insurance Studies, Washington, DC, November 1988.

Florida Department of Environmental Protection (2001). Consolidated Notice of Intent to Issue Joint Coastal Permit, Authorization to Use Sovereign Submerged Lands, and Variance. March 2001.

Florida Department of Environmental Protection (2009) Consolidated Joint Coastal Permit and Sovereign Submerged Lands Authorization. March 2009.

Florida Department of Environmental Protection Bureau of Beaches and Coastal Systems (2008) Strategic Beach Management Plan for the Southwest Gulf Coast Region. May 2008.

Florida Department of Environmental Protection Bureau of Beaches and Coastal Systems (2009) Critically Eroded Beaches in Florida. June 2009.

Florida Department of Environmental Protection Bureau of Beaches and Coastal Systems (2011) Critically Eroded Beaches in Florida. June 2011.

Foster, Emmett R. (1991) Inlet Behavior and the Effects on Beach Erosion. Proceedings of the 1991National Conference on Beach Preservation Technology, published by The Florida Shore & Beach Preservation Association, Tallahassee, FL, 32301, pp. 178-193.

Hubertz, J.M., and Brooks, R.M. (1989) Gulf of Mexico Hindcast Wave Information. WIS Report No. 18, Hydraulics Laboratory, U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, MS

Humiston and Moore Engineers (1997) Estero Island Beach Restoration Study. Prepared for the Board of Commissioners for Lee County. March 1997.

Humiston & Moore Engineers (2008) Matanzas Pass Federal Channel Dredging Project Drawings. Prepared for West Coast Inland Navigation District. October 2008.

Kreuzkamp A.J. and Dean, R.G. (1997) Pilot Program to Quantify Shoreline Change in Lee County. Annual Report, 2/27/1997.

Kivva, S.L., P. Kolomiets, T. Shepeleva, and M. Zheleznyak. 2006. CHEWPCE-MORPH. A Numerical Simulator for Depth-Averaged Surface Water Flow, Sediment Transport and Morphodynamics in Nearshore Zone. Version 2.0. User guide. Developed under U.S. Civilian Research and Development Foundation grant from 2004-2008 in Ukraine, Russia.

Larson, M., Wise, R., Kraus, N.C. (2004) Coastal Overwash, Part 2: Upgrade to SBEACH, ERDC/RSM-TN-15, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Lee County Beach Preservation Task Force (1995) Beach Management Plan. September 1995.

Moore, L.J. (2000) Shoreline Mapping Techniques. Journal of Coastal Research, 16(1), 111-124. Royal Palm Beach (Florida), ISSN 0749-0208.

Neal, Robert (2005) Impacts of Hurricane Charley on the Southwest Florida Coastline Focusing on Lee County. Prepared for Florida Shore and Beach Preservation Association National Conference on Beach Preservation Technology, February 2-4, 2005.

NOAA (2012) National Ocean Service Tides and Currents. http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8725110%20Naples,%20FL. Last accessed 6/2013

NOAA (2013a) National Ocean Service's GEODAS data clearinghouse http://www.ngdc.noaa.gov/mgg/geodas/geodas.html. Last accessed 8/2013

NOAA (2013b) Vertical Datum Transformation. http://vdatum.noaa.gov/

NOAA (2013c) Digital Coast http://www.csc.noaa.gov/digitalcoast/data/coastallidar/

Olsen Associates Inc. (1987) Beach Management Plan for Lee County; Final Report. Florida Department of Natural Resources, Division of Beaches and Shores, April 1987.

Stauble, D.K. and McVan, D.C. (1997) Geoacoustic Study and Beachfill Borrow Area Assessment of the Gulf of Mexico, Ft. Myers Beach, Lee County, Florida. USACE-Waterways Experiment Station. Prepared for the USACE-Jacksonville District. Technical Report CHL-??-??.

United States Environmental Protection Agency (1994) Coastal and Shoreline Erosion Action Agenda for the Gulf of Mexico. First Generation – Management Committee Report. July 1994.

Universal Engineering Sciences (1995) Geotechnical Investigation - Matanzas Pass Maintenance Dredging Project, Fort Myers, FL. Report No. 45663. Prepared for the Lee County Department of Natural Resources under Order No 50403-001-01, November 10, 1995.

US Army Corps of Engineers (1969) Beach Erosion Control Study on Lee County, Florida. Prepared by the US Army Corps of Engineers Jacksonville District July 29, 1969.

US Army Corps of Engineers (2001) Lee County, Florida Shore Protection Project (Gasparilla and Estero Islands) General Reevaluation Report with Final Environmental Impact Statement. Prepared by the US Army Corps of Engineers Jacksonville District.

U.S. Army Corps of Engineers. 2002. Coastal Engineering Manual. Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C. (in 6 volumes).

US Army Corps of Engineers (2009) Fort Myers Beach Maintenance Dredging 12-Foot Project Drawings. Prepared by the US Army Corps of Engineers Jacksonville District. March 2009.

US Army Corps of Engineers (2010) Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) Lidar: Gulf Coast of Florida. http://www.csc.noaa.gov/dataviewer/index.html?action=advsearch&qType=in&qFld=ID&qVal=1073

US Army Corps of Engineers (2013) Wave Information Study. http://wis.usace.army.mil/

Tracy, B. A., (undated) Directional Characteristics of the 1990-1999 Wave Information Studies: Gulf of Mexico Hindcast," 7th International Workshop on Wave Hindcasting and Forecasting, Banff, Canada, 10 pp. (online only): Comparison of the mean wave direction results of the Gulf of Mexico hindcast with directional measurements

van der Meer J. W., J.W. and Stam, C.J.M. (1992), Wave run-up on smooth and rock slopes of coastal structures, ASCE, Journal of WPC&OE, Vol.118, No.5, 534-550.

van der Meer, J.W., Briganti, R., Zanuttigh, B., and Want, B. (2005) Wave Transmission and Reflection at Low-Crested Structures: Design Formulae, Oblique Wave Attack, and Spectral Change. *Coastal Engineering*, Vol. 52, pgs 915-929.

Walton, T.L., W.D. Adams (1976) Capacity of inlet outer bars to store sand. In Proceedings of the 15th Coastal Engineering Conference, Honolulu, HI: ASCE, pp. 1919-37.

Wang., P., K.E. Brutsche, J.W. LaGrone, T.M. Beck, J.D. Rosati, and L.S. Lillycrop (2013) Performance Monitoring of a Nearshore Berm at Ft. Myers Beach, Florida: Final Report. Coastal and Hydraulics Laboratory US Army Engineer Research and Development Center. ERDC/CHL TR-13-11

Appendix A
Detailed Cost Estimates

Table 17. Conceptual estimate of probable construction cost for Alternative 1.2 – Short Groin Field.

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization and Demobilization	1	LS	$ 60,000	$ 60,000
2	Construction Surveying	1	LS	$ 20,000	$ 20,000
3	Stone	12,762	TON	$ 150	$ 1,914,300
4	Excavation	136,000	CY	$ 10	$ 1,360,000
5	Geotextile Fabric	9,088	SY	$ 6	$ 54,528
				SUBTOTAL	$ 3,408,828
				Contingency (30%)	$1,022,648
				CONSTRUCTION COST	$ 4,431,476

Table 18. Conceptual estimate of probable construction cost for Alternative 1.3 – Breakwater Field.

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization and Demobilization	1	LS	$ 60,000	$ 60,000
2	Construction Surveying	1	LS	$ 20,000	$ 20,000
3	Stone	50,000	TON	$ 150	$ 7,500,000
4	Geotextile Fabric	18,000	SY	$ 6	$ 108,000
				SUBTOTAL	$ 7,688,000
				Contingency (30%)	$ 2,306,400
				CONSTRUCTION COST	$ 9,994,400

Table 19. Conceptual estimate of probable construction cost for Alternative 2.1 – Onshore Beach Nourishment.

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization and Demobilization	1	LS	$ 550,000	$ 550,000
2	Construction Surveying	1	LS	$ 60,000	$ 60,000
3	Beach Nourishment	200,000	CY	$ 6.75	$ 1,350,000
				SUBTOTAL	$ 1,960,000
				Contingency (30%)	$ 588,000
				CONSTRUCTION COST	$ 2,548,000

Table 20. Conceptual estimate of probable construction cost for Alternative 2.2– Nearshore Beach Nourishment.

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization and Demobilization	1	LS	$ 550,000	$ 550,000
2	Construction Surveying	1	LS	$ 60,000	$ 60,000
3	Beach Nourishment	200,000	CY	$ 5.85	$ 1,170,000
				SUBTOTAL	$ 1,780,000
				Contingency (30%)	$ 534,000
				CONSTRUCTION COST	$ 2,314,000

Table 21. Conceptual estimate of probable construction cost for Alternative 3.1 – Breakwater Field.

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization and Demobilization	1	LS	$ 60,000	$ 60,000
2	Construction Surveying	1	LS	$ 20,000	$ 20,000
3	Stone	42,933	TON	$ 150	$ 6,439,950
4	Geotextile Fabric	18,911	SY	$ 6	$ 113,466
				SUBTOTAL	$ 6,633,416
				Contingency (30%)	$ 1,990,025
				CONSTRUCTION COST	$ 8,623,441

Table 22. Conceptual estimate of probable construction cost for Alternative 3.2 – Onshore Beach Nourishment.

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization and Demobilization	1	LS	$ 550,000	$ 550,000
2	Construction Surveying	1	LS	$ 60,000	$ 60,000
3	Beach Nourishment	250,000	CY	$ 6.10	$ 1,525,000
				SUBTOTAL	$ 2,135,000
				Contingency (30%)	$ 640,500
				CONSTRUCTION COST	$ 2,775,500

Table 23. Conceptual estimate of probable construction cost for Alternative 3.3 – Onshore Beach Nourishment and Breakwater Field.

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization and Demobilization	1	LS	$ 60,000	$ 60,000
2	Construction Surveying	1	LS	$ 20,000	$ 20,000
3	Beach Nourishment	250,000	CY	$ 6.10	$ 1,525,000
4	Stone	63,889	TON	$ 150	$ 9,583,350
5	Geotextile Fabric	23,000	SY	$ 6.00	$ 138,000
				SUBTOTAL	$ 11,326,350
				Contingency (30%)	$ 3,397,905
				ESTIMATED CONSTRUCTION COST	$ 14,724,255

Table 24. Conceptual estimate of probable construction cost for Alternative 3.4 – Nearshore Beach Nourishment.

Item No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization and Demobilization	1	LS	$ 550,000	$ 550,000
2	Construction Surveying	1	LS	$ 60,000	$ 60,000
3	Beach Nourishment	250,000	CY	$ 5.67	$ 1,417,500
				SUBTOTAL	$ 2,027,500
				Contingency (30%)	$ 608,250
				ESTIMATED CONSTRUCTION COST	$ 2,635,750

Table 6. Preliminary Opinion of Probable Project Cost

ESTERO ISLAND BEACH RENOURISHMENT PRELIMINARY OPINION OF PROBABLE PROJECT COSTS ANTICIPATED YEAR OF CONSTRUCTION: 2021-22					
Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Extended Price [1]**
1	Design and Permitting	LS	1	$190,000	$190,000
2	Mobilization/Demobilization	LS	1	$2,150,000	$2,150,000
3	Beach Fill	CY	250,000	$10.92	$2,730,000
4	Environmental Protection	LS	1	$30,000	$30,000
5	Turbidity Monitoring	Days	100	$500	$50,000
6	Shorebird Abatement	Days	110	$500	$55,000
7	Construction Management	LS	1	$300,000	$300,000
8	Biological Monitoring	Years	3	$30,000	$90,000
9	Physical Monitoring	Years	3	$50,000	$150,000
10	Beach Tilling	Years	3	$6,000	$18,000
[1] Values rounded to the nearest $1,000				**Subtotal**	**$5,763,000**
				10% Contingency	**$576,000**
				Grand Total	**$6,339,000**

Town of Fort Myers Beach
Agenda Item Summary

Blue Sheet Number: **2021-149**

1. **Requested Motion:**

Meeting Date: February 4, 2021

Annual On-site Special Event Permit for Non-profits properties in excess of 1.2+ acres ($1,200.00/year)

Why the action is necessary:
To facilitate the charity fund raising efforts of our volunteer community a streamlined special event permit could be adopted.

What the action accomplishes:

2. **Agenda:**
ITEMS FOR DISCUSSION

3. **Requirement/Purpose:**

---

5. **Background:**
To establish an annual on-site Special Event Permit for non-profits properties on the island.

Attachments:
1. 100 Chapel St - Green Sheet Exhibit A
2. 100 Chapel St - Green Sheet Exhibit B
3. 175 Sterling Ave - Green Sheet Exhibit
4. 2755 Estero Blvd - Green Sheet Exhibit

Financial Impact:

6. **Alternative Action**
Continue current practices

7. **Staff Recommendations:**
Approve for consideration at a public meeting.

8. **Recommended Approval:**

______________________ John R Herin Jr, Town Attorney	Date: January 27, 2021
______________________ Amy Baker, Town Clerk	Date: January 28, 2021
______________________ Roger Hernstadt, Town Manager	Date: January 28, 2021

Lee County Property Appraiser

Tax Year 2020

Next Parcel Number Previous Parcel Number Tangible Accounts Tax Estimator Tax Bills Print

Property Data

STRAP: 19-46-24-W3-0120B.0010 Folio ID: 10227710

Owner Of Record

[Change Address]

CHAPEL BY THE SEA
PO BOX 2997
FORT MYERS BEACH FL 33932

Site Address

Site Address maintained by E911 Program Addressing

100 CHAPEL ST
FORT MYERS BEACH FL 33931

Property Description

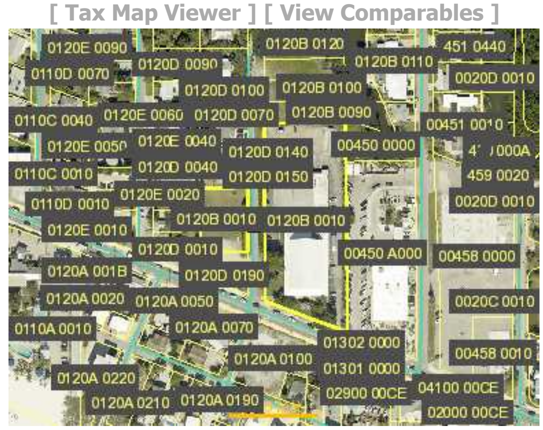
Do not use for legal documents!

SEAGRAPE SUBD.PB 4 PG 17
BLK.B LTS 1-8 + BLK D LTS
16 -18 + OR 221 PG 436

Classification / DOR Code

CHURCHES, TEMPLES / 71

[Tax Map Viewer] [View Comparables]



[Pictometry Aerial Viewer]

Current Working Values

Just	3,054,325

Attributes

Land Units Of Measure	SF
Units	101664.00
Total Number of Buildings	1
Total Bedrooms / Fixtures	0 / 48
Total Living Area	0
1st Year Building on Tax Roll	1978
Historic Designation	No

Image of Structure

Photo Date March of 2010 View other photos

Last Inspection Date: 08/18/2016

Exemptions

Values (2020 Tax Roll)

Taxing Authorities

Sales / Transactions

Building/Construction Permit Data

Parcel Numbering History

Location Information

Solid Waste (Garbage) Roll Data

Previous Parcel Number Next Parcel Number New Query Search Results Home
TRIM (proposed tax) Notices are available for the following tax years
[2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020]


0120D
0090
0120D
0100
0120B
0110
0120B
0100
0120D
0080
0120D
0110
0120D
0070
0120D
0120
0120B
0090
0120D
0060
0120D
0130
00450
0000
0120D
0140
0120D
0040
0120D
0150
0120D
0030
0120D
0020
0120B
0010
0120B
0010
0120D
0010
0120D
0190
TERO BLVD
CHAPEL ST
0120A
0050
0120A
0070
0120A
0040
0120A
0090
COTTAGE AVE
0120A
0100
01302
0000
01301
0000
02900
00CE
0120A
013A
01303
0120A
0200
0120A
0190
0120A
0180
0120A

Lee County Property Appraiser

Tax Year 2020

Next Parcel Number Previous Parcel Number Tangible Accounts Tax Estimator Tax Bills Print

Property Data

STRAP: 33-46-24-W2-00004.0000 Folio ID: 10230323

+ Owner Of Record - Sole Owner

[Change Address]

FORT MYERS BEACH WOMANS CLUB I
PO BOX 22
FORT MYERS BEACH FL 33931

Site Address

Site Address maintained by E911 Program Addressing

175 STERLING AVE
FORT MYERS BEACH FL 33931

Property Description

Do not use for legal documents!

BEG 1607.4 FT S OF NW COR
GOVT LOT 2 N ALG W LI LOT
2 454.36 FT TO PT 13.65

Classification / DOR Code

CLUBS, LODGES, UNION HALLS / 77

[Tax Map Viewer] [View Comparables]

[Pictometry Aerial Viewer]

Current Working Values

Just	1,281,901

Attributes

Land Units Of Measure	SF
Units	58806.00
Total Number of Buildings	1
Total Bedrooms / Fixtures	0 / 4
Total Living Area	0
1st Year Building on Tax Roll	1947
Historic Designation	No

Image of Structure

Photo Date September of 2017 View other photos

Last Inspection Date: 10/05/2015

+ Exemptions

+ Values (2020 Tax Roll)

+ Taxing Authorities

+ Sales / Transactions

+ Building/Construction Permit Data

+ Parcel Numbering History

+ Location Information

+ Solid Waste (Garbage) Roll Data

Previous Parcel Number Next Parcel Number New Query Search Results Home

TRIM (proposed tax) Notices are available for the following tax years

[2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020]

STRAP: 19-

Owner Of Record - Sole Owner

[Chang

FORT MYERS BEACH PUBLIC LIBRAR
2755 ESTERO BLVD
FORT MYERS BEACH FL 33931

Site Address

Site Address maintained by E911 Program Addressing

2755 ESTERO BLVD
FORT MYERS BEACH FL 33931

ALTERNATE ADDRESS INFORMATION:
126 SCHOOL ST

Property Description

Do not use for legal documents!

WINKLERS SUBD BLK K PB8/45 S 2FT OF LT 6 + LOTS 7 THRU 12 + LTS 13 THRU 20

Classification / DOR Code

MUNICIPAL - OTHER / 89

Current Working Values

Just

Attributes

Land Units Of Measure
Units
Total Number of Buildings
Total Bedrooms / Fixtures
Total Living Area
1st Year Building on Tax Roll
Historic Designation

Prope
46-24-W3-002
e Address]

8,006,859

SF
53890.00
1
0 / 36
0
1967
No

All Books News Maps Shopping More Settings

About 180,000,000 results (0.66 seconds)

Area

53890 = 1.2371442

Square foot Acre

Formula divide the area value by 43560

More info

Feedbac

People also ask

How do you calculate acres from square feet?

How much square feet is a acre?

What is the square feet of 1/2 acre?

What is the square footage of a 1/4 acre?

Fe

www.thecalculatorsite.com › conversions › area › squar...

Square Feet and Acres Converter (ft² and ac)

There are 43560 **square feet** in 1 **acre**. To convert from **acres** to **square feet**, multiply your figure by 43560 . How many **acres** are there in 1 **square foot**? There are ...

	AGENDA MANAGEMENT			Meeting
133	Resolution: FBIP Grant	Public Works	added 01.12.2021	02.01.2021
141	Proposed Emergency Declaration No. 8	Town Attorney	added 01.19.2021	02.01.2021
131	SWFL Regional Resiliency Compact MOU	TC	added 01.19.2021	02.01.2021
132	Resolution: Harbor Management Plan	Public Works	added 01.12.2021	02.01.2021
143	Arch location	TC	added 01.21.2021	02.01.2021
95	NAB implementation	Admin	added 10.15.2020	02.01.2021
134	Approval of Contract: CEI Services w/AECOM	Public Works	added 01.12.2021	02.01.2021
150	Presentation: 90% Plan Times Sqaure & Bayside Park	PW	added 01.26.2021	02.04.2021 M&P
151	Beach Renourishment	Environmental	added 01.26.2021	02.04.2021 M&P
141	Laguna Shores Dredging	Environmental	added 01.21.2021	02.04.2021 M&P
144	Approval of Lighting Consultant	PW		02.16.2021
145	Balancing Change Orders - Mitchell & Stark	Utilities	added 01.26.2021	02.16.2021
146	Piggyback - Angie Brewer contract	Utilities	added 01.26.2021	02.16.2021
147	Angie Brewer Change Order	Utilities	added 01.26.2021	02.16.2021
152	1st Reading: Text Amendment - Building Regulations	PL&Z	added 01.26.2021	02.16.2021
148	STA 2 - Corradino Group Phase 2	PL&Z	added 01.26.2021	02.16.2021
153	Slide Replacement at Beach Pool	Parks & Rec	added 01.26.2021	02.16.2021
138	FPL Representative	TC	added 01.11.2021	02.16.2021
137	Presentation: FDOT SR865 Project	Public Works	added 01.13.2021	03.01.2021
152	2nd Reading/Adoption: Text Amendment - Building Regulations	PL&Z	added 01.26.2021	03.01.2021
121	2nd Reading/Adoption: Water Supply Facilities Work Plan (pending DEO) approval	Utilities	added 12.7.2020	03.01.2021
154	Approval of Audit	Finance	added 01.26.2021	03.15.2021
148	LDC/Comp Plan Status Report from Corradino Group	PL&Z	added 01.26.2021	Apr/May TC
155	Preliminary Millage	TC		June
142	Beach Renourishment P&D	Environmental	added 01.21.2021	TBD TC Mtg (April?)
123	Veteran Tribute @ Bayside Park	TC	added 12.03.2020	TBD M&P
136	Mechanical Noise	TC	added 01.11.2021	TBD M&P
139	Acquiring HOA Beach Accesses	TC	added 01.21.2021	TBD M&P
140	Discussion: Regulations regarding footprint of a property	TC	added 01.21.2021	TBD M&P

County Estero Blvd. Update at the first M&P of each month