PROJECT INFORMATION REPORT

REHABILITATION EFFORT FOR THE PINELLAS COUNTY, FLORIDA – COASTAL STORM RISK MANAGEMENT (CSRM) PROJECT

October 2016

Table of Contents

PROJECT INFORMATION REPORT REHABILITATION EFFORT FOR THE PINELLAS COUNTY COASTAL STORM RISK MANAGEMENT PROJECT

Part I. Executive Summary.

This report was prepared at the request of the project sponsor in a letter dated September 13, 2016. This report recommends fully restoring the Sand Key segment of the Pinellas County Coastal Storm Risk Management Project (CSRM) Project in conjunction with the rehabilitation effort under Public Law (PL) 84-99.

Implementation Guidance pursuant to Section 3029(a)(2) of the Water Resources Reform and Development Act (WRRDA) of 2014, dated April 4, 2016, states that Coastal Storm Risk Management (CSRM) Project is the current term used in place of Hurricane/Shore Protection Project (HSPP) per ER 500-1-1, and therefore applied as such throughout this report.

This report finds that “extraordinary storm” criteria for Flood Control and Coastal Emergency (FCCE) rehabilitation are met. Based on the Storm Erosion Index, Hurricane Hermine was an extraordinary storm event for Pinellas County CSRM Project in terms of its potential to cause erosion damages. The analysis suggests that Hurricane Hermine registered as a Category 5 storm on the Peak Erosion Index (PEI) scale and Category 4 storm on the Storm Erosion Index (SEI) scale with an estimated return period, based on the twenty year record, of 15.0 years and 11.2 years, respectively. Recognizing the limitations of the data available and the margins of error of the PEI and SEI analyses, Hurricane Hermine was determined to be any extraordinary storm. Based on the PEI and SEI analyses, SAJ has found a preponderance of evidence to support the fact that Hurricane Hermine is an extraordinary storm per ER 500-1-1, 5-20.f.

The Pinellas County CSRM Project consists of three segments: Sand Key, Long Key, and Treasure Island. The Sand Key Segment incurred significant damage as detailed in this report. The remaining two segments, Long Key and Treasure Island did not incur significant damage from Hurricane Hermine. The Long Key Segment experienced a net accretion of 11,095 cubic yards, and the Treasure Island segment experienced 3,057 cubic yards of erosion as a result of the storm. Neither of these impacts are considered significant damage as a result of Hurricane Hermine pursuant to ER 500-1-1.

This report finds that the “significant damage” criteria (ER 500-1-1 5-20.e (2)(a)) is met for the Sand Key segment because the cost to restore the project to the design level of protection, minus mobilization and demobilization, is approximately

$10,790,000 which exceeds the $1,000,000 cost requirement, and the cost represents 12.84% of the first cost of initial construction in current dollars ($84,033,042) which exceeds the 2% requirement.

This report also finds that the “significant damage” criteria (ER 500-1-1 5-20.e(2)(c)) is met since Hurricane Hermine caused erosion impacts of 361,944 cubic yards to the Sand Key Segment. This volume is more than one-third of the 524,700 cubic yards of planned or historically placed sand for renourishment efforts of the segment.

The benefit-cost ratio to perform the emergency rehabilitation as a standalone project, not including recreation benefits, would be 5.5 to 1. Therefore, this project meets the eligibility criteria in ER 500-1-1, paragraph 5-20 (a) since the work would have had a benefit to cost ratio greater than 1.0.

Full project restoration provides for the placement of 877,819 cubic yards to fill the complete construction template. The volume of material for Construction General (CG) efforts is estimated at 524,700 cubic yards, which is the planned nourishment volume every 5 years.

Average annual expected damage reduction capability (benefits) for the authorizing document design profile is $26,625,600. The prorated ratio of average annual benefits provided by the quantity needed to restore to the design profile is estimated at 32.5% of the authorized project benefits. The incremental average annual benefit from undertaking the emergency placement is, thus, equivalent to $8,639,961.

Combining the FCCE restoration and the full construction template saves costs on an additional mobilization/demobilization, and also realizes the full average-annual storm damage reduction benefits of $26,625,000. This approach yields a benefit-cost-ratio of 9.29 with net-benefits of $23,759,443.

The project currently has authorized federal participation for 50 years until December 31, 2043. The recommended approach for rehabilitation includes combining FCCE and CG renourishment as the 4th renourishment event.

A Finding of No Significant Impact (FONSI) was signed June 5, 2011. The FONSI incorporates by reference an Environmental Assessment (EA) conducted for the beach renourishment project. Coordination with resource agencies would remain ongoing leading up to construction. The EA completed in 2011 tiers off of the 1997 and 2002 EAs as well as the 1984 Environmental Impact Statement. The Corps is the permittee for the project, holding a water quality certification (WQC) permit with the state of Florida that is valid for multiple placement events through July 06, 2021. The permit was previously modified to allow for the use of the Egmont Shoal as a borrow area, and is currently being modified to allow for use of adjacent passes as borrow sources for future regional sediment management initiatives.

The Project Cooperation Agreement (PCA) for the project was executed on April 7, 1995, and a Cooperation Agreement (CA) for the FCCE work will be executed prior to construction.

Part II. Basic Report.

1. NAME AND LOCATION.

This project is now referred to as the Pinellas County, Florida, Hurricane and Storm Damage Reduction (HSDR) Project – Sand Key Segment (previously referred to as the Beach Erosion Control Project). Pinellas County is on the gulf coast of Florida, about midway down on the peninsula. The County extends northerly about 39 miles from the main entrance to Tampa Bay to the vicinity of the mouth of the Anclote River. The Pinellas County coast consists of numerous keys or barrier islands extending almost north-south in the northerly half and northwest-southeast in the southerly half of the county. The barrier islands are narrow and low, ranging in width from about 200 to 2,000 feet. Sand Key is bounded on the north by Clearwater Pass and on the south by Johns Pass, Sand Key is a narrow, low, arc shaped island about 14.2 miles long. Natural ground elevations are generally below 10 feet mean low water (MLW). Access to Sand Key is by numerous bridges from the mainland and from Clearwater Beach Island and Treasure Island. Sand Key has portions of 9 municipalities within its borders. From north to south those municipalities are Clearwater, Belleair Beach, Belleair Shores, Indian Rocks Beach, Indian Shores, Redington Shores, and North Redington Beach. The general development is resort and residential.

2. PUBLIC SPONSOR.

Pinellas County Board of County Commissioners

3. POC FOR PUBLIC SPONSOR.

John Bishop and Andy Squires, Coastal Managers
Pinellas County Environmental Management
22211 US Hwy. 19 N, Bldg. 10,
Clearwater, Florida 33765
Phone: (727) 464-8766
jbishop@pinellascounty.org

4. PROJECT AUTHORIZATION.

The project was authorized by Section 101 of the Rivers and Harbors Act of 1966 (Public Law (PL) 89-789) in accordance with the report of the Chief of Engineers dated 14 September 1966. The original authorization allowed for improvements for beach erosion control for Clearwater Beach Island, Sand Key, Treasure Island, and Long Key by beach restoration, periodic nourishment, and revetments. Provisions of Section 156 of Water Resources Development Act (WRDA) 76 (PL 94-587) extended the period of Federal participation from 10 years to 15 years. The project authority was further amended by Section 501(b) of the WRDA of 1986 (PL 99-662) which authorized, subject to a favorable Chief's Report, the construction of the recommendations of the *Report of the Board of Engineers for Rivers and Harbors*, dated April 23, 1985. A favorable Chiefs Report was signed on July 27, 1987 recommending the project plan as formulated except that Federal participation in periodic nourishment should be limited to the 50-year economic life of the project. The authorized plan for the Sand Key segment consists of initial beach restoration and advance nourishment along 9.3 miles of shoreline. The Sand Key Segment Design Memorandum with Environmental Assessment, dated November 1996, (revised March 1997) is the most recent document to assess design and cost apportionment for the Sand Key Segment (62.8% Federal, 37.2% Non-Federal). This document detailed modifications to the 1994 LRR, and a total of 14.2 miles along Sand Key is authorized for periodic renourishment until December 31, 2043. The project has an estimated 5 year renourishment interval, with design berm width of 40-ft, to 6 feet MLW. The Egmont Shoal Borrow area will be utilized for all future renourishments in addition to adjacent passes as needed and available.

5. PROJECT CLASSIFICATION.

The primary purpose of the project is to provide hurricane and storm damage reduction to upland development and infrastructure. This project was not designed to protect against a particular storm frequency or event. The berm height of 6.0 feet mean low water (MLW) represents the 10-year storm surge elevation as described in the 1997 Design Memorandum; however it is designed per Engineering Manual (EM) 1110-2-1100 (Coastal Engineering Manual) which stipulates that the construction berm elevation should be the same or slightly less than the natural berm crest elevation. It is understood that the construction berm will erode and the beach fill will be redistributed to a more naturally shaped profile.

The prescribed volume of periodic nourishment is 524,700 cy and when placed in front of the design berm allows for 5 years of average annual erosion (recession) of the beach, while maintaining storm damage reduction for the upland development. The berm width of beach was optimized against predicted shoreline recession and damages associated with recession frequency. The 40-foot project berm width optimizes the annual storm damage reduction net benefits. Design berm widths are optimized based on economic analysis per ER 1105-2-100 (Planning Guidance Notebook).

6. DESIGN DATA OF PROJECT.

The authorized project as modified by the 1997 Design Memorandum provides for periodic renourishment of 8.7 miles of beach from DEP monuments 57 – 66 and 71 – 107 and beyond as needed. The town of Belleair Shores (R66 – R72), has not provided the necessary easements for construction, however is still part of the authorized project. The constructed project skips this 1-mile segment and continues at the town of Indian Rocks and continues south to North Redington Beach (DEP monuments 72 – 106). The beach fill transitioned between R-56 and

R-57; R-71 and R-72; and R-106 and R-107 to reduce end losses. There is no transition at R-66 going into Belleair Shores due to easements. The project can also place sand south of R-107 landward of the Mean High Water Line (MHWL) in accordance with the state permit, as needed.

The restored beach was designed to dissipate wave energy seaward of upland property and existing structures. The project cross-section consists of a level berm 40 feet wide at elevation +6.0 referenced to MLW with a foreshore slope of 1 vertical (V) on 20 horizontal (H) to MLW and a nearshore slope of 1V on 30H from MLW to the intersection with the existing bottom. The project design incorporated a 5- year interval for periodic nourishment of the restored beach (524,700 cy). The PIR addresses the work needed to restore the project to its design level of protection and to fully restore project dimensions of the authorized and permitted Federal project.

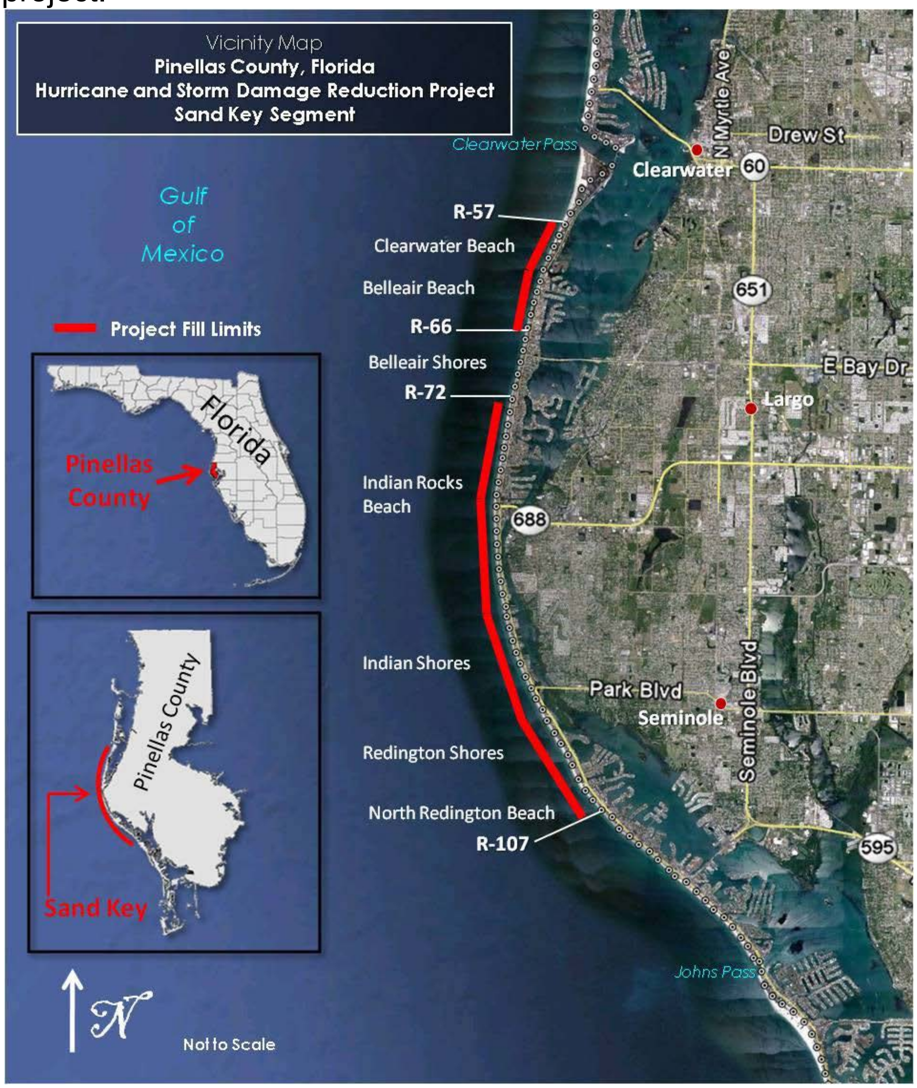


Figure 6- 1: Pinellas County Shore Protection Project, Sand Key Segment Map (Google Aerial)

<u>7. MAINTENANCE.</u>

The non-Federal sponsor is responsible for lands, easements, rights-of-way, relocations, and suitable borrow and/or disposal areas required for operation and maintenance of the project. The Project Cooperation Agreement (PCA) allows for the sponsor to request that the USACE obtain a suitable borrow area on their behalf. The sponsor is required to monitor the project annually to determine losses of nourishment material from the project design section and to determine impact of project construction on sea turtle nesting. Project inspections include periodic beach profiles, surveys, data collection, and other activities sufficient to document current beach sand volumes. The sponsor is also required to reshape the beach and dune profile using material within the project area and to maintain vegetation and other project features associated with the beach. The sponsor must also provide and maintain necessary access roads, parking areas and other public use facilities open and available to all on equal terms. The sponsor has fulfilled all of their non-Federal responsibilities to date in accordance with the PCA. The sponsor operates and maintains the project in accordance with the Florida Department of Environmental Protection (FDEP) permit. The sponsor performs required hydrographic and environmental monitoring and compliance activities. This project is active in the Rehabilitation and Inspection Program (RIP).

<u>8. PERIODIC NOURISHMENT.</u>

Initial construction of the Pinellas County, Florida, Beach Erosion Control Project (Sand Key Segment) was completed in three phases. Phase I took place in 1988 and nourished 1.5 miles of shoreline at Redington Shores and North Redington Beach (R99-R107). Over 300,000 cubic yards of sand was placed at a total cost of $2.6 million. The Sand Key Phase II Project, in 1990, placed 1.3 million cubic yards of sand along 2.65 miles at Indian Rocks Beach (R71-R85). The project took approximately 6 months and cost $14.5 million. Sand Key Phase III project took place in 1992, where 850,000 cubic yards of sand was placed on the beaches of Indian Shores and Redington Shores (R85-R107). This segment of the project was also about 2.6 miles long and cost $11.7 million. Sand Key Phase IV project took place in 1998, along the beaches of Clearwater Beach and Belleair Beach (R56-R66) and cost $13.5 million.

The first periodic nourishment of Sand Key took place in 1999, along the beaches of Indian Rocks beach, Indian Shores, Redington Shores and North Redington Beach from DEP monuments R72 – R107. This work was completed in October 1999 with a total project cost of $14 million.

The second periodic nourishment of Sand Key began on November 1, 2005, and was completed on August 14, 2006. The project placed 1.88 mcy of sand along 8.6 miles of Sand Key from DEP monuments R56 – R66 and R71 – R107. During this event 251,000 cy of the placed volume was covered by FCCE funds to cover damages to the beach resulting from the 2004 hurricane season. In March and

June 2006, during construction the nourished beach was impacted by Tropical Storm Alberto and another storm resulting in additional placement of 144,000 cy of material to repair the storm damaged profiles. This additional fill was not funded with FCCE funding.

The third periodic nourishment began in late May 2012. Construction had begun at the north end of the Sand Key Project. Work was halted due to weather conditions as TS Debby passed by the region. Work resumed once conditions calmed and was completed on November 26, 2012 with an estimated total volume placed of 1.25mcy. This renourishment was not funded with FCCE funding. The construction activity to date is summarized in **Table 8-1**. All Federally-funded beach erosion control placements can be seen in the in **Figure 8-1.**

Table 8-1: Sand Key Construction Activity

Year	Event	Volume (cy)	Cost $	Description
1986	Breakwater construction	N/A	569,000	R101 Redington Shores
1987	North jetty reconstruction	N/A	250,000	R127 Madeira Beach
1988	Initial Construction Phase I	300,000	2,600,000	300,000 cubic yards placed along 1.5 miles of shoreline at Redington Shores and North Redington Beach (R99-R107)
1990	Initial Construction Phase II	1,300,000	14,500,000	1,300,000 cubic yards placed along 2.65 miles at Indian Rocks Beach (R71-R85)
1992	Initial Construction Phase III	850,000	11,700,000	850,000 cubic yards placed along 2.6 miles of Indian Shores and Redington Shores (R85-R107).
1998	Initial Construction Phase IV		13,500,000	Clearwater Beach and Belleair Beach from DEP monuments R56 – R66
1999	1st Periodic Nourishment	2,612,000	14,000,000	placed from DEP monuments R72 – R107
2006	2nd Periodic Nourishment	1,880,000	30,990,000	1,880,000 cubic yards placed along 8.6 miles from DEP monuments R56 – R66 and R71 – R107. 251,000 cy of the placed volume was covered by FCCE
2012	3rd Periodic Nourishment	1,250,000	35,028,313	1,250,000 cubic yards placed along 8.6 miles from DEP monuments R56 – R66 and R71 – R107

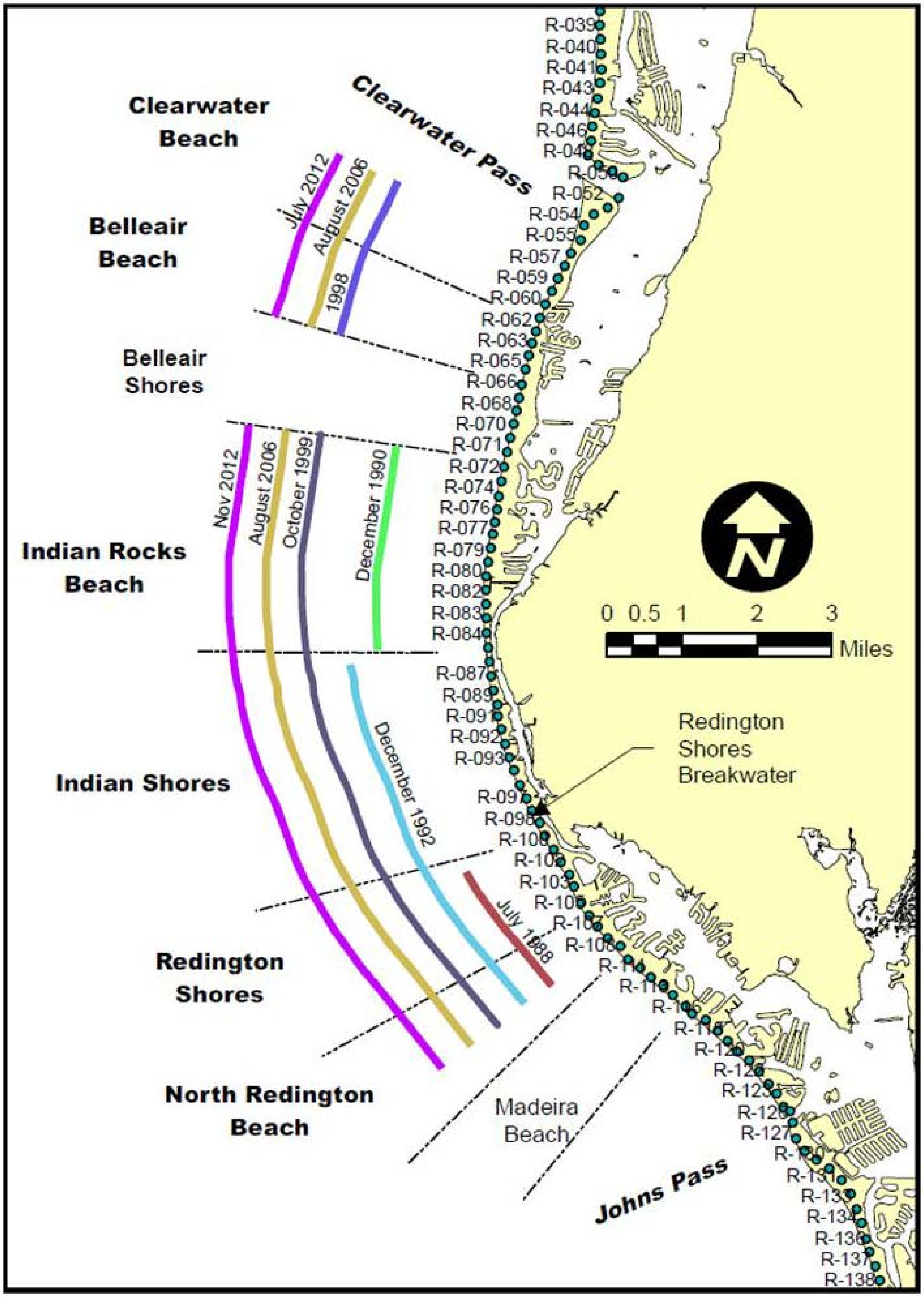


Figure 8-1. Location map and beach erosion control placement areas.

9. PREVIOUS PL 84-99 ASSISTANCE.

A PL 84-99 report was prepared in 2005 following the 2004 hurricane season when Hurricanes Frances, Ivan, and Jeanne significantly impacted the Sand Key Project. Storm damages resulted in a loss of 251,000 cubic yards of material from the project (48% of the planned periodic nourishment volume of 524,700cy). The report recommended emergency placement 251,000cy be performed in conjunction with second periodic nourishment to maximize benefits. The report was approved and construction was completed in August 2006.

10. DISASTER INCIDENT.

On September 2, 2016, Category 1 Hurricane Hermine made landfall just east of St. Marks Florida at peak intensity with a minimum pressure of 982 mbar and maximum sustained winds at 80 mph. Hermine became the first hurricane to make landfall in Florida since Wilma on October 24, 2005. Water levels reached over 1.2 m (4 ft) above mean sea level during two consecutive high tides, and peak wave height reached 7.3 m (24 ft), approximately 30% higher than the highest waves measured during Tropical Storm Debby in 2012. The following provides a description of the storm event and an analysis of the storm characteristics in order to determine if these events could be characterized as an “extraordinary storm” according to guidance in ER 500-1-1.

Hurricane Hermine

Hurricane Hermine developed from a tropical wave which originated off Cape Verde Islands. The wave was first noted on August 18 and was tracked as it moved westward over the next ten days. On August 28 Tropical Depression 9 was formed approximately 55 miles south of Key West, FL. On August 31 the system was named Tropical Storm Hermine as it tracked within the Gulf of Mexico. Around this time the storm stopped its westward progression and began to take a northwestward turn. On September 1 Hermine was upgraded to a Category 1 Hurricane. It strengthened slightly to a peak intensity of 80 mph by 00:00 UTC on September 2 before making landfall at 05:30 UTC on September 2, 2016 just east of St. Marks, FL. The closest that Hermine came to a Jacksonville District HSDR Project within Pinellas County was between 1800 UTC on September 1 and 000 UTC on September 2 when the storm was approximately 150 miles northwest off the Sand Key Federal Project in Pinellas County. Post-landfall Hermine weakened and continued to track northwest, eventually transitioning to a post-tropical cyclone on September 3 off the Outer Banks of North Carolina. (National Hurricane Center, Weather Underground). See **Figure 10-1** for Tropical Storm track.

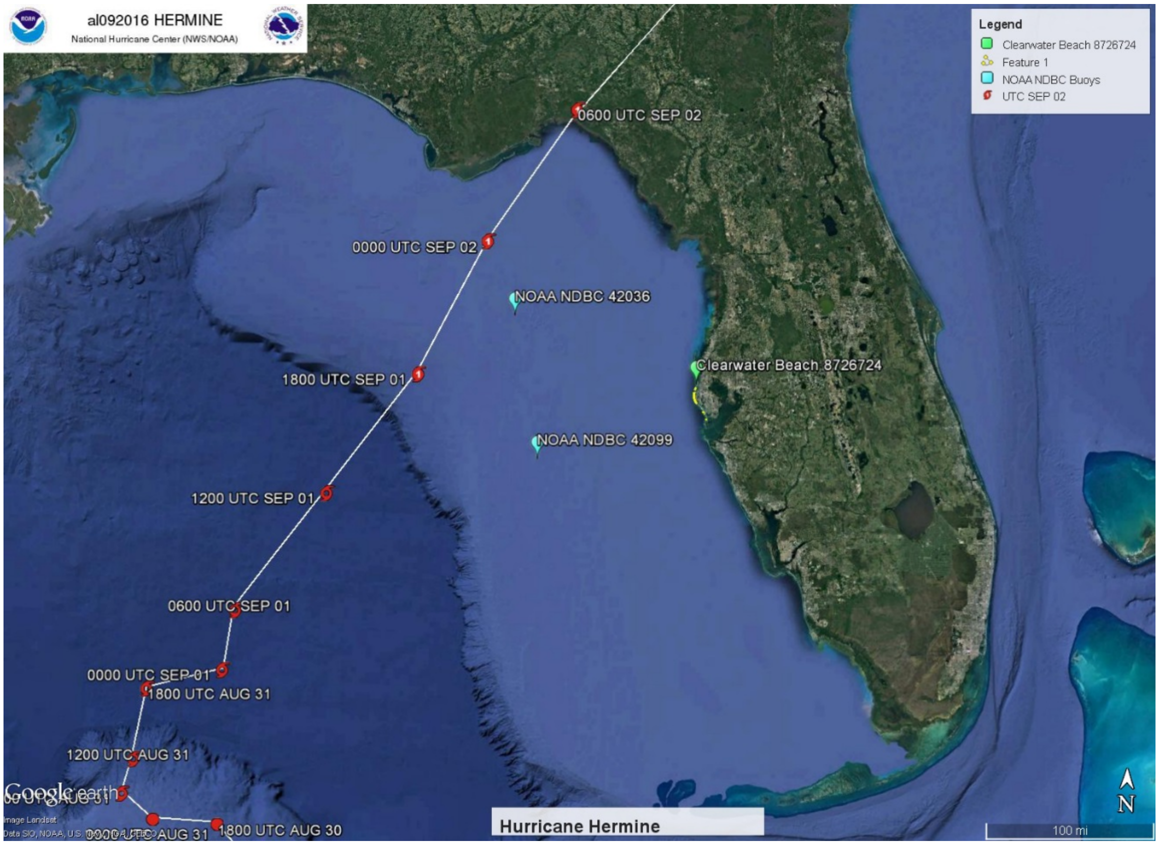


Figure 10-1: Storm Paths, Data Stations, and Federal HSDR project in Pinellas County. (Google Imagery and data from NOAA)

<u>“Extraordinary Storm” Determination</u>

ER 500-1-1, “Emergency Employment of Army and Other Resources, CIVIL EMERGENCY MANAGEMENT PROGRAM” dated 30 September 2001 provides guidance to determine whether a storm event is characterized as an “extraordinary storm”. The pertinent sections of the guidance contained in ER 500-1-1 for this analysis are as follows:

ER 500-1-1 Paragraph 5-20(e). ***The Extraordinary Storm****. To be eligible for Rehabilitation Assistance, the HSPP must be substantially eroded/damaged by wind, wave, or water action of an other than ordinary nature. USACE defines this as an "extraordinary storm". An extraordinary storm is a storm that, due to length or severity, creates weather conditions that cause significant amounts of damage to a Hurricane/Shore Protection Project.*

ER 500-1-1 Paragraph 5-20(e)(1). "Length or severity" refers to a Category 3 or higher hurricane as measured on the Saffir-Simpson scale, or a storm that has an exceedance frequency equal to or greater than the design storm of the project.

Jacksonville District, beach nourishment projects for Hurricane and Storm Damage Reduction (HSDR) purposes do not have a “design storm” that they are engineered to protect against. They are designed to provide protection against historical storms experienced in the project area. The berm height is designed per EM 1110-2-3301 which stipulates that the construction berm elevation should be the same or slightly less than the natural berm crest elevation. Through economic analysis, the berm width is optimized against predicted shoreline recession and damages associated with recession per ER 1105-2-100.

*ER 500-1-1 Paragraph 5-20(f). **Extraordinary Storm Justification**. The PIR must include justification that substantiates the occurrence of an extraordinary storm. The determination of whether a storm qualifies as extraordinary will be made by the Director of Civil Works, in consultation with the Assistant Secretary of the Army for Civil Works (ASA(CW)) if necessary. PIR justification will include relevant data from the National Weather Service. Saffir-Simpson scale Category I and Category II hurricanes (as measured at the HSPP project) are presumed to be ordinary storms in the absence of a preponderance of evidence that indicates a different conclusion.*

The storm characteristics of Hermine, including winds, surge, waves and duration have been considered in order to determine if this storm can be considered an "extraordinary" event. Winds and surge levels were recorded at NOAA NOS Station 8726724 in Clearwater Beach, FL. Wave data was measured by a 3-meter discus buoy at NDBC Station 42099 located at a water depth of 93.88 m (308 ft) approximately 100 miles west southwest of Upham Beach on Long Key and at another 3-meter discuss buoy, NDBC Station 42036 located at a water depth of 50.6 m (166.0 ft) approximately 100 miles offshore of Long Key. **Figure 10-1** shows the locations where storm data was measured, storm tracks, and the location of authorized Federal Hurricane and Strom Damage Reduction (HSDR) Projects in Pinellas County, FL. The locations where storm data has been gathered for this analysis provide an adequate data set for describing general storm conditions in Pinellas County, FL. Although the severity of erosion along the shorelines of the 3 Federal projects in the region was variable, the "extraordinary storm" characterization of Hermine is applicable to all projects in the region.

Storm Winds

The guidance in ER 500 1-1 states that Saffir-Simpson scale category 1 and 2 hurricanes are presumed ordinary storms. The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Federal HSDR projects are not designed to reduce damages caused by high winds. They are designed to reduce damages to coastal infrastructure caused by erosion of the shoreline. Wind speed alone does not provide an indication of the erosional damages expected from a storm event. Therefore, other storm characteristics more indicative of erosion damage such as surge, waves, and duration should be used to determine if the storms were "extraordinary" events.

Hermine ranked on the Saffir-Simpson scale as a category 1 hurricane while off Pinellas County beaches. **Figure 10-2** shows the winds speed measured at NOS Station 8726724, in Clearwater Beach, FL, as the storm passed through the Gulf of Mexico. During Hermine, winds from the south averaging 35 knots and gusting to 50 knots-plus were experienced for a little over 12 hours as the storm passed offshore of the project areas.

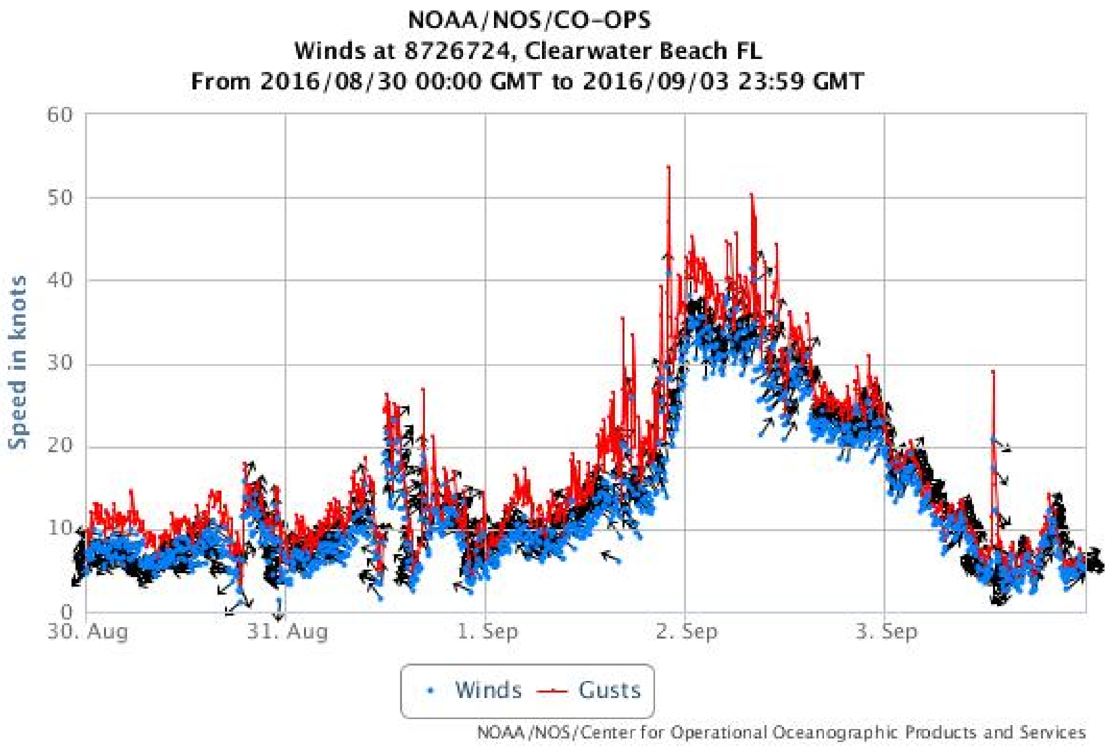


Figure 10-2: Clearwater Beach Wind Speed and Wind Gust during Hurricane Hermine. Image from NOAA.

Storm Surge

Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tides. Increased water levels during a storm can allow waves to propagate further across a beach leading to increased erosional damages. Figure 10-3 shows the storm surge associated with Hermine measured at NOS Station 8726724 in Clearwater Beach.

The water level reached 4.27 ft above mean sea level during the passage of Hurricane Hermine. High surge over 3 ft lasted for approximately two tidal cycles during Hurricane Hermine. This duration of high surge is very important when considering a storm's erosion potential and should be considered in addition to maximum water elevations when making an extraordinary storm determination.

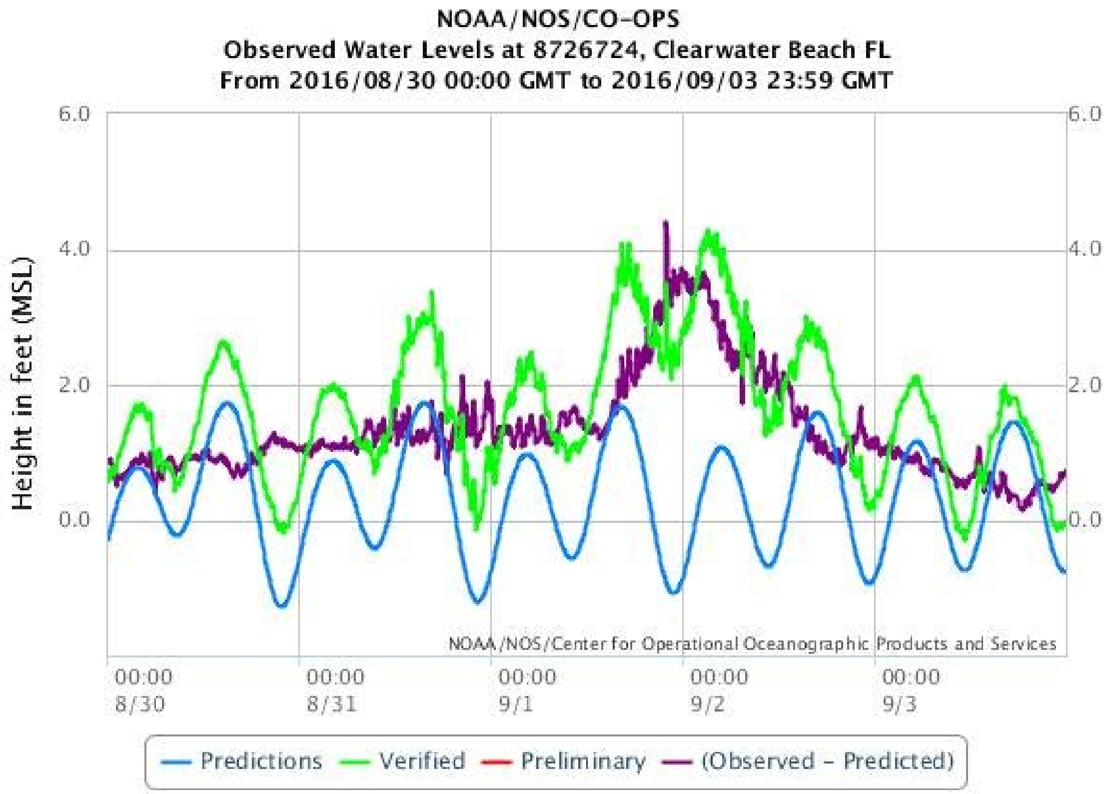


Figure 10-3: Predicted and observed water levels during Hurricane Hermine at NOAA Clearwater Beach water level station 8726724.

The maximum storm surge plus tide (maximum water elevation) measured at NOS Station 8726724 was 4.27 ft MSL from Hermine. **Table 10-1** lists the return intervals of extreme water levels at the NOAA Clearwater Beach station. The value presented is the projected exceedance probability level in 2015 assuming a continuation of the linear historic trend. The water levels presented are a combination of the astronomical tide, the storm surge, and limited wave setup caused by breaking waves. They do not include wave runup. The peak water level measured during Hermine exceeds the 10 year return period value. From **Figure 10-4**, obtained from NOAA, the 4.27 ft MSL (3.00 ft MHHW) value corresponds to approximately a 15 year event. The water level remained elevated above the 2 year return period level for over 10 hours while water levels exceeded the 10 year exceedance probability for just under 1 hour.

Table10- 1: Projected exceedance probability levels for NOS Station 8726724 (Source NOAA)

Return Period (Years)	Exceedance Water Level (ft above MSL)
1	2.46
2	3.11
10	4.17
100	6.46

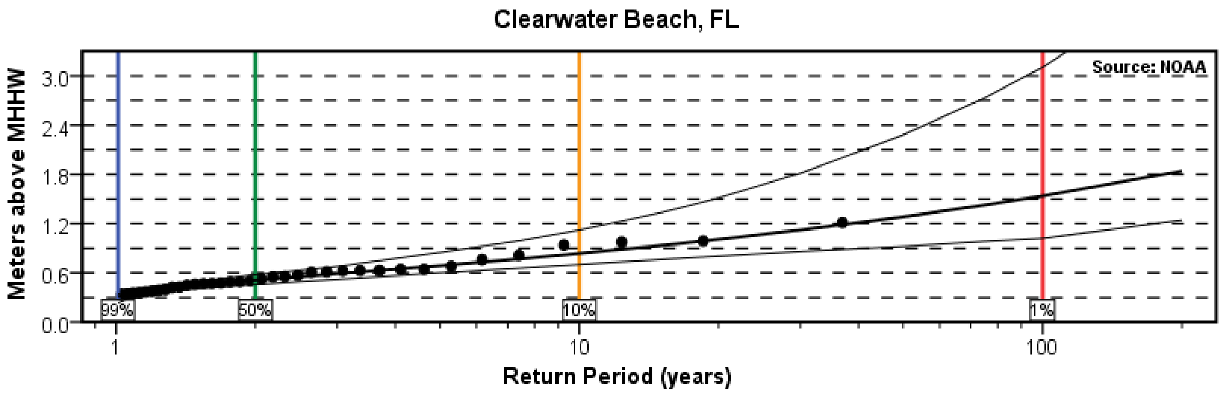
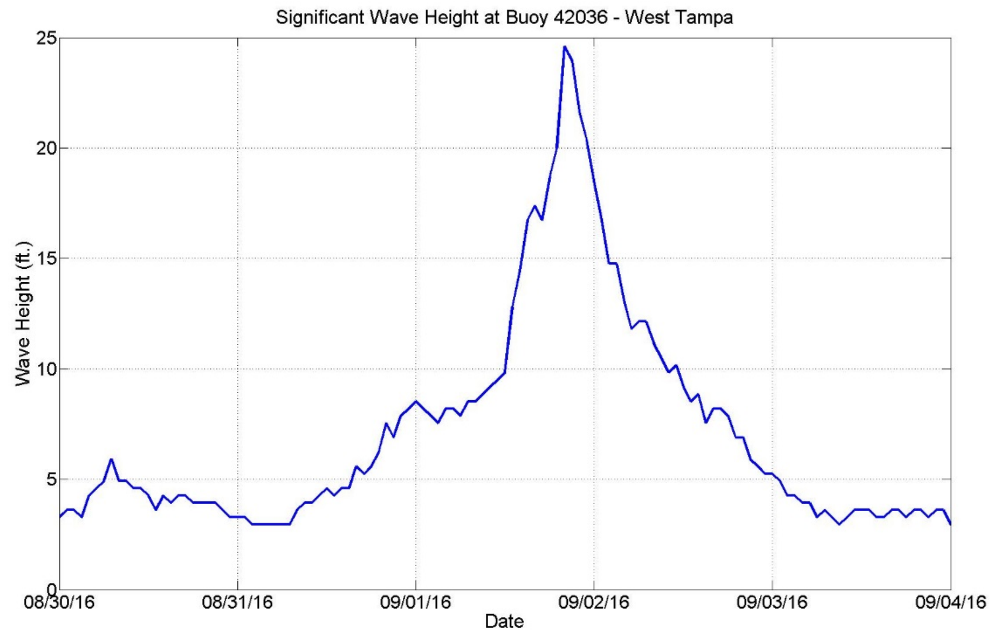
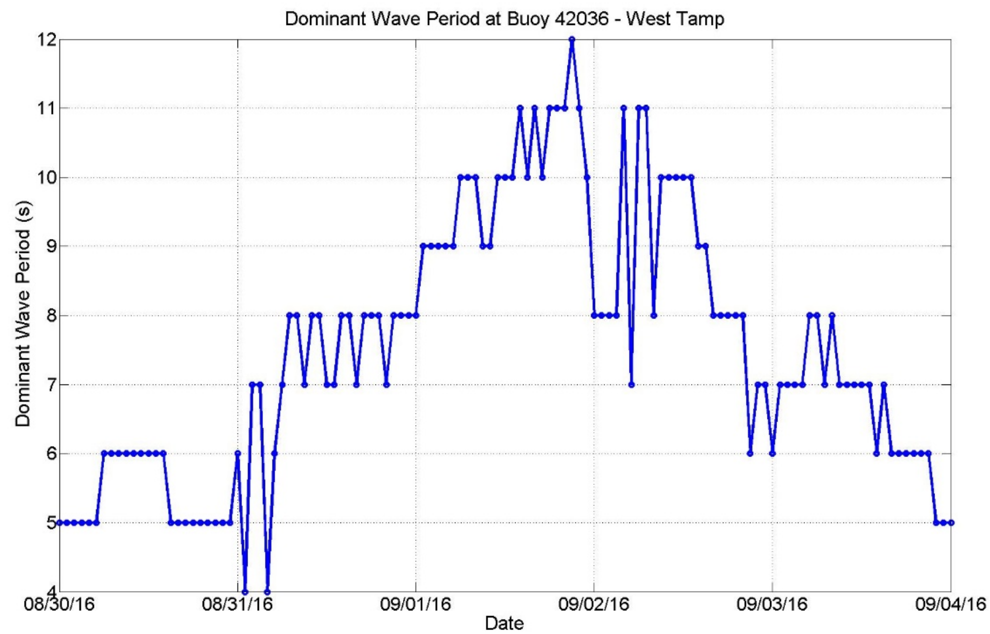


Figure 10-4: Annual exceedance probability curves for NOAA Clearwater Beach water level station 8726724.

Storm Waves

Larger than normal wave action generated by storms, along with surge, is the direct cause of erosion damages to shorelines during storms. Wave data during Hermine was measured at NDBC Stations 42036 and 42099 **Figure 10-5** and **10-6** shows the wave heights, period, and direction measured during the storm at buoys 42036 and 42009.


Significant Wave Height at Buoy 42036 - West Tampa
Wave Height (ft.)
0
5
10
15
20
25
08/30/16
08/31/16
09/01/16
09/02/16
09/03/16
09/04/16
Date


Dominant Wave Period at Buoy 42036 - West Tamp
Dominant Wave Period (s)
4
5
6
7
8
9
10
11
12
08/30/16
08/31/16
09/01/16
09/02/16
09/03/16
09/04/16
Date

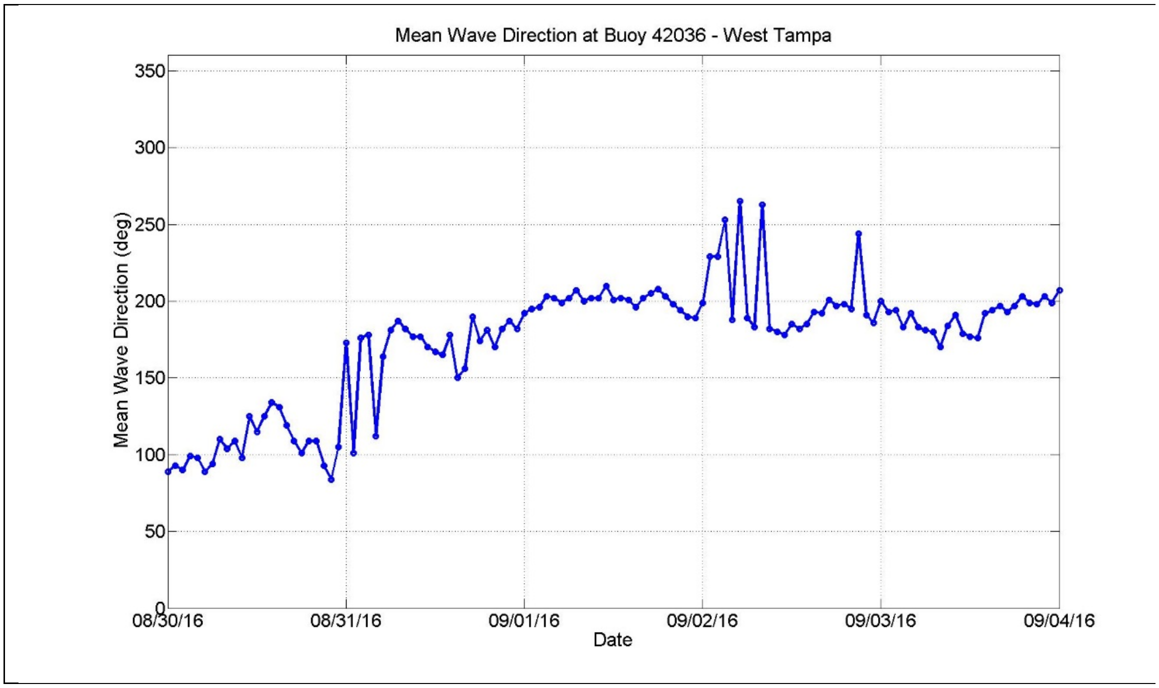
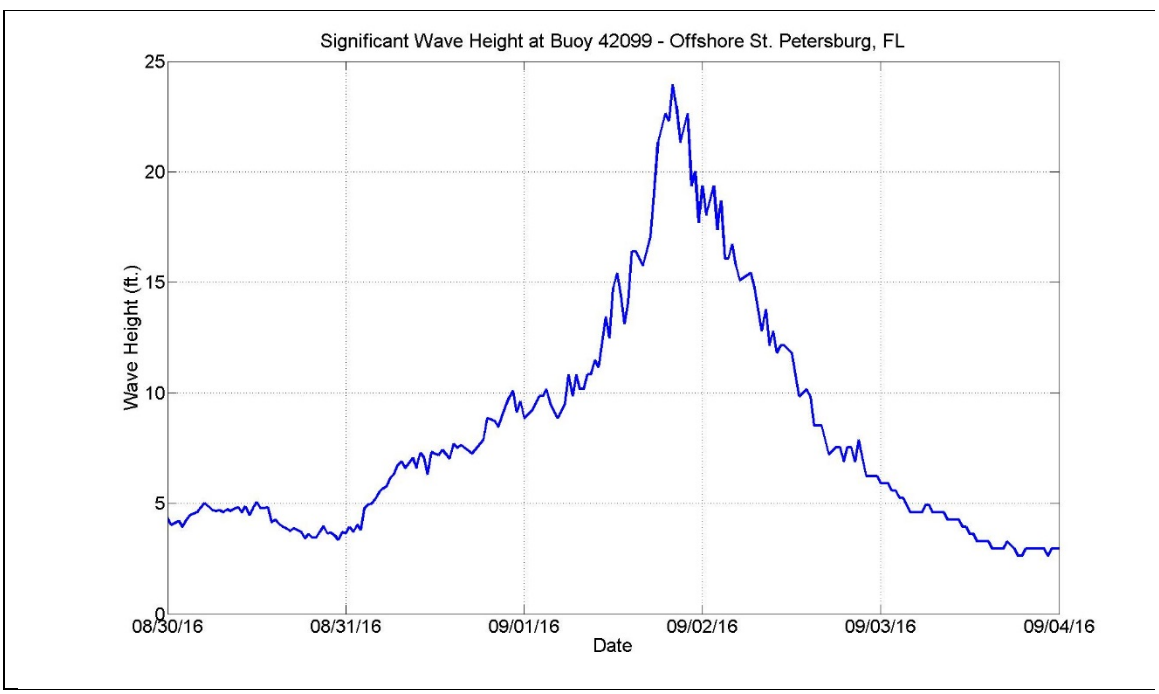
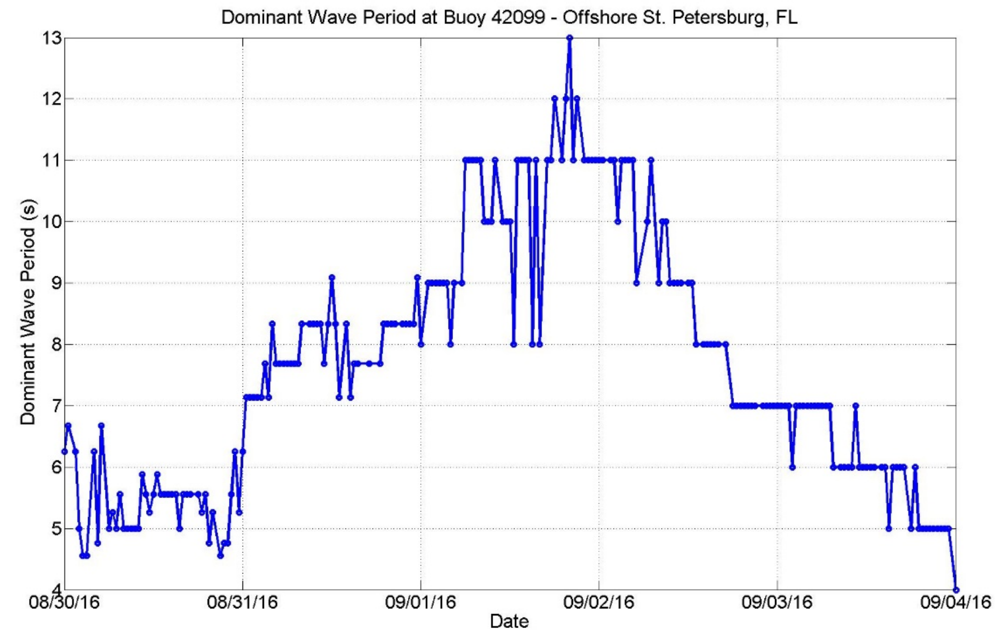


Figure 10-5: Wave heights, period, and direction during Hurricane Hermine at NBDC station 42036 at location 28.5 deg N, 84.517 deg W.





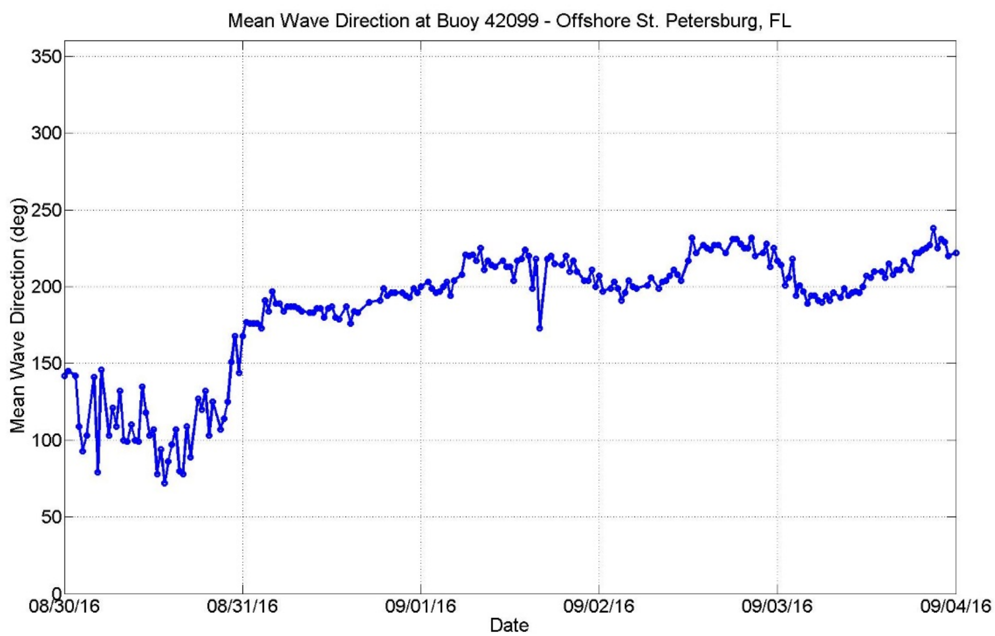


Figure 10-6: Wave heights, period, and direction during Hurricane Hermine at NBDC station 42099 at location 27.341 deg N, 84.272 deg W.

The significant wave height at NDBC Station 42099 reached a maximum of 23.95 ft during Hermine and NDBC Station 42036 reached a maximum of 24.61 ft. Wave hindcast data from WIS Station 73360 is available for the same general vicinity of buoy 42099 while WIS Station 73362 is available for the same general vicinity of buoy 42036. Both datasets are available from 1980-2014. **Figure 10-7** shows a plot of all wave events with significant wave heights exceeding 3 meters from 1980-2014 at WIS Station 73360 while **Figure 10-8** presents the same plot for Station

73362. Based on these data sets from 1980-2014 the maximum significant wave heights from Hermine at these locations would have a return period around 10 years.

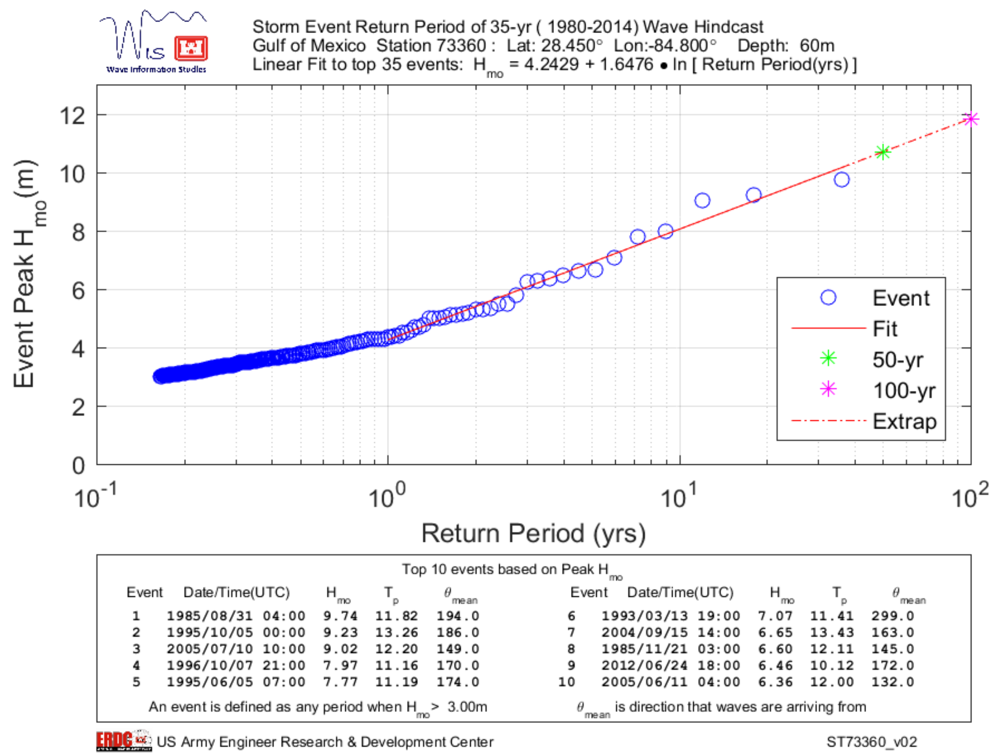
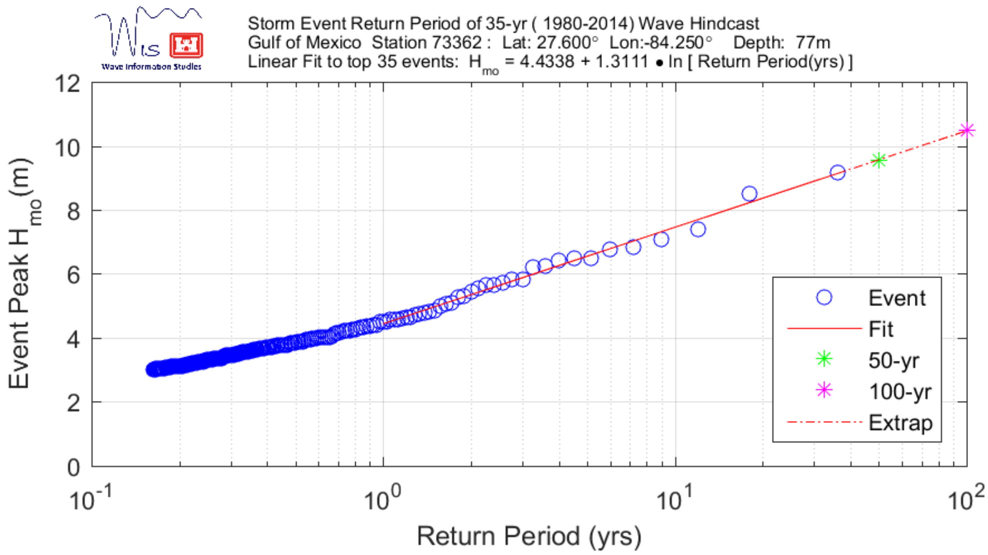


Figure 10-7: Storm event return period plot based on maximum significant wave height for WIS Station 73360.



Top 10 events based on Peak H_{mo}

Event	Date/Time(UTC)	H_{mo}	T_p	θ_{mean}	Event	Date/Time(UTC)	H_{mo}	T_p	θ_{mean}
1	1995/10/04 23:00	9.18	12.52	188.0	6	1985/08/31 07:00	6.76	10.36	215.0
2	2005/07/10 05:00	8.49	12.04	146.0	7	2004/09/15 12:00	6.49	13.09	168.0
3	2000/09/17 12:00	7.38	11.21	140.0	8	1985/11/21 00:00	6.47	10.95	149.0
4	2005/06/11 01:00	7.07	11.33	140.0	9	1996/10/07 22:00	6.41	10.95	192.0
5	1993/03/13 20:00	6.84	11.85	296.0	10	2013/06/06 13:00	6.24	10.05	202.0

An event is defined as any period when H_{mo} > 3.00m θ_{mean} is direction that waves are arriving from

ERDC US Army Engineer Research & Development Center   ST73362_v02

Figure 10-8: Storm event return period plot based on maximum significant wave height for WIS Station 73362.

The duration of the increased wave and water level action is very important to consider for storms erosion potential, and should also be considered in addition to the wave heights for making an extraordinary storm determination.

Storm Duration and Severity

Assessing only the maximum water elevation or wave height for a storm event does not provide a complete picture of a storm's potential to cause erosional damages. The amount of time that a beach is subject to storm surge and storm waves is critical to the amount of erosion a storm will cause. That is why the storm's duration should be considered along with surge and waves in determining if an event is extraordinary in terms of potential to cause erosion.

With the understanding that the significance of a storm and its potential impacts cannot be classified using stand-alone meteorological conditions, several methods have been developed in order to classify the severity of a storm that account for water levels, waves, and the duration over which they occur. In this report the Storm Erosion Index (SEI) was used as an erosion parameter to analyze the severity of Hurricane Hermine to Pinellas County beaches.

Storm Erosion Index

The Storm Erosion Index (SEI) is an erosion parameter intended to represent the severity of both tropical and extra-tropical storms. The SEI considers the wave heights and direction, water levels, a representative beach profile and the duration of storm events. The SEI parameter was calculated for Hermine using wave data from NDBC station 42036 and water level data from NOS station 8726724 (shown in **Figure 10-1**). This data covers a period of record from 1996-present. Results suggest that Hurricane Hermine has the second greatest SEI of any storm over the 20 year record. Similar to the SEI, the Peak Erosion Index is an instantaneous measure of a storms erosive potential. The SEI is a cumulative measure of the PEI. Hurricane Hermine also ranks second greatest in the 20 year record in terms of PEI. This indicates that Hermine was both highly energetic and of long enough duration to lead to beach erosion. Hermine was classified as a Category 5 on the PEI scale and Category 4 on the SEI scale (both scales normalized from 1 to 5) with an estimated return period based on the twenty year record of 15.0 years (for PEI) and 11.2 years (for SEI).

These SEI values were calculated by Jon Miller and Laura Lemke with Stevens Institute of Technology and independently verified. More details on the SEI and how it was calculated for Hermine can be found in **Appendix H**, *Hermine Update to* "*Evaluation of Storm Severity along the Florida Gulf Coast in the Wake of Tropical Storm Debby and Hurricane Isaac"* by Miller and Wehof with update prepared by Laura Lemke and Jon Miller.

"Extraordinary Storm" Conclusion

In conclusion, based on the Storm Erosion Index, water levels, and wave heights Hurricane Hermine was an extraordinary storm event for the beaches of Pinellas County.

11. DAMAGE DESCRIPTION

Damage within the Sand Key, Treasure Island, and Long Key project areas includes scarped dunes, deflation of the berm, and loss of dune grass (**Figure 11-1**). These damages have lessened the project's ability to provide the designed coastal storm damage reduction.

Figure 11-1: Storm overwash deposits in the dune field, landward of the seawall (Photo from USF)

In order to determine beach volume and shoreline changes, surveys taken before and after Hurricane Hermine were compared. The post event surveying for Hurricane Hermine was conducted by the University of South Florida Coastal Research Laboratory. Pre-storm profiles were surveyed by USACE contractor Hyatt Surveying as part of annual monitoring requirements between June 22 and July 29, 2016. Post-storm profiles were surveyed approximately a few days after Hurricane Hermine passed; September 7 through September 12, 2016.

Volume losses as a result of Hurricane Hermine were calculated by comparing the overall losses from the pre and post storm surveys as well as losses within the authorized design template and the constructed template in comparison to the authorized project berm widths. The shoreline change was calculated as the change in MHW position (0.61 ft NAVD) between the pre and post storm locations relative to the FDEP range monuments.

Volume change varied throughout the project sites. Overall a net erosion of approximately 361,944 cy was calculated for Sand Key. The majority of this erosion occurred along the southern portion (Indian Rocks Beach, Indian Shores, Redington Shores and North Redington Beach) of the project area from about R-71A to R-107. Based on the post-storm survey approximately 353,119 cy is needed to rebuild the authorized design template and 877,819 cy to build the full construction template that would provide 5 years of protection. Along Treasure Island a net erosion of 3,057 cy was calculated. A little over 50,000 cy and 200,000 cy is needed to rebuild the authorized design template and the previous construction template, respectively. The volume change calculated along Long

Key shows a net accretion of 11,095 cy. Even with the slight accretion, 40,000 cy and 187,000 cy would be needed to rebuild the authorized design and the construction templates, respectively. Like volume change, shoreline change varied but averaged 22 ft of recession at Sand Key, 13 ft of recession at Treasure Island and 11 ft of recession at Long Key.

12. NEED FOR PL 84-99 REHABILITATION.

Eligibility for project rehabilitation under PL 84-99 is contingent upon the storm event under consideration being classified as a significant storm (see Section 10 above) and that at least one of the criteria of the Significant Damage Assessment is met, as required by Engineer Regulation (ER) 500-1-1. The regulation requires documentation that significant amounts of damage have occurred based on; (a) the cost of the construction effort to effect repair of the Project or separable element thereof (exclusive of dredge mobilization and demobilization costs) exceeds one million dollars and is greater than two percent of the original construction cost (expressed in current day dollars) of the HSPP or separable element thereof; or, (b) the cost of the construction effort to effect repair of the HSPP or separable element thereof (exclusive of dredge mobilization and demobilization costs) exceeds six million dollars; or (c) more than one-third of the planned or historically placed sand for renourishment efforts for the HSPP (or separable element thereof) is lost.

The cost of the rehabilitation effort (placement of 353,119 cubic yards) to its design level would be approximately $10,790,000 (exclusive of dredge mobilization and demobilization costs). This exceeds the $1,000,000 damage criteria and represents approximately 12.84 percent of the initial construction cost in current dollars ($84,033,042), which meets the 2 percent or greater requirement of ER 500-1-1. The project also meets the justification criteria in (c) above because the required 353,119 cubic yards of sand is well above one-third (68.98%) of the planned renourishment volume of 524,700 cy.

As a result of this extraordinary storm, the project suffered significant erosion of the beach and dunes in several areas. The Sand Key segment of the Pinellas County CSRM Project is below its authorized level of protection, and damage to public and private infrastructure, and potentially risk to life and safety of residents and visitors, is likely if another storm of similar or greater magnitude occurs before the project can be rehabilitated.

13. PROPOSED WORK.

The sponsor wishes to reconstruct the full construction template with FCCE funds paying for the portion to rehabilitate to the design level of protection, and then cost sharing in restoring the project’s advanced nourishment berm width. The full template construction would consist of the placement of 877,819 cy of material from DEP monuments (56 – 66; 71 – 109).

The proposed sand borrow source for the work is Egmont Shoal borrow area, a large ebb-shoal complex north of the Tampa Bay entrance channel. This borrow site is located approximately 18 miles south of the project area. Although the method of work will not be dictated to the contractor, it is assumed there would be mobilization and demobilization of a cutter suction dredge, spider barge configuration, un-loader, associated pipeline, and shore equipment. This is representative of the equipment that has been used historically. The total construction time for project completion is 195 days, including 40 days for mobilization/demobilization.

14. COST ESTIMATE.

The amount of sand needed to rebuild the project from the post-storm conditions to its design level of protection is estimated at 353,119 cubic yards. The total estimated cost to rehabilitate the project is $15,472,000. This estimate includes mobilization, contingency, preconstruction, engineering and design (PED), and supervision and administration (S&A) in accordance with EP 500-1-1 and ER 500-1-1. The total cost, including mobilization and other associated costs to rebuild the full construction template with 877,819 cy cubic yards is $31,563,000. The estimated cost presented in this report (Table 14-1 & Table 14-2), are at the fiscal year 2017 price level (1 October 2016-30 September 2017). These costs were generated from the volumetric quantities required for each of the options mentioned above. Cost estimate details are included in **Appendix K.**

Table14- 1: Restore Post Storm to Design Template Cost

WBS Code	**Project Feature**	**Restore Post Storm to Design Template**
17	Mobilization and Demobilization	$4,209,000
17	Beach Replenishment	$10,331,000
17	Associated General Items	$459,000
1	Lands and Damages	$33,000
30	Engineering and Design	$110,000
31	Construction Management	$330,000
	Total Cost	**$15,472,000**

Table14- 2: Restore to Full construction Template Cost

WBS Code	Project Feature	Restore to Full Construction Template
17	Mobilization and Demobilization	$4,209,000
17	Beach Replenishment	$26,423,000
17	Associated General Items	$458,000
1	Lands and Damages	$33,000
30	Engineering and Design	$110,000
31	Construction Management	$330,000
	Total Cost	**$31,563,000**

Cost Allocation

All work associated with the FCCE funds will be 100% Federal. The Construction General (CG) work will be apportioned according to terms and conditions of the Project Cooperation Agreement (PCA). Costs allocated to the CG portion of the project will be shared 62.8% Federal and 37.2% Non-Federal.

Cost Apportionment

The proportion of volume for FCCE material vs. the CG material is the basis for determining the cost sharing on such items as mobilization/demobilization, dredging, beach filling, environmental monitoring and real estate. With 353,119 cubic yards for FCCE and 877,819 cy for the CG effort this leads to apportionment of 40.23% for FCCE portions of the proposed work. Per guidance in ER 500-1-1, a contingency of 15% was used for this analysis.

Table 14-3 provides the breakdown on costs; these are the cost estimates for constructing the FCCE and CG work as one project and also includes the addition of post-construction monitoring costs of $50,000/yr for 5 years.

Table 14-3: Cost apportionment

COST APPORTIONMENT OF SHORE PROTECTION PROJECT					
Project Feature	Project Cost	Federal Share	Federal Cost	Non-Federal Share	Non-Federal Cost
Mobilization	$4,209,000				
FCCE* (40.23% Proportional Cost)	$1,693,148	100.00%	$1,693,148	0.00%	$0
CG proportional MOB costs	$2,515,852	62.80%	$1,579,955	37.20%	$935,897
Beach Replenishment	$26,423,000				
FCCE* (40.23% Proportional Cost)	$10,629,143	100.00%	$10,629,143	0.00%	$0
Shore Protection - CG	$15,793,857	62.80%	$9,918,542	37.20%	$5,875,315
Associated Items	$458,000				
FCCE* (40.23% Proportional Cost)	$184,239	0.00%	$0	0.00%	$0
Shore Protection - CG	$273,761	62.80%	$171,922	37.20%	$101,839
Engineering & Design SUNK	$110,000				
FCCE* (40.23% Proportional Cost)	$44,250	100.00%	$44,250	0.00%	$0
Shore Protection - CG	$65,750	62.80%	$41,291	37.20%	$24,459
Post Constr Monitoring Costs	$250,000				
FCCE* (40.23% Proportional Cost)	$100,567	100.00%	$100,567	0.00%	$0
Shore Protection - CG	$149,433	62.80%	$93,844	37.20%	$55,589
Construction Management	$330,000				
FCCE* (40.23% Proportional Cost)	$132,749	100.00%	$132,749	0.00%	$0
Shore Protection - CG	$197,251	62.80%	$123,874	37.20%	$73,378
Real Estate/Administrative SUNK	$33,000				
FCCE* (40.23% Proportional Cost)	$13,275	100.00%	$13,275	0.00%	$0
Shore Protection - CG	$19,725	62.80%	$12,387	37.20%	$7,338
Total Cost	**$31,813,000**				
FCCE* (40.23% Proportional Cost)	$12,797,370	100.00%	$12,797,370	0.00%	$0
Shore Protection - CG	$19,015,630	62.80%	$11,941,815	37.20%	$7,073,814
		total	**$24,739,186**		**$7,073,814**

15. ECONOMICS.

OVERVIEW

This economic analysis for Flood Control and Coastal Emergencies (FCCE) has been conducted in accordance with EP 500-1-1, Appendix D, and was developed to compare the economic benefits versus the economic costs of emergency restoration and nourishment activities for the Sand Key segment of Pinellas County. Emergency restoration and nourishment is defined as the placement of PL 84-99 material on the beach of the subject project in order to repair and restore the project to the design level of protection (i.e. design template). The portion eligible for PL 84-99 Rehabilitation Assistance will be the amount of sand necessary to restore this profile. The primary objective of this analysis is to determine whether or not FCCE emergency restoration is justified (i.e. has a benefit-cost-ratio greater than 1.0). A secondary objective is to compare FCCE restoration to alternative nourishment options.

Two scenarios were considered in the economic analysis in order to establish the best allocation of resources: (1) FCCE restoration to design template only (hereafter referred to as Alternative 1) and, (2) simultaneous FCCE and CG cost-shared efforts to bring the project to full construction template (hereafter referred to as Alternative 2).

KEY ASSUMPTIONS

This project was first operational in 1993, with the completion of Phase III. The remaining project life is now 27-years, concluding in 2043, with an authorized nourishment interval of five years. Two items were considered in order to establish the period of analysis for Alternative 1. The first to consider is that expected construction of the next periodic nourishment, due to budgetary processes, will not occur for at least another six years from publication of this report, despite the five-year authorized interval. The second item to consider is that in order for the emergency restoration to achieve the estimated average annual benefits it must last until the next scheduled nourishment will be constructed. Therefore, the period of analysis for Alternative 1 will be six years (measured from the fiscal year of this report). The period of analysis for Alternative 2 will be 27-years (i.e. the remaining project life), and construction will not be expected to physically complete until early FY18. Recreation benefits are not a part of the analysis. Benefits will be expressed at the price level in the 1997 Design Memorandum[1], and the costs of the emergency restoration will be deflated back to this price level (2Q96).

Economic Evaluation of FCCE Restoration to Design Template (Alternative 1)

BENEFITS

The authorizing document design profile estimate of coastal flood damage reduction benefits has been applied as the initial assessment point. Engineering has provided the incremental loss in cubic yardage of sand from the design profile. This lost quantity is to be compared to the total cubic-yardage of 1,088,200 utilized to initially construct the authorized project design profile. The incremental loss of sand of 353,119 cubic-yards will serve as input to derive a proxy value to be used to estimate storm protective capability lost. The incremental loss of sand serves as the numerator value and is divided by the total cubic-yardage of sand denominator that had initially been required to construct the authorizing document design profile. This resultant percentage is the proxy value to be multiplied by total average annual storm damage reduction benefits (as determined in the authorizing document). The net result is an approximation of the storm damage protective capability to be provided by the restoration of the project to the design profile from the end of construction until the next periodic nourishment.

The benefits are expressed at the authorizing document price level of March 1996. The structure inventory on which benefits are based has not significantly changed since the last authorizing document and, therefore, are assumed to still be valid.

Average annual expected damage reduction capability (benefits) for the authorizing document design profile is $26,625,600. The prorated ratio of average annual benefits provided by the quantity needed to restore to the design profile is estimated at 32.5% of the authorized project benefits. The incremental average

[1] 1997 Design Memorandum

annual benefit from undertaking the emergency placement is, thus, equivalent to $8,639,961.

COSTS

Costs of the emergency restoration have been deflated back to the authorizing document price level by applying the Civil Works Construction Cost Index System (CWCCIS), EM 1110-2-1304, quarterly cost index tables (current version, 31 March 2016). This cost adjustment is necessary to place costs and benefits on a comparable price-level basis.

The cost at the FY17 price level for the project's emergency placement as a standalone project is $15,472,000. Deflating this cost back to the authorizing document price level provides an adjusted cost of $8,509,049. This deflated cost has then been annualized over the remaining period of analysis (six years), by applying the FY17 discount rate of 2.875%. The average annual cost of the emergency placement of material for restoration to the design profile is equivalent to $1,564,248.

BENEFIT-COST RATIO

The benefit–cost ratio is 5.52-to-1, with net benefits of $7,075,713.

CONCLUSION

The benefits exceed the costs of the emergency placement of material.

Economic Evaluation of FCCE Rehabilitation in Combination with Full Construction Template (Alternative 2)

As noted above, the emergency restoration work alone has a benefit-to-cost ratio greater than 1.0 indicating the project meets the eligibility criteria in ER 500-1-1, paragraph 5-20 (A). The next step of the process will be to analyze the alternative of FCCE rehabilitation in combination with full construction template and to compare the net-benefits with those of the FCCE restoration only alternative.

BENEFITS

When considering the alternative of combining FCCE rehabilitation with placement to the full construction template it is important to note that this would normally reset the periodic nourishment cycle. However, it is assumed that Alternative 2 will be completed in FY18, which is when the next periodic nourishment is normally scheduled. Therefore, the nourishment schedule and resulting benefit and cost stream[2] will be unaffected.

[2] The cost stream is unaffected as it pertains to the dates in which the costs are incurred. The cost in FY18 will increase commensurate with the additional quantity of FCCE restoration sand.

COSTS

This particular alternative involves the placement of 877,819 CY of sand at an estimated cost of $31,563,000 (FY18), or $17,358,525 deflated back to FY96 price levels. Combining the FCCE restoration and the full construction template in effect saves costs on an additional mobilization/demobilization. This alternative also realizes the full average-annual storm damage reduction benefits of $26,625,000. With the nourishment schedule shifting forward a year, the average annual cost is estimated to be $2,866,157.

BENEFIT-COST RATIO

Alternative 2 yields a benefit-cost-ratio of 9.29 with net-benefits of $23,759,443.

CONCLUSION

Therefore, when analyzing FCCE restoration only with the combination of FCCE restoration and full construction template, the combined effort has greater net-benefits of $23,759,443 compared with $7,075,713.

16. ENVIRONMENTAL CONSIDERATIONS.

Summaries of the environmental considerations are discussed below. Renourishment of the full construction template was most recently completed in November of 2012.

a. Impacts, Beach Nourishment. As stated in the 2011 Environmental Assessment (EA) for this project, all practicable means to avoid and/or minimize adverse environmental impacts were included in plan formulation and have been incorporated into the authorized project.

(1) The purpose of renourishing the previously nourished beach is to restore and maintain the hurricane protection and storm damage reduction benefits of the project. Shore protection projects are typically designed to provide a minimum level of protection plus additional nourishment to optimize the renourishment interval (typically enough sand to achieve a renourishment interval of 3 to 7 years). The “construction profile” undergoes a period of reworking by waves and currents. An “equilibrium profile” is achieved in about a year following the renourishment event. Direct burial of shoreline bottom (benthic) habitat would occur within this “equilibrium profile”. During the first year following the renourishment event, there would be a high potential for greater than normal erosion of the dry beach along with possible loss of sea turtle nests.

(2) Some elevation in turbidity for the nearshore waters might also be expected during the renourishment event and during the first year following the event as the beach profile equilibrates but this has not been shown to happen. To reduce impacts, the sand used for renourishment is required to be similar to the “natural” or “existing” beach, the level of “fines” (material passing through a #200

sieve) must not exceed 5%, the beach is tilled if compaction exceeds 500 psi, scarps are removed just prior to sea turtle nesting season, and renourishment occurs outside the sea turtle nesting window or sea turtle nests are relocated to a "safe hatchery" as required by the Statewide Programmatic Biological Opinion (revised 2015) from the U.S. Fish and Wildlife Service. Monitoring for escarpments and compaction is typically performed on an annual basis just prior to sea turtle nesting season for three years following construction.

b. Impacts, Borrow Site. Borrow sites are selected for quality and quantity of sand, proximity to the beach, minimizing impact to valuable underwater resources (reef, hard ground, potential historic/cultural resources). A buffer zone between the borrow site boundary and such resources is typically required to minimize or avoid impacts. Buffer zones are specified in both the South Atlantic and Gulf of Mexico Regional Biological Opinions from the National Marine Fisheries Service (NMFS) as well as the State permit. If required to deliver sand to the beach, pipeline corridors are selected to minimize impact to benthic resources. The same pipeline corridor is used for subsequent renourishment events to limit impacts to one specific location. Temporary impacts consisting of increased turbidity and mortality of benthic macroinvertebrates would be expected at the borrow site. The Egmont Channel Shoal borrow area will be used exclusively for the proposed work.

c. Potential "Show-Stoppers". Completion of updated Endangered Species Act (ESA) consultation is needed. See paragraphs below for additional discussion on ESA, EFH and permits.

d. NEPA. Renourishment to restore the pre-hurricane condition requires consideration under the National Environmental Policy Act (NEPA). A FONSI and EA was completed in June 2011 for the beach renourishment project. As previously stated, the 2011 EA tiers off of the 1997 and 2002 EAs as well as the 1984 Environmental Impact Statement for this project.

e. Borrow Site. The use of the Egmont Channel Shoal borrow site was most recently utilized in 2012 third renourishment.

f. Endangered Species. The project would be performed in compliance with the Programmatic Biological Opinion (revised 2015) and the Programmatic Piping Plover Biological Opinion (2013) issued by the U.S. Fish and Wildlife Service (USFWS). The rufa red knot was Federally listed subsequent to the issuance of these opinions. Consultation on the knot shall be completed prior to initiation of work. NMFS protected species (sea turtles, gulf sturgeon, smalltooth sawfish) is covered under the Gulf Regional Biological Opinion (revised 2007; Management Protocol, revised 2010).

(1) Borrow Site.

(a) The use of the offshore borrow areas was recently coordinated in 2013 with the USFWS and the National Marine Fisheries Service (NMFS). The use of a dredge to obtain borrow material offshore or from a navigation channel has the potential to impact sea turtles. The "taking" of sea turtles in this manner from an offshore borrow site is very rare and it is more commonly associated with hopper dredging of a navigation channel. The NMFS has issued a Regional Biological Opinion for the South Atlantic Coast and another for the Gulf of Mexico. Activities using a hopper dredge will comply with the terms and conditions of the incidental take statements of the applicable Regional Biological Opinion. Use of other dredging equipment [other than hopper dredge] has been determined to have no effect or "not likely to adversely affect" sea turtles. Any applicable requirements with respect to whales in the Regional Biological Opinion will also be followed. Impacts to the manatee are minimized with the "standard manatee protection measures" in the project specifications. Use of the standard manatee protection measures results in a "may affect but not likely to adversely affect" condition. This has typically been interpreted by the USFWS to also satisfy the requirements of the Marine Mammal Protection Act. Appropriate protective magnetometer buffer zone size at the borrow area locations has been coordinated with the Florida Department of Environmental Protection and the State Historic Preservation Office.

(2) Beach Placement.

(a) The placement of sand on the beach was covered in previously completed NEPA documents. Protection measures for nesting sea turtlesand piping plovers shall be incorporated into the project plans and specifications in order to comply with the terms and conditions of the Statewide Programmatic Biological Opinion and Programmatic Piping Plover Biological Opinion issued by the U.S. Fish and Wildlife Service. Protection measures for the rufa red knot shall also be implemented.

(b) The USFWS has jurisdiction over sea turtles on the beach (nesting adults, incubating eggs, or hatching young). In accordance with the Statewide Programmatic Biological Opinion, sand may be placed year round in Pinellas County. Sea turtle nesting shall be monitored and nests may be relocated.

g. <u>Archeological and Cultural Resources</u>. Previously the Corps has utilized the entire Egmont shoal as a borrow source for the project. The Corps and Pinellas County conducted an archaeological investigations in the ebb shoal in 1998 and documented the results in the study entitled; Marine magnetometer survey of a proposed sand borrow site and sand transfer site, Indian Rocks Beach, Pinellas County, Florida by ESPEY Huston and Associated and in 2001 the eastern lobe of the shoal and current project area was subject to additional investigations; A Remote Sensing Survey of the Proposed Egmont Channel Borrow Area, Pinellas

County, Florida by Tidewater Atlantic, Inc. Subsequently, identified targets were in both areas of the Egmont Shoal were subjected to diver identification and the following report was produced; Diver Evaluations of 34 Targets in the Egmont Shoals Borrow Area Pinellas County, Florida, by Panamerican Consultants. Finally, in 2011 portions of the western lobe of the shoal were nominated as a State of Florida Underwater Archaeological Preserve, to protect and encourage tourism and to explorer the underwater wrecks located with the preserve.

While it is anticipated that use of the project will have no adverse effect on significant resources, updated consultation was performed in 2013 prior to use of the borrow area. No additional restrictions were requested beyond the previous buffering of significant resources that had been utilized for past renourishments. Consultation with the State Historical Preservation Office (SHPO) and appropriate federally recognized tribes was conducted in 2013 as part of the previous emergency rehabilitation effort.

h. Section 404(b) Clean Water Act. A Section 404(b) analysis has been previously completed and coordinated with appropriate stake holders.

i. Coastal Zone Consistency. The State of Florida has determined that the proposed work is consistent with the State's Coastal Zone Management Program. This determination was made with issuance of the State permit for this project.

j. Coastal Barrier Resources Act (CBRA). This project does not involve a CBRA unit as part of the placement or borrow areas.

k. Essential Fish Habitat. The Magnuson-Stevens Fishery Conservation and Management Act requires the Federal Agency to prepare an Essential Fish Habitat (EFH) Assessment for the NMFS. Activities initiated prior to the May 3, 1999, "finding" from NMFS are exempted from this requirement (grandfathered) unless the activity is re-opened for evaluation with an EA, EIS, or Public Notice (pursuant to the Clean Water Act and National Environmental Policy Act). Assessments were prepared and coordinated with NMFS during public review of the 2011 and 2002 EAs.

l. Storm Drains. There are no storm drains located within the project footprint. Therefore, no storm drains will be affected by the proposed work.

17. PERMITS.

Section 401, Clean Water Act, Water Quality Certification (WQC).

Nourishment. Project/Segment specific authorization is required for placement of sand. The Corps is the permittee for the project, holding a permit that expires July

06, 2021. The Corps is permitted under the Sand Key Beach Nourishment, No. 0238664-001-JC and sub sequential modifications for the following activity:

The project is to nourish 8.7 miles (14.0 km) of beach on Sand Key. This includes two beach fill segments: from R-56 to R-66 and from 85 feet north of R-71A to R-108. Between R-107 and R-108, fill will only be placed landward of the mean high water line. A one-mile gap between the segments (from R-66 to R-71A) will not be filled. The project is authorized to occur multiple times, on an as-needed basis, with the first event requiring approximately 1,017,000 cubic yards of beach-compatible sand. The sand will be dredged from an offshore borrow area located in federal waters and the Egmont Shoal East Borrow Area. The project has a design berm elevation of +4.1 feet (1.3 m) NAVD88, with a one-foot construction tolerance to a maximum elevation of +5.1 feet NAVD88 (1.6 m). Berm widths and volumes vary from each section. An additional 2,000 cubic yards of beach-compatible sand will be placed between 4 feet south of R-60 and 182 feet south of R-61A for the purpose of dune nourishment, with a dune crest elevation of 7.1 feet (NAVD) and a crest width of 7.5 feet. "

18. REAL ESTATE REQUIREMENTS.

The lands required for the Pinellas County Shore Protection Project – Sand Key Segment authorized footprint are currently being obtained by the local sponsor for certification. Refer to Appendix N for more details.

19. IMPLEMENTATION SCHEDULE.

Table 19-1: Implementation Schedule.

CONSTRUCTION MILESTONE DATES Pinellas County, FL Shore Protection Project Sand Key Segment	
Activity Name	**Finish Date**
Complete Review and Update of Plans & Specs	27-Nov-16
P&S Final ATR and BCOE Certification	27-Dec-16
Construction Contract Advertised	26-Jan-17
Construction Contract Awarded	15-Feb-17
Design Template Work Complete (60 days)	10-Jun-17
Full Construction Template Work Complete (140 Days)	29-Aug-17

20. RECOMMENDATIONS.

Based on study findings, Hurricane Hermine meets the criteria in ER 500-1-1 for extraordinary storm event, significant amounts of damage, and a positive benefit to cost ratio for the Sand Key Segment of the Pinellas County Coastal Storm Risk Management Project. I recommend that emergency rehabilitation of the Project, as described herein, be performed under the authority of Public Law 84-99. The recommended plan provides the greatest net National Economic Development benefits. The proposed work also includes a full restoration of the project to its authorized dimensions. The FCCE portion of this work involves the rehabilitation of 353,119 cubic yards of material which reflects the beach fill lost due to the extraordinary storm and restores the design level of the project; while the recommended cost shared renourishment volume of 524,700 cubic yards provides additional storm damage reduction benefits and is a cost effective acquisition strategy. The combined work is justified with the average annual cost at FY96 prices being $2,866,157. Average annual storm damage reduction benefits at FY2017 prices are $26,625,000, the remaining benefit to remaining cost ratio is 9.3 to 1.0, and net benefits are $23,759,443.

Jason Kirk
Colonel, U.S. Army
District Engineer

List of Acronyms

ASA(CW) - Assistant Secretary of the Army for Civil Works
ASWE - Accumulated Storm Wave Energy
BCOE – Biddability, Constructability, Environmental review
BCR - Benefit–to-Cost Ratio
CA – Cooperation Agreement
CBRA – Coastal Barrier Resource Act
CG - Construction General
COSI - Coastal Storm Impulse Parameter
CWCCIS - Civil Works Construction Cost Index System
CY – cubic yards
EA - Environmental Assessment
EFH - Essential Fish Habitat
EIS - Environmental Impact Statement
EM - Engineering Manual
ER – Engineer Regulation
ESA - Endangered Species Act
FCCE - Flood Control and Coastal Emergency
FDEP - Florida Department of Environmental Protection
FEMA - Federal Emergency Management Agency
FY – Fiscal year
GRBO - Gulf of Mexico Regional Biological Opinion
HSDR - Hurricane and Storm Damage Reduction
HSPP – Hurricane/Shore Protection Project
MCACES - Micro-Computer Aided Cost Estimating System
MLW - Mean Low Water
MLLW - Mean Lower Low Water
NAVD88 - North American Vertical Datum of 1988
NEPA - National Environmental Policy Act
NGVD - National Geodetic Vertical Datum
NMFS- National Marine Fisheries Service
NOAA - National Oceanic and Atmospheric Administration
NOS - National Ocean Service
PCA - Project Cooperation Agreement
PED – Preconstruction, Engineering and Design
PL 84-99 - Public Law 84-99
RBO - Regional Biological Opinion
RBRCR - Remaining benefit to remaining cost ratio
RIP - Rehabilitation and Inspection Program
S&A - Supervision and administration
SHPO - State Historic Preservation Office
SPBO - Statewide Programmatic Biological Opinion
SPP - Shore Protection Project
TS - Tropical Storm
USF – University of South Florida

USFWS - U.S. Fish and Wildlife Service
UTC - Coordinated Universal Time
WQC - Water Quality Certification
WRDA - Water Resources Development Act

Part III. Appendices

Appendix A. Public sponsor's request for assistance

Pinellas County PUBLIC WORKS

September 13, 2016

Laurel Reichold, Project Manager
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Subject: REQUEST TO THE USACE TO SEEK REHABILITATION FOR THE PINELLAS COUNTY SHORE PROTECTION PROJECT

Dear Ms. Reichold:

The Pinellas County Shore Protection Project at Sand Key, Treasure Island and Long Key, has received damage from Hurricane Hermine. We request that the Unites States Army Corps of Engineers evaluate and repair the damage to this project.

On behalf of Pinellas County, I am grateful for all the effort put forth in maintaining the Pinellas County Shore Protection Project and look forward to continued collaborative efforts with the US Army Corps of Engineers moving forward.

Sincerely,

John E. Bishop

John E. Bishop, Ph.D.
Coastal Management Coordinator
Division of Environmental Management

Pinellas County Public Works
22211 U.S. 19 N. • Building 1
Clearwater, FL 33765
Main Office: (727) 464-8900
FAX: (727) 464-8915
V/TDD: (727) 464-4062

www.pinellascounty.org

Appendix B. Project map(s)

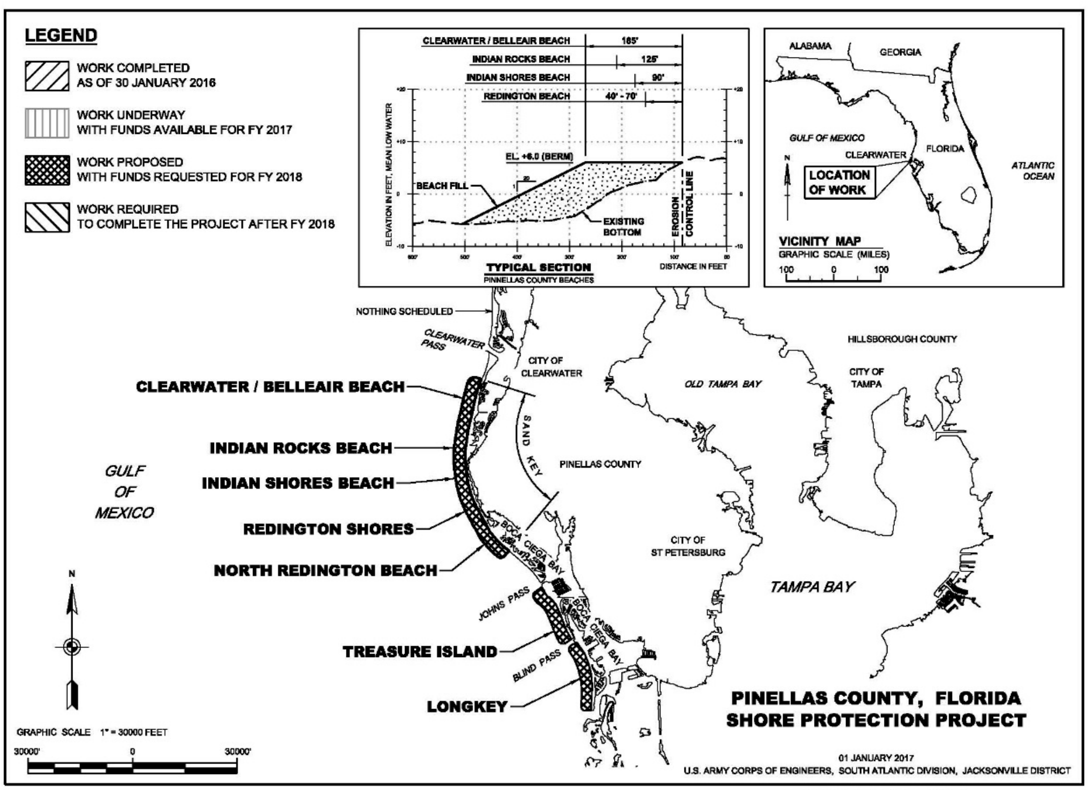
See Figure 6-1 in the main report.

Appendix C. Project Overview

See Section 1-8 in the main report.

Appendix D. Project Design Data

See Section 6 in the main report.



PROJECT STATUS MAP (RCS CECW-B-13)

Appendix E. Project Maintenance Data

See Section 7 in the main report.

Appendix F. Project Renourishment Data

See Section 8 and **Table 8-1** in the main report.

Appendix G. Previous PL 84-99 or Other Federal Agency Assistance

See Section 9 in the main report.

Appendix H. Disaster Incident

The disaster incident and determination of an extraordinary storm is covered in detail in section 10 of the main report. This Appendix includes a paper from Stevens Institute of Technology on the SEI of Hurricane Hermine, and a table and graphs showing the storm durations and momentums used to calculate the COSI parameter for Hermine, Debby, Isaac, and several of the 2004 hurricanes from Old Dominion University.

Hermine Update to “Evaluation of Storm Severity along the Florida Gulf Coast in the Wake of Tropical Storm Debby and Hurricane Isaac”

Originally Prepared by:
Jon K. Miller, Ph.D. & Jennifer Wehof
for
Jacksonville District, U.S. Army Corps of Engineers

Update Prepared by:
Laura Lemke & Jon K. Miller, Ph.D.

SIT-DL-16-9-2963

October 2012
Revised September 2016

REVISION HISTORY

Revision Number	Date	Description
1	September 2016	The document was updated after the landfall of Hurricane Hermine in roughly the same study area.

INTRODUCTION

Erosion due to coastal storms is the removal of sand from the dry beach resulting from the mechanisms to redistribute sand such as wave action and increased water levels. Three important parameters define the severity of the erosion caused by a storm. The total water level, comprised of both the tide level and the storm surge, dictates how high up on the beach the water will rise. The wave conditions characterize the amount of energy available to move sediment around and if it will accrete or erode. Finally, the duration of the storm tells how long the beach is subjected to these conditions, and thus how much damage is accumulated over the length of the storm.

Traditional measures of the significance of a storm include water level or storm surge or wave height alone, such as in a stage frequency analysis. There are also several indices that combine some or all of these parameters to predict what kind of erosion will occur. Tropical systems are often classified based on their meteorological properties such as barometric pressure, maximum wind speed, and potential storm surge. These properties are well-understood for these warm-core cyclones and allow for a fairly simple classification system. The Saffir-Simpson hurricane scale categorizes the storm based on its predicted ability to cause flooding and high storm surge and labels each storm with a number from 1 to 5 for easy interpretation by the public and comparison between storms (Dolan & Davis, 1992).

Northeasters cannot be classified the same way as hurricanes in terms of meteorological properties alone; they are formed from cold-core system over land or water, having no direct relationship between wind speed and the amount of destruction that can occur from flooding and ocean conditions (Herrington & Miller, 2010). The Dolan and Davis (1992) scale is based on the wave power and places a storm into one of five classes, with Class I being a weak northeaster with only minor erosion, and Class V a strong northeaster with "extreme beach erosion". Another index for northeasters is the storm intensity scale developed by Kriebel et al. (1996). This index incorporates the maximum storm surge (not storm tide), maximum significant wave height offshore, and the duration of the storm in terms of tidal cycles. It is converted into a 5 point scale to be consistent with the Saffir-Simpson scale for categorizing hurricanes.

The Storm Erosion Index (SEI), is an erosion parameter which is based on work by (Miller & Dean, 2004), and later further developed by Miller and Livermont (2008), which is intended to represent the severity of both tropical and extratropical storms. The SEI considers the wave heights, water levels, and the duration of storm events. Miller and Livermont showed that the severity of storms ranked by traditional methods (cumulative energy, breaking wave height, and total water level) differed from the ranking by SEI, and that the SEI was more closely correlated to post storm erosion than traditional indices. Miller and Livermont evaluated the SEI using data from Wildwood, NJ, Daytona Beach, FL, Clatsop Plains, OR; Torrey Pines, CA, and The Gold Coast, Australia.

This preliminary evaluation focuses on the application of the SEI to the Florida Gulf Coast, and specifically to the impacts of Tropical Storm Debby and Hurricane Isaac during the summer of 2012. While Debby did not even reach hurricane status, the reported erosion was severe. The Tampa Bay Times reported that a University of South Florida professor of geology said Debby caused the most widespread beach erosion in the 11 years she has been studying the area (Phillips, 2012). Debby was followed less than 2 months later by Hurricane Isaac, a slow moving yet destructive Category 1 storm. Isaac impacted the already weakened beaches and caused even more erosion.

METHODS

The method used in the calculation of the PEI and SEI has its foundations in the beach profile response that occurs from increased water levels. The well-known Brunn rule describes the relationship of storm surge to shoreline change (Dean & Dalrymple, 2002)

$$\Delta y = -S\frac{W_*}{(h_* + B)} \tag{1}$$

in which $(h_* + B)$ represents the vertical dimension and Δy is the horizontal recession of the profile. This rule was modified by (Dean & Dalrymple, 2002) to represent the shoreline change caused by a combination of waves (due to setup) and storm surge:

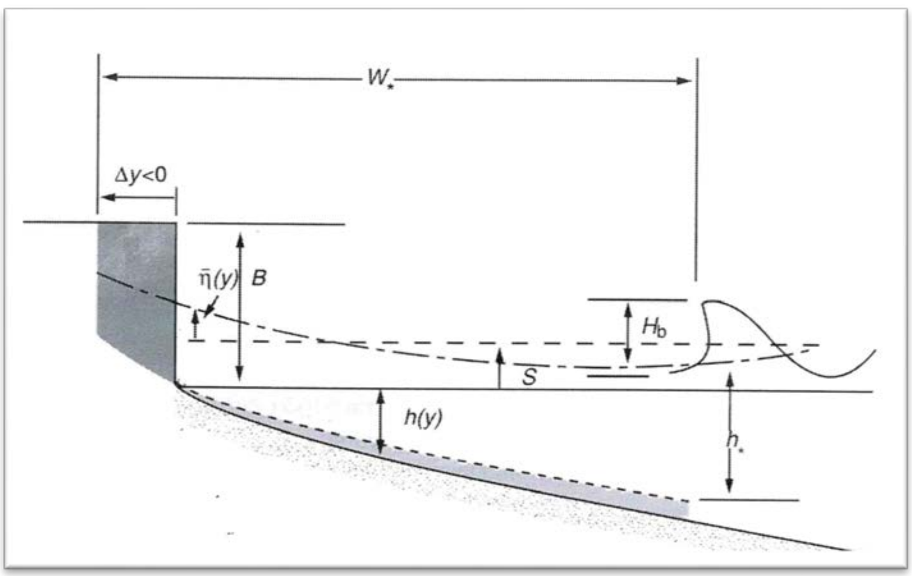


Figure 1: Definition sketch for IEI parameters.

$$\Delta y = -W_*\left[\frac{0.068H_b + S}{B + 1.28H_b}\right] \tag{2}$$

Where S represents the uniform increase in water level across the profile, H_b is the breaking wave height and W_* is the width of the active surfzone which can be taken as the distance to the breakpoint. When considered as a function of time (through time varying H_b, S, and W_*) the parameters can be considered to define an instantaneous erosion intensity,

$$IEI(t_i) = W_*(t_i)\left[\frac{0.068H_b(t_i) + S(t_i)}{B + 1.28H_b(t_i)}\right] \tag{3}$$

The negative sign is dropped for convenience, and the berm height *B* is assumed to be constant over time. Two useful parameters that are based on the IEI are the Peak Erosion Index (PEI) and the Storm Erosion Index (SEI). The PEI is simply the maximum value of the IEI over the life of a storm, while the SEI is the sum of the IEI during a storm.

$$SEI = \sum_{t_d} IEI(t_i) = \sum_{t_d} W_*(t_i)\left[\frac{0.068H_b(t_i) + S(t_i)}{B + 1.28H_b(t_i)}\right] \tag{4}$$

where t_d is the duration of the storm.

The SEI values obtained can be normalized to result in a categorical scale from 1 through 5, consistent with many of the existing indices for storm intensity. This process assigns the minimum SEI value at the site to be category 1 and the maximum SEI value at the site to be category 5. Then, linear interpolation is used to find what the category would be for a given value of the SEI according to the following formula:

$$\text{Category} = 5 * \left(\frac{SEI_{\max} - SEI}{SEI_{\max} - SEI_{\min}}\right) \tag{5}$$

This value is rounded up to the next whole integer to arrive at a category for the storm based on the SEI. The same normalization method can be used for the PEI.

Finally, a measure of the seasonal storm strength can be obtained by summing the SEI values over a storm season. In the present analysis a storm season was defined from the start of hurricane season on June 1 until the following May 31st.

DATA

The intent of the present analysis was to place Debby and Isaac in a historical context so data sources with long records were sought out. The wave and water level data were obtained from publicly accessible NOAA sources. The wave data from NDBC station 42036 (West Tampa) were shoaled and refracted using linear wave theory to the breakpoint. Where directional data was not available, waves were assumed to approach from due west. Waves with a steepness greater than 0.025 (Johnson, 1949) were assumed to be accretional and were removed from the record prior to the calculation of the ISI. Water level data from the NOS tide gauge at Clearwater Beach (8726724) were used to compliment the wave data.

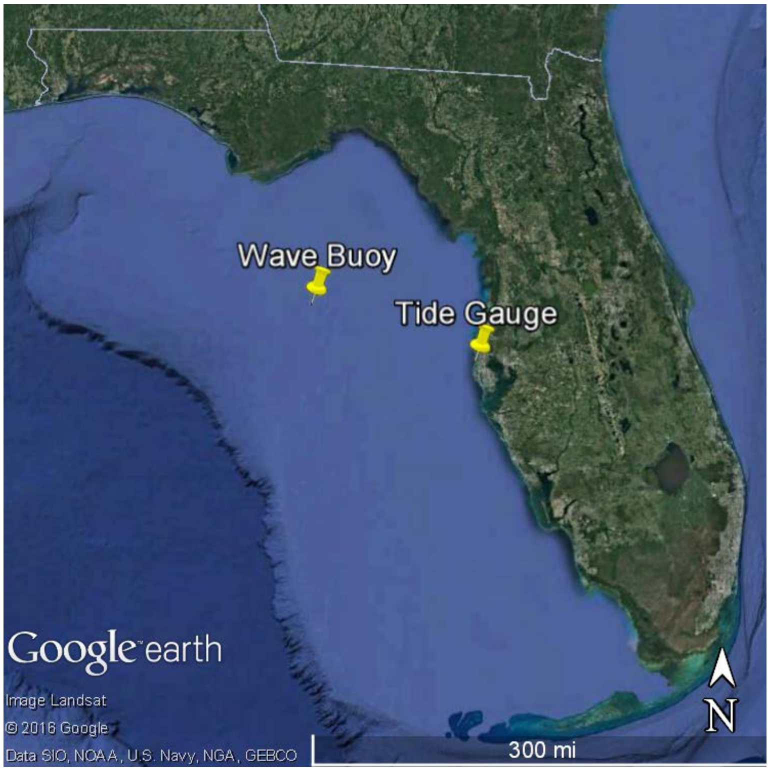


Figure 2: Location of wave buoy (NDBC 42036) and tide gauge (NOS 8726724)

In summing the ISI, over storm duration an objective criterion was used to define each storm. When either the wave height or water level exceeds the mean plus two standard deviations, a storm is initiated. The storm persists as long as either of the two parameters exceeds the threshold. To account for cases where the storm wanes temporarily and then picks up in intensity again, storms separated by less than 24 hours are considered a single storm.

RESULTS

The SEI has most recently been applied to data from the Gulf of Mexico for Tropical Storm Debby, which hit on June 23, 2012 and caused severe beach erosion in Pinellas County, Florida. A study by the University of South Florida, too recent to be published, was reported by the Tampa Bay Times to have found a total 630,900 cubic yards of sand displaced from the shore. Previous storms, such as Hurricane Frances, had higher wind speeds but passed over quickly (Phillips, 2012). Debby lingered in the Gulf of Mexico, and thus the SEI captures the erosion from the long duration of waves and elevated water levels. The preliminary results suggest that Debby was a Category 5 storm based on erosion potential. A return period can be calculated for each storm based on its SEI value. Here, a Peaks Over Threshold approach was used, where the exceedances of a defined threshold were fit to a GPD distribution. Using this approach, Debby has a return period of 23.4 years.

Individually, Hurricane Isaac was much less significant than Tropical Strom Debby according to the SEI. Isaac only registered as a Category 2 storm, with a return period of 3 years suggesting the storm generated conditions fairly typical for the area. It should be noted, that in the case of Isaac, this conclusion is heavily dependent on the steepness threshold used to separate accreting and eroding waves. During Isaac the waves measured in excess of 3 m for a full 48hrs; however during a significant portion of this time the calculated wave steepness is just under the 0.025 threshold. This results in some large waves being excluded from the SEI calculation. The 0.025 threshold was selected based on its use in the literature and to be consistent with other applications of the SEI; however as the dividing line between erosion and accretion is far from certain, more analysis should be done to establish a more appropriate erosion/accretion threshold. A very quick sensitivity analysis shows that lowering the steepness threshold to 0.02 causes Isaac to jump to a Cat 4 storm based on SEI, with a return period closer to 10 yrs.

To assess the cumulative impacts of the two storms relative to the historical record, the SEI was summed over the period from June 1st to May 31st of the following year for each year in the record. The data were then normalized by the highest yearly total. The results are shown below, where the 2012-2013 storm season is already the second most severe on record with 7 months to go. Only the 1998-1999 season containing Hurricane's Earl and Georges among others ranks higher. The second parameter presented in the graph is Accumulated Storm Wave Energy (ASWE).

Table 1: SEI values, Categories, and return periods for West Coast Florida storms

Date	Storm	PEI	PEI Cat	T_r	SEI	SEI Cat	T_r
24-Jun-2012	Debby	70.02	4	5.1	1694	5	23.4
02-Sep-1998	Earl	76.66	4	7.3	1045	4	9.3
26-Sep-1998	Georges	75.62	4	6.9	1105	4	10.4
07-Oct-1996	Josephine	109.6	5	60.5	831	3	6.2
28-Aug-2012	Isaac	49.57	3	1.8	550	2	3.0

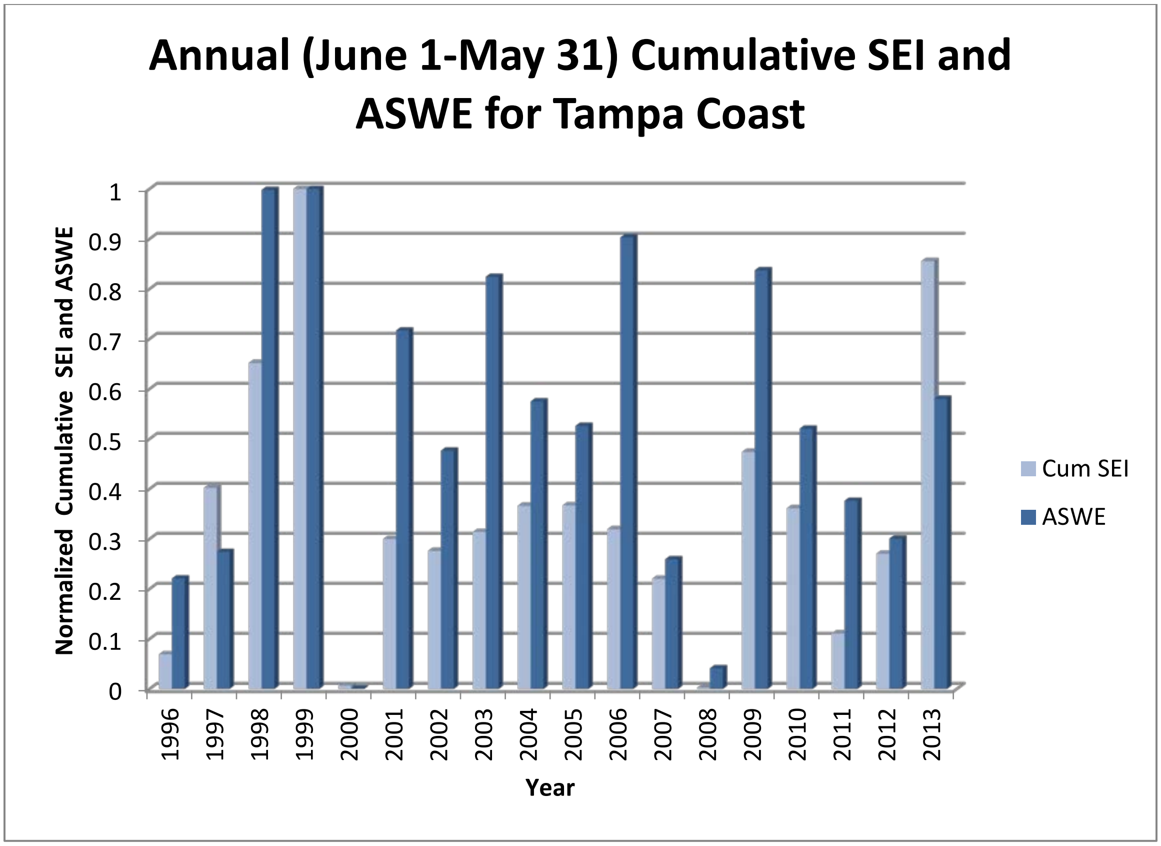


Figure 3: Comparison of annual cumulative SEI for the Tampa coast.

CONCLUSIONS

The Storm Erosion Index which has been used to successfully evaluate storm severity in NJ, Washington State and even internationally was applied to data from the Gulf Coast of Florida. The application comes in response to the back to back storms of 2012, which resulted in a large amount of beach erosion, more than would typically be associated with such "small" storms. In both cases, the duration of the storm conditions played a significant role in the amount of beach erosion experienced. The analysis suggests that Debby was the more damaging of the two storms, registering as a Cat 5 storm based on the SEI, with a return period of 23.4 years. Isaac was clearly the lesser of the two storms, however its cumulative impact coming on the heels of Debby made it much worse than it would have been had it occurred in isolation. As discussed above, the steepness threshold plays a significant role in exactly how Isaac is classified. If the traditional 0.025 is used, Isaac only registers as a Category 2 storm, with a return period of 3 years. A slight adjustment however (which might be justified) bumps Isaac up to a Category 4 storm with a return period of closer to 10 years. Based on the impacts, this seems more realistic. A more thorough study would need to be performed to more precisely establish the local erosion/accretion threshold. Cumulatively, the 2012-2013 season already stands as the 2nd most severe on record with 7 months to go. Only 1998-1999 was worse.

REFERENCES

Dean, R. & Dalrymple, R., 2002. *Coastal Processes with Engineering Applications.* New York, NY: Cambridge University Press.

Dolan, R. & Davis, R. E., 1992. An Intensity Scale for Atlantic Coast Northeast Storms. *Journal of Coastal Research,* Volume 8, pp. 352-264.

Herrington, T. & Miller, J. K., 2010. A Comparison of Methods Used to Calculate Northeaster Damage Potential. *Shore and Beach,* 78(2), pp. 20-25.

Johnson, J. W., 1949. Scale Effects in Hydraulic Models Involving Wave Motions. *Transactions of the* American Geophysical Union*,* 30(4), pp. 517-525.

Kriebel, D., Dalrymple, R., Pratt, A. & Sakovich, V., 1996. Shoreline Risk Index for Northeasters. *Proceedings of the International Conference and Exposition on Natural Disaster Reduction,* ASCE*,* pp. 251-252.

Miller, J. K. & Dean, R. G., 2004. A Simple New Shoreline Change Model. *Coastal Engineering,* 51(7), pp. 531-556.

Miller, J. K. & Livermont, E., 2008. A Predictive Index for Wave and Storm Surge Induced Inundation. *Proceedings of the 31st International Conference on Coastal Engineering,* World Scientific Press*,* pp. 561-572.

Phillips, A. M., 2012. Tropical Storm Debby delivered massive losses to Pinellas beaches, USF study says. *Tampa Bay Times*.

Rich, J., 2016. Pinellas beaches show effects from Hurricane Hermine. *Tampa Bay Times*.

ADDENDUM 1

In September 2016 an update to this report was performed following the passing of Hurricane Hermine. Hermine formed as a tropical storm in the Gulf of Mexico on August 31, 2016. On September 2, 2016 it made landfall as a Category 1 Hurricane just east of St. Marks, Florida. Reports of massive erosion, particularly in Pinellas County, located due west of Tampa have been accounted. The University of South Florida's Coastal Research Laboratory performed surveys pre- and post-storm in these areas and have noted 3 to 4 ft elevation drops near the beach accesses (Rich, 2016). At date, no further information has been published relating to these surveys.

The same methodology presented in the body of this report was applied to determine the SEI values, categories, and return periods for Hurricane Hermine. The results suggest that Hermine was a Category 4 storm based on SEI and has a return level of 11.2 years. Based on this parameter it is the second highest storm in the twenty-year record (1996-2016), only falling behind Hurricane Debby (June 2012) which was classified at a Category 5 storm with a return period of 23.5 years. A potential explanation for this is the difference in the durations of the two storms. Although breaking wave heights for Hermine were generally larger than for Debby, the duration of Debby was over twice that of Hermine, resulting in a higher SEI.

Table 2: SEI values, Categories, and return periods for West Coast Florida storms

Date	Storm	PEI	PEI Cat	T_r	SEI	SEI Cat	T_r
24-Jun-2012	Debby	71.3	4	5.3	1711	5	23.5
01-Sep-2016	Hermine	91.6	5	15.0	1170	4	11.2
26-Sep-1998	Georges	78.9	4	7.9	1139	4	10.6
02-Sep-1998	Earl	80.0	4	8.4	1078	4	9.6
07-Oct-1996	Josephine	113.0	5	43.9	883	3	6.6
28-Aug-2012	Isaac	49.8	3	1.7	547	2	2.9

Appendix I. Damage Description

This appendix includes pictures and reports from the non-Federal sponsor showing the pre-storm and post-storm beach profiles, including two separate reports titled;

Pinellas County Beaches Immediately after the Impact of Hurricane Hermine, A Report Summarizing a Post-Strom Field Investigation on September 3, 2016, by Ping Wang, Jun Cheng and Zachary Westfall, Coastal Research Laboratory, University of South Florida.

Volume and Shoreline Changes along Pinellas County Beaches during the Passage of Hurricane Hermine, by Ping Wang, Jun Cheng, and Zachery Westfall Coastal Research Laboratory, University of South Florida, September 19, 2016.

Pinellas County Beaches Immediately after the Impact of Hurricane Hermine

A Report Summarizing a Post-Strom Field Investigation on September 3, 2016

by

Ping Wang, Jun Cheng and Zachary Westfall

Introduction

After being a tropical depression and a tropical storm during most of its duration, Hermine strengthened to become a Category 1 hurricane about 18 hours before landfall (Figure 1). Hermine made landfall just east of St. Marks Florida at peak intensity with a minimum pressure of 982 mbar and maximus sustained wind at 80 mph. Hermine became the first hurricane to make landfall in Florida since Wilma on October 24, 2005.

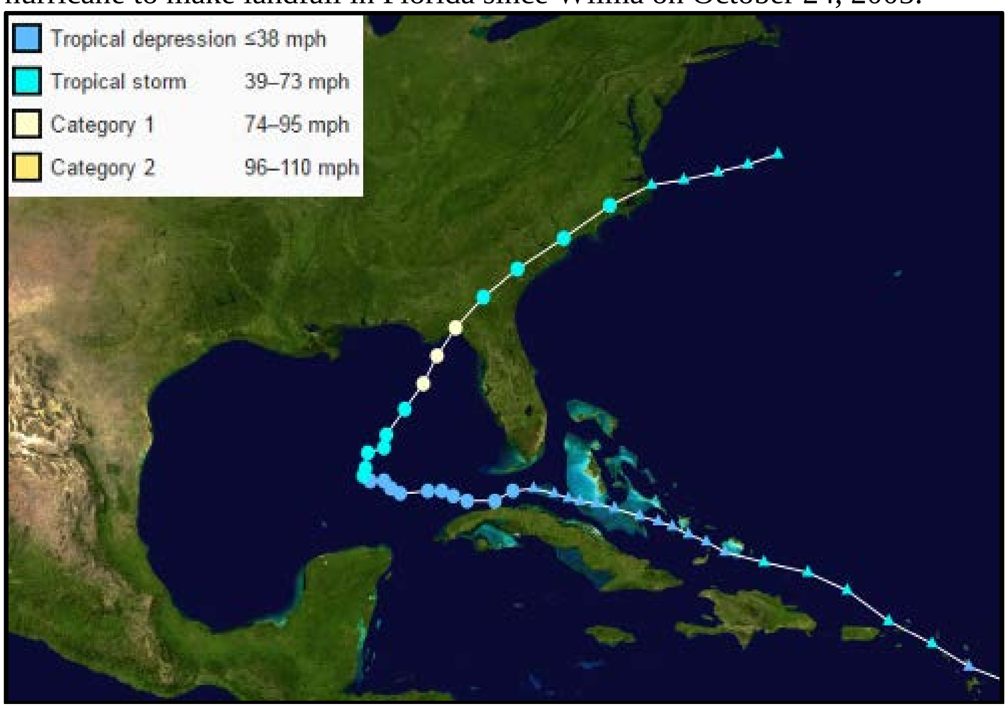


Figure 1. Track of Hurricane Hermine. The markers represent the locations of the storm very six hours.

For Pinellas County coast, Hurricane Hermine imposed the first significant storm impact since Tropical Storm Debby in late June 2012. This report provides an initial qualitative assessment of Hurricane Hermine impact along Pinellas County beaches based on field observations one day after the passage of the storm. Post-storm beach survey is being conducted by USF Coastal Research Laboratory. The post-storm data will be compared with the pre-storm data collected two weeks before the storm impact. Quantitative changes of beach volume and shoreline and dune-line positions will be presented in a following report after the completion of the post-storm beach survey.

This report is organized as follows:

1) a brief comparison of oceanographic conditions along Pinellas County coast associated with Hurricane Hermine and Tropical Storm Debbie as measured by nearby NOAA tide and wave gauges,
2) beach changes, described from north to south, along Sand Key, Treasure Island, Long Key, Shell Key, and Mullet Key (Ft. Desoto Park) are illustrated with post-storm photos, and
3) the beach changes are qualitatively compared with those associated with Tropical Storm Debby and with observations by the authors before the storm.

Storm Wave and Surge along Pinellas County Coast Associated with the Passage of Hurricane Hermine

Although Hurricane Hermine did not make landfall within Pinellas County, it passed the coast rather closely and generated very energetic conditions. Two nearby NOAA measurement stations, wave buoy 42099 (about 90 miles west of the mouth of Tampa Bay) and Clearwater Beach tide station, provided measured wave and water level (storm surge) conditions associated with the storm (Figure 2). Conditions measured during the passage of Tropical Storm Debby in 2012 are compared with that measured during Hurricane Hermine.

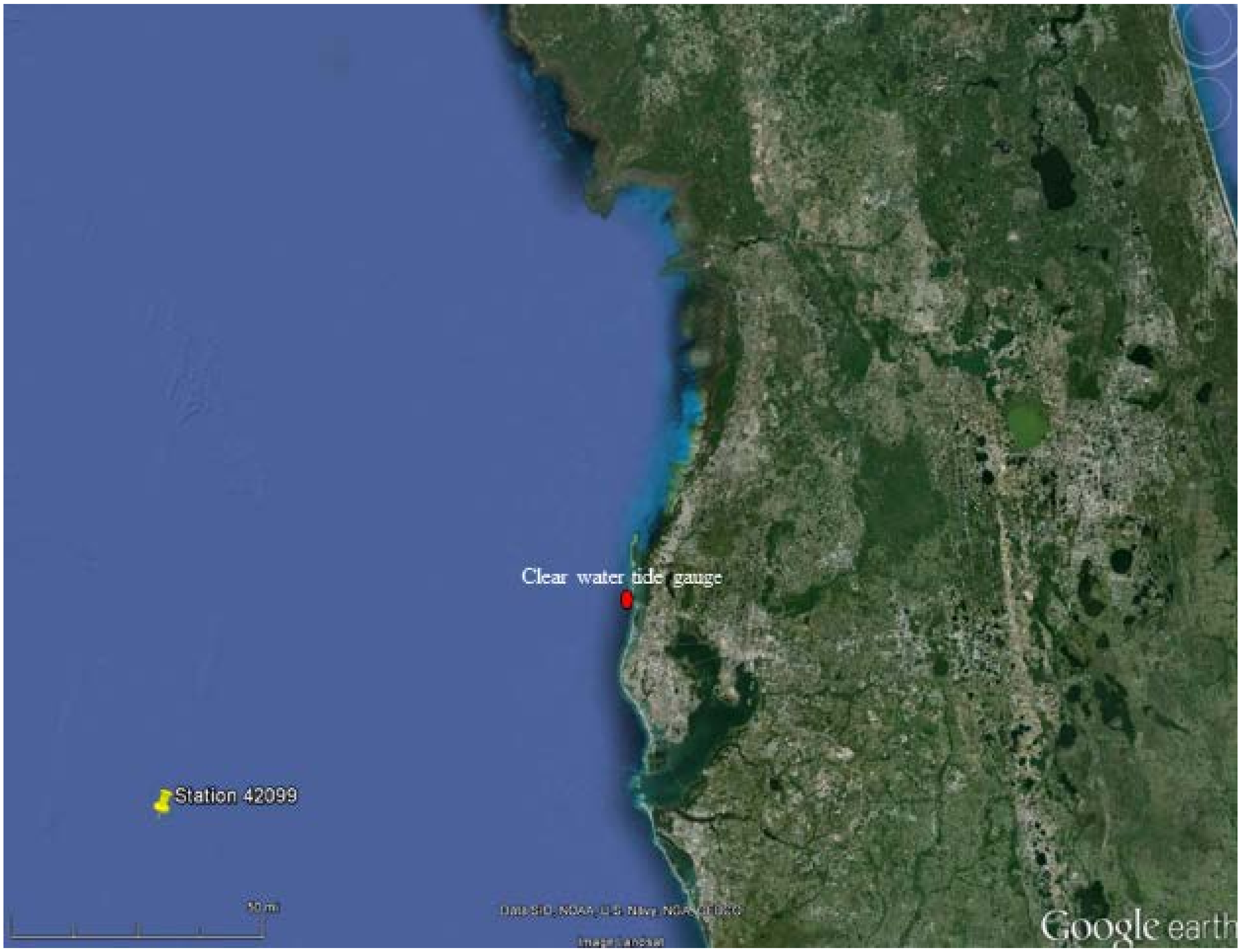


Figure 2. NOAA wave and tide measurement stations near Pinellas County coast.

Figure 3 illustrates the measured water level during the passages of Hurricane Hermine (upper panel) and Tropical Storm Debby (lower panel). The water level reached over 1.2 m (4 ft) above mean sea level during two consecutive high tides during the passage of Hurricane Hermine. This is about 0.15 m (or 0.5 ft) higher than the maximum storm surge level of Tropical Storm Debby. However, the high water conditions of up to 1 m (3.3 ft) above mean sea level lasted over four tidal cycles during Tropical Storm Debby, as opposed to two tidal cycles during Hurricane Hermine. In other words, the storm surge reached higher level during Hurricane Hermine but did not last as long as the surge during Tropical Storm Debby.

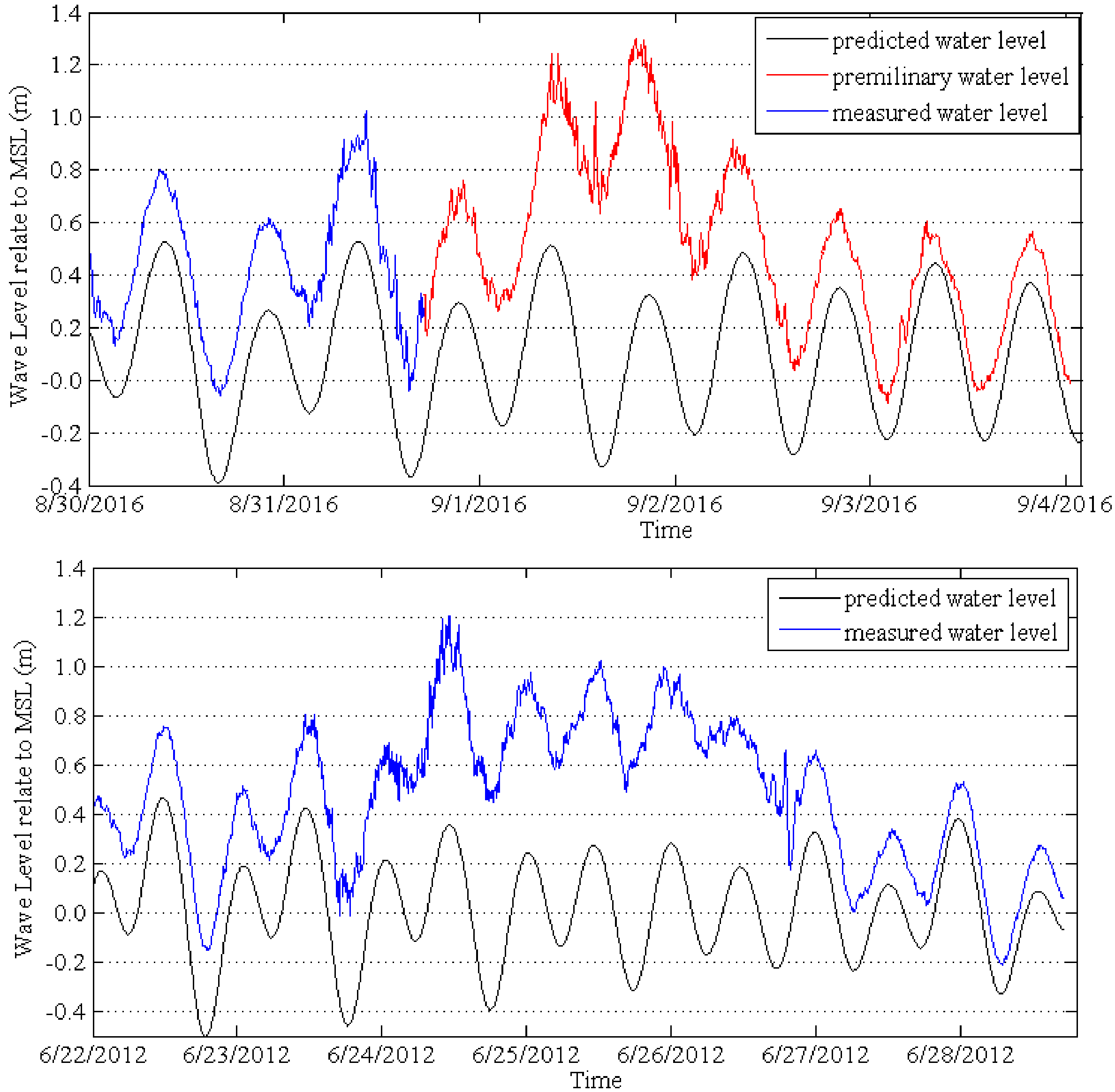


Figure 3. Measured water level at NOAA Clearwater Beach station. Upper: during Hurricane Hermine. Lower: during Tropical Storm Debby.

Figure 4 illustrates the measured offshore wave conditions during the two storms. It is worth noting that this wave gauge is about 90 miles from the shoreline. Nearshore waves should be lower than those measured at this location. The peak significant wave height during the passage of Hurricane Hermine reached 7.3 m (24 ft), which is about 30% higher than the highest wave of 5.6 m (18 ft) during Tropical Storm Debby. However, similar to the situation of storm surge, the high wave conditions of over 3 m (10 ft) lasted much longer during Tropical Storm Debby, 60 hours for Debby versus 35 hours for Hermine. Therefore, Hurricane Hermine is a more energetic storm than Tropical Storm Debby, but Debby was a longer lasting storm (Figure 4).

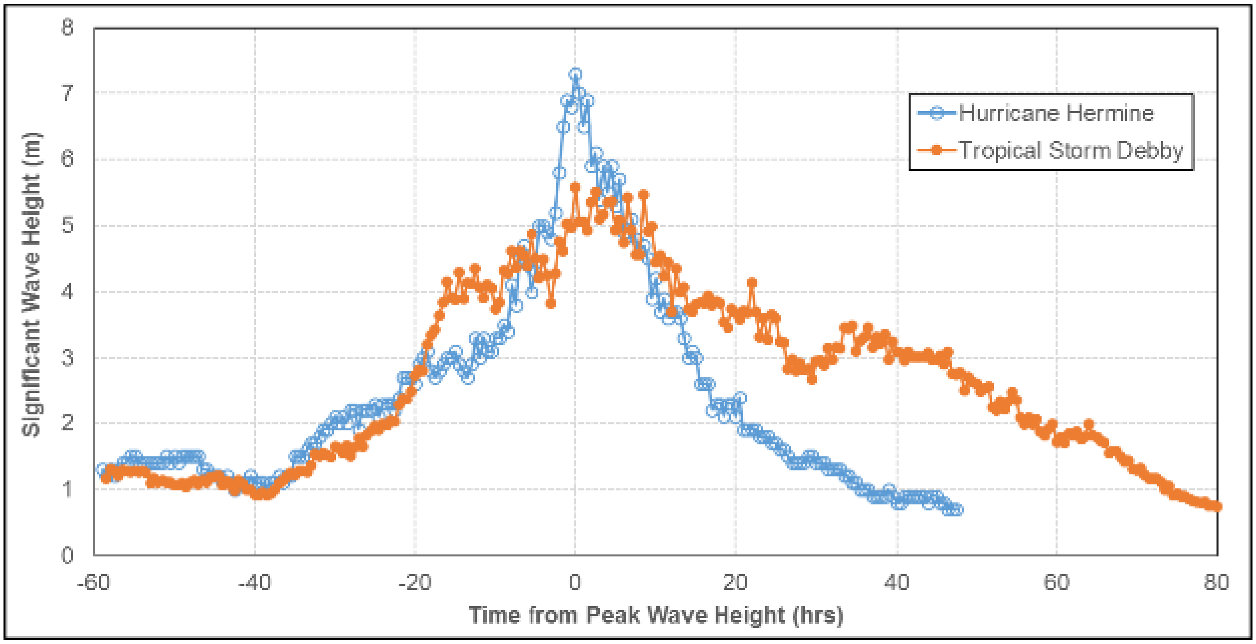


Figure 4. Measured significant wave height at NOAA wave buoy 42099 about 90 miles west of the mouth of Tampa Bay. Negative hours represent time before wave peak. Positive hours represent time after wave peak.

The energetic waves generated by both Hurricane Hermine and Tropical Storm Debby both came from the southerly direction, as shown in Figure 5. However, near the peak wave conditions, the waves from Hurricane Hermine approached from a more southwest direction than those during Tropical Storm Debby. The southwest wave approach during Hermine would have a more energetic onshore component that the southerly approaching Debby waves.
In summary, Hurricane Hermine generated higher storm surge and higher storm waves than those during Tropical Storm Debby. However, energetic conditions during Debby lasted longer than that during Hermine, approximately 60 hours versus 35 hours.

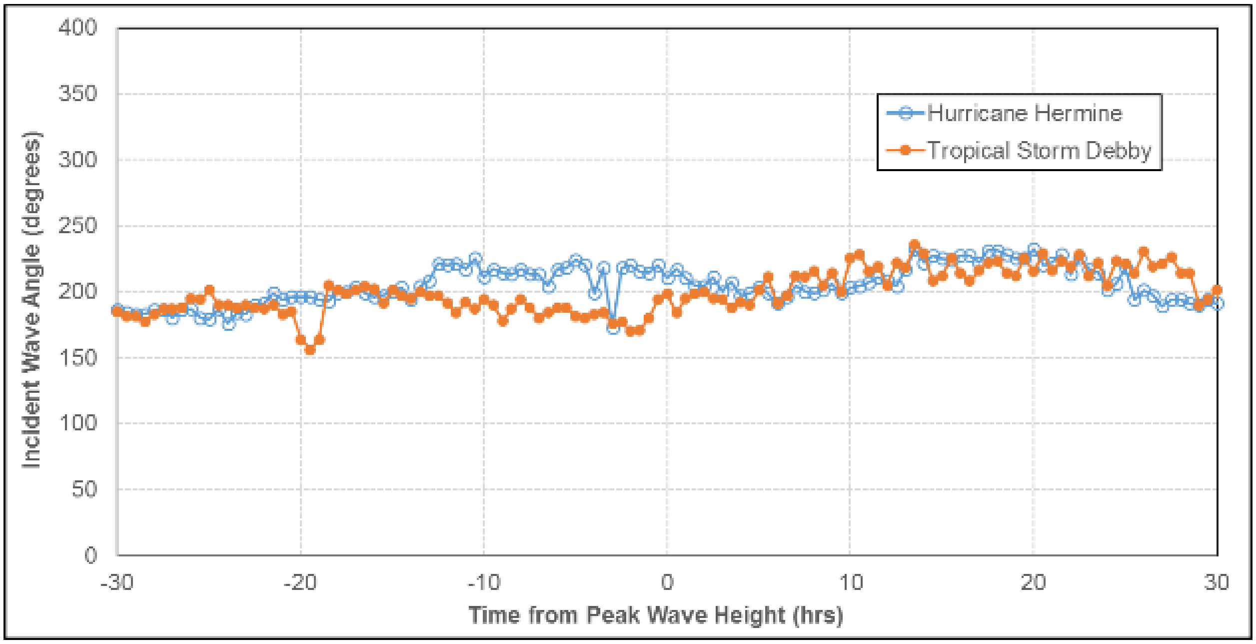


Figure 5. Measured incident wave angle at NOAA wave buoy 42099 about 90 miles west of the mouth of Tampa Bay. Negative hours represent time before wave peak. Positive hours represent time after wave peak.

Beach and Dune Changes Induced by Hurricane Hermine

In the following, beach changes are described from north to south, from Sand Key to Mullet Key. The authors have just finished the beach survey two weeks before Hermine impact. In addition, they have made similar storm observations during Tropical Storm Debby. Therefore, comparisons with pre-storm beach conditions and with impacts from Tropical Storm Debby are also provided.

Sand Key

North End of Sand Key

The north end of Sand Key, directly south of the Clearwater Pass south jetty, is characteristic of a wide beach, partly due to the sand impoundment at the jetty (Figure 6, yellow circle). Due to the very wide beach, the sand dune did not suffer any storm damage. The storm impact to this section of the beach is the flooding and ponding of the low-lying portion of the back beach (Figure 7). Similar flooding also occurred during Tropical Storm Debby.

The pre-storm active berm crest has experienced some erosion. At least part of the eroded sand was transported landward, forming a higher storm berm. Some of the vegetation on the back beach was covered by the “back-beach overwash” (Figure 8).

Figure 6. North end of Sand Key (yellow circle).


Figure 7. Flooding of the low-lying portion of the back beach at the northern end of Sand Key.

Figure 8. Development of the storm berm (or back-beach overwash) burying the vegetation there. The vegetation (top left) just landward of the per-storm active berm experienced erosion.

Belleair Beach

Belleair Beach (Figure 9) is an erosional hot spot on Sand Key. This section of the beach was rather narrow before the storm with an erosional scarp at the edge of the dune. The storm has pushed the dune scarp further landward. At the northern end of this section between R60 and R61, the dune is almost completely eroded, exposing the seawall at the landward limit of the back beach (Figure 10). Some sand was washed over the seawall covering some of the grass type vegetation landward. Along most section of this beach, it seems that the pre-storm dune scarp was pushed landward of an estimated 3-10 m (10-30 ft). Sand deposition occurred at the dune scarp, resulting in a much shorter scarp, as compared to the pre-storm scarp. As a matter of fact, overwash over the low dune system is observed in many places (Figure 11). Many dune and vegetation signs were scoured and fell down (Figure 12).

Overall, this section of the beach has a fairly continuous dune scarp of 1-4 ft tall, with sand deposition directly seaward of the scarp. At places when the dunes are relatively low, overwash into the dune field occurred. The impact by Hurricane Hermine here is more severe than that from Tropical Storm Debby which did not induce dune overwash.

Figure 9. Belleair Beach section (yellow circle).

Figure 10. The narrow pre-storm dune was completely eroded, exposing the seawall at the landward limit of the back beach.

Figure 11. Pre-storm dune scarp was pushed further landward. Sand deposit occurred at the dune scarp.

Figure 12. The low dune was overtopped by the storm water, resulting in overwash deposit in the dune field and many fell-down signs.

Belleair Shores

Belleair Shores section of the beach (Figure 13) did not receive sand from the recent several beach nourishments. The pre-storm beach was quite narrow with a narrow strip of dune along the seawall. Along nearly the entire stretch, the narrow pre-storm beach and dune were completely eroded, exposing the seawall directly at (or slightly above) the high tide line. Sand was washed over the seawall at many locations (Figure 14).
At some locations, considerable erosion occurred at the seawall, exposing the riprap along the toe of the seawall. Some structural damage was observed, including damage to the wood stairs and fences (Figure 15). At a neighborhood park without seawall, the pre-storm beach and dune were eroded back substantially (Figure 16).
Overall, along this section, the narrow beach and dune were completed eroded, exposing the seawall to direct wave attack. Considerable amount of sand was washed over the seawall. Scour at the seawall occurred at various places. The impact by Hurricane Hermine along this stretch is considerably more severe than that from Tropical Storm Debby which did not induce overwash over the seawall and did not cause severe scour along the wall.

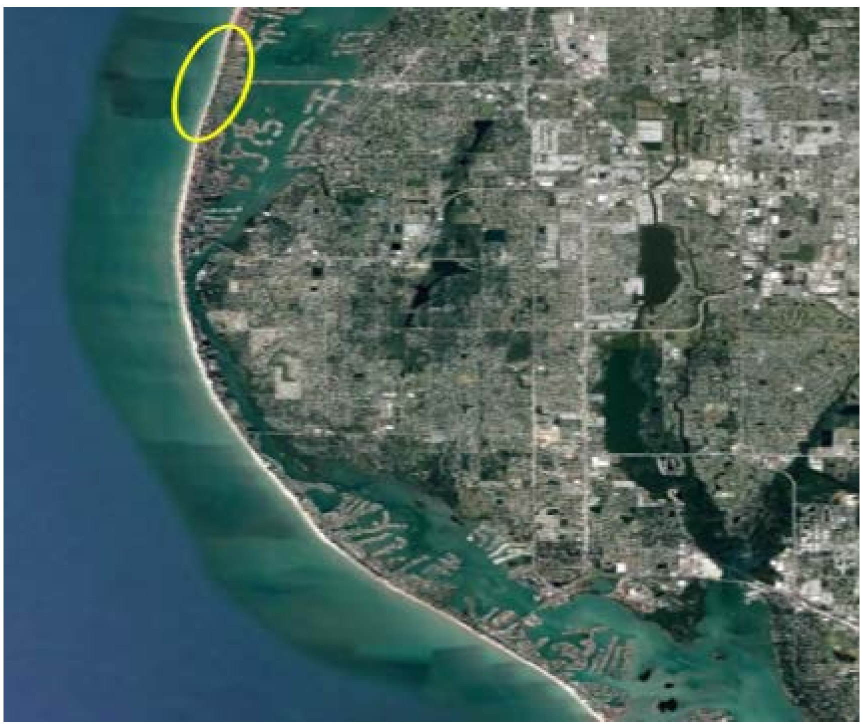


Figure 13. Belleair Shores (yellow circle). This section did not receive beach nourishment in recent years.

Figure 14. Sand was washed over the seawall. The narrow pre-storm beach and dune were almost completely eroded.

Figure 15. Scour at the seawall, damaging the wood stairs and exposing the riprap.


Figure 16. Erosion at a section (a neighborhood park) without seawall.

Indian Rocks Beach

Indian Rocks Beach (Figure 17) experienced significant beach and dune erosion. The entire flat portion of the back beach was eroded. A continuous 2-5 ft tall dune scarp extends along the entire stretch (Figure 18). Similar to the Belleair Beach to the north, some deposition occurred directly in front of the scarp. At most places, the dunes are relatively high, little to no sand was washed over the dunes. Overwash did occur at places with no sand dune.

Nearly all the dune walkovers have experienced scour underneath. For several walkovers with the stairs leading the beach, the stairs portion of the dune walkover was washed away (Figure 19). Compared to the damage by Tropical Storm Debby, Hurricane Hermine has caused considerably more damage to the dune walkovers. Dune erosion also seems to be more severe. This will be confirmed quantitatively by post-storm beach survey.

Figure 17. Indian Rocks Beach section (yellow circle).

Figure 18. Extensive dune scarping along Indian Rocks Beach.

Figure 19. Most of the dune walkovers suffered damage. Upper: dune walkover at Indian Rocks Beach Park, the stairs leading to the beach was washed away. Lower: significant scour underneath and dune erosion of about 10 m (30 ft) at around R72.

Indian Shores and Redington Shores

Beach and dune erosion continued along this section of the beach (Figure 20). At the northern end of this section, scour underneath the dune walkovers and buildings occurred (Figure 21). For most of this stretch, the pre-storm beach was considerably wider than that along the stretches to the north. Dune erosion was not as severe since it was protected by a wider beach (Figure 22). Dune scarping occurred at various locations but is not as continuous and as tall as along the beaches to the north. In the vicinity of the breakwater, the wide back beach seems to have received some sand deposition in the form of "back beach overwash" or development of storm berm.

Along the few stretches of the beach that are not protected by dunes, sand was washed over the seawall (Figure 23). On the beach near the Redington Fishing Pier, pieces of wood were found (Figure 24). They appear to have been broken off from the pier.

Overall, this stretch of the beach benefited significantly from the wide pre-storm beach. Dune scarping is not as severe as compared to the beach to the north. Some sand was still washed over the seawall along sections without a dune.

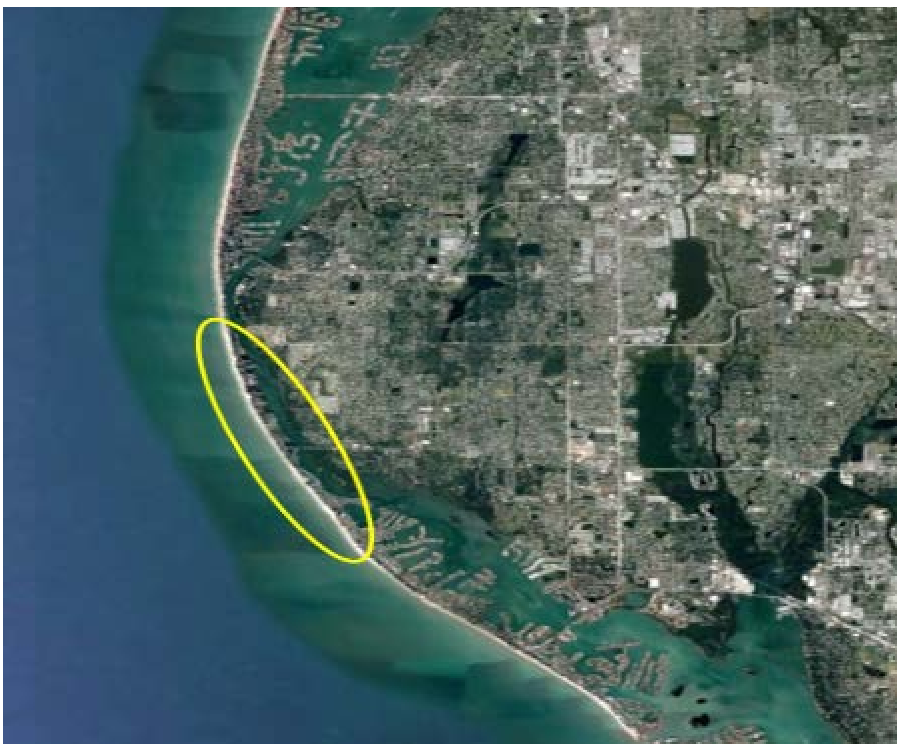


Figure 20. Indian Shores and Redington Shores section (yellow circle).

Figure 21. Severe beach and dune erosion at R84.

Figure 22. Discontinuous dune scarping along Indian Shores.

Figure 23. Sand deposition on the wide back beach at the breakwater.

Figure 24. Sand washed over seawall along stretches without dunes.

Figure 25. Wood debris near the Redington Fishing Pier, likely broken off from the pier.

North Redington Beach, Redington Beach, and Merderia Beach

This section of the beach is located along the southern end of Sand Key (Figure 26). Except at the northern end, most of this stretch of the beach have not been nourished. Furthermore, a section of the beach, from R106-R114 for about 1.5 miles, was quite narrow with little to no dunes before the storm impact. Significant overwash over the seawall occurred along this 1.5-mile stretch of the beach (Figure 27). The washover sand layer can be up to 0.3 m (1 ft) think. Severe scour along a stretch of seawall (between R108 and R109) occurred (Figure 28). The storm surge plus wave runup had overtopped the seawall, resulted in sand deposit landward. Considerable damage to various infrastructures, including fences, pavers, and beach access stairs or walkways, occurred (Figures 29 and 30).

Sand was washed into the parking lot of Madeira Beach Park through the beach access entrance (Figure 31). The relatively wide beach directly north of John’s Pass did not suffer dune erosion and overwash. However, a large amount of debris, both natural and artificial, were washed onto the beach there (Figure 32).

Overall, except a short stretch of the wide beach directly north of John’s Pass, this section of the beach experienced the most severe impact along Sand Key from the storm with nearly complete erosion of the rather narrow pre-storm beach and dune system and substantial sand overwash landward of the seawall into parking lots and beach resort decks. Some infrastructural damage occurred. The impact to this section of the beach by

Hurricane Hermine is considerably worse than that associated with Tropical Storm Debby which did not cause any significant overwash.

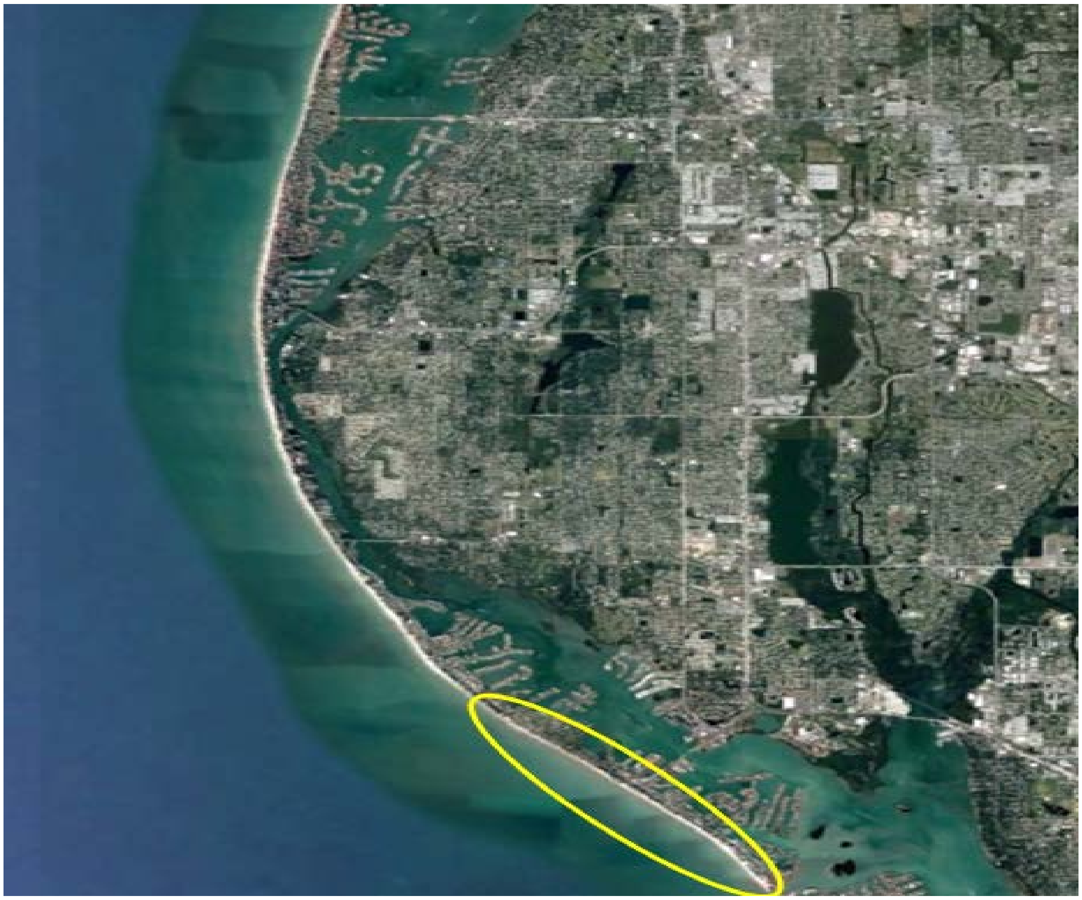


Figure 26. North Redington Beach, Redington Beach, and Merderia Beach sections along the southern end of Sand Key (yellow circle).

Figure 27. Sand washed onto the decks of beach front properties.

Figure 28. Severe scour along a stretch of seawall. The storm had overtopped the wall and deposited sand landward.

Figure 29. Some structural (fence and beach access stairs) damage with sand washed over the seawall.

Figure 30. Pavers collapsed due to scour underneath.


Figure 31. Sand washed into the parking lot of the Madeira Beach Park through the beach access.

Figure 32. Debris, both natural (shells) and artificial (tires), washed onto the beach near John's Pass inlet.

Overall, Hurricane Hermine induced substantial changes on Sand Key, resulting in extensive dune scarping and back-beach erosion. In addition, rather extensive overwash landward of the seawalls occurred along the entire barrier island. At locations with relative wide but low dunes, overwash into the dune field also occurred. At locations where seawalls were not protected by a relatively wide dune, sand was washed over the seawall into parking lots or decks of beach front resorts. Modest infrastructure damage occurred, including damages to many dune walkovers, beach access stairs, fences, and pavers. The damage caused by Hurricane Hermine is considerably more severe than that from Tropical Storm Debby which did not induce any significant overwash. This can be explained by the higher storm surges and waves from Hermine (Figures 3 and 4).

Treasure Island

Sunshine Beach at the Northern Section

The Sunshine Beach at the northern end of Treasure Island (Figure 33) had a relatively wide pre-storm beach. No dune erosion or scarping occurred along this stretch of the beach. As a matter of fact, considerable sand accumulation occurred directly along the seaward edge of the dune (Figure 34). The post-storm beach is still relatively wide (Figure 35). The back-beach elevation seems to have increased due to the “back beach overwash”. The sedimentation on this beach is likely relatively to the southerly approaching storm forcing (Figure 5).

Figure 33. Sunshine Beach at the northern end of Treasure Island (yellow circle).

Figure 34. Sand accumulation at the toe of dune at Sunshine Beach (upper panel). Considerable sand accumulation also occurred at the dune walkover (lower panel).

Figure 35. The post-storm beach is still relatively wide with sand deposition along the edge of vegetation.

Middle Section of Treasure Island

The middle section of Treasure Island is characteristic of a wide beach (Figure 36). Little to no dune erosion or scarping occurred. The storm impact to this section of the beach is mostly in the form of flooding of the low-lying portion of the back beach and accumulation of a storm berm, or “back beach overwash” (Figure 37).

Along a section of the beach, a large amount of debris, both artificial and natural, were washed onshore (Figure 38). It is not clear where these debris came from. The debris are quite localized, distributed along a roughly 1000 ft stretch of the beach. Both the nearshore water quality and beach quality improved significantly and rapidly away from the debris pile.

Figure 36. Middle section of Treasure Island with wide beach.

Figure 37. Flooding of the low-lying portion of the back beach and the back beach overwash.

Figure 38. A large amount of debris, both artificial (tires and traps) and natural (shells), washed onto the beach in the middle of Treasure Island.

Sunset Beach

Sunset Beach along the southern portion of Treasure Island (Figure 39) is a persistent erosional hot spot. The pre-storm beach was relatively narrow. Extensive and continuous dune scarping of 2 to 4 ft high occurred along this stretch of the beach (Figure 40). Beach access stairs and fences were damaged at several locations (Figure 41). At locations where dunes are absent or been eroded, sand was washed over the seawall and deposited in the parking lot (Figure 42). The impact of Hurricane Hermine is slightly more severe than that during Tropical Storm Debby. Debby caused severe beach erosion and dune scarping but did not overtop the seawall and therefore did not induce overwash. Infrastructure damage also seems to be slightly more severe for Hurricane Hermine.

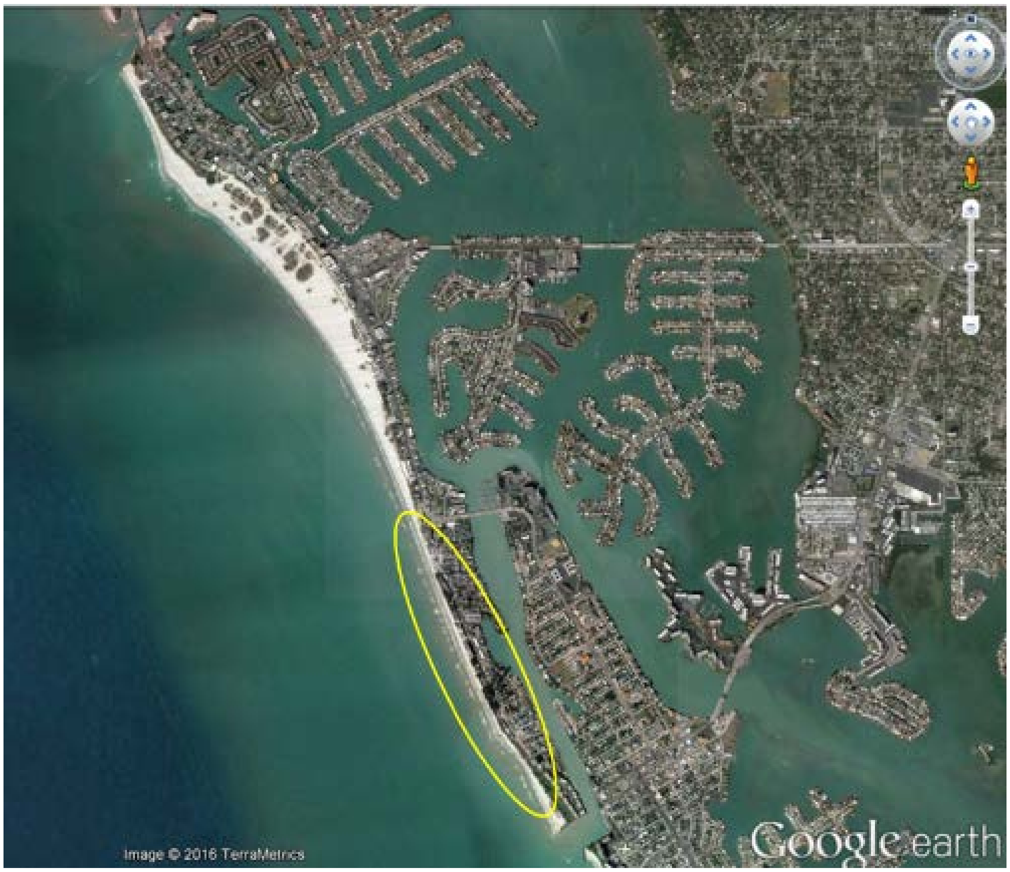


Figure 39. Sunset Beach along the southern portion of Treasure Island (yellow circle).

Figure 40. Continuous dune scarping along Sunset Beach.

Figure 41. Fence and beach access damage along Sunset Beach.


Figure 42. The seawall was overtopped and sand was washed into the parking lot.

Overall, the impact of Hurricane Hermine at Treasure Island focused mostly along Sunset Beach in the southern portion of the barrier island. Extensive beach and dune erosion occurred with some structural damage to the beach access stairs and fences. Along the sections where dune were completely eroded, some sand was washed over the seawall. The wider beach to the north seemed to have absorbed the storm impact reasonably well. Although considerable beach erosion seems to have occurred, the post-storm beach is still quite wide.

Long Key

Upham Beach at the Northern Section

The Upham Beach at the northern end of Long Key (Figure 43) had a relatively wide pre-storm beach except at the very north end. Although severe beach erosion had occurred, little to no dune erosion or scarping occurred along this stretch of the beach (Figure 44). The seawall at the very north end was exposed before the storm impact. Additional scour at the base of the seawall seems to have occurred. A large amount of sand was washed over the seawall and deposited over the grass (Figure 45). T-groin #4 becomes exposed due to severe beach erosion (Figure 46). However, T-groin #5 which was exposed before the storm had become completely buried due to the considerable deposition over the back beach (Figure 47). Overwash sand accumulation on the back beach was observed along the wide portion of Upham Beach. Similar to the case along the wide portions of Sand Key and Treasure Island, flooding and ponding at the lower portion of the back beach occurred at various locations (Figure 48). Compared to the impact of Tropical Storm Debby, the more energetic Hermine washed a large amount of sand over the seawall, which did not happen after Debby.

Figure 43. Upham Beach at the northern end of Long Key (yellow circle).

Figure 44. Beach erosion along the northern portion of Upham Beach.

Figure 45. Large amount of sand was washed over the seawall.

Figure 46. Severe beach erosion exposed T-groin #4, which as completely buried before the storm.

Figure 47. The T-groin #5 which was partially exposed before the storm became completely buried by “back beach overwash”, also notice the partial burial of the sea oaks due to the overwash.

Figure 48. Flooding and ponding at the lower portion of wide back beach.

Middle and Southern Portion of Long Key

The middle portion of Long Key has quite wide beach before the storm. The southern portion of Long Key, the Pass-A-Grille beach, was nourished in 2014 and the beach has remained relatively wide since then. These two portions are described here together (Figure 49). Flooding and ponding at the lower portion of the back beach were observed along the wide section of the beach (Figure 50). Considerable sand accumulation occurred on the back beach and extended into the low vegetated dunes (Figure 50). This sand deposition is illustrated by the burial of sea oaks and may beach chairs. In other words, the elevation of the back part of the back beach was increased due to storm overwash. Similar case was also observed here after Tropical Storm Debby. It is likely that the sand came from the erosion of the lower beach and the intertidal beach, as for the case of Debby. However, since the beach is quite wide, it is difficult to estimate the amount of landward shoreline retreat. The post-storm survey will quantify the changes. Due to the wide beach, little to no dune erosion and scarping occurred along this stretch of the beach.

Pass-A-Grill Beach was severely eroded with extensive dune scarping during Tropical Storm Debby partly due to the narrow pre-storm beach. The seawall protecting the beach front shop was severely scoured. However, for Hurricane Hermine, the pre-storm beach was much wider. The wider beach absorbed the storm energy and protected the dunes. Instead of dune scarping, sand deposition occurred at the toe of the dune resulting in higher elevation there. The beach south of the snack bar was not inspected.

Figure 49. Middle and southern portion of Long Key (yellow circle).

Figure 50. Flooding of the lower portion of the wide back beach in the middle Long Key.

Figure 51. Sand deposition at the toe of the dune, resulting in the burial of some vegetation (upper panel) and beach benches (lower panel). No dune scarping occurred.

Overall, except at the very northern end, the pre-storm beach at Long Key was relatively wide. The wide beach provided protection to the dunes, resulting in little to no dune erosion or scarping. Instead, sand deposition along the toe of the dune occurred, burying some vegetation and beach benches. It is likely that the lower portion of the beach and the intertidal zone have experienced severe erosion. This will be confirmed and quantified by the post-storm beach survey. However, reasonable beach width is maintained after the storm along most of Long Key.

Comparing the storm impacts on Sand Key, Treasure Island, and Long Key, the more recent 2014 beach nourishment projects on Treasure Island and Long Key appear to have helped the beaches by maintaining a relatively wide pre-storm beach. The last beach nourishment on Sand Key was in 2012. Sections of relatively narrow beach suffered substantial damage in the form of beach-dune erosion, extensive dune scarping, and considerable sand overwash into the low dune field and landward of the seawall. The extensive dune scarping along Sand Key resulted in substantial scour and damage of many dune walkovers.

North Beach at Mullet Key

The North Beach on Mullet Key (Figure 52) has been experiencing aggressive beach erosion over the past three years. The beach has been migrating landward recently. Substantial landward beach migration occurred due to the impact of Hurricane Hermine. The landward migration of the beach has resulted in the buried (or partial burial) of some of beach facilities, e.g., a shower (Figure 53). Post-storm survey will quantify the landward migration of the beach. The boardwalk to the beach experienced scour underneath and was damaged in the middle (Figure 54).

The northern end of Mullet Key experienced extensive overwash. The overwash lobe extended into the back-barrier bay and partially buried some of the sea oaks (Figure 55). However, no breaching occurred. The vegetation on the “outback island” is visible from Mullet Key (Figure 56). The island is not inspected. Post-storm survey will quantify the position change of the island, if any.

Figure 52. The northern end of Mullet Key.


Figure 53. A section of the beach has migrated landward of the previous mangrove swamp. The beach existed before the storm. However, the storm has pushed the beach further landward and partially buried a shower station (lower panel). Note the foot wash faucet is almost at the sand surface.

Figure 54. The boardwalk to the beach is severely scoured underneath (upper panel) and was damaged (lower panel).

Figure 55. Extensive overwash occurred at the northern end (upper panel) and partially buried some sea oaks.


Figure 56. Vegetation on the “outback island” is still visible.

The Breach on Shell Key

Over the past several months, a breach was developing at Shell Key (Figure 57). Considerable amount of water was flowing into the estuary behind Shell Key during spring high tide (Figure 58 upper panel). It has been hypothesized that the breach may be significantly expanded under energetic storm conditions. This did not happen during the impact of Hurricane Hermine. The breach was not expanded by the storm. Instead, significant overwash deposit landward of the vegetation line (Figure 58 lower panel) has led to the closure of the breach. Based on field estimation, the elevation of the overwash deposit is above the spring high tide level and should block tidal flow through there.

Figure 57. A developing breach at Shell Key.

Figure 58. The developing breach at Shell Key was closed by the overwash deposits from Hurricane Hermine. Upper panel: water flowing through Shell Key breach on May 6, 2016. Lower panel: the overwash deposit effectively closed the breach.

Volume and Shoreline Changes along Pinellas County Beaches during the Passage of Hurricane Hermine

Ping Wang, Jun Cheng, and Zachery Westfall
Coastal Research Laboratory
University of South Florida
September 19, 2016

Introduction

This report discusses the volume and shoreline changes induced by the passage of Hurricane Hermine along three barrier islands in Pinellas County, Sand Key, Treasure Island, and Long Key. A large portion of the beaches along the three barrier islands has been artificially maintained over the past 30 years. Hurricane Hermine impacted the Pinellas County beaches from September 1st to 3rd, 2016 and generated high waves and elevated water level for approximately two days. Beach and nearshore profiles were surveyed two weeks (August 14 through 21) before and approximately four days after (September 7 through 14) the storm to quantify the impact of Hurricane Hermine. This report quantifies the sand volume changes along the three barrier islands. Location changes of two contour levels representing the dune-line and high tide line were also examined.

After being a tropical depression and a tropical storm during most of its duration, Hermine strengthened to become a Category 1 hurricane about 18 hours before landfall (Figure 1). Hermine made landfall just east of St. Marks Florida at peak intensity with a minimum pressure of 982 mbar and maximus sustained wind at 80 mph. Hermine became the first hurricane to make landfall in Florida since Wilma on October 24, 2005. For Pinellas County coast, Hurricane Hermine imposed the first significant storm impact since Tropical Storm Debby in late June 2012.

Although Hurricane Hermine did not make landfall within Pinellas County, it passed the coast rather closely and generated very energetic conditions. Two nearby NOAA measurement stations, wave buoy 42099 (about 90 miles west of the mouth of Tampa Bay) and Clearwater Beach tide station, provided measured wave and water level (storm surge) conditions associated with the passage of the storm (Figure 2). Conditions measured during the passage of Tropical Storm Debby in 2012 are compared with that measured during Hurricane Hermine.

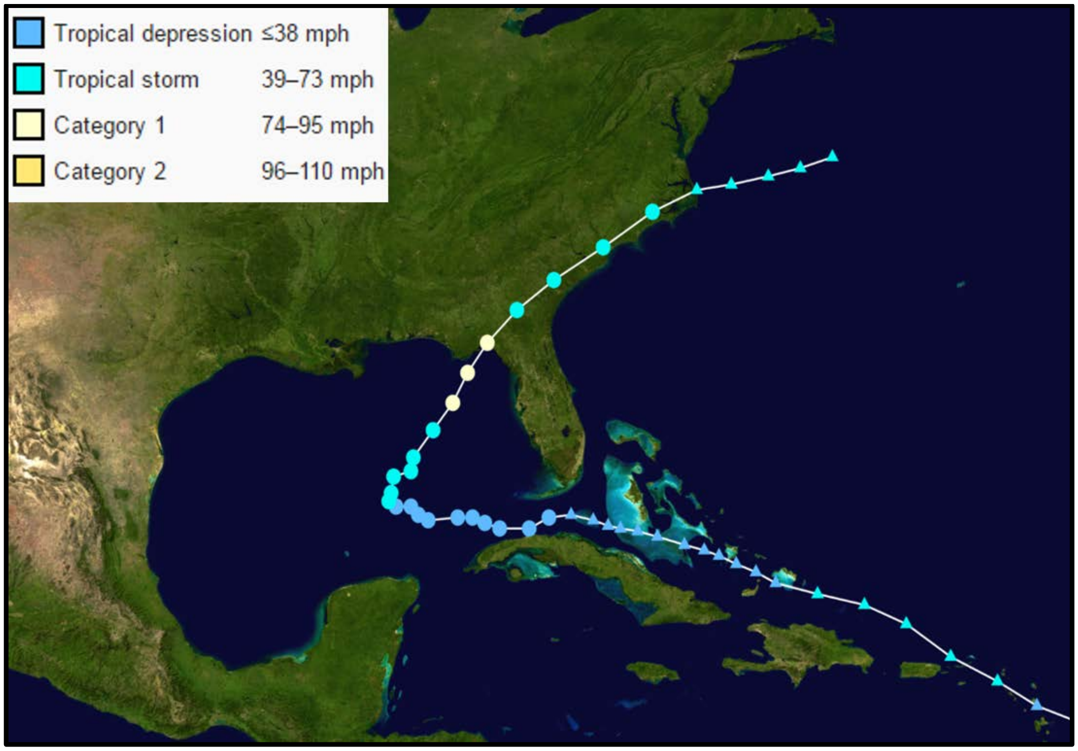


Figure 1. Track of Hurricane Hermine. The markers represent the locations of the storm very six hours.

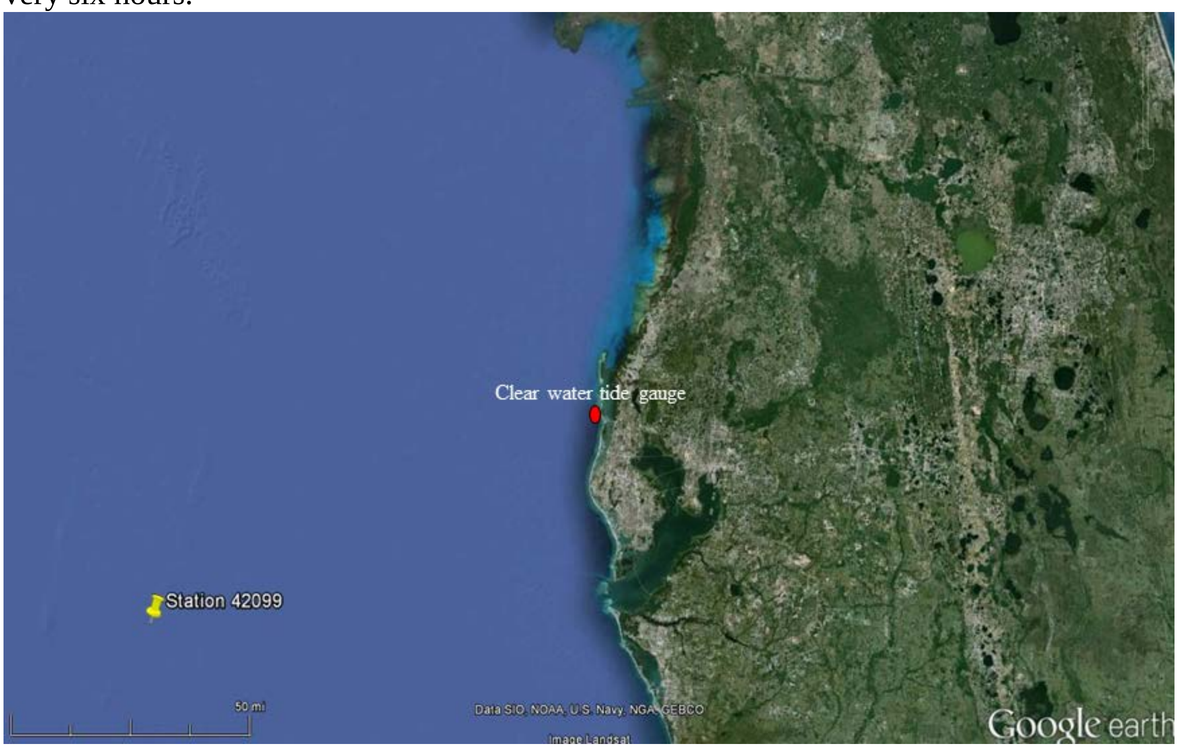


Figure 2. NOAA wave and tide measurement stations near Pinellas County coast.

Figure 3 illustrates the measured water level during the passages of Hurricane Hermine (upper panel) and Tropical Storm Debby (lower panel). The water level reached 1.3 m (4.3

ft) above mean sea level during the passage of Hurricane Hermine. This is about 0.10 m (or 0.33 ft) higher than the maximum storm surge level of Tropical Storm Debby. However, the high water conditions of up to 1 m (3.3 ft) above mean sea level lasted four tidal cycles during Tropical Storm Debby, as opposed to two tidal cycles during Hurricane Hermine. In other words, the storm surge reached higher level during Hurricane Hermine but did not last as long as the surge during Tropical Storm Debby.

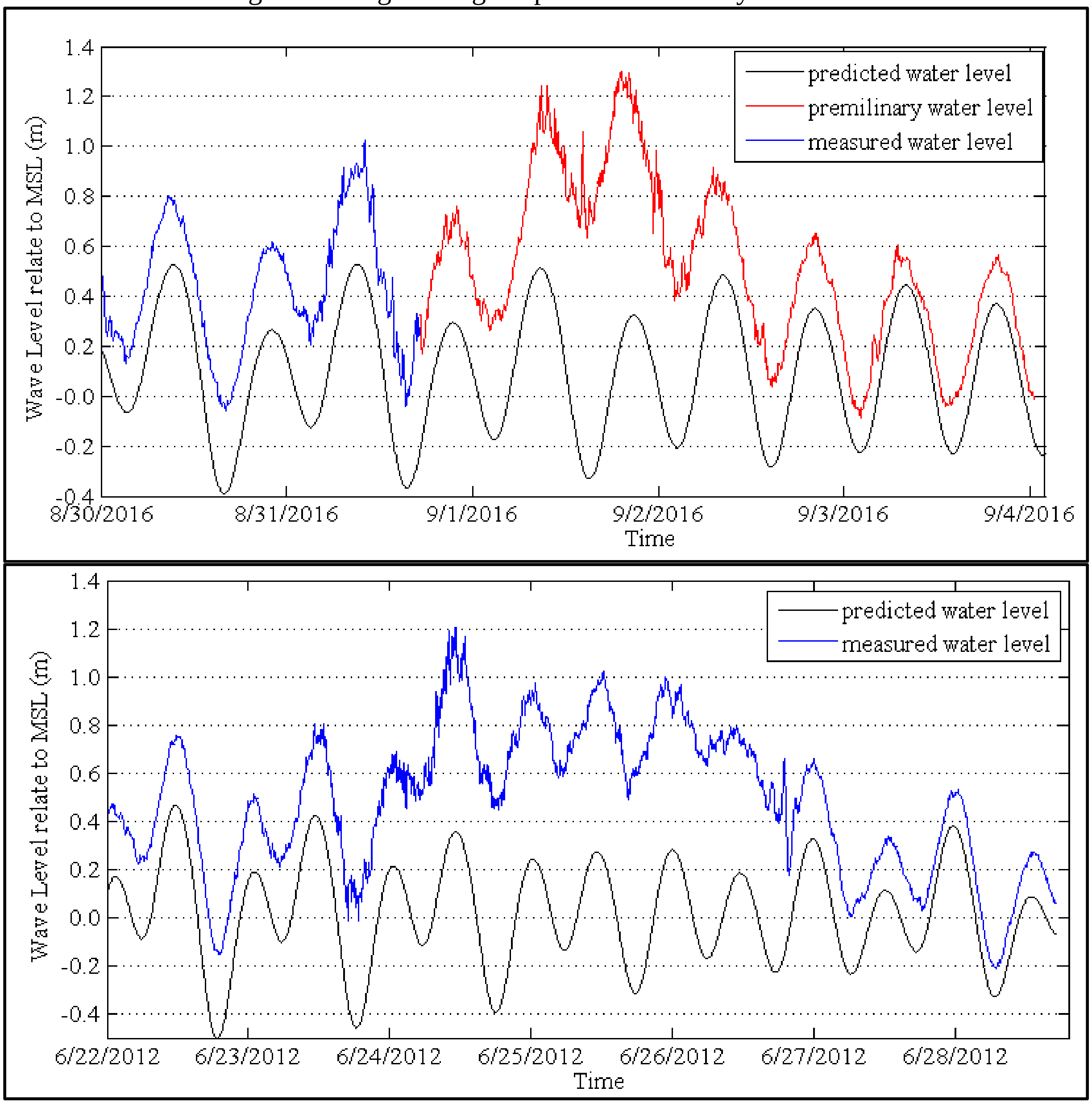


Figure 3. Measured water level at NOAA Clearwater Beach station. Upper: during Hurricane Hermine. Lower: during Tropical Storm Debby.

Figure 4 illustrates the measured offshore wave conditions during the two storms. It is worth noting that this wave gauge is about 90 miles from the shoreline. Nearshore waves should be lower than those measured at this location. The peak significant wave height during the passage of Hurricane Hermine reached 7.3 m (24 ft), which is about 30% higher than the highest wave of 5.6 m (18 ft) during Tropical Storm Debby. However, similar to the situation of storm surge, the high wave conditions of over 3 m (10 ft) lasted much longer during Tropical Storm Debby, 60 hours for Debby versus 35 hours for Hermine. Therefore, Hurricane Hermine is a more energetic storm than Tropical Storm Debby, but Debby was a longer lasting storm (Figure 4). The elevated water level, consists of storm surge plus wave runup, should have reached higher level during Hurricane Hermine than during Tropical Storm Debby. As discussed in the following, this is reflected in the measured beach-dune changes.

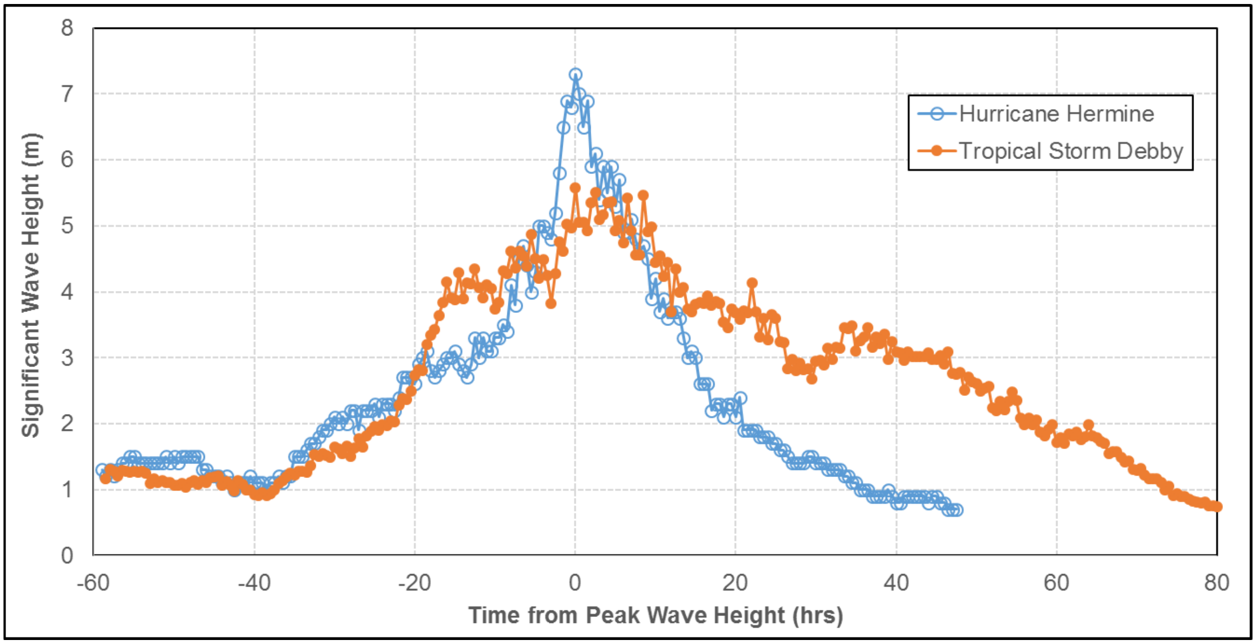


Figure 4. Measured significant wave height at NOAA wave buoy 42099 about 90 miles west of the mouth of Tampa Bay. Negative hours represent time before wave peak. Positive hours represent time after wave peak.

The energetic waves generated by Hurricane Hermine and Tropical Storm Debby both came from the southerly direction (around 200 degrees), as shown in Figure 5. However, near the peak wave conditions, the waves from Hurricane Hermine approached from a more southwest direction (220 degrees) than those during Tropical Storm Debby (180 degrees). The southwest wave approach during Hermine would have a more energetic onshore component than the southerly approaching Debby waves.
In summary, Hurricane Hermine generated higher storm surge and higher storm waves than those during Tropical Storm Debby. However, energetic conditions during Debby lasted longer than that during Hermine, approximately 60 hours versus 35 hours.

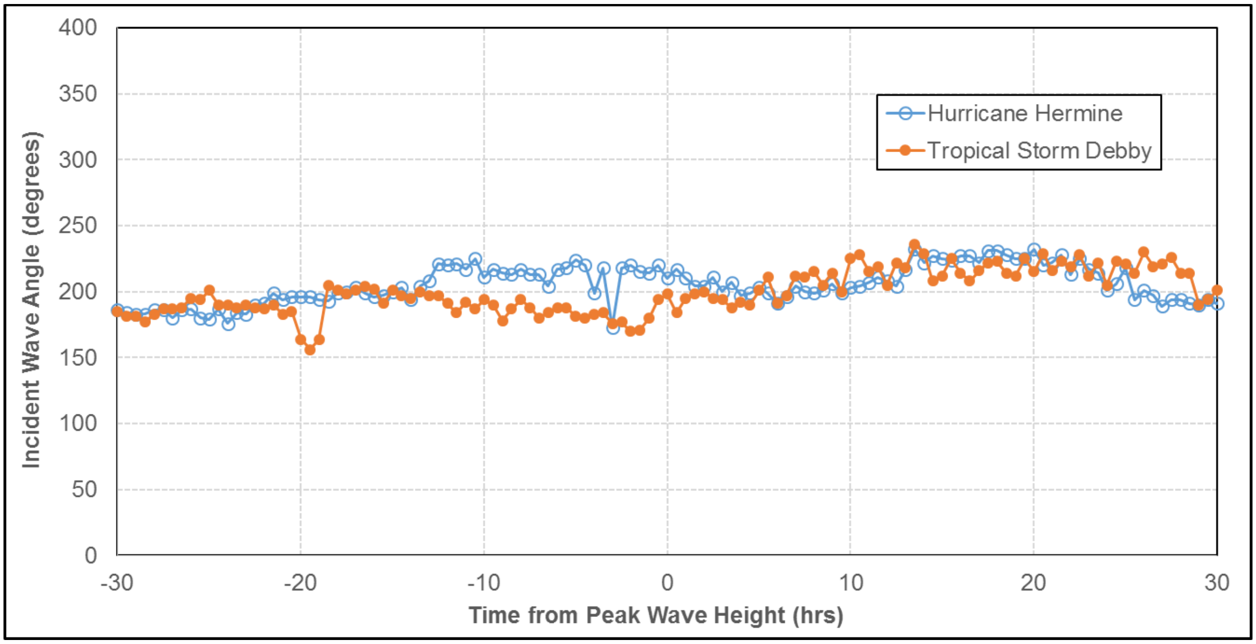


Figure 5. Measured incident wave angle at NOAA wave buoy 42099 about 90 miles west of the mouth of Tampa Bay. Negative hours represent time before wave peak. Positive hours represent time after wave peak.

Methodology

A total of 121 beach profiles were surveyed approximately every 300 m (1000 ft) at R-monuments established by the State of Florida. The survey lines extended to roughly -3 m (10 ft) NAVD88, or to the short-term closure depth in this area. This closure depth seems to have held reasonably during the occurrence of large waves induced by Hurricane Hermine, as indicated by the converging pre- and post-storm beach profiles near the seaward end. All pre- and post-storm beach profiles are shown in the Appendix. Horizontal and vertical controls were established using Real-Time Kinematic (RTK) Global Positioning System (GPS). Level-and-transit survey procedures were followed using an electronic total survey station and a 4-m (13 ft) survey rod. The survey was conducted using NAD83 State Plane (Florida West 0902) coordinate system in meters, referenced to NAVD88 which is 8.7 cm (0.285 ft) above mean sea level in the study area. Beach volume and contour analysis were conducted using the software RMAP (Regional Morphology Analysis Package), developed by the U.S. Army Corps of Engineers. Erosion or deposition in the dune field, on the dry beach, above the nearshore region, over the sand bar, and across the entire profile was calculated. The dune field is generally defined here as the portion of the beach above 1.3 m (4.3 ft) NAVD88 (the elevation of typical beach fill along this coast). However, at several locations, the overwash over the wide back beach reached the elevation that is higher than 1.3 m (4.3 ft). In this case, dune field and its seaward edge (i.e., dune line) is determined based on morphological characteristics. The dry beach is defined here as the portion of the beach between elevations of 1.3 m (4.3 ft) and 0.3 m (1.0 ft) NAVD88 (approximately Mean Higher High Water, MHHW). The nearshore portion of the beach is determined based on the characteristics of individual profile changes (discussed in the following). The short-term closure depth is also determined based on the changes measured at each individual profile, discussed in the following. At some profiles, especially those near the tidal inlets, the survey did not extend to closure depth due to the extensive distance of shallow water offshore associated with ebb tidal shoals.

In the following, the beach volume and contour-line (i.e., dune line and MHHW) changes are described from north to south. Based on previous research on the beach behavior, as well as the nourishment range in Pinellas County, the beaches along the three barrier islands are divided into the following segments:

Sand Key Barrier Island:

Northern End of Sand Key:	R55 – R57:	not nourished.
North Sand Key:	R57 – R66:	nourished in 2012.
Belleair Shore:	R66-R71:	not nourished.
Indian Rocks Beach:	R71-R82:	nourished in 2012.
Headland:	R82-R89:	nourished in 2012.
Indian Shores:	R89-R100:	nourished in 2012.
North Redington Beach:	R100-R107:	nourished in 2012.
Redington Beach:	R107-R116:	not nourished.
Madeira Beach:	R116-R124:	not nourished.

Treasure Island Barrier Island:

Sunshine Beach:	R127-R129:	nourished in 2014.
Middle Treasure Island:	R129-R137:	not nourished.
Sunset Beach:	R137-R143:	nourished in 2014.

Long Key Barrier Island:

Upham Beach:	LK1B-LK6:	nourished in 2014 with geotextile T-Groins
Middle Long Key:	LK6-R160:	not nourished.
Pass-A-Grille Beach:	R160-R165:	nourished in 2014.

General Beach Profile Changes

Considerable longshore variations of beach profile changes were measured. Patterns of beach profile change play a significant role in volume-change calculations and interpretation of the results. This section describes general characteristics of the beach-nearshore profile changes. The goal is to provide a visual and qualitative description to help interpret the calculated volume and contour line changes. All the surveyed beach-nearshore profiles are illustrated in the Appendix at the end of this report. Influenced by the track of Hurricane Hermine, the wind and waves approached from a highly oblique southerly angle, driving a northward longshore sand transport. Beach morphology changes reflected this northward longshore transport.

In general, sand loss occurred in the dune field, on the dry beach, and in the nearshore zone, while sand gain occurred over the nearshore bar, particularly on the seaward slope of the sand bar. At most of the profile locations, the sand bar moved offshore. This pattern of profile change is illustrated in Figure 6. Sand volume change associated with the dune field was calculated as the volume change above the contour level of 1.3 m (4.3 ft) NAVD88. Volume change on the dry beach was calculated as the volume change between contour levels 0.3 m (1.0 ft) and 1.3 m (4.3 ft) NAVD88. In the case of profile R74 (Figure 6), overall sand volume loss (including sand losses from the dune, the dry beach and the nearshore) was calculated as the changes landward of approximately 125 m (410 ft) distance, where mostly erosion occurred. Volume gain over the sandbar was calculated as the changes seaward of 125 m (410 ft), where mostly accumulation occurred. In the case of R74, the nearshore bar moved seaward (Figure 6) about 30 m (100 ft). Except at three profile locations, where sand bar moved onshore, offshore sand bar movement was measured at all Sand Key locations. Sand bar behavior, i.e., onshore or offshore movement, on Treasure Island and Long Key are more variable than that on Sand Key. The two relatively closely spaced tidal inlets, John's Pass and Blind Pass, and their ebb shoals may have some influence on the sand bar behavior.

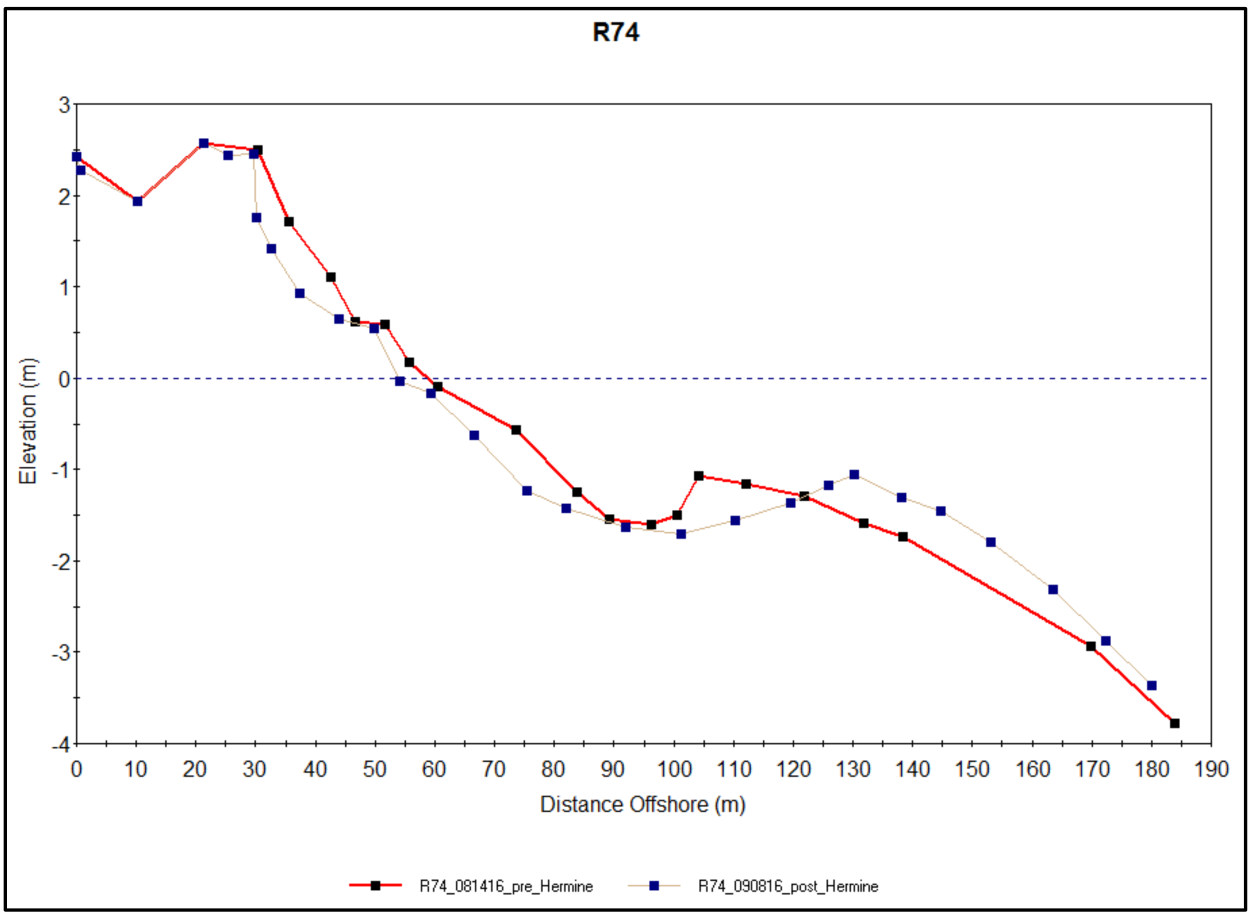


Figure 6. Example profile at R74, illustrating erosion of the dune, dry beach and nearshore area, with deposition over the nearshore bar.

Along some beach profiles, especially those with a wide pre-storm backbeach, a "storm berm" formed (Figure 7). Part of the backbeach gained sand and resulting in an overall higher elevation. At many profile locations, the peak elevation of the storm berm exceed 1.3 m (4.3 ft). However, this is not accounted for as dune line (defined here as 1.3 m contour) gain because the storm berm often developed in the middle of the back beach away from the established dunes. Substantial erosion typically occurred on the dry beach and in the nearshore area (Figure 7). In the case of R58A (Figure 7), the nearshore bar moved offshore for about 30 m (100 ft). In the case of profile R58A (Figure 7), the overall sand volume loss was calculated as the changes landward of approximately 125 m (410 ft), where erosion mostly occurred. It is worth noting that volume gain occurred on the dry beach between 10 and 30 m (cross-shore distance) due to overwash. This gain was included in the overall volume loss calculation landward of the 125 m (328 ft). Volume gain over the sand bar was calculated as the changes seaward of 125 m (410 ft), where accumulation occurred mostly. At several locations where the pre-storm beach was relatively narrow, the overwash extended into the low dune field.

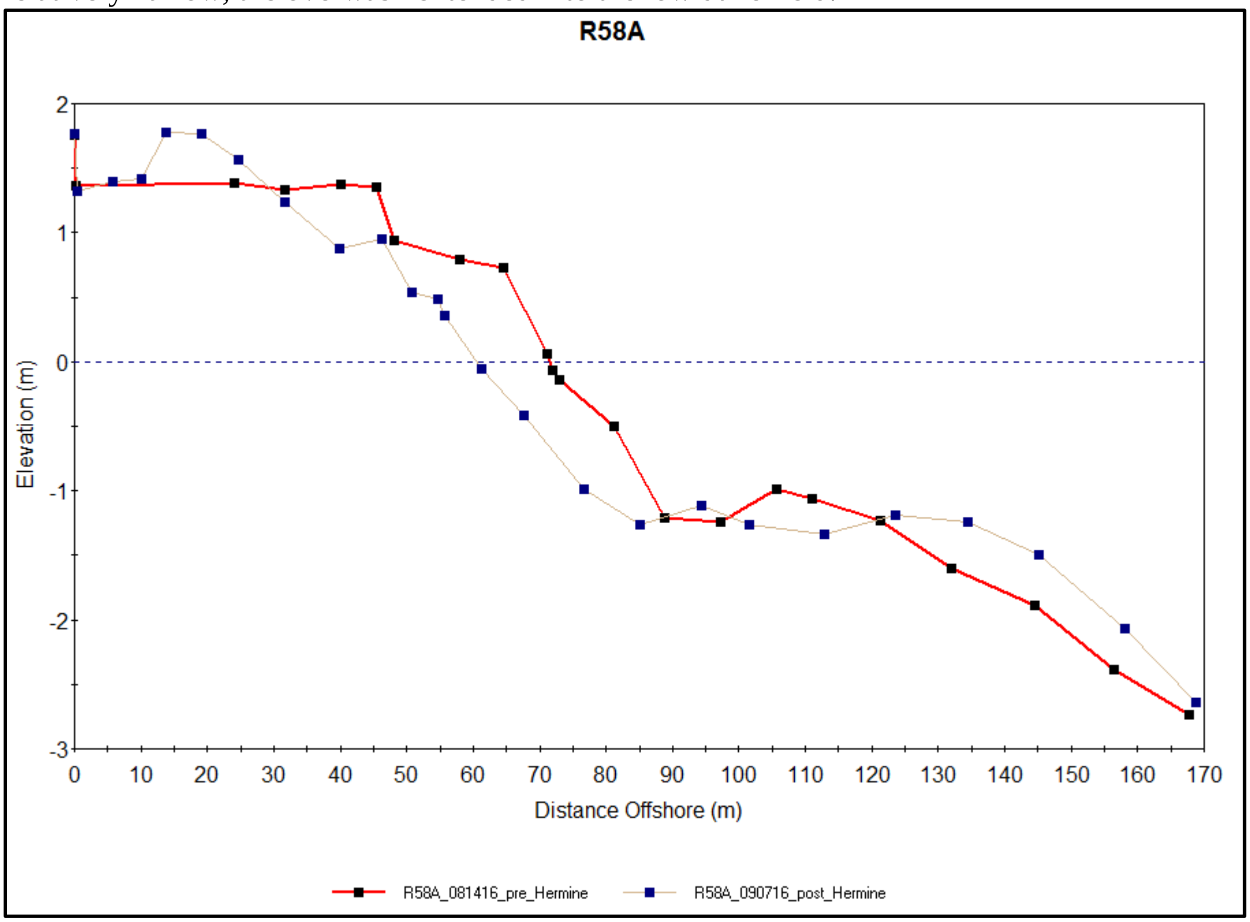


Figure 7. Example profile at R58A, illustrating formation of a storm berm (between 10 m (33 ft) and 30 m (100 ft) cross-shore distance), and erosion of dry beach and nearshore area, with deposition over the nearshore bar.

Along sections with a narrow pre-storm beach, the dune suffered significant erosion (Figure 8), resulting in the formation of a high dune scarp or landward movement of the pre-storm scarp. In the case of R138 (Figure 8) where a dune scarp existed before the storm, the scarp became higher and moved landward for about 5 m (16 ft), along with severe beach and nearshore erosion. In this case, the nearshore also gained considerable amount of sand and the sand bar moved onshore. Overall sand volume loss was calculated as the changes landward of approximately 25 m (82 ft), where erosion occurred mostly. Volume gain over the sand bar was calculated as the changes seaward of 25 m (82 ft), where accumulation occurred mostly.

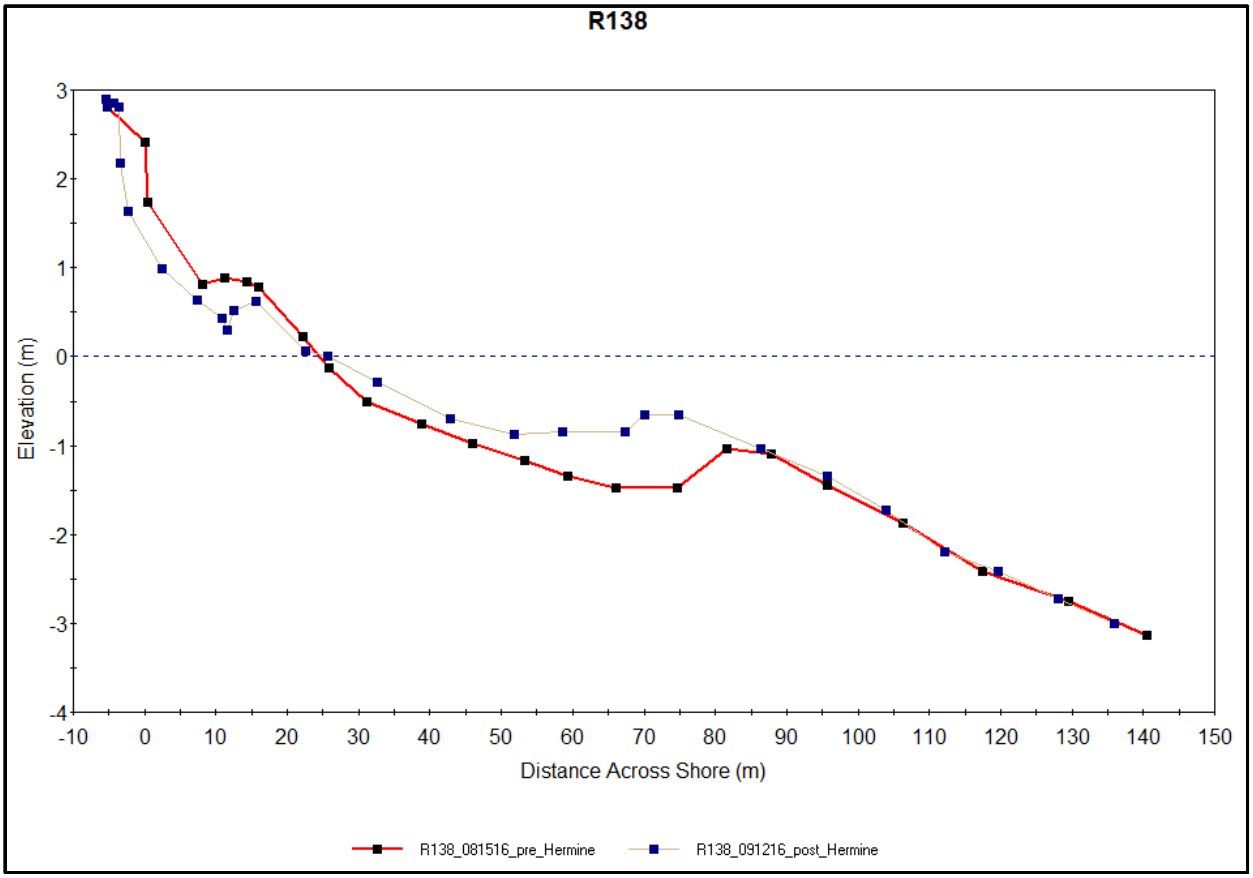


Figure 8. Example profile at R138, illustrating landward movement of dune scarp, erosion of dry beach, and deposition in the nearshore area and onshore migration of the bar.

Along sections with a narrow pre-storm beach backed by a seawall, severe erosion occurred on the dry beach with scour in front of the seawall (Figure 9) exposing the riprap at several locations. In the case of R108A, severe scour occurred along the exposed seawall. It is worth noting that the seawall was exposed before the storm. In the case of R108A, nearly the entire profile was eroded resulting in an overall elevation decrease.

The combined storm surge and wave runup from Hurricane Hermine overtopped the seawall at many locations where the pre-storm beach was relatively narrow (Figure 10).

This resulted in wide spread overwash into the beach front properties and into the low-lying dune fields (Figure 11). It is worth noting that the photos in Figure 10 were taken in the afternoon before the peak of the storm, which arrived that evening when the water level should have reached higher.

The above response to the exposed seawall also occurred at the Belleair Shore beach. Along a considerable section of Belleair Shore, the pre-storm beach was narrow with seawall directly exposed or fronted by a narrow strip of dune. Scour at the seawall occurred along with considerable overwash deposit landward of the seawall. The narrow strip of dune and associated vegetation were eroded at almost all locations, exposing the seawall which experienced scour and overwash.

Significant overwash did not occur during Tropical Storm Debby. Therefore, in the aspect of storm overwash, the impact of Hurricane Hermine is more severe than Tropical Storm Debby. This is consistent with the higher storm surge and storm wave associated with the stronger Hurricane Hermine (Figures 3 and 4). Overwash deposit reached nearly 0.3 m (1 ft) in many locations.

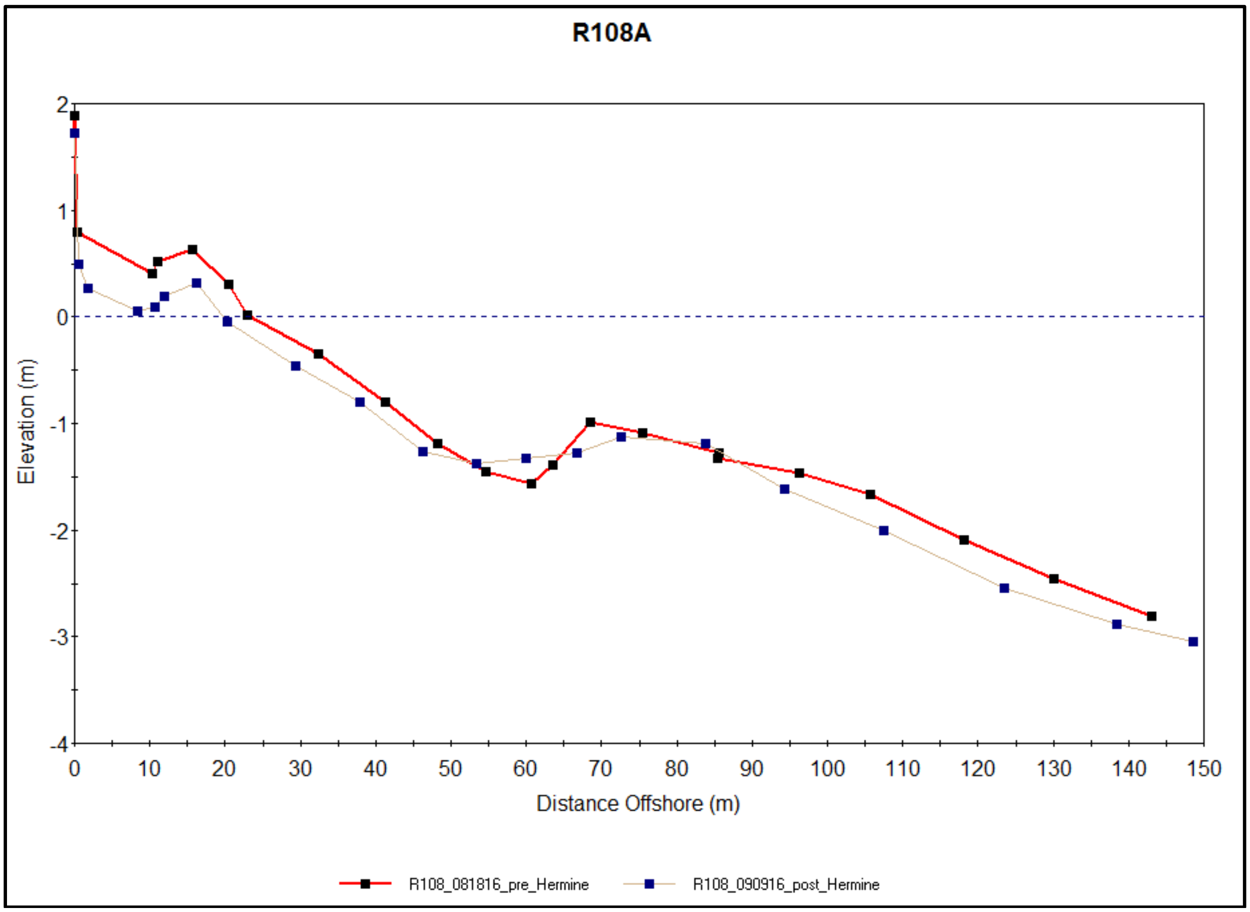


Figure 9. Example profile at R108A, illustrating severe scour in front of the seawall, erosion of nearly the entire profile.

Figure 10. Storm surge plus wave runup reached the dune field (upper panel) and overtopped the seawall (lower panel) during the storm.

Figure 11. Storm overwash deposits in the dune field (upper panel) and landward of the seawall (lower panel). Photos were taken at similar locations as in Figure 10 during the storm.

Volume and Contour-line Changes

Overall, the dune field lost sand due to storm-induced erosion, resulting in the wide spread development of a dune scarp and landward retreat of the dune line. It is worth noting that the "dune line" here is defined at the location of the 1.3 m (4.3 ft) NAVD88 contour line. This line generally coincides with the vegetated dune line at most of the profiles. However, along some sections of the beach, this contour level does not represent the vegetated dune line. This is discussed individually in the following when this case occurs. The contour line at 0.3 m (1.0 ft) NAVD88 is used to represent the seaward limit of the dry beach.

The passage of Hurricane Hermine induced strong, sustained southerly wind for about two days. This southerly wind and associated southerly approaching waves induced northward longshore sand transport. Morphological evidence of the northward longshore transport can be observed at various locations. For example, sand losses at the northern end of Treasure Island and Long Key, i.e., Sunshine Beach and Upham Beach, respectively, are relatively less than the rest of the barrier islands. This is likely related to the impoundment of the northward longshore transport by the inlet jetties.

In the following, sand volume and contour-line location changes are discussed along several sections of the beach from north to south. It is worth noting that the length of individual sections is different. It should be reminded that the overall volume change is also influenced by length of the individual section of the beach.

Sand Key

As discussed above, the approximately 73,000 ft long Sand Key extending around a broad headland is divided into nine sections based on the general behavior of the beach, as well as the nourishment status. Slightly over 4000 ft of Sand Key Beach near Clearwater Pass was not monitored by this study. Approximately 45,000 ft of Sand Key beach was nourished in 2012 and several times before that. The nine sections, from north to south, are discussed in the following.

North End Sand Key: R55-R57 (Not nourished)

This section of the beach is approximately 2,000 ft long and is just north of the north Sand Key beach nourishment project area. It is worth noting that the northern-most beach profile R55 is about 4000 ft south of the long Clearwater Pass south jetty. Beach changes between profile R55 and the Clearwater Pass south jetty were not measured. The following changes can be summarized along this section of the beach:

1) The dune field lost 2,100 cubic yards of sand, mostly from the frontal dunes at profiles R55 and R56.
2) The frontal dune line at R55 and R56 moved landward of 16 ft and 2.5 ft, respectively. R57 has no frontal dune and the back dunes were not impacted by the storm.
3) The dry beach lost 2,300 cubic yards of sand, with an average shoreline (MHHW line at 0.3 m NAVD88) retreat of 19.3 ft.

4) Including the erosion in the nearshore zone, this section lost 15,800 cubic yards of sand.
5) The offshore area gained 2,100 cubic yards of sand. It is worth noting that the survey did not extend to the short-term closure depth due to the influence of the large Clearwater ebb shoal.

North Sand Key: R57-R66 (Last nourished in 2012)

This section of the beach is approximately 9,000 ft long, representing an erosional hot spot on Sand Key. This section typically receives relatively large volume of beach nourishment. Persistent erosion was measured since the last beach nourishment in 2012. The following changes can be summarized along this section of the beach:

1) The dune field lost 4,900 cubic yards of sand, mostly from profiles south of R60. The pre-storm beach north of R60 was quite wide and provided protection to the back dune, resulting in no dune erosion.
2) On average (R60 through R66) the dune line moved landward 17.1 ft.
3) The dry beach lost 11,000 cubic yards of sand.
4) On average (R57 through R66), the MHHW line moved landward 17.2 ft.
5) Including the erosion in the nearshore zone, this section lost 83,700 cubic yards of sand.
6) The sandbar gained 69,600 cubic yards of sand, less than the overall loss.

Belleair Shore: R66-R71 (Not nourished)

This section of the beach is approximately 6,000 ft long and was not nourished in 2012 and before. The beach was quite narrow before the storm, with a narrow strip or no dunes in front of the seawall. The narrow dunes were completely eroded. Substantial scour in front of the seawall occurred. The following changes were measured along this section of the beach:

1) The dune field lost 8,600 cubic yards of sand.
2) On average, the dune line retreated landward 18.3 ft, varying from 10 ft to 25 ft.
3) The dry beach lost 8,000 cubic yards of sand.
4) On average, the MHHW line moved landward 9.2 ft, ranging from 3.6 ft to 14.7 ft loss. The relatively small dry beach loss along this stretch of beach was partially influenced by the narrow pre-storm beach with not much sand to be eroded.
5) Including the erosion in the nearshore zone, this section lost 57,900 cubic yards of sand.
6) The sandbar gained 34,800 cubic yards of sand, which is considerably less than the volume that was eroded.

Indian Rocks Beach: R71-R82 (Last nourished in 2012)

This section of the beach is approximately 12,000 ft long and was nourished in 2012. A nearly continuous vegetated dune field existed before the storm. Dune scarping occurred along nearly the entire stretch, including scour at many dune overwalks. Indian Rocks beach suffered substantial erosion due to the impact of Hurricane Hermine. The following changes were measured along this section of the beach:

1) The dune field lost 18,300 cubic yards of sand.
2) On average, the dune line retreated landward15.3 ft, with considerable longshore variations ranging from 10.0 ft (R71) to 27.9 ft (R80A) retreat.
3) The dry beach lost 21,300 cubic yards of sand.
4) On average, the MHHW line moved landward 5.0 ft, with substantial longshore variation ranging from 16.4 ft gain at R78 (likely due to substantial development of the ridge and runnel system) to 18.0 ft loss at R75.
5) Including the erosion in the nearshore zone, this section lost a total of 117,100 cubic yards of sand.
6) The sandbar gained 92,000 cubic yards of sand, considerably less than the overall loss.

Headland: R82-R89 (Last nourished in 2012)

This protruding section of the beach is approximately 7,000 ft long and was nourished in 2012. A nearly continuous vegetated dune field existed before the storm. Scarping occurred along most sections of the dune field. The headland section also suffered severe erosion due to the impact of Hurricane Hermine. The following changes were measured along this section of the beach:

1) The dune field lost 10,600 cubic yards of sand.
2) On average, the dune line retreated landward 17.4 ft, with substantial longshore variations ranging from 0 ft (R87 due to the lack of pre-storm dune) to 29.3 ft (R85A) retreat, largely influenced by the pre-storm beach and dune characteristics.
3) The dry beach lost 30,900 cubic yards of sand.
4) On average, the MHHW line moved landward 29.2 ft, with substantial longshore variation ranging from 6.7 ft retreat at R82 to 46.5 ft retreat at R83.
5) Including the erosion in the nearshore zone, this section lost a total of 66,900 cubic yards of sand.
6) The sandbar gained 30,000 cubic yards of sand, less than half of the overall loss,

Indian Shores: R89-R100 (Last nourished in 2012)

This section of the beach is approximately 10,000 ft long and was nourished in 2012. A vegetated dune field extended along most of this stretch before the storm. Scarping occurred along most sections of the dune field. The following changes were measured along this section of the beach:

1) The dune field lost 7,000 cubic yards of sand.

2) On average, the dune line retreated landward 12.8 ft, with substantial longshore variations ranging from 0 ft (R99 and R100) to 33.0 ft (R93).
3) The dry beach lost 30,500 cubic yards of sand.
4) On average, the MHHW line moved landward 35.3 ft, with substantial longshore variation ranging from 10.5 ft retreat at R89 to 48.9 ft retreat at R93.
5) Including the erosion in the nearshore zone, this section lost a total of 63,300 cubic yards of sand.
6) The sandbar gained 21,000 cubic yards of sand, less than one-third of the overall loss.

North Redington Beach: 100-R107 (Last nourished in 2012)

This section of the beach is approximately 7,000 ft long and was nourished in 2012. This section comprises the southern end of the 2012 beach nourishment. The section is characterized by a rather rapid southward decreasing beach width. Profiles R106 and R107 at the southern end of this section had quite narrow beach before the storm impact. A surf zone breakwater exists at the northern end (between R100A and R101) of this section. The following changes were measured along this section of the beach:

1) The dune field lost 3,000 cubic yards of sand.
2) The dry beach lost 16,700 cubic yards of sand.
3) On average, the MHHW line moved landward 32.0 ft, with substantial longshore variation ranging from 17.4 ft retreat at R105 to 47.2 ft retreat at R107.
4) Including the erosion in the nearshore zone, this section lost a total of 23,900 cubic yards of sand.
5) The sandbar gained 14,200 cubic yards of sand, slightly more than half of the overall loss.

Redington Beach: R107-R116 (Not nourished)

This section of the beach is approximately 8,000 ft long and was not nourished in 2012 or before. A vegetated dune field existed from R110 to R116 before the storm, while the seawall was exposed along the stretch from R107 to R109. Scour in front of the exposed seawall occurred at profiles R107, R108, and R109, along with some infrastructure damage such as pavers and fences of beach front resorts. In addition, extensive washover deposits occurred landward of the seawall, covering decks and into swimming pools. The following changes were measured along this section of the beach:

1) The dune field lost 3,000 cubic yards of sand.
2) On average, the dune line retreated landward 10.1 ft from profile R110 to R116, with substantial longshore variations ranging from 2.0 ft (R113) to 30.5 ft (R111), largely influenced by the pre-storm beach and dune characteristics.
3) The dry beach lost 12,300 cubic yards of sand.

4) On average, the MHHW line moved landward 29.3 ft, with substantial longshore variation ranging from 5.4 ft gain at R114 to 60.9 ft retreat at R108A. The excessive erosion at profile R108A is related to the scour at the exposed seawall.
5) Including the erosion in the nearshore zone, this section lost a total of 34,700 cubic yards of sand.
6) The sandbar gained 12,700 cubic yards of sand, slightly more than one-third of the overall loss.

<u>Madeira Beach: R116-R124 (Not nourished)</u>

This section of the beach is approximately 8,000 ft long and was not nourished in 2012 and before. A vegetated dune field existed before the storm at most of the beach profile locations. Minor scarping occurred along some sections of the dune field. This section of the beach extends to the north jetty of John's Pass. The following changes were measured along this section of the beach:

1) The dune field lost 800 cubic yards of sand. This small loss is related to the protection from the relatively wide pre-storm beach and likely sheltering of the southerly approaching waves by the large John's Pass ebb shoal.
2) The dry beach lost 11,800 cubic yards of sand.
3) On average, the MHHW line moved landward 18.4 ft, with substantial longshore variation ranging from 6.0 ft gain at R124 to 42.5 ft retreat at R118. This shoreline change pattern is likely related to the John's Pass north jetty and ebb shoal, providing wave sheltering for R124, while the sheltering effect decreases northward.
4) Including the erosion in the nearshore zone, this section lost a total of 15,500 cubic yards of sand.
5) The sandbar gained 13,300 cubic yards of sand, slightly less than the overall loss.

<u>The Entire Sand Key - Summary</u>

Overall, almost all of Sand Key suffered dune, dry beach, and nearshore erosion, while the nearshore bar gained substantial amount of sand. Overall along the 69,000 ft studied section of Sand Key, a total of 58,500 cubic yards of dune sand was eroded, in addition to 144,600 cubic yards of sand eroded from the dry beach. Substantial erosion also occurred in the nearshore zone, extending to the trough landward of the sand bar at up to approximately -1.8 m (6.0 ft) NAVD88. Including the dune, dry beach, and nearshore erosion, the total sand loss along Sand Key amounted to 481,200 cubic yards. A total sand volume gain of 287,400 cubic yards was measured at the sand bar. Most of the deposition occurred along the seaward slope of the sand bar. Only 60% of the sand loss from the dune, dry beach, and nearshore can be accounted for by the deposition on the sand bar. The rest of the sand is likely deposited on the ebb shoals. Deposition seaward of the survey limit and overwash deposits landward of the seawall may also contribute to the imbalance.

Tabulated beach volume and shoreline position changes for all three barrier islands, Sand Key, Treasure Island, and Long Key, are summarized in Tables 1 and 2 below.

For the nourished sections of Sand Key, a total of 43,900 cubic yards of dune sand was eroded. The dry beach portion, extending across shore from the dune line to high tide line, experienced a total of 110,400 cubic yards of sand loss. Substantial erosion also occurred in the nearshore zone, extending to the trough landward of the sand bar at up to approximately -1.8 m (6.0 ft) NAVD88. Combining the dune, dry beach, and nearshore erosion, the total sand loss along the nourished sections of Sand Key amounted to 357,400 cubic yards. A total sand volume gain of 226,500 cubic yards was measured at the sand bar. Most of the deposition occurred along the seaward slope of the sand bar. Nearly 63.3% of the sand loss from the dune, dry beach, and nearshore can be accounted for by the deposition on the sand bar.

The 45,000 ft sections of nourished beach represent 65% of the studied stretch of Sand Key (or 62% of the entire length of Sand Key). In terms of sand volume loss, the 357,400 cubic yards of sand loss along the nourished sections represent 74.3% of the total 481,200 cubic yards loss along the studied stretch of Sand Key. In other words, the nourished sections experienced more erosion per length of beach as compared to the entire island. This can be explained by the fact that the pre-storm beaches were generally wider along the nourished sections, and therefore had more sand to absorb the erosion associated with the storm. Several sections of the not-nourished beach were severely depleted of sand before the storm, and therefore had less sand available for erosion.

Compared to the beach volume changes measured during the last significant storm, Tropical Storm Debby in 2012, the overall sand volume loss from Hurricane Hermine is 13.5% greater; 481,200 cubic yards versus 424,000 cubic yards. A significant difference is the amount of sand deposition on the nearshore bar. For Tropical Storm Debby, nearly all the sand lost can be accounted for by the accumulation on the sand bar, which was 445,600 cubic yards (slightly greater than the 424,000 cubic yards of loss). However, only 60% of the sand loss for Hurricane Hermine can be accounted by the deposition on the sand bar.

Treasure Island

The studied section of Treasure Island is approximately 16,000 ft long and is divided into three sections based on the general behavior of the beach, as well as the nourishment status. About 1000 ft of Treasure Island Beach near John’s Pass south jetty was not monitored by this study. Approximately 9,000 ft of Treasure Island beach was nourished in 2014 and several times before that. The three sections, from north to south, are discussed in the following.

Sunshine Beach: R127-R129 (Last nourished in 2014)

This short section of the beach is approximately 2,000 ft long and was recently nourished in the summer of 2014. A vegetated dune field existed before the storm at both of the profiles. This section of the beach extends to the south jetty of John’s Pass. Due to the extensive John’s Pass ebb shoal, the profile survey could not extend to the short-term closure depth. Slightly over 300 cubic yards of sand volume gain was measured in the dune field, with the positions of dune line essentially unchanged. Overall, 3,600 cubic yards of sand was lost from the dry beach. On average, the MHHW line moved landward

15.6 ft, with substantial longshore variation ranging from 19.5 ft gain at R127 to 62.3 ft retreat at R129. This volume and shoreline change pattern is likely related to the attachment point of the John's Pass ebb shoal, which is located in the vicinity of profile R129 and the northward longshore sand transport during the storm.

<u>Middle Treasure Island: R129-R136 (Not nourished)</u>

This section of the beach is approximately 7,000 ft long and was not nourished in 2014 or before. A vegetated dune field existed before the storm at most of the profiles. This section is characteristic of a very wide beach except at the south end (R136 and R137). The following changes were measured along this section of the beach:

1) The dune field gained 2,000 cubic yards of sand, mostly due to overwash into the low-lying dune field.
2) The dry beach lost 13,400 cubic yards of sand.
3) On average, the MHHW line moved landward 23.9 ft, with substantial longshore variation ranging from 12.5 ft retreat at R136 to 62.3 ft retreat at R129.
4) Including the erosion in the nearshore zone, this section lost a total of 41,000 cubic yards of sand.
5) The sandbar gained 36,200 cubic yards of sand, slightly less than the overall loss.

<u>Sunset Beach: R136-R143 (Last nourished in 2014)</u>

This section of the beach is approximately 7,000 ft long and was recently nourished in the summer of 2014. Profile R143 at the very south end of Treasure Island was not nourished in 2014. It is included in this section because it is directly influenced by the nourishment. A vegetated dune field existed before the storm at all of the profiles. This section of the beach was fairly narrow before the storm impact. The following changes were measured along this section of the beach:

1) The dune field lost 3,100 cubic yards of sand. Dune scarping and dune line retreat were measured at two of the profiles, with 11.7 ft retreat at R138 and 6.5 ft retreat at R140.
2) The dry beach lost 10,500 cubic yards of sand.
3) On average, the MHHW line moved landward 12.5 ft, with substantial longshore variation ranging from 5.2 ft gain at R141 to 23.5 ft retreat at R143.
4) Including the erosion in the nearshore zone, this section lost a total of 24,900 cubic yards of sand.
5) The sandbar gained 29,200 cubic yards of sand, slightly more than the overall loss.

<u>The Entire Treasure Island - Summary</u>

Overall, the entire Treasure Island suffered dune, dry beach, and nearshore erosion, especially along the Sunset Beach where the pre-storm beach was relatively narrow, while the nearshore bar gained substantial amount of sand. Overall along the 16,000 ft studied section of Treasure Island, a total of 800 cubic yards of dune sand loss was measured. The dry beach lost 27,400 cubic yards of sand. Substantial erosion also occurred in the nearshore zone, extending to the trough landward of the bar at up to approximately -1.5 m (4.9 ft) NAVD88. Including the dune, dry beach, and nearshore erosion, the total sand loss along Treasure Island amounted to 69,000 cubic yards. Most of the sand was deposited on the nearshore bar, with a total sand volume gain of 68,500 cubic yards. The balanced erosion and deposition at Treasure Island is different from the situation at Sand Key where significantly more erosion was measured from the dune to the nearshore zone than the deposition over the sand bar. Tabulated beach volume and shoreline position changes for all three barrier islands, Sand Key, Treasure Island, and Long Key, are summarized in Tables 1 and 2 below.

For the nourished sections of Treasure Island, a total of 2,800 cubic yards of dune sand was eroded. The dry beach portion, extending across shore from the dune line to high tide line, experienced a total of 14,100 cubic yards of sand loss. Substantial erosion also occurred in the nearshore zone, extending to the trough landward of the sand bar at up to approximately -1.5 m (4.9 ft) NAVD88. Combining the dune, dry beach, and nearshore erosion, the total sand loss along the nourished sections of Treasure Island amounted to 28,000 cubic yards. A total sand volume gain of 32,400 cubic yards was measured at the sand bar. Most of the deposition occurred along the seaward slope of the sand bar. Slightly more deposition was measured in the offshore area than the erosion on the dune, dry beach, and nearshore area.

The 9,000 ft sections of nourished beach represent 56% of the entire length of Treasure Island. In terms of sand volume loss, the 28,000 cubic yards of sand loss along the nourished sections represent 41% of the total 69,000 cubic yards loss along the entire Treasure Island. In other words, the nourished sections experienced less erosion per length of beach as compared to the entire barrier island. This can be explained by the fact that the pre-storm beaches were much wider along the not-nourished sections, and therefore had more sand to absorb the erosion associated with the storm. This is the opposite of the situation at Sand Key as discussed above.

Compared to the beach volume changes measured during the last significant storm, Tropical Storm Debby in 2012, the overall sand volume loss from Hurricane Hermine is 26.2% less; 69,000 cubic yards versus 93,500 cubic yards. Similar to the case of Tropical Storm Debby in 2012, the volume loss from dune field, dry beach and nearshore can be accounted for by the sand gain in the offshore bar area.

Long Key

The studied section of Long Key is approximately 20,500 ft long extending nearly the entire barrier island and is divided into three sections based on the general behavior of the beach, as well as the nourishment status. Approximately 7,200 ft of Long Key beach was nourished in 2014 and several times before that. The three sections, from north to south, are discussed in the following.

Upham Beach: LK1-LK6 (Last nourished in 2014).

This section of the beach is approximately 2,200 ft long and was recently nourished in 2014 and is further protected by five experimental geotextile T-groins. A vegetated dune field existed from LK6 through LK3 before the storm. The section of the beach from LK6 to LK3 was fairly wide before the storm impact. No dune field existed from LK1B to LK 2A before the storm, with a narrow beach along this section. The seawall was exposed at profiles LK 2 and LK 2A. Upham Beach suffers from aggressive chronic erosion and serves as the feeder beach to the middle section of Long Key. The following changes were measured along this section of the beach:

1) The dune field along the back side of the wide beach from LK3 through LK6 was minimally impacted by the storm. However, considerable overwash deposits (i.e., storm berm development) occurred on the back beach, with elevation reached over 1.3 m (4.3 ft) NAVD88. The accumulation above 1.3 m (4.3 ft) contour was accounted for as dune volume gain here, which amounted to 1,800 cubic yards. The dune line position along the back beach is not changed.
2) The dry beach lost 2,600 cubic yards of sand.
3) On average, the MHHW line moved landward 6.4 ft, with substantial longshore variation ranging from 43.4 ft gain at LK1B (due to the impoundment at the Blind Pass south jetty) to 28.6 ft retreat atLK2 due to the scour at the seawall.
4) Including the erosion in the nearshore zone, this section lost a total of 5,900 cubic yards of sand.
5) The sandbar gained 12,700 cubic yards of sand, almost double the overall loss.

Middle Long Key: LK6-R160

This section of the beach is approximately 13,300 ft long and was not nourished in 2014 or before. A vegetated dune field existed before the storm at almost all the profiles. This section of the beach was fairly wide with extensive dune field before the storm impact and has been benefiting from the "feeder" Upham Beach to the north. The following changes were measured along this section of the beach:

1) The dune field gained 9,100 cubic yards of sand. This gain is related to the development of the storm berm (with a peak elevation extending above 1.3 m (4.3 ft) NAVD88), similar to the case at Upham Beach.
2) The dry beach lost 32,200 cubic yards of sand.
3) On average, the MHHW line moved landward 15.2 ft, with substantial longshore variation ranging from 4.3 ft gain at R154 to 52.2 ft retreat at R155.
4) Including the erosion in the nearshore zone, this section lost a total of 52,600 cubic yards of sand.
5) The sandbar gained 42,100 cubic yards of sand, slightly less than the overall loss.

Pass-A-Grille Beach: R160-R165

This section of the beach is approximately 5,000 ft long and was nourished in 2014. A vegetated dune field existed before the storm at all of the profiles. The following changes were measured along this section of the beach:

1) The dune field lost 3,600 cubic yards of sand.

2) The dry beach lost 14,900 cubic yards of sand.
3) On average, the Mean High Tide (MHHW) line moved landward 24.6 ft, with substantial longshore variation ranging from 3.3 ft retreat at R161 to 41.8 ft retreat (landward movement) at R164.
4) Including erosion in the nearshore zone, this section lost a total of 21,800 cubic yards of sand.
5) The sandbar gained 15,800 cubic yards of sand, which is considerably less than the overall loss.

The Entire Long Key - Summary

Overall, the entire Long Key suffered dune, dry beach, and nearshore erosion, while the nearshore bar gain substantial amount of sand. Overall, along the 20,500 ft studied section of Long Key (nearly the entire Long Key), a total of 7,300 cubic yards of sand gain was measured in the dune field, attributable to the overwash deposits. The dry beach lost 49,700 cubic yards of sand. Substantial erosion also occurred in the nearshore zone, extending to the trough landward of the bar at up to approximately -1.5 m (4.9 ft) NAVD88. Including the dune, dry beach, and nearshore erosion, the total sand loss along Long Key amounted to 80,200 cubic yards. Most of the sand was deposited on the nearshore bar, with a total sand volume gain of 70,500 cubic yards. The nearly balanced erosion and deposition at Long Key is similar to the situation at Treasure Island but is different from the situation at Sand Key where significantly more erosion was measured from the dune to the nearshore zone than the deposition over the sand bar. Tabulated beach volume and shoreline position changes for all three barrier islands, Sand Key, Treasure Island, and Long Key, are summarized in Tables 1 and 2 below.

For the nourished sections of Long Key, a total of 1800 cubic yards of dune sand was eroded. The dry beach portion, extending across shore from the dune line to high tide line, experienced a total of 17,500 cubic yards of sand loss. Substantial erosion also occurred in the nearshore zone, extending to the trough landward of the sand bar at up to approximately -1.5 m (4.9 ft) NAVD88. Combining the dune, dry beach, and nearshore erosion, the total sand loss along the nourished sections of Long Key amounted to 27,700 cubic yards. A total sand volume gain of 28,100 cubic yards was measured at the sand bar. Most of the deposition occurred along the seaward slope of the sand bar. Slightly more deposition was measured in the offshore area than the erosion on the dune, dry beach, and nearshore area.

The 7,200 ft sections of nourished beach represent 35% of the entire length of Long Key. In terms of sand volume loss, the 27,700 cubic yards of sand loss along the nourished sections represent 35% of the total 80,200 cubic yards loss along the entire Long Key. In other words, the nourished sections experienced similar amount of erosion per length of beach as compared to the entire barrier island. This can be explained by the fact that the pre-storm beach along the entire Long Key was relatively wide except at the very north end. This is different from the situations at both Sand Key and Treasure Island as discussed above.

Compared to the beach volume changes measured during the last significant storm, Tropical Storm Debby in 2012, the overall sand volume loss from Hurricane Hermine is 29.3% less; 80,200 cubic yards versus 113,400 cubic yards. For all three barrier islands, Sand Key experienced more volume loss during Hurricane Hermine than that during Tropical Storm Debby, while erosion at Treasure Island and Long Key was not as severe.

Summary

The energetic Hurricane Hermine induced severe beach and dune erosion along the Pinellas County coast. Storm impacts along the beaches fronting three heavily developed barrier islands, Sand Key, Treasure Island, and Long Key are quantified here based on pre- and post-storm beach profile surveys. Substantial portions of beach along the three barrier islands are nourished regularly. Specifically in terms of length, beaches along 65% of Sand Key, 56% of Treasure Island, and 35% of Long Key are artificially maintained through beach nourishments.

Dune erosion in the form of extensive dune scarping was measured along nearly the entire Sand Key, resulting in a total dune-sand volume loss of 58,500 cubic yards. The dry beach along Sand Key lost 144,600 cubic yards of sand, with section-averaged Mean Higher High Water (MHHW) line retreat landward ranging from 5 to 35 ft. Substantial erosion also occurred in the nearshore zone. Including the sand loss in the nearshore zone, the overall sand volume loss on Sand Key was 481,200 cubic yards. Only 60% of this sand volume loss can be accounted for by the sand gain over the nearshore bar, where an overall gain of 289,500 cubic yards was measured. The rest of the sand was likely moved onto the ebb shoals at the tidal inlets, transported further offshore beyond the survey extent, and washed landward over the seawall (i.e., landward limit of the survey)

Dune erosion was measured along the southern portion of Treasure Island, i.e., the Sunset Beach. Dune scarp that existed before the storm was pushed landward at some locations, specifically 12 ft at profile R138 and 7 ft at profile R140. The dry beach along Treasure Island lost 27,400 cubic yards of sand, with section-averaged Mean Higher High Water (MHHW) line retreat landward ranging from 11 ft to 24 ft. Substantial erosion also occurred in the nearshore zone, with an overall sand volume loss on Treasure Island of 69,000 cubic yards, when including the sand loss in the nearshore zone. Most of this sand volume loss can be accounted for by the sand gain over the nearshore bar, where an overall gain of 68,500 cubic yards was measured.

A small amount of dune erosion was measured along the southern portion of Long Key, i.e., the Pass-A-Grille Beach. Dune scarp was minimal along most of Long Key. The dry beach along Long Key lost 49,700 cubic yards of sand, with section-averaged Mean Higher High Water (MHHW) line retreat landward ranging from 6 ft at Upham Beach to 23 ft at Pass-A-Grille Beach. Substantial erosion also occurred in the nearshore zone, with an overall sand volume loss on Long Key of 80,200 cubic yards, when including the sand loss in the nearshore zone. Most of this sand volume loss can be accounted for by the sand gain over the nearshore bar, where an overall gain of 70,500 cubic yards was measured.

Overall, along the three studied barrier islands, the dune field, defined here as the portion of the beach that is above 1.3m (4.3 ft) NAVD88 lost a total of 52,000 cubic yards of sand. The dry beach, defined here as the portion of the beach between 1.3 m (4.3 ft) NAVD88 and 0.3 m (1.0 ft) NAVD88 (or Mean Higher High Water line), lost 221,700 cubic yards of sand. A substantial amount of sand was also move seaward from the nearshore area (roughly above -1.8 m (5.9 ft) NAVD88 contour) to the nearshore bar. Combining sand losses from the dune field, the dry beach, and the nearshroe zone, a total of 630,400 cubic yards of sand were lost. About 68% of the sand lost can be accounted for by the deposition over the nearshore bar, with a total gain of 428,500 cubic yards of sand. Table 1 summarized the sand volume changes along the three barrier islands.

Compared to the last significant storm impact by Tropical Storm Debby in 2012, overall sand volume loss from Hurricane Hermine on Sand Key is 13.5% greater; 481,200 cubic yards versus 424,000 cubic yards. On Treasure Island, the Hermine impact was less severe than the longer lasting Tropical Storm Debby. The overall sand volume loss from Hurricane Hermine is 26.2% less; 69,000 cubic yards versus 93,500 cubic yards. On Long Key, Hermine impact was also less severe than Debby. The overall sand volume loss from Hurricane Hermine is 29.3% less; 80,200 cubic yards versus 113,400 cubic yards. Overall for the three barrier islands, similar sand volume loss was measured, 630,400 cubic yards for Hermine and 631,000 cubic yards for Debby.

Many sections of the three barrier islands are comprised of nourished beaches. Table 2 summarizes the sand volume changes along the nourished beaches. Overall, along the nourished beaches at the three barrier islands, a total of 48,500 cubic yards of sand was eroded from the dune field. The dry beach lost 142,000 cubic yards of sand. Combining sand losses from the dune field, dry beach, and nearshore zone, a total of 413,100 cubic yards of sand were lost from the nourished beaches. The nearshore bar gained 287,000 cubic yards of sand, accounting for nearly 70% of the sand lost.

Compared to the last significant storm impact by Tropical Storm Debby in 2012, overall sand volume losses from the nourished portions of the three barrier islands are roughly the same, 413,100 cubic yards for Hurricane Hermine and 419,000 cubic yards for Tropical Storm Debby. Nourished sections on Sand Key lost more sand during Hermine, while nourished sections on Treasure Island and Long

Table 1. Volume Changes Measured along the entire Sand Key, Treasure Island, and Long Key

			Volume changes				MHHW line change
			Dune	dry beach	overall loss	overall gain	
Sand Key Barrier Island:			Cu. yds	Cu. yds	Cu. yds	Cu. yds	ft
North End Sand Key:	R55-R57:	Not nourished	-2100	-2300	-15800	2100	-19.3
North Sand Key:	R57-R66:	Nourished in 2012	-4900	-11000	-83700	69600	-17.2
Belleair Shore:	R66-R71:	Not nourished	-8600	-8000	-57900	34800	-9.2
Indian Rocks Beach:	R71-R82:	Nourished in 2012	-18300	-21300	-117100	91900	-5.0
Headland:	R82-R89:	Nourished in 2012	-10600	-30900	-66900	30000	-29.2
Indian Shores	R89-R100:	Nourished in 2012	-7100	-30500	-66300	21000	-35.3
North Redington Beach:	R100-R107:	Nourished in 2012	-3000	-16700	-23400	14000	-32.0
Redington Beach:	R107-R116:	Not nourished	-2800	-12300	-34700	12700	-29.3
Madeira Beach:	R116-R124:	Not nourished	-800	-11800	-15500	13300	-18.4
Total Sand Key			-58500	-144600	-481200	289500	
Treasure Island Barrier Island:							
Sunshine Beach:	R127-R129:	Nourished in 2014	300	-3600	-3100	3100	-15.6
Middle Treasure Island:	R129-R136:	Not nourished	2000	-13400	-41000	36200	-23.9
Sunset Beach:	R136-R143:	Nourished in 2014	-3100	-10500	-24900	29200	-11.0
Total Treasure Island:			-800	-27400	-69000	68500	
Long Key Barrier Island:							
Upham Beach:	LK1-LK6:	Nourished in 2014	1800	-2600	-5900	12300	-6.4
Middle Long Key:	LK6-R160:	Not nourished	9100	-32200	-52500	42100	-15.2
Pass-A-Grille Beach:	R160-R165:	Nourished in 2014	-3600	-14900	-21800	15800	-23.1
Total Sand Key			7300	-49700	-80200	70500	

Table 2. Volume Changes Measured along nourished sections of Sand Key, Treasure Island, and Long Key

			Volume changes				MHHW line change
			Dune	dry beach	overall loss	overall gain	
Sand Key Barrier Island:			Cu. yds	Cu. yds	Cu. yds	Cu. yds	ft
North Sand Key:	R57-R66:	Nourished in 2012	-4900	-11000	-83700	69600	-17.2
Indian Rocks Beach:	R71-R82:	Nourished in 2012	-18300	-21300	-117100	91900	-5.0
Headland:	R82-R89:	Nourished in 2012	-10600	-30900	-66900	30000	-29.2
Indian Shores	R89-R100:	Nourished in 2012	-7100	-30500	-66300	21000	-35.3
North Redington Beach:	R100-R107:	Nourished in 2012	-3000	-16700	-23400	14000	-32.0
Total Nourished Sand Key			-43900	-110400	-357400	226500	
Treasure Island Barrier Island:							
Sunshine Beach:	R127-R129:	Nourished in 2014	300	-3600	-3100	3100	-15.6
Sunset Beach:	R136-R143:	Nourished in 2014	-3100	-10500	-24900	29200	-11.0
Total Nourished Treasure Island			-2800	-14100	-28000	32400	
Long Key Barrier Island:							
Upham Beach:	LK1-LK6:	Nourished in 2014	1800	-2600	-5900	12300	-6.4
Pass-A-Grille Beach:	R160-R165:	Nourished in 2014	-3600	-14900	-21800	15800	-23.1
Total Nourished Long Key			-1800	-17500	-27700	28100	

Appendix J. Proposed Work

See Section 13 in the main report.

Appendix K. Cost Estimate Data

PROJECT INFORMATION REPORT
FOR REHABILITATION
ASSISTANCE FOR
PINELLAS COUNTY, SAND KEY SEGMENT, FLORIDA

APPENDIX K
COST ENGINEERING

OCTOBER 2016

TABLE OF CONTENTS

PROJECT INFORMATION REPORT FOR REHABILITATION ASSISTANCE FOR PINELLAS COUNTY, SAND KEY SEGMENT, FLORIDA

K. COST ESTIMATES

K1. GENERAL INFORMATION

US Army Corps of Engineers' cost estimates for planning purposes are prepared in accordance with the following guidance:

- Engineer Technical Letter (ETL) 1110-2-573, Construction Cost Estimating Guide for Civil Works, 30 September 2008
- Engineer Regulation (ER) 1110-1-1300, Cost Engineering Policy and General Requirements, 26 March 1993
- ER 1110-2-1302, Civil Works Cost Engineering, 30 June 2016
- ER 1110-2-1150, Engineering and Design for Civil Works Projects, 31 August 1999
- Engineer Manual (EM) 1110-2-1304 (Tables Revised 31 September 2015), Civil Works Construction Cost Index System, 31 March 2000
- ER 500-1-1, Emergency Employment of Army and Other Resources, Civil Emergency Management Program - Procedures, 30 September 2001
- EP 500-1-1 Emergency Employment of Army and Other Resources, Civil Emergency Management Program – Procedures, 30 September 2001
- Implementation Guidance WRRDA 2014 Section 3029a , 04 April 2016

The cost estimates for the rehabilitation of the shore protection project at Sand Key is based on dredging material from an offshore borrow area, Egmont Shoal, and placing that material on areas damaged by the recent storm event. This material will be placed as beach fill and then shaped into a protective berm for protection against storm damage. PL 84-99 provides for restoration of the project to design level of protection at 100% Federal cost. The non-Federal sponsor, Pinellas County, at their option may request project rehabilitation to full project dimensions which would be cost shared.

K.1.1 Rehabilitation Plan

The rehabilitation of a shore protection project within the requirements of PL 84-99 requires the calculation of two separate cost estimates. The first cost estimate for consideration is the cost to restore the project from the post storm condition to its Design Template. This estimate includes all labor, equipment and material to return the protective features to the full design template. This estimate does not include any advanced maintenance or "sacrificial" berm. The funding for this estimate is 100% Federal with no Sponsor funds required. The second estimate for consideration is to restore the project from the post storm condition to the Full Construction Template including material for an advanced maintenance berm. The cost of this option that exceeds the estimate for returning the project to the Design Template is cost shared in accordance with the existing cost share agreement between the Federal government and the project Sponsor. The project Sponsor has the option of choosing to pursue the Full Construction Template project. The MCACES/MII cost estimates are based on the scopes and are formatted in the CWWBS. The notes provided in the body of the estimate detail the estimate parameters and assumptions. These include pricing at the Fiscal Year 2017 price level (1 October 2016-30 September 2017).

The construction costs fall under the following feature code:

- 17 Beach Replenishment

The non-construction costs fall under the following feature codes:

- 01 Lands and Damages
- 30 Planning, Engineering and Design
- 31 Construction Management

K.1.2 Construction Cost

Construction costs were developed in MCACES/MII and include all major project components categorized under the appropriate CWWBS to the sub- feature level. The construction costs for dredging operations were developed using the Cost Engineering Dredge Estimating Program (CEDEP) and then transferred into the MCACES/MII estimates. Total Project Costs on each plan contain contingencies that were in accordance with the requirements of ER 500-1-1 which set a maximum contingency for dredging projects at 15%.

K.1.3 Non-construction Cost

Non-construction costs typically include Lands and Damages (Real Estate), Engineering & Design (E&D) and Construction Management Costs (Supervision & Administration, S&A). These costs were provided by the Project Manager and appropriate PDT members as a lump sum cost. The lump sum amount has been checked to ensure that it is within the maximum six percent of the construction contract costs as specified in ER 500-1-1 Section 5. Lands and Damages cover the real estate administration costs necessary for verifying easements prior to award of the construction contract. This allows the contractor to access the beach and use as an equipment laydown area. Engineering and Design (E&D) costs for the preparation of contract plans and specifications (P&S) have been provided by the project manager as a lump sum. Construction Management (S&A) costs are for the supervision and administration of the contract required to perform the various aspects of construction required for this project and includes Project Management, Construction Quality Assurance and Contract Administration costs. These costs were provided by the project manager based upon recent similar projects.

K2. PIR COST ESTIMATES

Cost estimates for the alternative plans were generated based on quantities derived from the post-storm surveys taken after the significant storm event and comparing these surveys to (a) pre-storm conditions, (b) the design template for the protective beach system and (c) the design template for the protective beach system including advanced maintenance which is the periodic renourishment quantity. These quantities were used to derive cost estimates that reflect as best as possible the conditions expected in each of the alternatives of this project.

K.2.1 Design Template Cost Estimate

The following table provides a cost estimate for placing 353,119 CY of sand on the damaged areas of the beach by utilizing a dredge plant and associated equipment with borrow material being taken from an Egmont Shoal. Egmont Shoal is approximately 12 miles from the southernmost portion of Sand Key. Historically this work has been completed using a clamshell or cutter suction dredge, with a spider barge and scows for hauling material. This is the quantity required to return the project to the design template for the protective berm. The cost includes mobilization/demobilization of the dredge plant and associated equipment, dredging of material, placement on the beach, environmental monitoring, beach tilling, vibration monitoring, surveys, etc. Additionally, non-construction costs include real estate costs, design costs and construction management costs. The MII estimate for this alternative is contained on the following pages.

WBS Code	Project Feature	Restore Post Storm to Design Template Cost
17	Mobilization and Demobilization	$4,209,000
17	Beach Replenishment	$10,331,000
17	Associated General Items	$459,000
1	Lands and Damages	$33,000
30	Engineering and Design	$110,000
31	Construction Management	$330,000
	Total Cost	**$15,472,000**

K.2.2 Full Construction Template Cost Estimate

The following table provides a cost estimate for placing 877,819 CY of sand along the entire project limits with borrow material being taken from an Egmont Shoal. This is the quantity required to return the project to the full construction template for the protective berm and includes advanced maintenance which is the periodic renourishment quantity. The cost includes mobilization/demobilization of the dredge plant and associated equipment, dredging of material, placement on the beach, environmental monitoring, beach tilling, vibration monitoring, surveys, etc. Additionally, non-construction costs include real estate costs, design costs and construction management costs. The MII estimate for this alternative is contained on the following pages.

WBS Code	Project Feature	Restore to Full Construction Template
17	Mobilization and Demobilization	$4,209,000
17	Beach Replenishment	$26,423,000
17	Associated General Items	$458,000
1	Lands and Damages	$33,000
30	Engineering and Design	$110,000
31	Construction Management	$330,000
	Total Cost	**$31,563,000**

Pinellas County, Florida Hurricane and Storm Damage Reduction Project. Estimate associated with Project Information Report resulting from Hurricane Hermine.

Estimated by EN-TC (Tony Ledford)
Designed by Jacksonville District
Prepared by EN-TC (Tony Ledford)
Preparation Date 10/15/2016
Effective Date of Pricing 10/1/2016
Estimated Construction Time Days

Date	Author	Note
10/14/2016 10:51:06 AM	T. Ledford	**116684 PINELLAS SAND KEY FY17 BUDGET ESTIMATES TO SUPPORT PROJECT INFORMATION REPORT (PIR) IN RESPONSE TO DAMAGES SUSTAINED FROM HURRICANE HERMINE.**

THIS MII PROVIDES A COMPARISON BETWEEN A RENOURISHMENT TO GO FROM POST STORM TO DESIGN BERM (AKA FCCE RENOURISHMENT) AND TO GO FROM POST STORM TO FULL CONSTRUCTION TEMPLATE (AKA FULL RENOURISHMENT).

This MII estimate is based upon the budget submission MII baseline estimate which was certified in FY16 for the FY18 Budget Submission. Since the previous estimate was updated within 1 year (2 years or less) no update of labor, equipment, and materials is necessary. The estimate has used CWCCIS escalation to bring the cost from FY16 to FY17 price levels. Unnecessary folders associated with the FY18 Budget Submission have been omitted from the MII file.

This project was last renourished in 2012 by Norfolk Dredging Company.

Acquisition Plan: The most likely acquisition plan at this point is would be a IFB. The MATOC Group 4 would typically be the acquisition strategy, however, since it is set to expire within the FY this may not be the most likely case. This has been used on multiple occasions by SAJ on shore protection, hurricane and storm damage reduction, and navigation projects.

Sub-contracting Plan: Subcontracting of environmental monitoring and vibration monitoring has been assumed within the estimate. All other work has been assumed to be completed by the prime dredging contractor.

Scope of Work Overall Project: The Pinellas County Sand Key Segment requires 5 additional renourishments to take the project to the end of Federal participation in 2043. The project begins at Clearwater Beach and extends south to North Redington Beach. The constructed berm will have a minimum elevation of 4.1 feet NAVD88 with a 0.5' fill tolerance. The beach fill material will most likely come from Egmont Shoal Borrow Area approximately 22 miles from the northern project segments.

Scope of Work for the PIR:
The PIR considers two scenarios. One to renourish with the quantity of beach fill necessary to restore/rehab the beach from the post storm condition to the design berm. This would have no impact on the currently schedule renourishment layout for the remaining project life. The second scenario would be to rehab and renourish with the quantity of beach fill necessary to restore the beach from the post storm condition to the full construction template. This could potentially shift the renourishment intervals on year sooner. However, this is unlikely based taking into consideration the timeframe for receipt of funds and execution of the work.

Documents Used as the Basis for this Estimate: 1997 DM/ FY18 Budget Submission SOW/ FY17 PIR

Date **Author** **Note**

Narrative and Analytical Description on Rate/Price/Cost Development:
The costs for this project have been developed in CEDEP based upon historic project contract production. Prices from CEDEP for dredging and mobilization/demobilization work were transferred into MII where the remaining cost development was completed.

Analysis of Historic Pricing:

Review of the last renourishment abstract of offers was performed and an aggregate unit price was calculated taking the total average bid price divided by the bid quantity. This aggregate unit price was then escalated from FY11 price level to FY16 price level using 30 SEP 15 CWCCIS factors. The adjusted average unit price which contains both profit and contingency was calculated to be approximately $30.16. The aggregate estimated cost in the FY18 Budget Submission MII (total contract cost divided by the quantity) is calculated to be $32.55/CY without application of contingency. This serves as a check of the reasonableness of the current working estimate being used to support the FY18 Budget Submission. See the "BID EVALUATION_PINELLAS_SAND KEY_BudgSubmTest.xlsx" in the estimate backup. Additionally, reference the 1700 level folder in this estimate for the calculated aggregate unit price in the MII estimate.

Based upon previously chose equipment by Contractors a spider barge configuration has been assumed. This same equipment choice was utilized during the 2012 contract.

Dredging Costs were developed using the Spider CEDEP spider_120213A (Cost Engineering Dredge Estimate Program). (See ETL 1110-2-573, Appendix D-4d.)

Mobilization and Demobilization - (See ETL 1110-2-573, Appendix D-11):
The cost for mobilization and demobilization was developed within CEDEP and accounts for preparing the dredges and attendant plant for transfer, mobilization transfer costs, preparing plant for work, site preparation, demobilization of plant, demobilization transfer costs. A mobilization distance of 1000 miles was assumed to the job and 500 miles away from the job. This accounts for the location of plants owned by multiple contractors either in the Gulf of Mexico or along the Eastern United States.

Associated Work Items - (See ETL 1110-2-573, Appendix D-2):
Work includes, but is not limited to; beach tilling, construction/vibration controls and monitoring, and turbidity monitoring.

Quantity Calculations/Sources:
Quantities for the periodic renourishment/advanced fill were taken from the 1997 DM and reviewed by Kevin Hodgens, EN-WC and

Date Author Note

Jim Lagrone, EN-DW. Quantities for the post storm to design are based upon recent survey data provided by the Non-Federal Sponsor Pinellas County. This data was analyzed by Drew Condon, EN-WC and Jim Lagrone, EN-DW to to determine the necessary quantity to restore from post storm to the design berm.

Effective Dates for Labor, Equipment and Material Pricing: 2016

Supporting Databases:
MII English Cost Book 2012-b, MII Equipment 2014 Region 3, MII Labor Library Florida 2016

Major Project Features:
Mobilization/Demobilization, Excavation, Beach Fill, Beach Tilling, Vibration Controls and Monitoring, Endangered Species Monitoring, Turbidity Monitoring

Construction Schedule (including date of mid-point of construction):

FCCE Rehabilitation (Post Storm to Design)

Commencement: 45 Days (Includes mobilization)
Construction: Approximately 1.81 MOs - 56 Days, Assume 60 Days
Demobilization: 10 Days
Total: 115 Calendar Days from NTP

FULL Renourishment (Post Storm to Full Construction Template)

Commencement: 45 Days (Includes mobilization)
Construction: Approximately 4.5 MOs - 137 Days, Assume 140 Days
Demobilization: 10 Days
Total: 195 Calendar Days from NTP

Construction Windows: None
Escalation: None applied within MII. Escalation has been applied within the TPCS.

General Assumptions:
1. Taxes: 7%

Date Author Note

2. FOOH: 10%
3. HOOH: 6.5%
4. Profit: 10%
5. Bond: 1.5%
6. Price Level: 2017

7. Contingency: Contingency of 15% has been applied to dredge mobilization/demobilization costs, beach fill costs, and other associated construction costs. Contingency of 10% has been applied for all other allowable costs. Contingency in these amounts has been included based on EP 500-1-1 (30 Sep 01), Section 5-18, page 5-37 and ER 500-1-1 (30 Sep 01), Section 5, page 5-5.

8. PED costs: A lump sum PED amount has been provided by the PM Laurel Reichold. The lump sum amount has been checked to ensure that it is within the maximum of six percent of the construction cost since in this case since the construction cost is greater than $100,000. Reference ER 500-1-1 (30 Sep 01), Section 5, page 5-5.

9. S&A costs: A lump sum S&A amount has been provided by the PM Laurel Reichold. The lump sum amount has been checked to ensure that it is within the maximum of six percent of the construction cost since in this case since the construction cost is greater than $100,000. Reference ER 500-1-1 (30 Sep 01), Section 5, page 5-5.

Site Access: Site access has previously been provided along each project segment.

Borrow Areas: Egmont Shoal has been assumed for future renourishments. This borrow area has been used for other segments of Pinellas County successfully.

Weather Days: This has been accounted for using historical production and through rounding of estimated construction durations.

Unique Construction Techniques: None

Equipment and Labor Availability and Distance Traveled: It is likely that equipment will be available for this project. However, it is uncertain at this point how many FCCE emergency contracts there could be along the East Coast of the U.S as a result of Hurricane Matthew. This could have an impact

Environmental Concerns during Construction: Weather if work is completed during hurricane season.

Volatile Cost Items: Fuel, Quantity of material required to fill beach template, Limited contractor resources (see equipment availability

Date	Author	Note
		discussed above)

Description	Quantity	UOM	CostToPrime	ContractCost	Escalation	Contingency	ProjectCost
Project Cost Summary Report			31,534,103	40,245,596	689,248	6,097,227	47,032,071
Alternative Projects	1.00	LS	31,534,103	40,245,596	689,248	6,097,227	47,032,071
FCCE Renourishment (Post Storm to Design)	1.00	LS	10,417,606	13,246,685	224,292	1,999,147	15,470,124
Construction Cost	1.00	LS	9,987,606	12,816,685	224,292	1,956,147	14,997,124
17 Beach Replenishment	1.00	LS	9,987,606	12,816,685	224,292	1,956,147	14,997,124
			28.28	*36.30*			*42.47*
1700 Beach Replenishment	353,119.00	CY	9,987,606	12,816,685	224,292	1,956,147	14,997,124
170001 Mob, Demob & Preparatory Work	1.00	LS	2,799,420	3,596,343	62,936	548,892	4,208,171
Dredge Mob/Demob	1.00	LS	2,608,155	3,352,490	58,669	511,674	3,922,832
Shore Equipment Mob/Demob	1.00	LS	23,378	30,050	526	4,586	35,162
			167,887.12	*213,803.96*			*250,177.36*
Preparatory Work and Associated General Items	1.00	EA	167,887	213,804	3,742	32,632	250,177
			20.36	*26.11*			*30.55*
Aggregate Beach Fill Cost (Exc., Placement, & Assoc. Items)	353,119.00	CY	7,188,186	9,220,342	161,356	1,407,255	10,788,953
			17.50	*22.49*			*26.32*
170014 Special Purpose Dredge	353,119.00	CY	6,179,583	7,943,157	139,005	1,212,324	9,294,487
			1.95	*2.51*			*2.93*
170070 Beach Operation	353,119.00	CY	689,034	885,675	15,499	135,176	1,036,350
170099 Associated General Items	1.00	LS	319,570	391,510	6,851	59,754	458,116
Non-Construction Cost	1.00	LS	430,000	430,000	0	43,000	473,000
30 Engineering and Design (E&D)	1.00	LS	100,000	100,000	0	10,000	110,000
31 Supervision and Administration (S&A)	1.00	LS	300,000	300,000	0	30,000	330,000
01 Lands and Damages	1.00	LS	30,000	30,000	0	3,000	33,000
0123 Construction Contract Documents	1.00	LS	30,000	30,000	0	3,000	33,000
Full Renourishment (Post Storm to Construction Template)	1.00	LS	21,116,497	26,998,911	464,956	4,098,080	31,561,947
Construction Cost	1.00	LS	20,686,497	26,568,911	464,956	4,055,080	31,088,947
17 Beach Replenishment	1.00	LS	20,686,497	26,568,911	464,956	4,055,080	31,088,947
			23.57	*30.27*			*35.42*
1700 Beach Replenishment	877,819.00	CY	20,686,497	26,568,911	464,956	4,055,080	31,088,947
170001 Mob, Demob & Preparatory Work	1.00	LS	2,799,420	3,596,343	62,936	548,892	4,208,171
Dredge Mob/Demob	1.00	LS	2,608,155	3,352,490	58,669	511,674	3,922,832
Shore Equipment Mob/Demob	1.00	LS	23,378	30,050	526	4,586	35,162
			167,887.12	*213,803.96*			*250,177.36*
Preparatory Work and Associated General Items	1.00	EA	167,887	213,804	3,742	32,632	250,177
			20.38	*26.17*			*30.62*
Aggregate Beach Fill Cost (Exc., Placement, & Assoc. Items)	877,819.00	CY	17,887,077	22,972,568	402,020	3,506,188	26,880,776

Description	Quantity	UOM	CostToPrime	ContractCost	Escalation	Contingency	ProjectCost
			17.46	*22.44*			*26.26*
170014 Special Purpose Dredge	**877,819.00**	**CY**	**15,326,720**	**19,700,772**	**344,764**	**3,006,830**	**23,052,366**
			2.55	*3.28*			*3.84*
170070 Beach Operation	**877,819.00**	**CY**	**2,240,884**	**2,880,404**	**50,407**	**439,622**	**3,370,433**
170099 Associated General Items	**1.00**	**LS**	**319,473**	**391,392**	**6,849**	**59,736**	**457,978**
Non-Construction Cost	**1.00**	**LS**	**430,000**	**430,000**	**0**	**43,000**	**473,000**
30 Engineering and Design (E&D)	**1.00**	**LS**	**100,000**	**100,000**	**0**	**10,000**	**110,000**
31 Supervision and Administration (S&A)	**1.00**	**LS**	**300,000**	**300,000**	**0**	**30,000**	**330,000**
01 Lands and Damages	**1.00**	**LS**	**30,000**	**30,000**	**0**	**3,000**	**33,000**
0123 Construction Contract Documents	**1.00**	**LS**	**30,000**	**30,000**	**0**	**3,000**	**33,000**

Appendix L. BCR Data

Alternative One – FCCE Restoration Only BCR Calculation Table

PROJECT: Pinellas County - Sand Key Segment		
	Values	***Notes***
Current Price Level	**Oct-17**	*2017*
Project Base Year	**1994**	
Period of Analysis (Yrs)	**6**	*Minimum time estimated before next periodic nourishment is* ***constructed***
Cost Estimate- Emergency Restoration to Design Template	**$15,472,000**	*Cost for Emergency Restoration including Mob and DeMob from EN-C*
Authorizing Document Price Level	**Mar-96**	*1997 Design Memorandum linked to in cell C26*
EM 1110-2-1304 Current Price Level Beach Replenishment Index Value (1Q 17)	**883.73**	CWCCIS Beach Replenishment March 31, 2016
EM 1110-2-1304 Authorizing Document Price Level Beach Replenishment Index Value (2Q 96)	**486.02**	CWCCIS Beach Replenishment March 31, 2016
Ratio of Authorized to Current Price Level (Deflation)	**0.550**	
Cost Estimate- Emergency Restoration to Design Template (Deflated)	**$8,509,049**	
FY 2017 Discount Rate	**2.8750%**	
Capital Recovery Factor (Remaining Project Life)	**0.183833**	
Annualization of Cost Estimate-Emergency Restoration (Deflated)	**$1,564,248**	
Volume Required to Restore Design Template (CY)	**353,119**	*Based on USF surveys verified by EN-WC*
Authorized Project Design Profile (Cubic Yards)	**1,088,200**	*Volume of Design Fill required for entire Sand Key Project on which benefits are based from Table 1 on page 8 of the 1997 Design Memorandum linked to in cell C26*

Ratio of Lost Sand From Storm versus Authorized Project Sand Quantity	**32.45%**	
Authorized Project Design Profile: Storm Damage Reduction Annualized Benefits	**$26,625,600**	*This is only storm damage prevention benefits and does not include recreation benefits. From 1997 Design Memo linked in cell C26*
(Authorizing Document Price Level)		
Annualized Benefits Estimation (Proxy Value) from Emergency Restoration	**$8,639,961**	
to Pre-Storm Profile		
Benefit-Cost Ratio	**5.52**	
Net Benefits	**$7,075,713**	
		1997 Design Memorandum

Alternative Two – Remaining Project Cost Stream from FY18

Year	Cost	Event
2018	$31,563,000	4th Renourishment + FCCE Restoration
2019	$86,140	
2020	$86,140	
2021	$76,700	
2022	$1,244,900	
2023	$21,379,436	5th Renourishment
2024	$86,140	
2025	$86,140	
2026	$76,700	
2027	$1,244,900	
2028	$21,379,436	6th Renourishment
2029	$86,140	
2030	$86,140	
2031	$76,700	
2032	$1,244,900	
2033	$21,379,436	7th Renourishment
2034	$86,140	

2035	$86,140	
2036	$76,700	
2037	$1,244,900	
2038	$21,379,436	8th Renourishment
2039	$86,140	
2040	$86,140	
2041	$76,700	
2042	$76,700	
2043	$76,700	
Total	**$123,458,645**	

Alternative Two - BCR Table

	Current Rate (FY17)
Rate:	2.875%
Total Present Value:	**$53,316,097**
IDC	
Amortized:	**$2,866,157**
AAEQ Benefits	**$26,625,600**
Total BCR	**9.29**

Appendix M. Environmental Considerations

The PIR Format in EP 500-1-1 Figure 5-8 requires that specific statements for tabs M-1 to M-6 be provided in Appendix M.

Tab M-1. A statement on the effect of proposed work on the environment.
- See section 16, paragraphs a and b.

Tab M-2. Environmental Assessments (2011; 2002; 1997) and an Environmental Impact Statement for this project have been completed.
- The 2011 EA can be viewed at the following link:
http://www.saj.usace.army.mil/About/Divisions-Offices/Planning/Environmental-Branch/Environmental-Documents/

Tab M-3. Considerations under Section 7 of the Endangered Species Act of 1973 (PL 93-205).
- See section 16, paragraph f.

Tab M-4. Archeological Investigations.
- See section 16, paragraph g.

Tab M-5. Section 404(b) evaluations.
- See section 16, paragraph h.

Tab M-6. A statement on the applicability of EO 11988.
- The proposed project is in the base flood plain (100-year flood) and has been evaluated in accordance with Executive Order 11988. The proposed work is within the same footprint as the existing Federal Pinellas County shore protection project that has been found to be in compliance with Executive Order 11988. The USACE has considered alternatives to avoid adverse effects and incompatible development in the floodplain.

Tab M-7. Coastal Barrier Resource Act
- See section 16, paragraph j.

Tab M-8. Essential Fish Habitat
- See section 16, paragraph k.

Tab M-9. Water Quality Certificate
- See section 17.

Appendix N. Sample Department of the Army Right-of-Entry for Construction

PERPETUAL STORM DAMAGE REDUCTION EASEMENT

This Perpetual Storm Damage Reduction Easement (this "Easement") is made as of this _____ day of ________________, 2016, by and between DANILO FERNANDEZ, JR., LLC, a Florida limited liability corporation ("GRANTOR"), and PINELLAS COUNTY, FLORIDA, a political subdivision of the State of Florida ("GRANTEE"). GRANTOR and GRANTEE together shall be known as the "Parties."

WITNESSETH:

WHEREAS, GRANTOR is the owner of beachfront property located at 18812 Gulf Boulevard, Indian Shores, FL 33785 (Parcel ID# 30-30-15-42822-002-0110) and recorded at Pinellas County O.R. 18120, Page 408;

WHEREAS, GRANTEE and the U.S. Army Corps of Engineers have entered into a Cooperation Agreement for the Federal Sand Key Shore Protection Project (the "Project") whereby GRANTEE has agreed to be the Local Sponsor for the Project, which provides for beach nourishment and other shoreline protection measures in the Sand Key region;

WHEREAS, as Local Sponsor for the Project, GRANTEE is seeking to obtain "perpetual storm damage reduction" easements from owners of property in the Sand Key region such as GRANTOR; and

WHEREAS, it is in GRANTOR's interest to grant this Easement to prevent storm damage and restore adjacent beach.

NOW THEREFORE, in consideration of the mutual benefits to be derived from the permitted uses described below and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, GRANTOR does hereby bargain, convey, and grant a perpetual and assignable easement in, on, over, and across the land described and depicted as "Proposed Easement SK-358" in Exhibit A, which is attached hereto and incorporated herein, for use by GRANTEE, its representatives, agents, contractors, and assigns to:

a) construct, preserve, patrol, operate, maintain, repair, rehabilitate, and replace a public beach, a dune system, and other erosion control and storm damage reduction measures together with any appurtenances and operations in support thereof, including but not limited to the right to deposit sand;
b) accomplish any alterations or contours needed;
c) construct berms and dunes;

d) nourish and renourish periodically;
e) move, store, and remove equipment and supplies;
f) erect and remove temporary structures;
g) perform any other work necessary and incident to the construction, periodic renourishment, and maintenance of any use permitted in this Easement, together with the right of public use and access;
h) plant vegetation on dunes and berms;
i) erect, maintain, and remove silt screen and sand fences;
j) facilitate preservation of dunes and vegetation through limitation of access to dune areas; and
k) trim, cut, fell, and remove all trees, underbrush, debris, obstructions, and any other vegetation, structures, and obstacles.

GRANTOR its successors and assigns reserve the right to construct dune walkover structures in accordance with any applicable Federal, State, or local laws or regulations, provided that:

a) such structures shall not violate the integrity of the dune in shape, dimension, or function;
b) prior written approval of the plans and specifications for such structures is obtained from the County Administrator of Pinellas County, Florida, or his/her designee; and
c) such structures are subordinate to any construction, operation, maintenance, repair, rehabilitation, and replacement of any use permitted in this Easement, which may require removal of such structures at GRANTOR'S expense.

GRANTOR its successors and assigns further reserve all such rights and privileges as may be used and enjoyed by a fee owner without interfering with or abridging any right or privilege acquired by GRANTEE in this Easement, subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

GRANTOR shall not commit any act that interferes with any right or privilege acquired by GRANTEE in this Easement including but not limited to removing or placing any sand, vegetation, or other substance inside or outside Proposed Easement SK-385 to the extent such placement or removal interferes with any right or privilege acquired by GRANTEE in this Easement, unless such act is compliant with any applicable local, State, and Federal laws and is properly permitted by all appropriate local, State, and Federal agencies with permitting jurisdiction over such activities.

The Parties agree to be responsible for their own acts of negligence when acting within the scope of this Easement and agree to be liable for any damages resulting from said negligence. Nothing herein is intended to be a waiver of sovereign immunity by GRANTEE. Nothing herein shall be construed as consent by either party to be sued by third parties in any manner arising out of this Easement.

This Easement shall become effective upon proper execution by GRANTOR.

The covenants, rights, privileges, restrictions, and reservations set forth herein shall run with the land.

The terms and conditions of this Easement shall be deemed severable. Consequently, if any term or condition in this Easement shall be held illegal or void, such determination shall not affect the validity or legality of the remaining terms and conditions, and not withstanding any such determination, this Easement shall continue in full force and effect unless the particular term or condition held illegal or void renders the balance of the Easement impossible to perform.

IN WITNESS WHEREOF, GRANTOR has signed and sealed these presents the day and year first above written.

Signed, sealed and delivered in the presence of:

______________________________ Witness #1 Signature	GRANTOR:
______________________________ Witness #1 Printed Name	______________________________ Danilo Fernandez Jr., Manager DANILO FERNANDEZ JR., LLC 18812 Gulf Boulevard Indian Rocks, FL 33785
______________________________ Witness #2 Signature	
______________________________ Witness #2 Printed Name	

STATE OF FLORIDA)
) SS
PINELLAS COUNTY)

The foregoing instrument was acknowledged before me this ____ day of ______________, 2016, by ___________________________, who appeared before me, and is personally known to me, or has produced ____________________ as identification and did take an oath.

My Commission Expires: NOTARY:

____

Print Name: _________________________

Notary Public, State of Florida at Large

ProLaw Doc No 59850

Appendix O – Y

Not applicable.

Appendix Z. PIR Review Checklist