

*Hurricane Michael Post-Storm
Beach Conditions and Coastal Impact Report*

**Division of Water Resource Management
Florida Department of Environmental Protection**

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I. Introduction

Hurricane Michael made landfall on October 10, 2018, in northwest Florida at Tyndall Air Force Base. At landfall, Hurricane Michael was a strong Category 4 hurricane on the Saffir-Simpson hurricane intensity scale. Hurricane Michael substantially impacted the coast from Panama City Beach to St. Marks. This report documents the impact of Hurricane Michael on the beaches, dunes, and coastal construction. It will assist the Florida Department of Environmental Protection (Department) and local governments to identify areas where storm erosion has left upland development and infrastructure vulnerable to imminent damage from future storms, where beaches and dunes may be restored, and where expedited permitting procedures are needed to assist homeowners with repairs and reconstruction.

The Department developed this Post-Storm Beach Conditions and Damage Assessment Report to quantify the damages caused by Hurricane Michael. This report provides an assessment of storm impact, beach and dune erosion, and structural damages to the coast of northwest Florida. Although extensive structural damage occurred well inland of the coast, the damage assessment in this report specifically focuses on damage within the Coastal Building Zone, as defined in Chapter 161, Florida Statutes.

Following the impact of Hurricane Michael, damage assessment teams from the Department collected field data in Bay, Gulf, Franklin, and Wakulla Counties. Detailed damage assessments were conducted of all construction within the Coastal Building Zone. The damage assessment teams from the Department included Ralph Clark, P.E., Coastal Engineer; Mike Manausa, Coastal Engineer; Guy Weeks, Planning Manager; Tyler Boland, Surveyor; Peter Bacopoulos, P.E., Coastal Engineer; Shane Duinkerken, Surveyor; Jennifer Steele, P.G., Coastal Geologist; Kevin Smith, Surveyor; and Keith Davie, Engineer.

In addition to the field data assessments, post-storm vertical aerial photography provided by the National Oceanic and Atmospheric Administration (NOAA) assisted the assessments of coastal conditions.

This post-storm report provides photographs taken by the damage assessment teams of some of the damage and beach erosion conditions relevant to the hurricane impact discussions. For additional Hurricane Michael photography obtained by the damage assessment teams, readers are referred to the Department's "Collection of Aerials and Shoreline Trends System" ([C.O.A.S.T.S.](#)) webpage.

II. Hurricane Michael, October 7-12, 2018

Hurricane Michael, the thirteenth storm of the 2018 hurricane season for the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico, spawned from a tropical depression in the northwestern Caribbean Sea off the coast of the Yucatan Peninsula on Sunday, October 7, 2018. At 11:55 AM CDT, satellite wind data indicated that the depression had strengthened into the season's thirteenth tropical storm. The maximum sustained winds were estimated to be 40 mph with higher gusts. At 10:00 PM CDT, Tropical Storm Michael was moving at 5mph toward the north over the Yucatan Channel between the coast of Mexico and Cuba, with maximum sustained winds near 60 mph.

Michael intensified overnight, and at 10:00 AM CDT on Monday, October 8, Michael became a Category 1 hurricane on the Saffir-Simpson hurricane intensity scale, with maximum sustained winds of 75 mph. Hurricane-force winds extended 30 miles from the center, and tropical-storm-force winds extended 175 miles. Hurricane Michael continued to move northward near the western tip of Cuba and into the southeastern Gulf of Mexico. The estimated minimum central pressure based on Air Force Reserve reconnaissance data was 982 millibars.

Hurricane Michael continued to intensify throughout the evening and into Tuesday, October 9. By 7:00 AM CDT, Michael had intensified to a Category 2 hurricane with maximum sustained winds near 100 mph. The minimum central pressure reported by NOAA aircraft was 968 millibars and the hurricane was moving toward the north-northwest near 12 mph. Hurricane-force winds extended 40 miles from the center and tropical-storm-force winds extended 195 miles. In the southern Gulf of Mexico, NOAA buoy 42003 reported one-minute mean winds of 47 mph and a wind gust of 54 mph. Hurricane Michael intensified throughout the day and by 7:00 PM CDT, the maximum sustained winds were reported to be near 120 mph with higher gusts, as Michael had become a Category 3 hurricane. The minimum central pressure based on data from an Air Force Reserve Hurricane Hunter aircraft was measured to be 953 millibars.

Rapid intensification continued Tuesday evening as Hurricane Michael tracked northward across the Gulf of Mexico at about 12 mph. Early Wednesday morning, October 10, at 1:00 AM CDT, data from Air Force Reserve and NOAA Hurricane Hunter aircraft indicated that the maximum sustained winds had increased to near 130 mph with higher gusts. Michael had become a dangerous Category 4 hurricane. The minimum central pressure was estimated to be 945 millibars. Hurricane-force winds extended 45 miles from the center and tropical-storm-force winds extended 175 miles. Landfall on the northwest coast of Florida was imminent. By 10:00 AM CDT, Hurricane Michael had intensified further

and had accelerated toward the north-northeast near 14 mph. Data from the Air Force Reserve Hurricane Hunter aircraft indicated that the maximum sustained winds were near 145 mph with higher gusts. The minimum central pressure had fallen to 928 millibars.

At 12:30 PM CDT, Wednesday, October 10, the eye of Hurricane Michael made landfall just northwest of Mexico Beach, Florida, across Crooked Island and Tyndall Air Force Base. Hurricane Michael continued to intensify at landfall with maximum sustained winds near 155 mph and higher gusts. A wind gust of 130 mph was reported at a University of Florida/Weatherflow observing site near Tyndall Air Force Base before the instrument failed. A wind gust to 129 mph was reported at the Panama City Airport. The minimum central pressure based on data from an Air Force Reserve reconnaissance aircraft was 919 millibars, making Hurricane Michael the third strongest hurricane to landfall in the continental United States in recorded history, dating back to 1851.

Hurricane Michael maintained its intensity as it crossed the Florida Panhandle and entered southwest Georgia. After Hurricane Michael was downgraded Wednesday afternoon, it became the first Category 3 hurricane to hit Georgia since 1898. A wind gust of 102 mph was measured at the airport in Marianna, Florida near the state line. To the east, a wind gust of 71 mph was measured at the Tallahassee airport. Hurricane Michael continued across Georgia Wednesday evening and Thursday before moving out into the Atlantic Ocean and dissipating on October 12.

Figure 1 illustrates the track history of Hurricane Michael combined with satellite imagery. This composite was developed by the Cooperative Institute of Meteorological Satellite Studies (CIMSS) at the University of Wisconsin – Madison.

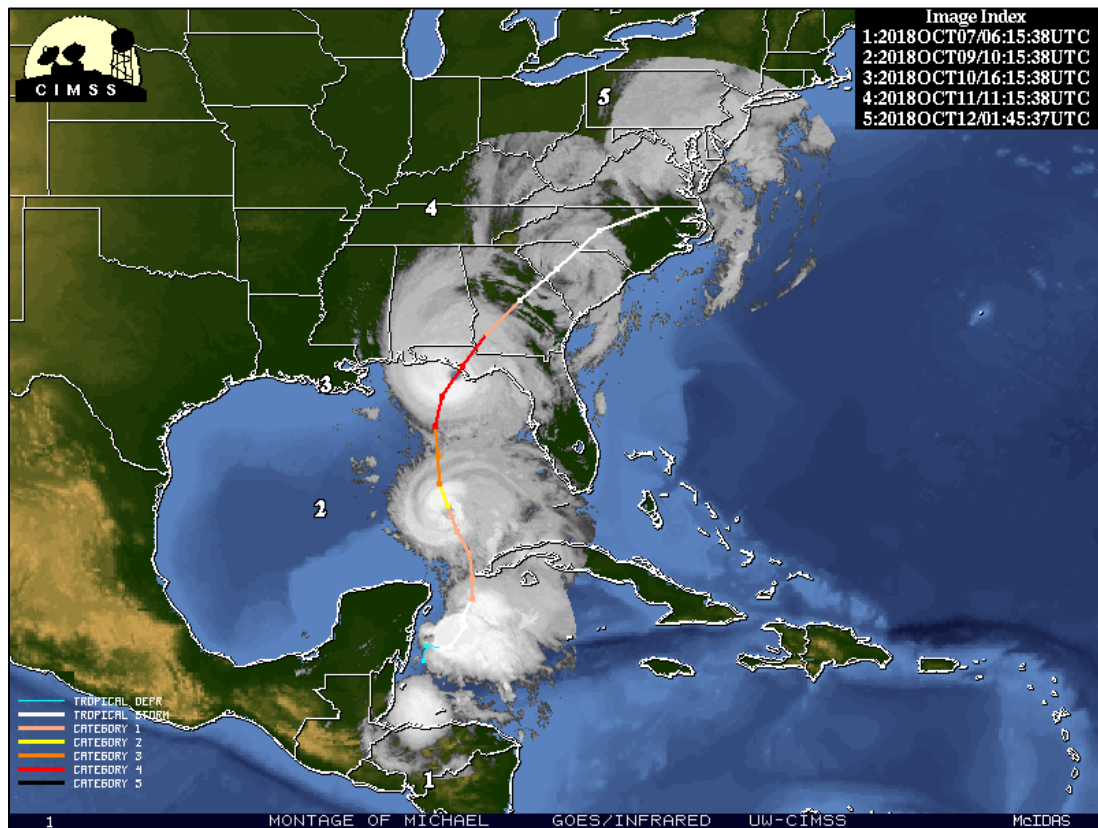


Figure 1. Hurricane Michael track with landfall in Bay County, Florida (Source: CIMSS/Univ. of Wisconsin-Madison).

Closer views of GOES-16 Visible and Infrared images (**Figure 2**) showed Hurricane Michael made landfall near Mexico Beach, Florida, at Tyndall Air Force Base around 12:30 PM CDT as a strong Category 4 hurricane with maximum sustained winds of 155 mph and a minimum central pressure of 919 millibars.

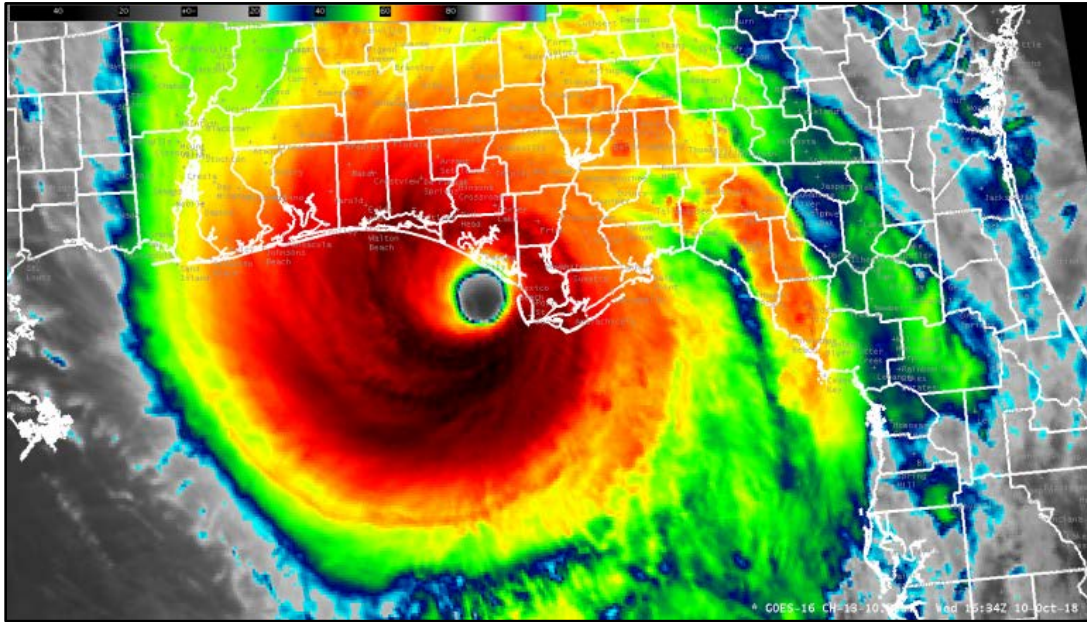


Figure 2. Hurricane Michael wind field during landfall in Bay County, Florida
(Source: CIMSS/Univ. of Wisconsin – Madison).

Wind gust data is available from reporting stations throughout Northwest Florida. **Figure 3** maps strategic wind data reports along the coast of Florida by presenting peak wind gusts from selected weather monitoring stations.



Figure 3. Hurricane Michael wind gusts data from recording stations [Data sources – NOAA and National Weather Service].

Storm tide data along northwest Florida is available from several of NOAA’s recording tide gauges. **Figure 4** shows a peak tide level of +8.6 feet NAVD was measured at the bay entrance of the Apalachicola River. In addition to NOAA tide gauges, the U.S. Geological Survey (USGS) deployed special storm-tide sensors that measured the height, extent, and timing of the storm tide. The storm tide, +15.6 feet above NAVD, was measured at the USGS Sensor Gauge tide station located at Mexico Beach shortly after Hurricane Michael’s landfall (**Figure 5**). Additional storm tide data from surveyed seaweed wrack lines and mud lines inside of buildings were available at some sites. The highest high-water mark, +21.2 feet NAVD, was recorded at the west end of Beacon Hill at the county line between Bay and Gulf Counties. Wave data from the National Data Buoy Center (NDBC) buoy station 42039, located offshore and south of Panama City, was available prior to gauge failure. A graph depicting the peak storm tide levels and wave height during Hurricane Michael is presented in **Figure 6**.

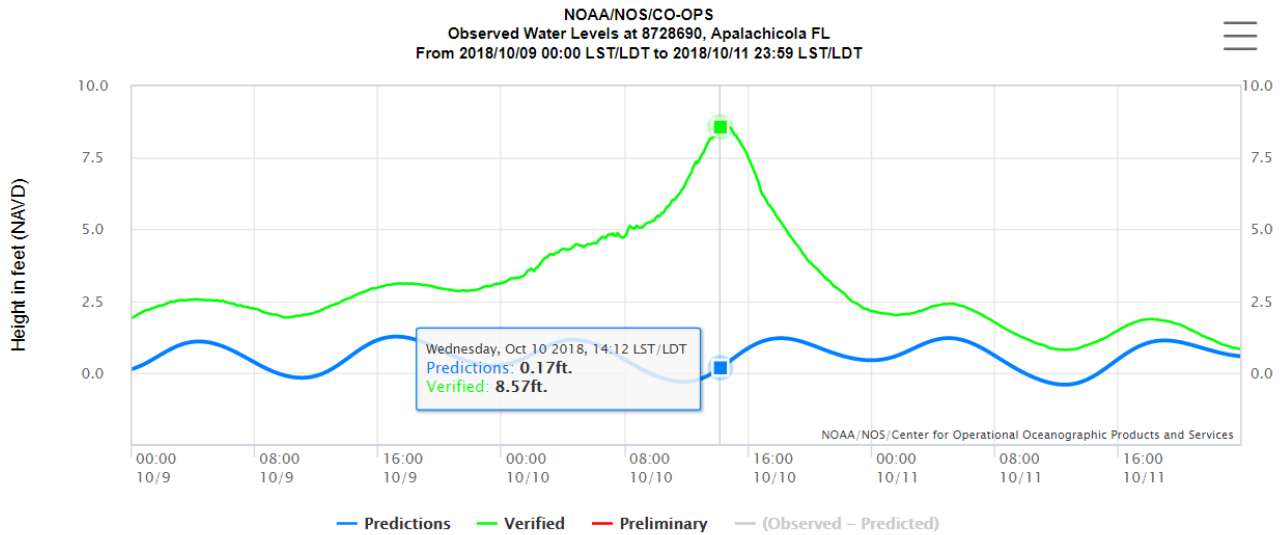


Figure 4. Measured storm tide levels at Apalachicola Bay during Hurricane Michael [Data from NOAA].

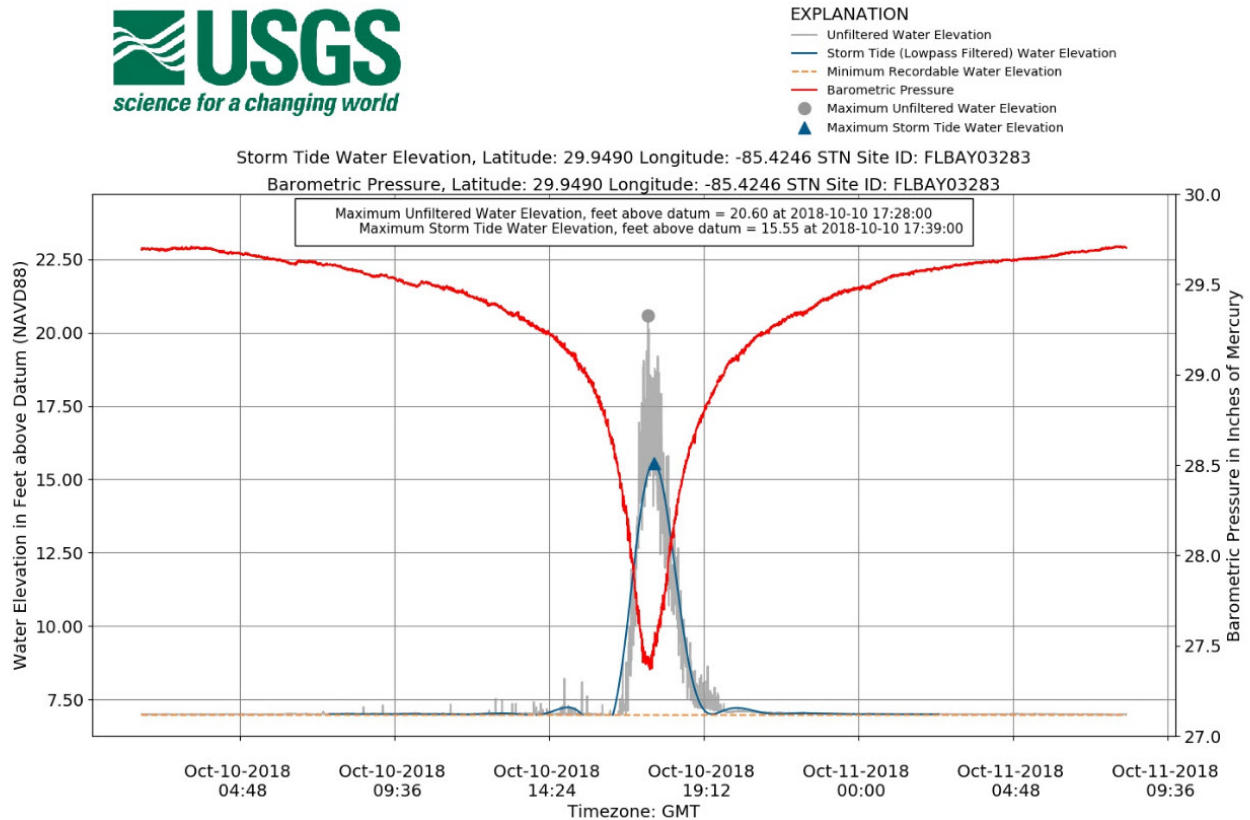


Figure 5. Measured storm tide levels at Mexico Beach during Hurricane Michael [Data from USGS].



Figure 6. Hurricane Michael peak storm tide levels and the maximum offshore wave height [Data sources – NDBC, NOAA and USGS].

III. Hurricane Michael Impact Summary and Overview

This section provides a summary of the beach and dune erosion, and structural damage, that occurred in the four substantially affected coastal counties: Bay, Gulf, Franklin, and Wakulla. **Table 1** lists beach and dune erosion conditions starting with Bay County and continuing eastward to Wakulla County. Areas with no erosion are listed as [-]. Reference or Range (“R”) monuments are historical survey markers established by the Department that are spaced approximately every 1000 feet to measure beach erosion. A graphic depiction of the classification of beach erosion conditions is provided in **Figure 7**.

Table 1. Post-storm beach and dune erosion summary.

Bay County

| Table 1. Post-Storm Beach and Dune Erosion Summary. | Reference Monuments | Erosion Condition |
|--|----------------------------|--------------------------|
| Panama City Beaches | R0 – R91 | I |
| St. Andrews State Park | R92 – R97 | III-IV |
| Shell Island | R98 – V009 | IV |
| Crooked Island | V009 – R127 | IV |
| Mexico Beach | R127 – R144 | IV |

Gulf County

| Locations | Reference Monuments | Erosion Condition |
|--|----------------------------|--------------------------|
| Beacon Hill | R1 – R13 | IV |
| Windmark | R14 – R31 | II |
| St. Joseph Peninsula, including State Park | R32 – R105 | IV |
| Cape San Blas – west shore | R106 – R118 | IV |
| Cape San Blas – east shore | R119 – R133 | II |
| Indian Peninsula | R134 – R159 | II |
| Indian Pass | R159 – R161 | IV |

Franklin County

| Locations | Reference Monuments | Erosion Condition |
|---|----------------------------|--------------------------|
| St. Vincent Island | V301 – V345 | IV |
| Cape St. George Island State Preserve | R1 – R51 | IV |
| St. George Island Plantation | R52 – R73 | IV |
| St. George Island, including State Park | R73 – R148 | IV |
| Dog Island | R150 – R192 | IV |
| Alligator Point | R195 – R209 | II |
| Southwest Cape | R209 – R217 | III |
| Lighthouse Point to Bald Point | R217 – R239 | II |

Wakulla County

| Locations | Reference Monuments | Erosion Condition |
|----------------------------|----------------------------|--------------------------|
| Mashes Sands – south beach | N.A. | IV |
| Mashes Sands – east beach | N.A. | II |
| Shell Point – west beach | N.A. | - |
| Shell Point – east beach | N.A. | I |

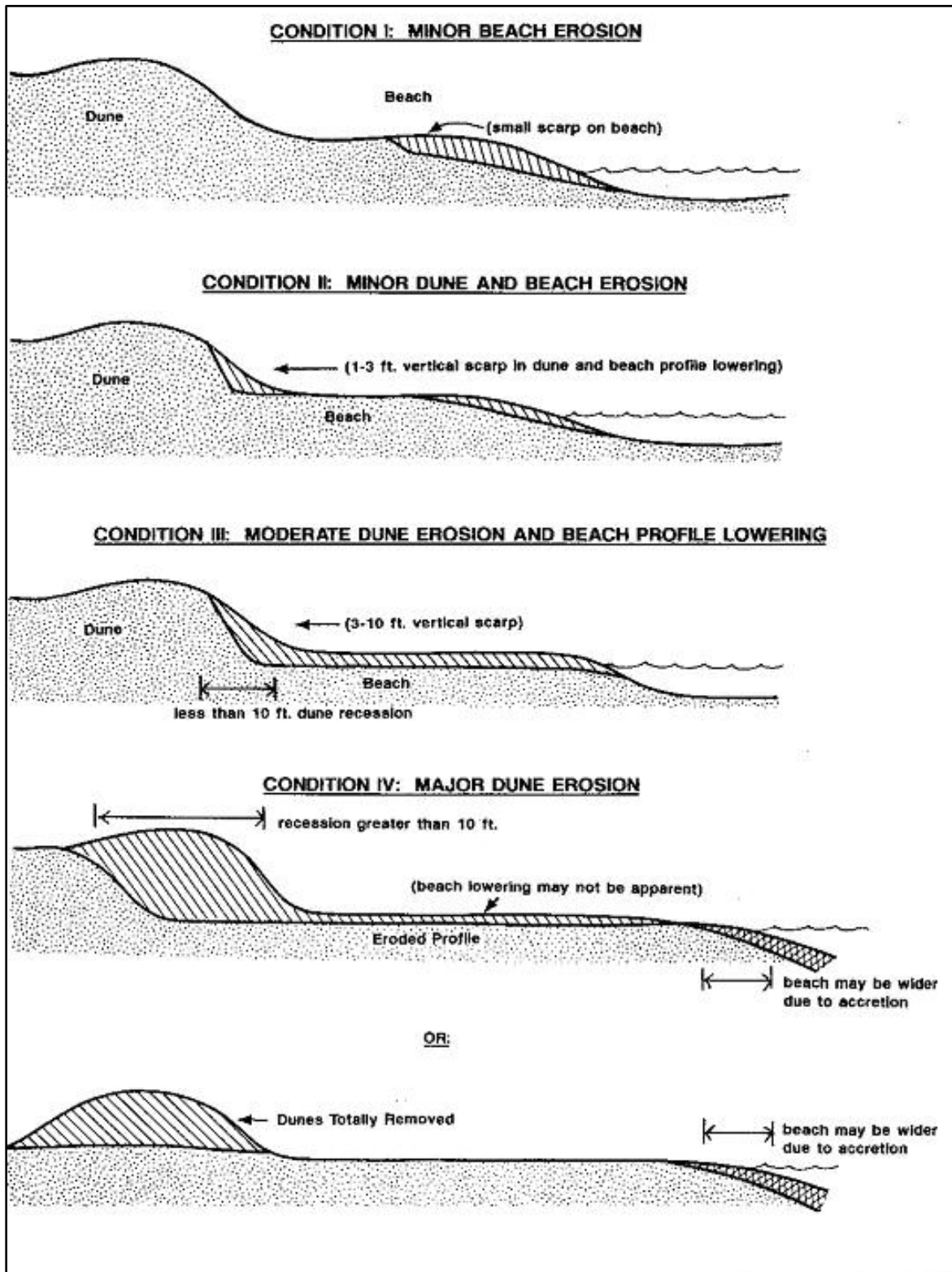


Figure 7. Post-storm beach and dune erosion conditions (I to IV).

Major Structural Damage

An overall summary of structural damage to major structures is given in **Table 2**. A summary of damage to coastal armoring, including seawalls, bulkheads, retaining walls, revetments, sills, or other rigid coastal protection structures, is provided in **Table 3**. Not included in this table is damage to rigid shore-protection structures like groins and breakwaters, or navigation structures like jetties. A more detailed description of these impacts by specific location is provided in Section IV of this report. **Figure 8** provides an aerial photo comparison of the worst impacted segment of coastal damage as seen in Mexico Beach, Bay County.

Table 2. Summary of major structural damage to major structures in the Coastal Building Zone by Hurricane Michael in northwest Florida.

| County | # Single-Family Dwellings Damaged | # Multifamily Dwellings ¹ Damaged | # Other Major Structures ² Damaged | Total # Damaged ³ |
|--------------|-----------------------------------|--|---|------------------------------|
| Bay | 1,324 | 128 | 118 | 1,570 |
| Gulf | 840 | 88 | 56 | 984 |
| Franklin | 160 | 3 | 2 | 165 |
| Wakulla | 4 | 0 | 2 | 6 |
| TOTAL | 2,328 | 219 | 178 | 2,725 |

- 1) Multi-family dwellings include condominiums, townhouses, apartments, hotels, and motels.
- 2) Other major structures include: commercial buildings (restaurants, stores, beach bars, etc.), recreational buildings and non-habitable major structures (i.e., piers, pools, pavilions and parking lots).
- 3) Not included in this summary are: minor structures (i.e., walkways, decks, driveways, patios, etc.), coastal and shore protection structures (i.e., seawalls, revetments, sills, groins, jetties), minor damage to major structures, structures located inland of the coastal building zone, or structures with hydrostatic flooding damage caused by the storm surge or storm water runoff.

Table 3. Summary of coastal armoring damage caused by Hurricane Michael.

| County | Armoring Damage in Feet |
|--------------|-------------------------|
| Bay | 1,460 |
| Gulf | 1,870 |
| Franklin | 4,670 |
| Wakulla | 100 |
| TOTAL | 8,100 |



Figure 8. Aerial photo comparison of the severe damage in Mexico Beach (R127-R132). Source: Vexcel Imaging/NICB Geospatial Intelligence Center.

IV. Detailed Damage Assessment by County

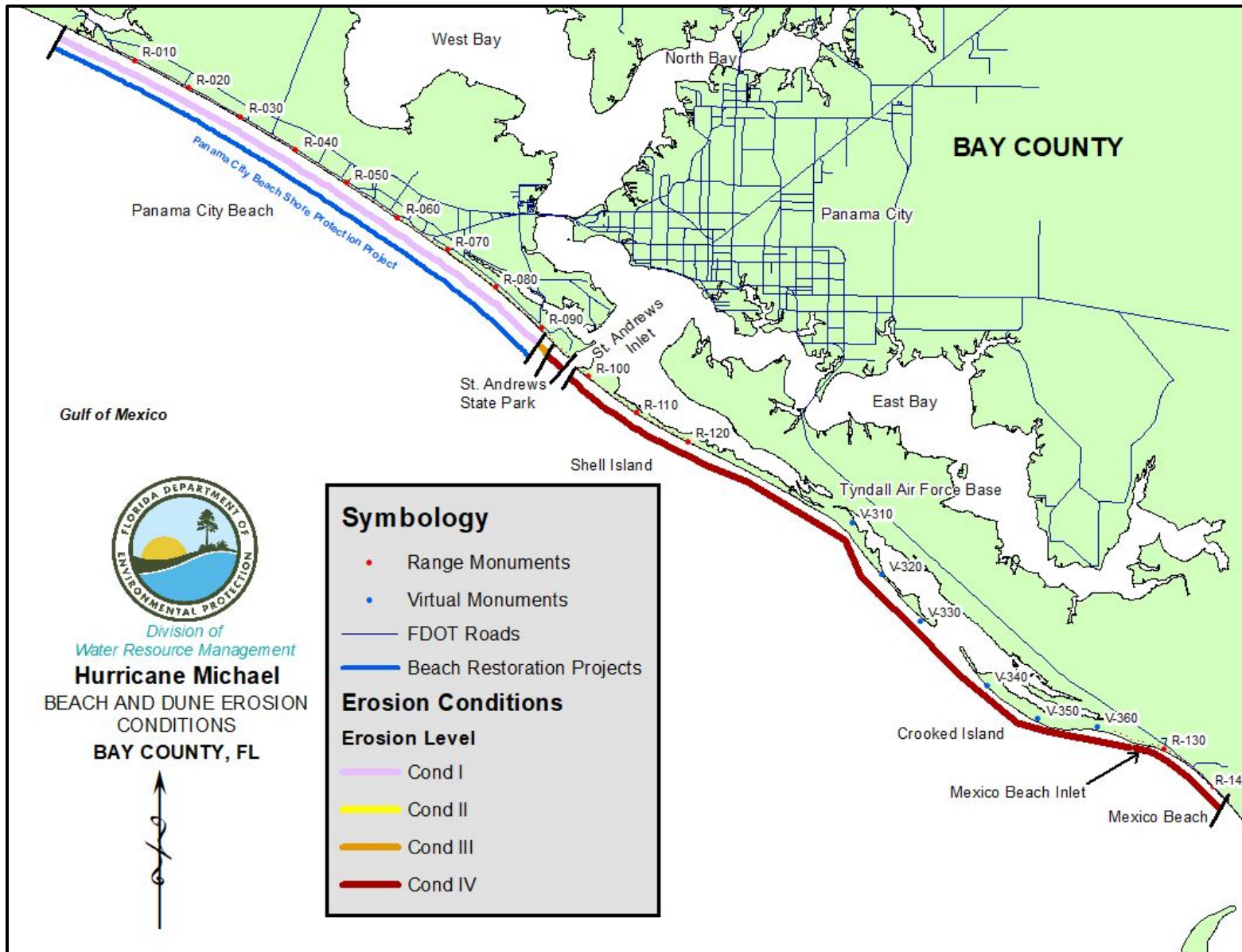


Figure 9. Bay County beach and dune erosion conditions from Hurricane Michael.

Bay County

The Bay County coast extends for 41.2 miles between Walton and Gulf Counties, and includes the barrier beach communities and major park systems of Sunnyside, Panama City Beach, St. Andrews State Park, Tyndall Air Force Base, and Mexico Beach (**Figure 9**). The western coast of Bay County along the Panama City Beaches is a federal beach restoration project extending for 18.6 miles between the Walton County line to St. Andrews State Park. St. Andrews Inlet to the east of St. Andrews State Park has a federal navigation project, which likely experienced significant shoaling due to Hurricane Michael. To the east of St. Andrews Inlet extends Shell Island, a barrier island now connected to the mainland due to the closure of the old natural eastern entrance to St. Andrews Bay. East of the closed inlet extends Crooked Island, a former barrier island that is now likewise attached to the mainland near the closed inlet and at its eastern end near the City of Mexico Beach. Crooked Island, which is part of Tyndall Air Force Base, is split by an inlet created by Hurricane Eloise in 1975. Shell Island and Crooked Island have relatively broad, gradually sloping beaches and large dynamic dune fields. At the east end of Bay County, there is an upland canal system at Mexico Beach that connects with the Gulf of Mexico through a jettied inlet. Substantial shoaling was observed at Mexico Beach Inlet, which also provided a conduit for the ebb flow of Michael's storm surge.

The direction of longshore transport along the Bay County coast extends both westward and eastward. West of St. Andrews Inlet, the net direction of longshore transport is generally to the west, whereas to the east of St. Andrews Inlet, the net direction of longshore transport is generally to the east. This longshore transport reversal to the east is substantially affected by the orientation of the shoreline, which trends to the southeast, and by the wave sheltering created by Cape San Blas and St. Joseph Peninsula to the southeast.

There are two critically eroded beach areas (19.5 miles), three non-critically eroded beach areas (10.1 miles) and one critically eroded inlet shoreline (0.2 mile) in Bay County. The entire western half of Bay County extending 18.6 miles between the Walton County line and St. Andrews Inlet (R1–R97) is critically eroded, threatening development and recreational interests. Inlet sand transfer is periodically conducted at St. Andrews State Park, and the Panama City Beach Shore Protection Project has been constructed from the western county line to St. Andrews State Park. The western shoreline of St. Andrews Inlet adjacent to Gator Lake is critically eroded, requiring periodic fill placement. A shoreline stabilization project of nearshore detached breakwaters has been constructed to extend the fill placement interval. To the east of St. Andrew's Inlet, along the western 6.1 miles of Shell Island (R9–V9), the

beach is non-critically eroded without any threatened interests. East of Shell Island along Crooked Island, there are two non-critically eroded areas split by Eloise Inlet. The western segment (V16–V30+2000) extends 2.8 miles to the west and the eastern segment (V36 – V41) extends 1.2 miles to the east. The eastern 0.9 mile of Bay County (R132–R137.8) along the City of Mexico Beach is critically eroded. Inlet sand transfer is periodically conducted at Mexico Beach Inlet and dune restoration has been conducted following Hurricanes Opal (1995) and Dennis (2005).

Storm Effects and Erosion Conditions

The storm tides of Hurricane Michael in Bay County generally ranged between five and nineteen feet above sea level. Using a surge gauge mounted to the fishing pier, the USGS measured a storm surge in Mexico Beach at +15.6 feet NAVD. Based on storm surge modelling by the Beaches and Shores Resource Center (FSU, 2007), this surge elevation is comparable to a one in 280-year return interval storm surge event. However, roughly 750 feet landward of the surge gauge, the USGS measured a high-water mark from a seed line on the interior of a grade level concrete building to be +17.6 feet NAVD. Further, the USGS in Mexico Beach measured additional high-water marks ranging from +17.9 feet NAVD near the west end of town, to +19.1 feet NAVD near the east end of town. The latter mark was located near DEP reference monument R137.

Table 4 provides erosion volumes in cubic yards for Bay County beaches fronting on the Gulf of Mexico. The erosion volumes were obtained from a post-storm U.S. Army Corps of Engineers' LIDAR survey, and then compared to the most recent pre-storm survey for all DEP monument locations above Mean Low Water (MLW). Four segments of shoreline are tabulated. The federal shore protection project (R0-R92) and the St. Andrews State Park (R92-R102) cover western Bay County. Between R102 and R122, is Tyndall Air Force Base along Shell Island and Crooked Island, where insufficient pre-storm data existed to quantify erosion losses. Eastern Bay County is broken up into the short segment of Mexico Beach west of Mexico Beach Inlet (R122-R127) and the developed stretch east of the inlet (R128-R144). In much of Bay County the frontal dunes were essentially removed and large amounts of eroded material were deposited upland. Therefore, calculations were made of the total volume eroded as well as the volume eroded with this upland deposition included, or the net erosion volume.

Table 4. Bay County erosion volumes above Mean Low Water (MLW).

| Location | DEP Monuments | Average Erosion cy/ft | Total Erosion Volume cy | Average Net cy/ft | Net Erosion Volume cy |
|------------------------|---------------|-----------------------|-------------------------|-------------------|-----------------------|
| Panama City Beach | R0-R92 | -8.4 | -786,984 | -3.9 | -368,896 |
| St. Andrews State Park | R92-R102 | -15.6 | -152,672 | -13.0 | -126,662 |
| West Mexico Beach | R122-R127 | -9.9 | -53,210 | -2.0 | -7,193 |
| Mexico Beach | R128-R144 | -15.6 | -252,997 | -11.5 | -189,623 |
| Total | | | -1,245,863 | | -692,373 |

Along western Bay County, minor to major beach and dune erosion was sustained (Condition I-IV). **Figure 10** shows the net erosion plotted across western Bay County west of Tyndall Air Force Base, including St. Andrews State Park (R92-R102) where major beach and dune erosion was sustained. Along the federal shore protection project (R0-R92), which was subject to storm tides of five to six feet, a total erosion volume of approximately -787,000 cubic yards above mean low water (MLW) was calculated. Much of the eroded volume remained above MLW in the form of overwash across the beach berm, and therefore a net erosion volume of approximately -369,000 cubic yards was calculated.

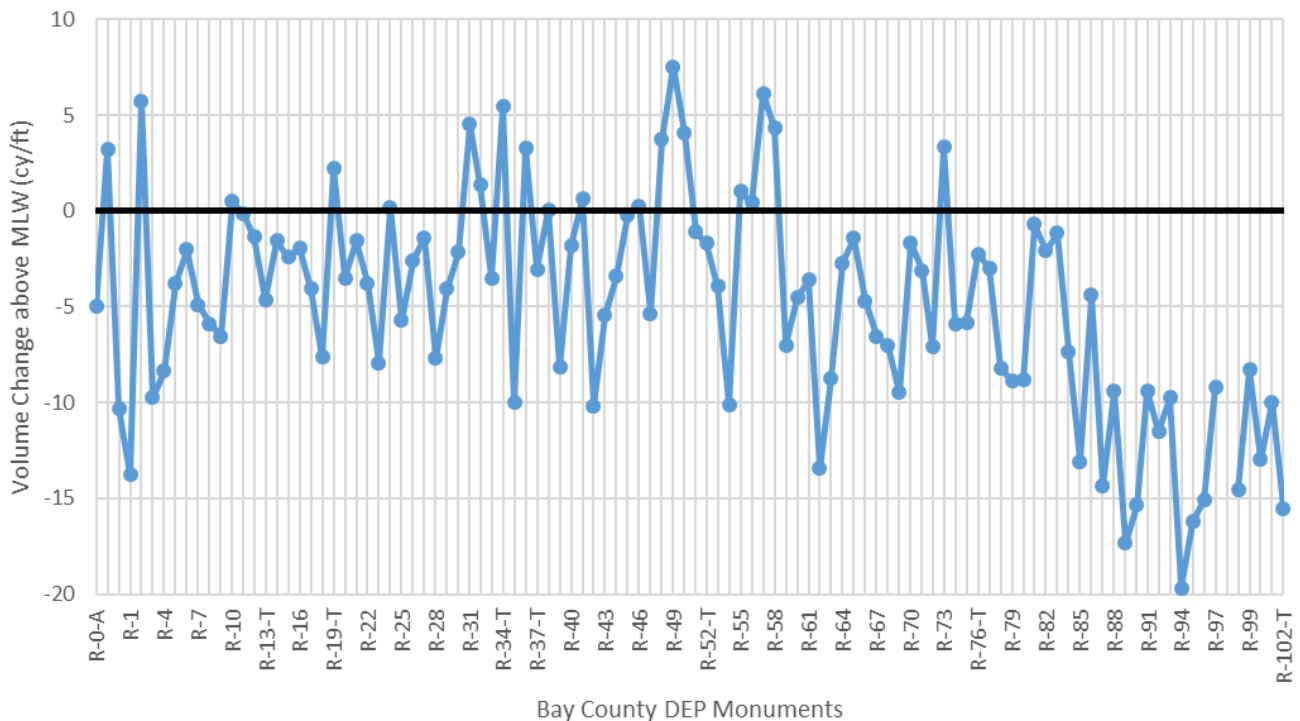


Figure 10. Net erosion along western Bay County (R0-R102) above Mean Low Water (MLW).

A post-storm survey of the federal shore protection project was obtained by Aptim, Inc. for Bay County, which evaluated erosion for the full project width out to the depth of closure, or -20 feet NAVD. The

post-storm survey calculated a total loss of material for the project to be approximately -546,000 cubic yards. **Figure 11** shows post-storm beach conditions along the shore protection project near R57.



Figure 11. Beach erosion near R57, east of the M.B. Miller Pier, Panama City Beach.

East of the shore protection project, erosion was more severe, as an average net erosion loss of -13 cubic yards per foot of shoreline was sustained within St Andrews State Park. **Figure 12** shows the major beach and dune erosion (Condition IV) within the state park near R97. **Figure 13** provides a comparison of pre-storm and post-storm profile surveys at R96 within the state park. This comparative graphic indicates as much as approximately 50 feet of dune recession was sustained during Hurricane Michael within the state park.



Figure 12. Major beach and dune erosion near R97, St. Andrews State Park.

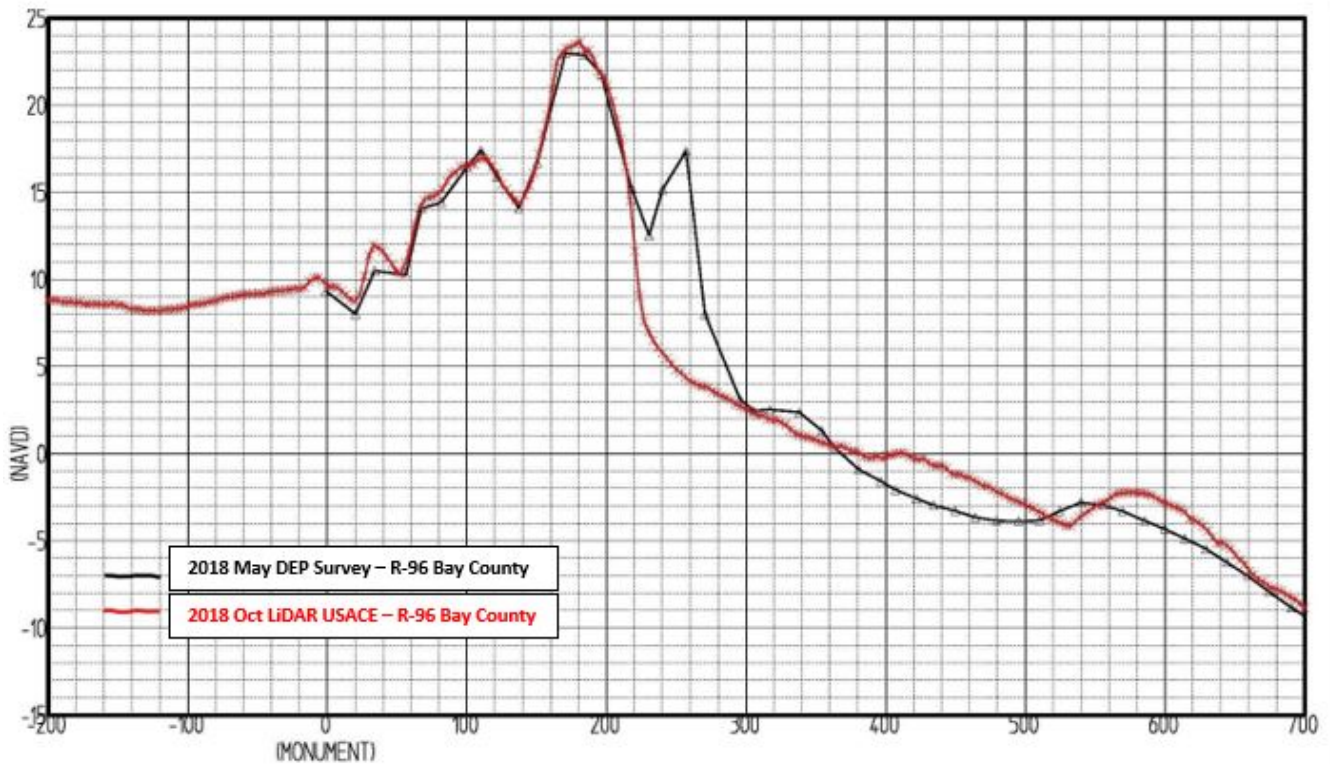


Figure 13. Pre-storm and post-storm profile comparison of major dune erosion in St. Andrews State Park, R96.

Michael’s impact along the eastern coast of Bay County east of St. Andrews Inlet was particularly severe. From St. Andrews State Park through Mexico Beach, including Shell Island and Crooked Island, major beach and dune erosion (Condition IV) was sustained. Along Shell Island and Crooked Island, major washover fans were developed due to the storm surge that flooded these barrier islands and leveled dunes. An unquantified large volume of beach and dune sediments were transported into St. Andrews Bay. A relatively smaller volume of washover sediments were transported landward along Mexico Beach across U.S. Highway 98. Along Mexico Beach, the storm erosion left upland properties vulnerable to flooding from future storm events. **Figure 14** shows the net erosion plotted across Mexico Beach from just west of the Mexico Beach Canal Entrance (also known as Mexico Beach Inlet) eastward to the Gulf County line. The inlet is located between DEP reference monuments R127 and R128. To the west of the inlet, some “up-drift” accretion was measured. From the inlet, eastward to the county line (R128-R144), approximately -190,000 cubic yards of beach and dune sand was lost above MLW.

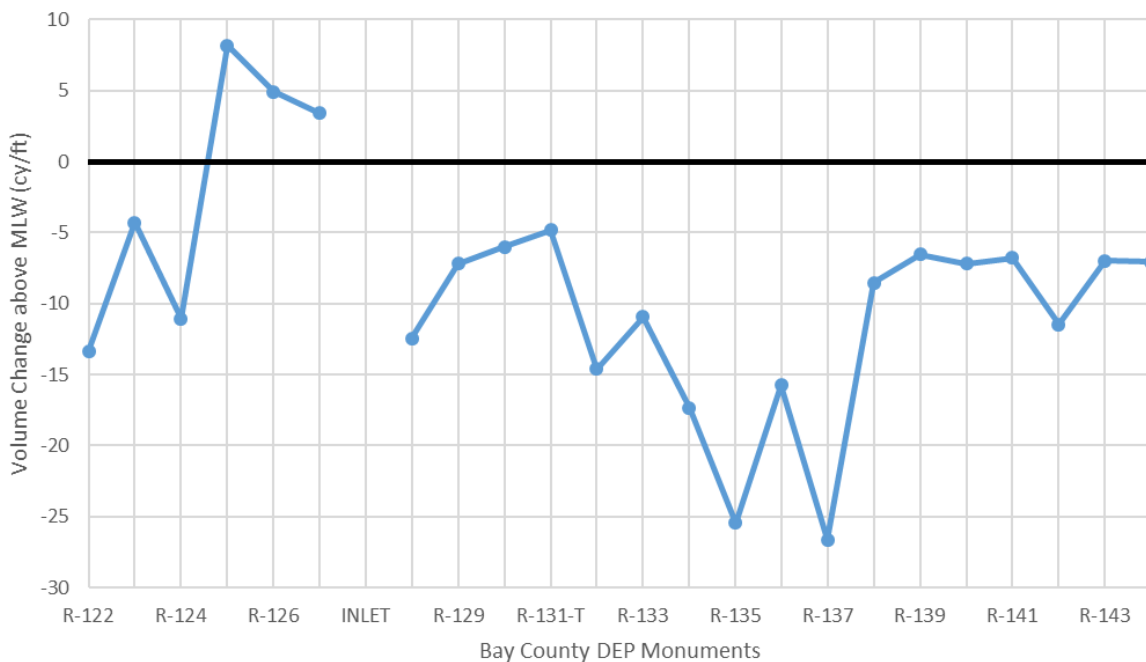


Figure 14. Net erosion along Mexico Beach, eastern Bay County (R122-R144) above MLW.

Storm Damage

By all accounts, Hurricane Michael was an epic storm event for the northern Gulf of Mexico coast. The most severe damage occurred to the right (east) of the hurricane’s eye at landfall. Mexico Beach in Bay County and Beacon Hill in Gulf County sustained the greatest impact from the storm’s surge, waves, and winds. The eye of Hurricane Michael made landfall at Tyndall Air Force Base and caused extensive

damage to nearly every major structure throughout the base. To the left (west) of the eye at landfall, substantial wind damage was also sustained throughout Panama City and adjacent communities, as well as the eastern half of Panama City Beach. The severe wind damage from Hurricane Michael extended inland across the county, leveling pine forests and devastating inland structures. Within the Coastal Building Zone fronting on the Gulf of Mexico, Bay County sustained major damage to 1,570 major structures. In contrast, Bay County had only seen major damage to 514 major structures in the Coastal Building Zone from all the northwest Florida hurricanes dating back to, but not including, Hurricane Eloise in 1975.

The damage from Hurricane Michael was sporadic in western Bay County. Roughly five miles from the Walton County line, damage became more prevalent and continued to become more wide-spread about 10 miles from the western county line. Storm tides generally ranged from five to six feet above sea level along Panama City Beaches, and winds of the western eye wall typically gusted from 80 to 100 mph. The Panama City Beach Shore Protection Project adequately protected all beach fronting development and infrastructure along Panama City Beach. In contrast, prior to the beach restoration project, Hurricane Opal (1995) caused damage to 471 buildings and numerous seawalls along Panama City Beach. All the major damage along Panama City Beaches was due to the high winds, with extensive damage being sustained to 466 major structures, including six that were destroyed.

East of St. Andrews Inlet, along Shell Island and Crooked Island, two major structures were damaged including one single-family dwelling that was destroyed. The eye of Michael crossed the coast at these largely undeveloped coastal barriers. However, as previously noted, severe wind damage was sustained throughout Panama City and Tyndall Air Force Base immediately landward of these islands.

To the east of Crooked Island, the most severe damage from Hurricane Michael was sustained along the mainland coast of eastern Bay County at Mexico Beach (**Figure 8**). On top of the storm surge, breaking waves caused the most severe damages. Many exterior water marks to 30 feet above sea level suggest the wave setup and wave uprush resulted in the destruction of most of the development seaward of U.S. Highway 98. Hurricane Michael's extreme storm tides and the high winds greatly exceeded the hurricane-resistant coastal construction standards of the Florida Building Code. Of the 210 buildings in Mexico Beach with major damage seaward of the Coastal Construction Control Line (CCCL), 180 buildings were destroyed, or roughly 85%. In addition, landward of the CCCL to the landward limit of the Coastal Building Zone, roughly 45% of the damaged buildings were destroyed. Within the Coastal

Building Zone in Mexico Beach, 1,102 major structures sustained major structural damage, including 595 that were destroyed. See **Figure 15** through **Figure 43** for examples of damage in Bay County.



Figure 15. Bank with severe wind damage on 23rd Street, Panama City.



Figure 16. Dry storage marina with wind damage on Thomas Drive, Panama City Beach.



Figure 17. Wind damages on the Sunbird Condominiums near R67, Panama City Beach.



Figure 18. Wind damages on a multifamily dwelling near R73, Panama City Beach.



Figure 19. Roof damage and destroyed dwelling near R82, Panama City Beach.



Figure 20. Roof damage on a single-family dwelling near R86, Panama City Beach.



Figure 21. Collapsed pavilion near R97, St. Andrews State Park.



Figure 22. Tyndall Air Force Base, aircraft hangar damage.



Figure 23. Bay County, pine forest leveled.



Figure 24. Mexico Beach Canal, R128.



Figure 25. Aerial photo comparison of severe damage in Mexico Beach (R127.5-R130). Source: Vexcel Imaging/ NICB Geospatial Intelligence Center.



Figure 26. Debris and damages at Mexico Beach Canal, R127.5.



Figure 27. Rows of beach houses destroyed and removed by the storm surge, R127.5, Mexico Beach.



Figure 28. Beach dwellings north of U.S. 98 lifted off their foundations, R128, Mexico Beach.



Figure 29. Remains of typical beach house destroyed near R128, Mexico Beach.



Figure 30. Mexico Beach pier destroyed near R129.



Figure 31. Multifamily dwelling destroyed near R129, Mexico Beach.



Figure 32. Pile-supported dwelling destroyed near R129, Mexico Beach.



Figure 33. Pile-supported multifamily dwelling destroyed near R129, Mexico Beach.



Figure 34. Buildings transported several hundred feet landward by the flood across U.S. 98 and deposited on 15th Street, R130, Mexico Beach.



Figure 35. Beach dwelling transported across U.S. 98 by the storm surge, Mexico Beach.



Figure 36. Dwellings destroyed by storm surge near R132, Mexico Beach.



Figure 37. City water tower collapsed under high winds near R134, Mexico Beach.



Figure 38. Over 700 feet of reinforced concrete seawall destroyed at R135, Mexico Beach.



Figure 39. Storm surge transported debris and sand overwash across U.S. 98 near R135, Mexico Beach.



Figure 40. Debris transported by the storm surge inland near R136, Mexico Beach.



Figure 41. Dwelling transported across U.S. 98 by the storm surge near R136, Mexico Beach.



Figure 42. Roof of dwelling transported across U.S. 98 by the storm surge near R138, Mexico Beach.



Figure 43. Segment of U.S. 98 destroyed near R139, Mexico Beach.

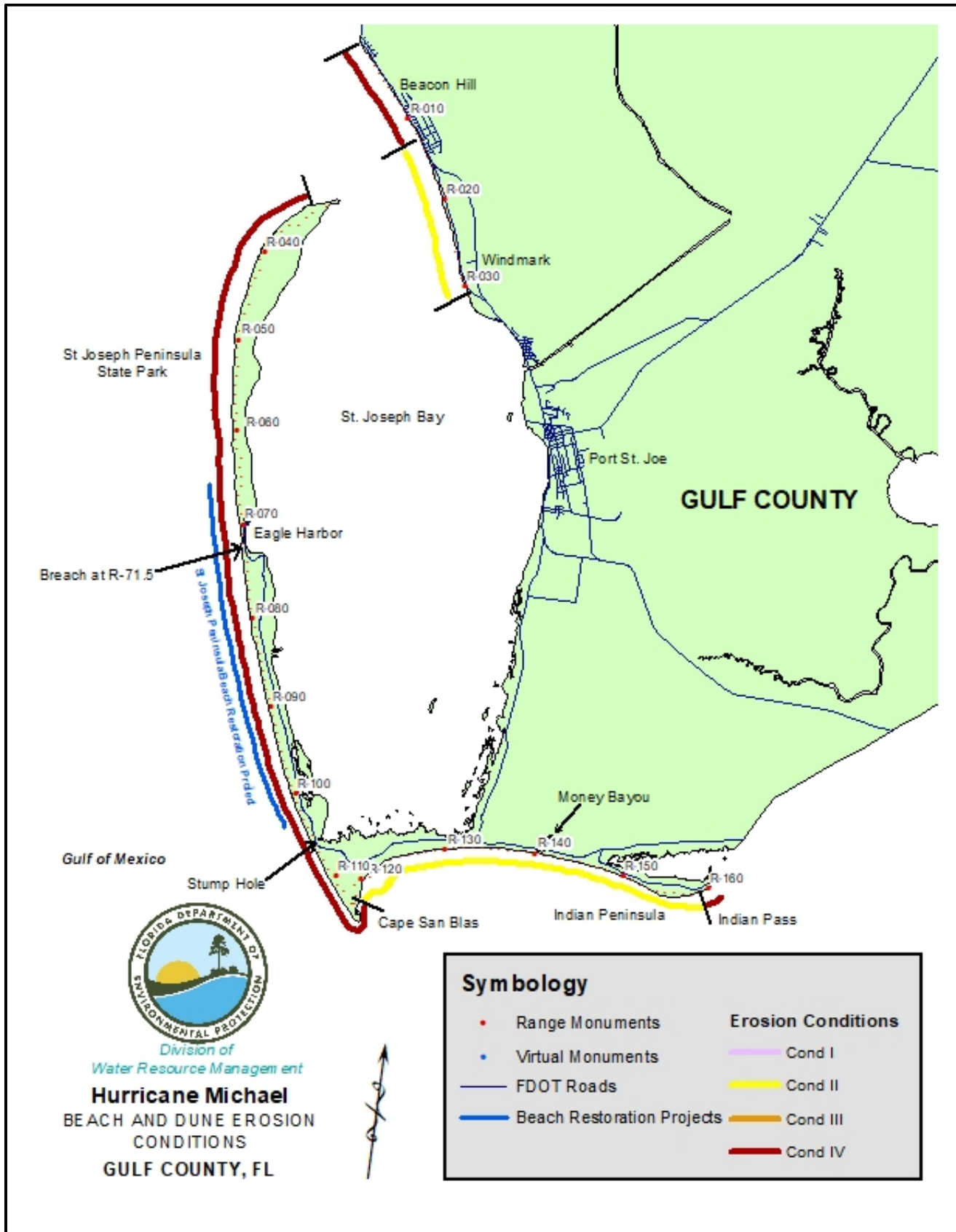


Figure 44. Gulf County beach and dune erosion conditions from Hurricane Michael.

Gulf County

The Gulf of Mexico fronting beaches of Gulf County extend for 28.8 miles between Bay County and Franklin County and include the following communities and major parks: Beacon Hill, Windmark, T.H. Stone Memorial St. Joseph Peninsula State Park, William J. Rish Recreational Park, and Eglin Air Force Base at Cape San Blas (*Figure 44*). At the northwestern reach of Gulf County is a mainland stretch of coast along the community of Beacon Hill. Offshore from the mainland is St. Joseph Peninsula, a north-south trending barrier spit, which is separated from the mainland by St. Joseph Bay. At the entrance to St. Joseph Bay is a federal navigation project that is part of the Port St. Joe Harbor Navigation Project. Hurricane Michael caused substantial shoaling in the navigation channel adjacent the northern tip of St. Joseph Peninsula. To the south of St. Joseph Peninsula and separated by a narrow barrier segment called Stump Hole is Cape San Blas, where the shoreline takes an abrupt change in alignment. East of Cape San Blas, the coast trends in a general east-west direction with a mainland beach extending to Indian Peninsula, which extends east to Indian Pass at the eastern Gulf County line.

The net direction of longshore transport along the mainland coast at Beacon Hill is to the east, due to the wave sheltering created by St. Joseph Peninsula and Cape San Blas to the southeast. St. Joseph Peninsula extends for approximately 17 miles, with primary dunes ranging in height from five to nearly 40 feet. With widths ranging from 600 to 4,600 feet, the barrier spit is subject to storm surge overwash. The net direction of longshore transport is northerly along St. Joseph Peninsula and the erosion rates reach a maximum to the south at Stump Hole, which is a drift divide for longshore transport. The west shore of Cape San Blas has the highest erosion rate on the Florida gulf coast (approximately 40 feet per year), while longshore transport is generally southward with sediments being carried onto shoals off the cape. Sensitivity of shoreline change to storm tides and wave conditions was witnessed during two hurricanes in 1985, when approximately 2,500 feet of the southward projecting cape disappeared. Over the past 40 years, all the Eglin Air Force Base buildings and infrastructure, as well as the Cape San Blas Lighthouse and associated buildings gulfward of County Road 30E, have been lost or relocated off the cape.

There are two critically eroded areas (8.3 miles) and three non-critically eroded areas (8.6 miles) in Gulf County. Most of St. Joseph Peninsula is eroded between R41–R106. A segment of T.H. Stone Memorial St. Joseph Peninsula State Park (R41–R69) is non-critically eroded for 5.5 miles, and a segment of St. Joseph Peninsula (R69–R106) is critically eroded for 7.2 miles due to threatened development and recreational interests. The St. Joseph Peninsula Beach Restoration Project (R67-R105.5) was completed

in the winter of 2009. The severely eroded west shoreline of Cape San Blas (R106-R111.5) is designated critically eroded for 1.1 mile south of Stump Hole. An engineered boulder mound structure was constructed in 2009 at Stump Hole to replace an earlier rock mound to provide major storm protection to County Road 30E, which connects St. Joseph Peninsula to Cape San Blas. South of the existing Eglin Air Force Base facilities, Cape San Blas (R111.5-R114) has sustained severe but non-critical erosion for an additional 0.5 mile. Indian Peninsula (R150-R162) at the eastern end of Gulf County is also designated non-critically eroded for 2.6 miles.

Storm Effects and Erosion Conditions

The storm tides of Hurricane Michael in Gulf County generally ranged between 7 and 21 feet above sea level (**Figure 6**). In Beacon Hill, the USGS measured storm surge high water marks ranging from +21.2 feet NAVD at the west end of town to +12 feet NAVD at the eastern end of town, which was somewhat more protected in the lee of St. Joseph Peninsula. To the east with greater protection from St. Joseph Peninsula, the Windmark development experienced storm tides ranging from +11.2 feet NAVD to +10.6 feet NAVD. The storm tide maintained its elevation along the mainland shoreline leading into and along the City of Port St. Joe, where high water measurements were obtained between +10.1 feet NAVD and +12.1 feet NAVD.

The USGS measured a storm surge on St. Joseph Peninsula with a surge gauge strapped to a beach walkway piling at William J. Rish Park to be +7.8 feet NAVD. The storm surge along the northern half of the peninsula appeared to be substantially greater than eight feet, as observed from overwash deposits. Within the T.H. Stone Memorial St. Joseph Peninsula State Park, a debris line was measured in the dunes to be +17.3 feet NAVD. Wave uprush undoubtedly contributed to the higher water levels observed with the overwash deposits along the peninsula. Along the southern half of St. Joseph Peninsula, the USGS measured high water marks ranging between +9.3 feet NAVD and +10.9 feet NAVD. No high-water data was measured on Cape San Blas; however, along the isthmus connecting Cape San Blas to the mainland, the USGS measured several high-water marks ranging between +10.9 feet NAVD and +11.7 feet NAVD. These high-water marks likely represented the storm surge setup at the upper south reach of St. Joseph Bay with flow across the isthmus. This phenomenon was also observed previously with Hurricane Kate in 1985.

Along the eastern gulf shore of the county extending to Indian Peninsula, the USGS measured high water marks ranging between +10.0 feet NAVD and +11.4 feet NAVD. The storm surge caused significant flooding along Indian Peninsula and major flood impacts were observed in the vicinity of

Money Bayou, near R141. Just west of Money Bayou, the USGS measured a high-water mark of +12.2 feet NAVD inside a shuttered hurricane door of a building's understructure. Inside Indian Pass at the eastern end of Indian Peninsula, a high-water mark of +9.5 feet NAVD was measured.

Table 5 provides erosion volumes in cubic yards for Gulf County beaches fronting on the Gulf of Mexico. Six segments of shoreline are tabulated. The erosion volumes were obtained from a post-storm U.S. Army Corps of Engineers LIDAR survey compared to the latest pre-storm survey for all DEP monument locations above Mean Low Water (MLW). In much of Gulf County, the frontal dunes were essentially removed, and large amounts of eroded material were deposited upland. Therefore, calculations were made of the total volume eroded as well as the volume eroded with this upland deposition included, or the net erosion volume. Computations showed a total erosion volume of approximately three million cubic yards countywide, of which approximately two thirds were lost from the system; and therefore, a net erosion volume of approximately two million cubic yards was calculated.

Table 5. Gulf County erosion volumes above Mean Low Water (MLW).

| Location | DEP Monuments | Average Erosion cy/ft | Total Erosion Volume (cy) | Average Net cy/ft | Net Erosion Volume (cy) |
|----------------------------|----------------|-----------------------|---------------------------|-------------------|-------------------------|
| Beacon Hill / Windmark | R1-R31 | -7.8 | -233,760 | -1.3 | -37,710 |
| North St. Joseph Peninsula | R32-R71 | -31.2 | -1,288,135 | -22.0 | -911,129 |
| Michael's Cut | R71-R73 | | -288,733 | | -172,237 |
| South St. Joseph Peninsula | R73-R106 | -17.9 | -617,260 | -15.0 | -522,357 |
| Cape San Blas | R107-R112 | -16.3 | -91,408 | -15.7 | -87,628 |
| Indian Peninsula | R119-R161 | -12.3 | -502,110 | -5.3 | -210,054 |
| Countywide Total | R1-R161 | | -3,021,405 | | -1,941,114 |

Given Gulf County's location to the right (east) of the hurricane's eye at landfall, Michael's erosion impact was severe. Major beach and dune erosion (Condition IV) was sustained on the mainland at Beacon Hill, as well as along the entire gulf shoreline of St. Joseph Peninsula and the western shore of Cape San Blas. East of Beacon Hill, along the Windmark development, minor beach and dune erosion (Condition II) was sustained for a shoreline segment substantially protected in the lee of St. Joseph Peninsula. The eastern shore of Cape San Blas and the isthmus connecting Cape San Blas to the mainland, as well as much of Indian Peninsula, was somewhat sheltered from Hurricane Michael's most extreme wave energy, and only sustained minor beach and dune erosion (Condition II). This stretch of

coast has a very wide beach backed by a low wide dune field and the slope across the beach/dune system extending offshore is very gradual. This naturally gradual slope likely contributed to significant dampening of storm waves propagating shoreward. However, major dune erosion (Condition IV) was also observed along the terminus of Indian Peninsula at Indian Pass between R159-R161, as the storm tide surged into St. Vincent Sound and strong currents scoured the toe of the primary dunes.

Hurricane Michael's greatest geomorphological impact to the Gulf County coast was a barrier breach near the midpoint of St. Joseph Peninsula. This breakthrough of the barrier peninsula occurred generally between R71 and R72, at a place called Eagle Harbor just north of the marina within T.H. Stone Memorial St. Joseph Peninsula State Park (**Figures 45-46**). To the north of the breach, northern St. Joseph Peninsula, now an island extending between R32 and R71, sustained a net loss of approximately one million cubic yards of beach and dune sand above MLW.



Figure 45. Breach across St. Joseph Peninsula between R71 and R72.

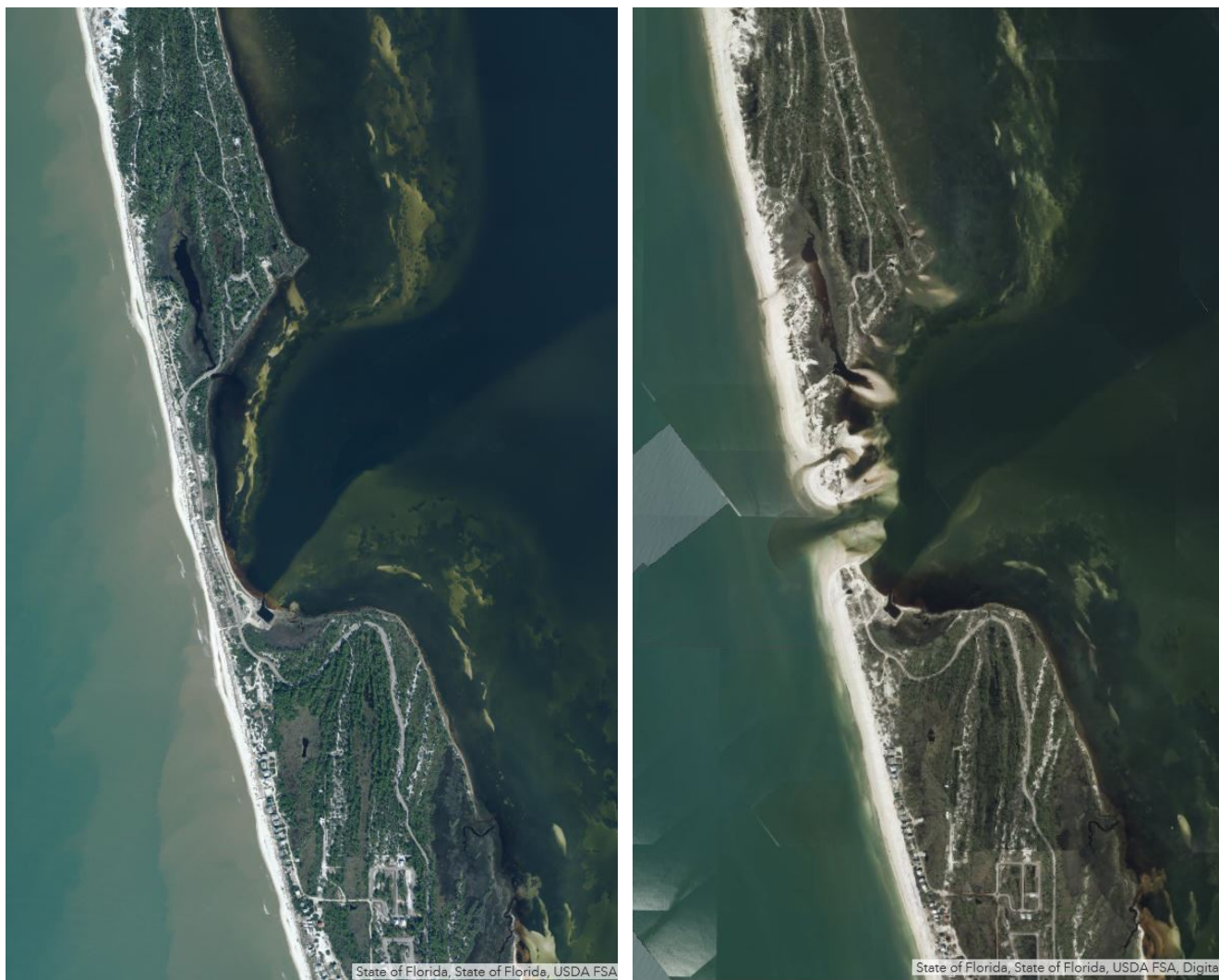


Figure 46. Before and after aerial photos of breach across St. Joseph Peninsula between R71 and R72 (Source: Vexcel Imaging/ NICB Geospatial Intelligence Center).

A primary breach of approximately 900 feet in width resulted in the scouring of a tidal channel approximately 200 feet wide by an average of six to eight feet deep. **Figure 47** shows a post-storm profile view through the breach compared to pre-storm profiles near R72. The pre-storm profiles show that an approximately 30-foot high barrier dune existed prior to Hurricane Michael, which created a channel to nearly -14 ft. NAVD. This represents a significant 44-foot change in grade elevation. A smaller and less hydraulically stable breach was also created immediately to the north of the larger breach near R71. The significant effect of these breaches has been to truncate the peninsula as well as the state park, isolating all the campgrounds, cabins, some park administration facilities, and much of the park's infrastructure from vehicular access. Natural closure of the breach through the continued loss of sand off the adjoining gulf beaches will cause a significant long-term physical impact to the park's

beaches. Longshore sediment transport may be expected to remove a large volume of sand from the adjoining beaches and carry the material into the aquatic preserve within St. Joseph Bay.

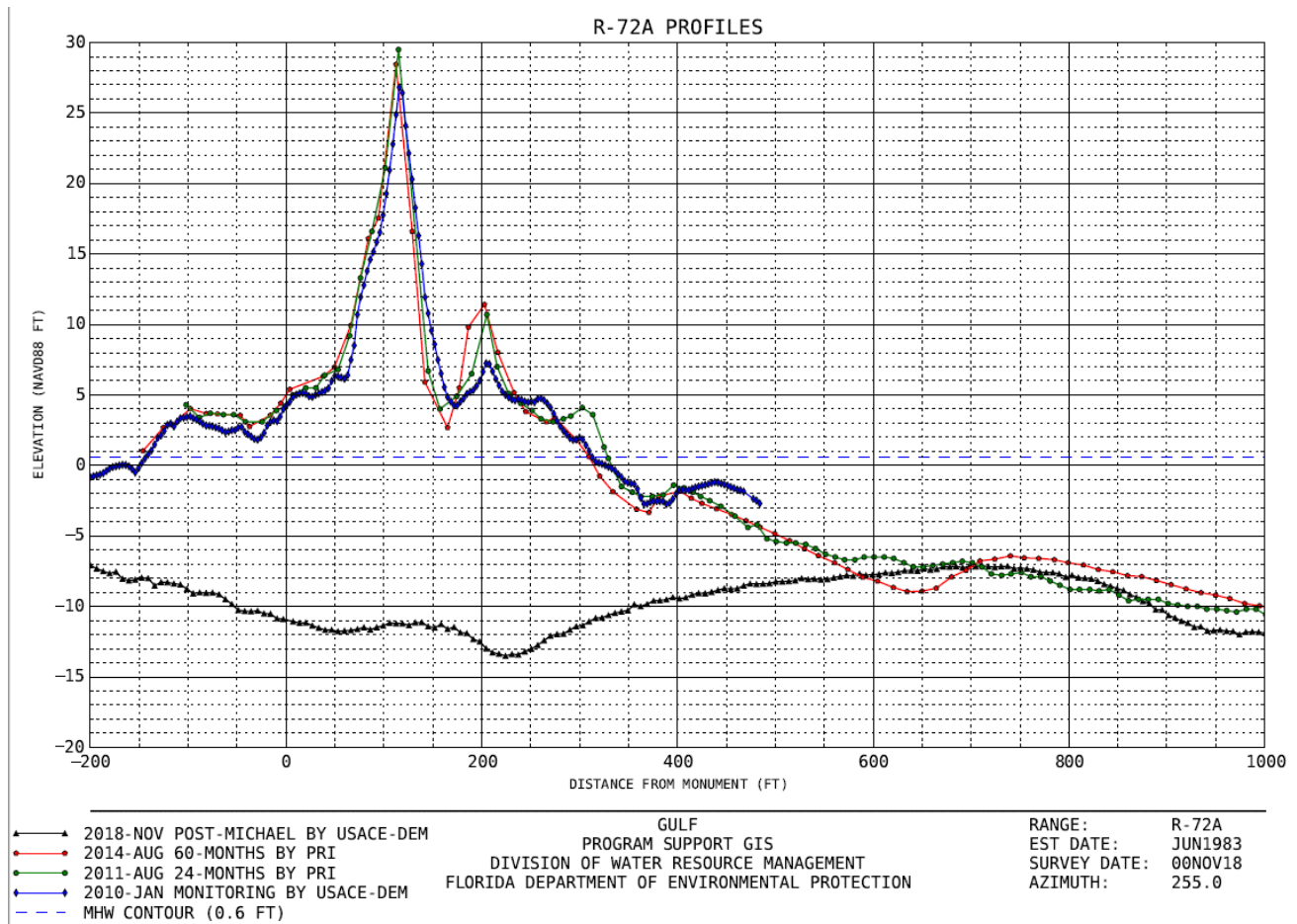


Figure 47. Pre-storm and post-storm profile comparison at the site of the breach across St. Joseph Peninsula.

South of the breach, along the developed southern half of St. Joseph Peninsula (R73-R106) and the western shore of Cape San Blas (R107-R112), approximately -600,000 cubic yards of beach and dune sand was lost above MLW. **Figure 48** graphs the total erosion and net erosion along the southern half of St. Joseph Peninsula, where the average net erosion was -15.0 cubic yards per foot of shoreline above MLW. **Figure 49** graphs the total erosion and net erosion along the western shoreline of Cape San Blas, where the average net erosion was -15.7 cubic yards per foot of shoreline above MLW.

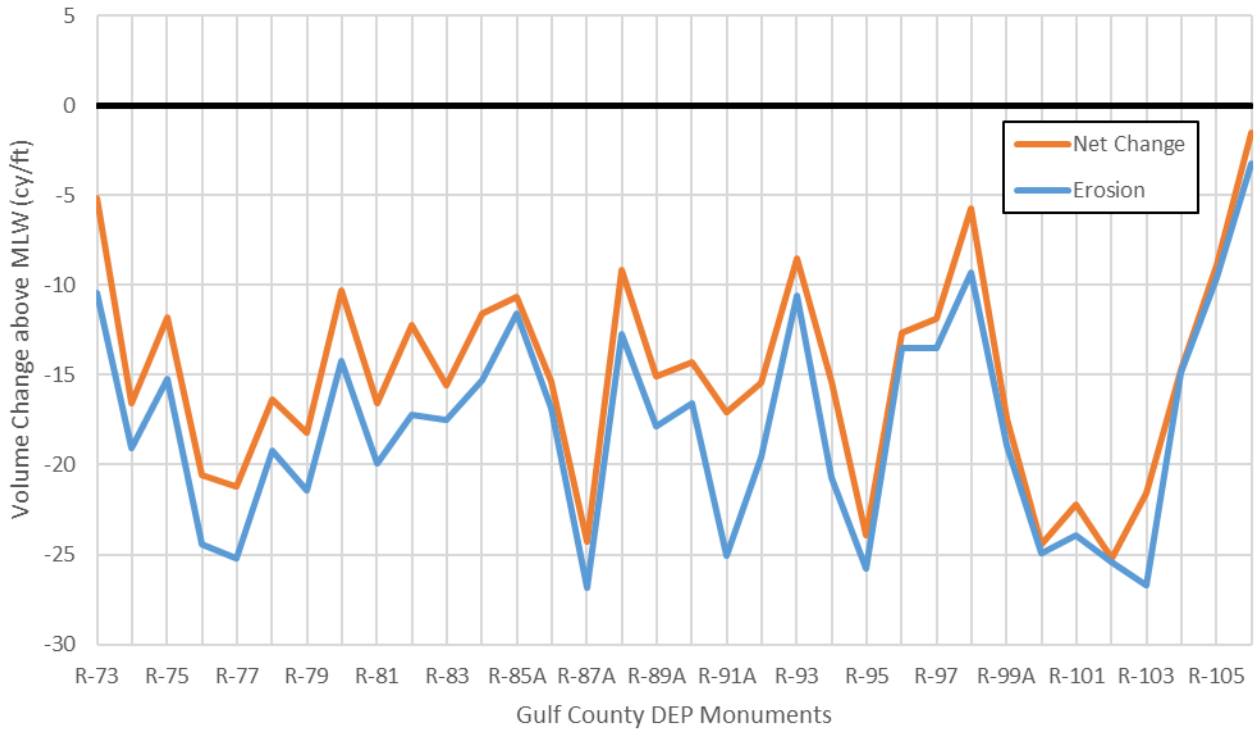


Figure 48. Total and net volume change along southern St. Joseph Peninsula above MLW.

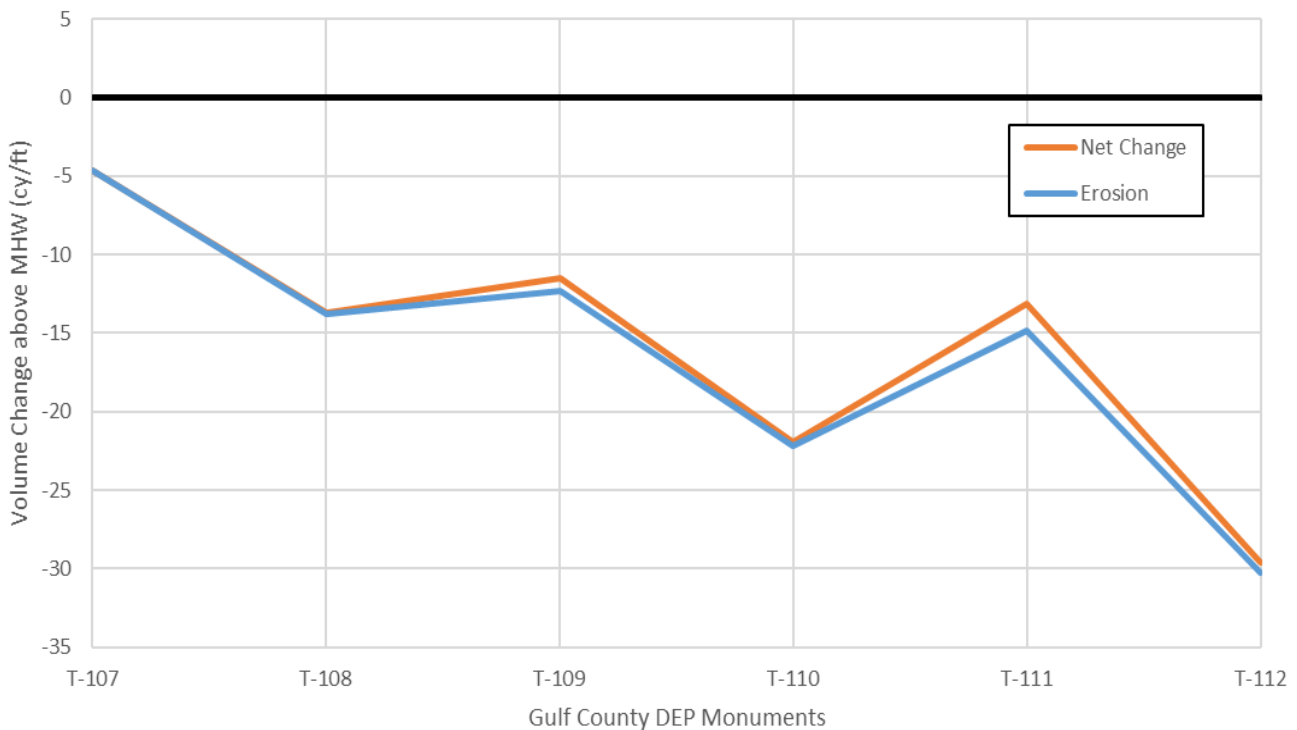


Figure 49. Total and net volume change along the western shoreline of Cape San Blas above MLW.

Major dune erosion at R74 within the state park is shown in **Figure 50**. Also, major dune erosion is seen looking south from R77 along the developed segment of St. Joseph Peninsula in **Figure 51**.



Figure 50. Major dune erosion (12-foot escarpment) near R74, St. Joseph Peninsula.



Figure 51. Major dune erosion, R77, St. Joseph Peninsula.

South of St. Joseph Peninsula, the west shore of Cape San Blas has a historic background erosion rate of -40 feet per year of shoreline recession. **Figure 52** shows the severe erosion conditions following Hurricane Michael near R110 at the site of the historic Cape San Blas Lighthouse, which was relocated to Port St. Joe in 2014. Another major geomorphological change to the Gulf County coast caused by Hurricane Michael was observed through the loss of approximately 660 feet off the southern tip of Cape San Blas (**Figure 53**).



Figure 52. Severe beach and dune erosion at Cape San Blas, R110.



Figure 53. Before and after aerial photos of Cape San Blas showing the loss of 660 feet off the cape at R118. (Source: Vexcel Imaging/NICB Geospatial Intelligence Center)

Storm Damage

Hurricane Michael caused major damage throughout Gulf County, which was located within the strongest wind field to the right (east) of the hurricane's eye at landfall. Gulf County was subjected to the maximum storm surge, greatest wave energy, and strongest winds during Hurricane Michael. The severe wind damage extended inland across the county, leveling pine forests and devastating inland structures, including the northern county community of Wewahitchka. Along the coast, damage was particularly severe from Beacon Hill to Indian Pass, including St. Joseph Peninsula and Cape San Blas. Within the Coastal Building Zone fronting on the Gulf of Mexico, Gulf County sustained major damage to 984 major structures, including 176 destroyed. In contrast, Gulf County had only seen major damage to 71 major structures in the Coastal Building Zone from all the northwest Florida hurricanes dating back to 1975.

The greatest impact from Hurricane Michael was sustained along Beacon Hill, including the sparsely constructed Windmark development to the east of Beacon Hill. This mainland segment of coast sustained the greatest damage within the county with major damage being sustained to 588 major structures, including 149 that were destroyed. Most of the major damage was caused by the storm surge and waves, which inflicted severe flood damage extending as much as 500 to 700 feet inland of U.S. Highway 98. The severe wind loads added to the flood damage throughout the Coastal Building Zone. Many structures, regardless of foundation type, were floated inland with the storm surge and deposited on roads or neighboring properties. Most of the structures seaward of U.S. Highway 98 were destroyed. Typically, the newer pile-supported, state-authorized structures seaward of the highway and seaward of the established Coastal Construction Control Line, fared well structurally and only sustained some roof and siding damage from the winds, as well as understructure damage to breakaway elements below the habitable floor level.

The flood and wind damage continued eastward along the mainland coast of Gulf County into the city of Port St. Joe fronting on St. Joseph Bay. The Department's damage assessment teams did not conduct detailed damage assessments along the St. Joseph Bay shoreline; however, major damage was observed throughout this area. The public marina facilities were particularly hard hit in Port St. Joe, with docks, roads, and shoreline armoring sustaining major damages. Vessels within the marina were either sunken, impaled on top of dock pilings, or floated onto adjacent upland areas. Churches, office buildings, banks, and various commercial buildings within the city's center sustained major wind damages. Flood

damages to residential neighborhoods east of downtown Port St. Joe were particularly severe, as most of the single-family dwellings were constructed on-grade, with many dating to the 1950s and 1960s.

Much of the Gulf County coast is dominated by St. Joseph Peninsula, and with the eye of Hurricane Michael passing laterally just offshore, major damage was incurred along this barrier spit. The northern 6.6 miles of the barrier spit (R32-R67) has no development, but substantial development is between R67 within St. Joseph Peninsula State Park south to R105 at Stump Hole. St. Joseph Peninsula sustained major damage to 279 major structures, including 22 that were destroyed. Due to the storm surge and waves, another 64 major habitable structures sustained understructure damage to breakaway walls, parking slabs, and utilities. A number of structures that predated the Department's coastal building standards were destroyed or severely damaged by the storm surge and waves, but much of the damage was caused by the extreme wind loads to roofs and siding. Of note, nourishment of the St. Joseph Peninsula Beach Restoration Project was scheduled to start at the time Hurricane Michael made landfall. While the project certainly assisted in the protection of many structures along the peninsula, the project's design template was substantially depleted along its southern end, and therefore, was not able to provide its full protective benefit. The upland properties and development along St. Joseph Peninsula are now vulnerable to the flooding and dune erosion of future storms.

A narrow-armored isthmus called Stump Hole divides St. Joseph Peninsula from Cape San Blas. After years of progressive erosion stress at this longshore sediment drift divide, and multiple storms that damaged the road and rock rubble protection, Gulf County constructed a 1,550-foot-long boulder mound structure designed to withstand a 50-year storm event and to protect County Road 30E in 2012-13. This coastal protection structure provided substantial protection to the road from Hurricane Michael's storm surge and waves. However, the ends of the structure proved particularly vulnerable, and 900 feet of road was destroyed to the north and 300 feet was destroyed to the south of the boulder mound structure.

To the south of Stump Hole, Cape San Blas is substantially federal land, which is part of Eglin Air Force Base. An entire complex of air force buildings and infrastructure, along with the historic Cape San Blas Lighthouse was previously removed over the years due to the extreme erosion stress. No development remained to be affected by Hurricane Michael. To the east, along the isthmus connecting Cape San Blas to the mainland, 21 major structures sustained major damage. This area was somewhat sheltered from the storm waves, and substantial flooding occurred from the St. Joseph Bay shore over the isthmus. Extreme wind forces contributed to most of the major damage, but two dwellings also had understructure damage from the storm surge.

Along the mainland coast east of Cape San Blas and along Indian Peninsula, 96 major structures sustained major damage, including five that were destroyed. The high-water mark measured by the USGS at Money Bayou was just under a 100-year storm surge event, and 127 dwellings sustained understructure damage from the storm surge and waves. In addition, many buildings also had wind damage to roofs and siding. At Money Bayou, 150 feet of bulkheads sustained Level 3 major damage, and a timber pile bridge was destroyed along with 170 feet of road. See **Figures 54** through **78** for examples of damage in Gulf County.



Figure 54. Site of high water mark of +21.2 feet NAVD along U.S. 98 and S.R. 386 near R1, Beacon Hill.



Figure 55. Before and after aerial photo comparison in Beacon Hill (R1). Source: Vexcel Imaging/ NICB Geospatial Intelligence Center.



Figure 56. Dwelling transported across U.S. 98 by the storm surge near R2, Beacon Hill.



Figure 57. Dwellings along U.S. 98 destroyed near R3, Beacon Hill.



Figure 58. Dwellings destroyed along U.S. 98 near R3.5, Beacon Hill.



Figure 59. Dwelling transported by storm surge onto Trade Winds Dr. near R6, Beacon Hill.



Figure 60. Aerial photo comparison in Beacon Hill (R7). Source: Vexcel Imaging/ NICB Geospatial Intelligence Center.



Figure 61. Townhouses destroyed near R7, Beacon Hill.



Figure 62. Major damage to dwelling due to high winds and fallen trees, Beacon Hill.



Figure 63. Marina damage due to the storm surge, Port St. Joe.



Figure 64. Ship carried onto upland by the storm surge, Port St. Joe.



Figure 65. First Baptist Church with major wind damage, Port St. Joe.



Figure 66. Dwelling destroyed by the storm surge from St. Joseph Bay, Port St. Joe.



Figure 67. Destroyed dwelling transported across S.R.30A by the storm surge, St. Joseph Bay.



Figure 68. Major roof damage due to high winds near R85, St. Joseph Peninsula.



Figure 69. Remains of four destroyed townhouse buildings on Nassau Lane near R90.5, St. Joseph Peninsula.



Figure 70. Pile-supported dwelling destroyed near R97.5, St. Joseph Peninsula.



Figure 71. Dwelling destroyed near R99.5, St. Joseph Peninsula.



Figure 72. Over six feet of vertical loss of grade beneath structure near R104.



Figure 73. Major damage to bulkheads and swimming pools near R104.



Figure 74. County Road 30E destroyed north of the Stump Hole boulder mound, R105.



Figure 75. County Road 30E destroyed south of the Stump Hole boulder mound, R107.



Figure 76. Storm surge damages at Money Bayou, R140.



Figure 77. Bridge destroyed across Money Bayou, R140.5.



Figure 78. Bulkhead on Money Bayou damaged, R141.

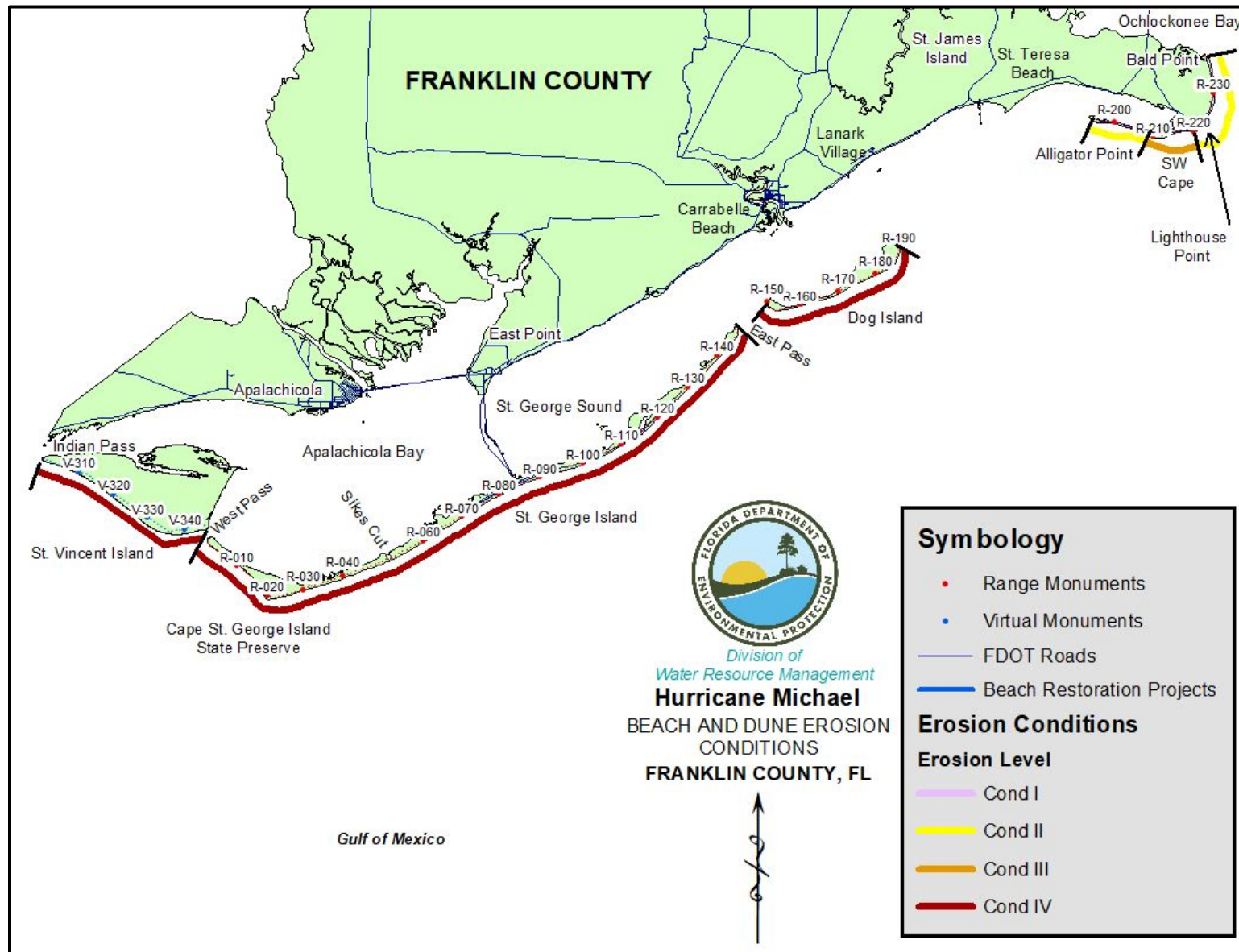


Figure 79. Franklin County beach and dune erosion conditions from Hurricane Michael.

Franklin County

The Gulf of Mexico fronting barrier beaches of Franklin County extend for 54.6 miles between Gulf and Wakulla Counties. There are additional mainland beaches along the Franklin County coast that are not included in the Department's coastal construction regulatory program. Franklin County includes the following barrier beach communities and major parks: St. Vincent National Wildlife Refuge, Cape St. George Island State Preserve, St. George Island Plantation, Dr. Julian G. Bruce St. George Island State Park, and Bald Point State Park (*Figure 79*).

There are four barrier islands and a barrier spit in Franklin County. At the western end of the county to the east of Indian Pass lies St. Vincent Island, a triangularly-shaped barrier island about 7.5 miles long, which is comprised of a unique complex of multiple beach ridges trending generally southeast to east-southeast. St. Vincent Island is an undeveloped federal wildlife refuge. To the east and separated by West Pass is the barrier island complex of Little St. George Island and St. George Island, which is about 29 miles long and ranges from 1,100 feet to a mile in width. From West Pass to Cape St. George, the shoreline has the same southeasterly orientation as St. Vincent Island. Little St. George Island was once a separate island prior to closure of a natural pass in the early 20th century. At Cape St. George, the island changes orientation trending in a northeasterly direction. Little St. George Island, which includes Cape St. George, and the historic west end of St. George Island, are now part of the Cape St. George Island Preserve, which extends from West Pass to Bob Sikes Cut. Bob Sikes Cut, the only federally-owned inlet in Florida, is a man-made channel across St. George Island and is part of a federal navigation project between the Gulf of Mexico and the town of Apalachicola on the mainland fronting Apalachicola Bay.

St. George Island extends east of Bob Sikes Cut to East Pass, a two-mile-wide natural inlet. There is a federal navigation project at East Pass; however, the channel has never required dredging. The mainland coast landward of East Pass fronting St. George Sound includes the beach community of Carrabelle Beach. To the east of East Pass lies Dog Island, the easternmost barrier island on the northern gulf coast. Dog Island is approximately 6.9 miles long and has two narrow segments along the western portion of the island that are subject to frequent inundation during even minor storm tides.

The easternmost segment of the Franklin County coast is a mainland peninsula, known as St. James Island, which lies between the gulf and Ochlockonee Bay. The eastern end of the peninsula extends in a north-south orientation for about 3.4 miles from Bald Point southward to Lighthouse Point. From Lighthouse Point, a barrier spit extends for five miles west, past the Southwest Cape, and terminates at

Alligator Point. The coast of St. James Island between Dog Island and Alligator Point includes the beach communities of St. Teresa Beach and Lanark.

There are six critically eroded beach areas (11.1 miles), nine non-critically eroded beach areas (19.7 miles), and one non-critically eroded inlet shoreline area (0.5 mile) in Franklin County. St. Vincent Island has a 3.2-mile long non-critically eroded area along its most gulfward protruding midsection (V317–V334). To the east, a 0.9-mile segment of St. Vincent Island (V334–V339) is critically eroded into the maritime forest, which has resulted in the loss of beach wildlife habitat.

Severe erosion exists at Cape St. George on Little St. George Island, which has resulted in the loss of the historic pre-Civil War lighthouse. This critically eroded area (R18.5–R22.5) extends along a 0.6-mile length of shoreline and is adjoined at both ends by a 0.7-mile non-critically eroded segment to the west (R15–R18.5) and a 0.3-mile non-critically eroded segment to the east (R22.5–R24). The west end of the historical length of St. George Island west of Bob Sikes Cut (R34–R51) is non-critically eroded for 3.3 miles. Both interior shorelines of Bob Sikes Cut also have non-critical erosion for 0.5 mile. East of Bob Sikes Cut, the St. George Island Plantation (R53–R69) is designated non-critically eroded for 3.3 miles. After Hurricane Dennis (2005) severely impacted Dr. Julian G. Bruce St. George Island State Park, the entire developed stretch of the park (R106–R128.5) was designated critically eroded for 4.5 miles due to the impact to recreational interests and park infrastructure. The undeveloped eastern 3.8 miles (R128.5–R147) is considered non-critically eroded.

Most of Dog Island is eroded, including the western 2.6 miles (R154–R168) which is non-critically eroded. To the east, a 3.6-mile segment (R168–R187.2) is designated critically eroded. The undeveloped historic west end of Alligator Point (R194–R196) is severely eroded for 0.4 mile and designated non-critically eroded. The eastern end of Alligator Peninsula (R210–R216) between the Southwest Cape and Lighthouse Point is designated critically eroded for 1.1 miles, where past storms have destroyed and continue to threaten private development and a county road. The southeastern end of St. James Island is critically eroded, extending north from Lighthouse Point (R220–R222) for 0.4 mile, threatening residential development. Further north from Lighthouse Point (R222–R232), a non-critically eroded area extends for 2.1 miles.

Storm Effects and Erosion Conditions

The storm tides of Hurricane Michael in Franklin County generally ranged from 8 to 12 feet above sea level (**Figure 6**). The USGS measured high water marks along St. George Island ranging between +8

feet NAVD and +10.6 feet NAVD. At Apalachicola on the mainland shore of Apalachicola Bay, storm tides were experienced of 8 to 9 feet above sea level. At the bay entrance of the Apalachicola River, a NOAA tide gauge measured a peak tide level from Hurricane Michael of +8.6 feet NAVD (**Figure 4**). At East Point on the mainland shore of St. George Sound behind St. George Island, the USGS measured high water marks ranging between +8.6 feet NAVD to +10.6 feet NAVD. These elevations were comparable to those measured along the gulf shore of St. George Island. At the eastern end of St. George Island, a debris line was measured at +9.7 feet NAVD, and along the mainland beach adjacent to East Pass, a high-water mark was measured inside a storage shed to be +11.8 feet NAVD. No high-water marks have yet been measured on Dog Island, but storm tides of 9 to 10 feet above sea level were measured along the shoreline at Carrabelle fronting on St. George Sound. Likewise, storm tides of 9 to 11 feet above sea level were measured along the gulf fronting shoreline of St. James Island. The USGS measured high water marks along Alligator Peninsula, including the Southwest Cape and Lighthouse Point, ranging between +8.8 feet NAVD and +10.7 feet NAVD.

Hurricane Michael's storm surge caused extensive washover fans into the dune field and maritime forest of St. Vincent Island generally between DEP virtual stations V317 and V339. All along St. Vincent Island's gulf beach are storm tide runout channels that carried the ebbing flood waters back across the beach. A large developing cusped foreland at the southwestern point of St. Vincent Island experienced substantial growth, enclosing a now entrapped lagoon (**Figure 80**). This lagoon is the seventh and most seaward of a progression of coastal lakes formed in likely similar manner. Immediately offshore, two subaerial shoals have substantially eroded with only a fragment of one now exposed. The sediment of these shoals may have contributed to the avulsive growth of the cusped foreland.

The length of the St. George Island barrier complex experienced storm surge flooding and substantial overwash deposits. Extensive washover fans exist between R5 and R13 on Little St. George Island. As was seen along St. Vincent Island, the Cape St. George area has several storm tide runout channels that carried the ebbing flood waters back across the beach. East of the cape, between R29 and Bob Sikes Cut at R51, Hurricane Michael's storm surge caused extensive washover fans across the island. The western jetty at the cut is separated from the island at high tide. Substantial shoaling appears to have occurred within the inlet, with substantial beach material having been removed from the St. George Plantation east of Sikes Cut. At R52 at Sikes Cut, the eastern jetty was breached, separating it from St. George Island (**Figure 81**). The eastern and western jetty breaches had previously occurred during Hurricanes Elena and Kate in 1985.



Figure 80. Before (above) and after (below) aerial photos showing major coastal changes to St. Vincent Island. Source: Vexcel Imaging/ NICB Geospatial Intelligence Center.

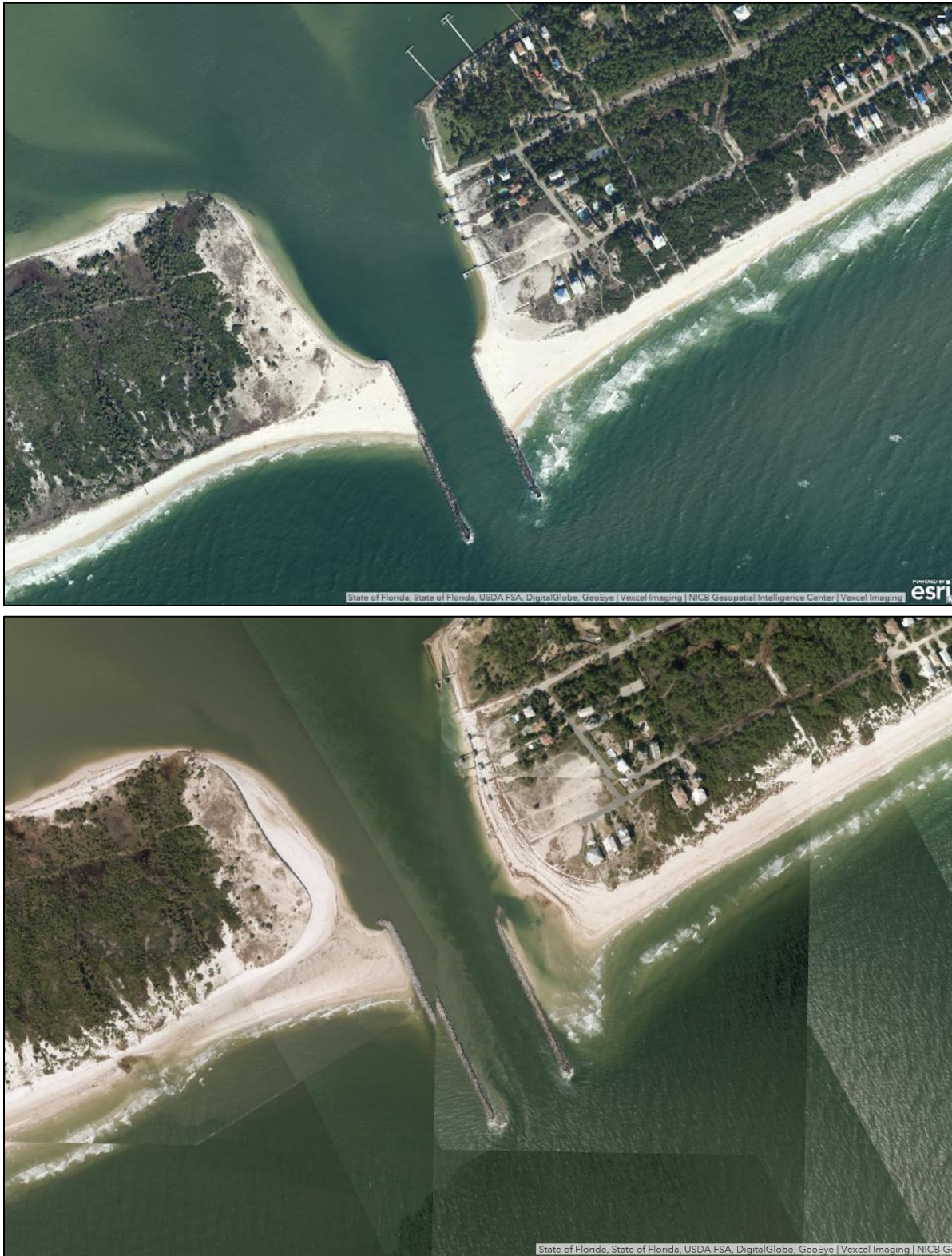


Figure 81. Before (above) and after (below) aerial photos showing breaching of the Bob Sikes Cut jetties from St. George Island, R51-R52. Source: Vexcel Imaging/ NICB Geospatial Intelligence Center.

Table 6 provides erosion volumes in cubic yards for Franklin County beaches fronting on the Gulf of Mexico. Four segments of shoreline are tabulated. The erosion volumes were obtained from a post-storm

U.S. Army Corps of Engineers LIDAR survey compared to the latest pre-storm survey for all DEP monument locations above Mean Low Water (MLW). In much of Franklin County, the frontal dunes were essentially removed, and large amounts of eroded material were deposited upland. Therefore, calculations were made of the total volume eroded as well as the volume eroded with this upland deposition included, or the net erosion volume. Pre-storm data was not available for St. Vincent Island or Dog Island, but computations were made of the rest of the gulf front shoreline on the coastal barriers. Computations showed a total erosion volume of approximately two million cubic yards of beach and dune sand for the remainder of the county, of which approximately one-half were lost from the system, and therefore, a net erosion volume of approximately one million cubic yards was calculated above MLW. **Figure 82** graphs the total erosion and net erosion along Franklin County above MLW.

Table 6. Franklin County erosion volumes above Mean Low Water (MLW).

| Location | DEP Monuments | Average Erosion cy/ft | Total Erosion Volume (cy) | Average Net cy/ft | Net Erosion |
|---------------------------------|----------------|-----------------------|---------------------------|-------------------|-------------------|
| Little St. George Island | R1-R51 | -11.9 | -541,967 | -4.7 | -182,537 |
| St. George Island | R52-R149 | -13.5 | -1,391,838 | -9.3 | -955,395 |
| Alligator Pt. to Lighthouse Pt. | R194-R220 | -4.6 | -122,757 | 0.5 | 13,603 |
| Lighthouse Pt. to Bald Pt. | R221-R239 | -2.6 | -48,031 | 3.6 | 72,015 |
| Total | R1-R239 | | -2,104,594 | | -1,052,315 |

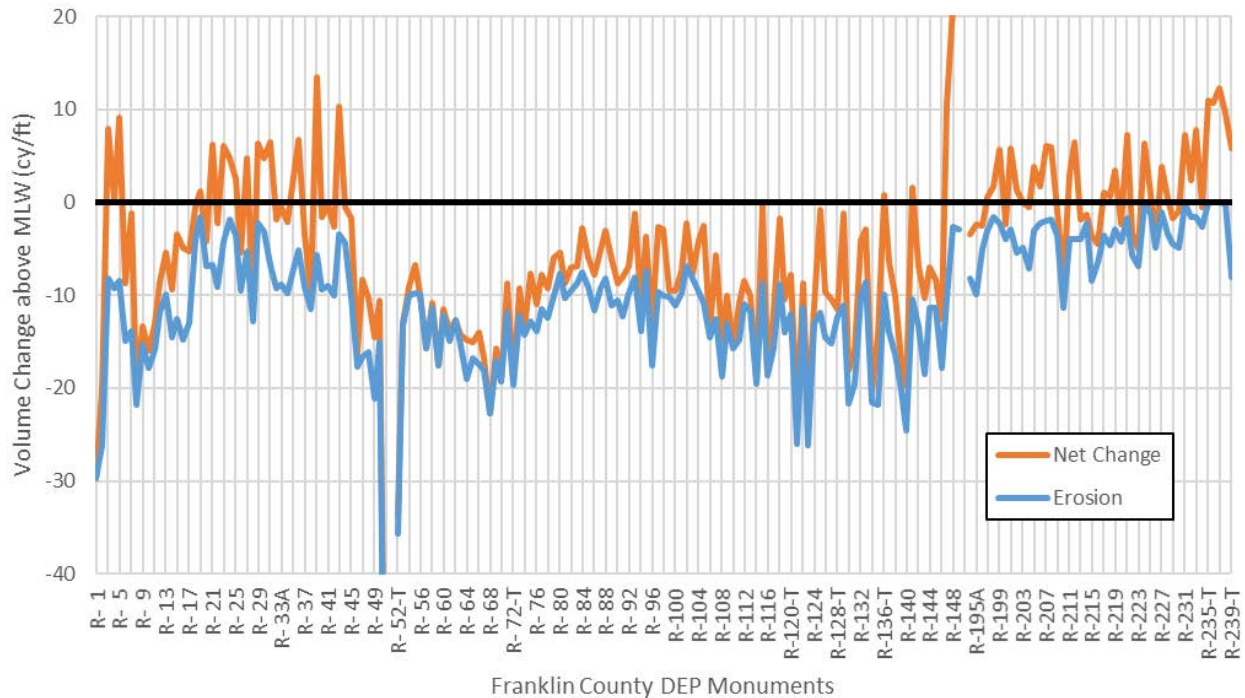


Figure 82. Total and net volume change along Franklin County above MLW.

Along St. Vincent Island, Little St. George Island, and St. George Island, major beach and dune erosion (Condition IV) was sustained. Severe dune erosion was sustained at Bob Sikes Cut at R52 (**Figure 83**). Along St. George Island Plantation (R52-R73), the dunes retreated as much as 50 feet (**Figure 84**).



Figure 83. Major beach and dune erosion at Bob Sikes Cut at R52, St. George Island.



Figure 84. Major dune erosion at R72, St. George Island.

Some of the higher primary dunes now have vertical escarpments as high as 12 to 15 feet. To the east of the St. George Island Plantation, along the central stable beaches of St. George Island between R73 and R99 where low profile foredunes existed, the vegetation line retreated as much as 100 feet and greater, and the low foredunes were completely leveled. Between East Gorrie Drive and East Gulf Beach Drive, generally between R87 and R99, an intermittent inland lake existed after the storm due to both the storm surge and the rainfall (**Figure 85**). These interdunal depressions typically flood during major rain events. Between R99 and R104, behind a higher dune field than to the west, substantial flooding existed along East Gulf Beach Drive. Major dune erosion (Condition IV) was sustained along this area of residential development.



Figure 85. Flooded interdunal depression on St. George Island between R87-R99. Source: Vexcel Imaging/ NICB Geospatial Intelligence Center.

In the Dr. Julian G. Bruce St. George Island State Park, which extends along the eastern 8.4 miles of St. George Island between R105 and R149, major beach and dune erosion (Condition IV) was sustained (**Figure 86**).



Figure 86. Dunes leveled across St. George Island State Park.

Near the state park entrance at R105.4 and R106, large storm tide runout channels cross the beach and dune region gulfward of the park road. This area was a region of large washover fans where the storm surge flowed across the island into St. George Sound. This same area experienced similar flooding impacts during Hurricanes Agnes (1972), Elena and Kate (1985), and Dennis (2005). Between R110 and R117 at East Slough, extensive washover fans exist where the storm surge flowed across this narrow segment of the island. Similar to conditions along East Gulf Beach Drive, the park segment between the two high public use areas at East Slough (R117.5) and Sugar Hill (R128), has a generally continuous elongated meandering lake both gulfward and landward of the park road left from the entrapment of the storm surge, between the primary dune field and a more landward ancient dune field. Several more storm tide runout channels cross the beach and dune region gulfward of the park road along this stretch between East Slough and Sugar Hill. East of Sugar Hill between R128 and R149 at the eastern end of St. George Island, there was nearly total inundation of the island during the storm surge, which leveled the dunes and left large washover deposits.

To the east of St. George Island and East Pass, Dog Island (R150-R192) sustained major beach and dune erosion (Condition IV). The two narrow segments of western Dog Island between R155-R160 and

between R165-R169 were inundated by the storm surge, causing further deflation of these narrow island segments with substantial sediment transport into the St. George Sound side of Dog Island (**Figure 87**).



Figure 87. Narrows near R159, Dog Island.

This overwash and landward beach migration has uncovered historical 19th century shipwrecks and remnants of a commercial dock near R158, which was destroyed in the “Carrabelle Hurricane” of 1899 (**Figure 88**). Along much of the remainder of the island, the vegetation line retreated as much as 50 feet and greater.



Figure 88. 19th century shipwreck uncovered by erosion near R158, Dog Island.

The erosion conditions moderated along the coastal barriers further to the east. Alligator Peninsula between Alligator Point (R195) and the Southwest Cape (R209) sustained minor beach and dune erosion (Condition II). Along the barrier peninsula east of the Southwest Cape between R209 and R217, moderate beach and dune erosion was sustained (Condition III). From Lighthouse Point (R217) northward to Bald Point (R239), minor beach and dune erosion (Condition II) was sustained. Portions of the Alligator Point to Bald Point barrier complex were completely inundated by the storm surge. Sand was sporadically deposited in washover fans between the dune and the road between Lighthouse Point and Bald Point. The dune was leveled, with sand being deposited on and across the road near R228.

Storm Damage

Hurricane Michael caused major structural damage to 165 major structures within the Coastal Building Zone on St. George Island, Dog Island, and the coast barrier system between Alligator Point and Bald Point. Past hurricanes impacted fewer major structures in the Coastal Building Zone of Franklin County,

including Hurricanes Elena (22 major structures) and Kate (159 major structures) in 1985, Hurricane Opal (eight major structures) in 1995, Hurricane Earl (eight major structures) in 1998, and Hurricane Dennis (52 major structures) in 2005. Many of the structures damaged by Hurricanes Elena and Kate were located along U.S. Highway 98 between Apalachicola and St. Teresa Beach on St. James Island. The Department's damage survey teams did not conduct a detailed investigation of the damage along U.S. Highway 98 after Hurricane Michael; however, it was noted that a number of major structures were substantially damaged in and near Apalachicola, two commercial buildings were destroyed and five more sustained major damage in Eastpoint, four single-family dwellings were destroyed and two more sustained major structural damage in Carrabelle Beach, and five single-family dwellings were destroyed along St. Teresa Beach.

On St. George Island, 96 major structures sustained major damage. In addition, another 29 single-family dwellings sustained understructure damage, and a number of older grade-level dwellings sustained static flood damage to their interiors. Along the St. George Island Plantation (R52-R73), the damages sustained were predominantly understructure damage to breakaway walls, parking slabs, and utilities due to the storm surge and waves, as well as some roof and siding damages. At least three swimming pools were sanded by the storm surge. Along East and West Gorrie Drive, major wind damage was sustained by roofs and siding, and static flood damage was sustained by grade-level dwellings. Siding damage was particularly widespread between R84 and R85. Three swimming pools along East Gorrie Drive were also sanded by the storm surge. Along the developed reach of St. George Island (R52-R104) numerous beach access walkways were destroyed or sustained major damage. Fences, decks, and gazebos were also damaged.

In St. George Island State Park, five segments of the park road, totaling 625 feet, were destroyed between R108 and R114; however, much greater lengths were observed to have sustained minor to moderate damage. Additionally, long segments of the park road are under sand overwash deposits and the condition of the road in these areas was not observable. Likewise, the parking lots at the East Slough and Sugar Hill public access areas were covered with sand, although these paved structures do not appear to have sustained damage. The beach pavilions and bath houses at East Slough and Sugar Hill did not sustain major structural damage, but the beach access walkways were damaged throughout the park.

The damage to major structures on Dog Island from Hurricane Michael was the greatest of any past hurricane. A major factor for this has been the progressive erosion stress, which continues to deplete the natural beach and dune protection seaward of residential construction that was originally considered

sufficiently well sited landward of the beach. Hurricane Kate (1985) caused major dune erosion, but only destroyed one dwelling by the storm surge and erosion, along with causing major damage to eight others by the wind. At that time, most dwellings were still substantially landward of the beach. After another 20 years of erosion, Hurricane Dennis caused major damage to 15 single-family dwellings, including seven that were destroyed. All but one of these were damaged by the storm surge and erosion. Following another 13 years of erosion with partial recovery after Hurricane Dennis, Hurricane Michael caused major damage to 25 major structures, including 12 that were destroyed. A timber bulkhead of 165 feet was also destroyed, and ten dwellings sustained understructure damage. On Dog Island, a number of dwellings remain threatened by another storm of comparable intensity as Hurricanes Kate, Dennis, and Michael.

Between Alligator Point and Bald Point, Hurricane Michael caused major damage to 44 single-family dwellings, including five that were destroyed. An additional 1,506 feet of walls were damaged, along with 3,000 feet of rock revetment that sustained major damage. Approximately 3000 feet of Alligator Point Drive paralleling the rock revetment was destroyed including where it connects to Chip Morrison Drive on the west end of the revetment. At the end of Gulf Shore Blvd on Lighthouse Point, the easternmost 175 feet of road was destroyed. These damages compare to those of Hurricane Dennis (2005), when 26 major structures sustained major damage, including 16 that were destroyed. Between Alligator Point and Bald Point, most of the damages sustained were predominantly understructure damage to breakaway walls, parking slabs, and utilities due to the storm surge and waves, as well as some roof and siding damages. Fences, decks, and walkovers were also damaged. Within Bald Point State Park, the beach walkovers were damaged and some of the picnic pavilions were left lightly sanded by the washover deposits. The pier at the end of Bald Point State Park was not damaged. See **Figures 89** through **102** for examples of damage in Franklin County.



Figure 89. Dwelling damaged near R78, St. George Island.



Figure 90. State park road destroyed near R108, St. George Island.



Figure 91. Dunes leveled and park road destroyed at R114, St. George Island.



Figure 92. U.S. Highway 98 damaged near Eastpoint.



Figure 93. Dwelling destroyed near R173, Dog Island.



Figure 94. Dwelling destroyed near R174, Dog Island.



Figure 95. Dwelling destroyed near R176, Dog Island.



Figure 96. Dwelling destroyed near R178, Dog Island.



Figure 97. Dwelling destroyed near R179, Dog Island.



Figure 98. Pelican Inn destroyed near R183, Dog Island.



Figure 99. 3,000 feet of road and revetment destroyed between R211-R214, Southwest Cape.



Figure 100. Dwelling destroyed near R210, Southwest Cape.



Figure 101. Dwelling destroyed near R211, Southwest Cape.



Figure 102. Dwelling and bulkhead damaged near R214.5, Southwest Cape.

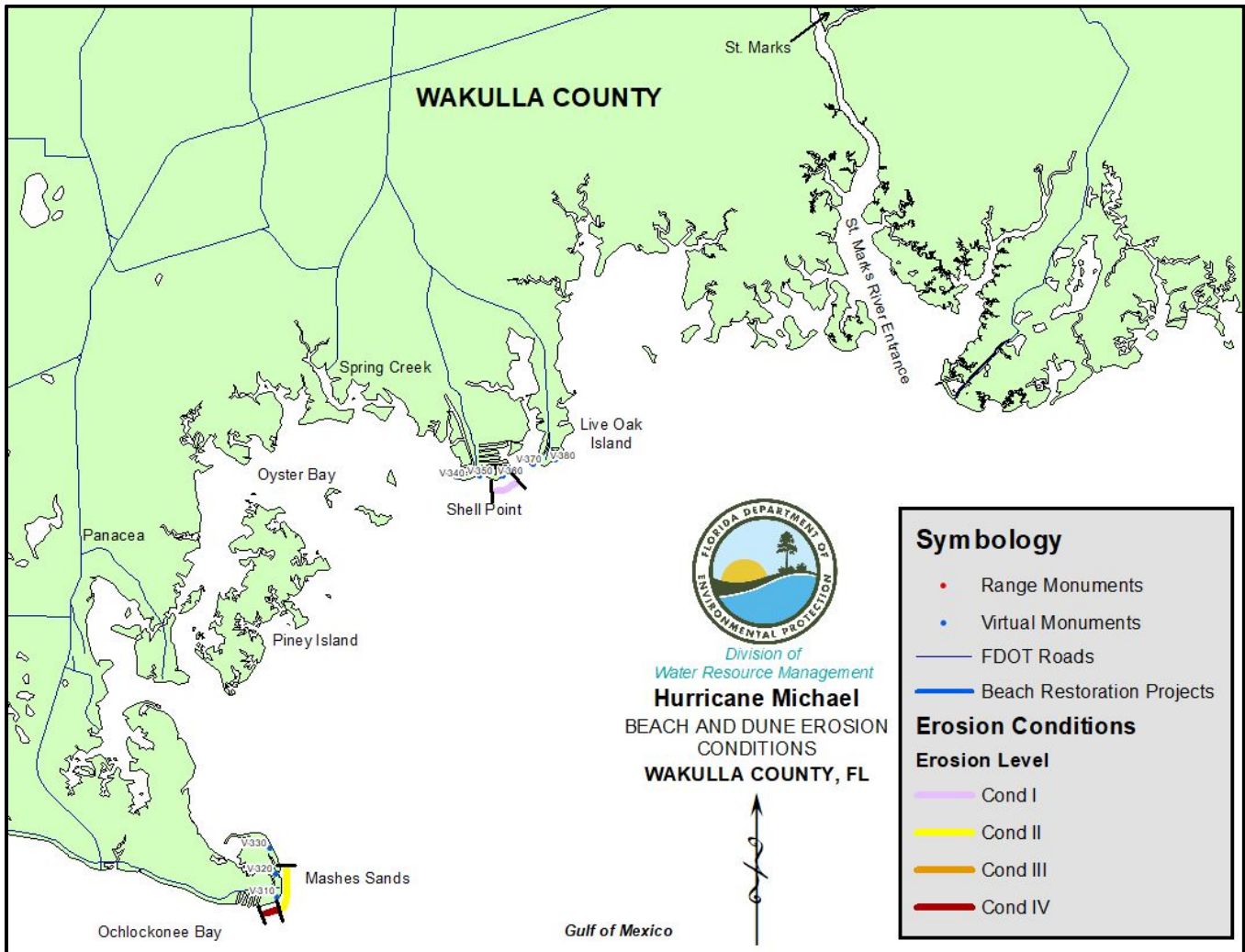


Figure 103. Wakulla County beach and dune erosion conditions from Hurricane Michael.

Wakulla County

Wakulla County is considered the easternmost county in the Florida Panhandle, with approximately three miles of barrier coastal beaches (**Figure 103**). It is also considered part of the Big Bend Coast, which stretches for approximately 240 miles from Ochlockonee Bay on its western end, east and south to Anclote Key just north of Tampa. Coastal Wakulla County includes the following communities and parks: Mashes Island Park, Panacea, Spring Creek, Shell Point, Live Oak Island, Wakulla Beach, St. Marks, and the St. Marks National Wildlife Refuge. The Wakulla County coast includes entrances to two major rivers, the Ochlockonee River and the St. Marks River, and numerous tidal creeks, including many that are spring fed.

The most prominent barrier coastal beach in Wakulla County is Mashas Sands (a chenier beach) just north of the entrance to Ochlockonee Bay. The southern shoreline at the bay entrance is severely eroding. The eastern beach to the north of the bay experiences classical chenier migration landward with storm surge overwash into a tidal wetland. The dominant direction of longshore transport along this beach is to the north. To the east is a beach along Shell Point: a developed headland between tidal creeks and wetlands. Most of Shell Point is now armored with seawalls and rock revetments, except along a county owned public beach.

There are two critically eroded beach areas (1.3 miles) and one non-critically eroded beach area (0.4 mile) in Wakulla County. Mashas Sands is designated critically eroded along its southern end for 0.3 mile, threatening recreational interests at the county park. Non-critical erosion extends another 0.4 mile to the north. Shell Point has 1.0 mile of critical erosion threatening development and a county park.

Storm Effects and Erosion Conditions

The storm tides of Hurricane Michael in Wakulla County generally ranged from 9 to 12 feet above sea level. The USGS measured high water marks along the shore of Ochlockonee Bay, including at Mashas Sands between 9 and 10 feet above sea level. High water marks between +10.0 feet NAVD and +10.7 feet NAVD were measured at Spring Creek, Shell Point, and Live Oak Island. At the St. Marks Lighthouse at the entrance to the St. Marks River, the USGS measured a high-water mark of +9.8 feet NAVD. Upriver at the Town of St. Marks, high water marks were measured between 9 and 10 feet above sea level.

Major beach and dune erosion (Condition IV) was sustained along the southern shoreline of Mashas Sands. Generally minor beach and dune erosion (Condition II) was sustained northward along the eastern shoreline of Mashas Sands. No erosion was observed along the western segment of shoreline west of the bath house at the public beach at Shell Point, where most of the community was flooded by the storm surge. East of the bath house, however, minor beach erosion (Condition I) was sustained along the public beach and along the shoreline extending eastward to the entrance to Walker Creek.

Storm Damage

Hurricane Michael caused substantially less coastal building damage in Wakulla County than was sustained during Hurricane Kate (1985; 46 major structures) or Hurricane Dennis (2005; 37 major structures). Hurricane Michael caused major damage to six major structures on coastal Wakulla County.

On Mashes Sands, two nonhabitable major structures were substantially destroyed. On the southern shoreline, the Mashes Sands timber fishing pier was substantially destroyed by the storm surge and wave forces. Along the same shoreline, 300 feet of elevated timber walkway that provided access to the pier was destroyed. The terminal boulder mound groin at the canal entrance near the pier was undamaged. At the Mashes Sands eastern shoreline, the public bath house was destroyed.

At Shell Point, four single-family dwellings sustained major structural damage, including one grade-level house that was destroyed. Another 12 single-family dwellings sustained understructure damage. Many dwellings throughout Shell Point sustained static flood damage to their interiors. While much of the shoreline at Shell Point is now armored with bulkheads and revetments, only 100 feet of rock revetment at one property sustained Level 3 major damage. Another 240 feet of timber bulkhead has been compromised with Level 1 damage due to the backfill being scoured out behind the wall. See **Figures 104** through **108** for examples of damage in Wakulla County.



Figure 104. Fishing pier and access walkway damaged at Mashes Sands, V303.



Figure 105. Bathhouse destroyed at Mashas Sands, V314.



Figure 106. Dwelling with major damage from the storm surge at Shell Point, V342.



Figure 107. *Minor erosion to public beach at Shell Point, V355.*



Figure 108. *Rock revetment damaged and dwelling with parking slab and bracing damage at Shell Point, V361.*

V. Summary of Hurricane Michael's Impacts

Hurricane Michael was the third strongest hurricane to make landfall in continental United States in recorded history. Hurricane Michael was an epic storm event for the northern Gulf of Mexico coast of Florida, causing substantial impact from Panama City Beach to St. Marks. The most severe damage, occurring to the right (east) of the hurricane's eye at landfall, was sustained in Mexico Beach (Bay County) and Beacon Hill (Gulf County). Along the coast of Bay, Gulf, Franklin, and Wakulla Counties, major beach and dune erosion was sustained, and a total of 2,725 major structures sustained major structural damage within the Coastal Building Zone. This document will assist the Department and local governments to identify areas where storm erosion has left upland development and infrastructure vulnerable to imminent damage from future storms, where beaches and dunes may be restored, and where expedited permitting procedures are needed to assist homeowners with repairs and reconstruction.