Hurricane Ian & Hurricane Nicole Post-Storm Beach Conditions and Coastal Impact Report

Office of Resilience and Coastal Protection

Florida Department of Environmental Protection

December 2022

(revised in August 2023)

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I. Introduction

Hurricane Ian made landfall on September 28, 2022, at approximately 3:00 p.m. Eastern Daylight Time (EDT), at Cayo Costa, Lee County, in southwest Florida as a strong Category 4 hurricane on the Saffir-Simpson hurricane intensity scale. Six weeks later, Hurricane Nicole made landfall on November 10, 2022, at approximately 3:00 a.m. Eastern Standard Time (EST), at Avalon Beach, St. Lucie County, just south of Vero Beach, on the Atlantic coast of Florida.

Ian came ashore with maximum sustained winds of 150 mph, which was the fifth-strongest measured hurricane to strike the United States. Ian had a storm surge on Estero Island and southern Sanibel Island in excess of +13 feet NAVD, which approximated a 100-year return interval storm event (refer to DEP's recommended 100-year Storm Tide Levels for Lee County). High water marks were measured between +12 to +18 feet in southern Lee County revealing the devastating effects of the storm waves above the storm surge. Hurricane Ian made landfall very near the same location as Category 4 Hurricane Charley in 2004. Following landfall, Ian crossed Florida on a northeasterly tract with hurricane force winds and extreme rainfall, which exceeded 21 inches near Orlando in Orange County. After reaching the Atlantic coast as a tropical storm and exiting Florida at Cape Canaveral, Ian strengthened to a Category 1 hurricane on September 30 and battered the northeast coast of Florida before turning northwestward and making landfall in South Carolina. In Florida, over 100 people died, with the largest number of fatalities in Lee County by drowning in the storm surge. With the track of Ian northeasterly up the peninsula of Florida, a major part of the state felt some impact from either the wind, rain, or storm surge. Beach erosion and structural damage was the greatest along the southwest coast of Florida severely devastating Lee and Collier counties. On the northeast coast of Florida, the wind and storm surge resulted in major dune and beach erosion, and extensive seawall failures in Flagler, and Volusia counties, endangering upland properties and infrastructure.

In contrast to Hurricane Ian, Nicole formed in the Atlantic Ocean east of the Bahamas as a subtropical storm and gradually reorganized as a tropical storm that slowly tracked westward making landfall on the east coast of Florida. Prior to making landfall, Nicole reached minimal Category 1 hurricane intensity based upon the strength of its winds. However, the very large size of the storm coupled with its slow development and forward speed, led to a large wind field across a large region of the Atlantic Ocean. This set the stage for the development of a high energy wave climate resulting in the creation of offshore wave heights measured in excess of 30 feet. Wave heights over 30 feet off the Florida coast are typically associated with Category 4 and 5 major hurricanes. Given the vulnerability of the Florida

east coast, particularly between St. Johns and Brevard counties following Hurricane Ian, Nicole caused additional severe beach and dune erosion. The high wave energy coupled with the multiple tide cycles occurring over a couple days during Nicole's passage, caused severe dune erosion as well as substantial damages to upland properties fronting on the Atlantic Ocean. Additional extensive damages to seawalls and revetments took place in Volusia, Flagler and St. Johns counties, endangering additional upland properties and infrastructure.

This report documents the post-storm beach conditions and coastal impact of both Hurricane Ian and Hurricane Nicole. 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 sand berms could be placed to fortify and assist in the recovery of the beach and dunes, and where expedited permitting procedures are needed to assist homeowners in repairs and reconstruction. This report will support a recovery plan to be prepared by the Department recommending potential beach nourishment and dune restoration funding to address coastal erosion. The recovery plan was partially funded by the legislature in December 2022 in special session and fully funded in the regular legislative session of 2023.

The Department developed this Post-Storm Beach Conditions and Coastal Impact Report to quantify the damages caused by both Hurricane Ian and Hurricane Nicole. This report provides a qualitative and quantitative assessment of storm impact, beach and dune erosion, and structural damages to the coastal regions of Florida fronting the Gulf of Mexico and Atlantic Ocean. Storm impacts in Florida Keys were excluded from this report due to lack of post-storm beach condition and storm damage data. 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 of 1,500 feet upland of the Coastal Construction Control Line (CCCL), as defined in Chapter 161, Florida Statutes.

II. Procedures Employed for Evaluating Coastal Impacts of Hurricane Ian

Immediately following the impacts of Hurricane Ian and Hurricane Nicole, damage assessment teams were dispatched to the affected coastal areas multiple times. The damage assessment teams from the Department included: Ralph Clark, P.E., Coastal Engineer; Guy Weeks, Planning Manager; Shamim Murshid, Coastal Engineer; Ty Amorosano, Coastal Engineer; Kristen Becker, Coastal Geologist; Sarah Lindeman, Coastal Geologist; Ashley Johnson, GIS Specialist; Shane Duinkerken, Surveyor; Chad Jones, Surveyor; Rob Davis, Surveyor, and office support Bud Bostick, GIS Manager, Gary Thigpen,

GIS Specialist, Ted Kiper, GIS Specialist and Bob Brantly, P.E., Coastal Engineer.

These hurricane damage assessment teams conducted the detailed damage assessments for the following counties: Collier, Lee, Charlotte, Sarasota, St. Johns, Flagler, and Volusia. Additional data, information, and assistance was provided to the Department staff by various state parks staff, Volusia County, Brevard County, Indian River County, Pinellas County, Collier County, and various private coastal engineering firms. This report is a document, and additional data and information on the substantial damage in affected counties, as well as quantitative volumetric and shoreline position changes, will subsequently be added when available to create the final post-storm impact report.

The post-storm damage assessment teams conducted detailed field inspections and assessments of the beach and dune erosion conditions and coastal structural damages within the coastal building zone using criteria consistently employed by Department staff over the past 40 years. The damage assessment teams evaluated major damages to buildings including roof damage, siding damage, other structural damage and flooding damage on residential and commercial buildings, including single-family dwellings, multifamily dwellings, and other major structures such as swimming pools, fishing piers, parking lots, roads, restaurants, public and commercial buildings, etc. Damages were also assessed for rigid coastal and shore protection structures including seawalls, revetments, groins, and jetties. The damage assessment teams logged observations into computer tablets and field books while inspecting the beach and dune erosion conditions and structures. **Figure 1** reflects a segment of coast showing the Coastal Building Zone, which extends 1,500 ft. landward of the CCCL and is displayed on the tablets by the yellow dashed line, while the red line is the CCCL. The colored dots in Figure 1 are the data points that were collected in the field and posted on a geographic information system (GIS) map layer. Post-storm reports have been prepared by the Department staff since 1979 and are available on the Department's website. The post-storm reports and the recovery plans are shared with coastal stakeholders and local governments, the Florida Legislature, and the Federal Emergency Management Agency (FEMA).

Following Hurricane Ian, the Department's Office of Resilience and Coastal Protection (RCP) contracted the acquisition of oblique aerial videography that greatly assisted with damage assessments along the southwest coast of Florida between Anclote Key and Cape Romano. This data was particularly useful in evaluating the beach conditions throughout southwest Florida as well as developing the damage assessments for the inaccessible islands of Cayo Costa, North Captiva Island, Captiva Island, Sanibel Island, Lovers Key, and Keewaydin Island. The long term storage of the oblique aerial videography for

Hurricane Ian will be stored at the Department's COASTS web page. Post-storm vertical aerial photography was provided by the National Oceanic and Atmospheric Administration (NOAA) following both storms and greatly assisted the damage assessments for this report. Following Hurricane Nicole, the Department's RCP requested through the State's Emergency Operations Center (EOC) to have the Civil Air Patrol fly the east coast of Florida to capture oblique aerial photography points of the coastal damages. This data was also particularly useful in evaluating the beach conditions along the east coast of Florida as well as developing the damage assessments at the segments of shoreline not visited by the damage assessment teams or needed additional review in the office.

The summary of post-hurricane field data collected after both Hurricane Ian and Hurricane Nicole can be viewed in section V and in each coastal county section of this report.

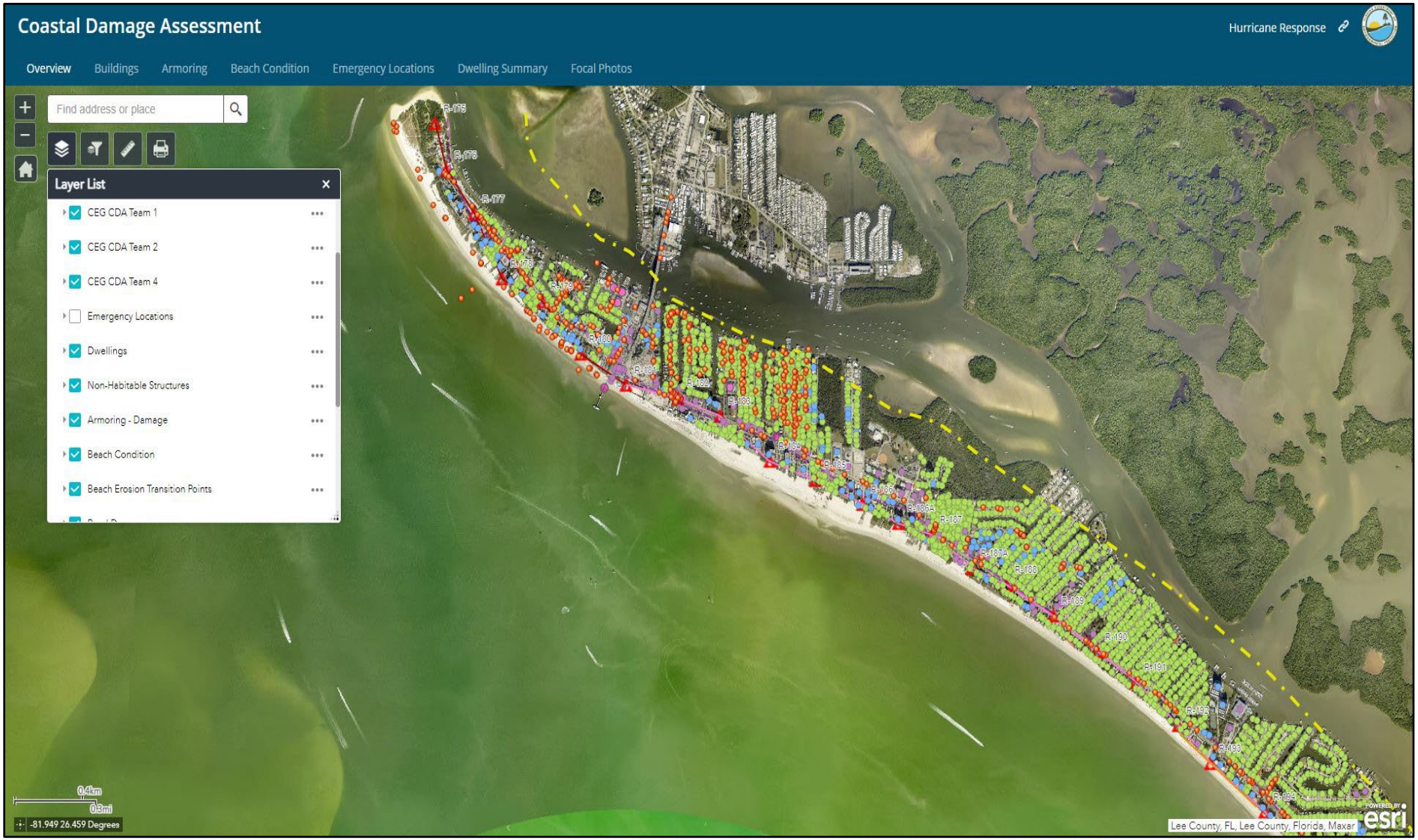

Figure 1. A snapshot of DEP data points collected within the coastal building zone that goes landward to the yellow dashed line.

III. Hurricane Ian: September 23 – October 2, 2022

Hurricane Ian, the fourth hurricane (wind speed ≥ 74 mph) and the second major hurricane (wind speed ≥ 111 mph) of the 2022 hurricane season for the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico, spawned from a tropical depression (wind speed ≤ 38 mph) that formed in the central Caribbean Sea in the early morning of September 23. It was upgraded to a tropical storm (wind speed 39 to 73 mph) and named Ian by 11:00 p.m. EDT with maximum sustained wind of 40 mph that was moving west northwestward at 12 mph. By the end of September 24, a hurricane watch was issued for western Cuba as Tropical Storm Ian was forecasted to become a hurricane. In the next 24 hours, Ian continued to strengthen and on Monday, September 26, it became a category 2 hurricane with maximum wind speeds of 105 mph. Ian experienced rapid intensification gaining at least 35 mph in wind speeds within 24 hours.

After midnight on Tuesday, September 27, Ian intensified to a category 3 hurricane with maximum sustained winds of 115 mph. At about 4:30 a.m. EDT, major Hurricane Ian made landfall southwest of the town of La Coloma in the Piñar Del Rio Province of Cuba with estimated maximum sustained winds of 125 mph. After battering western Cuba with high winds and storm surge, Ian headed slightly northeastward toward the eastern Gulf of Mexico coast. Ian intensified to a Category 4 hurricane on Wednesday morning September 28 with maximum sustained winds of 155 mph (only 2 mph below a category 5 hurricane). At 6:26 a.m. CDT, the National Data Buoy Center buoy (Station 42097) at Pulley Ridge offshore from Naples recorded a maximum significant wave height of 27.2 feet.

Hurricane Ian slowed to a forward speed of 9 mph. Forecasted to impact the densely populated Tampa Bay region, Ian eventually tracked northeasterly and made landfall further south in Lee County. At noon Wednesday, September 28, the eye of Hurricane Ian was located 45 miles southwest of Punta Gorda and 50 miles west-northwest of Naples. A weather station near Sanibel Island reported sustained winds of 71 mph and a maximum wind gust of 98 mph. Another station at Redfish Pass north of Captiva Island reported sustained winds of 67 mph and a maximum wind gust of 84 mph.

The eye of Hurricane Ian made landfall approximately 3:05 p.m. EDT on September 28 at Cayo Costa in northern Lee County. Data from an Air Force Reserve reconnaissance aircraft estimated that the maximum sustained wind at landfall was near 150 mph, making Ian the fifth-strongest measured hurricane to make landfall in the United States and the fourth strongest on record in the state of Florida. The estimated minimum central pressure was 940 mb (27.75 inches) at landfall. The Punta Gorda

airport reported a maximum wind gust of 124 mph and a weather station at the Cape Coral Fire Department reported a maximum wind gust of 110 mph.

Hurricane Ian weakened as it slowly tracked northeastward across peninsular Florida bringing flooding rains throughout the night over a wide swath of central Florida. On Thursday morning September 29, Ian weakened to tropical storm after producing heavy rains and catastrophic flooding over east-central Florida. There were over 30 postings of over 11 inches of rain on the CoCoRaSH network of reporting rain gages in Brevard, Volusia, Osceola, Orange and Seminole counties (reference: https://www.cocorahs.org/Login.aspx). The peak measurement came from a posting in Orange County where the 24-hour rainfall reached 16.67 inches.

At 5:40 a.m. EDT Thursday, September 29, the National Data Buoy Center buoy (Station 41009) located 20 nautical miles offshore from Cape Canaveral recorded a maximum significant wave height of 18.7 feet. The northern eye-wall of Ian caused storm tides and wave conditions comparable to a major northeaster along the northeast Atlantic coast of Florida with the most severe coastal impacts being sustained in Volusia, Flagler and St. Johns counties. On Thursday afternoon, September 29, Ian became a category 1 hurricane again with maximum wind speed of 75 mph. Before midnight its strength increased with wind speed reaching 85 mph. On Friday, September 30, Hurricane Ian accelerated and tracks northward making landfall again at 2:05 p.m. EDT near Georgetown, South Carolina with maximum sustained winds of 85 mph and an estimated minimum central pressure of 977 mb (28.85 inches). By 5:00 p.m. EDT, Ian had lost its tropical characteristics. By 11:00 p.m., the remnants of Ian bought heavy rain and gusty wind inland over North Carolina, and eventually dissipated across southern Virginia.

Figure 2 illustrates the track history of Hurricane Ian overlayed on satellite imagery combined with timelines of wind speed and atmospheric pressure along its path. Ian was a large, slow-moving storm as it approached (**Figure 3**) and impacted Florida with extreme winds, waves, storm surge and rainfall.

Figure 2. Hurricane Ian track (Source: Zoom Earth).

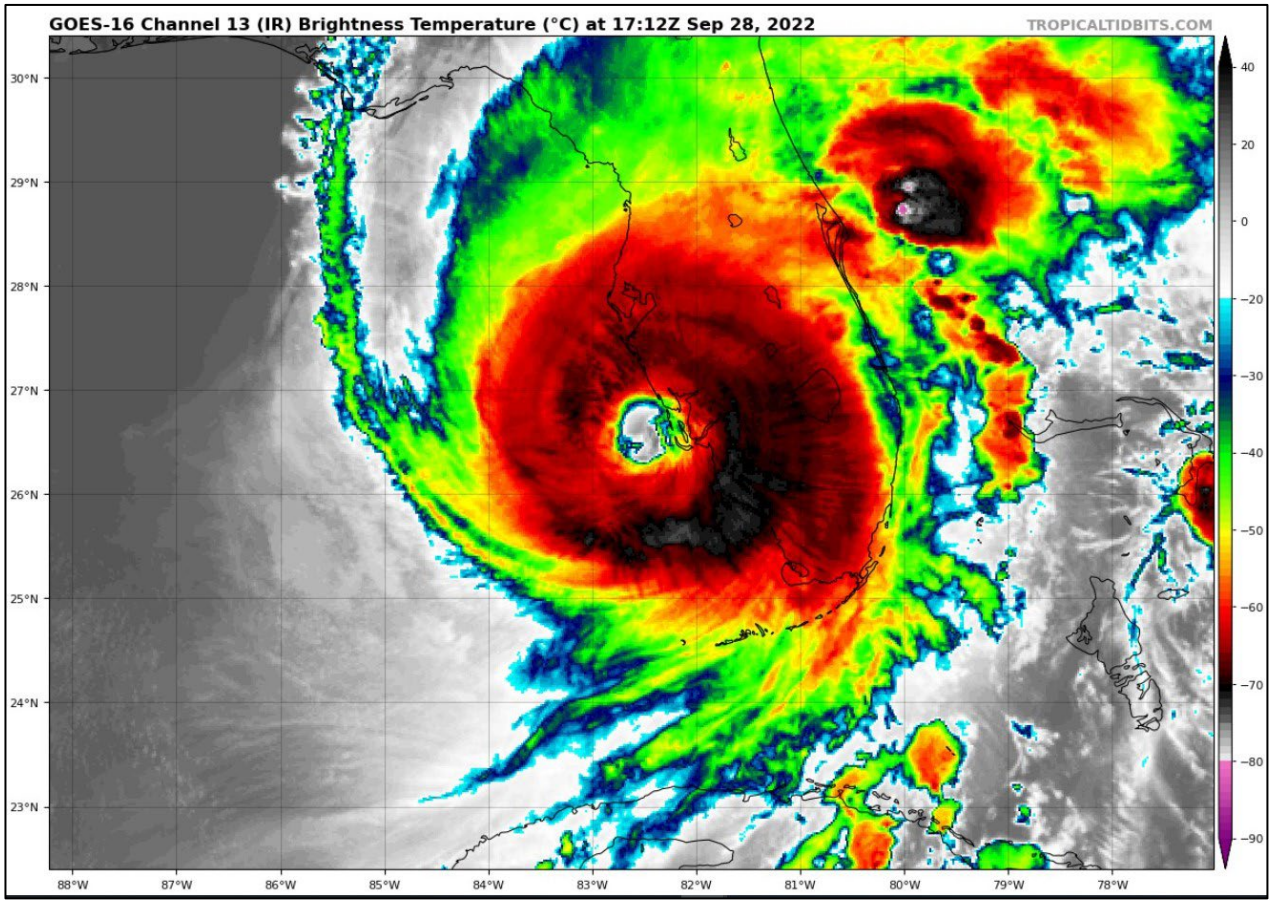

Figure 3. Satellite image of Hurricane Ian (Source: NOAA Goes-16 Satellite and Tropical Tidbits).

Storm tide data around Florida's coast is available from several of NOAA's recording tide gages. In addition to NOAA tide gauges, special storm-tide sensors that can measure the height, extent, and timing of the storm tide were deployed by the U.S. Geological Survey (USGS). Additional storm tide data from surveyed seaweed wrack lines and mud lines inside of buildings are not currently available.

The highest storm tide for southwest Florida was measured at a USGS water level sensor at the Fort Myers Beach Municipal Pier in Lee County. The maximum storm tide water elevation measured was +13.23 feet NAVD. On southern Sanibel Island, a USGS water level sensor recorded a maximum storm tide of +13.1 feet NAVD. The unfiltered water elevation was as high as 16.6 feet-NAVD at Fort Myers Pier, and 15.6 feet-NAVD at Sanibel Island. **Figure 4** shows the time series of storm tide for these two stations. It is noteworthy that the 100-year combined total storm tide level predicted in Lee County near the Fort Myers Beach Pier is +13.1 feet NAVD (Beaches & Shores Resource Center, 1990). Thus, the most severely impacted area along Sanibel Island and Estero Island experienced a 100-year return interval storm tide event (Beaches & Shores Resource Center, 1990).

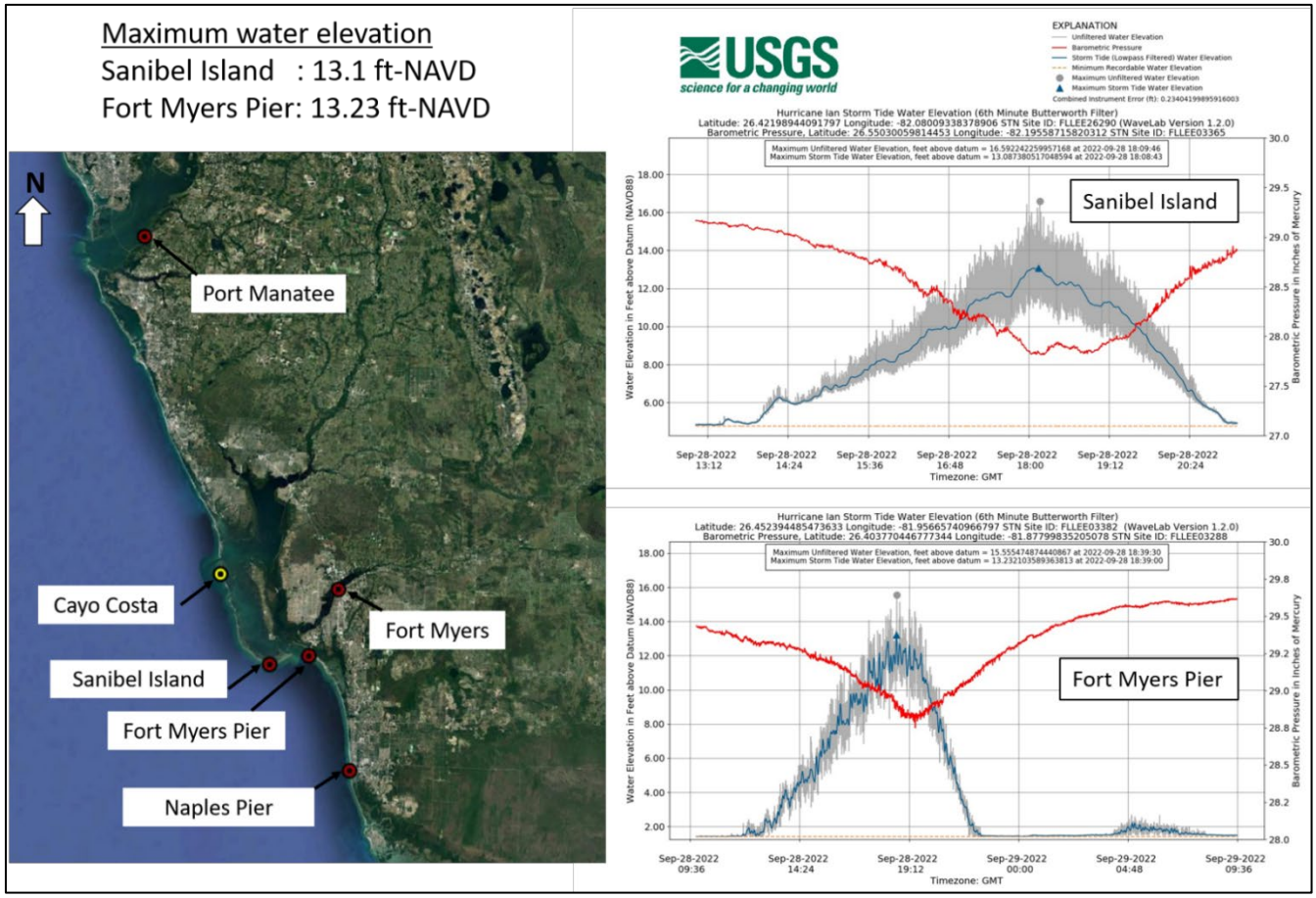

Figure 4. Water level elevations at Sanibel Island and Fort Myers Pier (Source: USGS).

Inland from the coast on the Caloosahatchee River, near the Caloosahatchee Bridge at the City of Fort Myers, NOAA tidal station 8725520 recorded a maximum water level of +7.53 feet NAVD (**Figure 5**). This tide level was the highest on record at this location and explains the flooding sustained in the City of Fort Myers inland from the coast. Further south, at the Naples Pier on the open coast, the probable breakdown of water level sensor was identified as the storm tide reached close to +7 feet NAVD. In contrast, prior to the landfall of Hurricane Ian, a large drop in the water level at Tampa Bay exposed extensive sandy bay bottoms. This drop in water level was recorded at NOAA tidal station 8726384 located at Port Manatee (Figure 5). The position of Tampa Bay to the north-northwest of Ian's eye resulted in winds blowing offshore that caused a set-down or squat of the bay's water level, which was measured to reach roughly -4.0 feet NAVD at Port Manatee. As the eye of the hurricane passed inland, the wind field rotating around the eye shifted to onshore, resulting in the eventual return of the water level to normal conditions.

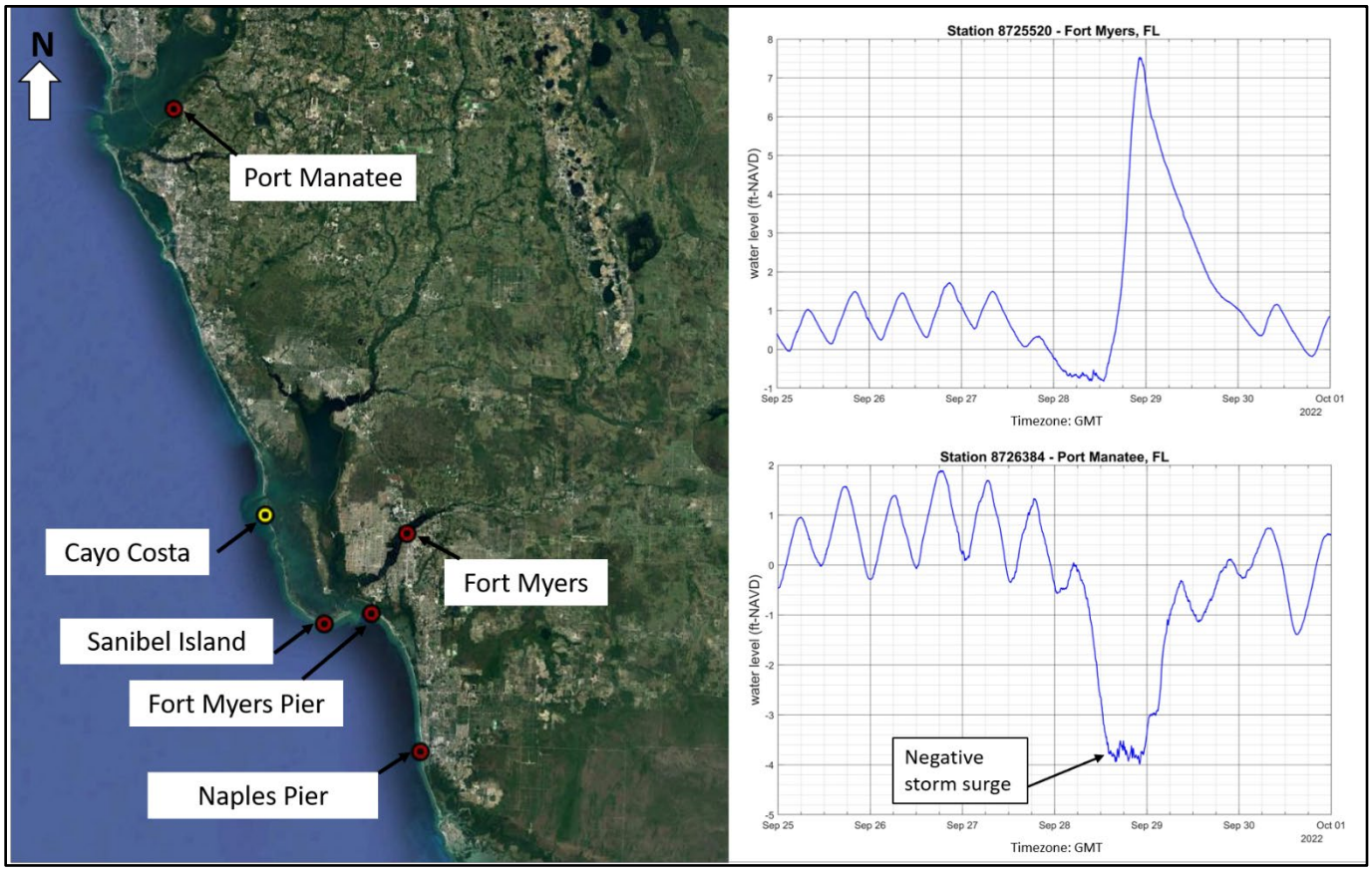

Figure 5. Water level elevations at Fort Myers and Port Manatee (Source: NOAA).

On the east coast of Florida, a USGS storm tide sensor at the Main Street Pier in Daytona Beach measured a maximum storm tide level of approximately +8.0 feet NAVD, whereas the instantaneous unfiltered water elevation reached +9.8 feet NAVD (**Figure 6**). At Flagler Beach, a peak storm tide level of +8.3 feet NAVD was recorded and at the St. Augustine Beach Fishing Pier, a peak storm tide of +7.43 feet NAVD was recorded.

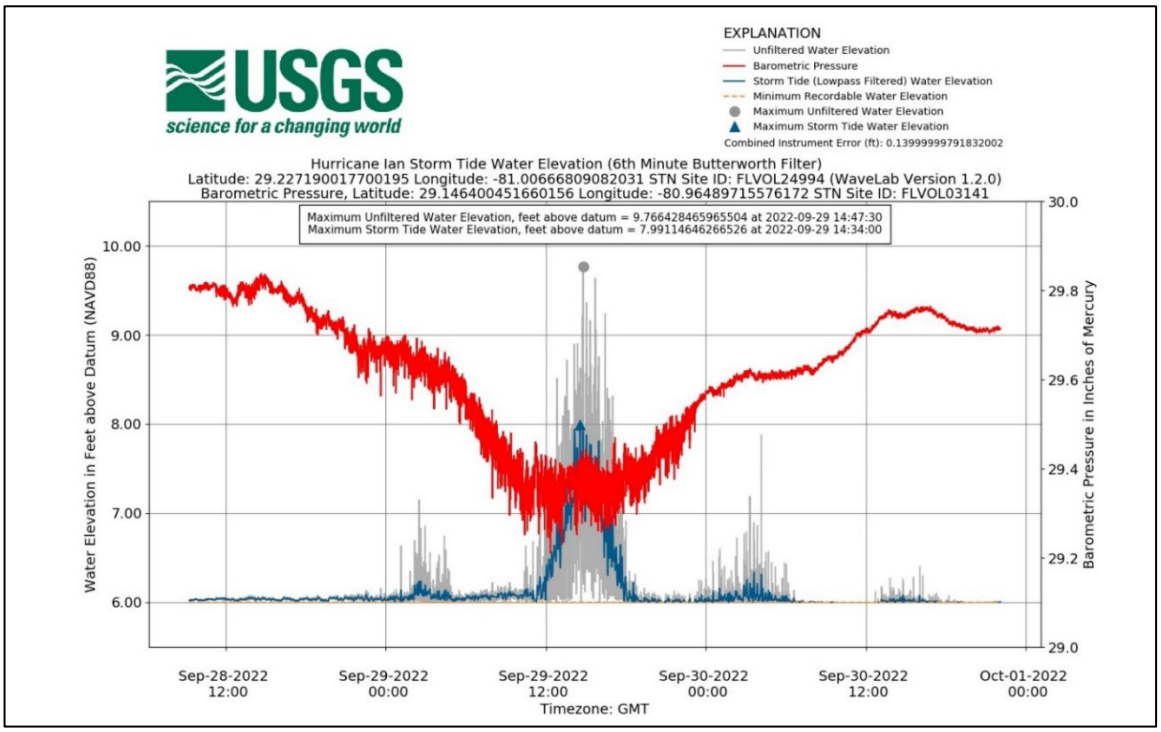

Figure 6. Water level elevation at Daytona Beach in Volusia County (Source: USGS).

IV. Hurricane Nicole: November 7 – November 11, 2022

Hurricane Nicole, the eighth hurricane (wind speed ≥ 74 mph) of the 2022 hurricane season for the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico, spawned from a subtropical storm that formed over the Atlantic east of the northwestern Bahamas on Monday morning, November 7. At 1:00 p.m. EST, the subtropical storm was moving toward the northwest at approximately 9 mph with maximum sustained winds of nearly 45 mph. Tuesday morning, November 8, Nicole strengthened and became a tropical storm having complete air mass rotation around its geometric center, or eye. Tuesday evening, Nicole tracked west-southwest approaching the northwestern Bahamas and intensified to 70 mph maximum sustained winds that prevailed overnight. Wednesday morning, November 9, the center of Nicole made landfall at 11:55 a.m. EST on Great Abaco Island in the northwestern Bahamas with an estimated sustained wind of 70 mph. An Air Force Reserve reconnaissance aircraft indicated that the minimum pressure at that time was 985 mb. By 6:00 p.m. EST, November 9, data from NOAA Hurricane Hunter aircraft indicated that Nicole had become a Category 1 hurricane with maximum winds of 75 mph. Before midnight, radar imagery indicated that the center of Nicole was moving away from Grand Bahama Island and tracking westward towards the east coast of Florida. The size of Nicole was several hundred miles across and the large wind field had already created a wave climate that was battering the coast of Florida in advance of the official landfall of the hurricane's eye.

On Thursday, November 10, after midnight, the center of Hurricane Nicole was located about 30 miles east-southeast of Fort Pierce, Florida with maximum sustained winds of 75 mph. The hurricane was moving toward the west-northwest at nearly 14 mph. About 2:00 a.m. EST, the NOAA buoy 41009, located about 20 nautical miles east of Cape Canaveral, reported a recent sustained wind of 49 mph, a wind gust to 65 mph, and a maximum significant wave height of 31.8 feet. A weather station at Patrick Air Force Base reported a sustained wind of 53 mph with a wind gust of 61 mph. A NOAA tide gauge at Fernandina Beach, Florida observed a water level of 4.5 feet above Mean Higher High Water. About 3:00 a.m. EST, the center of Nicole made landfall on the east coast of Florida at Avalon Beach, St. Lucie County, immediately south of Vero Beach. The maximum sustained winds were estimated to be 75 mph and the minimum central pressure were estimated to be 981 mb. Nicole was only the third November hurricane that made landfall in Florida since record keeping began in 1853. Nicole made landfall only 43 days after Hurricane Ian.

By 4:00 a.m., November 10, Nicole had weakened to tropical storm intensity while storm tides and

waves continued to batter northeast Florida as the center moved west-northwestward over central Florida. Throughout the morning of November 10, Nicole crossed the Florida peninsula with strong winds and heavy rains covering a broad area. About 4:00 p.m. EST, the center of Nicole was straddling the gulf coast of Florida's Big Bend region with maximum sustained winds nearly 45 mph. For the next several hours, the storm center tracked northwestward over the far northeastern Gulf of Mexico before moving inland over the eastern Florida Panhandle. Nicole caused heavy rain in north Florida and south Georgia. By 10:00 p.m., Nicole weakened to a tropical depression. Over the next 24 hours on September 11, Nicole continued to move north-northeast over the southern Appalachians with tornadoes and rainfall, before dissipating further inland.

Figure 7 illustrates the track history of Hurricane Nicole overlayed on satellite imagery combined with timelines of wind speed and atmospheric pressure along its path. Although Nicole was significantly weaker than Ian in terms of wind speed, it's very large size (**Figure 8**) and slow forwarding speed created a strong on-shore wind field over a very large area that led to the development of high energy wave condition onto the east coast of Florida. This severe wave condition persisted for almost three days prior to the landfall resulted in severe beach and dune erosion, especially in Volusia, St. Johns and Flagler counties.

Figure 7. Hurricane Nicole track (Source: Zoom Earth).

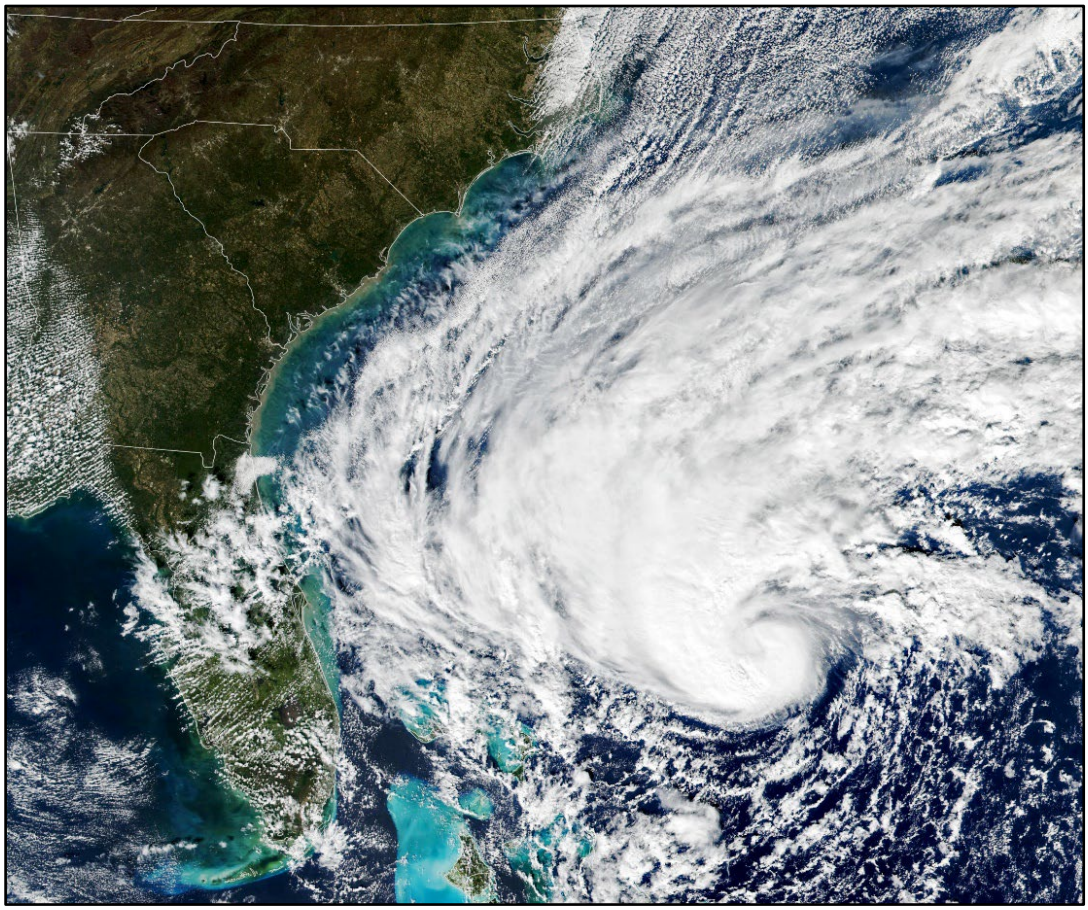

Figure 8. Satellite image of Hurricane Nicole (Source: NASA).

Wave and storm tide data around Florida's east coast is available from several of NOAA's recording wave gauges and tidal stations. A wave buoy located 20 nautical miles east of Cape Canaveral recorded significant wave height more than 30 feet (**Figure 9**). NOAA tidal gauges at Fernandina Beach in Nassau County and Mayport Naval Station in Duval County recorded maximum water levels of +6.55 feet NAVD and +5.54 feet NAVD, respectively (**Figure 10**).

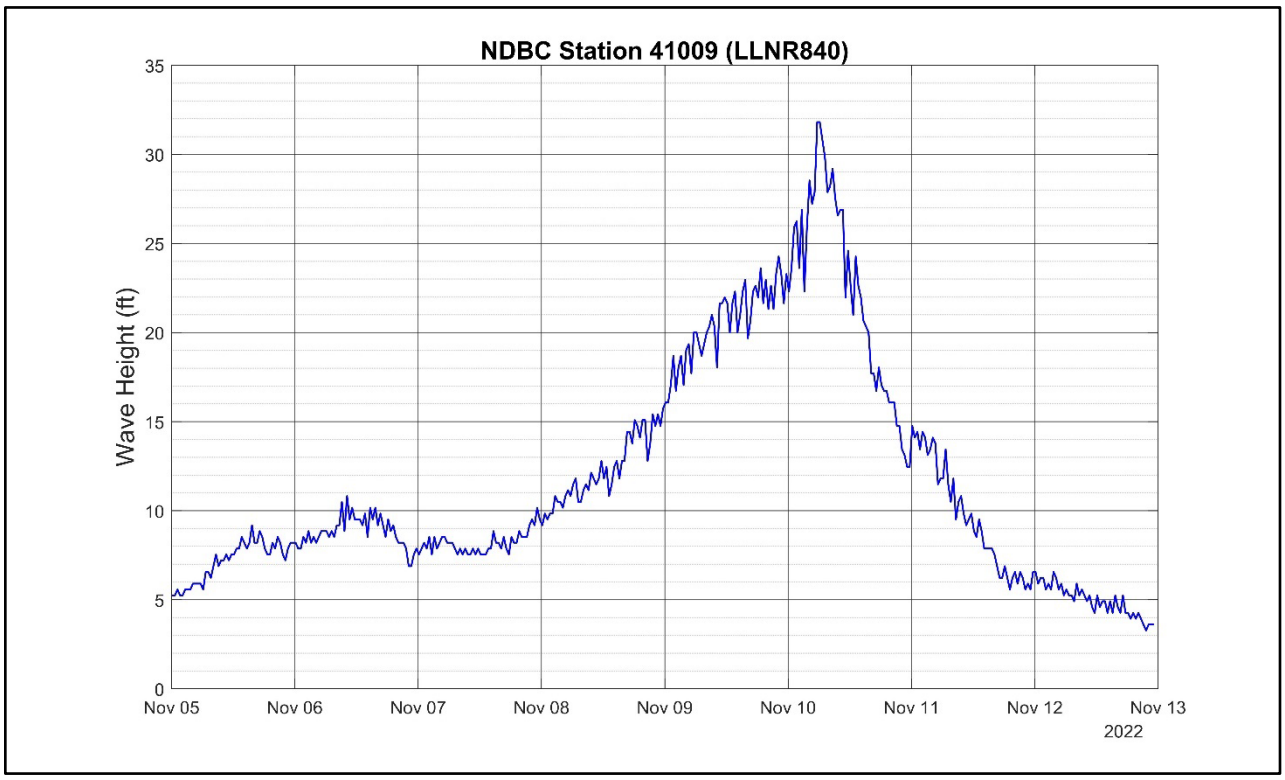

Figure 9. Wave heights at NOAA wave buoy located 20 nautical miles east of Cape Canaveral (Source: NOAA).

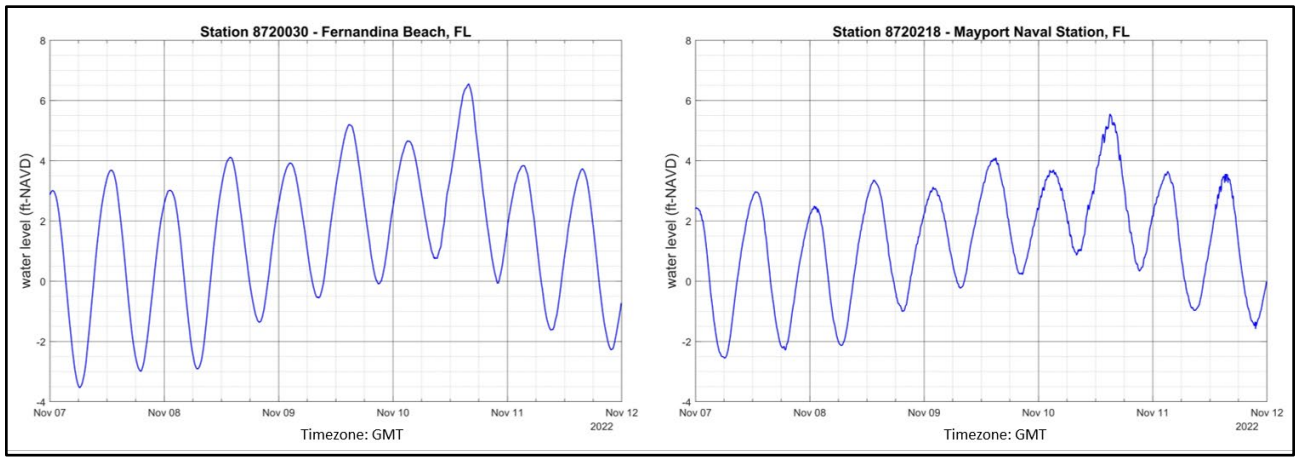

Figure 10. Water level elevations at Fernandina Beach and Mayport Naval Station (Source: NOAA).

V. Hurricane Ian and Hurricane Nicole Impact Summary and Overview

This section provides a summary of the beach and dune erosion, and structural damage, that occurred in the more substantially affected coastal counties. **Table 1** lists beach and dune erosion conditions around the state of Florida, starting with southwest Florida from Sarasota County and continuing southward through Collier County, and then crossing to the east coast of Florida starting from St. Johns County and continuing southward through Martin County. Areas with no erosion are listed as 0 in Table 1. Reference or Range ("R") monuments are survey markers established and maintained since 1972 by the Department that are spaced approximately every 1000 feet to measure beach and dune conditions. A graphic depiction of the classification of beach erosion conditions is provided in **Figure 11**.

Table 1. Beach and Dune Erosion Summary.

Sarasota County

Locations	Range Monuments	Erosion Condition
Venice Beach	R117 – R131	I
Venice Beach	R131 – R135	0
Venice Beach	R135 – R136	I
Venice Beach	R136 – R141	0
Caspersen Beach	R141 – R143	I
Caspersen Beach	R143 – R148	0
Caspersen Beach / Manasota Key	R148 – R182	I

Charlotte County

Locations	Range Monuments	Erosion Condition
Manasota Key - Englewood Beach	R1 – R2	I
Manasota Key - Englewood Beach	R8 – R9	II
Manasota Key - Englewood Beach	R10 – R11.5	I
Don Pedro Island	R21.5 – R22	II
Don Pedro Island	R25 – R29	I
Don Pedro Island	R29 – R30	II
Don Pedro Island	R30 – R36	I
Don Pedro Island	R36	II
Don Pedro Island	R36 – R38	I
Don Pedro Island	R38 – R40	II
Don Pedro Island	R40 – R41	I
Don Pedro Island	R51 – R54	II
Don Pedro Island	R54 – R56.5	I
Don Pedro Island	R56.5 – R57.5	II
Gasparilla Island	R58 – R60	II
Gasparilla Island	R63 – R66	I
Gasparilla Island	R66 – R68	II

Lee County

Locations	Range Monuments	Erosion Condition
Gasparilla Island	R1 – R6	II
Gasparilla Island	R6 – R26	I
Cayo Costa Island	R27 – R28	IV
Cayo Costa Island	R28 – R46	II
Cayo Costa Island	R46 – R47	III
Cayo Costa Island	R47 – R52	IV
Cayo Costa Island	R52 – R53	III
Cayo Costa Island	R53 – R59	II
Cayo Costa Island	R59 – R60	III
Cayo Costa Island	R60 – R65	IV
North Captiva Island	R66	III
North Captiva Island	R66.5 – R69	II
North Captiva Island	R69 – R71	I
North Captiva Island	R71 – R72	III
North Captiva Island	R73 – R75	IV
North Captiva Island	R75A	II
North Captiva Island	R76 – R82	IV
Captiva Island	R83 – R109	IV
Sanibel Island	R110 – R174	IV
Estero Island (Ft. Myers Beach)	R175 – R210	IV
Lovers Key	R211 – R222	IV
Big Hickory Island	R222 – R225	IV
Bonita Beach	R225 – R239	IV

Collier County

Locations	Range Monuments	Erosion Condition
Barefoot Beach	R1 – R16	IV
Delnor-Wiggins Pass State Park	R17 – R22	IV
Vanderbilt Beach	R22 – R39	IV
Pelican Bay Beach	R39 – R41	IV
Naples	R42 – R89	IV
Keewaydin Island	R90 – V302	IV
Sea Oat Island	V304 – V308	IV
Hideaway Beach	V311 – V312	I
Marco Island	R128 – R133	IV
Marco Island	R133 – R148	I
Kice Island	V320 –V332	I
Cape Romano/ Morgan Beach/ Morgan Island	V333 –V343	I

St. Johns County

Locations	Range Monuments	Erosion Condition
Ponte Vedra	R1 – R4	III
Ponte Vedra	R4 – R6	II
Ponte Vedra	R6 – R14	III
Ponte Vedra	R14 – R16	IV

Ponte Vedra	R16 – R24	II
Ponte Vedra	R24 – R26	III
Ponte Vedra	R26 – R33	IV
Ponte Vedra	R33 – R36	III
Ponte Vedra/ GTM Reserve	R36 – R67	II
South Ponte Vedra	R67 – R75	I
South Ponte Vedra	R75 – R83	II
South Ponte Vedra	R83 – R85	I
South Ponte Vedra/ Vilano Beach	R85 – R118	IV
Vilano Beach	R118 – R120	II
Vilano Beach	R120 – R122	I
Anastasia State Park	R124 – R128	III
Anastasia State Park	R128 – R131	IV
Anastasia State Park	R131 – R141	III
St. Augustine Beach	R141 – R174	IV
Crescent Beach	R174 – R195	IV
Matanzas Inlet North Shore	R195 – R196	IV
Summer Haven	R197 – R209	IV

Flagler County

Locations	Range Monuments	Erosion Condition
Marineland	R1 – R3	IV
Marineland	R3 – R5	III
Matanzas Shores	R5 – R13	II
Washington Oaks State Park	R13 – R15	III
North Flagler County	R15 – R19	II
North Flagler County	R19 – R20	III
North Flagler County	R20 – R21	IV
Malacompa Park	R21 – R22	II
Malacompa Park	R22 – R23	IV
Ocean Hammock Beach	R23 – R27	II
Hammock Dunes Beach	R27 – R30	III
Hammock Dunes Beach	R30 – R34	II
Hammock Dunes Beach	R34 – R35	III
Hammock Dunes Beach	R35 – R45	IV
Hammock Dunes Beach	R45 – R46	III
Varn Park	R46 – R49	IV
Painters Hill	R49 – R50	III
Painters Hill	R50 – R53	IV
Painters Hill	R53 – R59	III
Beverly Beach	R59 – R62	II
Beverly Beach/ Flagler Beach	R62 – R70	IV
Flagler Beach	R70 – R71	II
Flagler Beach	R71 – R75	I
Flagler Beach	R75 – R78	II
Flagler Beach	R78 – R79	III
Flagler Beach	R79 – R100/CL	IV

Volusia County

Locations	Range Monuments	Erosion Condition
North Peninsula State Park	CL – R2	IV
North Peninsula State Park	R2 – R8	II
North Peninsula State Park	R8 – R12	III
North Peninsula State Park/ Ormond Beach	R12 – R19	II
Ormond Beach	R19 – R23	I
Ormond Beach	R23 – R24	III
Ormond Beach	R24 – R26	IV
Ormond Beach	R26 – R27	III
Ormond Beach	R27 – R31	IV
Ormond Beach	R31 – R33	III
Ormond Beach	R33 – R36	II
Ormond Beach	R36 – R39	III
Ormond Beach/ Daytona Beach/ Daytona Beach Shores/Wilbur by the Sea/ Ponce Inlet	R46 – R148	IV
New Smyrna Beach	R149 – R153	IV
New Smyrna Beach	R153 – R163	III
New Smyrna Beach	R163 – R167	I
New Smyrna Beach	R167 – R170	IV
New Smyrna Beach	R170 – R174	III
New Smyrna Beach/ Bethune Beach	R174 – R208	IV
Canaveral National Seashore	R208 – R210	III
Canaveral National Seashore	R210 – V337	Not Available

Brevard County

Locations	Range Monuments	Erosion Condition
Canaveral National Seashore/ Playalinda Beach	BE V301 – BE V467	Not Available
Cocoa Beach	R12 – R22	I
Cocoa Beach	R22 – R28	II
Cocoa Beach	R28 – R31	I
Cocoa Beach	R31 – R35	II
Cocoa Beach	R35 – R40	I
Cocoa Beach	R40 – R43	II
Cocoa Beach	R43 – R48	I
Cocoa Beach	R48 – R52	II
Patrick Space Force Base	R52 – R64	II
Patrick Space Force Base	R64 – R65	III
Patrick Space Force Base	R65 – R67	II
Patrick Space Force Base	R67 – R70	I
Patrick Space Force Base	R70 – R74	II
Satellite Beach	R74 – R85	III
Satellite Beach	R85 – R86	IV
Satellite Beach	R86 – R88	III
Satellite Beach	R88 – R90	IV
Satellite Beach	R90 – R91	III
Satellite Beach/ Indian Harbour Beach	R91 – R103	IV

Indian Harbour Beach	R103 – R105	III
Canova Beach Park	R105 – R106	IV
Brevard County	R106 – R109	III
Brevard County	R109 – R110	II
Brevard County	R110 – R115	III
Indialantic	R115 – R121	II
Indialantic	R121 – R122	III
Indialantic	R122 – R124	II
Indialantic/ Melbourne Beach	R124 – R130	II
Melbourne Beach	R130 – R133	I
Melbourne Beach	R133 – R139	II
Brevard County	R139 – R141	III
Brevard County	R141 – R159	IV
Brevard County	R159 – R161	III
Brevard County	R161– R173	IV
Brevard County	R173 – R181	III
Floridana Beach	R181 – R188	IV
Brevard County	R188 – R194	III
Brevard County	R194 – R201	II
Brevard County	R201 – R203	III
Brevard County	R203 – R208	II
Sebastian Inlet State Park	R208 – R215	III
Sebastian Inlet State Park	R215 – R219	II

Indian River County

Locations	Range Monuments	Erosion Condition
Sebastian Inlet State Park	R1 – R9	II
Sebastian Inlet State Park	R9 – R14	IV
Sebastian Inlet State Park/ Ambersand Beach	R14 – R17	III
Wabasso Beach	R17 – R21	I
Wabasso Beach	R21 – R23	II
Treasure Shores Park	R23 – R26	III
Wabasso Beach	R26 – R28	II
Wabasso Beach	R28 – R29	III
Wabasso Beach	R29 – R31	IV
Golden Sands Park	R31 – R33	III
Town of Orchid and Sea Grape Park	R33 – R47	IV
Wabasso Beach	R47 – R54	III
Wabasso Beach/ Vero Beach	R54 – R56	II
Vero Beach	R56 – R64	III
Vero Beach/ Jaycee Park/ Humiston Park	R64 – R83	IV
Vero Beach	R83 – R84	III
Vero Beach	R84 – R86	II
South Beach/ Ocean Ridge Subdivision	R86 – R104	I
South Beach/ Porpoise Point	R104 – R106	IV
South Beach/ Round Beach	R106 – R117	II

St. Lucie County

Locations	Range Monuments	Erosion Condition
Avalon State Park	R1 – R3	II
Avalon State Park	R3 – R14	I
Ft. Pierce Beach	R14 – R17	II
Ft. Pierce Beach	R17 – R46	I
St. Lucie County	R46 – R58	II
St. Lucie County	R58 – R75	I
St. Lucie County	R75 – R79	II
St. Lucie County/ Walton Rocks Beach	R79 – R89	III
South St. Lucie Beaches	R89 – R98	0
South St. Lucie Beaches	R98 – R100	I
South St. Lucie Beaches	R100 – R115	0

Martin County

Locations	Range Monuments	Erosion Condition
Jensen Beach	R1 – R12	0
Jensen Beach	R12 – R25	I
Stuart Beach/House of Refuge/ Chastain Beach	R25 – R34	III
Bathtub Beach	R34 – R36	III
Sailfish Point	R-36 – R42	II
Jupiter Island	R45 – R127/CL	I - II

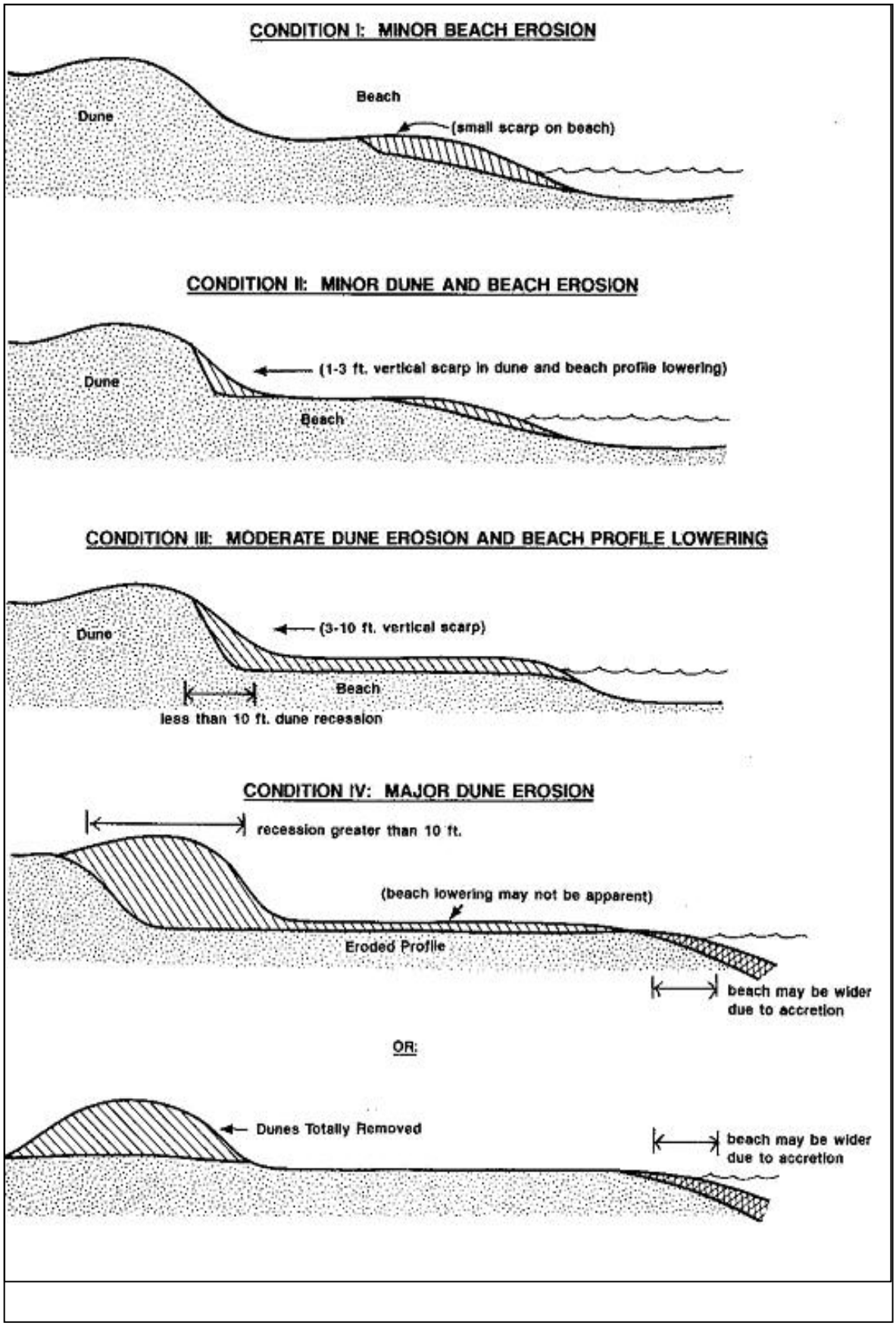

Figure 11. Beach Erosion Conditions I to IV.

Major Structural Damage

A summary of damage to coastal armoring, including seawalls, bulkheads, revetments, or other rigid coastal protection structures fronting on the Gulf of Mexico and Atlantic Ocean, is provided in **Table 2**. See Appendix A or Figure 125 that describes the different damage levels to coastal armoring structures. Not included in this table is damage to retaining walls, concrete block walls, or concrete gravity walls that do not provide protection from erosion and storm tides and waves, or armoring on interior tidal waters. Also not included are jetty structures constructed for navigation at ports and inlets. Hurricane Ian caused major damage to 4,502 major structures, including 1,581 that were destroyed (**Figure 12)**. The most severe structural damage on the coast from Ian occurred in southwest and northeast Florida. Along the Gulf of Mexico, the greatest structural damage occurred in Sarasota, Charlotte, Lee and Collier counties. Along the Atlantic coast of Florida, the greatest structural damage occurred in St. Johns, Flagler and Volusia counties. Hurricane Nicole caused major damage to another 158 major structures. The most severe structural damage on the coast from Nicole occurred along the Atlantic coast of Florida from St. Johns through Indian River counties. An overall summary of structural damage to major structures is given in **Table 3.** A more detailed description of these impacts by each county is provided in Section VI of this report.

Table 2. Summary of Coastal Armoring Damage Caused by Hurricane Ian & Hurricane Nicole.

Hurricane Ian – Armoring Damage		
County	**Major Damage (Feet)**	**Minor Damage (Feet)**
Lee	4,756	1,525
Collier	3,036	0
St. Johns	0	845
Flagler	1,200	9,350
Volusia	6,330	3,435
TOTAL	**15,322 (2.9 miles)**	**15,155 (2.87 miles)**

Hurricane Nicole – Armoring Damage		
County	**Major Damage (Feet)**	**Minor Damage (Feet)**
St. Johns	2,008	1,243
Flagler	7,790	2,036
Volusia	13,262	3,265
TOTAL	**23,060 (4.37 miles)**	**6,544 (1.24 miles)**

Note: see Appendix A or Figure 120 that describes the different damage levels to coastal armoring structures.

Table 3. Summary of Major Structural Damage to Major Structures by Hurricane Ian & Hurricane Nicole along the Coast of Florida.

Hurricane Ian – Major Structural Damages				
County	**# Single-Family Dwellings Damaged**	**# Multi-family Dwellings[1] Damaged**	**# Other Major Structures[2] Damaged**	**Total # Damaged[3]**
Sarasota	32	12	1	45
Charlotte	156	62	5	223
Lee	2,791	502	220	3,513
Collier	173	69	20	262
St. Johns	16	3	0	19
Flagler	61	5	10	76
Volusia	272	68	24	364
TOTAL	**3,501**	**721**	**280**	**4,502**

Hurricane Nicole – Major Structural Damages				
County	**# Single-Family Dwellings Damaged**	**# Multi-family Dwellings[1] Damaged**	**# Other Major Structures[2] Damaged**	**Total # Damaged[3]**
St. Johns	10	2	1	13
Flagler	7	1	1	9
Volusia	35	12	62	109
Brevard	14	3	2	19
Indian River	2	3	2	7
Broward	0	0	1	1
TOTAL	**68**	**21**	**69**	**158**

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.

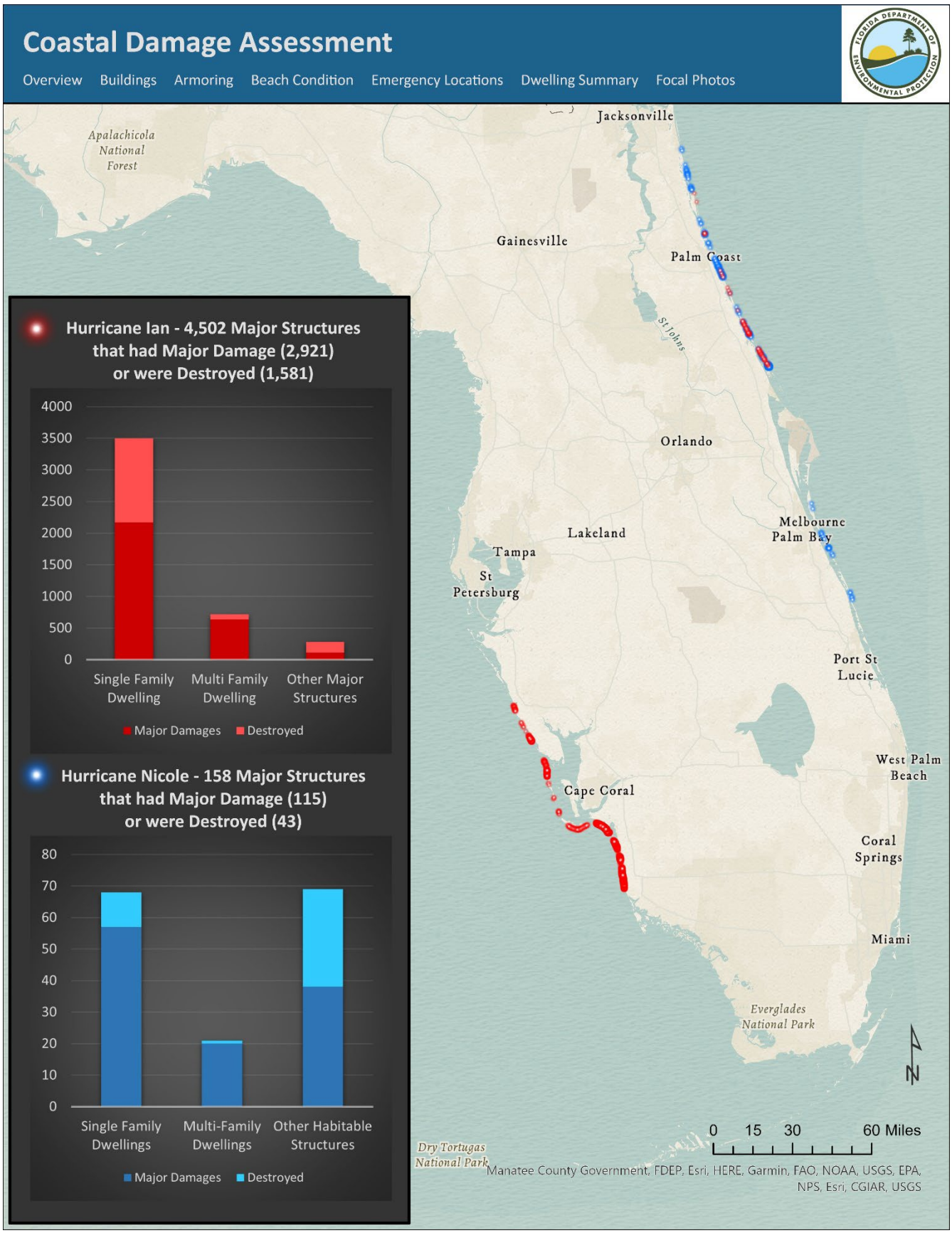

Figure 12. Summary of major damages to major structures from Hurricanes Ian and Nicole.

VI. Detailed Damage Assessment by County

The counties with the most significant damages are discussed individually as follows. This includes the southwest Florida counties extending from southern Sarasota through Collier and the northeast Florida counties of St. Johns through Volusia. Other southwest Florida counties from northern Sarasota (**Figure 13**) through Manatee and Pinellas, plus northeast Florida counties Nassau and Duval, as well as southeast Florida counties from Brevard southward through Monroe, are not discussed in detail in this post-storm report.

Quantitative beach erosion was estimated by comparing available pre-storm survey data and post-storm LIDAR data from USACE. Different interpolation and geoprocessing tools were used in ArcGIS Pro for volumetric analysis. ArcGIS Pro was used to create Triangular Irregular Network (TIN) surfaces for both pre- and post-storm beach conditions using elevation data from pre- and post-storm beach profiles. In general, TIN is a digital means to represent surface morphology. In the next step, the "TIN to Raster" geoprocessing tool was used on TIN surfaces to create pre- and post-storm rasters by interpolating the elevations assigned to the TIN. Then volume losses and gains were calculated using the "Cut/Fill" geoprocessing tool. The seaward boundary of the analysis was the location of pre-storm mean high water (MHW) elevation for the given reach of shoreline and the landward boundary was generally the landward extent of pre-storm survey data or to an existing road or seawall. The net volume loss for a stretch of shoreline was estimated by substracting the "gain volume" from the "loss volume".

Volumetric change above mean high water was calculated for southern Sarasota through Collier counties for the southwest Gulf coast region and St. Johns through Indian River counties for northeast and central Atlantic coast. On the east coast of Florida, both St. Lucie County and Martin County had predominantly minor beach and dune erosion (Condition I and II) except for a couple pockets of moderate beach and dune erosion (Condition III) at Walton Rocks, House of Refuge and Bathtub Reef. Further south, most beaches sustained only minor erosion except for localized hotspots of more significant erosion. Southeast Florida certainly had significant waves as the Anglin's Fishing Pier in Lauderdale-by-the-Sea (Broward County) was substantially destroyed.

Each detailed county summary is preceded by a county map showing the qualitative beach and dune erosion conditions graphically displayed. Each detailed county summary also includes photographic examples of the type of damage sustained. County maps showing beach and dune erosion conditions are also included for Brevard, Indian River, St. Lucie and Martin counties (Figures 116 – 119).

Sarasota County

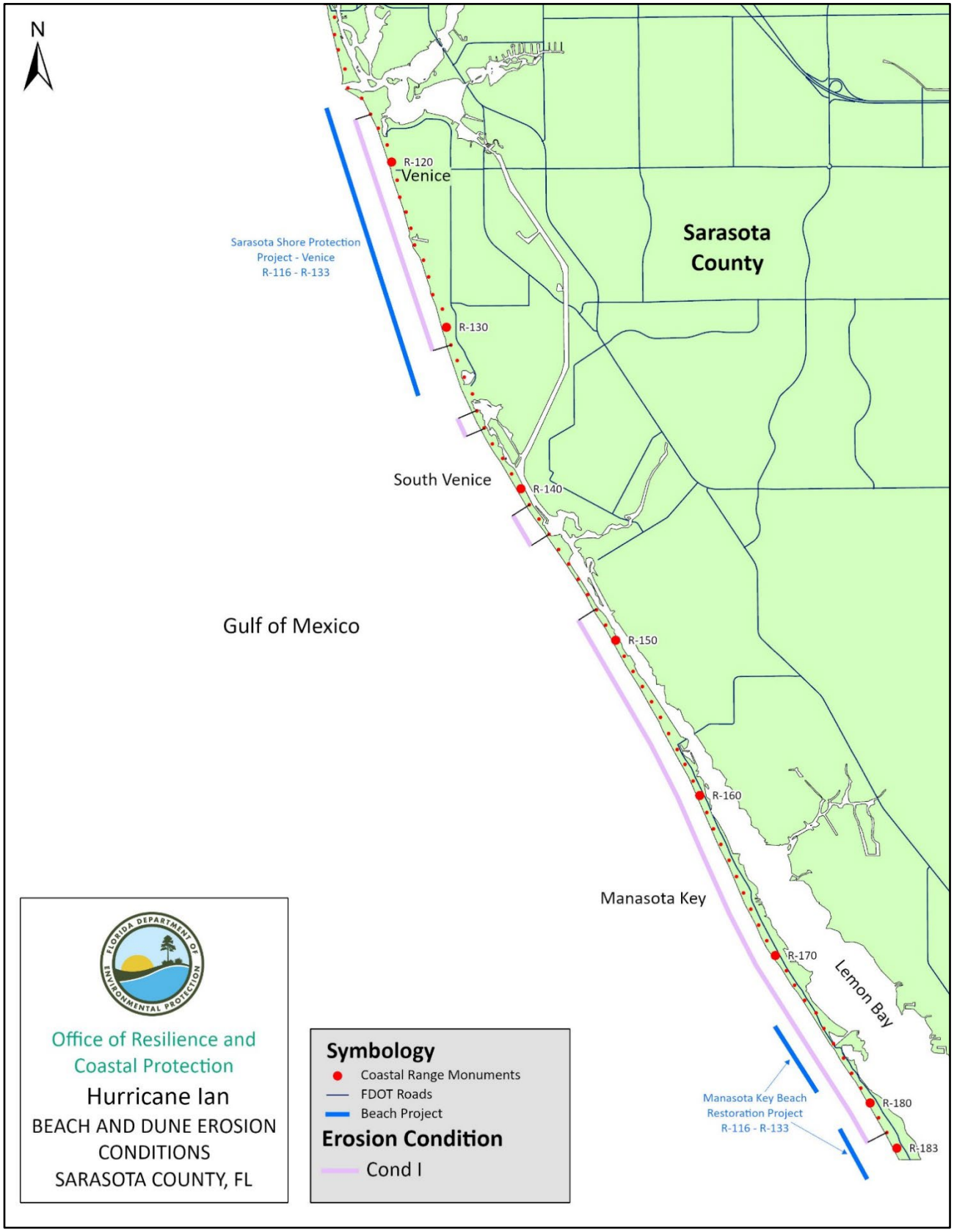

Figure 13. Sarasota County (Southern Section) Beach and Dune Erosion Conditions from Hurricane Ian.

Sarasota County

Sarasota County is located on Florida's southwestern coast fronting the Gulf of Mexico (**Figure 13)** and has 34.7 miles of beaches extending southward from Manatee County to Charlotte County. The coast of Sarasota County includes the southern half of Longboat Key, Lido Key, Siesta Key, Casey Key, a mainland segment along Venice, and a northern segment of Manasota Key. Sarasota County has three inlets: New Pass between Longboat Key and Lido Key, Big Sarasota Pass between Lido Key and Siesta Key, and Venice Inlet between Casey Key and the City of Venice. Coastal Sarasota County includes the following beach communities: Town of Longboat Key, Lido Key within the City of Sarasota, and City of Venice.

Storm Effects and Erosion Conditions

The northern 21.5 miles of beaches (R1 – R114), located north of the Venice Inlet including Longboat Key, Lido Key, Siesta Key and Casey Key did not undergo beach and dune erosion. At the south side of the inlet, the beach (R117 – R118) sustained minor erosion (condition II). Moving south along Venice Beach, major dune erosion (condition IV) was observed intermittently at different locations (R122 – R123, R126 – R127, R128 – R129, and R130 – R131) with the presence of stormwater runoff gullies (**Figure 14– 17**). For reference, the Venice Fishing Pier is located just north of R131. Localized moderate dune erosion (condition III) was observed at R127 – R128 north of the Pier, and at R135 – R136 south of the Pier. Further south, at Caspersen Beach minor beach erosion with small scarps (condition I) were observed south of the at R141.5 – R141.7 and then it continued for more than 2.5 miles between R148 and R163.

The volumetric changes were calculated by comparing the volume lost or gain above mean high water elevations between a pre-storm monitoring survey and post-storm LIDAR data from the USACE. For the Venice Beach area from R117 – R136, comparing a pre-storm June 2022 monitoring survey with post-storm LIDAR data, the net volume change above mean high water was estimated to be -55,806 cy (erosion) with an average rate of -2.9 cy/ft of shoreline. A major portion of this erosion is associated with formation of stormwater gullies. Moving further south in Manasota Key, for R170 through R183, the net volume change above mean high water elevation was estimated to be -13,894 cy (erosion) with an average rate of -1.1 cy/ft of shoreline. The shoreline between R137 and R169 was excluded from these volumetric calculations due to the lack of an appropriate pre-storm survey.

Storm Damage

Coastal communities in Sarasota County sustained major structural damages due to storm surge, high wind and waves. A total of 45 major structures were damaged that included 32 single-family dwellings, 12 multifamily dwellings and one other major structure. Most of these damages occurred in the densely populated Venice area located south of Venice Inlet. Apart from these damaged structures, numerous structures within the Coastal Building Zone, sustained flooding to some extent.

Figure 14. Storm water runoff gullies, Venice Beach (R-130).

Figure 15. Storm water runoff gullies, Venice Beach (R-127).

Figure 16. Storm water runoff gullies at Alhambra Road, Venice Beach (R-122).

Figure 17. Storm water runoff gullies at Alhambra Road, Venice Beach (R-122).

Figure 18. Storm water flooding on Manasota Key Road in Sarasota County (R-180).

Charlotte County

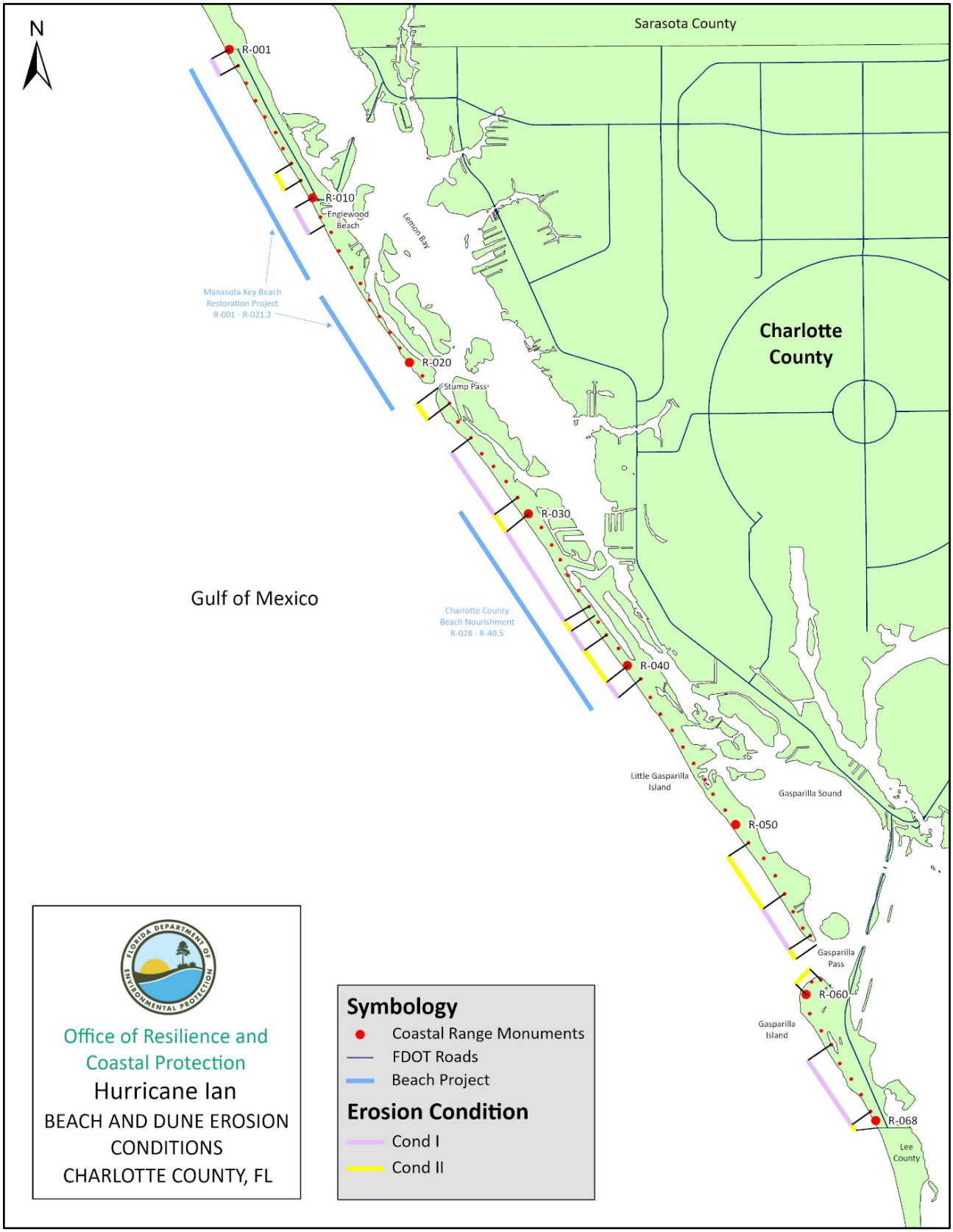

Figure 19. Charlotte County Beach and Dune Erosion Conditions from Hurricane Ian.

Charlotte County

Charlotte County is located on Florida's southwestern coast fronting the Gulf of Mexico (**Figure 19**) and has 12.2 miles of beaches extending southward from Sarasota County to Lee County. The coast of Charlotte County includes the southern half of Manasota Key, the Knight Island-Bocilla Island-Little Gasparilla Island barrier complex (also known as Don Pedro Island), and the northern mile and a half of Gasparilla Island. There are two natural inlets in Charlotte County: Stump Pass between Manasota Key and Knight Island, and Gasparilla Pass between Little Gasparilla Island and Gasparilla Island. Coastal Charlotte County includes the beach community of Englewood Beach and Stump Pass State Park.

Storm Effects and Erosion Conditions

Situated north of Cayo Costa, where the eye made landfall, Charlotte County was moderately impacted by Hurricane Ian. **Table 4** provides the countywide erosion volumes in cubic yards (cy) and average volume change per foot of shoreline (cy/ft). The erosion volumes were obtained by comparing the volume lost above mean high water elevations between pre-storm monitoring surveys and post-storm LIDAR flown by the USACE. For Manasota Key, Englewood Beach and Don Pedro Island, a monitoring survey from June 2022 was used as a pre-storm survey. For Gasparilla Island, a monitoring survey from June 2021 was used as a pre-storm survey.

Table 4. Charlotte County Erosion Volume

Location	DEP Monuments	Volume Change above MHW (cy)	Average Volumetric Change (cy/ft)
Manasota Key, Englewood Beach	R1 – R22	-32,214	-1.5
Don Pedro Island*	R22 – R40	-37,976	-2.1
Gasparilla Island	R58 – R68	-10,887	-1.1

* No pre-storm data for R40 – R57

Along nearly two miles of Manasota Key (R1 – R11.5), minor beach erosion (condition I) and minor beach and dune erosion (condition II) was observed at intermittent locations. From the southern part of Englewood Beach to the north of Stump Pass, beach erosion was minimal. South of Stump Pass, Don Pedro Island (R21.5 – R57.5) intermittently sustained minor beach erosion (condition I) and minor beach and dune erosion (condition II). Along the southern end of the county, Gasparilla Island sustained minor beach and dune erosion (condition II) at R58 – R60 and R66 – R68, and minor beach erosion (condition I) at R63 – R66. Flooding from heavy rainfall and the storm surge was observed in numerous areas of

the county.

Figure 20. Minor beach and dune erosion, northern Gasparilla Island (R-59).

Storm Damage

Coastal Charlotte County sustained major structural damages due to the storm surge, waves and hurricane force winds. A total of 223 major structures sustained major structural damage, including 156 single-family dwellings, 62 multifamily dwellings and five other major structures. Almost all the mobile homes at multiple trailer parks in Englewood Beach were destroyed. Apart from the major structures with major structural damage, most of the remaining structures within the Coastal Building Zone sustained either flooding damage or understructure damage. There was also armoring damage on the interior tidal waters where 83 feet of walls were destroyed.

Figure 21. Condominiums destroyed in Englewood Beach (R-11).

Figure 22. Multi-family dwelling destroyed by fire off Estada Street (R-8).

Figure 23. Mobile homes destroyed at Englewood Beach on Manasota Key (R-9).

Figure 24. Storm surge and rainfall flooding on northern Gasparilla Island (R-61).

Figure 25. Major roofing damage on condominiums on northern Gasparilla Island (R-64).

Figure 26. Palm Harbor Marina destroyed in Placida.

Lee County

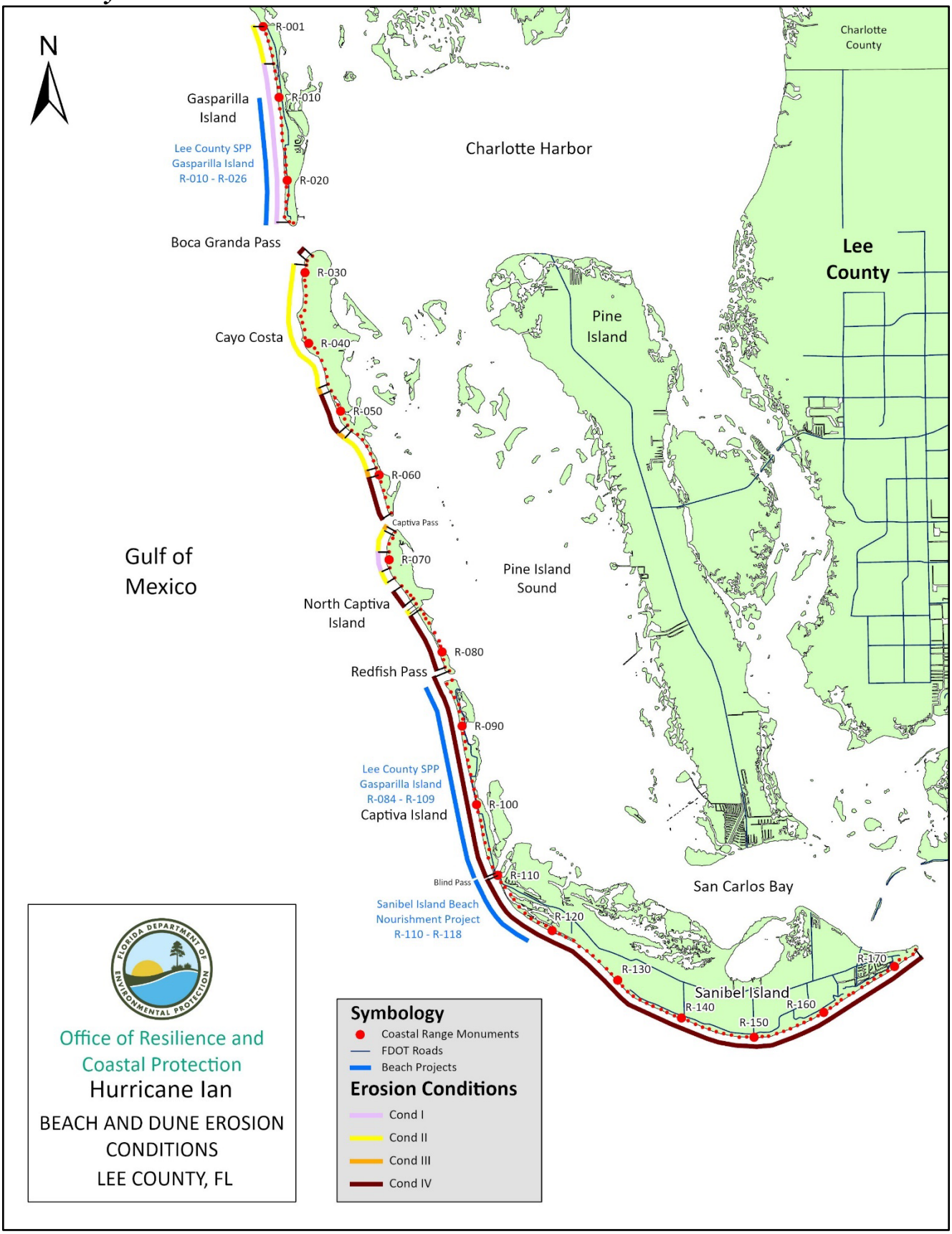

Figure 27. Lee County (North Section) Beach and Dune Erosion Conditions from Hurricane Ian.

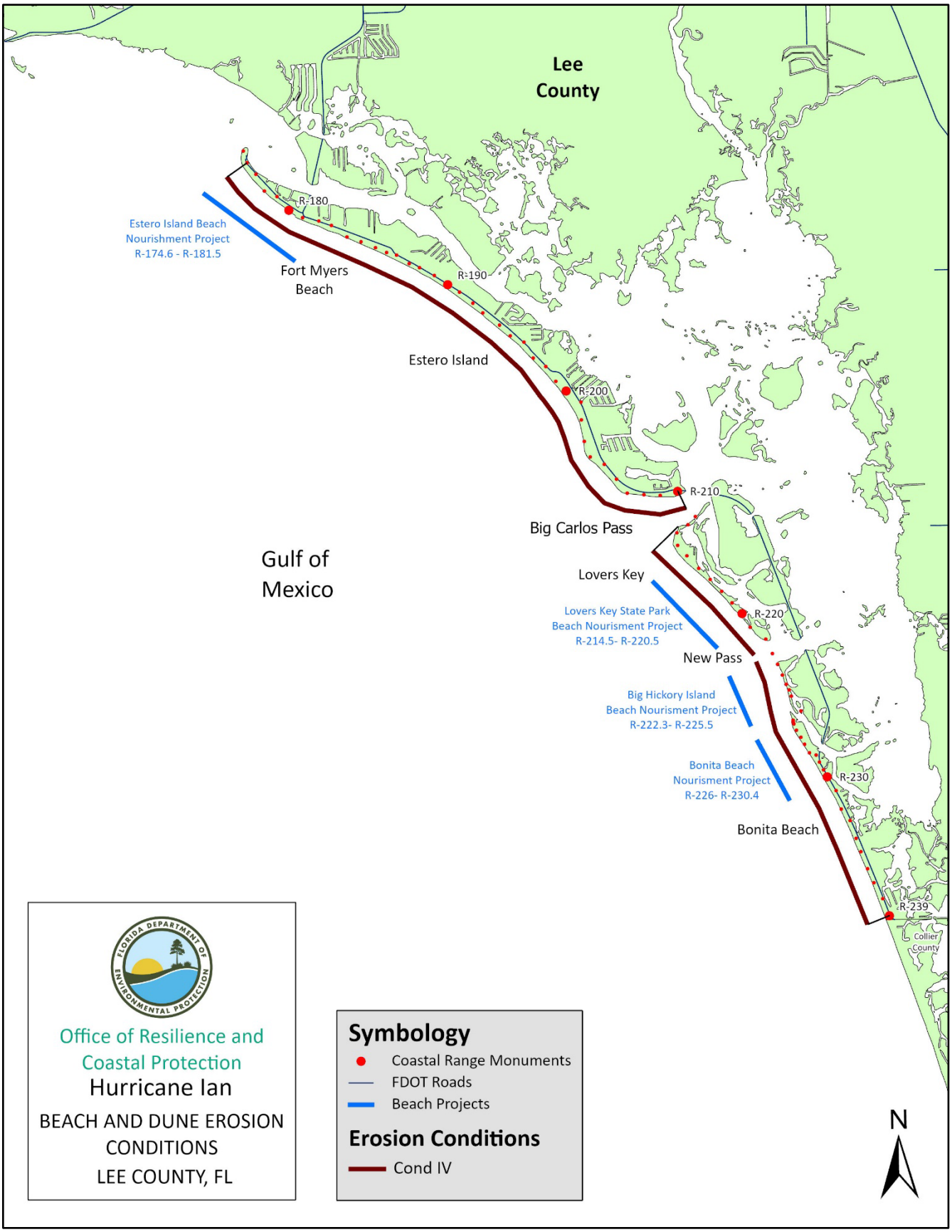

Figure 28. Lee County (South Section) Beach and Dune Erosion Conditions from Hurricane Ian.

Lee County

Lee County is located on Florida's southwestern coast fronting the Gulf of Mexico (**Figure 27 and Figure 28**) and has 47.3 miles of beaches extending southward from Charlotte County to Collier County. The coast of Lee County includes most of Gasparilla Island, Cayo Costa Island, North Captiva Island, Captiva Island, Sanibel Island, Estero Island, Lovers Key, Big Hickory Island, and Bonita Beach on Little Hickory Island. Lee County has eight coastal inlets including Boca Grande Pass, Captiva Pass, Redfish Pass, Blind Pass, San Carlos Bay Entrance, Big Carlos Pass, New Pass, and Big Hickory Pass.

Storm Effects and Erosion Conditions

Hurricane Ian made landfall on Wednesday, September 28 at 3:05 p.m. EDT, with the geographic center of the eye crossing Cayo Costa in Lee County. Lee County sustained the greatest impacts from Hurricane Ian on the coast of Florida as the southern eye wall of Ian caused the greatest damage across southern Sanibel Island and Estero Island (Ft. Myers Beach). Ian caused major beach and dune erosion (condition IV) along most of the beaches of Lee County, especially at Captiva Island, Sanibel Island, Estero Island, Lovers Key and Big Hickory Island. **Table 5** provides the countywide erosion volumes in cubic yards (cy) and average volume change per foot of shoreline (cy/ft). The erosion volumes were obtained by comparing the volume lost above mean high water elevations between a pre-storm 2021 monitoring survey and post-storm LIDAR flown by the USACE.

Table 5. Lee County Erosion Volume

Location	DEP Monuments	Volume Change above MHW (cy)	Average Volumetric Change (cy/ft)
Gasparilla Island	R1 – R26	-67,071	-2.7
Cayo Costa Island	R27 – R65	No pre-storm data	NA
North Captiva	R66 – R82	No pre-storm data	NA
Captiva Island	R83 – R109	-461,742	-17.8
Sanibel Island	R110 – R174	-404,987	-6.3
Estero Island	R175 – R210	-301,423	-8.6
Lovers Key	R213 – R221	-52,835	-6.6
Big Hickory Island	R222 – R225	-21,914	-7.3
Bonita Beach	R227– R239	-66,895	-5.6

The northern 4.8 miles of beach in Lee County extend along Gasparilla Island from the north county line south to Boca Grande Pass and were located just north of the landfall of Ian's eye. As with the beaches to the north, the northern eye wall caused the winds to blow offshore until after passage of the storm and therefore resulted in lesser impacts to the beaches and dunes. The northern 1.0-mile of beach from R1 to

R6 was subjected to minor beach and dune erosion (condition II) as seen in **Figure 30**, and the 3.6 miles between R6 and R26 sustained minor beach erosion (condition I). A few significant structural damages occurred on Gasparilla Island with a cell tower collapse in Boca Grande **(Figure 31**) and a restaurant catching fire on a southern beach of Gasparilla Island (**Figure 32**). South of Boca Grande Pass, the beach conditions along 7.0 miles of Cayo Costa revealed greater impacts where the hurricane's eye crossed the coast. Major dune erosion (condition IV) was observed at the northern tip of the island fronting on Boca Grande Pass (R27 – R28); however, the northern half of the island between R29 and R46 sustained only minor beach and dune (condition II). This portion of the island includes Murdock Harbor, a lagoon that received flooding from the storm tides. Major beach and dune erosion (condition IV) was sustained to the south along a 1.0-mile segment between R47 and R52 adjacent Murdock Bayou. To the south along a relatively stable 1.0-mile segment, minor beach and dune erosion (condition II) again prevailed between R53 and R59. At the southern roughly 1.0-mile of beach to Captiva Pass between R60 and R65, major beach and dune erosion (condition IV) was sustained.

South of Captiva Pass, North Captiva Island experienced a mix of erosion conditions, but generally other than some moderate beach and dune erosion (condition III) at the island's north tip at R66, the northern approximately one third of the island sustained only minor beach and dune erosion (condition II) between R66.5 and R69 and between R71 and R72, or minor beach erosion (condition I) between R69 and R71. The southern approximately two thirds of the island generally sustained major beach and dune erosion (condition IV) between R73 and R82 at Redfish Pass. The storm surge completely inundated this end of the island and numerous storm surge scour holes were left on the Pine Island Sound side of the island. In 2004, Hurricane Charley caused a major breach across the southern part of the island between R77 and R80 that was referred to as Charley's Cut. In the following years, Charley's Cut closed with sediments being transported southward along the island with the natural longshore transport. Hurricane Ian did not create the same magnitude breach across North Captiva Island; however, the Charley's Cut segment was completely awash with the storm surge leaving significant wash over fans along with a small temporary breach near R79A.

Between Redfish Pass and San Carlos Bay Entrance, both Captiva Island (R83 – R109) and Sanibel Island (R110-R174) were in the southern eye wall of Hurricane Ian. These developed barrier islands sustained major beach and dune erosion (condition IV). Blind Pass between Captiva and Sanibel Islands was open and flowing; however, significant shoaling likely occurred during the flood tide of Ian. South of Blind Pass are two relic channels of the historic locations of Blind Pass. Clam Bayou at R113 was closed before Ian, and although the storm surge flooded into Clam Bayou, a breach was not opened

during Ian. To the south at R115, Old Blind Pass was closed before Ian, but a significant breach with three channels were opened. Sanibel Island beach conditions were unique after Ian due to the shore-normal storm tide discharge gullies that crossed the beach (**Figure 33**). In the Gulf Shores area of Sanibel Island, a large discharge gully exists between R131 and R132. Starting in the Lake Murex area near R142 and extending southeast to Point Ybel at R174, over 80 major storm surge discharge gullies exist along with many more minor gullies. Many of these were scoured a few feet below surrounding grade and retained flood waters following the storm. As discussed in *Section III*, the storm tide measured by USGS was +13.11 feet NAVD that represented a 100-year return interval storm tide for Sanibel Island.

Sanibel Island is connected to the mainland by a bridge and causeway system. The extreme storm tide and waves destroyed sections of the bridge and causeway system cutting off all vehicular traffic to and from the developed barrier island (**Figure 34** and **Figure 35**). Pine Island, east of Cayo Costa, North Captiva Island and Captiva Island also lost its bridge and causeway system by the extreme storm tide and waves from Hurricane Ian (**Figure 36** and **Figure 37**). Florida State University's Emergency Management Program Team assessed damages on Pine Island and other areas in Southwest Florida after Hurricane Ian.

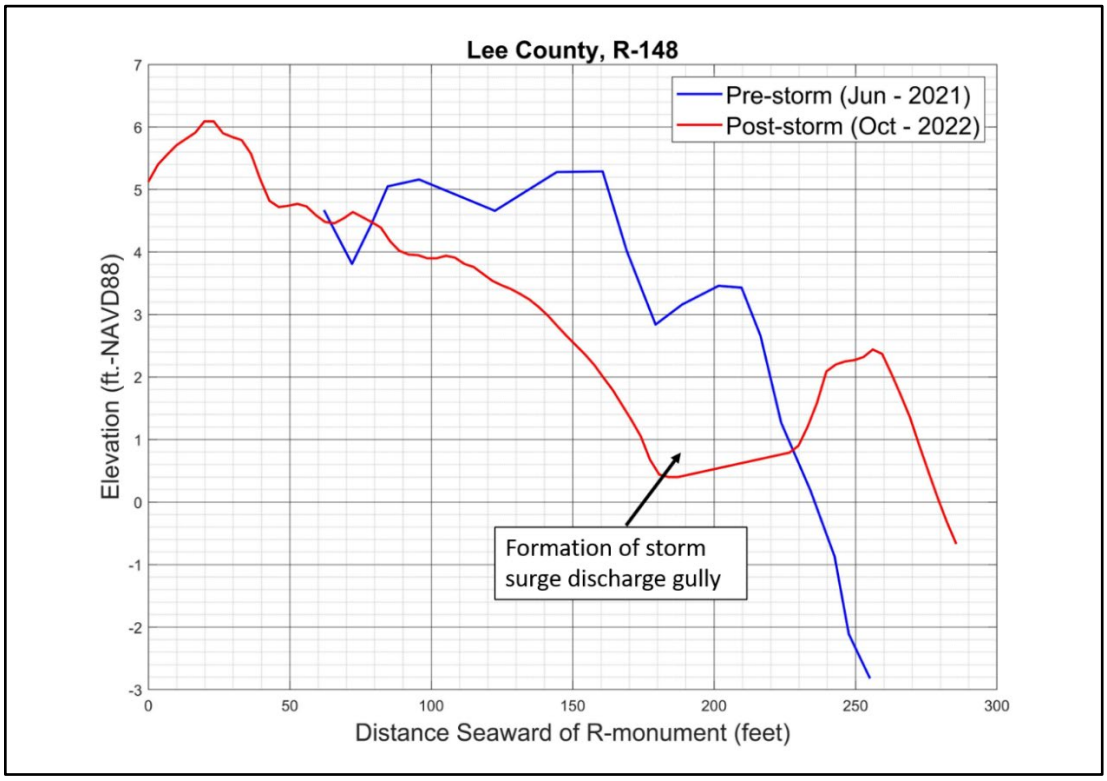

Figure 29. Pre- and post-storm profiles show formation of storm discharge gully in Sanibel Island, (R-148).

Figure 30. Condition II erosion at R-2 in Lee County near the county line between Charlotte and Lee Counties.

Figure 31. Collapse of an older cell tower onto the local bakery in Boca Grande from hurricane winds landward of R-14.

Figure 32. South Beach Bar and Grill Restaurant on Gasparilla Island near R-25 that caught fire during Hurricane Ian.

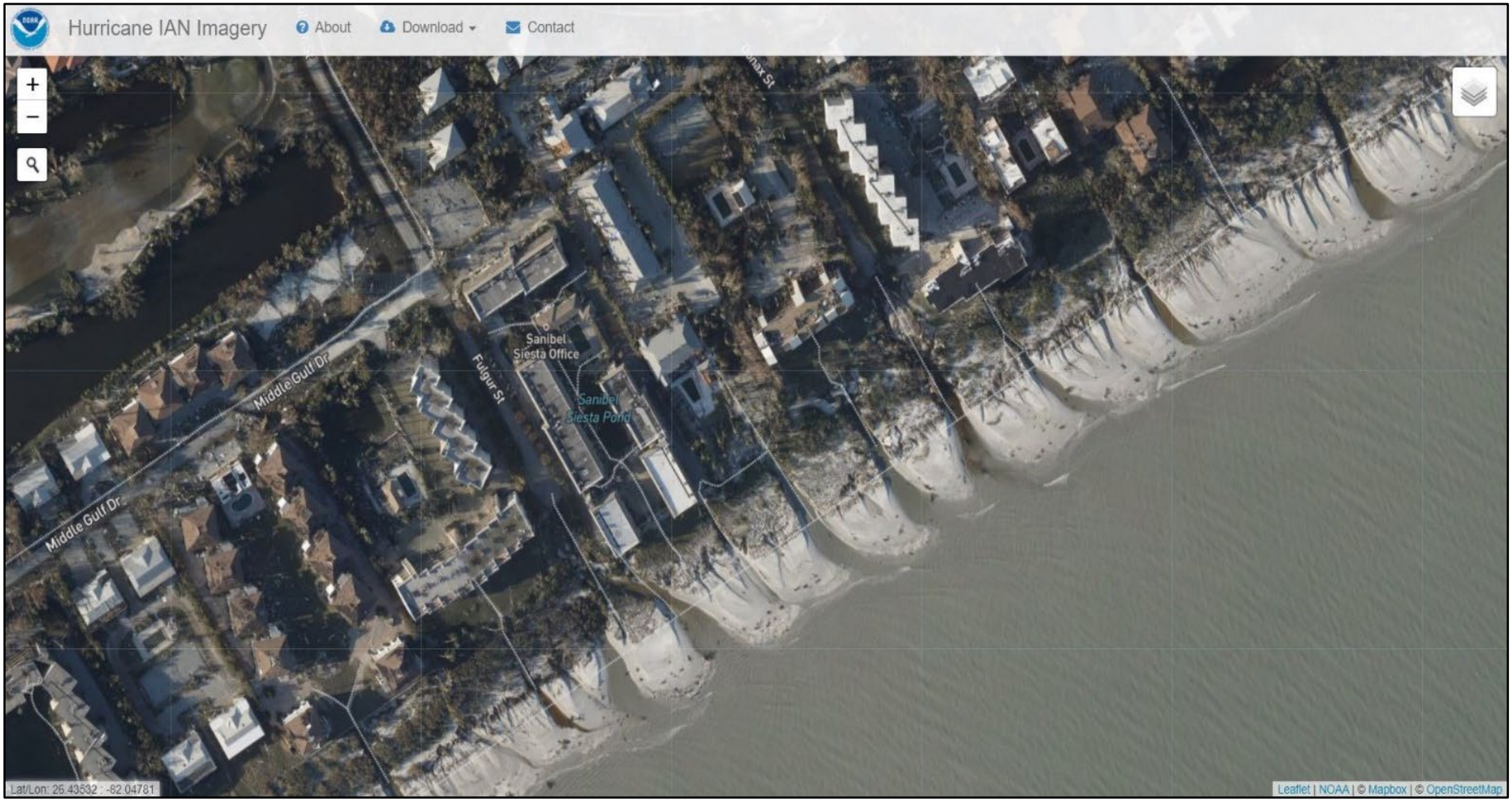

Figure 33. Storm surge discharge gullies on Sanibel Island (NOAA image), near R-162 in Lee County.

Figure 34. Sanibel Island bridge and causeway destroyed. (Image source: Active Camera Systems and Camera Copters).

Figure 35. Sanibel Island bridge and causeway destroyed. (Image source: Active Camera Systems and Camera Copters).

Figure 36. Pine Island causeway destroyed. Photo courtesy of Florida State University - Emergency Management and Homeland Security Program/ Florida UAS-1. Photo taken on September 29th, 2022.

Figure 37. Pine Island causeway destroyed. Photo courtesy of Florida State University - Emergency Management and Homeland Security Program/ Florida UAS-1. Photo taken on September 29th, 2022.

The southwest coast of Florida south of San Carlos Bay with Estero Island at its north end is unique by virtue of its gradational change in physiography from north to south. These islands contrast with the barrier islands to the north because they are sheltered from northwest wave energy by Sanibel Island, and the bays like Estero Bay behind these coastal barriers are much smaller in comparison to Charlotte Harbor or Pine Island Sound to the north. Due to the sheltering effect from Sanibel Island, the net longshore transport rates along Estero Island are much less than the rates along the islands to the north. These islands are typically subject to lesser wave energy; however, Hurricane Ian was the exception by virtue of its southwest approach with a storm tide and wave energy from the southwest. Estero Island is a very low barrier island fronting Estero Bay and ground levels are very low making the island particularly vulnerable to any storm surge. As discussed in *Section III*, the storm surge measured at the municipal fishing pier by USGS was +13.25 feet NAVD and represented a 100-year return interval storm tide for Estero Island. Given the severe impact of Hurricane Ian, Estero Island sustained major beach and dune erosion (condition IV) throughout its length between R175 at Bowditch Point south to R210 at Big Carlos Pass. Like Sanibel Island, Estero Island also had numerous storm surge discharge gullies; however, much of the surge crossed over the island into Estero Bay. At the south end of Estero Island, the attached Little Estero Island continued its evolution of northeastward migration between R202 and R209. The entrapped lagoon was diminished between R204 and R206. The narrow, shallow lagoon between R207 and R209 has become narrower and filled with storm surge washover sediments. Three small temporary breaches existed across Little Estero Island in this area.

South of Estero Island between Big Carlos Pass and New Pass, Lovers Key (R211 – R221) is a barrier island state park. As with Sanibel and Estero Islands, Lovers Key was severely impacted by the storm surge and waves of Hurricane Ian. Major beach and dune erosion (condition IV) was sustained throughout Lovers Key. As with southern Sanibel Island and Estero Island, numerous storm surge discharge gullies existed. A substantial breach also formed at R218.5 connecting Gulf of Mexico waters with the lagoon between Lovers Key 1 and Lovers Key 2.

South of Lovers Key between New Pass and Big Hickory Pass, Big Hickory Island (R222 – R225) was severely impacted by Hurricane Ian. Major beach and dune erosion (condition IV) was sustained as the island has substantially diminished. Along with storm surge discharge gullies spaced on roughly 100-foot intervals, three major breaches have formed at R223, R224 and R225.4. During post-storm recovery, this island will likely go through a major evolutionary change in its morphology.

The south end of Lee County is the developed Little Hickory Island known as Bonita Beach (R226 –

R239). As with the other southern Lee County beaches, major beach and dune erosion (condition IV) was sustained. Bonita Beach also has storm surge discharge gullies, but they were generally not as large as observed on the islands to the north.

Storm Damage

Lee County was "ground zero" for the landfall of Hurricane Ian and widespread damage was sustained along the entire coast. There were 3,512 major structures assessed to have major structural damage throughout Lee County within the Coastal Building Zone. This included 2,787 single-family dwellings, 501 multifamily dwellings and 224 other major structures. The most damages were concentrated on Sanibel Island and Estero Island; however, substantial damages were also sustained on the northern and southern most islands of Gasparilla Island and Little Hickory Island. Also, 6,281 feet (1.2 mile) of armoring damage was sustained along the coast of Lee County with the most damage sustained on Captiva Island and Estero Island. Among these armoring damages, 4,756 feet (0.90 mile) was major damage, and the rest 1,525 feet (0.3 mile) was minor damage.

Given the northern two islands, Gasparilla Island and Cayo Costa, were largely in the lee of the eye of Ian, there was predominantly only wind damage sustained. Gasparilla Island sustained major damage to 254 major structures. One single-family dwelling was destroyed, and 174 dwellings sustained major damage. Three multifamily dwelling structures were destroyed and 48 sustained major damage. One other major structure was destroyed and 27 sustained major damage. On Cayo Costa, which is largely an undeveloped state park, with some single-family dwellings at its south end, 12 major structures sustained major damage. One single-family dwelling was destroyed, and 10 other dwellings sustained major damage. One other major structure at the state park was also damaged.

North Captiva Island is developed with a couple hundred homes on its north end and a dozen at its south end. In between are undeveloped state park lands. Of the 50 single-family dwellings with major damage on North Captiva Island, three were destroyed and four more sustained major damage from the storm surge and waves of Ian. The other 43 dwellings with major damage sustained major roof or siding damage from the winds of Ian.

Captiva Island sustained major damage to 78 major structures. Of these, two single-family dwellings were destroyed and 38 sustained major damage. 33 multifamily dwellings sustained major damage, including one whose roof blew off. In addition, a garage building was destroyed, and four other major structures sustained major damage. Of the damaged major structures, six were destroyed or damaged by the storm surge and waves. The other 72 major structures sustained major damage from the winds.

Sanibel Island was located within the maximum wind field of Ian as well as receiving a 100-year storm surge. Sanibel sustained major damage to 535 major structures. 59 single-family dwellings were destroyed, and another 225 dwellings sustained major damage. 35 multifamily dwellings were destroyed and another 200 sustained major damage. In addition, 11 other major structures were destroyed and five sustained major damage. Of the 535 major structures with major damage, 105 or approximately 20 percent were destroyed. A relatively greater number of structures were damaged by the storm surge and waves of Ian than occurred on the islands to the north. A pocket of such damage from the storm surge occurred at the island's vulnerable north end south of Blind Pass (R110 – R111). In this area, about 12 major structures including single-family dwellings and commercial buildings were destroyed or sustained major structural damage from the storm surge. Scattered throughout the rest of the island were approximately 145 major structures that were destroyed or sustained major damage from the storm surge of Ian. Roughly 30 percent of the major damage was due to the storm surge and 70 percent due to the winds of Ian.

Like Sanibel Island, Estero Island was located within the maximum wind field of Ian as well as receiving a 100-year storm surge. Roughly two thirds of the county-wide damage from Ian occurred on Estero Island where 2,329 major structures sustained major damage. 1,153 single-family dwellings were destroyed and another 871 sustained major damage. 42 multifamily dwellings were destroyed and another 123 sustained major damage. In addition, 110 other major structures were destroyed and another 30 sustained major damage. Of note, the 560-ft long concrete Ft. Myers Beach Fishing Pier was destroyed near R181 (**Figure 38**). Most all the major damage on Estero Island was due to the storm surge and waves, with only a handful of major structures with major damage solely by wind.

South of Estero Island is Lover's Key State Park, where three park buildings were destroyed by the storm surge and waves. At the south end of Lee County at Bonita Beach on Little Hickory Island, 251 major structures sustained major damage. 77 single-family dwellings were destroyed and another 126 sustained major damage. One multifamily dwelling was destroyed and another 16 sustained major damage. In addition, 23 other major structures were destroyed and another eight sustained major damage.

Throughout Lee County, 6,281 feet of coastal armoring was damaged with the most damage seen on Captiva Island (2,700 feet) and on Estero Island (2,690 feet). Gasparilla Island (275 feet), North Captiva Island (100 feet), Sanibel Island (200 feet) and Bonita Beach (316 feet) had smaller segments of armoring damage. Sanibel also had 350 feet of wood retaining wall destroyed.

Figure 38. Ft. Myers Beach structures and pier with major damages, R-181 (Image source: Active Camera Systems and Camera Copters).

Figure 39. Storm surge transported Lahaina resort structures across Estero Blvd. (R-196).

Figure 40. Storm surge impacts at Outrigger Beach Resort at Ft. Myers Beach (R-199).

Figure 41. Major damages at the Gulf Marine Yachtworks at bayside of Ft. Myers Beach (R-181).

Figure 42. Stranded boats on the yards of multi-family dwellings at Ft. Myers Beach (R-203).

Figure 43. Homes destroyed and removed off pilings, Ft. Myers Beach near Matanzas St. (R-179).

Figure 44. Single-family dwelling destroyed at Ft. Myers Beach near Lazy Way (R-196).

Figure 45. Storm surge impact on St. Peter's Lutheran Church near Bay Mar Dr. (R-190).

Figure 46. High-water mark on a bay-side single-family dwelling on Clearview Blvd. (R-201).

Collier County

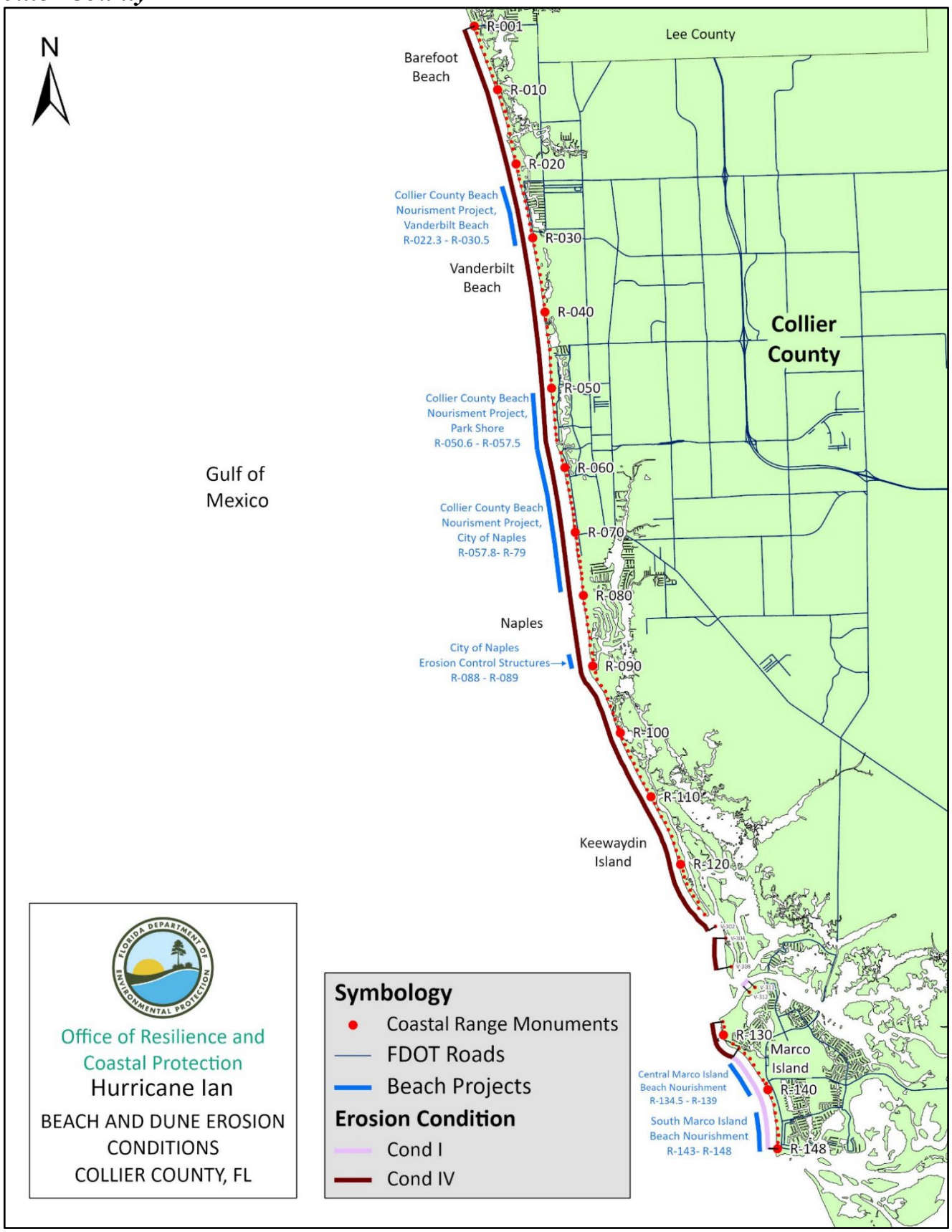

Figure 47. Collier County Beach and Dune Erosion Conditions from Hurricane Ian.

Collier County

Collier County is located on Florida's southwestern coast fronting the Gulf of Mexico (**Figure 47**) and has 34.1 miles of beaches extending southward from Lee County to the southwest tip of Cape Romano. Coastal Collier County includes the following beach communities and major parks: Lowdermilk Park, Barefoot Beach County Park, Delnor-Wiggins Pass State Park, Vanderbilt Beach, Park Shore, Naples, Keewaydin Island, Sea Oat Island, Isle of Capris, Hideaway Beach, Marco Island, Kice Island, Morgan Island, Cape Romano, Goodland, Weavers Station, Everglades City, Plantation Key, and Chokoloskee.

Storm Effects and Erosion Conditions

A NOAA tidal gauge at Naples Pier located just south of R74 measured the storm tide elevation up to nearly +7.0 feet-NAVD before the sensor was damaged. Based on the observed mud line and high-water marks on the exterior of different beachfront properties in Naples, four to five feet of storm surge above the street level was observed. These high-water marks decreased to two to three feet above the ground further landward within the Coastal Building Zone.

At the northern end of the county, beaches on both sides of Wiggins Pass sustained major beach and dune erosion (Condition IV) that include Barefoot Beach (R1 – R16) and Delnor-Wiggins Pass State Park (R17 – R22), which are located respectively, at the north and south sides of the pass. Substantial shoaling was apparent at Wiggins Pass with piles of debris existing at different locations in the ebb shoal. South of Wiggins Pass, Vanderbilt Beach (R22 – R39), Pelican Bay Beach (R39 – R41), and City of Naples (R42 – R89) sustained major beach and dune erosion (condition IV) with significant beach profile lowering. South of Gordon Pass, Keewaydin Island (R90 – V302) and the uninhabited Sea Oat Island (V304 – V308) sustained major beach and dune erosion (condition IV). Keewaydin Island sustained a major breach near R-99 (**Figure 49**). On the northern shore of Marco Island, Hideaway beach (V311 – V312), stabilized by a T-groin field, sustained minor beach erosion (condition I). Fronting the Gulf of Mexico on Marco Island (R128 – R133), major beach and dune erosion (condition IV) was sustained for approximately 1.0 mile, which threatens a mangrove forest. The southern 3.0 miles of Marco Island (R133 – R148) sustained minor beach erosion (condition I). Major beach and dune erosion (condition IV) was sustained south of Caxambas Pass along Morgan Island and Cape Romano.

Table 6 provides the countywide erosion volumes in cubic yards (cy) and average volume change per foot of shoreline (cy/ft). The erosion volumes were obtained by comparing the volume lost above mean high water elevations between pre-storm monitoring surveys and post-storm LIDAR flown by the USACE. For Barefoot Beach (R1 – R16), located north of Wiggins Pass, a monitoring survey from June 2021 was used as the pre-storm survey, and for R17 – R148, a monitoring survey from January 2022 was used as the pre-storm survey.

Table 6. Collier County Erosion Volume

Location	DEP Monuments	Volume Change above MHW (cy)	Average Volumetric Change (cy/ft)
North Collier*	R1 – R9, R17 – R41	-167,550	-5.2
Naples	R42 – R89	-290,398	-6.2
Marco Island	R128 – R148	-79,828	-4.0

* No pre-storm data is available for R10 – R16

Figure 48. Major beach and dune erosion, Naples (R-85).

Figure 49. Major breach across Keewaydin Island (R-99).

Storm Damage

Coastal communities in Collier County sustained major structural damages due to storm surge, high wind and waves. A total of 262 major structures sustained major structural damage including 173 single-family dwellings, 69 multifamily dwellings and 20 other major structures. Aside from major structural damages, most of the major structures within the Coastal Building Zone sustained flooding damage and understructure damage.

The Naples Pier sustained damage as much of its breakaway deck was lost. The piles and bentsappeared to be intact; however, subsequent structural assessments determined that the pier would need to be totally reconstructed (**Figure 51**).

A total of 3,036 feet of coastal armoring damage was sustained along the coast of Collier County. In Naples, approximately 2,886 feet of concrete seawall collapsed from just north of R47 to R49.5. South of Doctors Pass, between R58 and R60, two buried groins were exposed by erosion (**Figure 54**). In Naples, 977 feet of wood retaining wall was destroyed along with 150 feet of concrete seawall.

Figure 50. Understructure damage in Naples (R-60).

Figure 51. Damage to the Naples Pier (R-74).

Figure 52. High water mark shown on a single-family dwelling, Naples (R-71).

Figure 53. Single-family dwelling with storm surge damage, Naples (R-85).

Figure 54. Concrete seawall collapsed in Naples at R-47 (left) and buried groin exposed at R-58 (right).

St. Johns County

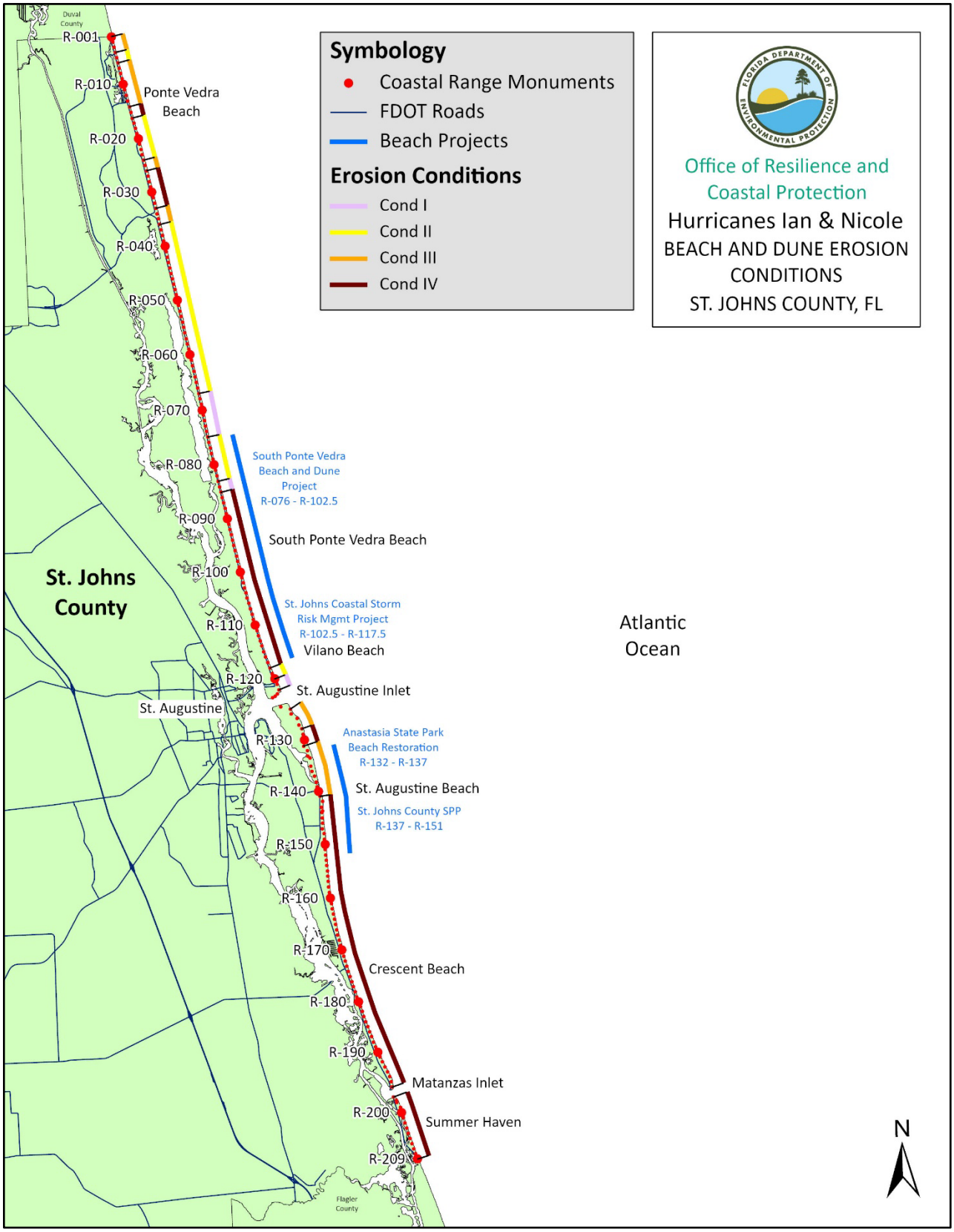

Figure 55. St. Johns County Beach and Dune Erosion Conditions from Hurricanes Ian and Nicole.

St. Johns County

The St. Johns County coast extends for 41.1 miles between Duval and Flagler Counties and includes the barrier beach communities and major park systems of Ponte Vedra Beach, Guana River State Park, South Ponte Vedra Beach, Vilano Beach, Porpoise Point, Conch Island (Anastasia State Park), St. Augustine Beach, Crescent Beach, Fort Matanzas National Monument, and Summer Haven (**Figure 55**). St. Augustine Inlet between Vilano Beach and Conch Island has a federal navigation project, which likely experienced significant shoaling due to Hurricane Ian.

Storm Effects and Erosion Conditions due to Hurricane Ian

The storm tides of Hurricane Ian in St. Johns County generally ranged between six and eight feet NAVD. The USGS measured a storm tide in the southern portion of St. Johns County near Matanzas Inlet to be +7.62 feet NAVD. Although it was lower than the storm tide of Hurricane Irma in 2017 (+9.54 feet NAVD), substantial beach and dune erosion was sustained. At Ponte Vedra, the northern (R1 – R16) and the southern (R34 – R46) segments of shoreline sustained minor dune and beach erosion (condition II), whereas, in between an approximately 3.5-mile segment of shoreline (R16 – R34) sustained moderate beach and dune erosion (condition III). Moderate beach and dune erosion (condition III) was sustained along Guano State Park and South Ponte Vedra between R46 and R79. Along most of Vilano Beach (R103 – R117) moderate beach and dune erosion (condition III) was sustained. The south end of Vilano Beach (R117 – R122) sustained minor beach and dune erosion (condition II). Along the developed segment of Anastasia Island (R138 – R196), including St. Augustine Beach, Crescent Beach, and Matanzas Shores including Matanzas Inlet National Monument, the island sustained major dune and beach erosion (condition IV). South of Matanzas Inlet, Summer Haven (R197 – R209) sustained major beach and dune erosion (condition IV). The Summer Haven branch of the Matanzas River received large washover deposits that has completely blocked flow in the lagoon at three locations between R200 and R205. A breach occurred beneath a pile supported single-family dwelling at R205 (**Figure 66 and 67**). This area experienced major beach and dune erosion and barrier breaches during Hurricanes Matthew (2016), Irma (2017) and Dorian (2019).

Storm Effects and Erosion Conditions due to Hurricane Nicole

The discussion above preceded the impact of Hurricane Nicole. The beaches of the entire county were impacted during Hurricane Ian that made the coastal armoring and upland properties extremely vulnerable to another major storm. Due to lack of any significant recovery after Hurricane Ian, Hurricane Nicole exacerbated the overall beach erosion conditions in St. Johns County. **Table 7** provides the combined Ian and Nicole countywide erosion volumes in cubic yards (cy) and average volume change per foot of shoreline (cy/ft). The erosion volumes were obtained from pre-storm and post-storm LIDAR flown by the USACE, and represent volumes lost above mean high water.

Table 7. St. Johns County Erosion Volumes

Location	DEP Monuments	Volume Change above MHW (cy)	Average Volumetric Change (cy/ft)
Ponte Vedra	R2* – R46	-465,050	-10.6
GTM National Estuarine Research Reserve	R46 – R67	-170,597	-8.1
South Ponte Vedra	R67 – R101	-516,553	-15.2
Vilano Beach	R101 – R122	-390,499	-18.6
Anastasia Island State Park	R123 – R141	-511,533	-28.4
St. Augustine to Matanzas Inlet	R141 – R196	-1,479,424	-26.9
Summer Haven	R197 – R209	-244,774	-20.4
Countywide	**R2 – R209**	**-3,778,430**	**-18.3**

* The northernmost extent of the post-storm LIDAR data.

Moderate to major beach and dune erosion (Condition III and Condition IV) was prevalent in the heavily developed shoreline of Ponte Vedra (R1 – R36). Approximately 9.5 miles of shoreline between R36 and R85, which include Guana Tolomato Matanzas (GTM) National Estuarine Research Reserve and South Ponte Vedra, sustained minor beach and dune erosion (Condition I and Condition II). Approximately 6.0 miles of beaches in South Ponte Vedra and Vilano Beach (R85 – R118) sustained major dune erosion (Condition IV) that threatened multiple beachfront properties. The erosion conditions on beaches south of St. Augustine Inlet including Anastasia State Park and the developed segment of Anastasia Island (R122 – R196A), which already sustained major beach and dune erosion (Condition IV) during Hurricane Ian, was worsened with significant dune retreat. South of Matanzas Inlet at Summer Haven, in addition to the previous breach at R205 during Hurricane Ian, another breach was observed at R200 immediately south of the rock revetment (**Figure 67)**.

Figure 56. Major beach and dune erosion in Ponte Vedra (R-15).

Figure 57. Major beach and dune erosion in South Ponte Vedra Beach (R-86).

Figure 58. Major damage to a pavilion due to erosion in a county park in South Ponte Vedra (R-95).

Figure 59. Major beach and dune erosion at the Reef Restaurant, South Ponte Vedra Beach (R-109).

Figure 60. Major beach and dune erosion and road damage at Vilano Beach (R-115).

Figure 61. Major beach and upland erosion at St. Augustine Beach, looking south from pier (R-142).

Figure 62. Major beach and upland erosion at St. Augustine Beach, looking north to pier (R-144).

Figure 63. Major beach and dune erosion at Crescent Beach (R-172).

Figure 64. Major beach and dune erosion at Crescent Beach (R-193).

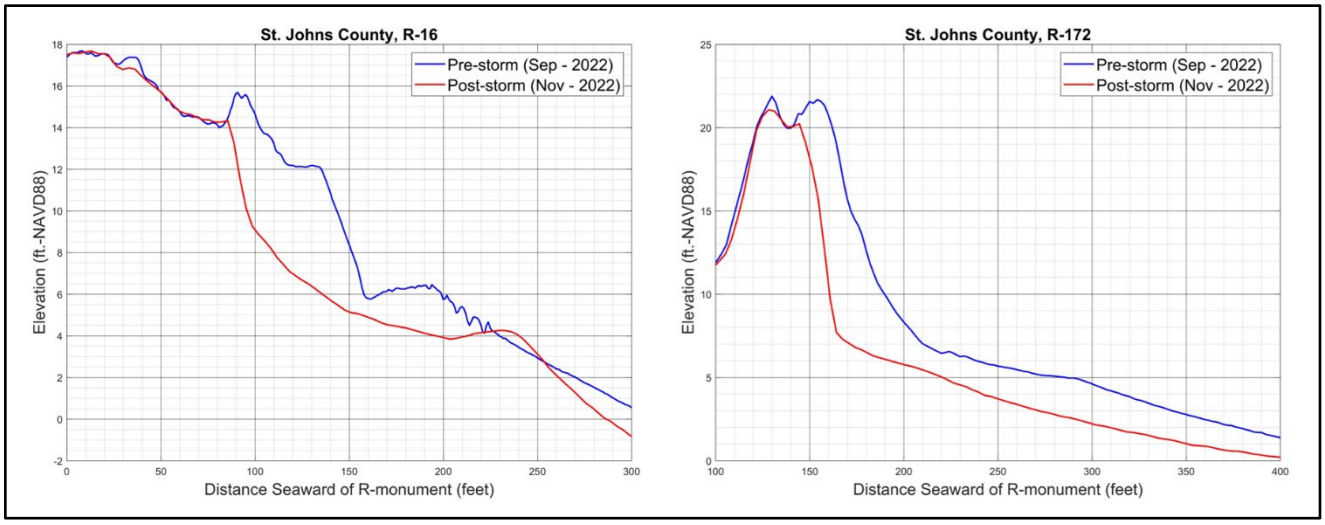

Figure 65. Major dune erosion is evident from pre- and post-storm profiles in St. Johns County.

Figure 66. Coastal barrier breach at Summer Haven (R204.9).

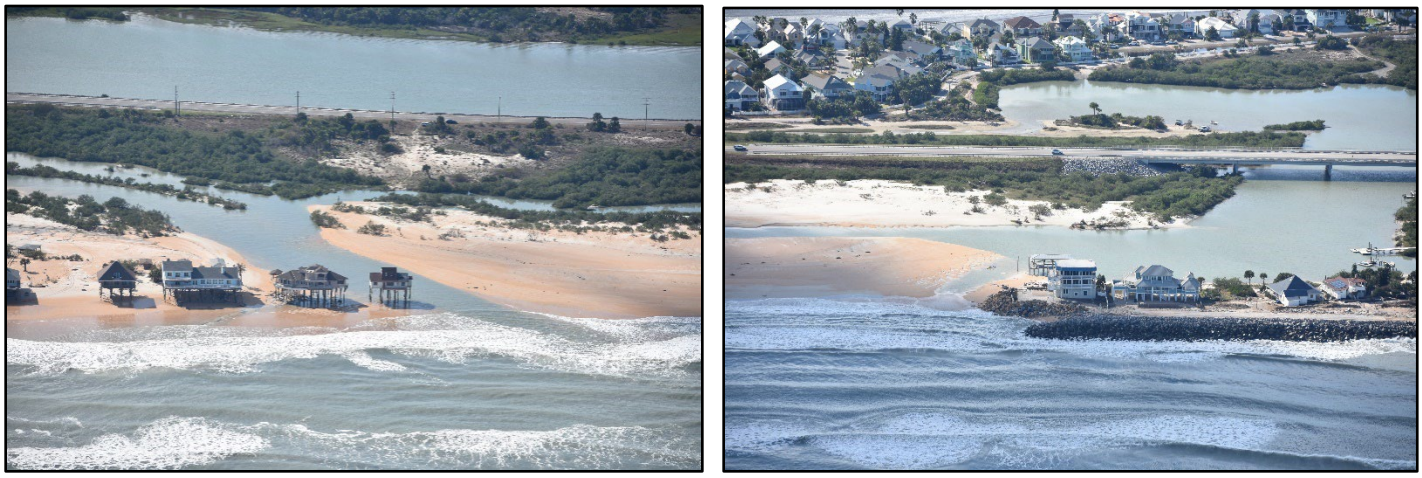

Figure 67. Coastal barrier breaches at Summer Haven at R204.9 (left) and R200 (right). Aerial oblique photos taken by the Civil Air Patrol on November 12, 2022.

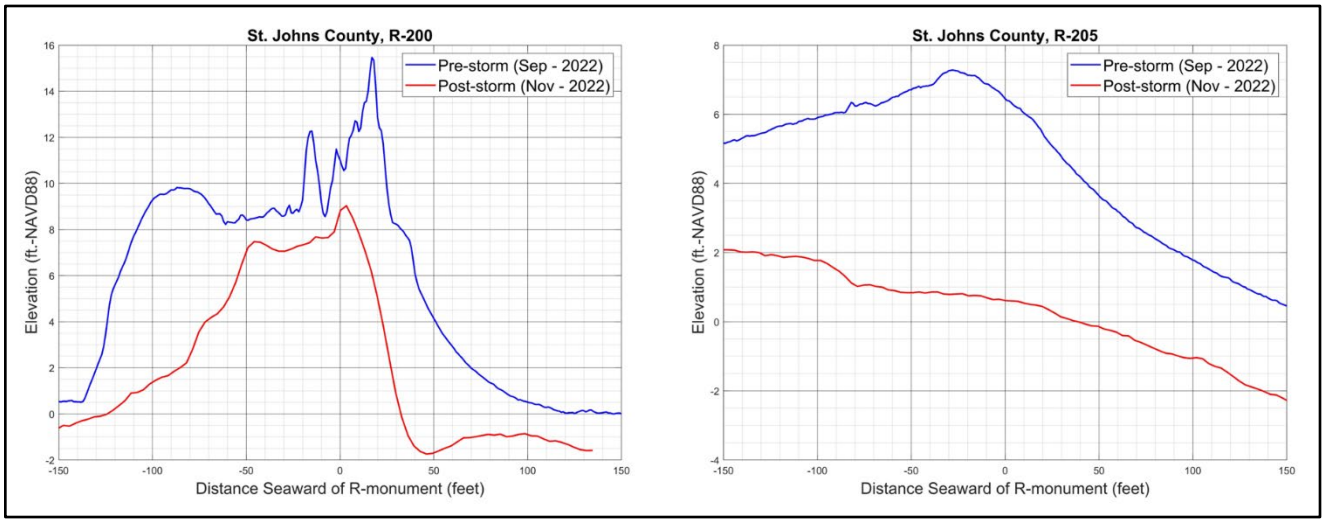

Figure 68. Coastal barrier breaches are evident from pre- and post-storm profiles at Summer Haven.

Storm Damage by Hurricane Ian

Along with substantial beach and dune erosion throughout St. Johns County, major structural damages were observed to 19 major habitable structures that included 16 single-family dwellings and three multifamily dwellings. In contrast, Hurricane Irma (2017) caused major damage to 171 major structures and Hurricane Matthew (2016) caused major damage to 86 major structures within the Coastal Building Zone.

Storm Damage by Hurricane Nicole

Hurricane Nicole caused major structural damage to 13 major structures within the Coastal Building Zone of Flagler County, which included 10 single-family dwellings, two multifamily dwellings, and one beachside pavilion. The damages were mostly associated with major dune erosion that undermined the foundations of the structures. In Vilano Beach, State Road A1A was collapsed between R114 and R115 and in several other places it was flooded and became impassable. Between R114 and R115, two road segments were damaged with lengths of approximately 454 feet and 370 feet.

Coastal armoring damage was observed in a few locations along the developed beach segments. The total length of armoring damage for St. Johns County was approximately 3,231 feet that include 2,008 feet of major damage and 1,243 feet of minor damages. South of Matanzas Inlet in Summer Haven, approximately 2,000 feet of rock revetment sustained major damage. In a few places, significant displacement of rocks was observed which caused the revetment to be deflated.

Flagler County

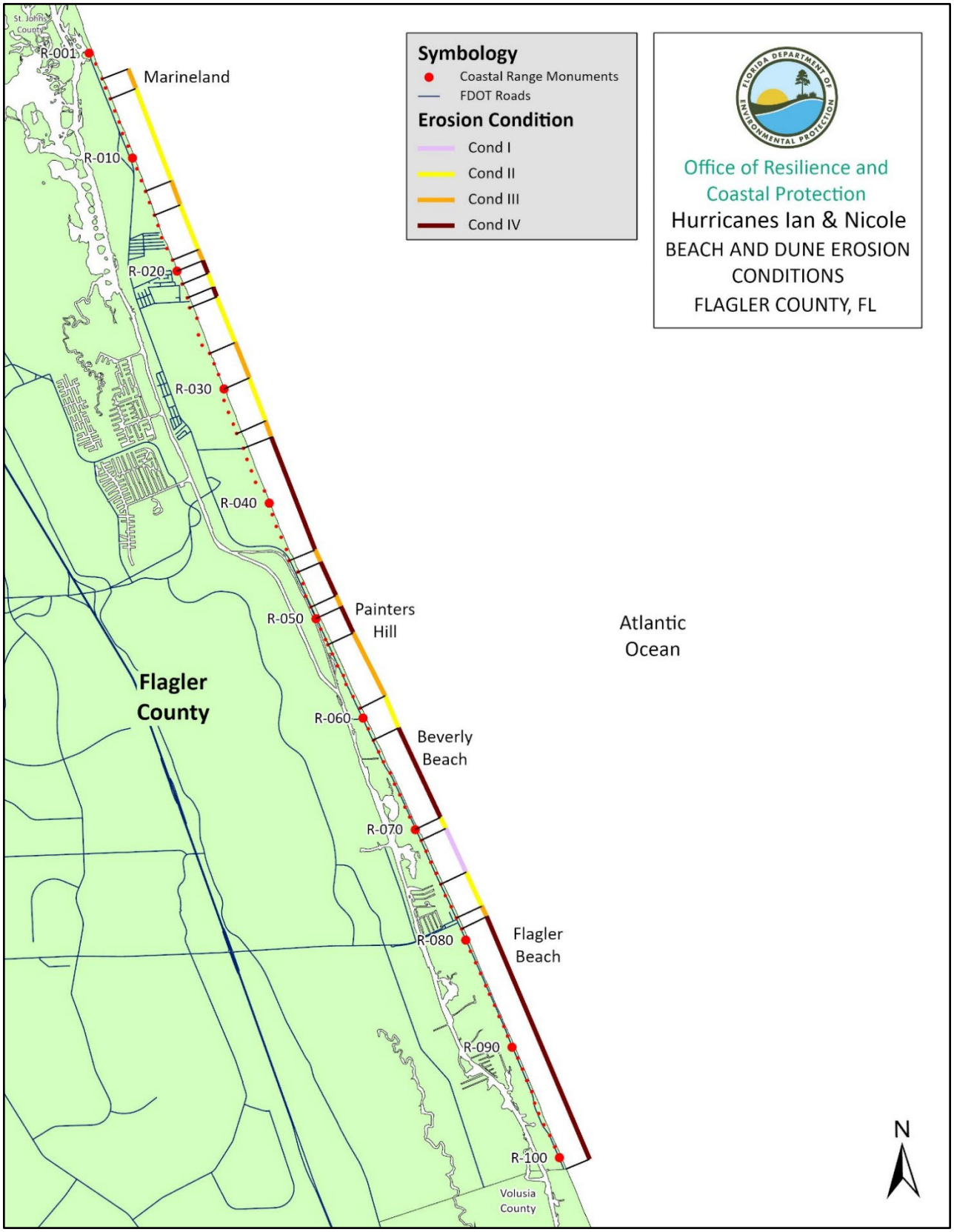

Figure 69. Flagler County Beach and Dune Erosion Conditions from Hurricanes Ian and Nicole.

Flagler County

The Atlantic Ocean fronting beaches of Flagler County extend for 18.1 miles between St. Johns County and Volusia County, that include the following communities and major parks: Marineland, Washington Oaks State Park, Palm Coast, Hammock Dunes, Painters Hill, Beverly Beach, Flagler Beach, and Gamble Rogers State Park (**Figure 69**).

Storm Effects and Erosion Conditions due to Hurricane Ian

The storm tides of Hurricane Ian in Flagler County generally ranged between seven and nine feet above sea level. The USGS measured a maximum storm tide in Flagler Beach to be +8.3 feet NAVD. Flagler County appears to have been north of the northern eye wall of Hurricane Ian but was substantially impacted by the storm tides and waves that were comparable to a major northeaster. Flagler County sustained moderate to major beach and dune erosion (conditions III and IV) throughout the county.

At the north end of the county, the community of Marineland sustained major beach and dune erosion (condition IV) between R1 and R5. The beach and dune erosion exposed the underlying Anastasia rock formation. To the south through Washington Oaks State Park (R5 – R17) moderate beach and dune erosion (condition III) was sustained. South of Washington Oaks State Park to Malacompra Drive (R17 – R22) minor beach and dune erosion was sustained. To the south between Malacompra Drive and Jungle Hut Road (R22 – R35) moderate beach and dune erosion (condition III) was sustained. The southern roughly two thirds of the county between Jungle Hut Road (R35) and the south end of Flagler Beach (R95) sustained major beach and dune erosion (condition IV). The dune restoration projects constructed by both Flagler County and private interests following the impact of Hurricanes Matthew and Irma were substantially lost to the erosion of Ian. The armoring along Beverly Beach and Flagler Beach has become exposed due to the erosion of sediments covering the structures. The secant wall (a unique auger cast-in-place concrete seawall) recently constructed by the Florida Department of Transportation has become exposed throughout much of its length between R65 and R68 (**Figure 75**). At the south end of the county, Gamble Rogers State Park (R95 – R100) sustained moderate beach and dune erosion (condition III).

Storm Effects and Erosion Conditions due to Hurricane Nicole

The discussion above preceded the impact of Hurricane Nicole. The beaches of the entire county were substantially impacted during Hurricane Ian that made the coastal armoring and upland properties extremely vulnerable to another major storm. Due to lack of any significant recovery after Hurricane Ian, Hurricane Nicole exacerbated the overall beach erosion conditions in Flagler County. **Table 8** provides the combined Ian and Nicole countywide erosion volumes in cubic yards (cy) and average volume change per foot of shoreline (cy/ft). The erosion volumes were obtained by comparing the volume lost above mean high water elevations between a pre-storm 2021 monitoring survey and post-storm LIDAR flown by the USACE.

Table 8. Flagler County Erosion Volumes

Location	DEP Monuments	Volume Change above MHW (cy)	Average Volumetric Change (cy/ft)
North Flagler	R1 – R60	-598,288	-10.1
South Flagler	R60 – R100	-170,613	-4.3
Countywide	**R1 – R100**	**-768,901**	**-7.8**

In general, the beaches in Flagler County sustained moderate to major dune erosion (Condition III and Condition IV). In the northern part of the county, major beach and dune erosion was observed at Marineland just south of the groins, which exposed the underlying Anastasia rock formation (**Figure 70**). Beaches at Washington Oaks State Park (R13 – R15) sustained moderate dune erosion. South of Washington Oaks State Park to Malacompra Drive (R15 – R23) major beach and dune erosion (Condition IV) was sustained in most of the locations. The erosion conditions on beaches from Ocean Hammock Beach to the county line in the south (R23 – R100), which already sustained major beach and dune erosion (Condition IV) during Hurricane Ian, were deteriorated further with significant dune retreat.

Figure 70. Major beach and dune erosion at Marineland's River to Sea Preserve (R3).

Figure 71. Home flooded and sanded south of Seascape Drive (R-17).

Figure 72. Major beach and dune erosion at Ocean Hammock after Hurricane Ian (R-38).

Figure 73. Ocean Hammock after Hurricane Nicole (R-37).

Figure 74. Single-family dwelling with first floor damage and major pool damage in Beverly Beach (R-53).

Figure 75. Major beach and dune erosion exposed the new secant wall constructed by the Florida Department of Transportation (R-66).

Figure 76. Flagler Beach after Hurricane Nicole (R-69).

Figure 77. Major beach and dune erosion from Ian north of the Flagler Beach Pier (R-79).

Figure 78. Major revetment damage due to Hurricane Ian south of the pier (R-80).

Storm Damage by Hurricane Ian

Although the beach and dune erosion conditions were severe throughout Flagler County, structural damages were not as great as observed in Volusia County to the south. The winds of Ian were generally of tropical storm strength and did not cause the widespread wind damage that was observed in northern Volusia County. Ian caused major structural damage to 76 major structures within the Coastal Building Zone of Flagler County, which included 61 single-family dwellings, 5 multifamily dwellings and 10 other major structures. The Flagler Beach Fishing Pier was essentially destroyed (**Figure 79**). The seaward 165 feet of the pier was lost and much of the deck and piling of the remaining pier sustained substantial damage to the point that the pier was rendered unsafe for further use. At the south end of the Flagler Beach revetment, approximately 200 feet sustained major damage and at the north end several hundred feet sustained major damage .

Storm Damage by Hurricane Nicole

Hurricane Nicole caused major structural damage to nine major structures within the Coastal Building Zone of Flagler County, which included seven single-family dwellings, one multifamily dwelling and one beachside swimming pool. Most of the damage was associated with major dune erosion that undermined the foundation of the structures. South of the Flagler Beach Fishing Pier, a total of approximately 395 feet of road damage was observed at different locations between R81 and R85.

Including seawalls and boulder revetments, the total length of armoring damage for Flagler County was approximately 9,826 feet (1.86 miles) that included 7,790 feet (1.48 miles) of major damages and 2,036 feet (0.38 miles) of minor damages. Extensive rock revetment damage was observed along much of the City of Flagler Beach south of the fishing pier. In the area between 7th Street South (R80) and 23rd Street South (R90), approximately 9,100 feet of boulder revetment sustained some level of damage that included 7,500 feet of major damage (**Figure 80**).

Figure 79. Flagler Beach Fishing Pier with 165 ft. of the seaward end destroyed (R-79).

Figure 80. A1A revetment and road damage after Hurricane Nicole in Flagler Beach at 17th Street South (R-88) [Drone footage courtesy of Olsen Associates and Flagler County].

Volusia County

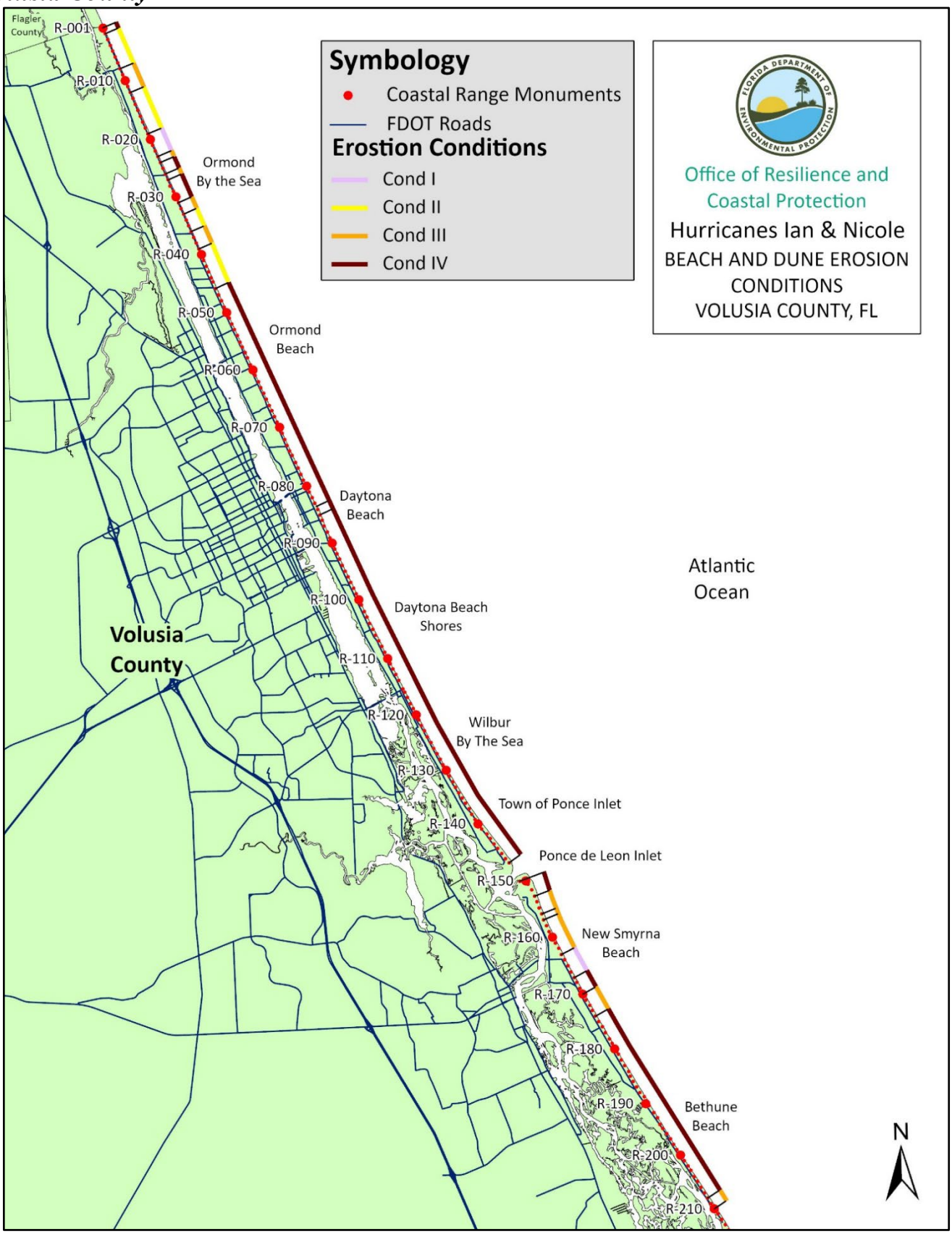

Figure 81. Volusia County Beach and Dune Erosion Conditions from Hurricanes Ian and Nicole.

Volusia County

Volusia County, the southern-most of the five northeast Florida coastal counties, extends for 48.8 miles between Flagler and Brevard counties. Volusia County includes the following barrier beach communities and major parks: North Peninsula State Park, Ormond-by-the-Sea, Ormond Beach, Daytona Beach, Daytona Beach Shores, Wilbur-by-the-Sea, Town of Ponce Inlet, Ponce de Leon Inlet County Park, New Smyrna Beach, Bethune Beach, and Canaveral National Seashore (**Figure 81**). Ponce de Leon Inlet between the north and south peninsulas of Volusia County has a federal navigation project, which experienced significant shoaling due to Hurricanes Ian and Nicole. The northern portion of the county located north of Ponce de Leon Inlet is known as the northern peninsula, whereas the southern portion located south of the inlet is known as the south peninsula.

Storm Effects and Erosion Conditions due to Hurricane Ian

The storm tides of Hurricane Ian in Volusia County generally ranged between seven and nine feet above sea level. The USGS measured a maximum storm tide in Daytona Beach to be +8.0 feet NAVD (**Figure 6**). Thursday morning, September 29, wave heights peaked off the northeast Florida coast. The National Data Buoy Center's buoy (Station 41009) located 20 nautical miles offshore from Cape Canaveral measured a peak significant wave height of 18.7 feet. As Hurricane Ian tracked northeastward with the eye passing over Cape Canaveral, the hurricane's northern eye wall severely impacted the northern peninsula of Volusia County with storm tides and waves comparable to a major northeaster.

The northern peninsula of Volusia County (R1 – R148) between the north county line and Ponce de Leon Inlet, sustained major beach and dune erosion (Condition IV) for roughly 28 miles. The only deviation in the severe erosion conditions was immediately south of the Main Street Pier in Daytona Beach between the pier and approximately R85 (roughly 1,200 ft) where only minor beach and dune erosion was observed because of the relatively stable salient in the beach due to the long-term effects of the pier. Along these 28 miles of beach, the upper beach berm was lowered by two to five feet, which has resulted in the complete loss of beach at high tide along a substantial segment of coast. This lowering of the beach profile seaward of surviving seawalls resulted in much greater pressures against the upland side of the walls. A future significant rainfall event could add enough of a load behind some walls for failure. Or a strong northeaster with continuous wave attack could cause additional wall failures. Likewise, with the beach berm lowered from Hurricane Ian, upland

properties behind failed seawalls are particularly vulnerable to seasonal high tides and energetic wave conditions.

Much of the southern peninsula of Volusia County (R149 – R208) between Ponce de Leon Inlet and Canaveral National Seashore also sustained major beach and dune erosion (Condition IV). A notable exception was the unincorporated community of Bethune Beach (R194 – R208) where accretion, not erosion, was sustained. In contrast to the fine white quartz sand beaches to the north, the sediments of Bethune Beach consist of a generally orange colored coarse shelly material.

In the development of this post-storm report, the beach and dune conditions along southern Volusia County within the Canaveral National Seashore were not assessed; however, moderate beach and dune erosion (Condition III) was observed in the northern reaches of the park.

Storm Effects and Erosion Conditions due to Hurricane Nicole

The discussion above preceded the impact of Hurricane Nicole. Prophetically, the severely eroded beach conditions caused by Hurricane Ian made seawalls and upland properties extremely vulnerable to another major storm. This coupled with the lack of any significant recovery, either natural or man-assisted, set the stage for catastrophic impacts during the storm tides, extreme wave conditions and additional severe erosion of Hurricane Nicole roughly six weeks after the impact of Hurricane Ian.

The entire county is considered to have major beach and dune erosion in the wake of both Hurricanes Ian and Nicole. **Table 9** provides the combined Ian and Nicole countywide erosion volumes in cubic yards (cy) and average volume change per foot of shoreline (cy/ft). The erosion volumes were obtained by comparing the volume lost above mean high water elevations between a pre-storm 2019 monitoring survey and post-storm LIDAR flown by the USACE. Volusia County through their consultant assessed the LiDAR data as well and their report can be viewed at this OCULUS link.

Table 9. Volusia County Erosion Volumes calculated by DEP.

Location	DEP Monuments	Volume Change above MHW (cy)	Average Volumetric Change (cy/ft)
Northern Volusia	R1 – R39	-688,833	-18.1
Ormond Beach to Ponce Inlet	R39 – R148	-1,843,867	-16.9
New Smyrna Beach to Bethune	R149 – R208	-641,072	-10.7
Canaveral National Seashore	R208 – R234	No data	NA

Figure 82. Major beach and dune erosion in the Town of Ponce Inlet (R147).

Figure 83. Severe dune erosion threatening upland properties in the Town of Ponce Inlet (R138).

Storm Damage by Hurricane Ian

Hurricane Ian caused substantially more coastal building damage along the coast of Volusia County than any storm in over the past 50 years. Ian caused major structural damage to 364 major structures within the Coastal Building Zone of Volusia County. In contrast, Hurricane Irma (2017) caused major damage to 106 major structures and Hurricane Matthew (2016) caused major damage to 75 major structures within the Coastal Building Zone. Previously in 2004, Hurricane Frances caused major damage to 46 major structures and Hurricane Jeanne caused major damage to 45 major structures.

Most of the coastal building damage (97%) was due to the winds of Hurricane Ian (**Figure 84**); however, some of the damage was due to the loss of seawalls, particularly to several swimming pools (**Figure 85**) and a couple of parking lots. The seaward 220 feet the Sun Glow Fishing Pier in Daytona Beach Shores was destroyed seaward of the pier restaurant, and wave and erosion damage were also sustained by a couple of beach vehicular access ramps (**Figure 86**).

Figure 84. Roof blown off dwelling (left, R94); siding damage on hotel (right, R111).

Figure 85. Swimming pools destroyed with seawall failure (R101).

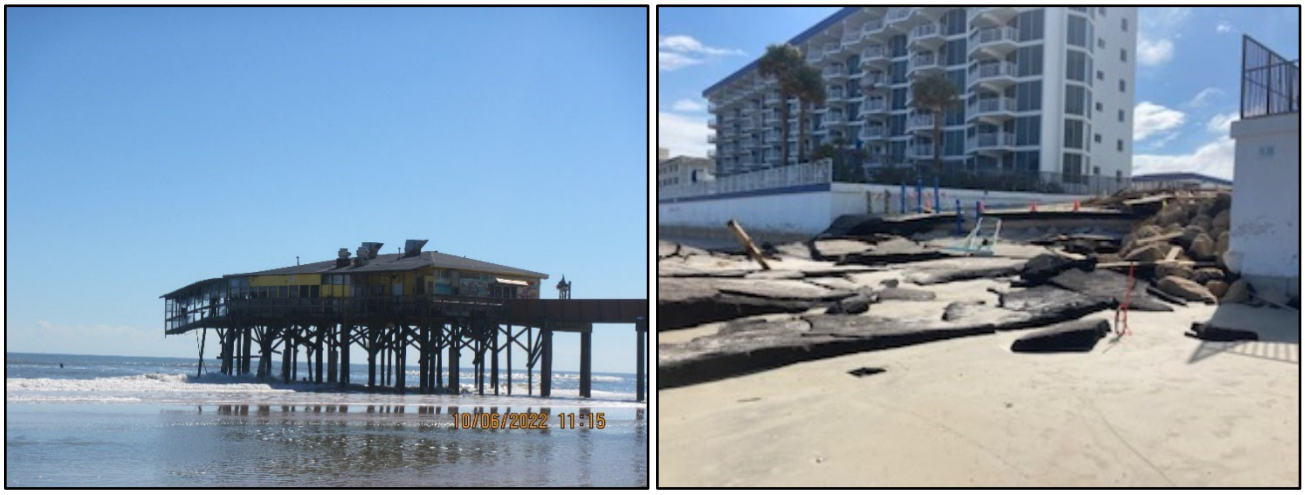

Figure 86. Sun Glow Fishing Pier destroyed (left, R118); Demotte Ave. beach ramp destroyed (right, R116).

The greatest economic impact was seen in the damage to coastal armoring (seawalls and revetments) along the northern peninsula of Volusia County. A detailed investigation of the beach front damage determined that 53 seawalls were destroyed resulting in major damage to 6,330 feet (roughly 1.2 miles) of armoring that will require major repair or reconstruction. Another 3,435 feet (0.65 mile) of seawalls and revetments sustained minor damage that will require repair, resulting in a total of 9,765 feet (roughly 1.85 miles) of damaged armoring. In addition, another 3,195 feet of retaining walls and gravity walls were destroyed or sustained major damage. These types of walls are often called seawalls; however, they are expendable and provide no protection from beach erosion and wave forces. Historically, only Hurricane Jeanne (2004) caused seawall damages comparable to Hurricane Ian. Hurricane Jeanne destroyed 19 seawalls county-wide for a damage length of 5,430 feet (slightly

over one mile). While all the destroyed seawalls from Ian were in the northern peninsula area, most of the destroyed seawalls from Jeanne were in the southern peninsula area.

The newer replacement seawalls constructed after Hurricane Jeanne were better able to withstand the storm tides, erosion and wave impacts of Hurricane Ian, so no seawalls were destroyed throughout the New Smyrna Beach area. Most of the seawalls destroyed in Daytona Beach, Daytona Beach Shores and Wilbur-by-the-Sea were old walls that were constructed over 30 years ago. These walls had various issues that led to their failure. The most outstanding problems with the failed seawalls were –

- age
- corroded reinforcement steel
- inadequate tie-backs
- insufficient pile penetration (short panels)
- inadequate wall thickness (typically 4 inches)
- lack of an adequate filter drainage system behind the walls

All these issues coupled with the significantly lowered beach profile, high storm tides and wave conditions, led to the catastrophic collapse of 53 seawalls. Examples of the problems are seen in **Figures 85 – 91**. In many cases, the seawall failures resulted in substantial loss of upland property which threatened the upland buildings (**Figures 92** – **97**).

Figure 87. Seawall failure due to inadequate panel thickness of only 4 inches.

Figure 88. Old seawall with corroded reinforcing steel in Daytona Beach Shores (R116).

Figure 89. Seawall destroyed with inadequate pile penetration resulting in a destroyed swimming pool (R116).

Figure 90. Inadequate sheet pile penetration.

Figure 91. Old seawall destroyed by wave impact loads resulting in substantial loss of property in Daytona Beach Shores (R99).

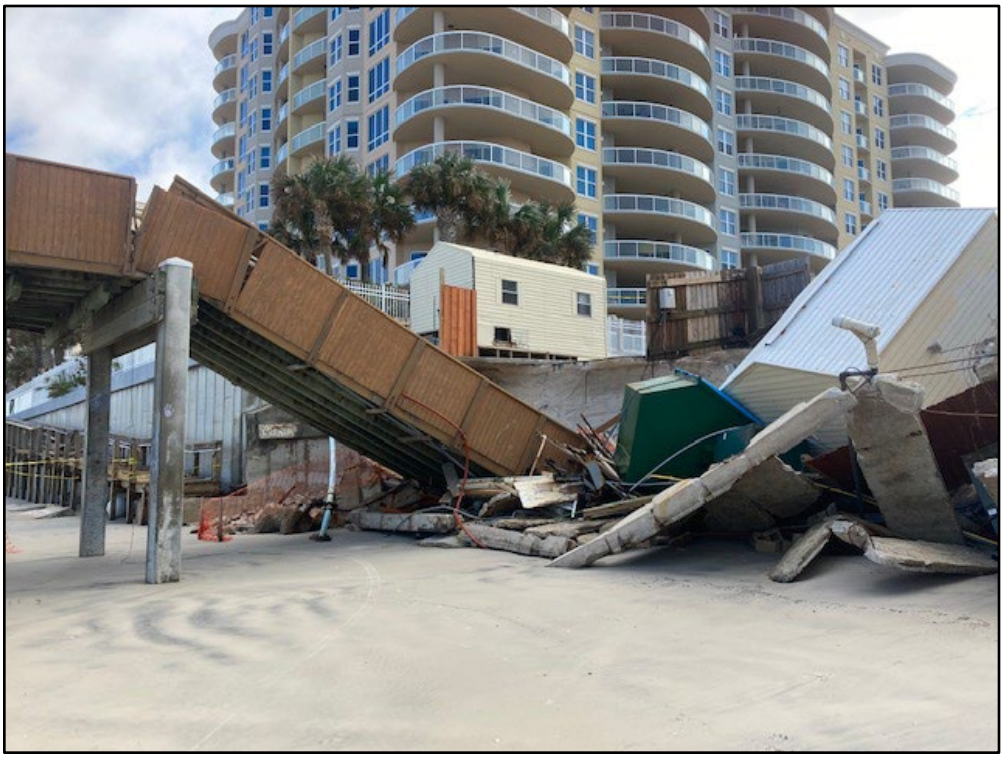

Figure 92. Multiple failures: landward section of Sun Glow Pier, seawall destroyed, building and parking lot destroyed (R118).

Figure 93. Seawall failure due to beach profile lowering and lack of tie-backs in Wilbur by the Sea (R124).

Figure 94. Catastrophic seawall collapse with loss of upland property in Wilbur by the Sea (R125).

Figure 95. Wilbur-by-the-Sea dwelling threatened following seawall failure (R125).

Figure 96. Catastrophic seawall failure threatens condominium in Daytona Beach Shores (R114).

Figure 97. Substantial loss of property with seawall failure.

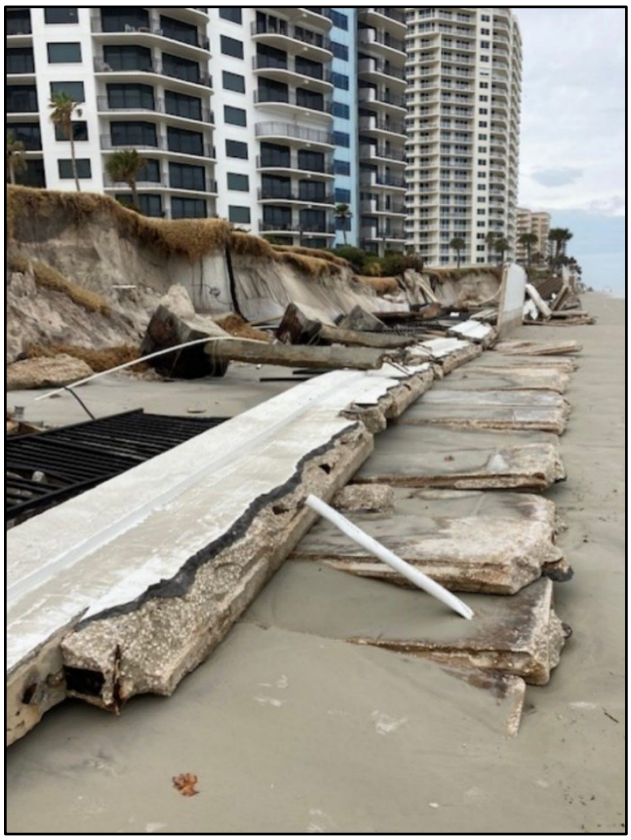

Figure 98. Catastrophic seawall failure threatens buildings in Daytona Beach (R75).

Figure 99. Inadequate seawall tie-backs, wall thickness and pile penetration (R-71.5).

Aside from all the damage to coastal armoring (seawalls and revetments), the north jetty of Ponce de Leon Inlet was severely damaged along a 100-foot segment at the Atlantic beach shoreline (**Figure 100**). This breach in the jetty resulted in substantial beach and dune erosion occurring along the beaches to the north. Unfortunately, this same segment of the jetty was previously breached in Hurricane Matthew (2016) and further damaged by Hurricane Irma (2017) only to be repaired by the U.S. Army Corps of Engineers in 2021. The north jetty pier also sustained damage, mostly to its stainless steel railing (**Figure 101**).

Figure 100. Damaged north jetty to Ponce de Leon Inlet (R-148).

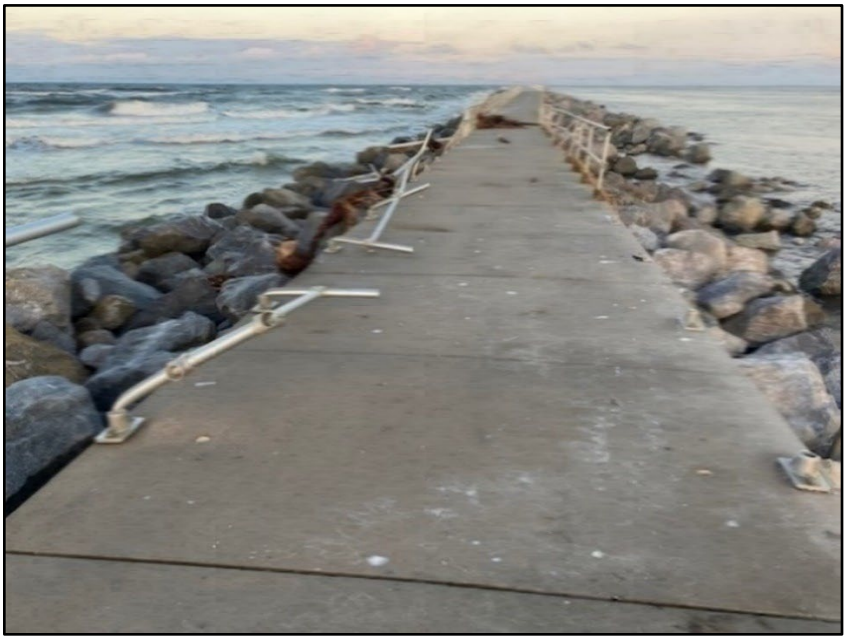

Figure 101. Damaged north jetty fishing pier at Ponce de Leon Inlet (R148).

Storm Damage by Hurricane Nicole

Following Hurricane Ian, most of developed coastal Volusia County was at high risk for a subsequent storm event. At least two dozen habitable major structures and 7.7 miles of seawalls were considered exposed and threatened by another major storm. Conditions had deteriorated such that the beach had lowered significantly resulting in much greater pressures against the upland side of the seawalls. Also, in areas without seawalls, the dune line had receded to within proximity to the foundations of single-family dwellings and condominium buildings. After Ian, it was believed that another strong storm like a northeaster with continuous wave attack over multiple high tides would likely cause some additional seawall failures and the possible collapse of threatened dwellings. This proved to be an underestimate.

The worst-case scenario occurred with the impact of Hurricane Nicole. The slow development of Nicole, first as a subtropical storm and then as a strong tropical storm before reaching hurricane strength took a few days and created a large wind field with a 40-mile-wide central eye. Peak significant wave heights measured at two NOAA buoys 20 and 120 nautical miles offshore from Cape Canaveral measured respectively, 31.8 feet and 32.2 feet. Wave heights exceeding 30 feet are typically only associated with Category 4 and Category 5 hurricanes off the coast of Florida.

Although the winds at landfall caused generally insignificant damage, the several storm tides occurring for a couple days with extremely high wave energy severely damaged upland properties and resulted in major damages to another 109 major structures. Of these, 42 major structures were destroyed.

Another detailed investigation of the beach front damage after Nicole determined that another 98 seawalls and three revetments were destroyed or sustained major damage resulting in another 13,261 feet (roughly 2.5 miles) of armoring that will require major repair or reconstruction in addition to the major damage caused by Ian. Another 3,265 feet (0.62 mile) of seawalls and revetments sustained minor damage that will require repair, resulting in a total of 16,526 feet (roughly 3.13 miles) of damaged seawalls and revetments due solely to Nicole. In addition, another 2,941 feet of retaining walls and gravity walls were destroyed or sustained major damage.

Determining the damage to seawalls and revetments attributable to either Ian or Nicole was very complicated; however, it was determined that the combined impact of both storms caused damage to 4.2 miles of seawalls and revetments. Nicole destroyed most of the seawalls that Ian left with minor damage and many of those left vulnerable but without any visible damage after Ian. A combined total of approximately 154 seawalls and revetments were destroyed or sustained major damage from both storms. Most of the damage occurred along a roughly 13-mile segment of the northern peninsula of the county between DEP reference monuments R62 and R130 (**Figure 102** and **Figure 104**). Along this segment of coast, 127 buildings and 8.4 miles of seawalls and revetments are now considered threatened or vulnerable to another major coastal storm.

Figure 102. Major erosion damages to seawalls and upland properties at Toronita Avenue in Wilbur by the Sea (R-125). [Credit: Oblique aerial photo by the Civil Air Patrol, November 12, 2022.]

Figure 103. House and pool in imminent danger from major beach and dune erosion .

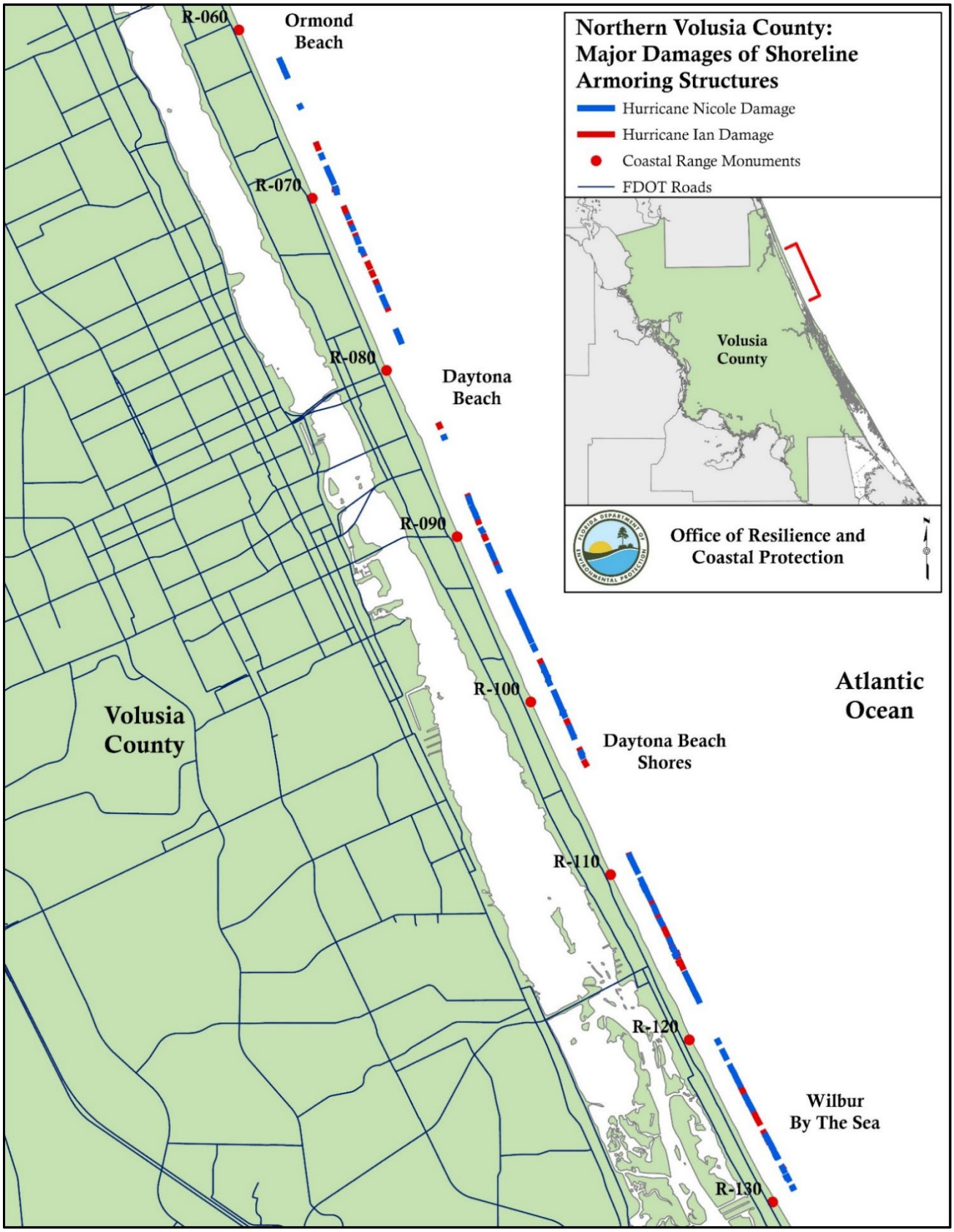

Figure 104. Major damages to armoring after Hurricanes Ian and Nicole in northern Volusia County. **Note:** see Appendix A that describes the different damage levels to coastal armoring structures.

Figure 105. Threatened multifamily dwelling with foundation piles suspended (R117).

Figure 106. Condominium in imminent danger with roofing and siding damages.

Figure 107. House and pool in imminent danger, Wilbur-by-the-Sea (R122).

Figure 108. House and pool destroyed, Wilbur-by-the-Sea (R125).

Figure 109. House destroyed, Wilbur-by-the-Sea (R125).

Figure 110. Homes destroyed, Wilbur-by-the-Sea (R125).

Figure 111. Homes destroyed, Wilbur-by-the-Sea (R125).

Figure 112. Multifamily dwelling in imminent danger of collapse (R131).

Figure 113. House in imminent danger of collapse, Wilbur-by-the-Sea, (R126).

Figure 114. House in imminent danger of collapse, Wilbur-by-the-Sea (R125).

Figure 115. Partial collapse of house.

Figure 116. Multifamily dwelling in imminent danger following severe dune erosion.

Figure 117. Undermined pile-supported pool in Volusia County.

Figure 118. Damaged multifamily dwelling in Volusia County.

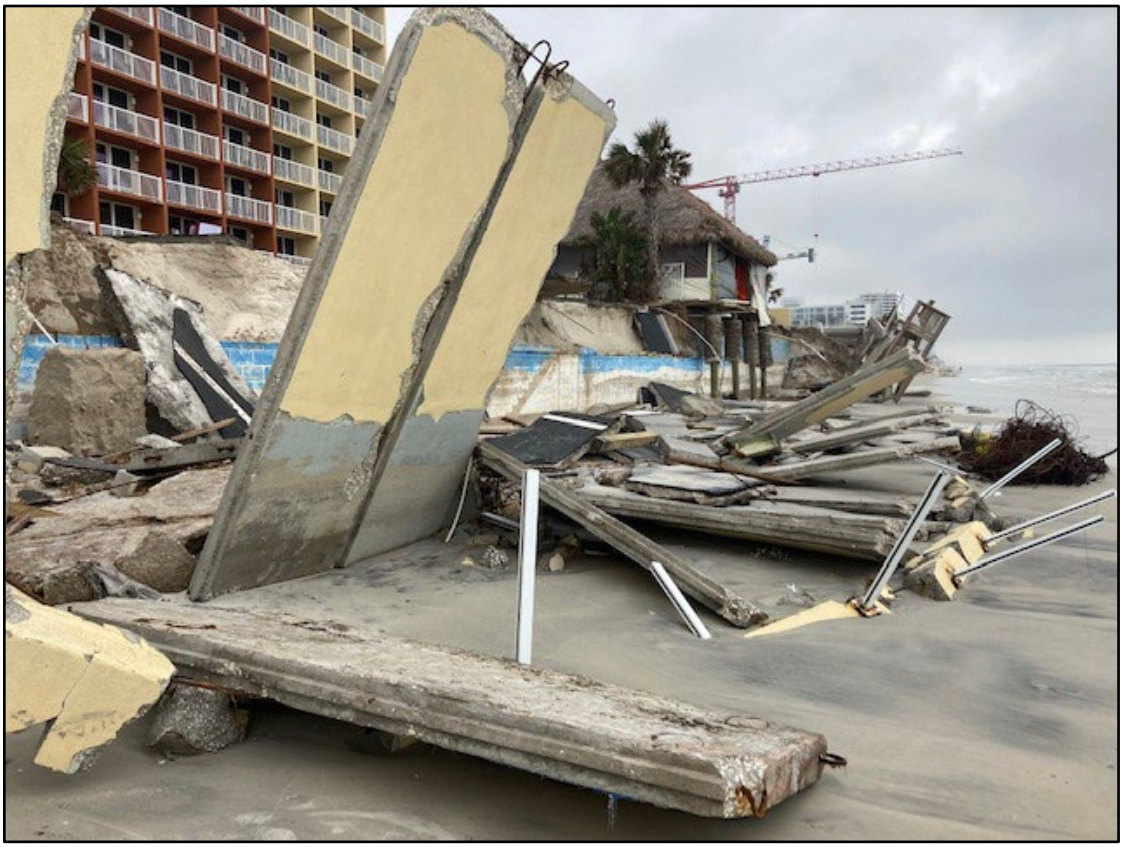

Figure 119. More seawall damage by Hurricane Nicole.

Figure 120. More threatened houses following severe erosion in Daytona Beach Shores (R-103).

Brevard County

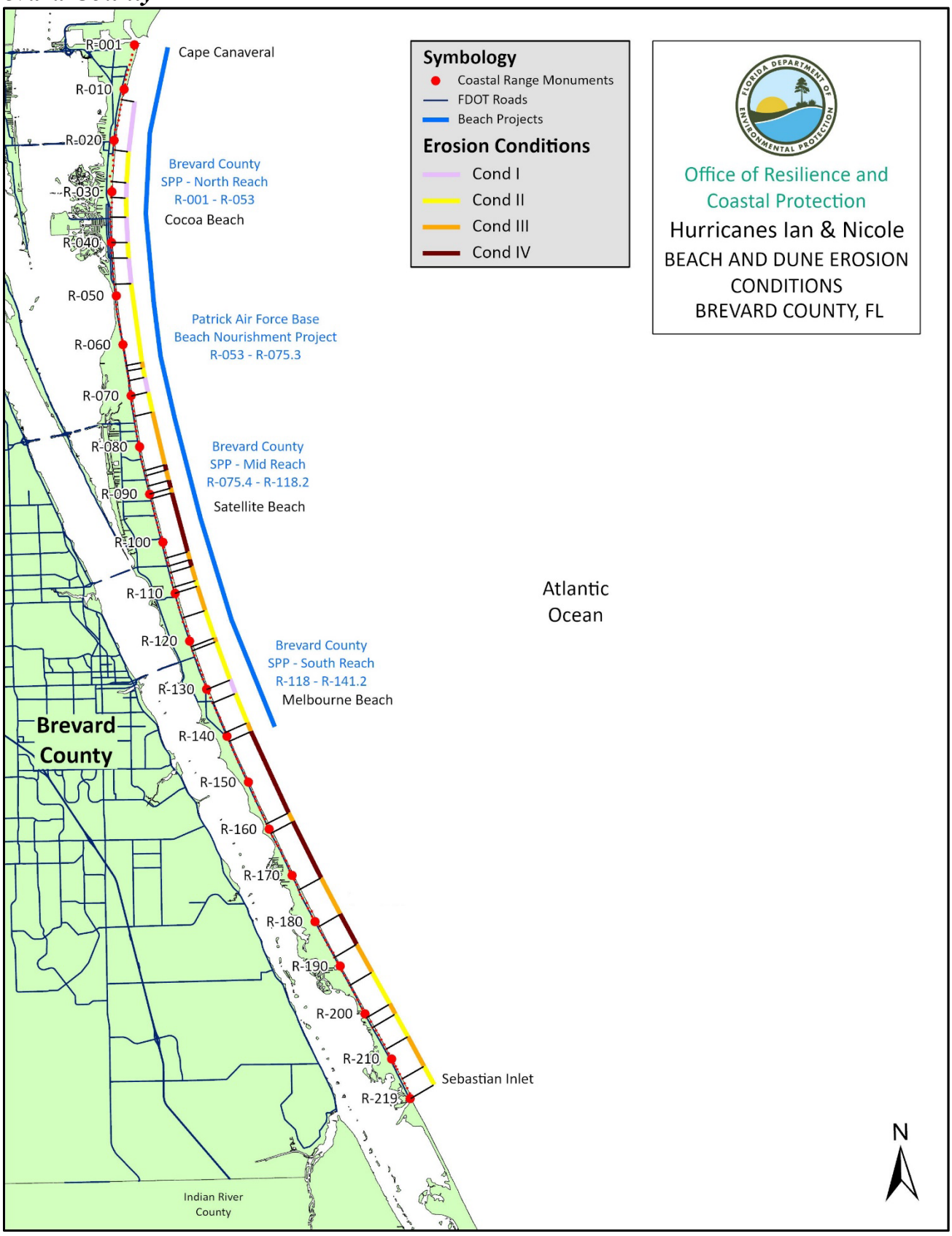

Figure 121. Brevard County Beach and Dune Erosion Conditions from Hurricanes Ian and Nicole.

Brevard County

Brevard County (**Figure 121**) had moderate to major beach and dune erosion (condition III to IV) from Satellite Beach to Indialantic (generally R74 – R122) and along the south county (R139 – R215). In addition, 19 major structures sustained major structural damage as they were impacted by the erosion. **Table 10** provides the combined Ian and Nicole countywide erosion volumes in cubic yards (cy) and average volume change per foot of shoreline (cy/ft). No post-storm LIDAR data was available for Brevard County. The erosion volumes were obtained by comparing the volume lost above mean high water elevations between a pre-storm June 2022 monitoring survey and a post-storm November 2022 monitoring survey.

Table 10. Brevard County Erosion Volume

Location	DEP Monuments	Volume Change above MHW (cy)	Average Volumetric Change (cy/ft)
North Reach	R33 – R53	-224,941	-11.2
Mid-Reach	R76 – R118	-553,967	-13.2
South Reach	R120 – R138	-345,630	-19.2
South Beaches	R149– R213	-597,744	-9.3

Indian River County

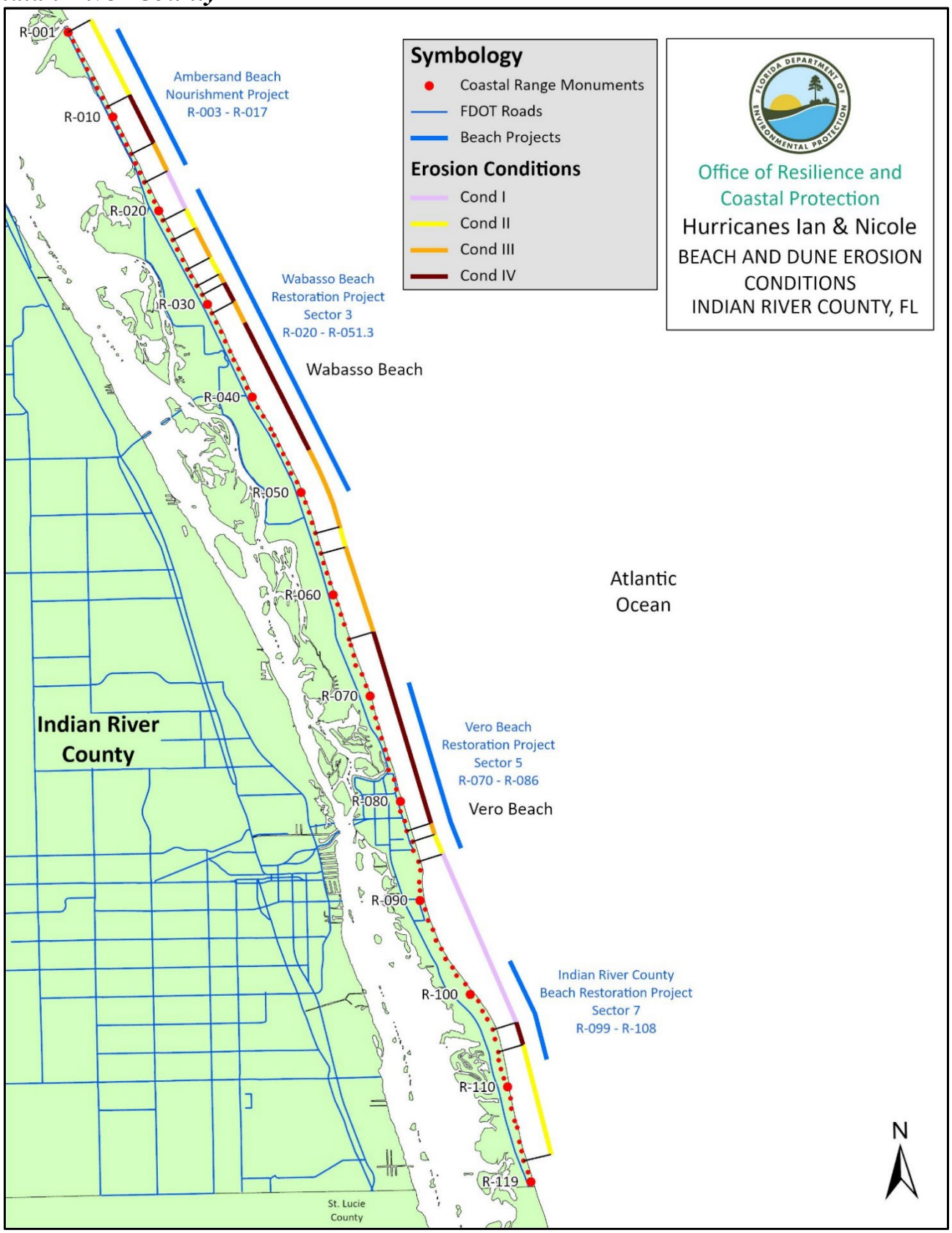

Figure 122. Indian River County Beach and Dune Erosion Conditions from Hurricanes Ian and Nicole.

Indian River County

Indian River County (**Figure 122**) had segments of moderate to major beach and dune erosion (Condition III to IV) in Wabasso Beach and Vero Beach. In addition, seven major structures sustained major structural damage as they were impacted by the erosion. No post-storm LIDAR data was available for Indian River County. However, a monitoring survey was conducted in January 2023 from R20 to R119. The erosion volumes were obtained by comparing the volume lost above mean high water elevations between a pre-storm June 2020 monitoring survey and a post-storm January 2023 monitoring survey. For the segment of shoreline between R20 and R119, the total volume change above mean high water was -44,673 cubic yards (erosion) with an average net change of -0.5 cy/ft of shoreline.

St. Lucie County

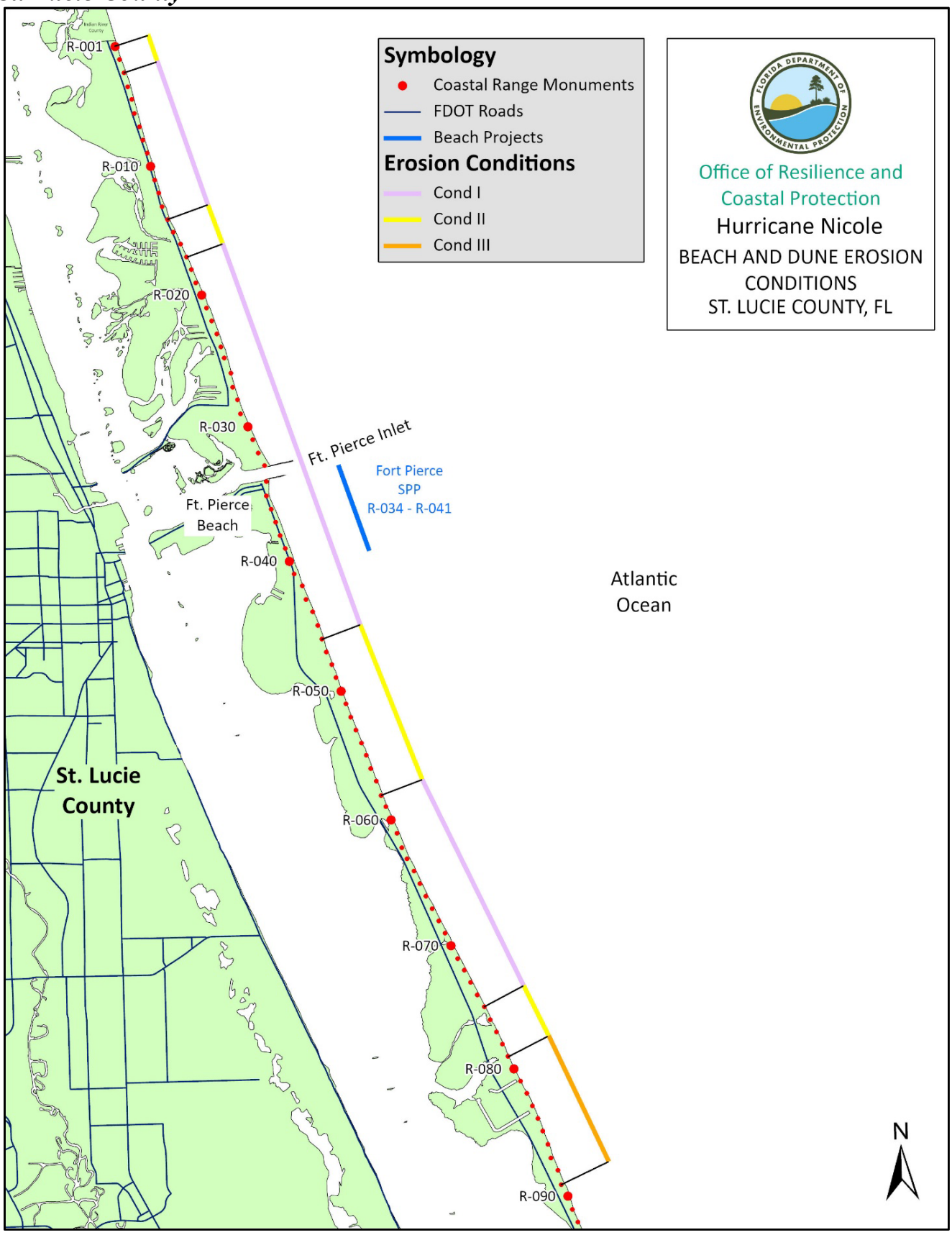

Figure 123. St. Lucie County Beach and Dune Erosion Conditions from Hurricane Nicole.

Martin County

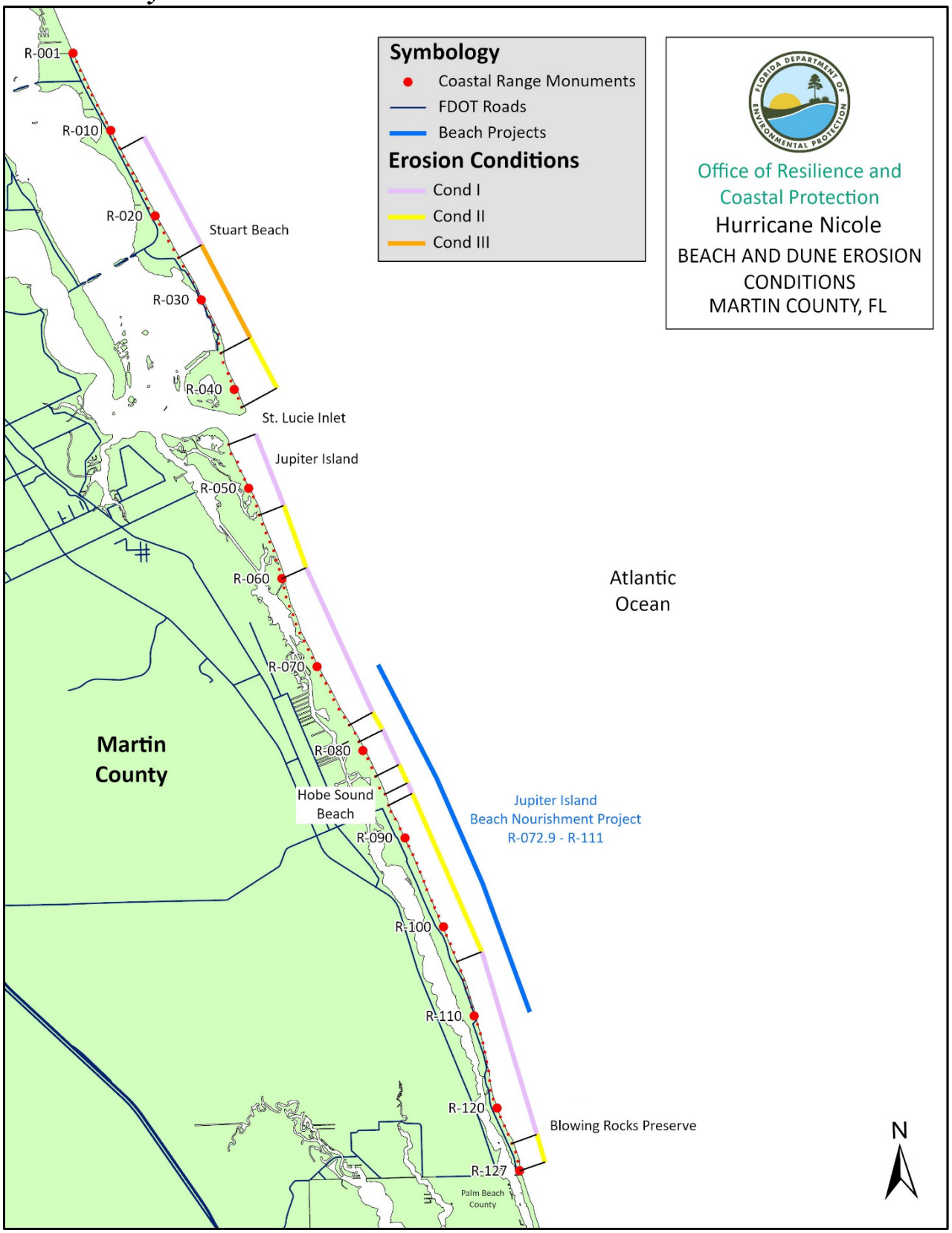

Figure 124. Martin County Beach and Dune Erosion Conditions from Hurricane Nicole.

Appendix A

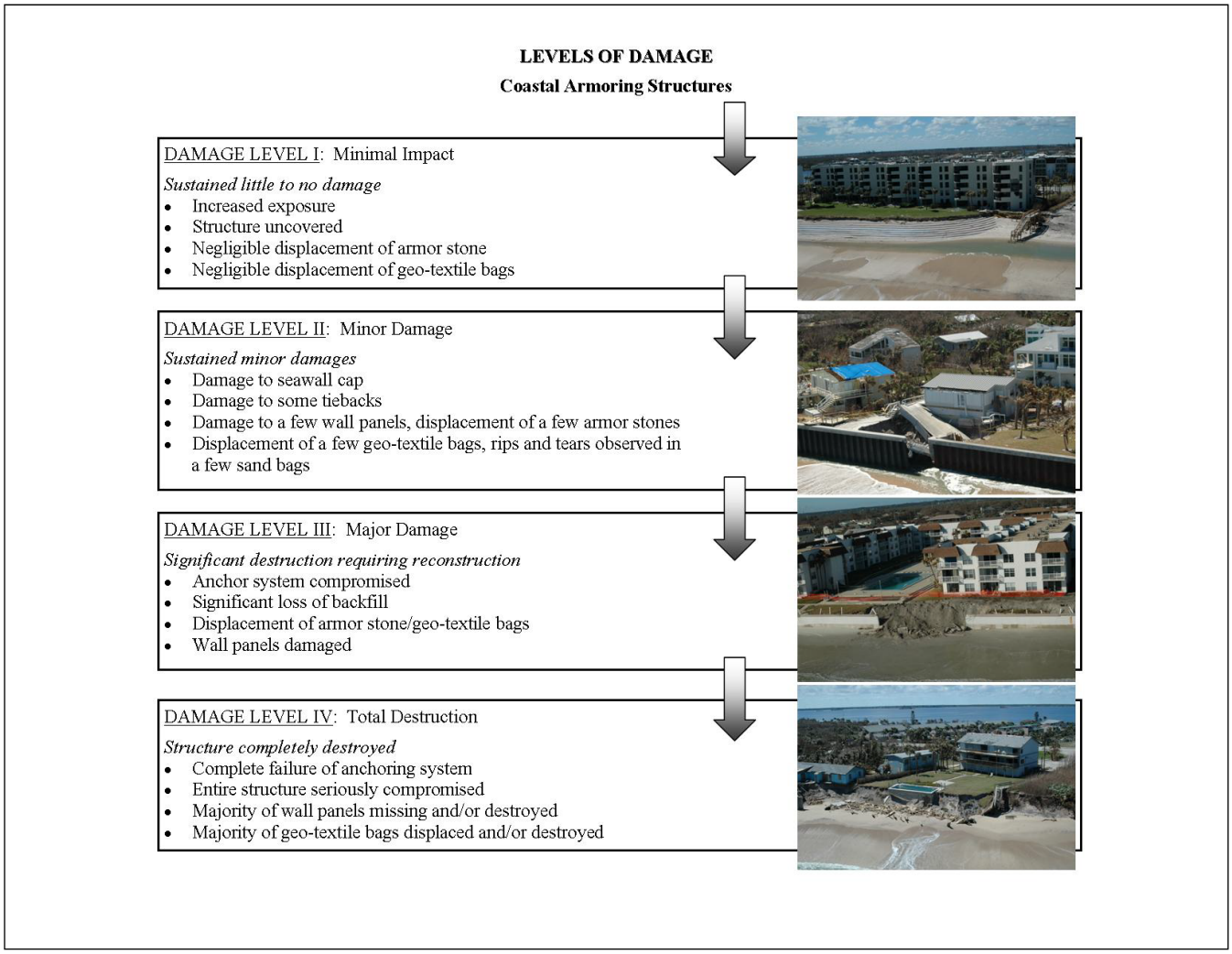

Figure 125. DEP's Coastal Engineering graphic describing the levels of damage (I – IV) to coastal armoring structures, including seawalls and revetments.