5.2 COASTAL EROSION & SEA LEVEL RISE

SECTION 5.2 COASTAL EROSION & SEA LEVEL RISE

5.2.1 HAZARD DESCRIPTION COASTAL EROSION

Erosion and flooding are the primary coastal hazards that lead to the loss of lives or damage to property and infrastructure in developed coastal areas. Coastal storms are an intricate combination of events that impact a coastal area. A coastal storm can occur any time of the year and at varying levels of severity. One of the greatest threats from a coastal storm is coastal flooding caused by storm surge. Coastal flooding is the inundation of land areas along the oceanic coast and estuarine shoreline by seawaters over and above normal tidal action. Many natural factors affect erosion of the shoreline, including shore and nearshore morphology, shoreline orientation, and the response of these factors to storm frequency and sea level rise. Coastal shorelines change constantly in response to wind, waves, tides, sea-level fluctuation, seasonal and climatic variations, human alteration, and other factors that influence the movement of sand and material within a shoreline system. Unsafe tidal conditions, as a result of high winds, heavy surf, erosion, and fog are ordinary coastal hazard phenomena. Some or all of these processes can occur during a coastal storm, resulting in an often-detrimental impact on the surrounding coastline. Factors including: (1) storms such as Nor'Easters and hurricanes, (2) decreased sediment supplies, and (3) sea-level rise contribute to these coastal hazards.

Coastal erosion can result in significant economic loss through the destruction of buildings, roads, infrastructure, natural resources, and wildlife habitats. Damage often results from an episodic event with the combination of severe storm waves and dune or bluff erosion. Historically, some of the methods used by municipalities and property owners to stop or slow down coastal erosion or shoreline change have actually exacerbated the problem. Attempting to halt the natural process of erosion with shore parallel or perpendicular structures such as seawalls (groins and jetties) and other hard structures typically worsens the erosion in front of the structure (i.e. walls), prevents or starves any sediment behind the structure (groins) from supplying down-drift properties with sediment, and subjects down-drift beaches to increased erosion. Since most sediment transport associated with erosion and longshore drift has been reduced, some of the State's greatest assets and attractions – beaches, dunes, barrier beaches, salt marshes, and estuaries – are threatened and will slowly disappear as the sediment sources that feed and sustain them are eliminated.

Sandy barrier/bluff coastlines are constantly changing as the result of wind, currents, storms, and sea-level rise. Because of this, developed sandy shorelines are often stabilized with hardened structures (seawalls, bulkheads, revetments, rip-rap, gabions, and groins) to protect coastal properties from erosion. While hardened structures typically prove to be beneficial in reducing property damage, the rate of coastal erosion typically increases near stabilization structures. This increased erosion impacts natural habitats, spawning grounds, recreational activity areas, and public access (Frizzera, 2011). Table 5.2-1 summarizes the number and type of NJDEP shoreline structures off the coastline of New Jersey along the Atlantic Ocean and Inland Bays (current as of 1993).

Table 5.2-1 Number and Type of NJDEP Shoreline Structures

County	Breakwater	Groin	Jetty	Revetment	Seawall
Atlantic County	0	30	3	0	0
Cape May County	1	94	8	4	3
Cumberland County	0	1	1	0	0
Middlesex County	0	4	0	0	0
Monmouth County	0	172	9	1	11
Ocean County	0	72	3	0	0
Total	1	368	24	5	14

Source: NJDEP 1993

To counteract the negative impact of hard structures, alternative forms of shoreline stabilization that provide more natural forms of protection can be used. Along the New Jersey coast, beach nourishment and dune restoration are now the main forms of shoreline protection. In addition, existing groins have been notched to reestablish the flow of sediment to previously sand-starved areas of the beach. The sheltered coastlines in New Jersey consist of tidal marshlands and a few narrow, sandy beaches—all of which naturally migrate inland as the sea level rises. Experts have stated that marshes can keep pace with a 0.1 inch per year (inch/year) rate of sea level rise; however, the State's current rate is approximately 0.11 to 0.16 inch/year, a rate that is predicted to continue increasing (Frizzera, 2011). Currently, bulkheads and revetments are the primary form of shore protection along these tidal areas. As sea level rises and coastal storms increase in intensity, coastal erosion and requests for additional shoreline stabilization measures are likely to increase (Frizzera, 2011). Figure 5.2-1 shows beach nourishment activities in Sea Girt, New Jersey.

Figure 5.2-1 Beach Nourishment Activities in Sea Girt, New Jersey

Source: NJDEP, 2012

Sea Level Rise

In the previous plan, 2012 National Oceanic and Atmospheric Administration (NOAA) projections for Sea Level Rise were referenced. The National Oceanic and Atmospheric Administration (NOAA) at the time identified four (4) scenarios for global mean sea level rise in its 2012 report, "Global Sea Level Rise Scenarios for the United States National Climate Assessment". Based on these four scenarios, labeled "Lowest", "Intermediate -Low", "Intermediate-High" and "Highest", NOAA estimated, factoring in future potential conditions, global sea level rise by the year 2050 at the following four levels, respectively: 0.3 feet; 0.7 feet; 1.3 feet; and 2.0 feet.

There is currently no coordinated, interagency effort to identify agreed upon estimates for future sea level rise. The United States National Climate Assessment Development and Advisory Committee, a federal committee writing the next National Climate Assessment, outlines sea level rise scenarios in the National Oceanic and Atmospheric Administration's Office of Oceanic and Atmospheric Research, Climate Program Office, Technical Report OAR CPO-1 entitled 'Global Sea Level Rise Scenarios for the United States National Climate Assessment'.

For this plan update, more recent and localized projections from Rutgers University are referenced for the State of New Jersey. Local and regional sea level projections for New Jersey are summarized in a 2016 Rutgers University Science and Technical Advisory Panel (STAP) Report, entitled, Assessing New Jersey's Exposure to Sea-Level Rise and Coastal Storms: Report of the New Jersey Climate Adaptation Alliance Science and Technical Advisory Panel (Kopp et al., 2016). This STAP Report was requested by the New Jersey Climate Adaptation Alliance, which is a network of policymakers, public and private sector practitioners, academics, nongovernmental organizations, and business leaders designed to build climate change preparedness capacity in New Jersey. Projected sea level rise estimates for New Jersey from the STAP Report are presented in Table 5.2-2.

Table 5.2-2 Projected Seal Level Rise for New Jersey

	Central Estimate	Likely Range	1-in-20 Chance	1-in-200 Chance	1-in-1000 Chance
Year	50% probability SLR meets or exceeds…	67% probability SLR is between…	5% probability SLR meets or exceeds…	0.5% probability SLR meets or exceeds…	0.1% probability SLR meets or exceeds…
2030	0.8 ft	0.6 – 1.0 ft	1.1 ft	1.3 ft	1.5 ft
2050	1.4 ft	1.0 – 1.8 ft	2.0 ft	2.4 ft	2.8 ft
2100 Low emissions	2.3 ft	1.7 – 3.1 ft	3.8 ft	5.9 ft	8.3 ft
2100 High emissions	3.4 ft	2.4 – 4.5 ft	5.3 ft	7.2 ft	10 ft

Estimates are based on Kopp et al. (2014). Columns correspond to different projection probabilities. For example, the 'Likely Range' column corresponds to the range between the 17th *and 83rd percentile; consistent with the terms used by the Intergovernmental Panel on Climate Change (Mastrandrea et al., 2010). All values are with respect to a 1991-2009 baseline. Note that these results represent a single way of estimating the probability of different levels of SLR; alternative methods may yield higher or lower estimates of the probability of high-end outcomes.*

Source: Kopp et al., 2016

The state is consistently applying Sea level Rise projection tools to inform the development of this plan. In addition, as part of the State's comprehensive effort to assess the potential long term efficacy and fiscal sustainability of specific risk reduction measures and improvements using CDBG funding, the State intends to uses available tools to consider the impact of potential sea level rise and consider whether project designs should be enhanced to address potential sea level rise scenarios, where such enhancements are cost effective and reasonably practical given the inherent uncertainty in sea level rise modeling.

5.2.1.1 REGULATORY PROGRAMS

Section 3 Coordination of Local Planning discusses the regulatory programs in place that protect the New Jersey coast. The two main programs are summarized below.

New Jersey Shore Protection Program

The New Jersey Shore Protection Program was created to provide for the protection of life and property along the coastline, to preserve vital coastal resources, and to maintain safe and navigable waterways throughout New Jersey. The Bureau of Coastal Engineering, which operates under the Office of Engineering and Construction within the New Jersey Department of Environmental Protection's (NJDEP) Natural and Historic Resources Group, is responsible for administering beach nourishment, shore protection, and coastal dredging throughout the State. The Bureau also maintains the State's aid to navigation, provides 24-hour operation of the Raritan Bayshore Floodgate, and conducts storm surveys, damage assessments, and emergency repairs for coastal storms that impact New Jersey (NJDEP, 2012).

New Jersey Coastal Management Program

The New Jersey Coastal Management Program (CMP), an extension of the NJDEP, is the lead for issues related to coastal erosion across the State. The CMP's mission is to ensure that coastal resources and ecosystems are maintained and to enhance the sustainability of coastal communities in the State. The CMP's central component is the Coastal Management Office. The Coastal Management Office is part of the Commissioner's Office of Policy and administers the planning and enhancement measures of the

CMP. The Office is responsible for developing long-term projects related to coastal sustainability. The Office also advises the CMP on related policies and works with municipal, state, and federal partners on coastal erosion projects and grant funding opportunities (NJDEP, 2012).

In addition to the activities of the CMP, the NJDEP's Bureau of Coastal Engineering also plays a role in the prevention of and response to coastal erosion. The Bureau of Engineering, in cooperation with the United States Army Corps of Engineers (USACE) provides beach nourishment and re-nourishment projects along the New Jersey Coastline. Beach nourishment involves replacing sand that has been eroded from natural sediment movement or as a result of a storm (NJDEP, 2012).

In order to ensure the prompt and coordinated acquisition of easements or other interests in real property necessary to facilitate the timely completion of a comprehensive system of Flood Hazard Risk Reduction Measures, as directed by the Governor under Executive Order (EO) 140, the NJDEP Commissioner established the Office of Flood Hazard Risk Reduction Measures ("the Office"). The Office is headed by a director, appointed by the NJDEP Commissioner. The Office is a single State entity responsible for the rapid acquisition of property vital to the post-Sandy reconstruction efforts. The Office will lead and coordinate the efforts of the NJDEP to acquire the necessary interests in real property to undertake Flood Hazard Risk Reduction Measures and shall perform such other duties as the NJDEP Commissioner may from time-to-time prescribe. No municipality, county or other agency or political subdivision shall enact or enforce any order, rule, regulation, ordinance, or resolution which will or might in any way conflict with any of the provisions of EO 140.

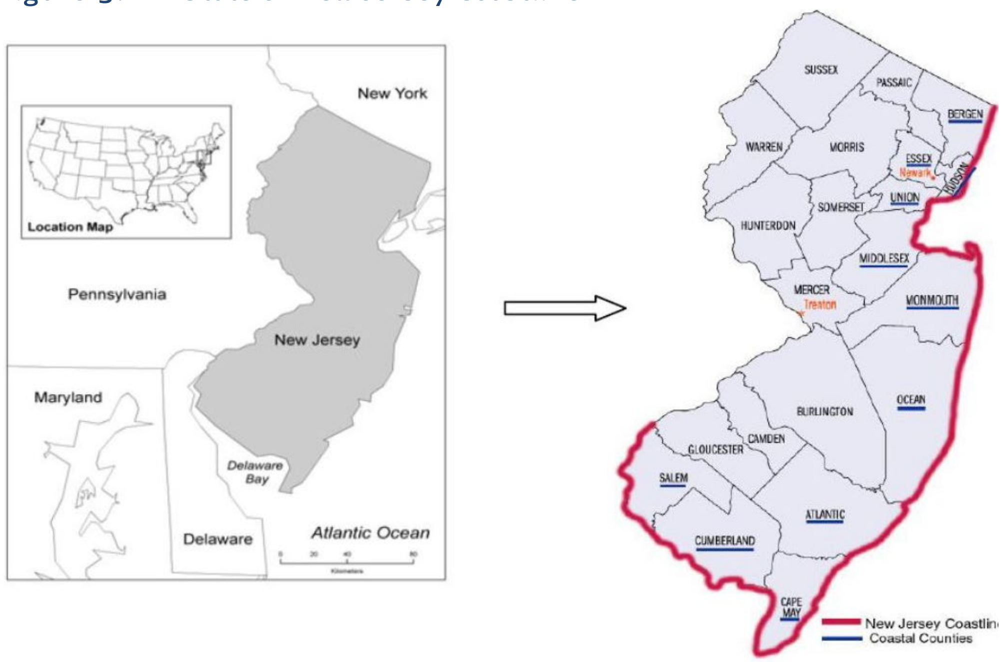
5.2.2 LOCATION

New Jersey and its coastal communities are vulnerable to the damaging impacts of major storms along its 127 miles of coastline. New Jersey's coastal zone includes portions of eight counties and 126 municipalities. The coastal boundary of New Jersey encompasses the Coastal Area Facility Review Act (CAFRA) area and the New Jersey Meadowlands District. The coastal area includes coastal waters to the limit of tidal influence including: the Atlantic Ocean (to the limit of New Jersey's seaward jurisdiction); Upper New York Bay, Newark Bay, Raritan Bay and the Arthur Kill; the Hudson, Raritan, Passaic, and Hackensack Rivers, and the tidal portions of the tributaries to these bays and rivers. The Delaware River and Bay and other tidal streams of the Coastal Plain are also in the coastal area, as is a narrow band of adjacent uplands in the Waterfront Development area beyond the CAFRA area. Figure 5.2-2 shows the coastline of New Jersey with the coastal counties noted.

Over 300,000 acres of tidal wetlands provide breeding and nursery habitats for finfish and shellfish and act as a natural flood and pollution control system along the coastline of the State. More than 50 species of fish and shellfish are commercially and recreationally harvested in New Jersey. Bays, rivers, and coastline provide recreational opportunities for residents and visitors of the State (NJDEP, 2002).

A number of counties in New Jersey have non-coastal shoreline that may be vulnerable to coastal erosion. New Jersey is bordered on three sides by water, including the Delaware River along the western border. Other counties that may be affected by shoreline change include the riverine counties of Gloucester, Camden, Burlington, Mercer, Hunterdon, Warren, and Sussex.

Figure 5.2-2 State of New Jersey Coastline



Source: Cooper et al., 2005

The Richard Stockton College Coastal Research Center (CRC)

In 1986, the Richard Stockton College CRC established the New Jersey Beach Profile Network (NJPBN) for the purpose of monitoring shoreline conditions along the coastline of New Jersey. NJBPN is made up of 105 beach profile sites along the State's entire shoreline, including the Raritan and Delaware Bays. The sites are located in Monmouth, Ocean, Atlantic, and Cape May Counties. The profile sites are spaced approximately one mile apart, with at least one site located in each oceanfront municipality. The dune, beach, and near-shore areas are surveyed at each profile site twice a year, in the fall and spring, and are analyzed for seasonal and multi-year changes in shoreline position and sand volume. Reports on each beach profile are published annually. The 2016 reports are summarized below (Richard Stockton College CRC, 2016).

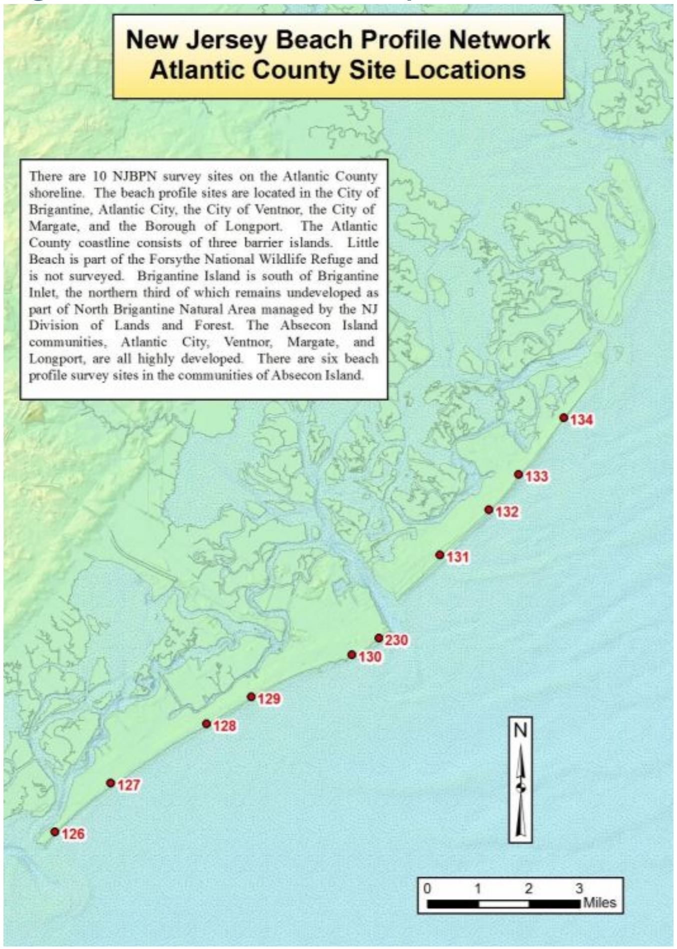
Atlantic County

Atlantic County features a series of barrier island communities, making the County very prone to impacts of sea level rise. While a relatively high percentage of the County shoreline is protected under this program, the existing development along the shoreline makes it the most developed of the New Jersey coastal counties, which means that there is more infrastructure to protect from sea level rise. As part of the on-going research conducted annually by the Coastal Research Center, ten beach profile sites are analyzed annually as part of the NJBPN (Richard Stockton College CRC, 2016).

Atlantic County communities have been the direct or indirect beneficiaries of federally sponsored beach nourishment projects, as well as having been the sites of multiple state and locally sponsored projects in past 30 years. Because of the density of development and storm exposure risk both Absecon Island and Brigantine Island have a long history of beach nourishment shore protection projects. Sand has been systematically harvested from Brigantine Inlet or Absecon Inlet to substantially add to the beach's width and sand volume, and has enhanced the dune protection for landward properties (Richard Stockton College CRC, 2016).

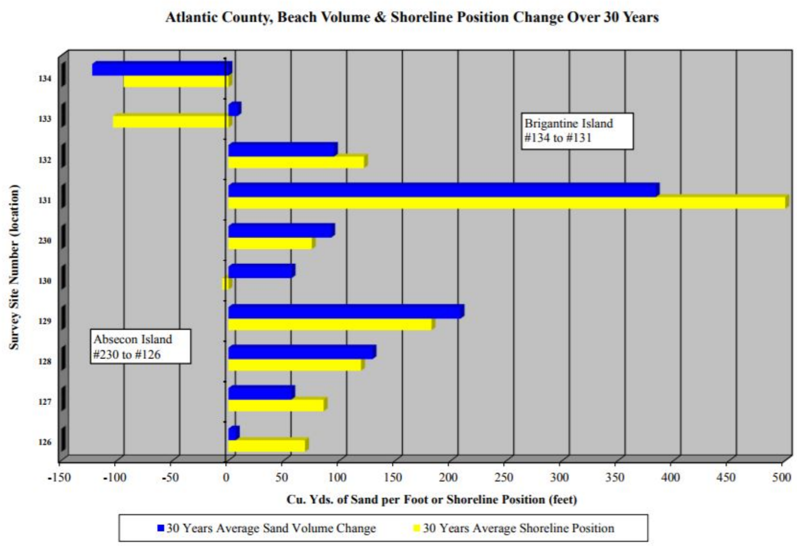
Figure 5.2-3 illustrates the beach profile locations in Atlantic County and Figure 5.2-3 shows the beach volume and shoreline change over the last 30 years for each of the profile stations in Atlantic County.

Figure 5.2-3 Atlantic County Profile Site



Source: Richard Stockton College CRC, 2016

Figure 5.2-4 30 Year Beach Volume and Shoreline Position Changes, Atlantic County



Source: Richard Stockton College CRC, 2016

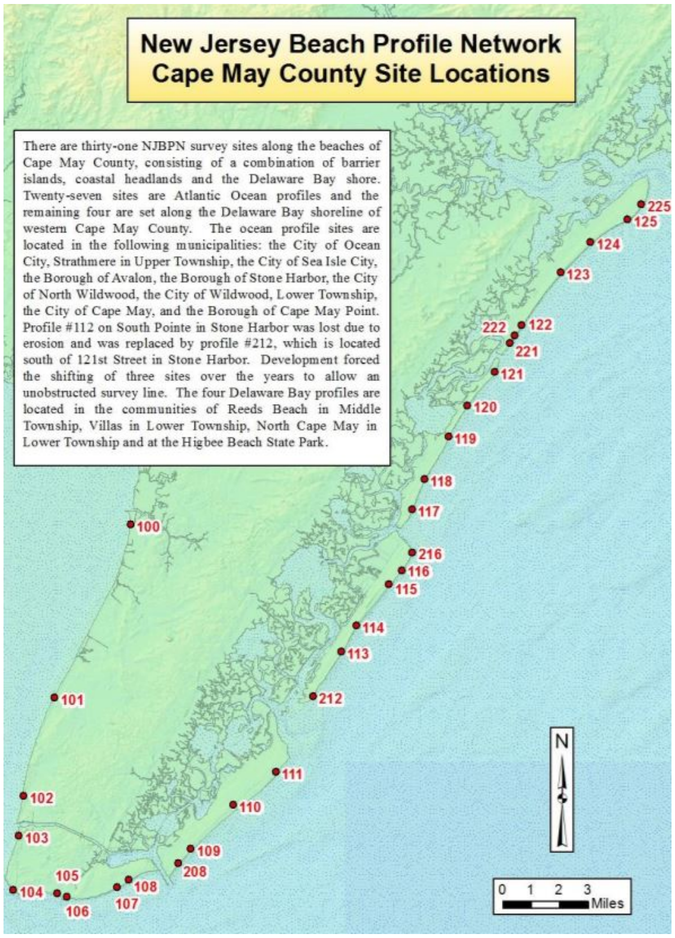
Cape May County

Cape May County contains 31 NJBPN survey sites along the beaches, consisting of barrier islands, coastal headlands, and the Delaware Bay shoreline. Of those 31 sites, 27 survey sites are Atlantic Ocean profiles and four sites are set along the Delaware Bay shoreline of western Cape May County. The sites located on the north end of each barrier island have an erosional tendency, especially in North Wildwood (#111). Multiple beach nourishment projects have given Cape May County a strong, positive change value in both sand volume and shoreline position. The five Delaware Bay cross sections have much smaller magnitude change rates (Richard Stockton College CRC, 2016).

The 30-year assessment for Cape May County has shown that the multiple episodes and variety of beach restoration projects significantly improved the quality, shore-protection value, and recreational use of the beaches throughout the County. Various federal, state and local projects have been completed to help protect the shoreline. Some projects include USACE adding sand to the shoreline, the state aiding in expanding beach berms, localities moving sand from the location it accumulates to areas that experience losses, habitat restoration and many more.

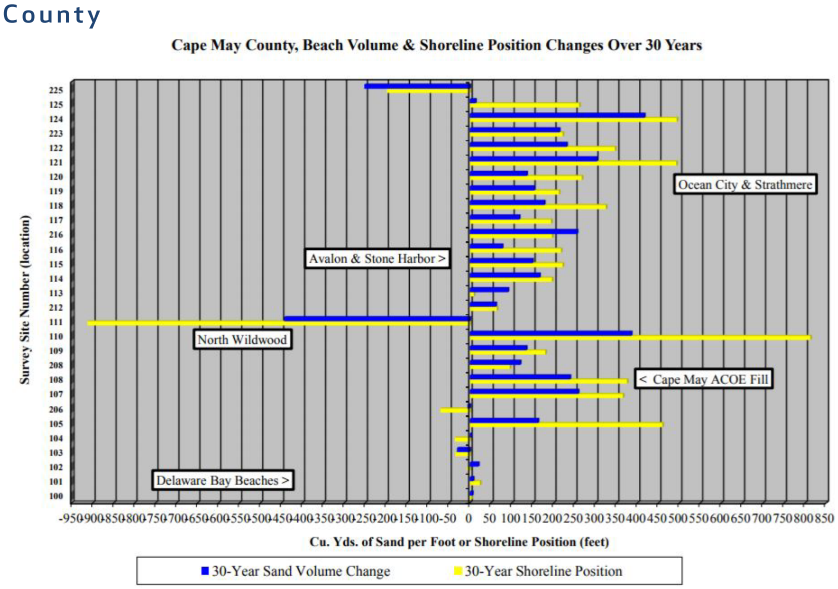
Figure 5.2-5 shows the profile locations in Cape May County and Figure 5.2-6 shows the beach volume and shoreline change over the last 30 years for each of the profile stations in Cape May County.

Figure 5.2-5 Cape May County Beach Profile Locations



Source: Richard Stockton College CRC, 2016

Figure 5.2-6 30 Year Beach Volume and Shoreline Position Changes, Cape May County



Source: Richard Stockton College CRC, 2016

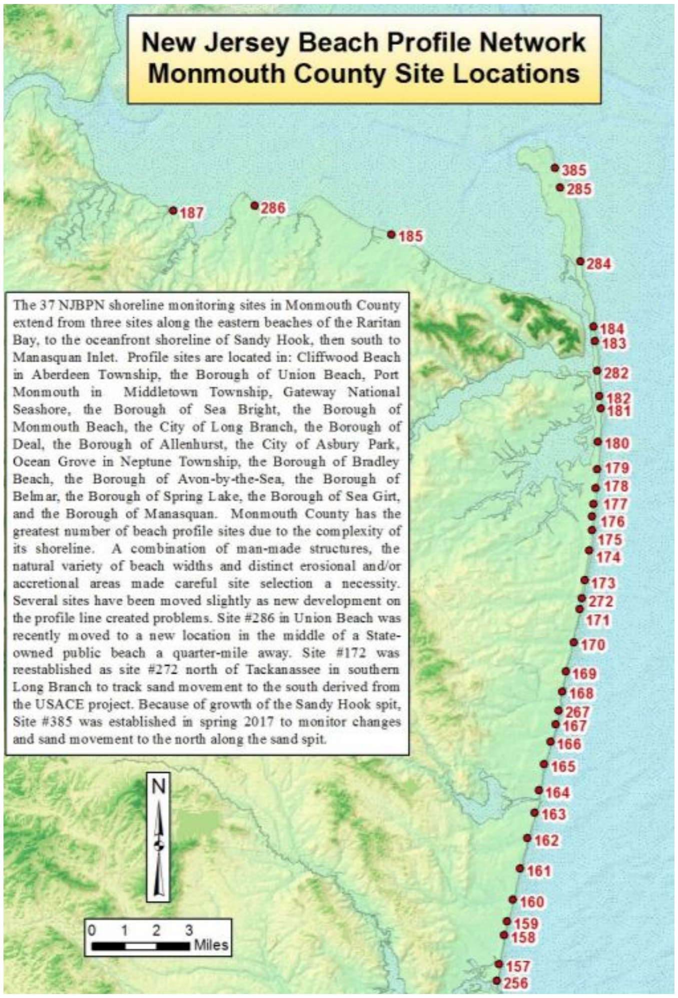
Monmouth County

The 36 NJBPN shoreline monitoring sites in Monmouth County extend from the eastern beaches of the Raritan Bay, to the oceanfront shoreline of Sandy Hook, then south to Manasquan Inlet. Monmouth County has the greatest number of beach profile sites because of the complexity of its shoreline. (Richard Stockton College CRC, 2016).

Monmouth County is considered to be in good shape for volume and shoreline position when compared to the 1986 conditions. Beach nourishment is credited for the positive state of Monmouth County beaches, with only a few locations suffering from erosion. Since 1986 USACE undertook various efforts to help restore the beaches. For example, many of the sites show the influence of the federal beach nourishment project and subsequent maintenance fill that was added to several locations in response to a storm in 1997. Also, the federal government stepped in post Hurricane Sandy and placed a significant amount of sand along many areas of Monmouth County's shoreline. Due to these efforts, over the past 30 years the county survey sites have averaged a net gain of 113.72 yds3/ft of sand volume and a shoreline advance average of 218 feet. (Richard Stockton College CRC, 2016).

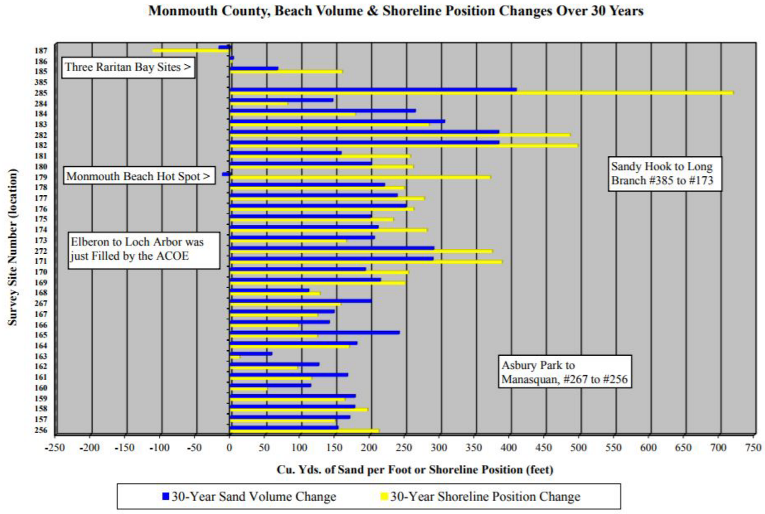
Figure 5.2-7 shows the profile locations in Monmouth County and 5.2-8 shows the beach volume and shoreline change over the last 30 years for each of the profile stations in Monmouth County.

Figure 5.2-7 Monmouth County Profile Site Locations



Source: Richard Stockton College CRC, 2016

Figure 5.2-8 30 Year Beach Volume and Shoreline Position Changes, Monmouth County



Source: Richard Stockton College CRC, 2016

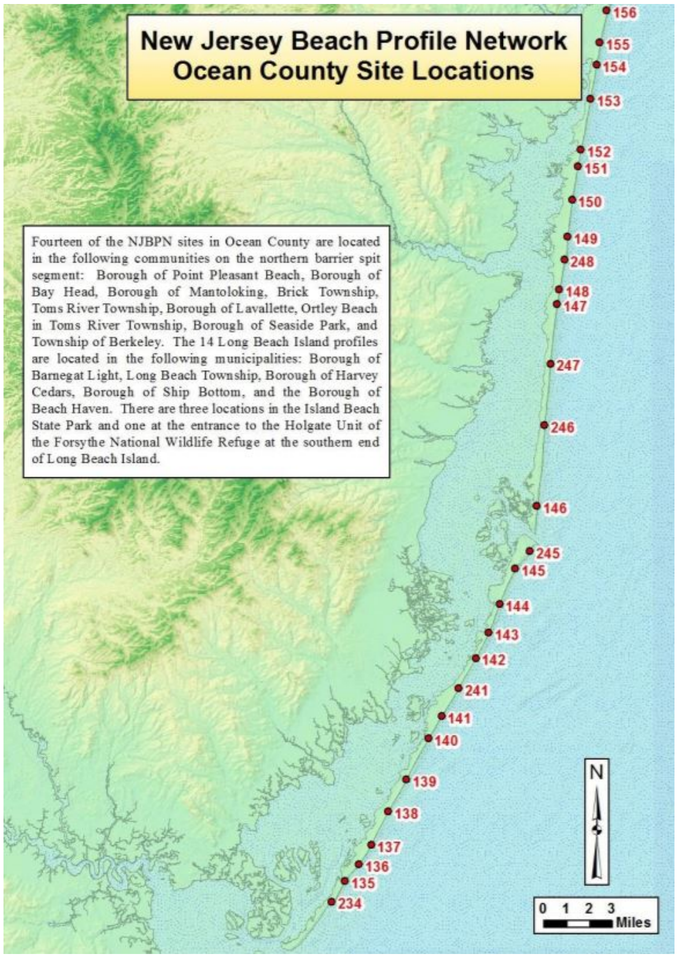
Ocean County

Ocean County has the longest oceanfront shoreline of the four coastal counties (45.2 miles). The northern section comprises 23.6 miles, and Long Beach Island makes up 21.6 miles. Ocean County includes one inlet—Barnegat Inlet—dividing the northern section from Long Beach Island between Manasquan Inlet to the north and Little Egg Inlet on the south. The northern section is unique along the New Jersey coastline in that it lies within a zone where sand transport parallel to the shoreline is essentially zero over long periods of time (Richard Stockton College, CRC 2016).

The shoreline in the northern Ocean County segment has not been the recipient of significant amounts of beach nourishment sand over the past 30 years. Beach or dune restoration projects that occurred in these segments were completed by local efforts. In contrast, sections of the Long Beach Island shoreline and southern portions of the county have received large quantities of beach nourishment sand.

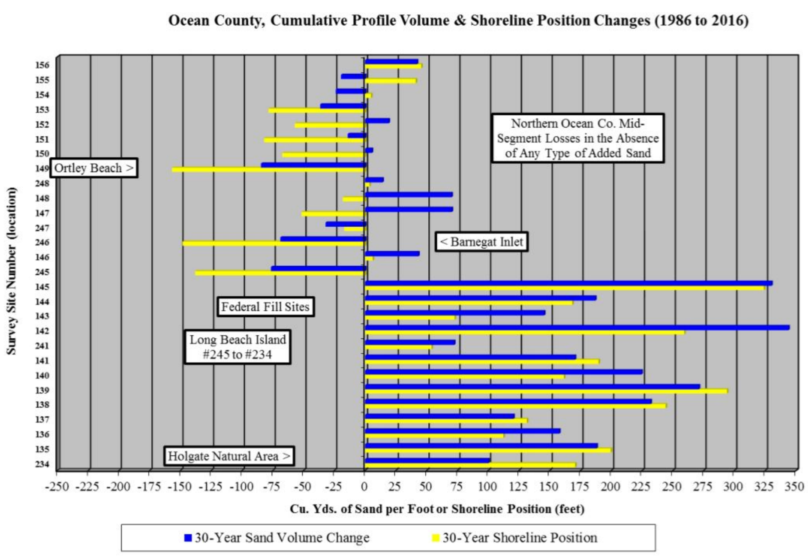
Figure 5.2-9 shows the profile locations in Ocean County and 5.2-10 shows the beach volume and shoreline change over the last 30 years for each of the profile stations in Ocean County. This chart clearly depicts the impact of federal involvement in shore protection in the southern portion of the County.

Figure 5.2-9 Ocean County Profile Site Locations



Source: Richard Stockton College CRC, 2016

Figure 5.2-10 30 Year Beach Volume and Shoreline Position Changes, Ocean County



Source: Richard Stockton College CRC, 2016

5.2.3 EXTENT

Coastal Erosion

Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a period of time (FEMA, 1996). A number of factors determine whether a community experiences and/or is vulnerable to greater long-term erosion or accretion:

- Exposure to high-energy storm waves;
- Sediment size and composition of eroding coastal landforms feeding adjacent beaches;
- Near-shore bathymetric variations which direct wave approach;
- Alongshore variations in wave energy and sediment transport rates;
- Relative sea level rise;
- Frequency and severity of storm events; and
- Human interference with sediment supply (e.g. revetments, seawalls, jetties) (Woods Hole Sea Grant, 2003).

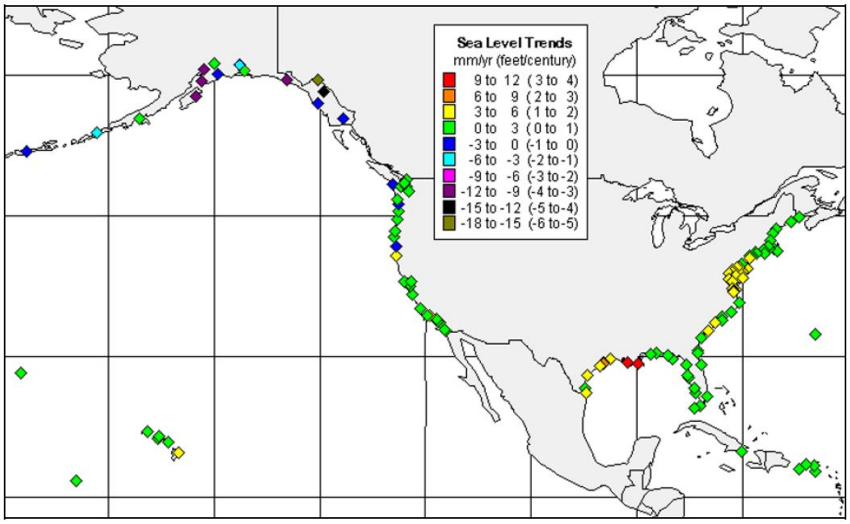
Such erosion may be intensified by activities such as boat wakes, shoreline hardening, or dredging.

Sea Level Rise

According to the USGS, the coastal vulnerability index (CVI) provides a preliminary overview, at a National scale, of the relative susceptibility of the Nation's coast to sea-level rise. This initial classification is based upon variables including geomorphology, regional coastal slope, tide range, wave height, relative sea-level rise, and shoreline erosion and accretion rates. The combination of these variables and the association of these variables to each other furnish a broad overview of coastal regions where physical changes are likely to occur due to sea-level rise.

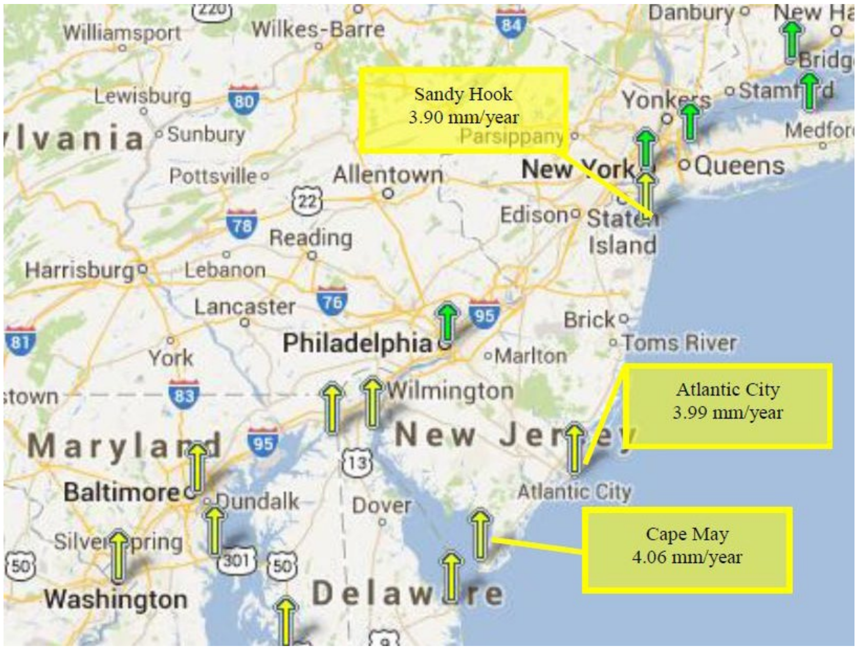
The Center for Operational Oceanographic Products and Services has been measuring sea level for over 150 years, with tide stations of the National Water Level Observation Network operating on all coastlines of the United States. Changes in mean sea level (MSL), either a sea level rise or sea level fall has been computed at128 long-term water level stations using a minimum span of 30 years of observations at each location. The measurements have been averaged by month to remove the effect of higher frequency phenomena (storm surge) in order to compute an accurate linear sea level trend (NOAA 2013).

Figure 5.2-11 Relative Sea Level Variations of the United States



Source: NOAA, 2013

Figure 5.2-12 Sea Level Trends in New Jersey



Source: NOAA, 2013

Figure 5.2-11 is a map of regional MSL in the United States. This map provides an overview of variations in the rates of relative local MSL at long-term tide stations. The variations in sea level trends primarily reflect differences in rates and sources of vertical land motion. Areas that experienced little-to-no change in MSL are shown in green, including stations consistent with average global sea level rise rate of 1.7 to 1.8 mm/year. These stations do not experience significant vertical land motion. Stations that experienced positive sea level trends (yellow to red) experience both global sea level rise and lowering or sinking of the local land, causing an apparent exaggerated rate of relative sea level rise. Stations that are blue to brown have experienced global sea level rise and a greater vertical rise in local land, causing an apparent decrease in relative sea level. The rates of relative sea level rise reflect actual observations and must be accounted for in any coastal planning or engineering applications (NOAA, 2013). Table 5.2-3 shows these changes for Atlantic City, Sandy Hook, and Cape May.

The global sea level trend has been recorded by satellite altimeters since 1992 and the latest calculation can be obtained from NOAA's Laboratory for Satellite Altimetry. The University of Colorado's Sea Level Research Group compares global sea level rates calculated by different research organizations and provides detailed explanations about the issues involved (NOAA, 2013).

Table 5.2-3 Mean Sea Level Rise Trends

Station Name	First Year	Last Year	MLS Trends (mm/yr)	MLS Trends (ft/century)
Atlantic City	1911	2016	4.07	1.34
Cape May	1965	2016	4.55	1.49
Sandy Hook	1932	2016	4.05	1.33

Source: NOAA, 2016

Figure 5.2-12 presents the most recent NOAA relative sea level variations along the Mid-Atlantic coast. Three NOAA tide gauge stations are located on the New Jersey coastline, where tide gauge measurements are made with respect to a local fixed reference level on land. Table 5.2-3 presents the history and MSL trends at the three New Jersey stations, which show the result of a combination of the global sea level rate and the local vertical land motion.

5.2.4 PREVIOUS OCCURRENCES AND LOSSES

As mentioned previously, coastal erosion can occur gradually as a result of natural processes or from episodic events such as hurricanes, Nor'Easters, and tropical storms. Coastal erosion also results from sea-level rise, which occurs due to a combination of factors which may differ by location. Based on all sources researched, known

Figure 5.2-13 Beach Erosion Post Tropical Storm Hermine

Source: NJ.com

events that have caused coastal erosion in the State of New Jersey and its counties are identified in Table 5.2-4.

For those events that resulted in a FEMA disaster declaration, see Table 5.2-5. Detailed information regarding those events is presented in Appendix D.

5.2.4.2 FEMA DISASTER DECLARATIONS

Between 1954 and 2012, FEMA declared that the State of New Jersey experienced eight erosion-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe storms, coastal storms, heavy rain, tropical storm, hurricane, high winds, and high tide. Generally, these disasters cover a wide region of the State and have impacted many counties, though not all with coastal erosion effects (FEMA 2013).

Based on all sources researched, known erosion-related events that have affected New Jersey and were declared a FEMA disaster are identified in Table 5.2-6. Figure 5.2-14 illustrates the number of FEMA- declared disasters by County.

Table 5.2-4 Major Coastal Erosion Incidents in New Jersey, 1936 to 2017

Date(s) of Event	Event Type	Counties Affected	Description
4/19/1905	Hurricane	Ocean	A Category 2 hurricane hit parallel to the New Jersey coastline. Strong waves flooded much of Long Beach Island and caused severe beach erosion along the coast. Approximately 200 feet of sand near the Barnegat Lighthouse were lost, threatening the foundation of the lighthouse.
4/27/1905	Tropical Storm	Cape May	A tropical storm hit Cape May County after passing through the Delmarva Peninsula, causing severe beach erosion and high tides.
March 6-8, 1962	Nor'Easter	Coastal New Jersey	The most damaging Nor'Easter since the 1888 Blizzard. The damage from this storm was primarily caused by its prolonged duration, resulting in damaging overwash and flooding through five successive high tides. It struck the New Jersey coast for three days and generated a 3.5-foot storm surge over three successive high tides, with each tide peaking at 8.8 feet above mean lower low water (MLLW). Massive waves of up to 40 feet high generated by sustained winds of 45 knots blew over 1,000 miles of open ocean and came crashing towards the coastline. This coastal storm took nine lives, damaged 16,407 structures, and flooded 21,533 structures to various degrees. The storm caused approximately $120 million in damages.

Date(s) of Event	Event Type	Counties Affected	Description
October 28 –November 4, 1991	Halloween Nor'Easter	Coastal New Jersey	The 1991 Halloween Nor'Easter, also known as the Perfect Storm, caused strong waves of up to 30 feet in height. High tides along the shore were the second highest on record—only surpassed by the 1944 hurricane—while significant bay flooding occurred. Strong waves and persistent intense winds caused extreme beach erosion, amounting to 13.5 million cubic feet of sand lost in one location. In all, damage amounted to $90 million, though no deaths occurred in the State.
September 22-26, 1992	Tropical Storm Danielle	Coastal New Jersey	Tropical Storm Danielle made landfall in the Delmarva Peninsula and caused significant beach erosion across the mid-Atlantic region, including New Jersey. Despite avoiding a direct hit, the State still suffered erosion.
December 10-17, 1992	Coastal Storm	Ocean, Monmouth, Cape May, Cumberland, Bergen, Salem, Middlesex, Atlantic, Union, Essex and Hudson	A peak storm surge of 4.3 feet was measured on December 11, 1992, as the water reached an elevation of 9.14 feet MLLW. The water did not recede until December 14th. Waves of up to 44 feet were measured 30 miles offshore of Long Branch during the storm. This coastal storm took two lives, damaged 3,200 homes, and caused approximately $750 million in damages.
August 8-30, 1994	Hurricane Felix	Coastal New Jersey	Although the strong winds and heavy rains did not directly affect the United States, large swells generated by Felix produced dangerous surf conditions including some coastal flooding and rip currents from northeastern Florida to New England. Isolated areas of severe beach erosion occurred along the New Jersey coast.
December 22-26,1994	Storm	Coastal New Jersey	This storm caused $17 million in damages and tides were 2.5 feet above normal, which led to significant coastal erosion and flooding.
January 7-8, 1996	Blizzard	Atlantic, Burlington, Mercer, Monmouth, and Ocean	A record-breaking snowfall hit most of New Jersey. The storm produced moderate flooding with moderate-to-severe beach erosion from Manasquan south along the Jersey Shore. A total of 28 deaths and numerous injuries were reported, as well as over $50 million in damages.
7/13/1996	Tropical Storm Bertha	Atlantic, Cape May, Cumberland, and Monmouth	Wind gusts ranged from 43 mph in Atlantic City to 60 mph in Seaside Park. Approximately 40,000 customers were without power. Tidal departures were about two feet or less from normal levels. Monmouth Beach suffered severe beach erosion. Approximately 60 feet of 120-foot-wide beach at the south of the Borough was gone.

Date(s) of Event	Event Type	Counties Affected	Description
February 4-9, 1998	Nor'Easter	Atlantic, Cape May, Cumberland, Monmouth and Ocean	The strongest Nor'Easter of the winter hit coastal New Jersey, from Ocean County southward, bringing damaging winds, moderate-to-severe coastal flooding, extensive beach erosion, several dune breaches, and heavy rain. A State of Emergency was declared for all coastal counties, and Atlantic and Cape May Counties were declared federal disaster areas. Beach erosion was the largest problem in Monmouth and Ocean Counties. In Avalon, beach erosion left 10-foot cliffs. Severe beach erosion was reported at Cape May Point. In Brigantine, substantial flooding and beach erosion was experienced, especially at the north end of the island. About 75% of its sand was carried away. In Longport, the ocean met the bay from 11th through 24th Streets and erosion caused vertical cliffs of four to five feet. Longport streets had to be cleared of debris. Ocean County had $9 million in damages, mainly from beach erosion. Beaches at Point Pleasant to Island Beach State Park suffered moderate to severe erosion. In Bay Head, remnants of its old boardwalk were uncovered and the Borough lost 10 feet of dunes and 130 feet of beach at its south end. Ortley Beach's dune line was flattened. In Harvey Cedars, erosion was worse at the south end of the town where the surf exposed the gravel base. Brant Beach suffered the worst erosion in the County as the ocean broke through at two places. In Monmouth County, moderate-to-severe beach erosion was experienced. Total damage in New Jersey was estimated at $17 million.
4/16/2007	Nor'Easter	Statewide	In the wake of the departing Nor'Easter, the combination of strong winds, snow on tree limbs and heavy rain loosening the ground caused many tree limbs, trees and wires to be knocked down on April 16. The strong winds caused about 120,000 homes and businesses in the state to lose power.
November 11-15, 2009	Remnants of Tropical Storm Ida (Nor'Easter)	Atlantic, Cape May, and Ocean	Remnants of Hurricane Ida brought 30- to 40-mph winds and 8- to 15-foot swells. Maximum-sustained winds were near 45 mph, with higher gusts at times. This three-day Nor'Easter was considered one of the worst to impact the State in recent years and caused significant erosion along the New Jersey shoreline. Atlantic and Cape May Counties experienced widespread tidal flooding. The north end of Avalon in Cape May County experienced substantial beach erosion as a result of the storm. Beaches on the north end lost 125,700 cubic yards of sand and the dunes in the north end lost 34,000 cubic yards of sand. The large volume of sand loss was evident, as the sea wall under the dune crest was completely exposed. Long Beach Island in Ocean County sustained significant damage from this storm. Harvey Cedars and Holgate suffered the most severe erosion of their beaches and dunes. Large sections of dune were lost throughout Long Beach Island. Several beach-front properties were completely undercut by wave action in Beach Haven while other properties had the dune completely removed seaward of their house.

Date(s) of Event	Event Type	Counties Affected	Description
August 27-September 5, 2011	Hurricane Irene	Coastal New Jersey	Hurricane Irene made landfall near the Little Egg Inlet along southern New Jersey on August 28. This was the first hurricane to make landfall in the State since 1902. The storm created 15- to 18-foot drop offs on some beaches. The NJDEP reported beach erosion of two to four feet in height and 50 to 100 feet wide was common along most of the shoreline. At Seven Presidents Oceanfront Park in Long Branch, their access steps and 300 feet of beach were lost and had sporadic cuts in the dune. Beaches that lost up to 150 feet of sand included Ocean Grove, Bradley Beach, Loveladies, Long Beach Township, Wildwood, and Wildwood Crest. Beaches that experienced 200-foot-wide areas of erosion included Harvey Cedars, Surf City, Ship Bottom, Beach Haven, and the Holgate section of Long Beach Township. Other areas of erosion included Seaside Heights (140 feet of erosion), Seaside Park (120 feet), Avon-by-the-Sea (between 50 and 120 feet), and Belmar (between 80 and 100 feet). Bay Head suffered cuts to its dune system throughout the Town, ranging from three to eight feet high and five to 15 feet wide. Mantoloking and Lavalette had similar cuts to their dune systems.
10/29/2011	Nor'Easter	Coastal New Jersey	Northeast New Jersey experienced snow from this storm, while coastal New Jersey experienced flooding and strong winds. Peak wind gusts averaged 50 mph along the coast. Cliffwood Beach in Monmouth County lost some beach elevation and experienced shoreline retreat (loss of 7.07 yds3/ft with a 17-foot shoreline retreat. In Port Monmouth at Spy House in Monmouth County, the sand volume decreased by 10.81 yd3/ft because of a 0.24-foot decrease in bay bottom elevations across 1,000 feet and the shoreline retreated three feet.
October 26 - November 8, 2012	Superstorm Sandy	Statewide	Record-breaking high tides and wave action combined with sustained winds as high as 60 to 70 mph with wind gusts as high as 80 to 90 mph to batter the State. Statewide, Sandy caused an estimated $29.4 billion in damage, destroyed or significantly damaged 30,000 homes and businesses, affected 42,000 additional structures, and was responsible directly or indirectly for 38 deaths. A new temporary inlet formed in Mantaloking (Ocean County) where some homes were swept away. About 2.4 million households in the State lost power. It would take two weeks for power to be fully restored to homes and businesses that were inhabitable. Also devastated by the storm was New Jersey's shellfish hatcheries including approximately $1 million of losses to buildings and equipment, and product losses in excess of $10,000 at one location alone. Overall, average rainfall totals were 2.78 inches with a maximum rainfall of 10.29 inches at the Cape May (Cape May County) station. Another source indicated a maximum rainfall total of 12.71 inches in Stone Harbor (Cape May County). A maximum wind gust of 78 mph was reported in Robbins Reef. A maximum storm surge of 8.57 feet was reported in Sandy Hook.
March 1-8, 2013	Nor'Easter	Coastal New Jersey	Strong wind and flooding caused significant erosion along the barrier islands.
January 23 - 30, 2015	Winter Storm Juno	Coastal New Jersey	Widespread dune erosion occurred in parts of the Jersey Shore Monday.
10/2/2015	Nor'Easter	Coastal New Jersey	High winds and flooding from the nor'easter caused damage to many beaches along the shore. Above normal tidal cycles and onshore flow persisted beyond the storm, creating even more erosion.

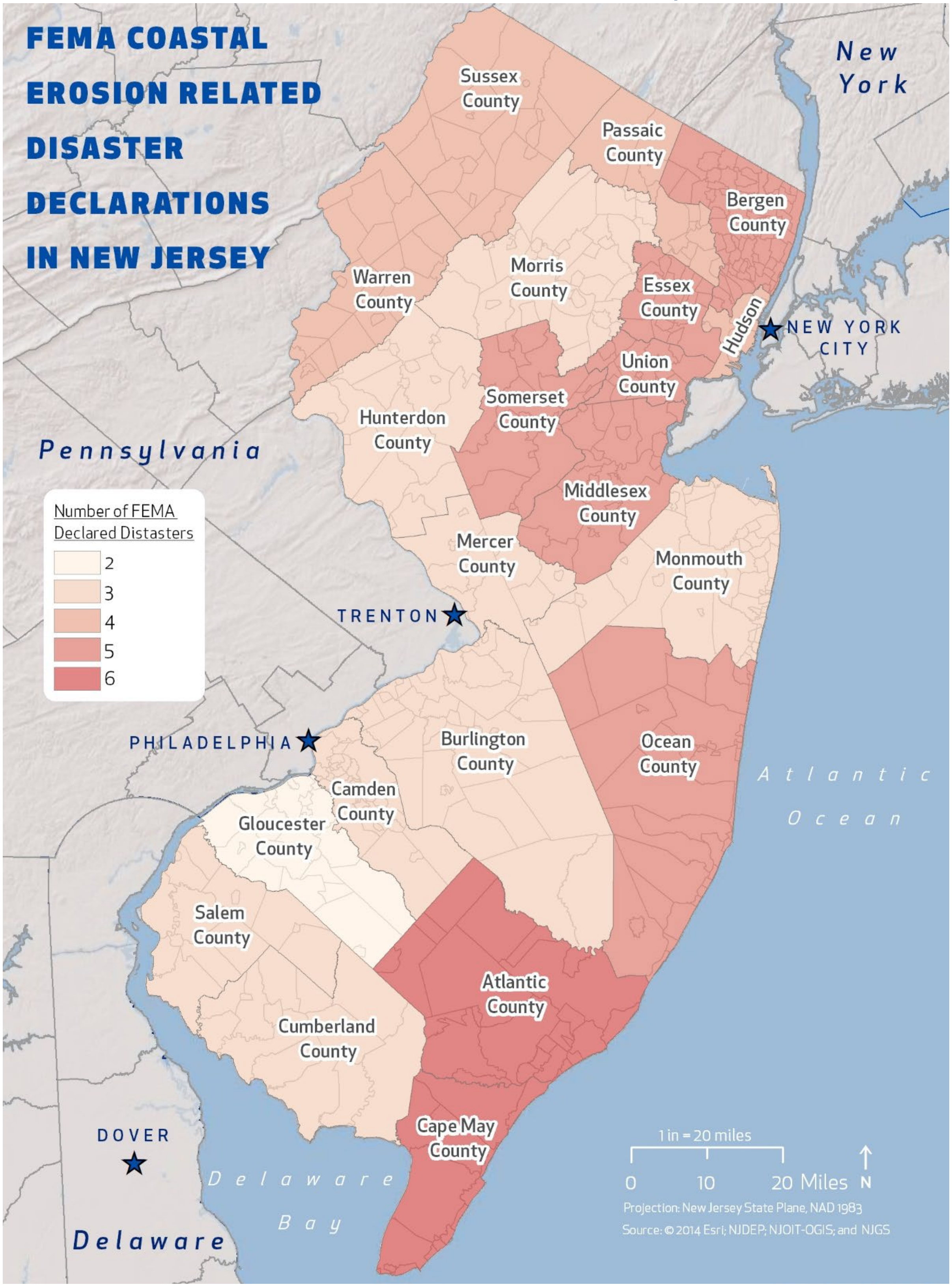
Date(s) of Event	Event Type	Counties Affected	Description
January 22 - 24, 2016	Blizzard	Statewide	Strong easterly winds combined with high tide levels, resulting in major flooding along parts of the New Jersey. In parts of southern New Jersey, coastal flooding was higher than during Superstorm Sandy in 2012.
August 28 - September 8, 2016	Tropical Storm Hermine	Ocean, Atlantic, Cape May Counties	Many beaches along the shore experienced severe erosion. A week after Hermine made its way toward New Jersey, whipping up high waves, the southernmost beaches in Brick Township remain closed because of severe erosion.
3/14/2017	Nor'Easter	Coastal New Jersey	Most shore towns experienced at least some beach erosion. This event provided a short window to replenish the beaches before tourist season.
September 5-26, 2017	Hurricane Jose	Coastal New Jersey	Of the 66 municipalities and beach areas surveyed after the hurricane, 55 were determined to have minor beach or dune erosion, 11 had moderate beach or dune erosion and 0 had major beach or dun erosion.

Table 5.2-5 FEMA Coastal Erosion-Related Disaster Declarations, 1954 to 2012

Disaster Number	Disaster Type	Declaration Date	Incident Period	Atlantic	Bergen	Burlington	Camden	Cape May	Cumberland	Essex	Gloucester	Hudson	Hunterdon	Mercer	Middlesex	Monmouth	Morris	Ocean	Passaic	Salem	Somerset	Sussex	Union	Warren	Impacted Number of Counties
DR-124	Severe Storm, High Tides, Flooding	3/9/1962	3/9/1962	Data Not Available																					
DR-973	Coastal Storm, High Tides, Heavy, Rain, Flooding	12/18/1992	12/10/1992 – 12/17/1992	X	X			X	X	X		X			X	X		X		X	X		X		12
DR-1206	Coastal Storm	3/8/1998	2/4/1998 – 2/8/1998	X				X										X							3
DR-1694	Severe Storms, and Inland and Coastal Flooding	4/26/2007	4/14/2007 – 4/20/2007	X	X	X	X			X		X		X	X		X		X		X	X	X	X	14
DR-1867	Severe Storms, and Flooding Associated with Tropical Depression Ida and a Nor'Easter	12/22/2009	11/11/2009 – 11/15/2009	X				X										X							3
DR-4021	Hurricane Irene	8/31/2011	8/27/2011 – 9/5/2011	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21
DR-4048	Severe Storm	11/30/2011	10/29/2011		X			X		X			X		X				X		X	X	X	X	10
DR-4086	Hurricane Sandy	10/30/2012	10/26/2012 – 11/8/2012	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21

Source: FEMA, 2017

Figure 5.2-14 FEMA-Declared Coastal Erosion Declarations by County



Source: FEMA, 2017

5.2.5 PROBABILITY OF FUTURE OCCURRENCES

Coastal Erosion

Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a specific period of time, measured in units of feet or meters per year. Erosion rates vary as a function of shoreline type and are influenced primarily by episodic events. Monitoring of shoreline change based on a relatively short period of record does not always reflect actual conditions and can misrepresent long-term erosion rates due to storm frequency.

A number of factors determine whether a community exhibits greater risk of long-term erosion or accretion:

- Exposure to high-energy storm waves;
- Sediment size and composition of eroding coastal landforms feeding adjacent beaches;
- Near-shore bathymetric variations that direct wave approach;
- Alongshore variations in wave energy and sediment transport rates;
- Relative sea-level rise; and
- Human interference with sediment supply (such as revetments, seawalls, and jetties) (Woods Hole Sea Grant 2003).

The long-term patterns of coastal erosion are difficult to detect because of substantial and rapid changes in coastlines in the short-term (that is, over days or weeks from storms and natural tidal processes). It is usually severe short-term erosion events, occurring either singly or cumulatively over a few years, that cause concern and lead to attempts to influence the natural processes. Analysis of both long- and short-term shoreline changes are required to determine which is more reflective of the potential future shoreline configuration (FEMA 1996).

The return period of an episodic erosion event is directly related to the return period of a coastal storm, hurricane or tropical storm. The one-percent annual chance erosion event can be determined using a predictive model that establishes the one-percent annual chance tide and water surface level, or surge elevation and the resulting wave heights. Storm wave heights, periods and directions have specific impacts on the dunes, currents, and other erosion processes. Analyses of coastal erosion impacts from the one-percent annual chance flood event are included in high-hazard zone determinations shown on NFIP maps. The impacts may vary for each reach of coastline.

A more significant measure of coastal erosion is the average annual erosion rate. Erosion rates can be used in land-use and hazard management to define areas in which development should be limited or where special construction measures should be used. The average annual erosion rate is based on analysis of historical shorelines derived from maps, charts, surveys, and aerial photography obtained over a period of record.

From Sandy Hook south to Little Egg Inlet, the maximum long-term erosion rate is -8.6 meters per year and the maximum short-term erosion rate is -6.1 meters per year. From Little Egg Inlet south to Cape May Inlet, the maximum long-term erosion rate is -4.3 meters per year and the maximum short-term rate is -19.3 meters per year. These rates show that shorelines are eroding (USGS 2011).

In New Jersey, coastal erosion will continue to be an on-going problem along many areas of coastline. It is difficult to assign a probability to the near constant small on-going erosion that may occur over a continuous period of time. However, a probability can be assigned to larger storm events such as Nor'Easters and hurricanes, which can result in significant, rapid coastal erosion. The period of time suggests the probability of coastal erosion will be about the same in the future, with year-to-year variations (Gutierrez et al. 2007).

In order to help prevent future impacts of coastal erosion, New Jersey has participated in many beach nourishment projects. Between 1936 and 2015 the State has participated in 36 projects and 269 events at many different locations along the shore. The known total cost of all of these projects exceeds $1 billion (National Beach Nourishment Database, 2018).

Sea Level Rise
The CVI, as described in the Extent section of this profile, uses physical characteristics of the coastal system to classify the potential effects of sea-level rise on open coasts. This approach combines the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, yielding a quantitative measure of the shoreline's natural vulnerability to the effects of sea-level rise (Gutierrez et al.2007).

5.2.5.1 POTENTIAL EFFECTS OF CLIMATE CHANGE

Coastal Erosion
Coastal areas may be impacted by climate change in different ways. Coastal areas are sensitive to sea-level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures. According to NASA, warmer temperatures may lead to an increase in frequency of storms, thus leading to more weather events that cause coastal erosion.

Sea Level Rise
Changes in global temperatures, hydrologic cycles, coverage of glaciers and ice sheets, and storm frequency and intensity are captured in long-term sea level records. Sea levels provide a key to understanding the impact of climate change (NOAA, 2013).

Sea level rise increases the risks coastal communities face from coastal hazards (floods, storm surges, and chronic erosion). It may also lead to the loss of important coastal habitats. The historical rate of sea level rise along the New Jersey coast over the past 50 years was 0.12 to 0.16 inches per year. Future rates are projected to increase even more according to a 2016 Rutgers University Science and Technical Advisory Panel (STAP) Report, entitled, Assessing New Jersey's Exposure to Sea-Level Rise and Coastal Storms: Report of the New Jersey Climate Adaptation Alliance Science and Technical Advisory Panel (Kopp et al., 2016). The STAP report states, "it is likely that coastal areas of New Jersey will experience sea-level rise between 1.0 and 1.8 feet prior to 2050, regardless of future greenhouse gas emissions. Under a worst-case scenario, these communities could see as much as 2.8 feet of sea-level rise by 2050." Under a high-emissions scenario, it is likely that coastal areas of New Jersey will experience between 2.4 and 4.5 feet of sea-level rise by 2100; and, under a low-emissions scenario, it is likely that coastal areas of New Jersey will experience between 1.7 and 3.1 feet of sea-level rise by 2100.

5.2.6 IMPACT ANALYSIS

5.2.6.1 SEVERITY AND WARNING TIME

Coastal Erosion
Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a period of time. It is generally caused by storm surges, hurricanes, windstorms, and flooding. Coastal erosion may be exacerbated by human activities, such as boat wakes, shoreline hardening, and dredging (FEMA 1996).

Natural recovery after erosion events can take months or years. If a dune or beach does not recover quickly enough via natural processes, coastal and upland property may be exposed to further damage in subsequent events. Coastal erosion can cause the destruction of buildings and infrastructure (FEMA 1996).

Meteorologists can often predict the likelihood of weather events that can impact shoreline communities in the short term and ultimately the shoreline. NOAA's National Weather Service monitors potential events, and provides forecasts and information, sometimes several days in advance of a storm, to help prepare for an incident. With the number of structures increasing along the coast, the shoreline becomes increasingly modified. Impact from weather incidents will continue to influence the State's coastal areas, intensifying and exacerbating the coastal erosion situation.

Sea Level Rise

Extreme weather events will continue to be the primary driver of increasing water levels. However, a consensus has not yet been reached on how the frequency and magnitude of storms may change in coastal regions of the United States (NOAA, 2012).

5.2.6.2 SECONDARY HAZARDS

Windstorm events can blow beach and dune sand overland into adjacent low-lying marshes, upland habitats, inland bays, and communities. Flooding from extreme rainfall events can scour and erode dunes as inland floodwaters return through the dunes and beach face into the ocean (FEMA 1996).

Shore protection structures such as seawalls and revetments often are built to attempt to stabilize the upland property. However, typically they eliminate natural wave run-up and sand deposition processes and can increase reflected wave action and currents at the waterline. Increased wave action can cause localized scour in front of structures and prevent settlement of suspended sediment (FEMA 1996).

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. All of these factors change during extreme weather and climate events (NOAA 2012). Other secondary hazards that could occur along the mid-Atlantic coast in response to sea-level rise:

Bluff and upland erosion – shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments (Gutierrez et al. 2007).

Overwash, inlet processes, shoreline retreat, and barrier island narrowing – as sea-level rise occurs, storm overwash will become more likely. Tidal inlet formation and migration will become important components of future shoreline changes. Barrier islands are subject to inlet formation by storms. If the storm surge produces channels that extend below sea level, an inlet may persist after the storm. The combination of rising sea level and stronger storms can create the potential to accelerate shoreline retreat in many locations. Assessments of shoreline change on barrier islands have shown that barrier island narrowing has been observed on some islands over the last 100 years (Gutierrez et al. 2007).

Threshold behavior – changes in sea level rise can lead to conditions where a barrier system becomes less stable and crosses a geomorphic threshold; making the potential for rapid barrier-island migration or segmentation/disintegration high. Unstable barriers may be defined by rapid landward recession of the ocean shoreline, decrease in barrier width and height, increased overwashing during storms, increased barrier breaching and inlet formation, or chronic loss of beach and dune sand volume. With the rates of sea-level rise and climate change, it is very likely that these conditions will worsen (Gutierrez et al. 2007).

Loss of critical habitat – natural ecosystems may be impacted by warmer temperatures and associated changes in the water cycle. The changes could lead to loss of critical habitat and further stresses on some threatened and endangered species (Rutgers 2013).

Threatened coastline – New Jersey is vulnerable to significant impacts due to geologic subsidence, topography of its coastline, current coastal erosion, and a high density of coastal development. According to median projections of current sea level rise, it would threaten the majority of the State's coastal areas (Rutgers 2013).

5.2.6.3 ENVIRONMENTAL IMPACTS

Coastal erosion can impact beaches, wetlands, marshes, and coastal habitats. The erosion that could be experienced on the barrier islands will decrease their ability to function as buffers against further estuarine, wetland, and land loss. If there is a reduction of these natural environments and the ecological and natural functions they provide, coastal communities may experience more frequent and destructive flooding, compromised water supplies, and smaller or fewer beaches (Center for Ocean Solutions 2013).

Post Superstorm Sandy Beach Nourishment Activities

This section will only describe the beach nourishment activities that took place after the Storm.

Following Superstorm Sandy, the USACE Philadelphia District has been working to restore previously constructed coastal storm risk management projects in New Jersey and Delaware. Work has been ongoing through the months since the storm. The USACE projects in New Jersey include:

- Long Beach Island - dredging and pumping operations are completed at Harvey Cedars, Surf City and Brant Beach (34-57th Streets)
- Absecon Island - dredging and pumping operations are ongoing at Atlantic City. Work will then proceed to Ventnor and is expected to be completed in October and November.
- Brigantine - work completed
- North Ocean City - work completed
- Avalon & Stone Harbor - work completed
- Cape May City - work to begin in late September
- Lower Cape May Meadows - periodic nourishment work completed

As of August 2013, approximately 17 million cubic yards of sand was slated to be placed throughout New Jersey through the near-term coastal restoration work, including two projects managed by the USACE New York District (Keansburg and Sea Bright to Manasquan). The Keansburg project included the placement of approximately 875,000 cubic yards of sand along 2.5 miles of shoreline along Raritan Bay. Repairs to eroded levees, repairs to the damaged wingwall adjacent to the tide gate, and debris removal along the levees will also be part of this project (USACE, 2013a).

The Sea Bright to Manasquan project included the placement of approximately eight million cubic yards of sand along 18 miles of the coastline from Manasquan to Sea Bright. It included replacement of sand in areas eroded during Sandy as well as sand to restore the project area to its original design profile (USACE, 2013).

As discussed earlier in subsection 5.2.1 Hazard Description, the State under EO 140 created the Office of Flood Hazard Risk Reduction Measures. On October 17, 2013, the Christie Administration and the USACE announced a list of projects for critical USACE beach and dune construction projects that reduce risk to lives, properties, and infrastructure by rebuilding 44 miles of the New Jersey coastline and providing the State with the most comprehensive and continuous coastal protection system it has ever had. The projects in these areas were previously designed and authorized; however, not constructed due to a need to secure funding easements. Congress appropriated $1 billion for these and additional flood protection projects in New Jersey as part of the Hurricane Sandy Disaster Relief Appropriations Act of 2013 (Drewniak and Reed 2013). The projects are as follows:

- Port Monmouth portion of Raritan Bay and Sandy Hook Bay project area
- Southern Ocean City, Upper Township, and Sea Isle City portions of the Great Egg Harbor Inlet to Townsends Inlet project area
- Longport and Margate portions of Absecon Island within the Brigantine Inlet to Cape May Inlet project area
- Beach Haven, Long Beach Township and Ship Bottom on the Long Beach Island portion of the Little

Egg Inlet project area

Bay Head, Berkeley, Brick, Lavallette, Mantoloking, Point Pleasant Beach, Toms River, Seaside Heights and Seaside Park within the Manasquan Inlet to Barnegat Inlet project area

Allenhurst, Deal, Loch Arbour and the Elberon section of Long Branch within the Sandy Hook to Barnegat Inlet Section I project area

The Union Beach section of the Raritan Bay and Sandy Hook Bay project area

Recent Beach Nourishment Activities

To counteract the effects of natural erosion as well as to prevent storms from devastating the beachfront communities, the Bureau of Coastal Engineering (NJDEP) works with the federal government and has undertaken numerous beach nourishment and re-nourishment projects in the beach counties of New Jersey (NJDEP, 2012).

The Bureau also constructs and maintains shore protection structures including jetties, groins, seawalls, breakwaters, and bulkheads, which maintain the coastline as well as navigation channels across the State. These various stabilization methods help to slow the gradual erosion of sediment from New Jersey beaches. State protection projects are funded through a Shore Protection Fund, which supports federal, state, and local cost-sharing processes depending on the size and scope of the project (NJDEP, 2012).

The United States Army Corps provide a list of completed and ongoing projects in New Jersey. Table 5.2-6 lists these projects and their status

Table 5.2-6 Beach Replenishment Projects in New Jersey

Project	Type	Location	Status
Raritan Bay & Sandy Hook Bay	Hurricane and Storm Damage Reduction	Monmouth County	Work completed to date on the feasibility study includes a topographic survey, economic, hydraulic, geotechnical, and environmental project area field surveys, development of existing and future conditions, and preliminary storm damage reduction alternatives. Recently, the study was reevaluated to reflect post Hurricane Sandy conditions in study area. A draft unfavorable report has been provided to New Jersey Department of Environmental Protection for review.
Sandy Hook to Barnegat Inlet	Beach Nourishment	Monmouth County	York District awarded a $38 million contract on January 20, 2015 to Manson Construction Company to reconstruct beaches, storm water outfalls and implement modifications to existing groins along an area from Elberon to Loch Arbour, in Monmouth County, New Jersey.
Manasquan Inlet to Barnegat Inlet	Coastal Storm Risk Management	Ocean County	The Chief of Engineers Report was completed in December 2003. This project was authorized in the 2007 Water Resources Development Act (WRDA).
Barnegat Inlet to Little Egg Inlet	Long Beach Island Coastal Storm Risk Management	Ocean County	The Dredges Liberty Island (front), Dodge Island, Padre Island and Terrapin Island, of Great Lakes Dredge & Dock Company, transit offshore to dredge sand and pump it onto Long Beach Island, NJ in June of 2013. The work is part of a larger effort by the U.S. Army Corps of Engineers to restore its Coastal Storm Risk Management projects.
Brigantine Inlet to Great Egg Inlet	Brigantine Coastal Storm Risk Management	Atlantic County	The U.S. Army Corps of Engineers Philadelphia District pumped 667,000 cubic yards of sand onto the beach at Brigantine, NJ. Work was completed in February of 2013 and is designed to reduce damages from coastal storms.

Project	Type	Location	Status
Brigantine Inlet to Great Egg Inlet	Absecon Island Coastal Storm Risk Management	Atlantic County	The U.S. Army Corps of Engineers Philadelphia District pumped 667,000 cubic yards of sand onto the beach at Brigantine, NJ. Work was completed in February of 2013 and is designed to reduce damages from coastal storms.
Great Egg Harbor and Peck Beach	Ocean City Coastal Storm Risk Management	Cape May County	The Great Egg Harbor and Peck Beach, (Ocean City) project was first constructed in 1992 and has been periodically nourished over the years resulting in a wider beach.
Great Egg to Townsend's Inlet	Flood and Coastal Storm Damage Reduction	Cape May County	Planning, Engineering and Design was completed in FY05. Chief of Engineer's Report was signed on 24 October 2006. The project was authorized in the 2007 Water Resources Development Act. The Record of Decision was signed on 18 October 2011.
Hereford Inlet to Cape May Inlet	Flood and Storm Damage Reduction	Cape May County	The project successfully completed a Civil Works Review Board on 21 August 2014 and obtained a signed Chief's Report on 23 January 2015. Following Congressional notification, the district will begin the Planning Engineering and Design (PED) phase, sign a Project Partnership Agreement (PPA) and to begin the initial construction.
Cape May Inlet to Lower Township	Cape May Coastal Storm Risk Management	Cape May County	The U.S. Army Corps of Engineers Philadelphia District began the Cape May Inlet to Lower Township more than 20 years ago, resulting in a widened beach and reduced damages from many storms
Lower Cape May Meadows	Ecosystem Restoration, Flood and Coastal Storm Damage Reduction	Cape May County	The project restores and protects fish and wildlife habitat and provides flood and storm damage reduction throughout the entire study area. This project was completed on 15 June 2007.
Reeds Beach & Pierces Point	Ecosystem Restoration	Cape May County	In order to proceed, the Army Corps requires additional funding to support initial construction. The current initial construction costs need to be reviewed based on impacts from Hurricane Sandy to account for changed initial conditions based on the damages caused by the storm.
Villas and Vicinity – Delaware Bay	Ecosystem Restoration	Cape May County	This project has not received funding since FY 06. The initiation of initial construction is dependent on the establishment of an adequate funding stream. The next steps toward initial construction once adequate funding is received is to complete a Limited Reevaluation Report; develop, approve and execute the Project Partnership Agreement; acquire the necessary real estate; complete plans and specifications; and advertise and award the construction contract.
Townsend's Inlet to Cape May Inlet	7-Mile Island Coastal Storm Risk Management	Cape May County	Beachfill was completed in 2002 and the Avalon and Hereford seawall construction was completed in 2009.
East Point Beach – CAP Program	Flood Damage Reduction	Cumberland County	No information provided

Project	Type	Location	Status
Passaic River at Minish Park	Flood Damage Reduction	Essex County	A Hurricane Sandy Limited Evaluation Report was approved in October of 2016. Currently designs for the next construction contract (3A) are being worked on for bulkhead work that will provide a continuous bulkhead from approximately Center Street north to approximately Lombardy Street; a construction award is anticipated in the Summer of 2018. Designs for remaining bulkhead work are underway; construction contracts will be awarded upon completion of full design packages.
Mordecai Island	Ecosystem Restoration	Ocean County	Several erosion protection measures were evaluated and a 90% level design for an offshore wave barrier was completed in 2009.
Oakwood Beach – Delaware Bay	Flood and Coastal Storm Damage Protection	Salem County	Initial construction started in November 2014 and was completed and May 2015.
Heislerville Dike Repair	Coastal Storm Risk Management	Cumberland County	The Bid Date for this project was April 26, 2018.
Harrison Avenue Landfill Closure & Shoreline Restoration	Shoreline & Ecosystem Restoration	Camden County	Construction Phase
Sea Bright and Monmouth Beach Seawall	Coastal Storm Risk Management	Monmouth County	Construction Phase
Manasquan Inlet Bulkhead Replacement	Coastal Storm Risk Management	Ocean County	Construction Phase
Seabreeze Restoration	Ecosystem Restoration	Cumberland County	Planning, Engineering and Design
Absecon Inlet Jetty	Coastal Storm Risk Management	Atlantic County	Planning, Engineering and Design
Atlantic City Inlet Bulkhead	Coastal Storm Risk Management	Atlantic County	Planning, Engineering and Design
Fish & Wildlife Cape May Canal Gabions	Ecosystem Restoration	Cape May County	Planning, Engineering and Design
Trenton Marine Terminal Bulkhead	Coastal Storm Risk Management	Mercer County	Planning, Engineering and Design

5.2.7 VULNERABILITY ASSESSMENT

The following discusses New Jersey's vulnerability to the coastal erosion and sea level rise hazards. To understand risk, the assets exposed to the hazard areas are identified. For the coastal erosion and sea level rise hazards, the entire coastline of New Jersey is exposed. However, certain areas are at greater risk than others.

Coastal erosion and sea-level rise are of concern to the State because of the large number of communities and cultural resources located along the coast. Beaches serve as a buffer and protect the built environment and other natural resources on the mainland from coastal storm events such as hurricanes, tropical storms, and Nor'Easters, which can cause shoreline erosion or accretion.

The New Jersey Administrative Code Coastal Zone Management Rules defines erosion hazard areas as, "shoreline areas that are eroding and/or have a history of erosion causing them to be highly susceptible to further erosion, and damage from storms. Erosion hazard areas may be identified by any one of the following characteristics:

- Lack of beaches
- Lack of beaches at high tide
- Narrow beaches
- High beach mobility
- Foreshore extended under boardwalk
- Low dunes or no dunes
- Escarped foredune
- Steep beach slopes
- Cliffed bluffs as adjacent to beach
- Exposed, damaged, or breached jetties, groins, bulkheads, or seawalls
- High long-term erosion rates
- Pronounced downdrift effects of groins (jetties)

Further, erosion hazard areas are defined as extending inland from the edge of a stabilized upland area to the limit of the area likely to be eroded in 30 years for one- to four-unit dwelling structures, and 60 years for all other structures, including developed and undeveloped areas (N.J.A.C., 2013). The extent of an erosion hazard area is calculated by multiplying the projected annual erosion rate at a site by 30 for the development of one- to four-unit dwelling structures, and by 60 for all other developments.

A USGS report for the National Assessment of Shoreline Change entitled *Historical Shoreline Change along the New England and Mid-Atlantic Coasts* was released in 2011. The New England and Mid-Atlantic shores were subdivided into a total of 10 analysis regions for the purpose of reporting regional trends in shoreline change rates. The average rate of long-term shoreline change for the New England and Mid-Atlantic coasts was -0.5 meters per year. The average net long-term rate of shoreline change for the New Jersey 'North' region (located from Sandy Hook to south to Little Egg Inlet) was -0.6 meters per year. Meanwhile, the long- term net shoreline change rate in the New Jersey 'South' region (located from Little Egg Inlet south to Cape May Point) is strongly accretional (0.8 meters per year) (USGS, 2011).

To estimate exposure to long-term coastal erosion for purposes of this risk assessment, the following shoreline types as defined by NJDEP were used: (1) "beach," which includes waterfront areas composed of 100 percent sand; and (2) "erodible," which includes any soft shoreline other than beach, such as rock, marsh, sea wall or earthen dike. Figure 5.2-15 illustrates the NJDEP shoreline classifications. To generate the extent of the estimated coastal erosion hazard area, an erosion rate of 0.6 meters per year was multiplied by 60 to include all structure types and developed/undeveloped areas (annual erosion rate of 0.6 meters x 60 years = 36 meters or approximately 120 feet). Although the 'South' region indicated an average accretion rate, to estimate potential vulnerability and losses, the average rate of erosion of the 'North' region was used. Therefore, population, buildings, and infrastructure within 120 feet of the identified beach or erodible shoreline types are identified as vulnerable to long-term coastal erosion. Please note this methodology assumes that once lost to erosion, an area of land is not subsequently restored. This methodology is consistent with that used to evaluate coastal erosion in the Atlantic and Monmouth County hazard mitigation plans.

Figure 5.2-15 NJDEP Shoreline Classifications

Source: NJDEP, 1993

The Richard Stockton College CRC conducted an analysis to identify and rank the areas with greatest susceptibility to coastal erosion in Ocean County as a result of a 100-year storm event. These locations are listed in Table 5.2-7 below and illustrated in Figure 5.2-16. This coastal erosion susceptible area was also used to estimate exposure to the hazard in Ocean County and is discussed further below.

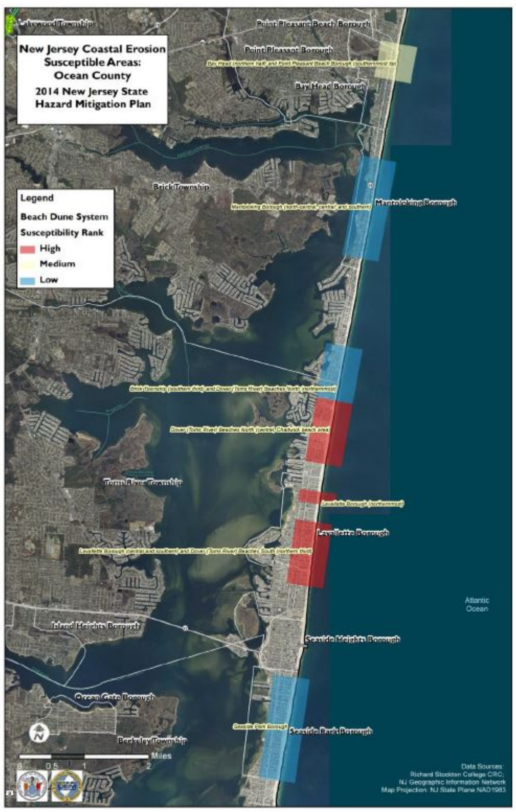
Table 5.2-7 Coastal Erosion Areas Susceptible to a 100-Year Storm Event in Ocean County

Location in Ocean County	Susceptibility Rank
Lavallette Borough (northernmost)	High
Dover (Toms River) Beaches North (central, Chadwick beach area)	High
Lavallette Borough (central and southern) and Dover (Toms River) Beaches South (northern third)	High
Bay Head (northern half) and Point Pleasant Beach Borough (southernmost tip)	Medium
Brick Township (southern third) and Dover (Toms River) Beaches North (northernmost)	Low
Mantoloking Borough (north-central, central, and southern)	Low
Seaside Park Borough	Low

Source: Richard Stockton College CRC, 2013

The following sections address assessing vulnerability and estimating potential losses by jurisdiction and to State facilities. Refer to Section 5.8 (Hurricane) which discusses the State's exposure to storm surge using the FEMA Region IV Coastal Flood Loss Atlas team's storm surge inundation grids from the National Hurricane Center's Sea, Lake and Overland Surge from Hurricanes (SLOSH) model. Storm surge mapping may also be used to identify facilities that may be potentially at risk to coastal erosion.

Figure 5.2-16 Coastal Erosion Areas Susceptible to a 100-Year Storm Event in Ocean County



Source: Richard Stockton College CRC, 2013

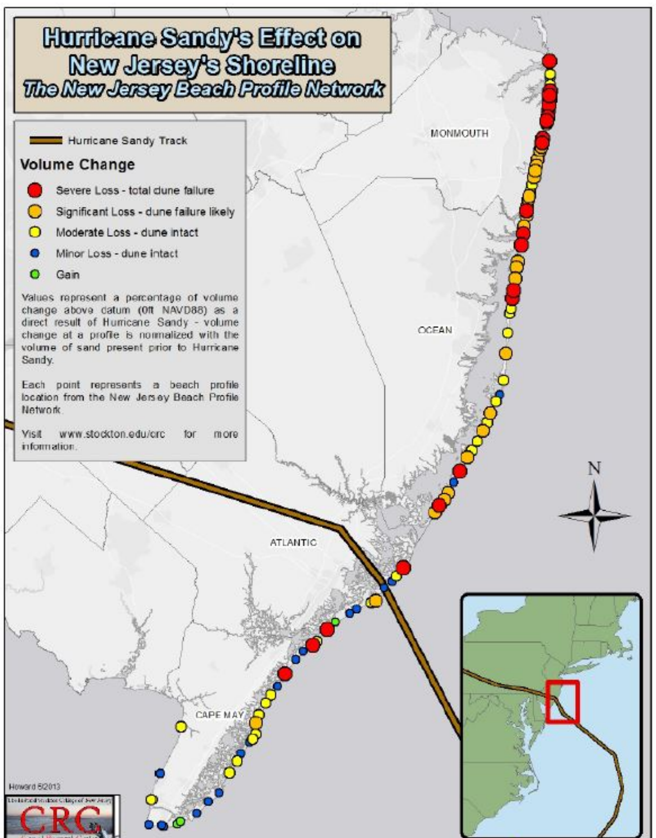
5.2.7.2 ASSESSING VULNERABILITY BY JURISDICTION

A review of historic shoreline data dating back to 1863 provided by NJDEP indicates the coastline of the State has significantly changed (moving landward and seaward) because of the effects of erosion, accretion, beach nourishment, and structural shoreline protection measures. Shoreline change, whether erosion or accretion, is dependent upon several factors including location (e.g., open-ocean facing shore) and exposure to high-energy storm waves. The coastal high hazard area (or V zone where "V" stands for velocity wave action) is the most hazardous part of the coastal floodplain, because of its exposure to wave effects. Section 5.6 (Flood) discusses the assets exposed and vulnerable in the V zone.

Further, storm surge inundation can exceed the regulatory floodplain boundaries (V and A zones), which can also contribute to coastal erosion. Section 5.8 Hurricane discusses the storm surge areas generated by FEMA's Coastal Flood Loss Atlas team as a result of Category One through Four hurricanes in the following 15 NJ Counties: Atlantic, Bergen, Burlington, Cape May, Cumberland, Essex, Gloucester, Hudson, Mercer, Middlesex, Monmouth, Ocean, Passaic, Salem, and Union Counties.

Twelve of the 21 New Jersey counties included erosion (either coastal and/or riverine erosion) as a hazard of concern in their hazard mitigation plans. Table 5.1-2 in Section 5.1 State Risk Assessment Overview summarizes these hazard-of-concern identifications. In addition to the coastal counties on the Atlantic Ocean or along inland bays, inland counties indicated they experience minor erosion along their river shorelines. Camden County's hazard mitigation plan indicates that they experience minor erosion along the Delaware River, which runs along the western edge of the County. Passaic County's hazard mitigation plan identifies erosion as a hazard because of the presence of the Passaic River. Essex County indicates in their hazard mitigation plan that they have a low vulnerability to coastal erosion.

Figure 5.2-17 Superstorm Sandy's Effect on New Jersey's Shoreline



Source: Richard Stockton College CRC, 2013

Based on the historic record, review of the local hazard mitigation plans, and the updated State risk assessment results that continue to be presented in this section, the counties most threatened by coastal erosion are Atlantic, Cape May, Monmouth, and Ocean. More specifically in these counties, engineering in channels has created offsets leaving the northeast corners of the barrier islands to the south highly vulnerable to wave action and thus coastal erosion.

As discussed earlier in this hazard section, the Richard Stockton College Coastal Research Center (CRC) researchers monitor shoreline change at 105 beach sites in four counties (Atlantic, Cape May, Monmouth, and Ocean). A 30-year shoreline change analysis of each of the 105 monitoring sites was conducted to present the overall trend for each county. Richard Stockton College CRC also conducts post-storm survey and assessment of the New Jersey shoreline in response to severe beach erosion resulting from the impact of storm events. Nearly all of the 105 NJBPN sites were surveyed immediately after Superstorm Sandy to provide accurate assessments of sand volume losses to New Jersey's beaches. Figure 5.2-17 illustrates the percent volume change above datum (0 feet NAVD88) as a direct result of Superstorm Sandy at each beach profile site. The volume change at each site is normalized with the volume of sand present prior to Superstorm Sandy. As this figure depicts, nearly all of these sites in Atlantic, Cape May, Monmouth, and Ocean Counties showed evidence of sand volume losses as a result of Superstorm Sandy in 2012 (Richard Stockton College CRC, 2013).

To estimate population and buildings exposed to this hazard, a spatial analysis was conducted using the 2010 U.S. Census blocks, the default general building stock inventory available in HAZUS-MH at the Census-block level and the two hazard areas described above: 1) Richard Stockton College (RSC) CRC susceptible areas in Ocean County and 2) long-term coastal erosion (within 120 feet of the identified beach or erodible shoreline). Where the Census block centroid was located within the defined hazard area the population was totaled. Tables 5.2-8 and 5.2-9 summarize these results by county. Please note there are limitations to this analysis and the results should only be used as an estimate. Further, the information in these tables does not account for the increase in population (of both residents and tourists) during the summer months, or the changes in occupancy of homes seasonally or post-Superstorm Sandy. As improved statewide building footprint data becomes available, these estimates will be updated.

Using the long-term coastal erosion hazard area, the spatial analysis indicates that five of the 21 counties are exposed: Atlantic, Cape May, Middlesex, Monmouth and Ocean Counties. In summary, an estimated 32,381people (or less than one-percent of the total population) and an estimated $10 billion in building replacement cost value are potentially vulnerable.

Table 5.2-8 Population Exposed to Coastal Erosion

County	Total Populatio n (2015 ACS)	Population in RSC Coastal Erosion Susceptible Area	% of Total	Population in the Approximate Coastal Erosion Hazard Area (Long-Term)	% of Total
Atlantic	275,376	0	0.0%	3,305	1.2%
Bergen	926,330	0	0.0%	0	0.0%
Burlington	450,556	0	0.0%	0	0.0%
Camden	511,998	0	0.0%	0	0.0%
Cape May	95,805	0	0.0%	4,886	5.1%
Cumberland	157,035	0	0.0%	157	0.1%
Essex	791,609	0	0.0%	0	0.0%
Gloucester	290,298	0	0.0%	0	0.0%
Hudson	662,619	0	0.0%	0	0.0%
Hunterdon	126,250	0	0.0%	0	0.0%
Mercer	370,212	0	0.0%	0	0.0%
Middlesex	830,300	0	0.0%	830	0.1%
Monmouth	629,185	0	0.0%	16,359	2.6%
Morris	498,192	0	0.0%	0	0.0%
Ocean	583,450	2,917	0.5%	7,001	1.2%
Passaic	507,574	0	0.0%	0	0.0%
Salem	65,120	0	0.0%	0	0.0%
Somerset	330,604	0	0.0%	0	0.0%

County	Total Populatio n (2015 ACS)	Population in RSC Coastal Erosion Susceptible Area	% of Total	Population in the Approximate Coastal Erosion Hazard Area (Long-Term)	% of Total
Sussex	145,930	0	0.0%	0	0.0%
Union	548,744	0	0.0%	0	0.0%
Warren	107,226	0	0.0%	0	0.0%
State Total	8,904,413	2,917		32,538	0.0%

Source: ACS 2015; Richard Stockton College CRC 2013; NJDEP 1993

Table 5.2-9 Building Replacement Cost Value of the General Building Stock Exposed to Coastal Erosion by County

County	Total Building RCV	RCV in RSCs Coastal Erosion Susceptible Area	% of Total	RCV in the Approximate Coastal Erosion Hazard Area (Long-Term)	% of Total
Atlantic	$ 437,234,696	$ -	0.0%	$ 18,363,857	4.2%
Bergen	$ 167,418,063	$ -	0.0%	$ -	0.0%
Burlington	$ 638,782,952	$ -	0.0%	$ -	0.0%
Camden	$ 498,714,249	$ -	0.0%	$ -	0.0%
Cape May	$ 114,971,807	$ -	0.0%	$ 9,772,604	8.5%
Cumberland	$ 643,881,700	$ -	0.0%	$ 643,882	0.1%
Essex	$ 822,674,560	$ -	0.0%	$ -	0.0%
Gloucester	$ 105,866,503	$ -	0.0%	$ -	0.0%
Hudson	$ 280,805,250	$ -	0.0%	$ -	0.0%
Hunterdon	$ 260,655,560	$ -	0.0%	$ -	0.0%
Mercer	$ 2,952,671,103	$ -	0.0%	$ -	0.0%
Middlesex	$ 632,983,190	$ -	0.0%	$ 632,983	0.1%
Monmouth	$ 463,386,037	$ -	0.0%	$ 19,462,214	4.2%
Morris	$ 385,747,921	$ -	0.0%	$ -	0.0%
Ocean	$ 310,626,835	$ 7,765,671	2.5%	$ 10,871,939	3.5%
Passaic	$ 299,429,912	$ -	0.0%	$ -	0.0%
Salem	$ 134,460,134	$ -	0.0%	$ -	0.0%
Somerset	$ 226,685,451	$ -	0.0%	$ -	0.0%
Sussex	$ 98,346,368	$ -	0.0%	$ -	0.0%
Union	$ 164,566,538	$ -	0.0%	$ -	0.0%
Warren	$ 79,870,209	$ -	0.0%	$ -	0.0%
State Total	$9,719,779,03 9	$ 7,765,671		$ 59,747,479	

Source: HAZUS-MH 4.2

Preliminary results of a Richard Stockton College CRC study of Cape May County indicate that overall, with the exception of isolated areas on the barrier islands, Cape May County is less susceptible to erosion when compared to Atlantic, Monmouth, and Ocean Counties because of the offshore topography.

To assess the Counties exposed to sea level rise, the NOAA spatial layers of the four sea level rise scenarios were overlaid on the State in GIS. Figure 5.2-18 illustrates the four sea level rise scenarios and their estimated area of impact in the following Counties: Atlantic, Burlington, Bergen, Cape May, Essex, Hudson, Middlesex, Monmouth, Ocean, and Union. As mentioned earlier, Cumberland and Salem Counties located along the Delaware Bay as well as Gloucester, Camden and Burlington Counties located along the tidally influenced portion of the Delaware River are excluded from this analysis.

Future changes in growth and development may impact vulnerability. Section 4 State Profile indicates an increase in the number of housing units authorized by building permits over the past five years. for many of the coastal counties exposed to coastal erosion and sea level rise: Bergen, Essex, Hudson, Middlesex, Monmouth, Ocean, and Union. If the proposed new development is located within the hazard areas, there is a potential increase in risk to life, property and the environment. However, the State has controls through CAFRA which regulates development in defined CAFRA boundaries. In addition, new construction will be required to meet current standards which are designed to provide increased protection compared to existing development in the area.

Coastal areas impacted by Superstorm Sandy are in the redevelopment phase. Similar to new construction, redevelopment will be required to meet current standards which may provide increased protection compared to their pre-event conditions. Dune replenishment projects will continue and their role in mitigating vulnerabilities considered. The U. S. Army Corps of Engineers dune replenishment projects as described in earlier in this section and illustrated in Figure 5.2-13 will serve to help mitigate the impacts of coastal erosion. Any identified vulnerabilities will be considered as the State continues to rebuild and redevelop in the aftermath of Superstorm Sandy and beyond.

Figure 5.2-18 Global Mean Sea Level Rise Scenarios for New Jersey

Source: NOAA, 2017

5.2.7.3 ASSESSING VULNERABILITY OF STATE FACILITIES

To assess the vulnerability of the State-owned and leased facilities provided by New Jersey's Office of Management and Budget, a spatial analysis was conducted using the coastal erosion hazard areas. Using geographic information system (GIS) software, these hazard areas were overlaid with the State facility data outlined in Section 5.1 to determine the number of State facilities potentially at risk to coastal erosion. Table 5.2-10 summarizes the State-owned and leased facilities vulnerable to coastal erosion by county, and Table 5.2-11 summarizes the facilities by State agency. The analysis indicates there is one state building located in Ocean County, vulnerable to coastal erosion. These State buildings is owned by NJDEP.

Coastal erosion and sea level rise can also severely impact roads and infrastructure. As coastline evolution continues, evacuation and emergency routes need to be considered. As discussed in the New Jersey Hurricane Evacuation Study Transportation Analysis, Cape May, Atlantic, Ocean, and Monmouth Counties are principal origination points for evacuation movements in the State during a hurricane evacuation event. These counties include significant westbound and northbound evacuation routes. Using the hurricane evacuation routes in the New Jersey spatial dataset, routes used to direct traffic inland in case of a hurricane threat are located in the coastal erosion hazard area. These include portions of Atlantic City Expressway; United States Route 40; State Highways 35, 36, 37, 72, and 152; and County Roads 12A, 520, 607, 619, 621, and 630.

To assess the vulnerability of State buildings and critical facilities to sea level rise, a spatial analysis was conducted using the NOAA sea level rise scenario polygon data. In summary, it is estimated that between 135 and 184 State-owned and leased buildings may potentially be vulnerable to sea level rise by the year 2050. Tables 5.2-10 and 5.2-11 summarize these results.

Any identified vulnerabilities to State facilities will be considered as the State continues to rebuild and redevelop in the aftermath of Superstorm Sandy and beyond. Dune replenishment projects will continue and their role in mitigating vulnerabilities considered.

To assess the vulnerability of critical facilities, a spatial analysis was conducted with the defined coastal erosion hazard areas and the critical facilities and infrastructure defined in Section 5.1.

Table 5.2-10 Number of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by County

County	Total Number of Buildings	Number of State Buildings in RSC's Coastal Erosion Susceptible Area			Number of State Buildings in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Atlantic	165	-	-	-	-	-	-
Bergen	79	-	-	-	-	-	-
Burlington	683	-	-	-	-	-	-
Camden	154	-	-	-	-	-	-
Cape May	191	-	-	-	-	-	-
Cumberland	464	-	-	-	-	-	-
Essex	102	-	-	-	-	-	-
Gloucester	55	-	-	-	-	-	-
Hudson	53	-	-	-	-	-	-
Hunterdon	501	-	-	-	-	-	-
Mercer	673	-	-	-	-	-	-
Middlesex	334	-	-	-	-	-	-
Monmouth	450	-	-	-	-	-	-

County	Total Number of Buildings	Number of State Buildings in RSC's Coastal Erosion Susceptible Area			Number of State Buildings in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Morris	227	-	-	-	-	-	-
Ocean	244	-	-	-	1	-	1
Passaic	250	-	-	-	-	-	-
Salem	121	-	-	-	-	-	-
Somerset	138	-	-	-	-	-	-
Sussex	446	-	-	-	-	-	-
Union	53	-	-	-	-	-	-
Warren	225	-	-	-	-	-	-
Total	5,608	-	-	-	1	-	1

Source: NJOMB, 2018; Richard Stockton College CRC 2013

Table 5.2-11 Number of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by Agency

Agency	Total Number of Buildings	Number of State Buildings in RSC's Coastal Erosion Susceptible Area			Number of State Buildings in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Agriculture	10	-	-	-	-	-	-
Banking and Insurance	1	-	-	-	-	-	-
Chief Executive	2	-	-	-	-	-	-
Children and Families	157	-	-	-	-	-	-
Community Affairs	10	-	-	-	-	-	-
Corrections	801	-	-	-	-	-	-
Education	66	-	-	-	-	-	-
Environmental Protection	2,004	-	-	-	1	-	1
Health	9	-	-	-	-	-	-
Human Services	729	-	-	-	-	-	-
Judiciary	92	-	-	-	-	-	-
Juvenile Justice Commission	199	-	-	-	-	-	-
Labor and Work Force Development	50	-	-	-	-	-	-
Law and Public Safety	27	-	-	-	-	-	-
Legislature	6	-	-	-	-	-	-
Military and Veterans Affairs	273	-	-	-	-	-	-
Miscellaneous Commissions	2	-	-	-	-	-	-

Agency	Total Number of Buildings	Number of State Buildings in RSC's Coastal Erosion Susceptible Area			Number of State Buildings in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Motor Vehicles Commission	141	-	-	-	-	-	-
Personnel	2	-	-	-	-	-	-
State	19	-	-	-	-	-	-
State Police	141	-	-	-	-	-	-
Transportation	617	-	-	-	-	-	-
Treasury	250	-	-	-	-	-	-
Total	5,608	-	-	-	1	-	1

Source: NJOMB, 2018 ; Richard Stockton College CRC 2013

Table 5.2-12 Number of State-Owned and Leased Buildings Vulnerable to Sea Level Rise by County

County	Total Number of Buildings	+1 ft MHHW			+3 ft MHHW		
		Owned	Leased	Total	Owned	Leased	Total
Atlantic	165	3	-	3	3	1	4
Bergen	79	-	-	-	3	-	3
Burlington	683	115	-	115	115	-	115
Camden	154	-	-	-	-	-	-
Cape May	191	-	-	-	2	-	2
Cumberland	464	6	-	6	20	-	20
Essex	102	-	-	-	-	-	-
Gloucester	55	-	-	-	-	-	-
Hudson	53	-	-	-	1	-	1
Hunterdon	501	-	-	-	-	-	-
Mercer	673	-	-	-	-	-	-
Middlesex	334	2	-	2	2	-	2
Monmouth	450	1	-	1	7	1	8
Morris	227	-	-	-	-	-	-
Ocean	244	4	-	4	22	1	23
Passaic	250	-	-	-	-	-	-
Salem	121	4	-	4	6	-	6
Somerset	138	-	-	-	-	-	-
Sussex	446	-	-	-	-	-	-
Union	53	-	-	-	-	-	-
Warren	225	-	-	-	-	-	-
Total	5,608	135	-	135	181	3	184

Source: NJOMB, 2018; NOAA, 2017

Table 5.2-13 Number of State-Owned and Leased Buildings Vulnerable to Sea Level Rise by Agency

Agency	Total Number of Buildings	+1 ft MHHW			+3 ft MHHW		
		Owned	Leased	Total	Owned	Leased	Total
Agriculture	10	-	-	-	-	-	-
Banking and Insurance	1	-	-	-	-	-	-
Chief Executive	2	-	-	-	-	-	-
Children and Families	157	-	-	-	-	-	-
Community Affairs	10	-	-	-	-	-	-
Corrections	801	-	-	-	-	-	-
Education	66	-	-	-	-	-	-
Environmental Protection	2,004	130	-	130	172	-	172
Health	9	-	-	-	-	-	-
Human Services	729	-	-	-	-	-	-
Judiciary	92	-	-	-	1	-	1
Juvenile Justice Commission	199	-	-	-	-	-	-
Labor and Work Force Development	50	-	-	-	-	-	-
Law and Public Safety	27	-	-	-	-	1	1
Legislature	6	-	-	-	-	-	-
Military and Veterans Affairs	273	-	-	-	1	-	1
Miscellaneous Commissions	2	-	-	-	-	-	-
Motor Vehicles Commission	141	-	-	-	-	-	-
Personnel	2	-	-	-	-	-	-
State	19	-	-	-	-	-	-
State Police	141	5	-	5	6	2	8
Transportation	617	-	-	-	1	-	1
Treasury	250	-	-	-	-	-	-
Total	5,608	135	-	135	181	3	184

Source: NJOMB, 2018; NOAA, 2017

5.2.7.4 ESTIMATING POTENTIAL LOSSES BY JURISDICTION

Life, property and the environment located within the coastal erosion hazard areas defined earlier in this section are potentially at risk for loss from coastal erosion. As stated earlier, eight of the 21 counties are within the jurisdiction of the Coastal Area Facility Review Act (CAFRA), six of which are located in the defined long-term coastal erosion hazard areas: Atlantic, Cape May, Cumberland, Middlesex, Monmouth, and Ocean Counties. Further, the Richard Stockton College CRC identified areas with greatest susceptibility to coastal erosion in Ocean County as a result of a 100-year storm event. Building and infrastructure damage as a result of coastal erosion can impact a community's economy and tax base. The replacement cost value of buildings within the coastal erosion hazard areas are summarized in Table 5.2-9 above.

Current replacement cost data is not available at the structural level for the general building stock across the State. Table 5.2-9 identifies a total risk exposure using the default general building stock in HAZUS-MH at the Census-block level. As more current replacement cost data becomes available either at the aggregate or structure level, and probabilistic modeling is developed to estimate potential loss as a result of coastal erosion, this section of the Plan will be updated.

The State's coastal resources are an enormous driver to the local and statewide economy and losses can greatly impact the State's tax base and the local industries (e.g., tourism). Refer to Section 4 State Profile for details on the State's economy.

Future changes in growth and development may affect vulnerability and potential losses in the future. As stated earlier, coastal areas impacted by Superstorm Sandy are in the redevelopment phase. Similar to new construction, redevelopment will be required to meet current standards which may provide increased protection compared to their pre-event conditions and result in a decrease in future potential losses.

5.2.7.5 ESTIMATING POTENTIAL LOSSES OF STATE FACILITIES

All State-owned and leased buildings and critical facilities located within the coastal erosion hazard areas presented earlier in this section are potentially at risk for loss from coastal erosion. There is a total risk exposure of $294,029 for the one NJDEP building located within 120 feet of the identified beach and erodible shoreline types. Refer to Tables 5.2-16 and 5.2-17 below.

There is also potential risk for loss from sea level rise. There is a total risk of $66,165,259 loss from sea level rise. Tables 5.2-18 and 5.2-19 show details on loss due to sea level rise below.

Table 5.2-14 Total Replacement Cost Value of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by County

County	RCV of Buildings	RCV in RSC's Coastal Erosion Susceptible Area			RCV in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Atlantic	$ 437,234,696	$ -	$ -	$ -	$ -	$ -	$ -
Bergen	$ 167,418,063	$ -	$ -	$ -	$ -	$ -	$ -
Burlington	$ 638,782,952	$ -	$ -	$ -	$ -	$ -	$ -
Camden	$ 498,714,249	$ -	$ -	$ -	$ -	$ -	$ -
Cape May	$ 114,971,807	$ -	$ -	$ -	$ -	$ -	$ -
Cumberland	$ 643,881,700	$ -	$ -	$ -	$ -	$ -	$ -
Essex	$ 822,674,560	$ -	$ -	$ -	$ -	$ -	$ -
Gloucester	$ 105,866,503	$ -	$ -	$ -	$ -	$ -	$ -

County	RCV of Buildings	RCV in RSC's Coastal Erosion Susceptible Area			RCV in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Hudson	$ 280,805,250	$ -	$ -	$ -	$ -	$ -	$ -
Hunterdon	$ 260,655,560	$ -	$ -	$ -	$ -	$ -	$ -
Mercer	$ 2,952,671,103	$ -	$ -	$ -	$ -	$ -	$ -
Middlesex	$ 632,983,190	$ -	$ -	$ -	$ -	$ -	$ -
Monmouth	$ 463,386,037	$ -	$ -	$ -	$ -	$ -	$ -
Morris	$ 385,747,921	$ -	$ -	$ -	$ -	$ -	$ -
Ocean	$ 310,626,835	$ -	$ -	$ -	$ 294,029	$ -	$ 294,029
Passaic	$ 299,429,912	$ -	$ -	$ -	$ -	$ -	$ -
Salem	$ 134,460,134	$ -	$ -	$ -	$ -	$ -	$ -
Somerset	$ 226,685,451	$ -	$ -	$ -	$ -	$ -	$ -
Sussex	$ 98,346,368	$ -	$ -	$ -	$ -	$ -	$ -
Union	$ 164,566,538	$ -	$ -	$ -	$ -	$ -	$ -
Warren	$ 79,870,209	$ -	$ -	$ -	$ -	$ -	$ -
Total	$9,719,779,039	$ -	$ -	$ -	$ 294,029	$ -	$ 294,029

Source: NJOMB 2018; Richard Stockton College CRC 2013; NJDEP 1993

Table 5.2-15 Total Replacement Cost Value of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by Agency

Agency	Total RCV	RCV in RSC's Coastal Erosion Susceptible Area			RCV in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Agriculture	$ 8,096,184	$ -	$ -	$ -	$ -	$ -	$ -
Banking and Insurance	$ 58,349,889	$ -	$ -	$ -	$ -	$ -	$ -
Chief Executive	$ 41,711,042	$ -	$ -	$ -	$ -	$ -	$ -
Children and Families	$ 710,790,282	$ -	$ -	$ -	$ -	$ -	$ -
Community Affairs	$ 133,856,589	$ -	$ -	$ -	$ -	$ -	$ -
Corrections	$ 1,159,804,016	$ -	$ -	$ -	$ -	$ -	$ -
Education	$ 177,472,231	$ -	$ -	$ -	$ -	$ -	$ -
Environmental Protection	$ 756,535,586	$ -	$ -	$ -	$294,029.00	$ -	$294,029.00
Health	$ 187,466,620	$ -	$ -	$ -	$ -	$ -	$ -
Human Services	$ 1,120,601,472	$ -	$ -	$ -	$ -	$ -	$ -
Judiciary	$1,096,424,568	$ -	$ -	$ -	$ -	$ -	$ -
Juvenile Justice Commission	$ 246,910,955	$ -	$ -	$ -	$ -	$ -	$ -
Labor and Work Force Development	$ 328,156,420	$ -	$ -	$ -	$ -	$ -	$ -
Law and Public Safety	$ 284,215,262	$ -	$ -	$ -	$ -	$ -	$ -
Legislature	$ 120,556,954	$ -	$ -	$ -	$ -	$ -	$ -

Agency	Total RCV	RCV in RSC's Coastal Erosion Susceptible Area			RCV in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Military and Veterans Affairs	$ 737,946,664	$ -	$ -	$ -	$ -	$ -	$ -
Miscellaneous Commissions	$ 18,027,989	$ -	$ -	$ -	$ -	$ -	$ -
Motor Vehicles Commission	$ 563,493,240	$ -	$ -	$ -	$ -	$ -	$ -
Personnel	$ 9,656,017	$ -	$ -	$ -	$ -	$ -	$ -
State	$ 152,151,016	$ -	$ -	$ -	$ -	$ -	$ -
State Police	$ 432,772,085	$ -	$ -	$ -	$ -	$ -	$ -
Transportation	$ 320,748,453	$ -	$ -	$ -	$ -	$ -	$ -
Treasury	$1,054,035,504	$ -	$ -	$ -	$ -	$ -	$ -
Total	$9,719,779,039	$ -	$ -	$ -	$ 294,029	$ -	$ 294,029

Source: NJOMB 2018; Richard Stockton College CRC 2013; NJDEP 1993

Table 5.2-16 Total Replacement Cost Value of State-Owned and Leased Buildings Vulnerable to Sea Level Rise by County

County	Total RCV	+1 ft MHHW			+3 ft MHHW		
		Owned	Leased	Total	Owned	Leased	Total
Atlantic	$ 437,234,696	$ 1,612,004	$ -	$ 1,612,004	$ 1,612,004	$ 13,891,235	$ 15,503,239
Bergen	$ 167,418,063	$ -	$ -	$ -	$ 8,159,491	$ -	$ 8,159,491
Burlington	$ 638,782,952	$20,980,417	$ -	$20,980,417	$20,980,417	$ -	$20,980,417
Camden	$ 498,714,249	$ -	$ -	$ -	$ -	$ -	$ -
Cape May	$ 114,971,807	$ -	$ -	$ -	$ 42,120	$ -	$ 42,120
Cumberland	$ 643,881,700	$ 1,210,889	$ -	$ 1,210,889	$ 2,032,874	$ -	$ 2,032,874
Essex	$ 822,674,560	$ -	$ -	$ -	$ -	$ -	$ -
Gloucester	$ 105,866,503	$ -	$ -	$ -	$ -	$ -	$ -
Hudson	$ 280,805,250	$ -	$ -	$ -	$ 2,940	$ -	$ 2,940
Hunterdon	$ 260,655,560	$ -	$ -	$ -	$ -	$ -	$ -
Mercer	$ 2,952,671,103	$ -	$ -	$ -	$ -	$ -	$ -
Middlesex	$ 632,983,190	$ 250,302	$ -	$ 250,302	$ 250,302	$ -	$ 250,302
Monmouth	$ 463,386,037	$ 117,822	$ -	$ 117,822	$ 12,372,714	$ 420,911	$ 12,793,626
Morris	$ 385,747,921	$ -	$ -	$ -	$ -	$ -	$ -
Ocean	$ 310,626,835	$ 2,496,881	$ -	$ 2,496,881	$4,564,442	$ 411,951	$ 4,976,393
Passaic	$ 299,429,912	$ -	$ -	$ -	$ -	$ -	$ -
Salem	$ 134,460,134	$ 1,185,676	$ -	$ 1,185,676	$ 1,423,859	$ -	$ 1,423,859
Somerset	$ 226,685,451	$ -	$ -	$ -	$ -	$ -	$ -
Sussex	$ 98,346,368	$ -	$ -	$ -	$ -	$ -	$ -
Union	$ 164,566,538	$ -	$ -	$ -	$ -	$ -	$ -

County	Total RCV	+1 ft MHHW			+3 ft MHHW		
		Owned	Leased	Total	Owned	Leased	Total
Warren	$ 79,870,209	$ -	$ -	$ -	$ -	$ -	$ -
Total	$9,719,779,039	$ -	$ -	$ -	$51,441,161	$14,724,097	$66,165,259

Table 5.2-17 Total Replacement Cost Value of State-Owned and Leased Buildings Vulnerable to Sea Level Rise by Agency

Agency	Total RCV	+1 ft MHHW			+3 ft MHHW		
		Owned	Leased	Total	Owned	Leased	Total
Agriculture	$ 8,096,184	$ -	$ -	$ -	$ -	$ -	$ -
Banking and Insurance	$ 58,349,889	$ -	$ -	$ -	$ -	$ -	$ -
Chief Executive	$ 41,711,042	$ -	$ -	$ -	$ -	$ -	$ -
Children and Families	$ 710,790,282	$ -	$ -	$ -	$ -	$ -	$ -
Community Affairs	$ 133,856,589	$ -	$ -	$ -	$ -	$ -	$ -
Corrections	$ 1,159,804,016	$ -	$ -	$ -	$ -	$ -	$ -
Education	$ 177,472,231	$ -	$ -	$ -	$ -	$ -	$ -
Environmental Protection	$ 756,535,586	$24,343,763	$ -	$24,343,763	$42,136,495	$ -	$42,136,495
Health	$ 187,466,620	$ -	$ -	$ -	$ -	$ -	$ -
Human Services	$ 1,120,601,472	$ -	$ -	$ -	$ -	$ -	$ -
Judiciary	$1,096,424,568	$ -	$ -	$ -	$ 5,205,010	$ -	$ 5,205,010
Juvenile Justice Commission	$ 246,910,955	$ -	$ -	$ -	$ -	$ -	$ -
Labor and Work Force Development	$ 328,156,420	$ -	$ -	$ -	$ -	$ -	$ -
Law and Public Safety	$ 284,215,262	$ -	$ -	$ -	$ -	$ 13,891,235	$ 13,891,235
Legislature	$ 120,556,954	$ -	$ -	$ -	$ -	$ -	$ -
Military and Veterans Affairs	$ 737,946,664	$ -	$ -	$ -	$ 324,419	$ -	$ 324,419
Miscellaneous Commissions	$ 18,027,989	$ -	$ -	$ -	$ -	$ -	$ -
Motor Vehicles Commission	$ 563,493,240	$ -	$ -	$ -	$ -	$ -	$ -
Personnel	$ 9,656,017	$ -	$ -	$ -	$ -	$ -	$ -
State	$ 152,151,016	$ -	$ -	$ -	$ -	$ -	$ -
State Police	$ 432,772,085	$ 3,510,227	$ -	$ 3,510,227	$ 3,772,297	$ 832,862	$ 4,605,159
Transportation	$ 320,748,453	$ -	$ -	$ -	$ 2,940		$ 2,940
Treasury	$1,054,035,504	$ -	$ -	$ -	$ -	$ -	$ -

Agency	Total RCV	+1 ft MHHW			+3 ft MHHW		
		Owned	Lease d	Total	Owned	Leased	Total
Total	$9,719,779,03 9	$27,853,99 0	$ -	$27,853,99 0	$51,441,161	$14,724,09 7	$66,165,25 9

Source: NJOMB, 2018; NOAA, 2017