5.4.1 COASTAL EROSION

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the coastal erosion hazard in Burlington County.

2019 Plan Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences (updated with events that occurred between January 1, 2013 and December 31, 2017), probability of future occurrence, and potential climate change impacts using best available data.
- A vulnerability assessment section was completed for the coastal erosion hazard that provides a more accurate estimated exposure and potential losses to Burlington County.

5.4.1.1 Profile

Hazard Description

Erosion is the process of the wearing away of beaches and bluffs along the coastline by large storms, flooding, strong wave action, sea level rise, fluvial currents, and human activities. Erosion occurs when the waves and currents remove sediment from the shoreline. The loss of sediment causes the land along the shore to become narrower and lower in elevation. During storms, waves and currents carry the sand away from the shoreline, depositing and storing the sediment in the nearshore sandbars or down-drift to adjacent shorelines. In weeks and months following the storm, the nearshore sediment can be returned to the shoreline by calmer waves (CRS User Manual 2017).

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).

Location

As defined through the New Jersey Coastal Management Program (NJCMP), the coastal zones of New Jersey include all areas where the State has authority, through the NJDEP and the Meadowlands Commission, to regulate land and water uses that may have significant impact on coastal resources. The primary implementing authorities for NJCMP are the Coastal Area Facility Review Act (CAFRA), the Waterfront Development Law, the Wetlands Act of 1970, Tidelands Statutes and the Hackensack Meadowlands Reclamation Development Act (NJDEP, 2002).

While Burlington County has no open water on the Atlantic Ocean or Delaware Bay, it has two distinct areas that are at risk of shoreline erosion: the western border along the Delaware River and the southeastern portion along Mullica River Great Bay and its tributaries. **Error! Reference source not found.** illustrates the coastal boundary of the State of New Jersey and shows that a small portion of Burlington County lies within the CAFRA area. In the Township of Bass River, there is a small, 19-acre center located in the CAFRA area, where U.S. Route 9, a county road, and the Garden State Parkway intersect. The rest of the southeast portion of the County is in Pinelands protected area zoning (Craghan et al., 2010).

Figure 5.4.2-1 illustrates the coastal areas of Burlington County. The figure shows that the county borders or contains numerous tidally influenced waterways including the Mullica River, the Delaware River, and their tributaries.

Figure 5.4.1-1. New Jersey Coastal Boundary Map

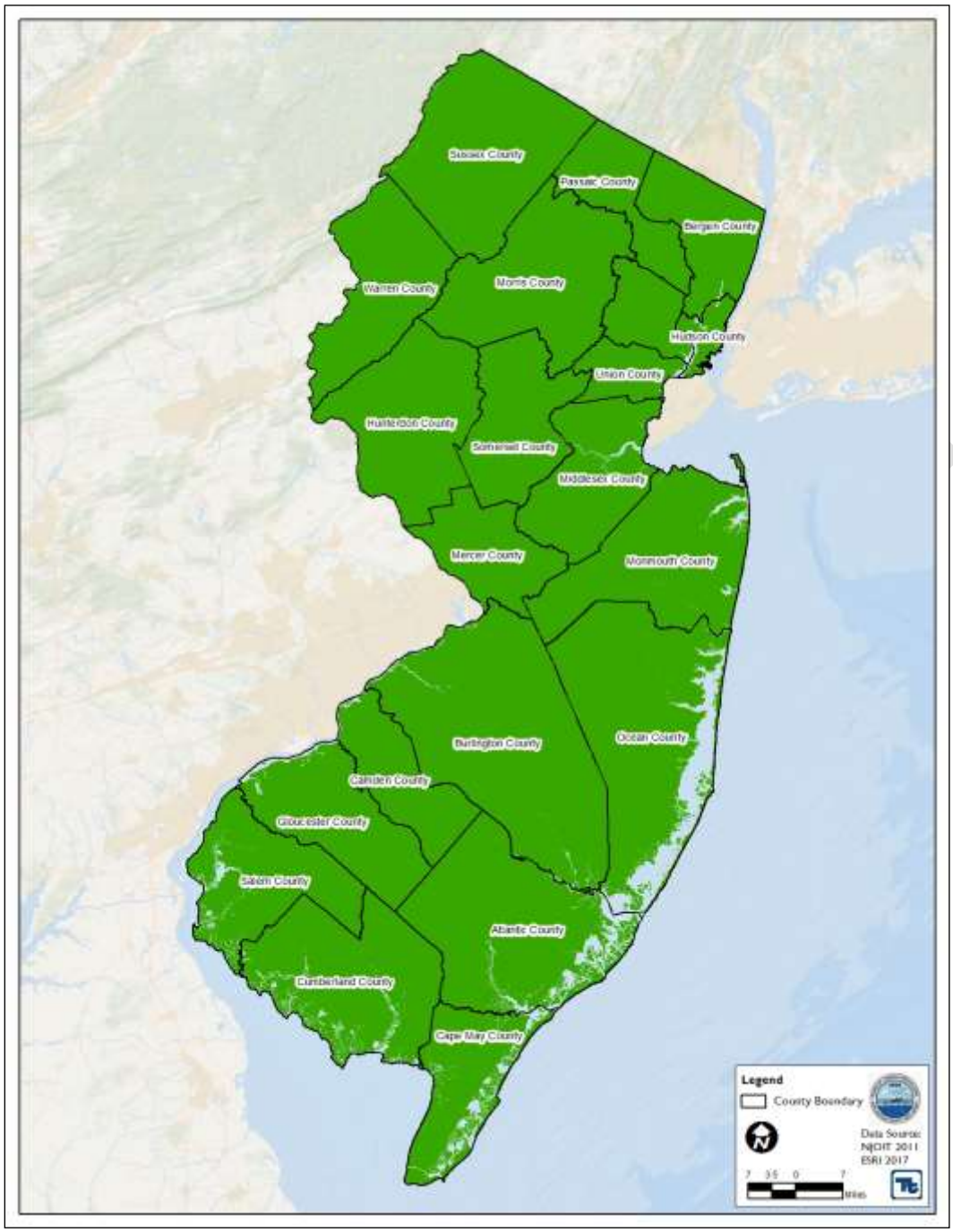
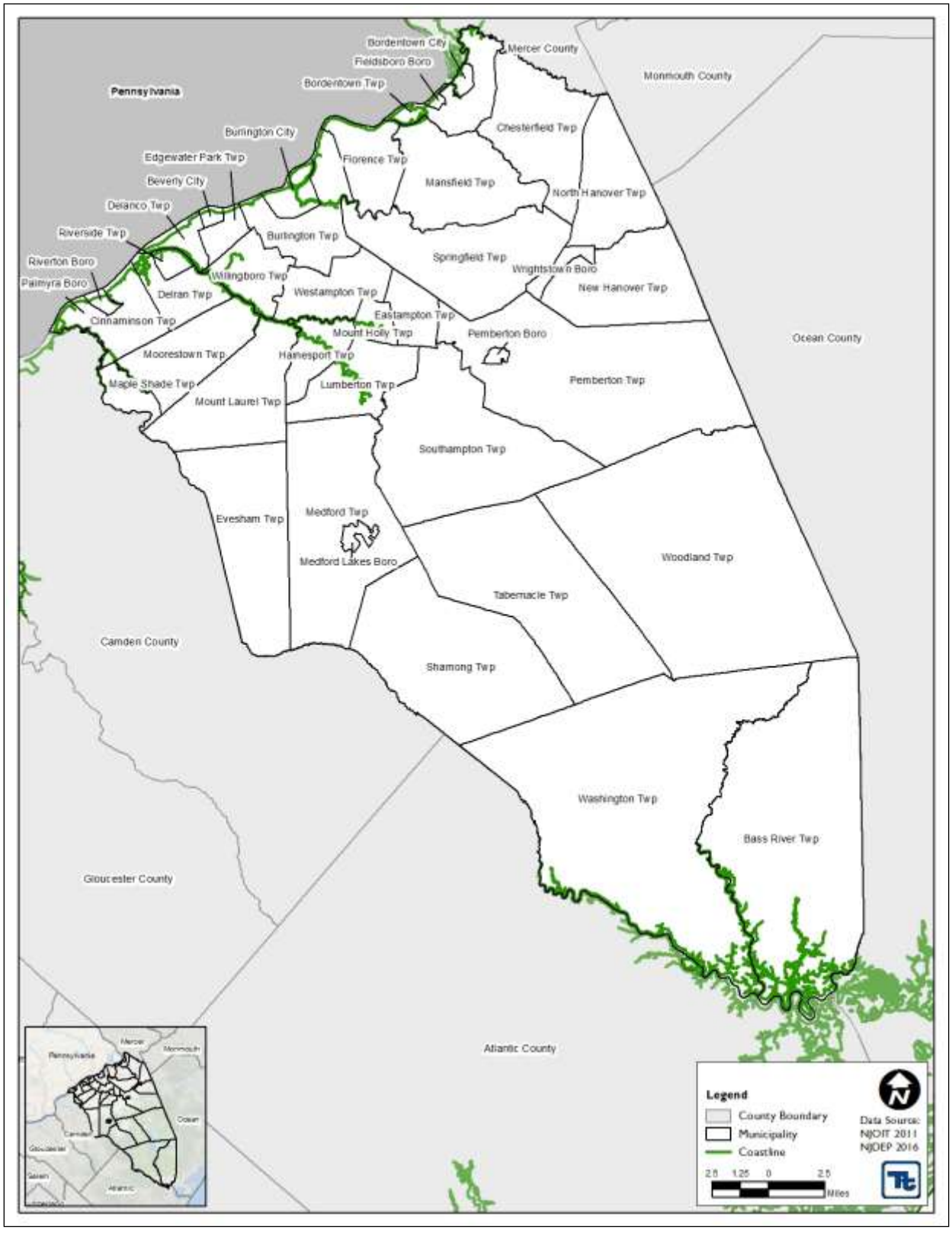


Figure 5.4.1-2. Coastline of Burlington County



Extent

Shorelines are affected by storms and other natural events that cause erosion; however, the extent and severity of erosion differs across the United States. It may be intensified by activities such as boat wakes, shoreline hardening, or dredging. Coastal erosion is classified as short-term and long-term. The long-term changes of shoreline may not be evident on a day-to-day or even year-to-year basis. They occur over a period of decades, over which short-term changes tend to average out to the underlying erosion or accretion trend. However, short-term changes due to storm events are immediately noticed. Short-term changes occur over periods ranging from a few days to a few years. They can be highly variable in direction and magnitude. Natural recovery after erosive episodes can take months or years. If a shoreline 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 1997).

Coastal erosion hazards and the vulnerability of development and infrastructure vary significantly by geographic region. By virtue of their location at the interface between oceans and land, coastal areas are among the most dynamic environments on earth susceptible to a broad range of natural hazards. Many parts of New Jersey's densely populated coast are highly vulnerable to the effects of flooding, storm surge, episodic erosion, chronic erosion, sea level rise, and extra-tropical storms. Much of the developed shoreline of New Jersey has been stabilized with seawalls and other armaments, which in some areas have caused extensive beach loss (NJOEM, 2012).

Erosion is typically expressed as a rate: rate of linear retreat (feet of shoreline recession per year) or volumetric loss (cubic yards of eroded sediment per linear foot of shoreline frontage per year). Erosion rates are cited as positive numbers, with corresponding shoreline change rates as negative numbers. For example, an erosion rate of two feet per year is equivalent to a shoreline change rate of -2 feet per year. Accretion rates are stated as positive numbers, with corresponding shoreline change rates as positive numbers. For example, an accretion rate of two feet per year is equivalent to a shoreline change rate of two feet per year.

Erosion rates are usually computed and cited as long-term, average annual rates. However, erosion rates are not uniform in time or space and can vary substantially. This includes: from one location along the shoreline to another, even when the two locations are only a short distance apart; over time at a single location; or seasonally (FEMA 2015).

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 for a variety of reasons. Many sources provided historical information regarding previous occurrences and losses associated with coastal erosion events throughout the State of New Jersey and Burlington County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

Between 1954 and 2017, the State of New Jersey was included in eight FEMA coastal erosion-related disasters (DR) or emergencies (EM), classified as one or a combination of the following event types: severe storm, flood, coastal storm, high tides, heavy rain, Nor'Easter, tropical storm, and hurricane. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties.

For this 2019 Plan Update, known coastal erosion events were not identified due to limitations in datasets that were researched. However, municipal specific erosion descriptions are described in Section 9.

Probability of Future Occurrences

Long-term coastal erosion is a continuous and dynamic process, impacting the coastal counties along the Atlantic Ocean, Delaware Bay, and Delaware River. It is anticipated that coastal erosion will continue due to the predicted increase in sea level rise and storm frequency and intensity. For Burlington County, impacts will vary from place to place along the surge-impacted areas of the County. As temperatures increase (see climate change impacts), the probability for future events will likely increase as well. It is estimated that Burlington County will continue to experience direct and indirect impacts of coastal erosion on occasion.

In Section 5.3, the identified hazards of concern for the County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for coastal erosion in the County is considered 'occasional' (likely to occur within 100 years, as presented in Table 5.3-3).

Impacts of Climate Change

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.

Temperatures in the Northeast United States have increased 1.5 degrees Fahrenheit (°F) on average since 1900. Most of this warming has occurred since 1970. The State of New Jersey, for example, has observed an increase in average annual temperatures of 1.2°F between the period of 1971-2000 and the most recent decade of 2001-2010 (ONJSC, 2011). Winter temperatures across the Northeast have seen an increase in average temperature of 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007). By the 2020s, the average annual temperature in New Jersey is projected to increase by 1.5°F to 3°F above the statewide baseline (1971 to 2000), which was 52.7°F. By 2050, the temperature is projected to increase 3°F to 5°F (Sustainable Jersey Climate Change Adaptation Task Force 2013).

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 predicted to increase to 0.5 inches/year (Miller and Kopp 2013).

Under a low emissions scenario, New Jersey coastal areas are likely (about 67% probability) to experience rates of 0.2-0.4 in/yr. through 2100. Under a high emissions scenario, New Jersey coastal areas are likely (about 67% probability) to experience rates of 0.3-0.5 in/yr. over the 2030-2050-time period and 0.3-0.7 in/yr. over the 2050-2100-time period (Kopp et al. 2016).

5.4.1.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. Coastal erosion may impact public safety, property, infrastructure, environmental resources and local economies. The following text evaluates and estimates the potential impact of coastal erosion on Burlington County. Figure 5.4.1-3 below displays the shoreline classifications for Burlington County; none of which are considered to be highly susceptible to coastal erosion. Refer to Section 5.2 for additional details on the methodology used to assess coastal erosion risk.

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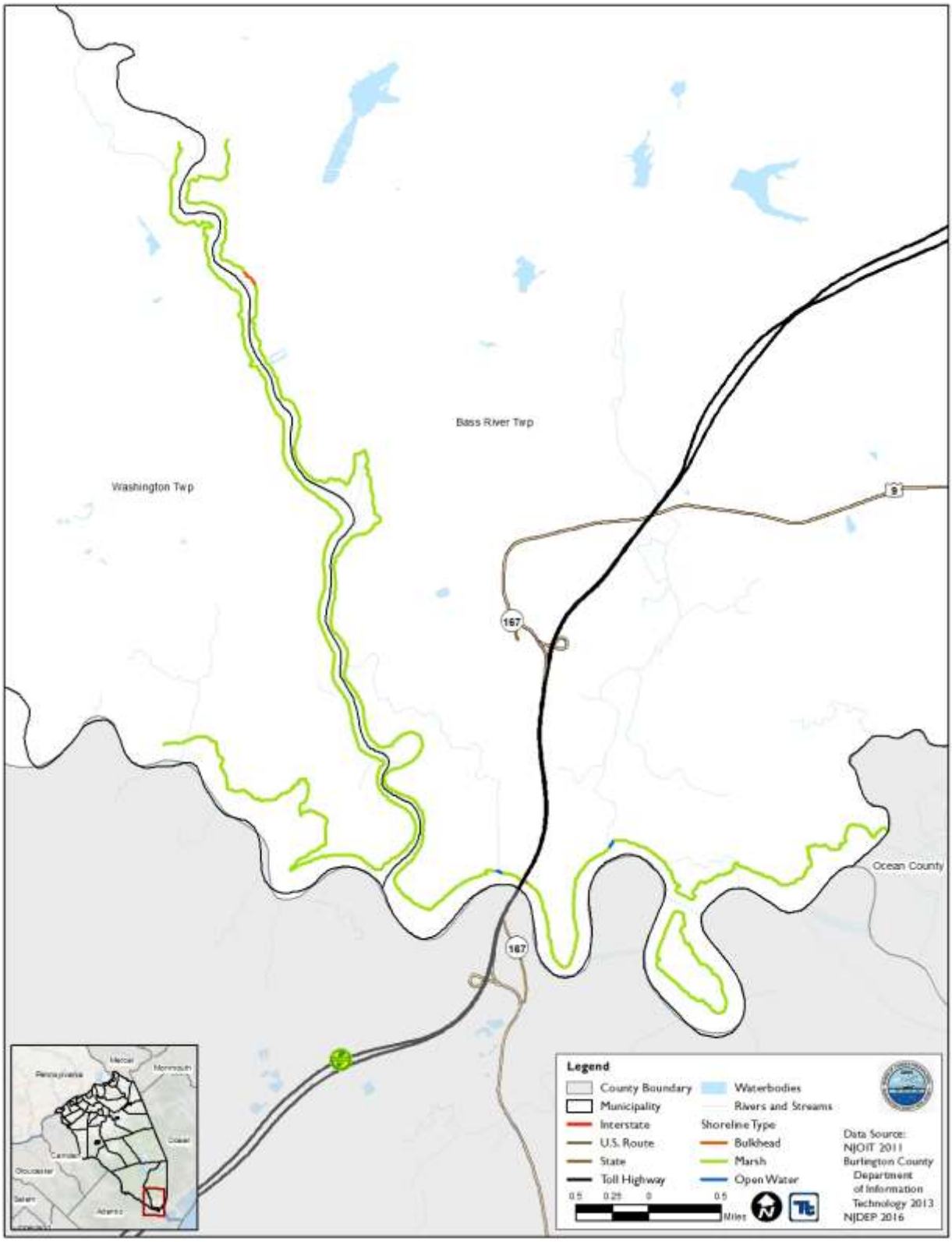
Figure 5.4.1-3. NJDEP Shoreline Classification for Burlington County



Impact on Life, Health and Safety

Coastal erosion is not generally considered an imminent threat to public safety when the changes are gradual over many years. However, drastic changes to the shoreline may occur as a result of a single storm event which can threaten homes and public safety. The population exposed, or located in the estimated hazard area, is also considered vulnerable to this hazard. None of the County is exposed to the 120' beach or erodible shoreline buffer hazard area, as defined in Section 5.2 – Methodology and Tools.

Table 5.4.1-1 summarizes these results by municipality. The analysis indicates that 2,668 people are located in the estimated 2-foot sea-level rise hazard area. Burlington Township has the greatest number of people exposed to the hazard area with 393 people (approximately 1.7% of the total population). However, while not having the greatest total exposure, Washington Township has the greatest percentage of its population exposed to the hazard area 32.6%. Socially vulnerable populations (e.g. the elderly and low-income populations) are particularly vulnerable to a hazard event. Of these 2,668 people, 340 people are over the age of 65 and 204 people considered low income populations.

Table 5.4.1-1. Estimated Population Exposed to the 2-foot Sea-Level Rise Scenario

Municipality	U.S. Census 2010 Population	Estimated Population Exposed	
		Number in the Sea-Level Rise Hazard Area	% of Total Exposed
Bass River Township	1,443	197	13.7%
Beverly City	2,577	0	0.0%
Bordentown City	3,924	69	1.8%
Bordentown Township	11,367	449	4.0%
Burlington City	9,920	59	0.6%
Burlington Township	22,594	393	1.7%
Cinnaminson Township	15,569	113	0.7%
Delanco Township	4,283	3	0.1%
Delran Township	16,896	289	1.7%
Edgewater Park Township	8,881	0	0.0%
Florence Township	12,109	0	0.0%
Hainesport Township	6,110	90	1.5%
Lumberton Township	12,559	216	1.7%
Mansfield Township	8,544	36	0.4%
Maple Shade Township	19,131	233	1.2%
Moorestown Township	20,726	0	0.0%
Mount Holly Township	9,536	0	0.0%
Mount Laurel Township	41,864	0	0.0%
Palmyra Borough	7,398	0	0.0%
Riverside Township	8,079	109	1.3%
Riverton Borough	2,779	10	0.4%
Springfield Township	3,414	38	1.1%

Municipality	U.S. Census 2010 Population	Estimated Population Exposed	
		Number in the Sea-Level Rise Hazard Area	% of Total Exposed
Washington Township	687	224	32.6%
Westampton Township	8,813	0	0.0%
Willingboro Township	31,629	140	0.4%
Burlington County	**448,734**	**2,668**	**0.6%**

Source: U.S. Census 2010, NOAA, 2016
Note: The NOAA 2-foot SLR boundary was overlaid on the U.S. Census block; the blocks with their centroids within the hazard are were totaled for each municipality.

Impact on General Building Stock

As detailed above, none of the County is exposed to the 120' beach or erodible shoreline buffer hazard area. Table 5.4.1-2 summarizes the total replacement cost value of buildings in the area mapped with 2-feet of sea level rise. Bass River Township has the greatest total number of buildings and percentage of its building stock located in the 2-foot sea level rise hazard area (59 buildings, of 3.2% of the total building stock, worth $62.4 million, or 6.1% of the Township's total replacement cost value).

Table 5.4.1-2. Estimated Buildings Exposed to the Coastal Erosion Hazard

Municipality	Total # Buildings	Total RCV (Structure and Contents)	Estimated Building Stock Exposed			
			Number in the Sea-Level Rise Hazard Area	% of Total Exposed	RCV in the Sea-Level Rise Hazard Area	% of Total Exposed
Bass River Township	1,863	$1,027,917,130	59	3.2%	$62,431,039	6.1%
Beverly City	964	$471,487,138	1	<1%	$73,441	<1%
Bordentown City	1,219	$1,244,995,904	1	<1%	$235,495	<1%
Bordentown Township	3,113	$2,820,041,247	7	<1%	$4,916,624	<1%
Burlington City	3,644	$3,215,233,092	16	<1%	$12,466,747	<1%
Burlington Township	7,757	$8,013,259,672	6	<1%	$4,767,843	<1%
Cinnaminson Township	6,358	$5,703,895,752	38	<1%	$26,507,336	<1%
Delanco Township	1,562	$1,422,201,479	22	1.4%	$22,228,590	1.6%
Delran Township	5,191	$5,145,622,596	33	<1%	$15,333,892	<1%
Edgewater Park Township	2,567	$2,307,285,215	1	<1%	$265,724	<1%
Florence Township	2,522	$2,787,263,607	0	0.0%	$0	0.0%
Hainesport Township	2,747	$3,447,208,735	27	1.0%	$76,170,793	2.2%
Lumberton Township	4,009	$5,459,557,257	8	<1%	$9,585,084	<1%
Mansfield Township	2,798	$4,056,501,589	0	0.0%	$0	0.0%
Maple Shade Township	6,006	$4,385,500,913	0	0.0%	$0	0.0%
Moorestown Township	8,736	$10,108,801,626	10	<1%	$32,373,121	<1%

Municipality	Total # Buildings	Total RCV (Structure and Contents)	Estimated Building Stock Exposed			
			Number in the Sea-Level Rise Hazard Area	% of Total Exposed	RCV in the Sea-Level Rise Hazard Area	% of Total Exposed
Mount Holly Township	4,573	$3,498,352,996	3	<1%	$5,654,446	<1%
Mount Laurel Township	12,900	$14,653,800,804	3	<1%	$10,098,807	<1%
Palmyra Borough	2,713	$1,788,398,557	2	<1%	$486,633	<1%
Riverside Township	2,868	$2,039,139,951	13	<1%	$4,865,588	<1%
Riverton Borough	1,274	$916,434,789	0	0.0%	$0	0.0%
Springfield Township	2,876	$3,853,514,909	1	0.0%	$1,486,222	<1%
Washington Township	939	$597,426,933	18	1.9%	$12,625,914	2.1%
Westampton Township	3,006	$4,269,433,407	10	<1%	$18,856,759	<1%
Willingboro Township	12,395	$8,259,747,413	7	<1%	$2,436,725	<1%
Burlington County	**173,044**	**$165,526,729,867**	**286**	**<1%**	**$323,866,823**	**<1%**

Source: Burlington County, NOAA 2016
Note: The NOAA 2-foot SLR boundary was overlaid on the custom general building stock inventory; the structures with their centroids within the hazard are were totaled for each municipality.

Impact on Critical Facilities

Coastal erosion can also impact critical facilities. It can degrade the surrounding infrastructure and utility lines, depending on their location on the property. This could inhibit the facilities ability to respond during or after an emergency event. In the case of a single, severe event, the structural foundation of a facility can be compromised as well. As detailed above, none of the County is exposed to the 120' beach or erodible shoreline buffer hazard area. There are 10 critical facilities located in the 2-foot sea-level rise hazard area. Of these 10, the majority are dams located within the hazard area; the frequent to permanent inundation of these dams will hinder each dam's ability to function as intended. Refer to Table 5.4.1-3 for these results by municipality and critical facility type.

Table 5.4.1-3. Critical Facilities Located in the Estimated Coastal Erosion Hazard Area

Municipality	Facility Type			
	Airport	Chemical	Dam	Tier Facility
Burlington City	0	0	0	1
Cinnaminson Township	0	1	3	0
Hainesport Township	0	0	1	0
Lumberton Township	0	0	1	0
Mount Holly Township	0	0	1	0
Palmyra Borough	0	0	0	1

Municipality	Facility Type			
	Airport	Chemical	Dam	Tier Facility
Washington Township	1	0	0	0
Burlington County	**1**	**1**	**6**	**2**

Source: Burlington County, NOAA 2016

Impact on Economy

Coastal erosion can also severely impact roads and infrastructure. None of the County's roadways are located within the 120' beach or erodible shoreline buffer. However, there are 6.1 miles of roadway (Interstate, US Route, State Route, County Route, and local roads) that lie within the 2-foot sea-level rise boundary. These include portions of I-295, NJ-38, NJ-413, NJ-73, NJ-90, US-130, US-206, US-9, Marne Highway, the Garden State Parkway, and the NJ Turnpike.

Future Growth and Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the County. Any areas of growth located in the defined coastal erosion hazard areas could be potentially impacted by coastal erosion similar to those that currently exist within the County. Please refer to Figure 5.4.1-4 for the potential new development in the County and the coastal erosion hazard area.

There are 8 recent and proposed developments around the County located in the 2-foot sea level rise hazard area. Burlington Township has the most developments located in the hazard area (3 developments). Refer to each jurisdictional annex for the results of each exposure analysis on new development.

Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of events that exacerbate coastal erosion. While predicting changes of coastal erosion under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society, and the environment (U.S. Environmental Protection Agency [EPA], 2006).

Impacts of climate change can lead to shoreline erosion, coastal flooding, and water pollution, affecting man-made coastal infrastructure and coastal ecosystems. 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. Additionally, oceans are absorbing more carbon dioxide from the rising atmospheric concentrations of the gas, resulting in oceans becoming more acidic. This could have significant impacts on coastal and marine ecosystems (EPA 2013). As previously stated, warmer temperatures may lead to an increase in frequency of storms, thus leading to more weather events with potentially increased severity, that cause coastal erosion.

Change of Vulnerability Since 2014 HMP

Burlington County and all plan participants continue to be vulnerable to the coastal erosion hazard. Several differences exist between the 2014 Plan and this update. For this plan update, an updated general building stock

based upon replacement cost value from MODIV tax assessment data and 2018 RS Means, and an updated critical facility inventory were used to assess the county's risk to the hazard areas. An updated hazard area was used as well; the 2016 sea-level rise spatial layer from FEMA was used. Overall, the 2016 FEMA spatial layer increased the 2-foot sea-level rise extent to encompass a larger area of the County; in Bass River Township, 24 people were exposed to the sea-level rise hazard, while in this plan update, there are 197 people exposed to the hazard area. The updated vulnerability assessment provides a more current exposure analysis for the county.

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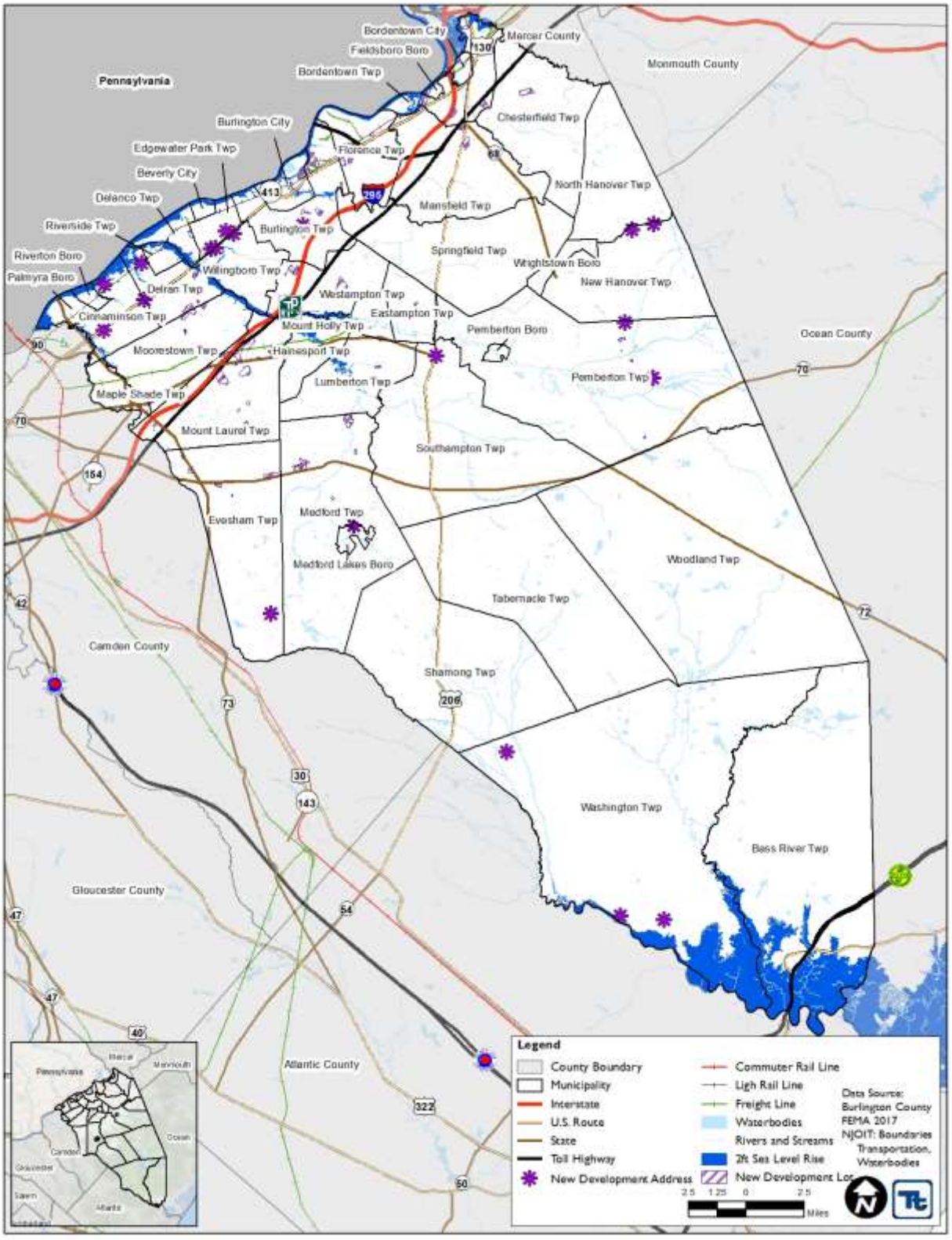
Figure 5.4.1-4. Potential New Development in Burlington and the Coastal Erosion Hazard Area



Source: FEMA 2017, Burlington County