4.0 RISK ASSESSMENT

4.0 RISK ASSESMENT

4.1 OVERVIEW AND CHANGES SINCE 2021

Hazard Identification

Jurisdictions in Monmouth County face vulnerability to both natural and man-made hazards. For the 2026 plan update, the Steering Committee reviewed the hazards that were included in the 2021 plan, the 2024 NJ State Hazard Mitigation Plan, and the history of events that has occurred since the previous update.

The 2026 plan update includes 15 natural hazards, and 7 human-caused hazards. Transportation Accidents was the only new hazard identified for this update. Tsunami, included in the previous plan was removed as a hazard of concern in this plan update due to low probability and low frequency of previous occurrences.

Hazard events not identified for inclusion at this time may be addressed during future evaluations and updates to the risk assessment if deemed necessary by the Steering Committee.

Hazard Ranking

The conclusions drawn from the planning process for Monmouth County, including input from the Steering Committee, resulted in the classification of risk for each identified hazard according to three categories: High Risk (H), Moderate Risk (M) and Low Risk (L). For purposes of these classifications, risk is expressed in relative terms according to the estimated impact that a hazard will have on human life and property throughout all of Monmouth County. It should be noted that although some hazards are classified below as posing low risk, their occurrence of varying or unprecedented magnitudes is still possible in some cases and their assigned classification will continue to be evaluated during future plan updates. **Table 4.1– 1 Hazard Risk Rankings for Monmouth County** presents conclusions on hazard risk for the County as a whole.

Table 4.1-1 Hazard Risk Rankings for Monmouth County

Hazard Risk Rankings for Monmouth County	
HIGH RISK	Hurricane and Tropical Storm Nor'easter Coastal Erosion Flood Storm Surge Wave Action Pandemic
MODERATE RISK	Dam Failure Extreme Temperatures Extreme Wind Tornado Winter Storm Wildfire Cyber Attack Economic Disruption Power Failure Terrorism Transportation Accidents
LOW RISK	Lightning Drought Earthquake Landslide Civil Unrest

4.2 RISK ASSESSMENT UPDATE PROCESS

This HMP was prepared in compliance with federal and State requirements for mitigation planning as established under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by the Disaster Mitigation Act of 2000 (42 USC 5165) as well as New Jersey Bill A2324 which requires hazard mitigation plans in the State to include climate change-related threat assessments and hazard prevention and mitigation strategies. For this plan update, the risk assessment process followed the intent identified in the current FEMA Local Planning Mitigation Policy Guide to focus the information in this section to what helps jurisdictions within the planning area to understand their historical, current, and future risk to identified natural and man-made hazards. Where possible, this risk assessment uses local, State, and federal data (in that order, depending on availability) to understand the locations that are most exposed to each hazard, the predicted level of impact and severity the County may face, how the hazard has affected communities in the County previously, and how climate change will influence risk and vulnerability to this hazard in the future. With this information, vulnerabilities were assessed, both qualitatively and quantitively. Where appropriate, FEMA's National Risk Index was used.

Input from municipalities, Steering Committee members, other stakeholders and members of the general public was used to refine the identification of hazards, their profiles, and the vulnerability assessments. The hazards in this report were selected for review based on research into hazards present in Monmouth County, reviewing the previous hazard mitigation plans for the State, Ocean County, and neighboring jurisdictions. Transportation Accidents was added as a new medium-risk hazard due to the several important regional transportation routes which pass through the County. Tsunami, a natural hazard included in the previous plan update, was removed from this iteration of the plan due to low perception of risk by the County and local jurisdictions as well as low frequency of past occurrences. Although still possible, tsunami triggers such as earthquakes are somewhat rare in the Atlantic Ocean.

In addition to this chapter, information on current and future flood risk is included in each jurisdictions annex. If a jurisdiction is particularly vulnerable to wildfire, that hazard is also included in the local risk assessment contained in the annex. Hazards that have consistent exposure and vulnerability across the County are detailed in this section.

4.3 IDENTIFICATION OF HAZARDS

Major Disaster Declarations

Table 4.3-1 FEMA Major Disaster Declarations in Monmouth County displays emergency and disaster declarations in Monmouth County. Presidential Major Disaster, Emergency, and Fire Management Assistance Declarations are issued when it has been determined that State and local governments need assistance in responding to a disaster event. There have been 21 Major Disaster Declarations and 10 Emergency Declarations since 1965.

Table 4.3-1 FEMA Major Disaster Declarations in Monmouth County

FEMA Disaster No.	Disaster Date	Type of Disaster
DR205	August 1965	Water shortage
DR310	September 1971	Heavy rains, flooding
DR519	August 1976	Severe storms, high winds, flooding
DR528	February 1977	Ice conditions
EM3083	October 1980	Water shortage
DR701	April 1984	Coastal storms, flooding
DR749	October 1985	Hurricane Gloria
DR936	March 1992	Coastal storm
DR519	August 1976	Severe storms, high winds, flooding
DR528	February 1977	Ice conditions

FEMA Disaster No.	Disaster Date	Type of Disaster
EM3083	October 1980	Water shortage
DR701	April 1984	Coastal storms, flooding
DR749	October 1985	Hurricane Gloria
DR936	March 1992	Coastal storm
DR973	December 1992	Coastal storm
EM3106	March 1993	Severe blizzard
DR1088	January 1996	Snow, blizzard
EM3148	September 1999	Hurricane Floyd
EM3156	November 2000	Virus threat
EM3169	September 2001	Terrorist attack emergency declaration
EM3181	March 2003	Snowstorm
EM3257	September 2005	Hurricane Katrina evacuation
DR1897	April 2, 2010	Severe Storms and Flooding
DR1954	February 4, 2011	Severe Winter Storm and Snowstorm
EM3332	August 2011	Hurricane Irene
DR4086	October – November 2012	Hurricane Sandy
EM3354	October – November 2012	Hurricane Sandy
DR4264	March 14, 2016	Severe Winter Storm and Snowstorm
DR4488	March 25,2023	COVID-19 Pandemic
DR4574	December 11, 2020	Tropical Storm Isaias
DR4614	September 5, 2021	Remnants of Hurricane Ida

Source: FEMA, 2024

Hazard Profile

This section includes detailed profiles for each of the hazards identified in the previous section. Each hazard profile includes a general description of the hazard, its location and extent, its magnitude or severity, notable historical occurrences and the probability of future occurrences. Profiles also include specific items noted by members of the Planning Committee as it relates to unique historical or anecdotal hazard information for Monmouth County or a particular municipal jurisdiction.

During the planning process individual jurisdictions were asked to rank each hazard. **Table 4.3 – 2 Natural Hazard Risk Rankings, by Jurisdiction** and **Table 4.3-3 Human-based Hazard Risk Rankings**, by Jurisdiction presents an overview of the resultant hazard risk rankings for each jurisdiction.

Table 4.3-2 Natural Hazard Risk Rankings, by Jurisdiction

Jurisdiction	Extreme Temperatures	Extreme Wind	Hurricane/ Tropical Storm	Lightning	Nor'easter	Tornado	Winter Storm	Coastal Erosion	Dam Failure	Landslide	Drought	Flood	Storm Surge	Wave Action	Earthquake	Wildfire
Aberdeen, Township of	M	M	H	L	H	M	M	H	N/A	N/A	L	H	H	M	L	L
Allenhurst, Borough of	M	M	M	L	H	M	M	M	N/A	N/A	L	H	H	M	L	L
Allentown, Borough of	M	M	M	L	M	M	M	N/A	H	N/A	M	L	N/A	N/A	L	L
Asbury Park, City of	M	M	H	L	H	M	M	M	N/A	N/A	L	H	H	M	L	L

Jurisdiction	Extreme Temperatures	Extreme Wind	Hurricane/ Tropical Storm	Lightning	Nor'easter	Tornado	Winter Storm	Coastal Erosion	Dam Failure	Landslide	Drought	Flood	Storm Surge	Wave Action	Earthquake	Wildfire
Atlantic Highlands, Borough of	M	H	H	L	H	M	M	M	N/A	H	L	H	H	M	L	L
Avon-By-The-Sea, Borough of	M	M	H	L	H	M	M	M	N/A	N/A	L	H	H	M	L	L
Belmar, Borough of	M	M	H	L	H	M	M	M	N/A	N/A	L	H	H	M	L	L
Bradley Beach, Borough of	M	M	H	L	H	M	M	M	N/A	N/A	L	H	H	M	L	L
Brielle, Borough of	M	M	H	L	H	M	M	M	N/A	N/A	M	H	H	M	L	L
Colts Neck, Township of	M	M	M	L	M	M	M	N/A	M	N/A	L	M	N/A	N/A	L	M
Deal, Borough of	M	M	H	L	H	M	M	H	N/A	N/A	L	H	H	M	L	L
Eatontown, Borough of	M	M	H	L	H	M	M	N/A	M	N/A	M	H	L	N/A	L	L
Englishtown, Borough of	M	M	M	L	H	M	M	N/A	L	N/A	L	H	N/A	N/A	L	L
Fair Haven, Borough of	M	M	H	L	H	M	M	M	N/A	L	L	M	H	M	L	L
Farmingdale, Borough of	M	M	M	L	H	M	M	N/A	N/A	L	L	H	N/A	N/A	L	L
Freehold, Borough of	M	M	M	L	H	M	M	N/A	N/A	N/A	L	L	N/A	N/A	L	L
Freehold, Township of	M	M	M	L	M	L	M	N/A	L	N/A	L	H	N/A	N/A	L	L
Hazlet, Township of	M	M	H	L	H	M	M	N/A	N/A	N/A	L	H	H	N/A	L	L
Highlands, Borough of	M	M	H	L	H	M	M	M	N/A	H	L	H	H	M	L	L
Holmdel, Township of	M	M	M	L	H	M	M	N/A	N/A	N/A	L	H	M	N/A	L	M
Howell, Township of	M	M	M	L	H	M	M	N/A	L	N/A	L	H	N/A	N/A	L	H
Interlaken, Borough of	M	M	H	L	H	M	M	N/A	N/A	N/A	L	H	H	N/A	L	L
Keansburg, Borough of	M	M	H	L	H	M	M	M	N/A	N/A	L	H	H	M	L	L
Keyport, Borough of	M	M	H	L	H	M	M	H	M	N/A	L	H	H	M	L	L
Lake Como, Borough of	M	M	H	L	H	M	M	N/A	N/A	L	L	H	H	L	L	L
Little Silver, Borough of	M	M	H	L	H	M	M	M	N/A	L	L	H	H	M	L	L
Loch Arbour, Village of	M	M	H	L	H	M	M	M	N/A	N/A	L	H	H	M	L	L

Jurisdiction	Extreme Temperatures	Extreme Wind	Hurricane/ Tropical Storm	Lightning	Nor'easter	Tornado	Winter Storm	Coastal Erosion	Dam Failure	Landslide	Drought	Flood	Storm Surge	Wave Action	Earthquake	Wildfire
Long Branch, City of	M	M	H	M	H	M	M	M	N/A	N/A	L	H	H	M	L	L
Manalapan, Township of	M	M	M	L	H	M	M	N/A	L	N/A	L	H	N/A	N/A	L	L
Manasquan, Borough of	M	M	H	L	H	M	M	M	N/A	N/A	L	H	H	M	L	L
Marlboro, Township of	M	M	M	L	H	M	M	N/A	L	L	L	H	N/A	N/A	L	L
Matawan, Borough of	M	M	M	L	H	M	M	N/A	H	N/A	L	H	H	N/A	L	L
Middletown, Township of	L	M	H	L	H	M	M	M	L	M	L	H	H	M	L	L
Millstone, Township of	M	M	M	L	H	M	M	N/A	M	L	L	M	N/A	N/A	L	H
Monmouth Beach, Borough of	L	M	H	L	H	M	M	H	N/A	N/A	L	H	H	M	L	L
Neptune City, Borough of	M	M	H	M	H	M	M	M	N/A	N/A	L	M	H	M	L	L
Neptune, Township of	M	M	H	L	H	M	M	M	L	N/A	L	H	H	M	L	L
Ocean, Township of	M	M	M	L	H	M	M	N/A	N/A	L	L	H	H	N/A	L	L
Oceanport, Borough of	M	M	H	L	H	M	M	M	N/A	L	L	H	H	H	L	L
Red Bank, Borough of	M	M	M	L	H	M	M	L	N/A	M	L	H	M	L	L	L
Roosevelt, Borough of	M	M	M	L	H	M	M	N/A	N/A	N/A	L	L	N/A	N/A	L	H
Rumson, Borough of	M	M	H	L	H	M	M	M	N/A	L	L	H	H	M	L	M
Sea Bright, Borough of	M	M	H	L	H	M	M	H	N/A	N/A	L	H	H	H	L	L
Sea Girt, Borough of	M	M	H	L	H	M	M	M	N/A	N/A	L	H	H	M	L	L
Shrewsbury, Borough of	M	M	H	L	H	M	M	N/A	N/A	L	L	H	M	N/A	L	L
Shrewsbury, Township of	M	M	M	L	M	M	M	N/A	N/A	N/A	L	L	N/A	N/A	L	L
Spring Lake, Borough of	M	M	H	L	H	M	M	H	N/A	N/A	L	H	H	M	L	L
Spring Lake Hts., Borough of	M	M	M	L	H	M	M	N/A	N/A	N/A	L	H	H	N/A	L	L
Tinton Falls, Borough of	M	M	M	L	H	M	M	N/A	L	M	L	H	M	N/A	L	M
Union Beach, Borough of	M	M	H	L	H	M	M	H	N/A	N/A	L	H	H	M	L	L

Jurisdiction	Extreme Temperatures	Extreme Wind	Hurricane/ Tropical Storm	Lightning	Nor'easter	Tornado	Winter Storm	Coastal Erosion	Dam Failure	Landslide	Drought	Flood	Storm Surge	Wave Action	Earthquake	Wildfire
Upper Freehold, Township of	M	M	H	H	H	M	M	M	L	N/A	M	H	H	M	L	L
Wall, Township of	M	M	M	L	H	L	M	M	M	N/A	L	M	M	M	L	M
West Long Branch, Borough of	M	M	M	L	H	M	M	N/A	N/A	N/A	L	M	H	N/A	L	L
Monmouth County	**M**	**M**	**N**	**L**	**N**	**M**	**M**	**N**	**L**	**M**	**L**	**N**	**N**	**N**	**L**	**M**

Table 4.3-3 Human-based Hazard Risk Rankings, by Jurisdiction

Jurisdiction	Civil Unrest	Cyber Attack	Economic Disruption	Pandemic	Power Failure	Terrorism	Transportation Accidents
Aberdeen, Township of	L	M	M	H	L	M	M
Allenhurst, Borough of	M	M	M	H	M	M	M
Allentown, Borough of	L	L	L	H	M	L	M
Asbury Park, City of	M	M	M	H	L	M	M
Atlantic Highlands, Borough of	L	M	M	H	M	M	M
Avon-By-The-Sea, Borough of	L	M	M	H	L	M	M
Belmar, Borough of	L	M	M	H	M	M	M
Bradley Beach, Borough of	L	M	M	H	L	M	M
Brielle, Borough of	L	M	M	H	M	M	M
Colts Neck, Township of	L	M	M	H	M	M	M
Deal, Borough of	L	M	M	H	L	M	M
Eatontown, Borough of	L	M	M	M	L	M	M
Englishtown, Borough of	L	M	M	H	L	M	M
Fair Haven, Borough of	L	M	M	H	M	M	M
Farmingdale, Borough of	L	M	M	H	H	M	M
Freehold, Borough of	L	M	M	H	M	M	M
Freehold, Township of	L	H	M	H	L	M	M
Hazlet, Township of	L	M	M	H	M	M	M
Highlands, Borough of	L	M	M	H	H	M	M
Holmdel, Township of	L	M	M	H	M	H	M
Howell, Township of	M	M	M	H	H	M	M
Interlaken, Borough of	L	M	M	H	L	M	M
Keansburg, Borough of	L	M	M	H	L	M	M
Keyport, Borough of	M	M	M	H	M	M	M
Lake Como, Borough of	L	M	M	H	M	M	M
Little Silver, Borough of	L	M	M	H	M	M	M
Loch Arbour, Village of	L	M	M	H	L	M	M
Long Branch, City of	L	M	M	H	M	M	M
Manalapan, Township of	L	M	M	H	L	M	M

Jurisdiction	Civil Unrest	Cyber Attack	Economic Disruption	Pandemic	Power Failure	Terrorism	Transportation Accidents
Manasquan, Borough of	L	M	M	M	L	M	M
Marlboro, Township of	L	M	M	H	H	M	M
Matawan, Borough of	L	M	M	M	M	M	M
Middletown, Township of	L	M	M	M	M	M	M
Millstone, Township of	L	M	M	H	H	M	M
Monmouth Beach, Borough of	L	M	M	M	M	M	M
Neptune City, Borough of	L	M	M	H	L	M	M
Neptune, Township of	L	M	M	H	L	M	M
Ocean, Township of	L	M	M	H	M	M	M
Oceanport, Borough of	L	M	M	H	L	M	M
Red Bank, Borough of	L	M	M	H	L	M	M
Roosevelt, Borough of	L	M	M	H	M	L	M
Rumson, Borough of	L	M	M	H	L	M	M
Sea Bright, Borough of	L	M	M	H	L	M	M
Sea Girt, Borough of	L	M	M	H	M	M	M
Shrewsbury, Borough of	L	M	L	H	L	M	M
Shrewsbury, Township of	L	M	M	H	L	M	M
Spring Lake, Borough of	L	M	M	H	L	M	M
Spring Lake Hts., Borough of	L	M	M	H	L	M	M
Tinton Falls, Borough of	L	M	M	H	M	M	M
Union Beach, Borough of	L	M	M	H	L	M	M
Upper Freehold, Township of	L	M	M	H	H	M	M
Wall, Township of	L	M	M	H	H	M	M
West Long Branch, Borough of	L	M	M	H	H	M	M
Monmouth County	**L**	**M**	**M**	**H**	**L**	**M**	**M**

Identification and Characterization of Assets in Hazard Areas

An inventory of Monmouth County's georeferenced assets (identified assets with specific, identified locations) was created in order to identify and characterize property and persons potentially at risk to the identified hazards. By understanding the type and number of assets that exist and where they are located in relation to known hazard areas, the relative risk and vulnerability for such assets can be assessed using GIS analysis.

Critical Facilities were identified in cooperation with each municipality using FEMA's Community Lifelines as a framework. FEMA created the eight Community Lifelines to contextualize information from incidents, communicate impacts in plain language, and promote a more unified effort across a community that focuses on stabilization of these lifelines during response. The eight categories of community lifelines are:

- Safety and Security
- Food, Hydration, Shelter
- Health and Medical
- Energy
- Communications
- Transportation
- Hazardous Materials

- Water System

These community lifelines must continue to operate before, during, and after an emergency and/or hazard event and/or are vital to health and safety. Community lifelines have been identified as the most fundamental services in each community that when stabilized enable all other aspects of society to function. A total of 1,207 lifelines were identified for this update. The critical facilities, infrastructure and community lifelines spatial inventory includes assets that, although not always publicly owned, have been defined as critical in accordance with the above definitions. **Table 4.3-4 Number of Critical Facilities in Each Community Lifeline Category by Jurisdiction** summarizes the number of identified community lifelines in each jurisdiction.

Table 4.3-4 Number Of Critical Facilities in Each Community Lifeline Category by Jurisdiction

Jurisdiction	Commu-nications	Energy	Food, Hydration, Shelter	Hazardous Materials	Health & Medical	Safety & Security	Trans-portation	Water Systems
Aberdeen, Township of	0	0	0	0	1	21	0	1
Allenhurst, Borough of	0	1	0	0	1	2	1	0
Allentown, Borough of	0	0	0	0	0	7	0	4
Asbury Park, City of	3	0	0	0	1	20	1	2
Atlantic Highlands, Borough of	0	0	0	0	1	6	1	1
Avon-By-The-Sea, Borough of	0	0	0	0	1	4	0	2
Belmar, Borough of	1	1	1	0	0	8	1	2
Bradley Beach, Borough of	0	0	0	0	1	7	0	0
Brielle, Borough of	0	0	0	0	0	6	0	6
Colts Neck, Township of	0	0	0	0	1	15	0	7
Deal, Borough of	0	0	0	0	1	5	0	0
Eatontown, Borough of	1	1	0	2	1	19	0	1
Englishtown, Borough of	0	0	0	0	0	5	0	3
Fair Haven, Borough of	1	0	0	0	1	8	0	1
Farmingdale, Borough of	0	0	0	0	1	4	0	0
Freehold, Borough of	0	1	0	0	2	20	0	8
Freehold, Township of	0	0	1	2	2	43	0	10
Hazlet, Township of	0	0	0	0	0	25	1	0
Highlands, Borough of	0	0	0	0	1	6	1	0
Holmdel, Township of	0	0	0	0	2	19	0	6
Howell, Township of	0	0	0	0	2	46	0	14
Interlaken, Borough of	0	0	0	0	0	2	0	0
Keansburg, Borough of	0	0	0	0	1	11	0	0
Keyport, Borough of	1	1	0	1	4	14	8	7
Lake Como, Borough of	1	0	0	0	0	4	1	0
Little Silver, Borough of	0	0	0	0	1	9	0	0
Loch Arbour, Village of	0	0	0	0	2	34	2	2
Long Branch, City of	0	0	0	0	1	33	0	1
Manalapan, Township of	0	0	0	0	0	0	0	15
Manasquan, Borough of	0	0	0	0	1	10	0	0
Marlboro, Township of	0	0	0	0	2	27	1	5
Matawan, Borough of	0	0	0	0	1	11	0	2
Middletown, Township of	0	0	0	0	6	78	2	7
Millstone, Township of	0	0	0	0	1	9	0	7
Monmouth Beach, Borough of	3	1	0	0	1	4	0	1

Jurisdiction	Commu-nications	Energy	Food, Hydration, Shelter	Hazardous Materials	Health & Medical	Safety & Security	Trans-portation	Water Systems
Neptune City, Borough of	0	0	0	0	1	5	0	1
Neptune, Township of	4	1	0	3	5	38	1	7
Ocean, Township of	0	0	0	0	2	36	0	6
Oceanport, Borough of	0	0	0	0	1	4	0	0
Red Bank, Borough of	0	0	0	0	3	21	0	0
Roosevelt, Borough of	0	0	0	0	1	3	0	0
Rumson, Borough of	0	0	0	0	1	11	0	0
Sea Bright, Borough of	0	0	0	0	1	2	0	0
Sea Girt, Borough of	0	0	0	0	0	5	0	2
Shrewsbury, Borough of	0	0	0	0	1	9	0	0
Shrewsbury, Township of	0	0	0	0	0	0	0	0
Spring Lake, Borough of	0	0	0	0	0	9	0	1
Spring Lake Heights, Borough of	0	0	0	0	0	6	0	0
Tinton Falls, Borough of	0	0	0	0	3	25	1	2
Union Beach, Borough of	0	1	0	1	1	10	0	1
Upper Freehold, Township of	0	2	1	0	1	7	1	18
Wall, Township of	0	0	0	0	2	32	1	14
West Long Branch, Borough of	0	0	0	0	1	13	0	2
Monmouth County	**15**	**10**	**3**	**9**	**65**	**775**	**24**	**169**

Source: Monmouth County Jurisdictions

Information regarding critical facilities, infrastructure, and the attributes and locations of community lifelines are considered sensitive in nature. Therefore, all assets reported in the HMP Update will be at the aggregate level (by type or jurisdiction). Individual assets will not be specifically identified.

Vulnerability Of Assets

All assets throughout Monmouth County are exposed to extreme temperatures, extreme winds, hurricanes and tropical storms, lightning, nor'easters, tornadoes, winter storms, drought and earthquakes. Some hazards have discrete, delineable hazard areas associated with them. In other words, lines can be drawn on a map to show approximate areas that are potentially susceptible to the hazard versus those that are not. For the hazards with delineable hazard areas (i.e., flood and sea level rise), tables showing the exposure of Monmouth County's critical facilities by jurisdiction are included in the corresponding hazard sub-sections. Exposure of these assets was determined through GIS analysis of hazard areas using georeferenced point locations for critical facilities, which were aggregated by community lifeline type.

Damage Estimates

Methodology

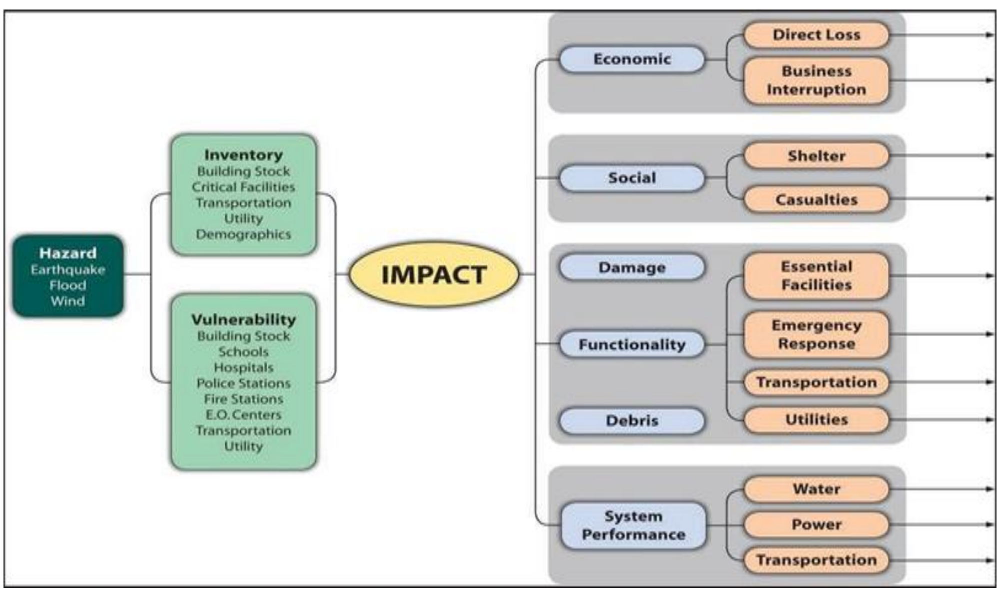
This multi-jurisdictional vulnerability assessment was conducted with two distinct methodologies, utilizing GIS-based analysis and using FEMA National Risk Index data. Each approach provides estimates for the potential impact of hazards by using a common, systematic framework for evaluation, including historical occurrence information. The results of the multi- jurisdictional vulnerability assessment are provided for each hazard immediately following the Hazard Profiles of each hazard. Below is a brief description of these approaches.

GIS-Based Analysis

For GIS-based assessment, digital data was collected from local, State, and national sources. ESRI® ArcGIS™ Pro 3.3.0 was used to assess risk utilizing digital data including local tax records for individual parcels and georeferenced point locations for critical facilities. Using these data layers, vulnerability was assessed to determine where these assets intersected with delineable hazard areas. HAZUS-MH is used to model hurricane winds, riverine flood, and earthquakes, and estimate potential losses for these hazards. HAZUS-MH is FEMA's standardized loss estimation software program built upon an integrated GIS platform (see **Figure 4.3 – 4 Conceptual Model of HAZUS-MH Methodology**) to conduct analysis at a regional level (i.e., not on a structure-by-structure basis). The objective of the GIS-based analysis was to determine the estimated vulnerability of people, buildings and critical facilities to the identified hazards for Monmouth County using best available geospatial data. A more specific description of the GIS-based analysis for each particular hazard is provided under the vulnerability assessment section of each respective hazard.

The HAZUS-MH risk assessment methodology is parametric, in that distinct hazard and inventory parameters (i.e., wind speed and building types) were modeled using the HAZUS-MH software to determine the impact (i.e., damages and losses) on the built environment. This risk assessment applied HAZUS-MH to produce countywide profiles and estimate losses for hazards at the jurisdictional level. This HMP update uses HAZUS-MH version 7.0, which is run at a Level 2 analysis, with updated census tract data, critical facilities, and depth grids for preliminary and effective FEMA Flood Insurance Rate Maps (FIRMs) for the 1% Annual Chance Flood Event. For the 2021 Plan, the analyses were run using HAZUS-MH 4.2. A Level 1 analysis yields a rough estimate based on the nationwide database and is a great way to begin the risk assessment process and prioritize high-risk communities. In contrast, the Level 2 analysis type used for this Plan Update produces more accurate loss estimates by including detailed information on local hazard conditions and/or by replacing the national default inventories with more accurate local inventories of buildings, essential facilities and other infrastructure.

Figure 4.3-1 Conceptual Model of HAZUS-MH Methodology



The results of the HAZUS-MH model analysis include annualized loss estimates for each jurisdiction so that potential loss values may be compared to one another throughout Monmouth County.

National Risk Index (NRI) Methodology

In order to estimate losses for hazards of concern that were outside the scope of HAZUS-MH and the GIS-based risk assessment, data from FEMA's National Risk Index was used. FEMA's National Risk Index dataset and online tool leverages data on natural hazards and community risk factors to develop a baseline risk measurement for 18 natural hazards by County and Census tract (FEMA, n.d.). Expected annual loss (EAL) is the natural hazards component of the National Risk Index; the EAL score and rating represent the average economic loss in dollars resulting from natural hazards each year for a community when compared to all other communities at the same level. The following formula was used to calculate the EAL:

$$Exposure * Annualized\ Frequncy * Historic\ Loss\ Ratio = Estimated\ Potential\ Annual\ Loss$$

Exposure is the representative value of buildings, population, or agriculture potentially exposed to a natural hazard consequence. Annualized frequency is the expected frequency or probability of a natural hazard occurrence per year. Historic loss ratio is the estimated percentage of the exposed building value, population, or agriculture value expected to be lost due to a natural hazard occurrence (FEMA, n.d.).

Risk is presented in terms of EAL in dollars. Building EAL is the predominant measure used across hazards, however, depending on the nature of the hazard, in some instances agricultural EAL, population equivalence EAL, or total EAL (the sum of building, agricultural and population equivalence EAL) is used. In general, presenting results in the annualized form is useful in three ways:

- This approach accounts for the contribution of potential losses from all future disasters;
- Annualized results for different hazards are readily comparable, thus easier to rank; and
- The use of annualized losses is the most objective approach for evaluating mitigation alternatives.

Loss estimates provided in this vulnerability assessment are based on best available data, and the methodologies applied result in an approximation of risk. These estimates should be used to understand relative risk from hazards and potential losses. Uncertainties are inherent in any loss estimation methodology, arising in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from approximations and simplifications that are necessary for a comprehensive analysis (i.e., incomplete inventories, demographics or economic parameters). Additionally, because NRI data is available at the census tract level. In instances where one or more municipalities were located within the census tract, loss estimates were divided equally between all municipalities regardless of population or building density.

Resilience Analysis and Planning Tool (RAPT) Methodology

FEMA's Resilience Analysis and Planning Tool (RAPT) is a data and GIS mapping tool used to understand community risk. RAPT was used in the dam failure section as a vulnerability analysis of dam failure is not within the scope of the HAZUS or NRI methodologies. RAPT was used to conduct a spatial analysis of each high hazard potential dam to vulnerable populations and critical infrastructure within the planning area. In order to understand the impact of a potential dam failure, RAPT's incident analysis tool was used. The tool allows the user to create a buffer zone (or incident area) around an incident, in this case, dam failure, by setting an incident location. A 5-mile buffer was selected to estimate the at-risk area. The tool identifies critical facilities within the buffer zone. Additionally, the population counter tool was used which provides the estimated number of people with a specific characteristic within a drawn shape, by using the same 5-mile buffer around the dam.

Findings for each hazard are detailed in the hazard-by-hazard vulnerability assessment that follows each Hazard Profile.

Hazards Potential Impact on the Future

Potential for Future Development to Impact Vulnerability for Hazards

As more residential and commercial buildings, infrastructure, public facilities and other assets are constructed, potential future hazard vulnerability is likely to increase. In general, more people, buildings, and infrastructure will be exposed to natural hazards over time. If current demographic trends continue, the proportion of the population representing young children, the elderly, and those with other special needs is likely to increase somewhat in the foreseeable future. Monmouth County is cognizant of the risks that it faces due to the impacts of natural hazards. Management of risk in the midst of growth is of paramount importance in each community's overall attainment of sustainability and disaster resiliency. Many municipalities have programs in place today which address certain natural hazards - whether it is a comprehensive or master plan, floodplain management ordinance, or erosion hazard area construction limitations. New development on undeveloped parcels will increase exposure to natural hazards - though many impacts are expected to be reduced or eliminated because they are built to codes and standards which, in many cases, offer a certain degree of protection from future damages. In addition to development of undeveloped parcels, Monmouth County's more densely populated areas (particularly in the Coastal and Bayshore communities that are essentially built out) are undergoing significant redevelopment. Older buildings (built before current codes and standards were adopted) are being demolished and replaced with new buildings built to current codes and standards. This trend has been observed in Monmouth County in recent years, and it has been exacerbated due to the recovery process from the devastating impacts of Superstorm Sandy. This type of development in hazard areas is actually working to somewhat reduce overall vulnerabilities for those parcels due to the fact that the redeveloped structures are being built to higher codes and standards than the previous structures had been.

In terms of conditions affecting vulnerability, redevelopment would likely offer some reduction in community vulnerability with substantial improvements bringing pre-existing building stock into compliance with current codes and standards, thus offering a certain degree of protection from future events. Greenfield development, on the other hand (that development that occurs on previously undeveloped parcels), is more likely to result in an increase in a community's vulnerability to the hazards because it represents an increase in exposure of people and property.

Note that new construction must comply with more stringent building codes than those that existed in decades past. Therefore, any substandard housing units replaced by new units through infill or redevelopment would be required to be built to higher codes and standards which in many cases would incorporate various levels of disaster resistance. For an example, replacing a pre- FIRM residential structure with a building elevated above the Base Flood Elevation (BFE) could increase community resiliency and decrease vulnerability. However, at the same time, when parcels are redeveloped with higher value and larger structures (i.e. going from a two-bedroom cottage to a four-bedroom house), these factors would contribute to an increase in vulnerability at that same site. For the purposes of this planning level assessment, it has generally been assumed that infill and redevelopment would not typically result in a significant increase in a community's overall vulnerability. This assumption should be re-evaluated by the County Planning Department based on present-day conditions at the time of each future plan update.

NATURAL HAZARDS

4.4 COASTAL EROSION

Hazard Description

Coastal erosion is the landward displacement of a shoreline caused by the forces of waves and currents. 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 associated with episodic events such as hurricanes and tropical storms, nor'easters, storm surge and coastal flooding, but may also be caused by human activities that alter sediment transport. Construction of shoreline protection structures can mitigate the hazard but may also exacerbate it under some circumstances.

Location and Extent

All of Monmouth County's coastal jurisdictions are susceptible to the coastal erosion hazard to varying degrees depending on the type of shoreline they contain. Following a review of historic shoreline data dating back to 1836 provided by the New Jersey Department of Environmental Protection (NJDEP), it is clear that Monmouth County has experienced significantly changing shorelines (moving landward and seaward) due to the effects of erosion, accretion, beach nourishment and structural shoreline protection measures.

As can be seen in Figure 4.4-1 most of Monmouth County's shoreline is classified as susceptible to coastal erosion (including "beach" and "erodible" classifications). Coastal erosion in these areas, where coupled with densely developed or significant recreational shorelines, are routinely addressed through beach nourishment programs.

Figure 4.4-1 NJDEP Shoreline Classifications for Monmouth County

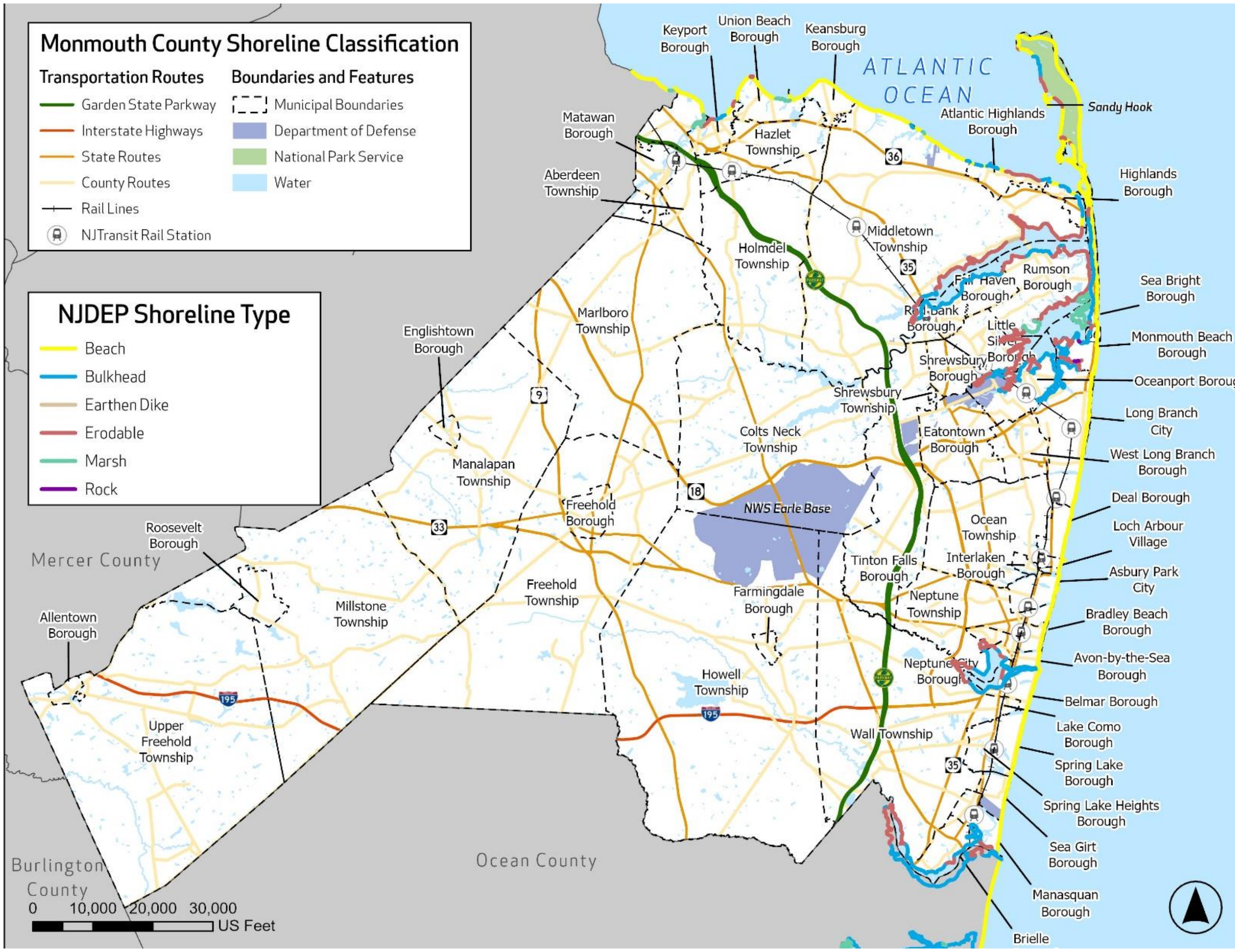


Figure 4.4 - 1 NJDEP Shoreline Classifications for Monmouth County illustrates the type of shorelines in Monmouth County as classified by NJDEP. **Table 4.4-1 Shoreline Types of Monmouth County** below details the types of shoreline, their definitions, and the overall mileage of shoreline of that type in Monmouth County.

Table 4.4-1 Shoreline Types of Monmouth County

Shoreline Type	Description	Mileage
Beach	Waterfront areas comprised of 100 percent sand.	36.8
Bulkhead	Manmade structures at the water's edge, after the riprap, which were designed to hold back water and protect the adjacent areas from erosion.	39.7
Marsh	Areas of natural marsh edge.	6.4
Earthen Dike	Structures which serve as natural barriers between the land and the water.	0.5
Erodible	Any soft shoreline other than beach, rock, marsh or earthen dike, which are vulnerable at the water's edge.	34.9
Rock	All riprap shorelines.	0.2
	Total	**118.32**

Source: NJDEP, 2024

The State HMP 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). Monmouth County is reported to have 0 breakwaters, 172 groins, 9 jetties, 1 revetment, and 11 seawalls. Although not identified in the 1993 State HMP or shown on the countywide map below, there are also many shoreline protection features located along the Monmouth County shore that are designed to reduce coastal storm and erosion hazards. These include hard structures such as jetties, groins, revetments, sea walls and breakwaters. Jetties and groins are protective structures (usually built from rock, wood or concrete) which extend outward from the shoreline. They look alike and provide similar function, but the difference between the two is that jetties are located at inlets, while groins are located along beaches. Sea walls are similar to bulkheads in function, but unlike bulkheads, they are located along the high beach line adjacent to the ocean, protecting property from ocean forces. Revetments are sea walls, which are surrounded on either side by rock or earth fill. A breakwater structure is a protective barrier placed in the water, out in front of a harbor.

In addition to hard structures, some areas also feature coastal protection systems incorporating engineered dunes and beaches, which are maintained through regular scheduled maintenance and nourishment. Failure to continue these activities would result in an increased risk of damage in many areas during coastal storm events, as the levels of protection are degraded. However, local government entities within Monmouth County and the State of New Jersey have been very active in cooperating with Federal government agencies to ensure that these activities continue to be implemented and adequately maintained. These practices are encouraged and expected to continue. Additionally, nature-based strategies such as living shorelines protect shorelines from erosion while also preserving, enhancing, or creating habitat have seen success in Monmouth County as demonstrated by projects such as the Sylvan Lake Restoration and Resilience Project.

Range of Magnitude

Monmouth County contains 27 miles of Atlantic Ocean coastline and 26 miles of Raritan Bay coastline, all of which is vulnerable to erosion. In 1986, the Richard Stockton College Coastal Research Center (CRC) established the New Jersey Beach Profile Network (NJBPN) for the purpose of monitoring shoreline conditions along the coastline of New Jersey. NJBPN is made up of beach profile sites along the State's entire shoreline, including Monmouth County. 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 (retreat or advance) in shoreline position and loss or gain of sand volume. Information from the 2016 and 2020 reports related to Monmouth County is included below .

There are 102 monitoring sites in Monmouth County that extend from the eastern beaches of the Raritan Bay to the oceanfront shoreline of Sandy Hook and south to Manasquan Inlet. Sixty-seven of these sites were added in the Fall of 2017 to increase monitoring capacity and because of the complexity of its shoreline. Monmouth County is considered to be in good condition for volume and shoreline position when compared to the 1986 conditions. 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 30 years between 1986 and 2016 the County survey sites have averaged a net gain of sand volume and a shoreline advance average of 218 feet. (Richard Stockton College CRC, 2016). The average changes for all sites in the County was a shoreline advance and sand volume gain, which shows the benefits of beach nourishment work done in the study period (Stockton University CRC, 2021).

Previous Occurrences and Losses

The NJ State HMP reports 33 instances of coastal erosion affecting Monmouth County from 1936 to 2024 (see **Table 4.4-2 Historical Incidents of Coastal Erosion in Monmouth County**). Seven of these events have occurred since the last version of the plan was prepared in 2021.

Table 4.4-2 Historical Incidents of Coastal Erosion in Monmouth County

Date	Associated Hazard Event
March 6-8, 1962	Nor'easter
October 28-November 4, 1991	Nor'easter
September 22-26, 1992	Tropical Storm Danielle
December 10-17, 1992	Coastal Storm
August 8-25, 1994	Hurricane Felix
December 22-26, 1994	Storm
January 7-8, 1996	Blizzard
July 13, 1996	Tropical Storm Bertha
February 4-9, 1998	Nor'easter
April 16, 2007	Nor'easter
August 27-September 5, 2011	Hurricane Irene
October 29, 2011	Nor'easter
October 29, 2012	Superstorm Sandy
March 1-8, 2013	Nor'easter
January 23 – 30, 2015	Winter Storm Juno
Friday, October 02, 2015	Nor'easter
January 22 – 24, 2016	Blizzard
March 14, 2017	Nor'easter
September 5-26, 2017	Hurricane Jose
March 6-7, 2018	Nor'easter
September 8-12, 2018	Tropical Storm Gordon
October 8-13, 2019	Nor'easter/ Subtropical Storm Melissa
August 1-6, 2020	Tropical Storm Isaias
August 14-17, 2020	Tropical Storm Kyle
September 11-16 & 18-23, 2020	Hurricanes Paulette and Teddy
December 16-17, 2020	Nor'easter
January 31 – February 2, 2021	Nor'easter
May 28 – May 30, 2021	Nor'easter
October 9-12, 2021	Nor'easter
August 26 – September 1, 2021	Post Tropical Storm Ida
January 16-17, 2022	Winter Storm
May 6 – 11, 2022	Coastal Storm Event
September 29 – October 5, 2022	Hurricane Ian

Source: 2024 NJ State HMP

Some of the more recent notable events include:

January 6-8, 1996. The Blizzard of 1996 created erosion damage as a result of high winds and waves. Sand was scoured away by the blizzard, leaving some locations vulnerable to future storms with the worst damage from Manasquan southward. In Manasquan, the storm scoured vertically about four feet of beach for a 500-foot stretch.

July 13, 1996. As a result of Tropical Storm Bertha, Monmouth Beach suffered severe beach erosion. Fifty percent of the beach at the south of the borough was gone. This beach is one of dozens in New Jersey that was being replenished under a USACE project. There was little beach erosion elsewhere.

February 4, 1998. The strongest nor'easter of the winter caused continuous onshore flow resulting in moderate to severe beach erosion in Monmouth County. Two to four feet of beach were lost in most areas. At Sandy Hook, about 80 percent of the new sand placed in a replenishment project was lost as several hundred feet of beach disappeared. Both Bradley Beach and Ocean Grove were hard hit by erosion. The waves washed sand onto Ocean Avenue in Bradley Beach.

Hurricane Irene (August 27-28, 2011). Many Monmouth County communities were hard hit by this storm and suffered significant beach erosion as waves washed ashore. Irene produced three to five feet of storm surge and brought torrential rain, which caused significant inland flooding due to the ground already being saturated from previous rainstorms. Several roads and bridges were damaged as a result of Irene, such as the Hubbard Ave where a water pipe and ripped apart the pavement. Sea Girt's beach was eroded and its boardwalk was severely damaged. Significant beach erosion was reported in Long Branch. Most every coastal community in Monmouth County was impacted to some degree or another by erosion, including those with USACE beach nourishment projects.

Superstorm Sandy (October 29, 2012). Many Monmouth County communities were hard hit by this storm and suffered severe beach erosion as waves washed ashore. Richard Stockton College researchers noted nearly all of their 105 monitored beach sites showed evidence of sand volume losses (Richard Stockton College 2013). NOAA's National Centers for Environmental Information (NCEI) reports estimated that the average New Jersey beach became 30 to 40 feet narrower. Despite early USACE estimates that 12 million cubic yards of sand were lost as a result of the storm, later reports indicated that only 6.2 million cubic yards were lost as a result of Sandy (Thompson 2013). Displacement was reported to have occurred primarily in Monmouth and Ocean counties.

October 8-13, 2019. Nor'easter/Subtropical Storm Melissa. Of the 105 areas surveyed, 82 were determined to have minor beach or dune erosion, 15 had moderate beach or dune erosion and 8 had major beach or dune erosion. Monmouth County was also especially hard hit, where towns like Sea Bright and parts of Long Branch had 25 feet of erosion.

January 31 – February 2, 2021. This Nor'easter had sustained winds near 50 mph with gusts over 60 mph and generated sea height peak of 23 feet. Tides reached minor to moderate flood stage levels due to astronomical tides, strong onshore winds, and the proximity of the storm to the coast. Of the 81 sites surveyed, 54 were determined to have minor beach or dune erosion, 18 had moderate beach or dune erosion, and 9 had major beach or dune erosion.

Hurricane Ian (September 29 – October 5, 2022). The storm resulted in a prolonged period of onshore winds, with gusts near 60 mph and peak sea heights of 22 feet. All oceanfront and back bay locations reached minor flooding stages, with several approaching moderate flooding due to the several days of strong onshore winds and the proximity of the storm's center to the coast. Of the 81 sites surveyed statewide, 63 had minor beach or dune erosion, 6 had moderate beach or dune erosion, and 12 had major beach or dune erosion. Erosion was greatest on the barrier islands, but Monmouth County experienced substantial coastal erosion as well.

Probability of Future Occurrence

Coastal erosion remains a natural, dynamic and continuous process for Monmouth County's coastal jurisdictions. It has 100% probability of occurring in the future along unhardened areas of the coast, though the frequency and extent depends on storm events, stabilization measures, and long-term effects of climate change and sea level rise.

Potential Effects of Climate Change

The frequency and intensity of coastal storms and severe weather events is expected to increase in the future due to climate change. Hurricanes are likely to become more intense with rising ocean temperatures. Coastal erosion rates are likely to increase with rising sea-levels.

Vulnerability Assessment

Unlike other hazards, the coastal erosion hazard is best described as a relatively slow natural process occurring over the long term, with occasional major impacts wrought by episodic natural events such as hurricanes and nor'easters. Another complicating factor in accurately determining specific coastal erosion hazard areas is the continuous implementation of shoreline reinforcement or nourishment projects completed by federal, State, and local government agencies. Typically, areas of high concern with regard to long term coastal erosion are addressed through shoreline hardening or stabilization projects, such as seawalls, breakwaters and beach nourishment. The ability to continue successfully mitigating the effects of coastal erosion hazards throughout Monmouth County will therefore depend on regular shoreline monitoring and the design and implementation of site-specific solutions, as has been done in the past.

Built Environment, Infrastructure, Community Lifelines

Monmouth County and its jurisdictions have an active history of pursuing and implementing successful shoreline protection strategies, particularly through the nourishment of critically eroding beaches and for areas in which property is threatened by continued erosion. Due to these aggressively implemented beach nourishment projects and other mitigating factors, it appears likely that buildings in coastal erosion hazard areas would be protected from the hazard for at least a foreseeable 30-year planning window (through 2044). Average annual building damages directly attributable to the erosion hazard have been considered to be negligible for the purposes of this risk assessment, assuming that these ongoing beach nourishment and shoreline stabilization practices are expected to be maintained aggressively, implemented on an ongoing basis, and encouraged to continue.

Population and Economy

Death and injury are not typically associated with coastal erosion, as erosive processes along the coast occur over long durations during which people in the affected areas have sufficient times to evacuate. However, after an erosion event, there can be a safety risk from the steep drop off in height if the area is not repaired. Coastal erosion can also represent a major threat to the local economies of coastal communities that rely on the financial benefits of their recreational beaches such as some jurisdictions in Monmouth County.

Ecosystems and Natural Assets

Dunes, beaches, wetlands and other coastal ecosystems are an important natural resource for Monmouth County. They help protect the coast from storms and flooding, provide habitat for birds, small mammals, reptiles, amphibians, and insects. Coastal erosion can impact a variety of natural systems including beaches, wetlands, marshes, and coastal habitats, degrading their natural functions through loss of land, and conversion to open water areas. Additionally, shoreline hardening, while preventing erosion, can also have a negative impact on natural systems.

Potential for Future Development to Impact Hazard Vulnerability

Development in coastal communities has the potential to impact vulnerability to coastal erosion. A growing population creates a greater demand for land for housing, placing pressure on coastal and waterfront industries, recreation, and public access to the water (NOAA 2024). Shore communities also face development pressure from economic sources such as tourism. When development takes place along the shoreline, especially in previously undeveloped areas, it can block the inland migration of wetlands in response of sea level rise and change the amount of sediment delivered to coastal areas, accelerating erosion (Environmental Protection Agency [EPA], 2017). Development also has cumulative effects, for example, the erection of a new dock or pier may have a small natural resource impact on its own, but if adjacent channels are deepened to access the new pier, demand for more docks or supporting infrastructure/development in nearby areas may increase and cause more extensive impacts (NOAA 2024).

Additionally, some measures taken to prevent coastal erosion can unintentionally exacerbate it. The construction of "hard" shoreline stabilization structures such as jetties and seawalls built to protect development from the sea can contribute to coastal erosion in other areas. These structures can interfere with the natural flow of sand and sediments along the coast causing erosion in areas that are deprived of these sediments. Some of these structures also redirect wave energy to neighboring areas accelerating erosion.

Negative impacts of development can be mitigated by taking into account the natural dynamics of the coastline and implementing design strategies that minimize disruption to sediment transport and natural protective features. Examples include beach nourishment, dune restoration, and "soft" stabilization techniques such as living shorelines (FEMA 2020).

4.5 DAM FAILURE

Hazard Description

A dam is any artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water (FEMA 2020). Dam failure is the collapse, breach, or other failure of a dam structure that adversely impacts the dams ability to impound water. Dam failure can result from natural events, human-induced events, or a combination of the two. Dam failures can result from one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam
- Foundational defects including settlement and slope instability
- Settlement and cracking of concrete or embankment dams
- Inadequate maintenance and upkeep
- Piping and internal erosion of soil in embankment dams (ASDSO 2024)

Location and Extent

The NJDEP Dams Database has identified and classified 113 State-regulated dams and 17 other structures located within Monmouth County. NJDEP classifies "other structures" as dams that are less than five feet, have been removed, never built, or failed. Of the 113 dams, 12 dams have been classified as having "High Hazard Potential," meaning their failure will likely cause loss of life or extensive property damage. Of the 113 dams, 15 dams have been classified as having "Significant Hazard Potential," meaning their failure may cause significant damage to property and project operation, but loss of human life is not probable. This classification applies to predominantly rural, agricultural areas, where dam failure may damage isolated homes, major highways or railroads or cause interruption of service of relatively important public utilities. The remaining 86 dams are classified as "low hazard potential" meaning their failure would cause loss of the dam itself but little or no additional damage to other property. It is important to note that dam hazard classification is based on the consequences of dam failure-not the condition, probability or risk of failure itself. NJDEP's list is available in **Table 4.5-1 State-Regulated Dams and Other Structures in Monmouth County**. Specific locations for all State-regulated dams that have been geo-referenced for mapping purposes are illustrated in **Figure 4.5-1 State-Regulated Dams and Other**

Structures in Monmouth County. Please note that all municipalities are not listed in the following table. Only municipalities that that contain State-regulated dams are listed.

Figure 4.5-1 State-Regulated Dams and Other Structures in Monmouth County

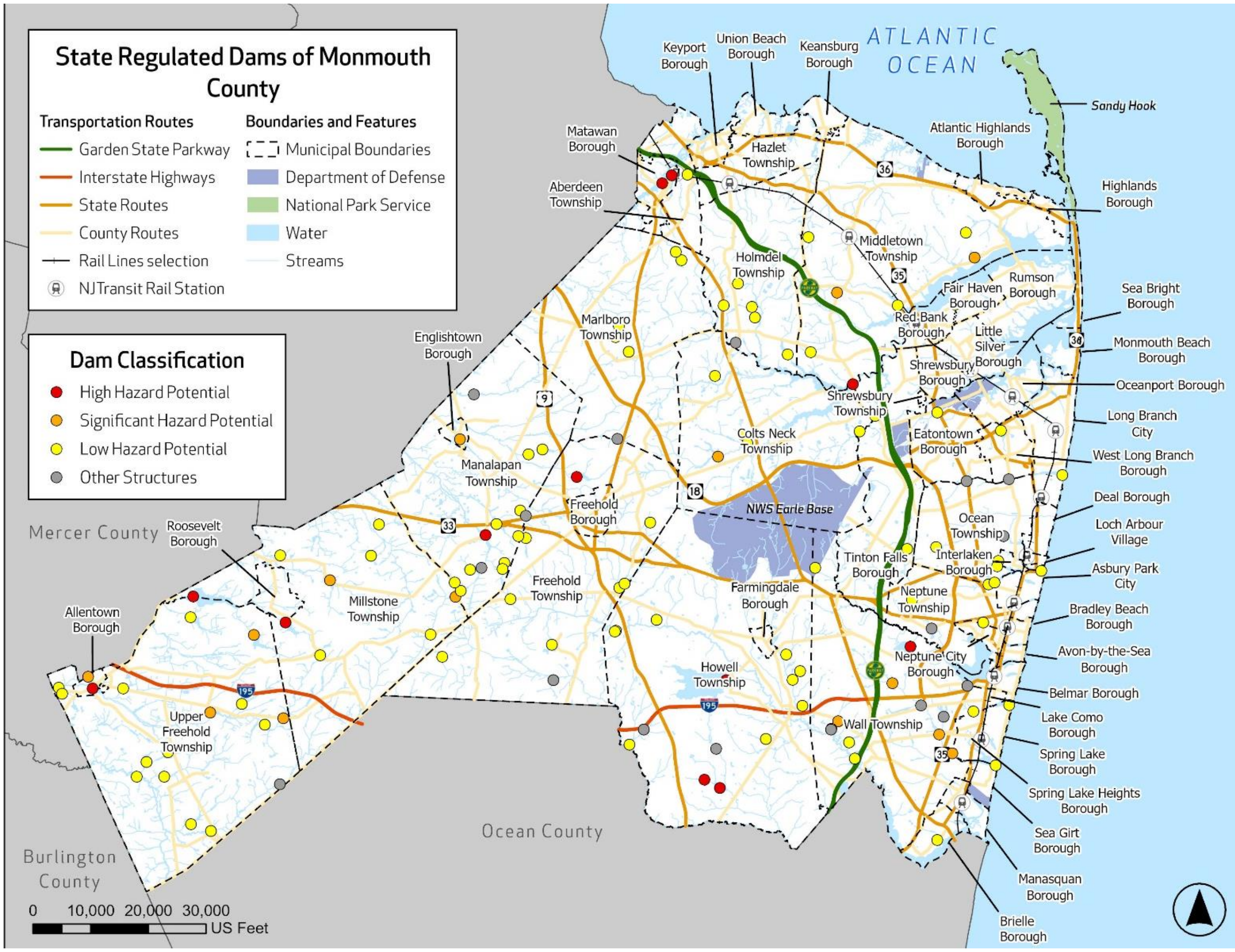


Table 4.5-1 State-Regulated Dams and Other Structures in Monmouth County

Jurisdiction	Total High Hazard Dams	Total Significant Hazard Dams	Total Low Hazard Dams	Total Number of Dams	Other Structures
Aberdeen, Township of	0	0	1	1	0
Allentown, Borough of	1	1	0	2	0
Asbury Park, City of	0	0	1	1	0
Brielle, Borough of	0	0	1	1	0
Colts Neck, Township of	1	1	5	7	0
Eatontown, Borough of	0	0	1	1	0
Englishtown, Borough of	0	1	0	1	0
Fair Haven, Borough of	0	0	1	1	0
Freehold, Township of	1	0	7	8	2
Holmdel, Township of	0	0	5	5	1
Howell, Township of	3	0	9	12	2

Jurisdiction	Total High Hazard Dams	Total Significant Hazard Dams	Total Low Hazard Dams	Total Number of Dams	Other Structures
Long Branch, City of	0	0	1	1	0
Manalapan, Township of	1	1	10	12	3
Marlboro, Township of	0	0	5	5	0
Matawan, Borough of	2	0	0	2	0
Middletown, Township of	0	3	4	7	0
Millstone, Township of	1	1	5	7	0
Neptune, Township of	0	0	4	4	1
Ocean, Township of	0	0	4	4	2
Sea Girt, Borough of	0	0	1	1	0
Spring Lake, Borough of	0	0	1	1	0
Tinton Falls, Borough of	0	0	2	2	0
Upper Freehold, Township of	1	3	12	15	1
Wall, Township of	1	5	4	10	4
West Long Branch, Borough of	0	0	1	1	1
Monmouth County Total	**12**	**15**	**86**	**113**	**17**

Source: New Jersey Department of Environmental Protection, Bureau of Dam Safety and Flood Control

According to NJDEP, there are 26 dams within Monmouth County that are in "poor" condition; of these, four are considered high hazard potential. These include the Matawan Lake Dam and Lake Lefferts Dam, both located in Matawan Borough, and two dams on the Assunpink Creek, one in Millstone Township and the other in Upper Freehold Township. All four municipalities address these dams in their mitigation strategy and note FEMA's National Dam Safety Program for High-Hazard Potential Dam Grant Program as a potential funding source.

Range of Magnitude

The magnitude of a dam failure event can be measured in terms of the classification of the dam. The NJDEP assigns one of four hazard classifications to State-regulated dams in New Jersey. The classifications relate to the potential for property damage and/or loss of life in the event of a dam failure:

- Class I (High-Hazard Potential) – Failure of the dam may result in probable loss of life and/or extensive property damage.
- Class II (Significant-Hazard Potential) – Failure of the dam may result in significant property damage; however, loss of life is not envisioned.
- Class III (Low-Hazard Potential) – Failure of the dam is not expected to result in loss of life and/or significant property damage.
- Class IV (Small-Dam Low-Hazard Potential) – Failure of the dam is not expected to result in loss of life or significant property damage.

Table 4.5-2 State Regulated Dams with High or Significant Hazard Potential lists information for all State-regulated dams in Monmouth County reported as having High (H) Hazard Potential or Significant (S) Hazard Potential. There are a total of 27 dams in the County classified as either high or significant hazard potential (12 dams are high hazard potential and 15 are classified as significant hazard potential)[1]. Of the 27 high and significant hazard potential dams in the County, all 27 dams have completed an Emergency Action Plan (EAP), which according to the Association of State Dam Safety of Officials is a written document that identifies incidents that can lead to potential emergency conditions at a dam, identifies the areas that can be affected by the loss of reservoir and specifies pre-planned actions to be followed to minimize property damage, potential loss of infrastructure and water resource, and potential loss of life because of failure or mis-operation of a dam.

Additionally, 24 high hazard dams have submitted an Operations and Maintenance Plan (O&M), which according to DEP is a formal document that provides guidance and instruction to project personnel for the proper operation and maintenance of the reservoir and dam. All the high-hazard dams have been inspected within the last two years. For the complete table of dams in Monmouth County, including information on the condition of each dam, refer to Appendix Volume I Jurisdictional Information Vol. 56 Monmouth County Dams (confidential version). Each of the nine municipalities that have high hazard potential dams created mitigation actions to mitigate against dam failure (see Appendix Vol. I – Jurisdictional Information).

Table 4.5-2 State-Regulated Dams with High or Significant Hazard Potential

Jurisdiction	Dam Name	Hazard Potential	River/Stream	Owner(s)
Allentown, Borough of	Allentown Dam	H	Doctors Creek	Monmouth County and Allentown
Colts Neck, Township of	Swimming River Reservoir Dam	H	Robins Swamp Brook	New Jersey-American Water Company
Freehold, Township of	Lake Topanemus Dam	H	McGellaird's Brook	Monmouth County, Freehold Borough, Freehold Township
Howell, Township of	Echo Lake Dam	H	Haystack Brook-TR	Monmouth County, Howell Township
Howell, Township of	Manasquan Reservoir Dam	H	Timber Swamp Brook	New Jersey Water Supply Authority
Howell, Township of	Lake Louise Dam	H	Branch of Haystack Brook	Monmouth County, Howell Township
Manalapan, Township of	Millhurst Lake Dam	H	Manalapan Brook	Monmouth County, Manalapan Township
Matawan, Borough of	Matawan Lake Dam	H	Gravelly Brook	Monmouth County, Matawan Borough
Matawan, Borough of	Lake Lefferts Dam	H	Matawan Creek	Monmouth County, Matawan Borough
Millstone, Township of	Assunpink #18 Dam	H	Assunpink Creek	Division of Fish & Wildlife
Upper Freehold, Township of	Assunpink #4 Dam	H	Assunpink Creek	Division of Fish & Wildlife
Wall, Township pf	Glendola Reservoir Dam	H	Robins Swamp Brook	New Jersey-American Water Company
Allentown, Borough of	Indian Dam	S	Indian Run	Monmouth County, Allentown Water Department, Mercer County
Colts Neck, Township of	Bucks Mill Dam	S	Yellow Brook	Monmouth County, Colts Neck Township

[1] *IN ADDITION TO THE DAMS LISTED IN TABLE 4.6-2, REPRESENTATIVES OF WALL TOWNSHIP HAVE ALSO EXPRESSED CONCERN ABOUT THE BRICK RESERVOIR. WHILE THIS DAM IS NOT CURRENTLY CONSIDERED A MAJOR DAM BY THE FEDERAL NID, OR A HIGH/SIGNIFICANT HAZARD DAM IN THE STATE'S INVENTORY, LOCAL AUTHORITIES HAVE REPORTED CONCERNS REGARDING THE IMPACT ANY FAILURE OF THIS DAM WOULD HAVE ON THE HERBERTSVILLE ROAD AREA OF THE TOWNSHIP.*

Jurisdiction	Dam Name	Hazard Potential	River/Stream	Owner(s)
Englishtown, Borough of	Englishtown Lake Dam	S	Matchaponix Brook	Monmouth County, Englishtown Borough
Manalapan, Township of	Manalapan Brook Pond Dam	S	Manalapan Brook	Monmouth County Park System
Middletown, Township of	Upper Pond Dam	S	Nut Swamp Brook-TR	Craig A. Fine, Esq.
Middletown, Township of	Navesink River Road Dam	S	Navesink River-TR	Monmouth County
Middletown, Township of	Shadow Lake Dam	S	Quioley Creek	Monmouth County, Middletown Township
Millstone, Township of	Perrineville Dam	S	Rocky Brook	Monmouth County
Upper Freehold, Township of	Red Valley Dam	S	Doctors Creek	Monmouth County, Fin Fur & Feather Club
Upper Freehold, Township of	Imlaystown Lake Dam	S	Doctors Creek	Division of Fish & Wildlife, Upper Freehold Township
Upper Freehold, Township of	Assunpink #19 Dam	S	Assunpink Creek	Division of Fish & Wildlife
Wall, Township of	Old Mill Pond Dam	S	Wreck Pond Brook	Township of Wall, JDE Spring Lake, LLC
Wall, Township of	Hurley Pond Dam	S	Wreck Pond Brook	Monmouth County, Pleviers, Wall Township
Wall, Township of	Brisbane Lake Dam	S	Mill Run	Division of Parks and Forestry, Monmouth County
Wall, Township of	Osborns Mills Dam	S	Wreck Pond Brook	Monmouth County, Wall Township

Source: New Jersey Department of Environmental Protection, Bureau of Dam Safety and Flood Control[2]

Previous Occurrences and Losses

According to NJDEP's Bureau of Dam Safety and Flood Control, New Jersey has not experienced any historic major dam failures but there have been an increasing number of small dam failures. This is largely attributed to the lack of maintenance and inspection, as well as the fact that many of the dams in the State are nearing the end of their design life. Although not catastrophic events, Monmouth County has experienced a number of small dam failure events that have caused reported property damages. Notable events include the following:

July 1989. According to the National Performance of Dams Program (NPDP) at Stanford University, the Holmdel Park Dam located in Holmdel reportedly failed following heavy rains at the spillway culvert, but no associated property damages were reported. Records indicate that seepage piping (soil erosion) was involved in the failure, and the dam was subsequently reconstructed.

October 13-14, 2005. Monmouth County experienced a heavy rain event which brought several inches to the area in a short amount of time. According to NCEI, this led to flooding on area creeks and rivers, which also caused minor dam failures at several locations. Dams failed on both Spring Lake and Mill Pond, and Deal Lake overflowed, forcing the evacuation of nearly 1,200 residents and a declared state of emergency. The failure of a dam on Wreck Pond caused the flooding of Spring Lake, Spring Lake Heights, Sea Girt and Wall. A mandatory evacuation of Spring Lake was implemented during the morning of the 14th. In Wall, the cost of repairing the Wreck Pond Dam was estimated at $4.2 million. On the

[2] **DAM ALSO LISTED AS A "MAJOR" DAM IN THE USGS NATIONAL INVENTORY OF DAMS (NID). MAJOR DAMS ARE DESCRIBED AS 50 FEET OR MORE IN HEIGHT, OR WITH A NORMAL STORAGE CAPACITY OF 5,000 ACRE-FEET OR MORE, OR WITH A MAXIMUM STORAGE CAPACITY OF 25,000 ACRE-FEET OR MORE.*

other side of the township, a dam breach on Mill Pond within Allaire State Park caused significant water damage and a roadway collapse in the Historic Village within the park, flooding the general purposes building.

Hurricane Irene 2011. Earthen dams at Shadow Lake and Lake Lefferts failed, flooding roads and forcing the closure of Hubbard Avenue in Middletown and Ravine Drive in Matawan.

Probability of Future Occurrence

Dam failures are rare and hard to forecast future occurrence, however they normally coincide with events that cause them such as earthquakes, landslides, and excessive rainfall and snowmelt. Dam failures in New Jersey are often caused by heavy rains or other precipitation. The probability of a dam failure occurrence in Monmouth County is relatively low due to routine inspection, repair and maintenance programs, though the possibility of a future failure event is likely increasing due to aging dam structures that may need repair or reconstruction. The NJDEP's Dam Safety program serves to ensure the safety and integrity of dams in New Jersey and, thereby, protect people and property from the consequences of dam failures.

Potential Effects of Climate Change

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns attributable to climate change can have significant effects on the hydrograph used for the design of a dam. Annual precipitation in New Jersey is expected to increase by 4% to 11% by 2050 (NJDEP, 2020) which could influence the hydrographs of many dammed rivers in the State. As a result, it is conceivable that a dam could lose some or all its entire designed margin of safety, also known as freeboard. Loss of designed margin of safety may cause floodwaters more readily to overtop the dam or create unintended loads. Such situations could lead to a dam failure.

Additional climate factors which could negatively influence dam performance include a possible increase in sediment in water flows due to more intense rainfall leading to soil erosion which can affect gate performance and routing capacity. Finally, compound extremes can also increase the risk of cascading infrastructure failure since some infrastructure systems rely on others, and the failure of one system can lead to the failure of interconnected systems, such as water–energy infrastructure (NCA, 2018).

Vulnerability Assessment

Dam failure can impact the built environment downstream of the dam near the outfall including damage and destruction of homes and businesses, as well as community lifelines such as transportation, energy, and communication infrastructure. Given the lack of historical data on significant dam failure occurrences or the availability of inundation maps for Monmouth County, it is assumed that while one major event may result in significant losses, annualizing structural losses over a long period of time would most likely yield a negligible annualized loss estimate for jurisdictions exposed to this hazard.

The general at-risk population in the event of a dam failure would be located downstream of the dam within close proximity of the outfall (most likely within one mile). Protection of human life through administration of proper emergency notification and evacuation planning is crucial to minimizing social losses due to dam failure.

Dam failure can have a negative impact on local economy with potential losses caused by destruction of infrastructure, disruption to businesses, impacts to agricultural land, as well as cost and time intensive rebuilding and recovery efforts following an event. Additionally, dam failure can affect water supply, potentially impacting water-intensive industry or goods production.

Impacts to ecosystems and natural habitats because of dam failure include habitat destruction, erosion of riverbanks, loss of aquatic biodiversity, contamination of water sources with sediment and potentially hazardous materials depending on any facilities with quantities of pollutants located within the inundation area.

To assess vulnerability to dam failure in Monmouth County, the Planning Team used FEMA's online Resilience Analysis and Planning Tool (RAPT) to conduct a spatial analysis of each high hazard dam to vulnerable populations and critical infrastructure within the planning area. In order to assess the impact of a potential dam failure, RAPT's incident analysis tool was used. The tool allows the user to create a buffer zone (or incident area) around an incident, in this case, dam failure, by setting an incident location. A five-mile buffer was selected to estimate the at-risk area. The tool identifies critical facilities within the buffer zone. Additionally, the population counter tool was used which provides the estimated number of people with a specific characteristic within a drawn shape, by using the same 5-mile buffer around the dam.

Table 4.5-3 Populations At Risk (PAR) and Critical Infrastructure Within a 5-Mile Radius of High Hazard Dam summarizes the RAPT vulnerability assessment of all twelve high hazard dams within the County. As shown in the table, Lake Louise Dam has the most significant impact to PAR and critical infrastructure followed by Echo Lake Dam and Lake Lefferts Dam.

Table 4.5-3 Populations At Risk (PAR) and Critical Infrastructure Within a 5-Mile Radius of High Hazard Dam

Dam Name	Total Population	Population 65+	Population with a Disability	Population Below Poverty Line	Population Living in Mobile Homes	Critical Facilities
Allentown Dam	46,111	8,248	4,401	1,919	489	68
Assunpink #18 Dam	38,301	6,348	2,976	1,435	93	31
Assunpink #4 Dam	55,096	9,212	4,694	2,635	380	66
Echo Lake Dam	190,391	18,614	12,144	34,588	1,543	552
Glendola Reservoir Dam	125,841	27,025	15,387	9,985	916	211
Lake Lefferts Dam	144,834	24,913	16,024	7,814	2,043	179
Lake Louise Dam	198,695	20,033	13,026	35,982	1,230	571
Lake Topanemus Dam	114,431	19,324	11,610	6,211	729	129
Manasquan Reservoir Dam	73,206	11,274	5,720	5,720	2,026	87
Matawan Lake Dam	141,394	24,286	15,817	7,653	2,288	184
Millhurst Lake Dam	80,907	13,054	8,068	4,418	714	94
Swimming River Reservoir Dam	100,462	19,588	9,498	5,831	850	156

Source: FEMA RAPT

The best way to mitigate dam failure is through the proper construction, inspection, maintenance and operation of dams, as well as maintaining and updating Emergency Action Plans for use in the event of a dam failure.

Potential for Future Development to Impact Hazard Vulnerability

Any development near or downstream from a dam increases a community's vulnerability to dam failure as it increases the population and assets at risk from the hazard. This is especially true of development occurring near or downstream from a dam categorized as high hazard potential. Additionally certain development activities especially those on previously undeveloped land, such as deforestation, can worsen the downstream impacts of a potential dam failure by amplifying severity of a resulting flood.

4.6 DROUGHT

Hazard Description

A prolonged period of less than normal precipitation such that the lack of water causes a serious hydrologic imbalance. Common effects of drought include crop failure, water supply shortages, and fish and wildlife mortality. High temperatures, high winds, and low humidity can worsen drought conditions and make areas more susceptible to wildfire. Human water demand and actions can hasten or mitigate drought-related impacts on local communities.

Location and Extent

Droughts occur in all parts of the County and at any time of year, depending on temperature and precipitation over time. While arid regions of the United States are more susceptible to long-term or extreme drought conditions, other areas such as Monmouth County tend to be more susceptible to short-term, less severe droughts. It is impossible to delineate a drought hazard area for the County, but it is generally assumed that drought is a County-wide hazard, with drought conditions being possible in all geographic areas.

Range of Magnitude

The severity of drought can depend on the duration, intensity, geographic extent, and the regional water supply demands made by human activities and vegetation. The intensity of the impact from drought could be minor to extreme damage in a localized area or regional damage affecting human health and the economy. Generally, impacts of drought evolve gradually, and regions of maximum intensity change with time. The severity of a drought is determined by areal extent as well as intensity and duration. The frequency of a drought is determined by analyzing the intensity for a given duration, which allows determination of the probability or percent chance of a more severe event occurring in a given mean return period.

The Palmer Drought Severity Index (PDSI) in one of many available drought indices used to assess the extent of a drought event. It was developed by Wayne Palmer in 1965 and indicates prolonged and abnormal moisture deficiency or excess. The PDSI tends to be used more commonly than other available indices, and is an important tool for evaluating the scope, severity, and frequency of prolonged periods of abnormally dry or wet weather. PDSI drought classifications are based on observed drought conditions and will range from -0.5 (incipient dry spell) to -4.0 (extreme drought). The PDSI also reflects excess precipitation using positive numbers. The PDSI is the most effective in determining long-term droughts; but has limitations in terms of use for short-term forecasts. **Table 4.6-1 Palmer Drought Severity Index (PSDI) classifications** displays the Index values and corresponding severity.

Table 4.6-1 Palmer Drought Severity Index (PSDI) Classifications

PDSI Value	Classification
4.0 or more	Extremely Wet
3.0 to 3.99	Very Wet
2.0 to 2.99	Moderately Wet
1.0 to 1.99	Slightly Wet
0.5 to 0.99	Incipient Wet Spell
0.49 to -0.49	Near Normal
-0.5 to -0.99	Incipient Dry Spell
-1.0 to -1.99	Mild Drought
-2.0 to -2.99	Moderate Drought
-3.0 to -3.99	Severe Drought

PDSI Value	Classification
-4.0 or less	Extreme Drought

Source: USDA

To improve monitoring and measurement of drought severity from region to region within the State of New Jersey, NJDEP implemented a unique set of indices in January 2001 specifically designed for the particular characteristics and needs of the State. This new set of statewide indicators supplements the PDSI with the measurement of regional precipitation, stream- flow, reservoir levels, and groundwater levels. The State has authority to order water use restrictions if necessary to mitigate the risk of drought conditions. New Jersey currently measures the status of each indicator as near or above normal, moderately dry, severely dry, or extremely dry. For the State, the severity of the drought is categorized, in order of increasing severity, as the following:

- Drought Watch: Indicates the NJDEP is closely monitoring drought indicators, including precipitation, stream flows, and reservoir and ground water levels and water demands. Under a drought watch, the public should begin voluntarily cutting back on water usage. The Commissioner of NJDEP is responsible for exercising non-emergency powers during a Drought Watch. Such non-emergency powers are used to develop alternative water supplies where necessary, rehabilitate and activate interconnections between water systems, and transfers water between different water systems.
- Drought Warning: A drought warning condition may be designated by the Commissioner of NJDEP as a non-emergency response to managing available water supplies. Under a designated drought warning, the DEP may order water purveyors to develop alternative sources of water and to transfer water around the State from areas with relatively more water to those with less. The aim of this stage of a response to drought conditions is to avert a more serious water shortage that would necessitate declaration of a water emergency and the imposition of mandatory water use restrictions.
- Water Emergency or Drought Emergency: There are four phases of water emergencies:
    - Phase I: Restricts water use for non-commercial plants, cars, streets, hydrant flushing, etc.
    - Phase II-III: Water is allocated and rationed. These restrictions are enforced when there is substantial threat to public health.
    - Phase IV: Considered a disaster stage where public water service is interrupted. Public health and safety cannot be guaranteed and selective business and industrial closings are enforced.

Previous Occurrences and Losses

According to NOAA NCEI, 44 recorded instances of drought conditions have affected Monmouth County between 1997 and April 2019, causing significant losses to agricultural crops. Four instances occurred since the last plan update. Significant drought events in Monmouth County are detailed in the table below (**Table 4.6-2 Past Drought Events in Monmouth County**).

Table 4.6-2 Past Drought Events in Monmouth County

Date	Description
October 1997	Unseasonably dry weather with below normal rainfall, which became worse during the summer months, forced the Delaware River Basin Commission to declare a drought warning on October 27th. The commission urged the seven million residents within the basin's 13,539 square mile area to voluntarily conserve water. Water levels in the New York City Reservoirs, which are in the headwaters of the Delaware River, fell below 40 percent of capacity in late October. Precipitation deficits through October 31st averaged around five inches.

Date	Description
1998-1999	What began as unseasonably dry weather became a drought, which heavily impacted agriculture and water supplies. As reservoir levels continued to fall, the Delaware River Basin Commission declared a drought warning in December 1998. Also, in December, NJDEP declared a drought warning for the entire State. In late December, the Delaware River Basin Commission declared Stage Two of its drought warning. In July 1999, Governor Christie Whitman declared a water shortage alert and called for residents to voluntarily conserve water by not watering lawns or washing cars. In Monmouth County, a drought emergency was declared, and odd/even non-essential watering restrictions were implemented. The drought finally ended as Tropical Storm Floyd dumped significant rainfall amounts across the State. Agricultural losses throughout the state as a result of this long drought were estimated at $80 million.
October 2001 - October 2002	Unseasonably dry weather again turned to drought as precipitation levels fell short of normal levels. Continued dry weather, the drop-in stream flow and groundwater levels and the reduced levels in the New York State reservoirs prompted NJDEP to upgrade the drought watch to a drought warning for counties in the Delaware River Basin and southern New Jersey in November 2001, including Monmouth County. By October 2002, a drought disaster was declared by the U.S. Department of Agriculture for several states including New Jersey. Several rain events in October 2002 helped quench the drought and returned the area's reservoirs to normal levels.
August to September 2008	Excessive heat in June followed by an unseasonably dry August resulted in drought conditions in August of 2008. Rainfall returned to above normal levels in September but was too late to be helpful for farmers. Crops had already been damaged by the combination of excessive June heat and an August hail storm and drought. The United States Secretary of Agriculture issued a drought disaster declaration for ten central and southern New Jersey Counties on September 22nd. Mercer, Monmouth, Burlington, Ocean, Camden, Gloucester, Atlantic, Salem, Cumberland and Cape May Counties were included in the declaration. This made farmers who suffered thirty percent or more direct losses to be eligible for low interest emergency loans from the Farm Services Agency. Loans could cover up to 100 percent of the dollar value of crop losses.
August to October 2010	On August 5, the NJDEP issued a drought watch for northeast New Jersey including Morris County. On a statewide average, August 2010 was the 15th driest August on record (dating back to 1895) with 2.37 inches of rain. The meteorological summer was the 10th driest (8.65 inches) on record dating back to 1895 in New Jersey and was also the driest summer since 1966. At the Atlantic City International Airport, it was the fourth driest August (1.09 inches) and fifth driest meteorological summer (5.92 inches) on record. In Trenton, it was the third driest August (0.80 inches) and fifth driest meteorological summer (5.90 inches) on record.
September to December 2015	After a wet start to the meteorological summer in June, the weather became progressively drier as the summer progressed into September, especially in the northeast part of the State. The United States Drought Monitor reached moderate levels in that part of the State. The New Jersey Department of Environmental Protection issued a drought watch on the 23rd for the northeast part of the State and this included all or parts of Morris, Hunterdon, Somerset, Middlesex, Monmouth, Mercer and Ocean Counties. The drought watch continued into December 2015 and was prompted by continued rainfall deficits that have decreased reservoir, ground water and streamflow levels in the area. Signs of stress in water supply indicators started to occur. Drinking water supply indicators were showing signs of stress from the dry weather and high water demands, including stream flows and ground water levels, as well as declining reservoir storage in the New Jersey Water Supply Authority's Spruce Run and Manasquan Reservoirs in Hunterdon and Monmouth Counties, respectively. A side effect of the dry weather was an expected smaller (in size) pumpkin crop. Farmers have had to endure increased costs of water and electricity to irrigate their crops.
October 2016 to April 2017	Drought conditions were the worst faced by New Jersey in 14 years. The entire State was experiencing some level of drought conditions at the height of the drought event in late November and early December, with nearly 38 percent of the State experiencing severe drought conditions, 34 percent experiencing moderate drought, and 28 percent was abnormally dry. NJDEP issued a Drought Warning for much of Northern and Central New Jersey due to the severity of this period of drought.
September 2019 to October 2019	At the heigh of the drought event, 37 percent of the State was experiencing moderate drought conditions. Salem County experienced drought conditions the longest, with parts of the County under moderate drought for around a month.
July to December 2022	A statewide Drought Watch was instituted from early August to late December. September was the most severe month, as 67 percent of the State was under moderate drought conditions and an additional 29 percent were under severe drought conditions during the first two weeks of the month
June 2024 to continuing	A record dry spell led to driest conditions the State has had in 120 years, with the southern half of the State experiencing the worst conditions. Monmouth County has been classified as experiencing moderate drought. The Manasquan Reservoir in Howell Township dropped below 50% of capacity in November of 2024. As of the writing of this plan, the County is still experiencing drought.

Source: USDA 2025

Probability of Future Occurrence

Based upon risk factors for past occurrences, it is likely that droughts can occur across New Jersey in the future. Monmouth County faces a low to moderate probability of severe drought conditions, though short-term instances of drought will occur more frequently.

Potential Effects of Climate Change

Climate change is anticipated to increase the risk of drought in the State due to factors including changes in precipitation patterns and increases in temperature. Climate change is a major driver of changes in the frequency, duration, and geographic distribution of rainfall. Although New Jersey is becoming wetter overall, it is also projected to experience more frequent and severe droughts. Increases in temperature due to climate change has the potential to impact water supply, thereby increasing drought risk.

Vulnerability Assessment

Droughts are slow onset hazards, but, over time, they can severely affect crops, municipal water supplies, recreational resources, and wildlife. If drought conditions extend over a number of years, the direct and indirect economic impacts can be significant. High temperatures, high winds, and low humidity can worsen drought conditions and also make areas more susceptible to wildfire. In addition, human actions and demands for water resources can accelerate drought-related impacts.

Built Environment, Infrastructure, and Community Lifelines

Although drought typically has negligible impact on building stock and infrastructure, it can present a challenge to community lifelines. Water supply in the County is serviced by public water systems that use groundwater wells, local surface water supplies, and purchased surface water from other parts of the State. The State monitors groundwater withdrawals for major operators. In addition, an unknown number of households rely on private wells. New Jersey maintains a real-time groundwater level monitoring system consisting of seven observation wells throughout the State. The network, a cooperative between the USGS and NJDEP, uses satellite telemetry to provide observations in four-hour increments. Observations are available on the USGS website at http://water.usgs.gov/nj/nwis/current/?type=gw. The primary purpose of the network is to provide information regarding the status of wells throughout the State and to anticipate potential shortages (NJDEP 2002). **Table 4.6-3 Total Number of Private Wells** lists the total number private wells that NJDEP tracks as part of their private well program, listed by number of wells.

Drought affects groundwater sources, but generally not as quickly as surface water supplies. Groundwater supplies generally take longer to recover. Reduced precipitation during a drought means that groundwater supplies are not replenished at a normal rate. This can lead to a reduction in groundwater levels and problems such as reduced pumping capacity or wells going dry. Shallow wells are more susceptible than deep wells. Reduced replenishment of groundwater affects streams also. Much of the flow in streams comes from groundwater, especially during the summer when there is less precipitation and after snowmelt ends. Reduced groundwater levels mean that even less water will enter streams when steam flows are lowest. Please note that all municipalities are not listed in the following table. Only municipalities private wells are listed.

Table 4.6-3 Total Number of Private Wells by Jurisdiction (NJDEP, 2019)

Jurisdiction	Number of Wells
Howell, Township of	1,277
Millstone, Township of	977
Colts Neck, Township of	788

Jurisdiction	Number of Wells
Upper Freehold, Township of	584
Manalapan, Township of	395
Freehold, Township of	241
Marlboro, Township of	148
Wall, Township of	80
Middletown, Township of	38
Tinton Falls, Borough of	26
Holmdel, Township of	19
Ocean, Township of	11
Eatontown, Borough of	10
Fair Haven, Borough of	10
Freehold, Borough of	10
Interlaken, Borough of	10
Little Silver, Borough of	10
Neptune, Township of	10
Oceanport, Borough of	10
Roosevelt, Borough of	10
Rumson, Borough of	10
West Long Branch, Borough of	10

Source: NJDEP

Population and the Economy

Drought impacts are mostly experienced in water shortages resulting in crop losses on agricultural lands and does not typically result in damages to buildings or population. To estimate land exposure to drought, agricultural land acreage was acquired from land use classification data as provided by the Monmouth County Office of GIS[11]. **Table 4.6- 4 Acreage of Agricultural Land by Jurisdiction and Expected Losses** shows agricultural land acreage in Monmouth County. Approximately 14 percent of land in Monmouth County is used for agriculture, orchards, and nurseries; these properties are located in 25 of the County's 53 communities. The final column in the table displays the Expected annual Losses (Agriculture) for each jurisdiction which was derived from FEMA's NRI. In addition to economic losses to agriculture, there could be potential economic impacts due to droughts effects on recreational resources and wildlife.

Table 4.6-4 Acreage of Agricultural Land by Jurisdiction

Jurisdiction	Total Acres	Agricultural Land (Acres)	Percentage of Total	Expected annual Losses - Agriculture
Aberdeen, Township of	3,588	14	0.40%	$56.47
Allenhurst, Borough of	162	0	0.00%	$-
Allentown, Borough of	399	11	2.80%	$210.86
Asbury Park, City of	955	0	0.00%	$-
Atlantic Highlands, Borough of	782	0	0.00%	$-
Avon-By-The-Sea, Borough of	292	0	0.00%	$-
Belmar, Borough of	888	0	0.00%	$-
Bradley Beach, Borough of	382	0	0.00%	$-
Brielle, Borough of	1,521	0	0.00%	$-

Jurisdiction	Total Acres	Agricultural Land (Acres)	Percentage of Total	Expected annual Losses - Agriculture
Colts Neck, Township of	20,713	3,600	17.40%	$15,159.81
Deal, Borough of	759	0	0.00%	$-
Eatontown, Borough of	3,765	16	0.40%	$-
Englishtown, Borough of	373	9	2.50%	$7,519.65
Fair Haven, Borough of	1,345	0	0.00%	$-
Farmingdale, Borough of	338	10	3.10%	$0.12
Freehold, Borough of	1,249	2	0.10%	$4,039.51
Freehold, Township of	24,673	2,662	10.80%	$8,283.68
Hazlet, Township of	3,682	16	0.40%	$33.78
Highlands, Borough of	463	0	0.00%	$-
Holmdel, Township of	11,419	1,761	15.40%	$5,283.80
Howell, Township of	39,425	4,359	11.10%	$15,952.71
Interlaken, Borough of	247	0	0.00%	$-
Keansburg, Borough of	748	0	0.00%	$-
Keyport, Borough of	937	0	0.00%	$-
Lake Como, Borough of	158	0	0.00%	$-
Little Silver, Borough of	2,133	9	0.40%	$-
Loch Arbour, Village of	77	0	0.00%	$-
Long Branch, City of	3,408	0	0.00%	$-
Manalapan, Township of	19,777	3,191	16.10%	$7,339.82
Manasquan, Borough of	983	0	0.00%	$-
Marlboro, Township of	19,676	1,850	9.40%	$3,297.91
Matawan, Borough of	1,510	0	0.00%	$-
Middletown, Township of	25,829	982	3.80%	$1,117.53
Millstone, Township of	23,910	6,279	26.30%	$14,630.46
Monmouth Beach, Borough of	1,243	0	0.00%	$-
Neptune City, Borough of	563	0	0.00%	$-
Neptune, Township of	5,642	21	0.40%	$39.21
Ocean, Township of	7,023	24	0.30%	$304.09
Oceanport, Borough of	2,431	12	0.50%	$14.46
Red Bank, Borough of	1,374	0	0.00%	$-
Roosevelt, Borough of	1,251	323	25.80%	$8,486.13
Rumson, Borough of	4,555	15	0.30%	$-
Sea Bright, Borough of	651	0	0.00%	$-
Sea Girt, Borough of	675	0	0.00%	$-
Shrewsbury, Borough of	1,404	12	0.90%	$-
Shrewsbury, Township of	62	0	0.00%	$-
Spring Lake, Borough of	902	0	0.00%	$-
Spring Lake Heights, Borough of	840	0	0.00%	$-
Tinton Falls, Borough of	9,965	249	2.50%	$619.86
Union Beach, Borough of	1,210	0	0.00%	$-
Upper Freehold, Township of	30,134	16,660	55.30%	$94,743.24
Wall, Township of	19,829	1,273	6.40%	$3,608.26
West Long Branch, Borough of	1,842	18	1.00%	$-
Monmouth County	**308,162**	**43,378**	**14.00%**	**$190,741.37**

Source: Monmouth County Office of GIS, FEMA NRI

Ecosystems and Natural Assets

Long periods without precipitation can alter the delicate balance of ecosystems. Examples of drought impacts to ecological systems may include reduced plant growth, local species reduction or extinction, and landscape-level transitions. Drought impacts to ecological systems may diminish the resources and services provided by those systems, including water filtration and quality, wildlife habitat, and sufficient water levels for recreation, tourism, and preponderance of aquatic species. The vulnerability of natural systems to withstand or adapt to drought disturbances depends on the sensitivity of the system, exposure to the hazard, and capacity to adapt and recover.

Potential for Future Development to Impact Hazard Vulnerability

Development has the potential to increase a community's vulnerability to drought. Population growth due to development can increase water demand putting increased stress on existing water resources. In addition to residential development, water intensive uses such as industrial development or data centers can increase demand for water as well. Increases in impervious surfaces can lessen the ability of groundwater and surface water supplies to recharge by reducing infiltration of rainwater into the soil.

4.7 EARTHQUAKE

Hazard Description

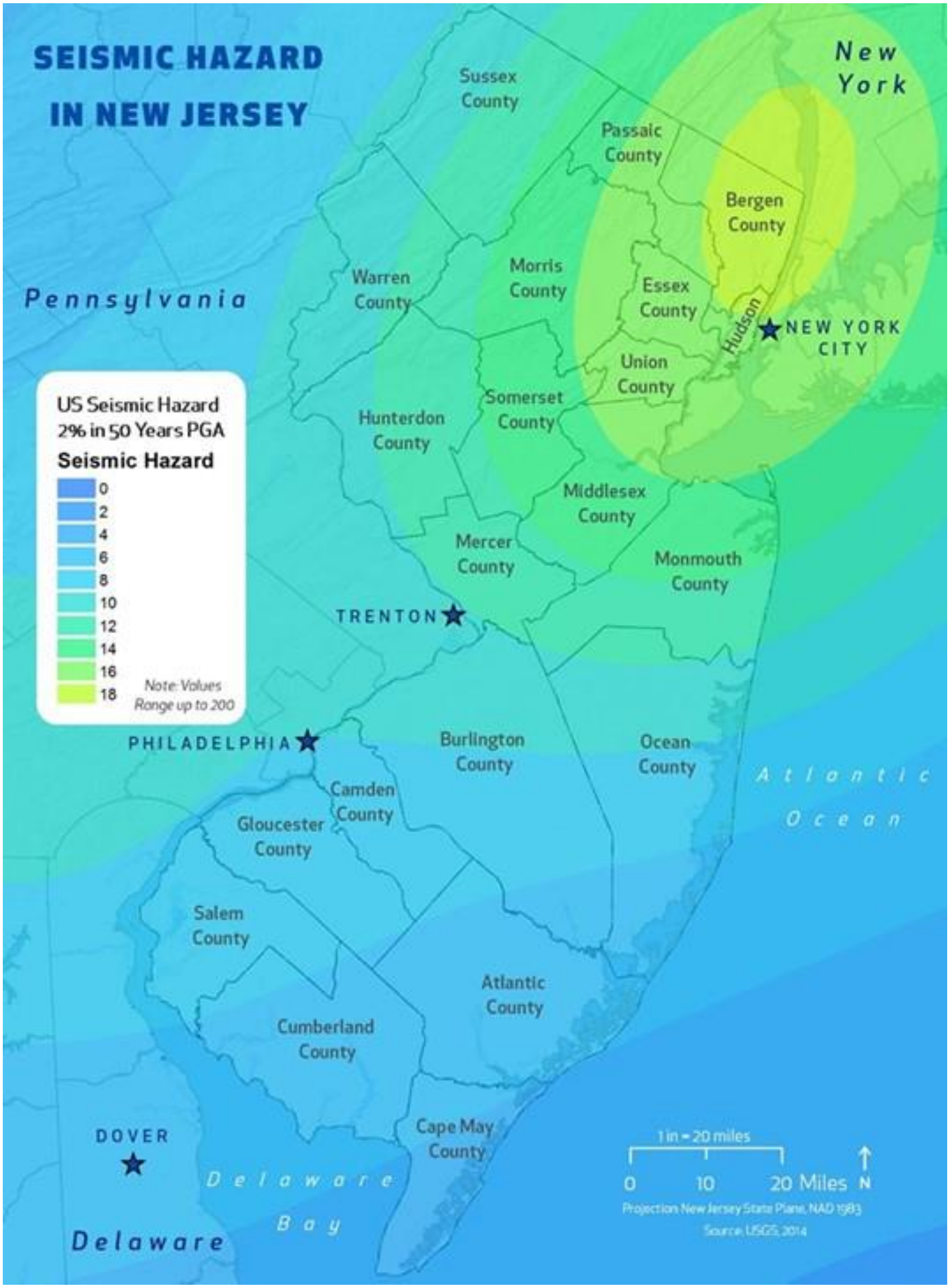
An earthquake is a sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the surface. This movement forces the gradual building and accumulation of energy. Eventually, strain becomes so great that the energy is abruptly released, causing the shaking at the earth's surface which we know as an earthquake. Roughly 90 percent of all earthquakes occur at the boundaries where tectonic plates meet, although it is possible for earthquakes to occur entirely within plates.

Location and Extent

The greatest earthquake threat in the United States is along tectonic plate boundaries and seismic fault lines located in the central and western states; however, the East Coast does face moderate risk to less frequent, less intense earthquake events. Generally, earthquake epicenters in North America area occur on known faults, a result of tectonic activity occurring more than 200 million years ago. There are many faults in New Jersey; however, the Ramapo Fault is the most significant, located in the northern portion of the State.

The probability of significant, damaging earthquake events affecting Monmouth County is low. **Figure 4.7-1** below shows the Seismic Hazard for New Jersey. The seismic hazard is measured as the peak ground acceleration (PGA) that has a 2 percent chance of being exceeded in 50 years (an annual probability of 0.000404). For Monmouth County this lies between 10 and 14, depending on the location, with northern Monmouth County having a greater seismic hazard than the south. An earthquake with PGA of 10-20%g would be felt by people and may cause minor-to-moderate damage in well-designed buildings, with potential higher levels of damage in poorly designed buildings. According to the United States Geological Survey (USGS), an earthquake with a 10 percent probability of exceedance over 50 years would have PGA values between 4%g and 5%g, which would result in light to moderate perceived shaking and damages ranging from none to very light. Further discussion of PGA is found later in this section.

Figure 4.7-1 Seismic Hazard for New Jersey



Source: NJ SHMP, 2024

Range of Magnitude

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude. Each unit increase in magnitude on the Richter Scale corresponds to a 10-fold increase in wave amplitude, or a 32-fold increase in energy. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale based on direct and indirect measurements of seismic effects. The scale levels are typically described using roman numerals, with a I corresponding to imperceptible (instrumental) events, IV corresponding to moderate (felt by people awake), to XII for catastrophic (total destruction). A detailed description of the MMI Scale of earthquake intensity and its correspondence to the Richter Scale is given in **Table 4.7-1 Magnitude/Intensity Comparison for Earthquakes.**

Table 4.7-1 Magnitude/Intensity Comparison for Earthquakes

Magnitude	Typical Maximum Modified Mercalli Intensity	Abbreviated Modified Mercalli Intensity Scale
1.0 - 3.0	I	I. Not felt except by a very few under especially favorable conditions.
3.0 - 3.9	II - III	II. Felt only by a few persons at rest, especially on upper floors of buildings. III. Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
4.0 - 4.9	IV - V	IV. Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably. V. Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
5.0 - 5.9	VI - VII	VI. Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight. VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
6.0 - 6.9	VII - IX	VII. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken. VIII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
7.0 and higher	VIII or higher	VII. Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations. X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

		XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly. XII. Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: US Geological Survey (http://earthquake.usgs.gov/learn/topics/mag_vs_int.php, page last modified September 29, 2014)

Modern intensity scales use terms that can be physically measured with seismometers, such as the acceleration, velocity, or displacements (movement) of the ground. The most common physical measure is PGA. PGA expresses the severity of an earthquake and is a measure of how hard the earth shakes, or accelerates, in a given geographic area. PGA is expressed as a percent acceleration force of gravity (%g). For example, 1.0%g PGA in an earthquake (an extremely strong ground motion) means that objects accelerate sideways at the same rate as if they had been dropped from the ceiling. 10%g PGA means that the ground acceleration is 10% that of gravity. Damage levels experienced in an earthquake vary with the intensity of ground shaking and with the seismic capacity of structures, as noted in **Table 4.7-2** below.

Table 4.7-2 Damage Levels Experienced in Earthquakes

Ground Motion Percentage	Explanation of Damages
1-2%g	Motions are widely felt by people; hanging plants and lamps swing strongly, but damage levels, if any, are usually very low.
Below 10%g	Usually causes only slight damage, except in unusually vulnerable facilities.
10 - 20%g	May cause minor-to-moderate damage in well-designed buildings, with higher levels of damage in poorly designed buildings. At this level of ground shaking, only unusually poor buildings would be subject to potential collapse.
20 - 50%g	May cause significant damage in some modern buildings and very high levels of damage (including collapse) in poorly designed buildings.
≥50%g	May cause higher levels of damage in many buildings, even those designed to resist seismic forces.

Source: NJ SHMP, 2024

Previous Occurrences and Losses

Earthquakes occur on a regular basis in New Jersey, though most are of very low magnitude (MMI intensity of less than II) and often not felt or capable of causing property damage. According to the New Jersey Geological Survey, there have been 218 recorded earthquakes in New Jersey since 1783, including ten with epicenters located in Monmouth County (as shown in **Figure 4.7-2 Historic Earthquake Epicenters in Monmouth County**). However, due to the nature of the hazard, New Jersey's susceptibility to earthquakes extends to events located beyond State borders, and some of the most damaging earthquakes in the State were associated with larger, more significant events occurring elsewhere along the East Coast. Most past earthquake damage in New Jersey has been damage to building contents and architectural damage such as fallen chimneys, cracked plaster and masonry, and items falling off shelves. Some of the more notable earthquake events (those with a magnitude of 4.00 or higher) for the New Jersey region are identified in **Table 4.7-3 Significant Earthquake Epicenters in and around Monmouth County**.

Figure 4.7-2 Historic Earthquake Epicenters in and around Monmouth County

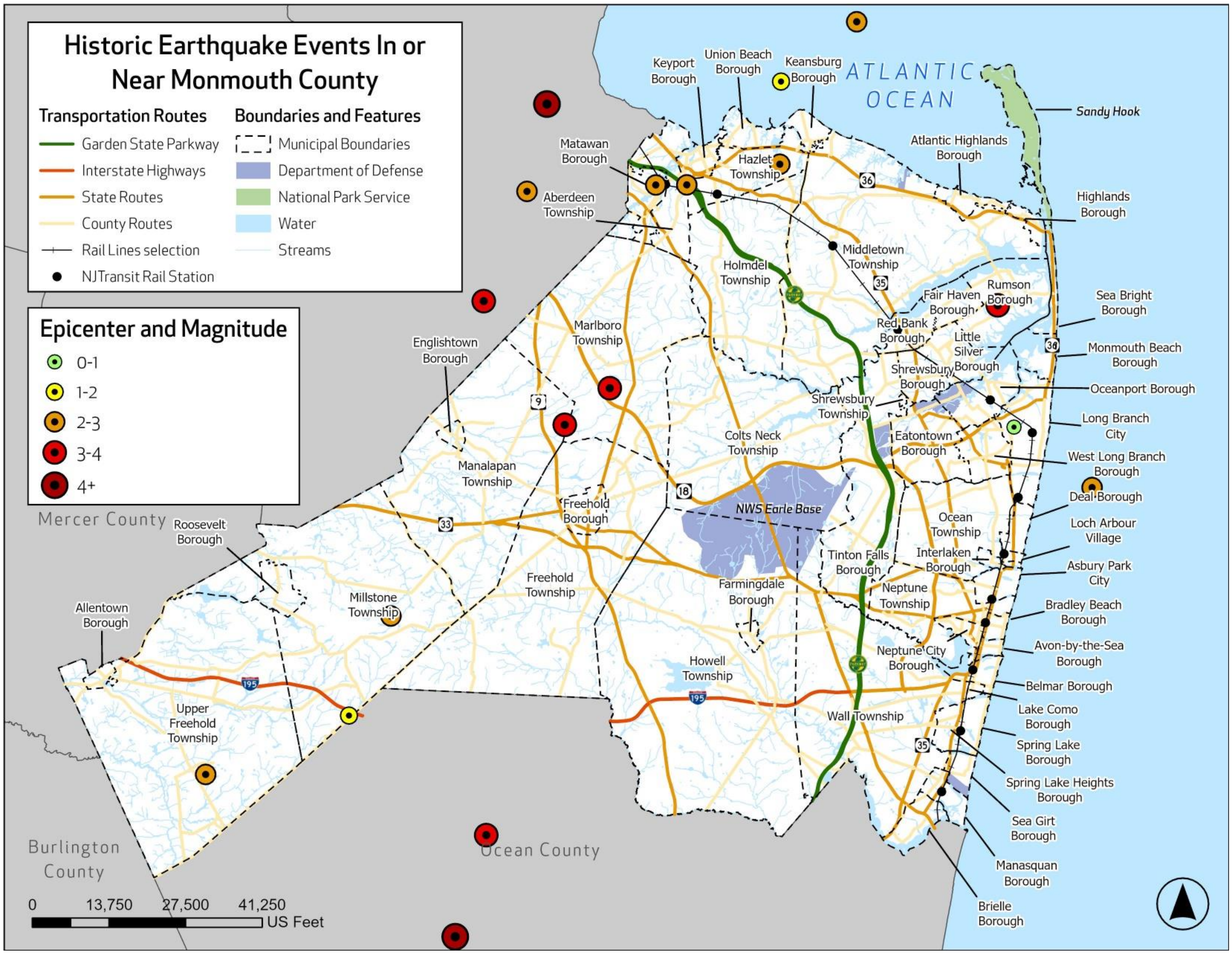


Table 4.7-3 Significant Earthquakes Felt in the New Jersey Region

Date	Location	Richter Magnitude	Description
12/19/1737	Greater NYC Area	5.20	Chimneys down in New York City. Felt from Boston, MA, to Philadelphia, PA.
11/30/1783	North-Central New Jersey	5.30	Felt from New Hampshire to Pennsylvania. Two foreshocks (11/24 and 11/30) and one aftershock (11/30); threw down chimneys.
08/10/1884	Greater NYC Area	5.20	Threw down chimneys; felt from Virginia to Maine
09/01/1895	Near High Bridge, NJ	7.70	Felt over a considerable area to the northeast and southwest. The total felt area covered points from Maine to Virginia in a long, narrow elliptical zone of about 92,000 square kilometers. Articles fell from shelves and buildings rocked (intensity VI) in several Hunterdon County towns. The shock was fairly sharp at Camden and Burlington. At Philadelphia, Pennsylvania, broken windows and overturned crockery were reported.
10/19/1985	Ardsley, NY	4.00	Many people in the NYC area felt this earthquake.
8/23/2011	Central Virginia	5.80	A moderate earthquake occurred in central Virginia and was felt throughout most of the east, from Georgia to southern Canada and from Indiana to coastal Maine. It was followed by four aftershocks. In New Jersey, the intensity ranged from one to four

Date	Location	Richter Magnitude	Description
			(weak to light). Areas underlain by thick silt and clay felt a stronger ground motion than did those where rock was very close to the surface. The quake was felt in South Brunswick and residents were calling 911 wanting to know what happened; some thought it was an explosion. It was also felt in the offices of Alcatel-Lucent in Murray Hill (Union County). Ceiling tiles fell out at a Sears store in Middletown. In Plainfield (Union County), employees in the Park Madison building were evacuated after the tremor. Union County's administration building in Elizabeth reported continuous shaking. In New Brunswick (Middlesex County), employees were evacuated from the County administration building. Atlantic City (Atlantic County) went into emergency mode with evacuations of high rises, hospitals, schools, casinos, and hotels. The County OEM received reports of a crack in a wall in a house and broken water pipe in a building. There were minor scattered power outages reported throughout the State.
4/5/2024	7.7 km ESE of Califon, NJ	4.8	This earthquake was the strongest reported in New Jersey since at least 1783. The earthquake had relatively minor impact, with no major damage reported. Minor damage to sewage and gas pipes were reported in the State as well as some damage to buildings in New York.

Source: 2024 State HMP

Probability of Future Occurrence

Earthquakes cannot be predicted and may occur any time of the day or year. The probability of damaging earthquakes affecting New Jersey is low. However, there is a definite threat of major earthquakes that could cause widespread damage and casualties in New Jersey including Monmouth County. Major earthquakes are infrequent in the State and may occur only once every few hundred years or longer, but the consequences of a major earthquake could be very high. For the purposes of this Plan update, the probability of future occurrences for earthquakes is defined by the number of events over a specified period of time. the entire historical record was consulted and there have been zero earthquake-related disasters declared for New Jersey. The historical record indicates 219 earthquakes recorded for New Jersey from 1783 to 2024.

Potential Effects of Climate Change

The potential impacts of global climate change on earthquake probability are unknown. Some scientists suggest that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the Earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. National Aeronautics and Space Administration (NASA) and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes.

Additionally, secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity because of the increased saturation. Dams storing increased volumes of water from changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts.

Vulnerability Assessment

Built Environment, Infrastructure and Community Lifelines

Because earthquakes often impact large areas and cross jurisdictional boundaries, all existing and future buildings, facilities and populations are considered to be exposed to this hazard and could potentially be impacted. Many buildings in Monmouth County were built without seismic design provisions increasing potential vulnerability in the case of an event.

To assess the vulnerability of Monmouth County to earthquakes, probabilistic scenarios of various potential events were created using HAZUS-MH. HAZUS-MH default ground shaking data, inventory and damage functions, and methodology was used to determine the potential estimated losses for 100-, 500-, 1000-, and 2500-year frequency events and annual expected loss at the census tract level, as well as exceeding probability curves. **Table 4.7 - 4 Peak Ground Acceleration (Ground Motion) for 100- and 500-Year Earthquake Events** lists the expected PGA for 100- and 500-year earthquake events by jurisdiction. It should be noted that some municipalities have no output in the HAZUS analysis. HAZUS outputs earthquake analysis to the Census tract level, and in order to aggregate the data to the municipal level, a spatial join in completed using centroids. Thus, if a single tract contains area in two municipalities, the data may not get captured in one jurisdiction, depending on the location of the tract centroid.

Table 4.7-4 Peak Ground Acceleration (Ground Motion) for 100- and 500-Year Earthquake Events

Jurisdiction	100-year PGA	500-year PGA
Aberdeen, Township of	0.0446	0.2236
Allenhurst, Borough of	-	-
Allentown, Borough of	0.0093	0.0424
Asbury Park, City of	0.0506	0.2394
Atlantic Highlands, Borough of	0.0085	0.0431
Avon-By-The-Sea, Borough of	0.0081	0.0385
Belmar, Borough of	0.0165	0.0779
Bradley Beach, Borough of	0.0162	0.0770
Brielle, Borough of	0.0088	0.0398
Colts Neck, Township of	0.0276	0.1322
Deal, Borough of	0.0092	0.0433
Eatontown, Borough of	0.0282	0.1351
Englishtown, Borough of	0.0096	0.0454
Fair Haven, Borough of	0.0092	0.0448
Farmingdale, Borough of	0.0092	0.0430
Freehold, Borough of	0.0376	0.1774
Freehold, Township of	0.0655	0.3090
Hazlet, Township of	0.0362	0.1808
Highlands, Borough of	0.0176	0.0876
Holmdel, Township of	0.0256	0.1289
Howell, Township of	0.0898	0.4163
Interlaken, Borough of	-	-
Keansburg, Borough of	0.0195	0.0959
Keyport, Borough of	0.0176	0.0894
Lake Como, Borough of	0.0086	0.0397
Little Silver, Borough of	0.0091	0.0444
Loch Arbour, Village of	-	-
Long Branch, City of	0.0750	0.3554
Manalapan, Township of	0.0753	0.3588
Manasquan, Borough of	0.0177	0.0802

Jurisdiction	100-year PGA	500-year PGA
Marlboro, Township of	0.0736	0.3583
Matawan, Borough of	0.0194	0.0951
Middletown, Township of	0.1356	0.6723
Millstone, Township of	0.0182	0.0850
Monmouth Beach, Borough of	0.0086	0.0423
Neptune City, Borough of	0.0086	0.0405
Neptune, Township of	0.0764	0.3610
Ocean, Township of	0.0617	0.2936
Oceanport, Borough of	0.0092	0.0443
Red Bank, Borough of	0.0371	0.1804
Roosevelt, Borough of	-	-
Rumson, Borough of	0.0173	0.0854
Sea Bright, Borough of	-	-
Sea Girt, Borough of	0.0089	0.0409
Shrewsbury, Borough of	0.0093	0.0451
Shrewsbury, Township of	-	-
Spring Lake, Borough of	0.0086	0.0398
Spring Lake Heights, Borough of	0.0179	0.0822
Tinton Falls, Borough of	0.0372	0.1771
Union Beach, Borough of	0.0095	0.0470
Upper Freehold, Township of	0.0089	0.0412
Wall, Township of	0.0528	0.2442
West Long Branch, Borough of	0.0188	0.0892

Source: HAZUS-MH

Earthquakes with higher levels of PGA cause more damage but have a low probability of occurrence. Conversely, earthquakes with low PGA levels such as those which could potentially impact Monmouth County, have a higher probability of occurrence but would only cause negligible to minor damage due to light shaking. In comparison to PGA levels above 0.25g which can cause strong to violent shaking and major damage, expected PGA levels for Monmouth County will likely only cause negligible to light shaking and negligible to minor damage. Estimated losses for a 100-year earthquake event in Monmouth County are considered to be negligible. **Table 4.7 - 5 Estimated Potential Losses From 500, 1000-, and 2500-year Earthquake Events** shows estimated potential losses for 500-, 1000-, and 2500-year events as estimated using HAZUS-MH as well as EALs calculated from these numbers.

Table 4.7-5 Estimated Potential Losses From 500-, 1000-, and 2500-year Earthquake Events

Jurisdiction	Potential Total Building Losses			
	500-Year Event	1000-Year Event	2500-Year Event	Expected Annualized Losses
Aberdeen, Township of	$1,709.88	$7,033.13	$32,420.38	$48.81
Allenhurst, Borough of	-	-	-	-
Allentown, Borough of	$403.84	$1,319.72	$4,813.07	$7.55
Asbury Park, City of	$1,296.66	$5,083.67	$22,947.94	$34.72
Atlantic Highlands, Borough of	$358.68	$1,596.06	$8,025.60	$11.95
Avon-By-The-Sea, Borough of	$184.02	$786.79	$4,001.32	$5.97
Belmar, Borough of	$742.68	$2,934.57	$13,611.24	$20.54

Jurisdiction	Potential Total Building Losses			
	500-Year Event	1000-Year Event	2500-Year Event	Expected Annualized Losses
Bradley Beach, Borough of	$332.13	$1,405.41	$7,077.76	$10.57
Brielle, Borough of	$1,161.96	$3,961.48	$15,441.74	$23.94
Colts Neck, Township of	$2,925.11	$10,726.31	$43,409.85	$66.62
Deal, Borough of	$1,019.58	$3,706.84	$15,123.67	$23.21
Eatontown, Borough of	$5,452.82	$19,485.00	$75,165.79	$116.14
Englishtown, Borough of	$595.16	$1,998.94	$7,324.80	$11.45
Fair Haven, Borough of	$1,048.46	$3,958.23	$16,691.82	$25.47
Farmingdale, Borough of	$351.89	$1,224.52	$4,677.23	$7.25
Freehold, Borough of	$2,664.28	$9,103.25	$34,284.52	$53.33
Freehold, Township of	$11,921.71	$41,872.12	$161,237.33	$249.58
Hazlet, Township of	$2,972.03	$11,228.84	$47,182.08	$72.00
Highlands, Borough of	$514.70	$2,105.10	$9,829.59	$14.79
Holmdel, Township of	$2,760.30	$11,740.30	$56,009.56	$83.93
Howell, Township of	$11,317.38	$39,504.95	$153,472.95	$237.50
Interlaken, Borough of	-	-	-	-
Keansburg, Borough of	$1,479.82	$5,181.20	$19,676.75	$30.51
Keyport, Borough of	$619.88	$2,738.02	$13,403.87	$20.01
Lake Como, Borough of	$197.08	$724.49	$3,033.41	$4.64
Little Silver, Borough of	$1,396.81	$5,356.33	$22,754.06	$34.65
Loch Arbour, Village of	-	-	-	-
Long Branch, City of	$6,950.53	$24,346.38	$93,387.93	$144.64
Manalapan, Township of	$9,696.21	$34,189.71	$132,774.26	$205.28
Manasquan, Borough of	$1,674.17	$5,747.98	$22,357.78	$34.65
Marlboro, Township of	$10,351.14	$38,569.02	$158,715.53	$242.90
Matawan, Borough of	$1,785.29	$6,479.32	$25,375.24	$39.10
Middletown, Township of	$11,299.01	$43,740.80	$188,701.78	$286.78
Millstone, Township of	$3,210.38	$11,600.69	$46,458.87	$71.46
Monmouth Beach, Borough of	$298.90	$1,338.32	$6,855.52	$10.20
Neptune City, Borough of	$1,078.56	$3,957.45	$16,178.49	$24.81
Neptune, Township of	$4,202.60	$15,833.78	$67,296.96	$102.62
Ocean, Township of	$4,714.30	$17,536.89	$73,356.84	$112.13
Oceanport, Borough of	$1,204.11	$4,402.30	$17,721.25	$27.22
Red Bank, Borough of	$3,994.68	$14,365.72	$55,860.43	$86.19
Roosevelt, Borough of	-	-	-	-
Rumson, Borough of	$961.06	$4,224.34	$21,464.30	$31.97
Sea Bright, Borough of	-	-	-	-
Sea Girt, Borough of	$834.54	$2,958.55	$11,945.56	$18.39
Shrewsbury, Borough of	$1,993.15	$7,107.97	$27,618.03	$42.65
Shrewsbury, Township of	-	-	-	-
Spring Lake, Borough of	$753.71	$2,815.48	$11,976.68	$18.27
Spring Lake Heights, Borough of	$865.18	$3,065.97	$12,369.54	$19.05
Tinton Falls, Borough of	$5,227.27	$18,479.09	$71,606.71	$110.70
Union Beach, Borough of	$854.00	$3,255.26	$13,331.30	$20.37
Upper Freehold, Township of	$2,361.98	$8,663.83	$34,985.42	$53.70
Wall, Township of	$7,114.37	$25,685.53	$103,747.37	$159.48

Jurisdiction	Potential Total Building Losses			
	500-Year Event	1000-Year Event	2500-Year Event	Expected Annualized Losses
West Long Branch, Borough of	$3,202.35	$11,139.86	$42,409.35	$65.78
Monmouth County	**$138,054.36**	**$504,279.51**	**$2,048,111.49**	**$3,143.46**

Source: HAZUS-MH

Population and Economy

The entire population is assumed to have equal vulnerability to earthquakes in Monmouth County. The degree of exposure is dependent on many factors, including the age and construction type of the structures people live in, the soil types their homes are constructed on, and their proximity to fault locations. Earthquakes have the potential to impact economies at both the local and regional scale. Losses can include structural and non-structural damage to buildings, loss of business function, damage to inventory, relocation costs, wage loss, and rental loss caused by the repair and replacement of buildings. Roads that cross earthquake-prone soils have the potential to be significantly damaged during an earthquake event, potentially impacting commodity flows. Additionally, economic loss includes business interruption losses associated with the inability to operate a business because of damage sustained during an earthquake, as well as temporary living expenses for those displaced.

Ecosystems and Natural Assets

Earthquakes can impact damage or disturb ecosystems, negatively affecting plant and wildlife. In addition, secondary hazards such landslides, mudslides, slope failure, dam failures, and tsunamis may be triggered by earthquake events which can be harmful to the environment as well.

4.8 EXTREME TEMPERATURES

Hazard Description

According to FEMA, extreme heat and extreme cold constitute different conditions in different parts of the country. Extreme cold can range from near freezing temperatures in the southern United States to temperatures well below zero in the northern states. Similarly, extreme heat is typically recognized as the condition where temperatures consistently stay ten degrees or more above a region's average high temperature for an extended period. Fatalities can result from extreme temperatures, as they can push the human body beyond its limits (hyperthermia and hypothermia).

Location and Extent

Monmouth County is located in a region of the country that is susceptible to both extreme heat and extreme cold. During periods of extreme temperature conditions, the effects are felt over a widespread geographic area and it is generally assumed that the entire planning area is uniformly exposed to extreme heat and extreme cold. Areas along the immediate coast might experience minor differences in apparent temperatures due to the combined effects of air temperature, relative humidity, and wind speed.

Range of Magnitude

The speed of onset of extreme temperature events typically offers 24 hours of warning time. The duration of historic events in Monmouth County is typically less than one week. The extent of extremely cold temperatures is typically measured through the Wind Chill Temperature (WCT) Index. The WCT Index provides a formula for calculating the dangers from winter winds and freezing temperatures. It is, essentially, a calculation of the temperature that is felt when the effects of wind speed are added to the base air temperature. **Figure 4.8-1 NWS Wind Chill Index** shows the NOAA NWS Wind Chill Chart.

Figure 4.8-1 NWS Wind Chill Index

Wind Chill Chart

Temperature (°F)

Wind (mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

The extent of the extremely hot temperatures is typically measured through the Heat Index, which calculates the dangers from high relative humidity and extremely hot temperatures. It is, essentially, a calculation of the temperature that is felt when the effects of relative humidity are added to the base air temperature. **Figure 4.8-2 NWS Heat Index** displays extreme temperatures as four different risk categories: caution, extreme caution, danger, and extreme danger.

Figure 4.8-2 NWS Heat Index

NWS Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Previous Occurrences and Losses

Extreme Heat

According to NOAA's NCEI, over 90 days of recorded heat events have affected Monmouth County since May 1996, resulting in 438 injuries and 4 deaths. According to the NCEI, 29 recorded extreme cold events have affected Monmouth County since 1996. No deaths or property damage were reported but 7 people did suffer injuries. **Table 4.8-1 Extreme Temperature Events from 2001-December 2024** in Monmouth County details events categorized by NOAA as excessive heat or extreme cold/wind chill.

Table 4.8-1 Extreme Temperature Events from 2001-December 2024 in Monmouth County

Date	Event	Duration (in days)	Max or Min Temperature (degrees F)	Deaths	Injuries	Property Damage
6/25/1998	Excessive Heat	2	96	0	16	0
7/4/1999	Excessive Heat	4	100	4	74	0
5/2/2001	Excessive Heat	2	92	0	0	0
1/14/2003	Extreme Cold/Wind Chill	2	4	0	6	0
8/1/2006	Excessive Heat	3	96	0	35	0
6/26/2007	Excessive Heat	2	95	0	0	0
7/9/2007	Excessive Heat	1	97	0	0	0
8/7/2007	Excessive Heat	1	95	0	0	0
8/25/2007	Excessive Heat	1	92	0	0	0
2/5/2007	Extreme Cold/Wind Chill	2	6	0	7	0
6/7/2008	Excessive Heat	3	97	0	6	0
8/10/2009	Excessive Heat	1	94	0	0	0
8/16/2009	Excessive Heat	5	93	0	6	0
6/23/2010	Excessive Heat	1	97	0	0	0
6/27/2010	Excessive Heat	1	96	0	0	0
7/5/2010	Excessive Heat	2	104	0	0	0
7/23/2010	Excessive Heat	2	97	0	0	0
7/21/2011	Excessive Heat	3	102	0	301	0
7/18/2012	Excessive Heat	1	100	0	0	0
1/23/2013	Extreme Cold/Windchill	1	5	0	1	0
7/18/2013	Excessive Heat	1	99	0	0	0
6/29/2021	Excessive Heat	3	Upper 90s	0	0	0
8/11/2021	Excessive Heat	3	Upper 90s	0	0	0
8/9/2022	Excessive Heat	1	Upper 90s	0	0	0
6/22/2024	Excessive Heat	1	Upper 90s	0	0	0
07/05/2024	Excessive Heat	2	Upper 90s	0	0	0
07/09/2024	Excessive Heat	2	Upper 90s	0	0	0
07/15/2024	Excessive Heat	3	Upper 90s	0	0	0
08/02/2024	Excessive Heat	1	Upper 90s	0	0	0

Source: NOAA NCEI, 2024

Probability of Future Occurrence

Extreme temperature events will continue to have a high probability of occurrence in Monmouth County, and the probability of future occurrences in Monmouth County is certain (higher for extreme heat than extreme cold). While the impact of such occurrences on people and property is typically minimal, it is anticipated that the threat to human lives and safety is increasing due to growing elderly populations in many of Monmouth County's municipal jurisdictions.

Potential Effects of Climate Change

As the climate changes, the number of extreme cold events are expected to decrease, and extreme heat events are anticipated to increase in the State. Global and regional temperatures are expected to continue increasing, with New Jersey warming faster than the rest of the Northeast region and the global average (NJDEP 2020). Summers in the State are becoming hotter and heat waves becoming longer and more frequent, leading to potential increased risk from extreme heat events.

Although the trend in the State is generally towards warmer temperatures, traditional weather phenomena such as the Polar Vortex may be disrupted leading to events where extremely cold weather patterns can move out of the arctic to lower latitudes such as New Jersey where they may settle, thus the State could continue to experience extreme cold events despite an overall warming.

Vulnerability Assessment

Built Environment. Infrastructure and Community Lifelines

While all of Monmouth County is exposed to extreme temperatures, existing buildings, infrastructure, and critical facilities are not considered vulnerable to significant damage caused by extreme heat or cold events. Damages can occur when thermal tolerances of various systems are exceeded. Extreme cold can cause thermal cracking of paved surfaces and freezing of pipes. Extreme heat can cause softening and traffic- related rutting of paved surfaces; and buckling of railway tracks. Extreme temperatures can place greater demand on utility systems, with possible associated power outages. While losses could be high for particular events and could result in increased maintenance costs over time with frequent occurrences, average annual property losses associated with extreme temperatures are anticipated to be minimal across the planning area.

Community lifelines may be impacted in the County during events, especially in the case of a power outage as a result of extreme temperature. Facilities without a backup generator may be forced to close until power is restored. Transportation infrastructure can also be disrupted by extreme temperatures as in some cases high temperatures can cause rail tracks and road surfaces to buckle. Prolonged periods of extreme heat can also worsen drought impacts when occurring simultaneously.

Population and Economy

Extreme temperatures are primarily a threat to human life and health, though they are also hazardous to livestock and agricultural crops which could result in economic losses. Extreme temperatures are likely to result in relatively minor impacts in Monmouth County, with very few injuries (if any), minor and sporadic property damage, and minimal disruption on quality of life. Common impacts associated with extreme heat in Monmouth County include injuries associated with swimming to escape extreme heat, and individuals seeking medical treatment for heat related illness (i.e., for heat stress, exhaustion, heat stroke, etc). Cooling centers are typically opened, and schools altering class schedules and/or activities to ensure student safety. Extreme heat events most heavily typically impact the elderly and disadvantaged. Primary impacts of concern for extreme cold temperatures include the life-threatening effects of overexposure hypothermia on people, particularly the elderly and disadvantaged. Other significant impacts include strains on livestock and agriculture. Monmouth County has Code Blue Warming Center system in place with transportation and notifications for residents during extreme cold temperatures.

Heat casualties are usually caused by lack of adequate air conditioning or heat exhaustion. The most vulnerable population to heat casualties are the elderly or infirmed, who frequently live on low fixed incomes and cannot afford to run air-conditioning on a regular basis. This population is sometimes isolated, with no immediate family or friends to look out for their well-being. Casualties resulting from extreme cold may result from a lack of adequate heat, carbon monoxide poisoning from unsafe heat sources and frostbite. The most vulnerable populations to cold casualties are the elderly or infirmed and low-income households, as they may not be able to afford to operate a heat source on a regular basis and may not have immediate family or friends to look out for their well-being.

Table 4.8-2 below summarizes potential EAL in population equivalency by municipality for Heatwave hazard. This data was derived from FEMA's NRI. EAL represents the average economic loss in dollars resulting from natural hazards each year, when expressed in terms of population equivalency, it represents the monetized cost of injury and fatality. Given the lack of historical data and limited likelihood for structural losses resulting from extreme heat or cold occurrences in Monmouth County, annualizing potential structural losses over a long period of time would most likely yield a negligible annualized loss estimate for the entire County. Expected annual losses from the Coldwave hazard category of the NRI are negligible at the municipal level and not included in the table below.

Table 4.8-2 Potential Expected Annual Losses (Population Equivalency) by Municipality for Heatwave Hazard

Municipality	Expected Annual Losses (Population Equivalency)
Aberdeen, Township of	$272,505
Allenhurst, Borough of	$4,309
Allentown, Borough of	$24,318
Asbury Park, City of	$107,549
Atlantic Highlands, Borough of	$57,068
Avon-By-The-Sea, Borough of	$13,496
Belmar, Borough of	$41,616
Bradley Beach, Borough of	$30,451
Brielle, Borough of	$35,172
Colts Neck, Township of	$142,164
Deal, Borough of	$4,309
Eatontown, Borough of	$179,558
Englishtown, Borough of	$97,082
Fair Haven, Borough of	$68,089
Farmingdale, Borough of	$21,391
Freehold, Borough of	$279,174
Freehold, Township of	$435,178
Hazlet, Township of	$286,052
Highlands, Borough of	$32,764
Holmdel, Township of	$247,687
Howell, Township of	$761,388
Interlaken, Borough of	$4,309
Keansburg, Borough of	$141,033
Keyport, Borough of	$101,874
Lake Como, Borough of	$12,068

Municipality	Expected Annual Losses (Population Equivalency)
Little Silver, Borough of	$62,413
Loch Arbour, Village of	$4,309
Long Branch, City of	$223,526
Manalapan, Township of	$483,424
Manasquan, Borough of	$41,645
Marlboro, Township of	$590,200
Matawan, Borough of	$135,101
Middletown, Township of	$929,122
Millstone, Township of	$124,023
Monmouth Beach, Borough of	$20,494
Neptune City, Borough of	$32,632
Neptune, Township of	$232,190
Ocean, Township of	$214,559
Oceanport, Borough of	$57,592
Red Bank, Borough of	$183,468
Roosevelt, Borough of	$35,819
Rumson, Borough of	$51,244
Sea Bright, Borough of	$4,799
Sea Girt, Borough of	$13,270
Shrewsbury, Borough of	$36,464
Shrewsbury, Township of	$36,464
Spring Lake Hts., Borough of	$19,834
Spring Lake, Borough of	$34,775
Tinton Falls, Borough of	$232,815
Union Beach, Borough of	$81,271
Upper Freehold, Township of	$105,500
Wall, Township of	$226,545
West Long Branch, Borough of	$61,066
Monmouth County	**$7,675,168**

Source: FEMA NRI

Ecosystems and Natural Assets

Extreme heat can negatively influence air quality, water quality, and ecosystems such as wetlands and forest. Prolonged events can disrupt food chains, cause disease outbreak, and increase wildfire risk. Extreme heat can also lead to heat casualties in livestock and wildlife from dehydration and heat exhaustion, especially amongst species which can't regulate their temperatures.

Potential for Future Development to Impact Hazard Vulnerability

Extensive development can increase a community's vulnerability to extreme temperature, especially extreme heat. Materials such as asphalt and concrete absorb and re-emit the sun's heat more than natural landscapes such as forests and water bodies. Urban and developed areas, where these structures are highly concentrated and greenery is limited, become "islands" of higher temperatures relative to outlying areas. These pockets of heat are referred to as "heat islands." Additionally, Growth in development raises energy consumption which can strain power grids during heatwaves and potentially lead to outages, leaving communities vulnerable without cooling technologies.

4.9 EXTREME WIND

Hazard Description

Wind is air that is in constant motion relative to the surface of the earth. Extreme wind events can occur suddenly without warning. They can occur at any time of the day or night, in any part of the country. Extreme winds pose a threat to lives, property, and vital utilities primarily due to the effects of flying debris and can down trees and power lines. Extreme winds are most commonly the result of hurricanes, tropical storms, nor'easters, severe thunderstorms and tornadoes, but can also occur in their absence as mere "windstorms." One type of windstorm, the downburst, can cause damage equivalent to a strong tornado.

Location and Extent

Extreme wind events are experienced in every region of the United States. The extreme wind hazard area covers the whole of Monmouth County and the entire planning area is uniformly susceptible to the extreme wind hazard. The County is also at risk to straight-line wind which comes out of a thunderstorm.

Range of Magnitude

Extreme winds can occur alone, such as during straight-line wind events and derechos, or it can accompany other natural hazards, including hurricanes and severe thunderstorms. Severe wind poses a threat to lives, property, and vital utilities primarily due to the effects of flying debris or downed trees and power lines. Severe wind will typically cause the greatest damage to structures of light construction, particularly manufactured homes. **Table 4.9-1 Severity and Typical Effects of Various Sustained Wind Speeds** illustrates the severity and typical effects of various sustained wind speeds. These would be reflective of high winds associated with thunderstorms, hurricanes, tropical storms and nor'easters. Typical effects of wind are very different for tornados; **Table 4.9 - 2 Severity and Typical Effects of Various Tornado Wind Speeds 3-Second Gust** illustrates the severity and typical effects of wind during tornados, as measured by various 3 second gusts. Note that tornados are addressed separately later in this plan section.

Table 4.9-1 Severity and Typical Effects of Various Sustained Wind Speeds

Sustained Wind Speed* (mph)	Equivalent Saffir-Simpson Scale** (Hurricanes)	Severity of Damage	Typical Effects
0-73 (V3S=0 to 88)	N/A	Isolated	Isolated damage for winds below 50 mph. Above 50 mph, expect some minor damage to buildings of light material. Small branches blown from trees.
74-95 (V_{3S} =89 to II5)	1	Minor	Very dangerous winds will produce some damage: Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
96-110 (V_{3S}=II6 to l30)	2	Extensive	Extremely dangerous winds will cause extensive damage: Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near total power loss is expected with outages that could last from several days to weeks.
111-129 (V_{3S}=l3l to l49)	3	Devastating	Devastating damage will occur: Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
130-156 (V_{3S}=l50 to l76)	4	Catastrophic	Catastrophic damage will occur: Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, and power poles downed. Fallen trees and power poles will isolate residential

Sustained Wind Speed* (mph)	Equivalent Saffir-Simpson Scale** (Hurricanes)	Severity of Damage	Typical Effects
			areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
157 or higher (V_{3S}>l77)	5	Catastrophic	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Table 4.9-2 Severity and Typical Effects of Various Tornado Wind Speeds 3-Second Gust

Maximum Wind Speeds 3 Second Gust (mph)	Equivalent Enhanced Fujita Scale* (Tornadoes)	Severity	Typical Effects
65-85	EF0	Light	Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
86-110	EF1	Moderate	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
111-135	EF2	Significant	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; high-rise windows broken and blown in; light-object missiles generated.
136-165	EF3	Severe	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
166-200	EF4	Devastating	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown, and large missiles generated.
Over 200	EF5	Incredible	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly in excess of 100 m (109 yd); trees debarked; steel reinforced concrete structures badly damaged.

Source: National Oceanic and Atmospheric Administration[3]

Previous Occurrences and Losses

According to NOAA's NCEI, 104 recorded high wind events have affected Monmouth County since 1950. Twelve of these have occurred since the last plan was prepared. As mentioned earlier, extreme wind events are often associated with other notable events such as hurricanes and tropical storms, nor'easters and winter storms - each of which are addressed separately within this section. According to NCEI, several notable extreme wind events in Monmouth County were directly associated with these event types. Events from the previous plan as well as those that have occurred since the last plan are in the table below.

Table 4.9-3 High Wind Events in Monmouth County to April 2024

Date	Associated Hazard Event	Deaths	Injuries	Property Damage
11/14/1995	Nor'easter	0	0	Not known
10/8/1996	Tropical Storm Josephine	0	0	Not known
3/31/1997	Winter Storm	0	0	Not known
11/7/1997	Nor'easter	0	0	Not known

[3] *THE 2003 INTERNATIONAL BUILDING CODE TABLE L609.3.L WAS USED TO CONVERT SAFFIR-SIMPSON SUSTAINED WIND SPEEDS TO 3- SECOND GUSTS (V3S) FOR THE PURPOSES OF COMPARISON BETWEEN HURRICANE AND TORNADO WINDS. THE SAFFIR-SIMPSON SCALE IS DESCRIBED FURTHER IN THIS SECTION UNDER HURRICANE AND TROPICAL STORM*

Date	Associated Hazard Event	Deaths	Injuries	Property Damage
2/4/1998	Nor'easter	0	0	Not known
2/23/1998-02/25/1998	Nor'easter	0	0	Not known
9/9/1998	Severe Thunderstorms	1	30	Not known
9/16/1999	Hurricane Floyd	0	0	Not known
1/25/2000	Winter Storm	0	0	Not known
4/9/2000	Winter Storm	0	0	Not known
8/7/2000	Severe Thunderstorms	0	0	$1 million
8/2/2002	Severe Thunderstorms	0	0	$10.2 million
9/11/2002	Tropical Storm Gustav	0	0	Not known
10/16/2002	Nor'easter	0	0	Not known
11/16/2002	Nor'easter	0	0	Not known
2/17/2003	Winter Storm	0	0	Not known
7/22/2003	Severe Thunderstorms	0	0	$500,000
9/18/2003	Tropical Storm Isabel	0	0	Not known
3/8/2005	Winter Storm	0	0	Not known
1/18/2006	Severe Thunderstorms	0	0	$250,000
2/11/2006	Winter Storm	0	0	Not known
9/1/2006	Remnants of Tropical Storm Ernesto	0	0	Not known
8/17/2007	Severe Thunderstorms	0	0	$5,000
11/3/2007	Remnants of Hurricane Noel	0	0	Not known
3/5/2008	Severe Thunderstorms	0	0	$100,000
9/7/2008	Tropical Storm Hannah	0	0	Not known
12/21/2008-12/22/2008	Winter Storm	0	0	Not known
3/1/2009	Nor'easter	0	0	Not known
10/5/2009	Nor'easter	0	0	Not known
11/13/2009	Nor'easter	0	0	Not known
3/13/2010	-	0	0	$500,000
12/26/2010	Blizzard	0	0	Not known
8/27/2011-08/28/2011	Hurricane Irene	0	0	Not known
10/29/2012	Superstorm Sandy	0	0	$1,750,000,000
11/7/2012	Nor'Easter	0	0	$13,000
12/21/2012	-	0	0	$50,000
12/26/2012	-	0	0	$25,000
1/31/2013	Severe Thunderstorms	0	0	$20,000
2/27/2013	-	0	0	$10,000
3/6/2013	Nor'Easter	0	0	$10,000
4/3/2016	Thunderstorms	0	0	$0
1/23/2017	-	0	0	$10
3/2/2017	Thunderstorms	0	0	$0

Date	Associated Hazard Event	Deaths	Injuries	Property Damage
3/2/2018	-	0	0	$0
10/27/2018	-	0	0	$0
07/22/19	Thunderstorm	0	1	Not Known
10/16/19	Nor'easter	0	0	Not Known
2/7/2020	-	0	0	$0
4/13/2020	Thunderstorm	0	0	$0
12/16/2020	Winter Storm	0	0	$0
12/24/2020	-	0	0	$0
2/1/2021	-	0	0	$0
4/30/2021	-	0	0	$0
10/29/2021	-	0	4	$0
5/7/2022	Coastal Storm	0	0	$0
10/2/2022	-	0	0	$0
3/4/2023	-	0	0	$0
9/23/2023	Tropical Storm Ophelia	0	0	$0

Source: NOAA NCEI, 2024

A longer description of some of these events is included below:

September 9, 1998. A squall line of severe thunderstorms capsized boats and downed trees and power lines throughout Monmouth County. The USCG rescued about 60 people from overturned boats –mostly in Sandy Hook Bay. About 30 people were injured and one man drowned. In Sea Bright, lifeguards rescued people from a capsized catamaran. A wind gust to 75 mph was reported in Freehold.

August 7, 2000. A strong downburst produced by a severe thunderstorm produced wind gusts between 75 and 90 mph which caused significant tree damage in Marlboro and Colts Neck. Property damages were estimated at $1 million. The most significant damage occurred in an area bounded by State Route 18 to the west, County Route 537 to the south, Dutch Land Road to the north and Montrose Road to the east.

August 2, 2002. A line of severe thunderstorms brought hurricane-force wind gusts and downed thousands of trees and power lines, damaging homes, vehicles and hundreds of poles. Most municipalities in the County reported damage and a state of emergency was declared in the County. Damages were estimated at $10.2 million. A wind gust of 83 mph was measured at the North Shrewsbury Ice Boat Clubhouse before the instrument broke. In West Long Branch Borough, Monmouth University suffered extensive damage.

July 22, 2003. A severe thunderstorm caused about $500,000 in property damage. About 4,000 homes and businesses lost power. Numerous tree limbs and one large tree were downed in Wall. In Belmar, about 25 homes and six cars were damaged, one home was shifted off its foundation, and another home's roof was ripped off.

January 18, 2006. Peak wind gusts nearly reached between 45 and 70 mph. In Middletown, a school bus struck a downed tree, but no injuries occurred. Vehicles were damaged by downed trees in Colts Neck and Englishtown.

August 17, 2007. High winds from strong to severe thunderstorms during the afternoon and evening of August 17th caused damages in several areas of the County. Trees and wires were downed in Monmouth Beach, Keansburg, from Holmdel through Deal, and from Freehold southeast to Manasquan. In Keansburg, a downed limb and wires resulted in a fire which spread along electrical lines into a house.

February 13, 2008. Strong winds collapsed two large window walls at the Ocean Township Elementary School gymnasium, which caused about $5,000 in damage. About 30 to 40 students from two gym classes were in the room at the time; however, none were injured.

March 5, 2008. A line of severe thunderstorms produced nearly $100,000 in wind related damage in Monmouth County. In Eatontown, a large uprooted tree crushed one trailer and ripped a hole in the roof of the trailer next door. The same storm ripped siding from some other homes in the area. Downed trees and closed roadways were reported in Farmingdale, Wall and Neptune. Power outages because of downed wires occurred in Bradley Beach, Eatontown, Farmingdale, Howell and Neptune. Wind gusts of 61 mph and 60 mph were measured in Sandy Hook and Tinton Falls respectively. Two women were injured when a tree fell on their vehicle in Manalapan. In Middletown, the Navesink section was hit the hardest. Outages because of downed trees and limbs occurred in Colts Neck, Englishtown, Freehold, Hazlet, Middletown, Neptune, Oceanport and Union Beach. A wind gust to 68 mph was measured at Sandy Hook.

March 13, 2010. Strong to high winds downed thousands of trees and tree limbs, damaged telephone poles and caused record breaking utility outages. Damages of $500,000 were reported by the NCEI for Monmouth County, though damages were incurred across the State. Fallen trees damaged homes. Numerous roadways were closed because of downed trees and debris. Rail services were also suspended because of downed wires and poles. A state of emergency was declared state-wide on the 14th.

August 27-28, 2011. Hurricane Irene made landfall as tropical storm at Brigantine (Atlantic County). Monmouth County was impacted by tropical storm force sustained winds, with higher gusts including 63 mph recorded at Sandy Hook and 52 mph in Belmar. High winds downed trees and power lines across the County, with power outages reported for 121,000 homes.

October 29, 2012. Superstorm Sandy made landfall in Atlantic County as a post tropical storm in Brigantine. Monmouth and Ocean Counties were the two hardest-hit counties in the State. Wind damage was estimated at $1.5 billion in eastern Monmouth County, and at $250 million in western Monmouth County. Monmouth County had the greatest number of sustained outages of any county in the State. Upwards of 45,000 fallen trees had to be cut through to restore power, and power was unable to be restored to thousands of shore and barrier island customers because of massive structure and infrastructure damages. Peak wind gusts ranged from 61 mph in Wall to 87 mph at Sandy Hook. Maximum sustained winds included 68 mph at Sandy Hook and 61 mph in Long Branch.

October 29, 2021. Strong high pressure located in eastern Canada and slow moving, strengthening low pressure approaching from the southeastern states resulted in a prolonged onshore flow along the Middle Atlantic coast. The easterly to northeasterly winds became strong as the pressure gradient tightened between the nearby high- and low-pressure centers. High wind conditions were mainly confined to near-coastal portions of the mid-Atlantic. This system was also responsible for producing significant coastal flooding due to the prolonged onshore flow. In Monmouth County, a tree fell on a tent at a Halloween party. Four people received non-life-threatening injuries. Wind gusts close to 60 mph were observed in the area.

Probability of Future Occurrence

Extreme wind events will continue to have a high probability of occurrence in Monmouth County, and the probability of future occurrences in Monmouth County is certain. The entire planning area is susceptible to a wide variety of recurring events that cause extreme wind conditions including severe thunderstorms (most frequent), tornadoes, hurricanes, tropical storms and nor'easters. Based on historic occurrence data, Monmouth County can expect approximately 5 to 10 extreme wind events per year.

Potential Effects of Climate Change

NASA scientists suggest that the United States will face more severe thunderstorms in the future, with deadly lightning, damaging hail, and the potential for tornadoes in the event of climate change. A recent study conducted by NASA predicts that smaller storm events like thunderstorms will also be more dangerous due to climate change (NASA 2007).

Vulnerability Assessment

Built Environment, Infrastructure and Community Lifelines

Because it cannot be predicted where extreme winds may occur, all existing and future buildings, infrastructure and community lifelines are considered exposed to this hazard and could potentially be impacted. Impacts associated with extreme wind in Monmouth County can be critical, large portions of property in the affected area can be damaged or destroyed (depending on the nature of the event), and a complete shutdown of critical facilities for more than one week could all be possible, depending on the type of wind event and the nature of the event. Flying debris, in extreme wind events, can cause secondary impacts while trees can be downed and buildings can be damaged. High winds can directly damage private property as well as roads and bridges, schools, hospitals, and other types of critical facilities and utilities and communications facilities. In addition, impaired access to these facilities during extreme wind events can cause secondary, indirect damages.

Table 4.9-4 Potential Annualized Losses from Extreme Wind by Jurisdiction shows potential annualized losses for the extreme wind hazard. This data was derived from FEMA's NRI. EAL represents the average economic loss in dollars resulting from natural hazards each year The table includes EAL for buildings as well as total EAL which includes building damage as well as damage to agriculture and population equivalency (the monetized cost of injury and fatality).

Table 4.9-4 Potential Annualized Losses from Extreme Wind by Jurisdiction

Jurisdiction	Expected Annual Losses - Building	Expected Annual Losses - Total
Aberdeen, Township of	$226,613.57	$322,959.36
Allenhurst, Borough of	$6,106.71	$27,449.97
Allentown, Borough of	$33,103.18	$44,422.45
Asbury Park, City of	$170,642.25	$246,090.58
Atlantic Highlands, Borough of	$65,941.50	$87,961.40
Avon-By-The-Sea, Borough of	$43,470.29	$53,113.35
Belmar, Borough of	$112,270.04	$141,737.99
Bradley Beach, Borough of	$74,395.92	$95,757.32
Brielle, Borough of	$109,423.04	$134,276.49
Colts Neck, Township of	$245,296.80	$294,968.80
Deal, Borough of	$6,106.71	$27,449.97
Eatontown, Borough of	$274,596.19	$400,014.63
Englishtown, Borough of	$152,233.43	$196,759.79
Fair Haven, Borough of	$104,846.90	$136,120.74
Farmingdale, Borough of	$21,118.59	$28,621.52
Freehold, Borough of	$275,011.88	$374,585.68
Freehold, Township of	$699,367.08	$859,159.73
Hazlet, Township of	$279,407.20	$379,738.91
Highlands, Borough of	$65,885.39	$88,937.93

Jurisdiction	Expected Annual Losses - Building	Expected Annual Losses - Total
Holmdel, Township of	$439,476.79	$526,279.29
Howell, Township of	$851,133.47	$1,118,046.18
Interlaken, Borough of	$6,106.71	$27,449.97
Keansburg, Borough of	$86,341.98	$135,889.24
Keyport, Borough of	$89,779.90	$125,718.13
Lake Como, Borough of	$21,956.06	$30,421.79
Little Silver, Borough of	$144,474.34	$175,059.74
Loch Arbour, Village of	$6,106.71	$27,449.97
Long Branch, City of	$416,435.62	$574,256.53
Manalapan, Township of	$810,787.04	$1,029,452.89
Manasquan, Borough of	$138,679.51	$168,302.11
Marlboro, Township of	$965,375.90	$1,187,197.12
Matawan, Borough of	$116,989.90	$164,706.33
Middletown, Township of	$1,115,371.03	$1,448,832.30
Millstone, Township of	$252,385.99	$350,229.43
Monmouth Beach, Borough of	$68,069.26	$83,903.24
Neptune City, Borough of	$85,955.38	$109,032.87
Neptune, Township of	$424,780.64	$564,767.13
Ocean, Township of	$449,901.10	$587,862.19
Oceanport, Borough of	$120,180.06	$178,530.62
Red Bank, Borough of	$220,770.92	$285,304.08
Roosevelt, Borough of	$41,194.86	$98,748.48
Rumson, Borough of	$204,286.38	$240,863.16
Sea Bright, Borough of	$39,146.86	$46,405.35
Sea Girt, Borough of	$83,491.73	$92,800.55
Shrewsbury, Borough of	$29,073.29	$71,266.73
Shrewsbury, Township of	$29,073.29	$71,266.73
Spring Lake Hts., Borough of	$98,122.90	$112,036.25
Spring Lake, Borough of	$80,044.78	$104,439.27
Tinton Falls, Borough of	$246,419.14	$360,345.41
Union Beach, Borough of	$71,433.15	$99,983.19
Upper Freehold, Township of	$260,422.24	$305,618.29
Wall, Township of	$597,265.30	$729,324.83
West Long Branch, Borough of	$176,077.56	$218,915.10
Monmouth County	**$11,752,946.47**	**$15,390,831.12**

Source: FEMA NRI

Population and Economy

The entire population of the State is considered exposed to high wind events. High wind events may threaten safety, damage buildings, and impact the economy, including loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Recovery and clean-up costs can also be costly and impact the economy as well. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life.

Ecosystems and Natural Assets

Winds and waves are the forces that cause coastal sand dunes to change. Natural dunes are dynamic and change in response to erosion from storm events and recover via wind- and wave-driven sediment transport between storm events (NOAA, 2021). Over time, trees develop strength and flexibility, known as wind firmness; however, windstorms can exceed a tree's wind firmness. When this happens, trees can break or blow over. Root damage can make trees more susceptible to fungi and insects and wound (debarking) can make trees more susceptible to disease or insect pests. Disturbed forestland is also more vulnerable to wildfire, pests, and invasive species (American Forest Foundation, n.d.a).

4.10 FLOOD

Hazard Description

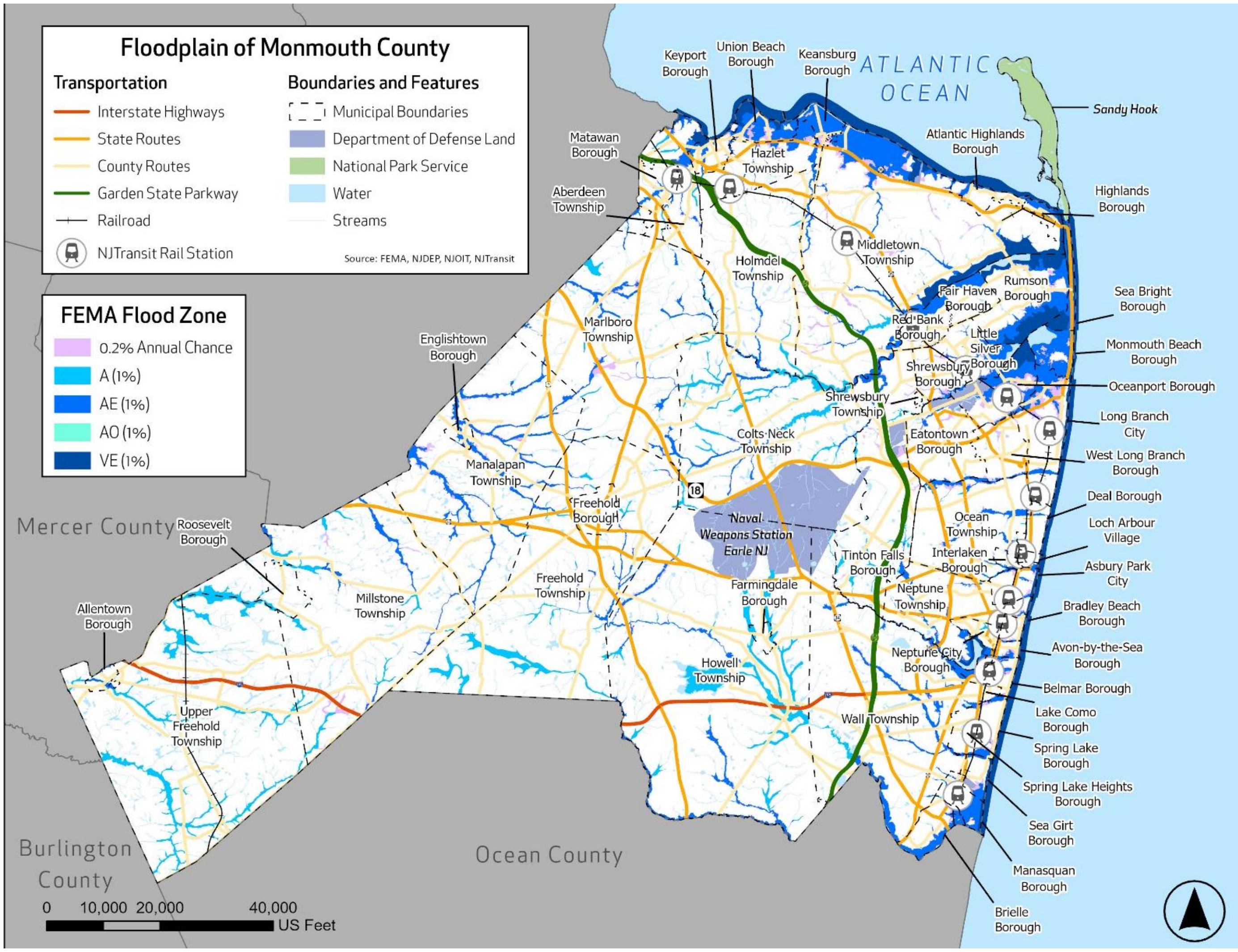
Flooding is caused by the accumulation of water within a water body which results in the overflow of excess water onto adjacent lands, usually floodplains. The floodplain is the land adjoining the channel of a river, stream, ocean, lake or other watercourse or water body that is susceptible to flooding. Most floods fall into the following three categories: riverine flooding, coastal flooding, or shallow flooding (e.g. sheet flow, ponding and urban drainage).

Monmouth County is subject to both riverine and coastal flooding. Riverine flooding occurs along inland channels such as rivers, creeks, and streams. When a channel receives too much water, the excess water flows over its banks and inundates low-lying areas. In addition, when there is debris in the channel, such as fallen trees or trash, the stream cannot fully infiltrate excess stormwater, therefore causing flooding. Coastal flooding, on the other hand, is a result of the storm surge where local sea levels rise to inundate areas along the coasts of oceans, bays, estuaries, coastal rivers, and large lakes. Hurricanes and tropical storms, severe storms, and nor'easters cause most of the coastal flooding in New Jersey.

Location and Extent

Many areas of Monmouth County are susceptible to riverine and urban (stormwater) flooding, and its coastal jurisdictions are also very susceptible to tidal and coastal flooding due to coastal storm events including storm surge.[7] It is estimated that nearly 10 percent of lands within Monmouth County are located in the 100- year floodplain. **Figure 4.10-1 Special Flood Hazard Areas in Monmouth County** illustrates the location and extent of currently mapped special flood hazard areas for Monmouth County based on FEMA's Preliminary and Effective Digital Flood Insurance Rate Maps (DFIRMs). This includes Zones A/AE (100-year floodplain), Zone VE (100-year coastal flood zones, associated with wave action) and Zone X500 (500-year floodplain). It is important to note that while FEMA digital flood data is recognized as best available data for planning purposes, it does not always reflect the most accurate and up-to-date flood risk. Flooding and flood-related losses often do occur outside of delineated special flood hazard areas - particularly in areas that were not included in detailed study areas.

Figure 4.10-1 Special Flood Hazard Areas in Monmouth County



Source: FEMA FIRM, 2024

Several municipalities in the County, mostly in coastal areas, already benefit from some existing flood protection structures such as floodwalls and beach/dune systems. The FEMA Flood Insurance Study (FIS) notes that small dams are located on Conines Mill Pond and Indian Run in the Borough of Allentown, on Swimming River in the Township of Middletown, on Pine Brook near Tinton Avenue in the Borough of Tinton Falls and scattered elsewhere throughout the County. Small weirs restrict the passage of tidal surges into inland areas on Whale Pond Brook and Poplar Brook in the Township of Ocean, and small erosion control structures have been placed along the streams in the Township of Holmdel. The Township of Wall has also placed small stone wave protection measures near roads and other critical infrastructure. A bulkhead was constructed along Marine Park in the Borough of Red Bank.

Table 4.10-1 Percent of Area in the Floodplain by Municipality displays the percentage of municipal area which lies within the 1% or 0.2% annual chance floodplain. This data was derived from existing and preliminary FIS data which have been combined into a composite layer representing the best available data.

Table 4.10-1 Percent of Area in the Floodplain by Municipality

Municipality	Percent Land Area in 1% Annual Chance Floodplain	Percent Land Area in 0.2% Annual Chance Floodplain
Aberdeen, Township of	17.5%	2.4%
Allenhurst, Borough of	10.2%	0.5%
Allentown, Borough of	15.4%	1.2%
Asbury Park, City of	14.7%	4.9%
Atlantic Highlands, Borough of	16.1%	3.7%
Avon-By-The-Sea, Borough of	25.8%	10.2%
Belmar, Borough of	25.1%	7.2%
Bradley Beach, Borough of	17.6%	5.9%
Brielle, Borough of	13.3%	3.2%
Colts Neck, Township of	7.9%	0.3%
Deal, Borough of	8.5%	0.6%
Eatontown, Borough of	3.0%	3.0%
Englishtown, Borough of	28.3%	4.1%
Fair Haven, Borough of	2.8%	0.6%
Farmingdale, Borough of	22.4%	0.0%
Freehold, Borough of	0.0%	0.0%
Freehold, Township Of	5.5%	0.3%
Hazlet, Township of	15.3%	4.6%
Highlands, Borough of	50.3%	0.8%
Holmdel, Township of	3.6%	0.2%
Howell, Township of	8.2%	0.4%
Interlaken, Borough of	22.1%	0.3%
Keansburg, Borough of	83.0%	8.6%
Keyport, Borough of	23.9%	4.2%
Lake Como, Borough of	6.8%	4.1%
Little Silver, Borough of	28.2%	5.3%
Loch Arbour, Village of	52.1%	5.5%
Long Branch, City of	21.4%	13.8%
Manalapan, Township of	8.0%	1.7%
Manasquan, Borough of	55.9%	7.4%
Marlboro, Township of	4.9%	1.2%
Matawan, Borough of	13.8%	0.2%
Middletown, Township of	14.8%	2.8%
Millstone, Township of	5.3%	1.0%
Monmouth Beach, Borough of	64.7%	5.1%
Neptune City, Borough of	10.4%	1.1%
Neptune, Township of	9.4%	1.2%
Ocean, Township of	8.8%	1.9%
Oceanport, Borough of	44.1%	11.9%
Red Bank, Borough of	5.1%	0.6%
Roosevelt, Borough of	3.9%	0.0%
Rumson, Borough of	34.5%	4.0%
Sea Bright, Borough of	99.5%	0.4%
Sea Girt, Borough of	29.2%	6.0%
Shrewsbury, Borough of	6.6%	9.8%

Municipality	Percent Land Area in 1% Annual Chance Floodplain	Percent Land Area in 0.2% Annual Chance Floodplain
Shrewsbury, Township of	NA	0.0%
Spring Lake Heights, Borough of	27.2%	8.8%
Spring Lake, Borough of	7.1%	1.3%
Tinton Falls, Borough Of	5.6%	1.6%
Union Beach, Borough of	81.9%	10.2%
Upper Freehold, Township of	7.1%	0.0%
Wall, Township of	6.5%	0.5%
West Long Branch, Borough of	2.9%	4.3%
Monmouth County	**10.6%**	**1.6%**

Source: FEMA, 2024

Range of Magnitude

In the case of riverine flood hazard, once a river reaches flood stage, the flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category has a definition based on property damage and public threat:

- Minor Flooding - minimal or no property damage, but possibly some public threat or inconvenience.
- Moderate Flooding - some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations (NWS 2011).

The extent of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies. Also referred to as the SFHA, this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the water elevation resulting from a given discharge level, which is one of the most important factors used in estimating flood damage.

Previous Occurrences and Losses

Flooding is the most common major natural hazard in New Jersey. The FIS notes that flooding in Monmouth County is attributed mainly to tropical storms, extratropical cyclones (nor'easters) and, to a lesser extent, severe thunderstorms. According to NOAA’s NCEI, over 190 recorded flood events (coastal flood, flash flood, and flood) have occurred in Monmouth County since 1996. These events have resulted in two reported injuries and an estimated $10 billion in property damages. Some recent notable events include the following:

February 4, 1998. In Monmouth County, damage was estimated at $500,000 as the County was spared by the eastward movement of the nor'easter off Cape Hatteras. The continuous onshore flow caused moderate to severe beach erosion (described under coastal erosion hazard). New Jersey State Route 36 was flooded in Sea Bright. In Raritan Bay, tidal flooding caused road closures in Middletown Township.

September 16, 1999. Hurricane Floyd brought torrential rains. In Monmouth County, the worst flooding related problems occurred when the torrential rain coincided with the high tide. The worst flooding was reported in Union Beach and bay areas of Middletown Township. For more information on Hurricane Floyd, please see the description of Hurricane Floyd under the Tropical Storms and Hurricanes subsection

October 13-14, 2005. Heavy rain associated with a low-pressure system southeast of New Jersey moved into Monmouth County on the 13th. Three-day storm totals (from the 11th through the 14th) in the County averaged between four and 11 inches, with the highest amounts near the coast. In Asbury Park and Loch Arbour Village, Deal Lake overflowed and forced the evacuation of about 65 homes in Loch Arbour and 30 homes in Asbury Park. In Eatontown Borough, Eatoncrest Apartments flooded as water was three to four feet deep in areas. In Belmar Borough, flooding occurred along Lake Como and along the Shark River. In Monmouth Beach, flooding along the Shrewsbury River affected several blocks. In Ocean Township, flooding along the Poplar Brook caused the evacuation of the entire 104-unit Poplar Village Senior Citizens Center. After the brook receded, 22 units were deemed uninhabitable. In Rumson Borough, flooding along the Shrewsbury River closed roads near the Sea Bright-Rumson Bridge. In Howell Township, seven units of the Friendship Gardens (Senior Citizen) complex were evacuated. Metedeconk River flooding also affected Freehold Township, the Borough of Spring Lake and Wall Township. The Manasquan River at Squankum reached its 7.5-foot flood stage on the 13th, cresting at 9.62 feet on the 14th. Specific storm totals included 11.58 inches in Manasquan and 10.15 inches in Tinton Falls.

March 2, 2007. Flooding occurred during the morning of the 2nd along State Route 35 in Hazlet and Aberdeen. The flooding may have been enhanced due to the high tide. Flooding also occurred along State Route 33, Howell Road, Church Road and Fairfield near Freehold. Rainfall totals include: 1.81 inches in Jackson; 1.54 inches in Marlboro; and 1.23 inches in Cream Ridge. The NCEI does not report injuries, fatalities, property damages, or crop damages for this event.

June 14, 2008. A slow-moving cold front helped trigger scattered showers and thunderstorms across New Jersey during the evening of the 14th. The thunderstorms moved slowly and caused flash flooding in Monmouth County. Torrential downpours caused roadway flooding and flooding of smaller streams and creeks in the northeastern part of Monmouth County. A Skywarn spotter measured three inches of rain within 45 minutes in Middletown Township. Roadway flooding was reported in Middletown and Highlands.

August 21, 2011. Thunderstorms with torrential downpours caused small stream flash flooding as well as poor drainage flooding in the southern half of Monmouth County. Howell, Ocean and Wall Townships were hardest hit with around a dozen homes damaged. The runoff also caused moderate flooding along the Manasquan River that lasted into the 22nd. In Howell, the Mariner's Cove development near the Manasquan River was hard hit by flooding. Rescue boats were used to evacuate families as mud and water entered the first floor of homes. The U.S. Route 9 bridge over the Manasquan River was closed due to concern about its integrity. It was re-opened on the 22nd. Another bridge over the Manasquan River on Allentown-Lakewood Road near Robert Brice Memorial Park was also flooded and closed. In Ocean Township, flooding displaced residents of the Middlebrook at Monmouth Apartments on Deal Road. In Freehold, Post Road flooded by a creek and State Route 33 was closed in both directions at Halls Mill Road. In Long Branch, 2nd Avenue was under three feet of water, and barricades were floating away. In Deal, State Route 71 was closed in both directions. Streams were reported out of their banks in Millstone Township. Precipitation totals included 4.61 inches in Howell Township, 3.75 inches in Ocean Township, 3.16 inches in Asbury Park and 2.96 inches in Eatontown.

Hurricane Irene 2011. Irene's torrential downpours caused major flooding and a number of record-breaking crests on area rivers and a three to five-foot storm surge that caused moderate to severe tidal flooding with extensive beach erosion over the weekend of August 27th and 28th. Moderate to severe tidal flooding occurred along the Atlantic Coast 2nd Raritan Bay. Event precipitation totals averaged 5 to 10 inches and caused widespread record-breaking flooding. For more discussion of Hurricane Irene, please see Hurricane Irene under the Tropical Storms and Hurricanes subsection.

Superstorm Sandy 2012. Monmouth County was one of the two hardest-hit counties in the State of New Jersey. For more discussion of Superstorm Sandy, please see Superstorm Sandy under the Tropical Storms and Hurricanes subsection.

May 5, 2017. Low pressure moving from Tennessee into western New York State lifted a warm front north through the State late Friday morning into early Friday afternoon on May 6, 2017. In advance of a cold front, which followed Friday evening, several rounds of heavy rainfall with embedded thunder traversed the State Friday morning into the afternoon. The heaviest rainfall occurred in a southwest to northeast swath covering portions of Atlantic, Salem, Burlington, Ocean, Monmouth, and Middlesex counties, where localized rainfall amounts ranged from two to over four inches. The highest rainfall amount was 4.38 inches at a Community Collaborative Rain, Hail & Snow Network (CoCoRaHS) site 6 miles northeast of Manchester Township in Ocean County. The large amount of rainfall in a relatively short period of time contributed to flooding, mainly across Monmouth County, including a report of flash flooding in Union Beach, where a car was stuck in an estimated 2 feet of water.

Remnants of Hurricane Ida, 2021

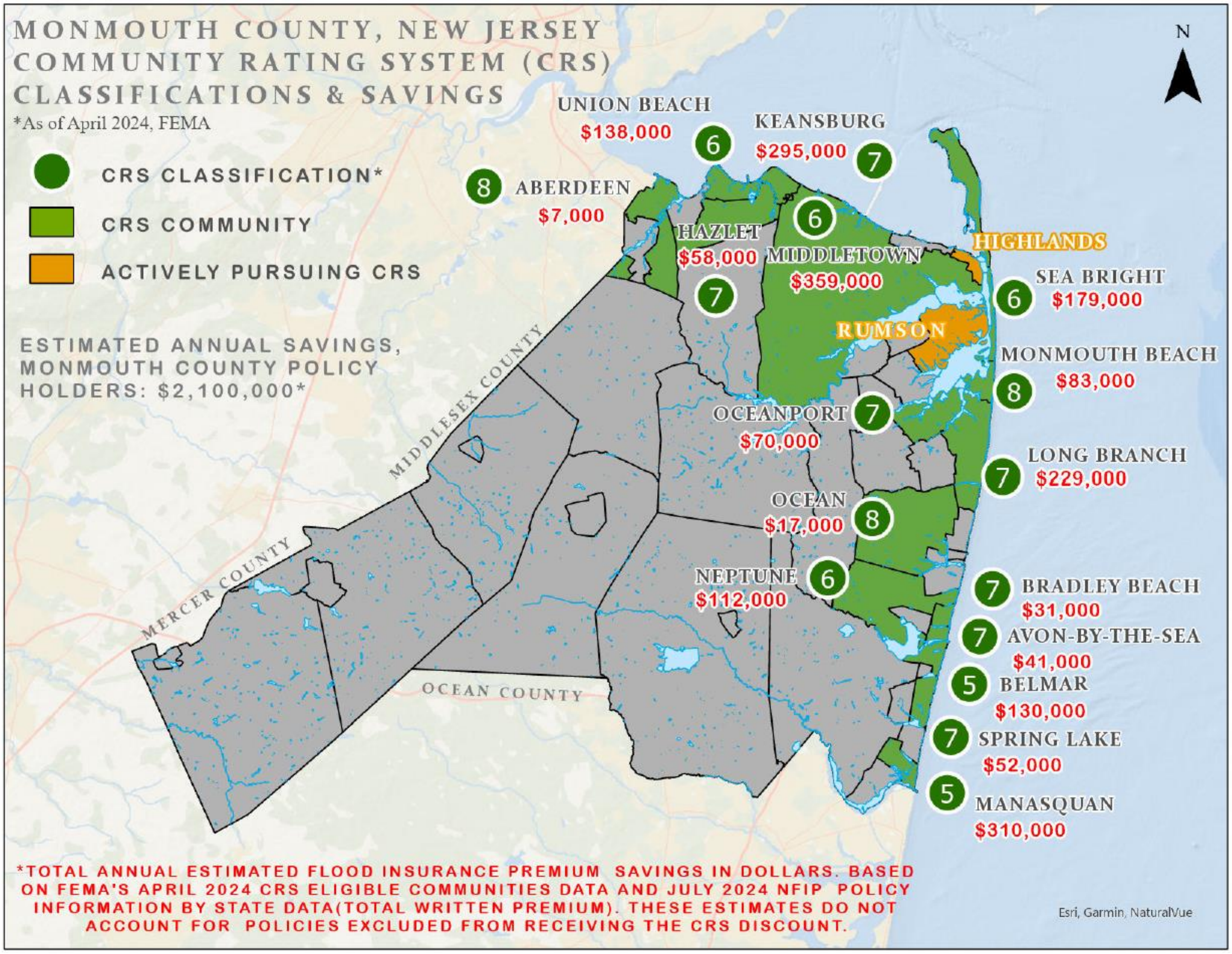
Many areas of the Shore saw heavy rainfall and a few gusty winds between 30 to 40 mph, but this area was not nearly as affected as most of northern New Jersey, according to Wednesday's advisory from the NWS. Police and emergency responders worked through the night to tend to flooded roads, specifically in areas near heavily battered Middlesex County such as in Hazlet, Keyport, Manalapan and Matawan in Monmouth County. Reports of rainfall totals were still being recorded as of Thursday morning, with most of the Shore seeing less than an inch of rainfall. The highest totals included 4 inches in Middletown and 3.13 inches in Holmdel, according to weather-tracking sources. Freehold Township had 2.54 inches, while Colts Neck saw 2.17 inches of heavy rainfall, according to data from the Community Collaborative, Rain, Hail and Snow Cooperative. Manasquan, Red Bank and Long Branch saw around 1.3 to 1.73 inches Wednesday night.

Historical Summary of Insured Flood Losses

According to FEMA flood insurance policy records, there have been 20,001 flood losses reported in Monmouth County through the NFIP from 1972 to 2024. Net NFIP loss payment statistics as of August 2024 total approximately $933.3 million. Every municipal jurisdiction in Monmouth County is listed by FEMA as being an active participant in the NFIP. The name of the Floodplain Administrator (the person responsible for ensuring that development activities comply with floodplain management ordinances and NFIP regulations) for each jurisdiction is included in the Capability Assessment section of the plan and notes within each of the jurisdiction’s appendix.

In addition to NFIP participation, the 16 communities of Aberdeen, Avon-By-The-Sea, Belmar, Bradley Beach, Hazlet, Keansburg, Long Branch, Manasquan, Middletown, Monmouth Beach, Neptune, Ocean, Oceanport, Sea Bright, Spring Lake, and Union Beach are listed by FEMA as CRS participating communities. Under the CRS, communities which implement floodplain management actions that go beyond the minimum requirements of the NFIP are eligible for discounts on flood insurance premiums for properties within that community.

Figure 4.10-2 Monmouth County CRS Classifications & Savings (as of April 2024)



Source: Monmouth County Division of Planning, FEMA, April 2024

Monmouth County OEM will continue to work with all jurisdictions in the County, encouraging them all to participate fully in the NFIP, and to take full advantage of additional FEMA programs such as the CRS. Jurisdictions already participating in the CRS will be encouraged to improve their CRS classification, while non-participating jurisdictions will be encouraged to work towards eligibility. The County will also support local jurisdiction participation in the Cooperating Technical Partners Program (CTP), of which the main objective is to increase local involvement in the floodplain mapping process.

Table 4.10-2 National Flood Insurance Program (NFIP) Community Rating System (CRS) Participation in Monmouth County summarizes the CRS classifications of participating Monmouth County municipalities.

Table 4.10-2 National Flood Insurance Program (NFIP) Community Rating System (CRS) Participation in Monmouth County as of October 1, 2024

CRS Number	Jurisdiction	Participation Status	Date Entered CRS	Current Effective Date	CRS Class (as of October 2024)	% Discount for SFHA	% Discount for Non-SFHA
340312	Aberdeen, Township of	Current	5/1/2010	10/1/2015	8	10	5
340287	Avon-By-The-Sea, Borough of	Current	10/1/2016	4/1/2023	7	15	5
345283	Belmar, Borough of	Current	5/1/2015	5/1/2020	5	25	10
340289	Bradley Beach, Borough of	Current	10/1/1995	10/1/2000	7	15	5
340298	Hazlet, Township of	Current	5/1/2011	4/1/2023	7	15	5
340303	Keansburg, Borough of	Current	5/1/2015	5/1/2015	7	15	5
340307	Long Branch, City of	Current	5/1/2018	5/1/2018	7	15	5
345303	Manasquan, Borough of	Current	10/1/1992	5/1/2018	5	25	10
340313	Middletown, Township of	Current	5/1/2012	10/1/2013	7	15	5
340315	Monmouth Beach, Borough of	Current	10/1/2017	10/1/2017	8	10	5
340317	Neptune, Township of	Current	5/1/2015	4/1/2023	6	20	10
340518	Ocean, Township of	Current	5/1/2014	10/1/2023	6	20	10
340320	Oceanport, Borough of	Current	5/1/2010	4/1/2023	8	10	5
345317	Sea Bright, Borough of*	Current	10/1/1992	10/1/2018	6	20	10
340329	Spring Lake, Borough of	Current	10/1/1994	4/1/2023	7	15	5
340331	Union Beach, Borough of	Current	10/1/2003	4/1/2023	7	15	5
NOTES: FOR THE PURPOSE OF DETERMINING CRS DISCOUNTS, ALL AR AND A99 ZONES ARE TREATED AS NON-SFHAS.							

Sources: FEMA April 2024 NFIP Flood insurance manual; Monmouth County Division of Planning

Table 4.10-3 National Flood Insurance Program Statistics lists relevant NFIP statistics, including the total number of losses under the NFIP by municipal jurisdiction. It should be emphasized that this listing includes only those losses to structures that were insured through the NFIP policies. Total number of losses includes some losses in which claims were sought and not received. It is likely that many additional instances of flood losses in Monmouth County were either uninsured or not reported.

Before Superstorm Sandy had even occurred, the total value of all claims paid countywide had increased by 42 percent between May 2008 and May 2012, ($76.8 million in May 2008 as compared to $109.5M in May 2012. At that time, many of the claims paid were due to Hurricane Irene. The impacts of Sandy are truly staggering. Between May 2008 and August

2014, the total value of all claims paid has increased from $76.8 million to $852 million. This represents about a 1009 percent increase over May 2008 values that were presented in the initial version of this HMP.

Repetitive Loss Properties

FEMA defines a Repetitive Loss (RL) property as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. A RL property may or may not be currently insured by the NFIP. According to FEMA RL property records there are 1,102 RL properties located in Monmouth County (as of September 14, 2023). These properties are associated with a total of 3,657 losses and approximately $161 million in claims payments under the NFIP since January 1978 (the earliest recorded date of loss).

While 48 (91 percent) of Monmouth County's 53 municipal jurisdictions identified as having one or more RL properties, Highlands and Manasquan have the most RL properties (177 and 135, respectively; 308 combined, roughly 25% of all the RL properties in the County). Total RL paid claims are the highest in three communities: Monmouth Beach ($26.9 million from 129 properties); Sea Bright ($20.1 million from 114 properties); and Highlands ($19.2 million from 177 properties). Paid claims per RL property are highest on average in the Borough of Red Bank where only three properties have been paid $1,487,369, or $495,790 per claim. (It should be noted that these properties are commercial buildings and the NFIP offers a higher amount paid per claim compared to residential.) Mitigating RL properties is a priority of the State HMP.

This plan does not show areas of the County where occasional isolated RL properties are located and show only the approximate areas covering clusters of RL properties, since the component data is subject to the 1974 Privacy Act. This legislation prohibits the public release of any information regarding individual NFIP claims or information which may lead to the identification of associated individual addresses and property owners. However, while this information is not available to the general public, the County may subsequently obtain comprehensive RL property data from FEMA for the purposes of targeted mitigation of RL areas or individual RL structures.

FEMA has indicated that their system depends heavily on programmed address matching to identify repetitive losses and, while the software makes some allowances for misspellings and incomplete addresses, it is not perfect and sometimes legitimate address matches are missed. Sometimes repetitive loss properties go undetected for years because of address anomalies. There are FEMA contractors and FEMA regional staff who are actively working with the repetitive loss system allowing them to link addresses that they have found should be linked. When they do, new repetitive loss properties can be created even though the loss dates may have been older. Sometimes repetitive loss properties can be combined as well and may create SRL.

The average repetitive loss property in Monmouth County has experienced 2.55 loss events. At the highest end, one property in Hazlet has 17 losses with an average payment of $16,462.97. The following five communities have no RL properties within their borders: Allentown, Fair Haven, Matawan, Millstone and Shrewsbury Township. The majority of all RL properties are located in the 100-year floodplain.

It should be noted that these Repetitive Loss and Severe Repetitive Loss statistics only include those properties that are insured through the NFIP and fit the NFIP definition for Repetitive Loss and Severe Repetitive Loss. This analysis does not capture claims which are related to privately insured properties.

Severe Repetitive Loss Properties

FEMA defines a SRL property as a residential property that is covered under an NFIP flood insurance policy and: (a) that has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or (b) for which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building; and (c) for both (a) and (b), at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart. According to FEMA repetitive loss property records (as of August 2024) there are a total of 153 severe repetitive loss properties located in 26 Monmouth County communities. These 153 severe repetitive loss properties are associated with a total of 752 losses and $44.06 million in claims payments under the NFIP since January 1978 (the earliest recorded date of loss). There is an average of 4.92 claims per property and an average payment of $287,996.12 paid per claim.

Table 4.10-3 National Flood Insurance Program Statistics

Jurisdiction	Total Policies in Force	Total Losses	Total RL Properties	Total SRL Properties	Total RL & SRL Combined	Total Mitigated Properties	Total RL and SRL Payments
Aberdeen, Township of	72	71	2	1	3	1	$796,071.29
Allenhurst, Borough of	44	22	2	0	2	0	$152,088.45
Allentown, Borough of	12	3	0	0	0	0	$0
Asbury Park, City of	458	74	5	0	5	0	$1,524,474.85
Atlantic Highlands, Borough of	105	86	5	1	6	0	$1,313,833.33
Avon-By-The-Sea, Borough of	347	303	10	1	11	9	$1,662,080.51
Belmar, Borough of	740	485	33	1	34	11	$3,637,886.05
Bradley Beach, Borough of	246	86	5	0	5	0	$216,501.73
Brielle, Borough of	197	214	8	1	9	1	$746,166.68
Colts Neck, Township of	26	41	2	0	2	0	$801,853.81
Deal, Borough of	123	89	1	2	3	0	$551,854
Eatontown, Borough of	23	18	1	0	1	0	$10,773.48
Englishtown, Borough of	21	35	5	0	5	0	$223,980.88
Fair Haven, Borough of	29	31	0	0	0	0	$0
Farmingdale, Borough of	3	28	7	0	7	0	$922,182.89
Freehold, Borough of	0	0	0	0	0	0	$0
Freehold, Township Of	69	52	5	0	5	0	$160,710.81
Hazlet, Township of	354	119	2	3	5	0	$753,413.24
Highlands, Borough of	636	1,739	164	13	177	59	$19,212,704.18
Holmdel, Township of	22	12	1	0	1	0	$63,948.47
Howell, Township of	108	45	2	0	2	2	$74,333.80
Interlaken, Borough of	12	18	2	0	2	0	$74,334
Keansburg, Borough of	1,228	1,343	38	1	39	18	$1,811,937.55
Keyport, Borough of	87	170	6	4	10	2	$3,059,725.98
Lake Como, Borough of	70	41	3	0	3	0	$85,300.87
Little Silver, Borough of	249	390	20	2	22	1	$5,217,890.55
Loch Arbour, Village of	35	99	17	1	18	1	$813,822.84
Long Branch, City of	1,585	1,374	49	9	58	3	$7,138,662.94
Manalapan, Township of	95	93	8	1	9	1	$609,107.21
Manasquan, Borough of	1,132	2,224	122	13	135	39	$11,905,687.58
Marlboro, Township of	104	92	7	0	7	0	$146,347.04
Matawan, Borough of	11	21	0	0	0	0	$0
Middletown, Township of	1,918	1,709	113	8	121	48	$9,218,097.10
Millstone, Township of	8	6	0	0	0	0	$0

Jurisdiction	Total Policies in Force	Total Losses	Total RL Properties	Total SRL Properties	Total RL & SRL Combined	Total Mitigated Properties	Total RL and SRL Payments
Monmouth Beach, Borough of	1,564	1,729	103	26	129	17	$26,833,222.99
Neptune City, Borough of	50	49	5	0	5	0	$827,507.42
Neptune, Township of	592	422	18	1	19	3	$2,245,561.79
Ocean, Township of	176	269	16	7	23	14	$2,003,204.40
Oceanport, Borough of	554	960	29	5	34	27	$5,976,046.89
Red Bank, Borough of	41	35	3	0	3	0	$1,487,368.59
Roosevelt, Borough of	1	4	1	0	1	0	$94,419.75
Rumson, Borough of	435	946	64	12	76	10	$14,551,223.29
Sea Bright, Borough of	887	1,950	81	18	99	69	$20,127,510.79
Sea Girt, Borough of	235	110	4	0	4	0	$215,574.98
Shrewsbury, Borough of	31	10	1	0	1	0	$5,627.78
Shrewsbury, Township of	0	0	0	0	0	0	$0
Spring Lake Heights, Borough of	83	47	1	2	3	3	$256,344.80
Spring Lake, Borough of	550	506	80	12	92	11	$7,904,001.79
Tinton Falls, Borough Of	33	12	1	0	1	0	$17,620.24
Union Beach, Borough of	870	1,556	44	8	52	34	$6,421,234.97
Upper Freehold, Township of	9	3	0	0	0	0	$0
Wall, Township of	137	82	5	0	5	1	$90,818.61
West Long Branch, Borough of	20	16	1	0	1	0	$7,772.84
Monmouth County	**16,437**	**20,001**	**1,102**	**153**	**1,255**	**385**	**$161,688,371.12**

Source: FEMA

Probability of Future Occurrence

Flooding will continue to have a high probability of occurrence in Monmouth County, and the probability of future occurrences in Monmouth County is certain. The probability of future flood events based on magnitude and according to best available data is illustrated in **Figure 4.11-1 Special Flood Hazard Areas in Monmouth County**, which indicates those areas susceptible to the 1 percent annual chance flood (100-year floodplain) and the 0.2 percent annual chance flood (500-year floodplain).

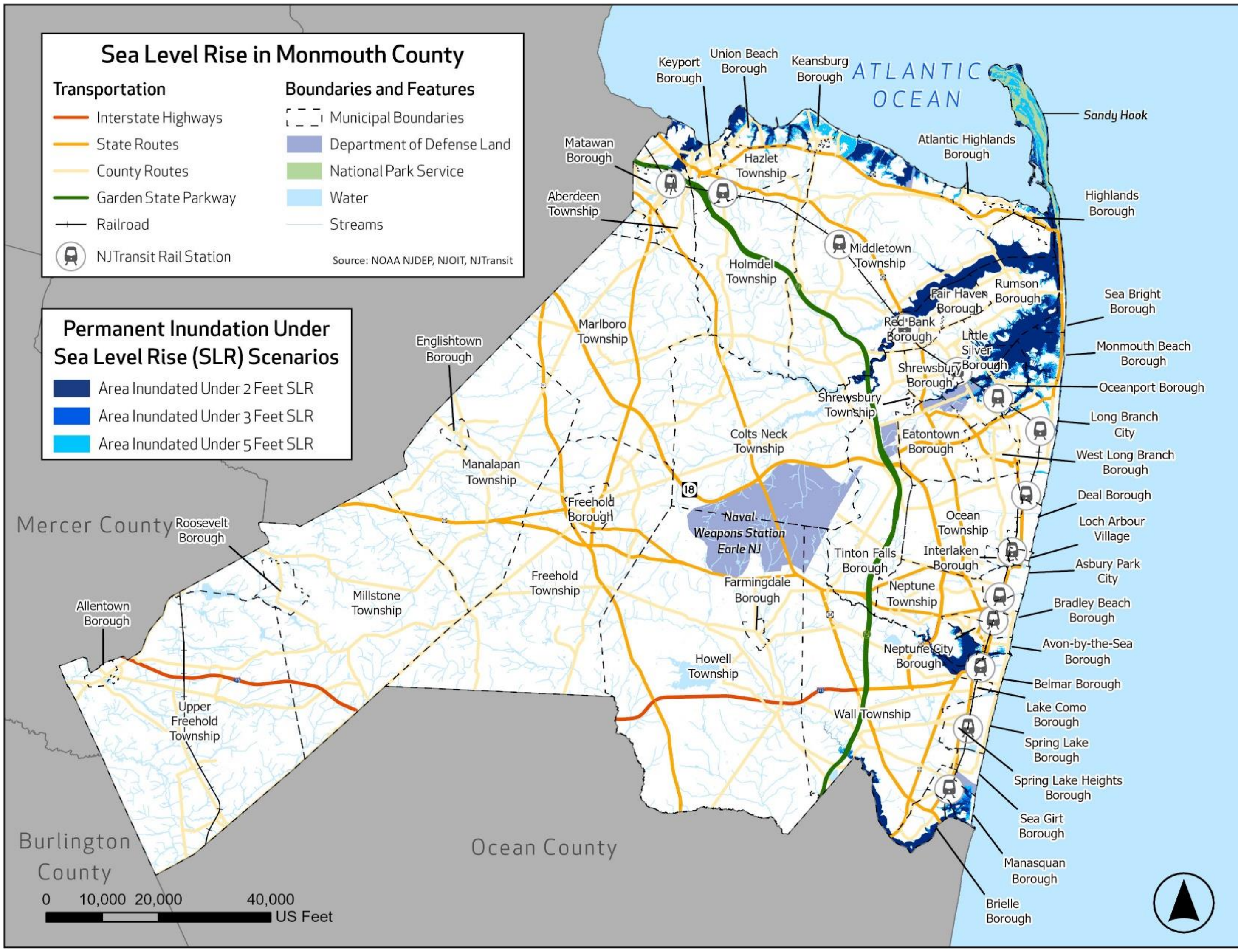
Flooding in Monmouth County is attributed mainly to tropical storms, nor'easters, and to a lesser extent severe thunderstorms. Usually occurring during late summer and early autumn, these storms can result in severe damage to coastal areas. Although extratropical cyclones can develop at almost any time of the year, they are more likely to occur during winter and spring. Thunderstorms are a common occurrence during the warm summer months.

Potential Effects of Climate Change

The frequency of intense precipitation events in Monmouth County is expected to increase in the future with climate change; this is likely to result in more riverine and flash flooding events. Within the last 10 years, there have been 58 coastal flood events in Monmouth County, estimating to $10 billion in property damage. It should also be noted that anticipated sea level rise will increase the risk of damages/losses due to future coastal flooding events. Rising sea level over time will shorten the return period (increasing the frequency) of significant flood events.

Sea level rise continues to impact areas along the Atlantic coast of New Jersey and the Raritan Bay. Effects will reach some low lying and inland communities as rivers that empty into either the Atlantic Ocean or Raritan Bay such as the Manasquan, Navesink, Shark, and Shrewsbury Rivers will experience a subsequent rise in their water levels. **Figure 4.11-3 Permanent Inundation Under Sea Level Rise Scenarios** in Monmouth County visualizes three potential flooding from sea level rise scenarios, at the 2-, 3- and 5- foot levels (measured from current mean higher high water levels), and their resulting areas of permanent inundation in Monmouth County.

Figure 4.10-3 Permanent Inundation Under Sea Level Rise Scenarios in Monmouth County

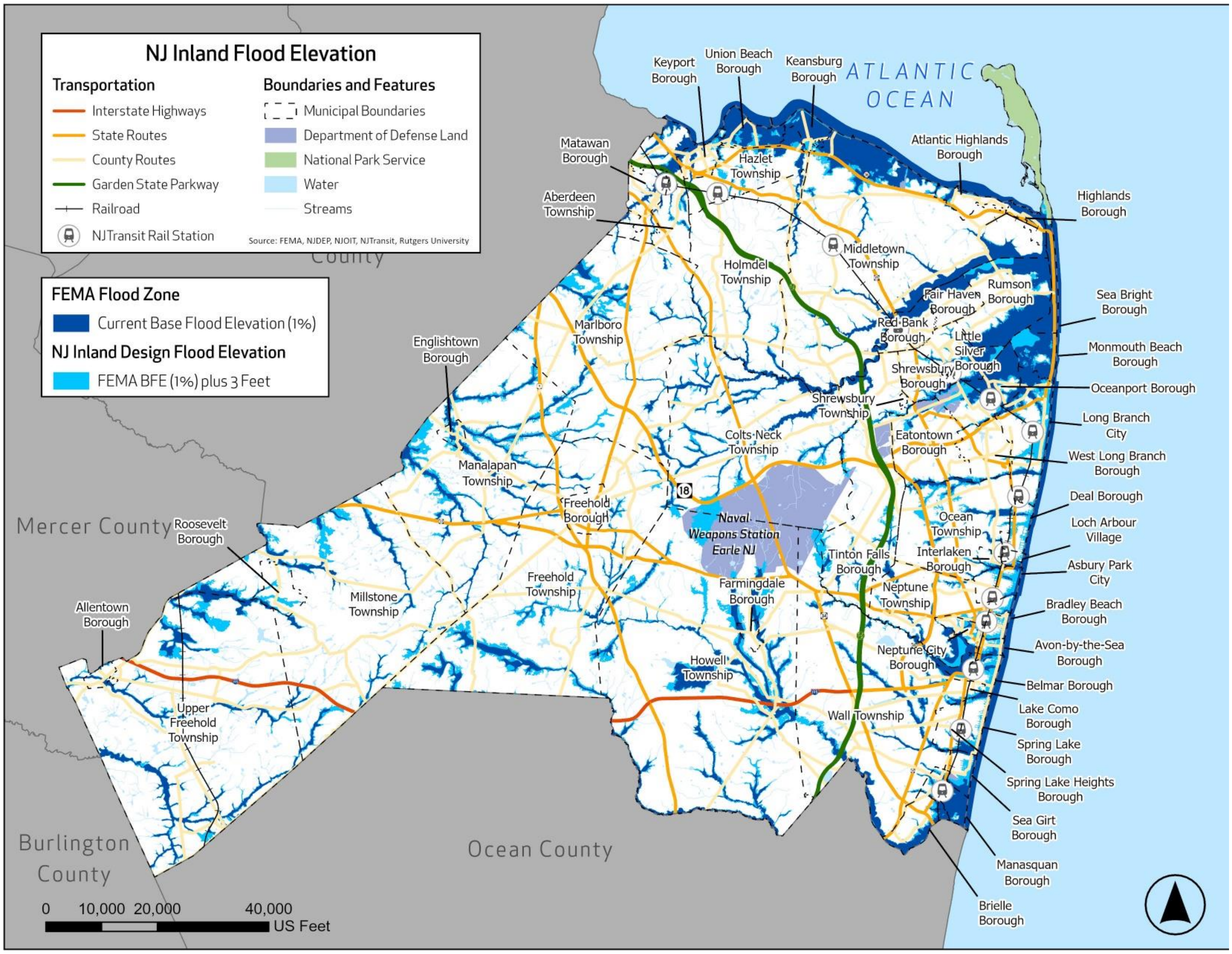


Source: NOAA, 2024

On July 17, 2023, NJDEP adopted its Inland Flood Protection Rule which, among other actions, establishes a new DFE standard for specific types of new construction and redevelopment. The new DFE is 3 feet above the elevation of the 1% Chance Annual Flood for New Jersey (which is also known as the 100-year flood) or, where NJDEP flood mapping is available, 2 feet above NJDEP's flood hazard area design flood elevation, if that results in a DFE higher than FEMA's 1% flood plus 3 feet. To help visualize the new rule, Rutgers University created the NJ Inland Design Flood Elevation Layer, to be used as a non-regulatory planning tool which helps visualize potential future conditions in the State. **Figure 4.11-4 NJ**

Inland Design Flood Elevation shows the new NJ Inland Design Flood Elevation in bright sky blue in comparison to the existing BFE which is depicted in navy blue.

Figure 4.10-4 NJ Inland Design Flood Elevation



Vulnerability Assessment

Built Environment, Infrastructure and Community Lifelines

In order to assess flood vulnerability, a GIS-based analysis was used to estimate exposure to flood events using FEMA's best available floodplain data in combination with local tax assessor records. The parcel level data was filtered to exclude undeveloped parcels such as open space or vacant parcels to determine the number of parcels in the town which were considered developed. The developed parcels were then intersected with the 1% and 0.2% annual chance floodplain layers to determine the percentage which lie at least partially within the floodplain. **Table 4.11-4 Vulnerability of Developed Parcels to Flood Hazard by Jurisdiction** contains the results of this analysis. Sea Bright, Keansburg, and Union Beach contained the highest percentage of developed parcels located within the floodplain while Shrewsbury Township, Freehold Borough and Roosevelt contained the lowest. This data helps to understand which municipalities contain the highest exposure to flood hazard and can help in identifying which communities have developed in areas which are more or less flood-prone when compared to total floodplain area numbers.

Table 4.10-4 Vulnerability of Developed Parcels to Flood Hazard by Jurisdiction

Municipality	Percent of Parcels Considered Developed	Percent Developed Parcels in 1% Annual Chance Floodplain	Percent Developed Parcels in 0.2% Annual Chance Floodplain
Aberdeen, Township of	92.7%	7.8%	2.0%
Allenhurst, Borough of	97.4%	1.8%	2.7%
Allentown, Borough of	94.2%	12.1%	1.2%
Asbury Park, City of	87.7%	2.4%	1.7%
Atlantic Highlands, Borough of	92.7%	10.1%	1.1%
Avon-By-The-Sea, Borough of	98.5%	19.0%	12.5%
Belmar, Borough of	97.4%	12.9%	14.1%
Bradley Beach, Borough of	97.5%	0.2%	7.7%
Brielle, Borough of	97.2%	19.0%	3.5%
Colts Neck, Township of	92.8%	18.8%	0.5%
Deal, Borough of	93.8%	9.5%	0.1%
Eatontown, Borough of	95.1%	2.6%	3.2%
Englishtown, Borough of	96.6%	21.9%	2.9%
Fair Haven, Borough of	98.3%	5.0%	1.0%
Farmingdale, Borough of	95.7%	7.2%	NA
Freehold, Borough of	97.8%	0.2%	NA
Freehold, Township Of	94.3%	4.0%	0.3%
Hazlet, Township of	96.8%	13.7%	4.7%
Highlands, Borough of	92.8%	56.1%	0.4%
Holmdel, Township of	96.1%	4.1%	0.2%
Howell, Township of	83.8%	3.5%	0.2%
Interlaken, Borough of	95.6%	15.2%	0.7%
Keansburg, Borough of	93.5%	90.6%	6.4%
Keyport, Borough of	94.5%	12.5%	4.3%
Lake Como, Borough of	96.1%	2.8%	4.7%
Little Silver, Borough of	97.9%	17.8%	4.5%
Loch Arbour, Village of	97.9%	39.4%	12.4%
Long Branch, City of	95.7%	16.7%	14.3%
Manalapan, Township of	97.2%	5.5%	0.9%
Manasquan, Borough of	96.4%	57.9%	7.8%
Marlboro, Township of	96.0%	4.4%	0.9%

Municipality	Percent of Parcels Considered Developed	Percent Developed Parcels in 1% Annual Chance Floodplain	Percent Developed Parcels in 0.2% Annual Chance Floodplain
Matawan, Borough of	94.0%	7.3%	0.0%
Middletown, Township of	96.0%	17.2%	3.4%
Millstone, Township of	91.8%	7.0%	0.7%
Monmouth Beach, Borough of	93.5%	72.8%	9.4%
Neptune City, Borough of	96.3%	11.8%	0.9%
Neptune, Township of	96.2%	8.6%	1.7%
Ocean, Township of	95.6%	6.5%	1.4%
Oceanport, Borough of	95.3%	42.2%	16.7%
Red Bank, Borough of	97.5%	3.4%	0.6%
Roosevelt, Borough of	93.4%	0.6%	NA
Rumson, Borough of	96.6%	27.4%	4.1%
Sea Bright, Borough of	89.1%	98.9%	1.0%
Sea Girt, Borough of	96.8%	10.6%	5.5%
Shrewsbury, Borough of	98.3%	3.7%	6.7%
Shrewsbury, Township of	99.7%	NA	NA
Spring Lake Heights, Borough of	97.5%	13.1%	8.9%
Spring Lake, Borough of	98.6%	4.4%	1.2%
Tinton Falls, Borough Of	96.3%	2.8%	1.5%
Union Beach, Borough of	89.6%	71.8%	15.0%
Upper Freehold, Township of	94.7%	10.4%	0.0%
Wall, Township of	96.1%	6.2%	0.4%
West Long Branch, Borough of	97.5%	1.6%	2.6%
Monmouth County	**94.3%**	**12.5%**	**2.8%**

Source: FEMA 2024, NJ MOD-IV

To estimate potential losses resulting from the flood hazard, a HAZUS-MH analysis was conducted for both riverine and coastal flooding using FEMA's Preliminary and Effective FIRMs. HAZUS-MH estimates floodplain boundaries, potential exposure for each event frequency, and loss estimates based on probabilistic scenarios for 10%, 2%, 1%, and 0.2% Annual Chance Flood Event using a Level 2 analysis. It should be noted that some municipalities have no output in the HAZUS analysis. HAZUS outputs flood analysis to the Census tract level as dasymetric blocks, so the analysis only focuses on areas with populations rather than the full geometry of the jurisdiction. If the flood depth grid doesn't intersect any of those dasymetric blocks, then it will not result in any damage output. **Table 4.11-5 Total Estimated Loss for the 1% Flood Event by Municipality** displays the results of the HAZUS analysis.

Table 4.10-5 Total Estimated Loss for the 1% Flood Event by Municipality

Jurisdiction	Expected Loss for the 1% Annual Chance Flood Event	Expected Annual Losses from the 1% Annual Chance Flood Event
Aberdeen, Township of	-	-
Allenhurst, Borough of	$832,000	$8,320
Allentown, Borough of	$8,652,000	$86,520
Asbury Park, City of	$26,854,000	$268,540
Atlantic Highlands, Borough of	$48,910,000	$489,100
Avon-By-The-Sea, Borough of	$42,326,000	$423,260
Belmar, Borough of	$111,094,000	$1,110,940
Bradley Beach, Borough of	$4,819,000	$48,190
Brielle, Borough of	$33,947,000	$339,470
Colts Neck, Township of	$13,474,000	$134,740

Jurisdiction	Expected Loss for the 1% Annual Chance Flood Event	Expected Annual Losses from the 1% Annual Chance Flood Event
Deal, Borough of	$10,427,000	$104,270
Eatontown, Borough of	$25,261,000	$252,610
Englishtown, Borough of	$15,124,000	$151,240
Fair Haven, Borough of	$3,110,000	$31,100
Farmingdale, Borough of	$3,331,000	$33,310
Freehold, Borough of	$6,000	$60
Freehold, Township Of	$19,999, 000	$199,990
Hazlet, Township of	$170,956,000	$1,709,560
Highlands, Borough of	$255,844,000	$2,558,440
Holmdel, Township of	$3,104,000	$31,040
Howell, Township of	$60,666,000	$606,660
Interlaken, Borough of	$12,851,000	$128,510
Keansburg, Borough of	$413,336,000	$4,133,360
Keyport, Borough of	$52,589,000	$525,890
Lake Como, Borough of	$3,769,000	$37,690
Little Silver, Borough of	$38,647,000	$386,470
Loch Arbour, Village of	$6,115,000	$61,150
Long Branch, City of	$208,060,000	$2,080,600
Manalapan, Township of	$38,665,000	$386,650
Manasquan, Borough of	$339,038,000	$3,390,380
Marlboro, Township of	$31,348,000	$313,480
Matawan, Borough of	-	
Middletown, Township of	$593,770,000	$5,937,700
Millstone, Township of	$4,753,000	$47,530
Monmouth Beach, Borough of	$118,635,000	$1,186,350
Neptune City, Borough of	$26,309,000	$263,090
Neptune, Township of	$147,588,000	$1,475,880
Ocean, Township of	$84,590,000	$845,900
Oceanport, Borough of	$166,900,000	$1,669,000
Red Bank, Borough of	$22,134,000	$221,340
Roosevelt, Borough of	$144,000,000	$1,440,000
Rumson, Borough of	$88,050,000	$880,500
Sea Bright, Borough of	$121,900,000	$1,219,000
Sea Girt, Borough of	$69,502,000	$695,020
Shrewsbury, Borough of	$3,941,000	$39,410
Shrewsbury, Township of	-	
Spring Lake Heights, Borough of	$24,717,000	$247,170
Spring Lake, Borough of	$19,242,000	$192,420
Tinton Falls, Borough Of	$14,333,000	$143,330
Union Beach, Borough of	$275,088,000	$2,750,880
Upper Freehold, Township of	$12,670,000	$126,700
Wall, Township of	$54,429,000	$544,290
West Long Branch, Borough of	$95,923,000	$959,230
Monmouth County	**$4,091,628,000**	**$40,916,280**

Source: HAZUS-MH

For the subset of structures identified as RL properties, a simple review of the history of paid claims suggests an annualized loss of approximately $3.37 million for these 1255 properties. Without efforts to mitigate these and other individual properties at risk from frequent flooding, annual repetitive losses can be expected to remain at this order of magnitude, and even to increase, as structures that have up until now only been flooded once become flooded repeatedly and hence meet the definition of "Repetitive Loss Property". A more detailed assessment of potential future losses suffered by these properties would require a comprehensive survey of each individual repetitive loss property, which was outside the scope of this plan. However, since the last plan was prepared, many more communities maintain a detailed inventory of repetitive loss properties, and targeted mitigation is something that has been considered by many jurisdictions for this plan update.

During the planning process of this HMP, jurisdictions were asked to identify critical facilities within their communities using FEMA community lifelines as a framework. Lifelines are the most fundamental services in the community that, when stabilized, enable all other aspects of society to function. Should these lifelines become disrupted following a hazard event, priority action may be needed to stabilize them during incident response. These facilities were geolocated and intersected with FEMA's Special Flood Hazard Area best available data layer**. Table 4.11-6 Percentage of Critical Facilities with Flood Risk by Jurisdiction** illustrates the percentage of critical facilities located within the 1% and 0.2% floodplain. In accordance with FEMA guidance, all analyses in this plan have been conducted using the best readily available data.

Table 4.10-6 Critical Facility Vulnerability to Flood by Jurisdiction

Jurisdiction	Total Number of Identified Critical Facilities	Percentage of Critical Facilities within the 1% Floodplain	Percentage of Critical Facilities within the 0.2% Floodplain
Aberdeen, Township of	23	0.0%	0.0%
Allenhurst, Borough of	5	0.0%	0.0%
Allentown, Borough of	11	27.3%	0.0%
Asbury Park, City of	28	3.6%	10.7%
Atlantic Highlands, Borough of	9	0.0%	0.0%
Avon-By-The-Sea, Borough of	7	0.0%	0.0%
Belmar, Borough of	14	14.3%	7.1%
Bradley Beach, Borough of	8	0.0%	0.0%
Brielle, Borough of	13	30.8%	0.0%
Colts Neck, Township of	30	20.0%	0.0%
Deal, Borough of	6	0.0%	0.0%
Eatontown, Borough of	26	7.7%	3.8%
Englishtown, Borough of	9	11.1%	11.1%
Fair Haven, Borough of	12	0.0%	0.0%
Farmingdale, Borough of	5	0.0%	0.0%
Freehold, Borough of	1	0.0%	0.0%
Freehold, Township Of	31	0.0%	0.0%
Hazlet, Township of	68	4.4%	0.0%
Highlands, Borough of	26	7.7%	7.7%
Holmdel, Township of	8	50.0%	0.0%
Howell, Township of	33	3.0%	0.0%
Interlaken, Borough of	76	10.5%	0.0%
Keansburg, Borough of	2	0.0%	0.0%
Keyport, Borough of	12	83.3%	8.3%

Jurisdiction	Total Number of Identified Critical Facilities	Percentage of Critical Facilities within the 1% Floodplain	Percentage of Critical Facilities within the 0.2% Floodplain
Lake Como, Borough of	36	2.8%	2.8%
Little Silver, Borough of	6	0.0%	0.0%
Loch Arbour, Village of	10	10.0%	0.0%
Long Branch, City of	41	7.3%	14.6%
Manalapan, Township of	65	7.7%	1.5%
Manasquan, Borough of	11	0.0%	9.1%
Marlboro, Township of	40	0.0%	0.0%
Matawan, Borough of	16	12.5%	0.0%
Middletown, Township of	100	12.0%	4.0%
Millstone, Township of	24	16.7%	0.0%
Monmouth Beach, Borough of	10	60.0%	10.0%
Neptune City, Borough of	7	0.0%	0.0%
Neptune, Township of	64	7.8%	0.0%
Ocean, Township of	50	8.0%	0.0%
Oceanport, Borough of	4	25.0%	50.0%
Red Bank, Borough of	24	8.3%	0.0%
Roosevelt, Borough of	4	0.0%	0.0%
Rumson, Borough of	12	16.7%	0.0%
Sea Bright, Borough of	3	100.0%	0.0%
Sea Girt, Borough of	8	12.5%	0.0%
Shrewsbury, Borough of	10	0.0%	0.0%
Shrewsbury, Township of	0	NA	NA
Spring Lake Heights, Borough of	11	9.1%	9.1%
Spring Lake, Borough of	6	0.0%	0.0%
Tinton Falls, Borough Of	33	6.1%	0.0%
Union Beach, Borough of	14	50.0%	14.3%
Upper Freehold, Township of	47	19.1%	0.0%
Wall, Township of	63	11.1%	0.0%
West Long Branch, Borough of	18	5.6%	5.6%
Monmouth County	**1200**	**10.6%**	**2.4%**

Source: FEMA, Monmouth County Office of GIS, NJDEP, NJGIN, Monmouth County Jurisdictions

Sea Level Rise

In order to assess the County's risk to sea level rise (SLR), a GIS-based analysis similar to the analysis performed for flood risk was conducted. This analysis seeks to estimate exposure to flood events using NOAA's sea level rise inundation data in combination with local tax assessor records. The parcel level data was filtered to exclude undeveloped parcels such as open space or vacant parcels to determine the number of parcels in the town which were considered developed. The developed parcels were then intersected with the delineated projection of 2- foot and 5-foot SLR layers to determine the percentage of developed parcels which are at least partially within the SLR inundation areas. As seen in **Table 4.11-7** below, Sea Bright Borough, Keansburg Borough, and Monmouth Beach Borough contained the highest percentage of developed parcels located within the SLR inundation areas while inland municipalities had no vulnerability. This data helps to understand which municipalities contain the highest exposure to flood hazard and can help in identifying which communities have developed in areas which are more or less vulnerable to sea level rise when compared to total land area inundation numbers.

Table 4.10-7 Vulnerability to Sea Level Rise by Jurisdiction

Municipality	Percent of Parcels Considered Developed	Percent Developed Parcels Vulnerable to 2 feet of SLR	Percent Developed Parcels Vulnerable to 5 feet of SLR	Percent Land Area Permanently Inundated under 2 feet SLR	Percent Land Area Permanently Inundated under 5 feet SLR
Aberdeen, Township of	92.7%	0.8%	1.8%	8.3%	10.0%
Allenhurst, Borough of	97.4%	0.3%	0.3%	1.1%	2.1%
Allentown, Borough of	94.2%	0.0%	0.0%	0.0%	0.0%
Asbury Park, City of	87.7%	0.0%	0.0%	0.5%	1.2%
Atlantic Highlands, Borough of	92.7%	1.2%	5.6%	2.0%	7.2%
Avon-By-The-Sea, Borough of	98.5%	6.6%	24.9%	13.4%	23.8%
Belmar, Borough of	97.4%	2.7%	5.6%	28.7%	32.5%
Bradley Beach, Borough of	97.5%	0.0%	0.0%	1.7%	2.6%
Brielle, Borough of	97.2%	8.9%	16.2%	24.2%	28.4%
Colts Neck, Township of	92.8%	0.0%	0.0%	0.0%	0.0%
Deal, Borough of	93.8%	2.3%	3.1%	1.7%	2.5%
Eatontown, Borough of	95.1%	0.0%	0.0%	0.1%	0.2%
Englishtown, Borough of	96.6%	0.0%	0.0%	0.0%	0.0%
Fair Haven, Borough of	98.3%	6.9%	7.5%	24.5%	25.3%
Farmingdale, Borough of	95.7%	0.0%	0.0%	0.0%	0.0%
Freehold, Borough of	97.8%	0.0%	0.0%	0.0%	0.0%
Freehold, Township Of	94.3%	0.0%	0.0%	0.0%	0.0%
Hazlet, Township of	96.8%	1.6%	6.2%	2.0%	5.1%
Highlands, Borough of	92.8%	10.6%	45.7%	19.3%	42.4%
Holmdel, Township of	96.1%	0.0%	0.0%	0.0%	0.0%
Howell, Township of	83.8%	0.0%	0.0%	0.0%	0.0%
Interlaken, Borough of	95.6%	0.0%	0.0%	0.0%	0.0%
Keansburg, Borough of	93.5%	1.9%	73.4%	6.2%	49.4%
Keyport, Borough of	94.5%	3.7%	7.7%	11.9%	16.5%
Lake Como, Borough of	96.1%	0.0%	0.0%	0.0%	0.0%
Little Silver, Borough of	97.9%	8.7%	14.4%	18.3%	27.4%
Loch Arbour, Village of	97.9%	0.0%	0.7%	1.6%	3.4%
Long Branch, City of	95.7%	2.6%	9.5%	5.4%	12.7%
Manalapan, Township of	97.2%	0.0%	0.0%	0.0%	0.0%

Municipality	Percent of Parcels Considered Developed	Percent Developed Parcels Vulnerable to 2 feet of SLR	Percent Developed Parcels Vulnerable to 5 feet of SLR	Percent Land Area Permanently Inundated under 2 feet SLR	Percent Land Area Permanently Inundated under 5 feet SLR
Manasquan, Borough of	96.4%	26.0%	58.3%	19.4%	40.2%
Marlboro, Township of	96.0%	0.0%	0.0%	0.0%	0.0%
Matawan, Borough of	94.0%	0.2%	0.2%	1.9%	2.2%
Middletown, Township of	96.0%	2.2%	10.0%	8.1%	13.6%
Millstone, Township of	91.8%	0.0%	0.0%	0.0%	0.0%
Monmouth Beach, Borough of	93.5%	20.1%	64.6%	53.2%	74.9%
Neptune City, Borough of	96.3%	2.2%	3.2%	1.9%	3.5%
Neptune, Township of	96.2%	2.0%	4.7%	8.3%	10.1%
Ocean, Township of	95.6%	0.0%	0.0%	0.0%	0.0%
Oceanport, Borough of	95.3%	15.7%	37.7%	24.9%	35.6%
Red Bank, Borough of	97.5%	4.4%	4.7%	20.8%	22.6%
Roosevelt, Borough of	93.4%	0.0%	0.0%	0.0%	0.0%
Rumson, Borough of	96.6%	19.0%	27.8%	34.8%	42.6%
Sea Bright, Borough of	89.1%	36.5%	79.6%	53.3%	75.7%
Sea Girt, Borough of	96.8%	0.1%	0.1%	0.8%	8.6%
Shrewsbury, Borough of	98.3%	1.8%	2.7%	2.5%	4.9%
Shrewsbury, Township of	99.7%	0.0%	0.0%	0.0%	0.0%
Spring Lake Heights, Borough of	97.5%	0.0%	0.0%	1.2%	2.4%
Spring Lake, Borough of	98.6%	0.0%	0.0%	0.0%	0.0%
Tinton Falls, Borough Of	96.3%	0.6%	0.7%	1.3%	1.6%
Union Beach, Borough of	89.6%	5.7%	34.6%	30.4%	48.3%
Upper Freehold, Township of	94.7%	0.0%	0.0%	0.0%	0.0%
Wall, Township of	96.1%	1.4%	1.5%	2.2%	2.7%
West Long Branch, Borough of	97.5%	0.2%	0.4%	0.1%	0.2%
Monmouth County	**94.3%**	**2.3%**	**7.0%**	**3.2%**	**5.7%**

Source: FEMA, Monmouth County Office of GIS, NOAA

As part of this analysis, geolocated Community Lifelines were intersected NOAA's sea level rise inundation data. Lifelines are the most fundamental services in the community that, when stabilized, enable all other aspects of society to function. Should these lifelines become disrupted following a hazard event, priority action may be needed to stabilize them during incident response. The following table illustrates the percentage of critical facilities within the 2-foot and 5-foot SLR areas of inundation by jurisdiction.

Table 4.10-8 Critical Facility Vulnerability to Sea Level Rise by Jurisdiction

Jurisdiction	Total Number of Identified Critical Facilities	Percentage of Critical Facilities Vulnerable to 2 feet Sea Level Rise	Percentage of Critical Facilities Vulnerable to 5 feet Sea Level Rise
Aberdeen, Township of	23	0.0%	0.0%
Allenhurst, Borough of	5	0.0%	0.0%
Allentown, Borough of	11	0.0%	0.0%
Asbury Park, City of	28	0.0%	0.0%
Atlantic Highlands, Borough of	9	0.0%	0.0%
Avon-By-The-Sea, Borough of	7	0.0%	0.0%
Belmar, Borough of	14	0.0%	7.1%
Bradley Beach, Borough of	8	0.0%	0.0%
Brielle, Borough of	13	0.0%	15.4%
Colts Neck, Township of	30	0.0%	0.0%
Deal, Borough of	6	0.0%	0.0%
Eatontown, Borough of	26	0.0%	0.0%
Englishtown, Borough of	9	0.0%	0.0%
Fair Haven, Borough of	12	0.0%	0.0%
Farmingdale, Borough of	5	0.0%	0.0%
Freehold, Borough of	1	0.0%	0.0%
Freehold, Township Of	31	0.0%	0.0%
Hazlet, Township of	68	0.0%	0.0%
Highlands, Borough of	26	12.5%	62.5%
Holmdel, Township of	8	0.0%	0.0%
Howell, Township of	33	0.0%	0.0%
Interlaken, Borough of	76	0.0%	0.0%
Keansburg, Borough of	2	0.0%	25.0%
Keyport, Borough of	12	0.0%	0.0%
Lake Como, Borough of	36	0.0%	0.0%
Little Silver, Borough of	6	0.0%	0.0%
Loch Arbour, Village of	10	0.0%	0.0%
Long Branch, City of	41	0.0%	1.5%
Manalapan, Township of	65	0.0%	0.0%
Manasquan, Borough of	11	0.0%	0.0%
Marlboro, Township of	40	0.0%	0.0%
Matawan, Borough of	16	0.0%	0.0%
Middletown, Township of	100	4.2%	8.3%
Millstone, Township of	24	0.0%	0.0%
Monmouth Beach, Borough of	10	0.0%	28.6%
Neptune City, Borough of	7	0.0%	0.0%
Neptune, Township of	64	0.0%	2.0%
Ocean, Township of	50	0.0%	0.0%
Oceanport, Borough of	4	0.0%	0.0%
Red Bank, Borough of	24	0.0%	0.0%
Roosevelt, Borough of	4	0.0%	0.0%
Rumson, Borough of	12	0.0%	0.0%
Sea Bright, Borough of	3	0.0%	0.0%
Sea Girt, Borough of	8	0.0%	0.0%
Shrewsbury, Borough of	10	0.0%	0.0%

Jurisdiction	Total Number of Identified Critical Facilities	Percentage of Critical Facilities Vulnerable to 2 feet Sea Level Rise	Percentage of Critical Facilities Vulnerable to 5 feet Sea Level Rise
Shrewsbury, Township of	0	NA	NA
Spring Lake Heights, Borough of	11	0.0%	0.0%
Spring Lake, Borough of	6	0.0%	0.0%
Tinton Falls, Borough Of	33	0.0%	0.0%
Union Beach, Borough of	14	0.0%	7.1%
Upper Freehold, Township of	47	0.0%	0.0%
Wall, Township of	63	0.0%	1.6%
West Long Branch, Borough of	18	0.0%	0.0%
Monmouth County	**1200**	**0.2%**	**1.6%**

Source: FEMA, Monmouth County Office of GIS, NJDEP, NJGIN, Monmouth County Jurisdictions

Population and Economy

The most vulnerable population of those exposed to the hazard include the economically disadvantaged and the elderly. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make evacuation decisions based on the net economic impact to their family. Those over 65 are also more vulnerable because they are more likely to seek or need medical attention which may not be available during a flood event, and they may have more difficulty evacuating.

Ecosystems and Natural Assets

While some flooding can be beneficial for certain ecosystems, excessive or sudden flooding can have significant negative environmental impacts. Loss of biodiversity and overall habitat degradation can be caused by soil erosion, destruction of vegetation, contamination of water supply by pollutants, leveling of dunes and erosion of beaches, and harm to wildlife.

Potential for Future Development to Impact Hazard Vulnerability

Infill development and redevelopment would not be likely to substantially increase a jurisdiction's overall exposure to flooding because existing structures would be replaced with new structures, and the new structures would be built to higher codes and standards offering a certain degree of protection from the hazard. However, greenfield development would be more likely to have the potential to substantially increase a jurisdiction's overall vulnerability to the hazard because a new structure would be placed on previously undeveloped land increasing impervious surface.

Jurisdictions with a potential for future development trends to substantially increase flood hazard vulnerability under existing conditions should: (a) include flood mitigation measures in their mitigation strategies; and/or (b) select jurisdictional plan integration initiatives for the next plan maintenance phase that can potentially reduce risk for future development.

Jurisdictions with a potential for future development trends to substantially increase flood hazard vulnerability under future conditions (with sea level rise) should: (a) include sea level rise mitigation measures in their mitigation strategies; and/or (b) select jurisdictional plan integration initiatives for the next plan maintenance phase that can potentially reduce risk for future development.

4.11 HURRICANE AND TROPICAL STORM

Hazard Description

Hurricanes and tropical storms are classified as cyclones and defined as any closed circulation developing around a low-pressure center in which the winds rotate counterclockwise in the Northern Hemisphere (or clockwise in the Southern Hemisphere) and with a diameter averaging 10 to 30 miles across. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name, and is closely monitored by the National Hurricane Center. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation and tornadoes. Coastal areas are also vulnerable to the additional forces of storm surge, wind-driven waves and tidal flooding which can be more destructive than cyclone wind. The majority of hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico during the official Atlantic hurricane season, which extends from June through November.

Location and Extent

The entire planning area is located within a geographic area that is affected by hurricanes and tropical storms.

Range Of Magnitude

As a hurricane develops, barometric pressure (measured in millibars or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 mph, the system is designated a tropical storm, given a name and is closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach 74 mph the storm is deemed a hurricane.

Hurricane intensity is further classified by the Saffir-Simpson Scale (see **Table 4.12 - 1 Saffir-Simpson Scale for Hurricanes**), which rates hurricane intensity in categories on a scale of 1 to 5 based upon wind, with Category 5 being the most intense. The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure and storm surge potential, which are combined to estimate potential damage. Categories 3, 4 and 5 are classified as "major" hurricanes, and while hurricanes within this range comprise only 20 percent of total tropical cyclone landfalls, they account for over 70 percent of the damage in the United States.

Table 4.11-1 Saffir-Simpson Scale for Hurricanes

Storm Category	Maximum Sustained Wind Speed (mph)	Minimum Surface Pressure (Millibars)	Storm Surge (ft)	Damage Level	Description of Damages
1	74-95	Greater than 980	3-5	Minimal	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery and trees. Also, some coastal flooding and minor pier damage.
2	96-110	979-965	6-8	Moderate	Some roofing material, door and window damage. Considerable damage to vegetation, mobile homes, etc. Flooding damages piers and small craft in unprotected moorings might break their moorings.

Storm Category	Maximum Sustained Wind Speed (mph)	Minimum Surface Pressure (Millibars)	Storm Surge (ft)	Damage Level	Description of Damages
3	111-129	964-945	9-12	Extensive	Some structural damage to small residences and utility buildings, with a minor amount of curtainwall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures, with larger structures damaged by floating debris. Terrain might be flooded well inland.
4	130-156	944-920	13-18	Extreme	More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain might be flooded well inland.
5	157 +	Less than 920	19+	Catastrophic	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas might be required.

Source: National Oceanic and Atmospheric Administration

Previous Occurrences and Losses

Monmouth County has a history of hurricanes and tropical storms. According to NOAA historical records, five tropical storm tracks traversed directly through Monmouth County since 1850. **Figure 4.12-1 Historical Hurricane and Tropical Storm Tracks, 1851 – 2016** the track of each recorded historical storm track in relation to Monmouth County. As can be seen in the figure, almost all hurricane and tropical storm tracks traverse northward through the area. For each event, **Table 4.12-2 Hurricane and Tropical Storm Tracks Directly over Monmouth County Since 1850** provides the date of occurrence, storm name (if applicable), maximum wind speed and category of the storm based on the Saffir-Simpson Scale.

Notable Storms within 75 miles of Monmouth County are listed in further detail on the next page. Although a hurricane or tropical storm making direct landfall can have a more serious impact, when a hurricane or tropical storm track parallel to the coast impacts can be widespread (Lam, 2016).

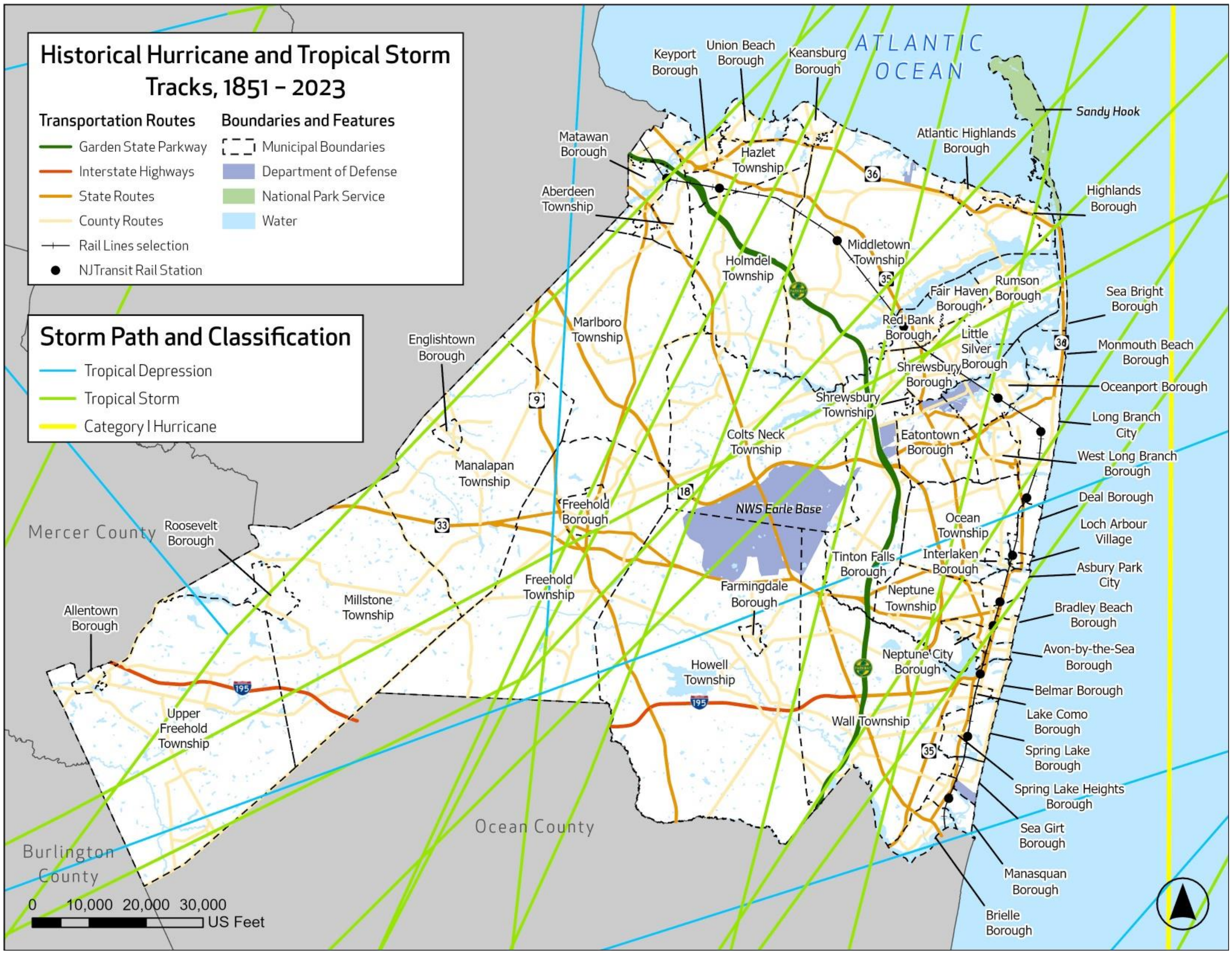
Table 4.11-2 Hurricane and Tropical Storm Tracks Directly over Monmouth County Since 1850

Date	Storm Name	Maximum Wind Speed (mph)	Storm Category
9/28/1861	Unnamed	55	Tropical Storm
10/30/1866	Unnamed	60	Extratropical Storm
10/26/1872	Unnamed	45	Tropical Storm
9/30/1874	Unnamed	65	Tropical Storm
9/30/1924	Unnamed	60	Extratropical Storm
6/19/1934	Unnamed	45	Extratropical Storm
7/30/1960	Brenda	50	Tropical Storm
8/28/1971	Doria	60	Tropical Storm
7/13/1996	Bertha	70	Tropical Storm
9/6/2008	Hanna	45	Tropical Storm

Date	Storm Name	Maximum Wind Speed (mph)	Storm Category
8/28/2011	Irene	65	Tropical Storm
7/11/2020	Fay	40	Tropical Storm
9/2/2021	Ida	45	Extratropical Storm

Source: NOAA 2024

Figure 4.11-1 Historical Hurricane and Tropical Storm Tracks, 1851 – 2023



Source: (NOAA, 2024)

September 14-15, 1944 The entire coast of New Jersey was struck by hurricane force winds associated with the Category 2 Hurricane. Wind velocities ranged from 90 miles per hour at Atlantic City to over 100 miles per hour at New York City. The storm produced a maximum tidal elevation of 7.4 feet at a gage in Sandy Hook, located in the Township of Middletown.

September 12, 1960 (Hurricane Donna) Hurricane Donna was a Category 2 storm when it reached Monmouth County with wind speeds up to 110 miles per hour. The concurrence of the hurricane tidal surge and mean high tide resulted in a maximum tidal elevation of 8.6 feet at the gage at Sandy Hook.

August 9, 1976 (Hurricane Belle) Hurricane Belle, a Category 1 storm with wind speeds up to 90 miles per hour. In Asbury Park, 2.56 inches of rain fell in a 24-hour period. At Beach Haven, a tidal surge combined with high tide levels produced a tidal height six feet above normal stage.

September 27, 1985 (Hurricane Gloria) Hurricane Gloria came ashore in Long Island, New York, as a Category 2 storm. The storm knocked out power and forced people to be evacuated from homes along the Jersey Shore, including Monmouth County. Floodwaters on Long Beach Island split the island in half for a period of time. Gloria downed thousands of trees and caused extensive power outages across the State. Storm surge tides averaged two meters above predicted tide levels; however, coastal flooding was minimized as the peak surge arrived during low tide.

July 13, 1996 (Tropical Storm Bertha) A weakening Tropical Storm Bertha passed across eastern parts of the State on July 13th. One storm-related death occurred on the 12th. A 41-year-old man from New Egypt drowned while surfing at Ocean Beach in the Borough of Belmar. Most beaches were already closed due to the rough surf and the potential for rip tides. Otherwise, tidal departures were about two feet or less from normal. Only Monmouth Beach suffered severe beach erosion. Sixty feet of the 120-foot-wide beach at the south of the borough was gone. This beach is one of dozens in New Jersey that was being replenished under a USACE project. There was little beach erosion elsewhere. While there was urban and poor drainage flooding, no serious property or vehicular damage was reported and there were only a few water rescues of trapped motorists.

July 16, 1999 (Tropical Storm Floyd) Tropical Storm Floyd will go down in history as one of the greatest natural disasters to impact New Jersey before Superstorm Sandy in 2012. Wind gusts rarely exceeded 50 mph, but all the flooding rains made it easier for trees to be knocked over. In Monmouth County, the worst flood-related problems occurred as the torrential rain coincided with the high tide. The worst flooding was reported in Union Beach and bay areas of Middletown, requiring some evacuation. State Routes 35 and 36 were closed due to flooding. Farther inland, Manalapan was hardest hit with overflowing brooks that forced the closure of six roads and sandbagging of homes on Birmingham Road. The strongest winds occurred during the evening and blew down transformers, wires, tree limbs and several trees throughout the County. Coastal areas escaped with minimal damage: just some minor beach erosion and minor back bay flooding at times of high tide. Precipitation storm totals in Monmouth County include 6.4 inches in Hazlet, 5.82 inches in Marlboro, 5.2 inches in Sandy Hook, and 4.57 inches in Keansburg.

September 18-19, 2003 (Tropical Storm Isabel). Isabel produced strong winds and rough surf. In Monmouth County, $100,000 in property damage was recorded by NCEI. Peak wind gusts included 52 mph in Keansburg, and downed trees, tree limbs and power lines. While tide heights along the oceanside only reached minor, wave action caused beach erosion. The heaviest rain with tropical systems often falls west of its storm track, thus the region was spared from the heavier rain with most locations reporting less than 1.5 inches.

September 6, 2008 (Tropical Storm Hanna) Tropical Storm Hanna made landfall on September 6th near the border of North and South Carolina before making a second landfall in New Jersey in eastern Cumberland County. Hanna brought heavy rain and strong winds with storm totals ranging from around 2 to 5 inches and peak wind gusts in Monmouth County of 45 mph in Keansburg and Ocean Grove. The combination of the winds and heavy rain caused some weak trees and tree limbs to be knocked down. About 2,600 homes and businesses lost power in Monmouth and Ocean Counties. All power was restored by the 7th. Minor tidal flooding occurred as the surge averaged around two feet. Many scheduled events were either cancelled or postponed. Strong rip currents on the 7th claimed the life of a 38-year- old man in Spring Lake and led to multiple rescues along Monmouth County beaches including Long Branch, Sea Bright, and Bradley Beach.

August 27-28, 2011 (Tropical Storm Irene) Irene produced torrential downpours that resulted in major flooding and a number of record-breaking crests on area rivers, tropical storm force wind gusts with record breaking outages for New Jersey utilities, and a three to five-foot storm surge that caused moderate to severe tidal flooding with extensive beach erosion over the weekend of August 27-28, 2011. Irene was the costliest natural disaster in the history of New Jersey after Tropical Storm Floyd (before Sandy later struck in 2012). In Keansburg, Monmouth Beach and Sea Bright it was mandatory for all residents to evacuate. Evacuations in Asbury Park, Belmar, Bradley Beach, Highlands, Middletown, Manasquan, Spring Lake, Union Beach, and Wall Township were limited to flood prone areas. Power outages were widespread. Moderate to severe tidal flooding occurred along the Atlantic Coast and Raritan Bay. Coastal erosion was a major impact. Preliminary damage estimates statewide were near one billion dollars to approximately 200,000 homes and businesses. The combination of wind and flooding forced the closure of about 350 main roadways in the State. Among the major roadways that were closed included U.S. Route 9 and State Routes 33, 35, 36 and 79. In Middletown, a dam broke at the Swimming River Reservoir and flooded the southern part of the township around County Route 50. Elsewhere in the township, a bridge washed out at Hubbard Avenue over the Navesink River. In Allentown, businesses located near Doctors Creek and Conines Millpond were damaged. In Matawan, a thirty-five-foot sinkhole forced the suspension of service along the New Jersey Transit North Jersey Coast Line. The Manasquan River at Squankum had major and record-breaking flooding, cresting at 13.06 feet on the 28th. Event rainfall totals included 8.75 inches in Freewood Acres, 8.57 inches in Howell, 8.07 inches in Red Bank, 6.72 inches in Eatontown and 6.13 inches in Lake Como. FEMA reported that federal disaster assistance statewide topped $275 million through December 12, 2011, with the following approvals:

- 48,904 registrations were approved for assistance;
- Nearly $152 million was approved under the Housing Assistance program for housing repairs;
- Nearly $100 million was approved in U.S. Small Business Administration low-interest loans to 2,585 households and businesses;
- More than $13 million was approved for Other Needs Assistance (i.e., personal property, transportation, medical/dental expenses, etc.);
- More than $10 million in Public Assistance funds for rebuilding public infrastructure; and
- Nearly $100,000 Disaster Unemployment Assistance for those who lost jobs because of the disaster.

October 29, 2012 (Superstorm Sandy). Prior to Sandy's arrival, Governor Christie called for voluntary evacuations of barrier communities on the 26th. A State of Emergency was declared on the 27th and a mandatory evacuation of all barrier island communities was ordered. More than 2,000 National Guard troops were deployed. Tolls along sections of the Garden State Parkway and all of the Westbound Atlantic City Expressway were suspended. On October 28th, President Barack Obama signed a federal emergency declaration for New Jersey. All State Parks and Historic Sites were closed. Late that afternoon, New Jersey Transit began a gradual system-wide shut down.

Sandy made landfall in Atlantic County as a post tropical storm in Brigantine City on the 29th. Approximately 130 miles of the Garden State Parkway was closed from Woodbridge in Middlesex County to its terminus in Cape May County. The New Jersey Turnpike was closed in Central New Jersey. Most schools were closed. The nuclear power plants at Oyster Creek (Ocean County) and Salem (Salem County) suspended operations because of tidal flooding. On the 30th, the day after Sandy's landfall, all 580 school districts in the State were closed. All courts and State offices were closed. Over 200 roadways were closed. Numerous boil water advisories were issued for the northern and coastal parts of the State, some that lasted into November. Governor Christie postponed Halloween in the State until November 5th. On October 31st, Amtrak started limited rail service. State offices were still closed, but some schools reopened. Most major roadways away from the immediate coast including the New Jersey Turnpike were reopened. On November 1st, Governor Christie rescinded evacuation orders for some of the Atlantic County barrier islands. The River Line Transit service between Camden and Trenton resumed. New Jersey Transit bus service resumed as did the Cape May-Lewes Ferry. On November 2nd, the governor lifted the evacuation order for Atlantic City and the casinos opened the next day. Evacuation orders were also lifted for Cape May County. Limited New Jersey Rail Service resumed. Because of power outages, lines for gas reached 100 cars long in the northern part of the State. The governor declared a limited state of emergency and imposed odd-even rationing for gasoline purchases in twelve northern New Jersey counties because of the shortages. They remained in effect through November 12th. The EPA temporarily suspended some Clean Air Act restrictions. The entire State was also under odd-even water restrictions. On November 3rd about 75 major roadways were still closed. On November 4th, rail service between Philadelphia and Atlantic City resumed. It was estimated that the average New Jersey beach became 30 to 40 feet narrower. It was difficult for people whose homes were uninhabitable to find rental properties.

Sandy was the costliest natural disaster by far in the State of New Jersey. Record breaking high tides and wave action combined with sustained winds as high as 60 to 70 mph with gusts as high as 80 to 90 mph battered 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 for 12 deaths. A new temporary inlet formed in Mantoloking (Ocean County) where some homes were swept away. About 2.4 million households in the State lost power. It would take weeks for power to be fully restored.

Hardest hit were the coastal areas of Ocean and Monmouth Counties. Every municipality that bordered Raritan Bay and the Atlantic Ocean suffered widespread damage in Monmouth County and every inland municipality had at least some sporadic damage. Union Beach and Sea Bright were among the hardest hit locations. In Sea Bright, many businesses were totally destroyed, and the fishing pier collapsed. Both Spring Lake and Belmar had miles of their boardwalks destroyed. Some schools were damaged beyond use. Monmouth University was used as an evacuation center. The New Jersey Transit line had to be rebuilt because it was severely damaged. Ferry service between Manhattan and Atlantic Highlands was suspended indefinitely.

Sandy produced record breaking power outages. Statewide, 2.7 million utility customers lost power, by far surpassing the record from Tropical Storm Irene in 2011. Public Service Electric and Gas alone had power lost to 1.4 million of its customers and reported about 48,000 trees had to be removed or trimmed to restore power and over 2,400 poles had to be replaced. Jersey Central Power and Light estimated that nearly 1.0 million of its customers lost power, about ninety percent of its customer base. This included hardest hit areas of Ocean and Monmouth Counties. Monmouth County had the greatest number of sustained outages of any county in the State. The utility had to cut through approximately 45,000 fallen trees. It was unable to restore power to about 30,000 of its shore and barrier island customers because of massive infrastructure damage to those homes and businesses. Elsewhere in the State, power restoration was hampered by a nor'easter that occurred on November 7th. Public Service Electric and Gas restored all power on November 12th and Jersey Central Power and Light by November 14th.

The unique aspect of Sandy and unlike most tropical systems was the multi-tide cycle increase of onshore winds prior to landfall. This caused multiple high tide cycles with tidal flooding and helped produce catastrophic wave action. Record breaking or near record breaking high tides were exacerbated by the high astronomical spring tides associated with the full moon. Sandy's landfall coincided closely with the high tide cycle on the evening of the 29th.

On the ocean side, Raritan Bay, and the lower Delaware Bay experienced minor tidal flooding starting during the high tide cycle on the morning of the 28th with some moderate tidal flooding during the high tide cycle on the evening of the 28th. Widespread major tidal flooding occurred during the morning and evening high tide cycles on the 29th. The highest tide (and surge) along the ocean front and Raritan Bay was with the landfalling high tide cycle on the evening of the 29th.

The ocean front and Raritan Bay surge was 5 to 9 feet. A new all-time record tide was set in Sandy Hook. The tide reached 13.31 feet above mean lower low water before the pier collapsed about 45 minutes before high tide. An after the event survey performed by the USGS and Rutgers University determined that an estimated crest of 14.40 feet above mean lower low water will be used as the new record for Sandy Hook. The entrance to New York Harbor Buoy (a relatively new buoy) had record breaking seas of 32.5 feet. The Delaware Bay Buoy (about 19 miles east of Fenwick Island, Delaware) had seas that reached 24.5 feet.

It was estimated that waves likely reached 12 to 24 feet along the ocean front with the largest waves along Monmouth County. Most of the surveyed damage to barrier island homes that were either destroyed or moved indicated that it was the storm surge and wave action that caused most of the damage. Either minor or no tidal flooding occurred with the subsequent high tide cycles the rest of the month. The highest tide reached a record breaking 13.31 feet above mean lower low water in Sandy Hook before the pier collapsed approximately 45 minutes before the evening high tide on the 29th. The previous record was 10.1 feet above mean lower low water during Hurricane Donna on September 12, 1960, and the December 11, 1992 nor'easter. While there are no established benchmarks for tidal flooding levels at these other stations, the following is a list of the highest tides during Sandy. These may not represent the highest actual tide as there were power outages and some of the graphs plateaued at high crest. The tide gages whose peak crest looks suspect (and may be higher) are marked with an asterisk. At Keansburg the highest crest was 8.96 feet above mean lower low water, at Sea Bright, the highest crest was 13.79 feet above mean lower low water, at Belmar the highest crest was 8.70 feet above mean lower low water.

Strong winds associated with Sandy started to spread across the State during the morning of the 29th; most of the peak wind gusts (between 70 mph and 90 mph) occurred during the late afternoon and evening hours as Sandy was making landfall. Most of the strong wind gusts were over by the following morning. The most widespread measured hurricane force wind gusts occurred in northern Ocean County and Monmouth County. Peak wind gusts included 87 mph at Sandy Hook, 79 mph in Sea Girt, Barnegat Light (Ocean County) and High Point (Sussex County), 78 mph in Brick Township (Ocean County), 75 mph in Long Branch, 73 mph in Monmouth Beach, and 61 mph in Wall Township. Maximum sustained winds included 68 mph at Sandy Hook and 61 in Long Branch. Sandy was estimated to have caused $1.75billion in wind-related property damages in Monmouth County alone.

Heavy rain also occurred with Sandy. This made it easier for shallow rooted and leafed trees to be uprooted, as well as complicating tidal flooding. Event rainfall totals averaged 1 to 3 inches in the northern half of the State and 3 to 7 inches in the southern half of the State, except 6 to 12 inches along the southern tier counties of Salem, Cumberland, Cape May, and coastal Atlantic County. The steady rains associated with Sandy occurred from the 28th to the 30th throughout most of the State.

August 4th, 2020 (Tropical Storm Isaias)

On Tuesday morning, August 4, 2020, Isaias reached southern New Jersey in the form of heavy rainfall followed by strong winds. Western areas of the State received the heaviest rainfall as its center clipped western Warren County before heading into New York. Isaias' winds were the strongest statewide since Sandy in 2012, toppling countless trees that brought down power lines, blocked roads and caused widespread damage to buildings and vehicles. Sustained winds of 45 to 55 mph with higher gusts were measured near Manasquan and Sandy Hook.

Isaias' impact on New Jersey was especially devastating due to its unusual track as it reached the State. As the storm moved into New Jersey in a northerly direction it veered inland towards the western part of the State exposing most of New Jersey to the storm's right front quadrant where its winds were strongest.

By late afternoon on August 4, 2020, a statewide peak of over 1.3 million electric utility customers without power was recorded, mostly due to downed power lines from tree damage caused by high winds. In Monmouth County, 135,116 Jersey Central Power and Light customers remained without electricity, just under half of the utility's customers in the County.

September 1st, 2021 (Remnants of Hurricane Ida)

Many areas of the Shore saw heavy rainfall and a few gusty winds between 30 to 40 mph, but Monmouth County was not nearly as affected as most of northern New Jersey, according to the National Weather Service.

Police and emergency responders worked through the night to tend to flooded roads, specifically in areas near heavily battered Middlesex County such as in Hazlet, Keyport, Manalapan and Matawan in Monmouth County.

Most of the Shore saw less than an inch of rainfall. The highest totals included 4 inches in Middletown and 3.13 inches in Holmdel. Freehold Township had 2.54 inches, while Colts Neck saw 2.17 inches of heavy rainfall, according to data from the Community Collaborative, Rain, Hail and Snow Cooperative. Manasquan, Red Bank and Long Branch saw around 1.3 to 1.73 inches Wednesday night.

Probability of Future Occurrences

The probability of future hurricane and tropical storm events for Monmouth County is high. According to NOAA statistical data, Monmouth County is in an area with an annual probability of a Named Storm between 18 and 24 percent according to NOAA. This empirical probability is consistent with other scientific studies and observed historical data made available through a variety of federal, State and local sources. According to the NOAA data on historical storm tracks, the annual probability of a hurricane or tropical storm coming within 75 miles of Monmouth County is 22 percent. A 2008 study headed by Colorado State University's Dr. William Gray concluded that the probability of a named storm making landfall in the vicinity of Monmouth County is 13.2 percent.

Occurrences are most likely during the official Atlantic hurricane season, which encompasses the months of June through November. The peak of the Atlantic hurricane season is in early to mid-September and the average number of storms that reach hurricane intensity per year in this basin is six. The probability of storm occurrences will vary significantly based on the return interval for different categories of magnitude. The probability of less intense storms (lower return periods) is higher than more intense storms (higher return periods). **Table 4.11-3 Peak Gust Wind Speeds Versus Return Period for Monmouth County** profiles the potential peak gust wind speeds that can be expected in Monmouth County during a hurricane event for various return periods according to FEMA's HAZUS-MH loss estimation methodology.

Table 4.11-3 Peak Gust Wind Speeds Versus Return Period for Monmouth County, NJ

10-Year	20-Year	50-Year	100-Year	200-Year	500-Year	1,000-Year
44 mph	63 mph	86 mph	102 mph	115 mph	132 mph	143 mph

Source: HAZUS-MH, MR2

Potential Effects of Climate Change

The frequency and intensity of coastal storms and severe weather events is expected to increase in the future due to climate change. In the years to come, it is anticipated that Monmouth County will observe drastic changes in storm character, intensity, frequency, and storm tracking. Hurricanes are likely to become more intense with rising sea water temperatures.

The following types of impacts can be anticipated in Monmouth County's future as a result of climate change and sea level rise: inundation of low-lying areas; increased frequency and extent of storm-related flooding; wetland loss; saltwater intrusion into estuaries and freshwater aquifers; land loss through submergence and erosion of lands in coastal areas; migration of coastal landforms and habitats; increased salinity in estuaries and coastal fresh; impacts to human populations (property losses, more frequent flood damage, more frequent flooding of roadways and urban centers, risks to people as the population of coastal areas increases); more buildings and infrastructure exposed; currently exposed buildings and infrastructure could be subject to potentially greater losses as water levels increase, and continued rapid coastal development exacerbates the impacts of sea level rise; impacts on gravity flow stormwater systems; impacts on non-coastal areas.

Impacts of climate change and sea level rise can affect all parts of a community, including: transportation infrastructure (ports, marinas, airports, roads, bridges, railways); public infrastructure (stormwater and wastewater management systems, drinking water supply and distribution systems, power utility systems, communications systems); public facilities (i.e., police, fire, ambulance, hospitals, schools, daycare centers, adult living facilities, historic landmarks, government buildings, libraries, parks, etc.); and economic viability of a community - particularly for communities where tourism tends to drive local economies, as is the case in many of Monmouth County's coastal communities. Climate change and sea level rise could lead to a potential loss of assets that support tourism (i.e., beaches themselves as well as beach access points, lodging, restaurants, marinas, fishing habitats, ecotourism, etc.).

Vulnerability Assessment

Built Environment, Infrastructure, and Community Lifelines

Coastal areas of Monmouth County are particularly dynamic environments and are quite susceptible to hazards associated with hurricanes and tropical storms. These susceptibilities are expected to increase over time due to the effects of sea level rise. Impacts of hurricanes and tropical storms are associated with damages as a result of flooding (riverine, coastal back bay and oceanfront), as well as storm surge, high winds, damaging waves, and coastal erosion. It is possible for the entire County to be impacted by hurricanes and tropical storms, though in different ways. For example, wind impacts may be widespread but more severe in immediate coastal areas. Structures closest to the Atlantic Coast could suffer catastrophic damages from wind, surge, waves and beach erosion while impacts to inland structures would be less substantial due to lower wind speeds and absence of surge. Riverine flooding would be limited to riverine flood zones and being of slower velocities in most cases would cause less severe types of structure damages. Roads and bridges across the County would be susceptible to overtopping and damage from floodwaters.

All property types are impacted, with residential and commercial impacts being greatest due to their proximity to the coast. Roads, bridges, schools, hospitals and other types of critical facilities are susceptible to wind and water damage. Secondary impacts would be associated with flying debris, as well as drifting sand from storm surges. Sand covered roads and bridges would be common impacts. Transportation, communications, and governmental services may be severely impacted. Impacts would be exacerbated when coincident with high tides, or during prolonged types of events that extend across several tidal cycles. Sea level rise will increase impacts over time.

Hurricanes and tropical storms are complex combinations of discrete component hazards occurring simultaneously. Damages during these events result from the cumulative impacts of a wide range of hazards including flooding, storm surge, coastal erosion, wave action, and high winds. No two hurricanes or tropical storms are identical. Even hurricanes of the same category can bring with them wildly different impacts depending on whether they occur during a time of high tide or low tide. Variations in inland wind affects and precipitation amounts, for example, can vary widely. Thus, it is difficult to estimate total potential losses from these cumulative effects in a manner that would allow for the calculation of a meaningful annual 'hurricane and tropical storm' average annual loss estimate. The current HAZUS-MH hurricane model only analyzes hurricane winds and is not capable of modeling and estimating cumulative losses from all hazards associated with hurricanes; therefore, only hurricane wind losses are reported in this section. This particular Hurricane and Tropical Storm subsection of the plan assesses vulnerability strictly with regard to hurricane winds. Vulnerability to the component hazards of hurricane and tropical storm events such as flooding, storm surge, coastal erosion, wave action, and high winds are addressed separately in this section.

As part of the plan update, a probabilistic scenario was created using HAZUS-MH to assess the vulnerability of Monmouth County to hurricane winds. Default HAZUS-MH wind speed data and damage functions, and methodology were used to determine the potential estimated losses for 50-, 100-, 200-, 500-, and 1000-year frequency events and annual expected loss at the census tract level. According to USGS, the term 50-, 100-, 200-, 500, and 1000-year flood is used to simplify the definition of a flood that statistically has a certain percent chance of occurring in any given year. In any given year, a 50-year flood has a 1 in 50 chance of occurring, a 100-year flood a 1 in 100 chance, a 500-year flood a 1 in 500 chance, and a 1,000-year flood a 1 in 1,000 chance for occurring. **Table 4.11-4 Estimated Potential Losses from 50-, 100-, 200-, 500-, and 1000-year Hurricane Wind Events** shows estimated potential losses for 50-, 100-, 200-, 500- and 1000-year hurricane wind event scenarios by jurisdiction as well as potential annualized property damage. It should be noted that some municipalities have no output in the HAZUS analysis. HAZUS outputs hurricane analysis to the Census tract level, and in order to aggregate that data to the municipal level, a spatial join is completed using centroids. If a single tract contains area in two municipalities, the data may not get captured in one jurisdiction, depending on the location of the tract centroid.

Table 4.11-4 Estimated Potential Losses from 50-, 100-, 200-, 500-, and 1000-year Hurricane Wind Events

Jurisdiction	Potential Total Losses from Hurricane Wind (2024 Values)					
	50-Year Hurricane Wind Event	100-Year Hurricane Wind Event	50-Year Hurricane Wind Event	500-Year Hurricane Wind Event	50-Year Hurricane Wind Event	Total Annualized Losses
Aberdeen, Township of	$4,132,690	$11,121,189	$15,519,265	$97,806,821	$121,051,256	$742,975
Allenhurst, Borough of	$-	$-	$-	$-	$-	$-
Allentown, Borough of	$251,433	$864,195	$610,610	$15,474,321	$33,368,858	$73,993
Asbury Park, City of	$10,985,180	$28,525,694	$81,720,084	$109,742,837	$196,594,226	$1,340,406
Atlantic Highlands, Borough of	$4,312,442	$8,961,834	$20,155,623	$31,512,654	$36,586,289	$489,660
Avon-By-The-Sea, Borough of	$2,544,952	$6,770,919	$26,074,516	$33,716,322	$70,139,769	$392,525
Belmar, Borough of	$6,956,863	$18,495,214	$65,168,764	$90,881,515	$190,594,767	$1,040,466
Bradley Beach, Borough of	$5,491,433	$14,578,413	$46,599,796	$60,088,110	$119,490,052	$727,701
Brielle, Borough of	$11,341,740	$23,246,258	$65,092,860	$100,837,370	$223,560,614	$1,118,814
Colts Neck, Township of	$5,425,308	$14,191,721	$23,894,371	$111,903,952	$179,062,372	$924,559
Deal, Borough of	$5,530,520	$14,427,032	$52,188,134	$70,155,842	$132,190,810	$886,152
Eatontown, Borough of	$9,163,251	$25,153,771	$61,467,637	$122,827,908	$190,722,023	$1,411,963
Englishtown, Borough of	$305,024	$1,024,529	$1,198,687	$11,652,968	$20,617,232	$72,871
Fair Haven, Borough of	$7,950,323	$16,376,298	$31,643,720	$62,176,408	$74,390,136	$845,681
Farmingdale, Borough of	$944,395	$2,239,351	$3,480,359	$11,248,309	$20,068,664	$103,104
Freehold, Borough of	$3,282,679	$8,872,327	$12,520,917	$75,738,813	$137,682,307	$545,244
Freehold, Township of	$19,677,196	$49,753,821	$66,935,784	$422,270,297	$821,152,818	$3,110,008
Hazlet, Township of	$5,333,392	$13,982,246	$22,453,206	$110,727,058	$125,233,949	$971,004
Highlands, Borough of	$4,085,155	$9,478,593	$24,691,684	$33,017,323	$39,798,943	$547,629
Holmdel, Township of	$8,115,329	$21,375,010	$33,098,537	$158,721,793	$198,526,592	$1,379,178
Howell, Township of	$30,833,867	$73,320,845	$117,401,172	$469,501,483	$938,440,219	$3,874,767
Interlaken, Borough of	$-	$-	$-	$-	$-	$-
Keansburg, Borough of	$2,214,238	$5,756,793	$11,093,842	$39,165,008	$47,176,703	$414,175
Keyport, Borough of	$1,659,868	$4,660,577	$7,617,090	$39,792,983	$44,822,089	$328,238
Lake Como, Borough of	$1,126,619	$3,030,521	$10,241,921	$15,860,290	$35,077,441	$176,904
Little Silver, Borough of	$11,512,685	$23,857,373	$48,469,204	$92,325,340	$124,303,424	$1,161,358

Jurisdiction	Potential Total Losses from Hurricane Wind (2024 Values)					
	50-Year Hurricane Wind Event	100-Year Hurricane Wind Event	50-Year Hurricane Wind Event	500-Year Hurricane Wind Event	50-Year Hurricane Wind Event	Total Annualized Losses
Loch Arbour, Village of	$-	$-	$-	$-	$-	$-
Long Branch, City of	$22,941,056	$58,075,412	$180,478,769	$232,339,765	$368,973,473	$3,243,087
Manalapan, Township of	$12,212,736	$34,710,412	$39,949,017	$339,443,788	$637,178,048	$2,295,250
Manasquan, Borough of	$8,712,600	$22,610,098	$78,138,548	$122,332,499	$293,936,752	$1,278,526
Marlboro, Township of	$19,121,461	$49,372,984	$62,550,893	$378,521,799	$577,406,428	$2,913,463
Matawan, Borough of	$1,962,370	$5,541,631	$7,725,053	$45,812,648	$57,435,885	$354,625
Middletown, Township of	$33,764,765	$82,591,545	$166,791,802	$467,285,666	$564,268,353	$5,185,988
Millstone, Township of	$3,924,290	$11,832,865	$12,172,468	$140,854,148	$300,929,196	$819,089
Monmouth Beach, Borough of	$4,284,409	$11,070,266	$36,327,233	$45,929,872	$67,951,503	$680,834
Neptune City, Borough of	$3,263,793	$9,612,418	$29,965,774	$45,491,362	$90,474,049	$511,062
Neptune, Township of	$21,263,891	$54,157,252	$149,711,961	$251,773,373	$477,735,873	$2,824,844
Ocean, Township of	$23,856,413	$54,820,836	$139,026,235	$238,075,858	$406,798,544	$2,885,456
Oceanport, Borough of	$4,238,262	$10,434,215	$34,304,218	$52,269,834	$84,027,576	$722,582
Red Bank, Borough of	$5,952,484	$17,209,967	$36,211,338	$98,013,982	$128,263,930	$1,075,958
Roosevelt, Borough of	$-	$-	$-	$-	$-	$-
Rumson, Borough of	$17,540,122	$35,015,499	$80,650,968	$126,645,283	$157,763,878	$1,897,063
Sea Bright, Borough of	$-	$-	$-	$-	$-	$-
Sea Girt, Borough of	$5,101,234	$13,982,489	$53,594,126	$78,858,583	$191,136,447	$819,517
Shrewsbury, Borough of	$2,994,835	$7,972,051	$18,963,405	$42,421,636	$65,892,933	$485,320
Shrewsbury, Township of	$-	$-	$-	$-	$-	$-
Spring Lake, Borough of	$6,672,343	$17,938,782	$68,734,359	$93,988,665	$219,796,782	$1,037,849
Spring Lake Heights, Borough of	$7,156,605	$16,139,193	$43,276,555	$63,617,945	$132,723,315	$742,304
Tinton Falls, Borough of	$13,316,126	$30,094,384	$59,168,565	$155,532,257	$244,612,323	$1,645,879
Union Beach, Borough of	$1,665,395	$3,887,078	$6,799,323	$34,243,583	$40,244,870	$321,813
Upper Freehold, Township of	$2,520,398	$7,530,993	$7,100,620	$153,521,349	$350,563,936	$746,163
Wall, Township of	$33,095,229	$76,473,711	$188,764,347	$376,146,601	$754,525,909	$3,875,854
West Long Branch, Borough of	$5,259,690	$14,955,002	$48,352,504	$78,021,651	$132,177,828	$996,353
Monmouth County	**$423,997,091**	**$1,046,093,604**	**$2,398,095,863**	**$6,048,287,872**	**$10,465,469,382**	**$60,038,256**

Source: HAZUS-MH

Population and Economy

Monmouth County is a tourist destination. With summer being the peak vacation time, coincident with hurricane season, the potential population at risk is at its peak during the time of year when Monmouth County is most likely to be impacted by a hurricane or tropical storm. Impacts to the general public include evacuation and sheltering needs, as well as emergency response for those who shelter in place or are injured during the event.

Natural Systems and Ecosystems

Beach erosion can often be severe during hurricanes and tropical storms; though beach restoration and maintenance activities are undertaken regularly to offset storm impacts. The Long Branch - Manasquan Project, between Sandy Hook and Manasquan Inlet, is one of the largest beach construction projects completed in the US with over 25 million cubic yards of sand placed on 25 miles of beaches.

4.12 Landslide

Hazard Description

Landslide is defined as the movement of a mass of rock, debris, or earth down a slope when the force of gravity pulling down the slope exceeds the strength of the earth materials that comprise to hold it in place. Slopes greater than 10 degrees are more likely to slide, as are slopes where the height from the top of the slope to its toe is greater than 40 feet. Slopes are also more likely to fail if vegetation cover is low and/or soil water content is high.

Location and Extent

Landslide incidence data from the New Jersey Geological and Water Survey (NJGWS), published in 2024, depicts a concentration of previous landslide occurrences in the boroughs of Atlantic Highlands and Highlands. These events were all triggered by heavy rainfall. The four other landslide events outside of these boroughs occurred in Middletown Township, Freehold Township, and Howell Township (NJGWS 2024). Historic landslide occurrences as recorded by the NJGWS are depicted in **Figure 4.12 – 1 Previous Occurrences of Landslides in Monmouth County and their Triggers.** Landslides in Atlantic Highlands and Highlands Boroughs are looked at more closely in **Figure 4.12-2 Previous Occurrences of Landslides in Monmouth County and their Triggers (Detail).**

Figure 4.12-1 Previous Occurrences of Landslides in Monmouth County and their Triggers

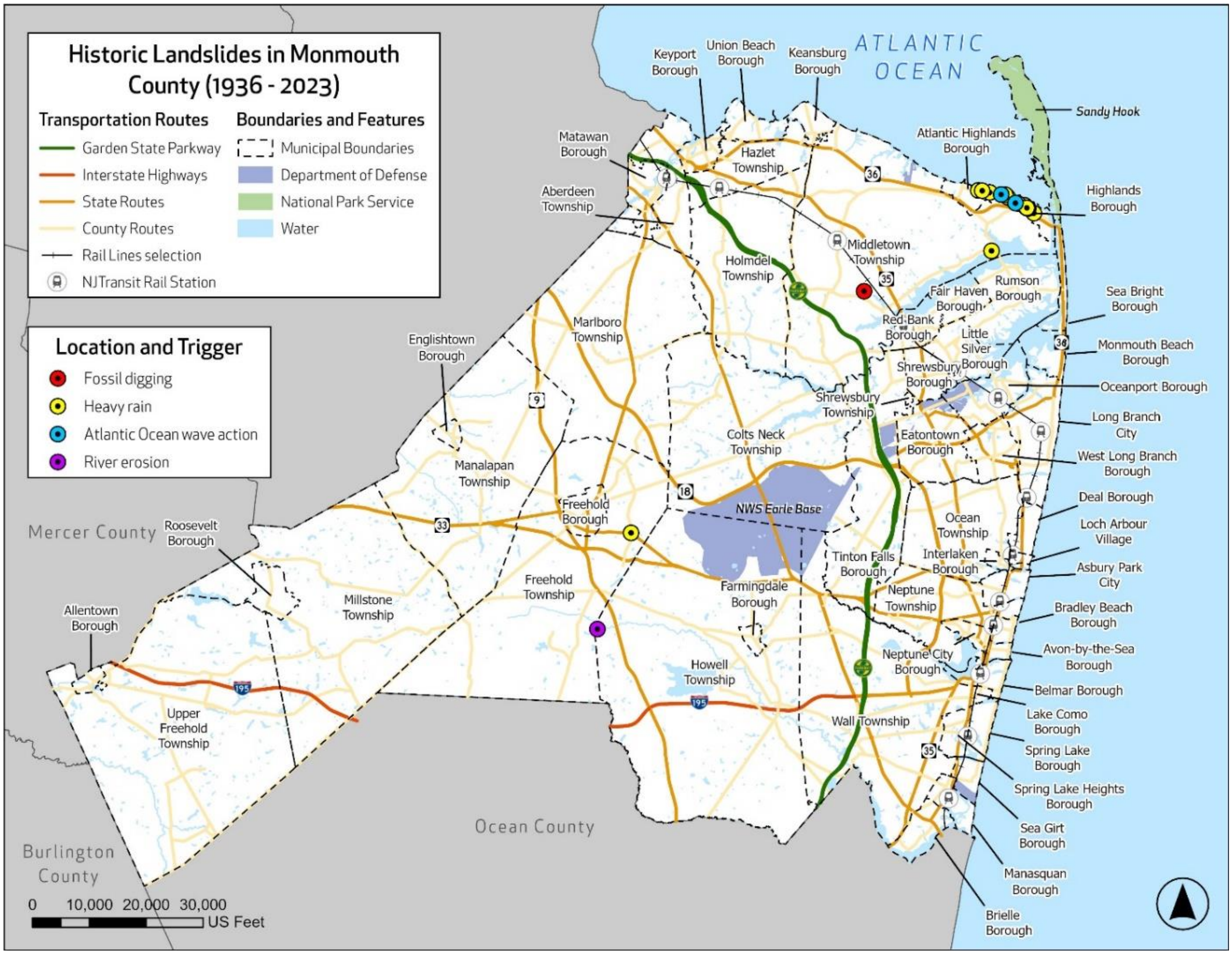
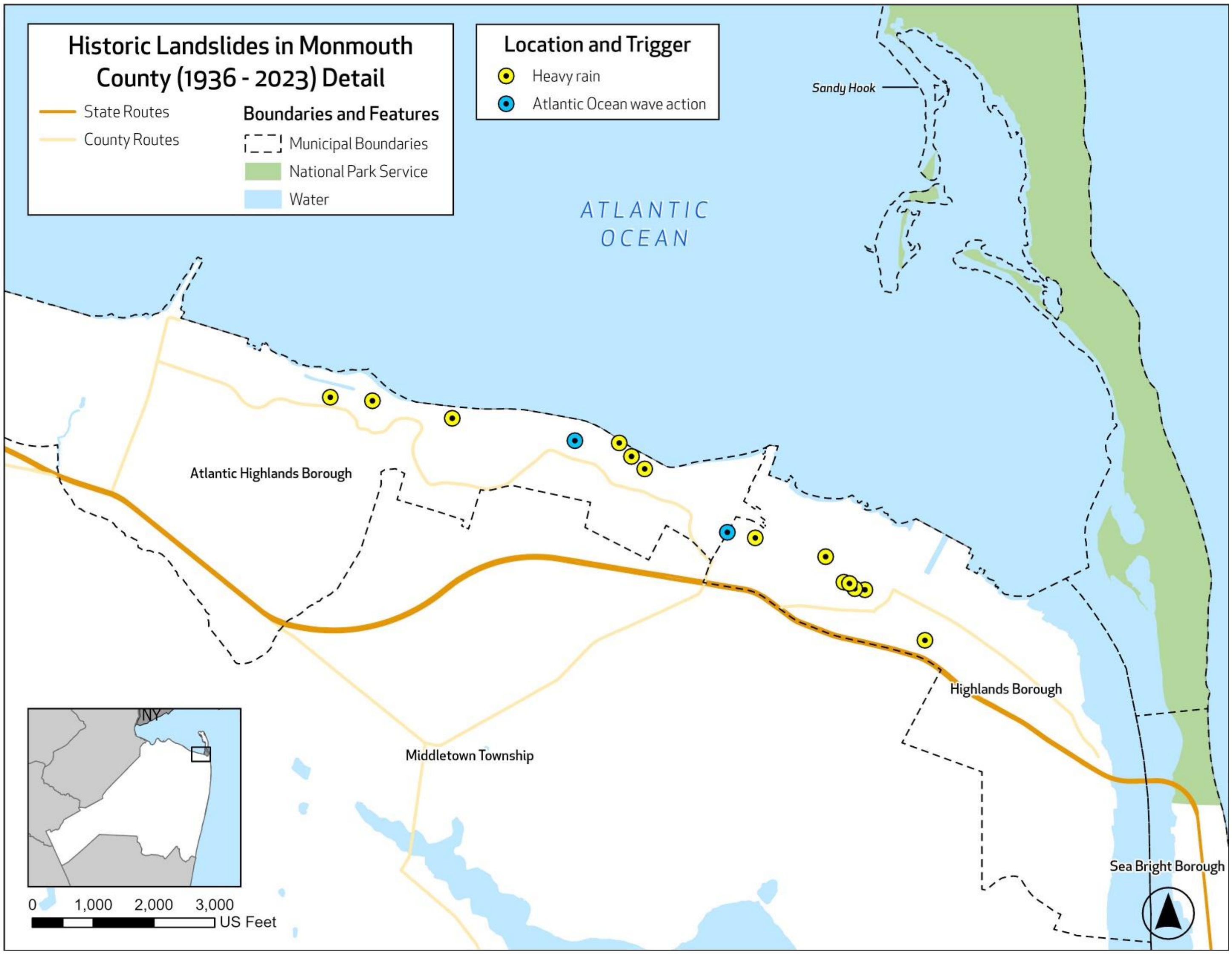


Figure 4.12-2 Previous Occurrences of Landslides in Monmouth County and their Triggers (Detail)



The NJGWS published its landslide susceptibility classifications of Monmouth County based on slope angle, geologic material on a slope, and groundwater level in 2023. Landslide susceptibility classifications correspond to those from the HAZUS User's Manual, Table 9.2 (National Institute of Building Sciences, 1997). While this data depicts varying levels of landslide susceptibility throughout the County, highly susceptible soils (Landslide Classes CVII-CX) are concentrated in northeastern Monmouth County (Atlantic Highlands Borough, Highlands Borough, and Middletown Township), Howell Township, and Upper Freehold Township. An analysis of Monmouth County's landslide susceptibility by census tract also from this study illustrates Extremely High (HAZUS Class 10) landslide susceptibility in Atlantic Highlands and Highlands Borough.

The 11 municipalities considered highly susceptible to landslide include Fair Haven Borough, Middletown Township, Little Silver Borough, Oceanport Borough, Rumson Borough, Freehold Township, Howell Township, Upper Freehold Township, Atlantic Highlands Borough, Highlands Borough, and Tinton Falls Borough. As part of this plan update, 9 of these 11 municipalities have a mitigation action to mitigate against landslides, while the other two have withdrawn actions as they have not been experiencing landslides. Additional municipalities may also have some areas susceptible to landslides. For a complete inventory of the land area susceptible to landslides in Monmouth County, please refer to **Table 4.12-1 Total Land Located in Landslide Areas (NJGWS)**.

As previously mentioned, the NJGWS published landslide susceptibility for Monmouth County in 2023. The total land area located in landslide hazard areas was calculated for each municipality, as presented in **Table 4.12-1 Total Land Located in Landslide Areas (NJGWS)** below. Based upon the analysis using NJGWS data, Upper Freehold Township (approximately 603 acres) has the greatest area delineated with landslide susceptible soils, while Highlands Borough (10.7%) and Atlantic Highlands Borough (9.6%) have the greatest percent of their land area delineated with landslide susceptible soils.

Table 4.12-1 Total Land Located in Landslide Areas (NJGWS)

Jurisdiction	Total Land Area of Municipality (Acres)	Total Land Area in NJGWS-Defined Landslide Susceptibility Area (Acres)	Percent of Total Land Area in NJGWS-Defined Landslide Susceptibility Area (Acres)
Aberdeen, Township of	3,615.25	92.18	2.5%
Allenhurst, Borough of	166.78	0.00	0.0%
Allentown, Borough of	396.12	5.38	1.4%
Asbury Park, City of	975.75	0.00	0.0%
Atlantic Highlands, Borough of	791.22	76.10	9.6%
Avon-By-The-Sea, Borough of	318.09	0.00	0.0%
Belmar, Borough of	951.2	0.00	0.0%
Bradley Beach, Borough of	413.35	0.00	0.0%
Brielle, Borough of	1,442.06	15.60	1.1%
Colts Neck, Township of	20,322.35	161.84	0.8%
Deal, Borough of	770.84	0.00	0.0%
Eatontown, Borough of	3,769.62	0.00	0.0%
Englishtown, Borough of	378.34	0.00	0.0%
Fair Haven, Borough of	1,335.93	0.00	0.0%
Farmingdale, Borough of	336.8	0.00	0.0%
Freehold, Borough of	1,235.59	0.00	0.0%
Freehold, Township of	24,881.36	80.59	0.3%
Hazlet, Township of	3,628.55	11.35	0.3%
Highlands, Borough of	547.83	58.57	10.7%
Holmdel, Township of	11,561.04	275.34	2.4%
Howell, Township of	39,148.96	181.80	0.5%
Interlaken, Borough of	254.6	0.00	0.0%
Keansburg, Borough of	776.33	0.00	0.0%
Keyport, Borough of	927.85	2.45	0.3%
Lake Como, Borough of	161.35	0.00	0.0%
Little Silver, Borough of	2,035.66	0.00	0.0%
Loch Arbour, Village of	73.96	0.00	0.0%
Long Branch, City of	3,505.50	0.00	0.0%
Manalapan, Township of	19,759.34	54.01	0.3%
Manasquan, Borough of	1,002.69	0.00	0.0%
Marlboro, Township of	19,477.44	186.09	1.0%
Matawan, Borough of	1,542.15	127.52	8.3%
Middletown, Township of	27,864.65	482.02	1.7%
Millstone, Township of	23,800.31	361.96	1.5%
Monmouth Beach, Borough of	1,261.94	0.00	0.0%
Neptune City, Borough of	574	0.00	0.0%

Jurisdiction	Total Land Area of Municipality (Acres)	Total Land Area in NJGWS-Defined Landslide Susceptibility Area (Acres)	Percent of Total Land Area in NJGWS-Defined Landslide Susceptibility Area (Acres)
Neptune, Township of	5,550.08	93.26	1.7%
Ocean, Township of	7,030.46	31.72	0.5%
Oceanport, Borough of	2,621.24	0.00	0.0%
Red Bank, Borough of	1,382.60	0.01	0.0%
Roosevelt, Borough of	1,246.51	11.99	1.0%
Rumson, Borough of	4,537.77	0.00	0.0%
Sea Bright, Borough of	781.65	0.00	0.0%
Sea Girt, Borough of	714.88	0.00	0.0%
Shrewsbury, Borough of	1,393.02	0.00	0.0%
Shrewsbury, Township of	62.75	0.00	0.0%
Spring Lake Hts., Borough of	837.15	0.00	0.0%
Spring Lake, Borough of	945.86	0.00	0.0%
Tinton Falls, Borough of	9,989.22	72.69	0.7%
Union Beach, Borough of	1,203.10	0.00	0.0%
Upper Freehold, Township of	30,311.34	603.42	2.0%
Wall, Township of	20,288.47	307.55	1.5%
West Long Branch, Borough of	1,850.28	0.00	0.0%
Monmouth County	**310,751.18**	**3,293.44**	**1.1%**

Source: NJOIT 2023, NJGWS 2023

Range of Magnitude

Areas that are generally prone to landslide hazards include previous landslide areas, the bases of steep slopes, the bases of drainage channels and developed hillsides where leach-field septic systems are used. Slopes greater than 10 degrees are more likely to slide, as are slopes where the height from the top of the slope to its toe is greater than 40 feet. Slopes are also more likely to fail if vegetative cover is low and/or soil water content is high. Landslides occur when the slope or soil stability changes from stable to unstable, which may be caused by earthquakes, storms, volcanic eruptions, erosion, fire, or additional human-induced activities. Although in New Jersey landslides are not as common as in other areas of the United States, they are a geologic hazard in areas with steep to moderate slopes or geologic units prone to failure. According to the NJOEM, the largest landslide events in New Jersey occur in the form of slumping along the coastal bluffs of the Navesink Highlands area of Monmouth County (including the Boroughs of Atlantic Highlands and Highlands and Township of Middletown). While originally attributed to coastal erosion, slumping has reportedly begun anew in the last 30 years likely due to development at the bottom of slopes, an unusually high water table and changes in vegetative patterns.

Previous Occurrences and Losses

According to NJGWS, 20 historical landslide events have occurred in Monmouth County since 1782, with 14 occurring between 1999 and 2024, as listed in **Table 4.12-2 Historical Landslide Occurrences in Monmouth County, 1999-2024**. These events caused minor property damages and three injuries.

Table 4.12-2 Historical Landslide Events in Monmouth County, 1999-2024

Event Date	Location	Type	Damage	Deaths	Injuries	Description
September 1999	Highlands	Debris Flow	Yes	0	2	Landslide, possibly due to fill material failure after heavy rain. One condominium unit destroyed, three others damaged.

Event Date	Location	Type	Damage	Deaths	Injuries	Description
August 2002	Middletown	Slump	No	0	0	Recent small slump in slump block possibly hundreds of years old on Navesink River bluff.
2003	Howell	Slump	Yes	0	0	Riverbank slumping on 26-foot high bank due to undercutting from the Manasquan River along 200 feet of Bergerville Road. Some road damage.
October 2005	Freehold Township	Debris flow	Yes	0	0	Landslide partially blocked road after heavy rain during road construction.
October 2005	Atlantic Highlands	Slump	Yes	0	0	Small backyard slump caused by water saturation after heavy rain, some property damage, estimated location.
April 2007	Highlands	Slump	Yes	0	0	Landslide on the bluff between Linden Avenue and Shore Drive, west of Waterwitch Drive in the Atlantic Highlands.
April 2010	Highlands	Debris flow	Yes	0	0	Triggered by nor'easter of March 31- April 1. Located on bluff between Linden Avenue and Shore Drive west of Waterwitch Drive. 50 feet wide 170 feet long. Deck and house threatened.
April 2010	Atlantic Highlands	Debris flow	Yes	0	0	Exact date unknown, first noticed in early April after back-to-back nor'easters of March/April.
April 2010	Atlantic Highlands	Debris flow	Yes	0	0	Exact date unknown, first noticed in early April after back-to-back nor'easters of March/April.
April 2010	Atlantic Highlands	Slump	No	0	0	Reactivation of old slump block.
August 2011	Highlands	Debris flow	Yes	0	0	Large landslide above condo complex triggered by heavy rain from Tropical Storm Irene damages condo complex.
August 2011	Highlands	Debris flow	Yes	0	0	Large landslide above condo complex triggered by heavy rain from Tropical Storm Irene damages condo complex. Reactivation of prior landslide.
April 2014	Atlantic Highlands	Slump	Yes	0	0	A landslide at 160 Ocean Boulevard in Atlantic Highlands on April 30-May 1, 2014 during heavy rains that supposedly “sent hundreds of thousands of cubic yards of dirt, sand, and rock” onto the Henry Hudson Trail at the base of the slope.
April 2017	Atlantic Highlands	Slump	Yes	0	0	Slump below a house along steep slope on Sandy Hook Bay.

Source: New Jersey Geological and Water Survey, 2024

Probability of Future Occurrence

According to the 2024 State HMP, landslides are highly likely to occur in New Jersey in the future. Given changes in precipitation, sea-level rise, and changes in development, it is possible that the potential for the magnitude/extent of the risk and frequency may also change. However, the location of susceptibility for landslide is expected to remain relatively static as the driving factors for the potential location of occurrence is underlying bedrock and soil formation.

Based on past occurrences described in **Table 4.12 - 2 Historical Landslide Events in Monmouth County**, **2000-2024** and depicted alongside landslide susceptibility **in Figure 4.12-1 Previous Occurrences of Landslides in Monmouth County and Their Triggers**, it is likely that future landslide events (primarily slumps and slump blocking) may occur in the northeast portion of Monmouth County, including the municipalities of Atlantic Highlands Borough, Highlands Borough, and Middletown Township.

Potential Effects of Climate Change

According to the 2024 State HMP, it is predicted that climate change will increase the frequency of geohazards such as landslide through changes in precipitation, temperature, and sea level rise. Intense rainfall can saturate and destabilize soil creating landslide conditions. Warming temperatures and changing precipitation patterns could increase the occurrence and duration of droughts, which could increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. Sea level rise could increase landslide probability for unprotected beaches and bluffs.

Vulnerability Assessment

Built Environment, Infrastructure and Community Lifelines

Secondary effects of landslides include the disruption of transportation route, power and communication failure, and the destabilization of building foundations. **Table 4.12-3: Expected Annualized Losses from Landslide by Jurisdiction** shows expected annualized losses for the landslide hazard. This data was derived from FEMA's NRI. Expected EAL represents the average economic loss in dollars resulting from natural hazards each year. The table includes EAL for buildings as well as total EAL which includes building damage as well as damage to agriculture and population equivalency (the monetized cost of injury and fatality).

Table 4.12-3 Expected Annual Losses from Landslide by Jurisdiction

Jurisdiction	Expected Annual Losses - Buildings	Expected Annual Losses - Total
Aberdeen, Township of	$1,573.30	$2,038.05
Allenhurst, Borough of	$-	$-
Allentown, Borough of	$-	$-
Asbury Park, City of	$1.07	$1.41
Atlantic Highlands, Borough of	$14,976.92	$19,765.92
Avon-By-The-Sea, Borough of	$-	$-
Belmar, Borough of	$-	$-
Bradley Beach, Borough of	$-	$-
Brielle, Borough of	$-	$-
Colts Neck, Township of	$4,250.95	$4,926.79
Deal, Borough of	$-	$-
Eatontown, Borough of	$891.82	$1,046.40
Englishtown, Borough of	$1,502.51	$1,797.13
Fair Haven, Borough of	$444.10	$516.09
Farmingdale, Borough of	$-	$-
Freehold, Borough of	$557.66	$741.49
Freehold, Township of	$1,632.86	$1,817.66
Hazlet, Township of	$195.15	$196.10
Highlands, Borough of	$1,906.18	$2,333.59

Jurisdiction	Expected Annual Losses - Buildings	Expected Annual Losses - Total
Holmdel, Township of	$12,680.11	$14,230.04
Howell, Township of	$2,094.37	$2,530.00
Interlaken, Borough of	$-	$-
Keansburg, Borough of	$-	$-
Keyport, Borough of	$-	$-
Lake Como, Borough of	$-	$-
Little Silver, Borough of	$1,764.93	$2,032.91
Loch Arbour, Village of	$-	$-
Long Branch, City of	$-	$-
Manalapan, Township of	$7,176.45	$8,322.26
Manasquan, Borough of	$-	$-
Marlboro, Township of	$11,853.29	$13,339.35
Matawan, Borough of	$916.16	$1,173.78
Middletown, Township of	$21,546.97	$25,366.91
Millstone, Township of	$5,060.05	$5,764.29
Monmouth Beach, Borough of	$-	$-
Neptune City, Borough of	$111.45	$137.63
Neptune, Township of	$10,110.80	$12,593.58
Ocean, Township of	$3,628.33	$4,048.81
Oceanport, Borough of	$-	$-
Red Bank, Borough of	$2,689.45	$3,246.18
Roosevelt, Borough of	$1,384.25	$1,605.17
Rumson, Borough of	$-	$-
Sea Bright, Borough of	$-	$-
Sea Girt, Borough of	$-	$-
Shrewsbury, Borough of	$-	$-
Shrewsbury, Township of	$-	$-
Spring Lake Hts., Borough of	$-	$-
Spring Lake, Borough of	$-	$-
Tinton Falls, Borough of	$2,814.68	$3,273.70
Union Beach, Borough of	$-	$-
Upper Freehold, Township of	$2,448.92	$2,711.45
Wall, Township of	$4,865.55	$5,423.28
West Long Branch, Borough of	$-	$-
Monmouth County	**$119,078.30**	**$140,979.97**

Source: FEMA NRI

Population and Economy

The population within the landslide areas may be vulnerable, especially those located downslope of the identified hazard areas. When populations are impacted, the landslide hazard can result in injury and even death. The health hazards associated with landslides and mudflows include rapidly moving water and debris that can lead to trauma; broken electrical, water, gas, and sewage lines that can result in injury or illness; and disrupted roadways and railways that can endanger motorists and disrupt transport and access to health care.

Ecosystems and Natural Assets

Landslide events disrupt and damage ecosystems, by destroying terrestrial and riverine habitats, changing topography, and causing soil and sediment runoff.

Potential for Future Development to Impact Hazard Vulnerability

Future development in areas prone to landslide can increase a community's vulnerability. Building on or near steep slopes without proper stabilization measures can disturb natural terrain and make the area more prone to landslides. Greenfield development which results in deforestation removes tree roots that stabilize soil, increasing the likelihood of slope failure during heavy rains or other triggering events.

Jurisdictions with a potential for future development to substantially increase landslide hazard vulnerability under existing conditions should: (a) include landslide mitigation measures in their mitigation strategies; and/or (b) select jurisdictional plan integration initiatives for the next plan maintenance phase that can potentially reduce risk for future development.

4.13 LIGHTNING

Hazard Description

Lightning is a discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm, creating a "bolt" when the buildup of charges becomes strong enough. This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning rapidly heats the sky as it flashes, but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder. On average, 80 people are killed each year by lightning strikes in the United States.

Location and Extent

Monmouth County is located in a region of the country that is susceptible to lightning strikes, though not as susceptible as midwestern and southeastern states where thunderstorms are more frequently occurring. All areas of Monmouth County are equally susceptible to lightning strike. While lightning occurs randomly anywhere and anytime, the most common location for lightning fatalities and injuries to people is in open areas such as parks, beaches, golf courses and other recreational areas. Monmouth County remains susceptible to lightning deaths and injuries due to the large number of people who engage in outdoor activities, particularly more so along the shoreline of its coastal jurisdictions.

Previous Occurrences and Losses

According to NOAA's NCEI, 52 recorded lightning strike incidents have affected Monmouth County from May 1997 to November 2024. All incidents combined have resulted in a reported total of seven direct deaths and 13 direct injuries and caused an estimated $2.44 million in property damages. Some more notable events include the following:

September 15, 2000. Lightning struck the communications tower of the Neptune Township Police Department, damaging the police radios, repeaters and dispatch consoles. All 911 calls were forwarded to the County center. The police operated from a backup communications center until normal operations resumed later in the evening. Damages were estimated at $40,000.

August 27, 2001. Lightning struck a three-story home in Upper Freehold Township. The four-alarm fire totally destroyed the home and damages were estimated at $500,000.

July 11, 2002. A woman was fatally struck by lightning in Bradley Beach. She was found in distress on the beach with burn marks on the mid-section of her body before she died.

August 17, 2007. A severe thunderstorm caused two fatalities and an estimated $200,000 in damages across Monmouth County. A woman was struck by lightning as she was about to enter a restaurant on U.S. Route 9 North in Howell. She was pronounced dead about one hour later. A two-story home's roof was struck by a bolt of lightning in Middletown Township. A fire in the attic area caused moderate damage.

June 1, 2010. A 12-story condominium was evacuated for three days after a lightning strike struck one of the towers and knocked out the sprinkler system pump, which is needed to get water up to the twelfth floor in the event of a fire. Estimated damages were $10,000.

July 13, 2010. Two lightning strikes caused about 8,200 homes and businesses to lose power in Ocean Township. The lightning struck a power substation and a transformer around East Mall Drive and State Route. Damages were estimated at $5,000.

July 19, 2010. A line of strong to locally severe thunderstorms occurred. A man was struck and killed by lightning in Middletown while in contact with a tree and observing a house fire that was started by a previous lightning strike. Another man and a police officer were also injured by the same lightning strike. A lightning strike set the attic of a house on fire in Middletown Township. One firefighter was injured. Damages were estimated at $25,000.

September 16, 2010. Lightning struck the roof of an apartment building in Eatontown. About three apartments sustained fire damage and all units below them suffered water and smoke damage. Tenants from all twenty-four units were evacuated for at least one night. No injuries were reported. Damages were estimated at $100,000.

July 7, 2011. For the third time in 2011, the water treatment plant in Allentown Borough was struck by lightning. This lightning strike fried computerized controls and caused about an estimated $40,000 in damages.

August 14, 2011. A lightning strike and ensuing fire badly damaged a Maxim Road home in Howell. The fire started toward the rear of the home's attic and third floor and spread to the second floor before it was declared under control at 9 a.m. EDT. No serious injuries were reported but the fire was estimated to have caused $225,000 in damages.

August 21, 2011. An estimated $22,000 in damages was reported due to lightning strikes during this event. A lightning strike started an insulation fire at a home in Atlantic Highlands. Lightning struck a cable wire and traveled along it and ignited the home's insulation. No injuries were reported. Lightning struck the Monmouth County 911 radio tower in Freehold. A lightning strike to one of its water towers on Union Lane caused Brielle to declare an emergency on the 21st The lightning strike damaged electrical panels and also short circuited the entrance gate and a computer on the premises.

June 25, 2012. An approaching cold front helped trigger strong to locally severe thunderstorms in two waves across central and southern New Jersey. The first occurred during the morning of the 25th and the second during the late afternoon and early evening later that day. A lightning strike and subsequent fire and water damage destroyed eight units of a condominium complex in Manalapan Township, amounting to $1 million in damages. About ten people were displaced. No injuries were reported.

August 13, 2013. A complex of showers and thunderstorms produced wind damage and flash flooding. Cloud-to-ground lightning strikes peaked at 6,000 per hour as this complex moved through New Jersey. The thunderstorms caused about 14,500 homes and businesses to lose power on the 13th. A lightning strike at the Borough Hall in Manasquan caused damage and disrupted the communication systems in the borough. They were transferred to other facilities.

July 16, 2016. A cold frontal boundary along with several shortwaves and a sea breeze produced numerous showers and thunderstorms across the southern and central portions of New Jersey during the afternoon and evening hours of the

16th. A few strong wind gusts not associated with damage were measured or estimated at 53 mph in Toms River, 57 mph in Berkeley Township, and 50 mph in northern Howell Township. A lightning strike caused a house fire in Manalapan.

Probability of Future Occurrence

The probability of occurrence for future lightning events in Monmouth County is certain. According to NOAA, Monmouth County is located in an area of the country that experiences three lightning flashes per square kilometer per year (approximately 2,300 flashes countywide per year). Given this regular frequency of occurrence, it can be expected that future lightning events will continue to threaten life and cause minor property damages throughout Monmouth County.

Potential Effects of Climate Change

NASA scientists suggest that the United States will face more severe thunderstorms in the future, with deadly lightning, damaging hail, and the potential for tornadoes in the event of climate change. A recent study conducted by NASA predicts that smaller storm events like thunderstorms will also be more dangerous due to climate change (NASA 2007).

Vulnerability Assessment

Built Environment, Infrastructure and Community Lifelines

Lightning strikes can cause damage to buildings, critical facilities, and infrastructure, largely by igniting a fire. Lightning can strike communications equipment (i.e., radio or cell towers, antennae, satellite dishes, electrical transformers, etc.) and hamper communication and emergency response.

Because it cannot be predicted where lightning may strike, all existing and future buildings and facilities are considered to be exposed to this hazard and could potentially be impacted. **Table 4.13 - 1 Expected Annualized Losses from Lightning by Jurisdiction** shows expected annualized losses for the lightning hazard. This data was derived from FEMA's NRI. EAL represents the average economic loss in dollars resulting from natural hazards each year The table includes EAL for buildings as well as total EAL which includes building damage as well as damage to agriculture and population equivalency (the monetized cost of injury and fatality) where applicable.

Table 4.13-1 Expected Annualized Losses from Lightning by Jurisdiction

Jurisdiction	Expected Annual Losses - Buildings	Expected Annual Losses - Total
Aberdeen, Township of	$2,560.22	$76,568.10
Allenhurst, Borough of	$217.44	$2,037.33
Allentown, Borough of	$303.88	$7,327.26
Asbury Park, City of	$1,519.84	$46,958.12
Atlantic Highlands, Borough of	$783.81	$18,440.89
Avon-By-The-Sea, Borough of	$372.98	$5,967.57
Belmar, Borough of	$966.34	$18,100.26
Bradley Beach, Borough of	$639.04	$13,051.27
Brielle, Borough of	$962.55	$15,602.98
Colts Neck, Township of	$2,472.16	$36,067.44
Deal, Borough of	$217.44	$2,037.33
Eatontown, Borough of	$2,811.44	$46,285.99
Englishtown, Borough of	$1,398.57	$29,132.57
Fair Haven, Borough of	$1,037.26	$21,810.24
Farmingdale, Borough of	$225.57	$5,664.02
Freehold, Borough of	$3,118.48	$77,791.83
Freehold, Township of	$7,414.41	$119,847.74

Jurisdiction	Expected Annual Losses - Buildings	Expected Annual Losses - Total
Hazlet, Township of	$3,138.22	$79,483.27
Highlands, Borough of	$724.46	$17,893.32
Holmdel, Township of	$4,426.08	$63,252.20
Howell, Township of	$9,534.32	$212,540.51
Interlaken, Borough of	$217.44	$2,037.33
Keansburg, Borough of	$912.32	$36,308.80
Keyport, Borough of	$1,087.42	$30,734.66
Lake Como, Borough of	$195.68	$5,294.28
Little Silver, Borough of	$1,335.73	$20,525.22
Loch Arbour, Village of	$217.44	$2,037.33
Long Branch, City of	$3,727.20	$99,271.56
Manalapan, Township of	$7,060.19	$135,087.19
Manasquan, Borough of	$1,168.15	$18,040.31
Marlboro, Township of	$9,300.57	$154,561.92
Matawan, Borough of	$1,312.86	$37,722.68
Middletown, Township of	$11,526.84	$245,403.51
Millstone, Township of	$2,910.52	$40,934.18
Monmouth Beach, Borough of	$602.71	$10,082.69
Neptune City, Borough of	$761.02	$14,481.44
Neptune, Township of	$4,034.60	$94,513.40
Ocean, Township of	$4,042.54	$86,919.79
Oceanport, Borough of	$1,182.09	$23,401.99
Red Bank, Borough of	$2,245.98	$46,638.35
Roosevelt, Borough of	$868.08	$12,578.15
Rumson, Borough of	$1,996.54	$26,354.72
Sea Bright, Borough of	$361.98	$4,814.45
Sea Girt, Borough of	$709.78	$6,065.21
Shrewsbury, Borough of	$543.45	$8,863.45
Shrewsbury, Township of	$543.45	$8,863.45
Spring Lake Hts., Borough of	$882.91	$9,348.14
Spring Lake, Borough of	$720.24	$15,562.47
Tinton Falls, Borough of	$2,618.67	$54,756.59
Union Beach, Borough of	$879.31	$24,823.54
Upper Freehold, Township of	$2,691.31	$33,948.53
Wall, Township of	$5,880.42	$92,553.04
West Long Branch, Borough of	$1,517.13	$26,733.17
Monmouth County	**$118,899.07**	**$2,345,121.73**

Source: FEMA NRI

Population and Economy

All populations are considered to be at equal risk from lighting strike, however, members of the general public who are outdoors are particularly vulnerable during an event. Historical impacts in Monmouth County have included direct health impacts to individuals struck by lightning, and death in some cases.

Ecosystems and Natural Assets

Lightning strike can lead to wildfire, especially during dry or drought conditions, which can harm ecosystems. Impacts of additional hazards associated with thunderstorms such as strong, straight-line winds and hail also apply.

4.14 NOR'EASTER

Hazard Description

Similar to hurricanes, nor'easters are ocean storms capable of causing substantial damage to coastal areas in the Eastern United States due to their associated strong winds and heavy surf. Nor'easters are named for the winds that blow in from the northeast and drive the storm up the East Coast along the Gulf Stream, a band of warm water that lies off the Atlantic coast. They are caused by the interaction of the jet stream with horizontal temperature gradients and generally occur during the fall and winter months when moisture and cold air are plentiful. Nor'easters are known for dumping heavy amounts of rain and snow, producing hurricane-force winds, and creating high surf that causes severe beach erosion and coastal flooding.

Location and Extent

The entire planning area is located within a geographic area that is affected by nor'easters.

Range of Magnitude

While there are a variety of indicators for nor'easter intensity, **Table 4.14 - 1** describes the Dolan-Davis Nor'easter Intensity Scale which is based on coastal storm erosion, degradation and property damage.

Table 4.14-1 Dolan-Davis Nor'easter Intensity Scale

Storm Class	Beach Erosion	Dune Erosion	Overwash	Property Damage
1-Weak	Minor Changes	None	No	No
2-Moderate	Modest; Mostly to Lower Beach	Minor	No	Modest
3-Significant	Erosion Extends Across Beach	Can be Significant	No	Loss Of Many Structures at Local Level
4-Severe	Severe Beach Erosion and Recession	Severe Dune Erosion or Destruction	On Low Beaches	Loss Of Structures At Community-Scale
5-Extreme	Extreme Beach Erosion	Dunes Destroyed Over Extensive Areas	Massive In Sheets and Channels	Extensive at Regional Scale; Millions Of Dollars

Source: FEMA

Previous Occurrences and Losses

Monmouth County has a lengthy history of devastating impacts wrought by nor'easters. This includes damages caused by the effects of extreme wind, heavy rain, snow, wave action, storm surge, coastal flooding and beach erosion (also addressed separately within this section).

One of the State's worst nor'easters occurred on March 6-8, 1962, when gale force winds (sustained of 45 miles per hour and gusts to 70 miles per hour) kept storm surges on shore for five successive high tides during a three-day period with a maximum tidal elevation of 7.8 feet at the Sandy Hook gage. During these tides, waves reached heights of 20 to 30 feet doing tremendous damage to dunes and coastal properties. The erosive effect of the storm reportedly changed the face of the shoreline, eroding some beaches entirely away, while also carving new channels and inlets in Monmouth County. Many inland areas were inundated as well, with hundreds of homes damaged or destroyed.

Other notable nor'easter events include the following:

November 25, 1950. This nor'easter brought gale force winds and more than three inches of rainfall to the entire coastline of Monmouth County. A wind velocity of 70 miles per hour was recorded in the City of Long Branch. The gage at Sandy Hook recorded a maximum tidal elevation of 7.2 feet.

March 1984, October 1991, and January 1992. Nor'easters in March 1984, October 1991, and January 1992 all caused severe beach and dune erosion, widespread damage to oceanfront roads, promenades and boardwalks, as well as extensive flooding to coastal and riverine areas. These storm events coincided with astronomically high tides, which worsened the flooding, erosion and associated damages.

December 1992. The nor'easter of December 1992 was the harshest New Jersey storm since 1962, in terms of both damage and weather conditions. The storm caused extreme coastal flooding and extensive beach erosion. Tide heights ranged from a little over 9 feet above mean low water along the ocean front, to an estimated 10 feet above mean low water on some back bays, which is four to five feet above normal. The storm resulted in destruction of public property including debris-ridden roadways, beach erosion, collapsed public facilities, boardwalks and damage to storm drainage facilities. Private properties were also pummeled by the storm; some of these properties were rendered uninhabitable.

March 12-13, 1993. According to the National Weather Service, this "Storm of the Century" was an extremely intense nor'easter which impacted New Jersey with a wide variety of hazardous weather. It was one of the most powerful storms (tropical or extratropical) on record to hit New Jersey, having a record low minimum central pressure of 961 millibars at almost the same time as it passed over New Jersey. Accumulations ranged from three to six inches on the southeastern sections, six to 14 inches in east central and southwestern sections, 10 to 18 inches in west central and northeastern sections, and 15 to 26 inches in northwestern sections. Winds were sustained at 30 to 45 mph, with gusts to 75 mph (hurricane force) measured in Cape May. Moderate coastal flooding occurred the morning of the 13th as a result of the high winds, tides and pounding surf, with waves of six to eight feet above high tide levels. Tide levels reached seven to 7.5 feet above mean low water in the back bays.

February 4, 1998. The strongest nor'easter of the winter season battered coastal New Jersey. Monmouth County was spared by the eastward movement of the nor'easter off of Cape Hatteras, experiencing moderate to severe beach erosion due to the continuous onshore flow. Two to four feet of beach were lost in most areas. At Sandy Hook, tides measured 3.2 feet above normal and about 80 percent of the new sand placed in a replenishment project was lost as several hundred feet of beach disappeared. Both Bradley Beach and Ocean Grove were hard hit by erosion. The waves washed sand onto Ocean Avenue in Bradley Beach. State Route 36 was flooded in Sea Bright. In Middletown, Raritan Bay tidal flooding closed roads.

February 24, 1998. Another strong nor'easter brought very strong winds and coastal flooding to the New Jersey Shore. But, unlike the previous nor'easter, the worst conditions affected Monmouth County. Tidal departures averaged around three feet above normal. A breach in the sea wall occurred in Allenhurst. Flooding forced the closure of New Jersey State Routes 35 and 36 in Keyport, Ocean Avenue in Sea Bright and the entrance road to Sandy Hook, as well as several roads along the bay side of Sea Bright. Wind gusts reached as strong as 61 mph in Ocean Grove.

October 16, 2002. A strong nor'easter caused tidal flooding along the New Jersey coast and in the back bays, gusty winds and beach erosion. Tides, winds and erosion were worse in Ocean and Monmouth counties than farther south. Two downed trees damaged a home in Wall Township. Peak wind gusts included 49 mph winds in Keansburg and 47 mph winds at Sandy Hook. Streets were knee deep in water in Sea Bright. Water spilled over the docks along the Shark River and also in Manasquan. Several roads were flooded in Manasquan, and the Glimmer Glass Bridge was left in the open position. Tides reached seven feet above mean low water at Sandy Hook and six feet above average tide levels in Sea Bright.

December 5-6, 2003. A nor'easter dropped heavy snow across much of New Jersey. Many municipalities declared snow emergencies to help clear the roads for plowing. A man died in Millstone Township after his vehicle left the westbound lanes of Interstate 195 and struck a tree. Specific snow accumulations included 15 inches in Clarksburg, 12.8 inches in Cream Ridge, and 11.5 inches in Oakhurst.

March 15-17, 2007. Strong to high winds along coastal areas with heavy rain and snowfall and minor tidal flooding occurred as a result of the nor'easter. Precipitation started as rain on the evening of the 15th and changed over quickly to snow. Storm totals averaged 1.5 to 3.0 inches across southeast New Jersey, 2 to 6 inches across much of central New Jersey (including Monmouth County) and 6 to 12 inches across northwestern New Jersey. High winds caused a few scattered power outages. Heavy rains that preceded the snow resulted in minor flooding. Minor tidal flooding occurred with the evening high tide on the 16th including 6.89 feet above mean lower low water at Sandy Hook. Motor vehicle accidents were widespread. Two people were injured after their vehicle struck a pole on State Route 36 in Middletown. In Highlands, on the same route, five people were injured in a three-vehicle accident.

April 15-16, 2007. Statewide damage was estimated at $180 million dollars. NOAA NCEI damage records indicate $1 million dollars of damages in Monmouth County associated with this system. At the time, it was the second worst rainstorm (not related to a hurricane) in the State's history. Widespread minor tidal flooding with pockets of moderate tidal flooding occurred along Delaware Bay, Raritan Bay and the Atlantic Ocean. It also caused beach erosion. The worst reported tidal flooding occurred in Monmouth County where tidal flooding occurred for up to three high tide cycles. The combination of the run-off from the heavy rain and the tides caused many roads to flood including State Roads 35 and 36. Areas affected by tidal and roadway flooding included Aberdeen, Belford, Belmar, Hazlet, Manasquan, Middletown, Port Monmouth, Sea Bright and Union Beach. In an effort to reduce tidal flooding, water was pumped from Lake Como in Belmar. On the beaches themselves, vertical cuts to the beaches averaged 2 to 4 feet but reached as high as 6 feet in Sea Bright, Deal and Asbury Park. Cuts to the dune systems themselves occurred in Deal, Long Branch, Monmouth Beach and Sea Bright. The horizontal dune cut in Sea Bright reached 1500 feet. The highest tides included 8.13 feet above mean lower low water at Sandy Hook (Monmouth County) on the morning of April 16. Minor tidal flooding starts at 6.7 feet above mean lower low water and moderate tidal flooding starts at 7.7 feet above mean lower low water. The heavy rain also closed roadways inland in Monmouth County in Brielle, Howell, Manasquan and Middletown. In Wall Township, the Allenwood-Lakewood Bridge was closed. Precipitation totals included 3.64 inches in Keansburg, 3.00 inches in Oceanport, 2.45 inches in Sea Girt, 2.38 inches in Manasquan, and 2.32 at Belmar Airport. The combination of the heavy rain, some snow and winds knocked down numerous trees and power lines. Peak wind gusts averaged between 40 and 60 mph.

October 15-19, 2009. A pair of nor'easters caused minor to moderate tidal flooding along the ocean from the evening high tide of October 15 into the morning high tide of October 19. Heavy surf contributed to and exacerbated erosion along the coast. Several major roadways were flooded and closed. In Monmouth County, roadways were closed in Monmouth Beach, Sea Bright and Manasquan. Peak wind gusts reached around 45 mph from Monmouth County southward. A few trees were knocked down in Monmouth County.

November 12-14, 2009. A powerful nor'easter produced wind gusts to nearly 60 mph, widespread moderate tidal flooding, heavy rain and severe beach erosion along the New Jersey coast. By several measures this was one of the worst nor'easters to affect New Jersey since 1990. The Dolan Davis Nor'easter power ranking for Long Island Buoy 44025 ranked it fourth strongest nor'easter to affect New Jersey since 1990, and the strongest since March of 1994. The Miller Storm Erosion

Index and the Kraus and Wise Maximum Wave Run-up Index were both ranked second only to December 1992 nor'easter. The highest winds occurred from the afternoon of November 12 into the afternoon of November 13. Several thousand people lost power. The heaviest rain fell on November 12. The highest tides in Monmouth County occurred with the morning high tide on November 14. Those were the highest tides in central and southern New Jersey since either 1998 or 1996. Tidal departures reached up to four feet. Governor Jon Corzine declared a state of emergency in Atlantic, Burlington, Cape May, Cumberland, Ocean and Monmouth counties on November 15. More than $500,000 in damages was reported by NOAA in Monmouth County.

March 7, 2013. An intense nor'easter brought strong to high winds across most of central and southern New Jersey on March 7 as well as minor to moderate tidal flooding along Raritan Bay, lower Delaware Bay and on the ocean side. The coastal flooding caused new breaches in Mantoloking, flooded roadways and prompted some voluntary evacuations in Monmouth and Ocean Counties. At least minor tidal flooding persisted into the morning high tide cycle on March 10. This was the greatest and most persistent tidal flooding to affect the New Jersey coast since Superstorm Sandy. In Monmouth County, voluntary evacuations were requested in Brielle and Manasquan. Along Raritan Bay, New Jersey State Route 35 was closed in Aberdeen. In Union Beach, Florence Avenue and Front Street (near the Flat Creek) were closed. Along the ocean side, New Jersey State Route 36 (Ocean Avenue) was closed from Sea Bright through Highlands. In Sea Bright, flood waters reached homes and in the downtown area, vehicles and buildings were surrounded by flood waters. Flooding also occurred along New Jersey State Route 36 in Long Branch. Other road closures occurred in Manasquan, Monmouth Beach and Sea Girt. Northeast winds intensified on the morning of March 6 and reached their peak during the afternoon and early evening. As winds slowly backed to the north during the evening, wind speeds diminished. In Monmouth County, the chafing by high tension wires (caused by the wind) led to a fire at a condiment factory in Sea Bright. Peak wind gusts included 61 mph in Sea Girt, 57 mph in Belmar, 51 mph in Eatontown, and 49 mph in Cream Ridge. Although there were no injuries and no fatalities, the storm caused $85,000 in property damage.

December 9, 2014. A strong nor'easter caused strong winds as well as minor to moderate tidal flooding in Upper Delaware Bay and around Raritan Bay and moderate tidal flooding in Lower Delaware Bay and Atlantic Coastal New Jersey on December 9. The nor'easter also caused minor to moderate beach erosion. Peak wind gusts averaged 45 to 55 mph along coastal New Jersey and knocked down weak trees, tree limbs and power lines. Tidal flooding affected all of the coastal counties in New Jersey. In Monmouth County, in Sea Bright, two women were rescued from flooded waters in two separate incidents on Ocean Avenue. They both attempted to drive through flood waters. Flooding was also reported along Raritan Bay. Along the tidal Watson Creek at Manasquan, minor flooding occurred on December 8 and moderate flooding occurred on December 9. Sea Bright and Belmar experienced at least minor tidal flooding. Peak wind gusts included 49 mph in Sea Girt, 47 mph in Monmouth Beach, and 46 mph in Sandy Hook. There were no injuries or fatalities.

January 23, 2016. A strong nor'easter that produced blizzard conditions along the eastern seaboard caused major to record flooding in parts of New Jersey and Delaware during the morning high tide on Saturday, January 23. The Atlantic coast and the Raritan Bay shore experienced flooding during this event. Other waterways that experienced flooding during each of the three high tide cycles beginning the morning of January 23 include the Shrewsbury River at Sea Bright, the Shark River at Belmar, and the Watson Creek at Manasquan. In Sea Bright, large chunks of snow and ice floated down Ocean Avenue during the evening high tide on January 23. Highway 36 was shut down in Sea Bright until the flood waters receded. In Manasquan, which issued a voluntary evacuation order Friday, January 22, firefighters with the borough's high-water rescue team spent the evening wading through icy waters to perform welfare checks on flooded residents. In Belmar, residents had power knocked out after a sailboat got tangled in power lines. There were no injuries or fatalities.

January 4, 2018. An area of low pressure tracked up the east coast interacting with a cold front which led to rapid development of a winter storm across the State. Blizzard conditions occurred along many coastal locations. Top wind gusts were generally around 40 mph across the State and southern and coastal New Jersey dealt with over six inches of snow.

Totals were only a few inches further northwest. A state of emergency was declared during the height of the storm. Several hundred vehicles were stranded, and hundreds of thousands were without power at some point.

March 1-3, 2018. At the Jersey Shore, the storm caused minor flooding and road closures during the high tide on the morning of March 2. Two local roads in Absecon were closed from flooding and there was flooding on U.S. Route 40 leading into Atlantic City. Flooding also caused lane closures along portions of Route 35 in Brick and Belmar while floodwaters covered roads in Neptune and Highlands. Some flights were cancelled at Newark Liberty International Airport. Atlantic City Electric reported 29,111 customers without power and PSE&G reported tens of thousands of customers without power. New Jersey Transit cancelled some service.

March 7, 2018. Two to three feet of snow fell from New Jersey to New England. At least one person died from the storm. This was the second of three nor'easters to hit the east coast in a two-week span. The third nor'easter on 3/13 did not significantly impact New Jersey

March 20-22, 2018. A complex area of low pressure over the middle Atlantic, which involved several individual centers, slowly consolidated off the Virginia Capes. As this precipitation moved northward into a colder air mass, snow and sleet developed across southern New Jersey. Snowfall amounts varied from less than 3 inches in portions of northern Sussex County and Cape May County, with a general 6 to 12 inches elsewhere, with the exception of portions of Monmouth, Ocean, and Burlington Counties, where some areas received 12 to 15 inches.

March 2-4, 2019. An offshore low-pressure system brought a period of heavy precipitation to the mid-Atlantic. A mix of rain, sleet, and snow was observed, with snow confined mainly to interior areas and sleet and rain more abundant near the coast. Snowfall totals inland approached 10 inches, with snowfall rates exceeding one inch per hour for several hours. A sharp gradient in snowfall with a steep drop in snow totals was observed just west of the Interstate 95 corridor.

December 16-17, 2020. Low pressure developed along the Middle Atlantic coast on Wednesday December 16, 2020. Arctic high pressure situated over southeast Canada provided a cold and dry air mass ahead of the low supporting moderate to locally heavy snowfall throughout much of the storm. The storm significantly impacted travel during the evening commute on Wednesday December 16, 2020, and the morning commute on Thursday December 17, 2020. Many accidents resulted from the snow-covered roads and poor visibilities. Snowfall rates ranged from 1 to 2 inches per hour Wednesday evening. Total snowfall ranged from around 6 to 12 inches with strong wind gusts ranging from 35 to 50 mph.

January 31- February 3, 2021. Low pressure developed over the Ohio Valley and Middle Atlantic on Sunday, January 31, 2021, before intensifying and slowly tracking to the north-northeast. The low brought a major winter storm to northeast New Jersey, with the most significant impacts occurring on Monday, February 1, 2021. Three to six inches of snow had already accumulated by the start of the morning commute. Near blizzard conditions then occurred through the rest of the morning into the early afternoon with snowfall rates of 1 to 3 inches per hour. Snowfall totals ranged 15 to 20 inches of snow with some locations receiving around two feet. Winds gusted 40 to 55 mph at times, which caused power outages. Travel was also severely impacted as many flights were cancelled and travel by train was suspended. COVID testing and vaccination sites were close

January 3, 2022. A strengthening area of low pressure developed over the Southeast US late on January 2 and moved northeast, tracking offshore of the mid-Atlantic in a typical nor'easter setup. A widespread 6 to 12 inches of snow with locally higher amounts fell across the Eastern Shore of Maryland, most of Delaware, and several counties of southern New Jersey. The storm was notable for having a very sharp cutoff in the northern extent of accumulating snow. The passage of a strong cold front brought rapid cooling in the hours leading up to the storm, and very heavy snowfall rates, at times well more than 1 inch per hour, overwhelmed any lingering warm ground from previous days of higher temperatures and caused accumulation to occur.

January 28, 2022. A nor'easter tracked just east of the benchmark bringing snow and gusty winds. Strong winds also occurred, with gusts of 40 to 50 mph and a few over 60 mph observed. The combination of strong winds and heavy snow led to whiteout conditions along the coast and was sufficient for blizzard criteria to be met along both the New Jersey coast and the Delaware Beaches, making this the first blizzard to affect any portion of the region since 2018.

Probability of Future Occurrence

Nor'easters will continue to have a high probability of occurrence for Monmouth County, and the probability of future occurrences affecting all of Monmouth County's jurisdictions is certain.

Potential Effects of Climate Change

The frequency and intensity of coastal storms including nor'easters is expected to increase in the future due to climate change. In the years to come, it is anticipated that Monmouth County will observe drastic changes in storm character, intensity, frequency, and storm tracking. these storms are likely to become more intense with rising sea water temperatures.

The following types of impacts can be anticipated in Monmouth County's future as a result of climate change and sea level rise: inundation of low-lying areas; increased frequency and extent of storm-related flooding; wetland loss; saltwater intrusion into estuaries and freshwater aquifers; land loss through submergence and erosion of lands in coastal areas; migration of coastal landforms and habitats; increased salinity in estuaries and coastal fresh; impacts to human populations (property losses, more frequent flood damage, more frequent flooding of roadways and urban centers, risks to people as the population of coastal areas increases); more buildings and infrastructure exposed; currently exposed buildings and infrastructure could be subject to potentially greater losses as water levels increase, and continued rapid coastal development exacerbates the impacts of sea level rise; impacts on gravity flow stormwater systems; impacts on non-coastal areas.

Impacts of climate change and sea level rise can affect all parts of a community, including: transportation infrastructure (ports, marinas, airports, roads, bridges, railways); public infrastructure (stormwater and wastewater management systems, drinking water supply and distribution systems, power utility systems, communications systems); public facilities (i.e., police, fire, ambulance, hospitals, schools, daycare centers, adult living facilities, historic landmarks, government buildings, libraries, parks, etc.); and economic viability of a community - particularly for communities where tourism tends to drive local economies, as is the case in many of Monmouth County's coastal communities. Climate change and sea level rise could lead to a potential loss of assets that support tourism (i.e., beaches themselves as well as beach access points, lodging, restaurants, marinas, fishing habitats, ecotourism, etc.).

Vulnerability Assessment

Built Environment, Infrastructure, and Community Lifelines

All property types are impacted, with residential and commercial impacts being greatest due to their proximity to the coast. Roads, bridges, schools, hospitals and other types of community lifelines and critical facilities are susceptible to wind and water damage. Secondary impacts would be associated with flying debris, as well as drifting sand from storm surges. Sand covered roads and bridges would be common impacts. Beach erosion can be catastrophic depending on the particular area and the nature of the event. Transportation, communications, and governmental services may be severely impacted. Impacts would be exacerbated when coincident with high tides, or during prolonged types of events that extend across several tidal cycles.

It is possible for the entire County to be impacted by nor'easters, though in different ways. For example, wind impacts may be widespread but more severe in immediate coastal areas. Structures close to the Atlantic Coast could suffer catastrophic damages from wind, surge, waves and beach erosion while impacts to inland structures would be less substantial due to lower wind speeds and absence of surge impacts. Riverine flooding would be limited to riverine flood zones and being of slower velocities in most cases would cause less severe types of structure damages than in coastal areas but could be more widespread geographically. Roads and bridges across the County would be susceptible to overtopping and damage from floodwaters.

Similar to hurricanes and tropical storms, nor'easters are complex combinations of discrete component hazards occurring simultaneously. Damages during these events result from the cumulative impacts of component hazards such as flooding, storm surge, coastal erosion, wave action, and high winds. No two nor'easters are identical. Even storms of the same magnitude and intensity can bring with them wildly different impacts depending on whether they occur during a time of high tide or low tide; and, since it is not uncommon for nor'easters to stall off the coast, damages are often affected by the number of tidal cycles during which they occur. Variations in inland wind affects and precipitation amounts can also vary widely. Thus, it is difficult to estimate total potential losses from these cumulative effects in a manner that would allow for the calculation of a meaningful average annual loss estimate for nor'easters. Estimated losses would likely be similar to those experienced during a hurricane or tropical storm. For further information on estimated damages as a result of hurricane and tropical storm hazard, see **Table 4.11-4 Estimated Potential Losses from 50-, 100-, 200-, 500-, and 1000-year Hurricane Wind Events**.

Population and Economy

Monmouth County's shore is vital to the local economy but remains highly susceptible to the effects of major coastal storms, including nor'easters. Monmouth County is a tourist destination. With summer being the peak vacation time - opposite the time of the typical nor'easter occurrences in winter, tourists are not generally impacted. Impacts to the general public include evacuation and sheltering needs, as well as emergency response for those who shelter in place or are injured during the event. Groups which are particularly vulnerable include children, the elderly, and other socially vulnerable populations.

Ecosystems and Natural Assets

Beach erosion can often be severe during nor'easters; though beach restoration and maintenance activities are undertaken regularly to offset storm impacts. As noted earlier, the Long Branch - Manasquan Project, between Sandy Hook and Manasquan Inlet, is one of the largest beach construction projects completed in the US with over 25 million cubic yards of sand placed on 25 miles of beaches.

4.15 STORM SURGE

Hazard Description

A storm surge is a large dome of water often 50 to 100 miles wide and rising anywhere from four to five feet in a Category 1 hurricane up to more than 30 feet in a Category 5 storm. Storm surge heights and associated waves are also dependent upon the shape of the offshore continental shelf (narrow or wide) and the depth of the ocean bottom (bathymetry). A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water close to the shoreline, tends to produce a lower surge but higher and more powerful storm waves. Storm surge arrives ahead of a storm's actual landfall and the more intense the hurricane is, the sooner the surge arrives. Storm surge can be devastating to coastal regions, causing severe beach erosion and property damage along the immediate coast. Further, water rise caused by storm surge can be very rapid, posing a serious threat to those who have not yet evacuated flood-prone areas. Storm surge can be exacerbated if occurring at or near high tide.

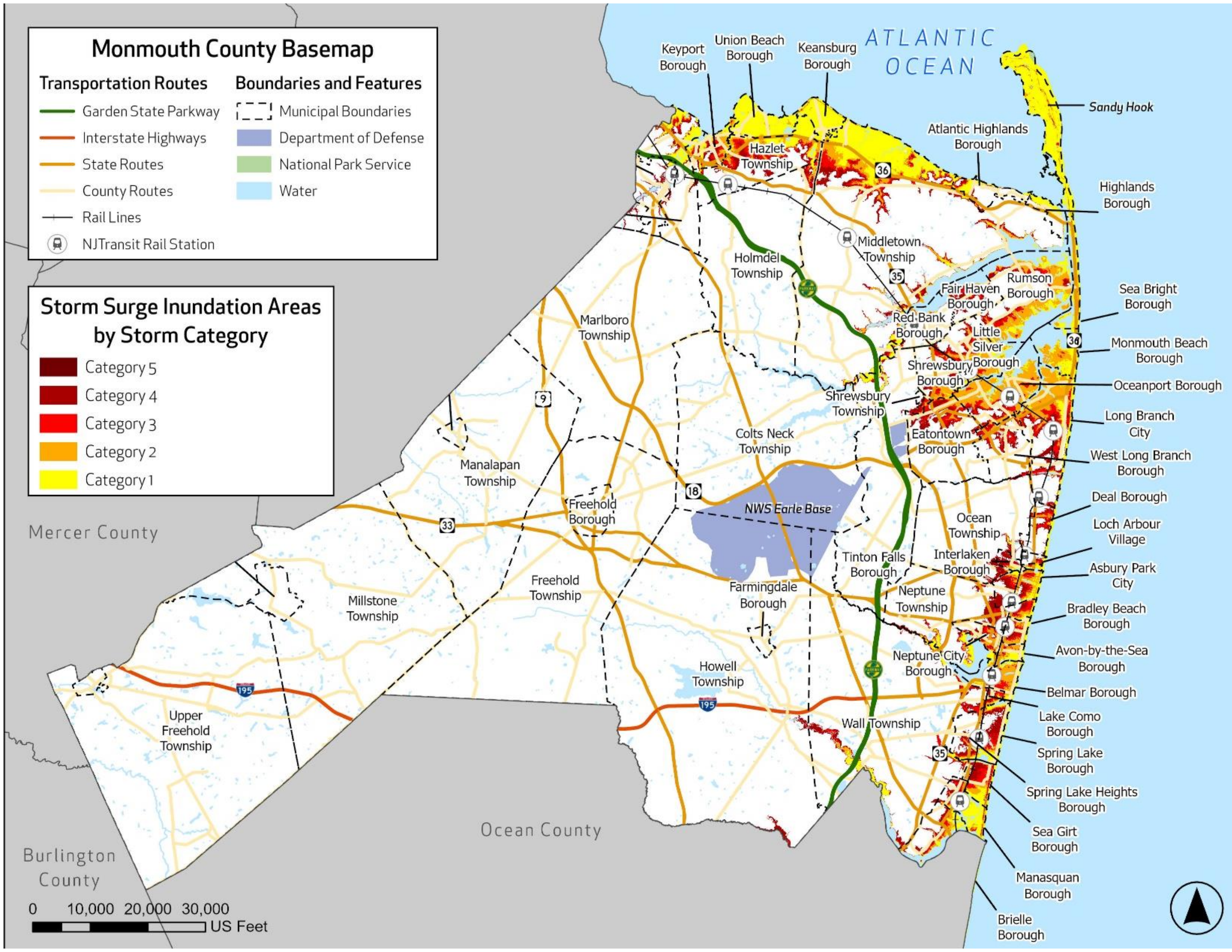
Location

There are many areas in Monmouth County subject to potential storm surge inundation. **Figure 4.15 – 1 Hurricane Storm Surge Inundation Zones in Monmouth County** illustrates inundation zones storm surges associated with hurricanes of Category 1 to 4 for Monmouth County derived from georeferenced Sea, Lake and Overland Surge from Hurricanes (SLOSH) data produced by NOAA's National Weather Service[4]. SLOSH is a modeling tool used to estimate storm surge for coastal areas resulting from historical, hypothetical or predicted hurricanes taking into account maximum expected levels for pressure, size, forward speed, track and winds. Therefore, the SLOSH data is best used for defining the potential maximum surge associated with various storm intensities for any particular location. Storm surge arrives prior to a hurricane's landfall, and the greater the hurricane's intensity, the sooner the surge arrives. In 2016, Monmouth County used the SLOSH models to create their own awareness program, Know Your Zone. This educational campaign informs residents, businesses, and visitors of the County of the new hurricane evacuation zones and their vulnerability to storm surge, especially in those high-risk communities.

As shown in the **Figure 4.15-1**, all of the County's coastal jurisdictions are at high risk to storm surge inundation. While non-coastal areas may not be directly impacted by storm surge inundation, they might experience flooding caused by storm surge and extremely high tides that can affect the drainage of areas further inland. In total, 41 (77 percent) of municipal jurisdictions have been identified as being at risk to the storm surge hazard in Monmouth County.

[4] *THIS DATA REPRESENTS A POLYGON FEATURE SET IN MONMOUTH COUNTY SHOWING THE LIMITS OF POTENTIAL FLOODING FROM CATEGORY 1-4 HURRICANES. THE DATA WAS COMPILED BY THE U.S. ARMY CORPS OF ENGINEERS AS PART OF A HURRICANE EVACUATION STUDY (HES) IN 2005-2006 (HTTP://WWW.NAP.USACE.ARMY.MIL/HES/NJ/INDEX.HTML). THE USACE GATHERED 2003 CONTOUR LINES DATA FROM MONMOUTH COUNTY AS PART OF ITS CALCULATIONS IN USING THE NATIONAL WEATHER SERVICE- NATIONAL HURRICANE CENTER'S SLOSH MODEL (SEA, LAKE AND OVERLAND SURGES FROM HURRICANES)*

Figure 4.15-1 Hurricane Storm Surge Inundation Zones in Monmouth County



Source: NOAA, 2024

Extent

The magnitude or severity of the storm surge hazard is generally related to the associated winds resulting from coastal storms (i.e., hurricanes, tropical storms, nor'easters). NOAA's Coastal Inundation Dashboard is used to measure the extent of storm surge.

Previous Occurrences and Losses

Before Superstorm Sandy, there is very limited data available for historical weather events that have caused storm surge inundation in Monmouth County. According to NCEI records, Monmouth County experienced a storm surge event in February 2006 that accounted for an estimated $900,000 in property damages, as described below. Storm surge has been a major factor associated with other weather events affecting Monmouth County, particularly nor'easters.

February 12, 2006. The winter storm that affected New Jersey had a major impact on the New Jersey shore. Strong onshore winds along with high tides produced coastal flooding along with beach erosion. Across coastal Monmouth County, minor to locally moderate coastal flooding was reported across many areas. In the Monmouth Beach area, a storm surge flooded the Patten Avenue Bridge along with some other streets during the early morning, where some cars were overtaken by water.

Hurricane Irene 2011 and **Superstorm Sandy 2012.** Storm surge associated with Hurricanes Irene and Sandy was extensive and devastating for most coastal and Bayshore communities. This is discussed in detail in the section on Hurricanes and Tropical Storms.

Probability of Future Occurrence

The probability of a named storm making landfall in the vicinity of Monmouth County is 13 percent but is less for events that cause significant storm surge (dependent on storm speed, direction, tides, etc.). However, less severe to moderate storm surge events typically associated with nor'easters and less intense coastal storms are more likely to occur, and in the case of nor'easters will last longer and possibly cause more damage than fast-moving hurricanes. Additionally, the long-term rise in sea level can be expected to impact the occurrence of significant storm surges and hence future damages from coastal flooding in Monmouth County. Rising sea levels over time will shorten the return period (or exceedance interval) and hence increase the frequency of significant storm surge events. To take a hypothetical example, a one-foot rise in sea level over 50 years could result in a storm surge event with a current annual occurrence probability of 2% (a "50-year" event) becoming an event of 10% annual probability (a "10-year" event).

Potential Effects of Climate Change

The frequency and intensity of coastal storms and severe weather events is expected to increase in the future due to climate change. In the years to come, it is anticipated that Monmouth County will observe drastic changes in storm character, intensity, frequency, and storm tracking. Hurricanes are likely to become more intense with rising sea water temperatures. Coastal erosion rates are likely to increase with rising sea-level to levels higher than those rates that have been observed over the last century. Storm effects will be more extensive in the future.

The following types of impacts can be anticipated in Monmouth County's future as a result of climate change and sea level rise: inundation of low-lying areas; increased frequency and extent of storm-related flooding; wetland loss; saltwater intrusion into estuaries and freshwater aquifers; land loss through submergence and erosion of lands in coastal areas; migration of coastal landforms and habitats; increased salinity in estuaries and coastal fresh; impacts to human populations (property losses, more frequent flood damage, more frequent flooding of roadways and urban centers, risks to people as the population of coastal areas increases); more buildings and infrastructure exposed; currently exposed buildings and infrastructure could be subject to potentially greater losses as water levels increase, and continued rapid coastal development exacerbates the impacts of sea level rise; impacts on gravity flow stormwater systems; impacts on non-coastal areas.

Impacts of climate change and sea level rise can affect all parts of a community, including: transportation infrastructure (ports, marinas, airports, roads, bridges, railways); public infrastructure (stormwater and wastewater management systems, drinking water supply and distribution systems, power utility systems, communications systems); public facilities (i.e., police, fire, ambulance, hospitals, schools, daycare centers, adult living facilities, historic landmarks, government buildings, libraries, parks, etc.); economic viability of a community - particularly for communities where tourism tends to drive local economies, as is the case in many of Monmouth County's coastal communities. Climate change and sea level rise could lead to a potential loss of assets that support tourism (i.e., beaches themselves as well beach access points, lodging, restaurants, marinas, fishing habitats, ecotourism, etc.).

Vulnerability Assessment

Built Environment, Infrastructure, and Critical Facilities

To analyze potential losses from storm surge, FEMA's NRI was used. The NRI contains a category for coastal flood which it defines as inundation of normally dry coastal land as a result of high or rising tides or storm surges. **Table 4.15-1** below displays the EAL for coastal flood by jurisdiction. EAL is calculated using a multiplicative equation that includes exposure, annualized frequency, and historic loss ratio risk factors Total losses includes building losses as well as population equivalency losses (the monetized cost of injury and fatality) and agricultural losses.

Table 4.15-1 Annualized Losses for Coastal Flood Hazard by Jurisdiction

Jurisdiction	Expected Annualized Losses - Buildings	Expected Annualized Losses - Total
Aberdeen, Township of	$1,081,119.50	$1,195,891.90
Allenhurst, Borough of	$18,845.05	$19,660.23
Allentown, Borough of	$0.00	$0.00
Asbury Park, City of	$22,334.25	$24,358.10
Atlantic Highlands, Borough of	$258,745.22	$278,753.80
Avon-By-The-Sea, Borough of	$339,098.32	$388,587.42
Belmar, Borough of	$316,318.73	$354,932.08
Bradley Beach, Borough of	$1,679.57	$1,827.76
Brielle, Borough of	$1,062,156.05	$1,184,032.07
Colts Neck, Township of	$14.08	$16.66
Deal, Borough of	$18,845.05	$19,660.23
Eatontown, Borough of	$66,520.02	$75,413.18
Englishtown, Borough of	$0.00	$0.00
Fair Haven, Borough of	$2,237.00	$2,541.83
Farmingdale, Borough of	$0.00	$0.00
Freehold, Borough of	$0.00	$0.00
Freehold, Township of	$0.00	$0.00
Hazlet, Township of	$1,386,866.70	$1,767,343.44
Highlands, Borough of	$4,549,620.70	$5,542,828.38
Holmdel, Township of	$2,535.99	$3,124.93
Howell, Township of	$2,174.09	$2,521.52
Interlaken, Borough of	$18,845.05	$19,660.23

Jurisdiction	Expected Annualized Losses - Buildings	Expected Annualized Losses - Total
Keansburg, Borough of	$1,777,218.56	$2,414,277.13
Keyport, Borough of	$165,750.79	$213,584.50
Lake Como, Borough of	$901.44	$1,066.01
Little Silver, Borough of	$1,421,805.04	$1,524,314.37
Loch Arbour, Village of	$18,845.05	$19,660.23
Long Branch, City of	$1,381,499.88	$1,638,944.23
Manalapan, Township of	$0.00	$0.00
Manasquan, Borough of	$12,514,082.78	$13,498,111.13
Marlboro, Township of	$37.28	$42.94
Matawan, Borough of	$4,338.92	$5,092.71
Middletown, Township of	$5,359,029.67	$6,621,800.43
Millstone, Township of	$0.00	$0.00
Monmouth Beach, Borough of	$3,961,155.33	$4,497,736.79
Neptune City, Borough of	$95,007.53	$114,013.24
Neptune, Township of	$1,090,898.61	$1,225,710.04
Ocean, Township of	$16,035.17	$18,200.62
Oceanport, Borough of	$1,828,746.73	$2,079,998.68
Red Bank, Borough of	$12,502.09	$14,862.95
Roosevelt, Borough of	$0.00	$0.00
Rumson, Borough of	$3,887,527.41	$4,302,973.60
Sea Bright, Borough of	$5,292,786.30	$6,005,205.25
Sea Girt, Borough of	$275,768.30	$276,729.97
Shrewsbury, Borough of	$103,082.12	$113,779.67
Shrewsbury, Township of	$51,541.06	$56,889.84
Spring Lake, Borough of	$30,179.14	$32,452.76
Spring Lake Heights, Borough of	$13,596.27	$16,932.26
Tinton Falls, Borough of	$3,835.34	$4,173.39
Union Beach, Borough of	$3,803,859.26	$4,559,756.50
Upper Freehold, Township of	$0.00	$0.00
Wall, Township of	$478,502.67	$521,275.42
West Long Branch, Borough of	$29,073.18	$30,024.14
Monmouth County	**$52,765,561.28**	**$60,688,762.58**

Source: FEMA NRI

Population and Economy

Monmouth County is a tourist destination. With summer being the peak vacation time, coincident with hurricane season, the potential population at risk is at its peak during the time of year when Monmouth County is most likely to be impacted by storm surge from a hurricane or tropical storm. Impacts to the general public include evacuation and sheltering needs, as well as emergency response for those who shelter in place or are injured during the event.

Natural Systems and Ecosystems

Storm surge can destroy beaches and dunes, transporting sand inland and burying vegetation. It can also negatively disrupt coastal habitats, especially estuaries and wetlands which perform vital ecosystem functions.

Potential for Future Development to Impact Hazard Vulnerability

Coastal development increases the population and infrastructure along coastlines often increases the exposure of people and assets to storm surge impacts. Additionally certain coastal development activities, like clearing wetlands or development with impacts to dunes eliminate natural buffer areas that reduce storm surge intensity.

Jurisdictions with a potential for future development to substantially increase storm surge hazard vulnerability under existing conditions should: (a) include storm surge mitigation measures in their mitigation strategies; and/or (b) select jurisdictional plan integration initiatives for the next plan maintenance phase that can potentially reduce risk for future development.

4.16 TORNADO

Hazard Description

A tornado is a violently rotating column of air that has contact with the ground and is often visible as a funnel cloud. It rotates cyclonically creating a vortex with wind speeds ranging from as low as 40 mph to as high as 300 mph. Tornadoes are most often generated by thunderstorm activity when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The destruction caused by tornadoes ranges from light to catastrophic depending on the intensity, size and duration of the storm.

Location and Extent

Monmouth County is susceptible to tornados, though their occurrence is not nearly as frequent or intense as it is in other regions of the country. Of the roughly five tornadoes that touch down in New Jersey each year, most tend to be of low magnitude (from EF0 to EF2) and typically impact relatively small areas. Tornadoes are completely random, and it is not possible to predict specific tornado hazard areas. Tornadoes can occur anywhere, and no one location is more susceptible than another. All of Monmouth County is uniformly exposed.

Range of Magnitude

Table 4.16 - 1 Enhanced Fujita Scale for Tornados shows the Enhanced Fujita Scale for Tornadoes which was developed to measure tornado strength and associated damages.

Table 4.16-1 Enhanced Fujita Scale for Tornados

Storm Category	Damage Level	3 Second Gust (mph)	Description of Damages
EF0	LIGHT	65-85	Some damage to chimneys; branches broken off trees; shallow- rooted trees pushed over; sign boards damaged.
EF1	MODERATE	86-110	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
EF2	SIGNIFICANT	111-135	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; high-rise windows broken and blown in; light-object missiles generated.
EF3	SEVERE	136-165	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
EF4	DEVASTATING	166-200	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown, and large missiles generated.
EF5	INCREDIBLE	200+	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 m (109 yd); trees debarked; steel reinforced concrete structures badly damaged.

Source: National Oceanic and Atmospheric Administration; Federal Emergency Management Agency

The tornadoes associated with tropical cyclones are most frequent in September and October when the incidence of tropical storm systems is greatest. This type of tornado usually occurs around the perimeter of the storm, and most often to the right and ahead of the storm path or the storm center as it comes ashore. These tornadoes commonly occur as part of large outbreaks and generally move in an easterly direction.

Previous Occurrences and Losses

According to NCEI, there have been 17 recorded tornado events in Monmouth County between 1950 and April 2023. Two tornadoes have occurred since the last version of the plan was prepared. Most of these events were determined to be of minimal tornado intensity, as shown in **Table 4.16-2 Historical Tornadoes in Monmouth County**. Since 1950 no recorded tornadoes in Monmouth County have resulted in deaths or injuries, but they did cause an estimated $1.525 million in property damages, with the most severe event being an F2 tornado that touched down in northern Manalapan Township and extreme southwest Marlboro Township in May 2001 that caused an estimated $1M in damages.

Table 4.16-2 Historical Tornadoes in Monmouth County Since 1950

Date	Location	Magnitude	Details	Damages
8/10/1952	Millstone Township	F1	-	$25,000
10/16/1955	Tinton Falls Borough	F2	-	-
4/18/1960	Upper Freehold Township	F1	-	$250
3/10/1964	Howell Township	F1	-	$250,000
3/26/1964	Neptune Township	F0	-	$25,000
11/1/1994	Loch Arbour Village	F0	A tornado briefly touched down in the Village of Loch Arbour around 6 p.m. at the intersection of Euclid and Edgemont Avenues. The tornado lifted between Spier and Corlies Avenue about 100 yards from the Atlantic Ocean. About five homes on Euclid Avenue suffered substantial roof damage. Most of the eight other homes which sustained minor damage were on Buena Vista Court. About two dozen trees were uprooted. Most of them were decaying within. Tops were sheared off a number of other trees. Damage was estimated by the NCEI at $75,000; however, the Village indicated that damages were closer to $200,000 for this event.	$75,000
8/13/1997	Middletown Township and Highlands Borough	F0	A F0 tornado touched down briefly in Middletown Township and Highlands Borough before it went into Sandy Hook Bay and dissipated. The path length was about 1.2 miles and the path width about 75 yards. The tornado damaged several cars and homes, and uprooted and/or snapped numerous trees, but no injuries were reported. The tornado touched down in northeastern Middletown Township near Pape Drive and Navesink Avenue, moving northeast where it uprooted a tree on Williams Street that crushed three parked cars. Another car was burned when it came in contact with downed wires on Buttermilk Valley Road. A tree also crushed an awning in the Shadow Lane Mobile Home Park. In Highlands Borough, a shed was blown off its foundation and carried by the tornado between two houses. Other structural damage was mainly confined to broken windows, torn shingles and gutters. Maximum wind speeds were estimated at the high end of the F0 scale at about 70 mph.	$50,000
5/27/2001	Manalapan and Marlboro Township	F2	An F2 tornado struck extreme northern Manalapan and extreme southwest Marlboro Townships. The tornado's path length was estimated at 1.5 miles and its path width was around 200 feet. It was initially a relatively weak tornado (F0) but intensified into an F1 before it reached Kentucky Court in Manalapan Township. One property on Kentucky Court lost dozens of trees. The tornado also downed trees on Ivanhoe and Rowena Roads. The tornado reached its maximum strength (F2) as it passed through Debracy Court, where the worst damage occurred. Four houses were severely damaged, and about 12 others suffered minor damage. The tornado weakened to an F1 after it	$1,000,000

Date	Location	Magnitude	Details	Damages
			left Debracy Court. As the tornado crossed into Marlboro Township, it knocked down dozens of trees in Hawkins Road Park. As the tornado exited the park, it weakened to an F0. It still knocked a tree onto a house on MacLeisch Drive and ripped shingles and gutters from homes on Guest and MacLeisch Drives. The tornado lifted as it approached Barclay Brook	
8/9/2011	Millstone Township	EF0	An EF0 tornado touched down in Millstone Township in Monmouth County. The tornado initially touched down north of Buono Farm and tracked northeast where it crossed New Jersey State Route 33 and damaged a flagpole and business fencing. A barn was damaged on Prodelin Way. Numerous trees and some wires were knocked down along its path, especially on Prodelin and Arrowhead Ways and Bergen Mills Road. The tornado moved along Arrowhead Way before it lifted. The tornado's approximate path length was 1.7 miles, maximum path width of 50 yards and estimated maximum wind speed of 70 mph. No deaths or injuries were reported, though property damages were estimated at $100,000.	$100,000
6/24/2017	Howell Township	EF0	A band of gusty convective showers moved through during the morning hours in association with the remnants of tropical storm Cindy. Several reports of damage were reported from the winds. Thousands lost power. The tornado touched down near Ft. Plains Rd. in Howell for approximately two minutes, then briefly touched down again near Lower Squankum (Howell) a few minutes later (see below).	-
6/24/2017	Howell Township	EF0	A large pine tree near a soccer field in the park was snapped toward the base of the trunk and several large metal trash cans were pushed over, with all of these damage indicators facing to the southeast. On the other side of the soccer field, numerous hardwood trees were uprooted, falling to the northeast. There were additional downed trees in the park as the storm moved southeast before quickly dissipating.	-
08/19/2020	Middletown, Township of	EF0	A tornado touched down on a baseball field on the campus of Brookdale Community College in the Lincroft section of Middletown Township in Monmouth County, New Jersey. It tossed a set of metal bleachers adjacent to the field, then crossed over Phalanx Road into a residential area, with numerous trees sustaining damage. Tree damage mainly consisted of broken limbs and the snapping of some trees near their tops. At least one tree was also uprooted in this area. The tornado then entered another residential area near Swimming River Road and Normandy Road, producing a continued path of damaged trees. The tornado lifted as it entered the Riverdale West Park, where tree damage was no longer observed. The tornado did not appear to cause any direct structural damage, though a couple of homes sustained damage from falling tree debris.	-
05/20/2022	Hazlet, Township of	EF0	The tornado began on the border between Strathmore Township and Hazlet Township where several large limbs were blown off and a couple softwood tree trunks were snapped. The snapped tree trunks caused collateral damage to utility poles and power lines. The center of circulation continued east-northeast into a residential neighborhood where the most significant damage from the tornado occurred. At least a dozen homes in this area sustained cosmetic damage, including vinyl siding blown off, soffit damage, gutter damage, and/or roof shingles blown off. The only structural damage noted was due to a tree falling onto a home which caused some structural damage to its roof. A few larger softwood trees were uprooted in the residential area and several vinyl fence sections were blown over.	-
04/01/2023	Upper Freehold, Township of	EF1	A strong cold front approached the region, with a line of strong showers and thunderstorms developing out ahead of the front. Storms produced damaging winds, multiple tornadoes, and small to medium-	-

Date	Location	Magnitude	Details	Damages
			sized hail in New Jersey. In Monmouth County multiple tornadoes downed trees and damaged buildings consistent with wind speeds estimated to be 100-120 mph in some areas.	
04/01/2023	Upper Freehold, Township of	EF1	A new quasi-linear convective system (QLCS) tornado developed just west of a neighborhood on Walnford Road southeast of Allentown. The most significant damage from the tornado occurred to properties within the neighborhood, especially those along an open field to the southeast. The tornado was also near its widest point in this area. Numerous trees were uprooted or snapped within the neighborhood. A few homes sustained removal of roofing material, siding removal, windows blown out, and a couple garage doors blown out.	-
04/01/2023	Howell Township	EF1	A tornado formed along an eastward moving rotating supercell within a line of thunderstorms and made an initial touchdown on the north side of Palomino Drive. A 100-yard-wide path of dozens of large hardwood and softwood trees were snapped or uprooted and several houses having minor to moderate siding, gutter, awning, deck and roof shingle damage. The worst damage occurred to a house facing to the southwest on the southwest corner of Spicy Pond Road, whose whole roof was lifted and tossed into their backyard and immediate neighbor backyards	-
04/01/2023	Manasquan Borough	EF2	A tornado formed from an east southeast moving rotating supercell within a line of thunderstorms and made a brief touchdown on the National Guard Training Center Grounds in Sea Girt, NJ.	-
Total				**$1,525,250**

Source: NOAA-NCEI 2024

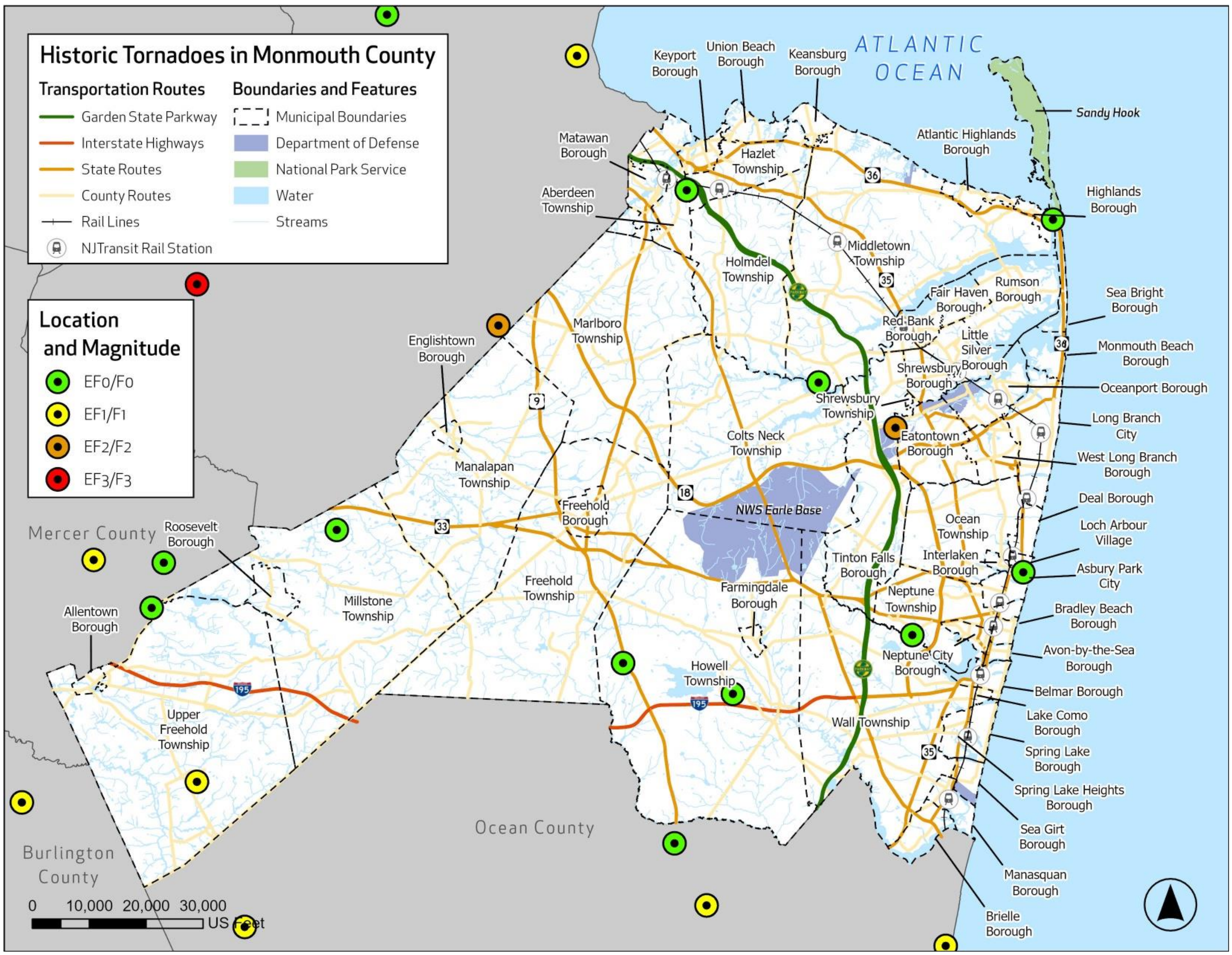
Table 4.16 - 3 Historical Tornadoes in Monmouth County (1950-November 2024) by Jurisdiction lists the number of tornado events in Monmouth County only for jurisdictions that experienced tornado activity. Estimated magnitude for each tornado is also listed. As tornado events might impact multiple jurisdictions, the total number of events in this table is greater than the number of records provided by NCEI based on detailed information regarding impacted areas. The specific location of reported touchdown occurrences for each of these events in or near Monmouth County (where known) is shown in **Figure 4.16-1 Historical Tornado Touchdown Locations.** Please note that all municipalities are not listed in the following table. Only municipalities that have experienced historical occurrences of tornadoes are listed, additionally some tornados affected multiple jurisdictions and thus a single event may appear twice in the table.

Table 4.16-3 Historical Tornadoes in Monmouth County (1950-October 2023) by Jurisdiction

Jurisdiction	Number of Events	Magnitude (Enhanced Fujita Scale)						Maximum F Scale
		EF0	EF1	EF2	EF3	EF4	EF5	
Hazlet, Township of	1	1	0	0	0	0	0	EF0
Highlands, Borough of	1	1	0	0	0	0	0	EF0
Howell, Township of	3	2	1	0	0	0	0	EF1
Jackson Township	1	0	0	1	0	0	0	EF2
Loch Arbour, Village of	1	1	0	0	0	0	0	EF0
Manalapan, Township of	1	0	0	1	0	0	0	EF2
Manasquan, Borough of	1	0	0	1	0	0	0	EF2
Marlboro, Township of	1	0	0	1	0	0	0	EF2
Middletown, Township of	2	2	0	0	0	0	0	EF0

Jurisdiction	Number of Events	Magnitude (Enhanced Fujita Scale)						Maximum F Scale
		EF0	EF1	EF2	EF3	EF4	EF5	
Millstone, Township of	2	1	1	0	0	0	0	EF1
Neptune, Township of	1	1	0	0	0	0	0	EF0
Tinton Falls, Borough of	1	0	0	1	0	0	0	EF2
Upper Freehold, Township of	3	0	2	0	0	0	0	EF1

Figure 4.16-1 Historical Tornado Touchdown Locations



Probability of Future Occurrence

It is likely that Monmouth County will continue to experience weak to moderate tornado events, though their frequency of occurrence will continue to be fairly low. Probability data made available through NOAA's National Severe Storms Laboratory (NSSL) indicate that Monmouth County is in an area that experiences less than one tornado event per year. Historical storm data made available through NCEI confirm this data (17 confirmed events in 63 years, resulting in an estimated annual probability of a tornado event of 27 percent). In New Jersey, tornadoes are more likely to occur during the months of March through August and tend to form in the late afternoon and early evening.

Potential Effects of Climate Change

NASA scientists suggest that the United States will face more severe thunderstorms in the future, with deadly lightning, damaging hail, and the potential for tornadoes in the event of climate change. A recent study conducted by NASA predicts that smaller storm events like thunderstorms will also be more dangerous due to climate change (NASA 2007).

Vulnerability Assessment

Tornados are nature's most violent storms. The most intense tornados can cause fatalities and catastrophic damage to both trees and the built environment in a matter of seconds. The number of deaths, injuries, and dollar amount of damages can fluctuate drastically depending on the severity of the tornado and the degree and type of development in the damage path.

Built Environment, Infrastructure and Community Lifelines

The destruction caused by tornadoes ranges from light to catastrophic depending on the intensity, size, and duration of the storm. These impacts tend to be felt in rather limited areas, due to the nature of the tornado hazard itself (tornados with limited widths and path lengths after touchdown). Property damage can be significant within the tornado's path. Typically, tornadoes cause the greatest damage to structures of light construction, including residential dwellings and particularly manufactured homes.

Emergency responders are called upon for search and rescue, to tend to the injured, assist in evacuations, and to close roads and direct traffic. Transportation, communications, and safety and security community lifelines could be affected by an incident. Power outages can occur causing cascading problems.

Table 4.16-4 Estimated Potential Annual Losses for Tornado by Jurisdiction below shows potential EAL for tornado by jurisdiction in Monmouth County. Expected annual loss was derived from FEMA’s NRI and is separated into two categories, EAL for building value, and Total EAL which includes loss estimates for building value, population, and agriculture value. All values are shown in dollars.

Table 4.16-4 Expected Annual Losses for Tornado by Jurisdiction

Municipality	Expected Annual Loss – Buildings	Expected Annual Loss – Total
Aberdeen, Township of	$19,283	$31,819
Allenhurst, Borough of	$2,079	$2,472
Allentown, Borough of	$3,622	$5,436
Asbury Park, City of	$14,520	$24,337
Atlantic Highlands, Borough of	$5,611	$8,476
Avon-By-The-Sea, Borough of	$3,699	$4,954
Belmar, Borough of	$9,553	$13,388
Bradley Beach, Borough of	$6,330	$9,110

Municipality	Expected Annual Loss – Buildings	Expected Annual Loss – Total
Brielle, Borough of	$9,311	$12,545
Colts Neck, Township of	$20,877	$27,384
Deal, Borough of	$2,079	$2,472
Eatontown, Borough of	$27,772	$37,354
Englishtown, Borough of	$16,655	$23,815
Fair Haven, Borough of	$8,922	$12,991
Farmingdale, Borough of	$1,797	$2,773
Freehold, Borough of	$23,918	$37,099
Freehold, Township of	$61,769	$83,507
Hazlet, Township of	$23,777	$36,837
Highlands, Borough of	$5,606	$8,606
Holmdel, Township of	$37,397	$48,708
Howell, Township of	$72,439	$107,218
Interlaken, Borough of	$2,079	$2,472
Keansburg, Borough of	$7,347	$13,794
Keyport, Borough of	$7,640	$12,316
Lake Como, Borough of	$1,868	$2,970
Little Silver, Borough of	$12,294	$16,273
Loch Arbour, Village of	$2,079	$2,472
Long Branch, City of	$35,435	$55,971
Manalapan, Township of	$87,555	$122,244
Manasquan, Borough of	$11,801	$15,655
Marlboro, Township of	$88,196	$118,962
Matawan, Borough of	$9,955	$16,164
Middletown, Township of	$94,911	$138,308
Millstone, Township of	$20,569	$26,478
Monmouth Beach, Borough of	$5,792	$7,853
Neptune City, Borough of	$7,314	$10,317
Neptune, Township of	$36,146	$54,361
Ocean, Township of	$38,284	$56,240
Oceanport, Borough of	$11,886	$16,943
Red Bank, Borough of	$18,786	$27,183
Roosevelt, Borough of	$9,015	$11,671
Rumson, Borough of	$17,383	$22,143
Sea Bright, Borough of	$3,331	$4,276
Sea Girt, Borough of	$7,104	$8,316
Shrewsbury, Borough of	$4,948	$6,656
Shrewsbury, Township of	$4,948	$6,656
Spring Lake, Borough of	$8,349	$10,160
Spring Lake Heights, Borough of	$6,811	$9,985
Tinton Falls, Borough of	$23,715	$34,342
Union Beach, Borough of	$6,079	$9,794
Upper Freehold, Township of	$30,184	$38,137
Wall, Township of	$50,830	$68,034
West Long Branch, Borough of	$14,983	$20,557
Monmouth County	**$1,064,633**	**$1,509,004**

Source: FEMA NRI, 2024

Population and Economy

Tornadoes can cause physical injuries, including fractures, head injuries, and blunt force trauma. They can also cause fatalities, especially in communities that are unprepared. Children, the elderly and those with disabilities are especially vulnerable. Additionally, tornados can cause both direct and indirect losses to the economy through the destruction of businesses, roads, crops, and other assets as well as disruption to production and labor supply. Rebuilding and recovery costs can be significant following a tornado event.

Ecosystems and Natural Assets

The most significant effect of tornado to ecosystems and natural assets is habitat destruction. Depending on intensity and scale, tornados can uproot trees and even flatten entire sections of forest, disrupting ecosystems and causing displacement of wildlife. There is also potential for debris carried by tornados to cause contamination from hazardous material.

4.17 WAVE ACTION

Hazard Description

Wave action is the characteristics and effects of waves that move inland from an ocean, bay, or other large body of water. Large, fast-moving waves can cause extreme erosion and scour and their impact on buildings can cause severe damage. During hurricanes and other high-wind events, storm surge and wind increase the destructiveness of waves and cause them to reach higher elevations and penetrate further inland.

Location and Extent

The area most susceptible to wave action in Monmouth County are predominantly located along the immediate coastal and shoreline areas of the Atlantic Ocean and Raritan Bay. Additional areas may occasionally experience wave action during extremely large storm events that cause storm surge (addressed separately within this section). Figure 4.15-2 shows a typical transect illustrating coastal zones and the effects of energy dissipation and regeneration of a wave as it moves inland. Zones include Zone V, the Coastal A-Zone (characterized by Moderate Wave Action (MoWA) where waves Source: FEMA, 2009 can be between 1.5 to 3 feet during a BFE) and Zone A (characterized by Minimal Wave Action (MiWA) where waves are less than 1.5 feet during a BFE) which are separated by the Limit of Wave Action (LiMWA).Wave elevations are decreased by obstructions such as vegetation and rising ground elevation (FEMA, 2011).

Figure 4.17 – 2 Wave Action Hazard Zones in Monmouth County illustrates the wave action hazard zones for Monmouth County based on FEMA Preliminary and Effective FIRMs. This includes areas mapped as Zone VE according to the most recent FIS completed by FEMA. Zone VE is known as the coastal high hazard area and refers to coastal areas with a 1 percent or greater chance of flooding and an additional hazard associated with storm-driven velocity waves of three feet or more.[5]

[5] FIGURE 4.2-3ILLUSTRATES BEST AVAILABLE DATA BASED ON THE MOST RECENT FEMA FLOOD INSURANCE STUDY (FIS). IT SHOULD BE NOTED THAT ALTHOUGH WAVE ACTION HAZARD AREAS ARE NOT DELINEATED ALONG THE NAVESINK RIVER FOR THE MUNICIPALITIES OF RED BANK AND FAIR HAVEN IT HAS BEEN DETERMINED THAT THESE AREAS IN GENERAL SHOULD BE CONSIDERED SUSCEPTIBLE TO WAVE ACTION. IT IS ANTICIPATED THAT FUTURE MORE DETAILED FLOOD STUDIES FOR THE AREA WILL DELINEATE VE ZONES THAT WILL SUPPORT THIS DETERMINATION.

Figure 4.17-1 Transect Schematic of Zone V, Coastal A-Zone and Zone A

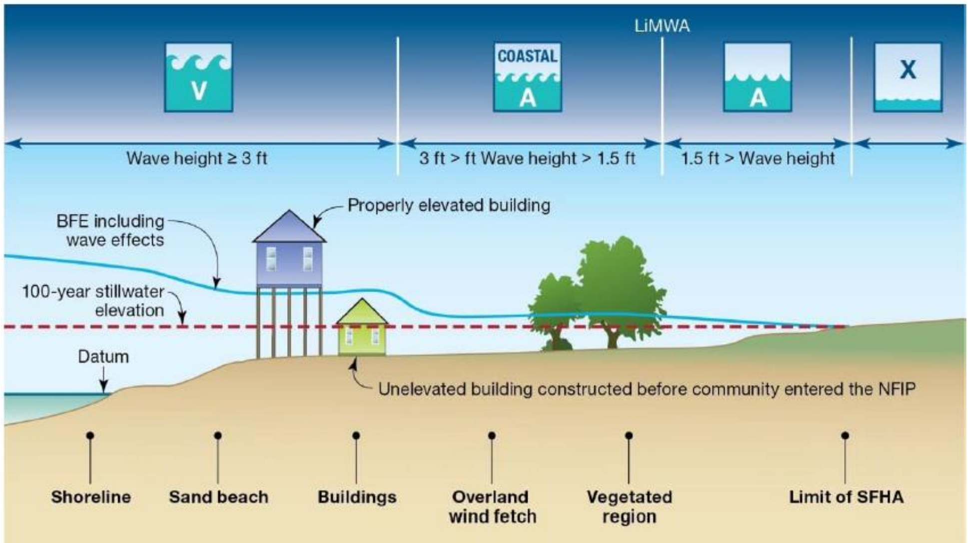
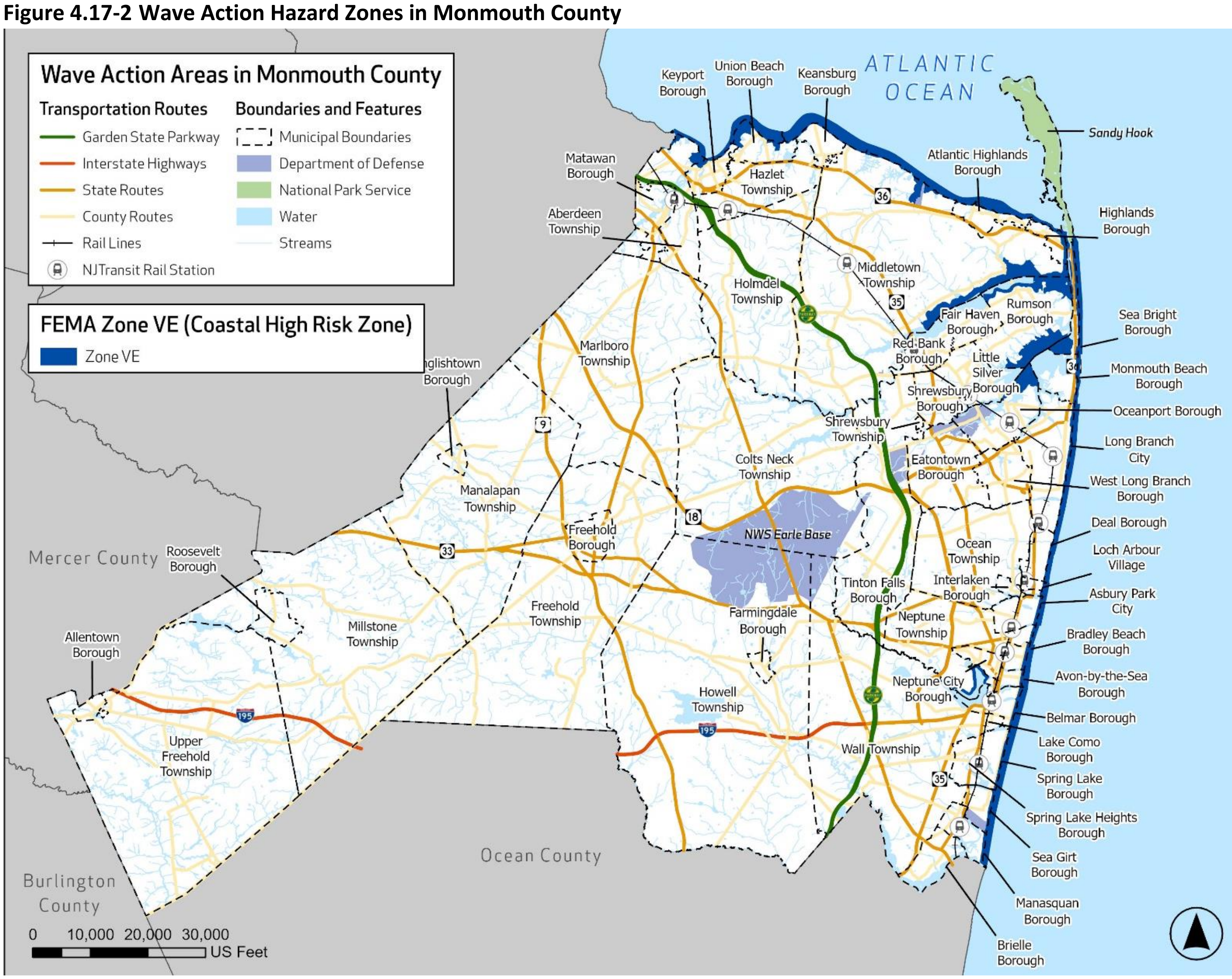


Figure 4.17-2 Wave Action Hazard Zones in Monmouth County



Source: FEMA DFIRM

Range of Magnitude

There is no particular scale that classifies the magnitude or severity of different wave events for different category storms. The extent of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies and this mapping does include mapping of the V-zone, or the lands that can support breaking waves of three feet or more. This boundary is therefore a convenient tool for assessing the extent of the wave action hazard and risk in flood-prone communities. Higher category storms on the Saffir-Simpson scale would, however, typically have more destructive waves breaking into the built environment at the coastline causing more extensive damages to those susceptible structures.

Previous Occurrences and Losses

According to NCEI's latest records, 29 recorded wave action events ("high surf") have affected Monmouth County from August 1996 to October 2023 (data excludes wave action associated with other major historical events addressed separately within this section, such as hurricanes and nor'easters). These incidents resulted in a reported total of four deaths and four injuries in Monmouth County and caused an estimated $40,000 in property damages. Some recent notable events include the following:

August 14-20, 1995. Swells associated with Hurricane Felix generated rough surf and rip currents for about one week along the New Jersey shore. A 17-year-old surfer drowned off Deal. Two boys were swept off the beach by a large wave at Point Pleasant Beach. A 45-year-old male drowned in Avon-By-The-Sea. Numerous injuries were reported, five alone in Long Beach Township. The rough surf spread to Monmouth County and municipalities along the shore began restricting bathing. By the 16th, waves reached up to eight feet at Sandy Hook and most bathing was prohibited. As Felix weakened offshore, bathing restrictions began to be lifted on the 20th.

August 23-28, 1998. Rip currents and large waves associated with Hurricane Bonnie in the Atlantic Ocean caused hundreds of water rescues and resulted in swimming restrictions up and down the New Jersey shore. In Monmouth County, 10 swimmers were rescued at Bradley Beach and 25 were rescued at Manasquan and Spring Lake. On the 24th, swimming restrictions started as swells increased to six to eight feet. The most reported rescues on the 24th were in Monmouth County (about 25) in Manasquan and Spring Lake. One teenager in Spring Lake was injured. As Bonnie neared the North Carolina Coast on the 26th, beach restrictions became tighter. Numerous beaches were closed, and surfing was banned in several communities.

August 30-31, 1999. The combination of swells from Hurricane Bonnie and a stiff northeast flow caused by a strong high-pressure system building over New England produced rough surf, some minor tidal flooding and beach erosion. A major contributing factor to the winds and rip currents was a very strong high-pressure system that built into eastern Canada and New England. Bathing restrictions were in place. The highest recorded tide in Monmouth County was 6.7 feet above average tide heights at Sandy Hook.

August 25-26, 2001. The northeast to east flow around a high and a developing low-pressure system produced rough surf and rip currents along the New Jersey shore. A person nearly drowned while fishing along the shore. A total bathing ban was in effect in Allenhurst, while yellow cautionary flags flew, and partial bathing bans were in effect in other places such as Sea Girt. A 17-foot vessel capsized half a mile off of Shark River Inlet in five to six-foot seas. In Belmar, a 42-foot sport fishing vessel carrying eight persons ran aground between the south jetty and a fishing pier.

November 5, 2008. A nor'easter that developed off the Carolina coast on the night of the 4th caused pounding surf and beach erosion along the New Jersey Coast on the 5th and 6th. It also claimed the life of a man in Monmouth County. At about 11 a.m. EST on the 5th, a man who was fishing on a jetty in Avon, slipped into the ocean. He was rescued about ten minutes later but could not be saved. The nor'easter formed off the Carolina coast overnight on the 4th and slowly moved northeast.

March 13, 2010. The pounding surf and moderate to locally severe coastal flooding took its toll on the New Jersey coast. The tidal flooding in Monmouth County brought back memories of the December 1992 nor'easter. Wave heights reached 7 to 9 feet. On the Raritan Bay side, a 20-foot-wide cut in a dune occurred at Point Comfort in Keansburg. Shore Boulevard was severely flooded. Smaller dune cuts also occurred in the Bayshore at Port Monmouth and Belford. On the ocean side, 4 to 5-foot vertical cuts were common. Sea Bright lost 50 percent of its dune system. Tidal flooding along the Shrewsbury River spilled into homes and businesses in the central and southern side of the borough. In Manasquan, road damage occurred at the intersection of Third Avenue and Riverside Drive.

September 2-4, 2010. Hurricane Earl, which passed about 165 miles east of Atlantic City during the afternoon of September 3rd, generated large swells, heavy surf, enhanced rip currents and caused minor tidal flooding with the afternoon high tide on the 3rd. The heavy surf also claimed the life of one swimmer on the 2nd.

September 19, 2017. Hurricane Jose meandered offshore for several days. Portions of Monmouth County saw high surf, coastal flooding and tropical storm force winds. Minor damage was reported at a fishing pier.

September 14, 2023. Swells from passing Hurricane Lee resulted in dangerous conditions along the ocean waters. Waves were around 8-12 feet. Broadcast media reported a capsized boat around Manasquan Inlet. The boat was hit with a 10-foot wave as it was approaching Manasquan Inlet. One fatality occurred while boating, as well as two injuries.

Note: See the Hurricane and Tropical Storm subsection for discussion of wave impacts during Sandy.

Probability of Future occurrence

Wave action will continue to have a high probability of occurrence for the coastal flood hazard zones of Monmouth County, and the probability of future occurrences is certain. Less severe wave action events will be more frequent but likely cause less impact (i.e., minor damages, coastal erosion, etc.), while more severe waves associated with less frequent coastal storm events such as hurricanes and nor'easters will cause higher impacts (including property damages) along Monmouth County's shoreline.

Potential Effects of Climate Change

The frequency and intensity of coastal storms and severe weather events is expected to increase in the future due to climate change. In the years to come, it is anticipated that Monmouth County will observe drastic changes in storm character, intensity, frequency, and storm tracking. Hurricanes are likely to become more intense with rising sea water temperatures. Coastal erosion rates are likely to increase with rising sea-level, to levels higher than those rates that have been observed over the last century. Storm effects will be more extensive in the future. The following types of impacts can be anticipated in Monmouth County's future as a result of climate change and sea level rise: inundation of low-lying areas; increased frequency and extent of storm-related flooding; wetland loss; saltwater intrusion into estuaries and freshwater aquifers; land loss through submergence and erosion of lands in coastal areas; migration of coastal landforms and habitats; increased salinity in estuaries and coastal fresh; impacts to human populations (property losses, more frequent flood damage, more frequent flooding of roadways and urban centers, risks to people as the population of coastal areas increases); more buildings and infrastructure exposed; currently exposed buildings and infrastructure could be subject to potentially greater losses as water levels increase, and continued rapid coastal development exacerbates the impacts of sea level rise; impacts on gravity flow stormwater systems; impacts on non-coastal areas. Impacts of climate change and sea level rise can affect all parts of a community, including: transportation infrastructure (ports, marinas, airports, roads, bridges, railways); public infrastructure (stormwater and wastewater management systems, drinking water supply and distribution systems, power utility systems, communications systems); public facilities (i.e., police, fire, ambulance, hospitals, schools, daycare centers, adult living facilities, historic landmarks, government buildings, libraries, parks, etc.); economic viability of a community - particularly for communities where tourism tends to drive local economies, as is the case in many of Monmouth County's coastal communities. Climate change and sea level rise could lead to a potential loss of assets that support tourism (i.e., beaches themselves as well beach access points, lodging, restaurants, marinas, fishing habitats, ecotourism, etc.).

Vulnerability Assessment

Built Environment, Infrastructure and Community Lifelines

Wave action is a significant hazard to buildings and infrastructure located in coastal areas. Large, fast-moving waves can cause extreme erosion and scour and their impact on buildings can cause severe damage. Storm surge and wind increase the destructiveness of waves and cause them to reach higher elevations and penetrate further inland.

Given the lack of readily available historical loss data on significant wave action occurrences in Monmouth County, it is assumed that while one major event (i.e., hurricane or nor'easter) may result in significant losses due to wave action, annualizing structural losses over a long period of time would most likely yield a negligible annualized loss estimate in each jurisdiction exposed to this hazard. However, it should also be noted that over the long term, anticipated sea level rise will increase the risk of damages/losses to future wave action events.

Population and Economy

Wave action can cause damage and erosion to beaches and dunes. A significant event resulting in large scale erosion could represent a major threat to the local economies of coastal communities that rely on the financial benefits of their recreational beaches such as some jurisdictions in Monmouth County.

Ecosystems and Natural Assets

Wave action can damage beaches, dunes, wetlands and other coastal ecosystems that are an important natural resource for Monmouth County. They help protect the coast from storms and flooding, provide habitat for birds, small mammals, reptiles, amphibians, and insects. Coastal erosion can impact a variety of natural systems including beaches, wetlands, marshes, and coastal habitats, degrading their natural functions through loss of land, and conversion to open water areas.

4.18 WILDFIRE

Hazard Description

Wildfire is an uncontrolled fire burning in an area of vegetative fuels such as grasslands, brush, or woodlands. Heavier fuels with high continuity, steep slopes, high temperatures, low humidity, low rainfall, and high winds all work to increase risk for people and property located within wildfire hazard areas or along the urban/wildland interface. Wildfires are part of the natural management of forest ecosystems, but most are caused by human factors. Over 80 percent of forest fires are started by negligent human behavior such as smoking in wooded areas or improperly extinguishing campfires. The second most common cause for wildfire is lightning.

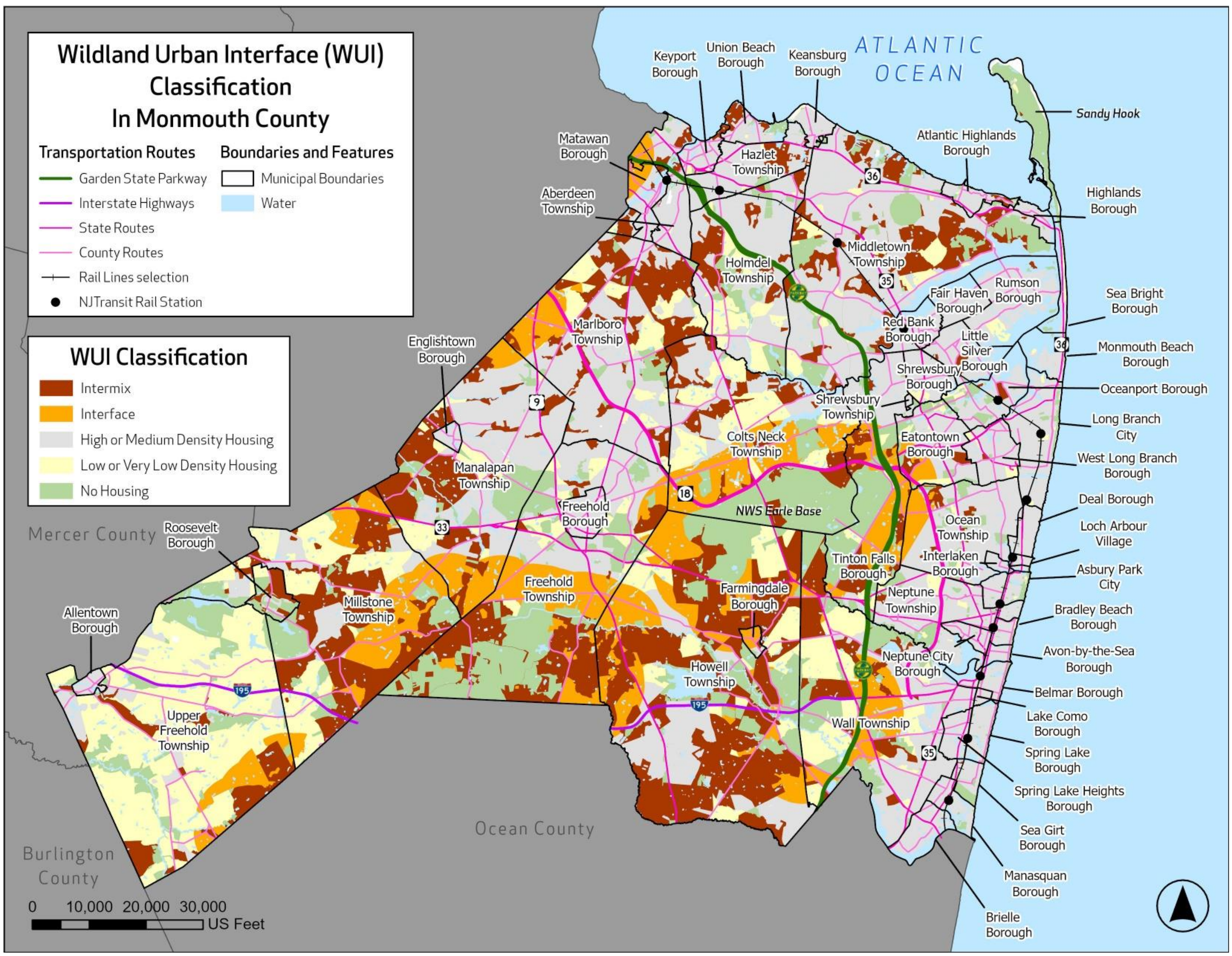
Location and Extent

Wildfires increasingly threaten homes and related structures, especially in the WUI. According to FEMA, the WUI is the zone of transition between unoccupied land and human development. It is the line, area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. The incidence of wildland fires, sometimes with catastrophic results of loss of life and property, is of particular concern in the ever burgeoning suburban, semi-rural, and rural zones. The WUI is often further distinguished into two WUI types based on housing densities:

- Interface: High-density development adjacent to undeveloped wildland vegetation.
- Intermix: Lower-density housing mingled with undeveloped wildland vegetation. The risk from wildfire is greatest in intermix areas.

The US Forest Service integrated U.S. Census and USGS National Land Cover Data to map the Federal Register definition of WUI for the conterminous United States. **Figure 4.18-2 Wildland Urban Interface Classification of Monmouth County** shows the WUI for Monmouth County as of 2020. This area is primarily located in the less developed inland portion of the County, while the more developed coastal areas face less risk from wildfire.

Figure 4.18-3 Wildland Urban Interface Classification of Monmouth County



Range of Magnitude

The extent of wildfires depends on weather and human activity. New Jersey Forest Fire Service (NJFFS) uses two indices to measure and monitor dryness of forest fuels and the possibility of fire ignitions becoming wildfires. The State HMP notes that these indices include the National Fire Danger Rating System's Buildup Index (BUI), and the Keetch-Byram Drought Index (KBDI). Both are used for fire preparedness planning, which includes the following: campfire and burning restrictions, fire patrol assignments, staffing of fire lookout towers, and readiness status for both observation and firefighting aircraft.

- The BUI is a number that reflects the combined cumulative effects of daily drying and precipitation in fuels with a 10-day time lag constant. The BUI can represent three to four inches of compacted litter or can represent up to six inches or more of loose litter (North Carolina Forest Service 2009).
- The KBDI is a drought index designed for fire potential assessment as defined by the United States Department of Agriculture Forest Service. It is a number representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff and upper soil layers. The index increases each day without rain and decreases when it rains. The scale ranges from zero (no moisture deficit) to 800 (maximum drought possible). The Florida Forest Service states that the range of the index is determined by assuming that 8 inches of moisture in a saturated soil is readily available to the vegetation. For different soil types, the depth of soil required to hold eight inches of moisture varies. A prolonged drought influences fire intensity, largely because more fuel is available for combustion. The drying of organic material in the soil can lead to increased difficulty in fire suppression.

There are also many other scales and fire weather indices that evaluate wildfire potential on any given day considering factors such as daily weather and vegetation condition information, fuel moisture, fuel hazard, moisture content in the lower atmosphere, etc.

Previous Occurrences and Losses

According to data made available through NJFFS, Monmouth County averages approximately 50 wildfire events per year though most of these are kept fairly small and are suppressed rather quickly (burning less than one acre). The 10-year average for number of wildfires in Monmouth County is 51 incidents per year, and the average number of acres burned was 35 per year (0.69 acres per fire). Notable events are outlined in **Table 4.18-1 Historic Occurrences of Wildfire in Monmouth County.**

Table 4.18-1 Historic Occurrences of Wildfire in Monmouth County

Date	Location	Details
September 7-10, 1838.	Burlington and Monmouth counties	The New York Herald reported a fire south and east of Bordentown in Burlington and Monmouth counties 14 miles wide by 20 miles long (approximately 179,200 acres). A good deal of property damage was reported, along with possible loss of life.
April 15, 1977	Howell, Township of	A local newspaper reported that approximately 300 acres of woods were burned in Howell Township. The fire was fanned by winds of 15 mph which swept across Yellowbrook Road. Approximately 20 fire departments assisted. Yellowbrook Road and a portion of Route 33 were closed for several hours.
April 30, 2001	Middletown, Township of	The unseasonably dry weather during the second half of April continued to make it easy for brush and wildfires to begin and then spread quickly. Three such wildfires occurred during the afternoon and evening on the 30th across central New Jersey. In Port Monmouth, a four-acre fire consumed vegetation. No property damage was reported.
May 1, 2001	Middletown, Township of	The extremely dry and unseasonably warm weather of early May made New Jersey primed for wild and forest fires. In the Belford section of Middletown Township, a wildfire consumed four grassy acres before it was under control. One home's siding was damaged when the fire crept close to it. Two smaller brush fires occurred that afternoon within the township off of County Route 520 and Harbor Way. No damage or injuries were reported.

Date	Location	Details
March 10, 2002	Middletown, Township of	A brush fire, largely exacerbated by strong gusty winds, scorched about 200 acres of brush in the Port Monmouth section of Middletown. The fire began near Main Street and Broadway. The strong winds fanned the fire and brought it close to several houses on Park Avenue, but none were damaged. About 100 firefighters fought the blaze. It was extinguished about two hours later.
February 19, 2011.	Manalapan, Township of	The combination of the strong west-northwest winds, low humidity levels, and recent dry weather helped cause the rapid spread of wildfires across New Jersey during the day on February 19. In all, 10 wildfires were reported across the State. In Manalapan, a brush fire reached 200 yards in length on Smithburg Road before it was contained. Other wildfires were reported in Sayreville and Old Bridge.
November 23, 2013	Middletown, Township of	A fire was reported in Port Monmouth north of Pew Creek in Monmouth County on the evening of the 23rd. The fire was reported at 735 p.m. EST on the evening of the 23rd. The wildfire burned woods and weeds between William Street, Port Monmouth Road and Bray Avenue. Residents on Port Monmouth Road and William Street were asked to evacuate as their homes were threatened. Seventy-five firefighters helped battle the blaze. The fire was declared under control at 910 p.m. EST on the 23rd and firefighters left at 11 p.m. EST that evening. The siding of one home was damaged by the heat, but no injuries were reported.

Source: NJFFS, NOAA NCEI, 2024

Probability of Future Occurrence

Wildfire probability depends on local weather conditions; outdoor activities such as camping, debris burning, and construction; and the degree of public cooperation with fire prevention measures. Wildfire events will continue to have a high probability of occurrence in Monmouth County, and the probability of future occurrences in Monmouth County is certain. However, these events are typically contained and extinguished rather quickly and those events causing major property damage or life/safety threats are much less likely to occur.

Potential Effects of Climate Change

Fire is determined by climate variability, local topography, and human intervention. Hot, dry spells create the highest fire risk. Increased temperatures may intensify wildfire danger by warming and drying out vegetation. When climate alters fuel loads and fuel moisture, this changes the forest susceptibility to wildfires. Climate changes also may increase winds that spread fires. Faster fires are harder to contain and thus are more likely to expand into residential neighborhoods.

Vulnerability Assessment

Built Environment, Infrastructure, and Community Lifelines

Beyond the loss of vegetation that wildfires leave in their wake, structures in the wildland/urban interface can be severely damaged or destroyed. **Table 4.18-2 Expected Annual Losses to Wildfire by Jurisdiction** shows potential EAL for wildfire by jurisdiction in Monmouth County. Expected annual loss was derived from FEMA's NRI and is separated into two categories: EAL for building value, and Total EAL which includes loss estimates for building value, population, and agriculture value. Most estimated losses from wildfire are building related, thus the EAL for buildings is similar to the total EAL. All values are shown in dollars.

Table 4.18-2 Expected Annual Losses to Wildfire by Jurisdiction

Municipality	Expected Annual Loss – Buildings	Expected Annual Loss – Total
Aberdeen, Township of	$19,946	$20,067
Allenhurst, Borough of	$2,448	$2,451
Allentown, Borough of	$3,563	$3,573
Asbury Park, City of	$-	$-
Atlantic Highlands, Borough of	$1,741	$1,753
Avon-By-The-Sea, Borough of	$-	$-

Municipality	Expected Annual Loss – Buildings	Expected Annual Loss – Total
Belmar, Borough of	$-	$-
Bradley Beach, Borough of	$-	$-
Brielle, Borough of	$6,638	$6,655
Colts Neck, Township of	$117,843	$118,199
Deal, Borough of	$2,448	$2,451
Eatontown, Borough of	$8,055	$8,074
Englishtown, Borough of	$28,697	$28,810
Fair Haven, Borough of	$521	$523
Farmingdale, Borough of	$5,940	$5,968
Freehold, Borough of	$74,230	$74,486
Freehold, Township of	$132,653	$133,053
Hazlet, Township of	$4,414	$4,437
Highlands, Borough of	$2,871	$2,881
Holmdel, Township of	$76,868	$77,058
Howell, Township of	$425,583	$427,009
Interlaken, Borough of	$2,448	$2,451
Keansburg, Borough of	$3,180	$3,190
Keyport, Borough of	$3,120	$3,142
Lake Como, Borough of	$-	$-
Little Silver, Borough of	$21,957	$22,032
Loch Arbour, Village of	$2,448	$2,451
Long Branch, City of	$1,315	$1,317
Manalapan, Township of	$139,053	$139,510
Manasquan, Borough of	$3,859	$3,863
Marlboro, Township of	$141,754	$142,181
Matawan, Borough of	$28,830	$28,998
Middletown, Township of	$148,755	$149,378
Millstone, Township of	$232,001	$232,663
Monmouth Beach, Borough of	$1,104	$1,107
Neptune City, Borough of	$-	$-
Neptune, Township of	$9,927	$9,986
Ocean, Township of	$48,851	$49,034
Oceanport, Borough of	$7,085	$7,127
Red Bank, Borough of	$1,774	$1,791
Roosevelt, Borough of	$86,371	$86,639
Rumson, Borough of	$21,090	$21,133
Sea Bright, Borough of	$729	$729
Sea Girt, Borough of	$-	$-
Shrewsbury, Borough of	$6,879	$6,904
Shrewsbury, Township of	$6,879	$6,904
Spring Lake, Borough of	$-	$-
Spring Lake Heights, Borough of	$-	$-
Tinton Falls, Borough of	$40,534	$40,680
Union Beach, Borough of	$4,426	$4,442
Upper Freehold, Township of	$137,261	$137,603
Wall, Township of	$212,908	$213,514
West Long Branch, Borough of	$6,903	$6,924

Municipality	Expected Annual Loss – Buildings	Expected Annual Loss – Total
Monmouth County	**$2,235,899**	**$2,243,143**

Source: FEMA NRI, 2024

Population and Economy

Wildfires have the potential to destroy large portions of a community. Firefighters are at risk during the time that they are trying to contain and control the blaze. Loss of life and injuries are possible for people living, working, or traveling through an impacted area. Depending on the scale of the impacted area and the type and numbers of buildings and infrastructure impacted, secondary effects are possible on local economies and the social fabric of communities following the event.

Ecosystems and Natural Assets

Although certain ecosystems depend on naturally occurring small scale wildfires to maintain the health of the ecosystem, large scale destructive wildfires can have significant negative impacts. Wildfire can cause destruction of natural wildlife through destruction of vegetation displacing wildlife and disrupting the food chain. Wildfire can also impact soil and water quality through introduction of ash and sediment into the air, soil, and water. Additionally, following a large wildfire, the possibility exists for significant increases in stormwater runoff and landslides which can lead to downstream flooding, and even landslides.

Potential for Future Development to Impact Hazard Vulnerability

Thirty of the 53 jurisdictions in Monmouth County contain developed areas which are considered Wildland-Urban Interface. The total area of these zones is approximately 91,906 acres. In other words, about 30 percent of the total land area of the County falls under the WUI classification. Of the WUI area, 31,935 acres are considered “interface” with the remaining 59,971 acres considered “intermix.” The municipalities with the greatest amount of Wildland-Urban Interface area are Howell Township, Millstone Township, and Freehold Township.

Infill development, redevelopment and greenfield are susceptible to wildfire if future development is located within the WUI, or undeveloped areas are developed into new zones of Wildland-Urban Interface. Ways to mitigate future development from the risk of wildfire is to regulate development in or near wildfire hazard areas through land use planning, such as conserving open space or a wildland-urban boundary zones to separate developed areas from high-hazard areas.

Jurisdictions with a potential for future development to substantially increase wildfire hazard vulnerability under existing conditions should: (a) include wildfire mitigation measures in their mitigation strategies; and/or (b) select jurisdictional plan integration initiatives for the next plan maintenance phase that can potentially reduce risk for future development.

4.19 WINTER STORM

Hazard Description

Winter storms may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Blizzards, the most dangerous of all winter storm, combine low temperatures, heavy snowfall, and winds of at least 35 miles per hour, reducing visibility to only a few yards. Ice storms occur when moisture falls and freezes immediately upon impact on trees, powerlines, communication towers, structures, roads and other hard surfaces. Winter storms and ice storms can down trees, cause widespread power outages, damage property, and cause fatalities and injuries to human life.

Location and Extent

Nearly the entire continental United States is susceptible to winter storms, but the degree of exposure typically depends on the normal expected severity of local winter weather. Monmouth County is accustomed to severe winter weather conditions and is prepared for the potential disruptions they might cause, though intense winter storms might still overwhelm local capabilities. While Monmouth County is located south of the typical boundary between freezing and non-freezing precipitation during wintertime, annual snowfall on a countywide basis averages 25 to 26 inches and the maximum recorded seasonal snowfall is 70 inches (1957-1958). All areas throughout the County are susceptible to the hazard effects of winter storms including snow and ice, and Monmouth County's coastal jurisdictions are also extremely susceptible to the added effects of storm surge, wave action, coastal erosion and tidal flooding that might be wrought by nor'easters, whose effects are discussed separately in this section.

Range of Magnitude

The magnitude or severity of a severe winter storm depends on several factors including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and time of occurrence during the day (i.e., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. NOAA's NCEI is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from one to five. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCEI has analyzed and assigned RSI values to over 500 storms since 1900. **Table 4.19 - 1 Regional Snowfall Index Ranking Categories** presents the five RSI ranking categories.

Table 4.19-1 Regional Snowfall Index Ranking Categories

Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	18.0+

Source: NOAA NCEI

Previous Occurrences and Losses

According to the NCEI, 172 recorded winter storm events (classified as: blizzard, heavy snow, ice storm, sleet, winter storm, winter weather) have affected Monmouth County between January 1996 and April 2019. Thirty-six events have occurred since the last plan update. All incidents resulted in no reported deaths or injuries in Monmouth County but are associated with approximately $5 million in property damages. Note that this statement only includes injuries reported by NCEI. **Table 4.19-2 Winter Storms in Monmouth County** lists all of the winter storm events that have occurred from September 2014 (last plan update)-April 2023. None of these events resulted in injury or fatality.

Table 4.19-2 Winter Storms in Monmouth County, September 2014-April 2023

Date	Event
1/26/2015	Heavy Snow
3/5/2015	Heavy Snow
2/21/2015	Winter Storm
3/1/2015	Winter Storm

Date	Event
1/22/2016	Winter Storm
1/7/2017	Winter Storm
2/9/2017	Winter Storm
1/4/2018	Winter Storm
3/21/2018	Winter Storm
1/23/2015	Winter Weather
2/1/2015	Winter Weather
2/9/2015	Winter Weather
2/14/2015	Winter Weather
2/16/2015	Winter Weather
3/1/2015	Winter Weather
3/3/2015	Winter Weather
3/20/2015	Winter Weather
1/12/2016	Winter Weather
1/17/2016	Winter Weather
2/5/2016	Winter Weather
2/15/2016	Winter Weather
3/4/2016	Winter Weather
12/17/2016	Winter Weather
1/5/2017	Winter Weather
2/9/2017	Winter Weather
3/10/2017	Winter Weather
12/9/2017	Winter Weather
3/7/2018	Winter Weather
3/12/2018	Winter Weather
4/2/2018	Winter Weather
11/15/2018	Winter Weather
2/11/2019	Winter Weather
2/20/2019	Winter Weather
3/1/2019	Winter Weather
3/3/2019	Winter Weather
12/2/2019	Winter Weather
12/16/2020	Winter Storm
01/31/2021	Winter Weather
02/01/2021	Winter Storm
02/07/2021	Winter Weather
2/11/2021	Winter Weather
2/13/2021	Winter Weather
2/18/2021	Winter Storm
1/5/2022	Winter Weather
1/7/2022	Winter Storm

Date	Event
1/16/2022	Winter Weather
1/28 to 1/29, 2022	Winter Weather
1/29/2022	Blizzard
2/7/2022	Winter Weather
2/13/2022	Winter Weather
12/23/2022	Winter Weather

Source: NOAA-NCEI, 2024

Notable events include the following:

January 6-8, 1996. The Blizzard of 1996 brought record breaking snow to most of New Jersey and paralyzed the region for several days, caused most municipalities to exceed their annual snow budgets during this one storm. A state of emergency was declared by Governor Whitman, which lasted a week. The State was also declared a federal disaster area. Snowfall accumulations averaged 20 to 30 inches in Monmouth County, with 30 inches in Howell and 28 inches in Freehold. In addition to the heavy snow, wind gusts reached hurricane force along the coast. Eight housing additions in Manasquan collapsed. Navigation Tower aides at Manasquan were toppled. Many areas lost power. Evacuations of some coastal residents occurred in Belmar, Port Monmouth, Sea Bright and Manasquan. Street flooding was reported in these areas and also in Avon. In Sea Bright, flooding from the Shrewsbury River exacerbated the flooding. State Route 36 was closed from the Highlands/Sea Bright Bridge through Monmouth Beach. The worst damage along the coast was the erosion.

February 16-17, 2003 (President's Day Storm). The most powerful storm to affect New Jersey since the Blizzard of 1996 struck during the President's Day Weekend. Governor McGreevey declared a state of emergency, and many municipalities declared their own snow emergencies. In Monmouth County, drifts reached six feet. In Wall, a high school roof collapsed on the 18th because of four-foot drifts at one corner of the roof. A country store was badly damaged in Freehold. The National Guard was deployed to assist with evacuations. The strong winds caused about 11,000 homes and businesses to lose power. Monmouth Beach was hit the hardest by power outages, waiting two days for power to be restored. Peak wind gusts included 49 mph in Keansburg and snow accumulations included 22.8 inches in Cream Ridge, 22 inches in Hazlet, 21 inches in Manalapan, and 20.5 inches in Wall.

January 22, 2005. A very potent Alberta low pressure system dropped heavy snow across northern and southwestern New Jersey and a wintry mix across southeastern New Jersey. Governor Codey declared a state of emergency, requiring vehicles to stay off of public roads and thoroughfares. Gusty northwest winds, which followed in the wake of the storm caused considerable drifting snow and hampered road crews' efforts as drifts continued to form on roads. The unseasonably cold weather also rendered the salt less effective. Snow emergencies were declared by many municipalities. Specific snowfall accumulations included 17 inches in Howell and 16.5 inches in Cream Ridge.

February 14, 2007 (Valentine's Day Storm). A severe winter storm impacted the Ohio Valley before moving northeast over New England. Monmouth County experienced a severe icing, with 0.5 inches of ice accumulation reported at Tinton Falls. Peak wind speeds ranged from 36 to 48 mph. Cream Ridge recorded 3.2 inches of total precipitation, which was all sleet. Numerous trees were downed, and extensive power outages plagued the area.

December 26, 2010. A major and for parts of eastern New Jersey record breaking winter storm and blizzard affected the State on Sunday the 26th and Monday the 27th. A state of emergency was declared in New Jersey. The heavy snow bands and blizzard conditions resulted in snowfall rates of two to three inches per hour at times. Strong to high winds continued to hamper snowplow operations through the 27th. Bus service was suspended throughout the State as of 8:30 p.m. on the 26th and did not resume until the 28th. While the overall number of accidents was low, about 2,300 motorists were stranded on average for 10 to 12 hours. The Red Cross opened shelters in the eastern part of the State. In addition, stranded motorists used town halls, rest stops and movie theaters as shelters. Blood supplies ran low. Trash schedules were delayed about a day and recycling schedules were delayed up to one week. Monmouth County was one of the counties that were most affected by the blizzard as many roadways were closed and remained closed through the 27th because of drifting. An eleven mile stretch of State Route 18 remained closed for a couple of days. The weight of the snow caused a roof collapse at the Naval Weapons Station Earle in Colts Neck. An overturned vehicle in Tinton Falls resulted in an injury. A train struck an abandoned vehicle in Red Bank, but no injuries were caused. Closed malls in Monmouth County did not open until the 28th at the earliest. The Sea Streak Manhattan Ferry service from Monmouth County ran on a modified schedule on the 27th. Athletic competitions were either postponed or cancelled. Major roadways such as Interstate 195 (8-foot drifts) and New Jersey State Routes 18, 35, 36, 66 and 138 were closed into the 27th. Long Branch emergency personnel alone responded to about 700 calls. This was a new single snowstorm record surpassing the previous record of 20.0 inches during the President's Day snowstorm of February 2003. Representative snowfall included 25.0 inches in Colts Neck, 24.0 inches in Neptune, 22.0 inches in Red Bank and 20.0 inches in Holmdel. At Sandy Hook, the high tide reached 7.13 feet above mean lower low water. Minor tidal flooding starts at 6.7 feet above mean lower low water.

November 7-8, 2012. A strong nor'easter caused high winds, heavy snow, and damaging waves and minor tidal flooding days after Superstorm Sandy, causing setbacks in the start of many local restoration efforts and forced evacuations of some coastal areas yet again. Unfortunately, the heaviest snow fell in the counties that were affected the hardest by Sandy and upwards of an additional 150,000 customers lost power. The combination of heavy snow and wind brought down additional trees, poles and wires. Representative snowfall included 13.0 inches in Freehold, 12.0 inches in Allaire, 11.0 inches in Howell, and 6.0 inches in Oakhurst.

March 5, 2015. Waves of low pressure that formed along a sinking cold front brought New Jersey heavy snow and the southern half of the State its heaviest snow of the season. Snowfall averaged 4 to 9 inches with the highest amounts in central New Jersey. Less snow fell in Sussex County. The heavy snow prompted Governor Chris Christie to declare a state of emergency and close State offices to non-emergency personnel. Nearly all schools and universities in the State were closed on the 5th. Many were also closed the next day. The snow also caused hazardous travel and hundreds of accidents, including a fatal one in Somerset County.

January 12, 2016. A strong southerly flow preceding a cold front produced wind gusts in the 30 to 40 mph range during the afternoon hours on January 12th. Higher gusts...in the 40 to 50 mph range, then occurred during the evening and early overnight hours as the cold front, then its associated upper level trough axis, moved through. Snow showers associated with this frontal passage produced the first coating of snow so far this winter season in some areas. Some specific wind gusts include 42 mph near Huguenot. Strong winds toppled a tree onto a house in Howell Township, NJ, but no one was home at the time.

January 4, 2018. An area of low pressure tracked up the east coast interacting with a cold front which lead to rapid development of a winter storm across the State. This storm quickly moved out by the 5th. However, snowfall accumulations and gusty winds occurred with the storm. Blizzard conditions occurred along many coastal locations. Top wind gusts were generally around 40 mph across the State but were highest in Ocean County, closer to 60 mph. Snow amounts were highest in southern and coastal New Jersey with over 6 inches, totals were only a few inches further northwest. A state of emergency was declared during the height of the storm. Several hundred vehicles were stranded, and hundreds of thousands were without power at some point. Severe cold continued for the next week leading to many locations going to code blue operations and closing of the Cape May Lewes Ferry. ASOS/AWOS sites indicated blizzard criteria was met. Snowfall was over a foot in many locations.

October 16, 2019: Now labeled a "bomb cyclone," this nor'easter brought 30- to 50-mph winds and heavy rains to the County. According to the NWS, a bomb cyclone is a low-pressure system that is a strong nor'easter, one that can even resemble a small tropical storm and can build strength very quickly. Middletown Township experienced the third highest power outages in the State with more than 330 residents without power.

Probability of Future Occurrence

Winter storm events will continue to have a high probability of occurrence in Monmouth County, and the probability of future occurrences in Monmouth County is certain. While the impact of snow and ice storms will cause major disruptions to transportation, commerce and electrical power as well as significant overtime work for government employees, large scale property damages and/or threats to human life and safety are not expected. Nor'easters occur less frequently but represent a much greater hazard of concern as it relates to the impacts of winter storm events (addressed separately within this section). Winter storms typically occur in New Jersey from late November through mid-April, with peak months being December through March. Nor'easters are one type of severe winter storm that typically bring high winds, coastal surge and tidal flooding along with heavy precipitation, which are addressed separately within this section.

Potential Effects of Climate Change

In terms of snowfall and ice storms, there is a lack of quantitative data to predict how future climate change will affect this hazard. It is likely that the number of winter weather events may decrease, and the winter weather season may shorten; however, it is also possible that the intensity of winter storms may increase. The exact effect on winter weather is still highly uncertain (Sustainable Jersey Climate Change Adaptation Task Force 2013).

Vulnerability Assessment

Built Environment, Infrastructure and Community Lifelines

Winter storms can have tremendous impacts on Monmouth County. Though typically short in duration, winter storms can result in significant snow accumulations, with tremendous impacts on local transportation via road, rail, and air. Impacts are exacerbated with storms having an ice component, as snow loads are increased and driving conditions substantially worsen. Significant snow loads on roofs of buildings has the potential to compromise the structural integrity with possible collapse. On vegetation, snow and ice loads can result in downed trees and limbs - particularly during periods of high winds - which can result in outages when limbs fall on power lines and communication lines. Secondary impacts from power outages can include frozen pipes, business losses, negative impacts on people associated with trying to heat their homes using portable heat sources (i.e., kerosene) or stoves including carbon monoxide poisoning and fire risks. Secondary impacts from downed communication lines can hamper the response and recovery efforts due to lack of communication.

Table 4.19 - 3 Expected Annualized Losses from Winter Storms by Jurisdiction shows potential annualized property losses and percent loss ratios resulting from the winter storm hazard for each jurisdiction in Monmouth County based on historic occurrences. For the plan update, population estimates were refined using Census 2010 block level data; and annualized expected property losses are based on updated (2012) improvement values.

Table 4.19-3 Expected Annualized Losses from Winter Storms by Jurisdiction

Municipality	Expected Annual Loss – Buildings	Expected Annual Loss – Total
Aberdeen, Township of	$853.26	$16,103.31
Allenhurst, Borough of	$80.38	$500.15
Allentown, Borough of	$94.49	$1,455.06
Asbury Park, City of	$561.46	$11,038.59
Atlantic Highlands, Borough of	$242.59	$3,668.07

Municipality	Expected Annual Loss – Buildings	Expected Annual Loss – Total
Avon-By-The-Sea, Borough of	$141.03	$1,455.77
Belmar, Borough of	$366.16	$4,420.25
Bradley Beach, Borough of	$244.87	$3,211.34
Brielle, Borough of	$357.22	$3,783.62
Colts Neck, Township of	$927.65	$8,854.67
Deal, Borough of	$80.38	$500.15
Eatontown, Borough of	$1,168.01	$12,476.65
Englishtown, Borough of	$439.28	$5,860.67
Fair Haven, Borough of	$370.44	$5,049.35
Farmingdale, Borough of	$79.87	$1,276.98
Freehold, Borough of	$1,021.48	$16,650.29
Freehold, Township Of	$2,562.03	$26,901.58
Hazlet, Township of	$1,056.65	$17,064.90
Highlands, Borough of	$216.35	$3,408.16
Holmdel, Township of	$1,661.99	$15,512.26
Howell, Township of	$3,219.05	$45,811.85
Interlaken, Borough of	$80.38	$500.15
Keansburg, Borough of	$326.10	$8,218.73
Keyport, Borough of	$335.30	$6,036.51
Lake Como, Borough of	$72.27	$1,247.91
Little Silver, Borough of	$499.05	$5,001.26
Loch Arbour, Village of	$80.38	$500.15
Long Branch, City of	$1,361.26	$23,136.48
Manalapan, Township of	$2,377.36	$29,417.46
Manasquan, Borough of	$445.18	$4,502.12
Marlboro, Township of	$3,428.30	$36,448.75
Matawan, Borough of	$440.12	$8,000.75
Middletown, Township of	$4,184.83	$57,038.88
Millstone, Township of	$847.57	$7,751.69
Monmouth Beach, Borough of	$203.61	$2,200.10
Neptune City, Borough of	$281.43	$3,460.31
Neptune, Township of	$1,436.03	$21,315.08
Ocean, Township of	$1,505.62	$20,923.85
Oceanport, Borough of	$455.50	$5,791.77
Red Bank, Borough of	$833.47	$11,100.90
Roosevelt, Borough of	$237.22	$2,227.36
Rumson, Borough of	$658.76	$5,650.73
Sea Bright, Borough of	$71.85	$542.72
Sea Girt, Borough of	$274.79	$1,567.50
Shrewsbury, Borough of	$218.15	$2,297.14
Shrewsbury, Township of	$218.15	$2,297.14
Spring Lake Heights, Borough of	$322.96	$2,255.11
Spring Lake, Borough of	$263.47	$3,651.14
Tinton Falls, Borough Of	$1,053.96	$14,081.45
Union Beach, Borough of	$269.49	$4,817.66
Upper Freehold, Township of	$789.28	$6,553.49
Wall, Township of	$2,058.60	$20,935.26

Municipality	Expected Annual Loss – Buildings	Expected Annual Loss – Total
West Long Branch, Borough of	$579.56	$6,528.43
Monmouth County	**$41,954.65**	**$531,001.66**

Source: FEMA NRI

Population and Economy

There is potential for injury and death during winter storms when individuals are exposed to the cold for a prolonged period resulting in hypothermia or frostbite. Additionally, injury or death may occur from accidents on icy roads or blizzards when driving conditions are unsafe, or even from slipping and falling while walking on icy surfaces. The human impact of winter storms tends to be exacerbated in areas of social vulnerability (for example, low income, and a high proportion of the very young and/or very old). The economy could be impacted when businesses are forced to close due to winter storm conditions. When a winter storm occurs late in the season and results in extremely low temperature, there is also risk for crop damage, negatively impacting harvest in agricultural communities.

Ecosystems and Natural Assets

Winter storms can cause damage to vegetation through tree breakage from heavy snow or ice build-up. Prolonged storms can affect food availability for certain species causing scarcity resulting in wildlife mortality or disruptions to natural cycles.

HUMAN-MADE HAZARDS

4.20 CIVIL UNREST

Hazard Description

Civil disturbance is a broad term that is typically used by law enforcement to describe one or more forms of disturbance caused by a group of people. Civil disturbance is typically a symptom of, and a form of protest against, major socio-political problems. Typically, the severity of the action coincides with the level of public outrage. In addition to a form of protest against major socio-political problems, civil disturbances can also arise out of union protest, institutional population uprising, or from large celebrations that become disorderly.

Civil disturbances can take the form of small gatherings or large groups blocking or impeding access to a building or disrupting normal activities by generating noise and intimidating people. Demonstrations can range from a peaceful sit-in to a full-scale riot, in which a mob burns or otherwise destroys property and terrorizes individuals. Even in its more passive forms, a group that blocks roadways, sidewalks, or buildings interferes with public order. Often protests intended to be a peaceful demonstration to the public and the government can escalate into general chaos.

There are two types of large gatherings typically associated with civil disturbances: a crowd and a mob. A crowd may be defined as a casual, temporary collection of people without a strong, cohesive relationship. A mob can be defined as a large disorderly crowd or throng. Mobs are usually emotional, loud, tumultuous, violent, and lawless.

In the State of New Jersey, a municipality in which a civil disorder occurs bears the first and primary responsibility to control the disturbance. Civil unrest that remains uncontrolled warrants local mutual aid from neighboring municipal and/or County resources. If the civil unrest remains beyond the capabilities of local law enforcement agencies alone, limited State Police assistance may be requested. If the restoration of law and order is beyond local, County and State abilities, the Governor may declare a State of Emergency calling on federal support such as the New Jersey National Guard to restore order.

Location and Extent

Government facilities, landmarks, prisons, and universities are common sites where crowds and mobs may gather. The concentration of buildings in and density of northeastern New Jersey, and State government buildings in Trenton may be targets of civil disturbance. New Jersey also has correctional facilities, treatment units, and youth development centers, as well as federal prison facilities and local and private facilities throughout the State that may be targets for civil unrest.

Range of Magnitude

The magnitude or severity of a civil unrest situation coincides with the level of public outrage. They can take the form of small gatherings or large groups blocking access to buildings or disrupting normal activities. Civil unrest situations can also be peaceful sit-ins or a full-scale riot.

Previous Occurrences and Losses

According to the State HMP there has been one instance of civil unrest in Monmouth County:

July 7, 1970. The Asbury Park civil disturbance began when a group of young people started breaking some windows after a youth dance at the West Side Community Center on the night of July 4. The violence increased in intensity and scope over the course of the next 7 nights. While extensive and far reaching, the rioting and damage was essentially limited to the major entertainment, business, and retail district of the Springwood Avenue, on the west side of Main Street. Before it was all over, there would be over $4 million in property damage, 167 arrests, 180 injured including 15 police, and countless numbers of families made homeless.

Probability of Future Occurrence

Although there is a low probability of occurrence, civil unrest incidents are still possible. As discussed in the Location section above, areas that are important to the State, region, and greater United States may be targets for civil unrest. These areas include universities, landmarks, correctional facilities, major industrial facilities, and others similar in nature. It is also worth noting that while the last major civil disturbance in New Jersey occurred in the 1970s, it is still possible for a future event to occur. Societal trends and emerging social issues should be watched closely as these types of issues have led to instances in the past.

Potential Effects of Climate Change

While civil unrest is a human-caused hazard, civil unrest may arise in response to changing climate conditions and public policy. Research into the connection between climate change and civil unrest is ongoing: not enough to make a definitive statement on their connection, but not little enough to ignore a possible connection.

Vulnerability Assessment

Civil unrest and civil disturbances can range from minor to significant events that can disrupt the functioning of a community for weeks or months. A worst case-scenario for a civil disturbance would be an incident that takes place in a large urban environment and lasts for an extended period of time. Although an event could be short in duration, the impacts and disruptions to the community can last from a day to several decades depending on social, economic, and cultural factors related to the event.

Civil disturbances often occur with little to no warning; however, certain events may trigger riots. As demonstrated in the Past Occurrences and Losses section and discussions regarding severity, riots can occur as a result of controversial court rulings, unfair working conditions, political controversy or general unrest. Riots can also be triggered as a result of favorable or unfavorable sports outcomes. Thus, generally there will be a certain degree of warning time that a riot may occur; however, achieving certainty that an incident is imminent is not possible.

Civil unrest can result in numerous secondary hazards. Depending on the size and scope of the incident, civil unrest may lead to widespread urban fire, transportation interruption, and environmental hazards. The most significant impact of civil unrest is the secondary hazard of interruption of continuity of government, which can also lead to several of the aforementioned secondary hazards. The extent of secondary hazards will vary significantly based on the extent and nature of the civil unrest.

Normally, instance of civil unrest will have a minimum impact on the environment. However, if petroleum or other chemical facilities were a target for vandalism or large-scale fires occurred, the impact on the environment could be significant.

For the purposes of measuring exposure, the entire population of Monmouth County is exposed to the civil unrest hazard. Those that live in densely populated areas, those living near colleges/universities, correctional facilities, landmarks, and other areas of significance may have a higher exposure and are thus more vulnerable to the effects of civil unrest.

Measuring the economic impact of civil unrest in Monmouth County is difficult. Elements that contribute to this are the volatility of the nature of civil disturbances, and the uncertainty of the duration of an incident. Local economies may be affected by a civil disturbance, as was the case during the Asbury Park Riots, which targeted the business sector in the community during the peak of tourist season. For the purposes of this assessment, the entire Monmouth County economy is considered exposed to the effects of civil disturbances. Should a large-scale civil unrest incident occur, the economy of Monmouth County will be affected and is therefore vulnerable. For example, a prolonged strike will affect production and tax revenues. Also, if a widespread riot occurred it would interrupt daily commerce, thus affecting the economy.

Critical facilities may be targets for civil unrest disturbances. Disruptions to critical facilities may have cascading secondary effects such as power outages. Because these facilities are vulnerable to civil unrest and may be a focal point during a protest, these facilities will need to be protected during incidents. It is difficult to quantify the potential losses to critical facilities because of the unpredictability of civil disturbances and their duration. The replacement cost value for critical facilities provides a total risk exposure.

4.21 CYBER ATTACK

Hazard Description

Cyber terrorism is the use of existing computers and information, particularly over the Internet, to cause physical or financial harm or a severe disruption of infrastructure service. Transportation, public safety, and utility services are all critical, and are highly dependent on information technology. The motive behind such disruptions can be driven by religious, political, or other objectives.

Location and Extent

Cyber threats to critical infrastructures can be posed by anyone with the capability, technology, opportunity, and intent to do harm. Potential threats can be foreign or domestic, internal or external, State-sponsored or a single rogue element. Terrorists, insiders, disgruntled employees, and hackers are included in this profile. The fact that most of the nation's vital services are delivered by private companies creates a significant challenge in assigning the responsibility for protecting our critical infrastructures from cyber-attacks. Across Monmouth County, countless systems rely on computers for day-to-day operations including but not limited to traffic signals; power plants; heating, ventilation, and air conditioning (HVAC) systems; as well as systems responsible for ensuing Monmouth County's local governments can operate. While these are just a few examples of critical systems vulnerable to cyber-attacks, it should be noted that an attack could cripple not only the operations of Monmouth County's systems but also the economy.

Range of Magnitude

The magnitude of extent of an incident will vary greatly based on the extent and duration of the impact. Additionally, the extent will vary based upon which specific system is affected by an attack, the warning time, and ability to preempt an attack. Attacks can be carried out by single individuals, domestic or foreign terror organizations, or even nation-states. Cyber-attacks can also vary in regard to their geographic extent; all levels of government from municipal to national are at risk.

The New Jersey Cybersecurity and Communications Integration Cell (NJCCIC) profiles different threats to various systems that can be impacted by an attack, providing some context of the extent an attack could have. **Table 4.21 - 1 Threat of Malware to Different Systems** describes the malware that can impact different systems.

Table 4.21-1 Threat of Malware to Different Systems

Threat	Description of Malware
Android	Malicious software designed to exploit the Android operating systems (OS) running on smartphones, tablets, and other devices. Some variants of Android malware have the capability of disabling the device, allowing a malicious actor to remotely control the device, track the user's activity, lock the device, or encrypt or steal personal information transmitted from or stored on the device. As users are increasingly turning to mobile devices for both business and personal use, cyber threat actors are devoting their efforts to developing malware designed to compromise the device software.
Botnets	A group of internet-connected computers and devices that have been infected by malware that allows a malicious actor to control them remotely. The malicious actor then uses the botnet for nefarious purposes such as sending spam email, stealing data, spreading additional malware infections to other devices, generating illicit advertising revenue through click-fraud, mining cryptocurrencies, or conducting distributed denial-of-service (DDoS) attacks. In the cases where botnets are used to conduct DDoS attacks, these infected devices are used to generate an excessive amount of network traffic designed to overwhelm a website, server, or online service to the point that legitimate users cannot access it.
Exploit Kits	Toolkits that automate the exploitation of vulnerabilities in popular software applications to maximize successful infections and serve as a platform to deliver malicious payloads such as Trojans, spyware, ransomware, and other malicious software. Most users will encounter EKs from visiting seemingly legitimate, high-traffic websites that either contain links to EKs embedded within malicious advertising (malvertising) or have malicious code hidden directly within the website itself. Malicious URLs linking to EKs are commonly distributed through spam email and spear-phishing campaigns.
ICS	A collective term for several types of control systems and other equipment used to operate and/or automate industrial processes and includes supervisory control and data acquisition (SCADA) systems – often incorrectly used interchangeably with ICS – and distributed control systems (DCS).
IOS	Malicious software designed to exploit Apple's iOS operating system running on smartphones, tablets, and other devices. Some variants of iOS malware have the capability of disabling the device, allowing a malicious actor to remotely control the device, track the user's activity, lock the device, or encrypt or steal personal information transmitted from or stored on the device. As users are increasingly turning to mobile devices for both business and personal use, cyber threat actors are increasingly devoting their efforts to developing malware designed to compromise mobile devices, including operating systems, like iOS, and applications, like those available in the App Store. Android devices have historically seen more malware threats than iOS largely due to the open-source operating system; however, malware specifically targeting iOS has increased in the last two years.
MACOS	Though the majority of known malware targeting operating systems are made to exploit Microsoft Windows, devices running macOS are vulnerable as well. Furthermore, as macOS has become increasingly popular, more malware has been created to target macOS. More macOS malware was discovered in the second quarter of 2017 than in all of 2016.
Point of Sale (PoS)	Malicious software designed to steal credit and debit card data from payment processing systems, known as point-of-sale (PoS) terminals.
Ransomware	Malicious software (malware) that attempts to extort money from victims by restricting access to a computer system or files. The most prevalent form of this profit-motivated malware is crypto-ransomware, which encrypts files into encoded messages that can only be decrypted (decoded) with a key held by the malicious actor.
Trojans	A type of malware that, unlike viruses and worms, does not self-replicate. Named after the mythological wooden horse used to sneak Greek warriors through the gates of Troy, trojans are often disguised as legitimate software to avoid detection or trick users into installing the trojan onto their system. Users can be exposed to trojans through numerous vectors, such as clicking on links or opening attachments in phishing emails, other forms of social engineering, malicious advertising (malvertisting), or by visiting compromised websites, known as drive-by downloads. Once a trojan executes, it often downloads other malware onto the system or provides an attacker with a backdoor to gain access and conduct further malicious activity, such as stealing, deleting, or modifying data.

Source: NJCCIC, 2017

Previous Occurrences and Losses

Cyber terrorism is an emerging hazard that can impact the County's computer infrastructure and the systems and services that are provided to the public. Across the United States, concerns over cyber terrorism are growing; former Federal

Bureau of Investigation (FBI) director Louis Freeh warns that cyber-terrorism could have a crippling effect in the United States (ANI, 2013).

Since 2016, New Jersey has released annual statistics on cyber breaches. The information released details breaches that involve the unauthorized access to personal information, such as a name, social security number, driver's license number, bank account, or other personally identifiable information (PII). In 2022, the State Police had 2023 data breaches reported to them. The number of threats reported has remained fairly constant as compared to 2022 (531) and 2021 (559)[6].

In 2018, a hacker maliciously attacked a small business in Asbury Park, stealing their domain name, hacking emails, and taking over the business' social media accounts. As a result, the business had to rename their company[7]. In 2023, The names, social security numbers, dates of birth, financial information, and medical and/or health insurance information of students in the Shore Regional High School District may have been exposed in a cyber attack[8]. The event even led to classes being canceled in Freehold Township.

Probability of Future Occurrence

Security experts describe the threat of cyber terrorism as eminent and highly likely to occur in any given year in New Jersey. As illustrated by the Freeh comments, cyber terrorism is expected to have a significant impact on the United States and New Jersey. The level of success of an attack and the subsequent damage it can create will vary greatly. Intrusion detection systems log thousands of attempts in a single month.

Although number of attempts are increasing, municipalities have also been investing in capabilities to reduce the vulnerability to cyber-attack.

Potential Effects of Climate Change

This plan does not recognize the link between cyber-attack and climate change.

Vulnerability Assessment

A cyber-attack can have potentially severe consequences. The following are potential impacts.

Table 4.21-2 Cyber Attack Impact Summary

Consideration	Description
General Public	Direct loss of life may occur when systems like Next Generation 9-1-1 (NG911) are attacked[9]. Indirect injuries or deaths may result from secondary effects to critical life-sustaining resources such as energy and water.
Response Personnel	No direct affects to the health and safety of response personnel are expected; however, critical response systems may be affected.
Property, Facilities and Infrastructure	Effects can range from annoyance to complete shutdown of critical infrastructures caused by infiltration of supervisory control and data acquisition (SCADA) systems. Secondary effects could disturb public welfare and property by denying services or providing false readings.
Economic	Because of the heavy reliance on the electronic transfer of economic and commercial information, the economy could be affected by communication difficulties.

[6] *HTTPS://WWW.CYBER.NJ.GOV/THREAT-LANDSCAPE/THREAT-ASSESSMENT*

[7] *HTTPS://WWW.APP.COM/STORY/MONEY/BUSINESS/CONSUMER/PRESS-ON-YOUR-SIDE/2019/01/22/ASBURY-PARK-SMALL-BUSINESS-NEARLY-KILLED-HACKER-AFTERRAIN-EPOCH-TRADING-POST/2265025002/*

[8] *HTTPS://WWW.NJ.COM/MONMOUTH/2024/05/NJ-HIGH-SCHOOL-STUDENTS-NAMES-SOCIAL-SECURITY-NUMBERS-MAY-HAVE-BEEN-EXPOSED-IN-DATA-BREACH.HTML*

[9] *HTTPS://WWW.DHS.GOV/SITES/DEFAULT/FILES/PUBLICATIONS/CYBERSECURITY%20RISKS%20FOR%20NG9-1-1%20%28100418%29_508C_FINAL.PDF*

Environment	Generally, cyber terrorism has no direct effect on the environment; however, the environment may be affected should a release of a hazardous material occur because of critical infrastructure failure.
Continuity of Operations	Severe effects to continuity of operations could result if a cyber-attack reached critical operational systems or systems that were needed to carry out the operation.
Reputation of the Entity	If exposed vulnerabilities were known and not reduced or eliminated before the attack, the entity would suffer major damage to their reputation for not taking action before the incident.
Delivery of Services	Cyber-attacks may affect delivery of services if the system was infiltrated and directed to malfunction by self-destructing or overloading.
Regulatory and Contractual Operations	Cyber-attacks would have no significant effect on regulatory or contractual obligations, other than the possible elimination of electronic records, which would affect both.

Source: NJ SHMP, 2024

A cyber terrorism attack can occur with relatively little or no warning. The New Jersey Office of Homeland and Preparedness is charged with gathering intelligence and monitoring cyber-terrorism threats affecting the State. At the federal level, numerous agencies (such as FBI and Central Intelligence Agency [CIA]) are working collaboratively to thwart cyber-terrorism attacks. The warning time depends upon the ability of these agencies to recognize that a threat exists and their ability to stop the attack. Even with these agencies on task to monitor cyber threats, a cyberattack can occur with no warning.

Because virtually all critical systems are reliant upon computer systems, the secondary hazards that could result from a cyber-terrorism attack could be devastating. For example, many of New Jersey's roadway systems rely on sophisticated traffic control systems that prevent gridlock and accidents daily. Without these systems, the risk of not only auto accidents increases, but also hazardous materials in-transit incidents. Additionally, a cyber-attack on a nuclear power plant could have devastating consequences should the plant suffer an intentional catastrophic failure. A cyber-attack could also completely incapacitate the communications infrastructure not only in New Jersey but across the United States, leading to disturbing secondary consequences and hazards. Because the power grid is also largely controlled by computer systems, a widespread power outage is also a possibility. A failure of the power grid would impact individuals reliant on power such as those with medical needs. The number of critical systems reliant on computer systems are numerous, thus disruption of one or more of the systems would cause severe secondary-cascading hazards.

For the purposes of this plan, the entire population of New Jersey is considered exposed to the effects of a cyber-terrorism attack. Because it is difficult to predict the particular target of cyber terrorism, assessing vulnerability to the hazard is also difficult. All populations who directly use a computer or those receiving services from automated systems are vulnerable to cyber terrorism. Although all individuals in New Jersey are vulnerable to an attack, certain types of attacks would impact specific segments of the population.

- If the cyber-attack targeted the State's power or utility grid, individuals with medical needs would be impacted the greatest. These populations are most vulnerable because many of the life-saving systems they rely on require power. Also, if an attack occurred during months of extreme hot or cold weather, New Jersey's elderly population (those 65 years of age and older) would be vulnerable to the effects of the lack of climate control. These individuals would require shelter or admission to a hospital. Other populations vulnerable to the secondary effects of cyber terrorism are young children.

- If a cyber-attack targeted a facility storing or manufacturing hazardous materials, individuals living adjacent to these facilities would be vulnerable to the secondary effects, should the attack successfully cause a critical failure at that facility. Individuals living within 10 miles of a nuclear power plant would be vulnerable should an attack occur at that caused a failure at a facility.

While these examples illustrate the vulnerability of specific populations to cyber-attacks, it is important to reiterate that because of the reliance on computerized systems, the entire population of New Jersey is vulnerable to cyber terrorism.

A significant portion of Monmouth County's economy is exposed to the effects of cyber-terrorist attacks. Cyber-crimes against banks and other financial institutions can cost many hundreds of millions of dollars every year. Cyber theft of intellectual property and business-confidential information can cost developed economies billions of dollars—how many billions is an open question. These losses could be considered simply the cost of doing business, or they could be a major new risk for companies and nations as these illicit acquisitions damage global economic competitiveness and undermine technological advantage (McAfee, 2013).

The cost of malicious cyber activity involves more than the loss of financial assets or intellectual property. Cyber-crimes can cause damage to a company's brand and reputation, consumer losses from fraud, the opportunity costs of service disruption and "cleaning up" after cyber incidents, and the cost of increased spending on cybersecurity (McAfee, 2013). In the United States, the costs of cyber terrorism are estimated somewhere between $24 billion and $120 billion annually. These costs represent approximately 0.2% to 0.8% of the total gross domestic product (GDP) in the United States (McAfee, 2013).

Given the proliferation of electronic commerce and the reliance on electronics, virtually all elements of New Jersey's economy are vulnerable to cyber-attacks. The secondary impacts of a significant attack would be devastating to the economy. For example, an attack that caused the loss of power to hundreds of thousands of businesses during peak holiday shopping months could potentially cost the State millions of dollars in tax revenue if these businesses were closed. Additionally, a disruption in New Jersey's manufacturing, agricultural, or tourism sectors would have devastating impacts on the economy. While it is difficult to quantitatively measure the economic impact of a cyber-terrorism attack, it is safe to say that the impact would be great, thus the economy is vulnerable to cyber-terrorism attacks.

Critical facilities are vulnerable to cyber-terrorism attacks based on the significance of the facilities, and the potential to interrupt critical systems in the County. As previously mentioned, many critical facilities are reliant upon computer networks to monitor and control critical functions. An example is nuclear power plants, which rely on sophisticated networks to prevent catastrophic failure. A cyber-terrorist attack could result in catastrophic failure of one of these facilities. Likewise, the power grid is reliant upon computer systems to distribute power to the County. These are just two examples of how critical facilities are vulnerable to cyber-terrorism attacks. Given the importance of critical facilities to daily living activities, these facilities are highly vulnerable to cyber-terrorism attacks.

It is difficult to quantify the potential losses to State facilities caused by a cyber-attack. As noted in the vulnerability assessment above, the physical facilities would not be damaged, other than the value of computer equipment damaged. The more significant loss would be to the functions of the facilities targeted and their value to the population of Monmouth County during the period of malfunction.

4.22 ECONOMIC DISRUPTION

Hazard Description

Economic Disruption is a breakdown in normal commerce facilitated by actions such as the destabilization of currency and/or hyperinflation, which results in social chaos or civil unrest. The term describes a variety of economic conditions from severe depressions with high unemployment and bankruptcy such as the Depression of the 1930s in the United States, to breakdowns of normal economic conditions such as hyperinflation or the effects of a sharp decline in population that causes an economic downturn.

Location and Extent

An economic disruption may impact some or all of Monmouth County, depending on the size and scope of the crisis. A major economic disruption would likely extend beyond Monmouth County and affect the entire State of New Jersey if not the nation. While social chaos and civil unrest could occur in specific locations, the effects of a severe and long-term event would eventually extend to all segments of the population.

Range of Magnitude

Economic disruption can be accompanied by social chaos and civil unrest. See Section 4.11 Civil Unrest for extent information regarding civil unrest.

Previous Occurrences and Losses

Two previous occurrences of a major economic disruption in New Jersey include the Great Recession of 2007, and the Great Depression of the 1930s. Both examples are described in the sections below.

The Great Depression

The Great Depression began when the stock market crashed on October 29, 1929, which marked the official beginning of the depression. Following the stock market crash, there was a run on the banks, forcing many thousands of banks to close. Businesses and segments of industry were also affected. Having lost much of their own capital in either the Stock Market Crash or the bank closures, many businesses started cutting back their workers' hours or wages. In turn, consumers began to curb their spending, refraining from purchasing such things as luxury goods. This lack of consumer spending caused additional businesses to cut back wages or, more drastically, to lay off some of their workers. Even with these cuts, many businesses could not stay open and soon closed their doors, leaving all their workers unemployed (Rosenberg, 2017).

The Great Depression continued through the 1930s until the bombing of Pearl Harbor and the entrance of the United States into World War II. Once the United States was involved in the war, both the United States people and industry became essential to the war effort. Weapons, artillery, ships, and airplanes were needed quickly. Men were trained to become soldiers and the women were kept on the home-front to keep the factories going. Food needed to be grown to feed the national population and to send overseas (Rosenberg, 2017).

In the United States, 13 million people were unemployed, and in 1932, 34 million people belonged to a family with no regular full-time wage earner. Industrial production fell nearly 45% and homebuilding dropped by 80% between 1929 and 1932. Unemployment rates soared across the country, peaking at 80% in Toledo, Ohio. Finally, from 1929 through 1933 the stock market lost approximately 90% of its value.

Before the Depression, New Jersey was experiencing the prosperity felt throughout the country in the 1920s. Developments brought many people a sense of hope for the future. However, this progress came crashing down with the onset of the Great Depression. New Jersey was severely hit when thousands of workers were laid off and had to rely on relief checks to survive. The impacted factories could not sell what they produced. The State attempted to aid the unemployed by establishing the Emergency Relief Administration, which gave $10 million to bankrupt areas. Franklin D. Roosevelt's Works Progress Administration (WPA) was a significant program in the New Deal that helped New Jersey succeed in establishing a strong workforce. WPA workers helped to improve roads, buildings, and other facilities and work from writers and artists aided in preserving the history of the time period (Kiefer, 2005).

Great Recession 2007

The Great Recession of 2007 affected the global economy and is the most recent example of a financial crisis affecting Monmouth County. The official time period of the recession occurred from December 2007 through June 2009. However, the effects of the recession continue to linger to the present. While the specific triggers of the recession have been debated, a combination of bursting of the United States housing bubble and subsequent foreclosures, subprime lending, mortgage fraud, predatory lending, high private debt limits, and mortgage underwriting are all cited as triggers that contributed to the financial crisis.

In the United States, the effects of the Great Recession were severe and far-reaching. The GDP contracted nearly $850 billion or 5.5% below its potential level, from 2008 through 2010 (FRED, 2013). The unemployment rate rose from its pre-recession level of 5% to over 10% at its peak late in 2009 (FRED, 2013). The number of unemployed individuals in the United States rose to 15 million at its peak in 2009, up from 7 million at the pre-crisis level (FRED, 2013). The housing market was particularly hard hit as housing prices fell approximately 30% from their peak in mid-2006 (FRED, 2013). Additionally, the stock market was affected as the Standard & Poor's (S&P) 500 index fell 57% from the October 2007 peak of 1,565, to a low of 676 in March 2009. Stock prices rose to pre-recession peak levels in April 2013.

New Jersey's recession began in January 2008, one month after it started nationally, and lasted through July 2009. The State lost 161,300 jobs, or 4 percent of its employment base. During the recession's first year, the State and national job bases declined at the same rate, but in 2009, the Garden State had shed jobs at a slower pace: 1.8 percent compared to the 2.9 percent national rate. With the deepening recession, New Jersey's unemployment rate increased sharply, from 4.5 percent in December 2007 to 6.8 percent 1 year later, and to 9.8 percent in September 2009. At the same time, growth in personal income fell, from 5.7 percent in 2007 to 3. percent in 2008 (Manas, 2009). The Great Recession also led to a significant tightening of the State budget. In fact, in 2009 New Jersey had a budget gap of $9 billion, or roughly 25 percent of the State's budget (Deitz et al. 2010). Although this recession has adversely affected the State, its effects pale in comparison to the Great Depression of the 1930s.

Although the Great Recession and the Great Depression were significant economic disruptions, they still do not represent true economic collapses. The effects of a true economic disruption on society would be much more severe than the effects experienced during these past occurrences.

Probability of Future Occurrences

The probability of an economic disruption is low, especially in New Jersey and in the United States as a whole. Although it was the closest the United States has come to a complete economic disruption, the Great Depression of the 1930s was not an economic disruption in the true sense of the definition.

Potential Effects of Climate Change

Sea level rise influenced by climate change may force affected property values lower. This could have an impact on revenue and local and State debt. Unlike prior housing downturns, there will not be a recovery to these property values.

Vulnerability Assessment

Events that include characteristics of economic disruption can range in severity from severe recessions (2007) and depressions (1930s) to complete economic failure. A complete economic disruption is characterized by hyperinflation, high unemployment rates, and societal breakdown. As mentioned, a complete economic disruption has never occurred in the United States.

Economic disruptions can occur quickly with relatively little warning (such as Black Tuesday). However, many experts believe they are able to recognize and warn against the signs of an economic disruption. Social disruption such as coups and wars can trigger an economic disruption to quickly follow.

Civil unrest is one of the primary secondary effects of economic disruption. During periods of economic instability, societal conditions may deteriorate, leading to civil unrest. Additionally, during or near economic disruptions workers may go on strike, as did the ditch diggers who went on strike in New Jersey during the Great Depression.

Another secondary hazard during economic disruption is pandemic. Because many families are unable to meet basic hygiene needs, diseases historically spread quickly through communities. During the Great Depression, the spread of tuberculosis significantly impacted large segments of the population.

Because an economic disruption would affect all segments of the population, all Monmouth County residents are vulnerable to the impact of this hazard. Although all of the population would be affected, the very young and elderly would be more vulnerable to the secondary hazard of pandemic than the rest of the population. Also, very young and elderly residents are vulnerable to the effects of malnutrition, which often results during these incidents. Aside from the health effects during economic disruption, lower-income individuals who struggle to cover average costs of living during thriving financial times would be greatly affected by economic disruption and would therefore be more vulnerable.

The entire Monmouth County economy is exposed to the effects of economic disruption. In today's global economy, Monmouth County's economy is vulnerable to disruption, and the effects of financial disruptions of governments around the world. The Great Recession demonstrated how economic conditions in one nation affect others around the world, demonstrating that counties and sub-national governments are vulnerable to the effects of economic disruption. The Great Recession also illustrated the ways in which state governments are vulnerable. During the most recent recession, New Jersey experienced a $9 billion budget shortfall. Also, it is apparent the economic recovery can take years, even decades.

Critical facilities are also exposed to the effects of economic disruption. Maintaining these facilities and infrastructure systems will be particular challenging when agencies managing these facilities lose operating capital and thus cannot maintain the facilities. This may lead to critical infrastructure failure. Whether they are privately or publicly owned, all critical facilities will be vulnerable to economic disruption.

4.23 PANDEMIC

Hazard Description

A pandemic is a global outbreak of disease. Pandemics happen when a new virus emerges to infect people and can spread between people sustainably. Because there is little to no pre-existing immunity against the new virus, it spreads worldwide. Conversely, an epidemic is much more limited in effect and impact and is usually restricted to one locale (U.S. Centers for Disease Control and Prevention [CDC], 2020).

In New Jersey, a municipality in which a pandemic occurs bears the first and primary responsibility to control the epidemic. Pandemics that remain uncontrolled warrant local mutual aid from neighboring municipal and/or County and State resources. If the epidemic remains beyond the capabilities of local law enforcement agencies alone, limited State Police assistance may be requested. If the restoration of public health is beyond local, County, and State abilities, the Governor may declare a state of emergency calling on Federal and worldwide support.

This section discusses some of the most severe global disease outbreaks that affected New Jersey within the last 100 years.

Coronavirus

Three versions of the coronavirus have affected New Jersey in the last two decades; Severe Acute Respiratory Syndrome (SARS-CoV), Middle East Respiratory Syndrome (MERS-CoV), and "SARS-CoV-2" also named Coronavirus Disease 2019 (COVID-19). Coronaviruses are a large family of viruses that are common in people and many different species of animals, including camels, cattle, cats, and bats. Animal coronaviruses can infect people and then spread between people, which is how SARS, MERS, and COVID-19 originated (CDC, 2020).

- SARS was first reported in Asia in February 2003 and spread to more than two dozen countries in North America, South America, Europe, and Asia before the SARS global outbreak of 2003 was contained. SARS causes mild to moderate upper respiratory tract illness in humans, including the common cold. No single medicine can effectively treat SARS. Different types of treatment regimens have been used for people who are severely ill and hospitalized including antibiotics, antivirals and steroids. Currently, there is no known SARS transmission anywhere in the world (CDC, 2020).
- MERS was first reported in Saudi Arabia in September 2012, however after further investigation, the first known cases of MERS occurred in Jordan in April 2012. Most MERS patients developed severe respiratory illness with symptoms of fever, cough and shortness of breath. About 3 or 4 out of every 10 patients reported with MERS have died (CDC, 2020).
- Coronavirus disease 2019, also known as COVID-19, is a very contagious disease caused by the virus SARS-CoV-2. When a person infected with COVID-19 breathes, droplets and very small particles that contain the virus can spread and infect other around them. COVID-19 can also spread through droplets and particles that land on people's eyes, nose, or mouth or when people touch contaminated surfaces. Once infected, people may first notice symptoms 2-14 days after being exposed to the virus. People infected with COVID-19 most commonly experience respiratory cold- and flu-like symptoms, although the disease may affect other parts of the body (CDC, 2023a).

Foodborne Disease Outbreaks

Food-borne illness is caused by consuming contaminated foods or beverages. Many different disease-causing microbes or pathogens can contaminate foods, so there are many different types of food-borne illnesses. Food-borne illness, caused by a variety of bacteria, viruses, and parasites, can be caused by consuming improperly prepared food items, poor hygiene among food handlers, or contamination in food processing facilities or farms. (NJDOH, 2020).

Mumps

Mumps is a contagious disease that is caused by a virus. It typically starts with a few days of fever, headache, muscle aches, tiredness, and loss of appetite (CDC, 2020).

Norovirus

Norovirus is a very contagious virus that spreads easily and causes vomiting and diarrhea in people. People with norovirus illness can shed billions of norovirus particles however only a few virus particles can make other people sick. The norovirus is not related to Influenza. (CDC, 2020).

Influenza

Influenza, known as the flu, comes in four type of viruses: A, B, C and D. Human influenza A and B viruses cause seasonal epidemics of disease (known as the flu season) almost every winter in the United States. Influenza A viruses are the only influenza viruses known to cause flu pandemics. Pandemics happen when new (novel) influenza A viruses emerge which are able to infect people easily and spread from person to person in an efficient and sustained way (CDC, 2020).

West Nile Virus

West Nile Virus is the leading cause of mosquito-borne disease in the continental United States. There are no vaccines to prevent or medications to treat the virus in people. Fortunately, most people infected do not feel sick. About 1 in 5 people who are infected develop a fever and other symptoms. About 1 out of 150 infected people develop a serious, sometimes fatal, illness (CDC, 2020).

Zika Virus

Zika Virus disease is caused by the Zika virus, which is spread to people primarily through the bite of an infected mosquito. The illness is usually mild with symptoms lasting up to a week, and many people do not have symptoms or will have only mild symptoms. However, Zika virus infection during pregnancy can cause a serious birth defect called microcephaly and other severe brain defects (CDC, 2020).

Location and Extent

Compared to epidemics which occur in a smaller geographic area, pandemics affect larger areas and populations. The exact location and extent of a pandemic depends on how easily the illness is spread, the mode of transmission, and the amount of contact between infected and uninfected individuals, Pandemics can occur anywhere including Monmouth County. Monmouth County may be more vulnerable to pandemic than other areas in the country due to geographic and demographic factors such as the comparatively dense population. Additional factors such as vaccination rates influence the ability of the illness to spread.

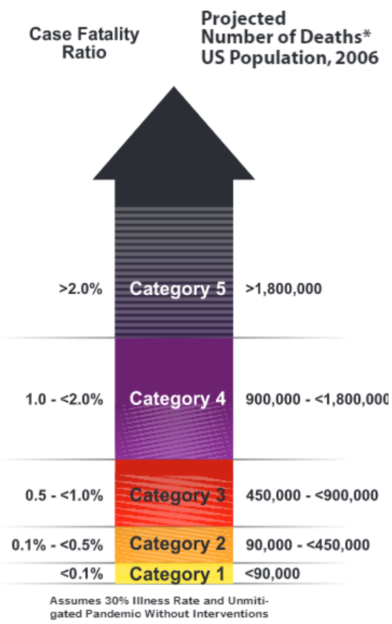
Vaccination Rates in Monmouth County

In Monmouth County, approximately 89.3% of children in Childcare, Pre-K, Kindergarten, and Grade 6 were immunized during the 2023-2024 school year, the lowest percentage of all New Jersey counties. This number is down from 90.7% during the 2022-2023 school year, following a general decreasing trend since the last plan update (Annual Immunization Status Reports, Communicable Disease Service, New Jersey Department of Health). Of the approximately 10% of non-immunized children, approximately 7.5% claimed a Religious Exemption, up from 5.5% during the 2022-2023 school year. Monmouth County has the second highest percent of Religious Exemptions in the State of New Jersey for the 2023-2024 school year behind Cape May County (7.7%). Only 0.3% of enrolled children claimed a medical exemption during the 2022-2023 and 2023-2024 school years (Annual Immunization Status Reports, Communicable Disease Service, New Jersey Department of Health).

Range of Magnitude

The severity of a pandemic or infectious disease threat in New Jersey will range significantly depending on the aggressiveness of the virus in question and the ease of transmission. Pandemics around the nation have the potential to affect New Jersey's populated areas.

Figure 4.23-1 Pandemic Severity



Source: NJDOH, 2012

The CDC and Prevention Community Strategy for Pandemic Influenza Mitigation guidance introduced a Pandemic Severity Index (PSI), which uses the case fatality ratio as the critical driver for categorizing the severity of a pandemic. The index is designed to estimate the severity of a pandemic on a population to allow better forecasting of the impact of a pandemic, and to enable recommendations on the use of mitigation interventions that are matched to the severity of influenza pandemic.

The severity and length of the next pandemic cannot be predicted; however, experts expect that its effect on the United States could be severe. Based on previous pandemics and without medications or vaccines available, it is estimated that a severe pandemic could cause almost 2 million deaths in the United States, more than nine million hospitalizations, and more than 90 million people ill (NJDOH, 2012). Pandemics are assigned to one of five discrete categories of increasing severity (Category 1 to Category 5) (NJDOH, 2017). **Figure 4.23 – 1 Pandemic Severity Index** illustrates the five categories of the PSI.

Pandemics are inevitable and arrive with very little warning. Air travel could hasten the spread of a new virus and decrease the time available for implementing interventions. Outbreaks are expected to occur simultaneously throughout much of the United States, preventing shifts in human and material resources. Warning time for any pandemic will depend on the origin of the virus and the amount of time needed to identify the virus.

Previous Occurrences and Losses

Table 4.23 - 1 Previous Pandemic Occurrences provides details on pandemic events that have impacted New Jersey.

Table 4.23-1 Previous Pandemic Occurrences

Date(s) of Event	Event Type	Area Affected	Description
1918-1919	1918 "Spanish" Influenza Pandemic	Statewide	The influenza pandemic of 1918-1919 caused between 20 and 40 million deaths, more than World War I. This pandemic has been cited as the most devastating pandemic in recorded history. More people died of influenza in a single year than in the four years of the Black Death Bubonic Plague from 1347 to 1351. By September 27, 1918, the State health officer announced that the disease "was unusually prevalent" throughout New Jersey. The State was reporting that 2,000 cases had been reported in the preceding three days. On October 10, State officials formally banned all public gatherings. By October 15, officials had reported 88,256 cases of influenza. By the October 22, State authorities estimated that there were at least 149,540 cases, with 4,398 deaths being officially reported. On October 22, the pandemic peaked in New Jersey. On that day, there were 7,449 new cases and 366 deaths. The situation slowly improved after the third week of October.
1999-2002	West Nile Virus Outbreak	Statewide	WNV was identified in New York City in 1999, and spread rapidly across the United States, with human disease documented in 39 states and the District of Columbia. In 2002, WNV spread westward and activity was reported in all but six states (Arizona, Utah, Nevada, Oregon, Alaska, and Hawaii) and triggered the largest human arboviral encephalitis epidemic in U.S. history. From June 10 to December 31, 2002, there were 4,156 cases of WNV (including 284 deaths) reported in 39 states and the District of Columbia.

Date(s) of Event	Event Type	Area Affected	Description
2002-2003	SARS coronavirus (SARS-CoV)	Statewide	SARS coronavirus (SARS-CoV) – virus identified in 2003. SARS-CoV is thought to be an animal virus from an as-yet-uncertain animal reservoir, perhaps bats, that spread to other animals (civet cats) and first infected humans in the Guangdong province of southern China in 2002. SARS affected 26 countries and resulted in more than 8,000 cases in 2003. Since then, a small number of cases have occurred as a result of laboratory accidents or, possibly, through animal-to-human transmission (WHO, 2020)
04/15/2009	Global H1N1 Pandemic	Statewide	The first novel H1N1 patient in the United States was confirmed April 15, 2009. The second patient was confirmed on April 17, 2009. On April 22, the CDC activated its Emergency Operations Center to better coordinate the public health response. On April 26, 2009, the U.S. government declared a public health emergency and began actively and aggressively implementing the country's pandemic response plan. By June 19, 2009, all 50 states in the United States reported novel H1N1 infection. On June 11, 2009, the WHO signaled that a global pandemic of H1N1 was underway by raising the worldwide pandemic alert level to Phase 6. At the time, more than 70 countries had reported cases of novel influenza A (H1N1) infection. In total there were 18,306 lab-confirmed deaths as a result of H1N1 worldwide. In the United States between April 2009 and August 2009 there were 9,079 cases that required hospitalization and 593 deaths. In New Jersey, cases were widespread in July 2009, with 1,414 confirmed cases and 15 deaths.
January – 2/1/2011	Escherichia coli O157:H7	N/A	Between January 10 and February 15, 2011, a total of 14 persons were infected with the outbreak strain of Escherichia coli O157:H7 were reported in five states, including two reports in New Jersey. Three of the 14 were hospitalized; no deaths occurred. The outbreak was associated with Lebanon bologna.
February – September 2011	Salmonella Heidelberg	N/A	Between February 27 and September 13, 2011, a total of 136 persons infected with the outbreak strain of Salmonella Heidelberg were reported from 34 states, including one report in New Jersey. Ill persons ranged in age from less than one year old to 90years old. Thirty-seven people were hospitalized; one death was reported.
April – November 2011	Salmonella Heidelberg	N/A	Between April 1 and November 17, 2011, a total of 190 illnesses occurred due to Salmonella Heidelberg that was linked to kosher broiled chicken livers. Sixty-two of those illnesses were reported in New Jersey. Ill person's ages ranged from less than 1 year old to 97 years old. Thirty of the infected people were hospitalized.
8/1/2011	Salmonella Enteritidis	N/A	A total of 43 individuals infected with the outbreak strain of Salmonella Enteritidis were reported from five states, including two cases in New Jersey. Ill persons ranged in age from less than one year old to 94 years old. Two patients were hospitalized; no deaths occurred. The outbreak was linked to Turkish pine nuts purchased from bulk bins at Wegmans grocery stores.
January – June 2012	Salmonella Infantis	N/A	Between January 4 and June 26, 2012, a total of 49 individuals (human) were infected with the outbreak strain of Salmonella Infantis linked to multiple brands of dry dog food produced by Diamond Pet Foods produced at a facility in Gaston, South Carolina. Ten people were hospitalized; there were no deaths. Twenty states reported an outbreak, including two cases in New Jersey. Ill persons ranged in age from less than 1 year old to 82 years old.
January – July 2012	Salmonella Bareilly and Salmonella Nchanga	N/A	Between January 1 and July 7, 2012, a total of 425 individuals were infected with the outbreak strain of Salmonella Bareillyand Salmonella Nchanga. Twenty-eight states reported outbreaks, included 46 cases in New Jersey. The outbreaks were associated with an imported frozen raw yellowfin tuna product, known as Nakaochi Scrape, from Moon Marine USA Corporation. Ill persons ages ranged from less than 1 year old to 86 years old.
March-September 2012	Salmonella Infantis, *Salmonella* Newport, and *Salmonella* Lille	N/A	Between March 1 and September 24, 2012, a total of 195 individuals were infected with the outbreak strain of Salmonella Infantis, Salmonella Newport, and Salmonella Lille. Twenty-seven states reported an outbreak, including five cases in New Jersey. The outbreak was linked to chicks, ducklings, and other live poultry from Mt. Healthy Hatchery in Ohio. Ill persons ranged in age from less than 1 year old to 100 years old.

Date(s) of Event	Event Type	Area Affected	Description
March-October 2012	Listeria monocytogenes Outbreak	N/A	Between March 28 and October 6, 2012, a total of 22 individuals were infected with the outbreak strain of Listeria monocytogenes. Ricotta salata cheese was the likely source of this outbreak. Thirteen states reported an outbreak, including three cases in New Jersey. Twenty of the persons infected were hospitalized, nine were related to pregnancy, and three were diagnosed in newborns. The others ranged from 30 years old to 87 years old.
June-September 2012	Salmonella Bredeney	N/A	Between June 14 and September 21, 2012, a total of 42 individuals were infected with the outbreak strain of Salmonella Bredeney. The outbreak was linked to Trader Joe's Valencia Peanut Butter. Twenty states reported an outbreak, including two cases in New Jersey. Ill persons ranged in age from less than 1 year old to 79 years old, with a median age of 7 years old.
July-September 2012	Salmonella Braenderup, *Salmonella* Typhimurium and Newport	N/A	Between July 3 and September 1, 2012, a total of 127 individuals were infected with the outbreak of Salmonella Braenderup linked to mangoes originating from Agricola Daniella of Sinaloa, Mexico. Fifteen states reported an outbreak, including one case in New Jersey. Ill persons ranged in age from less than 1 year old to 86 years old. Between July 6 and September 16, 2012, a total of 261 individuals were infected with the outbreak of Salmonella Typhimurium and Newport linked to cantaloupe originating from Chamberlain Farms Produce in Owensville, Indiana. Twenty-four states reported an outbreak, including two cases in New Jersey. Ill persons ranged from less than one year old to 100 years old.
2012	West Nile Virus Outbreak	Statewide	During the summer-fall months of 2012, the worst WNV outbreak in the United States occurred. As of December 11, 2012, 48 states reported WNV infections in people, birds, or mosquitoes. A total of 5,387 cases of WNV in people, including 243 deaths, have been reported to CDC. Of these, 2,734 (51%) were classified as neuroinvasive disease (such as meningitis or encephalitis) and 2,653 (49%) were classified as non-neuroinvasive disease. In New Jersey, there were 46 positive test results.
2012	Middle East Respiratory Syndrome (MERS)	Statewide	Health officials first reported the disease in Saudi Arabia in September 2012. Through retrospective (backward-looking) investigations, they later identified that the first known cases of MERS occurred in Jordan in April 2012. So far, all cases of MERS have been linked through travel to, or residence in, countries in and near the Arabian Peninsula. The largest known outbreak of MERS outside the Arabian Peninsula occurred in the Republic of Korea in 2015. The outbreak was associated with a traveler returning from the Arabian Peninsula (CDC, 2020).
July-October 2016	Zika Outbreak	Statewide	In August 2016 the number of Zika cases reported in New Jersey reached over 100. Two counties - Bergen and Passaic - accounted for more than a third of the cases statewide.
2019 Measles Outbreak	2019 Pacific Northwest measles outbreak	Statewide	The New Jersey Department of Health (NJDOH) and local health officials identified 33 cases of measles (30 confirmed cases in Ocean County and 3 connected cases in a Passaic County household) in an outbreak investigation lasting from October 2018 to January 2019. NJDOH and local officials then identified 12 cases of measles in Ocean and Monmouth counties in an investigation lasting from March 2019 to May 2019. Eight cases were confirmed in Ocean County and four cases were confirmed in one household in Monmouth County connected to the Ocean cases. All individuals involved in the more recent outbreak were unvaccinated or had no documentation of vaccination against measles.
January 2020- May 2023	Coronavirus Disease 2019 (COVID-19)	Statewide	The first confirmed case of COVID-19 in the U.S. was in Washington State on January 21, 2020; the first confirmed case in New Jersey was reported on March 4, 2020. From March 2020 to August 24, 2023, there have been 2,588,728 confirmed cases of COVID-19 in New Jersey. During that period, 172,973 people have been hospitalized with confirmed cases and 36,242 have died in deaths associated with COVID-19.

Sources: Billings 1997; DHHS 2013; CDC 2008; CDC 2009; WHO 2010; CDC 2011; Laday, 2012; Jaslow, 2012; Rochabrun, 2012; Rochabrun, Nj.com, 2016; 2012; CDC, 2018, CDC 2023a

Table 4.23-2 Communicable Disease Incidence in Monmouth County depicts the number of Reportable Diseases along with the Number of Cases by Year from 2021-2023, as reported by the New Jersey Department of Health (NJDOH). Campylobacteriosis (food-borne disease), Chronic Hepatitis C, COVID-19, Influenza-Type A, Influenza-Type B, Lyme Disease, Non-Typhoid Salmonellosis (food-borne disease), Shiga Toxin-Producing E.Coli (STEC) - Non O157:H7 (food-borne disease), and Shigellosis (food-borne disease) had a number of cases in the triple- and quadruple-digits. The table and chart depict counts of communicable diseases in Monmouth County through the years of 2021-2023.

Table 4.23-2 Communicable Disease Incidence in Monmouth County, 2022-2023

Reportable Disease	2021	2022	2023	3-Year Total
Alpha-Gal Syndrome	0	18	43	61
Amoebiasis	1	2	8	11
Babesiosis	34	25	32	91
Botulism - Infant	2	0	3	5
Brucellosis	0	0	1	1
Campylobacteriosis	83	111	149	343
Cryptosporidiosis	7	26	10	43
Cyclosporiasis	6	4	8	18
Dengue Fever- Dengue	0	1	0	1
Dengue Fever – Dengue-Like Illness	1	0	0	1
Ehrlichiosis/Anaplasmosis Anaplasma Phagocytophilum (Previously HGE)	6	3	6	15
Ehrlichiosis/Anaplasmosis - Ehrlichia Chaffeensis (Previously HME)	10	16	10	36
Ehrlichiosis/Anaplasmosis - Ehrlichia Ewingii	0	0	0	0
Giardiasis	13	20	27	60
Haemophilus Influenzae	7	15	20	42
Hepatitis A	4	0	8	12
Hepatitis B - Acute	0	0	3	3
Hepatitis B - Chronic	9	12	16	37
Hepatitis C - Acute	9	6	7	22
Hepatitis C - Chronic	296	262	138	696
Influenza, Human Isolates - Type 2009 H1N1	2	224	287	513
Influenza, Human Isolates - Type A (Subtyping Not Done)	873	5,304	2,482	8,659
Influenza, Human Isolates - Type A H3	87	1338	90	1,515
Influenza, Human Isolates - Type B	21	14	376	411
Legionellosis	9	10	15	34
Listeriosis	6	9	4	19
Lyme Disease	305	580	680	1,565
Leptospirosis	0	0	1	1
Malaria	1	1	1	3
Meningococcal Disease (Neisseria Meningitidis)	0	0	1	1
Mpox	0	38	2	40
Multisystem Inflammatory Syndrome (MIS)	0	3	0	3
Mumps	0	1	5	6
Novel Coronavirus-2019 NCOV	93,244	84,212	21,126	198,582
Pertussis	2	8	17	27

Reportable Disease	2021	2022	2023	3-Year Total
Salmonellosis - Non-Typhoid	88	133	101	322
Salmonellosis- Paratyphoid Fever	0	1	0	1
Shiga Toxin-Producing E.Coli (STEC)	0	21	20	41
Shiga Toxin-Producing E.Coli (STEC) - Non O157:H7	0	0	1	1
Shiga Toxin-Producing E.Coli (STEC) - O157:H7	2	1	1	4
Shigellosis	28	73	48	149
Spotted Fever Group Rickettsiosis	4	2	0	6
Streptococcus Agalactiae (GBS)	0	1	1	2
Streptococcus Pneumoniae	22	37	61	120
Streptococcus Pyogenes (GAS) - With Toxic Shock Syndrome	0	2	2	4
Streptococcus Pyogenes (GAS) - Without Toxic Shock Syndrome	19	21	31	71
Typhoid Fever	1	0	1	2
Varicella	7	23	14	44
Vibrio Infections (Other Than V.Cholerae Spp.)	13	11	15	39
West Nile Virus (WNV)	5	5	1	11
Yersiniosis	1	0	2	3
Totals	**95,228**	**92,594**	**25,875**	**213,697**

Source: Communicable Disease Reporting and Surveillance System, New Jersey Department of Health, 2024

Probability of Future Occurrences

It is difficult to predict when the next pandemic will occur and how severe it will be because viruses are always changing. The United States and other countries are constantly preparing to respond to pandemic. The Department of Health and Human Services and others are developing supplies of vaccines and medicines. Severity of the threat of pandemic is likely to increase. Factors, such as expanded rapid travel and evolution of resistance to medical treatments, are already changing the ways pathogens infect people, plants, and animals.

In Monmouth County, the probability for a future pandemic event is dependent on several factors. One factor that influences the spread of disease is population density. Populations that live close to one another are more likely to spread diseases. As population density increases in the State, so too will the probability of a pandemic event occurring. As seen in the COVID-19 pandemic, the State advised people to practice social distancing of at least six feet from other people to minimize the spread of the virus.

As previously shown, Monmouth County has a high percentage of unvaccinated school-aged children relative to the rest of the State and saw an increase from the 2022-2023 school year to the 2023-2024 school year. Further, the 2019 Measles Outbreak demonstrates how communicable diseases can spread across neighboring counties. Monmouth County should be advised that a growing unvaccinated community could decrease the County’s herd immunity and increase the probability of an outbreak.

Potential Effects of Climate Change

Climate change has the potential to increase the probability of pandemic occurring. While the relationship between climate change and increase in virus susceptibility is difficult to predict with certainty, there are scientific linkages between the two. As warm habitats that host insects such as mosquitoes increase, more of the population becomes exposed to potential virus threats (The Washington Post, 2017). The notion that rising temperatures will increase the number of mosquitoes that can transmit diseases such as West Nile Virus and Zika among humans (rather than just shift their range) has been the subject of debate over the past decade. Milder winters can also lead to increasing tick populations and increase in risk of contracting Lyme disease. Some believe that climate change may affect the spread of disease, while others are not convinced. However, many researchers point out that climate is not the only force at work in increasing the spread of infectious diseases into the future.

Vulnerability Assessment

The entire County's population is vulnerable to the effects of a pandemic. Areas with higher population density are more prone to being exposed to a virus. Additionally, vulnerable populations such as the young and elderly are considered at higher risk. The most significant impact on critical facilities would be the increase in hospitalization and emergency room visits that would take place as a result of the outbreak. This would create a greater demand on these critical facilities, their staff, and resources. CDC's model estimates an increase of more than 25% in the demand for hospitalization and intensive care unit services, even in a 'moderate pandemic' (United States Department of Health and Human Services, 2005). In addition to higher demand of critical facility use, it could be anticipated that there would be fewer employees available to run facilities. Employees who are unable to come to work would result in a loss of service, impacting the function of critical facilities. In addition to life and safety, a pandemic would have a significant impact on the economy in Monmouth County. There is the potential for shutdowns and social distancing requirements such as those experienced during the COVID-19 pandemic which could harm local businesses and lead to an increase in unemployment, especially in the services sector of the economy.

4.24 POWER FAILURE

Hazard Description

Power failure is defined as any interruption or loss of electrical service caused by disruption of power transmission caused by accident, sabotage, natural hazards, or equipment failure (also referred to as a loss of power or power outage). A significant power failure is defined as any incident of a long duration which would require the involvement of the local and/or State emergency management organizations to coordinate provision of food, water, heating, cooling, and shelter.

Location and Extent

Power failures in New Jersey are usually localized and are usually the result of a natural hazard event involving high winds or ice storms. New Jersey's power systems are overseen by the State of New Jersey Board of Public Utilities. Under New Jersey law, consumers can shop for electric suppliers through a variety of third-party vendors. While the supply portion of energy is open to competition, the delivery of electricity is limited geographically to the following service providers: Atlantic City Electric, Jersey Central Power and Light (JCP&L), Rockland Electric Company, and Public Service Electric and Gas (PSE&G). In Monmouth County, JCP&L is responsible for maintaining power in most of the County, although a small portion is covered by PSE&G. Power systems across the State are supported by a vast network of delivery systems, which bridge the gap between supplier and customer.

Power failure is particularly problematic for homes that are heated with electricity. Widespread power outages during the winter months can directly impact vulnerable populations such as the elderly and medically frail. According to the 2021 American Community Survey 5-year estimates, 30,627 homes across Monmouth County are heated with electricity. This represents roughly 12.5% of the total homes in the County (US Census, 2021). Almost all homes depend on electricity for cooling, through use of air conditioning and fans. Power failure can present a problem when it occurs in tandem with a heatwave.

Aside from the importance of power to heat and cool homes, power is vital to maintain out-of-hospital lifesaving systems for patients such as oxygen concentrators and ventilation machines. Without power, these individuals will require shelter at a medical-needs shelter or admission to a hospital.

Range of Magnitude

Power failures can range in duration from a few minutes to multiple days and also in the extent of impacts, from minor loss of communication systems at a facility to catastrophic loss of lifelines such as water and electricity. Utility interruptions usually occur because of, or in combination with, other emergency or disaster incidents, such as severe weather and flooding, and can exacerbate such emergencies.

Power failures often result from damage to or electrical hazards within an electric power system. System components include power generation plants, substations, circuits, switches, transformers, power lines, and power poles. Due to the varied nature of power outage causes ranging from vehicle accidents to severe weather, utility interruptions can happen at any time.

Power disruption can lead to significant consequences, including service disruption, disruption to infrastructure operations, and loss of heat or cooling that can cause further disturbance or injury.

Previous Occurrences and Losses

Monmouth County has experienced several widespread power outage incidents. These incidents have been caused by both natural and non-natural hazards. Recent and significant power outages are summarized in **Table 4.24-1 Historical Power Loss Events**. It is worth noting that power failure incidents occur frequently, often on smaller scales associated with high winds, ice storms, and power grid issues. Data were not readily available on the frequency of smaller power outages across the State.

Table 4.24-1 Historical Power Loss Events

Date(s) of Event	Event Type	Description
11/9/1965	Northeast Blackout of 1965	The Northeast Blackout of 1965 was a significant disruption in the supply of electricity, affecting parts of Ontario in Canada and Connecticut, Massachusetts, New Hampshire, Rhode Island, Vermont, New York, and New Jersey in the United States. Over 30 million people and 80,000 square miles (207,000 square kilometers) were left without electricity for up to 12 hours. The cause of the failure was human error that happened days before the blackout.
7/14/1977	New York City Blackout 1977	On July 14, 1977, lightning hit two Con Edison transmission lines north of New York City, tripping relays that soon shut down power plants in the New York metropolitan area. Parts of the City were dark for more than 25 hours, and there was widespread looting.
9/27/1985	Hurricane Gloria	The storm knocked out power and forced people to be evacuated from homes along the Jersey Shore, including Monmouth County. Gloria downed thousands of trees and caused extensive power outages across the State.
10/10/1992 – 10/12/1992	Nor'easter	The December 1992 Nor'easter produced record-high tides and snowfall across the northeastern United States. Throughout New Jersey, the Nor'easter damaged about 3,200 homes and caused an estimated $750 million in damage. Additionally, the storm left 102,000 customers of Jersey Central Power and Light without power. Damage to short circuits caused house fires in Monmouth County. The Borough of Fair Haven indicated that power outages lasted up to six days during the 1992 event.
7/16/1999	Tropical Storm Floyd	Wind gusts rarely exceeded 50 mph, but all the flooding rains made it easier for trees to be knocked over. The strongest winds occurred during the evening and blew down transformers, wires, tree limbs and several trees throughout the County.

Date(s) of Event	Event Type	Description
2/16/2003 – 2/17/2003	President's Day Storm (Winter Storm)	The strong winds caused about 11,000 homes and businesses to lose power. Monmouth Beach was hit the hardest by power outages, waiting two days for power to be restored.
9/18/03 – 9/19/03	Tropical Storm Isabel	Peak wind gusts included 52 mph in Keansburg, and downed trees, tree limbs and power lines.
2/14/2007	Valentine's Day Storm (Winter Storm)	Numerous trees were downed and extensive power outages plagued the area. The Borough of Fair Haven reported that the Valentine's Day Storm of 2007 caused power outages that lasted for several days. The Borough of Shrewsbury was heavily affected by the ice storm of February 2007, which caused three days of power outage for 90 percent of the area's homes and businesses, and up to seven days for several dozen homes.
6/15/2007 – 06/17/2007	Nor'easter	High winds caused a few scattered power outages
3/5/2008	Thunderstorm Wind	Power outages because of downed wires occurred in Bradley Beach, Eatontown, Farmingdale, Howell and Neptune. Outages because of downed trees and limbs occurred in Colts Neck, Englishtown, Freehold, Hazlet, Middletown, Neptune, Oceanport and Union Beach.
9/6/2008	Tropical Storm Hanna	About 2,600 homes and businesses lost power in Monmouth and Ocean Counties. All power was restored by the 7th.
3/14/2010	Severe Windstorm	A severe windstorm knocked out power to hundreds of thousands of customers primarily in southwestern Connecticut as well as parts of Westchester County and Long Island, in New York State, and New Jersey. The outage lasted as long as six days for some customers in the hardest-hit communities.
8/23/2011	Earthquake	There were minor scattered power outages reported throughout the State.
08/27/2011 – 08/28/11	Hurricane Irene	Hurricane Irene caused a power outage to over five million customers throughout the mid-Atlantic and northeast regions of the United States. Approximately 1.9 million New Jersey residents were without power as a result of this storm. High winds downed trees and power lines and caused reported power outages at 121,000 homes across Monmouth County.
10/28/2011 – 10/30/2011	2011 Halloween Nor'easter	The 2011 Halloween Nor'easter started as a large low-pressure area that produced unusually early snowfall across the northeastern United States. Snow fell on trees that were often still in leaf, adding extra weight. Trees and branches that bowed under the weight of the snow caused considerable damage, particularly to power lines. In New Jersey, 700,000 customers were without power as a result of the storm.
10/29/2012	Superstorm Sandy	One of the most significant power failure incidents in New Jersey occurred as a result of Superstorm Sandy in 2012. In total, the incident caused approximately 2.5 million power customers across the State to lose power for an extended period of time, forcing many shelters to remain open several weeks (United States Department of Energy, 2012). Power crews from across the country converged in the region to assist with power restoration efforts. Restoration efforts were hampered by the extent of the outages, and the sheer number of customers without power. For example, approximately 90% of JCP&L's customers were without power following the storm (Rose, 2012). In many cases it took weeks to fully restore power to the entire State. Monmouth County had the greatest number of sustained outages of any county in the state. The utility had to cut through approximately 45,000 fallen trees. It was unable to restore power to about 30,000 of its shore and barrier island customers because of massive infrastructure damage to those homes and businesses. To date, Superstorm Sandy remains as the most devastating natural disaster to impact the State, and the most extensive power failure incident.
11/7/2012	Winter Storm Athena	A winter storm left thousands across the east coast of the United States without power, adding to the blackouts after Superstorm Sandy. An estimated 60,000 people lost electricity as the Nor'easter moved through New Jersey, New York, and Connecticut. As of December 3, 2012, all customers who were able to receive electricity had power restored due to Superstorm Sandy and the subsequent Nor'easter.
1/31/2013	High Wind	Strong to high winds occurred across New Jersey from the middle of the evening on the 30th into the early afternoon of the 31st in New Jersey. Peak wind gusts reached between 45 mph and 65 mph and downed weak trees, tree limbs and power lines and caused power outages. Approximately 20,000 homes and businesses lost power. The wind damage was exacerbated by isolated severe thunderstorms that moved through the central part of the State during the early morning on the 31st. PSE&G reported about 11,000

Date(s) of Event	Event Type	Description
		outages across New Jersey, 3,400 of them in Burlington County. Power was expected to be fully restored later in the day on the 31st.
2/8/2013 – 2/9/2013	Winter Weather	scattered power outages were reported, mainly in the northern portion of the State, with service restored by Saturday afternoon.
2/5/2014	Winter Weather	A major winter storm brought heavy snow and sleet to northwest New Jersey and a wintry mix which included a significant accumulation of ice to the central third of New Jersey. Snowfall reached one foot in Sussex County and ice accumulations were as high as half an inch. The snow that was still on the trees from the just concluded winter storm was a major contributing factor to the power outages. The weight of the snow, then sleet and freezing rain on limbs all collaborated to cause more tree damage then would have occurred if trees were bare at the start of the event. It was the worst ice related outages in the Public Service Electric and Gas's service area since 1999. Public Service Electric and Gas reported about 110,000 of its customers lost power with Mercer, Burlington and Middlesex Counties most affected. Power was fully restored late in the day on the 7th. Jersey Central Power and Light reported about 44,000 of its customers lost power with Middlesex and Monmouth Counties most affected. Power was fully restored on the afternoon of the 6th. One of the hardest hit municipalities with outages was Lambertville as 40 percent of the city lost power. Atlantic City Electric reported about 2,000 of its customers lost power.
7/08/2014 - 7/10/2014	Thunderstorm Wind	A hot and humid air mass and a lee side trough helped trigger a squall line of strong to severe thunderstorms that moved through New Jersey during the evening of the 8th. The worst wind damage occurred across the central third of the State. About 80,000 homes and businesses lost power in the State. Hardest hit counties were Burlington, Gloucester and Monmouth. About 15,200 homes and businesses were without power on the morning of the 9th and 5,500 overnight on the 9th. Power was fully restored on the 10th.
2/2/2015	Strong Wind	Strong, gusty northwest winds occurred in the wake of a departing and intensifying low pressure system during the late afternoon into the middle of the evening on the 2nd in New Jersey. Peak wind gusts average around 50 mph and knocked down weak trees, tree limbs and wires. Scattered power outages occurred.
3/1/2015	Winter Weather	Ice accumulations on exposed surfaces reached as high as around one-third of an inch in the southern half of the State and caused scattered power outages
3/17/2015	Strong Wind	Gusty northwest winds following a cold frontal passage affected locations near and along Raritan Bay in New Jersey during the late afternoon and early evening on the 17th. Peak wind gusts averaged 45 to 50 mph and knocked down weak tree limbs and wires and caused isolated power outages.
3/20/2015	Winter Weather	The heaviest snow fell in the central third of the State. It was a heavy, wet snow and the snow did knock down some weak trees and tree limbs and caused isolated power outages in central New Jersey, primarily in Burlington County. About 100 homes and businesses were still without power on the morning of the 21st.
10/02/2015 – 10/03/2015	High Wind	In Pennsville (Salem County), a large falling tree limb was the cause of a major power outage that left more than 3,300 Atlantic City Electric customers in the dark for a couple of hours the evening of the 2nd. Other scattered power outages also occurred across portions of southern to central New Jersey during the height of the storm on the 2nd and 3rd.
7/22/19	Severe Weather	A heat wave gave way to powerful thunderstorms with 60-70 mph winds leaving more than 45% of the County without electricity. Heaviest hit areas were Wall, Howell, and Freehold Townships.
10/16/19	Nor’easter	A nor’easter, now labeled “bomb cyclone”, with winds between 30 to 50 mph created countywide power outages, with more than 330 residents without power in Middletown Township.
8/4/2020	Tropical Storm Isaias	Following the impact of Tropical Storm Isaias 135,116 Jersey Central Power and Light customers in Monmouth County were without electricity for over two days, just under half of the utility's customers in the County. Highlands, Fair Haven and Colts Neck were the most impacted jurisdictions with over 90% of customers affected.

Date(s) of Event	Event Type	Description
8/28/2024	Animal Interference	A squirrel caused widespread power outages for more than 11,000 JCP&L customers in Monmouth County when it came into contact with electrical equipment inside a Howell Township substation. This caused circuit breakers to cause outages in six neighborhoods
11/18/24	Animal Interference	A squirrel caused a blown insulator and a damaged disc which created a power outage affecting about 13,000 customers. Power was restored in less than four hours,
11/28/24	Downed Powerline	Over 7,000 customers in Monmouth County did not have power when a powerline went down on Thanksgiving afternoon. The power outage lasted about five hours. Most affected customers were in Middletown Township, Atlantic Highlands Borough, and Highland Borough.

Probability of Future Occurrences

While the probability of future power failure incidents in Monmouth County is difficult to predict, the historic record indicates that significant power failures have occurred as a result of high winds, lightning, winter weather, and technological failures. As shown in the table above, it can be anticipated that multiple power outage events caused by natural hazards can happen in a year. It is more difficult to predict the probability of power outages caused by technical error. The potential for another major power failure that disrupts power for many Monmouth County residents is always possible yet are expected to occur less frequently than smaller incidents.

Potential Effects of Climate Change

Future changes in climate may also impact the frequency and probability of future power failure occurrences. . Due to climate changes, the frequency of some severe weather events is projected to increase which could impact the power supply. Extreme temperatures, for example, are becoming more common occurrences due to climate change, place a burden on existing conveyance systems as electrical usage increases during more extreme hot weather event. Wind and rain from hurricanes and tropical storms, which are expected to increase in intensity, frequency and duration, can cause downed power lines leading to outages.

Vulnerability Assessment

Regional or widespread power outages are the most severe type of power failures. The severity of power failures can be linked to severe weather events, such as winter storms and hurricanes. Power failures lead to the inability to use electric-powered equipment, such as: lighting; HVAC and necessary equipment; communication equipment (telephones, computers, etc.); fire and security systems; small appliances such as refrigerators, sterilizers, etc.; and life dependent medical equipment. This all can lead to food spoilage, loss of heating and cooling, basement flooding due to sump pump failure, and loss of water due to well pump failure.

Widespread power outages can occur without warning or as a result of a natural disaster. Generally warning times will be short in the case of technological failure, such as a fire at a sub-station, traffic accident, human error or terrorist attack. In cases where a power failure is caused by natural hazards, greater warning time is possible. For example, high wind events such as tornados and hurricanes often cause widespread power failure and are often forecasted before they affect a community. Additionally, severe winter weather conditions such as ice storms, blizzards, and snowstorms often cause power failure. Incidents such as these often have plenty of warning time, thus power response crews can stage resources to prepare for power failure.

All critical facilities and infrastructure are exposed and vulnerable to a power failure event. Monmouth County may potentially experience losses because of an interruption of critical services. Further increased costs such as providing shelters, and costs related to cooling and heating centers may be incurred. Extended power outages will require officials to shelter victims who require heat and power for activities of daily living.

Critical facilities rely on power to conduct daily activities that support Monmouth County residents. Of particular concern are those facilities that rely on power to conduct life-saving operations, such as fire, police, and emergency medical services, which may be unable to respond to calls if their stations are not operational. Also important are 9-1-1 communications systems that rely on power to transmit emergency calls to first responders. Without a consistent power source, responders may be unable to charge equipment or operate critical systems, such as computer networks or communications devices. Response efforts could be hampered by the traffic delays caused by inoperable signals. Although many of these facilities typically have backup power, a prolonged power failure would pose challenges related to refueling backup systems. Also, backup power systems may malfunction if they are not regularly maintained, forcing the closure of the facility.

All critical facilities and infrastructure without backup power systems or islanding capabilities with distributed generation are exposed to power failure events. It is imperative that facilities that protect life and property and support emergency response, government, sheltering functions and recovery efforts remain operational during times of need. Examples of critical infrastructure includes sewer and stormwater pump stations, water treatment plants, traffic signals, and communication towers.

During power failure events, water purification systems may not be functioning. Further, populations on private wells will not have access to potable water. Many power outage events are caused by storm events that can lead to flooding. Without electricity, residents would be unable to pump water from their basements potentially causing structural and content damage to their homes.

Power failures can cause secondary hazards. One potential secondary hazard is chemical accidents that occur after power is restored to industrial facilities. Power interruptions at chemical handling plants are of particular concern because of the potential for a chemical spill during restart (EPA, 2001). Chemical spills in turn can have significant health and environmental impacts. Another secondary hazard that can result from power failure is a loss of communications capability by first responders, which may in turn have negative impacts on public safety. Backup systems such as amateur radio operators may be required during disaster to augment communications capabilities. Power outages can also lead to instances of civil disturbance, including looting. Wastewater and potable water utility interruption may occur as a result of a power failure. These critical utilities are essential to community continuity and recovery. Their interruption of service may have cascading economic and environmental impacts.

Power failure can have vast secondary impacts on the health of the community. During periods of extreme heat or extreme cold, vulnerable populations such as the elderly and medically frail can be affected and are susceptible to hypothermia or heat stroke. Additionally, power failure can lead to food spoilage, which has negative impacts on public health. Individuals with medical needs are vulnerable to power failures, because medical equipment such as oxygen concentrators requires electricity to operate. Individuals powering their homes with generators are subjected to carbon monoxide poisoning if proper ventilation procedures are not followed. Improperly connected portable generators are capable of ‘back feeding’ power lines which may cause injury or death to utility works attempting to restore power and may damage house wiring and/or generators (NJDCA, 2012).

Power failure may also lead to an increase in traffic accidents. Traffic accidents may increase because of the lack of traffic control devices such as stoplights and railroad crossing advisory signals. Power outages lasting a long duration will force law enforcement officials to man traffic control points to prevent accidents.

As discussed, power interruptions can cause economic impacts stemming from lost income, spoiled food and other goods, costs to the owners/operators of the utility facilities, and costs to government and community service groups. A prolonged power failure in Monmouth County could impact the County's economy. New Jersey hosts the busiest commuter rail network in the country, which operates primarily on electricity. Disruption in the rail network would mean that thousands of workers would not be able to travel to their jobs. For example, the 2003 Northeast Blackout cost states in the northeast an estimated $4 to $10 billion in losses collectively. A widespread power failure in New Jersey could have a similar effect on the State. Other factors include New Jersey's chemical industry and pharmaceutical industry, which rely heavily on power for manufacturing purposes.

4.25 TERRORISM

Hazard Description

Terrorism is the use of force or violence against persons or property with the intent to intimidate or coerce. Acts of terrorism include threats of terrorism; assassinations; kidnappings; hijackings; bomb scares and explosive attacks; cyber-attacks (computer-based attacks); and the use of chemical, biological, nuclear, and radiological weapons (FEMA, 2009). Various types of terrorism are discussed in the sections below.

Armed Attacks and Assassinations

Armed attacks include raids and ambushes. Assassinations are the killing of a selected victim, usually by bombings or small arms. Drive-by shootings are a common technique employed by unsophisticated or loosely organized terrorist groups. Historically, terrorists have assassinated specific individuals for psychological effect.

Arson and Firebombing

Incendiary devices are inexpensive and easy to hide. Arson and firebombings are easily conducted by terrorist groups that may not be as well organized, equipped, or trained as a major terrorist organization. An act of arson or firebombing against a utility, hotel, government building, or industrial center portrays an image to the public that the ruling government is incapable of maintaining order.

Bioterrorism

Bioterrorism refers to the intentional release of toxic biological agents to harm and terrorize civilians, in the name of a political or other cause. The CDC has classified the viruses, bacteria, and toxins that could be used in an attack. Category A Biological Diseases are those most likely to do the most damage. They include:

- Anthrax (Bacillus anthracis)
- Botulism (Clostridium botulinum toxin)
- The Plague (Yersinia pestis)
- Smallpox (Variola major)
- Tularemia (Francisella tularensis)
- Hemorrahagic fever, due to Ebola Virus or Marburg Virus

Explosive Attacks

Explosive Attack can be defined as an attack in which a bomb and or destructive device is used to destroy, incapacitate, harass, or distract. These devises are used by criminals, vandals, terrorists, suicide bombers and insurgents. Explosive devices used in an explosive attack can come in many forms ranging from a pipe bomb to a sophisticated device capable of causing massive damage and loss of life (The National Academies and Homeland Security). Bombings are the most common type of terrorist act. Typically, improvised explosive devices are inexpensive and easy to make. Modern devices are smaller and harder to detect and contain very destructive capabilities.

Cyber Terrorism

Cyber terrorists use information technology to attack civilians and draw attention to the terrorists' cause. This may mean that they use information technology, such as computer systems or telecommunications, as a tool to orchestrate a traditional attack. More often, cyber terrorism refers to an attack on information technology itself in a way that would radically disrupt networked services. For example, cyber terrorists could disable networked emergency systems or hack into networks housing critical financial information. A full discussion of cyber terrorism is presented in Section 5.16 Cyber Attack.

Domestic Terrorism

Domestic terrorism encompasses criminal acts dangerous to people or property, with the intent of inflicting malice. This manner of terrorism may include coercion, intimidation, kidnapping, assassination, or mass destruction, as defined by the Patriot Act. The most common form of domestic terrorism is the targeting of public masses, which often seeks to harm specific educational, religious, ethnic, or racial groups. Infrastructure, such as public spaces or utilities, may also be subject to domestic terrorism, as it causes an interruption in the function of a community. In response to this threat, Monmouth County municipalities are implementing measures such as security screening or infrastructure (e.g., bollards, surveillance cameras, checkpoints), and those that have not have listed them as mitigation action to implement in the future.

Ecoterrorism

Ecoterrorism is a recently coined term describing violence in the interests of environmentalism. In general, environmental extremists sabotage property to inflict economic damage on industries, businesses, or persons perceived as harming animals or the natural environment. Targets of ecoterrorist attacks have included fur companies, logging companies, and animal research laboratories.

Hijackings and Skyjackings

Hijacking is the seizure by force of a surface vehicle, its passengers, and/or its cargo. Skyjacking is the taking of an aircraft, which creates a mobile, hostage barricade situation; provides terrorists with hostages from many nations; and draws heavy media attention. Skyjacking also provides mobility for the terrorists to relocate the aircraft to a country that supports their cause and provides them with a human shield, making retaliation difficult.

Kidnappings and Hostage-Takings

Terrorists use kidnapping and hostage-taking to establish a bargaining position and to elicit publicity. Kidnapping is one of the most difficult acts for a terrorist group to accomplish, but, if a kidnapping is successful, it can gain terrorists money, release of jailed comrades, and publicity for an extended period. Hostage-taking involves the seizure of a facility or location and the taking of hostages present in that facility. Unlike a kidnapping, hostage-taking provokes a confrontation with authorities. It forces authorities to either make dramatic decisions or to comply with the terrorist's demands. It is overt and designed to attract and hold media attention. The terrorists' intended target is the audience affected by the hostage's confinement, not the hostage.

Nuclear Terrorism

Nuclear terrorism refers to a number of different ways nuclear materials might be exploited as a terrorist tactic. These include attacking nuclear facilities, purchasing nuclear weapons, or building nuclear weapons or otherwise finding ways to disperse radioactive materials. Nuclear attack can be defined as an attack in which nuclear weaponry is used to inflict crippling damage on a place and the people living there. Nuclear weapons are weapons of mass destruction, which means they can produce far ranging destruction in very short timeframe, while also having lasting impacts (Birks and Sherry, 1986).

Location and Extent

Terrorist attacks can occur anywhere. However, the State of New Jersey is a particularly attractive target of a potential terrorist activity because of its dense population and location relative to major urban areas. The State also houses the busiest commuter rail system in the United States, as well as the headquarters of major corporations in economically vital sectors such as the financial and pharmaceutical industries.

Additional targets in Monmouth County include the County's critical infrastructure such as utilities, roadways, bridges, tunnels, hospitals, schools, civic centers, and other high-profile venues. The link between NJ TRANSIT and New York City also makes this transportation system a target for terrorists. Locations with a high population density will be attractive targets for terror attacks.

NWS Earle, the largest weapons station on the East Coast, is located in Monmouth County and could potentially be targeted for a terrorist attack[10].

Range of Magnitude

Any acts of terrorism can occur anywhere at any time of day. The National Terrorism Advisory System (NTAS) communicates information about terrorist threats by providing detailed information to the public, government agencies, first responders, airports and other transportation hubs, and the private sector. When there is a threat, an NTAS Alert will be announced by the Secretary of Homeland Security and will be shared with the public. It may include specific information about the nature of the threat, including the geographic region, mode of transportation, or critical infrastructure potentially affected, as well as steps that individuals and communities can take to protect themselves and help prevent, mitigate or respond to the threat. The alert indicates whether the threat is elevated or imminent. Elevated threats are when there is no specific information about the timing or location. Imminent threats are when it is believed the threat is impending or very soon. The alerts will be posted online and released to the news media for distribution. The United States Department of Homeland Security (USDHS) will also distribute alerts through its social media channels (USDHS, 2013).

In New Jersey, the NJOEM, New Jersey Office of Homeland Security and Preparedness (OHSP), and the Regional Operations Intelligence Center (ROIC) have introduced NJ Alert, a mass text and email emergency notification system. During an emergency, NJ Alert assists these agencies in delivering emergency messages to the public through their handheld devices or computers, in addition to the Emergency Alert Systems and Amber Alert (NJEOM, 2009).

Previous Occurrences and Losses

Though no significant direct attacks of terrorism have occurred in Monmouth County, the County and its residents have been impacted by nearby terror events, especially due to the proximity of New York City, which greatly influences the county workforce, economy, real estate market, and culture. Now known as 9/11, the most significant terrorist incident

[10] *HTTP://CO.MONMOUTH.NJ.US/DOCUMENTS/24/NWS%20EARLE%20JLUS%20STUDY%20FACT%20SHEET.PDF*

to occur in the United States occurred on September 11, 2001, adjacent to New Jersey in Lower Manhattan, New York, when an extreme terrorist group hijacked two commercial airplanes and flew them into the Towers 1 and 2 of the World Trade Center. Even though the attack did not occur in the County, it had significant and lasting impacts as many of the survivors, victims, and first responders were from Monmouth County. With the bridges and tunnels closed, Monmouth County based ferries became a lifeline and were used to evacuate lower Manhattan, bringing survivors across the Bay into Monmouth County while first responders would take the ride back to ground zero to assist in recovery efforts. In total there were 147 people from Monmouth County who perished in the terrorist attacks of September 11, 2001.

Probability of Future Occurrences

While the potential for future terrorism incidents in Monmouth County is difficult to predict, the combination of past incidents and potential terrorist targets make a terrorism incident possible. Efforts from local, State, and federal officials must be coordinated to prevent future terrorist incidents from occurring. However, despite the best efforts of these entities, the reality is that a terrorist attack may occur in Monmouth County or the surrounding areas.

Figure 4.25-1 New Jersey's Assessed Threat Level in 2024 is taken from the New Jersey Office of Homeland Security and Preparedness' 2024 Terrorism Threat Assessment, which visualizes the Assessed Threat Level of various terrorist organizations and extremists in New Jersey.

Table 4.25-1 New Jersey's Assessed Threat Level in 2024

High	Homegrown Violent Extremists
	White Racially Motivated Extremists
Moderate	Abortion-Related Extremists
	Anarchist Extremists
	Anti-Government Extremists
	Black Racially Motivated Extremists
	Militia Extremists
	Sovereign Citizen Extremists
Low	Al-Qa'ida and Affiliates
	Animal Rights Extremists
	Environmental Extremists
	HAMAS
	Hizballah
	ISIS

Potential Effects of Climate Change

This plan does not recognize a link between climate change and terrorism.

Vulnerability Assessment

The effect of a terrorism event can vary depending on the type of attack and the magnitude of the event or events. A terrorism event can cause public fear regarding the use of mass transportation or leaving their homes in the event of a biological or nuclear attack. Communication systems, both public and private, can fail because of an overwhelming amount of usage or damage to its infrastructure. Healthcare facilities can become quickly inundated and must be prepared to triage injured patients, handle mass casualties, and conduct decontamination operations.

There is often very little if any warning time that a terrorist attack is about to occur. It is possible, however, to thwart terrorist attacks through aggressive intelligence monitoring and monitoring of individuals who exhibit radical tendencies. Some terrorist attacks may show warning signs that an incident may occur, such as a suspicious package left unattended. Local, State, and federal officials as well as the general public are responsible for recognizing the warning signs of terrorism incidents and for taking appropriate actions to mitigate against possible attacks. In New Jersey, the coordination, direction, and control of all law enforcement personnel and resources fall under the purview of the Attorney General. Additionally, the New Jersey OHS administers, coordinates, leads, and supervises New Jersey's counter-terrorism efforts.

Critical facilities are exposed to terrorist attacks, particularly because of the impact that an attack has on these types of facilities. Dams, power stations, and tunnels are all examples of critical infrastructure and facilities that are vulnerable. Additionally, communications systems, first-responder stations, and emergency operations centers are all vulnerable to terrorist attacks. Disrupting one of these facilities or destroying critical infrastructure would have devastating, cascading impacts on New Jersey. The potential losses to State facilities are difficult to quantify because of the unpredictability of terrorist events. The replacement cost value for State facilities provides a total risk exposure quantity.

The secondary hazards resulting from a terrorist attack depend on the size and scope of the incident. Some possible secondary hazards include widespread health effects such as epidemics or pandemics, flooding (if a dam was destroyed), and environmental contamination.

Because terrorist attacks are designed to take victims by surprise, predicting the location and nature of potential attacks is extremely difficult, as is assessing the population's vulnerability. Aside from population density, other indicators of vulnerable populations may be commuters using public transportation on a regular basis (as mass transit systems have been the targets of past terrorist attacks outside New Jersey), locations in and around military bases or government facilities (as was planned for Fort Dix in New Jersey in 2007), as well as high-profile gatherings of a large number of people (such as the attacks that occurred at the Boston Marathon in 2013).

Measuring the economic impact of a terrorist attack on the State is a difficult task. The initial impact can be measured in immediate costs such as costs related to responding to the event, and those associated with the immediate loss of productivity due to closed businesses. The fuller economic impact includes long-term costs such as terrorism mitigation activities. A terrorist attack occurring in Monmouth County along the Jersey Shore, could result in a significant negative impact on the local tourism industry.

Depending on the type and location of an act of terrorism, it can impact the environment and result in loss of life for humans and animals. A radiological device or an improvised nuclear device would have a long-term impact that could cost billions of dollars to remediate. Additionally, an attack on waste treatment, natural gas, petroleum, or chemical facilities could also have long term environmental impacts.

4.26 TRANSPORTATION ACCIDENTS

Hazard Description:

The safety of the traveling public remains a growing concern in Monmouth County and throughout the State. This is a new category for the Monmouth County HMP that reflects the increased focus and coordinated efforts occurring at multiple jurisdictional levels of government to reduce traffic-related injuries and fatalities. Between 2023 and 2024, traffic related fatalities in the State increased by 14% while pedestrian fatalities increased 32%. Recently, the governor signed A1476/S361 into law creating the Target Zero Commission charged with the goal of eliminating traffic deaths and serious injuries in New Jersey by 2040. The Commission will focus on data-driven strategies that prioritize roadway design, speed management, and safety for all road users, including pedestrians, cyclists, and drivers. The Monmouth County Division of Planning is leading a regional Safe Streets for All (SS4A) study. This initiative aims to identify actionable strategies that can mitigate or eliminate traffic-related incidents, allowing safe travel for everyone.

Location and Extent:

The threat from this hazard exists everywhere in Monmouth County, and no one location is excluded from a potentially harmful traffic-related incident. However, some locations do experience a higher level of occurrence than others due to a variety of factors including roadway geometry, traffic conditions, sight distance, weather conditions, seasonal light changes, adjacent land uses, or a lack of active transportation infrastructure. Different areas of the County face unique challenges due to their surrounding natural and manmade environments.

- **Coastal Areas**: These locations face significant challenges during the summer months when the influx of visitors and tourists dramatically increases traffic volume. This heightened activity elevates the risk of conflicts between cyclists, pedestrians, and motorists. Contributing factors include driver distraction caused by unfamiliarity with local traffic patterns, road detours for seasonal events and festivals, and an influx of vehicles throughout the summer and particularly on holidays and weekends.

- **Suburban Areas**: Many suburban neighborhoods are situated proximate to fast-moving arterial roads and State highways. Pedestrian fatalities are particularly common along these corridors, especially during evening or nighttime hours when reduced visibility and diminished driver reaction times significantly increase the risk.

- **Rural Areas**: Although rural roads generally experience less congestion, they often present hazards resulting from their historic design as narrow, one-lane country roads. These roadways frequently lack sufficient lighting and impeded sight distance, often creating potential conflicts between cyclists and motor vehicle traffic.

- **Downtowns**: In general, many downtown areas are equipped with infrastructure designed to mitigate traffic conflicts, including sidewalks, crosswalks, signage, and regulated intersections. However, these compact, high-activity locations often present the highest risk for conflicts due to their intensity of use and dynamic, fast-changing movements between different modes of travel. The growing popularity of electric scooters and motorized bikes has further complicated traffic compliance and introduced new safety challenges, creating additional risks for pedestrians, cyclists, and motorists navigating these busy areas.

Table 4.26-1 NJSP Fatal Crash Statistics for 2024

Municipality	Date	Time	Location	Fatalities
Middletown, Township of	12/30/2024	0829	County 520	1D
Neptune, Township of	12/10/2024	1917	State Highway 66 MP 1	1T
Freehold, Township of	12/09/2024	2227	County 23 MP 2	1D

Municipality	Date	Time	Location	Fatalities
Hazlet, Borough of	12/08/2024	1949	State Highway 36	1T
Colts Neck, Township of	12/02/2024	1023	County 537	1D
West Long Branch, Borough of	11/30/2024	2106	State Highway 36 MP 2.78	1B
Howell, Township of	11/30/2024	1943	State Highway 9	1T
Wall, Township of	11/09/2024	1842	State Highway 35	1T
Tinton Falls, Borough of	11/08/2024	1918	Garden State Parkway	1D
Tinton Falls, Borough of	10/26/2024	0420	Garden State Parkway MP 102.8	1D
Holmdel, Township of	10/21/2024	1703	Emory Pl	1T
Middletown, Township of	10/18/2024	2007	State Highway 36	1T
Neptune City, Borough of	10/16/2024	1846	State Highway 33	1T
Marlboro, Township of	10/15/2024	1516	State Highway 9	1D
Asbury Park, City of	10/14/2024	2227	State Highway 71 MP 8.66	1T
Millstone, Township of	09/13/2024	1627	County 1 MP 4.3	1D
Marlboro, Township of	09/09/2024	0943	School Road East	1B
Aberdeen, Township of	09/04/2024	1924	Atlantic Ave	1T
Freehold, Township of	08/29/2024	1424	Wemrock Rd	1P
Holmdel, Township of	08/12/2024	0753	Bethany Rd	1B
Freehold, Township of	08/10/2024	2056	State Highway 9	1T
Freehold, Borough of	08/07/2024	1123	State Highway 33 (Business) MP 2.68	1T
Neptune City, Borough of	08/06/2024	1445	State Highway 40 (Alternate)	1B
Shrewsbury, Borough of	08/05/2024	0244	County 13	1T
Tinton Falls, Borough of	07/20/2024	2137	Garden State Parkway MP 103.1	1D
Upper Freehold, Township of	07/10/2024	1058	County 539 MP 39.2	1D
Howell, Township of	07/09/2024	1653	Fort Plains Rd	1D
Englishtown, Borough of	07/04/2024	0152	County 527	1D
Upper Freehold, Township of	07/01/2024	2037	County 524 MP 11	1D
Upper Freehold, Township of	06/24/2024	1122	Sharon Station Rd	1P
Spring Lake Heights, Borough of	05/25/2024	1320	County 524 MP 39.15	1T
Hazlet, Borough of	05/17/2024	1311	Beers St	1D
Red Bank, Borough of	05/15/2024	2115	Bridge Ave	1T
Manalapan, Township of	04/25/2024	0426	State Highway 9	1D
Ocean, Township of	04/15/2024	2104	State Highway 35	1T
Colts Neck, Township of	04/09/2024	1802	State Highway 18 MP 17	1D
Shrewsbury, Borough of	04/08/2024	1405	State Highway 35	1D
Howell, Township of	04/02/2024	1028	State Highway 33 MP 32.72	1D
Shrewsbury, Borough of	03/31/2024	1545	Samara Drive	1B
Manalapan, Township of	03/29/2024	2155	County 527 (Alternate) MP 4.93	1D
West Long Branch Boro	03/29/2024	1954	State Highway 36 MP 2.59	1T
Manalapan, Township of	02/26/2024	2213	County 3 MP 3.67	1D
Ocean, Township of	02/22/2024	2018	State Highway 35 MP 25.79	1T
Aberdeen, Township of	02/22/2024	0429	Garden State Parkway MP 119.7	1D
Ocean, Township of	02/21/2024	1140	Carol Ave	1D
Tinton Falls, Borough of	02/13/2024	0703	Garden State Parkway MP 109.1	1T
Keansburg, Borough of	02/10/2024	1551	Forest Ave	1D
Howell, Township of	02/02/2024	0747	State Highway 34 MP 9.81	1D
Ocean, Township of	01/30/2024	1749	County 14 MP 1.24	1T

Municipality	Date	Time	Location	Fatalities
Tinton Falls, Borough of	01/15/2024	2000	Garden State Parkway MP 104.2	1D,1P
Howell, Township of	01/13/2024	1641	State Highway 34 MP 9.57	1P
Freehold, Township of	01/09/2024	1735	State Highway 9 MP 113.25	1T
Neptune, Township of	01/07/2024	1555	State Highway 33 MP 38.61	1P
Accident Count: 53 **County Totals: 54**				24D,5P,5B,20T

Note: *(Statistics are ordered by date & time - most recent first. Fatalities: D=Driver, P=Passenger, B=Pedalcyclist, T=Pedestrian)*

Previous Occurrences and Losses

New Jersey State Police Website

Table 4.26-2 Traffic Accidents Resulting in Fatalities

Year	Driver	Passenger	Cyclist	Pedestrian	Total
2014	27	4	3	13	47
2015	28	8	0	16	52
2016	33	7	0	10	50
2017	25	6	1	11	43
2018	16	3	1	9	29
2021	18	4	1	11	34
2022	29	11	1	13	54
2023	17	7	4	9	37
2024	24	5	5	20	54
2025	0	0	0	0	2

Source: New Jersey State Police Website as of 01/31/25. Data missing for years 2019 and 2020.

Probability of Future Occurrences

With increasing amounts of development (residential, commercial, warehousing, industrial, mixed-use, etc.) comes more vehicles and more vehicle miles traveled. Without implementing effective mitigation actions, the existing trend of motor vehicle conflicts resulting in property damage, serious injuries, or fatalities will continue unabated.

Potential Effects of Climate Change

Research from Rutgers University predicts an increase in heavier precipitation events and more intense storms. As these conditions become more frequent and severe, they are expected to have a considerable impact on traffic safety. Hazards such as roadway ponding, flash flooding, general flooding, diminished sight distance, and reduced driver reaction times will pose growing risks. Additionally, power outages disrupting traffic signals, roadway detours, and erosion along road verges will endanger those who walk along the side of roadways. Increased driver distraction during severe weather events will only compound these challenges.

Vulnerability Assessment

According to the National Safety Council, motor vehicles are the third leading cause of preventable injury-related deaths, accounting for 20% (46,027) of all preventable deaths and 9% (2,143,392) of all preventable nonfatal injuries in the nation in 2022. Applying the national proportions to local counts, the 692 preventable motor vehicle fatalities that occurred in

Monmouth County in 2024 suggests there may have been as many as 30,000 preventable motor vehicle related injuries during the same year.

4.27 CONCLUSIONS ON HAZARD RISK

The results of this vulnerability assessment are useful in at least three ways:

- Improving our understanding of the risk associated with the natural hazards in Monmouth County through better understanding of the complexities and dynamics of risk, how levels of risk can be measured and compared, and the myriad of factors that influence risk. An understanding of these relationships is critical in making balanced and informed decisions on managing the risk.
- Providing a baseline for policy development and comparison of mitigation alternatives. The data used for this analysis presents a current picture of risk in Monmouth County. Updating this risk "snapshot" with future data will enable comparison of the changes in risk with time. Baselines of this type can support the objective analysis of policy and program options for risk reduction in the region.
- Comparing the risk among the natural hazards addressed. The ability to quantify the risk to all these hazards relative to one another helps in a balanced, multi-hazard approach to risk management at each level of governing authority. This ranking provides a systematic framework to compare and prioritize the very disparate hazards that are present in Monmouth County. This final step in the risk assessment provides the necessary information for local officials to craft a mitigation strategy to focus resources on only those hazards that pose the most threat to the County.