5.6 FLOOD

SECTION 5.6 FLOOD

5.6.1 HAZARD DESCRIPTION

This section provides general information on the flood hazard which includes:

- riverine (inland) flooding;
- coastal flooding;
- ice jams;
- stormwater flooding;
- urban flooding;
- nuisance flooding; and,
- tsunamis.

Flooding caused by dam and levee failure is discussed in Section 5.3 (Dam and Levee Failure), and storm surge is discussed in Section 5.8 (Hurricane and Tropical Storms).

Floods are one of the most common natural hazards in the United States They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, coastlines and multiple counties or states) (FEMA 2008). Most communities in the United States have experienced some kind of flooding after spring rains, heavy thunderstorms, coastal storms, or winter snow thaws (George Washington University 2001). Floods are frequent and costly natural hazards in New Jersey in terms of human hardship and economic loss, particularly to communities that lie within flood-prone areas or floodplains of a major water source.

The flood-related hazards most likely to affect New Jersey are riverine (inland) flooding and coastal flooding. Other flood-related hazards that have historically occurred and will continue to affect the State include: flooding associated with ice jams, flooding associated with tsunamis, stormwater flooding due to local drainage and high groundwater levels, and storm surge/coastal flooding. Each is described below, along with the sub-categories associated with each hazard type. Storm surge and coastal flooding are discussed further in Section 5.8 (Hurricanes and Tropical Storms).

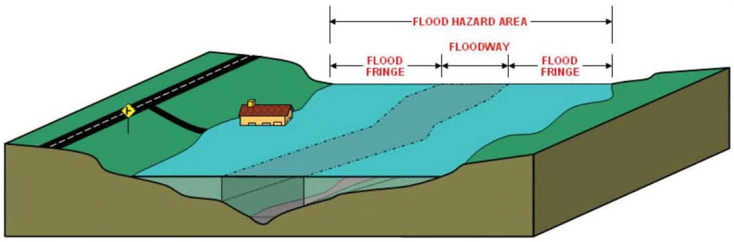
Riverine (Inland) Flooding

Riverine floods are the most common flood type. They occur along a channel and include overbank and flash flooding. Channels are defined, ground features that carry water through and out of a watershed. They may be called rivers, creeks, streams, or ditches. When a channel receives too much water, the excess water flows over its banks and inundates low-lying areas (FEMA, 2008; The Illinois Association for Floodplain and Stormwater Management, 2006).

Flash floods are "a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g., intense rainfall, dam failure, ice jam). However, the actual time threshold may vary in different parts of the country. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters" (National Weather Service [NWS] 2009).

A floodplain is defined as the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that becomes inundated with water during a flood. Most often floodplains are referred to as 100- year floodplains. A 100-year floodplain is not a flood that will occur once every 100 years, rather it is a flood that has a one-percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. Due to this misleading term, FEMA has properly defined it as the one-percent annual chance flood. This one-percent annual chance flood is now the standard used by most federal and state agencies and by the NFIP (FEMA, 2002).

Figure 5.6-1 Floodplain



Source: NJDEP, 2009

In New Jersey, new development within the floodway is severely restricted. Generally, only development that must occur within the floodway is permitted, such as bridges, culverts, or bank stabilization measures. New buildings are prohibited in the floodway. Buildings are prohibited in the floodway not only to protect those members of the public that could be present in the building during a flood, but also to protect first responders as well as other members of the public downstream from floating debris that could result from construction within the floodway. The regulations governing construction within the floodway are available at N.J.S.A. 12:5-3 (NJDEP 2018). The floodway limit is determined by using the 100-year flow rate reported by FEMA for the regulated water, assuming a maximum rise of 0.2 feet in the 100-year flood elevation (NJDEP, 2018).

Coastal Flooding

Coastal flooding occurs along the coasts of oceans, bays, estuaries, coastal rivers, and large lakes. Coastal floods are the submersion of land areas along the ocean coast and other inland waters caused by seawater over and above normal tide action. Coastal flooding is a result of the storm surge where local sea levels rise often resulting in weakened or destroyed coastal structures. Hurricanes and tropical storms, severe storms, and Nor'easters cause most of the coastal flooding in New Jersey. Coastal flooding has many of the same problems identified for riverine flooding but also has additional problems such as beach erosion; loss or submergence of wetlands and other coastal ecosystems; saltwater intrusion; high water tables; loss of coastal recreation areas, beaches, protective sand dunes, parks, and open space; and loss of coastal structures. Coastal structures can include sea walls, piers, bulkheads, bridges, or buildings (FEMA 2011).

There are several forces that occur with coastal flooding:

- *Hydrostatic forces* against a structure are created by standing or slowly moving water. Flooding can cause vertical hydrostatic forces, or flotation. These types of forces are one of the main causes of flood damage.
- *Hydrodynamic forces* on buildings are created when coastal floodwaters move at high velocities. These high-velocity flows are capable of destroying solid walls and dislodging buildings with inadequate foundations. High-velocity flows can also move large quantities of sediment and debris that can cause additional damage. In coastal areas, high-velocity flows are typically associated with one or more of the following:
    - Storm surge and wave run-up flowing landward through breaks in sand dunes or across low- lying areas
    - Tsunamis
    - Outflow of floodwaters driven into bay or upland areas
    - Strong currents parallel to the shoreline, driven by waves produced from a storm

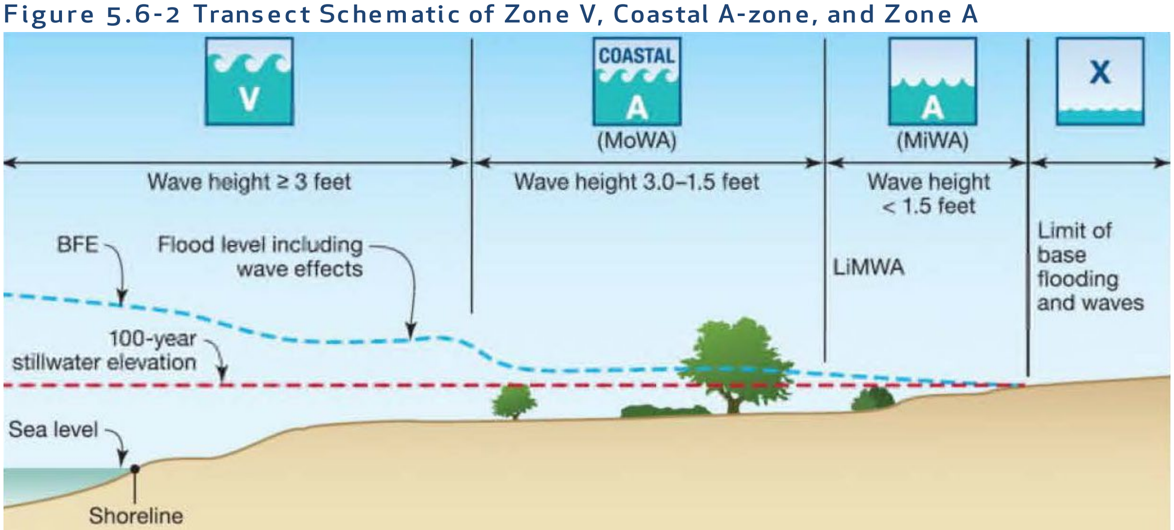
- o High-velocity flows

High-velocity flows can be created or exacerbated by the presence of manmade or natural obstructions along the shoreline and by weak points formed by roads and access paths that cross dunes, bridges or canals, channels, or drainage features.

- *Waves* can affect coastal buildings from breaking waves, wave run-up, wave reflection and deflection, and wave uplift. The most severe damage is caused by breaking waves. The force created by these types of waves breaking against a vertical surface is often at least 10 times higher than the force created by high winds during a coastal storm.
- *Flood-borne debris* produced by coastal flooding events and storms typically includes decks, steps, ramps, breakaway wall panels, portions of or entire houses, heating oil and propane tanks, cars, boats, decks and pilings from piers, fences, erosion control structures, and many other types of smaller objects. Debris from floods are capable of destroying unreinforced masonry walls, light wood-frame construction, and small-diameter posts and piles (FEMA 2011).

According to the Coastal Construction Manual, FEMA P-55, Zone V (including Zones VE, V1-30, and V) identifies the Coastal High Hazard Area. This is the portion of the special flood hazard area (SFHA) that extends from offshore to the inland limit of a primary frontal dune along an open coast and any other portion of the SFHA that is subject to high-velocity wave action from storms or seismic sources. The boundary of Zone V is generally based on wave heights (3 feet or greater) or wave run-up depths (3 feet or greater). Zone V can also be mapped based on the wave overtopping rate (when waves run up and over a dune or barrier). Zone A or AE, identify portions of the SFHA that are not within the Coastal High Hazard Area. These zones are used to designate both coastal and non-coastal SFHAs. Regulatory requirements of the NFIP for buildings located in Zone A are the same for both coastal and riverine flooding hazards. Zone AE in coastal areas is divided by the limit of moderate wave action (LiMWA). The LiMWA represents the landward limit of the 1.5- foot wave (FEMA 2011).

Figure 5.6-2 Transect Schematic of Zone V, Coastal A-zone, and Zone A



Source: FEMA, 2011

The area between the LiMWA and the Zone V limit is known as the Coastal A-zone (for building codes and standard purposes) and as the Moderate Wave Action area (by FEMA flood mappers). This area is subject to wave heights between 1.5 and 3 feet during the base flood. The area between the LiMWA and the landward limit of Zone A is known as the Minimal Wave Action area and is subject to wave heights less than 1.5 feet during the base flood (FEMA P-55 2011). Figure 5.6-2 shows a typical transect illustrating Zone V, the Coastal A-zone and Zone A, and the effects of energy dissipation and regeneration of a wave as it moves inland. Wave elevations are decreased by obstructions such as vegetation and rising ground elevation (FEMA, 2011).

Ice Jam

As per the Northeast States Emergency Consortium and FEMA, an ice jam is an accumulation of ice that acts as a natural dam and restricts flow of a body of water. Ice jams occur when warm temperatures and heavy rains cause rapid snowmelt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding (FEMA 2008). Ice jams may also be caused by frazil ice, which forms when mist freezes then float down a river, stream, or creek.

There are two different types of ice jams: freeze-up and breakup. Freeze-up jams occur in the early to mid-winter when floating ice may slow or stop due to a change in water slope as it reaches an obstruction to movement. Breakup jams occur during periods of thaw, generally in late winter and early spring. The ice cover breakup is usually associated with a rapid increase in runoff and corresponding river discharge due to a heavy rainfall, snowmelt, or warmer temperatures (United States Army Corps of Engineers [USACE] 2002).

Stormwater Flooding

Stormwater flooding described below is due to local drainage issues and high groundwater levels. Locally, heavy precipitation may produce flooding in areas other than delineated floodplains or along recognizable channels. If local conditions cannot accommodate intense precipitation through a combination of infiltration and surface runoff, water may accumulate and cause flooding problems. During winter and spring, frozen ground and snow accumulations may contribute to inadequate drainage and localized ponding. Flooding issues of this nature generally occur in areas with flat gradients and generally increase with urbanization which speeds the accumulation of floodwaters because of impervious areas. Shallow street flooding can occur unless channels have been improved to account for increased flows (FEMA, 1997).

High groundwater levels can be a concern and cause problems even where there is no surface flooding. Basements are susceptible to high groundwater levels. Seasonally high groundwater is common in many areas, while elsewhere high groundwater occurs only after a long period of above-average precipitation (FEMA, 1997).

Urban Flooding

NOAA defines urban flooding as the flooding of streets, underpasses, low lying areas, or storm drains. This type of flooding is mainly an inconvenience and is generally not life threatening.

Urban drainage flooding is caused by increased water runoff due to urban development and drainage systems. Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and other urban areas. They make use of a closed conveyance system that channels water away from an urban area to surrounding streams. This bypasses the natural processes of water filtration through the ground, containment, and evaporation of excess water. Since drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding in those streams can occur more quickly and reach greater depths than prior to development in that area (FEMA, 2008).

Nuisance Flooding

Nuisance flooding is a flood event influenced by minor impacts, such as high tide or minor rain storm occurrences. Nuisance flooding occurs fairly frequently because it is caused by events that happen on a regular basis.

Nuisance flooding causes public inconvenience by influencing frequent road closures, overwhelmed storm drains and deterioration of infrastructure. Recently, nuisance flooding has been increasing around the coastal United States due to sea level rise and land subsidence (NOAA, 2018).

Tsunami

FEMA and NOAA state that tsunamis are a series of traveling ocean waves created by sudden displacements of the ocean floor (earthquakes), landslides, or volcanic activity. A tsunami can move hundreds of miles per hour in the open ocean and crash into land with waves exceeding 100 feet in height (FEMA 2009).

A tsunami consists of a series of high-energy waves that travel outward, like pond ripples, from the area where the tsunami originated. The sequence of tsunami waves arrives at the shoreline over an extended period of time and build height as it gets closer (FEMA, 2007; Humboldt County Hazard Mitigation Plan, 2008). A tsunami approaching the shoreline may take three forms:

- Non-breaking waves that act as a rapidly rising tide
- A large, turbulent wall-like wave (bore)
- A series of partially developed waves (Humboldt County Hazard Mitigation Plan 2008)

There are two types of tsunamis: local and distant. A locally generated tsunami is caused by an undersea disturbance near the coast. They have minimal warning times and may be accompanied by earthquake damage due to ground shaking, surface faulting, liquefaction, or landslides. A local tsunami, due to its close proximity to the coast, leaves few options for escaping, except to run to high ground. Distant tsunamis may travel for hours before striking a coastline, leaving enough time for warning (Humboldt County Hazard Mitigation Plan, 2008; Grays Harbor County Hazard Mitigation Plan, 2005).

5.6.1.2 FEDERAL FLOOD PROGRAMS

National Flood Insurance Program

The NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in participating communities. For most participating communities, FEMA has prepared a detailed Flood Insurance Study (FIS). The study presents water surface elevations for floods of various magnitudes, including the 1% annual chance flood and the 0.2% annual chance flood (the 500-year flood). Base flood elevations and the boundaries of the 100-year floodplains are shown on Flood Insurance Rate Maps (FIRMs), which are the principal tool for identifying the extent and location of the flood hazard for the purposes of the flood insurance requirement. The FIRMs depict SFHAs - those areas subject to inundation from the 1% annual chance flood (also known as the Base Flood or the 100-Year Flood). Those areas are defined as follows:

- Zones A1-30 and AE: SFHAs that are subject to inundation by the base flood, determined using detailed hydraulic analysis. Base Flood Elevations are shown within these zones
- Zone A (Also known as Unnumbered A-zones): SFHAs where no Base Flood Elevations or depths are shown because detailed hydraulic analyses have not been performed.
- Zone AO: SFHAs subject to inundation by types of shallow flooding where average depths are between one and three feet. These are normally areas prone to shallow sheet flow flooding on sloping terrain.

- Zone VE, V1-30: SFHAs along coasts that are subject to inundation by the base flood with additional hazards due to waves with heights of three feet or greater. Base Flood Elevations derived from detailed hydraulic analysis are shown within these zones.
- Zone B and X (shaded): Zones where the land elevation as been determined to be above the Base Flood Elevation, but below the 500-year flood elevation. These zones are not SFHAs.
- Zones C and X (unshaded): Zones where the land elevation has been determined to be above both the Base Flood Elevation and the 500-year flood elevation. These zones are not SFHAs.

As of September 30, 2018, there are approximately 224,541 NFIP policies in New Jersey. To qualify for national flood insurance, one must live in a community that participates in the NFIP.

Flood Insurance Studies (FIS)

In addition to FIRM and Digital Flood Insurance Rate Maps (DFIRM), FEMA also provides FISs for entire counties and individual jurisdictions. These studies aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. They are narrative reports of countywide flood hazards, including descriptions of the flood areas studied, the engineered methods used, principal flood problems, flood protection measures, and graphic profiles of the flood sources.

Risk Mapping, Assessment, and Planning (Risk MAP)

Risk MAP is a FEMA program that provides communities with flood information and tools to enhance their mitigation plans and take action to protect their citizens. It builds on flood hazard data and maps produced during the Flood Map Modernization (Map Mod) program. Through more precise flood mapping products, risk assessment tools, and planning and outreach support, Risk MAP strengthens local ability to make informed decisions about reducing risk. It combines quality engineering with state-of-the-art flood hazard data to assist communities in planning and preventing risk using the most current information.

Risk MAP collaborates with state, tribal, and local governments and delivers quality data that increases public awareness and leads to action that reduces risk to property and life. Risk MAP focuses on products and services beyond the traditional FIRMs and works with officials to help put flood risk data and assessment tools to use. Risk MAP also helps effectively communicate risk to citizens and enable communities to enhance their mitigation plans and actions (FEMA 2012).

The goals of Risk MAP are as follows:

- Flood Hazard Data – addresses gaps in flood hazard data to form a solid foundation for risk assessment, floodplain management, and actuarial soundness of the NFIP.
- Public Awareness/Outreach – ensures that a measurable increase of the public's awareness and understanding of risk results in a measurable reduction of current and future vulnerability.
- Hazard Mitigation Planning – leads and supports states, local, and tribal communities to effectively engage in risk-based mitigation planning resulting in sustainable actions that reduce or eliminate risks to life and property from natural hazards.
- Enhanced Digital Platform – provides an enhanced digital platform that improves management of Risk MAP, conserves information produced by Risk MAP, and improves communication and sharing of risk data and related products to all levels of government and the public.
- Alignment and Synergies – aligns risk analysis programs and develops synergies to enhance decision-making capabilities through effective risk communication and management.

FEMA headquarters and regional offices lead a team of contractors and stakeholders to deliver its Risk MAP program. The team is made up of the following:

- FEMA Headquarters – responsible for overall program implementation
- FEMA Regions – manage regional flood map production and help implement the Risk MAP outreach

strategy

- State, Local, and Tribal entities – help ensure that updated mapping information is used to make informed decisions regarding risk
- Program Management Contractor – provide general oversight for Risk MAP including integration of activities, development and implementation of a national outreach strategy, and stakeholder relations
- Production and Technical Services Contractors – update flood hazard data and maps
- Customer and Data Services Contractor – provide the digital platform for sharing flood mapping products and information

FEMA also produces non-regulatory products through Risk MAP. Risk MAP provides state and community officials with three Flood Risk Products (Flood Risk Report, Flood Risk Map, and Flood Risk Database) to help them gain a better understanding of flood risk and its potential impact on communities and individuals. These products also enable communities to take proper mitigation actions to reduce flood risk. The products summarize information captured through the Flood Risk Datasets during a Flood Risk study (FEMA 2017). These datasets include:

- Changes since last FIRM
- Flood depth and analysis grids
- Flood risk assessment data
- Areas of mitigation interest

Flood risk products include a Flood Risk Report, Flood Risk Map, and Flood Risk Database. FEMA's Risk Map program has recently placed an emphasis on the Flood Risk Database and will create Flood Risk Reports and Flood Risk Maps as an optional product as needed through the program. Draft versions of certain flood risk tools are available for Atlantic, Bergen, Cape May, Cumberland, Essex, Hudson, Ocean, Middlesex, Monmouth, and Salem Counties. The Flood Risk Report provides stakeholders with a comprehensive understanding of flood hazard and risk exposure within their community, watershed, or other geographic area. The report parallels the Flood Insurance Study (FIS) by providing a narrative of the flood risk assessment methodology and results. The report provides risk assessment information at the project level, placing emphasis on risk reduction activities that may have impacts beyond the specific stream or community. The report also provides risk assessment information that can be incorporated into mitigation plans (FEMA 2017).

The Flood Risk Map depicts select flood risk data for jurisdictions within the project area, emphasizing that risk reduction activities have an impact beyond the site. The Flood Risk Database will be the primary source to access information collected and developed during the flood risk assessment process.

The Database parallels the FIRM database. It is a project-level database that includes flood risk assessment data collected, created, and analyzed during the flood risk project. FEMA will publish and maintain the database in a standardized form to support national, state, regional, and local distribution. Viewing tools are currently under development, to provide users without access to GIS software, the ability to visualize and understand the multiple flood risk datasets contained within the database. Communities can access this report on FEMA's Map Service Center website (FEMA 2017).

- *Flood Risk Report* - The Flood Risk Report provides readers with an understanding of local flood risk exposure. The risk assessment information included in the report can be used to develop and prioritize mitigation strategies and can be incorporated into local hazard mitigation plans. The information in this report can also be used to help communicate with the general public about local flood risk. The Flood Risk Report parallels, but is separate from, the FIS report which accompanies the FIRM (FEMA Region II 2014c).

- *Flood Risk Map* - The Flood Risk Map shows flood risk in the study area using the flood risk datasets listed above. The Flood Risk Map is intended to provide a high-level overview of the study area to help community officials identify flood risk "hot spots" and to promote coordination with neighboring communities. The Flood Risk Map parallels, but is separate from, the community FIRM (FEMA Region II 2014c).
- *Flood Risk Database* - The database files are accessed using specialized GIS software that many communities use for planning, permitting, and other purposes. The Flood Risk Database can be used to develop customized maps to communicate with the public about flood risk and to overlay with other datasets the community may have for planning efforts and/or further flood risk analysis. The Flood Risk Database parallels, but is separate from, the regulatory FIRM database (FEMA Region II 2014c).

Flood risk datasets include the following:

- *Coastal Flood Risk Assessment* – "Risk assessment" is a process to identify potential hazards and to analyze what could happen if the hazard occurs. The coastal flood risk assessment dataset provides estimates of potential flood damage based on the new coastal flood study results using FEMA's HAZUS software. The data can help guide community mitigation efforts by highlighting areas where risk reduction actions are needed and will have the biggest impact (FEMA Region II 2014c).
- Using this dataset, planners and officials can identify where risk reduction efforts may produce the highest return on investment. This can inform policy decisions about mitigation actions are pursued and how they are prioritized. It may also provide a baseline against which to evaluate loss reduction upon future updates.
- If the community uses this information and determines the need to adopt a more stringent flood protection standard for critical facilities, the community may receive CRS points if they followed through on the adoption.
- Flood risk data can be used to quantify potential losses from floods on the built environment, which would assist with the prioritization of mitigation areas, and may also be incorporated into a focused sustainability effort. By focusing on areas facing the greatest vulnerability, sustainability efforts can help a community reduce its short- and long-term risk from floods.
- The refined HAZUS analysis with annualized loss estimates makes the risk more tangible to the planners and property owners. Providing potential flood event scenarios with dollar damages for their properties create more understandable situations, which can be presented to the public. In addition to these benefits, elected officials, planners, and engineers can use these datasets to help address the concerns or criticisms expressed by local stakeholders associated with changing flood risk.
- *Changes Since Last Firm (CSLF)* - The CSLF dataset compares information shown on the preliminary FIRM with that of the effective FIRM. Specifically, this includes a comparison of the floodplain boundaries and zones, Base Flood Elevation changes, and where applicable, the regulatory floodway. The dataset also includes information about why changes are happening in particular areas and indicates where no changes are occurring as well. It can be used to help explain map changes to residents and to identify areas newly mapped in high risk flood zones where outreach efforts may need to be focused. It can also be used to inform planning decisions and to prioritize mitigation measures. For draft versions of the CSLF dataset, preliminary work map data will be compared with the effective FIRM. For final versions, the preliminary FIRM will be compared with the effective FIRM (FEMA Region II 2014c).
- Flood Depth Grids and Water Surface Elevation Change Grids
    - Flood Depth Grids - A flood depth grid is a data set of grid cells which show the

depth of the 1% annual chance flood for any given location within the study area. Depth grids can be used by communities to identify high risk areas and to help prioritize and evaluate the cost effectiveness of mitigation measures. Flood depth is often easier for people to understand than Base Flood Elevations shown on the FIRMs. Thus, depth grids can also be effective outreach tools for communicating with the public about local flood risk. For draft versions of the flood depth grids, preliminary work map data will be used. For final versions, the preliminary FIRM data will be used instead (FEMA Region II 2014c).

- Water Surface Elevation Change Grids - Similar to the flood depth grid is the Water Surface Elevation Change Grid which shows the change in the one-percent annual chance water surface elevation between the existing and revised mapped floodplain (FEMA Region II 2014c).

- *Areas of Mitigation Interest* - This dataset shows areas where local conditions/factors may have an impact (positive or negative) on the identified flood risk. Areas with a history of flood claims, structures that contribute to flooding problems (e.g., undersized culverts or bridges), and areas experiencing land use change or development can be included in this dataset. By identifying these factors, this dataset can assist communities in identifying and prioritizing potential mitigation opportunities. It also allows communities to see factors present in neighboring communities which may impact them, fostering collaboration on mitigation projects (FEMA Region II 2014c).
- *Primary Frontal Dune (PFD) Erosion Areas* – PFD is a mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach which is subject to erosion and overtopping from high tides and waves during major storms. The PFD, where present, is used to delineate the limit of the coastal high hazard area (also known as the 'V zone') shown on the FIRM. This dataset shows the erosion areas associated with the PFD which can be used for community mitigation planning and communication efforts (FEMA Region II 2014c).
- *Coastal Increased Inundation Areas* - This dataset shows hypothetical increases of one, two, and three feet in the total water levels along the coast using the inland extent of one-percent annual chance flooding shown on the flood depth grid. The inundation areas are showing yellow, orange, and red. Flood levels exceeding the BFE (blue) are shown at one-foot increments depicting additional areas at risk for flooding. The increased flood hazard scenarios depict possible increases in flooding due to stronger storms, sea level rise, or land subsidence. This information can contribute to a better local understanding of characteristics of land in your community, which can lead to more informed decisions to allow suitable and appropriate development in higher risk areas (FEMA Region II 2014c).
- The local floodplain manager could use the 'coastal increased inundation areas' for advising the local elected officials to consider adopting more freeboard in the local floodplain ordinance. This step could also be used for CRS points and this information could be used to advise elected officials and property owners that they should consider purchasing a Preferred Risk Flood Insurance policy due to their proximity of the SFHA.

The NJDEP executed a Cooperating Technical Partners (CTP) partnership agreement with FEMA on May 16, 2006. Since that time, NJDEP has become a full CTP partner with FEMA. Under the CTP agreement, the NJDEP works as a contractor to FEMA Region II on the production of both regulatory and non-regulatory Flood Risk MAP products for the State of New Jersey. Risk MAP is discussed further below and in Section 5.6 (Flood). Under the CTP program, NJDEP has a dedicated full-time and part-time production team with specialized capabilities in water resource engineering, hydrology, hydraulics, flood risk hazard mapping, geographic information systems (GIS) and land surveying.

Within the last few years, the NJDEP has been working on the update of hydrology, hydraulics and flood risk hazard mapping for over 120-stream miles within the Passaic-Hackensack watershed basin. Additionally, the NJDEP has been working on updated Flood Insurance Study (FIS) and Digital Flood Insurance Rate Map (DFIRM) regulatory products for the Counties of Bergen, Salem, Cumberland, Gloucester and Camden. Non-regulatory flood Risk MAP products including Changes Since Last FIRM (CSLF), Flood Depth and Water Surface Elevation Change Grids, Flood Risk Assessments, Areas of Mitigation Interest, Primary Frontal Dune (PFD) Erosion Areas, Coastal Increased Inundation Areas, Flood Risk Database, Flood Risk Report and Flood Risk Map are being produced for selected areas of the Passaic-Hackensack watershed basin, Atlantic Coastal Counties and Delaware Bay Coastal Counties. The NJDEP has also collected building footprint information in GIS for selected areas of the Passaic-Hackensack watershed basin, Atlantic Coastal Counties and Delaware Bay Coastal Counties.

FEMA and NJDEP are providing communities with these additional tools or non-regulatory Flood Risk MAP products that can be used in planning efforts to mitigate flood risk, communicate with the public, and create a dialogue with neighboring communities about ways to reduce future flood risk. These tools include GIS datasets and maps, as well as supporting reports. The tools are not directly tied to regulatory development and insurance requirements of the NFIP but are important resources to support community planning efforts (FEMA, 2014b).

The Richard Stockton College of New Jersey Coastal Research Center (CRC), Stevens Institute of Technology, Sea Grant, Monmouth University, and Jacques Cousteau National Estuarine Research Reserve of Rutgers University have partnered with FEMA and the NJDEP Bureau of Dam Safety and Flood Control to become Academic Cooperating Technical Partners. As CTPs they provide technical support, web-based outreach products, and meeting facilitation to increase public awareness of flood risks within New Jersey's coastal counties.

The flood risk tools are in the process of being released on a rolling basis by county. Draft versions of certain tools will be initially released at the time of Flood Risk Review and Flood Resilience meetings for each community. The Flood Risk Review Meeting occurs after the release of preliminary work maps and before the release of the preliminary FIRM and FIS report. It is a technically- focused meeting organized by FEMA and its partners that gives community officials the opportunity to review the draft Risk MAP products, including the preliminary work maps and certain draft flood risk datasets. Opportunities for incorporating Risk MAP products into local mitigation planning efforts are also presented during this meeting (FEMA Region II 2014b).

The Resilience Meeting occurs after the issuance of the preliminary FIRM and FIS report. During this meeting organized by FEMA and its partners, community officials will have the first opportunity to review the preliminary FIRM and FIS report and additional draft flood risk datasets and products. Ways the community can incorporate the Risk MAP products into ongoing risk assessment and planning efforts are also discussed during this meeting (FEMA Region II, 2014).

Final versions of the tools will be released at the time of the Consultation Coordination Officer (CCO) meeting. The CCO meeting is held by FEMA and its partners for communities after the issuance of the preliminary FIRM and the Resilience Meeting. The purpose of the CCO Meeting and associated public open house is to present the preliminary FIRM and data to community officials and the general public. During this meeting, differences between the new and the effective FIRM will be presented, along with an overview of the appeals and map adoption process (FEMA Region II 2014b).

Resources available to local, regional, state and Federal agencies that may assist with the specific mitigation strategies identified include:

- FEMA grants available to communities that participate in the NFIP
- Other Federal grants available from the U.S. Department of Housing and Urban Development (HUD) and others
- Resources from the NFIP, CRS (when applicable), and floodplain management
- FEMA technical resources available online, such as design guides for hazard resistant construction and structure retrofits
- Technical assistance by other Federal agencies and professional associations such as ASFPM, NAFSMA, NJAFM, state floodplain management associations, and others

Coastal Outreach Advisory Teams (COATs) are intended to increase local awareness and understanding of, and engagement in the flood study process, as well as awareness and understanding of the risk from flooding and other natural hazards. COAT members actively participate in periodic meetings to discuss outreach and communication opportunities, identifying potential issues, and providing input on strategies and tactics for communicating about flood risk and other natural hazards. COAT members include local partners, community officials, federal agency partners, representatives from non-profit organizations, academic institutions, and the private sector (FEMA Region II 2014d).

There are two COATs currently active in FEMA Region II. The New Jersey and New York COAT focuses on the coastal flood study underway and general flood risk for the region. The Puerto Rico COAT focuses on the unique flooding and natural hazards associated with Puerto Rico (FEMA Region II 2014d). The New Jersey and New York COAT supports the New Jersey and New York Coastal Flooding Outreach and Education Programs. It advocates risk awareness and engagement in the coastal flood mapping process among public officials, citizens, and other key stakeholders. COAT members actively participate through identifying, prioritizing, and discussing outreach and education opportunities, recognizing potential issues, and providing meaningful input on strategies and tactics for communicating coastal flood risk. Members serve as word-of- mouth ambassadors among fellow stakeholders to convey the importance of reducing flood risk through increased community resilience (RAMPP 2012).

Biggert-Waters Flood Insurance Reform Act of 2012

In July 2012, the United States Congress passed the Biggert-Waters Flood Insurance Reform Act of 2012 (BW-12) which calls on FEMA and other agencies to make a number of changes to the way the NFIP is run. Key provisions of the legislation will require the NFIP to raise rates to reflect true flood risk, make the program more financially stable, and change how FIRM updates impact policyholders. BW-12 also rolled the Repetitive Flood Claims and Severe Repetitive Loss programs into Flood Mitigation Assistance (FMA) program and made significant changes to FMA. These changes include:

- The definitions of repetitive loss and severe repetitive loss properties were modified and are as follows:
  1. A severe repetitive loss property is a structure that is covered under a contract for flood insurance made available under the NFIP. These properties have incurred flood-related damage for which four or more separate claims payments have been made under flood insurance coverage with the amount of each such claim exceeding $5,000 and with the cumulative amount of such claims payments exceeding $20,000. Or for which at least two separate claims payments have been made under such coverage, with the cumulative amount of such claims exceeding that market value of the insured structure.
  2. A repetitive loss property is a structure covered by a contract for flood insurance made available under the NFIP that has incurred flood-related damage on two occasions, in which the cost of the repair, on average, equaled or exceeded 25% of market value of the structure at the time of each such flood event. Also, at the time of the second incidence of

flood-related damage, the contract for flood insurance contains increased cost of compliance coverage.

- There is no longer a state cap of $10 million or a community cap of $3.3 million for any five-year period
- There is no longer a limit on in-kind contributions for the non-federal cost share
- Mitigation reconstruction is an eligible activity
- Cost-share requirements have changed to allow more federal funds for properties with repetitive flood claims and severe repetitive loss properties
- The development or update of mitigation plans shall not exceed $50,000 federal share to any applicant or $25,000 federal share to any sub applicant
- There is no longer a restriction that a planning grant can be awarded not more than once every five years to a state or community (FEMA 2013a)

Homeowners of certain older properties in high-risk areas had been charged premiums that do not reflect the full flood risk. Only properties known as “pre-FIRM” were eligible for these subsidies. Although only approximately 20% of NFIP policies nationwide are subsidized, 37.1% of New Jersey policies are considered to be “pre-FIRM”. BW-12 requires FEMA to phase out these subsidies for certain properties and prohibits FEMA from offering subsidies for other pre-FIRM properties. Not all subsidies will be removed the same way at the same time (FEMA 2013a). Increases to pre-FIRM subsided rates include the following:

- Owners of non-primary residences with pre-FIRM subsidized rates are scheduled to see a 25% annual increase until full-risk rates are reached, unless superseded by pending Congressional legislation.
- By October 1, 2013:
  - Owners of businesses with pre-FIRM subsidized rates will see a 25% annual increase until full-risk rates are reached
  - Owners of properties of one to four residences with a pre-FIRM subsidized rate that have experienced severe or repetitive flooding will see a 25% annual increase until full-risk rates are reached Pre-FIRM subsidized policies first in effect on or after July 6, 2012 will move directly to full- risk rates
  - Pre-FIRM subsidized policies on homes purchased on or after July 6, 2012 will move directly to full-risk rates
  - Lapsed pre-FIRM subsidized policies reinstated on or after October 4, 2012 will move directly to full-risk rates (FEMA 2013a)

In New Jersey there are a total of 1,238 SRL Properties. The county with the highest number of SRL properties is Passaic County (267 SRL properties). See section 8 Repetitive Loss Strategy for more information on repetitive loss and severe repetitive loss properties.

The Consolidated Appropriations Act of 2014

The Consolidated Appropriations Act of 2014 (Omnibus), prohibited FEMA through the National Flood Insurance Program (NFIP) from implementing Section 207 of the Biggert-Waters Flood Insurance Reform Act of 2012 (FEMA, 2014). Section 207 directed FEMA to ensure that certain properties’ flood insurance rates reflects their full risk after a mapping change or update occurs. Section 207 of the Act was never implemented and did not relate to changes to flood insurance rates that already had taken place. The Omnibus did not roll back any rate increases that occurred as a result of Biggert -Waters. Other provisions in Biggert-Waters were continued to be implemented, as directed by Congress, including the phase out of subsidies on certain Pre-Flood Insurance Rate Maps (Pre-FIRM) properties (FEMA, 2014).

Homeowner Flood Insurance Affordability Act of 2014

The Homeowner Flood Insurance Affordability Act of 2014 (HFIAA) repealed certain parts of previous law – Biggert-Waters, restoring grandfathering, putting limits on certain rate increases and updating the approach to ensuring the fiscal soundness of the fund by applying an annual surcharge to all policyholders (FEMA, 2014). The new law lowers the recent rate increases on some policies, prevents some future rate increases, and implements a surcharge on all policyholders. The Act also authorizes additional resources for the National Academy of Sciences (NAS) to complete an affordability study.

5.6.1.3 COMMUNITY RATING SYSTEM (CRS) PROGRAM

The CRS is a voluntary program within the NFIP encouraging floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premiums are discounted to reflect the reduced flood risk to meet the CRS goals of reducing flood losses, facilitating accurate insurance rating, and promoting awareness of flood insurance in the community.

For participating communities, flood insurance premium rates are discounted in increments of 5%. For example, a Class 1 community receives a 45% premium discount, and a Class 9 community receives a 5% discount. Class 10 communities do not participate in the CRS and therefore do not receive a discount. The CRS classes for local communities are based on 18 creditable activities in the following categories:

- Public information
- Mapping and regulations
- Flood damage reduction
- Flood preparedness

CRS activities (discussed below) can help save lives and reduce property damage. Communities participating in the CRS represent a significant portion of the nation's flood risk; over 66% of the NFIP's policy base is located in these communities. Small and large communities participate in and receive premium discounts through the CRS. These communities represent a mixture of flood risks, including both coastal and riverine flood risks. The Insurance Services Office (ISO) administers the CRS program under contract to FEMA.

As of 2018, there were 108 communities within the State of New Jersey participating in the CRS program. The participating communities are shown in Table 5.6-1. The CRS classifications in New Jersey range from a high of Class 10 (no discount) to a low of Class 3 (35% discount). The New Jersey Dam Safety program, state stormwater management requirements, and the development of all hazard mitigation plans are some of the efforts at the state level that provide CRS credits for all New Jersey municipalities. Communities are encouraged to adopt freeboard elevation requirements, which also provide CRS credits. Many municipalities in New Jersey are small and lack the professional support to fill out a CRS application, or do not have the flood insurance policy base to make it worthwhile. However, Community Assistance Visits (CAV), Community Assistance Contacts (CAC), technical assistance contacts, and workshops help to promote the CRS program in these small towns.

As of 2018, New Jersey has:

- 15 communities with a Class 10 (0%) premium reduction;
- 3 communities with a Class 9 rating (5% premium reduction);
- 21 communities with a Class 8 rating (10% premium reduction);
- 22 communities with a Class 7 rating (15% premium reduction);
- 28 communities with a Class 6 rating (20% premium reduction);
- 18 communities with a Class 5 rating (25% premium reduction); and,
- 1 community with a Class 3 rating (35% premium reduction).

Of the participating CRS communities, 15 of them had their CRS classifications rescinded due to failure to meet annual participation requirements. These communities are receiving no CRS Discount.

5.6.1.4 LOCATION

Flooding in New Jersey is often the direct result of frequent weather events such as coastal storms, Nor'easters, heavy rains, tropical storms, and hurricanes. Floods are the most frequent natural hazards in New Jersey and occur any time of the year. Areas of greatest risk occur in known floodplains where there is intense rainfall over a short period of time; prolonged rain over several days; and/or ice or debris jams causing rivers or streams to overflow (NJOEM, 2006). Areas within a floodplain become inundated during a flooding event. The areas within the one-percent annual chance flood areas have a higher chance of becoming inundated during storm events. The one-percent annual chance of flood hazard zones (both A and V-zones) and 0.2- percent annual chance flood zone throughout New Jersey are identified in Figure 5.6-3. through Figure 5.6-9. The data sources for the flood hazard zones depicted in these figures are listed in Table 5.6-8 and in the maps themselves.

The most damaging riverine floods in New Jersey appear to occur in the northern half of the State. This is a function of several physiographic and physical features of the landscape, as well as the densely developed floodplain. Greater geographic relief in the northern half results in flowing water moving down steeper gradients and being naturally or artificially channelized through valleys and gullies. Since the Delaware, Raritan and Passaic Rivers drain more than 90% of the northern New Jersey counties, these rivers and their tributaries are common locations for flooding. Areas in the one-percent and 0.2-percent annual chance flood zones are also common locations for flooding.

Table 5.6-1 Participating CRS Communities in New Jersey June 2018

COMMUNIT Y NUMBER	COMMUNITY NAME	CRS ENTRY DATE	CURREN T EFF. DATE	CLASS	% DISCOUNT FOR SFHA	% DISCOUNT FOR NON- SFHA	STATUS
340312	Aberdeen, Township of	05/1/10	10/1/15	8	10	5	C
340001	Absecon, City of	10/1/14	10/1/14	8	10	5	C
345278	Atlantic City, City of	10/1/92	05/1/18	6	20	10	C
345279	Avalon, Borough of	10/1/96	10/1/13	5	25	10	C
340287	Avon-by-the-Sea, Borough of	10/1/16	10/1/16	6	20	10	C
340396	Barnegat, Township of	05/1/14	05/1/14	7	15	5	C
345280	Barnegat Light, Borough of	10/1/92	10/1/01	8	10	5	C
345281	Bay Head, Borough of	10/1/93	10/1/13	6	20	10	C
345282	Beach Haven, Borough of	10/1/91	10/1/13	5	25	10	C
340427	Bedminster, Township of	10/1/96	05/1/07	6	20	10	C
345283	Belmar, Borough of	05/1/15	05/1/15	6	20	10	C
340369	Berkeley, Township of	10/1/92	10/1/13	6	20	10	C
340459	Berkeley Heights, Township of	10/1/94	05/1/99	10	-	-	R
340428	Bernards, Township of	10/1/10	05/1/17	7	15	5	C
340178	Bloomfield, Township of	10/1/92	10/1/97	10	-	-	R
345284	Bloomingdale, Borough of	10/1/16	10/1/16	8	10	5	C
340289	Bradley Beach, Borough	10/1/95	10/1/00	7	15	5	C

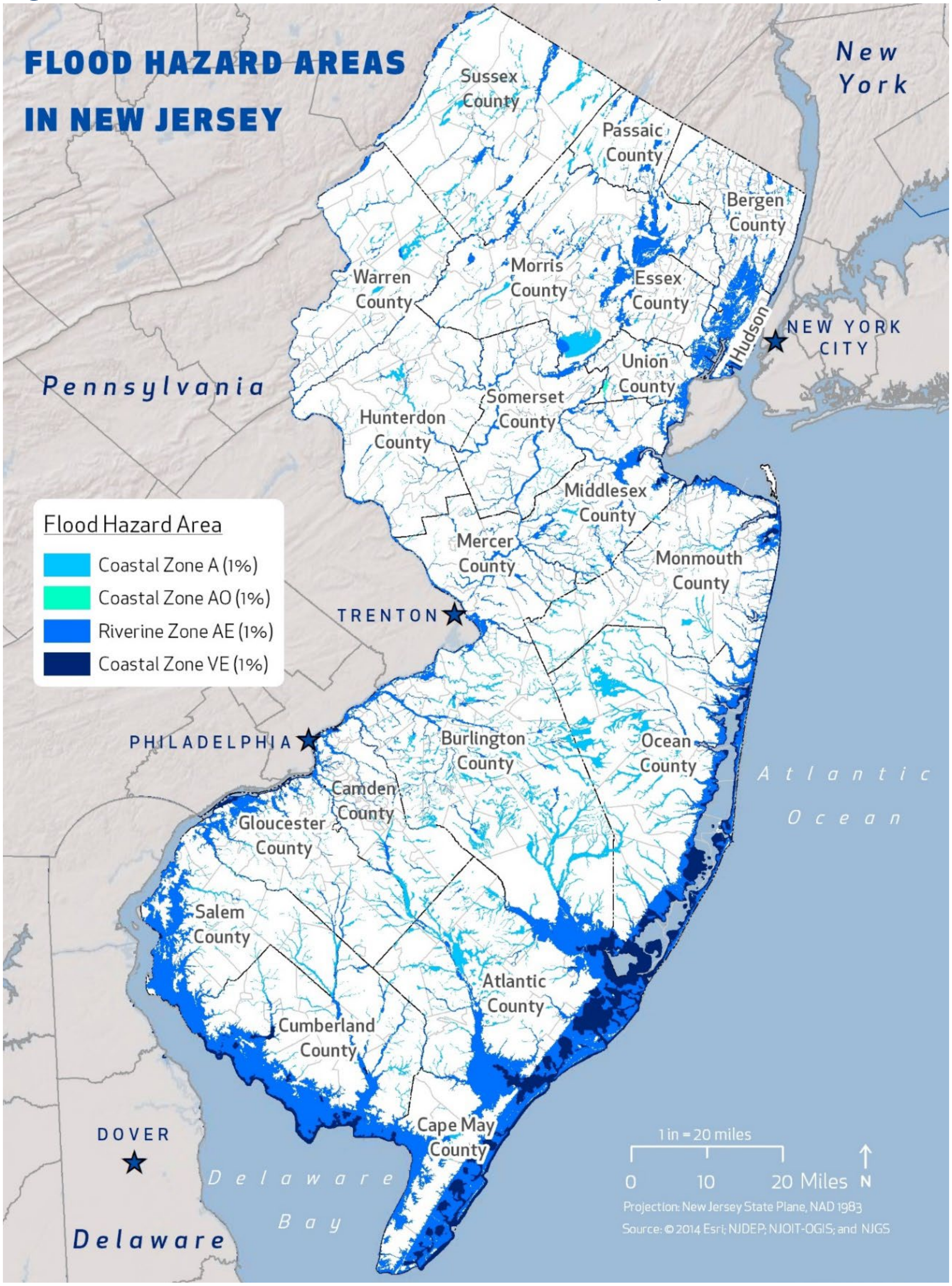
COMMUNIT Y NUMBER	COMMUNITY NAME	CRS ENTRY DATE	CURREN T EFF. DATE	CLASS	% DISCOUNT FOR SFHA	% DISCOUNT FOR NON- SFHA	STATUS
	of						
345285	Brick, Township of	05/1/17	05/1/17	6	20	10	C
345286	Brigantine, City of	10/1/92	10/1/15	5	25	10	C
345287	Burlington, City of	05/1/98	10/1/03	8	10	5	C
345288	Cape May City, City of	10/1/94	10/1/13	6	20	10	C
345289	Cape May Point, Borough of	10/1/93	10/1/13	6	20	10	C
345291	Cranford Township	10/1/16	10/1/16	7	15	5	C
345292	Denville, Township of	10/1/11	05/1/16	6	20	10	C
340026	Dumont, Borough of	10/1/17	10/1/17	9	5	5	C
340007	Egg Harbor, Township of	10/1/17	10/1/17	5	25	10	C
340031	Englewood, City of	10/1/91	10/1/01	10	-	-	R
345295	Fairfield, Township of	05/1/13	05/1/13	6	20	10	C
340434	Franklin, Township of	05/1/10	05/1/15	6	20	10	C
340037	Garfield, City of	05/1/12	10/1/14	0	-	-	R
340204	Greenwich, Township of	05/1/07	05/1/07	9	5	5	C
340246	Hamilton, Township of	10/1/92	10/1/02	8	10	5	C
345296	Harvey Cedars, Borough of	10/1/91	10/1/99	8	10	5	C
340298	Hazlet, Township of	05/1/11	10/1/13	6	20	10	C
340303	Keansburg, Borough of	05/1/15	05/1/15	7	15	5	C
340376	Lacey, Township of	10/1/92	10/1/93	10	-	-	R
340237	Lambertville, City of	05/1/12	05/1/17	7	15	5	C
340379	Lavallette, Borough of	05/1/04	10/1/13	6	20	10	C
345300	Lincoln Park, Borough of	05/1/16	05/1/16	5	25	10	C
340467	Linden, City of	10/1/91	10/1/02	8	10	5	C
340011	Linwood, City of	10/1/14	10/1/14	7	15	5	C
340380	Little Egg Harbor, Township of	05/1/18	05/1/18	6	20	10	C
340401	Little Falls, Township of	05/1/10	05/1/16	6	20	10	C
340046	Little Ferry, Borough of	10/1/15	10/1/15	7	15	5	C
340047	Lodi, Borough of	10/1/92	10/1/93	10	-	-	R
345301	Long Beach, Township of	10/1/92	10/1/13	5	25	10	C
340307	Long Branch, City of	05/1/18	05/1/18	7	15	5	C
340356	Long Hill, Township of	10/1/17	10/1/17	7	15	5	C
345302	Longport, Borough of	10/1/95	10/1/13	5	25	10	C
345303	Manasquan, Borough of	10/1/92	05/1/18	5	25	10	C
340383	Mantoloking, Borough of	10/1/92	10/1/13	5	25	10	C
340437	Manville, Borough of	10/1/14	10/1/14	7	15	5	C
345304	Margate City, City of	10/1/92	10/1/13	5	25	10	C
340313	Middletown, Township of	05/1/12	10/1/13	6	20	10	C
340315	Monmouth Beach, Borough of	10/1/17	10/1/17	8	10	5	C
340188	Montclair, Township of	10/1/94	10/1/95	10	-	-	R

COMMUNIT Y NUMBER	COMMUNITY NAME	CRS ENTRY DATE	CURREN T EFF. DATE	CLASS	% DISCOUNT FOR SFHA	% DISCOUNT FOR NON- SFHA	STATUS
340517	Mullica, Township of	10/1/94	05/1/08	10	-	-	R
340209	National Park, Borough of	10/1/12	10/1/17	8	10	5	C
340317	Neptune, Township of	05/1/15	05/1/15	6	20	10	C
340570	New Jersey Sports and Exposition Authority	10/1/92	05/1/09	7	15	5	C
345307	North Plainfield, Borough of	10/1/92	10/1/09	8	10	5	C
345308	North Wildwood, City of	10/1/00	05/1/17	6	20	10	C
345309	Oakland, Borough of	05/1/17	05/1/17	7	15	5	C
345310	Ocean City, City of	10/1/92	05/1/16	5	25	10	C
340518	Ocean, Township of	05/1/14	05/1/14	6	20	10	C
340319	Ocean Township	10/1/17	10/1/17	8	10	5	C
340320	Oceanport, Borough of	05/1/10	10/1/15	7	15	5	C
340110	Palmyra, Borough of	10/1/09	05/1/15	7	15	5	C
340355	Parsippany-Troy Hills, Township of	10/1/91	05/1/09	10	-	-	R
340512	Pennsville, Township of	10/1/16	10/1/16	8	10	5	R
345311	Pequannock, Township of	10/1/91	10/1/16	5	25	10	C
340272	Perth Amboy, City of	10/1/17	10/1/17	9	5	5	C
345312	Plainfield, City of	10/1/91	10/1/98	10	-	-	R
340015	Pleasantville, City of	10/1/14	10/1/14	7	15	5	C
345313	Point Pleasant, Borough of	10/1/93	10/1/15	7	15	5	C
340388	Point Pleasant Beach, Borough of	10/1/92	10/1/15	6	20	10	C
345528	Pompton Lakes, Borough of	10/1/91	05/1/13	5	25	10	C
345314	Rahway, City of	10/1/92	05/1/13	6	20	10	C
340067	Ridgewood, Village of	10/1/92	10/1/02	7	15	5	C
340359	Riverdale, Borough of	10/1/94	05/1/14	8	10	5	C
340070	Rochelle Park, Township of	10/1/06	10/1/06	8	10	5	C
340472	Roselle, Borough of	10/1/92	05/1/13	7	15	5	C
340473	Roselle Park, Borough of	10/1/15	10/1/15	8	10	5	C
340474	Scotch Plains, Township of	10/1/94	10/1/95	10	-	-	R
345317	Sea Bright, Borough of	10/1/92	10/1/97	10	-	-	R
345318	Sea Isle City, City of	10/1/92	05/1/18	3	35	10	C
340389	Seaside Heights, Borough of	05/1/17	05/1/17	8	10	5	C
345319	Seaside Park, Borough of	10/1/92	05/1/17	7	15	5	C
345320	Ship Bottom, Borough of	10/1/92	05/1/09	7	15	5	C
340017	Somers Point, City of	05/1/18	05/1/18	6	20	10	C

COMMUNIT Y NUMBER	COMMUNITY NAME	CRS ENTRY DATE	CURREN T EFF. DATE	CLASS	% DISCOUNT FOR SFHA	% DISCOUNT FOR NON- SFHA	STATUS
340280	South River, Borough of	10/1/14	10/1/14	6	20	10	C
340329	Spring Lake, Borough of	10/1/94	05/1/14	6	20	10	C
340393	Stafford, Township of	10/1/91	10/1/13	5	25	10	C
345323	Stone Harbor, Borough of	10/1/94	05/1/14	5	25	10	C
345324	Surf City, Borough of	10/1/92	05/1/18	6	20	10	C
345293	Toms River, Township of	10/1/92	05/1/13	8	10	5	C
340395	Tuckerton, Borough of	10/1/93	10/1/98	10	-	-	R
340331	Union Beach, Borough of	10/1/03	10/1/16	6	20	10	C
340159	Upper, Township of	10/1/11	05/1/17	5	25	10	C
345326	Ventnor City, City of	10/1/92	05/1/18	5	25	10	C
340446	Warren, Township of	05/1/10	05/1/15	8	10	5	C
345327	Wayne, Township of	10/1/91	05/1/15	7	15	5	C
345328	West Wildwood, Borough of	10/1/93	10/1/05	0	-	-	R
340081	Westwood, Borough of	10/1/16	10/1/16	8	10	5	C
345329	Wildwood, City of	05/1/16	05/1/18	5	25	10	C
345330	Wildwood Crest, Borough of	10/1/93	05/1/14	6	20	10	C
345331	Woodbridge, Township of	10/1/92	10/1/97	10	-	-	R
340412	Woodland Park, Borough of	10/1/16	10/1/16	8	10	5	C

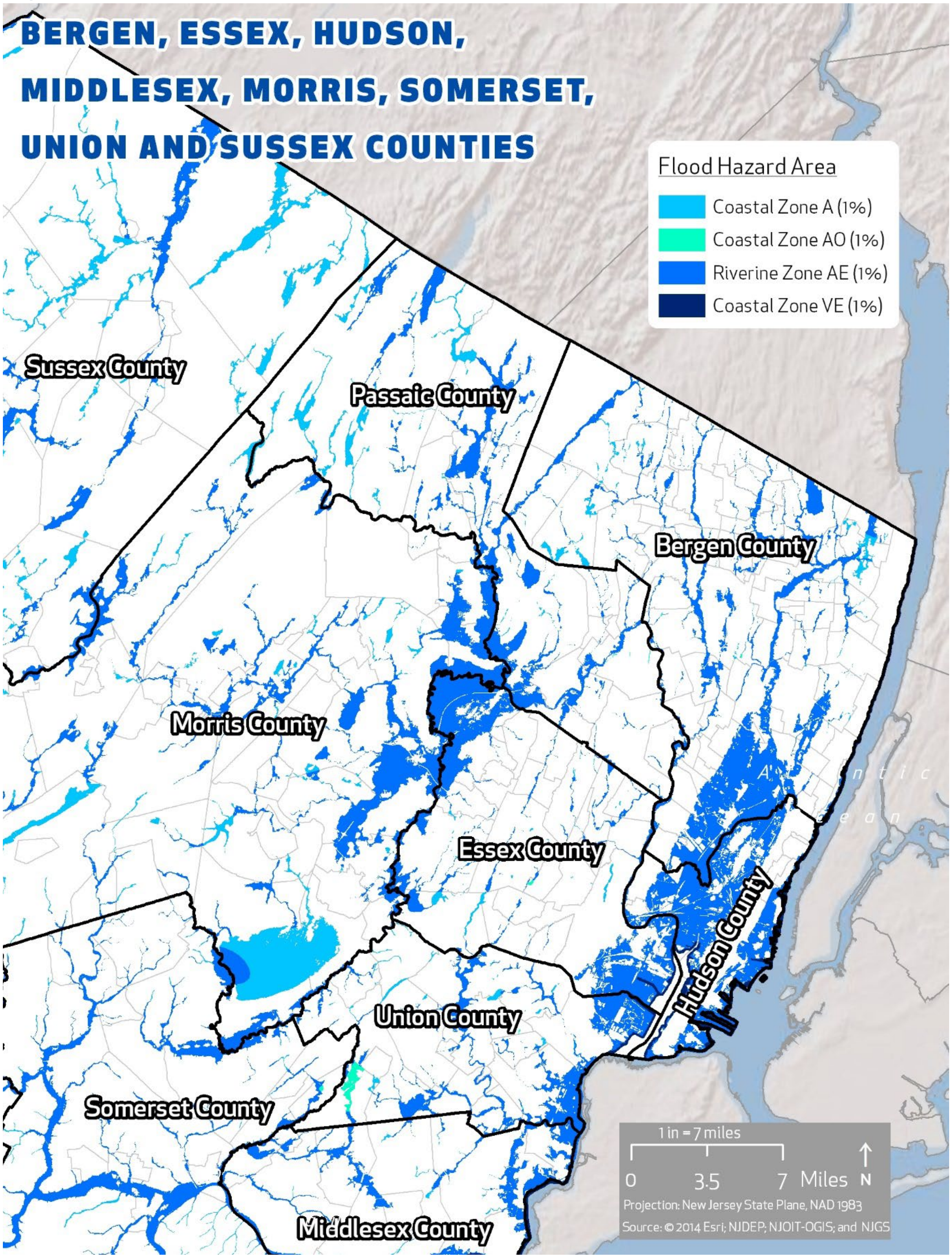
Source: FEMA, 2018

Figure 5.6-3 FEMA Flood Hazard Areas in New Jersey



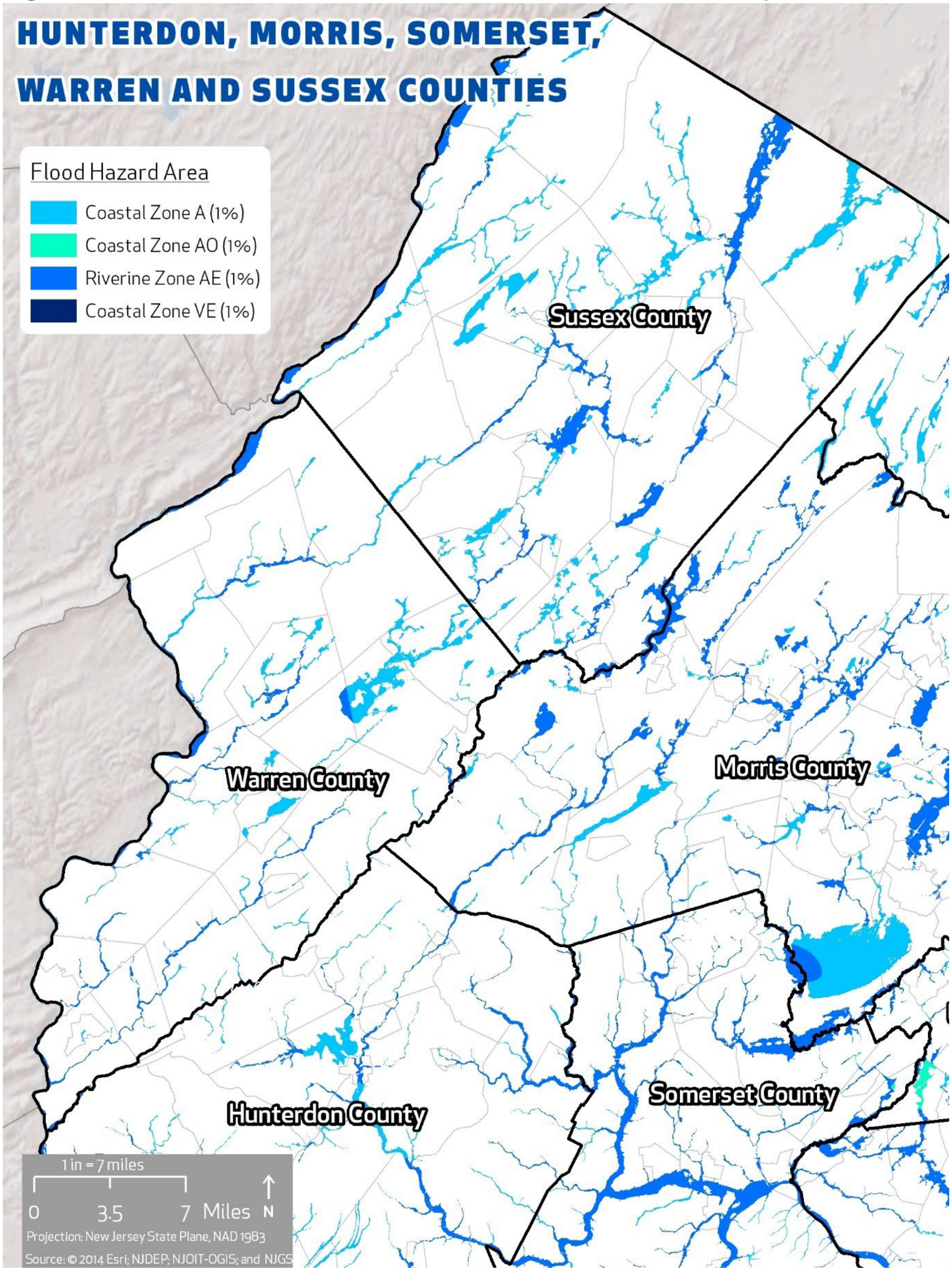
Source: NJGIS, 2018; FEMA, 2018

Figure 5.6-4 FEMA Flood Hazard Areas in Northeastern New Jersey



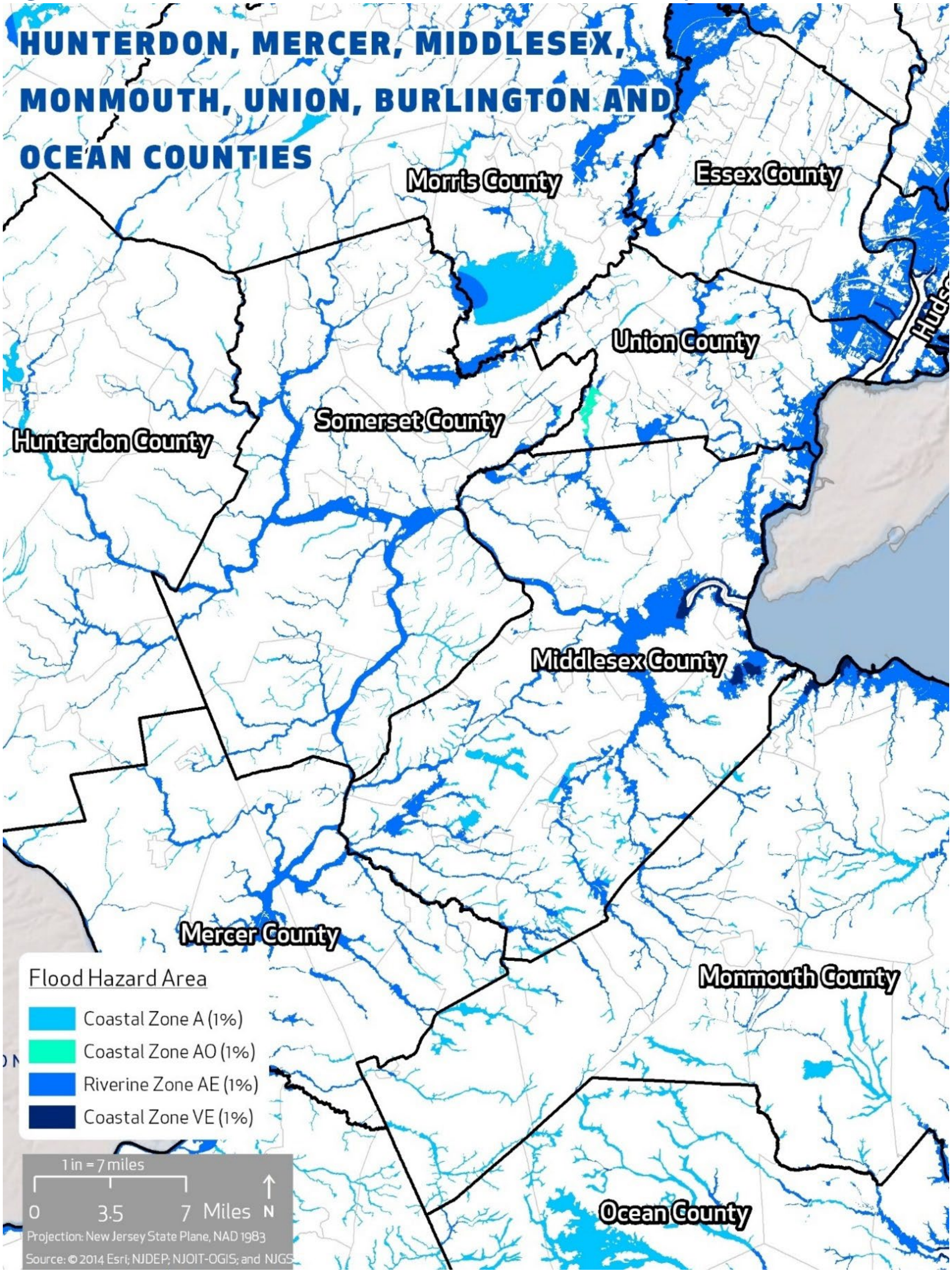
Source: NJGIS, 2018; FEMA, 2018

Figure 5.6-5 FEMA Flood Hazard Areas in Northwestern New Jersey



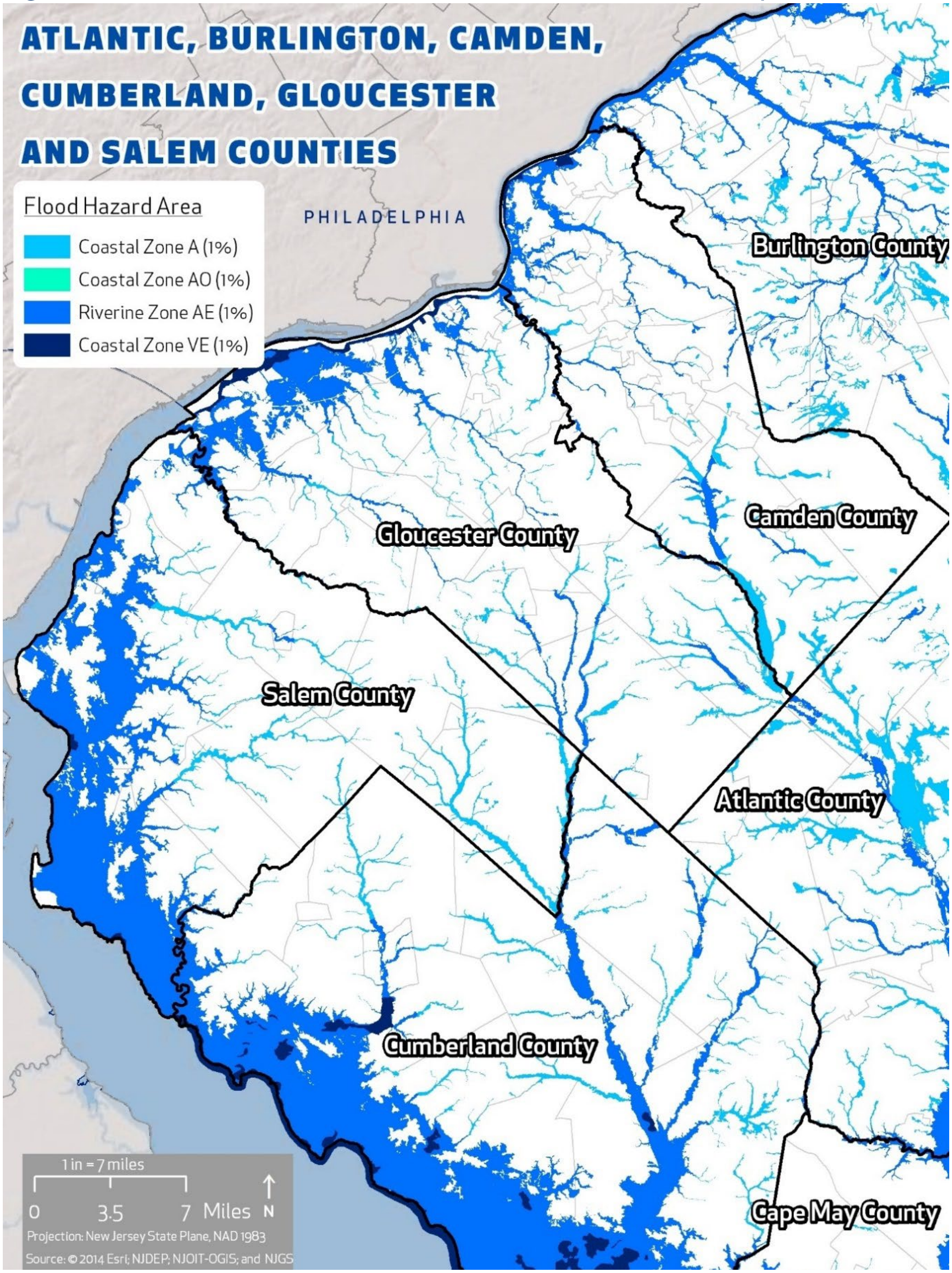
Source: NJGIS, 2018; FEMA, 2018

Figure 5.6-6 FEMA Flood Hazard Areas in Central New Jersey



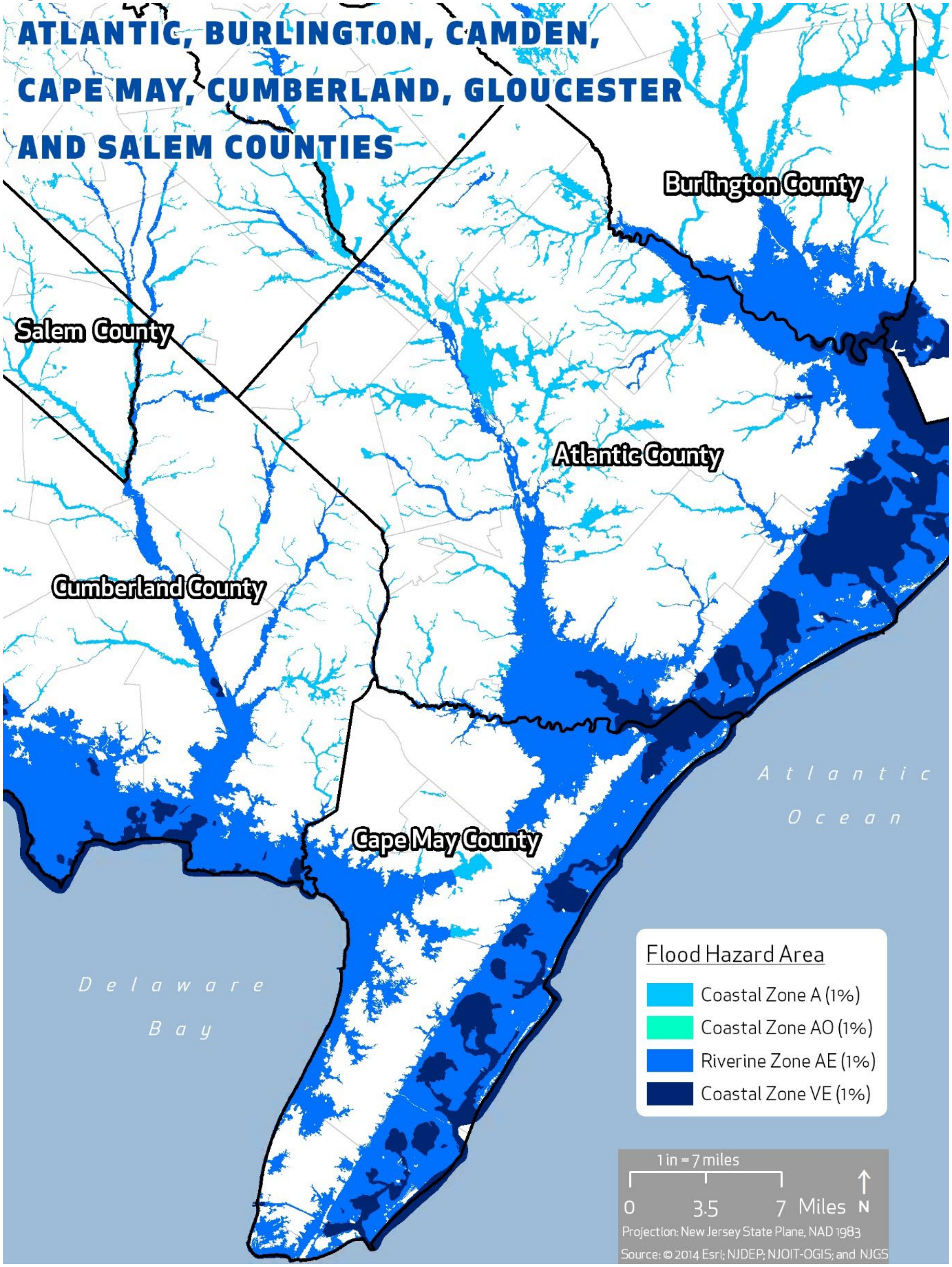
Source: NJGIS, 2018; FEMA, 2018

Figure 5.6-7 FEMA Flood Hazard Areas in Southwestern New Jersey



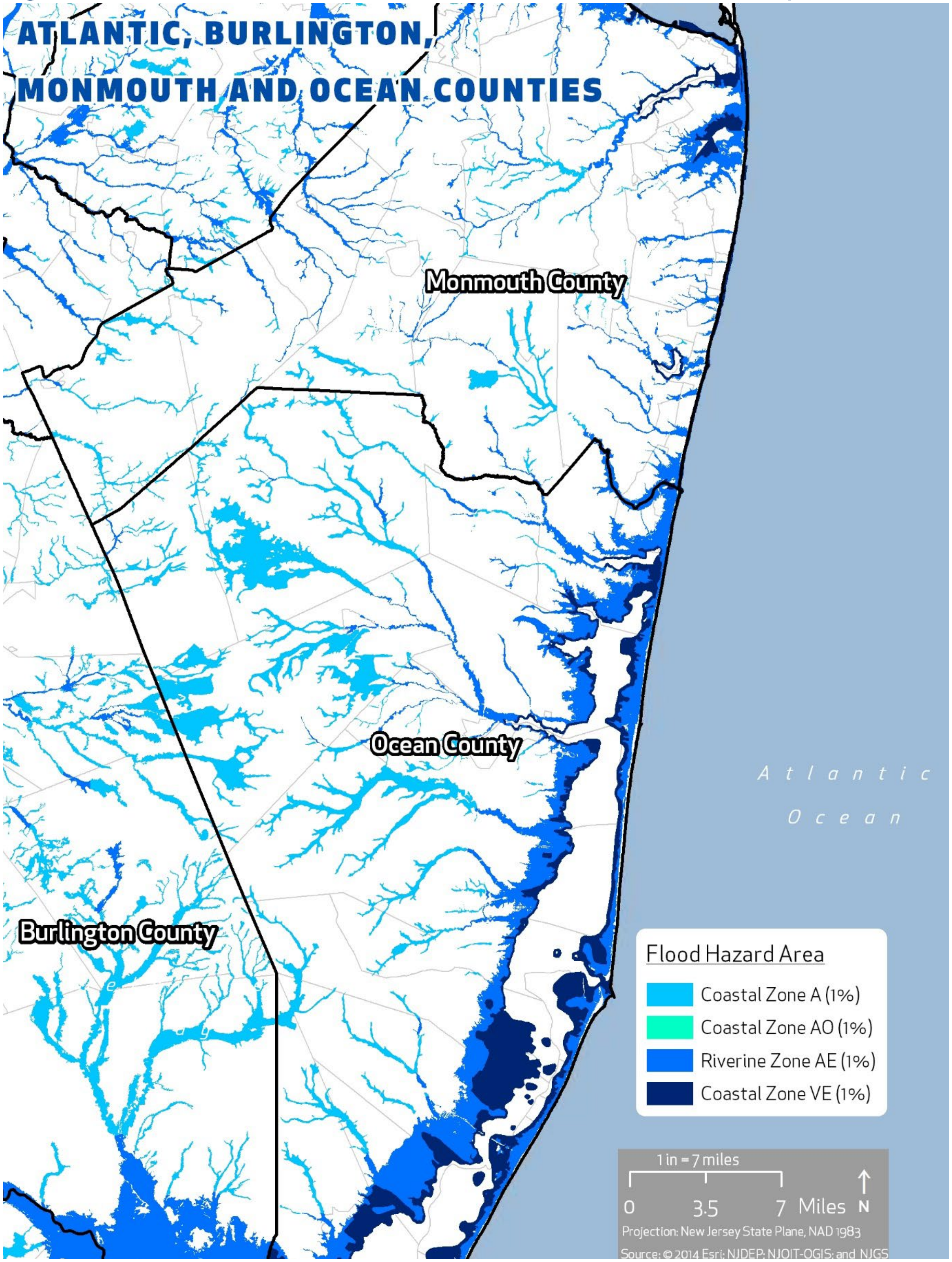
Source: NJGIS, 2018; FEMA, 2018

Figure 5.6-8 FEMA Flood Hazard Areas in Southern New Jersey



Source: NJGIS, 2018; FEMA, 2018

Figure 5.6-9 FEMA Flood Hazard Areas in Southeastern New Jersey



Source: NJGIS, 2018; FEMA, 2018

Coastal Flooding

New Jersey and its coastal communities are vulnerable to the damaging impacts of major storms along its 127 miles of coastline. New Jersey's coastal zone includes portions of eight counties and 126 municipalities. The coastal boundary of New Jersey encompasses the Coastal Area Facility Review Act (CAFRA) area and the New Jersey Meadowlands District. The coastal area includes coastal waters to the limit of tidal influence including: the Atlantic Ocean (to the limit of New Jersey's seaward jurisdiction); Upper New York Bay, Newark Bay, Raritan Bay and the Arthur Kill; the Hudson, Raritan, Passaic, and Hackensack Rivers, and the tidal portions of the tributaries to these bays and rivers. The Delaware River and Bay and other tidal streams of the Coastal Plain are also in the coastal area, as is a narrow band of adjacent uplands in the Waterfront Development area beyond the CAFRA area. Figure 5.6-10 shows New Jersey and the highlighted coastal zone area.

Coastal flooding is most commonly found along the State's 127 miles of coastline, stretching from Raritan Bay in the north, along the Atlantic Coast to Delaware Bay in the south and includes the counties of Atlantic, Cape May, Ocean, and Monmouth. Due to the impacts of Superstorm Sandy, coastal flooding has been the most costly type of flooding events causing significant beach erosion, damage to dunes and shore protection structures as well as tidal flooding impacts.

Figure 5.6-10 New Jersey Coastal Zone Area

Source: NJDEP, 2007

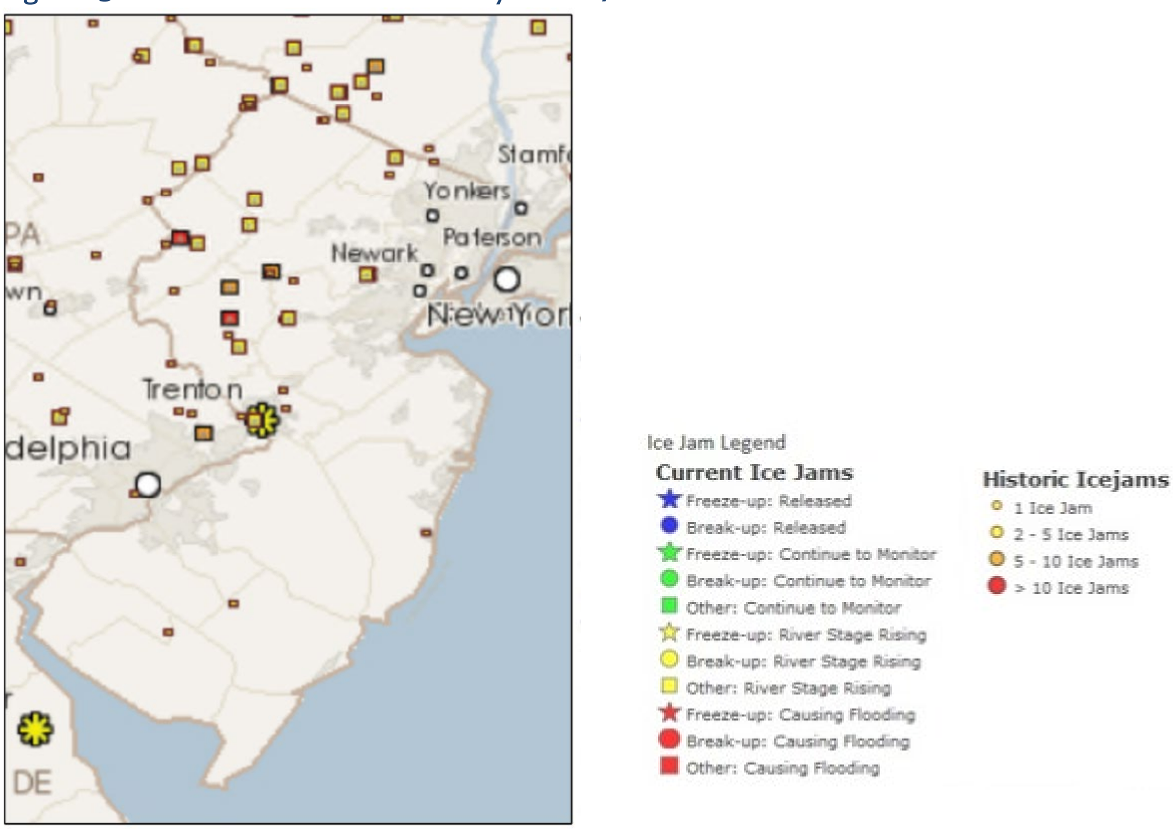
Storm surge also contributes to coastal flooding. Storm surges inundate coastal floodplains by dune overwash, tidal elevation rise in inland bays and harbors, and backwater flooding through coastal river mouths. Strong winds can increase in tide levels and water-surface elevations. Storm systems generate large waves that run up and flood coastal beaches. The combined effects create storm surges that affect the beach, dunes, and adjacent low-lying floodplains. Shallow, offshore depths can cause storm-driven waves and tides to pile up against the shoreline and inside bays. Based on an area's topography, a storm surge may inundate only a small area (along sections of the northeast or southeast coasts) or storm surge may inundate coastal lands for a mile or more inland from the shoreline. See Section 5.8 (Hurricane) for additional information regarding storm surge.

During Superstorm Sandy, water levels rose along the entire east coast of the United States, with the highest storm surges and greatest inundation on land occurring in New Jersey, New York, and Connecticut. In many of these locations, especially along the coast of central and northern New Jersey, the surge was accompanied by powerful, damaging winds. The highest storm surge measured by a tide gauge in New Jersey was 8.57 feet above normal tide levels at the northern end of Sandy Hook. Farther south, tide gauges in Atlantic City and Cape May measured storm surges of 5.82 feet and 5.16 feet. The deepest water occurred in areas that border Lower New York Bay, Raritan Bay, and the Raritan River. A high-water mark of 8.01 feet above mean higher high water (MHHW) was reported in Sandy Hook. In other locations, a high-water mark of 7.9 feet above ground level was measured in Keyport on the southern side of Raritan Bay and 7.7 feet above ground level was measured in Sayreville near the Raritan River. Water levels were highest along the northern portion of the Jersey Shore in Monmouth and Ocean Counties. Barrier islands were almost completely inundated in some areas, and breached in some cases, due to storm surge and large waves from the Atlantic Ocean meeting up with water from the back bays (Blake et al. 2013).

Ice Jams

Ice jams are common in the northeast United States and New Jersey is not an exception. In fact, according to the United States Army Corps of Engineers, New Jersey had over 100 ice jam incidents documented between 1904 and 2017 (CRREL 2018). The rivers that experienced the greatest number of ice jams during this time period included the Delaware River (33 reported ice jams) and the South Branch Raritan River (20 reported ice jams). Figure 5.6-11 presents the number of ice jam incidents in New Jersey during this time period.

Figure 5.6-11 Ice Jams in New Jersey from 1780 to 2018



Source: CRREL 2018

Tsunami

According to a document titled *U.S. States and Territories National Tsunami Hazard Assessment: Historical Record and Sources for Waves*, the United States Atlantic coast and the Gulf Coast states have experienced very few tsunamis in the last 200 years. Louisiana, Mississippi, Alabama, the Florida Gulf Coast, Georgia, Virginia, North Carolina, Pennsylvania, and Delaware have no known historical tsunami records. Only six tsunamis have been recorded in the other Gulf and East Coast states. Three of these tsunamis were generated in the Caribbean. Two of these tsunamis were related to a magnitude 7+ earthquake along the Atlantic coast. The other reported tsunami occurred in the Mid-Atlantic States that may have been related to an underwater explosion or landslide (Dunbar and Weaver 2008).

Unlike the Atlantic and Gulf Coasts, the Pacific territories, Puerto Rico, and the United States Virgin Islands have a moderate to very high tsunami hazard. The Pacific territories, including Guam, American Samoa and the Northern Marianas, all experience tsunamis and mostly have a moderate hazard. Studies show that Washington, Oregon, California, Puerto Rico, and the United States Virgin Islands have a high tsunami hazard (Dunbar and Weaver, 2008).

Tsunami and tsunami-like waves that have impacted the East Coast were analyzed by Lockridge et al. NOAA's National Geophysical Data Center (NGDC) compiled a listing of all tsunamis and tsunami-like waves of the eastern United States and Canada. Forty-nine potential tsunami events have been identified as possibly impacting the East Coast of the United States between 1668 and 2008. Of these events, eight were categorized as definite or probable tsunamis (NOAA NGDC, 2013).

The following present the most significant tsunami threats to the East Coast of the United States:

- *Mid-Atlantic Ridge*—The closest tectonic boundary to the East Coast is the spreading Mid-Atlantic Ridge, which contains numerous faults. However, according to the Maine Geological Survey, tsunamis are more likely to occur at convergent margins. In the Caribbean Sea, there is a convergent plate boundary and a region with a higher probability of generating earthquakes that could produce tsunamis. Tsunamis could potentially travel to New England from the Caribbean, the Mid-Atlantic Ridge, or from the Canary Islands.
- *Caribbean Islands*—The Caribbean is home to some of the most geologically active areas outside of the Pacific Ocean. Similar to the Indonesian Islands, this area has a subduction zone that is located just north of Puerto Rico. The North American plate is being subducted beneath the Caribbean Plate at the Puerto Rico Trench. This area includes other troughs and areas of plate tectonics that have produced numerous earthquakes, sub-marine landslides, volcanic eruptions, and resulting tsunami activity.
- *North Carolina/Virginia Continental Shelf*—Although the East Coast is much less likely to be affected by a tsunami than the west coast, tsunami threats do exist. Evidence of a large sub-marine landslide off the coasts of Virginia and North Carolina was found and named the Albemarle-Currituck Slide. This event occurred approximately 18,000 years ago when over 33 cubic miles of material slid seaward from the edge of the continental shelf, most likely causing a tsunami.
- *Canary Islands*—The Canary Islands are a volcanic island-arc chain located in the eastern Atlantic Ocean, just west of the Moroccan coastline. La Palma is the western-most and youngest of the Canary Islands and is volcanically active with three large volcanoes. It is also the location of the most active volcano of the Canary Islands, Cumbre Vieja, which most recently erupted in 1949 and again in 1971. Based on a study of past landslide deposits and existing geology of the volcano, some scientists suggest that the west flank of the Cumbre Vieja may experience failure during a future eruption, resulting in a landslide of a block of 15 to 20 kilometers wide and 15 to 25 kilometers long into the Atlantic Ocean. A sudden landslide of this magnitude could create a large tsunami. Although the flank instability of Cumbre Vieja is noted, other scientists disagree with massive failure scenarios for the western flank of the volcano. These scientists think it would happen in smaller, separate events that would not be capable of triggering a mega-tsunami.

No mega tsunamis have occurred in the Atlantic or Pacific Oceans in recorded history. The colossal collapses of Krakatau or Santorini generated catastrophic waves in the immediate area, but hazardous waves did not propagate to distant shores. Numerical and experimental models on such events and of the Las Palma event verify that the relatively short waves from these small occurrences do not travel as do tsunami waves from a major earthquake (State of Maine, 2013).

5.6.2 EXTENT

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 severity of a flood depends not only on the amount of water that accumulates in a period of time, but also on the land's ability to manage this water. The size of rivers and streams in an area and infiltration rates are significant factors. When it rains, soil acts as a sponge. When the land is saturated or frozen, infiltration rates decrease and any more water that accumulates must flow as runoff (Harris 2001).

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge has a 1% chance of being equaled or exceeded in any given year. The "annual flood" is the greatest flood event expected to occur in a given year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

Flood

One hundred-year floodplains (or one-percent annual chance floodplain) can be described as a bag of 100 marbles, with 99 clear marbles and one black marble. Every time a marble is pulled out from the bag, and it is the black marble, it represents a 100-year flood event. The marble is then placed back into the bag and shaken up again before another marble is drawn. It is possible that the black marble can be picked one out of two or three times in a row, demonstrating that a "100-year flood event" could occur several times in a row (Interagency Floodplain Management Review Committee 1994).

The 100-year flood, which is the standard used by most federal and state agencies, is used by the NFIP as the standard for floodplain management and to determine the need for flood insurance. A structure located within a SFHA shown on an NFIP map has a 26% chance or greater of suffering flood damage during the term of a 30-year mortgage.

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.

The term "500-year flood" is the flood that has a 0.2% chance of being equaled or exceeded each year. The 500-year flood could occur more than once in a relatively short period of time. Statistically, the 0.2% (500- year) flood has a 6% chance of occurring during a 30-year period of time, the length of many mortgages.

The 500-year floodplain is referred to as Shaded Zone X for insurance purposes on FIRMs. Base flood elevations or depths are not shown within this zone and insurance purchase is encouraged, but not required in this zone.

Tsunami

When a major undersea earthquake occurs near the coast at a shallow depth, a destructive tsunami can be generated. This tsunami could impact near-by coasts within minutes and could travel across entire ocean basins causing damage 1,000 miles away. To notify distant coastal areas, internationally-coordinated tsunami warning systems have been established to provide warning to countries regarding regional-to-distant tsunamis. This information is provided to emergency officials, and as appropriate, directly to the public (International Tsunami Information Centre 2008).

NOAA extensively monitors the Pacific Ocean for tsunamis that could impact Hawaii, Alaska, California, Oregon, and Washington. NOAA's Deep-ocean Assessment and Report Tsunamis (DART) program is part of the United States National Tsunami Hazard Mitigation Program and includes seismic networks, tsunami detection buoys and tidal gauges (Maine Geological Survey 2008).

In the Atlantic Ocean, there is no tsunami monitoring program. Although a monitoring program does not exist, the United States Geological Survey (USGS) operates the United States National Seismograph Network, which is part of the Global Seismic Network that monitors seismic activity around the world. These networks detect seismic events that are capable of producing a tsunami. Soon after an earthquake occurs, activity is recorded by seismographs and sent via satellite to the United States National Seismograph Network in Colorado. There, it is analyzed and warnings, if needed, are issued (Maine Geological Survey 2008).

5.6.3 PREVIOUS OCCURRENCES AND LOSSES

Many sources provided flooding information regarding previous occurrences and losses associated with flooding (riverine, inland, and stormwater) events throughout the State of New Jersey. With so many sources reviewed for the purpose of this Hazard Mitigation Plan (HMP), loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

NOAA's National Climatic Data Center (NCDC) storm events database reported that New Jersey experienced 1,582 flood events between 1950 and 2012. Between January 1, 2013, and December 31, 2017, an additional 643 flood events occurred in New Jersey. Total property damage was estimated at over $24.6 million between January 1, 2013 and December 31, 2017. Total crop damage is estimated to be over $800,000 in crop damage These events included flash floods, coastal flooding, and floods.

According to the Hazard Research Lab at the University of South Carolina's Spatial Hazard Events and Losses Database for the United States (SHELDUS), between 1960 and 2012, 413 flood events occurred within New Jersey. The database indicated that flood events and losses totaled over $23 billion in property damage and over $800,000 in crop damage. These events included coastal, coastal flooding, thunderstorms, hail, lightning, severe storms, wind, and flooding. SHELDUS indicated that these events resulted in four injuries and no fatalities. However, these numbers may vary due to the database identifying the location of the hazard event in various forms or throughout multiple counties or regions.

The 2011 Plan discussed specific flooding events that occurred in New Jersey through 2009. The 2014 Plan summarizes events that occurred between 2010 and 2012. For this HMP update, Table 5.6-2 includes flood events are summarized between 1984 and 2018 including data from both the 2011 and 2014 plan. With flood documentation for New Jersey being so extensive, not all sources have been identified or researched. Therefore, Table 5.6-2 may not include all events that have occurred throughout the State.

Ice Jams

There have been 110 reported ice jams in New Jersey since 1904 (CRREL 2018). According to the United States Army Cold Regions Research and Engineering Laboratory's (CRREL) database, ice jams have historically formed at various points along the Assunpink Creek, Beaver Brook, Cedar Creek, Delaware River, Flat Brook, Forked River, Great Egg Harbor River, Lamington (Black) River, Maurice River, Musconetcong River, Neshanic River, North and South Branch Raritan River, Passaic River, Pequest River, Raritan River, Stony Brook, Walnut Brook, Wanaque River, and West Brook. Locations of historical ice jam events are indicated in Figure 5.6-5.

Table 5.6-3 lists the total number of ice jam events that occurred in each county in New Jersey. Table 5.6-4 lists the ice jam events that have occurred in New Jersey between 1780 and 2018. Information regarding losses associated with these reported ice jams was limited.

Table 5.6-2 Flooding Events in New Jersey

Date(s) of Event	Event Type	Counties Affected	Description
4/1/1984	Flood	N/A	This flooding event in the Passaic River Basin claimed three lives and caused $335 million in damages. 9,400 people had to evacuate their homes.
January 19 to 26,1996	Flash Flood	N/A	Flashing flooding led to larger flooding, particularly along the Delaware and Raritan Rivers.
10/19/1996	Flooding	N/A	Heavy rain caused widespread and severe flooding throughout northern New Jersey, particularly along the Raritan River and its tributaries, as well as the Rahway and Passaic Rivers.
8/20/1997	Flash Flood	Atlantic	Torrential rain fell across southeast New Jersey as a low-pressure system developed over the Delmarva Peninsula and slowly moved northeast across southern New Jersey. Atlantic County bore the brunt of the storm. Storm totals exceeded eight inches from Estell Manor through Galloway Township, and 13.52 inches at the Atlantic City Airport. This storm caused severe flash flooding with several major roadways washing out and bridges collapsing.
9/16/1999	Flooding associated with Hurricane Floyd	N/A	Hurricane Floyd caused the largest flood on record along the Raritan River. Extensive flooding occurred throughout central and northern New Jersey. Rainfall totals exceeded 12 inches in several locations, with eight to 10-inch totals widespread.
August 12 to 13, 2000	Flooding	Atlantic, Cape May, Monmouth, Morris, Ocean, Sussex	The combination of a weak onshore flow from a nearly stationary low-pressure system off the Delmarva Peninsula and the high tides caused by the full moon led to some minor tidal flooding. A nearly unprecedented torrential downpour (approximately a 1,000-year event) remained stationary for about six hours in eastern Sussex County, resulting in considerable flooding in southeastern Sussex and western Morris Counties. The largest rainfall totals exceeded 12 inches.

Date(s) of Event	Event Type	Counties Affected	Description
7/12/2004	Flash and Poor Drainage Flood	Burlington	Flash flooding occurred during the late afternoon and evening of July 12, as thunderstorms with torrential downpours kept redeveloping along the Interstate 295 corridor in southern Burlington County. This continued for several hours and resulted in widespread storm totals exceeding six inches across most of the Rancocas Creek Basin. A storm total of 13.20 inches was reported in Tabernacle within a 12-hour period and represented a 1,000-year storm. The excessive rain caused record breaking flash flooding along nearly every stream in the Rancocas Basin and led to the failure or damage of 51 dams in Burlington County. Widespread poor drainage flooding also occurred.
9/18/2004	Flooding associated with remnants of Hurricane Ivan	Morris, Sussex, Warren	The remnants of Hurricane Ivan interacting with a slowly moving cold front caused widespread, heavy rain to fall during the first half of September 18 in Warren, Sussex, and Morris Counties. Storm totals averaged between three and six inches. This, in combination with even heavier rain in eastern Pennsylvania and southeastern New York State, resulted in the worst flooding along the Delaware River since 1955.
September 30 to 10/1/2010	Flooding	Bergen, Camden, Gloucester, Hudson, Hunterdon, Morris, Somerset, Sussex, Union	A series of low pressure systems that moved north along a slowly moving cold front brought heavy rain into the western half of New Jersey on September 30 and October 1. Event precipitation totals ranged between three and seven inches. Totals were lighter along the coastal counties. Several streams and rivers flooded across the area and there was also poor drainage flooding. The first round of heavy rain occurred mainly west of New Jersey during the early morning of September 30. The second and heavier round of precipitation moved in during the evening of September 30 and continued into the morning of October 1. The rain ended by the early afternoon of October 1. The flooding cause approximately $35,000 in property damage.
December 26-27, 2010	Heavy Snow	Statewide	A severe winter storm occurred, and a major disaster declaration was declared. Public assistance for 15 counties was requested and granted.
March 7 to 12, 2011	Flooding	Sussex, Morris, Warren	A slow moving, low pressure, cold front brought between 1.5 and four inches of rain across northern New Jersey from the early morning on March 6 into the early morning of March 7. Melting snow contributed to the runoff. The heaviest rain fell during the late afternoon and evening of March 6. Precipitation turned into snow over the higher terrain of northwest New Jersey during the early morning on March 7 and then ended briefly. In eastern Morris County, sections of the Pompton and Passaic Rivers were still above flood stage when another heavy rain event occurred from the early morning on March 10 into the morning on March 11. An additional two to five inches of rain fell and caused major flooding on both rivers. Governor Chris Christie declared a state of emergency before the start of the second round of heavy rain on March 9. Throughout the state, 683 homes were affected by both flooding events and 207 homes suffered at least major damage. About 1,500 people were evacuated and 2,000 residents were affected by the flood waters. The flooding caused over $11 million in property damage.

Date(s) of Event	Event Type	Counties Affected	Description
April 16 to 17, 2011	Flooding	Burlington, Camden, Cumberland, Gloucester, Morris, Salem	The strong southeast onshore flow on April 16, combined with the high tides associated with the full moon, produced minor to moderate tidal flooding along the New Jersey coast and moderate to severe flooding of the Delaware Bay in Cape May and Cumberland Counties. Tidal flooding departures increased farther up both Delaware and Raritan Bays. In addition, the funneling effect of southeast winds up the Delaware Bay contributed to increasing tidal departures. The high tide at Reedy Point (New Castle County, Delaware) established an all- time record high. One injury was reported from this event. The flooding cause approximately $2.75 million in property damage.
August 13 to 16, 2011	Flash Flood	Cumberland, Gloucester, Salem	A series of thunderstorms preceding a cold front brought three to seven inches of rain across a wide portion of New Jersey (less along most of the coast) from overnight on August 13 into the day on August 14. In southern Gloucester, eastern Salem and western Cumberland Counties, rainfall amounts reached seven to 11 inches. Scattered thunderstorms occurred on August 15 and into the morning of August 16. This slowed the recession of rivers and streams in the state. The combined event caused severe flash flooding with dam breaks in southwestern New Jersey and flash flooding and flooding across central and northern New Jersey. The flooding caused over $50 million in property damage.
August 27-28,2011	Hurricane Irene	Statewide	Hurricane Irene moved made its second landfall as a tropical storm near Little Egg Inlet along the southeast New Jersey coast at around 5:35 a.m. on August 28, 2011 Irene brought tropical- storm force winds, destructive storm surge, and record-breaking freshwater inland flooding across northeast New Jersey that resulted in three deaths, thousands of mandatory, and voluntary evacuations along the coast and rivers from surge and freshwater flooding, and widespread power outages that lasted for up to two weeks. The storm surge of three to five feet caused moderate-to-severe tidal flooding along the ocean side and moderate tidal flooding in Delaware Bay and tidal sections of the Delaware River. Major flooding occurred on the Raritan, Millstone, Rockaway, and Passaic Rivers. Overall, Irene brought an average rainfall total of 7.03 inches with a maximum rainfall total of 9.85 inches in Cranford (Union County). Another source indicated a maximum rainfall total of 11.27 inches in Freehold. A maximum wind gust of 65 mph was reported in Cape May (Cape May County). A maximum storm surge of 4.63 feet was reported in Sandy Hook. Irene caused approximately $1 billion in damages in New Jersey and seven deaths in the State.

Date(s) of Event	Event Type	Counties Affected	Description
September 7-10, 2011	Remnants of Tropical Storm Lee	Burlington, Camden, Cape May, Atlantic, Ocean	Remnants of Tropical Storm Lee brought three to eight inches of rain to many parts of New Jersey. The heavy rain caused flooding, mainly in west and northwest New Jersey. Most of the damage was reported along the Delaware River, where two homes were destroyed, 24 suffered major damage, 249 suffered minor damage, and 28 others were affected. Many roads were closed throughout the State because of flooding. Freshwater surge caused moderate tidal flooding along sections of the Delaware River. The State had approximately $11.5 million in damage.
August 25 to 26, 2012	Flash Flood	Cape May	A series of slow moving thunderstorms caused flash flooding in Cape May County during the evening and overnight on August 25 and into August 26. Doppler Radar storm total estimates reached around five inches. The flooding caused approximately $150,000 in property damage.
October 26 - November 8, 2012	Superstorm Sandy	Statewide	Superstorm 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 wind gusts as high as 80 to 90 mph to batter the State. Statewide, Sandy caused an estimated $29.4 billion in damage, destroyed or significantly damaged 30,000 homes and businesses, affected 42,000 additional structures, and was responsible directly or indirectly for 38 deaths. A new temporary inlet formed in Mantaloking (Ocean County) where some homes were swept away. About 2.4 million households in the State lost power. It would take two weeks for power to be fully restored to homes and businesses that were inhabitable. Also devastated by the storm was New Jersey's shellfish hatcheries including approximately $1 million of losses to buildings and equipment, and product losses in excess of $10,000 at one location alone. Overall, average rainfall totals were 2.78 inches with a maximum rainfall of 10.29 inches at the Cape May (Cape May County) station. Another source indicated a maximum rainfall total of 12.71 inches in Stone Harbor (Cape May County). A maximum wind gust of 78 mph was reported in Robbins Reef. A maximum storm surge of 8.57 feet was reported in Sandy Hook. Tide gages in Atlantic City and Cape May measured storm surges of 5.82 feet and 5.16 feet, respectively. Other areas experienced inundations along the coast due to the storm tide, ranging from two feet in Atlantic, Burlington, Cape May, Essex and Bergen Counties to nine feet in Monmouth and Middlesex Counties. Superstorm Sandy caused approximately $30 billion in damages in New Jersey and caused 12 deaths in the State.
12/21/2012	Heavy Rain	Hunterdon, Warren, Morris, Somerset, Bergen, Warren	Moderate to heavy rain fell across the state, with storm totals ranging between 1 to 3 inches. This rain resulted in some mainly minor flooding of smaller streams and creeks in southern New Jersey. The strong onshore flow contributed to higher high tides with minor to moderate tidal flooding occurring along the southern New Jersey oceanfront.

Date(s) of Event	Event Type	Counties Affected	Description
12/27/2012	Heavy Rain	Hunterdon, Monmouth, Middlesex, Ocean, Somerset, Burlington	Heavy rain caused poor drainage as well as flooding of streams and rivers in the central third of New Jersey. It had the greatest impact on waterways in Monmouth and Ocean Counties. The runoff from the heavy rain also exacerbated the tidal flooding.
1/31/2013	Heavy Rain	Hunterdon, Morris, Warren	The strong south to southwest winds preceding a cold frontal passage brought an unseasonably mild and moist air mass into New Jersey. This caused heavy rain to fall and caused poor drainage flooding as well as isolated stream and river flooding in northwest New Jersey on the 31st. Most of the waterway flooding was minor and all streams and rivers were back within bankfull by the evening of the 31st. Event precipitation totals averaged 1.5 to 2.5 inches in northwest New Jersey.
3/12/2013	Heavy Rain	Hunterdon	A slow moving cold front with waves of low pressure along it caused rain, heavy at times, to fall across northwest New Jersey on the 12th into the late afternoon. Event precipitation totals averaged 1.5 to around 2.0 inches with lesser amounts elsewhere across the state. This rain caused poor drainage flooding as well as isolated river flooding.
5/8/2013	Heavy Rain	Mercer, Hunterdon	Bands of heavy rain during the first half of the day on the 8th that preceded the passage of an occluded front caused poor drainage flooding. Event precipitation totals average between 2.0 and 3.5 inches.
June 7 - 8, 2013	Flooding Associated with Tropical Storm Andrea	Monmouth, Somerset, Union, Mercer, Bergen, Morris	The initial burst of heavy precipitation arrived during the early morning on the 7th as moisture surged into the Mid-Atlantic Region ahead of Tropical Storm Andrea. Runoff from heavy rain that fell during the 7th into the 8th led to flooding.
June 10-11, 2013	Heavy Rain	Burlington, Monmouth, Somerset	Heavy rain that fell on the 10th caused additional flooding across the central third of New Jersey. Event precipitation totals averaged between 1.0 and 2.5 inches.
6/14/2013	Heavy Rain	Morris	Several heavy rain events in the week leading up to the 14th contributed to rises across the areas creek and streams. Some of the heaviest rain was reported across northern New Jersey.
6/18/2013	Heavy Rain	Camden	The combination of a slowly moving cold front with a wave of low pressure along it and wet antecedent conditions helped develop a large area of light to moderate rain with embedded thunderstorms accompanied by heavy rain in New Jersey primarily during the afternoon of the 18th. This led to urban and poor drainage flooding and also flash flooding.
June 27-28, 2013	Heavy Rain	Somerset, Mercer	A series of thunderstorms accompanying a warm front caused very heavy rain during the late afternoon and early evening on the 27th. This caused flooding in central New Jersey that lasted overnight.
6/30/2013	Heavy Rain	Gloucester, Camden, Salem	A nearly stationary front helped trigger showers and thunderstorms with heavy rain that resulted in flash flooding
July 12-13, 2013	Poor Drainage	Mercer, Monmouth, Burlington, Cape May, Salem, Cumberland	Bands of showers and thunderstorms with heavy rain associated with a low-pressure system along the frontal boundary caused some poor drainage flooding

Date(s) of Event	Event Type	Counties Affected	Description
7/23/2013	Heavy Rain	Burlington	Storm total rainfall measurements ranged mainly between 2 and 7 inches across central to northern New Jersey. Run-off from waves of heavy precipitation resulted in areas of poor drainage and roadway flooding. In addition, the combination of the heavy rain and higher than normal astronomical tides associated with the full moon, caused minor tidal flooding.
July 28-29, 2013	Heavy Rain	Somerset, Burlington, Camden, Cumberland	A slow moving cold front coupled with a deep southerly flow of very moist air caused slow moving and, in some instances, back building thunderstorms to occur during the afternoon and evening of the 28th. This caused an all-time record breaking rainfall in nearby Philadelphia as well as flash flooding in southwestern New Jersey and parts of the Passaic and Raritan Basins in northern New Jersey. The flash flooding in the Philadelphia suburbs (Camden County in particular) led to people being stuck on roadways for hours on the 42 Freeway as well as Interstates 295, 76 and 676.
August 9-10, 2013	Heavy Rain	Sussex, Warren	A surface trof helped trigger showers and thunderstorms with torrential downpours during the morning of the 9th in northwestern New Jersey. Event totals reached 2 to 6 inches in western portions of Warren and particularly Sussex County and caused flash flooding of smaller streams as well as poor drainage flooding.
8/13/2013	Heavy Rain	Gloucester, Camden	A complex of showers and thunderstorms produced both wind damage and flash flooding in central and southwest New Jersey on the 13th. Doppler Radar storm total estimates averaged 2.5 to 5.0 inches.
8/22/2013	Heavy Rain	Burlington, Mercer, Middlesex, Morris, Somerset	Heavy rain caused flash flooding of smaller streams, roadways and rivers and also led to flooding
9/2/2013	Heavy Rain	Gloucester, Camden	Clusters of showers and thunderstorms with torrential downpours over sections of central and southern New Jersey during the late morning into the early afternoon on the 2nd. This caused urban, poor drainage and small creek flash flooding
9/22/2013	Heavy Rain	Gloucester, Camden	The runoff from heavy rain from showers and isolated thunderstorms caused minor flooding along the Cooper River.
11/27/2013	Heavy Rain	Bergen, Union	An area of low pressure tracked from the Gulf Coast through New England bringing several inches of rain to the Tri-State Area. This resulted in isolated small stream flooding.
January 6-8, 2014	Snow Melt and Freezing Rain, Ice Jam	Somerset, Mercer	The combination of the melting snow as well as freezing rain on the morning of the 5th and rain during the day on the 6th caused minor flooding along sections of the Millstone River. The unseasonably cold arctic air mass resulted in ice jam flooding north of the jam in Trenton.
February 22-24, 2014	Heavy Rain/Snow Melt	Somerset	Melting snow caused minor flooding along sections of the Millstone River from the 22nd through the 24th.
March 29 - April 1, 2014	Heavy Rain	Hunterdon, Somerset, Bergen, Monmouth, Burlington, Middlesex, Cumberland, Salem	An area of low pressure tracking along a stalled frontal boundary extending across the central Appalachians eastward through the Mid-Atlantic States produced multiple waves of heavy rain. Run-off from waves of heavy precipitation caused some poor drainage and roadway flooding.

Date(s) of Event	Event Type	Counties Affected	Description
April 15-16, 2014	Heavy Rain	Somerset	Some urban and poor drainage flooding occurred, because of the recent dry weather, but only isolated river flooding was reported.
April 30 - May 2, 2014	Heavy Rain	Statewide	A frontal system associated with a large cutoff low-pressure system over the Midwest and Lower Great Lakes region caused periods of heavy rain, which resulted in flooding across New Jersey. At the same time a slow moving low-pressure system and a deep southerly flow from the Gulf of Mexico and then the Atlantic Ocean dropped heavy rain across New Jersey centered on April 30th. Event precipitation totals averaged from 3 to 6 inches, with the highest amounts in central New Jersey. This caused widespread poor drainage flooding as well as flooding of creeks and rivers throughout most of the state.
6/10/2014	Heavy Rain	Gloucester, Camden	A nearly stationary frontal boundary focused slow moving thunderstorms with heavy rain in southwestern New Jersey during the late afternoon and early evening of the 10th. This caused poor drainage flash flooding as well as flash flooding of some smaller creeks.
July 15-16, 2014	Heavy Rain	Ocean, Burlington, Middlesex, Monmouth, Somerset	Thunderstorms with very heavy downpours produced flash flooding.
12/9/2014	Heavy Rain	Essex, Somerset	A coastal storm passed just south and east of the area causing strong winds and heavy rain with isolated flooding in portions of Northeast New Jersey.
January 18-20, 2015	Heavy Rain	Burlington, Mercer, Hunterdon, Union, Somerset	Precipitation totals averaged close to two inches and caused considerable poor drainage flooding as well as flooding along some smaller creeks and rivers mainly in the central third of New Jersey. The most reported flooding occurred in Somerset County where flooding persisted into the 20th. Most other creek and small river flooding ended by late in the evening on the 18th.
March 11-14, 2015	Heavy Rain/Snow Melt	Somerset, Hunterdon	Rainfall amounts combined with around 2 to 5 inches of snow on the ground, caused poor drainage and low-lying area flooding.
7/15/2017	Heavy Rain	Cumberland, Salem, Atlantic, Ocean, Gloucester	Double barrel cold fronts helped trigger a series of showers and thunderstorms across southern New Jersey during the morning of the 15th. Thunderstorms that were accompanied by very heavy rain caused flash flooding.
8/19/2015	Heavy Rain	Somerset	A moist airmass coupled with daytime heating allowed widely scattered thunderstorms to develop during the afternoon of the 19th. A few thunderstorms produced torrential downpours, leading to localized flash flooding.
9/10/2015	Heavy Rain	Monmouth, Gloucester	A series of thunderstorms which rode along a wavy cold frontal boundary brought heavy rain into New Jersey on the 10th. The heaviest rain fell along the Interstate 95/295 corridor (especially in Gloucester County) and along coastal sections of New Jersey. This caused poor drainage as well as some creek flash flooding.
February 24-25, 2016	Heavy Rain	Mercer, Sussex, Bergen	A strong low-pressure system moving north through the Great Lakes region, combined with its associated warm front and cold front, copious amounts of moisture, and low-level jet, produced strong to severe thunderstorms, heavy rain, flash flooding, and stream flooding.

Date(s) of Event	Event Type	Counties Affected	Description
May 29-30, 2016	Flooding Associated with Tropical Storm Bonnie	Burlington	Moisture from the remnants of tropical storm Bonnie moved northward into the region and interacted with a frontal boundary over the region. This resulted in several rounds of heavy rain on the night of the 29th and the early morning of the 30th.
6/21/2016	Heavy Rain	Ocean, Burlington, Middlesex, Monmouth, Somerset	A cold frontal boundary moved south into New Jersey during the morning hours of the 21st before stalling. This front served as a focal point for showers and thunderstorms to develop.
7/8/2016	Heavy Rain	Somerset	Heavy rainfall along with strong to severe thunderstorms occurred. Flooding was reported in low-lying areas.
7/25/2016	Heavy Rain	Ocean, Somerset, Mercer	A trough of low pressure led to the development of afternoon and evening showers and thunderstorms which became severe in spots and produced locally heavy rains. 40,000 were left without power across the state.
7/28/2016	Heavy Rain	Gloucester, Atlantic, Cape May	A cold frontal boundary moved southward into the region. This led to the development of afternoon showers and thunderstorms. Some of thunderstorms became severe with locally heavy rainfall as well. Many locations saw between 2 and 3 inches of heavy rainfall.
July 30-31, 2016	Heavy Rain	Middlesex, Ocean, Hunterdon	Several clusters of thunderstorms associated with several shortwaves and a cold front caused flooding.
9/19/2016	Flooding Associated with Tropical Storm Julia	Gloucester, Ocean, Atlantic, Cape May	The remnants of tropical storm Julia and a frontal boundary interacted leading to several rounds of rainfall over the region.
11/15/2016	Heavy Rain	Essex	Low pressure moving north along the east coast of the United States resulted in a widespread 1-3-inch rainfall event across northeast New Jersey. Isolated flooding was observed.
3/31/2017	Heavy Rain	Monmouth, Middlesex, Hunterdon, Somerset, Gloucester	Low pressure with an occluding frontal boundary moved through the region. With this system periods of heavy rain fell on the 31st. The heavy rain led to localized flooding issues.
4/6/2017	Heavy Rain	Camden, Hunterdon	Locally heavy showers and thunderstorms occurred. Some of thunderstorms were strong to severe with gusty winds.
5/5/2017	Heavy Rain	Monmouth, Atlantic, Salem, Burlington, Ocean, Middlesex	A large amount of rainfall in a relatively short period of time contributed to flooding.
5/13/2017	Heavy Rain	Monmouth, Atlantic, Cape May	Heavy rain led to some localized flooding.
6/24/2017	Flooding Associated with the Remnants of Tropical Storm Cindy	Somerset, Mercer, Middlesex, Morris	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.

Date(s) of Event	Event Type	Counties Affected	Description
7/1/2017	Heavy Rain	Passaic	Scattered showers and thunderstorms developed in a moist airmass. The combination of heavy rainfall and runoff resulted in flooding.
7/7/2017	Heavy Rain	Warren, Morris, Bergen	A stationary frontal boundary draped across the Delaware Valley lead to a period of heavy rainfall during the morning of July 7th. Widespread rainfall lead to flooding.
July 13-17, 2017	Heavy Rain	Statewide	A hot and humid airmass was present ahead of a frontal boundary which slowly moved southeast toward and then through the state. Several rounds of thunderstorms moved through the region ahead of this front over the course of a few days.
July 22-24, 2017	Heavy Rain	Somerset, Ocean, Cumberland, Warren	A stalled frontal boundary was the focus for several rounds of thunderstorms that produced damaging winds and flooding in spots.
July 28-29, 2017	Heavy Rain	Cumberland, Atlantic, Cape May,	A rare summertime Nor'easter tracked just offshore producing heavy rain, thunderstorms and wind. Coastal flooding and beach erosion also occurred.
August 2-3, 2017	Heavy Rain	Middlesex, Warren, Burlington, Morris, Middlesex, Burlington	A hot and humid airmass with weak boundaries led to slow moving strong to severe thunderstorms with damaging winds, hail and flooding.
8/7/2017	Heavy Rain	Cumberland, Atlantic, Cape May,	Thunderstorms developed along and ahead of a warm front. With a humid airmass in place, these storms produced heavy rain that led to flash flooding.
August 18-23, 2017	Heavy Rain	Ocean, Burlington Somerset, Camden, Gloucester	Severe thunderstorms formed in a hot and humid airmass ahead of a cold front.
9/16/2017	Heavy Rain	Morris	A series of disturbances in the jet stream and a weak surface trough lead to sufficient lift within a tropical air mass to produce slow moving, heavy rain showers across portions of New Jersey. This lead to localized urban and poor drainage flooding.
October 29-30, 2017	Heavy Rain	Statewide	A wave of low pressure formed along a slow moving cold front before rapidly deepening off the Mid Atlantic coast during the evening. This resulted in reports of flooding.

Source: NOAA-NCDC, 2017

Table 5.6-3 Number of Ice Jams Between 1904 and 2018, by County

County	Total Number of Ice Jams
Atlantic	1
Bergen	0
Burlington	0
Camden	0
Cape May	0
Cumberland	0
Essex	0
Gloucester	0
Hudson	0
Hunterdon	24
Mercer	27
Middlesex	0
Monmouth	0
Morris	6
Ocean	2

County	Total Number of Ice Jams
Passaic	4
Salem	1
Somerset	12
Sussex	11
Union	0
Warren	22
Total	110

Source: CRREL, 2018

Table 5.6-4 Ice Jams in New Jersey Between 1904 and 2018

Event Date	River/Location	County	Description/Losses
3/7/1904	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 11.2 feet, affected by backwater from ice. Bank- full stage eight feet.
3/8/1904	Delaware River at Trenton	Mercer	Maximum annual gage height of 22.8 feet, affected by backwater from ice.
1/7/1905	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 12.5 feet, affected by backwater from ice. Bank-full stage eight feet.
1/26/1907	Delaware River at Trenton	Mercer	Maximum annual gage height of 9.0 feet, affected by backwater from ice.
3/5/1920	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 11.5 feet, affected by backwater from ice. Bank-full stage eight feet.
1/22/1924	Musconetcong River at Hackettstown	Warren	Gage height of 3.44 feet, affected by backwater from ice.
1/23/1924	Beaver Brook at Belvidere	Warren	Gage height of 3.05 feet, affected by backwater from ice. Additional ice-affected gage height of three feet. Bank-full stage four feet.
12/27/1924	Beaver Brook at Belvidere	Warren	Gage height of 3.03 feet, affected by backwater from ice. Additional ice-affected gage height of 4.09 feet (maximum for year), reported on February 12. Discharge 600 cfs. Also, ice affected gage heights of 3.03 feet, reported on February 24, and 2.96 feet reported on February 27. Bank-full stage four feet.
2/12/1925	North Branch Raritan River at Raritan	Somerset	Maximum annual gage height of 9.0 feet, affected by backwater from ice.
2/19/1926	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 9.52 feet, affected by backwater from ice. Bank- full stage eight feet.
1/16/1927	Beaver Brook at Belvidere	Warren	Maximum gage height of 3.03 feet, affected by backwater from ice. Bank-full stage four feet.
1/20/1927	Lamington (Black) River at Pottersville	Somerset	Gage height of 2.83 feet, affected by backwater from ice. Bank-full stage five feet.
1/21/1927	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 8.01 feet, affected by backwater from ice. Bank-full stage eight feet.
1/3/1928	Beaver Brook at Belvidere	Warren	Gage height of 3.29 feet, affected by backwater from ice. Additional ice-affected gage height of 3.09 feet was reported on January 22. Bank-full stage four feet.
1/25/1930	Musconetcong River at Hackettstown	Warren	Maximum annual gage height of 3.58 feet, affected by backwater from ice.
1/26/1930	Delaware River at Trenton	Mercer	Maximum annual gage height of 8.08 feet, affected by backwater from ice.
1/27/1930	Beaver Brook at Belvidere	Warren	Maximum annual gage height of 3.10 feet, affected by backwater from ice. Bank- full stage four feet.

Event Date	River/Location	County	Description/Losses
12/19/1932	Beaver Brook at Belvidere	Warren	Gage height of 2.94 feet, affected by backwater from ice. Bank-full stage four feet.
2/13/1933	Delaware River at Trenton	Mercer	Gage height of 7.90 feet, affected by backwater from ice.
1/4/1934	Delaware River at Trenton	Mercer	Gage height of 11.83 feet, affected by backwater from ice. Additional ice- affected gage height of 14.2 feet (maximum for year), reported March 5.
1/31/1934	Beaver Brook at Belvidere	Warren	Gage height of 3.04 feet, affected by backwater from ice. Additional ice-affected gage height of 3.30 feet (maximum for year), reported on March 3. Bank-full stage four feet.
3/3/1934	Lamington (Black) River at Pottersville	Somerset	Gage height of 3.33 feet, affected by backwater from ice. Additional ice-affected gage height of 3.51 feet, reported on March 4. Bank-full stage five feet.
3/4/1934	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 10.05 feet, affected by backwater from ice. Daily mean discharge 2,980 cfs. Bank-full stage eight feet.
3/5/1934	Flat Brook at Flatbrookville	Sussex	Maximum annual gage height of 6.40 feet, affected by backwater from ice. Discharge 700 cfs. Bank-full stage five feet.
1/25/1935	Delaware River at Trenton	Mercer	Gage height of 7.12 feet, affected by backwater from ice.
12/26/1935	Delaware River at Trenton	Mercer	Gage height of 6.57 feet, affected by backwater from ice. Additional ice-affected gage height of 16.12 feet, reported on January 3 and ice-affected gage height of 10.20 feet, reported on January 22.
1/3/1936	Beaver Brook at Belvidere	Warren	Gage height of 3.24 feet, affected by backwater from ice. Additional ice-affected gage height of 3.10 feet, reported on January 21. Also, ice-affected gage height of 3.68 feet, reported on January 26. Bank-full stage four feet.
1/3/1936	North Branch Raritan River at Far Hills	Somerset	Maximum annual gage height of 4.81 feet, affected by backwater from ice.
1/3/1936	Wanaque River at Monks	Passaic	Gage height of 1.84 feet, affected by backwater from ice. Additional ice-affected gage height of 1.50 feet, reported on February 15.
1/3/1936	Lamington (Black) River at Pottersville	Somerset	Maximum annual gage height of 4.19 feet, affected by backwater from ice. Discharge 780 cfs. Bank-full stage five feet.
1/3/1936	Lamington (Black) River at Pottersville	Somerset	Maximum gage height of 4.19 feet caused by an ice jam reported by the USGS.
1/25/1936	Musconetcong River at Hackettstown	Warren	Gage height of 4.18 feet, affected by backwater from ice.
1/25/1936	Maurice River at Norma	Salem	Gage height of 4.01 feet, affected by backwater from ice. Bank-full stage 3.5 feet.
2/16/1936	Cedar Creek at Lanoka Harbor	Ocean	Maximum peak stage of 6.50 feet due to backwater from ice and tide.
1/28/1938	Beaver Brook at Belvidere	Warren	Gage height of 3.05 feet, affected by backwater from ice. Additional ice-affected gage height of 3.12 feet reported on January 29. Bank-full stage four feet.
1/27/1939	Delaware River at Trenton	Mercer	The gage reported water levels of 4.2 feet due to an ice gorge at the gage. Flood stage is 7.5 feet. The gorge was reported through January 28 and resulted in water levels of 4.1 feet on January 29 due to an ice gorge below the gage.

Event Date	River/Location	County	Description/Losses
1/30/1939	South Branch Raritan River at Stanton	Hunterdon	Gage height of 7.32 feet, affected by backwater from ice. Bank-full stage eight feet.
1/30/1939	Delaware River at Trenton	Mercer	Gage height of 7.40 feet, affected by backwater from ice.
1/15/1940	Flat Brook at Flatbrookville	Sussex	Gage height of 5.47 feet, affected by backwater from ice. Bank-full stage five feet.
1/15/1940	South Branch Raritan River at High Bridge	Hunterdon	Gage height of 10 feet, affected by backwater from ice.
1/15/1940	Lamington (Black) River at Pottersville	Somerset	Gage height of 3.54 feet, affected by backwater from ice. Bank-full stage five feet.
1/15/1940	South Branch Raritan River at Stanton	Hunterdon	Gage height of 7.91 feet, affected by backwater from ice. Additional ice-affected gage height of eight feet reported on February 11. Bank-full stage eight feet.
1/16/1940	Delaware River at Trenton	Mercer	Gage height of 8.12 feet, affected by backwater from ice.
2/15/1940	Wanaque River at Monks	Passaic	Gage height of 1.92 feet, affected by backwater from ice.
3/8/1941	Pequest River at Huntsville	Sussex	Maximum annual gage height of 3.25 feet, affected by backwater from ice. Bank-full stage four feet.
2/4/1942	Delaware River at Trenton	Mercer	Gage height of 6.53 feet, affected by backwater from ice.
12/4/1942	Beaver Brook at Belvidere	Warren	Gage height of 2.97 feet, affected by backwater from ice. Bank-full stage four feet.
12/22/1942	Lamington (Black) River at Pottersville	Somerset	Gage height of three feet, affected by backwater from ice. Bank-full stage five feet.
1/5/1943	Pequest River at Huntsville	Sussex	Gage height of 3.32 feet, affected by backwater from ice. Bank-full stage four feet.
2/16/1943	Delaware River at Trenton	Mercer	Gage height of 6.82 feet, affected by backwater from ice. Additional ice-affected gage height of 7.99 feet, reported on February 20.
1/10/1944	Beaver Brook at Belvidere	Warren	Gage height of 3.07 feet, affected by backwater from ice. Additional ice-affected gage height of 3.01 feet reported on February 15. Bank-full stage four feet.
2/15/1944	South Branch Raritan River at High Bridge	Hunterdon	Maximum annual gage height of 10.39 feet, affected by backwater from ice.
1/4/1945	Beaver Brook at Belvidere	Warren	Gage height of 3.03 feet, affected by backwater from ice. Additional ice-affected gage height of 3.03 feet reported on January 19. Ice-affected gage height of 3.02 feet was reported on January 20. Bank-full stage four feet.
1/12/1945	Delaware River at Trenton	Mercer	Gage height of 8.24 feet, affected by backwater from ice. Additional ice-affected gage height of 8.72 feet reported on January 17.
1/17/1945	Delaware River at Trenton	Mercer	Gage height of 8.72 feet, affected by backwater from ice.
2/22/1945	Neshanic River at Reaville	Hunterdon	Gage height of 8.42 feet, affected by backwater from ice. Bank-full stage nine feet.
2/22/1945	South Branch Raritan River at Stanton	Hunterdon	Gage height of 7.73 feet, affected by backwater from ice. Bank-full stage eight feet.
2/27/1945	Passaic River at Chatham	Morris	Maximum annual gage height of 6.67 feet, affected by backwater from ice.

Event Date	River/Location	County	Description/Losses
3/4/1945	Delaware River at Montague	Sussex	Maximum annual gage height of 17.54 feet, affected by backwater from ice. Additional ice-affected gage height of 15.42 feet was reported on February 28.
12/20/1945	Delaware River at Trenton	Mercer	Gage height of 8.67 feet, affected by backwater from ice. Additional ice-affected gage height of 11.01 feet (maximum for year), reported on December 26.
12/25/1945	South Branch Raritan River at High Bridge	Hunterdon	Maximum annual gage height of 9.75 feet, affected by backwater ice.
12/25/1945	Lamington (Black) River at Pottersville	Somerset	Gage height of 3.66 feet, affected by backwater from ice. Discharge 450 cfs. Bank-full stage five feet.
12/26/1945	Beaver Brook at Belvidere	Warren	Maximum annual gage height of four feet, affected by backwater from ice. Bank-full stage four feet.
12/26/1945	Walnut Brook at Flemington	Hunterdon	Gage height of 2.32 feet, affected by backwater from ice. Bank-full stage three feet.
12/26/1945	Wanaque River at Monks	Passaic	Gage height of 1.87 feet, affected by backwater from ice.
12/26/1945	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 9.06 feet, affected by backwater from ice. Bank- full stage eight feet.
12/27/1945	Delaware River at Montague	Sussex	Gage height of 14.7 feet, affected by backwater from ice.
2/10/1947	Delaware River at Trenton	Mercer	Maximum gage height of 7.9 feet, affected by backwater from ice.
1/25/1948	Musconetcong River at Bloomsbury	Hunterdon	Gage height of 3.64 feet, affected by backwater from ice. Bank-full stage four feet.
2/19/1948	South Branch Raritan River at Stanton	Hunterdon	Gage height of 8.54 feet, affected by backwater from ice. Bank-full stage eight feet.
2/20/1948	North Branch Raritan River at Raritan	Somerset	Maximum annual gage height of 9.39 feet, affected by backwater from ice.
2/21/1948	Delaware River at Montague	Sussex	Gage height of 17.88 feet, affected by backwater from ice.
2/24/1948	Passaic River at Chatham	Morris	Maximum annual gage height of 6.65 feet, affected by backwater from ice. Additional ice-affected gage height of 6.3 feet reported on February 20. Estimated daily mean discharge 1,000 cfs.
12/30/1948	West Brook at Wanaque	Passaic	Gage height of 2.65 feet, affected by backwater from ice. Discharge 388 cfs.
12/21/1951	Delaware River at Trenton	Mercer	Gage height of 9.48 feet, affected by backwater from ice.
1/21/1954	South Branch Raritan River at High Bridge	Hunterdon	Maximum annual gage height of 8.97 feet, affected by backwater from ice.
2/7/1955	Delaware River at Trenton	Mercer	Gage height of 7.27 feet, affected by backwater from ice.
1/23/1957	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 6.74 feet, affected by backwater from ice. Bank- full stage eight feet.
3/2/1958	Pequest River at Pequest	Warren	Maximum annual gage height of 3.61 feet, affected by backwater from ice. Bank-full stage four feet.
1/2/1959	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 7.59 feet, affected by backwater from ice. Discharge 2,310 cfs. Bank-full stage eight feet.
1/6/1959	Great Egg Harbor River at Folsom	Atlantic	Gage height of 4.72 feet, affected by backwater from ice. Bank-full stage five feet.

Event Date	River/Location	County	Description/Losses
1/21/1959	Lamington (Black) River at Pottersville	Somerset	Maximum annual gage height of 3.64 feet, affected by backwater from ice. Bank- full stage five feet.
1/22/1959	Pequest River at Pequest	Warren	Gage height of 3.53 feet, affected by backwater from ice. Discharge 640 cfs. Bank-full stage four feet
1/1/1961	Neshanic River at Reaville	Hunterdon	Maximum annual gage height of 7.07 feet, affected by backwater from ice. Bank- full stage nine feet.
2/19/1961	South Branch Raritan River at Stanton	Hunterdon	Maximum annual gage height of 7.28 feet, affected by backwater from ice. Bank-full stage eight feet.
2/20/1961	Flat Brook at Flatbrookville	Sussex	Maximum annual gage height of 5.67 feet, affected by backwater from ice. Bank- full stage five feet.
2/22/1961	Passaic River at Chatham	Morris	Maximum annual gage height of 6.59 feet, affected by backwater from ice.
1/15/1968	Delaware River at Trenton	Mercer	An ice jam was observed at Trenton along the Delaware River.
2/15/1971	Delaware River at Montague	Sussex	The USGS reported an ice jam on February 15 at Montague on the Delaware River. The estimated water discharge was 10,000 cfs. Maximum gage height was 12.57 feet.
1/18/1994	Assunpink Creek at Clarksville	Mercer	A flood warning was issued for this USGS gage. The river gage was reading 6.75 feet at 1:40 a.m. and had risen three feet since 7 p.m. due to an ice jam.
1/28/1994	South Branch Raritan River at High Bridge	Hunterdon	Maximum peak stage of 14.26 feet on January 28 as a result of an ice jam
2/1/1994	Delaware River at Trenton	Mercer	This jam was approximately one mile long with a backwater of approximately three to four feet. Downstream, the jam was a smooth ice cover about 0.5 to one-mile long.
1/21/1996	Delaware River at Trenton	Mercer	Ice jams were reported on the Susquehanna, Delaware, and Schuylkill Rivers on January 21. These jams caused severe flooding in Trenton, forcing the evacuation of 3,000 people in the area. Two local people drowned while seven other deaths in the State of Pennsylvania were reported. Ten thousand people in the Wilkes- Barre region were evacuated. The Delaware had risen 12 feet in 10 hours while the Susquehanna crested at 12 feet above flood stage. In Avondale, 109 people were evacuated by boat while another 90 were evacuated from the Bridgeport Towers apartments. Front Street row houses were evacuated as well. This began with a winter storm dumping incredible amounts of snow across Pennsylvania. Of the 40 inches on the ground, 28 inches of it melted. There were also high winds reaching 58 mph.
1/18/1999	Multiple locations	Sussex	The combination of showers and thunderstorms with heavy rain, already saturated ground, and ice jams along area streams caused flooding and led to the collapse of the foundations of three homes in Hamburg Borough and Andover Township.
1/22/1999	Delaware River at Depue Island	Warren	An ice jam formed slightly downstream of an existing jam on the Delaware River. Park Rangers reported that it extended from Depue Island north past Tocks Island to Poxono Island. The ice in the Delaware Water Gap was beginning to break up and was predicted to move out later that day.
2/7/2003	South Branch Raritan River at High Bridge	Hunterdon	A small ice jam formed on the South Branch Raritan River near High Bridge.
2/17/2003	Forked River at Forked	Ocean	An ice jam about 300 to 400 yards long formed on the canal

Event Date	River/Location	County	Description/Losses
	River		leading from Barnegat Bay to the Oyster Creek generating station. The head of the jam was at the Route 1 bridge. The jam in this tidal area was composed of broken ice pieces and slush ice. Its formation occurred after extremely cold air temperatures and a large snowstorm. The jam was restricting primary cooling water flow to the generating plant. Mechanical removal of the jam from the upstream end towards the downstream end was recommended.
2/19/2003	Delaware River at Trenton	Mercer	The NWS reported an apparent ice jam on the Delaware River at Trenton on February 19. A significant within-banks rise was occurring on the lower main stem of the Delaware River at Trenton, most likely due to an ice jam at the Calhoun Street Bridge. The stage was 15.1 feet at 6 p.m. The river had risen over two feet since noon but had stabilized at about 15 feet during the evening.
2/23/2003	Passaic River at Chatham	Morris	The NWS reported an ice jam along the Passaic River which caused some minor flooding near Chatham. The river stopped rising just above flood stage and stabilized.
2/24/2003	Passaic River at Chatham	Morris	Maximum gage height of 6.35 feet due to ice effects.
1/31/2004	Delaware River at Trenton	Mercer	The NWS noted that there was an ice jam north of Trenton on the Delaware River.
2/6/2004	Passaic River at Chatham	Morris	Maximum peak stage of 10.93 feet as a result of an ice jam. The average daily discharge was estimated to be 490 cfs.
2/6/2004	Green Brook	Morris	An ice jam developed on the Green Brook. Dynamite was used to break the jam.
2/6/2004	Stony Brook at Princeton	Mercer	Maximum gage height of 5.73 feet due to an ice jam. The average daily discharge was estimated to be 280 cfs.
2/7/2004	Raritan River at Raritan	Somerset	Maximum peak stage of 11.32 feet as a result of an ice jam. The average daily discharge was estimated to be 3,150 cfs.
2/14/2007	Pequest River at Belvidere	Warren	An ice jam formed between two dams on the Pequest River. The lower dam was just above the confluence with the Delaware River, and the upper dam was about 200 yards upstream. Based on descriptions of the ice and local weather, the jam was a freeze-up jam. The ice backed up water into local residents' basements.
1/27/2009	Delaware River at Minisink Island	Sussex	An ice jam at Minisink Island was reported to be creating several feet of backwater.
1/27/2011	Delaware River at Trenton	Mercer	An ice jam formed downstream from the gaging station at the Trenton Makes Bridge. Water levels increased from nine feet to 13 feet. The ice jam became more restrictive and pushed water up another two feet at the gage.
1/31/2011	Delaware River at Montague	Sussex	Solid ice cover was observed upstream from the Milford-Montague toll bridge. There was significant backwater from ice at the gaging station. There was an ice jam upstream in the area of Mashipacong Island.
1/7/2014	Delaware River	Mercer	According to blog.nj.com on 8 Jan 2014, the Delaware River was flooding at Trenton, NJ due to an ice jam. The river had risen 6 feet in the past 12 hours and was located about one mile south of the route 1 bridge. Flooding was reported at rte. 29 and Market St, and at the lower State House parking lot adjacent to the river.

Event Date	River/Location	County	Description/Losses
			There are inundation concerns once the jam breaks and released a wall of water downstream.
1/24/2018	Delaware River	Warren	Reports indicate the ice jam was approximately four miles long, from the confluence with Brodhead Creek to the Smithfield Beach National Recreation Area. No flooding was reported.

Source: CRREL 2018; NOAA-NCDC 2018

Tsunami

While the probability of a large tsunami impacting the coast of New Jersey is very small due to the position of New Jersey on the trailing edge of the North Atlantic Plate, the Mid-Atlantic region has been subjected to minor tsunami action over the past 250 years and perhaps significant tsunami action over the last geologic period.

Lockridge, et al. (2002) analyzed tsunami and tsunami-like waves that have impacted the East Coast of the United States NOAA's NGDC compiled a listing of all tsunamis and tsunami-like waves of the eastern United States and Canada. Thirty-nine potential tsunami events have been identified as possibly impacting the East Coast of the United States since 1668. Of these events, four are categorized as definite or probable tsunamis.

The NGDC identified seven potential tsunami events that have possibly impacted the State of New Jersey. Of those seven events, two were categorized as a probably tsunami. Table 5.6-5 describes potential tsunami events that have impacted the State of New Jersey. The most recent tsunami event occurred in 2013 and was a rare type of tsunami called a "meteotsunami" that was caused by a strong weather system that moved from across the eastern U.S. that day

Table 5.6-5 Potential Tsunami Events in New Jersey, 1821-2017

Event Date	Source Location	County	Description/Losses
September 3, 1821	North Carolina	N/A	A hurricane passed over the Outer Banks of North Carolina and over the Delmarva Peninsula. It entered Cape May County where it traveled up the Garden State Parkway. Miles of sandbars were exposed the next morning. A dull roar approached and then a solid mass of wind and rain came tearing great pines from the ground and moving houses from their foundations. A wall of water struck that carried away people and animals.
August 10, 1884	Philadelphia, PA	N/A	A 5.6 earthquake generated a tsunami that was reported from Philadelphia, Trenton, and Highlands. In Trenton, the water in the city reservoir was agitated and a small tidal wave was noticed on the canal and feeder. In Highlands, two men were fishing and felt as if the water was had gone out from under their boat and it was grating on the sand.
September 8, 1889	Asbury Park, NJ	Monmouth	This event occurred during the Mudhen Hurricane. Unusually high waves were reported between September 8 and 10 in the Mid-Atlantic Coast. In New Jersey, these waves were reported in Asbury Park, Atlantic City, Sea Isle City, Coney Island, Long Island, Staten Island and other exposed points.

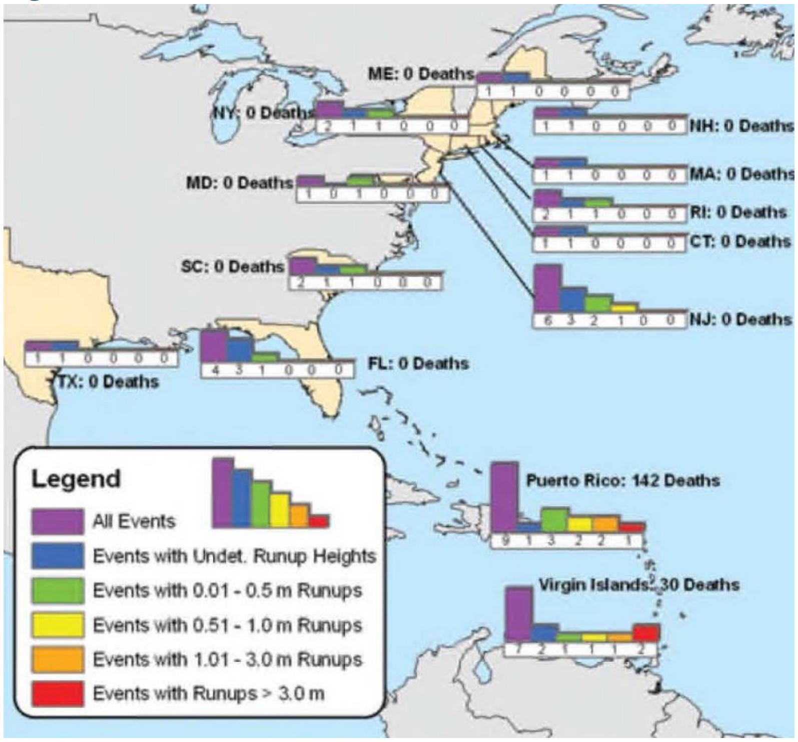
Event Date	Source Location	County	Description/Losses
September 1, 1895	High Bridge, NJ	Hunterdon	A 4.3 earthquake centered near High Bridge was felt over a large area to the northeast and southwest. The earthquake was felt from Maine to Virginia. The earthquake knocked articles from shelves and rocked buildings in several towns in New Jersey, Pennsylvania, and New York. In Asbury Park, NJ, plaster was knocked from walls. The earthquake caused a tsunami-like wave on Long Island. There was one run-up associated with this event. It caused one injury.
6/9/1913	Longport, NJ	Atlantic	It was reported that heavy tides were associated with this event. There were no reports of storms or earthquakes in the northeast United States on this date. Damage in Longport occurred at the Thoroughfare waterfront when a 250-foot section of the embankment at 23rd Street was carried away. The washout extended to within 15 feet of the near rail line. The tide tore away the wharf at the Schurch chandlery store and it undermined the soil from the building. The Lavine Wharf was completely torn away. This event caused $10,000 in damage. There was one injury associated with this event.
8/19/1931	Atlantic City, NJ	Atlantic	There was a sudden and brief onset of 3-meter waves in Atlantic City. Reports state that the surf was rough the day of the event and the waves rolled in shortly before noon. The waves arrived during high tide. There were other high wave events in the region, causing four people to drown. The weather bureau attributed this event to a tropical storm north of Puerto Rico.
6/13/2013	East Coast	Ocean	A rare type of tsunami called a "meteotsunami" hit the New Jersey coast. It was caused by a strong weather system that moved from across the eastern U.S. that day. The weather system caused a jump in air pressure, which created the wave. The impacts were greatest there in Barnegat Light," he said. An approximately 6-foot wave knocked three people off the inlet jetty, injuring at least two of them. No coastline damage was reported.

Source: Lockridge et al. 2002; NOAA, 2017

According to the 2008 NOAA study (*U.S. States and Territories National Tsunami Hazard Assessment: Historical Record and Sources for Waves*), tsunami events and losses were summarized for the Atlantic Region. Table 5.6-6 is a summary of their findings for the Atlantic Region. Figure 5.6-12 shows the number of tsunami events and total number of events causing run-up heights from 0.1 meters to greater than three meters for the United States and its territories in the Atlantic, Gulf Coast, Puerto Rico, and the United States Virgin Islands.

The table indicates that New Jersey has experienced seven tsunami events with any observed run-up. Run-up is a measurement of the height of the water onshore observed above a reference sea level. Tsunami run-up occurs when a peak in the tsunami wave travels from the near-shore region onto shore. There were no reported deaths or injuries associated with these events.

Figure 5.6-12 Total Number of Tsunami Events for the United States and Territories



Source: Dunbar and Weaver 2008

5.6.3.2 FEMA DISASTER DECLARATIONS

Between 1954 and 2017, FEMA declared that the State of New Jersey experienced 26 flood-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe storms, winter storms, snowstorms, coastal storms, flash flooding, heavy rains, tropical storms, hurricanes, high winds, ice jams, wave action, high tide, and tornadoes. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2013b).

Based on all sources researched, known flooding events that have affected New Jersey and were declared a FEMA disaster, are identified in Table 5.6-6. This table provides information on the FEMA disaster declarations for flooding, including disaster number, disaster type, declaration and incident dates, and counties included in the declaration. Figure 5.6-13 illustrates the number of FEMA-declared disasters by county.

Detailed information pertaining to each of the declared disasters since 2014 is provided in Appendix D of this Plan.

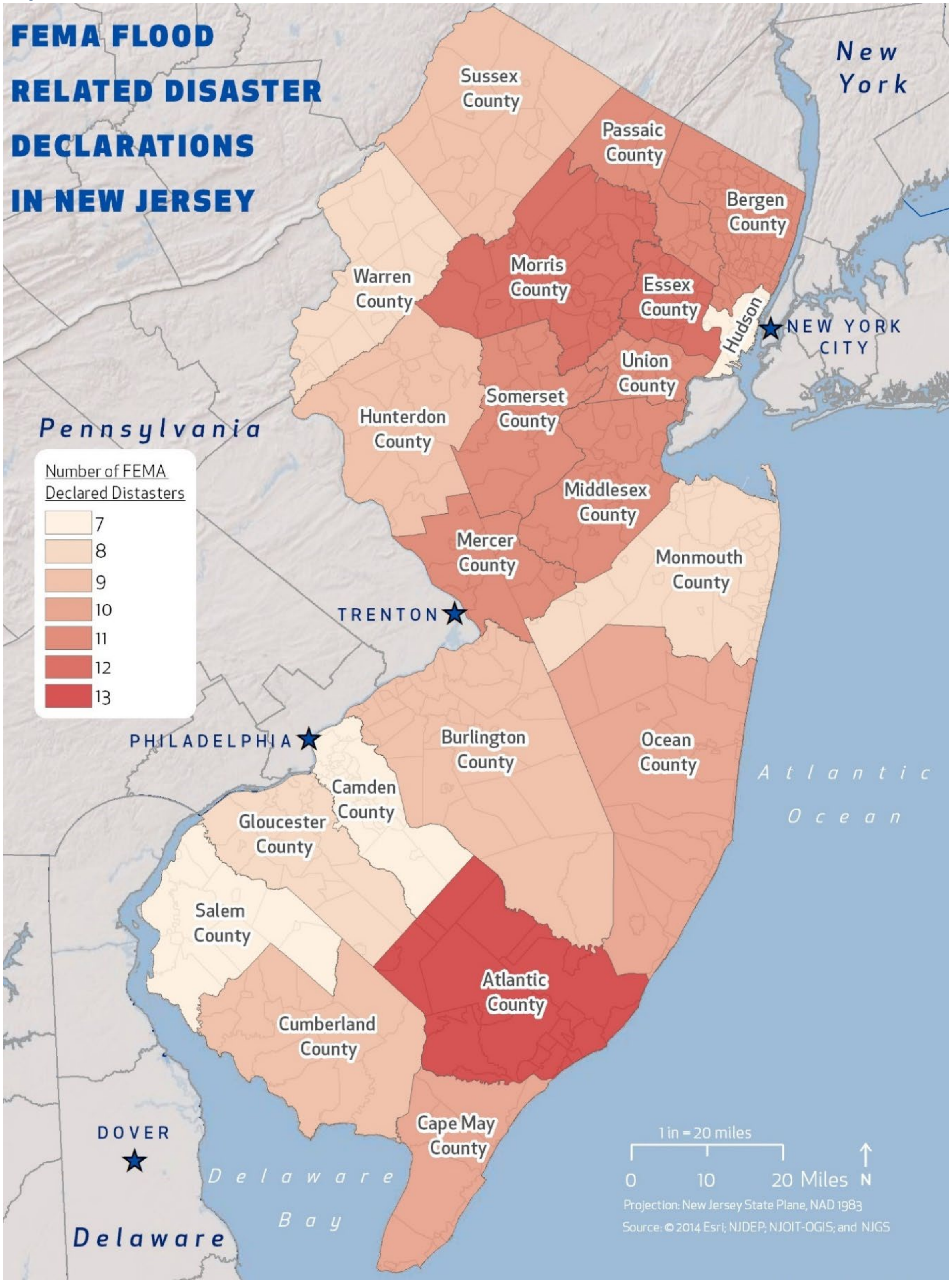
Table 5.6-6 FEMA Flood-Related Disaster Declarations (1954 to 2017)

Disaster Number	Disaster Type	Declaration Date	Atlantic	Bergen	Burlington	Camden	Cape May	Cumberland	Essex	Gloucester	Hudson	Hunterdon	Mercer	Middlesex	Monmouth	Morris	Ocean	Passaic	Salem	Somerset	Sussex	Union	Warren	Impacted Counties
41	Hurricane, Floods	8/20/1955	Not Available																					
124	Severe Storm, High Tides, Flooding	3/9/1962	Not Available																					
245	Heavy Rains, Flooding	6/18/1968		X					X					X		X		X		X		X		7
310	Heavy Rains, Flooding	9/4/1971	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21
402	Severe Storms, Flooding	8/7/1973							X					X						X		X		4
519	Severe Storms, High Winds, Flooding	8/21/1976	X				X								X		X							4
701	Coastal Storms, Flooding	3/28/1984 to 4/8/1984	X	X			X		X						X	X	X	X						8
973	Coastal Storm, High Tides, Heavy Rain, Flooding	12/10/1992 to 12/17/1992	X	X			X	X	X		X			X	X		X		X	X		X		12
1145	Severe Storms/Flooding	10/18/1996 to 10/23/1993									X			X		X				X		X		5
1189	Flooding	8/20/1997 to 8/21/1997	X																	X				1
1295	Hurricane Floyd	9/16/1999 to 9/18/1999		X					X			X	X	X		X		X		X		X		9
1337	Severe Storms, Flooding and Mudslides	8/12/2000 to 8/21/2000														X					X			2
1530	Severe Storms and Flooding	7/12/2004 to 7/23/2004			X	X																		2
1563	Tropical Depression Ivan	9/18/2004 to 10/1/2004										X	X								X		X	4
1588	Severe Storms and Flooding	4/1/2005 to 4/3/2005		X					X	X		X	X			X		X			X		X	9
1653	Severe Storms and Flooding	6/23/2006 to 7/10/2006										X	X								X		X	4
1694	Severe Storms and Inland and Coastal Flooding	4/14/2007 to 4/20/2007	X	X	X	X			X		X		X	X		X		X		X	X	X	X	14
1867	Severe Storms and Flooding Associated with Tropical Depression Ida and a Nor'easter	11/11/2009 to 11/15/2009	X				X										X							3
1873	Snowstorm	12/19/2009 to 12/20/2009	X		X	X		X		X							X		X					7
1889	Severe Winter Storm and	2/5/2010 to 2/6/2010	X		X	X	X	X		X									X					7

Disaster Number	Disaster Type	Declaration Date	Atlantic	Bergen	Burlington	Camden	Cape May	Cumberland	Essex	Gloucester	Hudson	Hunterdon	Mercer	Middlesex	Monmouth	Morris	Ocean	Passaic	Salem	Somerset	Sussex	Union	Warren	Impacted Counties
	Snowstorm																							
1897	Severe Storms and Flooding	3/12/2010 to 4/15/2010	X	X	X		X	X	X	X		X	X	X	X	X	X	X		X		X		16
1954	Severe Winter Storm and Snowstorm	12/26/2010 to 12/27/2010	X	X	X		X	X	X		X		X	X	X	X	X	X		X		X		15
4021	Hurricane Irene	8/27/2011 to 9/5/2011	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21
4033	Severe Storms and Flooding	8/13/2011 to 8/15/2011						X		X									X					3
4039	Remnants of Tropical Storm Lee	9/28/2011 to 10/6/2011										X	X					X			X		X	5
4086	Hurricane Sandy	10/26/2012 to 11/8/2012	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21
4231	New Jersey Severe Storm	June 23, 2015	X		X	X				X														4
4264	New Jersey Severe Winter Storm and Snowstorm	January 22, 2016 to January 24, 2016	X	X	X	X	X	X	X		X	X	X	X	X	X	X			X		X	X	17
4368	New Jersey Severe Winter Storm and Snowstorm	March 06, 2018 to March 07, 2018		X					X							X		X		X				5

Source: FEMA, 2017

Figure 5.6-13 Number of FEMA Flood Declared Disasters by County



Source: FEMA, 2017

5.6.4 PROBABILITY OF FUTURE OCCURRENCES

Flooding is a common occurrence in New Jersey and can take place any time of the year. Based on the history of flood events and the potential for a change in climate and sea level rise, flooding events may become more frequent throughout New Jersey. The State is vulnerable to riverine (inland) and coastal flooding, ice jam flooding, stormwater flooding, and flooding from a tsunami event. The historical record of FEMA declared disasters (flood-related) for the State indicates that New Jersey has experienced 29 flood-related disasters from 1954 to 2018 (FEMA 2018). Refer to Table 5.6-6 and Appendix D for a summary of these disasters. Based on these statistics, New Jersey may experience serious flooding events that result in a FEMA declaration once every two years. However, some areas of New Jersey are more flood prone than others and the frequency and size of flood events varies based on watershed, riverine reach, and location along each reach.

Floods are typically described in terms of their extent and their recurrence interval. The recurrence interval or return period is the average number of years between floods of a certain size. The actual number of years between floods of any given size varies because of the naturally changing climate (USGS 2013). Table 5.6-7 describes the recurrence intervals and probabilities of occurrences for flood events.

Table 5.6-7 Recurrence Intervals and Probabilities of Occurrences

Recurrence Interval (in years)	Probability of Occurrence in Any Given Year	Percent Chance of Occurrence in Any Given Year
100	1 in 100	1
50	1 in 50	2
25	1 in 25	4
10	1 in 10	10
5	1 in 5	20
2	1 in 2	50

Source: USGS

FEMA flood insurance rate maps (FIRMs), digital FIRMs (DFIRMs), and flood insurance studies (FIS) offer the best available information for states, counties and municipalities and where floods are likely to occur within specific areas (FEMA 2014). As previously stated in the 2011 New Jersey HMP, the probability of flood events must be estimated using engineering studies or FIS. FIRMs are the official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community. FIRMs also provide the basis for floodplain management standards for communities participating in NFIP and show the flood hazards that affect each community, from both coastal and inland flooding sources (FEMA 2013; FEMA 2014). A FIS is a compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community. When a flood study is completed for the NFIP, the information and maps are assembled into a FIS. The FIS report contains detailed flood elevation data in flood profiles and data tables (FEMA 2013).

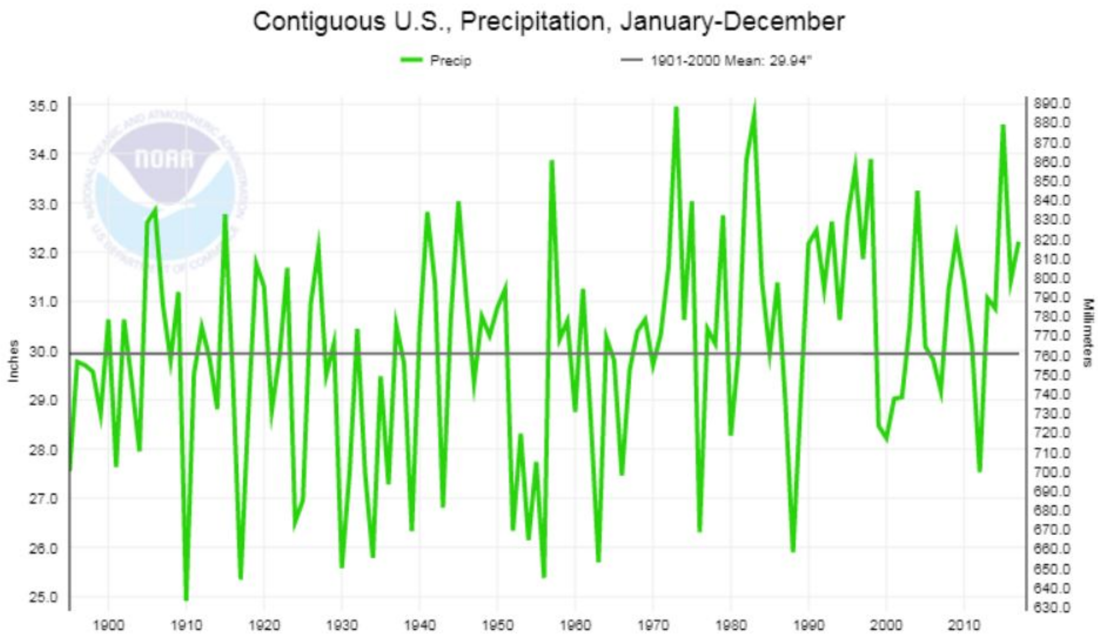
Since the previous plan update FEMA Region II has prepared a coastal flood study to update FIRMs for communities in coastal New Jersey and New York. The flood hazards shown on the FIRM are used to determine flood insurance rates and requirements and where floodplain development regulations apply (FEMA Region II, 2015). For further information regarding flood prone areas, updated FIRMs and coastal flood studies in New Jersey, see http://www.region2coastal.com/.

As stated previously, flood hazard areas, known as Special Flood Hazard Areas (SFHA) are identified on FIRMs. SFHA are defined as the area that will be inundated by the flood having a 1% chance of being equaled or exceeded in any given year (FEMA 2013e). The 1% annual chance flood is also referred to as the base flood or 100-year flood. SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30 (FEMA 2013f). Areas of minimal flood hazard, which are the areas outside of the SHFA and higher than the elevation of the 0.2-percent annual chance flood.

5.6.4.2 POTENTIAL EFFECTS OF CLIMATE CHANGE

Flooding may increase as a result of increased precipitation events. Both northern and southern New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over five inches (12%) greater than the average from 1895-1970. Southern New Jersey became two inches (5%) wetter late in the 20th century (Office of New Jersey State Climatologist). Average annual precipitation is projected to increase in the region by 5% by the 2020s and up to 10% by the 2050s. Most of the additional precipitation is expected to come during the winter months (New York City Panel on Climate Change [NYCPCC] 2009). Figure 5.6-14 shows the frequency of heavy precipitation events in the northeastern United States

Figure 5.6-14 Frequency of Heavy Precipitation Events in the Northeastern United States, 1895 to 2017



Source: NOAA, 2017

With this increase in frequency of precipitation, New Jersey may experience more flooding events. More intense, frequent flooding could lead to significant habitat loss for wildlife. Salt marshes and estuaries that serve as critical feeding grounds for birds and waterfowl, and as nursery habitats for commercial fish, could be lost (State of New Jersey 2010). Future climate change may also lead to sea level rise which could lead to more frequent and extensive flooding. See Section 5.2 (Coastal Erosion) for detailed information regarding sea level rise (NJDEP 2013c).

A 2013 report by Rutgers University indicates that sea level has been steadily rising with sea levels along the New Jersey coastline rising faster than the global average. Continued Seal Level Rise could indicate more frequent and more severe coastal flooding events (Rutgers 2013b). Flooding events associated with storm surge caused by hurricanes and tropical storms could therefore also increase. Section 5.2 (Coastal Erosion) contains a discussion of the State's efforts to address sea level rise.

5.6.5 IMPACT ANALYSIS

5.6.5.1 SEVERITY AND WARNING TIME

Flooding

As indicated, the principal factors affecting flood damage are flood depth and velocity. The deeper and faster flood flows become, the more damage they can cause. Shallow flooding with high velocities can cause as much damage as deep flooding with slow velocity. This is especially true when a channel migrates over a broad floodplain, redirecting high velocity flows and transporting debris and sediment. Flood severity can also be evaluated by examining peak discharges.

Due to the sequential pattern of meteorological conditions needed to cause serious flooding, it is unusual for a flood to occur without warning. Warning times for floods can be between 24 and 48 hours. Flooding is more likely to occur due to a rainstorm when the soil is already wet and/or streams are already running high from recent previous rains. Pre-existing conditions when a storm begins are called "antecedent conditions".

Ice Jams

Heavy snowfall and frigid temperatures, followed by sudden warmer temperatures can increase the risk of flooding from snowmelt and ice jams. When river ice piles up at shallow areas, it blocks the flow of water and may cause flooding of nearby areas (Northeast States Emergency Consortium 2013). Damage tends to be localized and relatively minor. However, depending on the magnitude of the ice jam, major damage and losses can result. Ice jams can damage roads, bridges, buildings, and homes. Impacts from ice jams tend to primarily affect areas along rivers, tributaries, or reservoirs. Typically, when ice jam events occur, flooding occurs within the localized areas upstream of the jam (before it breaks) or downstream from the jam when it suddenly moves or releases.

The rates of water level rise during an ice jam event can vary from feet per minute to feet per hour. In some cases, communities have many hours of lead time between the time an ice jam forms and its associated flooding. However, in other cases, the lead time can be as little as one hour (NOAA 2013).

Tsunamis

Tsunamis are a threat to life and property to anyone that lives near the ocean. The majority of tsunami events have occurred in the Pacific Ocean Basin. Tsunamis are a threat to life and property to anyone that lives near the ocean. According to NOAA's NGDC, between 2000 B.C. and 2013, 2,483 tsunamis were recorded globally. These events caused over 900,000 fatalities worldwide (NGDC 2013). Of those 2,483 events, 272 occurred along the United States shoreline, causing 941 fatalities, 35 injuries, and costing over $1 billion in damages.

The National Tsunami Hazard Mitigation Program was formed in 1995 by Congressional action which directed NOAA to form and lead a federal and state working group. The program is a partnership between NOAA, USGS, FEMA, the National Science Foundation (NSF), and the 28 United States coastal states, territories, and commonwealths.

One of the actions outlined by the National Tsunami Hazard Mitigation Program was the development of a tsunami monitoring system to monitor the ocean's activity and make citizens aware of a possible tsunami approaching land. In response, NOAA developed the DART monitoring buoys. To ensure early detection of tsunamis and to acquire data critical for real-time forecasts, NOAA placed DART stations in regions with a history of destructive tsunamis. NOAA completed the original 6-buoy operational array in 2001 and expanded to a full network of 39 stations in March 2008. The information collected by the DART buoys positioned at strategic locations throughout the ocean plays a critical role in tsunami forecasting.

When a tsunami event occurs, the first information available about the source of the tsunami is based only on the available seismic information for the earthquake event. As the tsunami wave propagates across the ocean and successively reaches the DART stations, these systems report sea level measurement information back to the Tsunami Warning Centers. The centers process the information and produce a new and more refined estimate of the tsunami source. The result is an increasingly accurate forecast of the tsunami that can be used to issue watches, warnings, or evacuations.

5.6.5.2 SECONDARY HAZARDS

Flooding

The most problematic secondary hazard for flooding is bank erosion and landslides, which in some cases can be more harmful than actual flooding. This is especially true in the upper courses of rivers with steep gradients, where floodwaters may pass quickly and without much damage, but scour the banks, edging properties closer to the floodplain or causing them to fall in. Flooding is also responsible for hazards such as landslides, when high flows on steep slopes with saturated soils cause them to fail. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into streams, rivers, or storm sewers.

Ice Jams

Ice jams in the United States result in three types of situations:

- No flood threat, but environmental and geomorphological impacts possible;
- Freeze-up jams or freezing of mid-season break-up jams that cause chronic flooding problems for the winter season; or
- Break-up ice jams that cause sudden or flash floods (USACE 2013).

Other impacts from ice jams can include structural damage from intake blockages, ice forces, or scouring under ice. Ice jams can cause bank failure, erosion and scour, and channel shifting. Natural habitats for fish, microbial communities, and riverine margins and estuaries may also be impacted by ice jams (USACE 2013).

Tsunamis

Aside from the tremendous hydraulic force of the tsunami waves themselves, floating debris carried by a tsunami can endanger human lives and batter inland structures. Ships moored at piers and in harbors often are swamped and sunk or are left battered and stranded high on the shore. Breakwaters and piers collapse, sometimes from scouring actions that sweep away their foundation and sometimes because of the direct wave impact. Railroad yards and oil tanks situated near the waterfront are particularly vulnerable. Oil fires frequently result and can be spread by the waves.

Port facilities, naval facilities, fishing fleets, and public utilities are often the backbone of the economy of the affected areas. These resources generally receive the most severe damage. Until debris can be cleared, wharves and piers rebuilt, utilities restored, and fishing fleets reconstituted, communities may find themselves without fuel, food, and employment. Wherever water transport is a vital means of supply, disruption of coastal systems caused by tsunamis can have far-reaching economic effects.

5.6.6 VULNERABILITY ASSESSMENT

The following sections address assessing vulnerability and estimating potential losses by jurisdiction and to state facilities. To assess the State's exposure to the riverine and coastal flood hazard, a spatial analysis was conducted using the most current 1% annual chance flood hazard areas (refer to Table 5.6-8 below). This data includes preliminary work maps, preliminary DFIRMs, regulatory DFIRMs, preliminary work maps and Quality 3 (Q3) data. To estimate potential losses, the Hazards U.S. Multi-Hazard (HAZUS-MH 4.2) flood model was used. Preliminary work map depth grids for the coastal areas provided by NJDEP were incorporated into HAZUS-MH. Where existing depth grids were not available, approximate depth grids were generated using the DFIRM databases for detailed study areas or HAZUS-MH for reaches without detailed studies. The digital elevation models (DEM) provided by New Jersey Office of Information Technology were used to generate the depth grids. The depth grids were integrated into HAZUS-MH and the model was run to estimate potential losses to the default general building stock in HAZUS-MH, State-owned and leased buildings in LBAM, and critical facilities as discussed in Section 5.1 for the 1% annual chance flood event.

Table 5.6-8 lists the data that was utilized for purposes of the vulnerability assessment.

Table 5.6-8 Flood Data Used for the 2019 Plan Update

County	Data (Source and Date)
Atlantic	Preliminary - 1/30/2015
Bergen	Preliminary - 5/5/2017
Burlington	Effective - 12/21/2017 & Preliminary - 12/22/2017
Camden	Effective - 8/17/2016
Cape May	Effective - 10/5/2017 & Preliminary - 1/30/2015 (Lower Twp. Only)
Cumberland	Effective - 6/16/2016
Essex	Effective - 6/4/2007 & Preliminary - 5/30/2014 & Preliminary 6/30/2017
Gloucester	Effective - 8/17/2016
Hudson	Preliminary - 1/30/2015
Hunterdon	Effective - 5/2/2012
Mercer	Effective - 7/20/2016
Middlesex	Preliminary - 1/30/2015
Monmouth	Preliminary - 1/30/2015 & Effective - 6/20/2018
Morris	Preliminary - 8/22/2017
Ocean	Preliminary - 1/30/2015 & Effective - 6/20/2018
Passaic	Preliminary - 8/30/2017
Salem	Effective - 6/16/2016
Somerset	Effective - 11/4/2016
Sussex	Effective - 9/29/2011
Union	Preliminary - 2/3/2015 & Preliminary - 4/18/2016
Warren	Effective - 9/29/2011

Source: NJDEP 2013c

There are no defined stormwater, tsunami or ice jam hazard areas available at this time. Therefore, the vulnerability to these hazards is discussed in a qualitative nature below. As tsunami inundation or hazard areas are developed, they will be used to conduct a spatial analysis to identify the most vulnerable residents and structures in the tsunami hazard zone and be used to focus public education and outreach efforts on these communities. Further, tsunami inundation maps will provide information needed to create evacuation maps.

5.6.6.2 ASSESSING VULNERABILITY BY JURISDICTION

Historically, floods have impacted all 21 New Jersey counties. All counties with local hazard mitigation plans identified flood as a hazard of concern, as listed in Table 5.1-2 in Section 5.1 (State Risk Assessment Overview). Of the five-local mitigation plans that ranked risk into high/medium/low categories for this hazard, the following New Jersey counties considered the flood hazard as high: Cape May, Essex, Monmouth, and Somerset counties.

New Jersey is located along the East Coast, is the most densely populated state, and one of the most densely developed states. A spatial analysis was conducted to calculate the total area located in the 1% annual chance flood zone [A zones, V zones, and total special flood hazard area (SFHA)] for each County. These results are summarized in Table 5.6-9. Please note the total area is inclusive of land and water.

The analysis indicates approximately 19% of New Jersey is located within the 1% annual chance flood zone, also known as the SFHA. Hudson and Cape May Counties have the greatest percentage of area located within the SFHA. Cape May, Atlantic and Ocean Counties have the highest percentage of land in the V-zone which is the most vulnerable portion of the SFHA.

Table 5.6-9 Area Located in the Flood Hazard Boundaries by County (Square Miles)

County	Total Area (land and water)	A-Zone		V-Zone		SFHA	
		Area (SqMi)	% of Total	Area (SqMi)	% of Total	Area (SqMi)	% of Total
Atlantic	610.65	147.91	24.22%	56.91	9.32%	204.82	33.54%
Bergen	239.83	36.88	15.38%	1.82	0.76%	38.70	16.14%
Burlington	820.32	139.40	16.99%	2.06	0.25%	141.46	17.25%
Camden	227.57	23.87	10.49%	1.05	0.46%	24.92	10.95%
Cape May	286.13	116.91	40.86%	41.33	14.44%	158.24	55.30%
Cumberland	501.80	132.03	26.31%	22.56	4.50%	154.59	30.81%
Essex	129.72	24.06	18.55%	0.80	0.62%	24.86	19.16%
Gloucester	336.20	40.24	11.97%	3.90	1.16%	44.14	13.13%
Hudson	51.53	22.41	43.49%	4.50	8.73%	26.91	52.22%
Hunterdon	437.32	23.39	5.35%	-	0.00%	23.39	5.35%
Mercer	228.80	24.69	10.79%	-	0.00%	24.69	10.79%
Middlesex	316.97	47.78	15.08%	4.24	1.34%	52.03	16.41%
Monmouth	485.68	44.07	9.07%	11.92	2.45%	55.99	11.53%
Morris	481.44	64.17	13.33%	-	0.00%	64.17	13.33%
Ocean	757.93	126.46	16.68%	52.76	6.96%	179.22	23.65%
Passaic	198.32	24.61	12.41%	-	0.00%	24.61	12.41%
Salem	347.12	88.11	25.38%	1.29	0.37%	89.40	25.75%
Somerset	304.88	30.93	10.14%	-	0.00%	30.93	10.14%
Sussex	535.47	43.59	8.14%	-	0.00%	43.59	8.14%
Union	105.38	17.87	16.96%	0.33	0.31%	18.19	17.26%
Warren	362.59	23.27	6.42%	-	0.00%	23.27	6.42%
Total	7,765.65	1,242.68	16.00%	205.46	2.65%	1,448.14	18.65%

Source: FEMA, 2018, NJOGIS

To better understand life and property at risk, the population and general building stock located in the SFHA were examined. The impact of riverine and coastal flooding on life, health, and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but everyone who may be affected by the effects of a hazard event. For example, people may be at risk while traveling in flooded areas, or emergency service access is compromised during an event. The degree of that impact will vary and is not strictly measurable.

To examine the population exposed to the SFHA, the 1% annual chance flood boundary was overlaid on the 2015 American Community Survey population for each county. Where the 2015 Census tract centroid was located within the flood boundary, the population in that Census tract was totaled. Table 5.6-10 lists the estimated population located within the 1% flood zones by county using the 2015 Census tract centroid. The limitations of this analysis are recognized and should only be used as estimates. The analysis indicates Cape May County has the highest percent of total population located within the SFHA (approximately 49%).

Table 5.6-10 Estimated Population Exposed to the 1% Annual Chance Flood Events

County	Total Population (2015 ACS)	A-Zone		V-Zone		SFHA	
		Population	% of Total	Population	% of Total	Population	% of Total
Atlantic	275,376	96,769	35.14%	18,820	6.83%	115,589	41.97%
Bergen	926,330	87,893	9.49%	8,739	0.94%	96,632	10.43%
Burlington	450,556	48,452	10.75%	0	0.00%	48,452	10.75%
Camden	511,998	56,722	11.08%	0	0.00%	56,722	11.08%
Cape May	95,805	45,364	47.35%	1,434	1.50%	46,798	48.85%
Cumberland	157,035	11,572	7.37%	0	0.00%	11,572	7.37%
Essex	791,609	44,900	5.67%	0	0.00%	44,900	5.67%
Gloucester	290,298	10,877	3.75%	0	0.00%	10,877	3.75%
Hudson	662,619	120,201	18.14%	53,929	8.14%	174,130	26.28%
Hunterdon	126,250	2,681	2.12%	0	0.00%	2,681	2.12%
Mercer	370,212	40,870	11.04%	0	0.00%	40,870	11.04%
Middlesex	830,300	72,023	8.67%	0	0.00%	72,023	8.67%
Monmouth	629,185	58,016	9.22%	5,885	0.94%	63,901	10.16%
Morris	498,192	72,433	14.54%	0	0.00%	72,433	14.54%
Ocean	583,450	102,133	17.51%	29,042	4.98%	131,175	22.48%
Passaic	507,574	31,451	6.20%	0	0.00%	31,451	6.20%
Salem	65,120	12,994	19.95%	0	0.00%	12,994	19.95%
Somerset	330,604	23,769	7.19%	0	0.00%	23,769	7.19%
Sussex	145,930	6,731	4.61%	0	0.00%	6,731	4.61%
Union	548,744	32,686	5.96%	0	0.00%	32,686	5.96%
Warren	107,226	2,272	2.12%	0	0.00%	2,272	2.12%
Total	8,904,413	980,809		117,849		1,098,658	

Source: American Community Survey 2015 5 Year Estimates; NJOGIS

Of the exposed population, the most vulnerable include the economically disadvantaged and those over the age of 65. 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. As of August 2018, the 2010 U.S. Census population spatial files do not include statistics on vulnerable population (e.g., elderly, low income); therefore, a spatial analysis could not have conducted to summarize the vulnerable population located in the SFHA. When this data becomes available, this analysis will be conducted for the State Plan.

As noted earlier, the population exposed to a tsunami cannot be determined at this time due to the lack of tsunami inundation areas or hazard zones. However, in general, the populations most vulnerable to the tsunami hazard are the elderly, disabled, and very young who reside near beaches, low-lying coastal areas, tidal flats, and river deltas that empty into ocean-going waters. In the event of a local tsunami generated in or near the State, there would be little warning time, so more of the population would be vulnerable. The degree of vulnerability of the population exposed to the tsunami hazard event is based on a number of factors:

- Whether there is a warning system in place;
- How much lead time a warning provides;
- The method for disseminating the warning; and
- Whether the people warned will evacuate.

To further assess what is at risk, each County's general building stock's exposure was examined. Damages to buildings can displace people from their homes, threaten life safety and impact a community's economy and tax base. To provide a general estimate of the structural/content replacement value exposure, the 1% annual chance flood boundary was overlaid on HAZUS-MH's default general building stock inventory at the Census block level for each county. Where the 2010 Census block centroid was located within the flood boundary, the building stock values in that Census block were totaled. There are limitations to this analysis.

Table 5.6-11 Estimated General Building Stock Exposure to the 1% Annual Chance Flood Event A-Zone

County	Total Value	A-Zone	
		Value	% of Total
Atlantic	$ 71,441,548,000	$ 24,144,898,181	33.8%
Bergen	$ 251,767,379,000	$ 23,956,805,620	9.5%
Burlington	$ 115,349,329,000	$ 6,064,309,719	5.3%
Camden	$ 124,338,493,000	$ 4,886,937,988	3.9%
Cape May	$ 46,770,193,000	$ 27,038,105,763	57.8%
Cumberland	$ 31,676,996,000	$ 1,214,518,190	3.8%
Essex	$ 189,343,113,000	$ 15,374,670,180	8.1%
Gloucester	$ 68,341,560,000	$ 1,811,923,325	2.7%
Hudson	$ 127,979,762,000	$ 32,653,815,427	25.5%
Hunterdon	$ 40,878,432,000	$ 1,438,635,217	3.5%
Mercer	$ 100,089,155,000	$ 3,830,786,481	3.8%
Middlesex	$ 214,970,463,000	$ 10,931,825,335	5.1%
Monmouth	$ 172,865,619,000	$ 14,664,992,065	8.5%
Morris	$ 155,505,420,000	$ 8,875,640,377	5.7%
Ocean	$ 145,147,672,000	$ 34,574,333,539	23.8%
Passaic	$ 110,998,109,000	$ 7,894,395,841	7.1%

County	Total Value	A-Zone	
		Value	% of Total
Salem	$ 15,101,513,000	$ 2,640,738,443	17.5%
Somerset	$ 95,819,752,000	$ 4,032,170,905	4.2%
Sussex	$ 42,546,395,000	$ 864,539,281	2.0%
Union	$ 131,924,654,000	$ 9,605,659,646	7.3%
Warren	$ 28,667,204,000	$ 1,210,055,528	4.2%
Total	$ 2,281,522,761,000	$ 237,709,757,051	10.4%

Source: HAZUS 4.0 General Building Stock Values, FEMA 2018

Table 5.6-12 Estimated General Building Stock Exposure to the 1% Annual Chance Flood Event V-Zone

County	Total Value	V-Zone	
		Value	% of Total
Atlantic	$ 71,441,548,000	$ 349,753,696	0.5%
Bergen	$ 251,767,379,000	$ 144,565,148	0.1%
Burlington	$ 115,349,329,000	$ -	0.0%
Camden	$ 124,338,493,000	$ 8,676,883	0.0%
Cape May	$ 46,770,193,000	$ 548,311,483	1.2%
Cumberland	$ 31,676,996,000	$ 30,264,499	0.1%
Essex	$ 189,343,113,000	$ 29,557,631	0.0%
Gloucester	$ 68,341,560,000	$ 6,515,362	0.0%
Hudson	$ 127,979,762,000	$ 871,992,592	0.7%
Hunterdon	$ 40,878,432,000	$ -	0.0%
Mercer	$ 100,089,155,000	$ -	0.0%
Middlesex	$ 214,970,463,000	$ 131,744,427	0.1%
Monmouth	$ 172,865,619,000	$ 741,893,731	0.4%
Morris	$ 155,505,420,000	$ -	0.0%
Ocean	$ 145,147,672,000	$ 1,183,889,088	0.8%
Passaic	$ 110,998,109,000	$ -	0.0%
Salem	$ 15,101,513,000	$ 4,413,461	0.0%
Somerset	$ 95,819,752,000	$ -	0.0%
Sussex	$ 42,546,395,000	$ -	0.0%
Union	$ 131,924,654,000	$ 26,562,011	0.0%
Warren	$ 28,667,204,000	$ -	0.0%
Total	$ 2,281,522,761,000	$4,078,140,011	0.2%

Source: HAZUS 4.0 General Building Stock Values, FEMA 2018

Table 5.6-13 Estimated General Building Stock Exposure to the 1% Annual Chance Flood Event SFHA

County	Total Value	SFHA	
		Value	% of Total
Atlantic	$ 71,441,548,000	$ 24,494,651,877	34.3%
Bergen	$ 251,767,379,000	$ 24,101,370,768	9.6%
Burlington	$ 115,349,329,000	$ 6,064,309,719	5.3%
Camden	$ 124,338,493,000	$ 4,895,614,871	3.9%
Cape May	$ 46,770,193,000	$ 27,586,417,246	59.0%
Cumberland	$ 31,676,996,000	$ 1,244,782,689	3.9%
Essex	$ 189,343,113,000	$ 15,404,227,811	8.1%
Gloucester	$ 68,341,560,000	$ 1,818,438,687	2.7%
Hudson	$ 127,979,762,000	$ 33,525,808,019	26.2%
Hunterdon	$ 40,878,432,000	$ 1,438,635,217	3.5%
Mercer	$ 100,089,155,000	$ 3,830,786,481	3.8%
Middlesex	$ 214,970,463,000	$ 11,063,569,762	5.1%
Monmouth	$ 172,865,619,000	$ 15,406,885,796	8.9%
Morris	$ 155,505,420,000	$ 8,875,640,377	5.7%
Ocean	$ 145,147,672,000	$ 35,758,222,627	24.6%
Passaic	$ 110,998,109,000	$ 7,894,395,841	7.1%
Salem	$ 15,101,513,000	$ 2,645,151,904	17.5%
Somerset	$ 95,819,752,000	$ 4,032,170,905	4.2%
Sussex	$ 42,546,395,000	$ 864,539,281	2.0%
Union	$ 131,924,654,000	$ 9,632,221,657	7.3%
Warren	$ 28,667,204,000	$ 1,210,055,528	4.2%
Total	$ 2,281,522,761,000	$ 241,787,897,062	10.6%

Source: HAZUS 4.0 General Building Stock Values, FEMA 2018

The spatial building analysis indicates Cape May County has almost 60% of the total buildings in the County located in the SFHA. In the state, approximately 10% of the entire state building stock lies in the SFHA.

As noted earlier, the buildings exposed to the tsunami hazard cannot be determined at this time. The impact of the waves and the scouring associated with debris that may be carried in the water could be very damaging to structures located in the tsunami's path. Structures that would be most vulnerable are those located in the front line of tsunami impact and those that are structurally unsound.

The NFIP data are also a useful tool to determine areas vulnerable to flood and severe storm hazards for each jurisdiction. Table 5.6-14 summarizes the NFIP policies, claims, RL, and SRL properties in each county in 2019. Appendix Q summarizes this data at the community level. Passaic County has the highest number of SRL properties in the State. Cape May County has the highest number of RL properties in the State.

Table 5.6-14 Status of NFIP Policies, Claims, and Repetitive Loss Statistics

County	Number of Policies	Number of Claims	Total Loss Payment	Number RL Properties	Number of SRL Properties
Atlantic	28,350	20,752	$487,181,979	1,072	52
Bergen	11,513	12,782	$351,518,415	1,896	130
Burlington	3,693	1,871	$25,183,639	188	12
Camden	1,802	1,077	$6,053,970	104	3
Cape May	53,382	28,110	$414,033,741	2,802	170
Cumberland	543	953	$14,911,361	103	2
Essex	4,218	4,748	$110,997,022	503	60
Gloucester	1,027	588	$3,892,642	61	0
Hudson	22,763	4,197	$153,534,293	433	20
Hunterdon	941	1,307	$24,748,714	228	28
Mercer	2,074	2,251	$37,083,805	298	10
Middlesex	3,770	4,259	$113,882,304	644	44
Monmouth	22,114	19,678	$931,418,211	1,645	79
Morris	3,886	8,937	$191,475,848	1,067	193
Ocean	50,500	52,454	$2,600,248,464	1,899	49
Passaic	3,567	13,650	$285,212,034	1,758	267
Salem	1,707	747	$7,009,808	50	5
Somerset	2,314	5.377	$159,872,303	1,034	61
Sussex	327	183	$1,822,920	16	0
Union	4,788	5,702	$97,814,017	739	32
Warren	553	1,212	$31,612,443	269	21
Unknown		234	$1,489,592		
Total	223,832	191,069	$6,050,997,526	16,809	1,238

Source: FEMA, 2019;

Of the 16,809 RL properties across the State, 11,730 (73%) are single family residences. The remaining properties are classified as the following: two to four family residence (2,406); condominium (246); other residential (479) and non-residential (1,425). Of the 1,238 SRL properties across the State, 1,023 (83%) are single family residences while 178 are two to four family residences and the remaining 37 properties are classified as other residential. This data is current as of August 2018.

Table 5.6-15 Comparison of NFIP Statistics from 2013 to 2019

County	Number of Policies			Number of Claims		
	2013	2019	Change	2013	2019	Change
Atlantic	31,600	28,350	(3,250)	20,356	20,752	396
Bergen	12,855	11,513	(1,342)	12,589	12,782	193
Burlington	4,168	3,693	(475)	1,691	1,871	180

County	Number of Policies			Number of Claims		
	2013	2019	Change	2013	2019	Change
Camden	2,476	1,802	(674)	961	1,077	116
Cape May	55,436	53,382	(2,054)	26,610	28,110	1,500
Cumberland	812	543	(269)	931	953	22
Essex	4,806	4,218	(588)	4,613	4,748	135
Gloucester	1,545	1,027	(518)	553	588	35
Hudson	20,167	22,763	2,596	4,056	4,197	141
Hunterdon	1,190	941	(249)	1,298	1,307	9
Mercer	2,466	2,074	(392)	2,168	2,251	83
Middlesex	4,622	3,770	(852)	4,140	4,259	119
Monmouth	21,825	22,114	289	19,408	19,678	270
Morris	4,806	3,886	(920)	8,900	8,937	37
Ocean	53,444	50,500	(2,944)	52,063	52,454	391
Passaic	5,045	3,567	(1,478)	13,484	13,650	166
Salem	2,238	1,707	(531)	698	747	49
Somerset	3,355	2,314	(1,041)	5,264	5,377	113
Sussex	411	327	(84)	176	183	7
Union	5,944	4,788	(1,156)	5,548	5,702	154
Warren	763	553	(210)	1,208	1,212	4
Unknown	29		(29)	234	234	-
Total	240,003	223,832	(16,171)	186,949	191,069	4,120

Sources: FEMA, 2019;

ASSESSING CHANGES TO POLICIES IN FORCE

A comparison analysis was conducted to understand the changes in overall NFIP statistics from the 2014 Plan to the 2019 Plan Update. Table 5.6-15 displays the number of policies in 2013 and 2019 and the difference in number of policies, by county. Overall, there was a reduction of 16,171 policies in the State and an increase of 4,120 claims.

Atlantic, Ocean, and Cape May County have the greatest loss of polices in force in the State. These three counties also have the highest number of policies and claims in the State. The total number of policies in force for Cape May and Ocean County are each over 50,000. Ocean County has the highest number of claims of any county with over 50,000. Cape May has the greatest increase in number of claims since the previous plan at 1,500 additional claims.

The following municipalities have no claims submitted in 2019: Township of Shrewsbury; Borough of Audubon Park; Borough of Woodbine; Borough of Pitman; Township of South Harrison; Borough of Elmer; Borough of Hamburg; Township of Oxford; Borough of Wenonah; Borough of Hi-Nella; Borough of Tavistock; Borough of Newfield; Borough of Freehold; and, Borough of Pine Valley.

It should also be noted that FEMA reports 29 policies where the community identification number has been mis-assigned in their policy database. These 29 policies have had 234 claims and a total payout of almost 1.5 million dollars.

There are many factors that may contribute to the change in total number of policies in force in the State. Some of the policies and events below may help explain the state's reduction in total policies since the previous plan update. The intention of the assessment below is to explore possible causal relationships that led to a decrease in policies; however, further statistical investigation is needed to determine if a true correlation may exist.

FEMA Cost Increases Due to Legislation Changes

Starting in April 2017, FEMA mandated that premiums for flood insurance policies increase by an average of 6.3 percent. This increase in flood insurance premiums was a result of the Biggert-Waters Flood Insurance Reform Act of 2012 and the Homeowner Flood Insurance Affordability Act of 2014 (HFIAA). Properties most affected by increases include: properties that meet NFIP's "Severe Repetitive Loss" definition; business properties; and secondary homes.

Properties in these categories may have had their flood coverage annual premiums rise by up to 25 percent. NFIP guidelines set a cap on how much flood insurance premiums can rise in any year – no single policy can go up by more than 18 percent per year until full-risk rates are achieved.

Housing Foreclosure Crisis in New Jersey

Bank repossessions in New Jersey hit an 11-year high in 2018, while the rest of the United States saw repossessions hit an 11-year low. As reported by Experian, New Jersey has the highest foreclosure rate in the nation, with one in every 605 properties in some stage of foreclosure. That is equivalent to a 1.61 percent foreclosure rate.

Among the 216 metropolitan statistical areas in the nation with a population of at least 200,000, those with the highest foreclosure rate were Atlantic City, New Jersey (3.39 percent of housing units with a foreclosure filing); Trenton, New Jersey (2.16 percent); Rockford, Illinois (1.54 percent); Philadelphia, Pennsylvania (1.53 percent); and Lakeland-Winter Haven, Florida (1.46 percent). Below are the 2019 foreclosure rates for each county in New Jersey as reported by RealtyTrac.

2019 Foreclosure Rates for each County

1 in every 326 homes - Cumberland County
1 in every 449 homes - Warren County
1 in every 458 homes - Atlantic County
1 in every 528 homes - Gloucester County
1 in every 641 homes - Salem County
1 in every 707 homes - Burlington County
1 in every 728 homes - Camden County
1 in every 750 homes - Sussex County
1 in every 817 homes - Ocean County
1 in every 891 homes - Bergen County
1 in every 1,000 homes - Hunterdon County
1 in every 1,010 homes - Mercer County
1 in every 1,228 homes - Union County
1 in every 1,277 homes - Monmouth County
1 in every 1,286 homes - Cape May County
1 in every 1,392 homes - Passaic County
1 in every 1,494 homes - Essex County
1 in every 1,629 homes - Middlesex County
1 in every 1,996 homes - Somerset County
1 in every 2,017 homes - Morris County
1 in every 3,230 homes - Hudson County

In the aftermath of the Great Recession and Superstorm Sandy, New Jersey Courts experienced a backlog of foreclosure cases that increased the processing time of foreclosure cases. During this time it was not uncommon for a foreclosure case to take many years to clear the courts. Now with the backlog of foreclosure cases cleared, the average time for an uncontested foreclosure case takes about 8 months. New Jersey's high foreclosure rates and expedited processing time may be a contributing factor to reductions in NFIP polices within the State.

RREM Program Policy

The Reconstruction, Rehabilitation, Elevation and Mitigation (RREM) Program assisted eligible applicants whose homes were damaged by Superstorm Sandy to complete the necessary work to make their homes livable and compliant with flood plain, environmental, and other state and local requirements.

The RREM Program was funded through Community Development Block Grant (CDBG) Disaster Recovery monies from the U.S. Department of Housing and Urban Development (HUD), which provided the State with two of three allocations for Sandy recovery, for a total of $3.2 billion. Of that amount, $1.1 billion was allocated to the RREM Program.

The RREM Program was intended to supplement other funds the owner received to repair or reconstruct their structure. The RREM Program provided a grant to eligible applicants of up to $150,000. This program was administered by the State of New Jersey Department of Community Affairs, Sandy Recovery Division under Governor Chris Christie's administration.

As of August 1, 2013, the RREM Program stopped accepting new applications and has since closed. During its operation the program was refined and streamlined in substantial ways. One of the policy implications of the RREM program policies was that it had no long-term insurance commitment for recipients of funds.

Acquisitions and Buyouts of Properties

According to FEMA's Hazard Mitigation Assistance (HMA) Mitigated Properties open data, there is a total of 167 property acquisitions through FEMA's HMA funding in New Jersey. These acquisitions occurred in Hunterdon County (8), Passaic County (140), Somerset County (7), and Warren County (12).

The New Jersey Department of Environmental Protection's Blue Acres program acquires properties (including structures) that have been damaged by, or may be prone to incurring damage caused by, storms or storm-related flooding, or that may buffer or protect other lands from such damage. Since its inception shortly after Sandy struck the State, the Blue Acres program has secured funding for the purchases of 981 homes. To date, the program has closed on the purchases of 688 properties and has completed 593 demolitions. The HUD CDBG-DR funded portion includes closings on 151 properties and 76 demolitions. Under the program, structures are demolished, and the land is converted into open space to serve as natural flood buffers.

The Blue Acres Program and its acquisition practices have earned national recognition as a flood-mitigation best practice, including awards from the Federal Emergency Management Agency (FEMA) and HUD.

Table 5.6-16 Comparison of Repetitive Loss Statistics from 2013 to 2018

County	Number of Repetitive Loss Properties			Number of Severe Repetitive Loss Properties		
	2013	2018	Change	2013	2018	Change
Atlantic	1,022	1072	50	89	52	(37)
Bergen	1,871	1896	25	178	130	(48)

County	Number of Repetitive Loss Properties			Number of Severe Repetitive Loss Properties		
	2013	2018	Change	2013	2018	Change
Burlington	166	188	22	9	12	3
Camden	88	104	16	3	3	-
Cape May	2,302	2802	500	249	170	(79)
Cumberland	101	103	2	2	2	-
Essex	499	503	4	73	60	(13)
Gloucester	58	61	3	1	0	(1)
Hudson	415	433	18	23	20	(3)
Hunterdon	229	228	(1)	33	28	(5)
Mercer	295	298	3	15	10	(5)
Middlesex	635	644	9	83	44	(39)
Monmouth	1,604	1645	41	122	79	(43)
Morris	1,064	1067	3	275	193	(82)
Ocean	1,817	1899	82	91	49	(42)
Passaic	1,759	1758	(1)	610	267	(343)
Salem	47	50	3	5	5	-
Somerset	1,031	1034	3	153	61	(92)
Sussex	16	16	-	-	0	-
Union	728	739	11	50	32	(18)
Warren	270	269	(1)	33	21	(12)
Total	16,017	16809	792	2,097	1238	(859)

Sources: NJ State Hazard Mitigation Plan 2014; FEMA, 2018; NJOEM, 2018

A comparison analysis was also conducted to understand the changes in repetitive loss and severe repetitive loss properties across the state pre- and post-Tropical Storm Irene and pre- and post-Superstorm Sandy. Table 5.6-15 summarizes these findings by county and Figure 5.6-15 through Figure 5.6-20 illustrates these findings.

The comparison between pre- and post-Tropical Storm Irene statistics indicates that Passaic County had the highest increase in the number of SRL properties (211), followed closely by Morris (141), Bergen (104), and Somerset (90) Counties. Essex County is the only county with a decrease in the number of SRL properties from April 2011 to August 2012. All counties experienced an increase in the number of policies. As shown in Table 5.6-17, Monmouth, Cape May, Bergen, Morris, and Hudson Counties experienced the greatest increase.

The comparison between pre-and post-Superstorm Sandy statistics indicates that Monmouth County had the highest increase in the number of SRL properties (85), followed by Cape May (57), Ocean (38), Atlantic (37), and Bergen (32) Counties. Ocean, Monmouth, Hudson, and Atlantic Counties experienced an increase in greater than 1,000 policies per county, with Ocean and Monmouth County exceeding 2,000 policies. Meanwhile Cumberland, Somerset, and Warren Counties saw a decrease in the number of NFIP policies. Ocean, Atlantic, Monmouth, and Cape May Counties experienced the highest number of claims from pre- to post-Superstorm Sandy.

Table 5.6-17 Pre- and Post-Tropical Storm Irene and Superstorm Sandy NFIP Statistics

County	Status	Number of Policies	Change	Number of Claims	Change	Number of Repetitive Loss Properties	Change	Number of Severe Repetitive Loss Properties	Change
Atlantic 1	Pre-Tropical Storm Irene	30,895		8,835		884		47	
Atlantic 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	31,080	185	9,035	200	900	16	52	5
Atlantic 3	Post Superstorm Sandy	32,151	1,071	20,282	11,247	1,022	122	89	37
Atlantic 4	Permits entry of next set of information								
Bergen 1	Pre-Tropical Storm Irene	14,069		6,983		817		42	
Bergen 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	14,752	683	10,399	3,416	1,347	530	146	104
Bergen 3	Post Superstorm Sandy	15,558	806	12,605	2,206	1,871	524	178	32
Burlington 1	Pre-Tropical Storm Irene	3,925		1,221		103		2	
Burlington 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	4,126	201	1,592	371	156	53	8	6
Burlington 3	Post Superstorm Sandy	4,194	68	1,706	114	166	10	9	1
Camden 1	Pre-Tropical Storm Irene	2,310		789		67		2	
Camden 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	2,430	120	918	129	81	14	3	1
Camden 3	Post Superstorm Sandy	2,480	50	967	49	88	7	3	-
Cape May 1	Pre-Tropical Storm Irene	54,379		16,524		2,072		191	
Cape May 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	55,128	749	16,761	237	2,102	30	192	1
Cape May 3	Post Superstorm Sandy	55,571	443	26,762	10,001	2,302	200	249	57

County	Status	Number of Policies	Change	Number of Claims	Change	Number of Repetitive Loss Properties	Change	Number of Severe Repetitive Loss Properties	Change
Cumberland 1	Pre-Tropical Storm Irene	792		701		77		1	
Cumberland 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	839	47	761	60	84	7	2	1
Cumberland 3	Post Superstorm Sandy	834	(4)	971	210	101	17	2	-
Essex 1	Pre-Tropical Storm Irene	4,356		3,153		331		237	
Essex 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	4,617	261	4,508	1,355	474	143	77	(160)
Essex 3	Post Superstorm Sandy	4,865	248	4,620	112	499	25	73	(4)
Gloucester 1	Pre-Tropical Storm Irene	1,434		379		23		1	
Gloucester 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	1,513	79	519	140	48	25	1	-
Gloucester 3	Post Superstorm Sandy	1,518	5	552	33	58	10	1	-
Hudson 1	Pre-Tropical Storm Irene	16,999		1,265		102		5	
Hudson 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	17,538	539	1,861	596	162	60	10	5
Hudson 3	Post Superstorm Sandy	18,883	1,345	4,062	2,201	415	253	23	13
Hunterdon 1	Pre-Tropical Storm Irene	1,088		997		190		15	
Hunterdon 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	1,171	83	1,292	295	229	39	34	19
Hunterdon 3	Post Superstorm Sandy	1,199	28	1,301	9	229	-	33	(1)
Mercer 1	Pre-Tropical Storm Irene	2,333		1,764		259		4	
Mercer 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	2,437	104	2,170	406	294	35	16	12

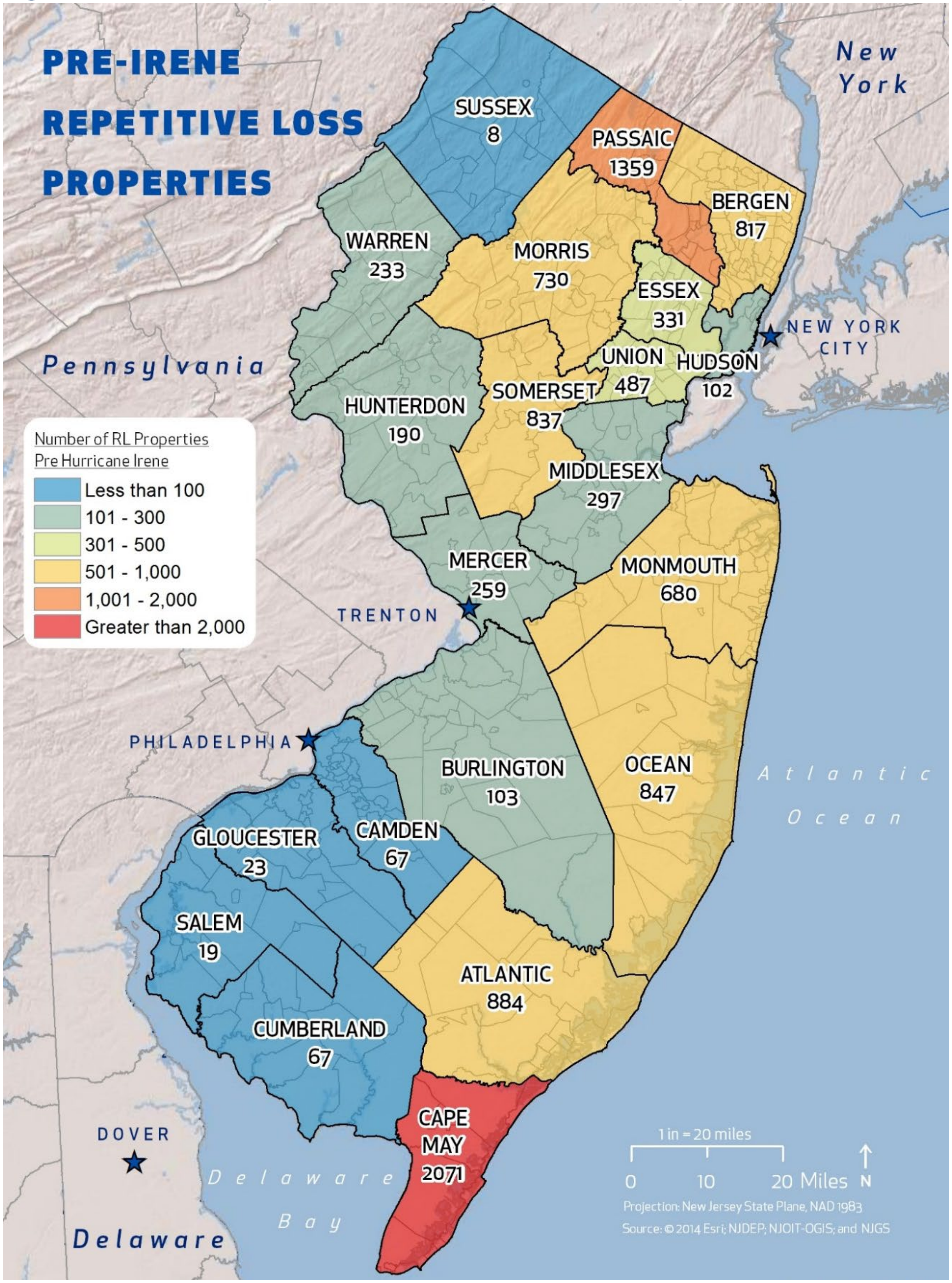
County	Status	Number of Policies	Change	Number of Claims	Change	Number of Repetitive Loss Properties	Change	Number of Severe Repetitive Loss Properties	Change
Mercer 3	Post Superstorm Sandy	2,476	39	2,197	27	295	1	15	(1)
Middlesex 1	Pre-Tropical Storm Irene	4,002		2,295		297		29	
Middlesex 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	4,420	418	3,393	1,098	482	185	64	35
Middlesex 3	Post Superstorm Sandy	4,853	433	4,140	747	635	153	83	19
Monmouth 1	Pre-Tropical Storm Irene	20,396		7,553		680		15	
Monmouth 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	21,226	830	9,329	1,776	820	140	37	22
Monmouth 3	Post Superstorm Sandy	23,232	2,006	19,378	10,049	1,604	784	122	85
Morris 1	Pre-Tropical Storm Irene	4,223		6,510		730		165	
Morris 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	4,762	539	8,862	2,352	1,062	332	306	141
Morris 3	Post Superstorm Sandy	4,833	71	8,910	48	1,064	2	275	(31)
Ocean 1	Pre-Tropical Storm Irene	52,107		13,317		847		42	
Ocean 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	52,510	403	14,496	1,179	904	57	53	11
Ocean 3	Post Superstorm Sandy	54,929	2,419	51,961	37,465	1,817	913	91	38
Passaic 1	Pre-Tropical Storm Irene	4,494		10,749		1,359		449	
Passaic 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	4,888	394	13,445	2,696	1,755	396	660	211
Passaic 3	Post Superstorm Sandy	5,013	125	13,486	41	1,759	4	610	(50)

County	Status	Number of Policies	Change	Number of Claims	Change	Number of Repetitive Loss Properties	Change	Number of Severe Repetitive Loss Properties	Change
Salem 1	Pre-Tropical Storm Irene	2,175		452		19		1	
Salem 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	2,242	67	552	100	25	6	3	2
Salem 3	Post Superstorm Sandy	2,248	6	697	145	47	22	5	2
Somerset 1	Pre-Tropical Storm Irene	3,134		3,861		837		62	
Somerset 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	3,315	181	5,231	1,370	1,026	189	52	90
Somerset 3	Post Superstorm Sandy	3,305	(10)	5,273	42	1,031	5	153	1
Sussex 1	Pre-Tropical Storm Irene	326		119		8		-	
Sussex 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	419	93	179	60	16	8	-	-
Sussex 3	Post Superstorm Sandy	432	13	182	3	16	-	-	-
Union 1	Pre-Tropical Storm Irene	5,523		3,721		487		8	
Union 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	5,897	374	5,380	1,659	685	198	34	26
Union 3	Post Superstorm Sandy	6,112	215	5,554	174	728	43	50	16
Warren 1	Pre-Tropical Storm Irene	668		1,054		233		31	
Warren 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	758	90	1,218	164	270	37	47	16
Warren 3	Post Superstorm	741	(17)	1,224	6	270	-	33	(14)

County	Status	Number of Policies	Change	Number of Claims	Change	Number of Repetitive Loss Properties	Change	Number of Severe Repetitive Loss Properties	Change
	Sandy								
Total 1	Pre-Tropical Storm Irene	229,628		92,242		10,422		1,349	
Total 2	Post Tropical Storm Irene/Pre-Superstorm Sandy	236,068	6,440	111,901	19,659	12,922	2,500	1,897	548
Total 3	Post Superstorm Sandy	245,428	9,360	186,830	74,929	16,017	3,095	2,097	200

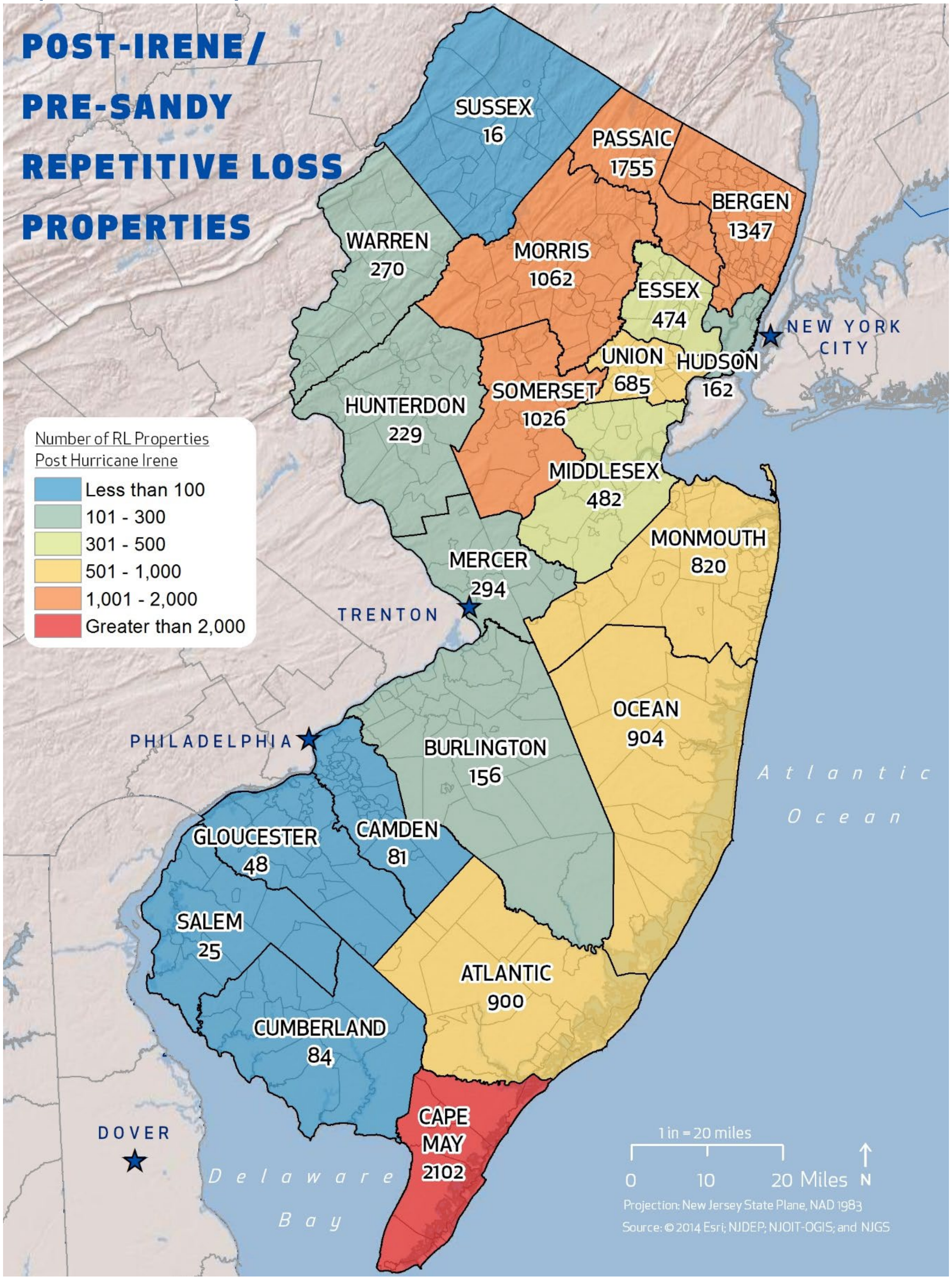
Source: NJDEP, 2013

Figure 5.6-15 NFIP Repetitive Loss Properties Pre-Tropical Storm Irene



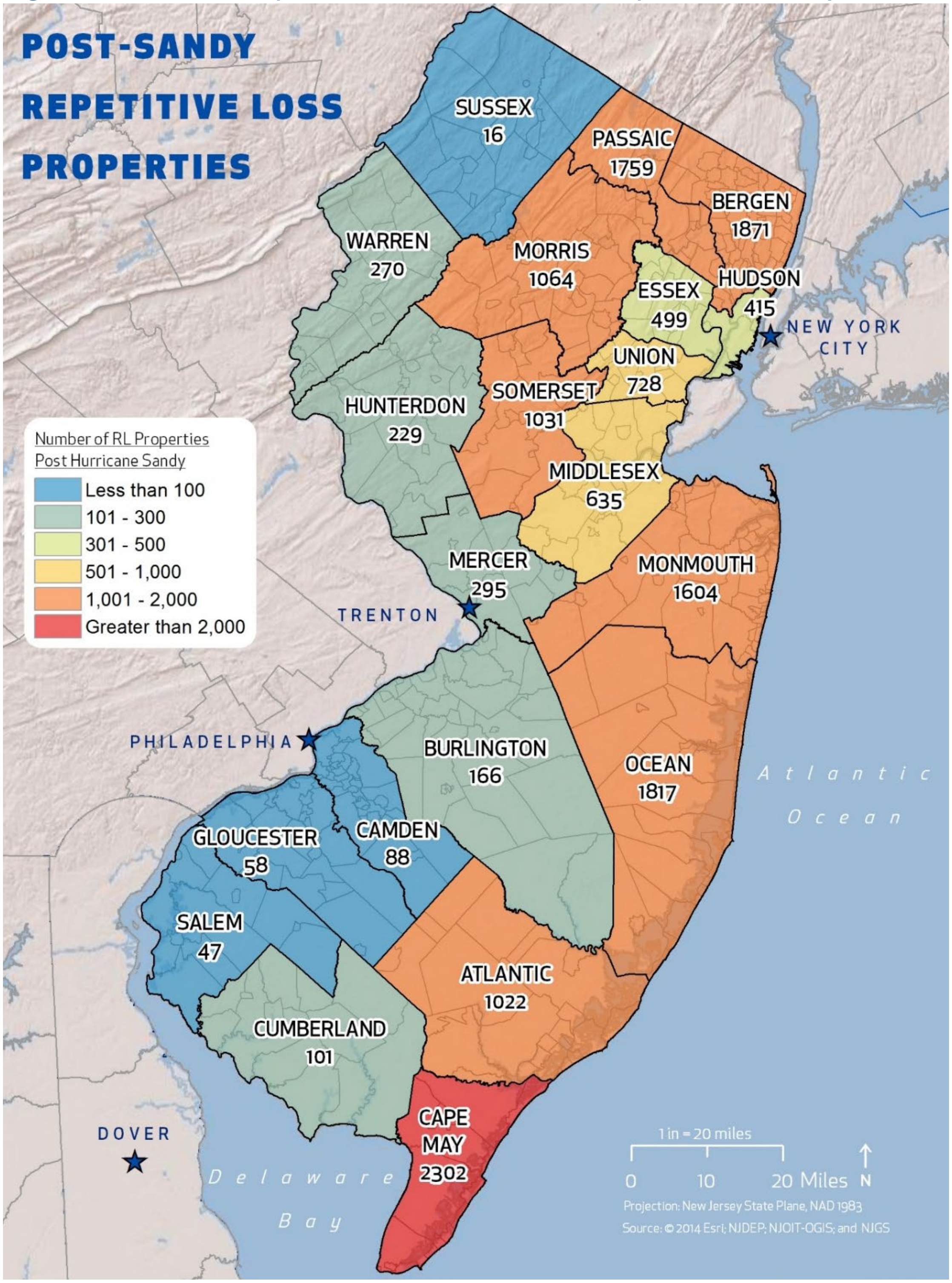
Source: NJ DEP 2013d; NJ State Hazard Mitigation Plan 2014

Figure 5.6-16 NFIP RL Properties Post-Tropical Storm Irene/Pre-SuperstormSandy



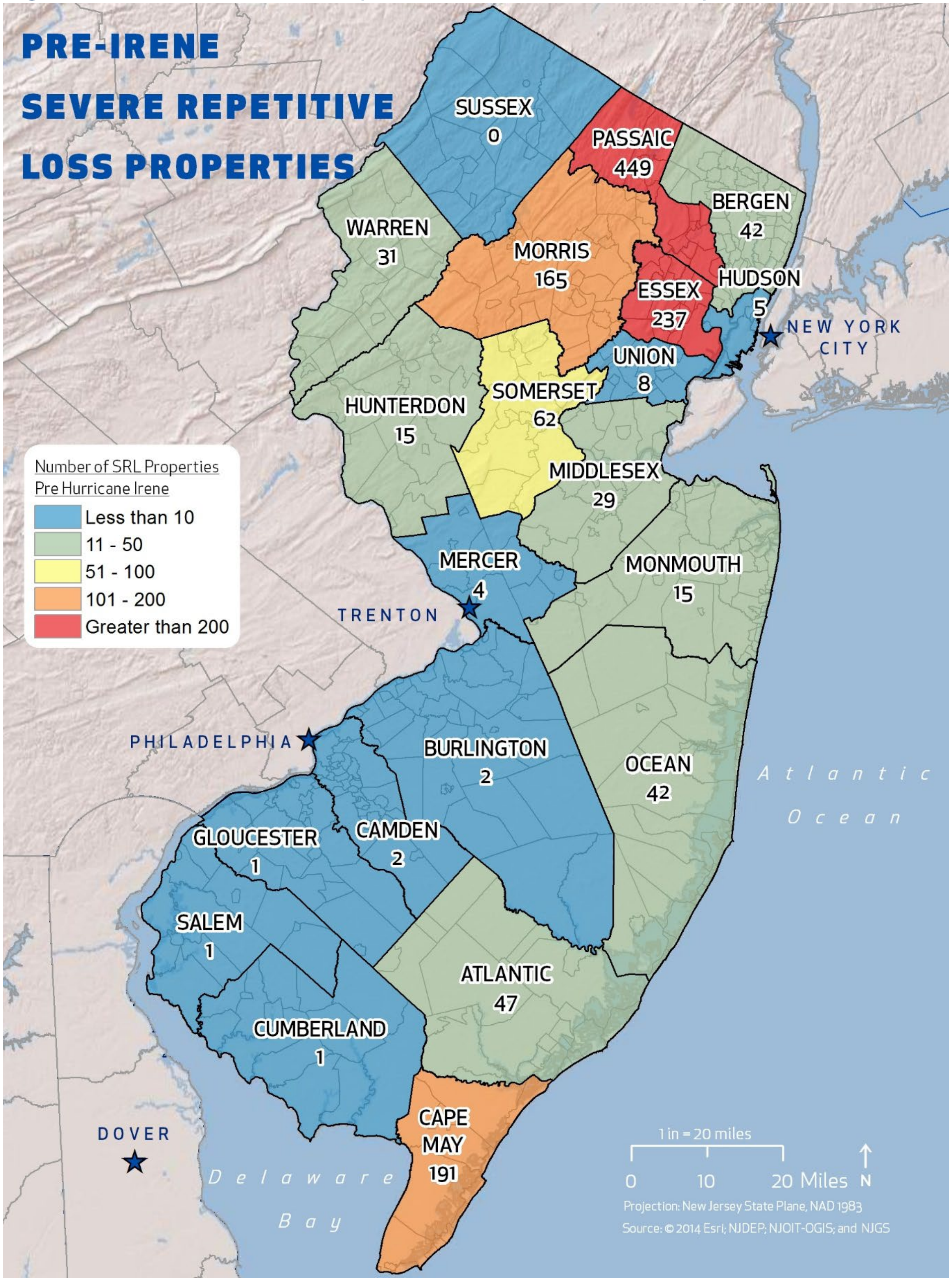
Source: NJDEP 2013d; NJ State Hazard Mitigation Plan 2014

Figure 5.6-17 NFIP Repetitive Loss Areas Post-Superstorm Sandy



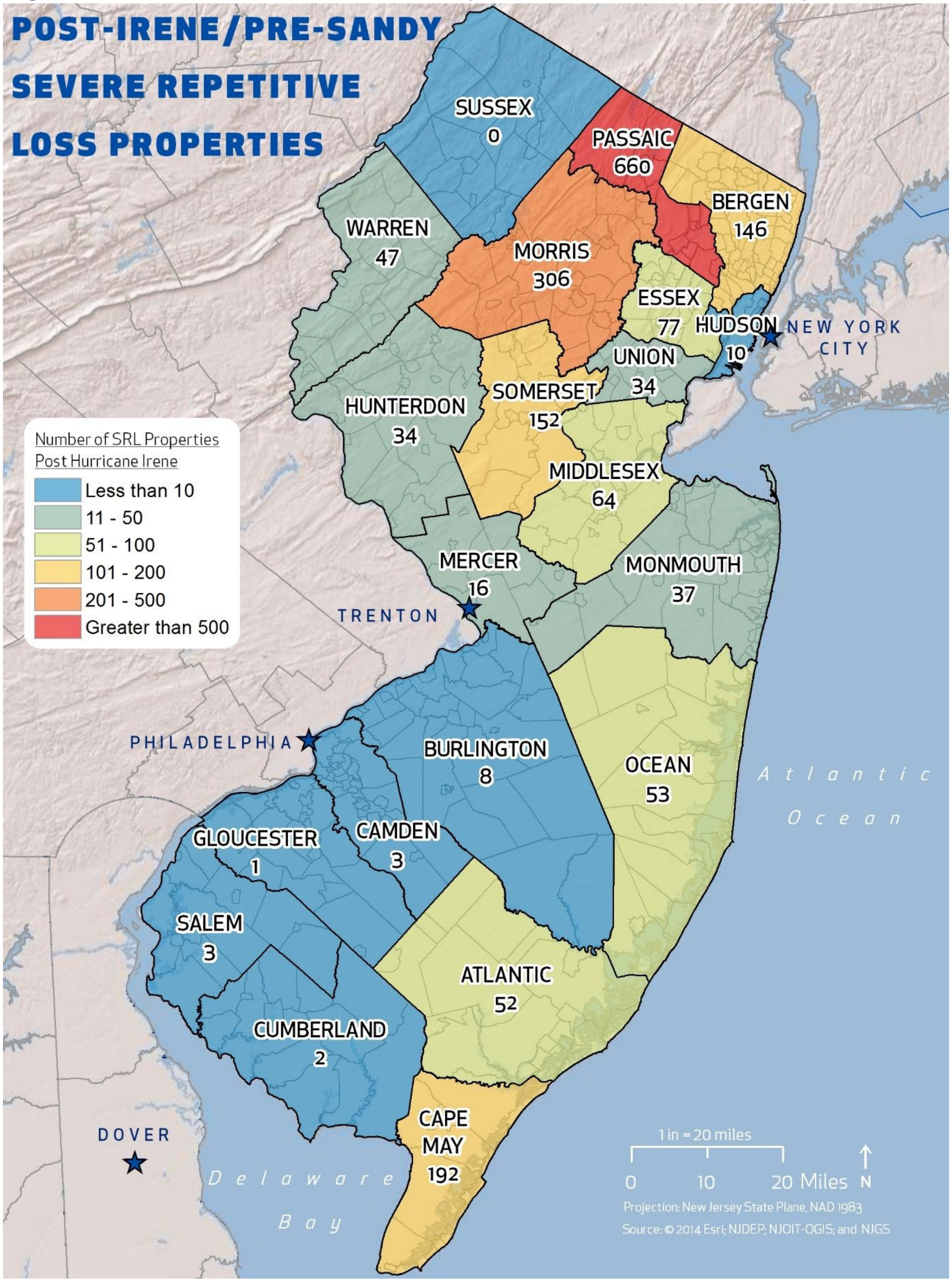
Source: NJDEP 2013d; NJ State Hazard Mitigation Plan 2014

Figure 5.6-18 NFIP Severe Repetitive Loss Areas Pre-Tropical Storm Irene



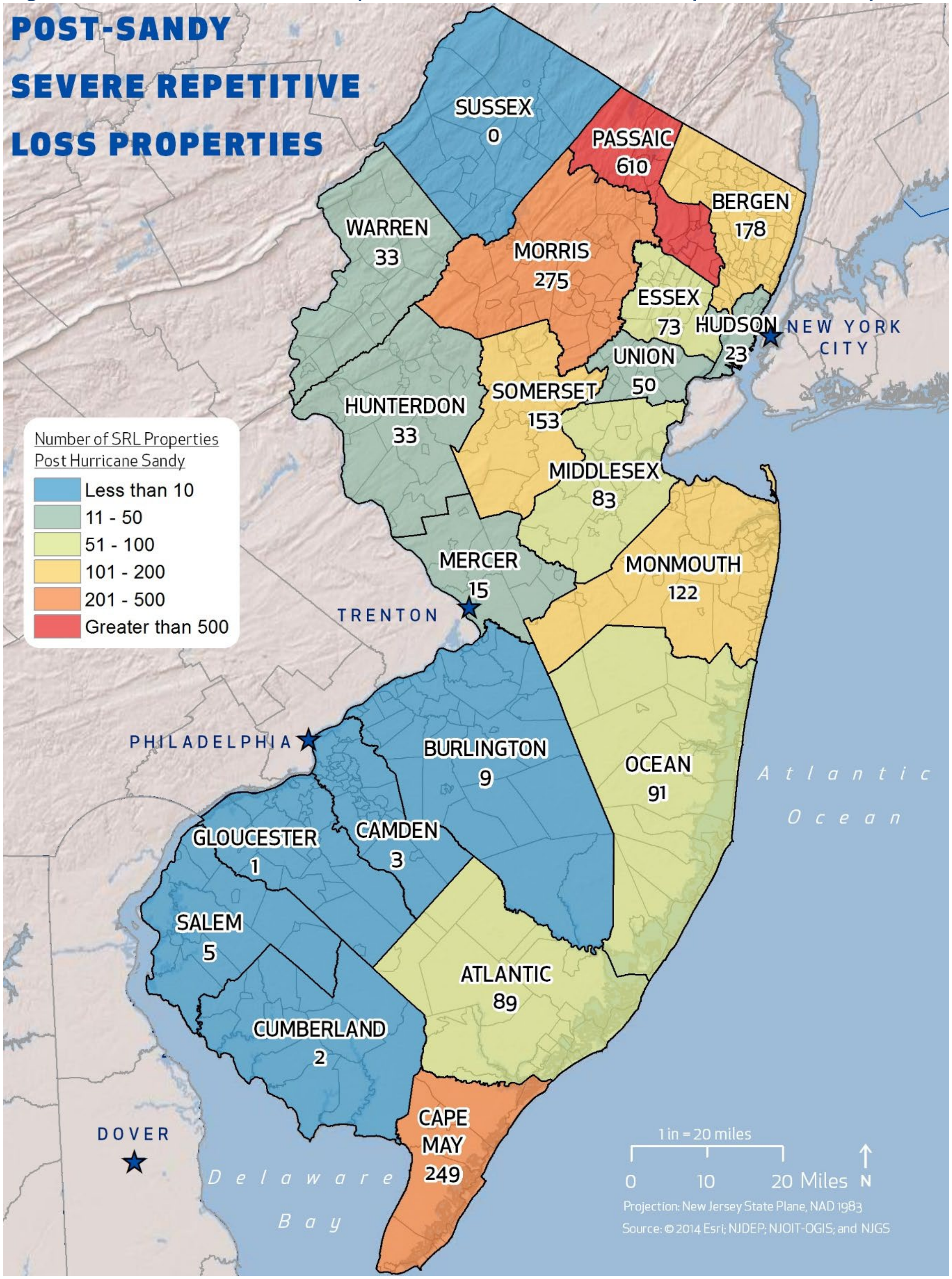
Source: NJDEP 2013d; NJ State Hazard Mitigation Plan 2014

Figure 5.6-19 NFIP SRL Areas Post-Tropical Storm Irene/Pre-Superstorm Sandy



Source: NJDEP 2013d; NJ State Hazard Mitigation Plan 2014

Figure 5.6-20 NFIP Severe Repetitive Loss Areas Post-Superstorm Sandy



Source: NJDEP 2013; NJ State Hazard Mitigation Plan 2014

As discussed in Section 5.1 subsection 'Changes in Development for Hazard-Prone Areas' changes in growth and development may impact vulnerability and potential losses. As New Jersey continues to develop, the State may remain vulnerable to the impacts of flood hazards, but with mitigating factors. Much of the undeveloped property within these flood prone hazard areas will likely remain undeveloped, and the State's priority to decrease the number of RL and SRL properties with post-disaster funding as described in Section 6 (Mitigation Strategy) will contribute to decreasing vulnerable structures in the future.

The release of FEMA's advisory Flood Hazard Areas and preliminary work maps in addition to the changes to New Jersey's Flood Hazard Area Control Act have helped mitigate the impacts of these events. The revisions to the Act set new minimum elevation standards for the reconstruction of houses and buildings in areas that are vulnerable to flooding. Through continued public outreach and education, people are becoming increasingly aware that measures, such as elevating their homes or using innovative stormwater management techniques like the installation of rain gardens, will help mitigate the impacts of flood hazards.

Construction and reconstruction within flood hazard areas will be influenced as a result of BW-12. Also, HFIAA rolled back primary residences, but second homes, non-residential, and SRL properties continue at 25 percent increases. Property owners are being strongly encouraged by NJDEP to consider long-term insurance costs when undertaking reconstruction or elevation of damaged buildings. A relatively small investment to raise the lowest floor of a building an additional foot or two may translate into significant future flood insurance savings. This will positively contribute to decreasing the vulnerability of structures in the flood hazard areas.

5.6.6.3 ESTIMATING POTENTIAL LOSSES BY JURISDICTION

Economic losses to New Jersey from flooding include but are not limited to: general building stock damage, agricultural losses, business interruption, impacts to tourism. These losses will negatively affect the tax base. Damage to general building stock can be quantified using HAZUS-MH 4.2 as discussed above. Other economic components such as loss of facility use, functional downtime, and social economic factors are less quantifiable. For the purposes of this analysis, the general building stock damage is discussed further.

To estimate the potential losses by county, the HAZUS-MH flood model was used to estimate the potential losses to the default general building stock provided by the model. This analysis has been refined since the 2011 Plan due to the updated and improved flood hazard areas and depth grids across the State. Table 5.6-18 summarizes the estimated potential losses to the default general building stock by county. As statewide building data (replacement cost value and building attributes required for modeling the flood hazard in HAZUS-MH) becomes available, the default inventory in HAZUS-MH will be updated to provide more accurate potential losses. As shown in table 5.6-18 he potential damage estimated to the general building stock inventory associated with the 1% annual chance flood is approximately $710, million which represents approximately 1% of the State's overall total general building stock inventory.

Table 5.6-18 Estimated General Building Stock Losses from the 1% Annual Chance Flood Event, by County

County	Total Building RCV	SFHA	
		Estimated Loss	% of Total
Atlantic	$ 437,234,696	$ 64,195,057	15%
Bergen	$ 167,418,063	$ 11,271,695	7%
Burlington	$ 638,782,952	$ 28,896,006	5%
Camden	$ 498,714,249	$ 45,085,830	9%
Cape May	$ 114,971,807	$ 6,356,721	6%
Cumberland	$ 643,881,700	$ 2,097,417	0%

County	Total Building RCV		SFHA		
			Estimated Loss		% of Total
Essex	$	822,674,560	$	158,792,032	19%
Gloucester	$	105,866,503	$	-	0%
Hudson	$	280,805,250	$	191,793,113	68%
Hunterdon	$	260,655,560	$	11,763,730	5%
Mercer	$	2,952,671,103	$	33,713,047	1%
Middlesex	$	632,983,190	$	8,734,683	1%
Monmouth	$	463,386,037	$	26,152,601	6%
Morris	$	385,747,921	$	8,891	0%
Ocean	$	310,626,835	$	28,955,258	9%
Passaic	$	299,429,912	$	79,222,602	26%
Salem	$	134,460,134	$	2,485,458	2%
Somerset	$	226,685,451	$	6,466,337	3%
Sussex	$	98,346,368	$	1,535,010	2%
Union	$	164,566,538	$	665,768	0%
Warren	$	79,870,209	$	2,272,059	3%
State Total	$	9,719,779,039	$	710,463,317	7%

Source: NJOMB 2018

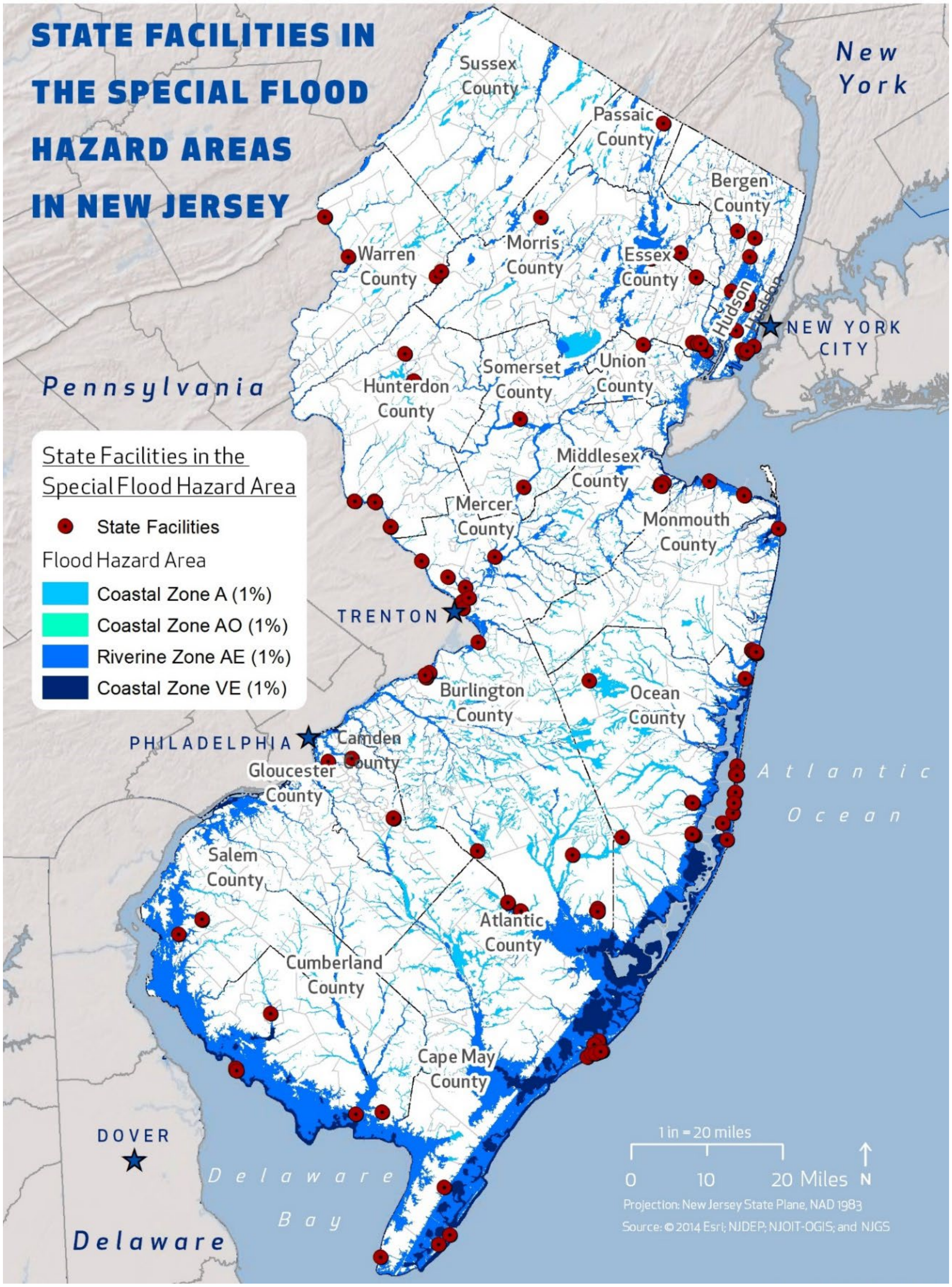
5.6.6.4 ASSESSING VULNERABILITY TO STATE FACILITIES

To assess the vulnerability of the state-owned and -leased facilities provided by New Jersey's Office of Management and Budget (NJ OMB), an analysis was conducted using the 1% annual chance flood hazard areas. Using geographic information system (GIS) software, these hazard areas were overlaid with the state facility data to determine the number of state facilities vulnerable. Figure 5.6-21 illustrates the state facilities located within the SFHA in New Jersey.

Overall, there are 603 state-owned or -leased buildings that are exposed to the 1% flood hazard (A and V-zones). The greatest number of State buildings in the 1% annual chance flood zone are located in Essex and Ocean counties. There are 46 state-owned buildings located in the V-zone, but no state-leased buildings located in the V-zone. The NJDEP has the greatest number of buildings vulnerable to the flood hazard. The NJDEP operates numerous flood control and water assets which accounts for the large number of structures in the flood zone. Refer to Table 5.6-17 to 5.6-19 and Table 5.6-20 to 5.6-22 below which summarize these findings by county and state agency, respectively.

There are 1,707 critical facilities and infrastructure located in the 1% flood hazard area (A and V-zones). Of these, 957 are dams. Excluding dams from the analysis, which by default are located in flood hazard areas, Hudson County has the greatest number of vulnerable critical facilities and infrastructure. Of all the facility types, schools have the greatest number of structures exposed (total of 154), followed by emergency medical services (EMS) (125) and fire (122). Table 5.6-23 summarizes the number of critical facilities and infrastructure located in the hazard area by facility type.

Figure 5.6-21 State Facilities in the FEMA Special Flood Hazard Areas in New Jersey



Source: NJ OMB 2018

Table 5.6-19 State Building Exposure to the 1% Annual Chance Flood Hazard A-Zone, by County

County	A-Zone				Total	
	Owned		Leased		Total	
	Count	Total Value	Count	Total Value	Count	Total Value
Atlantic	4	$ 14,794,288	9	$ 41,617,151	13	$ 56,411,440
Bergen	6	$ 9,531,214	1	$ 1,740,482	7	$ 11,271,695
Burlington	139	$ 27,080,528	2	$ 1,815,478	141	$ 28,896,006
Camden	11	$ 29,813,396	3	$ 15,272,435	14	$ 45,085,830
Cape May	20	$ 4,414,676	1	$ 1,942,046	21	$ 6,356,721
Cumberland	21	$ 72,981	-	$ -	21	$ 72,981
Essex	39	$ 149,110,770	4	$ 9,681,262	43	$ 158,792,032
Gloucester	-	$ -	-	$ -	-	$ -
Hudson	30	$ 74,744,729	2	$83,448,879	32	$ 158,193,608
Hunterdon	32	$ 5,982,039	2	$ 5,781,691	34	$ 11,763,730
Mercer	8	$ 4,787,268	7	$ 28,925,778	15	$ 33,713,047
Middlesex	6	$ 1,646,180	1	$ 6,938,029	7	$ 8,584,209
Monmouth	29	$ 5,004,934	1	$ 420,911	30	$ 5,425,846
Morris	1	$ 8,891	-	$ -	1	$ 8,891
Ocean	68	$ 25,584,801	1	$ 411,951	69	$ 25,996,752
Passaic	6	$ 2,843,052	3	$ 76,379,550	9	$ 79,222,602
Salem	15	$ 2,485,458	-	$ -	15	$ 2,485,458
Somerset	33	$ 6,466,337	-	$ -	33	$ 6,466,337
Sussex	24	$ 1,535,010	-	$ -	24	$ 1,535,010
Union	-	$ -	1	$ 665,768	1	$ 665,768
Warren	27	$ 2,272,059	-	$ -	27	$ 2,272,059
Total	519	$ 368,178,611	38	$ 275,041,412	557	$643,220,023

Source: NJ OMB 2018

Table 5.6-20 State Building Exposure to the 1% Annual Chance Flood Hazard V – Zone, by County

County	V-Zone					
	Owned		Leased		Total	
	Count	Total Value	Count	Total Value	Count	Total Value
Atlantic	18	$ 3,891,809	-	$ -	18	$ 3,891,809
Bergen	-	$ -	-	$ -	-	$ -
Burlington	-	$ -	-	$ -	-	$ -
Camden	-	$ -	-	$ -	-	$ -
Cape May	-	$ -	-	$ -	-	$ -
Cumberland	1	$ 1,012,218	-	$ -	1	$ 1,012,218
Essex	-	$ -	-	$ -	-	$ -
Gloucester	-	$ -	-	$ -	-	$ -
Hudson	1	$ 16,799,752	-	$ -	1	$ 16,799,752

County	V-Zone				Total	
	Owned		Leased		Total	
	Count	Total Value	Count	Total Value	Count	Total Value
Hunterdon	-	$ -	-	$ -	-	$ -
Mercer	-	$ -	-	$ -	-	$ -
Middlesex	1	$ 75,237	-	$ -	1	$ 75,237
Monmouth	10	$ 10,363,378	-	$ -	10	$10,363,378
Morris	-	$ -	-	$ -	-	$ -
Ocean	15	$ 1,479,253	-	$ -	15	$ 1,479,253
Passaic	-	$ -	-	$ -	-	$ -
Salem	-	$ -	-	$ -	-	$ -
Somerset	-	$ -	-	$ -	-	$ -
Sussex	-	$ -	-	$ -	-	$ -
Union	-	$ -	-	$ -	-	$ -
Warren	-	$ -	-	$ -	-	$ -
Total	46	$ 33,621,647	-	$ -	46	$33,621,647

Source: NJ OMB 2018

Table 5.6-21 State Building Exposure to the 1% Annual Chance Flood Hazard Total SFHA, by County

County	SFHA				Total	
	Owned		Leased		Total	
	Count	Total Value	Count	Total Value	Count	Total Value
Atlantic	22	$ 18,686,097	9	$ 41,617,151	31	$ 60,303,248
Bergen	6	$ 9,531,214	1	$ 1,740,482	7	$ 11,271,695
Burlington	139	$ 27,080,528	2	$ 1,815,478	141	$ 28,896,006
Camden	11	$ 29,813,396	3	$ 15,272,435	14	$ 45,085,830
Cape May	20	$ 4,414,676	1	$ 1,942,046	21	$ 6,356,721
Cumberland	22	$ 1,085,199	-	-	22	$ 1,085,199
Essex	39	$ 149,110,770	4	$ 9,681,262	43	$ 158,792,032
Gloucester	-	$ -	-	$ -	-	$ -
Hudson	31	$ 91,544,481	2	$83,448,879	33	$174,993,360
Hunterdon	32	$ 5,982,039	2	$ 5,781,691	34	$ 11,763,730
Mercer	8	$ 4,787,268	7	$ 28,925,778	15	$ 33,713,047
Middlesex	7	$ 1,721,417	1	$ 6,938,029	8	$ 8,659,446
Monmouth	39	$ 15,368,312	1	$ 420,911	40	$ 15,789,223
Morris	1	$ 8,891	-		1	$ 8,891
Ocean	83	$ 27,064,054	1	$ 411,951	84	$ 27,476,005
Passaic	6	$ 2,843,052	3	$ 76,379,550	9	$ 79,222,602
Salem	15	$ 2,485,458	-		15	$ 2,485,458
Somerset	33	$ 6,466,337	-		33	$ 6,466,337

County	SFHA					
	Owned		Leased		Total	
	Count	Total Value	Count	Total Value	Count	Total Value
Sussex	24	$ 1,535,010	-		24	$ 1,535,010
Union	-	$ -	1	$ 665,768	1	$ 665,768
Warren	27	$ 2,272,059	-		27	$ 2,272,059
Total	565	$401,800,258	38	$ 275,041,412	603	$676,841,670

Source: NJ OMB 2018

Table 5.6-22 State Building Exposure to the 1% Annual Chance Flood Hazard A-Zone by Agency

Agency	A-Zone				Total	
	Owned		Leased		Total	
	Count	Total Value	Count	Total Value	Count	Total Value
Agriculture	-	$ -	-	$ -	-	$ -
Banking and Insurance	-	$ -	-	$ -	-	$ -
Chief Executive	-	$ -	-	$ -	-	$ -
Children and Families	1	$ 1,965,613	4	$ 91,445,180	5	$ 93,410,793
Community Affairs	-	$ -	-	$ -	-	$ -
Corrections	38	$ 122,448,512	1	$ 1,417,239	39	$ 123,865,751
Education	-	$ -	1	$ 19,272,303	1	$ 19,272,303
Environmental Protection	370	$ 125,744,787	6	$ 7,796,035	376	$ 133,540,821
Health	1	$ 8,035,711	-	$ -	1	$ 8,035,711
Human Services	4	$ 177,203	1	$ 2,079,212	5	$ 2,256,416
Judiciary	3	$ 18,595,498	3	$ 4,925,450	6	$ 23,520,948
Juvenile Justice Commission	2	$ 26,974,340	-	$ -	2	$ 26,974,340
Labor and Work Force Development	-	$ -	4	$ 9,377,217	4	$ 9,377,217
Law and Public Safety	6	$ 411,930	3	$ 14,602,696	9	$ 15,014,626
Legislature	-	$ -	1	$ 2,809,814	1	$ 2,809,814
Military and Veterans Affairs	46	$ 21,414,604	-	$ -	46	$ 21,414,604
Miscellaneous Commissions	-	$ -	1	$ 8,415,544	1	$ 8,415,544
Motor Vehicles Commission	11	$ 10,127,495	2	$ 5,677,116	13	$ 15,804,611
Personnel	-	$ -	-	$ -	-	$ -
State	-	$ -	-	$ -	-	$ -
State Police	7	$ 3,571,372	7	$ 9,919,754	14	$ 13,491,126
Transportation	27	$ 4,606,776	-	$ -	27	$ 4,606,776
Treasury	3	$ 24,104,770	4	$ 97,303,854		$ 121,408,624
Total	519	$ 368,178,611	38	$ 275,041,412	557	$643,220,023

Source: NJ OMB 2018

Table 5.6-23 State Building Exposure to the 1% Annual Chance Flood Hazard V-Zone by Agency

Agency	V-Zone					
	Owned		Leased		Total	
	Count	Total Value	Count	Total Value	Count	Total Value
Agriculture	-	$ -	-	-	-	$ -
Banking and Insurance	-	$ -	-	-	-	$ -
Chief Executive	-	$ -	-	-	-	$ -
Children and Families	-	$ -	-	-	-	$ -
Community Affairs	-	$ -	-	-	-	$ -
Corrections	-	$ -	-	-	-	$ -
Education	-	$ -	-	-	-	$ -
Environmental Protection	44	$ 32,554,151	-	-	44	$ 32,554,151
Health	-	$ -	-	-	-	$ -
Human Services	-	$ -	-	-	-	$ -
Judiciary	-	$ -	-	-	-	$ -
Juvenile Justice Commission	-	$ -	-	-	-	$ -
Labor and Work Force Development	-	$ -	-	-	-	$ -
Law and Public Safety	1	$ 55,278	-	-	1	$ 55,278
Legislature	-	$ -	-	-	-	$ -
Military and Veterans Affairs	-	$ -	-	-	-	$ -
Miscellaneous Commissions	-	$ -	-	-	-	$ -
Motor Vehicles Commission	-	$ -	-	-	-	$ -
Personnel	-	$ -	-	-	-	$ -
State	-	$ -	-	-	-	$ -
State Police	1	$ 1,012,218	-	-	1	$ 1,012,218
Transportation	-	$ -	-	-	-	$ -
Treasury	-	$ -	-	-	-	$ -
Total	46	$33,621,647	-	-	46	$33,621,647

Source: NJ OMB 2018

Table 5.6-24 State Building Exposure to the 1% Annual Chance Flood Hazard Total SFHA by Agency

Agency	SFHA					
	Owned		Leased		Total	
	Count	Total Value	Count	Total Value	Count	Total Value
Agriculture	-	$ -	-	$ -	-	$ -
Banking and Insurance	-	$ -	-	$ -	-	$ -
Chief Executive	-	$ -	-	$ -	-	$ -
Children and Families	1	$ 1,965,613	4	$ 91,445,180	5	$ 93,410,793
Community Affairs	-	$ -	-	$ -	-	$ -
Corrections	38	$ 122,448,512	1	$ 1,417,239	39	$ 123,865,751
Education	-	$ -	1	$ 19,272,303	1	$ 19,272,303
Environmental Protection	414	$ 158,298,938	6	$ 7,796,035	420	$ 166,094,972
Health	1	$ 8,035,711	-	$ -	1	$ 8,035,711
Human Services	4	$ 177,203	1	$ 2,079,212	5	$ 2,256,416
Judiciary	3	$ 18,595,498	3	$ 4,925,450	6	$ 23,520,948
Juvenile Justice Commission	2	$ 26,974,340	-	$ -	2	$ 26,974,340
Labor and Work Force Development	-	$ -	4	$ 9,377,217	4	$ 9,377,217
Law and Public Safety	7	$ 467,208	3	$ 14,602,696	10	$ 15,069,903
Legislature	-	$ -	1	$ 2,809,814	1	$ 2,809,814
Military and Veterans Affairs	46	$ 21,414,604	-	$ -	46	$ 21,414,604
Miscellaneous Commissions	-	$ -	1	$ 8,415,544	1	$ 8,415,544
Motor Vehicles Commission	11	$ 10,127,495	2	$ 5,677,116	13	$ 15,804,611
Personnel	-	$ -	-	$ -	-	$ -
State	-	$ -	-	$ -	-	$ -
State Police	8	$ 4,583,590	7	$ 9,919,754	15	$ 14,503,344
Transportation	27	$ 4,606,776	-	$ -	27	$ 4,606,776
Treasury	3	$ 24,104,770	4	$ 97,303,854	7	$ 121,408,624
Total	565	$ 401,800,258	38	$ 275,041,412	603	$ 676,841,670

Source: NJ OMB 2018

As the State of New Jersey continues to be developed, the state facilities will need to be located to conveniently serve the population base. As the New Jersey population continues to grow, so will the need for state services and facilities. Refer to the discussion earlier in this section regarding existing legislation and mitigation measures at the federal and state-level to reduce the impacts to future flood event

Table 5.6-25 State Critical Facilities in the 1% Annual Chance Flood Hazard Area (A- and V-Zones)

County	Total Number	Airport	Special Needs	Communication	Correctional Institutions	Dams	Electric Power	EMS	EOC	Ferry	Fire	Highway Bridges	Highway Tunnels	Light Rail Facilities	Medical	Military	Natural Gas	Oil	Police	Ports	Potable Water	Rail Facilities	Rail Tunnels	School	Shelters	Storage of Critical Records	Wastewater
Atlantic	109	-	1	-	-	45	1	12	-	-	14	9	-	-	1	-	-	-	6	-	1	-	-	19	8	-	1
Bergen	128	1	2	-	1	57	1	13	-	1	13	-	-	-	1	-	-	-	10	-	1	1	-	14	7	-	4
Burlington	168	-	-	-	-	134	-	1	-	-	4	3	-	2	-	-	-	-	2	-	-	-	-	7	10	-	9
Camden	62	-	-	-	1	44	-	1	-	-	1	3	-	2	-	-	-	-	1	1	1	-	-	2	4	-	1
Cape May	75	1	2	-	-	9	-	12	-	1	16	2	-	-	-	-	-	-	6	1	1	-	-	11	12	-	1
Cumberland	39	-	-	-	-	32	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	1
Essex	55	2	-	-	2	22	-	3	-	-	2	2	-	-	-	-	-	-	2	3	1	1	-	9	5	-	2
Gloucester	52	-	-	-	-	45	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	4	-	-	2
Hudson	112	-	2	1	1	42	2	6	-	8	11	3	1	12	5	-	1	-	2	3	1	6	1	30	12	-	4
Hunterdon	57	-	-	-	-	37	-	6	-	-	4	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-
Mercer	49	-	-	-	-	38	-	1	-	-	1	-	-	-	-	-	-	-	-	-	1	1	-	2	4	-	2
Middlesex	63	-	-	-	-	64	-	3	-	-	3	4	-	-	-	-	-	1	1	-	2	-	-	6	5	-	1
Monmouth	67	-	3	-	-	109	-	14	-	2	13	1	-	-	-	1	-	-	5	2	-	-	-	12	-	-	5
Morris	134	1	3	-	-	69	-	7	-	-	9	-	-	-	-	-	-	-	4	-	-	1	-	2	4	-	3
Ocean	135	-	1	-	-	90	-	22	-	-	17	4	-	-	-	-	-	-	12	-	-	1	-	9	1	-	-
Passaic	108	-	-	-	-	33	-	3	-	-	1	-	-	-	-	-	-	-	-	-	3	1	-	6	3	-	2
Salem	55	-	1	-	-	55	-	4	-	-	4	1	-	-	-	-	-	-	1	-	-	-	-	4	4	-	3
Somerset	86	-	1	-	-	61	-	7	-	-	3	-	-	-	-	-	-	-	2	-	1	3	-	5	8	-	1
Sussex	61	-	1	-	-	28	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Union	61	-	2	-	-	23	1	4	-	-	2	1	-	-	-	-	-	-	3	5	1	-	-	11	4	-	2
Warren	44	-	-	-	-	45	-	5	-	-	1	4	-	-	-	-	-	-	-	-	-	-	-	2	3	-	1
Total	1,707	5	19	1	5	1,037	4	125	-	12	122	38	1	16	7	1	1	1	56	11	14	15	1	154	97	-	44

5.6.6.5 ESTIMATING POTENTIAL LOSSES TO STATE FACILITIES

To estimate the potential loss to state facilities, the HAZUS-MH flood model updated with the statewide Land and Building Asset Management (LBAM) database provided by the NJ OMB were used. Direct building losses are the estimated costs to repair or replace the damage caused to the building. Table 5.6-20 and Table 5.6-21 below summarize the estimated potential loss to state buildings by county and agency, respectively.

The potential damage estimated to state-owned and -leased buildings associated with the 1% annual chance flood is approximately $94 million which represents approximately 1% of the total inventory. Hudson County has the greatest estimated potential loss from State buildings as a result of the flood event. The New Jersey Department of Environmental Protection has the greatest estimated potential loss as a result of the flood event when compared with the other State departments and agencies.

Table 5.6-26 State Building Potential Loss to the 1% Annual Chance Flood Hazard, by County

County	Total Building RCV	SFHA Estimated Losses			
		Owned RCV Losses	Leased RCV Losses	Total RCV Losses	% of Total RCV
Atlantic	$ 437,234,696	$ 7,433,282	$ 1,980,141	$ 9,413,423	2.15%
Bergen	$ 167,418,063	$ 2,023,295	$ 906,698	$ 2,929,993	1.75%
Burlington	$ 638,782,952	$ 10,491,088	$ -	$ 10,491,088	1.64%
Camden	$ 498,714,249	$ 706,261	$ -	$ 706,261	0.14%
Cape May	$ 114,971,807	$ 987,120	$ -	$ 987,120	0.86%
Cumberland	$ 643,881,700	$ 2,596,099	$ -	$ 2,596,099	0.40%
Essex	$ 822,674,560	$ 8,340,260	$ 21,782	$ 8,362,042	1.02%
Gloucester	$ 105,866,503	$ -	$ -	$ -	0.00%
Hudson	$ 280,805,250	$ 25,144,143	$ 277,683	$ 25,421,826	9.05%
Hunterdon	$ 260,655,560	$ 2,386,195	$ -	$ 2,386,195	0.92%
Mercer	$ 2,952,671,103	$ 267,819	$ 10,260	$ 278,079	0.01%
Middlesex	$ 632,983,190	$ 706,589	$ -	$ 706,589	0.11%
Monmouth	$ 463,386,037	$ 13,517,285	$ -	$ 13,517,285	2.92%
Morris	$ 385,747,921	$ 67,422	$ -	$ 67,422	0.02%
Ocean	$ 310,626,835	$ 6,828,662	$ 2,053,018	$ 8,881,679	2.86%
Passaic	$ 299,429,912	$ -	$ -	$ -	0.00%
Salem	$ 134,460,134	$ 749,806	$ -	$ 749,806	0.56%
Somerset	$ 226,685,451	$ 4,113,521	$ -	$ 4,113,521	1.81%
Sussex	$ 98,346,368	$ 889,084	$ -	$ 889,084	0.90%
Union	$ 164,566,538	$ -	$ -	$ -	0.00%
Warren	$ 79,870,209	$ 2,033,741	$ -	$ 2,033,741	2.55%
Total	$ 9,719,779,039	$ 89,281,671	$ 5,249,582	$ 94,531,253	0.97%

Source: HAZUS 4.2, NJOMB 2018

*Values include both building damage cost and content damage cost

Table 5.6-27 State Building Potential Loss to the 1% Annual Chance Flood Hazard by Agency

Agency	Total Building RCV	SFHA Estimated Losses			
		Owned RCV Losses	Leased RCV Losses	Total RCV Losses	% of Total RCV
Agriculture	$ 8,096,184	$ -	$ -	$ -	0.00%
Banking and Insurance	$ 58,349,889	$ -	$ -	$ -	0.00%
Chief Executive	$ 41,711,042	$ -	$ -	$ -	0.00%
Children and Families	$ 710,790,282	$ 233,223	$ 1,631,923	$ 1,865,145	0.26%
Community Affairs	$ 133,856,589	$ -	$ -	$ -	0.00%
Corrections	$ 1,159,804,016	$ 7,049,911	$ 229,073	$ 7,278,984	0.63%
Education	$ 177,472,231	$ -	$ 122,032	$ 122,032	0.07%
Environmental Protection	$ 756,535,586	$ 64,816,478	$ 1,007,710	$ 65,824,188	8.70%
Health	$ 187,466,620	$ 1,544,854	$ -	$ 1,544,854	0.82%
Human Services	$ 1,120,601,472	$ -	$ -	$ -	0.00%
Judiciary	$ 1,096,424,568	$ 2,754,839	$ 508,576	$ 3,263,415	0.30%
Juvenile Justice Commission	$ 246,910,955	$ 485,054	$ -	$ 485,054	0.20%
Labor and Work Force Development	$ 328,156,420	$ -	$ 1,142,725	$ 1,142,725	0.35%
Law and Public Safety	$ 284,215,262	$ 578,732	$ 2,312,429	$ 2,891,161	1.02%
Legislature	$ 120,556,954	$ -	$ 556,154	$ 556,154	0.46%
Military and Veterans Affairs	$ 737,946,664	$ 6,038,735	$ -	$ 6,038,735	0.82%
Miscellaneous Commissions	$ 18,027,989	$ -	$ 1,231,620	$ 1,231,620	6.83%
Motor Vehicles Commission	$ 563,493,240	$ 208,812	$ 29,815	$ 238,627	0.04%
Personnel	$ 9,656,017	$ -	$ -	$ -	0.00%
State	$ 152,151,016	$ -	$ -	$ -	0.00%
State Police	$ 432,772,085	$ 3,073,472	$ 1,173,324	$ 4,246,795	0.98%
Transportation	$ 320,748,453	$ 1,301,690	$ -	$ 1,301,690	0.41%
Treasury	$ 1,054,035,504	$ 1,195,872	$ 27,308,686	$ 28,504,558	2.70%
Total	$ 9,719,779,039	$ 89,281,671	$ 37,254,065	$ 126,535,736	1.30%

Source: HAZUS 4.2, NJOMB 2018
*Values include both building damage cost and content damage cost

The replacement cost values for critical facilities were not available for this planning effort. As these data become available, the State will update this section of the Plan. Refer to the discussion in 'Assessing Vulnerability to State Facilities' presented earlier which summarizes the critical facility exposure analysis results.

Roads are the primary resource for evacuation to higher ground before and during the course of a riverine, coastal flood or tsunami event. Bridges exposed to flood events can be extremely vulnerable due to the forces transmitted by the wave run-up and by the impact of debris carried by the wave action. The forces of coastal flood and tsunami waves can also impact above ground utilities by knocking down power lines and radio/cellular communication towers. Power generation facilities can be severely impacted by both the velocity impact of the wave action and the inundation of floodwaters.

Flooding can cause extensive damage to public utilities and disrupt the delivery of services. Loss of power and communications may occur; and drinking water and wastewater treatment facilities may be temporarily out of operation. Flooded streets and roadblocks make it difficult for emergency vehicles to respond to calls for service. Floodwaters can wash out sections of roadway and bridges (Foster 2010).