SECTION 5 RISK ASSESSMENT

This section provides a profile and vulnerability assessment for the flood hazard in order to quantify the description, location, extent, history, probability, and impact of flood events in the Township of Brick. For the purpose of this Floodplain Management Plan (FMP), riverine, coastal/tidal/sea level rise and urban/stormwater are the main flood types of concern for the Township of Brick. The Township is vulnerable to other natural and man-made hazards, which are addressed in the 2018 Ocean County Multi-Jurisdictional All-Hazard Mitigation Plan.

5.1 Hazard Description

A flood is the inundation of normally dry land resulting from the rising and overflowing of a body of water. 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 2007). 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.

In the State of New Jersey, some areas are more vulnerable to flooding than others. In fact, Ocean County, along with Cape May County, Atlantic County, Salem County, Hudson County, and Monmouth County, is recognized for having over 10 percent of its population residing in the 1-percent annual chance flood zone. Additionally, Ocean County (along with Monmouth, Cape May, and Atlantic Counties) has one of the greatest percentages of population located in the V-Zone (coastal areas susceptible to wave damage, as defined by FEMA). The jurisdictions most threatened by the flood hazard have also experienced the most increase in permits for new construction and in overall population growth. This results in a situation where millions of people work, live, travel through, or use recreational facilities located in areas subject to flooding. Areas outside recognized and mapped flood hazard zones can also experience flooding (NJOEM 2019).

While Ocean County identified flooding as its primary hazard of concern, this hazard event particularly impacts the Township of Brick and other coastal jurisdictions in the county. The Township of Brick has the most privately-owned waterfront property of any municipality in New Jersey. This includes 1.79 miles of ocean-front property on the barrier island, 39.5 miles of river-front property, and 11.93 miles of bay-front property, totaling 53.2 miles. Of the 45,000 structures in the Township of Brick, over 10,000 are located in the 1-percent annual chance flood zone (Brick Township Strategic Recovery Planning Report [SRPR] 2014). The Township of Brick is particularly vulnerable to flooding from tropical storms, extra-tropical cyclones (Nor'easters), and severe thunderstorm activity, while local coastal flooding typically ties back to hurricanes (FEMA Flood Insurance Study [FIS] 2014). The Township's vulnerability to flooding is best demonstrated by the impact of Superstorm Sandy in 2012. Discussed in further detail later in this section, Superstorm Sandy caused significant damage to infrastructure, private property, the economy, and the community.

Most floods fall into three categories: riverine, coastal, and shallow (FEMA 2007). Other types of floods may include ice-jam floods, alluvial fan floods, dam failure floods, and floods associated with local drainage or high groundwater (as indicated in the previous flood definition). For the purpose of this FMP and as deemed appropriate by the Township of Brick FMP Planning Committee (Planning Committee), riverine, coastal/tidal and urban/stormwater are the main flood types of concern for the Township. Additionally, the impacts of coastal erosion, storm surge, and sea level rise will also be discussed. These types of flood are further discussed below.

5.1.1 Special Flood Hazard Area

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. Defined in further detail in the Frequency subsection of this profile, the 100-year flood (also known as the 1 percent annual chance flood) has a 1 percent chance of being equaled or exceeded each year. This 1 percent annual chance flood is now the standard used by most federal and state agencies and by the National Flood Insurance Program (NFIP) and is referred to as the Special Flood Hazard Area or SFHA (FEMA 2005).

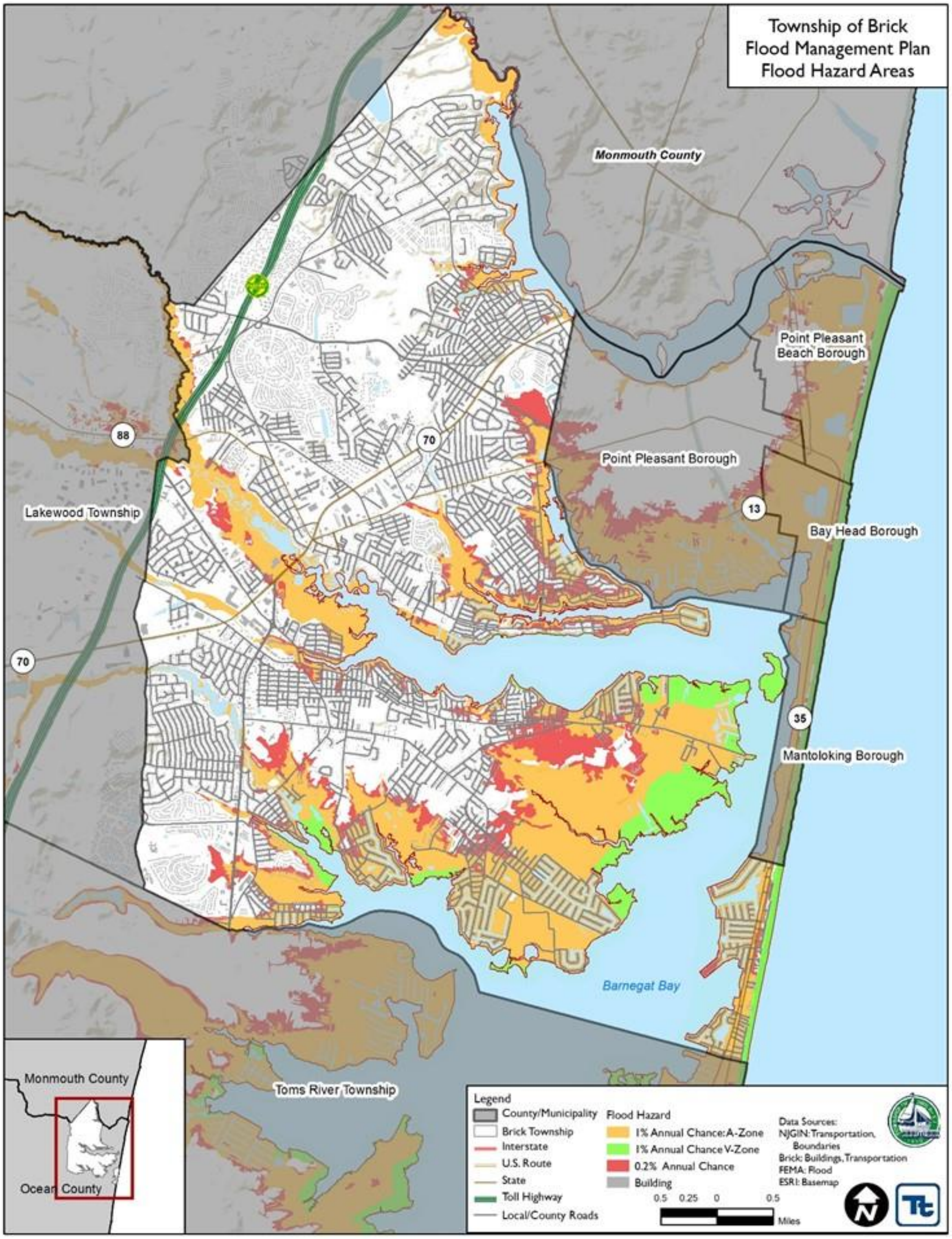
Special Flood Hazard Area Location

Although riverine, flash, and stormwater/urban flooding can occur anywhere in the Township of Brick, certain locations are more vulnerable or more likely to experience flooding than others in the Township. The Metedeconk River is the most frequent source of riverine flooding in the Township, based off previous occurrences and storm events. The Manasquan River, Barnegat Bay, Cedar Bridge Branch, and Beaverdam Creek are also sources of flooding, most typically due to the high percentage of impervious cover from land use, poor drainage facilities in the surrounding areas, and improper grading from development. Much of the Township has already been developed for residential, business, or other use, increasing the Township of Brick's vulnerability to flash flooding and urban flooding. While the Township has stormwater management systems in place in its residential neighborhoods, the capacity of the stormwater systems is not always sufficient. While more recently developed and renovated neighborhoods typically have systems with sufficient capacity, older neighborhoods frequently have stormwater management systems that have not been updated to handle current needs and populations, leading to insufficient drainage (Brick Township Stormwater Management Plan [Master Plan] 2007).

The following provides information regarding flood-prone areas in the Township. The main bodies of water (and sources of flooding) in the Township include the Manasquan River, Sawmill Creek, Beaverdam Creek, Metedeconk River, Cedar Bridge Branch, and Kettle Creek. Additionally, Barnegat Bay makes up the eastern border of the Township, and the Township is located in Watershed Management Area #13m Barnegat Bay. The Township is also located within four watersheds: Metedeconk River North Branch (NB), Manasquan River, Metedeconk River, and Kettle Creek/Barnegat Bay North. For details regarding the watershed management area and the watersheds, please refer to Section 4 (Township Profile).

Potential flood-level events are monitored and warnings are issued to residents when stream gages detect significant rises in water level from the action state of the waterway. Information on flooding levels for minor, moderate, and major events, as well as the action state, are presented under the 'Warning Time' subsection further in this profile.

Figure 5-1. FEMA Flood Hazard Areas in the Township of Brick



Special Flood Hazard Area Severity

Generally the severity of flooding can be measured by peak discharge rates. Table 5-1 lists peak flows used by FEMA to map the floodplains of the Township as noted in the preliminary FIS for the Township (FEMA 2014).

Table 5-1. Summary of Stillwater Elevations for Waterways Adjacent to the Township of Brick

Source/Location	Drainage Area (square miles)	Discharge (cubic feet/second)			
		10-Year	50-Year	100-Year	500-Year
North Branch Metedeconk River (at downstream corporate limits)	18.08	500	730	850	1,180

Source: FEMA FIS 2014

Peak discharge information for other identified water courses in the Township including the Manasquan River, Sawmill Creek, Beaverdam Creek, Cedar Bridge Branch, Kettle Creek and the Barnegat Bay are not available as of this writing.

Another way to consider the severity of flooding is to review the stillwater elevations for a water source. Stillwater elevations are the projected elevation of floodwaters in the absence of waves resulting from wind or seismic effects. In coastal areas, stillwater elevations are determined when modeling coastal storm surge; the results of overland wave modeling are used in conjunction with the stillwater elevations to develop base flood elevations. Table 5-2 shows the stillwater elevations identified in the effective FIS for the Township.

Table 5-2. Summary of Stillwater Elevations for Waterways within the Township of Brick

Source/Location	Elevation (feet NAVD)			
	10-Year	50-Year	100-Year	500-Year
Manasquan River	5.4	6.6	7.2	8.8
North Branch Metedeconk River	3.2	4.3	4.8	6.1
Kettle Creek	3.2	4.3	4.8	6.1
Barnegat Bay (entire shoreline within the Borough of Point Pleasant and the Township of Brick)	3.2	--	4.8	6.1

Source: FEMA FIS 2006
Note: The 2014 FIS did not contain stillwater elevations for the Township of Brick waterways; it only contained stillwater elevations for transects. This information is included in the appropriate table.
NAVD North American Vertical Datum of 1988

While riverine flooding severity can be measured by discharge rates, FEMA evaluates the potential impact of a flood event along the coastline through coastal hydraulic analysis, which consists of a combination of transect layout, field reconnaissance, erosion analysis, and overland wave modeling. Transects show the elevation of the ground both onshore and offshore, and they are the locations where the overland wave height modeling occurs. Transects are selected through consideration of local topography, land use, shoreline features, and shoreline orientation to capture the most useful data. The transects selected for the analysis recorded in the FIS are the sites of primary flooding in both the Township of Brick and Ocean County. In addition to considering wave heights, the coastal hydraulic analysis also evaluated stillwater elevations. Table 5-3 provides the transect data from the township's most recent FEMA FIS. Where applicable, the table includes riverine transect analysis data as well.

Table 5-3. Transect Data in the Township of Brick

Flood Source	Transect	Starting Wave Conditions for the 100-Year Flood			Starting Stillwater Elevation (feet NAVD) Range of Stillwater Elevations (feet NAVD)			
		Coordinates	Significant Wave Height	Peak Wave Period	10-Year	50-Year	100-Year	500-Year
Manasquan River	1	N 40.105073 W 74.096389	1.62	2.28	6.8	8.6	9.3	10.5
Manasquan River	2	N 40.094354 W 74.085057	1.67	2.33	6.8	8.5	9.1	10.3
Atlantic Ocean	14	N 40.029256 W 74.051492	18.92	13.98	7.1 4-7.1	9.2 6.4-9.2	10.1 7.4-10.1	12.2 9.6-12.2
Atlantic Ocean	15	N 40.021936 W 74.053220	19.15	13.98	7.1 3.9-7.1	9.2 6.3-9.2	10.0 7.3-10.0	12.2 9.5-12.2
Atlantic Ocean	16	N 40.015948 W 74.054657	19.44	14.00	7.2 4.0-7.2	9.3 6.3-9.3	10.1 7.3-10.2	12.2 9.5-12.3
Atlantic Ocean	17	N 40.008315 W 74.056716	19.28	14.07	7.3	9.3 6.2-9.3	10.1 7.2-10.1	12.2 9.5-12.2
Barnegat Bay	84	N 39.998920 W 74.081430	3.19	3.26	3.9 3.7-3.9	6.1 6.1-6.2	7.1 7.1-7.2	9.3 9.2-9.3
Barnegat Bay	87	N 40.057795 W 74.064079	2.60	2.74	3.8 3.6-3.9	6.3 6.1-6.4	7.4 7.2-7.5	10.1 10.1-10.2
Metedeconk River	88	N 40.055952 W 74.081676	2.26	2.62	3.9 3.7-3.9	6.3 6.0-6.3	7.4 7.0-7.5	10.2 10.1-10.4
Metedeconk River	89	N 40.055865 W 74.100744	2.10	2.53	3.8	6.3	7.4	10.3
Metedeconk River	90	N 40.056693 W 74.112268	1.68	2.23	3.7	6.1 6-6.1	7.3 7.0-7.3	10.2 10.1-10.2
Metedeconk River	91	N 40.062490 W 74.123279	1.58	2.19	3.8	6.3	7.4 7.1-7.4	10.4 10.2-10.4
Metedeconk River	92	N 40.053320 W 74.125179	1.44	2.21	3.7	6.0	7.1	10.2
Metedeconk River	93	N 40.049649 W 74.112644	1.75	2.27	3.8	6.3	7.4	10.3
Metedeconk River	94	N 40.049611 W 74.095754	2.08	2.53	3.5 3.4-3.5	6.3 6.2-6.3	7.4	10.2
Metedeconk River	95	N 40.048871 W 74.082997	2.20	2.56	3.6 3.6-3.8	6.3 5.8-6.3	7.4 7.0-7.4	10.2 9.8-10.2
Barnegat Bay	96	N 40.030559 W 74.076239	2.90	3.29	3.9 2.7-3.9	6.3 5.8-6.3	7.3 7.0-7.3	9.5 9.4-9.9
Barnegat Bay	97	N 40.017982 W 74.081212	3.29	3.45	3.9 3.2-3.9	6.2 5.8-6.2	7.2 6.9-7.2	9.4 9.1-9.4
Kettle Creek	98	N 40.016300 W 74.102401	3.05	3.32	3.9 3.6-3.9	6.2 5.7-6.2	7.1 6.8-7.2	9.4 9.1-9.4
Kettle Creek	99	N 40.024288 W 74.118366	2.21	2.55	3.9 1.0-3.9	6.3 5.5-6.3	7.2 6.8-7.2	9.4 9.1-9.4
Kettle Creek	100	N 40.021940 W 74.125405	2.19	2.46	3.9 3.5-3.9	6.2 6.1-6.2	7.2 7.0-7.2	9.4 9.1-9.5

Source: FEMA FIS 2014
N North W West NAVD North American Vertical Datum of 1988

The U.S. Geological Survey (USGS) provides other resources for tracking the severity and potential incidents for a coastal flooding event. The tide gage for Barnegat Bay at Mantoloking (the tide gage nearest Township of Brick), tracks tide elevations. This gage recorded a maximum elevation of 3.81 feet (from crest-stage) on

December 11, 1992, and a minimum elevation of an estimated -1.6 feet on October 30, 2006 (with the note that a lower tide likely occurred on February 16, 2007, but this record is missing). In addition, the tide gage records also note the monthly mean for gage height from May 1, 2000, to September 30, 2009:

- January: -0.01 feet
- February: -0.27 feet
- March: 0.02 feet
- April: 0.15 feet
- May: 0.24 feet
- June: 0.40 feet
- July: 0.40 feet
- August: 0.42 feet
- September: 0.50 feet
- October: 0.36 feet
- November: 0.14 feet
- December: -0.06 feet

Additionally, 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).

Special Flood Hazard Area Frequency

The 1 percent annual chance 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 a NFIP map has a 26 percent chance of suffering flood damage during the term of a 30-year mortgage.

The extent of flooding associated with a 1 percent annual chance flood (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 percent 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 percent annual chance flood has a 6 percent chance of occurring during a 30-year period of time, the length of many mortgages. The 500-year floodplain is referred to as the Shaded X Zone on flood insurance rate maps (FIRM). Base flood elevations or depths are not shown within this zone and insurance purchase is not required in this zone.

Special Flood Hazard Area Warning Time

Potential flood-level events are monitored, and warnings are issued to residents when flooding is forecast or tide gauges detect significant rises in waterways. Information on flooding levels for minor, moderate, and major events, are presented under the Warning Time subsection further in this profile.

Special Flood Hazard Area Secondary Hazards

Secondary hazards associated with the SFHA are largely determined by the source of flooding. Additional information on secondary hazards is detailed in the riverine, coastal flooding, coastal erosion, storm surge, and sea level rise hazard sections below.

5.1.2 Riverine (Inland) Flooding Hazard

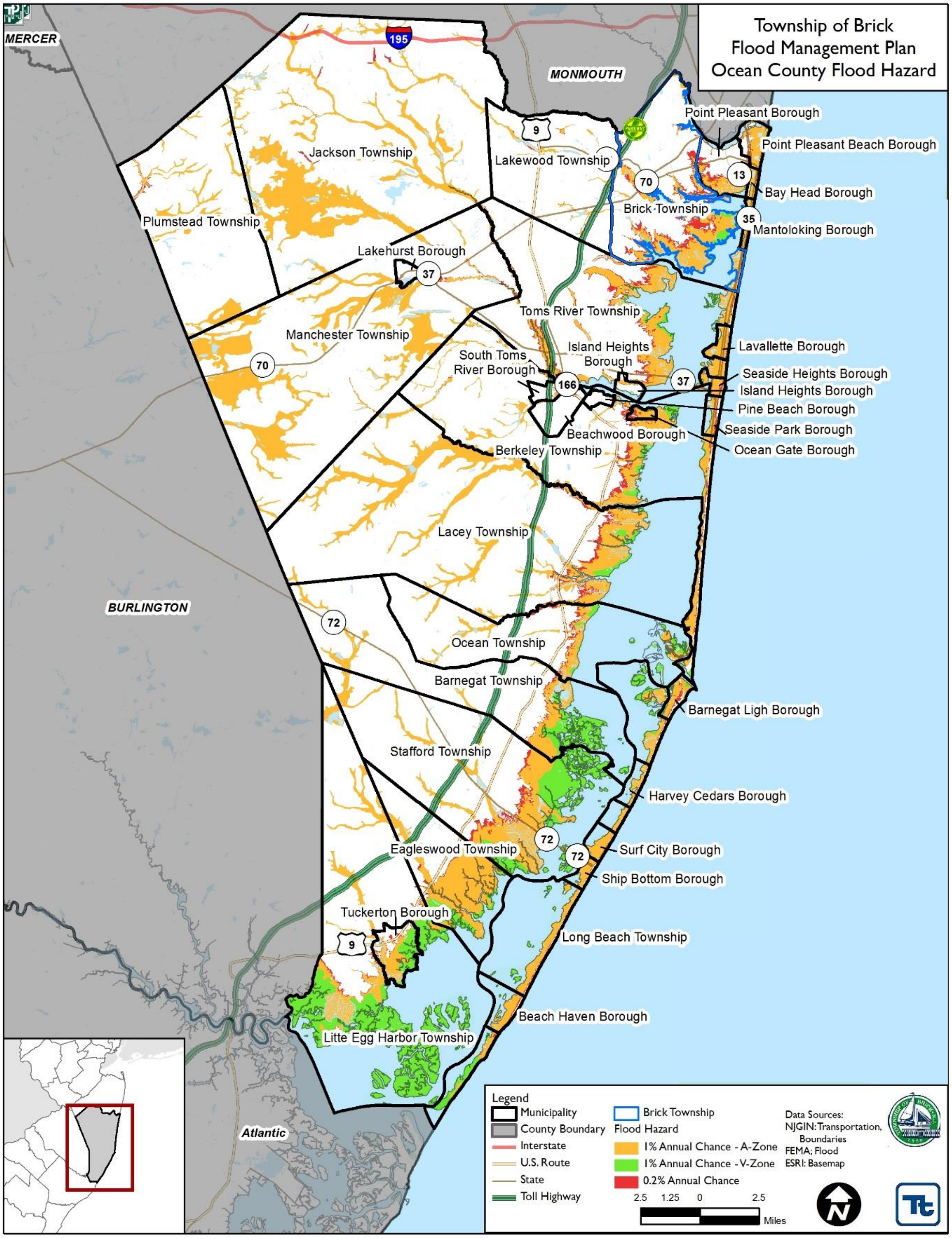
Riverine floods are the most common flood type. They occur along a channel and include overbank and flash flooding. Channels are defined, ground features that carry water through and out of a watershed. They may be called rivers, creeks, streams, or ditches. When a channel receives too much water, the excess water flows over its banks and inundates low-lying areas (FEMA 2007).

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).

Riverine Flooding Location

Flooding in New Jersey, including the Township of Brick, 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 the Township, and they can 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 (New Jersey Office of Emergency Management [NJOEM] 2007). Areas within a floodplain become inundated during a flooding event. The areas within the 1-percent annual chance flood areas have a higher chance of becoming inundated during storm events. The 1-percent annual chance of flood hazard zones (both A and V-zones) and 0.2 percent annual chance flood zone throughout Ocean County are identified in Figure 5-2. Figure 5-3 provides a visual of the flood zones at the township level for the Township of Brick.

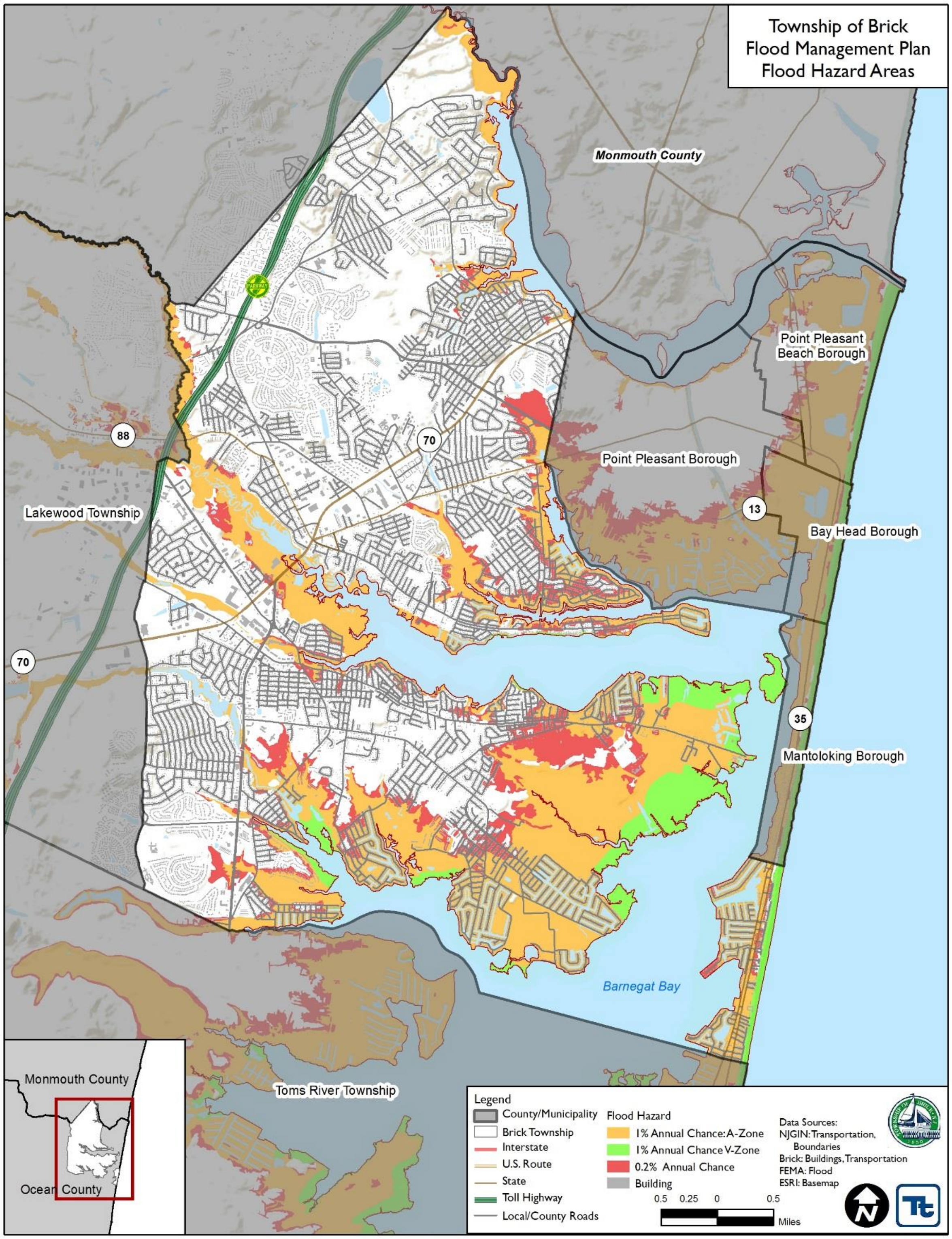
Figure 5-2. FEMA Flood Hazard Areas in the County of Ocean



Source: FEMA 2015, NJGIN 2015

Note: FEMA Federal Emergency Management Agency NJGIN New Jersey Geographic Information Network

Figure 5-3. FEMA Flood Hazard Areas in the Township of Brick



Source: FEMA 2015, NJGIN 2015

Note: FEMA Federal Emergency Management Agency

NJGIN New Jersey Geographic Information Network

Although riverine, flash, and stormwater/urban flooding can occur anywhere in the Township of Brick, certain locations are more vulnerable or more likely to experience flooding than others in the Township. The Metedeconk River is the most frequent source of riverine flooding in the Township, based off previous occurrences and storm events. The Manasquan River, Barnegat Bay, Cedar Bridge Branch, and Beaverdam Creek are also sources of flooding, most typically due to the high percentage of impervious cover from land use, poor drainage facilities in the surrounding areas, and improper grading from development. Much of the Township has already been developed for residential, business, or other use, increasing the Township of Brick's vulnerability to flash flooding and urban flooding. While the Township has stormwater management systems in place in its residential neighborhoods, the capacity of the stormwater systems is not always sufficient. While more recently developed and renovated neighborhoods typically have systems with sufficient capacity, older neighborhoods frequently have stormwater management systems that have not been updated to handle current needs and populations, leading to insufficient drainage (Brick Township Stormwater Management Plan [Master Plan] 2007).

The following provides information regarding flood-prone areas in the Township. The main bodies of water (and sources of flooding) in the Township include the Manasquan River, Sawmill Creek, Beaverdam Creek, Metedeconk River, Cedar Bridge Branch, and Kettle Creek. Additionally, Barnegat Bay makes up the eastern border of the Township, and the Township is located in Watershed Management Area #13m Barnegat Bay. The Township is also located within four watersheds: Metedeconk River North Branch (NB), Manasquan River, Metedeconk River, and Kettle Creek/Barnegat Bay North. For details regarding the watershed management area and the watersheds, please refer to Section 4 (Township Profile).

Potential flood-level events are monitored and warnings are issued to residents when stream gages detect significant rises in water level from the action state of the waterway. Information on flooding levels for minor, moderate, and major events, as well as the action state, are presented under the 'Warning Time' subsection further in this profile.

Riverine Flood Frequency

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-percent chance of being equaled or exceeded in any given year. The "annual flood" is the greatest flood event expected to occur in a typical 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 waterway.

The 100-year flood (or 1-percent annual chance flood) 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 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 a NFIP map has a 26% chance of suffering flood damage during the term of a 30-year mortgage.

The extent of flooding associated with a 1-percent 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 percent 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 percent (500-year) flood has a 6 percent chance of occurring during a 30-year period of time, the length of many mortgages. The 500-year floodplain is referred to as Zone X500 for insurance purposes on flood insurance rate maps (FIRM). Base flood elevations or depths are not shown within this zone and insurance purchase is not required in this zone.

Riverine Flood Severity

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).

Generally the severity of flooding can be measured by peak discharge rates. Table 5-1 lists peak flows used by FEMA to map the floodplains of the Township as noted in the preliminary FIS for the Township (FEMA 2014).

Table 5-4. Summary of Peak Discharges within Township of Brick

Source/Location	Drainage Area (square miles)	Discharge (cubic feet/second)			
		10-Year	50-Year	100-Year	500-Year
North Branch Metedeconk River (at downstream corporate limits)	18.08	500	730	850	1,180

Source: FEMA FIS 2014

Peak discharge information for other identified water courses in the Township including the Manasquan River, Sawmill Creek, Beaverdam Creek, Cedar Bridge Branch, Kettle Creek and the Barnegat Bay are not available as of this writing.

Another way to consider the severity of flooding is to review the stillwater elevations for a water source. Stillwater elevations are the projected elevation of floodwaters in the absence of waves resulting from wind or seismic effects. In coastal areas, stillwater elevations are determined when modeling coastal storm surge; the results of overland wave modeling are used in conjunction with the stillwater elevations to develop base flood elevations. Table 5-2 shows the stillwater elevations identified in the effective FIS for the Township.

Table 5-5. Summary of Stillwater Elevations for Waterways within the Township of Brick

Source/Location	Elevation (feet NAVD)			
	10-Year	50-Year	100-Year	500-Year
Manasquan River	5.4	6.6	7.2	8.8

Source/Location	Elevation (feet NAVD) 10-Year	50-Year	100-Year	500-Year
North Branch Metedeconk River	3.2	4.3	4.8	6.1
Kettle Creek	3.2	4.3	4.8	6.1
Barnegat Bay (entire shoreline within the Borough of Point Pleasant and the Township of Brick)	3.2	--	4.8	6.1

Source: FEMA FIS 2006
Note: The 2014 FIS did not contain stillwater elevations for the Township of Brick waterways; it only contained stillwater elevations for transects. This information is included in the appropriate table.
NAVD North American Vertical Datum of 1988

While riverine flooding severity can be measured by discharge rates, FEMA evaluates the potential impact of a flood event along the coastline through coastal hydraulic analysis, which consists of a combination of transect layout, field reconnaissance, erosion analysis, and overland wave modeling. Transects show the elevation of the ground both onshore and offshore, and they are the locations where the overland wave height modeling occurs. Transects are selected through consideration of local topography, land use, shoreline features, and shoreline orientation to capture the most useful data. The transects selected for the analysis recorded in the FIS are the sites of primary flooding in both the Township of Brick and Ocean County. In addition to considering wave heights, the coastal hydraulic analysis also evaluated stillwater elevations. Table 5-3 provides the transect data from the township's most recent FEMA FIS. Where applicable, the table includes riverine transect analysis data as well.

Table 5-6. Transect Data in the Township of Brick

Flood Source	Transect	Starting Wave Conditions for the 100-Year Flood			Starting Stillwater Elevation (feet NAVD) Range of Stillwater Elevations (feet NAVD)			
		Coordinates	Significant Wave Height	Peak Wave Period	10-Year	50-Year	100-Year	500-Year
Manasquan River	1	N 40.105073 W 74.096389	1.62	2.28	6.8	8.6	9.3	10.5
Manasquan River	2	N 40.094354 W 74.085057	1.67	2.33	6.8	8.5	9.1	10.3
Atlantic Ocean	14	N 40.029256 W 74.051492	18.92	13.98	7.1 4-7.1	9.2 6.4-9.2	10.1 7.4-10.1	12.2 9.6-12.2
Atlantic Ocean	15	N 40.021936 W 74.053220	19.15	13.98	7.1 3.9-7.1	9.2 6.3-9.2	10.0 7.3-10.0	12.2 9.5-12.2
Atlantic Ocean	16	N 40.015948 W 74.054657	19.44	14.00	7.2 4.0-7.2	9.3 6.3-9.3	10.1 7.3-10.2	12.2 9.5-12.3
Atlantic Ocean	17	N 40.008315 W 74.056716	19.28	14.07	7.3	9.3 6.2-9.3	10.1 7.2-10.1	12.2 9.5-12.2
Barnegat Bay	84	N 39.998920 W 74.081430	3.19	3.26	3.9 3.7-3.9	6.1 6.1-6.2	7.1 7.1-7.2	9.3 9.2-9.3
Barnegat Bay	87	N 40.057795 W 74.064079	2.60	2.74	3.8 3.6-3.9	6.3 6.1-6.4	7.4 7.2-7.5	10.1 10.1-10.2
Metedeconk River	88	N 40.055952 W 74.081676	2.26	2.62	3.9 3.7-3.9	6.3 6.0-6.3	7.4 7.0-7.5	10.2 10.1-10.4
Metedeconk River	89	N 40.055865 W 74.100744	2.10	2.53	3.8	6.3	7.4	10.3
Metedeconk River	90	N 40.056693 W 74.112268	1.68	2.23	3.7	6.1 6-6.1	7.3 7.0-7.3	10.2 10.1-10.2
Metedeconk River	91	N 40.062490 W 74.123279	1.58	2.19	3.8	6.3	7.4 7.1-7.4	10.4 10.2-10.4

		Starting Wave Conditions for the 100-Year Flood			Starting Stillwater Elevation (feet NAVD) Range of Stillwater Elevations (feet NAVD)			
Flood Source	Transect	Coordinates	Significant Wave Height	Peak Wave Period	10-Year	50-Year	100-Year	500-Year
Metedeconk River	92	N 40.053320 W 74.125179	1.44	2.21	3.7	6.0	7.1	10.2
Metedeconk River	93	N 40.049649 W 74.112644	1.75	2.27	3.8	6.3	7.4	10.3
Metedeconk River	94	N 40.049611 W 74.095754	2.08	2.53	3.5 3.4-3.5	6.3 6.2-6.3	7.4	10.2
Metedeconk River	95	N 40.048871 W 74.082997	2.20	2.56	3.6 3.6-3.8	6.3 5.8-6.3	7.4 7.0-7.4	10.2 9.8-10.2
Barnegat Bay	96	N 40.030559 W 74.076239	2.90	3.29	3.9 2.7-3.9	6.3 5.8-6.3	7.3 7.0-7.3	9.5 9.4-9.9
Barnegat Bay	97	N 40.017982 W 74.081212	3.29	3.45	3.9 3.2-3.9	6.2 5.8-6.2	7.2 6.9-7.2	9.4 9.1-9.4
Kettle Creek	98	N 40.016300 W 74.102401	3.05	3.32	3.9 3.6-3.9	6.2 5.7-6.2	7.1 6.8-7.2	9.4 9.1-9.4
Kettle Creek	99	N 40.024288 W 74.118366	2.21	2.55	3.9 1.0-3.9	6.3 5.5-6.3	7.2 6.8-7.2	9.4 9.1-9.4
Kettle Creek	100	N 40.021940 W 74.125405	2.19	2.46	3.9 3.5-3.9	6.2 6.1-6.2	7.2 7.0-7.2	9.4 9.1-9.5

Source: FEMA FIS 2014
N North W West NAVD North American Vertical Datum of 1988

The U.S. Geological Survey (USGS) provides other resources for tracking the severity and potential incidents for a coastal flooding event. The tide gage for Barnegat Bay at Mantoloking (the tide gage nearest Township of Brick), tracks tide elevations. This gage recorded a maximum elevation of 3.81 feet (from crest-stage) on December 11, 1992, and a minimum elevation of an estimated -1.6 feet on October 30, 2006 (with the note that a lower tide likely occurred on February 16, 2007, but this record is missing). In addition, the tide gage records also note the monthly mean for gage height from May 1, 2000, to September 30, 2009:

- January: -0.01 feet
- February: -0.27 feet
- March: 0.02 feet
- April: 0.15 feet
- May: 0.24 feet
- June: 0.40 feet
- July: 0.40 feet
- August: 0.42 feet
- September: 0.50 feet
- October: 0.36 feet
- November: 0.14 feet
- December: -0.06 feet

Additionally, 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 2008).

Riverine Flood Warning Time

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. Flash flooding can be less predictable, but potential hazard areas can be warned in advanced of potential flash flooding danger.

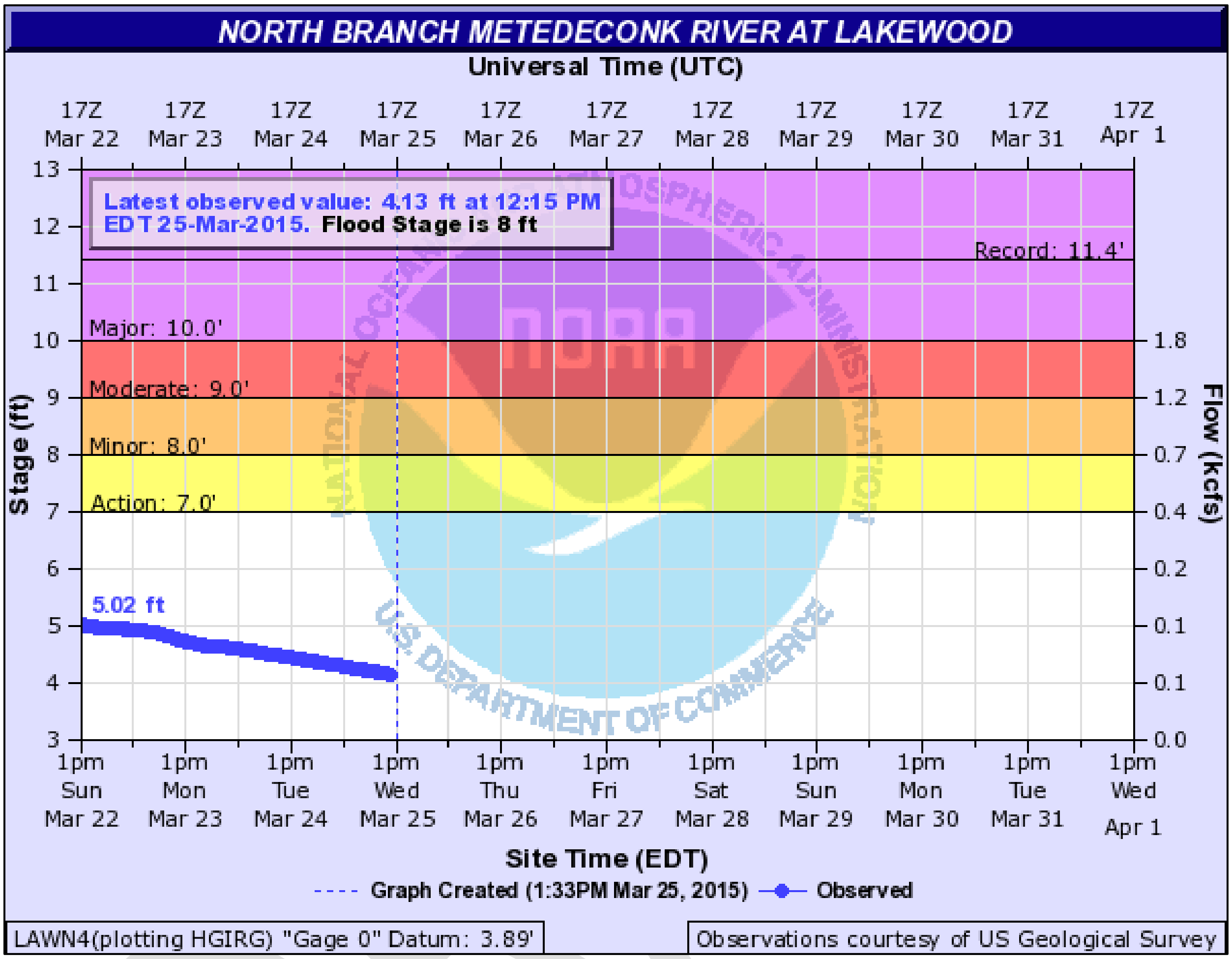
Each watershed has unique qualities that affect its response to rainfall. A hydrograph, which is a graph or chart illustrating stream flow in relation to time (see Figure 5-4 and Figure 5-5) is a useful tool for examining a stream's response to rainfall. Once rainfall starts falling over a watershed, runoff begins and the stream begins to rise. Water depth in the stream channel (stage of flow) will continue to rise in response to runoff even after rainfall ends. Eventually, the runoff will reach a peak and the stage of flow will crest. It is at this point that the stream stage will remain the most stable, exhibiting little change over time until it begins to fall and eventually subside to a level below flooding stage.

The potential warning time a community has to respond to a flooding threat is a function of the time between the first measurable rainfall and the first occurrence of flooding. The time it takes to recognize a flooding threat reduces the potential warning time for a community that has to take actions to protect lives and property. Another element that characterizes a community's flood threat is the length of time floodwaters remain above flood stage.

The Township's flood threat systems consists of a network of precipitation gages throughout the watersheds and stream gages at strategic locations in the Township that constantly monitor and report stream levels. This information is fed into a USGS forecasting program, which assesses the flood threat based on the amount of flow in the stream (measured in cubic feet per second). All of this information is analyzed to evaluate the flood threat and possible evacuation needs.

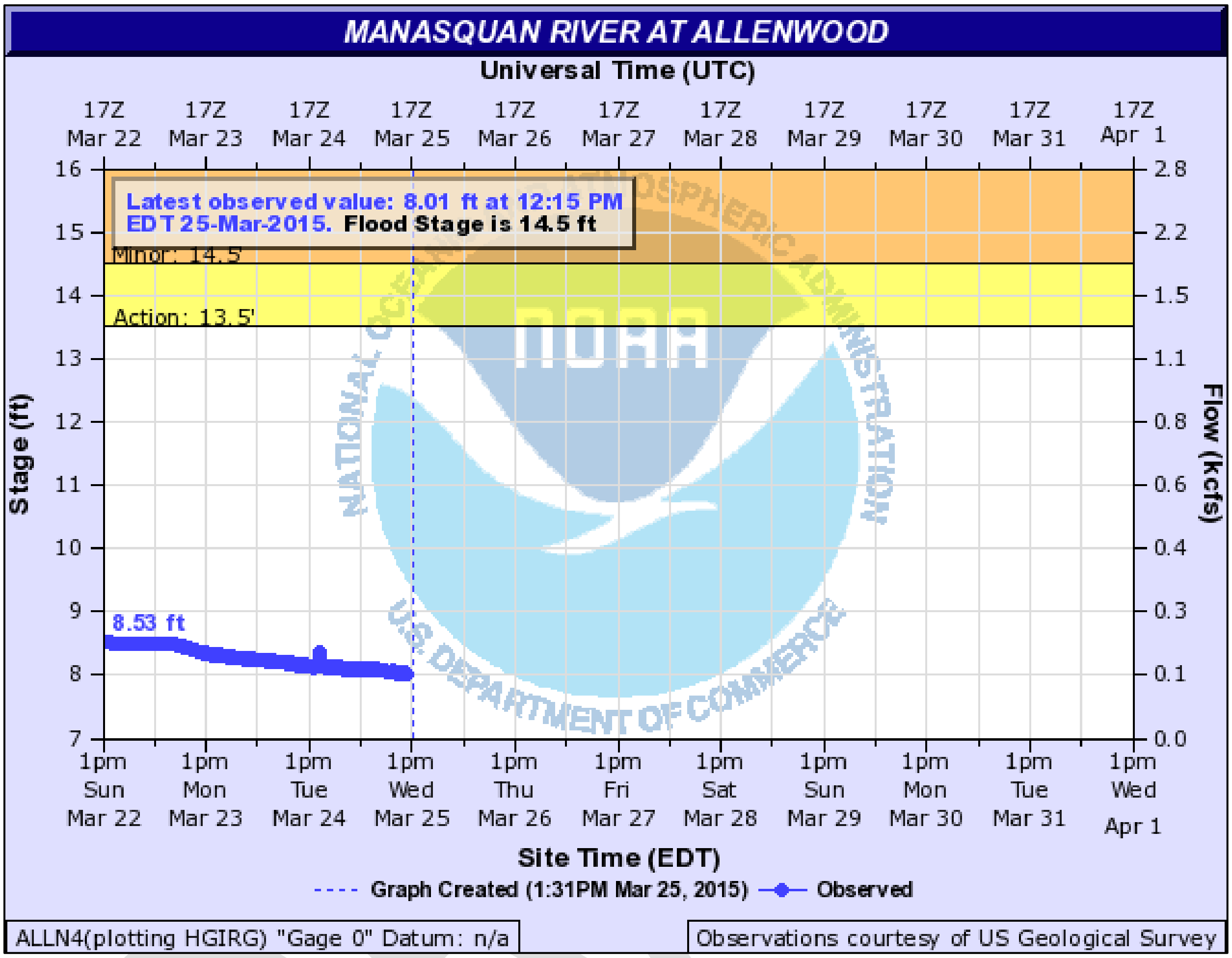
The following figures consist of hydrographs for major riverine waterways in or near the Township of Brick (as gages inside the Township were not available, the nearest gages outside corporate limits were used for graphing). The hydrographs provide real-time data with action levels, minor, moderate, and major flood stages in relation to current river heights.

Figure 5-4. North Branch of the Metedeconk River Hydrograph near Lakewood, NJ



Source: NOAA NWS 2015
Notes:
EDT *Eastern Daylight Time*
ft *feet*
kcfs *Kilo cubic feet per second*

Figure 5-5. Manasquan River Hydrograph near Allenwood, NJ



Source: NOAA NWS 2015
Notes:
EDT *Eastern Daylight Time*
ft *feet*
kcfs *Kilo cubic feet per second*

The NWS issues watches and warnings when forecasts indicate rivers may approach bank-full levels.

- Flood Watch: A Flash Flood Watch is issued when conditions are favorable for flash flooding. It does not mean that flash flooding will occur, but it is possible.
- Flood Warning: A Flash Flood Warning is issued when flash flooding is imminent or occurring (NWS 2011)

When a watch is issued, the public should prepare for the possibility of a flood. When a warning is issued, the public is advised to stay tuned to a local radio station for further information and be prepared to take quick action if needed. A warning means a flood is imminent, generally within 12 hours, or is occurring. Local media broadcast NWS warnings. Thresholds for flood warnings have been established on the major rivers in the Township of Brick, based on available stream gage information, as follows:

- North Branch of the Metedeconk River, near Lakewood, NJ
    - Action state is 7 feet

- Minor flooding/Initial flood stage is 8 feet
  - Moderate flooding is 9 feet
  - Major flooding is 10 feet
- Manasquan River near Allenwood, NJ
  - Action state is 13.5 feet
  - Minor flooding/Initial flood stage is 14.5 feet
  - Moderate and major flood stages are not currently available

Riverine Flooding Secondary Hazards

The most problematic secondary hazard for riverine flooding is bank erosion, 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 over saturate soils on steep slopes, causing 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.

5.1.3 Coastal Flooding Hazard

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).

Hurricanes and tropical storms (tropical cyclones), and Nor'easters cause most of the coastal flooding in New Jersey.

Hurricanes and Tropical Storm

A tropical cyclone is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain. Tropical depressions, tropical storms, and hurricanes are all considered tropical cyclones. Tropical cyclones strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. These storms rotate counterclockwise in the northern hemisphere around the center and are accompanied by heavy rain and strong winds (National Weather Service [NWS] 2013). Almost all tropical storms and hurricanes in the Atlantic basin (which includes the Gulf of Mexico and Caribbean Sea) form between June 1 and November 30 (hurricane season). August and September are peak months for hurricane development (NWS 2013a).

Tropical cyclones are fueled by a different heat mechanism than other cyclonic windstorms such as nor'easters and polar lows. The characteristic that separates tropical cyclones from other cyclonic systems is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings, a phenomenon called "warm core" storm systems (NWS 2013a).

The National Weather Service (NWS) issues hurricane and tropical storm watches and warnings. These watches and warnings are issued or will remain in effect after a tropical cyclone becomes post-tropical, when such a storm poses a significant threat to life and property. The NWS allows the National Hurricane Center (NHC) to issue advisories during the post-tropical stage. The following are the definitions of the watches and warnings:

- *Hurricane/Typhoon Warning* is issued when sustained winds of 74 mph or higher are expected somewhere within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm-force, the warning is issued 36 hours in advance of the anticipated onset of tropical storm-force winds (24 hours in the western north Pacific). The warning can remain in effect when dangerously high water or combination of dangerously high water and waves continue, even though winds may be less than hurricane force.
- *Hurricane Watch* is issued when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm-force, the hurricane watch is issued 48 hours prior to the anticipated onset of tropical storm-force winds.
- *Tropical Storm Warning* is issued when sustained winds of 39 to 73 mph are expected somewhere within the specified area within 36 hours (24 hours for the western north Pacific) in association with a tropical, subtropical, or post-tropical storm.
- *Tropical Storm Watch* is issued when sustained winds of 39 to 73 mph are possible within the specified area within 48 hours in association with a tropical, sub-tropical, or post-tropical storm (NWS 2013a).

Nor'Easter

A Nor'Easter is a cyclonic storm that moves along the East Coast of North America. It is called a Nor'Easter because the damaging winds over coastal areas blow from a northeasterly direction. Nor'Easters can occur any time of the year but are most frequent and strongest between September and April. These storms usually develop between Georgia and New Jersey within 100 miles of the coastline and typically move from southwest to northeast along the Atlantic Coast of the United States (NWS 2013b). A Nor'Easter event can cause storm surges, waves, heavy rain, heavy snow, wind, and coastal flooding. Nor'Easters have diameters that can span 1,200 miles, impacting large areas of coastline. The forward speed of a Nor'Easter is usually much slower than a hurricane, so with the slower speed, a Nor'Easter can linger for days and cause tremendous damage to those areas impacted. In order to be called a Nor'Easter, a storm must have the following conditions, as per the Northeast Regional Climate Center (NRCC):

- Must persist for at least a 12-hour period
- Have a closed circulation
- Be located within the quadrilateral bounded at 45°N by 65° and 70°W and at 30°N by 85°W and 75°W
- Show general movement from the south-southwest to the north-northeast
- Contain wind speeds greater than 23 miles per hour (mph)

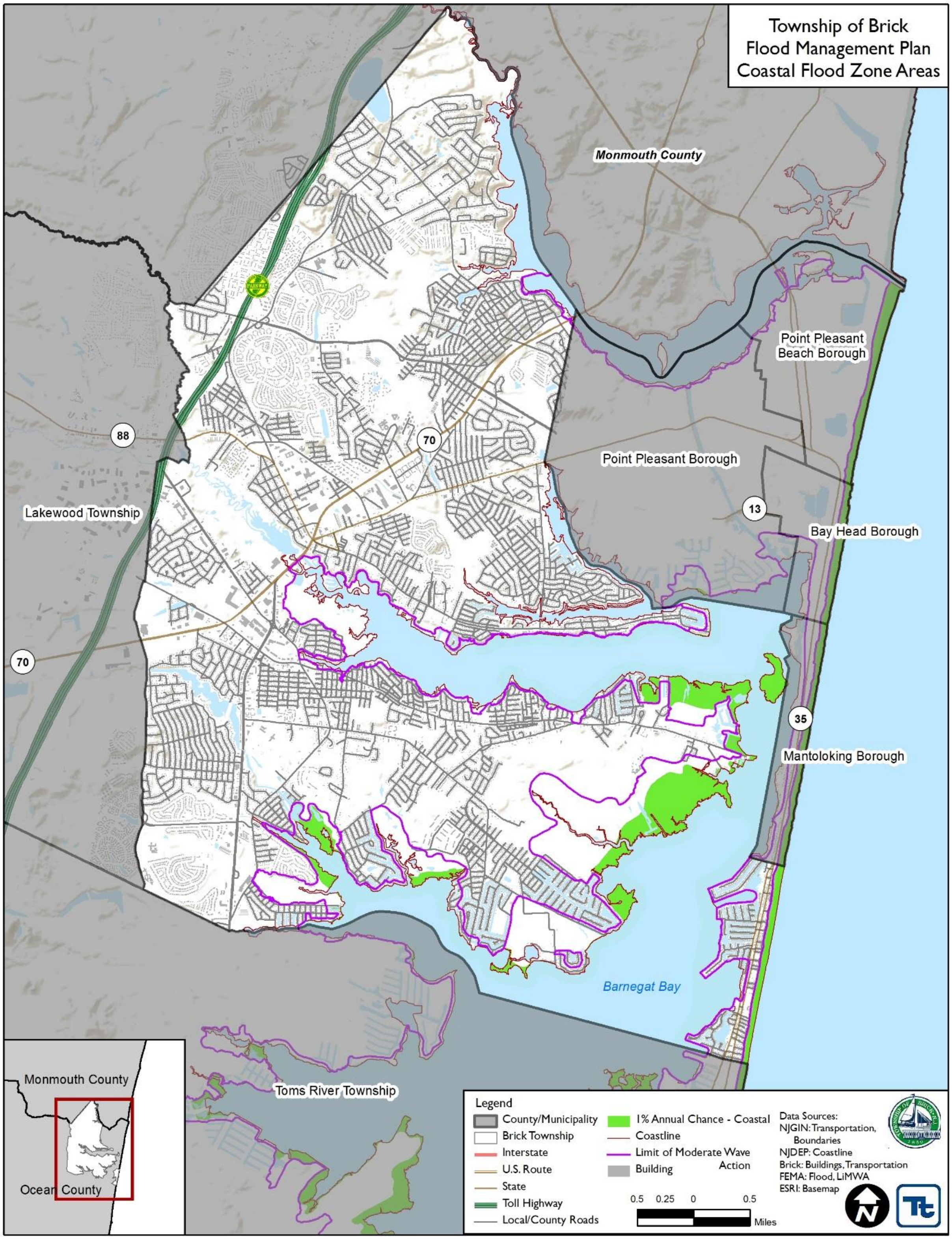
The intensity of a Nor'Easter can rival that of a tropical cyclone in that, on occasion, it may flow or stall off the Mid-Atlantic coast resulting in prolonged episodes of precipitation, coastal flooding, and high winds.

Coastal Flooding Location

Coastal communities are vulnerable to the damaging impacts of major storms along the coastline of New Jersey. The coastal zone of New Jersey includes 8 counties and 126 municipalities, including the Township of Brick. With regards to Ocean County specifically, the county has the longest oceanfront shoreline of any county in New Jersey, with 45.2 miles of coastline. Approximately 70 percent of this coastline is developed (31.8 miles), increasing the county's vulnerability to coastal flooding and coastal erosion significantly (Ocean County Hazard Mitigation Plan [OC HMP] 2014).

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 5-5 provides a visual representation of the 1-percent annual chance flood areas for the V-Zone in the Township of Brick. These areas have a greater chance of experiencing coastal flooding, wave damage, storm surge, and coastal erosion during a storm event.

Figure 5-6. Township of Brick Coastal Flood Zone Areas



Storm surge, detailed below, 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.

Coastal Flooding Severity

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).

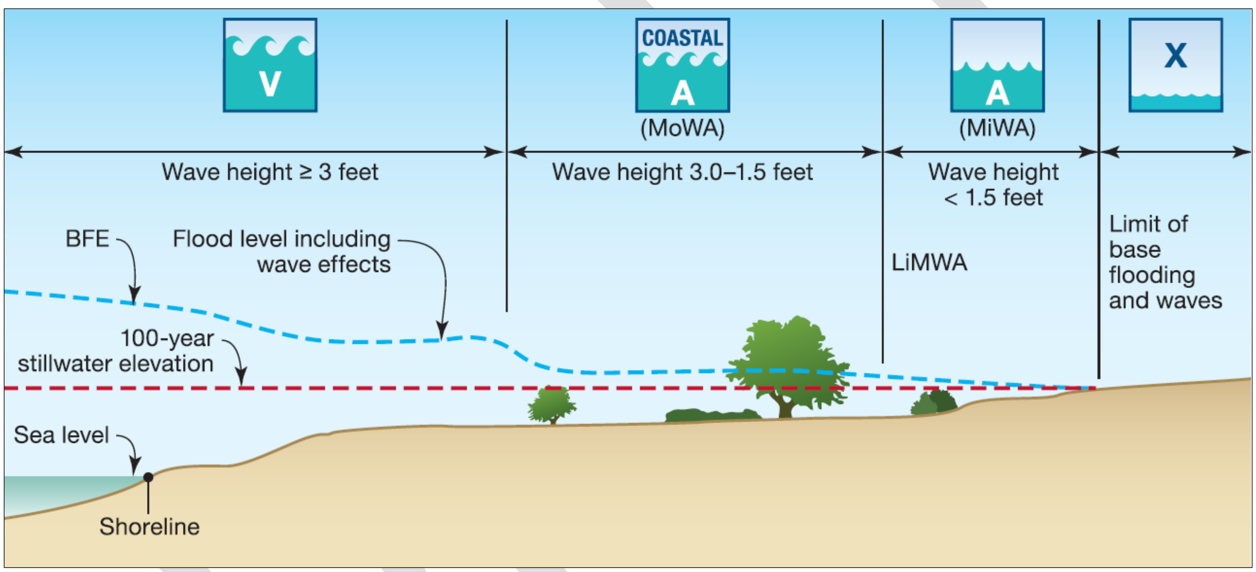
There are several forces that occur with coastal flooding:

- *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
  - High-velocity flows which can be created or exacerbated by the presence of man-made 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 2011 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). The LiMWA is indicated on the Township Preliminary FIRM dated January 30, 2015.

The area between the LiMWA and the Zone V limit is known as the Coastal A-Zone (CAZ) (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 2011). Figure 5-4 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). Since the LiMWA is delineated on the FIRM, the Uniform Construction Code requires new buildings and substantially improved buildings to comply with the requirements for Zone V. However, federal flood insurance in CAZs is rated using Zone A rates (lower than Zone V rates) (NJAFM Quick Guide 2015).

Figure 5-7. Transect Schematic of Zone V, Coastal A-Zone, Zone A, and Zone X



Source: FEMA 2011

<	*Less than*
≥	*Greater than or equal to*
BFE	*Base Flood Elevation*
LiMWA	*limit of moderate wave action*
MiWA	*Minimal Wave Action area*
MoWA	*Moderate Wave Action area*

Coastal Flood Frequency

Coastal flooding frequency is tied to the frequency of coastal storm events.

Coastal Flood Warning Time

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. Flash flooding can be less predictable, but potential hazard areas can be warned in advance of potential flash flooding danger.

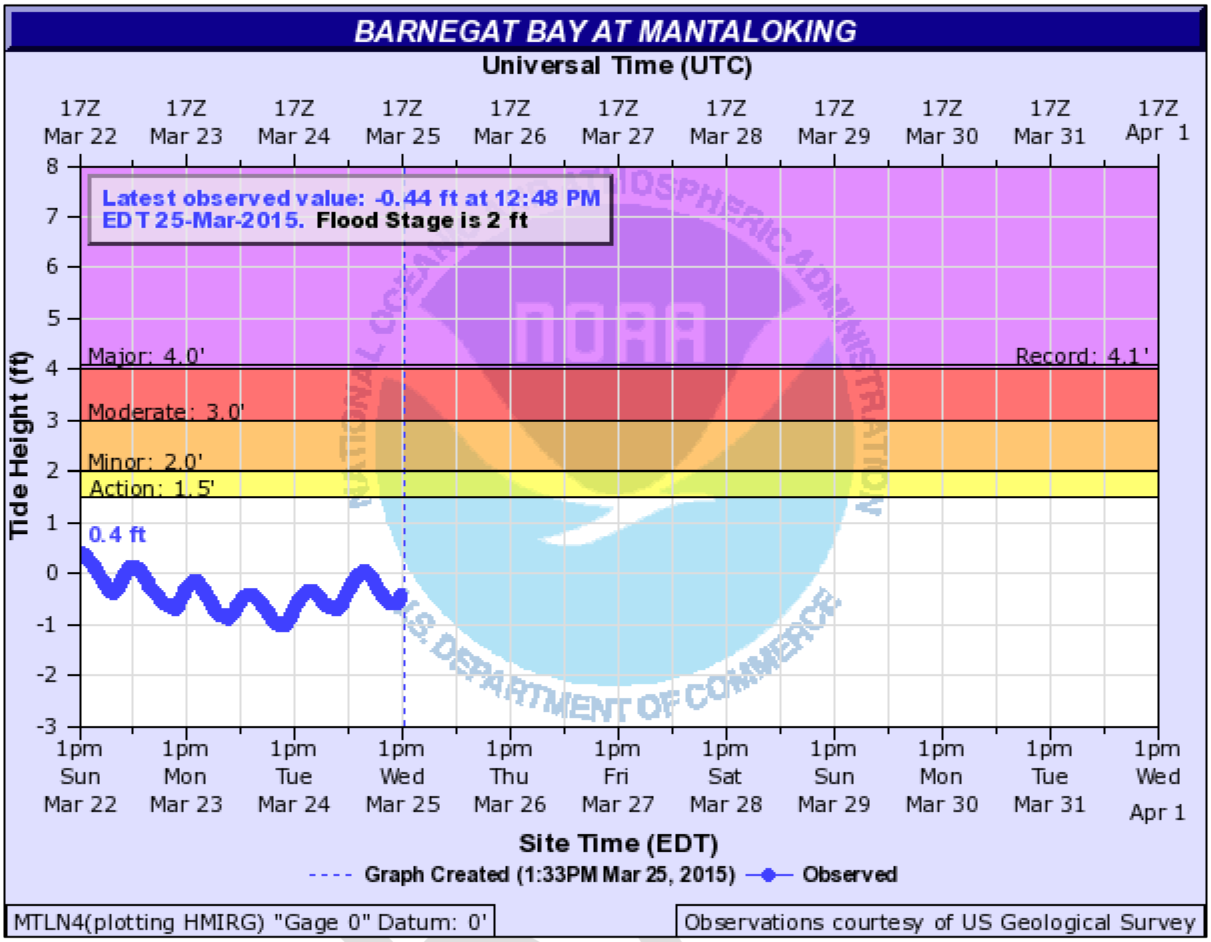
Each watershed has unique qualities that affect its response to rainfall or coastal flooding. A hydrograph, which is a graph or chart illustrating stream flow or tidal height in relation to time (Figure 5-8 and Figure 5-9) is a useful tool for examining a stream's response to rainfall or tidal water's response to storm surge.

The potential warning time a community has to respond to a flooding threat is a function of the time between the first measurable rainfall or start of storm surge and the first occurrence of flooding. The time it takes to recognize a flooding threat reduces the potential warning time for a community that has to take actions to protect lives and property. Another element that characterizes a community's flood threat is the length of time floodwaters remain above flood stage.

The Township's coastal flood threat systems consists of a network of tide gages along the coastline at strategic locations in the Township or the region that constantly monitor and report ocean and bay levels. Because coastal flooding is the community's most significant concern, the Township supports the placement of tide gages in or near corporate limits. The closest tide gage to the Township is the Barnegat Bay at Mantoloking, NJ. This gage is maintained by the USGS and has the site number of 01408168. For more information on this tide gage, please refer to the 'Severity' subsection earlier in this Flood Profile. In addition to this program, data and flood information is provided by the NWS. All of this information is analyzed to evaluate the flood threat and possible evacuation needs.

The following figure shows a hydrograph for Barnegat Bay near Mantoloking. The hydrographs provide real-time data with action levels, minor, moderate, and major flood stages in relation to current tidal heights.

Figure 5-8. Barnegat Bay Hydrograph near Mantoloking, NJ



Source: NOAA NWS 2015
Notes:
EDT Eastern Daylight Time
ft feet

The NWS issues watches and warnings when forecasts indicate rivers may approach bank-full levels. 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).

When a watch is issued, the public should prepare for the possibility of a flood. When a warning is issued, the public is advised to stay tuned to a local radio station for further information and be prepared to take quick action if needed. A warning means a flood is imminent, generally within 12 hours, or is occurring. Local media broadcast NWS warnings. Thresholds for flood warnings have been established for the Mantoloking tide gage in the Township of Brick, as follows:

- Barnegat Bay near Mantoloking, NJ
  - Action state is 1.5 feet
  - Minor flooding/Initial flood stage is 2 feet
  - Moderate flooding is 3 feet
  - Major flooding is 4 feet

Local tide gauges are also utilized in the Stevens Flood Advisory System. The system provides coastal flooding forecasts for each gauge four days into the future, taking into account astronomical tidal forecast and storm surge modeling (Stevens Institute of Technology 2020).

Coastal Flooding Secondary Hazards

The most problematic secondary hazard for flooding is coastal erosion, which in some cases can be more harmful than actual flooding. Hazardous materials spills are also a secondary hazard of flooding if storage tanks rupture and spill into waterways.

5.1.4 Coastal Erosion Hazard

Along with flooding, coastal erosion is one of the primary coastal hazards leading to loss of lives or damage to property and infrastructure in damaged coastal areas. Many natural factors affect erosion of the shoreline, including shore and near-shore morphology, shoreline orientation, and the response of these factors to storm frequency and sea level rise. Coastal shorelines change constantly in response to wind, waves, tides, sea level fluctuation, seasonal and climatic variations, human alteration, and other factors that influence the movement of sand and material within a shoreline system.

Unsafe tidal conditions, as a result of high winds, heavy surf, erosion, and fog, are ordinary coastal hazard phenomena. Some or all of these processes can occur during a coastal storm, resulting in an often-detrimental impact on the surrounding coastline. Factors including (1) storms such as Nor'easters and hurricanes, (2) decreased sediment supplies, and (3) sea level rise contribute to these coastal hazards.

Coastal erosion can result in significant economic loss through the destruction of buildings, roads, infrastructure, natural resources, and wildlife habitats. Damage often results from an episodic event with the combination of severe storm waves and dune or bluff erosion.

Historically, some of the methods used by municipalities and property owners to stop or slow down coastal erosion or shoreline change have actually exacerbated the problem. Attempting to halt the natural process of erosion with shore parallel or perpendicular structures such as seawalls (groins and jetties) and other hard structures typically worsens the erosion in front of the structure (i.e., walls), prevents or starves any sediment behind the structure (groins) from supplying down-drift properties with sediment, and subjects down-drift beaches to increased erosion. Since most sediment transport associated with erosion and longshore drift has been reduced, some of the state's greatest coastal assets and attractions—beaches, dunes, barrier beaches, salt marshes, and estuaries—are threatened and will slowly disappear as the sediment sources that feed and sustain them are eliminated.

Sandy barrier/bluff coastlines are constantly changing as the result of wind, currents, storms, and sea level rise. Because of this, developed sandy shorelines are often stabilized with hardened structures (seawalls, bulkheads, revetments, rip-rap, gabions, and groins) to protect coastal properties from erosion. While hardened structures typically prove to be beneficial in reducing property damage, the rate of coastal erosion typically increases near stabilization structures. This increased erosion impacts natural habitats, spawning grounds, recreational activity areas, and public access (Frizzera 2011). The Township of Brick is home to a number of shoreline structures, both along the Atlantic Ocean and inland coastal waters, including groins and bulkheads.

To counteract the negative impact of hard structures, alternative forms of shoreline stabilization that provide more natural forms of protection can be used. Along the New Jersey coast, beach nourishment and dune restoration are now the main forms of shoreline protection. The sheltered coastlines in New Jersey consist of tidal marshlands and a few narrow, sandy beaches—all of which naturally migrate inland as the sea level rises. Experts have stated that marshes can keep pace with a 2.5 millimeters per year rate of sea level rise; however, the state's current rate is approximately 3 to 4 millimeters per year, a rate that is predicted to continue increasing (Frizzera 2011). Currently, bulkheads and revetments are the primary form of shore protection along these tidal areas. As the sea level rises and coastal storms increase in intensity, coastal erosion and requests for additional shoreline stabilization measures are likely to increase (Frizzera 2011).

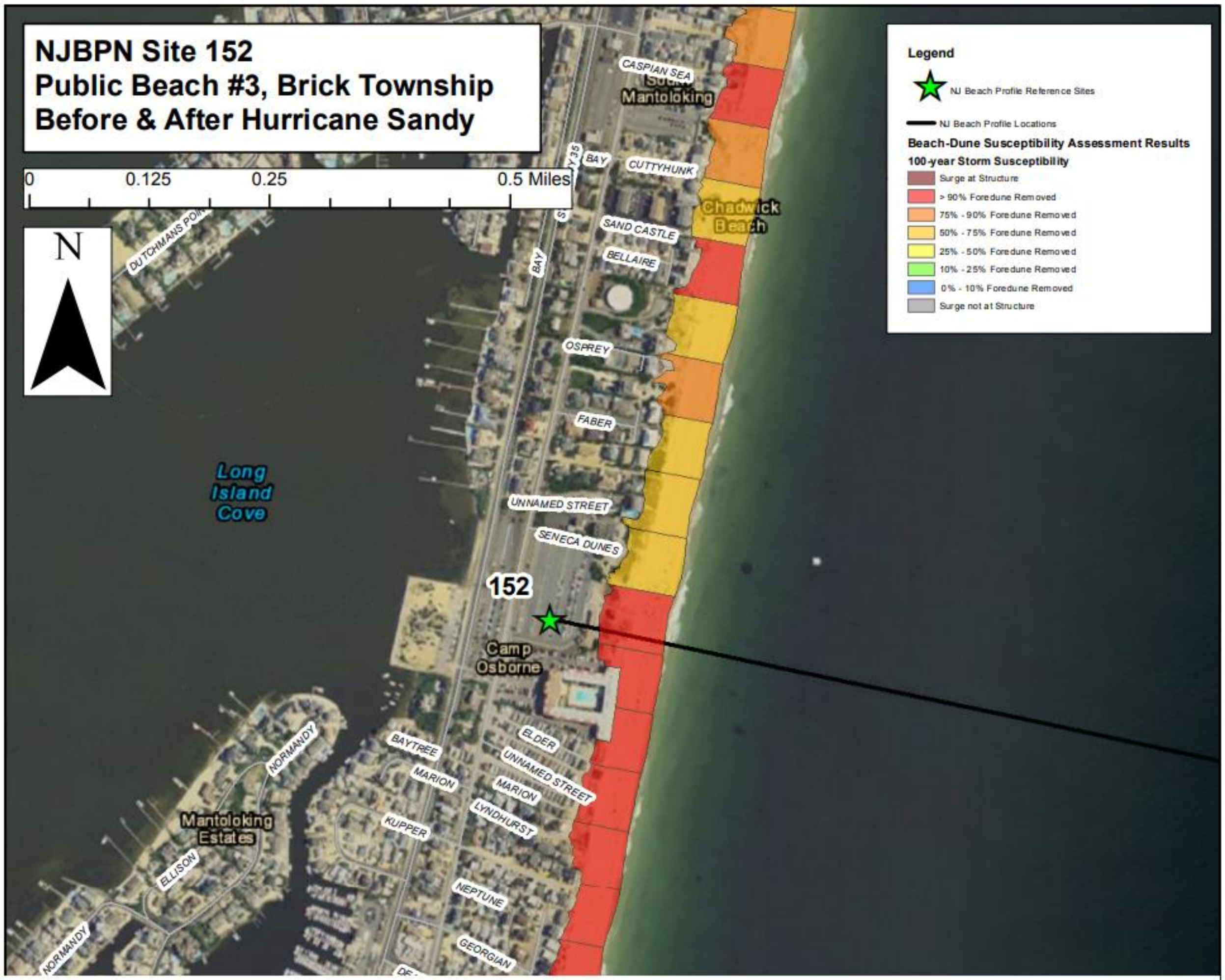
Erosion results in the transfer of sediment from one location to another. The addition of sediment to a location is referred to as accretion. Accretion can be beneficial if it strengthens a shoreline, leading to wider beaches and more material for dune building. However, accretion can also result in the narrowing and shoaling of channels and inlets. This can ultimately lead to a potential increase of coastal flooding risk.

Coastal Erosion Location

Although structural and other measures can be taken to reduce the impact or frequency of this hazard, all shorelines in the Township are vulnerable to coastal erosion. The properties most at risk to coastal erosion will be those located within 200 feet of the erodible shoreline and beaches. Coastal erosion is primarily a concern on the shoreline facing the Atlantic Ocean. However, natural shorelines on the mainland portion of the Township bordering Barnegat Bay, the Metedeconk River, the Manasquan River, Kettle Creek, and their tributaries are exposed to the coastal erosion hazard. The shoreline of the barrier island facing Barnegat Bay is largely protected by bulkheading.

Severe coastal erosion events, such as the overwash event that occurred during the landfall of Superstorm Sandy, can have devastating impacts on structures and infrastructure. Figure 5-9 displays the losses of the foredune at Public Beach #3 due to Superstorm Sandy. Reduction of the foredune resulted in increased damage from wave overwash to the structures and infrastructure previously protected by the dune.

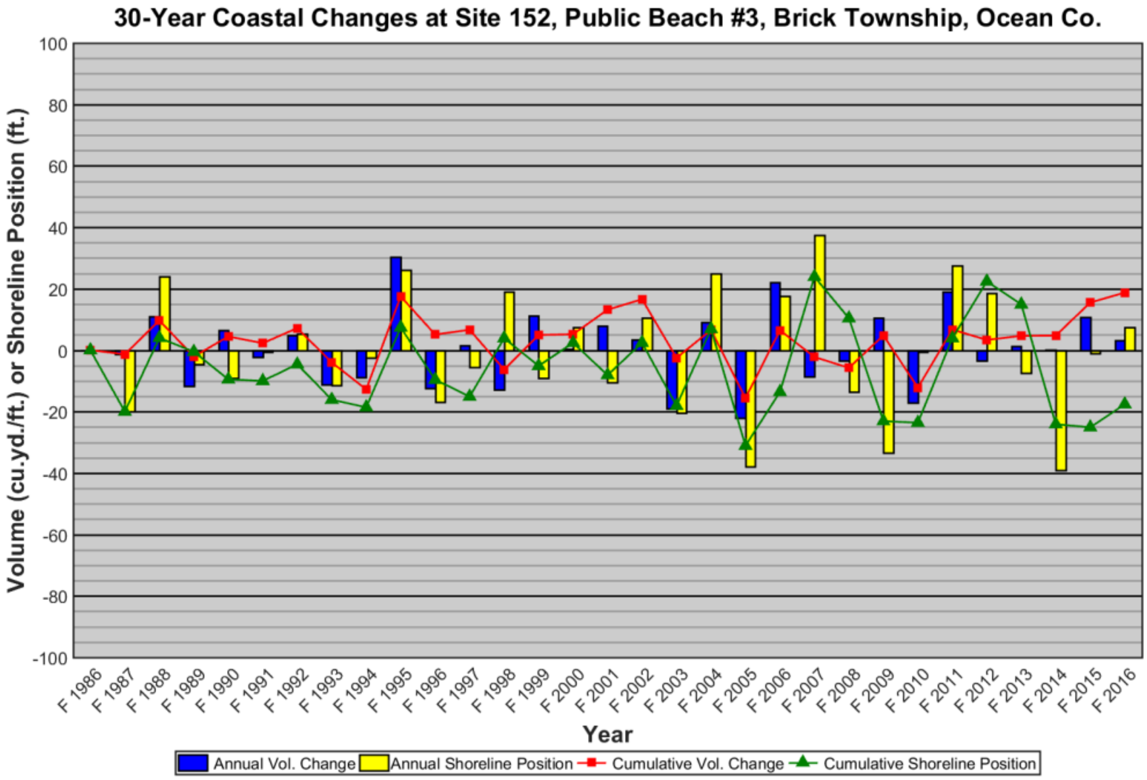
Figure 5-9. Stockton CRC Hurricane Sandy: Beach-Dune Performance Assessment of New Jersey Beaches Before & After Hurricane Sandy



Source: Stockton Coastal Research Center 2017

While coastal erosion can occur as a response of a severe weather event, shorelines, particularly the oceanfront, are exposed to constant wave, current, and wind energy that can result in substantial changes in shoreline position and beach profile volume over time. Figure 5-10 shows the 30-year (1986-2016) coastal changes at Public Beach #3. This shows that over the past 30-years, the Public Beach #3 location has had swings in sand volume and shoreline position that hovered around zero net change. Slight advances are noted in 2015 and 2016. Shoreline retreat that most recently began in 2014 is now 18 feet landward of the 1986 position (Stockton Coastal Research Center 2017).

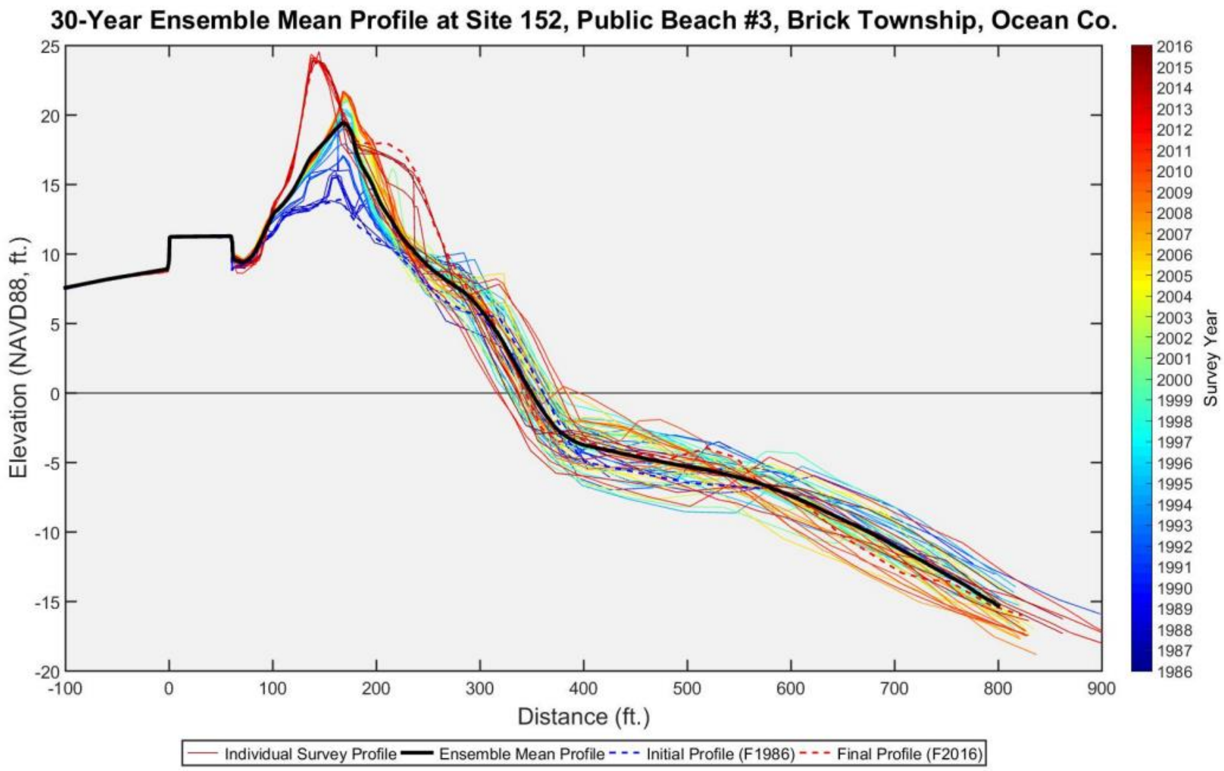
Figure 5-10. 30-Year Coastal Changes at Site 152, Public Beach #3, Brick Township, Ocean County



Source: Stockton Coastal Research Center 2017

Figure 5-11 shows the 30-year (1986-2016) ensemble mean profile at Public Beach #3. The post-Sandy dune was restored to a higher elevation than the 1986 dune and contains a steel sheet pile bulkhead in its core. The envelope of change on the beach and offshore remained relatively small in vertical distribution but highly variable over time since there is no obvious increasing or decreasing trend (as evident by the colors bouncing back and forth about the mean over time) (Stockton Coastal Research Center 2017).

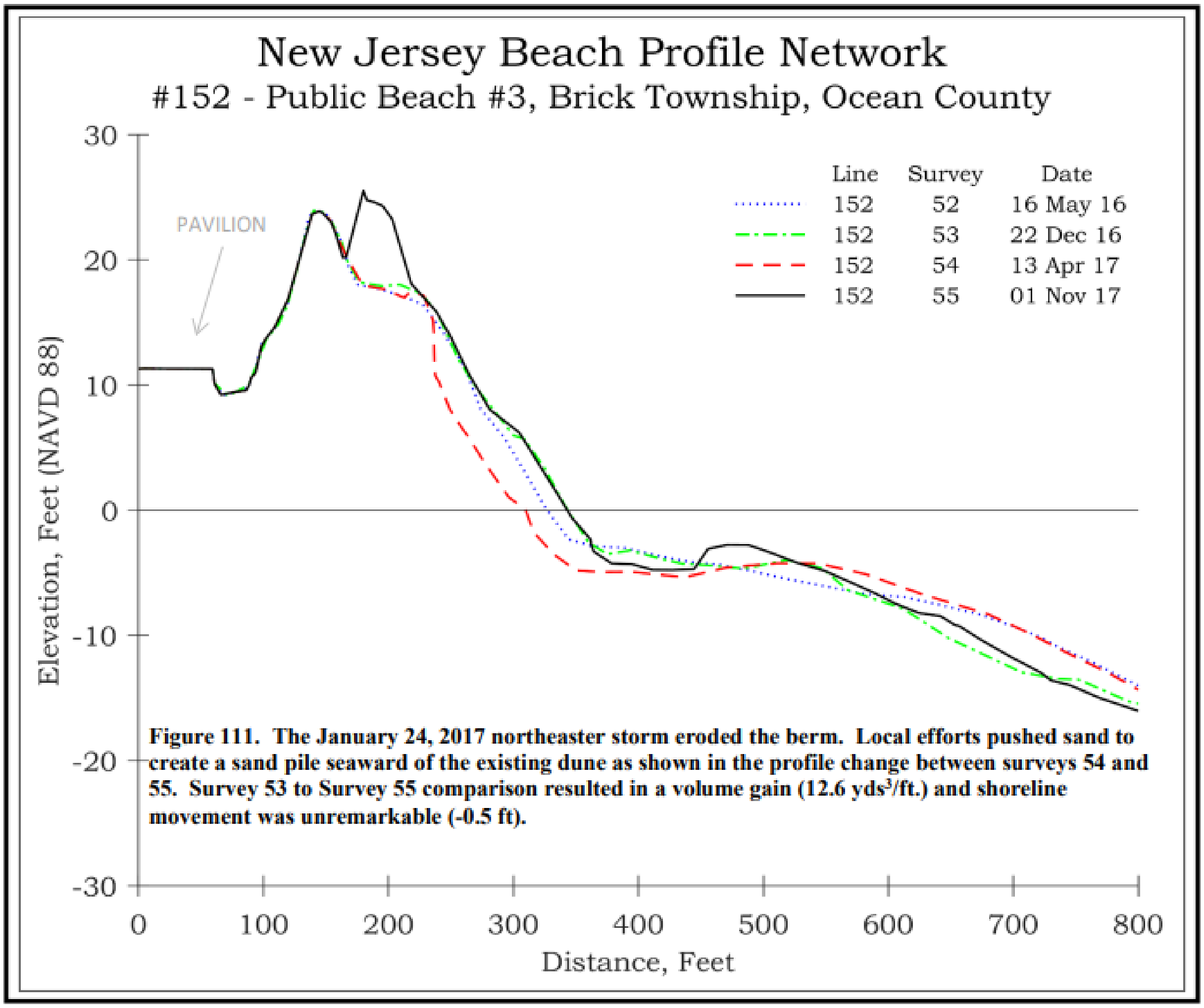
Figure 5-11. 30-Year Ensemble Mean Profile at Site 152, Public Beach #3, Brick Township, Ocean County



Source: Stockton Coastal Research Center 2017

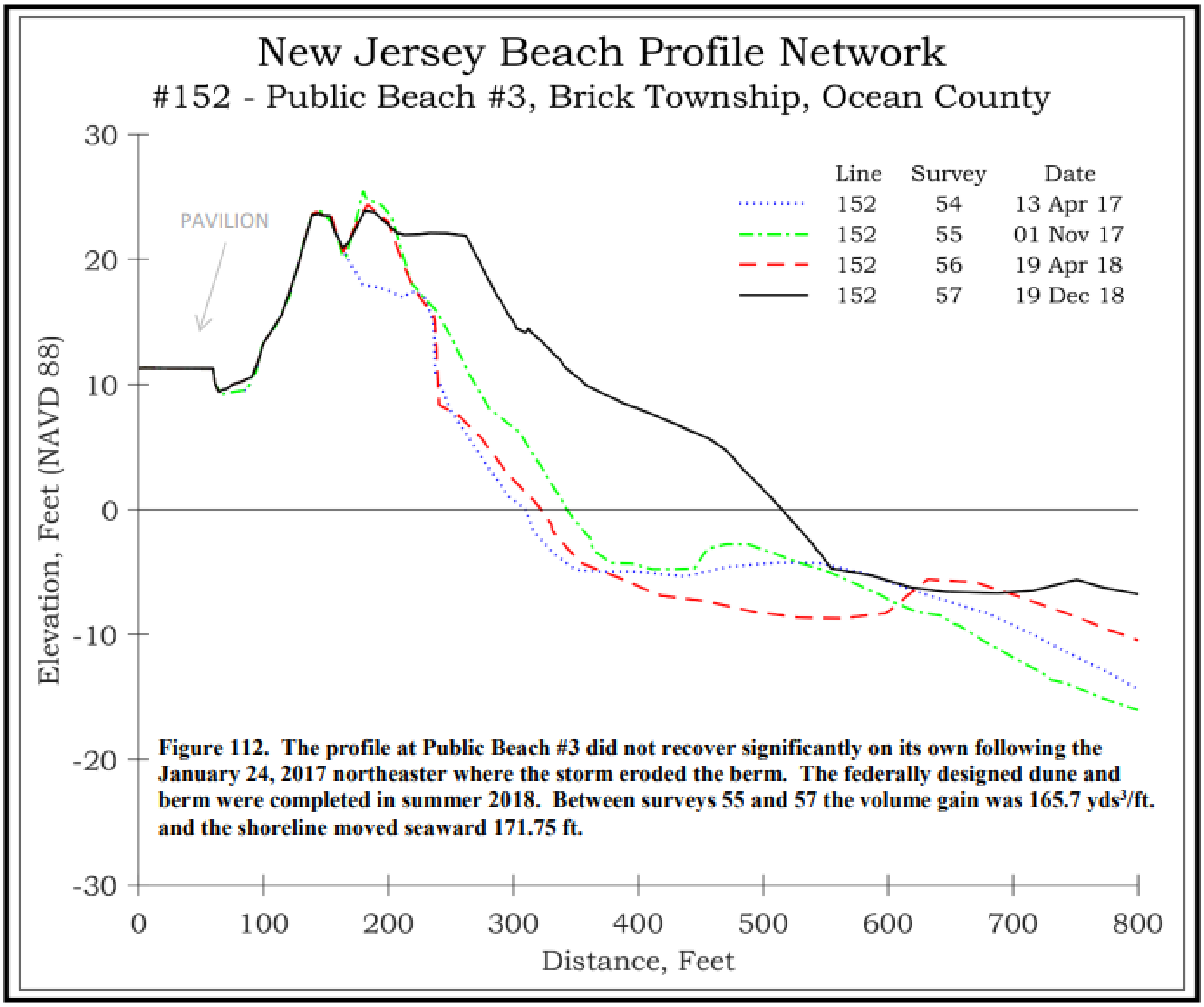
Figure 5-12 through Figure 5-14 display the beach profile at Public Beach #3 for 2017, 2018, and 2019. A nor'easter in January 2017 resulted in significant erosion which required manual reshaping of the beach sand to provide protection as the beach did not recover lost sand quickly enough. In summer 2018, the USACE completed beach replenishment and built an engineered dune.

Figure 5-12. 2017 Beach Profile at Public Beach #3, Brick Township, Ocean County



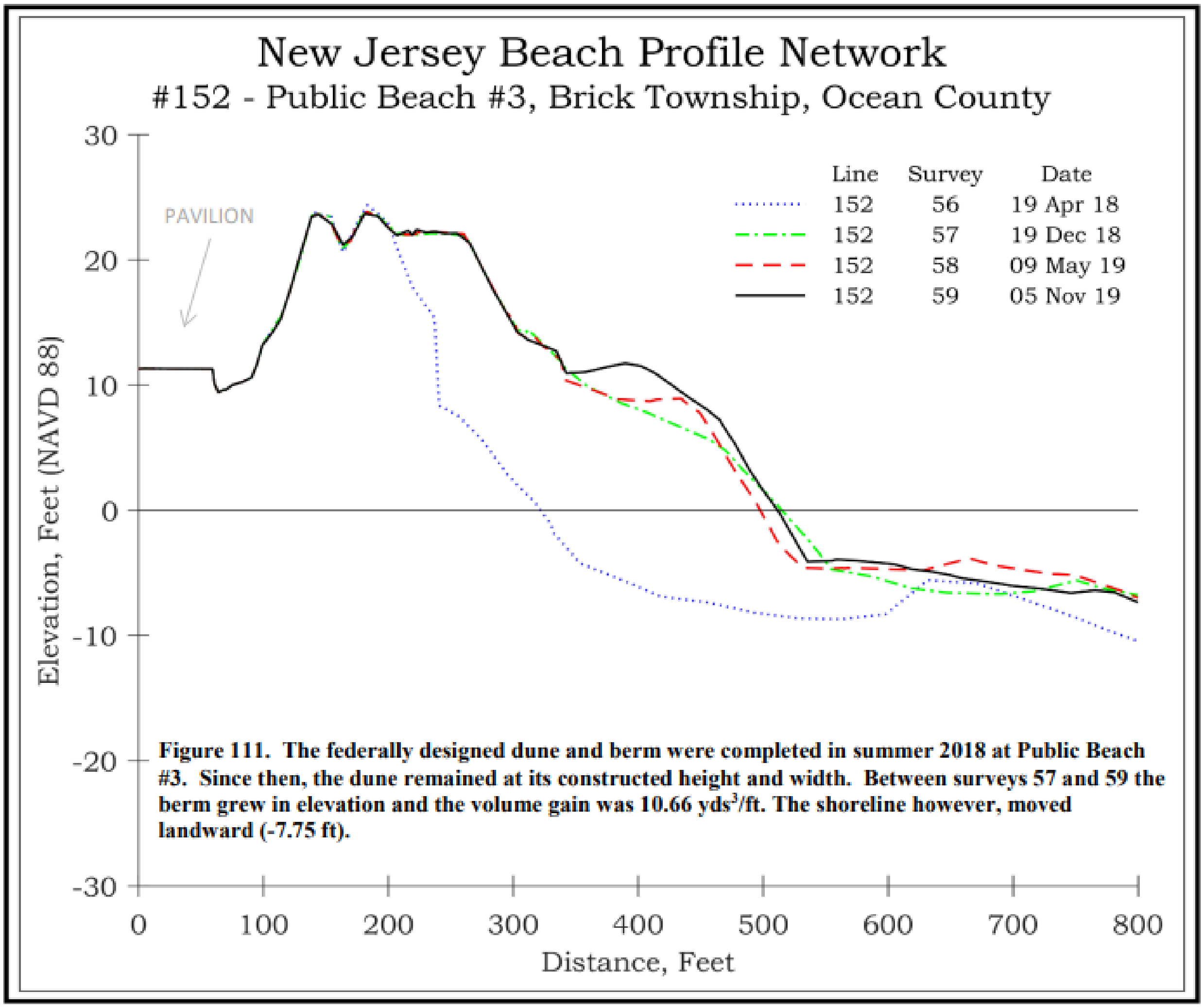
Source: Stockton Coastal Research Center 2018

Figure 5-13. 2018 Beach Profile at Public Beach #3, Brick Township, Ocean County



Source: Stockton Coastal Research Center 2019

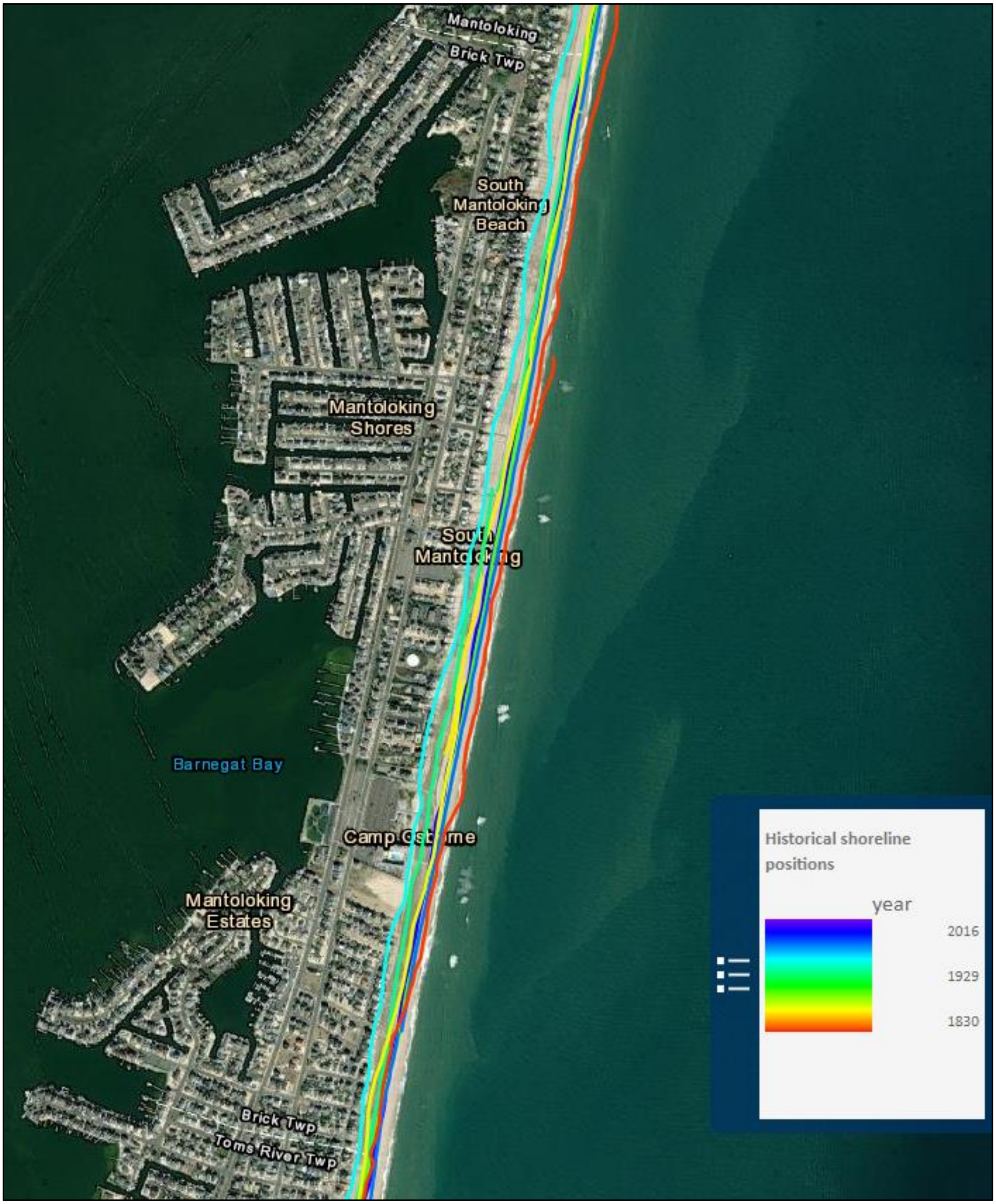
Figure 5-14. 2019 Beach Profile at Public Beach #3, Brick Township, Ocean County



Source: Stockton Coastal Research Center 2020

Barrier islands are notably prone to large impacts from erosion. Erosion is responsible for the position and shape of most barrier islands, outside of human influence. Longshore transport of eroded sediment can result in the migration of a barrier island or barrier spit, typically with one end of the island or spit lengthening due to accretion. In Brick Township, oceanfront sediment typically moves from north to south with shoreline position and nearshore features changing seasonally. USGS monitors the location of shoreline to determine long-term erosional trends. Figure 5-15 shows historical shoreline positions for the oceanfront of the Township of Brick that have been plotted by USGS. Variations in the shoreline position can be seen in the past 180 years with the difference between the most landward and seaward shoreline positions measuring roughly 150 meters.

Figure 5-15. Historical Shoreline Positions for Brick Township, NJ



Source: USGS 2021b

Despite a relatively stable ocean shoreline position, it should be noted that roughly 1,000 meters north of the Township of Brick is the location of a historical inlet, Herring Inlet which existed in the 18th century, in modern day Mantoloking (APP 2014). This site was also where the most extensive breach barrier island breach occurred during Hurricane Sandy. This breach was quickly filled by the USACE using 54,000 tons of sand, 200 tons of stone, and 2,200 tons of rip rap (USACE 2012). Had the breach not been filled, it is likely that a new inlet would have been established. Newly formed inlets in barrier islands are very dynamic and often migrate quickly and unexpectedly, causing significant and rapid erosion. Historical inlet locations on barrier islands are commonly hotspots for potential breaches and inlet formation. The nearby location of the Mantoloking breach and historical inlet points to the potential for severe coastal erosion events in this portion of Ocean County.

Following Superstorm Sandy, the NJDEP and the Federal Highway Administration completed installation of a 3.5 mile steel barrier in 2015 to protect Route 35 and oceanfront homes from future severe erosion events. 45 foot steel panels were driven 30 feet below sea level to form a stable seawall and establish a last line of defense from severe coastal erosion events (APP 2014). Figure 5-16 shows the steel barrier following installation. In 2018, the USACE and NJDEP completed a significant beach replenishment project to establish an engineered dune system with 22 foot high dunes and widen the beach in front of the steel barrier (Stockton CRC 2019). Figure 5-17 shows the changes of the oceanfront prior to Sandy in September 2012, following Sandy in November 2012, the newly placed dunes and beach in December 2018 with new dune grass plantings, and the established dune grass in November 2019.

Figure 5-16. Steel Wall Revetment Brick Beach III

Source: Daniel Nee 2015

Figure 5-17. Township of Brick Oceanfront changes from Superstorm Sandy and Beach Replenishment

September 14, 2012

November 8, 2012

December 19, 2018

November 5, 2019

Source: Stockton CRC 2012, Stockton CRC 2019

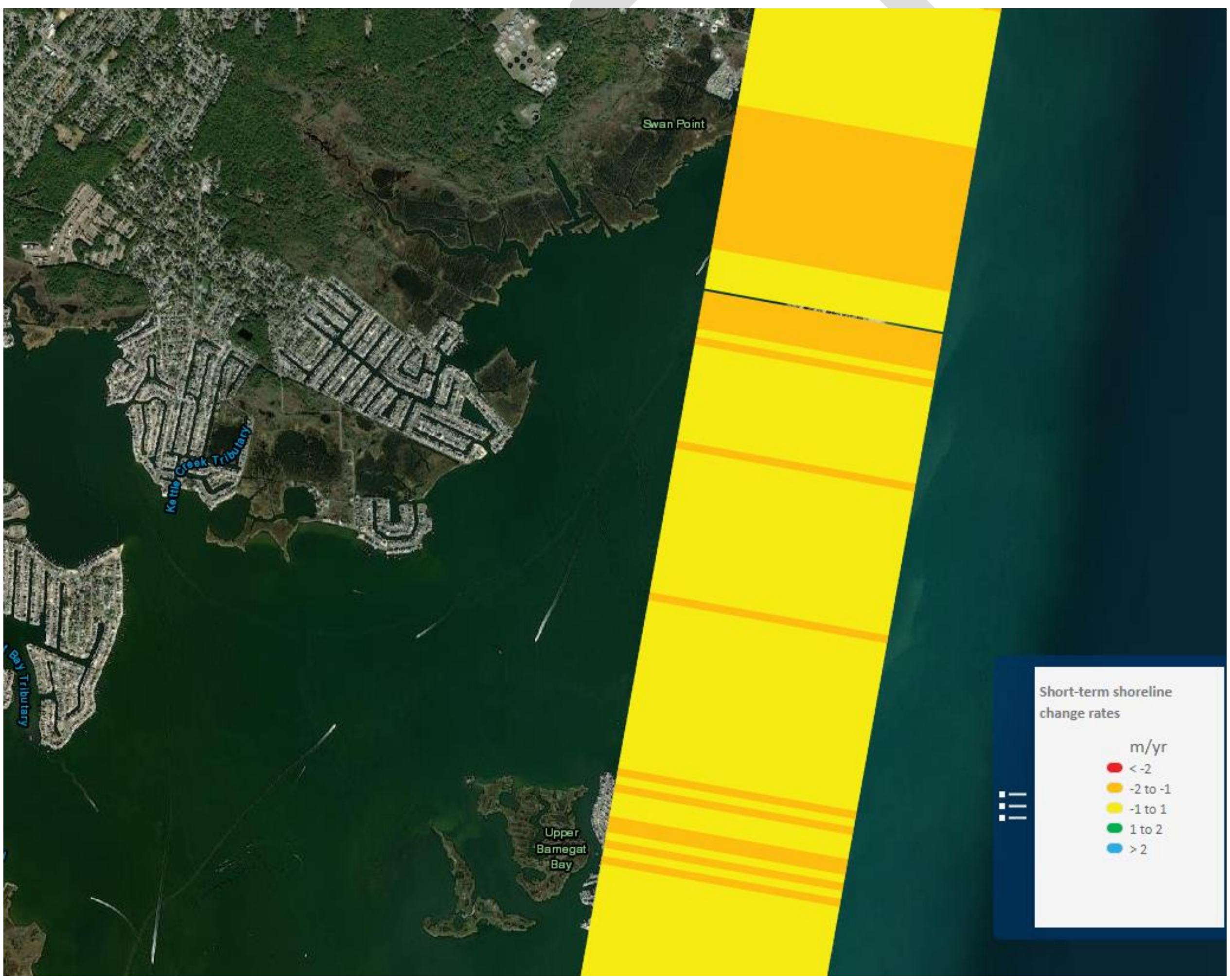
Coastal Erosion Severity

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

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

The USGS Coastal Change Hazards Portal hosts a short-term (30 years) change mapper, which displays the rate of average shoreline change on coastal shorelines. The Portal indicates that, over the past 30 years, the Township of Brick's oceanfront had a shoreline change of -2 meters to +1 meter per year. Figure 5-18 displays short-term shoreline change rates for the Township of Brick's oceanfront.

Figure 5-18. Shoreline Change Rates for the Township of Brick



Source: USGS 2021

Coastal Erosion Frequency

Coastal erosion is a frequent event and occurs because of both natural and human activities. All beaches are affected by coastal erosion, but the rate and severe erosion events vary in frequency. Chronic erosion is the gradual recession of a shoreline over a period of decades and will be impacted by wave heights, wave angles, climate changes, and human causes such as development, removal of vegetation, runoff from development, and impacts of hard structures in the coastal zone (NYS DEC 2021). Episodic erosion occurs in response to flood events or coastal storms, such as Superstorm Sandy, and is characterized by a rapid recession of the shoreline. Because coastal erosion is tied closely to other activities, frequency rates and severity levels are best evaluated in conjunction with other related hazards' probabilities and by analyzing secondary impacts from storms, human actions, and other factors.

The Township of Brick's oceanfront beaches were replenished by the USACE in 2018. The USACE has informed the Township that monitoring of coastal erosion will take place for the near future. The Stockton Coastal Research Center will also continue spring and fall beach profile sampling.

Coastal Erosion Warning Time

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

Coastal Erosion Secondary Hazard

Coastal erosion is typically a sporadic event and most typically associated with another hazard event, such as a hurricane. Additionally, erosion rates are influenced by local geographic features and man-made structures. Although most typically associated with flooding, coastal erosion can also be caused by windstorm events, which can blow beach and dune sand overland into adjacent low-lying marshes, upland habitats, inland bays, and communities. If related to a flood event, erosion is typically seen when extreme rainfall scours and erodes dunes and when inland floodwaters return through the dunes and beach face into the ocean (FEMA 1996).

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

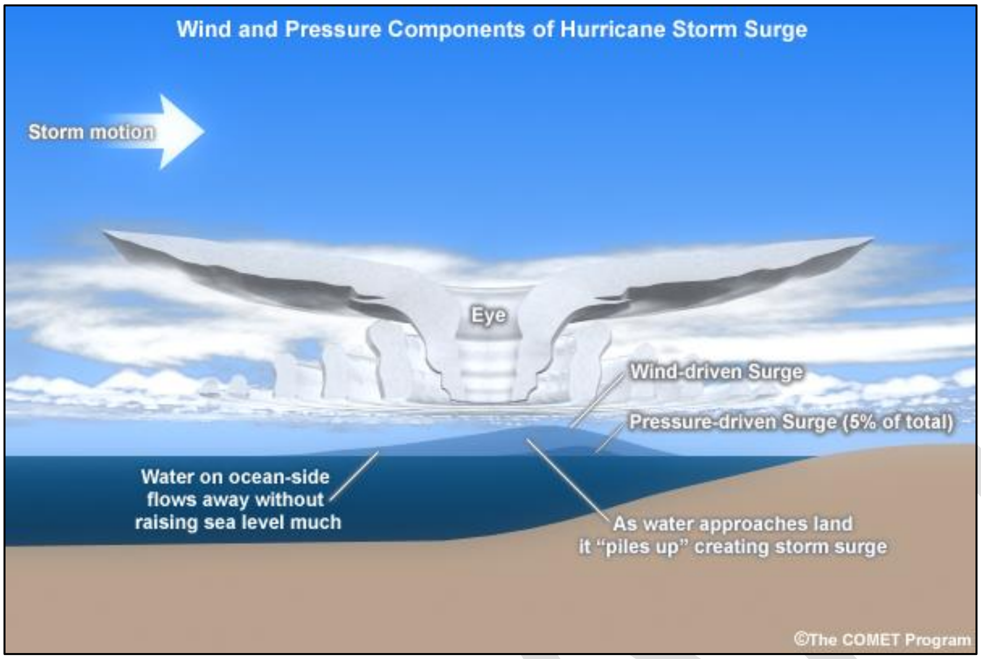
Coastal erosion is a frequent secondary hazard during coastal flooding events in Ocean County and the Township of Brick. Although not usually listed as an isolated event, coastal erosion is frequently included in a summary of damages.

5.1.5 Storm Surge Hazard

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 cause an 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 or a storm surge may inundate coastal lands for a mile or more inland from the shoreline. Figure 5-19. depicts the components of storm surge.

Figure 5-19. Storm Surge



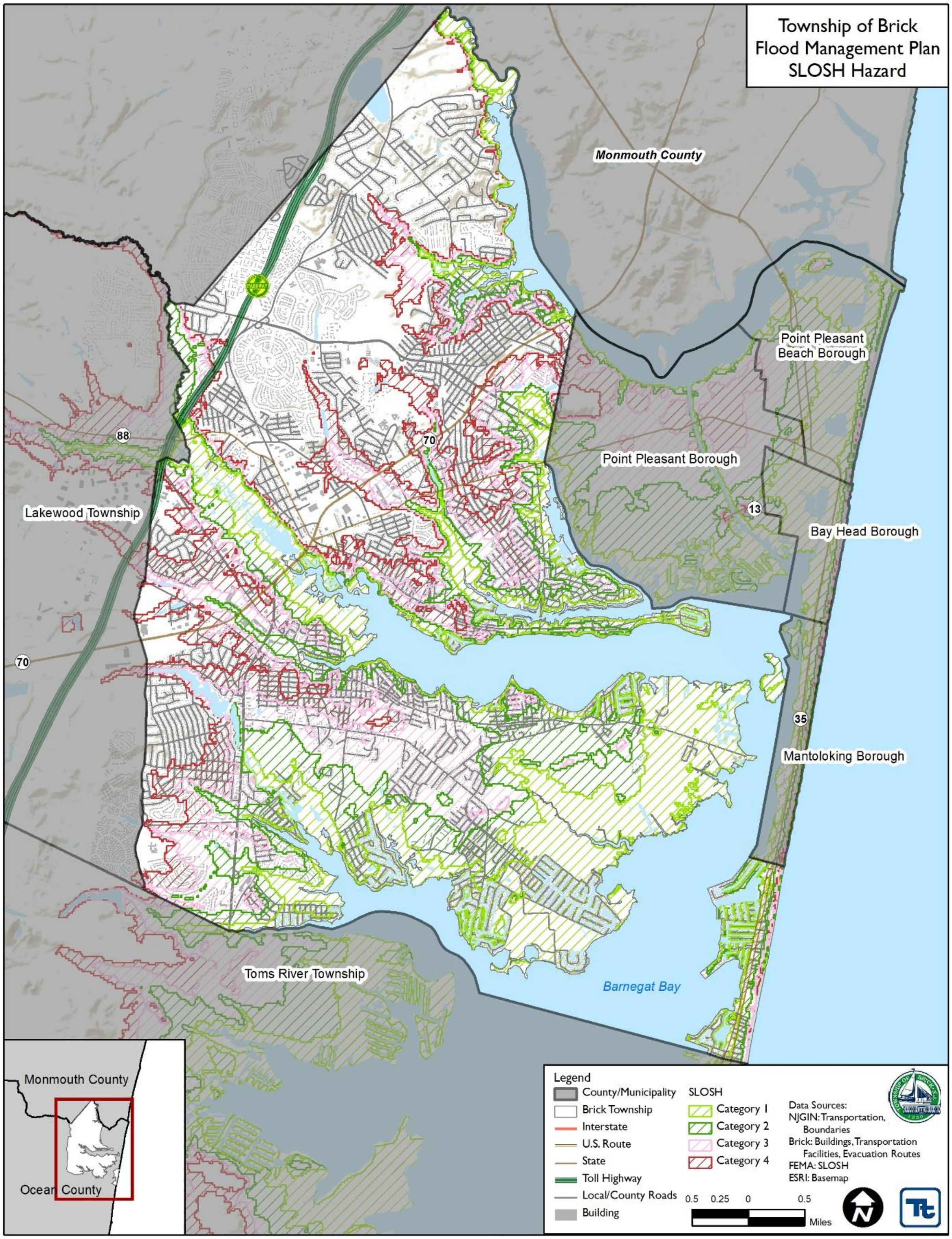
Source: NWS Date Unknown

Storm Surge Location

As noted above, inundation from storm surge has devastating impacts on coastal communities. The USACE, in cooperation with FEMA, initially prepared Sea, Lake and Overland Surge from Hurricanes (SLOSH) inundation maps. SLOSH maps represent potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide. It does not include riverine flooding caused by hurricane surge or inland freshwater flooding. The mapping was developed for the coastal communities in New Jersey using the computer model to forecast surges that occur from wind and pressure forces of hurricanes coastline topography. In New Jersey, hurricane category is the predominant factor in worst-case hurricane surges though individual storm factors (speed, size, angle of attack) can result in higher category storms having lower storm surges. The resulting inundation areas are grouped into Category 1 and 2 (dangerous), Category 3 (devastating), and Category 4 (catastrophic) classifications. The hurricane category refers to the Saffir/Simpson Hurricane Intensity Scale, summarized below.

FEMA Region IV Risk Analysis Team developed storm surge inundation grids for the State of New Jersey in a spatial format from the maximum of maximums outputs from the SLOSH model. These represent the worst-case storm surge scenarios for each hurricane category (1 through 4). To assess the Township's exposure to the hurricane/tropical surge, a spatial analysis was conducted using the SLOSH model. Refer to the Vulnerability Assessment presented later in this section. The SLOSH boundaries do not account for any inland flash flooding. Figure 5-20 illustrates the SLOSH zones and anticipated flood depths above ground level for Category 1-4 Hurricanes in the Township of Brick.

Figure 5-20. SLOSH Hazard



Source: FEMA 2012, NJGIN 2015

Storm Surge Frequency

Like coastal erosion, storm surge frequencies are tied to other hazard events. Storm surge most often occurs as a secondary threat from a hurricane or severe storm. In general, the severity of a storm can be used to roughly predict the existence of storm surge (in that a very severe storm or hurricane will likely lead to storm surge), although specific factors and details, such as the storm's intensity, approach, and angle to the shoreline, and the local coastline's geography, also play a significant role in the occurrence of storm surge.

Storm Surge Severity

Typically, storm surge is estimated by subtracting the regular/astronomical tide level from the observed storm tide. Storm surge heights can more than 25 feet. The exact height of the storm surge and which coastal areas will be flooded depends on many factors: strength, intensity, and speed of the hurricane or storm; the direction it is moving relative to the shoreline; how rapidly the sea floor is sloping along the shore; the shape of the shoreline; and the astronomical tide. Storm surge is the most damaging when it occurs along a shallow sloped shoreline, during high tide, in a highly populated, and developed area with little or no natural buffers (for example, barrier islands, coral reefs, and coastal vegetation).

The most common reference to a return period for storm surges has been the elevation of the coastal flood having a 1 percent chance of being equaled or exceeded in any given year. Detailed hydraulic analyses include establishing the relationship of tide levels with wave heights and wave run-up. The storm surge inundation limits for the 1 percent annual chance coastal flood event are a function of the combined influence of the water surface elevation rise and accompanying wave heights and wave run-up along the coastline.

A storm surge associated with storms of longer recurrence intervals may result in more storm surge flooding, higher water levels, larger waves, and an increased likelihood of dune overwash, wave damage, and possible breaching of barrier islands.

Storm Surge Warning Time

Storm surge is most frequently associated with severe coastal storms and hurricanes. To help identify and visualize areas most at risk from life-threatening surge, the NHC began issuing operationally a storm surge watch/warning graphic beginning in 2017 for tropical cyclones affecting the Gulf and Atlantic coasts of the United States. This graphic is intended to separate the watch/warning for life-threatening storm surge inundation from the previously existing wind watch/warning and serve as a call to action (NOAA NHC 2019).

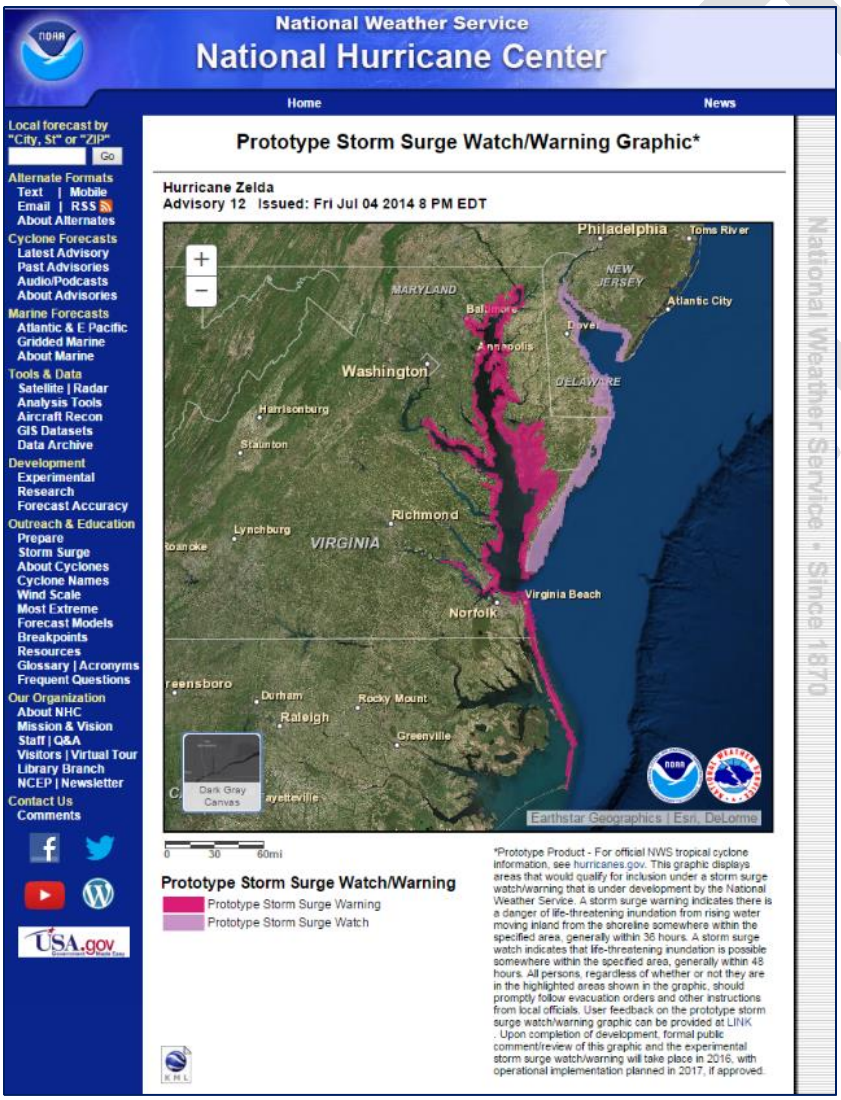
- **Storm Surge Watch:** A storm surge watch is defined as the possibility of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within 48 hours, in association with a tropical, subtropical, or post-tropical cyclone. The watch may be issued earlier when other conditions, such as the onset of tropical storm-force winds, are expected to limit the time available to take protective actions for surge (e.g., evacuations). The watch may also be issued for locations not expected to receive life-threatening inundation, but which could potentially be isolated by inundation in adjacent areas (NOAA NHC 2019).
- **Storm Surge Warning:** A storm surge warning is defined as the danger of life-threatening inundation from rising water moving inland from the shoreline somewhere within the specified area, generally within 36 hours, in association with a tropical, subtropical, or post-tropical cyclone. The warning may be issued earlier when other conditions, such as the onset of tropical storm-force winds, are expected to limit the time available to take protective actions for surge (e.g., evacuations). The warning may also be issued for locations not expected to receive life-threatening inundation, but which could potentially be isolated by inundation in adjacent areas (NOAA NHC 2019).

The Potential Storm Surge Flooding Map is based on the forecast track, intensity, and size of a tropical storm or hurricane. The storm surge watch/warning graphic takes into account:

- Flooding due to storm surge from the ocean, including adjoining tidal rivers, sounds, and bays
- Normal astronomical tides
- Land elevation
- Uncertainties in the track, landfall location, intensity, forward speed, and size of the cyclone
- Flooding inside levees, overtopping of levees, or flooding resulting from levee failures

The storm surge watch/warning graphic does not take into account wave action or freshwater flooding from rainfall (NOAA NHC 2019).

Figure 5-21. Prototype Storm Surge Watch/Warning Graphic



Source: NOAA NHC 2019

Storm Surge Secondary Hazard

Storm surge is considered the greatest threat to life and property from a hurricane. In fact, storm surge is usually the cause behind most hurricane-related deaths. Storm surge can cause significant property damage both by power and momentum of waves crashing into property and by eroding, undermining, and weakening structural foundations. This second form also contributes to additional coastal erosion and the destruction of roadways.

The NHC notes that the maximum potential for storm surge depends on a number of locational and event factors, including storm intensity, forward speed of the storm, size of the storm, the storm's angle of approach to the coast, central pressure, the width and slope of the continental shelf, and the shape and characteristics of coastal features.

Storm surge is a frequent secondary hazard during coastal flooding events in Ocean County and the Township of Brick. Although this event is sometimes categorized individually by NOAA and other hazard-tracking databases, it may also be included under a general flooding event in the summary of damages.

5.1.6 Urban Flooding Hazard

Urban flooding, also known as stormwater flooding, is a result of local drainage issues and high groundwater levels. Locally, heavy precipitation, especially during high lunar tide events, may produce flooding in areas other than delineated floodplains or along recognizable channels due to the existence of storm system outfalls that are inadequate to provide gravity drainage into the adjacent body of water. 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).

Heavy rainfall that overwhelms a developed area's stormwater infrastructure causing flooding is commonly referred to as urban flooding. Urban flooding can be worsened by aging and inadequate infrastructure and over development of land. The growing number of extreme rainfall events that produce intense precipitation are resulting in increased urban flooding (Center for Disaster Resilience 2016). While riverine and coastal flooding is mapped and studied by FEMA, urban flooding is not.

NOAA defines urban flooding as the flooding of streets, underpasses, low-lying areas, or storm drains. (NOAA 2009). Urban drainage flooding is caused by increased water runoff due to urban development and inadequate 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. The systems make use of a closed conveyance system that channels water away from an urban area to surrounding water bodies. This bypasses the natural processes of water filtration through the ground, containment, and evaporation of excess water (Harris 2008).

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 1996).

Urban Flooding Location

There are numerous areas within the Township of Brick that experience urban flooding. Typically, this flooding causes street inundation. The Township DPW regularly identifies, responds to, and mitigates urban flooding locations through cleaning stormwater components and removing debris. The Township Engineer also regularly identifies and addresses stormwater components that have become damaged or are in need of upgrade. Specific areas that have recently had flooding issues tied to stormwater components have been considered for inclusion within the action plan of this FMP.

As damages to the stormwater system can occur at any time, any area of the Township which has stormwater components may be exposed to urban flooding. Areas that have a higher percentage of impervious surface coverage are at higher risk for urban flooding due to increased stormwater runoff.

Urban Flooding Frequency

Urban flooding frequency is tied to occurrence of heavy rainfall events that exceed the carrying capacity of the stormwater system.

Urban Flooding Severity

As urban flooding is not mapped by FEMA, the severity of an urban flooding event will be determined by the urban flooding extent and depth.

Urban Flooding Warning Time

The NWS issues watches and warnings when forecasts indicate heavy rainfall may result in flash flooding events.

- **Flash Flood Watch:** A Flash Flood Watch is issued when conditions are favorable for flash flooding. It does not mean that flash flooding will occur, but it is possible.
- **Flash Flood Warning:** A Flash Flood Warning is issued when flash flooding is imminent or occurring.

Urban Flooding Secondary Hazard

Urban flooding can increase the threat of future urban flooding events due to potential damages and debris clogs that the stormwater infrastructure may incur during the flooding event.

5.1.7 Dam Failure Hazard

A dam is an artificial barrier that has the ability to store water, wastewater, or liquid-borne materials for many reasons (flood control, human water supply, irrigation, livestock water supply, energy generation, containment of mine tailings, recreation, or pollution control. Many dams fulfill a combination of these stated functions (Association of State Dam Safety Officials 2013). Dams are an important resource in the United States.

Man-made dams can be classified according to the type of construction material used, the methods used in construction, the slope or cross-section of the dam, the way the dam resists the forces of the water pressure behind it, the means used for controlling seepage, and, occasionally, the purpose of the dam. The materials used for construction of dams include earth, rock, tailings from mining or milling, concrete, masonry, steel, timber, miscellaneous materials (plastic or rubber), and any combination of these materials (Association of State Dam Safety Officials 2013).

Dam failures typically occur when the spillway capacity is inadequate and excess flow overtops the dam, or when internal erosion (piping) through the dam or foundation occurs. Complete failure occurs if internal erosion or overtopping results in a complete structural breach, releasing a high-velocity wall of debris-filled waters that rush downstream damaging and/or destroying anything in its path (FEMA 1996).

Dam failures can result from one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam
- Deliberate acts of sabotage
- Structural failure of materials used in dam construction
- Movement and/or failure of the foundation supporting the dam
- Settlement and cracking of concrete or embankment dams
- Piping and internal erosion of soil in embankment dams
- Inadequate maintenance and upkeep (FEMA 2013a)

Dam Failure Location

According to the U.S. Army Corps of Engineers (USACE) National Inventory of Dams (NID), four dams are located in the Township of Brick as displayed in Figure 5-4. Table 5-4 summarizes the number of dams and their hazard classifications in the Township of Brick.

Table 5-7. Dams in the Township of Brick by Hazard Ranking

Dam Name	River	Hazard	Use
Rainbow Dam	Kettle Creek	High	Recreation
Lake Riveria Dam	Kettle Creek	Significant	Recreation
Route 88 Dam	Beaverdam Creek	Significant	Recreation
BTMUA Reservoir Dam	Brick Twp Reservoir	High	Water Supply

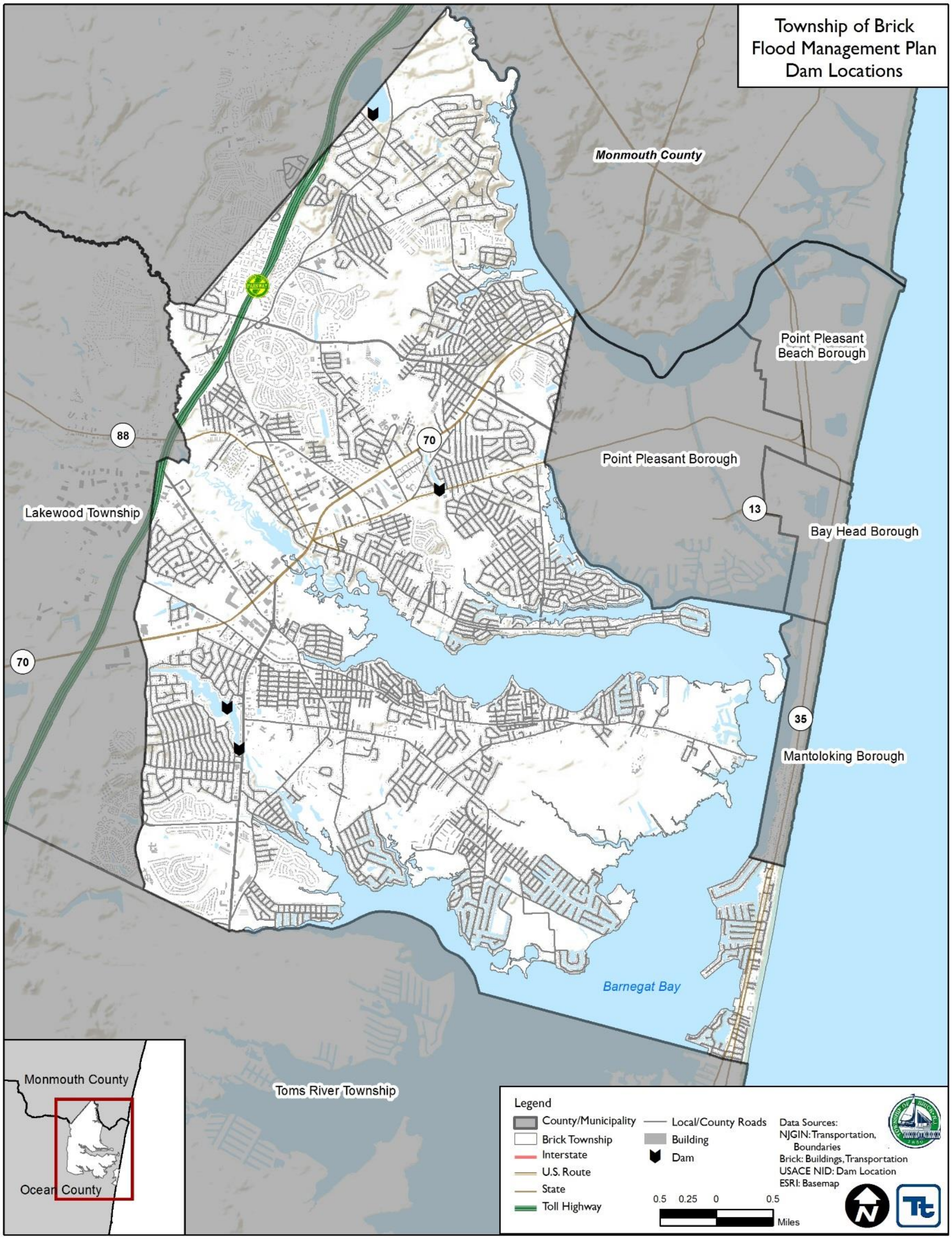
Source: USACE 2021

Dam Failure Frequency

Dam failures are difficult to predict and do not necessarily have an associated frequency. While large or catastrophic dam failures tend to be of greater concern to planners, municipal officials, and local residents, an analysis by the Nuclear Regulatory Commission (NRC) has indicated that causes for catastrophic failures are about the same as those due to the entire dam population. This means that planners and municipal officials should concentrate on mitigating the same types of potential damage causes for dams at greater risk of catastrophic failure as for those with lower risk failure. These causes include overtopping due to the exceedance of the reservoir level (often due to severe storms or heavy rainfall), foundation effects and internal erosion, poor design and maintenance, operational and mechanical failures, or seismic events and earthquakes.

Frequency cannot be determined as a consistent probability since dam failures are a non-natural hazard. Although probabilities can be estimated, vulnerability is unique to each dam in question (in regards to dam type, age, and previous incident information). While anecdotal and historical events are typically used as a basis for calculating risk and frequency, it must be recognized that these events may lack clarity or detailed information and data (Ferrante, Bensi, Mitman [n.d.]).

Figure 5-22. Dams Located in the Township of Brick



Source: USACE 2021, NJGIN 2015

Dam Failure Severity

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 is often evaluated by examining peak discharges.

The extent or magnitude of a dam failure event can be measured in terms of the classification of the dam. Additionally, the two factors that influence the potential severity of a full or partial dam failure are: (1) the amount of water impounded; and (2) the density, type, and value of development and infrastructure located downstream (City of Sacramento Development Service Department 2005). There are several classification tools used to identify the hazards of dam. FEMA, USACE, and NJDEP all have a form of classifying hazards. For the purpose of this Flood Management Plan, the NJDEP hazard classification will be explained in this section. Refer to the *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams* (2004) and *Safety of Dams – Police and Procedures* (2014) for an explanation of the FEMA and USACE classifications, respectively.

The NJDEP has four hazard classifications for dams located in New Jersey. The classifications relate to the potential of property damage and/or loss of life should a dam fail. The classifications are as follows:

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

It is required by the State of New Jersey that all High Hazard and Significant Hazard dams must have NJDEP-approved Emergency Action Plans (EAP) in place. It is the responsibility of the dam owner to review and update the EAP on an annual basis. The New Jersey Dam Safety Standards also require that dams are periodically inspected to identify conditions that may adversely affect the safety and functionality of a dam and its appurtenant structures; to note the extent of deterioration as a basis for long-term planning, periodic maintenance or immediate repair; to evaluate conformity with current design and construction practices; and to determine the appropriateness of the existing hazard classification. Inspection guidelines, as identified in the NJ HMP, are reproduced in Table 5-8 in brief. Complete inspection and operating requirements for dams can be found in the New Jersey Dam Safety Standards (N.J.A.C 7:20-1.11).

Table 5-8. New Jersey Dam Inspection Requirements

Dam Size/Type	Regular Inspection	Formal Inspection
Class I (High Hazard) Large Dam	Annually	Once every 3 years
Class I (High Hazard) Dam	Once every 2 years	Once every 6 years
Class II (Significant Hazard) Dam	Once every 2 years	Once every 10 years
Class III (Low Hazard) Dam	Once every 4 years	Only as required

Dam Size/Type	Regular Inspection	Formal Inspection
Class IV (Zero Hazard) Dam	Once every 4 years	Only as required

Source: NJ HMP 2014

In New Jersey, every dam in the state, as defined in the Safe Dam Act, N.J.S.A. 58:4, is required to meet state dam safety standards. The State dam safety laws and regulations provide the NJDEP with enforcement capabilities and powers to achieve statewide compliance with dam safety standards. This includes issuing orders for compliance to dam owners, and pursuing legal action if the owner does not comply (with the goal of compliance and possible fines levied on a per-day basis for violations). Of the four dams in the Township of Brick, the Brick Township Municipal Utilities Authority (BTMUA) Reservoir Dam and Rainbow Dam are classified as Class I dams, while the Lake Riviera Dam and Route 88 Dam are considered Class II dams.

Flood severity from a dam failure can be measured with a low, medium, or high severity level, which are further defined as follows:

- **Low severity -** No buildings are washed off their foundations; structures are exposed to floodwater depths of less than 10 feet.
- **Medium severity -** Homes are destroyed but trees or mangled homes remain for people to seek refuge in or on; structures are exposed to floodwater depths of more than 10 feet.
- **High severity -** Floodwaters sweep the area and nothing remains. Locations are flooded by the near instantaneous failure of a concrete dam, or an earthfill dam that turns into "jello" and washes out in seconds rather than minutes or hours. In addition, the flooding caused by the dam failure sweeps the area clean and little or no evidence of the prior human habitation remains after the floodwater recedes (Graham 1999).

Dam Failure Warning Time

Dams can fail with little warning. Intense storms may produce a flood in a few hours or even minutes for upstream locations. Flash floods can occur within six hours of the beginning of heavy rainfall, and dam failure may occur within hours of the first signs of breaching. Other failures and breaches can take much longer to occur, from days to weeks, as a result of debris jams, the accumulation of melting snow, buildup of water pressure on a dam with deficiencies after days of heavy rain, and other factors. Flooding can occur when a dam operator releases excess water downstream to relieve pressure from the dam (FEMA 2018).

Warning time for dam failure varies depending on the cause of the failure. In events of extreme precipitation or massive snowmelt, evacuations can be planned with sufficient time. In the event of a structural failure because of an earthquake, there may be no warning time. A dam's structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours (USACE 2019).

High and significant hazard dam owners are required to prepare and maintain an EAP. The EAP is to be used in the event of a potential dam failure or uncontrolled release of stored water. Owners are also required to have established protocols for flood warning and response to imminent dam failure in the flood warning portion of its adopted emergency operations plan (EOP). These protocols are tied to the EAPs also created by the dam owners. These documents are customarily maintained as confidential information, although copies are required to be provided to the NJDEP for response purposes. State and local offices of emergency management also have copies of the approved EAPs.

Dam Failure Secondary Hazard

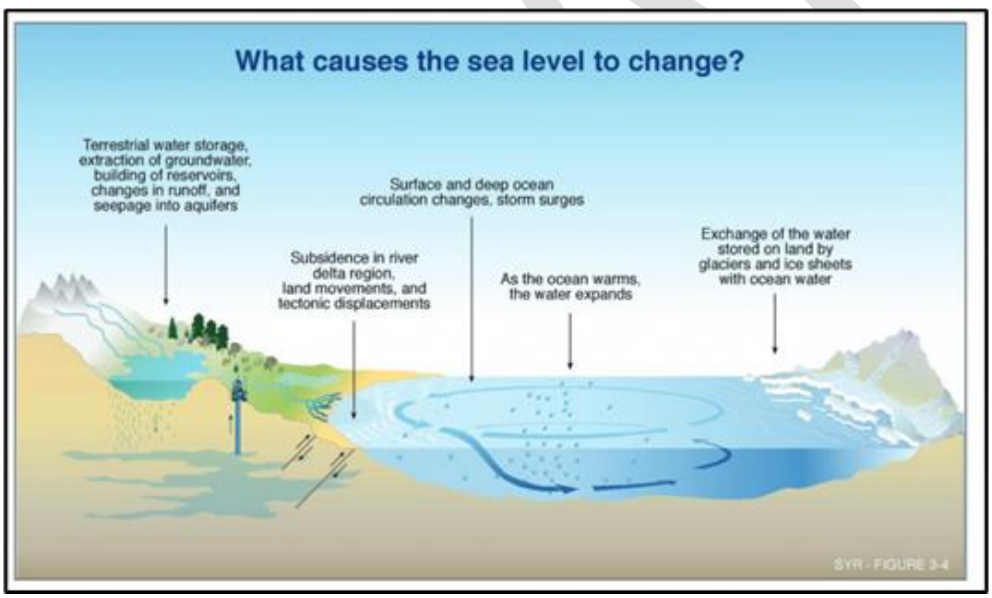
Dam failure can cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary hazards of dam failure are landslides around the reservoir perimeter, bank erosion on the rivers, and destruction of downstream habitat. Dam failures can occur as a result of structural failures, such as progressive erosion of an embankment or overtopping and breaching by a severe flood. Earthquakes may weaken dams. Floods caused by dam failures have caused loss of life and property damage (FEMA 1996). To date, there have been no recorded incidents or events at any of the dams located in the Township of Brick.

5.1.8 Sea Level Rise Hazard

Sea level rise associated with climate change will have significant effects on coastal areas, including the Township of Brick. Long-term sea level records show changes in global temperatures, hydrologic cycles, coverage of glaciers and ice sheets, and storm frequency and intensity. Sea levels provide a key to understanding the impact of climate change.

There are two types of sea level: global and relative. Global sea level rise refers to the increase currently observed in the average global sea level trend (primarily attributed to changes in ocean volume due to ice melt and thermal expansion). The melting of glaciers and continental ice masses can contribute significant amounts of freshwater input to the earth's oceans. In addition, a steady increase in global atmospheric temperature creates an expansion of salt water molecules, increasing ocean volume. Figure 5-23 illustrates the causes of sea level change.

Figure 5-23. Causes of Sea Level Change



Source: U.S. Climate Resilience Toolkit 2019

Local sea level refers to the height of the water as measured along the coast relative to a specific point on land. Water level measurements at tide stations are referenced to stable vertical points on the land and a known relationship is established. Measurements at any given tide station include both global sea level rise and vertical land motion (subsidence, glacial rebound, or large-scale tectonic motion). The heights of both the land and water are changing; therefore, the land-water interface can vary spatially and temporally and must be defined over time. Relative sea level trends reflect changes in local sea level over time and are typically the most critical sea level trend for many coastal applications (coastal mapping, marine boundary delineation, coastal zone management, coastal engineering, and sustainable habitat restoration) (U.S. Climate Resilience Toolkit 2019).

Short-term variations in sea level typically occur on a daily basis and include waves, tides, or specific flood events. Long-term variations in sea level occur over various time scales, from monthly to several years and may be repeatable cycles, gradual trends, or intermittent differences. Seasonal weather patterns (changes in the earth's declination), changes in coastal and ocean circulation, anthropogenic influences, vertical land motion, etc. may influence changes in sea level over time. When estimating sea level trends, a minimum of 30 years of data are used in order to account for long-term sea level variations and reduce errors in computing sea level trends based on monthly mean sea level (U.S. Climate Resilience Toolkit 2019).

Sea Level Rise Location

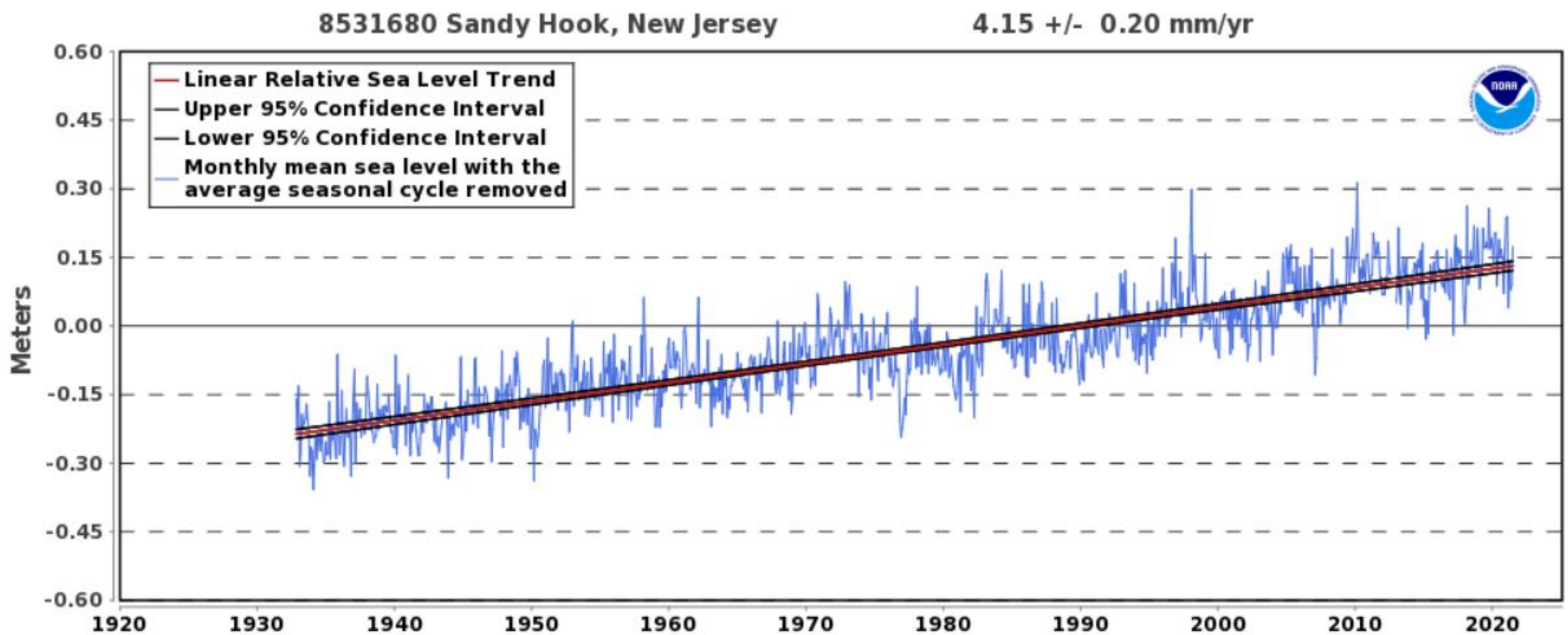
In New Jersey, sea levels are rising faster than they are globally due to changes in the Gulf Stream, localized land subsidence, and continued geologic influences as land slowly adjusts to the loss of the North American ice sheet at the end of the last ice age. In Atlantic City, Cape May, and Sandy Hook, sea-level has risen at a rate of approximately 0.2 to 0.5 inches per year since the beginning of the 20th century, and this rate will continue to increase (Kopp et al. 2019). The amount of greenhouse gases that are emitted is tied to rates of sea level rise. By 2050, New Jersey will likely experience at least a 0.9 to 2.1-foot increase (above the levels in 2000; all emissions scenarios), 1.4 to 3.1-foot increase by 2070 (moderate emissions scenario), and potentially a 2.0 to 5.1-foot increase by 2100 (moderate emissions scenario) (Kopp et al. 2019). Understanding how precipitation and sea level rise will change in the future is vital to New Jersey's coastal zone because low-lying coastal areas are already experiencing tidal flooding, even on sunny days in the absence of precipitation events.

Figure 5-24 shows the linear sea level rise trends for the Sandy Hook, New Jersey tidal gage, the long term tide gage nearest to the Township of Brick. Figure 5-25 shows the extent of sea level rise when combined with the 1 percent annual chance flood event.

Per the Township of Brick 'Getting to Resiliency Recommendations Report' (2014), even the relatively low end scenario of one foot of sea level rise will require adaptation as numerous streets and low lying bayside communities will see fairly regular tidal inundation including the Island Drive community, the David Beaton & Sons Boatyard, Jersey Shore Marina and Boat Sales, and western portions of Shore Acres. Scientists anticipate the arrival of one foot of sea level rise before 2050. As sea level rise is expected to accelerate this century, three feet of sea level rise is very likely before 2100.

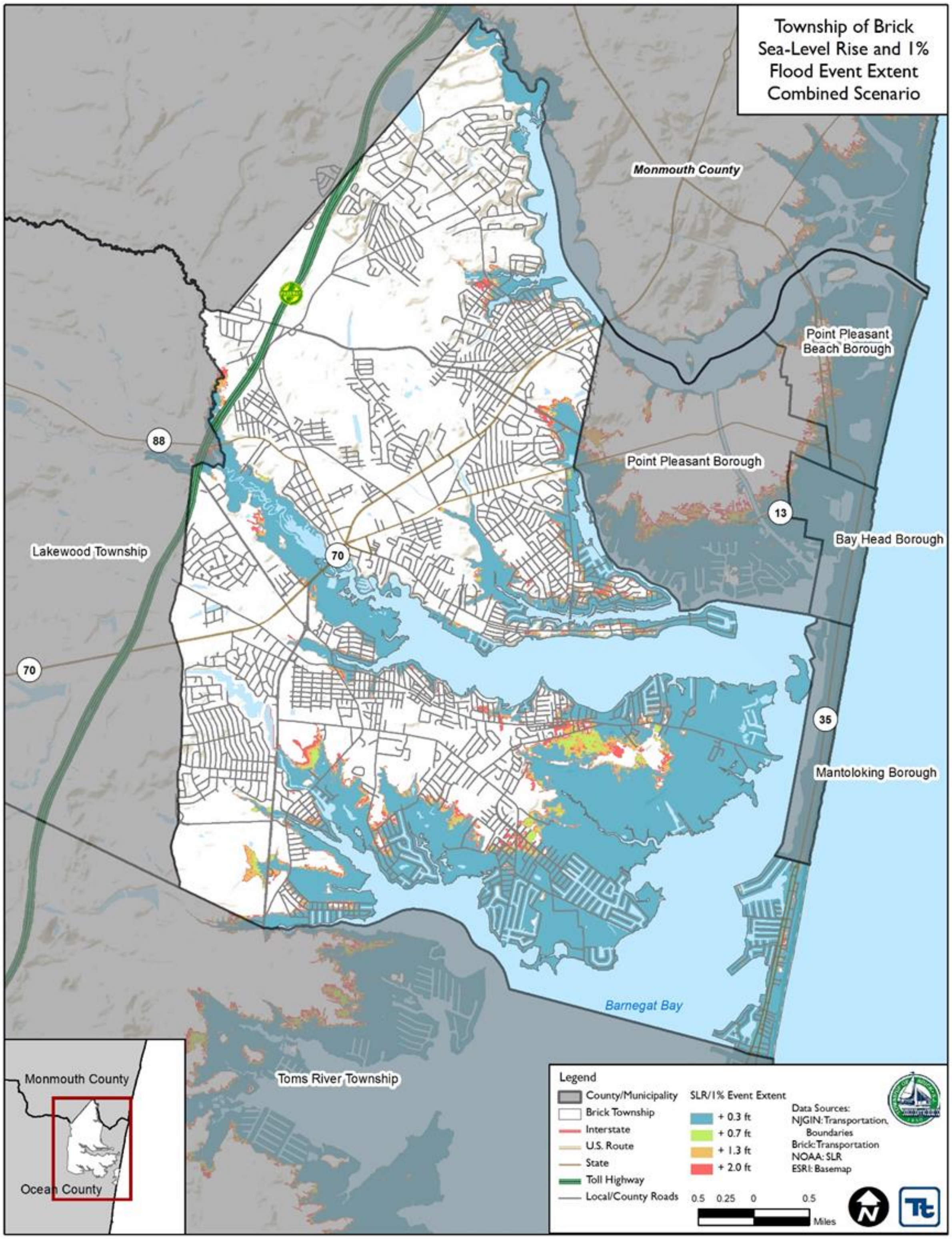
Furthermore, two feet of sea level rise would result in regular tidal flooding slowly impacting more of the bayside communities resulting in the isolation of the Mandalay section of the Township. Portions of Baywood, the eastern section of the Metedeconk community, properties bordering Beaverdam Creek, Bay Harbor Estates, the end of Tunes Brook Drive, and the Sandy Point community would begin to flood. The Island Drive community, the David Beaton & Sons Boatyard, Jersey Shore Marina and Boat Sales, and western portions of Shore Acres would experience heavy flooding. Three feet of sea level rise would result in regular tidal inundation near the shorelines of almost all waterfront communities. Shore Acres, Baywood and West Mantoloking would be impacted. The Cherry Quay community would experience street flooding along Royal Drive, Perch Creek, Captains Drive, and Seagoin Road. A three feet rise would also begin to impact the evacuation route of Mantoloking Road. However, the barrier island area of Brick appears to be one of the last waterfront areas impacted by sea level rise. Any level of inundation due to regular tidal flooding would have large scale impacts on emergency response. Sea level rise would also result in greater impact of storm events as a surge atop a higher sea level will be more dramatic than the same surge atop a lower sea level (Brick Township "Getting to Resilience" Recommendations Report 2014).

Figure 5-24. Linear Mean Sea Level Trend-Sandy Hook, New Jersey



Source: NOAA Tides and Currents 2021

Figure 5-25. Sea Level Rise and 1% Chance Flood Event Combined Scenarios for the Township of Brick



Sea Level Rise Frequency

Sea level change is an ongoing process and can be monitored on both long-term and shorter-term scales. Global sea level changes are due to the changes in the volume of water in ocean basins through thermal expansion, glacial melt, or net changes in the size of ocean basins. In fact, global sea rise has been occurring for the past 20,000 years as a natural result of glacial maximum decline.

Local and shorter-term sea level rise frequency is not as continuous but can still be predicted by surrounding factors. Permanent sea level rise will be more noticeable and frequent in low-lying areas already close to sea level or bayside locations. Sea level rise frequency can be partially predicted by nearby human activity, as mitigation measures like sea walls, levels, or dikes can affect the location and extent of the sea level rise.

Sea Level Rise Severity

Sea level rise severity is attributed to the number of feet sea level rises and the rate at which sea level rise takes place. A faster rate of sea level rise results in less ability of coastal municipalities to protect from and adapt to higher water levels and increased coastal flooding frequency.

The table below (Table 5-9) shows the “low”, “high”, and “best” estimates for sea level rise projects in New Jersey for the years 2050 and 2100. “Best” refers to a 50 percent likelihood of that level of sea level rise occurring.

Table 5-9. Sea Level Rise Projections for New Jersey (ft. above year 2000 average sea level) for New Jersey From 2030 to 2150 Under Low, Moderate and High Emissions Scenarios.

	Chance SLR Exceeds	2030	2050	2070 Emissions			2100 Emissions			2150 Emissions		
				Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Low End	>95% chance	0.3	0.7	0.9	1.0	1.1	1.0	1.3	1.5	1.3	2.1	2.9
Likely Range	>83% chance	0.5	0.9	1.3	1.4	1.5	1.7	2.0	2.3	2.4	3.1	3.8
	~50% chance	0.8	1.4	1.9	2.2	2.4	2.8	3.3	3.9	4.2	5.2	6.2
	<17% chance	1.1	2.1	2.7	3.1	3.5	3.9	5.1	6.3	6.3	8.3	10.3
High End	<5% chance	1.3	2.6	3.2	3.8	4.4	5.0	6.9	8.8	8.0	13.8	19.6

Source: Kopp et al. 2019
Note: The likely range represents the range of levels between which there is 66% chance that SLR will occur

Sea Level Rise Warning Time

Through NOAA, the Center for Operational Oceanographic Products and Services has measured sea level heights and rates for more than 150 years. The center calculates the mean sea level. This is calculated with sea level rises and falls, at 210 long-term water level stations. The center averages results at a monthly level to remove the effect of higher frequency phenomena and to determine a linear sea level trend.

NOAA identifies multiple factors that influence both short- and long-term sea level changes. While short-term variations fluctuate daily and include waves, tides, or flood events, long-term variations occur on a larger scale, most typically months to years. Long-term sea level changes can include gradual trends, repeatable cycles, or intermittent anomalies, and they may be influenced by seasonal weather patterns, variations in the Earth's declination, changes in coastal and ocean circulation, anthropogenic influences (such as dredging), vertical land motion, and the El Niño Southern Oscillation. Thus, while short-term sea level rises may have little warning time, long-term and consistent sea level rises are gradual and can be predicted through detailed observations, typically allowing for ample warning.

Sea Level Rise Secondary Hazard

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. Other secondary hazards that could occur along the Mid-Atlantic coast in response to sea level rise include:

- *Bluff and upland erosion* – Shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments (Gutierrez et al. 2007).
- *Overwash, inlet processes, shoreline retreat, and barrier island narrowing* – As sea level rise occurs, storm overwash will become more likely. Tidal inlet formation and migration will become important components of future shoreline changes. Barrier islands are subject to inlet formation by storms. If the storm surge produces channels that extend below sea level, an inlet may persist after the storm. The combination of rising sea level and stronger storms can create the potential to accelerate shoreline retreat in many locations. Assessments of shoreline change on barrier islands have shown that barrier island narrowing has been observed on some islands over the last 100 years (Gutierrez et al. 2007).
- *Threshold behavior* – Changes in sea level rise can lead to conditions where a barrier system becomes less stable and crosses a geomorphic threshold; making the potential for rapid barrier island migration or segmentation/disintegration high. Unstable barriers may be defined by rapid landward recession of the ocean shoreline, decrease in barrier width and height, increased overwashing during storms, increased barrier breaching and inlet formation, or chronic loss of beach and dune sand volume. With the rates of sea level rise and climate change, it is very likely that these conditions will worsen (Gutierrez et al. 2007).
- *Loss of critical habitat* – Natural ecosystems may be impacted by warmer temperatures and associated changes in the water cycle. The changes could lead to loss of critical habitat and further stresses on some threatened and endangered species (Rutgers 2013).

5.2 Previous Occurrences and Losses

Many sources provided flooding information regarding previous occurrences and losses associated with flooding events throughout the Township of Brick. With multiple sources reviewed for the purpose of this Flood Management Plan, loss and impact information for many events could vary depending on the source and the accuracy of monetary figures is based on information available at the time of development of this plan.

5.2.1 FEMA Major Disasters and Emergency Declarations

Between 1954 and 2021, FEMA included Ocean County in four flood-specific major disaster (DR) or emergency (EM) declarations. The County has also received 16 declarations for events including one or a combination of the following disaster types: severe storms, flooding, hurricanes, tropical depressions, heavy rains, landslides, ice storms, high tides, Nor'easters, tornadoes, snowstorms, severe winter storms, and inland/coastal flooding. Table 5-10 lists FEMA DR and EM declarations that have been declared for Ocean County for flood related events.

Table 5-10. FEMA DR and EM Declarations for Flood Events in Ocean County, 1954 to 2021

FEMA Declaration Number	Date(s) of Event	Date of Declaration	Event Type
DR-310	September 4, 1971	September 4, 1971	New Jersey Heavy Rains and Flooding

FEMA Declaration Number	Date(s) of Event	Date of Declaration	Event Type
DR-519	August 21, 1976	August 21, 1976	New Jersey Severe Storms, High Winds, Flooding
DR-701	March 28 to April 8, 1984	April 12, 1984	New Jersey Coastal Storms, Flooding
DR-936	January 4, 1992	March 3, 1992	New JerseySevere Coastal Storm
DR-973	December 10 to 17, 1992	December 18, 1992	New Jersey Coastal Storm, High Tides, Heavy Rain, Flooding
EM-3106	March 13 to 17, 1993	March 17, 1993	New Jersey Severe Blizzard
DR-1088	January 7 to 12, 1996	January 13, 1996	New Jersey Blizzard
DR-1206	February 4 to 8, 1998	March 3, 1998	New Jersey Coastal Storm
EM-3148	September 16 to 18, 1999	September 16, 1999	Hurricane Floyd
DR-1867	November 11 to 15, 2009	December 22, 2009	New Jersey Severe Storms And Flooding Associated With Tropical Depression Ida And A Nor'easter
DR-1897	March 12 to April 15, 2010	April 2, 2010	New Jersey Severe Storms and Flooding
EM-3332	August 26 to September 5, 2011	August 27, 2011	Hurricane Irene
DR-4021	August 26 to September 5, 2011	August 31, 2011	Hurricane Irene
EM-3354	October 28 to 30, 2012	October 28, 2012	Superstorm Sandy
DR-4086	October 28 to 30, 2012	October 30, 2012	Superstorm Sandy
DR-4264	January 22 to 24, 2016	March 14, 2016	New Jersey Severe Winter Storm And Snowstorm

Source: FEMA 2021

Flood Events

Known flood events, including FEMA disaster declarations that have impacted the Township of Brick between 1950 and 2021, are identified in Table 5-11. Event details include specific information to the Township of Brick where available and information from regional locations that likely had similar flooding impacts.

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
September 4, 1971	Heavy Rains, Flooding	DR-310	Yes	Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan. The following counties were designated under the FEMA DR for this event - Atlantic, Bergen, Burlington, Camden, Cape May, Cumberland, Essex, Gloucester, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Passaic, Salem, Somerset, Sussex, Union, and Warren.
August 21, 1976	Severe Storms, High Winds, Flooding	DR-519	Yes	Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan. The following counties were designated under the FEMA DR for this event - Atlantic, Cape May, Monmouth, and Ocean.
April 12, 1984	Coastal Storms, Flooding	DR-701	Yes	Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan. The following counties were designated under the FEMA DR for this event - Atlantic, Bergen, Cape May, Essex, Monmouth, Morris, Ocean, and Passaic.
March 3, 1992	Severe Coastal Storm	DR-936	Yes	Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan. The following counties were designated under the FEMA DR for this event - Atlantic, Cape May, Cumberland, Monmouth, and Ocean.
December 18, 1992	Coastal Storm, High Tides, Heavy Rain, Flooding	DR-973	Yes	Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan. The following counties were designated under the FEMA DR for this event - Atlantic, Bergen, Cape May, Cumberland, Essex, Hudson, Middlesex, Monmouth, Ocean, Salem, Somerset, and Union.
March 13 to 17, 1993	Blizzard, Coastal Erosion	EM-3106	Yes	The “Storm of the Century” resulted in coastal flooding and erosion on the New Jersey coast.
January 7-12, 1996	Coastal Flood, Coastal Erosion, Blizzard	DR-1088	Yes	Strong northeasterly flow during the Blizzard of ’96 produced moderate coastal flooding at the time of high tide on the evening of the 7th, with tides 3 to 4 feet above normal. Fortunately, winds switched to the northwest before worse flooding could occur at high tide on the morning of the 8th. Estimated regional property damage of $6.5 million. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
June 17, 1996	Flash Flood	N/A	N/A	A cluster of thunderstorms with torrential downpours dropped as much as 4 inches of rain (reported in Tuckerton Borough in Ocean County) during the afternoon of June 17. This caused considerable urban and poor drainage flooding, especially in the Township of Stafford (Ocean County). Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
August 29, 1996	High Surf	N/A	N/A	Rough surf, associated with Hurricane Edouard affected the coastal areas of New Jersey around the Labor Day Weekend and caused two drownings and one serious injury. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
September 17, 1996	Flash Flood	N/A	N/A	Heavy rain, associated with the remnants of Pacific Hurricane Fausto impacted Ocean County. The heavy rain from this event caused flooding throughout the county. Flooding led to road and bridge closures. Rainfall totals ranged from 2.97 inches to over 6 inches. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
October 19, 1996	Coastal Flood	N/A	N/A	In Ocean County, bay flooding was reported around Seaside Park and Ship Bottom. In Harvey Cedars several north-south roads were closed. In Toms River, back bay/river flooding approached several homes. In Point Pleasant Beach flooding was reported over the seawall and onto the Inlet Drive parking lot.
December 8, 1996	Coastal Flood	N/A	N/A	A low pressure system developed over South Carolina and Georgia the morning of December 7 and moved quickly northeast passing over the Delmarva Peninsula during the late afternoon of December 7 and just east of the New Jersey coast during the evening of December 7. The onshore flow accompanying the low pressure system kept the tide from receding overnight and the ensuing high tide the morning of December 8 was about 2 feet above normal south of Manasquan Inlet. Only minor tidal flooding was reported along New Jersey's coast. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
December 13, 1996	Coastal Flood	N/A	N/A	In Ocean County, back bay flooding inundated Ship Bottom's Central Avenue from 26th through 29th Streets. Eight blocks in Ocean City were closed due to flooding.
June 2, 1997	Coastal Flood	N/A	N/A	A series of low pressure systems moving east off the North Carolina coast and a relatively strong high pressure system over Eastern Canada brought a strong and persistent northeast flow from June 2 through 4. The onshore flow peaked during the evening of June 2 and the morning of June 3 and produced some minor tidal flooding at times of high tide. The heavy surf also caused some minor beach erosion. Specific

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
July 16, 1997	Flash Flood	N/A	N/A	Thunderstorms dropped torrential rains within about 90 minutes over southern parts of Ocean County in Barnegat, Ocean, and Stafford Townships. Four inches of rain fell in Barnegat. This caused considerable urban flooding as well as flooding of some of the creeks in Southern Ocean County. Lower Shore Road had considerable flooding in Barnegat Township.
July 24, 1997	Flood	N/A	N/A	Heavy rain, associated with weak low pressure systems riding along a nearly stationary frontal boundary in the southern Delmarva Peninsula, caused urban flooding, especially on the back bay sides of the barrier islands of Atlantic, Cape May, and Ocean Counties.
August 20, 1997	Coastal Flood	N/A	N/A	Very strong onshore winds coupled with torrential rain, that nearly coincided with the high tide along the back bays caused moderate tidal flooding along the barrier islands of Atlantic, Cape May, and Ocean Counties.
August 20, 1997	Flash Flood	N/A	N/A	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. A series of thunderstorms developed along this low pressure system's frontal boundaries and trained or moved over the same areas. This caused extremely heavy rain to fall over several hours especially across southern parts of Ocean County. Rainfall totals in the county ranged from 4.75 inches in East Dover to over 10 inches in Little Egg Harbor Township. No injuries or fatalities were reported for this event. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
September 1, 1997	Flash Flood	N/A	N/A	A severe thunderstorm produced frequent lightning and torrential downpours. This caused small stream flooding and urban flooding in parts of Ocean County. It was estimated that rain fell at three inches within one hour over parts of northern Ocean County.
November 14, 1997	Coastal Flood	N/A	N/A	In Ocean County, Harvey Cedars reported severe erosion and also lost some dune fencing. Barnegat Bay tidal flooding also occurred on Cedar Bonnet Island, Little Egg Harbor Township and Tuckerton. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
December 29, 1997	Coastal Flood	N/A	N/A	This low pressure system brought heavy rain to a large part of the state, high winds to Monmouth and Ocean Counties as it was intensifying, and some minor tidal flooding at the times of the evening high tide on December 29. The heavy rain in most places

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				coincided with the incoming tide and this exacerbated the poor drainage flooding along the coastal communities. In Ocean County, the tides and heavy rain forced the closure of several main roadways and one traffic circle in Long Beach Township, Ship Bottom, and Surf City. In addition to the heavy rain and tides, wind gusts reached around 60 mph and knocked down trees and power lines. GPU Energy reported about 6,300 homes and businesses lost power from Middletown Township in Monmouth County south through Toms River in Ocean County. Peak wind gusts included 61 mph in Brighton Beach and 57 mph in Harvey Cedars (both in Ocean County). Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
February 4, 1998	Coastal Flood	N/A	N/A	The strongest Nor'easter of the winter battered Coastal New Jersey, especially from Ocean County southward, with damaging winds, moderate to severe coastal flooding, extensive beach erosion, several dune breaches, and heavy rain.
February 17, 1998	Coastal Flood	N/A	N/A	A low pressure system moved from coastal North Carolina the morning of February 17 to about 150 miles east of Manasquan Inlet, New Jersey the morning of February 18. A strong high pressure system was anchored over Maine and the Canadian Maritimes at the same time. The difference in surface pressure between them produced strong gusty winds mainly during the afternoon of February 17. This also prevented the tide from receding during the low tide cycle around 6:00 p.m. Winds diminished by the time of the late evening/early morning tide on February 17 and 18. Nevertheless, the onshore flow helped produce some minor tidal flooding. The onshore winds lasted only one tide cycle and the astronomical tides were low. Thus, in spite of tidal departures of about 3 feet above normal, tidal flooding was only at the low end of the minor range. No serious damage was reported.
February 24, 1998	Coastal Flood	N/A	N/A	In Ocean County, the pounding surf ate away at the dune line in Bay Head and ate away much of the sand that was replaced at the foot of the 48th Street Beach in Brant Beach. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
March 3, 1998	Coastal Storm	DR-1206	Yes	No further details provided.
April 9, 1998	Coastal Flood	N/A	N/A	The onshore flow during the evening of April 9 produced minor tidal flooding in Atlantic, Cape May, and Ocean Counties and minor to locally moderate tidal flooding in Monmouth County.

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
May 11, 1998	Coastal Flood	N/A	N/A	The worst tidal flooding and erosion problems were reported in Ocean County. Isolated flooding was reported at Point Pleasant Beach. The erosion was described as substantial at Seaside Park. In Barnegat, the wind-driven waves were crashing onto East Bay Avenue and Bayshore Drive. On Long Beach Island, Long Beach Boulevard was flooded several times. Bayside road flooding occurred in Beach Haven and Harvey Cedars. In Brant Beach, the dunes were chopped along 53rd Street. In Ship Bottom and Surf City cliffs were formed. In Ship Bottom dune fencing dangled down a 20-foot drop that extended for several blocks. Shifting sands exposed an old barge. In Tuckerton Beach, minor flooding occurred the evening of May 11. In Stafford Township on Mallard Island minor flooding occurred as waves crashed onto the decks and docks on East Bay Avenue. Minor back bay flooding extended westward along Toms River into Avon Beach. Tidal flooding also occurred around Raritan Bay. On the evening of May 11, the police had to block off several roads in Woodbridge in Middlesex County.
January 3, 1999	Coastal Flood	N/A	N/A	On the evening of January 2, as one low pressure system headed into the Great Lakes, a second low pressure system formed along its frontal boundary along the coastal plains of the south Atlantic states. This second low increased the pressure gradient (or surface pressure difference between it and a strong high pressure system over the Canadian Maritimes) along the coast and increased the onshore flow. The low passed through New Jersey the morning of January 3. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
March 21, 1999	Coastal Flood	N/A	N/A	The onshore flow preceding a strong low pressure system that moved north along the Atlantic Seaboard during the evening of March 21 produced pockets of minor flooding along the New Jersey shore. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
August 20, 1999	Flash Flood	N/A	N/A	Thunderstorms with torrential downpours dropped a radar estimated 2.0 to 3.5 inches of rain across Eastern Ocean County within a two-hour period during the late afternoon of August 20. This caused considerable urban and poor drainage flooding on Long Beach Island and on the mainland. Flooding of some creeks also occurred on the mainland in Eastern Ocean County. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
August 26, 1999	Flash Flood	N/A	N/A	During the late afternoon and early evening of August 26 thunderstorms with torrential downpours caused considerable poor drainage flooding as well as flooding of some of the smaller creeks and streams. In Ocean County, part of New Jersey State Route 35 was washed away in Point Pleasant Beach. First floor flooding

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				occurred in the Bricks Estate in the Township of Brick. In Burlington County, several roads in Browns Mills were under water. Reported storm totals included 2.90 inches in New Lisbon and 2.19 inches at the McGuire Air Force Base.
August 30, 1999	Coastal Flood	N/A	N/A	Erosion occurred in Brant Beach (Ocean County). In Ocean County, elderly residents of Laurelton Gardens in the Township of Brick were evacuated after a creek flooded. Scattered trees and wires were knocked down throughout the county. A tree damaged a house in Toms River.
September 16, 1999	Hurricane/Typhoon, Flash Flood	N/A	N/A	Less rain and flooding occurred farther southeast than in other areas, with less urban and poor drainage flooding and only minor beach erosion and back bay flooding reported in Atlantic, Cape May, and Ocean Counties. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
September 16, 1999	Hurricane	EM-3148	Yes	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 8- to 10-inch totals widespread.
January 1, 2000	Flood	N/A	N/A	The worst wind damage occurred on the New Jersey State Route 72 Causeway between Long Beach Island and Stafford Township in Ocean County. Total accumulations included 10 inches in the Township of Brick.
March 21, 2000	Flood	N/A	N/A	The tight gradient (difference in surface pressures between a low pressure system along the mid-Atlantic coastal waters and a strong high pressure system in the Canadian Maritimes) produced isolated pockets of minor flooding the morning of March 21 and more widespread, but still minor tidal flooding during the evening of March 21. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
April 18, 2000	Flood	N/A	N/A	The combination of a low pressure system exiting the North Carolina coast, a large high pressure system over the Canadian Maritimes and higher than normal astronomical tides because of the approaching full moon produced some minor tidal flooding at the times of high tide during the evening of April 18. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
July 26, 2000	Flash Flood	N/A	N/A	In Ocean County, the heavy rain led to the closure of the causeway leading to the J. Stanley Tunney Bridge. Large parts of New Jersey State Route 35 were closed. The worst flooding occurred in Seaside Heights, Seaside Park, Lavallette, Bay Head, Point Pleasant, and Point Pleasant Beach and most of the flooding occurred near Barnegat Bay. In Point Pleasant alone, nine streets were closed. Farther south, the heavy rain led to flooding near the bay in Beach Haven and Beach Haven Crest.

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				Flood problems also occurred on the mainland. In the Township of Brick, two roads were closed and there was a voluntary evacuation of Laurelton Village. The rising Toms River flooded the beach and the flood waters reached behind the pine trees in South Toms River.
August 28, 2000	Flood	N/A	N/A	The combination of a weak onshore flow around a high pressure system building into New England and the adjacent coastal waters, a weak low pressure system off the south Atlantic coast, and the spring astronomical tides by the new moon caused some minor tidal flooding around the times of high tide the evening of August 28 and the evening of August 29. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
September 25, 2000	Flood	N/A	N/A	The combination of spring tides near the new moon, a high pressure system over New England and a low pressure system over the mid-Atlantic states produced widespread minor tidal flooding during the times of high tide from the evening of September 25 through the evening of September 26. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
November 10, 2000	Coastal Flood	N/A	N/A	Strong southeast winds combined with high astronomical tides to produce areas of minor tidal flooding around the time of high tide the morning of November 10. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
March 5, 2001	Flood	N/A	N/A	In Ocean County, significant erosion occurred in the Township of Brick as 50 feet of beach was lost.
June 16, 2001	Flash Flood	N/A	N/A	The remnants of Tropical Storm Allison produced showers and thunderstorms with heavy rain during the morning of June 17. This caused small stream and poor drainage flooding in the county with the worst reported flooding near and along the shore. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
August 13, 2001	Flash Flood	N/A	N/A	Thunderstorms with heavy downpours caused flooding of streams as well as urban and poor drainage flooding in Ocean County. Flooding was also reported along U.S. Route 9 in Lacey Township and on several roadways in the Township of Brick.
August 27, 2001	Flash Flood	N/A	N/A	Three-foot deep "lakes" formed in neighborhoods in Dover and the Township of Bricks. Sewers were overflowing. Basement flooding was also reported in the county. No serious injuries were reported.
September 14, 2001	Flood	N/A	N/A	The combination of spring tides around the new moon and onshore flow around a high pressure system produced minor tidal flooding around the times of the evening

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				high tides from September 14 through 16. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
October 1, 2001	Flood	N/A	N/A	The onshore flow around a Nor'easter brought minor to locally moderate tidal flooding along the New Jersey coast from September 29 through the morning of October 1. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
July 19, 2002	Flash Flood	N/A	N/A	Thunderstorms with torrential downpours dropped an adjusted Doppler Radar storm total estimate of 5 to 6 inches of rain in Lakewood and Jackson Townships. This caused considerable urban and poor drainage flooding as well as flooding of streams in northern Ocean County. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
October 16, 2002	Flood	N/A	N/A	A strong Nor'easter caused minor to locally moderate tidal flooding along the New Jersey coast and in the back bays, wind gusts to around 50 mph, and beach erosion. Tides, winds, and erosion were worse in Ocean and Monmouth Counties than farther south. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
February 23, 2003	Flood	N/A	N/A	The combination of heavy rain during the day on February 22 and snow melt run-off led to minor flooding along the North Branch of the Metedeconk River on February 23. The North Branch of the Metedeconk River in Lakewood was above its 7-foot flood stage from 1 p.m. through 6:43 p.m. on February 23. It crested at 7.18 feet at 6:15 p.m. on February 23.
December 6, 2003	Storm Surge, Tide	N/A	N/A	A Nor'easter caused erosion, minor tidal flooding, and dune damage along coastal New Jersey on December 5 and 6. The combination of the low pressure system moving northeast along the nearby Atlantic Ocean and a high pressure system in nearby Canada kept an onshore flow for two days along the New Jersey Coast. The worst erosion was reported in Bay Head and Mantoloking Boroughs in Ocean County. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
February 7, 2004	Flood	N/A	N/A	The combination of heavy rain and snow melt caused poor drainage flooding and eventually flooding along the Metedeconk River in Ocean County.
July 12, 2004	Flash Flood	N/A	N/A	A series of thunderstorms with torrential rain caused widespread poor drainage flooding and flooding of some of the streams in Ocean County. Nearly every municipality within the county reported flooding. New Jersey State Route 37 near Toms River was flooded. Doppler Radar storm total estimates exceeded one inch throughout the county and reached between 6 to 8 inches in Berkeley and Lacey Townships. Storm totals included 5.46 inches in Lakewood.

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
October 21, 2004	High Surf	N/A	N/A	Roadways along Barnegat Bay (Ocean County) had several inches of water during the times of high tide. Flooded streets were reported in Bay Head, Beach Haven, Seaside Park, and the Normandy Beach section of the Township of Brick.
October 24, 2004	Storm Surge, Tide	N/A	N/A	Roadways along Barnegat Bay (Ocean County) had several inches of water during the times of high tide. Flooded streets were reported in Bay Head, Beach Haven, Seaside Park, and the Normandy Beach section of the Township of Brick.
September 19, 2005	Hurricane Evacuation	EM-3257	Yes	No further details provided. This event is related to Hurricane Katrina and not a direct flooding event to the township.
October 12, 2005	Flood	N/A	N/A	Periods of heavy rain associated with a series of low pressure systems southeast of New Jersey fell across Ocean County (particularly the northern half) on October 12 and 13. This caused considerable poor drainage flooding as well as flooding of creeks and rivers as well as one lake. Three-day storm totals ranged from around one inch in the southern part of the county to around ten inches in the northern part of the county. The Metedeconk River flooded in Brick and Lakewood Townships. New Jersey State Route 88 was closed in Lakewood Township. Lake Carasaljio flooded nearby streets in the township. Roads were closed in Dover and the Township of Brick.
February 12, 2006	High Surf, Coastal Flood	N/A	N/A	Coastal Ocean County took a major hit from this winter storm. There was significant to severe damage to dunes across several locations, including Bayhead, Bricktown, Ortley Beach, Harvey Cedars, and Long Beach Township. Vertical cuts across most of the beaches ranged from 2- to 4-feet high by 50- to 75-feet wide. Minor to moderate coastal flooding was fairly widespread as a direct result of this potent winter storm.
June 23 to 28, 2006	Heavy Rain	N/A	N/A	Rainfall amounts of 2.1 inches were recorded at Point Pleasant and 2.09 inches were recorded at Barnegat Light.
October 6, 2006	Coastal Flood	N/A	N/A	A Nor'easter brought tidal flooding, heavy rain, strong winds, and beach erosion to coastal New Jersey. Widespread minor tidal flooding with areas of moderate tidal flooding occurred during the high tides on October 6 and 7. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
April 15, 2007	Flood	N/A	N/A	The heavy rain and Metedeconk River flooding forced road closures in the Township of Brick. Flooding along the Toms River caused road closures in Island Heights Borough. The North Branch of the Metedeconk at Lakewood was above its 7-foot flood stage from 9:39 p.m. on April 15 through 7:45 p.m. on April 17. It crested at 8.28 feet at 12:00 p.m. on April 16. Precipitation totals included 3.76 inches in

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				Beachwood, 3.04 inches in Point Pleasant, 2.65 inches in Brick, 1.90 inches in Berkeley, 1.76 inches in Seaside Heights, and 1.38 inches in Harvey Cedars.
May 11 to 13, 2008	Nor'easter	N/A	N/A	Peak wind gusts recorded near Barnegat were 59 mph. Heavy rain combined with high astronomical tides caused several roads to close in southern New Jersey and Delaware. Coastal flooding in New Jersey was comparable to the October 2006 floods. Beach erosion in Delaware and New Jersey due to the high surf was also attributed to this storm. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
September 25, 2008	High Surf	N/A	N/A	In Monmouth and Ocean Counties, the vertical cuts on the beaches averaged 2 to 4 feet with the sloping cuts around 40 feet. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
December 12, 2008	Flood	N/A	N/A	The North Branch of the Metedeconk River at Lakewood was above its 7 foot flood stage from 4:30 a.m. on December 12 through 8:15 a.m. on December 13. It crested at 7.86 feet at 10:45 a.m. on December 12. There was also minor tidal flooding at the time of the morning high tide along the ocean front. Event precipitation totals included 5.05 inches in Lavallette, 4.98 inches in Stafford Forge, 4.69 inches in the Township of Brick and 4.34 inches in Little Egg Harbor.
November 11, 2009	High Surf	N/A	N/A	A powerful Nor'easter produced wind gusts of nearly 60 mph, widespread moderate tidal flooding, heavy rain, and severe beach erosion along the New Jersey coast from November 12 through November 14. Initial damage estimates were placed at $180 million. By several measures this was one of the worst Nor'easters to affect New Jersey since 1990. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
December 9, 2009	Flood	N/A	N/A	The runoff from heavy rains produced flooding along sections of the North Branch of the Metedeconk River during the night of December 9. The North Branch of the Metedeconk River near Lakewood was above its 7-foot flood stage from 7:09 p.m. on December 9 through 1:07 a.m. on December 10. It crested at 7.2 feet at 9:15 p.m. Event precipitation totals included 3.09 inches in Bayville, 2.75 inches in Stafford Township, 2.43 inches in Barnegat Township, 2.32 inches in Little Egg Harbor Township, 2.25 inches in Berkeley Township, 2.05 inches in the Township of Brick, 2.02 inches in Toms River, and 1.95 inches in Point Pleasant.
December 22, 2009	Severe Storms and Flooding	DR-1867	Yes	This event is associated with Tropical Depression Ida and a Nor'easter. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
December 26, 2009	Flood	N/A	N/A	The North Branch of the Metedeconk at Lakewood was above its 7-foot flood stage from 5:15 p.m. on December 26 through 1:22 p.m. on December 28. It crested at 8.59 feet at 6:00 a.m. on December 27. Event precipitation totals included 2.78 inches in

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				South Toms River, 2.10 inches in Berkeley Township, 2.02 inches in the Township of Brick, and 1.98 inches in Lavallette.
February 25, 2010	Flood	N/A	N/A	The North Branch of the Metedeconk River at Lakewood was above its 7-foot flood stage from 2 a.m. on February 24 through 2:15 a.m. on February 25. It crested at 7.31 feet at 11 a.m. on February 24. Precipitation totals included 2.57 inches in Stafford Township, 2.53 inches in Point Pleasant, 2.43 inches in Pine Beach, 2.29 inches in Berkeley Township, 2.28 inches in the Township of Brick, and 1.95 inches in South Toms River.
March 29, 2010	Flood	N/A	N/A	The North Branch of the Metedeconk River at Lakewood was above its 7-foot flood stage from 4:30 p.m. on March 29 through 10:15 a.m. on April 1. It crested at 8.27 feet at 3 a.m. on March 31. Event precipitation totals included 4.61 inches in Lavallette, 4.60 inches in Oakwood, 4.50 inches in the Township of Brick, and 3.96 inches in Toms River.
April 2, 2010	Severe Storms and Flooding	DR-1897	Yes	FEMA distributed over $33 million to flood survivors from this event. Specific and detailed damages and/or losses for the Township of Brick were not readily available at the time of this plan.
March 11, 2011	Flooding	N/A	N/A	This event included 1.52 inches of rain falling in a 24-hour period at 2 N in the Township of Brick.
August 27 to 31, 2011	Hurricane	EM-3332, DR-4021	Yes	Hurricane Irene produced torrential downpour rains that resulted in major flooding and a number of record-breaking crests on area rivers, tropical storm force wind gusts with record-breaking outages for New Jersey utilities, one confirmed tornado, and a three-to-five foot storm surge that caused moderate to severe tidal flooding with extensive beach erosion over the weekend of August 27 and 28. The highest wind gusts in the Township of Brick were 58 mph.
October 28 to 30, 2012	Hurricane	EM-3354, DR-4086	Yes	Very high wind gusts were recorded due to Superstorm Sandy, with the strongest winds north and east of the center of the hurricane. Superstorm Sandy provided some areas of the mid-Atlantic region with their highest wind gusts since Hurricane Hazel 58 years earlier (October 1954), especially in New Jersey and eastern Pennsylvania. Several wind gusts in Ocean County, New Jersey were close to 90 mph, with many regions reporting gusts over 50 mph. The highest wind gust reported in the Mount Holly area was 89 mph in Surf City (Ocean County). Winds gradually began to increase Monday, peaking as the storm passed through the region Monday night. Many trees and power lines were taken down as a result of these wind gusts. A 61-year-old male drowned in his house on Vanders Drive by the Kettle Creek in the Township of Brick (Ocean County), and a 61-year-old male died in the Township of Brick (Ocean County) after a tree stump fell on him as he was trying to remove it. Peak wind gusts were recorded at 78 mph in the Township of Brick.
December 27, 2012	Coastal Flood	N/A	N/A	An intense low pressure system brought strong to high northeast winds into central and eastern New Jersey mainly during the evening of December 26. Peak wind gusts

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Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				reached hurricane-force gusts in Ocean County. The strong to high winds caused some structural damage as well as knocked down trees, tree limbs and wires, causing power outages. Jersey Central Power and Light reported approximately 7,000 of its customers lost power in Ocean and Monmouth Counties. Peak wind gusts were recorded at 74 mph in the Township of Brick. The Township of Brick closed off its part of the barrier islands to traffic and Toms River Township reported some ocean breaches on its barrier islands. In Barnegat Bay, tidal flooding caused the closure of Mandalay and Drum Point Roads.
March 7, 2013	Coastal Flood	N/A	N/A	An intense Nor'easter brought strong to high winds across most of central and southern New Jersey on March 6 and 7 with minor to moderate tidal flooding along Raritan Bay, lower Delaware Bay, and on the ocean side. The coastal flooding was exacerbated by wave action as waves off of Barnegat (Ocean County) reached 15 feet and seas offshore reached 25 feet. The coastal flooding caused new breaches in Mantoloking and flooded roadways. Voluntary evacuations were recommended in Toms River, the Township of Brick, and Long Beach Townships. Wind gusts of 56 mph were recorded in the Township of Brick.
May 1, 2014	Flood	N/A	N/A	The North Branch of the Metedeconk River at Lakewood had minor flooding and was above its 8-foot flood stage from 5:54 a.m. through 7:45 p.m. on May 1. It crested at 8.37 feet at 12:45 p.m. on May 1. Event precipitation totals included 4.25 inches in the Township of Jackson, 3.28 inches in the Township of Brick, 3.19 inches in the Township of Stafford, 3.12 inches in the Township of Whiting and 3.04 inches in the Township of Toms River.
July 15, 2014	Flood	N/A	N/A	The runoff from thunderstorms with very heavy rain caused minor flooding along the North Branch of the Metedeconk River during the early morning of July 15. The North Branch of the Metedeconk River near Lakewood was above its 8-foot flood stage from 3:05 a.m. through 6:45 a.m. on July 15. It crested at 8.08 feet at 4:15 a.m. Event precipitation totals included 3.42 inches in the Township of Jackson, and 2.95 inches in the Township of Brick.
July 15, 2014	Flash Flood	N/A	N/A	Thunderstorms with very heavy rain caused poor drainage and small creek flash flooding in the Township of Brick. Flash flooding closed the northbound exit to the Township of Brick off of the Garden State Parkway near the Cedar Bridge Branch. Event precipitation totals included 3.73 inches in the Township of Brick, one of the highest amounts to fall in New Jersey on July 15.
August 13, 2014	Flash Flood	N/A	N/A	Thunderstorms with torrential downpours caused flash flooding in eastern Ocean County, including the Township of Brick. Rainfall totals reached up to 9 inches in the impacted areas. Rainfall totals in the Township of Brick was 5.87 inches.
October 21, 2014	Flash Flood	N/A	N/A	Heavy rain from thunderstorms caused flash flooding within the Township of Brick. Motor vehicles were stuck in flood waters on Princeton Avenue and several motorists

Table 5-11. Flooding Events in the Township of Brick, 1950 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				had to be rescued. Event precipitation totals included 2.34 inches in the Township of Brick.
December 9, 2014	Nor'Easter	N/A	N/A	A strong Nor'easter brought strong winds and caused minor to moderate tidal flooding in Upper Delaware Bay and around Raritan Bay and moderate tidal flooding in Lower Delaware Bay and Atlantic Coastal New Jersey. The storm also caused minor to moderate beach erosion. Storm rainfall totals averaged one to three inches, with the highest amounts in the coastal counties. Peak wind gusts averaged 45 to 55 mph along the coastal portion of New Jersey. The winds downed weak trees, tree limbs and power lines. Tidal flooding affected all coastal counties in the State. In Ocean County, a steel sea wall was exposed in Mantoloking and Brick. In Brick Township, peak wind gusts reached 50 mph and rainfall totals measured at 2.9 inches.
June 27-28, 2015	Flash Flood	N/A	N/A	Showers and thunderstorms brought heavy rain to New Jersey and caused poor drainage and flash flooding in the southern portion of the state. In Ocean County, flash flood warnings were issued by the National Weather Service (NWS). Thunderstorms brought very heavy rain which led to flash flooding of smaller streams as well as poor drainage flooding. In Brick Township, total rainfall was 4.71 inches.
October 1-4, 2015	Nor'Easter	N/A	N/A	Several inches of rain in the Jersey Shore area, including Ocean County, as a result of a Nor'easter. Wind speeds reached up to 40 mph. The NWS issued a high wind warning and coastal flood warning for Ocean and Cape May Counties. The beaches at Mantoloking and Brick were closed following the storm due to dangerous drop-offs between a protective steel flood wall and the beach. The severe beach erosion at these locations resulted in drop-offs ranging between 5 to 10 feet.
January 10, 2016	New Jersey Severe Winter Storm And Snowstorm	DR-4264	Yes	Rain, wind and the moon phase caused low-lying areas to flood in Brick Township around Barnegat Bay. Rising water was noted around 10 am on January 10 in areas along the bayside of Route 35 in the Journey's End area of the Normandy Beach section, as well as in the Shore Acres section on the mainland.
September 19, 2017	Nor'Easter	N/A	N/A	Moderate coastal flooding affected Ocean County with the evening high tide on Tuesday, September 19. Widespread roadway flooding was reported in the communities along tidal waters and many roads were closed. The following tidal gauge reached the moderate flooding threshold: Atlantic City Inside Thorofare.
March 3-4, 2018	Nor'Easter	N/A	N/A	A cold front stalled across the region on March 1st. Meanwhile, a wave of low pressure developed along this front in the Ohio Valley and moved east, deepening just southeast of Long Island on March 2nd. This large and very deep area of low pressure moved slowly east over the open waters of the North Atlantic Ocean through Sunday March 4th. This lead to a variety of weather hazards during this time frame. Strong Northwest winds with gusts up to around 60 mph occurred on March 2nd and 3rd. This led to widespread damage to trees and power lines, causing

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Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Ocean County Designated?	Event Details
				extensive power outages across the region. Minor coastal flooding over multiple tide cycles occurred along the New Jersey coast March 2nd through 4th. Moderate flooding occurred during the morning high tide of Saturday the 3rd in Monmouth County, most of the NJ oceanfront Saturday evening and again Sunday morning the 4th. Moderate coastal flooding led to a number of road closures in the coastal communities of Ocean County. The peak tide was 2.82 feet MLLW at Bayshore, 4.52 feet MLLW at Barnegat Light and 5.88 feet MLLW at Tuckerton. Heavy rainfall occurred in New Jersey and Eastern Pennsylvania on March 1st and 2nd, with widespread rainfall amounts of 1 to 2 inches. In addition, areal and minor small stream flooding also occurred. As the rain changed to snow on the 2nd, localized heavy snowfall occurred, particularly over the higher elevations. Southeast of the New Jersey Turnpike and Interstate 95, up to around 3 inches of snowfall was observed.
August 13, 2018	Flash Flood	N/A	N/A	A stalled thunderstorm system dropped eight inches of rain in a three to four hour period resulting in significant flash flooding. The Greenbriar I community sustained heavy flooding with some homes sustaining floodwaters as deep as four to six feet. 100 people were evacuated. 100 homes were impacted primarily on Markum Road, Vaughn Court, and Kingsley Court. Sutton Village condominium complex also sustained flood damages. The flooding took place in an area that is not a regulated floodplain, meaning few residents had flood insurance.
September 9-10, 2018	Coastal Flood	N/A	N/A	A persistent onshore flow and unusually high astronomical tides associated with the new moon resulted in widespread moderate coastal flooding along the bays and other tidal waterways in central and southern New Jersey. The flooding occurred across three consecutive high tide cycles, from the evening of September 9 through the early hours of September 11. Moderate flooding occurred along the bays and other tidal waterways in Ocean County. The tide gauge at Tuckerton reached 5.95 feet MLLW. The tide gauge at Manasquan reached 6.84 feet MLLW.
October 27, 2018	Coastal Flood	N/A	N/A	Strong low pressure moved northward along the coasts of Delaware and New Jersey on October 27. The system brought moderate to major coastal flooding and high winds to the coastal counties of New Jersey during the morning and early afternoon hours. The tide gauge at Barnegat Light peaked at 4.69 feet MLLW. The tide gauge at Manasquan peaked at 7.81 feet MLLW.
October 10-11, 2019	Coastal Flood	N/A	N/A	Slow moving low pressure centered well off the coasts of New Jersey and Delaware produced coastal flooding during several consecutive high tide cycles from October 9 through October 12. Moderate coastal flooding occurred with the evening high tide on the 10th, and with the morning and evening high tides on the 11th. Numerous road closures occurred on October 10 with the tide gauge at Barnegat Light reached 4.71 feet MLLW, the tide gauge at Ship Bottom reached 4.21 feet MLLW, and the tide gauge at Tuckerton reached 6.15 feet MLLW. On October 11, the tide gauge at

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				Mantoloking reached 2.84 feet MLLW, the tide gauge at Bayshore (Seaside Heights) reached 3.15 feet MLLW, the tide gauge at Barnegat Light reached 4.83 feet MLLW, the tide gauge at Ship Bottom reached 4.34 feet MLLW, and the tide gauge at Tuckerton reached 6.20 feet MLLW.
February 1-2, 2021	Coastal Flood	N/A	N/A	Strong low pressure moved slowly northeastward over the waters off Delaware and New Jersey on February 1-2, 2021. The brisk onshore flow resulted in two consecutive high tide cycles with widespread moderate flooding along the New Jersey coast. Widespread moderate coastal flooding occurred in the tidal communities of Ocean County during the morning and early afternoon of February 1. There were numerous road closures. The water level reached 3.28 feet MLLW at Waretown, 4.53 feet MLLW at Barnegat Light, and 5.96 feet MLLW at Tuckerton. Widespread moderate coastal flooding occurred in the tidal communities of Ocean County during the late morning and early afternoon of February 2. There were numerous road closures. The water level reached 2.81 feet MLLW at Mantoloking, 3.22 feet MLLW at Bayshore, 3.60 feet MLLW at Waretown, 4.50 feet MLLW at Barnegat Light, 4.24 feet MLLW at Ship Bottom, and 5.56 feet MLLW at Tuckerton.

Source: FEMA 2021, NOAA NCEI 2021

Notes:

EST	*Eastern Standard Time*	*mph*	*miles per hour*
FEMA	*Federal Emergency Management Agency*	*MLLW*	*Mean Lower Low Water*
ft	*feet*	*N/A*	*Not Applicable*
kt	*knot(s)*		

Significant Flooding Events in the Township of Brick

Reviewing the events and losses discussed below helps identify targets for risk reduction and ways to increase the township's capability to avoid large-scale events in the future. Still, many flood events do not trigger federal disaster declaration protocol but have significant impacts on their communities. These events are also important to consider in establishing recurrence intervals for flooding. The following section provides an overview of some of the more significant floods in the Township.

Ash Wednesday Storm, March 6 to 8, 1962

Until a few years ago, the Ash Wednesday Storm was one of the most impactful storms to hit Ocean County's shoreline in recent history. From March 6 to 8, 1962, the storm pelted the entire coastline of New Jersey with gale force winds, high tides, and heavy snow/precipitation. The storm lasted for about 60 hours in Ocean County and Township of Brick, at times generating winds of 70 miles per hour (mph). The storm's impacts were augmented by the five successive high spring tides, leading to many river docks being underwater for several days after the storm. The storm caused severe flooding not only in Ocean County, but also along the entire New Jersey shoreline.

Local damage from the storm was mostly due to extensive flooding in developed areas along the 30-mile reach from Barnegat Bay and the Manasquan River (the Townships of Brick and Barnegat). Floodwaters reached depths of 1.5 feet over several streets in Seaside Park and 2 feet over portions of Ortley Beach in Township of Toms River (formerly the Township of Dover). While other parts of the state experienced more severe flood depths, the storm still caused significant damage to the township and county. A total of 5,759 residences and commercial establishments in this reach were damaged by inundation. Of these properties, 163 residences were structurally damaged. Additionally, beaches, dunes, and boardwalks throughout the area received substantial damage from storm surge and coastal flooding (FEMA FIS 2014).

Tropical Storm Doria, August 26 to 27, 1971

From August 26 to 27, 1971, New Jersey experienced significant amounts of flooding from the combined effects of Tropical Storm Doria and a heavy frontal storm. Flood damage was substantial enough to lead to a Presidential Disaster Declaration for the state, and the high water mark survey results from this storm were filed with the USGS Division of Water Resources.

The damage from the event was exacerbated by heavy rain on August 27, 1971, the day prior to Tropical Storm Doria's passage. Intense storm activity throughout the 3-day period led to 32 hours of rainfall in south-central, central, and northeastern New Jersey. Total stormfall amounts from this event ranged between 3 to 11 inches, depending on the location in the state. Storm runoff increased and led to record flows at all 47 gaging stations in New Jersey (FEMA FIS 2014).

Hurricane Floyd, September 16, 1999

On September 16, 1999, Hurricane Floyd made landfall in Cape Fear, North Carolina as a Category 2 hurricane. It then crossed over North Carolina and southeastern Virginia, briefly entering the Atlantic Ocean. New Jersey felt the impacts of the storm on September 17, 1999. Hurricane Floyd is most notable for its record-breaking flooding throughout the State of New Jersey. In addition to the Raritan River Basin experiencing record floods 4.5 feet higher than any previously recorded flood crests, the areas of Bound Brook and Manville were also severely impacted. Hurricane Floyd is estimated to have caused about $250 million in damage to the State of New Jersey, causing the President to issue an emergency declaration (FEMA FIS 2014).

Specifically in Ocean County, the damage estimates were about $5.5 million. Across the state, 3,900 homes, 1,208 apartments, and 1,683 businesses sustained major damaged along with 23,235 homes, 1,758 apartments, and 1,043 businesses which suffered minor damaged. Approximately 616,400 homes and businesses lost power throughout the state for up to five days and some municipalities had limited water use while sewage treatment plants were overwhelmed with runoff (OC HMP 2014).

Hurricane Irene, August 28, 2011

Having earlier been downgraded to an extra-tropical storm, Hurricane Irene came ashore in Little Egg Inlet in southern New Jersey; on August 28, 2011. In anticipation of the storm Governor Chris Christy declared a state of emergency of August 25, with President Obama reaffirming the declaration on August 27. Mandatory evacuations were ordered throughout the Ocean County barrier islands. Wind speeds were recorded at 75 mph and rain totals reached over 10 inches in many parts of the state. Long Beach Boulevard, the main road on Long Beach Island, was reportedly under 6 to 8 inches of water in Beach Haven. In Mantoloking, the eastern foot of the Mantoloking Bridge was completely submerged underwater. The bay has spilled out on to streets in Mantoloking, Bay Head, and further south into Normandy Beach and Chadwick Beach. In Ocean County 45,000 customers lost power during the storm. Overall damage estimates, for the State of New Jersey, came to over $1 billion; with over 200,000 homes and buildings sustaining damaged (FEMA FIS 2014).

In the Township of Brick, officials met prior to the storm to prepare the response necessary for storm management. The mayor was recorded in local media on advising local residents, particularly those in low-lying and back-bay areas, to prepare for all scenarios, including evacuations, and to have a basic emergency supply kit accessible (Brick Township 2011).

It is important to note that during this storm, the Metedeconk River experienced unprecedented flooding due to rainfall during this event.

Superstorm Sandy, October 29, 2012

Superstorm Sandy came ashore as an immense tropical storm in Brigantine, New Jersey, on October 29, 2012. Superstorm Sandy dropped heavy rain on the area; almost a foot in some areas. Wind gusts were recorded at 90 mph. A full moon made the high tides 20 percent higher than normal and amplified the storm surge. The New Jersey shore suffered the most damage. Some barrier island communities suffered severe “wash over” including the creation of two temporary inlets. At NOAA’s gage #8534720 in Atlantic City, the high water mark (which is considered as a stillwater elevation without waves) reached 8.76 feet. At NOAA’s gage #8531680 at Sandy Hook, the high water mark reached 9.21 feet. Seaside communities were damaged and destroyed up and down the coastline. Some 252,000 households in Ocean County lost power. Initial reports suggest that well over 24,000 homes and businesses were damaged or destroyed by the storm. Governor Chris Christy declared a state of emergency on October 31. Superstorm Sandy is estimated to have cost the State of New Jersey over $36 billion (FEMA FIS 2014).

Link to this photo | Comments about this photo essay

1 of 10 BEFORE - The Thunderbird Hotel and smaller, bungalow-style ocean block homes just south in Brick Township as the Jersey Shore prepares for Hurricane Irene's arrival Sunday morning August 26, 2011. This area was completely destroyed by Hurricane Sandy 14 months later. (Andrew Mills/The Star-Ledger)

The Township of Brick was particularly hard hit by Superstorm Sandy. The existing bulkheads along the Manasquan River were too low to protect against the storm surge, as were the existing bulkheads against the dredged lagoons. The dredged lagoons also did not have surge barriers. In addition, the residents in the southern area of the township are located in a low-lying area. All of this contributed to a greater vulnerability to Superstorm Sandy, particularly in the area of Barnegat Bay and along the Atlantic Ocean (Rutgers 2014).

Link to this photo | Comments about this photo essay

2 of 10 AFTER - A community of bungalow-style ocean block homes in Brick Township was completely destroyed by Hurricane Sandy just south of the Thunderbird Hotel October 31, 2012. (Andrew Mills/The Star-Ledger)

The Township experienced property damage, infrastructure damage, and severe impacts to its economy, community, and housing. In early 2014, 202 homes were reported as abandoned in the Township of Brick. Many of these homes, despite being primary residences, were abandoned as the owners were disqualified from most types of financial aid. Many residents were displaced by the storm, and there has been a small increase in the Township's homeless population since Superstorm Sandy.

The Township also experienced significant beach erosion and loss of dunes, further limiting the community's ability to protect itself from future coastal flooding and hazard events. In regards to economic and community impact, many businesses suffered interruption of operations from power outages and road closures. Even upon reopening, these businesses continued to be negatively impacted by a decrease in local and regional tourism (Brick Township SRPR 2014).

5.3 Probability of Future Occurrences

Given the history of flood events that have impacted the Township of Brick, it is apparent that future flooding of varying degrees will occur. The fact that the elements required for flooding exist and that major flooding has occurred throughout the county in the past suggests that many people and properties are at risk from the flood hazard in the future. It is estimated that the Township will continue to experience direct and indirect impacts of flooding events annually that may induce secondary hazards such as coastal erosion, storm surge in coastal areas, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents, and inconveniences.

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 Date Unknown). Table 5-12 describes the recurrence intervals and probabilities of occurrences for flood events.

Table 5-12. Recurrence Intervals and Probabilities of Occurrences

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

Recurrence Interval (in years)	Percent Chance of Occurrence in Any Given Year
10	10
5	20
2	50

Source: USGS Date Unknown

5.3.1 Coastal Erosion

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

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

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

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

5.3.2 Storm Surge

As noted earlier, no storm surge-specific scales exist due to the concern that no scale can adequately represent the storm surge's potential impact. Because of the threat posed by storm surge, the NHC continues to develop more accurate methods of analyzing and predicting storm surge, particularly those associated with tropical storms, hurricanes, and Nor'easters. The NHC also includes the probability of surge heights to be exceeded. The New Jersey coastal weather forecast offices typically provide impact graphics for storm surge watches and warnings.

In the Township of Brick, storm surge will remain a concern for many coastal flooding and hurricane events. Although the level of severity for storm surge may not always be accurate, the events are usually easy to predict since they are often a secondary effect from another hazard event (most typically hurricanes, severe storms, and coastal flooding).

5.3.3 Urban Flooding

Urban flooding frequency is a function of heavy rain events and the state of the stormwater system. Regular maintenance of the stormwater system reduces the frequency of urban flooding events.

5.3.4 Dam Failure

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides, and excessive rainfall and snowmelt. As noted in the Previous Occurrences and Losses section, dam failures typically occur in New Jersey as a result of heavy rains or other precipitation. There is a "residual risk" associated with dams. Residual risk is the risk that remains after safeguards have been implemented. For dams, the residual risk is associated with events beyond those that the facility was designed to withstand. However, the probability of any type of dam failure is low in today's dam safety regulatory and oversight environment.

5.3.5 Sea Level Rise

Sea level rise is a long-term and ongoing hazard. Unlike other floods, sea level rise occurs gradually and does not occur as individual episodes which would allow for probability to be calculated. With climate change continuing to raise global temperatures, leading to melting land ice and warming ocean temperatures, sea level rise will continue to take place and is likely to accelerate in the next century.

5.4 Climate Change Impacts

Climate change refers to changes over a long period of time in patterns of temperature, precipitation, humidity, wind, and seasons. Climate change is expected to have significant impacts on the mid-Atlantic and Northeast regions by the mid-21st century. Climate plays a fundamental role in shaping ecosystems and the human economies and cultures that depend on them. It is generally perceived that climate change will have a measurable impact on the occurrence and severity of flooding. As hydrology changes, what is currently considered a 100-year flood may strike more often, leaving many communities at greater risk. Planners will need to factor a new level of safety into the design, operation, and regulation of flood protection facilities such as dams, floodways, bypass channels, and levees, as well as the design of local sewers and storm drains. Climate change impacts have the potential to affect the Township of Brick, as well as the entire New Jersey region.

Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation and storm events.

5.4.1 Riverine

Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017).

5.4.2 Coastal Flood

Stronger coastal storms including hurricanes and nor'easters in addition to rising sea levels will increase the frequency and severity of coastal flooding events.

5.4.3 Coastal Erosion

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. Other secondary hazards that could occur along the Mid-Atlantic coast in response to sea level rise include:

- Bluff and upland erosion – Shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments (Gutierrez et al. 2007).
- Overwash, inlet processes, shoreline retreat, and barrier island narrowing – As sea level rise occurs, storm overwash will become more likely. Tidal inlet formation and migration will become important components of future shoreline changes. Barrier islands are subject to inlet formation by storms. If the storm surge produces channels that extend below sea level, an inlet may persist after the storm. The combination of rising sea level and stronger storms can create the potential to accelerate shoreline retreat in many locations. Assessments of shoreline change on barrier islands have shown that barrier island narrowing has been observed on some islands over the last 100 years (Gutierrez et al. 2007).

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). As temperatures increase so will the energy in a storm system, increasing the potential for more intense tropical storms (Huang et al. 2017), especially those of Category 4 and 5 (Melillo et al. 2014).

A study on increased storm wave heights from climate change indicated that coastal erosion and flooding may occur twice as fast from sea level rise alone and up to four times as fast as a doubling of the frequency of major El Niño events. Should all these potential subsequent events from climate change occur simultaneously, there could be up to an order of magnitude increase in both coastal erosion and flood frequency (compared against the current rate of those processes). While erosion rates would still be partially dependent on beach slopes and dune crest elevations, this possibility highlights the importance of incorporating climate change and climate control into mitigation practices (Ruggiero 2008).

5.4.4 Storm Surge

Climate change may result in changes to the frequency of coastal storms and the occurrence of storm surge. A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). As temperatures increase so will the energy in a storm system, increasing the potential for more intense tropical storms (Huang et al. 2017), especially those of Category 4 and 5 (Melillo et al. 2014).

As oceans warm, the length of hurricane season may expand. The past six hurricane seasons have featured a tropical system occurring before the official start of the season. In 2016, a very rare winter hurricane named Alex developed in the middle of January (BBC 2019). According to NOAA's database, 39 storms formed in the Atlantic Basin before June 1 from 1851 through 2020, a long-term average of one such early storm every four to five years. The 2010s had the most such storms, and there has been a steady increase since the 1990s. However, the 1950s had six such storms, the 1930s had four and there was another four preseason storm streak from 1887 through 1890. It is possible there were other such storms in the era before satellites – before the mid-1960s – that were missed by ship observations or reports from areas impacted. It remains to be seen if expansion of the traditional hurricane season is a long-term trend or a common occurrence (Weather.com 2020).

An increase in sea level also implies that storm surges will operate from an elevated base, so severe coastal flooding may be more frequent in the future (NJ Climate Adaptation Alliance 2016).

5.4.5 Urban Flooding

By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017).

The number of extreme precipitation events has also been above average over the last 10 years. During 2010–2014, the state experienced the largest number of extreme precipitation events (days with more than 2 inches) compared to any other 5-year period, about 50 percent above the long-term average. Winter and spring precipitation is projected to increase for the 21st century; extreme precipitation is also projected to increase. The projections of increasing precipitation are characteristic of a large area of the Northern Hemisphere in the northern middle latitudes, as well as increases in heavy precipitation events. This may result in increased coastal and inland flooding risks throughout the state (NCEI 2019).

Stormwater systems contribute to urban flooding even when operating properly, if their carrying capacity is exceeded. The increase in heavy precipitation events is likely to increase the number of urban flooding events.

5.4.6 Dam Failure

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can significantly affect the hydrograph used for the design of a dam. If the hygrograph changes, the dam conceivably could lose some or all of its designed margin of safety, also known as freeboard. Loss of designed margin of safety increases the possibility that floodwaters would overtop the dam or create unintended loads, which could lead to a dam failure.

Increasing rates of precipitation, occurrences of heavy precipitation events, and frequency of severe storms also increase the likelihood of dam failure.

5.4.7 Sea Level Rise

In New Jersey, sea levels are rising faster than they are globally due to changes in the Gulf Stream, localized land subsidence, and continued geologic influences as land slowly adjusts to the loss of the North American ice sheet at the end of the last ice age. In Atlantic City, Cape May, and Sandy Hook, sea-level has risen at a rate of approximately 0.2 to 0.5 inches per year since the beginning of the 20th century, and this rate will continue to increase (Kopp et al. 2019). The amount of greenhouse gases that are emitted is tied to rates of sea level rise. By 2050, New Jersey will likely experience at least a 0.9 to 2.1-foot increase (above the levels in 2000; all emissions scenarios), 1.4 to 3.1-foot increase by 2070 (moderate emissions scenario), and potentially a 2.0 to 5.1-foot increase by 2100 (moderate emissions scenario) (Kopp et al. 2019). Understanding how precipitation and sea level rise will change in the future is vital to New Jersey's coastal zone because low-lying coastal areas are already experiencing tidal flooding, even on sunny days in the absence of precipitation events.

5.5 Future Trends

The Township of Brick has established a clear commitment to furthering hazard mitigation and resilience efforts in the community. The Township has worked to secure additional backup generators for power redundancy, implemented beach erosion, and stabilization control projects in high risk areas and areas subject to storm surge scouring, implemented resilient (i.e., greater than pre-Superstorm Sandy levels) beach replenishment measures, installed man-made flood control structures, and more. The Township of Brick plans to continue these efforts through additional infrastructure upgrades and enhancements, a comprehensive plan update to incorporate more mitigation integration, economic development, communication and education, capital improvement, and efforts to increase the Township's standing in the Community Rating System (CRS) program.

The Township of Brick has a population of 76,101, based on the 2019 American Community Survey population estimates. This represents a 1.3 percent increase in population since the 2010 U.S. Census (75,072). The Township is focusing any new development away from flood hazard areas.

5.6 Scenario

The primary waterways and the coastline in the planning area have the potential to flood at regular intervals, generally in response to hurricanes, Nor'easters, or other severe storms. Storm patterns of warm, moist air usually occur between early November and late March; Nor'easters are most typical during winter months; and hurricane season officially runs from June 1 to November 30. A series of such weather events can cause severe flooding in the planning area. The worst-case scenario is an event similar to Superstorm Sandy with rainfall rates typically associated with a tropical system, i.e., a severe hurricane or a series of storms that leads to both coastal flooding and flash flooding. In addition to rain falling faster than the ground and waterways can absorb it, this type of event would cause secondary effects of coastal erosion and storm surge. This could overwhelm response and floodplain management capabilities within the planning area. Major roads could be blocked, preventing evacuation and critical access for many residents and critical functions. High in-channel flows could cause water courses to scour, possibly washing out roads and creating more isolation problems. In the case of a series of storms, the Township of Brick may not be able to make repairs quickly enough to restore critical facilities and infrastructure. The floodplain of the Township of Brick, which is essentially the entire Township, will continue to be impacted by these floods.

5.7 Issues

Important issues associated with flood hazards in the planning area include but are not limited to the following issues identified by the Planning Committee and members of the public:

- Better Stormwater drainage is needed
- Low lying roads experience flooding and need to be raised
- When the bay water rises, the water backs up out of the storm and floods roadways and adjacent properties in coastal areas. Backflow prevention devices are needed for outfalls that do not have them installed yet.
- Cherry Quay Road as it is the only means of entry/egress to Cherry Quay section. The road experiences flooding
- Drainage around the Greenbriar 1 community requires improvement.
- Improved flood education is needed.
- Long term risks from sea level rise require long term planning and identification of actions to address the threat.
- Homes with low elevations require the means to be elevated.
- Natural systems such as dunes and wetlands should be restored to increase natural floodplain functions. - the environment has intrinsic value, invest in open space preservation (natural shorelines, wetlands) to support those natural systems.
- Unnecessary impermeable surfaces contribute to urban flooding

Numerous locations in the Township were identified as being flood-prone. The Planning Committee and members of the public noted the following flood-prone locations:

- All areas of the Special Flood Hazard Area
- The barrier island community
- Waterfront and lagoon communities
- Cherry Quay Road
- Greenbriar 1 community
- Pilot Drive as it meets Alameda Drive
- Shore Acres
- Baywood
- Drum Point
- Route 35
- Route 88
- Seawood Harbor

5.8 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For the flood hazard, the hazard areas include the 1-percent and 0.2-percent annual chance flood zones, Category 1-4 Sea-Lake Overland Surge from Hurricane (SLOSH), and the NOAA 2050 Intermediate-High and High sea-level rise scenarios. The following text evaluates and estimates the potential impact of these hydrologic hazards for the Township of Brick including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, health and safety of residents, (2) general building stock, (3) critical facilities, (4) economy, and (5) future growth and development
- Effect of climate change on vulnerability
- Further data collections that will assist understanding this hazard over time

5.8.1 Overview of Vulnerability

The flood hazard is a significant concern for the Township of Brick. As discussed, this includes riverine and coastal flooding, storm surge, flooding from dam failure, and sea level rise. In addition, coastal erosion is a significant coastal hazard to the Township as well. To assess flood vulnerability, exposure to the 1- and 0.2-percent annual chance flood events was examined using the FEMA preliminary FIRM released in January 2015. Potential losses were also calculated for 1- percent annual chance flood event. The flood hazard exposure and loss estimate analysis is presented below.

For the Township of Brick, storm surge from coastal storm events is a major concern. Storm surge along the coast and river inlets may cause erosion and damage to the Township's infrastructure and buildings. The SLOSH hazard exposure and loss estimate analysis is presented below.

Lastly, sea level rise was evaluated. Based on discussions with the Township and Jacques Cousteau National Estuarine Research Reserve, as well as to align with the State of New Jersey Hazard Mitigation Plan, two NOAA sea level rise scenarios were examined to estimate exposure in the Township.

5.8.2 Data and Methodology

The 1- and 0.2-percent annual chance flood events were examined to evaluate the Township's risk to the flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as the NFIP. The FEMA preliminary flood maps released in January 2015 were used to evaluate the Township's exposure to this hazard. The data used for this analysis is shown in Figure 5-26.

To estimate potential losses, the FEMA Hazards U.S. Multi-Hazard (HAZUS-MH) flood model was used. The default building inventory in HAZUS-MH 2.2 was updated and replaced with a custom building inventory developed for the Township of Brick. The most current Township-provided parcel shapefile was joined to post-Hurricane Sandy tax data. The attributes from these files were aligned with HAZUS-MH's Comprehensive Data

Management System's required building stock fields. Where data was not available, reasonable assumptions were made. The user-defined table in HAZUS-MH was updated and a building-specific analysis was conducted. The 1-percent annual chance depth grid generated by NJDEP for Ocean County was integrated into the HAZUS-MH flood model and then run to estimate potential losses at the structure level using the HAZUS-MH default damage functions.

The National Hurricane Center's SLOSH model, which represents potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide was used to estimate exposure. The model forecasts surges that occur from wind and pressure forces of hurricanes, considers only storm surge height and does not consider the effects of waves. The FEMA Coastal Flood Loss Atlas storm surge inundation depth grids generated in GIS format from SLOSH Maximum of Maximums (MOMs) outputs per hurricane category were integrated into the HAZUS-MH flood model to estimate losses. Figure 5.9 illustrates the data used for this analysis.

To assess the Township's vulnerability to sea level rise, a spatial analysis was conducted with the NOAA sea level rise scenario polygon data. The 2050 Intermediate-High and the Highest NOAA sea level rise scenarios were selected to account for the full range of potential impacts. There are no depth grids associated with these scenarios, so estimated losses were not calculated in HAZUS-MH. This sea-level rise data set was generated by combining the best available SFHA at the time with the various sea-level rise scenarios; it displays a combination hazard of potential flooding hazards as a result of different sea-level rise scenarios.

- Intermediate-High [Best Available Special Flood Hazard Area (SFHA) + 1.3 feet]
- Highest (Best Available SFHA + 2.0 feet)

Figure 5-26 illustrates the flood hazard vulnerable location and critical facilities in the Township of Brick. It is noted that regarding fresh water intakes not identified in the figure, there is a long-term planning concern that sea-level rise may affect the Township fresh water supply, ultimately bringing brackish water further upstream and on a more frequent basis, making salt water presence at the water utility intake a more common occurrence.

Figure 5-26. FEMA Flood Hazard Vulnerability to the Township of Brick

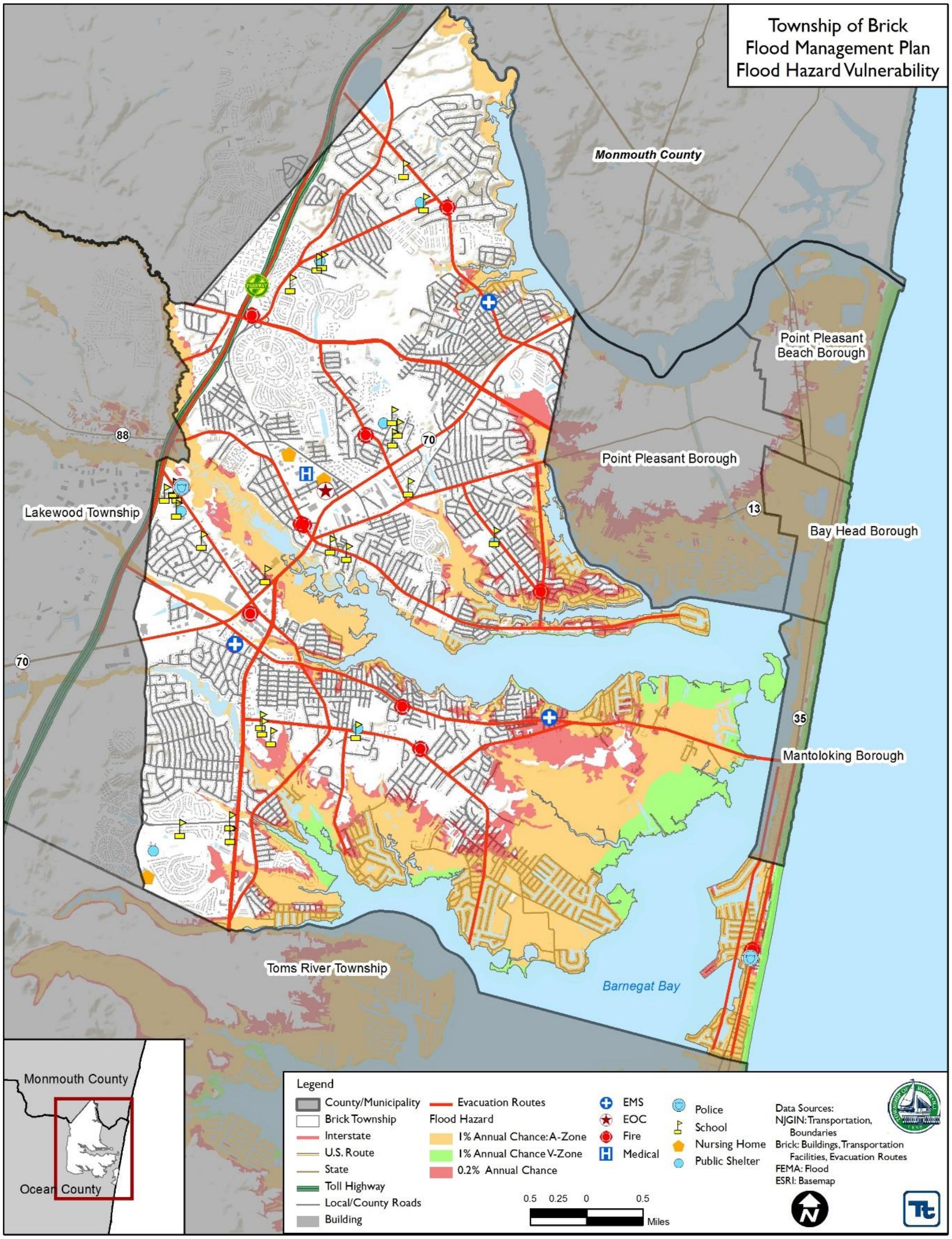
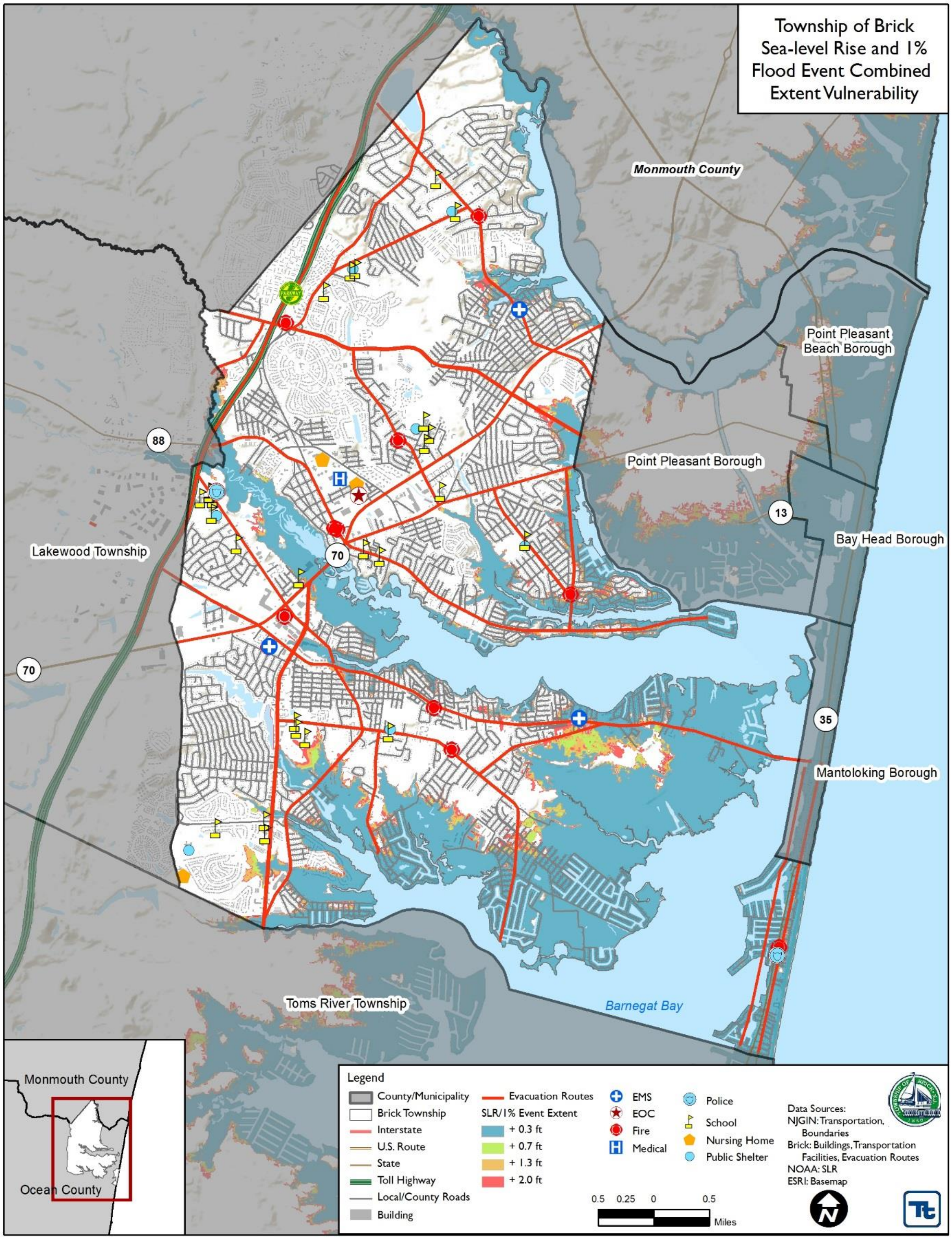


Figure 5-27. Sea-Level Rise Scenario Vulnerability to the Township of Brick



5.8.3 Total Area Located in the Hazard Areas

A spatial analysis was conducted to calculate the total area located in the hazard areas. The results are presented in the table below. The total area of the Township of Brick is approximately 16,753.6 acres.

Table 5-13. Total Land Area in the Flood Hazard Areas (Acres)

Hazard	Area (acres)	% of Total
1-percent Annual Chance Flood Event	4,861.2	29.0%
0.2% Annual Chance Flood Event	5,956.1	35.6%
SLOSH Category 1	3,313.3	19.9%
SLOSH Category 2	6,030.5	36.0%
SLOSH Category 3	8,743.1	52.2%
SLOSH Category 4	10,848.9	64.8%
2050 Intermediate-High Scenario Sea-Level Rise	5,220.3	31.2%
2050 Highest Scenario Sea-Level Rise	5,535.8	33.0%

Source: FEMA 2015, NJOEM 2013, NOAA 2012, NJGIN
Note: % - Percent; Cumulative analysis conducted.

5.8.4 Natural and Beneficial Floodplain Areas

Although typically associated as a hazard area, floodplains also serve beneficial and natural functions (on ecological/environmental, social, and economic levels). Disruption of these natural systems can have long-term consequences on entire regions; however, this potential impact has only recently been noted. Some of the more well-known water-related functions for floodplains include:

- Natural flood and erosion control
  - Provide flood storage and conveyance
  - Reduce flood velocities
  - Reduce flood peaks
  - Reduce sedimentation
- Surface water quality maintenance
  - Filter nutrients and impurities from runoff
  - Process organic wastes
  - Moderate temperatures of water
- Groundwater recharge
  - Promote infiltration and aquifer recharge
  - Reduce frequency and duration of low surface flows (FEMA 1996)

Areas in the floodplain that typically provide these natural functions are wetlands, riparian areas, sensitive areas, and habitats for rare and endangered species. According to NJ DEP 2015 Land-Use Land-Cover data and 2012 NJDEP Landscape Project Data, Brick Township has several floodplain areas that could serve natural and beneficial functions (Landscape Project contains the endangered species data). This information is summarized in Table 5-14.

Table 5-14. Natural and Beneficial Land in Brick Township

Wetlands	Area (acres)	Forest	Area (acres)	Endangered Species	Area (acres)
Atlantic White Cedar Wetlands	13.75	Coniferous Brush/Shrubland	2.34	Special Concern	752.50
Coniferous Scrub/Shrub Wetlands	9.36	Coniferous Forest (>50% Crown Closure)	65.94	State Endangered	85.71
Coniferous Wooded Wetlands	211.31	Coniferous Forest (10-50% Crown Closure)	35.13	State Threatened	1,859.84
Deciduous Scrub/Shrub Wetlands	42.96	Deciduous Brush/Shrubland	7.74		
Deciduous Wooded Wetlands	241.59	Deciduous Forest (>50% Crown Closure)	4.54		
Disturbed Tidal Wetlands	1.00	Deciduous Forest (10-50% Crown Closure)	8.67		
Disturbed Wetlands (Modified)	4.31	Mixed Deciduous/Coniferous Brush/Shrubland	16.07		
Herbaceous Wetlands	11.41	Mixed Forest (>50% Coniferous With >50% Crown Closure)	33.45		
Managed Wetland In Built-Up Maintained Rec Area	5.76	Mixed Forest (>50% Coniferous With 10-50% Crown Closure)	4.97		
Managed Wetland In Maintained Lawn Greenspace	0.00	Mixed Forest (>50% Deciduous With >50% Crown Closure)	11.71		
Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	44.34	Mixed Forest (>50% Deciduous With 10-50% Crown Closure)	2.45		
Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	106.87	Old Field (< 25% Brush Covered)	14.17		
Mixed Wooded Wetlands (Coniferous Dom.)	392.57				
Mixed Wooded Wetlands (Deciduous Dom.)	214.17				
Phragmites Dominate Coastal Wetlands	216.38				
Phragmites Dominate Interior Wetlands	47.76				
Phragmites Dominate Urban Area	0.15				
Saline Marsh (High Marsh)	113.74				
Saline Marsh (Low Marsh)	688.81				
Vegetated Dune Communities	4.24				

Wetlands	Area (acres)	Forest	Area (acres)	Endangered Species	Area (acres)
Wetland Rights-Of-Way	1.57				

Source: NJDEP 2015; NJDEP 2012
Note: An additional 792.68 acres of land didn't have a joinable ID number. This could be a miscellaneous potential habitat for endangered species. Endangered species listed for Brick Township include but are not limited to the bald eagle, barred owl, black-crowned night-heron, bog turtle, Caspian tern, Cooper's hawk, great blue heron, northern harrier, northern pine snake, osprey, and snowy egret.

5.8.5 Warning and Evacuation

The Township has developed a Flood Warning and response plan to assist the community in ensuring timely identification of impending flood threats and disseminating warnings to appropriate floodplain occupants in addition to coordinating flood response activities to reduce the threat to life and property. Further information may be obtained from the Township Office of Emergency Management.

5.8.6 Impact on Life, Health and Safety

The impact of the hydrologic hazards 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 the hazard areas that could be impacted should an 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 cascading impacts of a hazard event (e.g., people are at risk while traveling in flooded areas, or their access to emergency services is compromised during an event).

Cascading impacts may also include exposure to pathogens such as mold. As a result of repetitive flooding, mold has the potential to develop endangering the health of residents, especially those with already compromised immune systems (e.g., people with HIV infection, cancer patients receiving chemotherapy, and individuals who have received an organ transplant) along with other vulnerable populations, including infants, children, the elderly, and pregnant women. The degree of that impact will vary and is not strictly measurable. Molds can grow in as short a period as 24-48 hours in wet and dam areas of buildings that have not been cleaned after flooding. Very small mold spores can easily be inhaled, creating the potential for allergic reactions, asthma episodes, and other respiratory problems. Buildings should be properly cleaned and dried out to safely prevent mold growth (Centers for Disease Control and Prevention [CDC], 2015).

Molds and mildews are not the only public health risk associated with flooding. Floodwaters can be contaminated by pollutants such as sewage, human and animal feces, pesticides, fertilizers, oil, asbestos, and rusting building materials. Common public health risks associated with flood events also include:

- Unsafe food
- Contaminated drinking and washing water and poor sanitation
- Mosquitos and animals
- Carbon monoxide poisoning
- Secondary hazards associated with re-entering/cleaning flooded structures
- Mental stress and fatigue

Current loss estimation models such as Hazus are not equipped to measure public health impacts. The best level of mitigation for these impacts is to be aware that they can occur, educate the public on prevention, and be prepared to deal with these vulnerabilities in responding to flood events.

To estimate the population exposed to the hazard areas, the 1- and 0.2-percent floodplain boundaries, SLOSH zones, and sea-level rise scenarios were overlaid upon the 2010 Census population data in GIS (U.S. Census 2010). The 2010 Census blocks with their centroid in the hazard areas were used to calculate the estimated population exposed. The total population of the Township of Brick is 75,075 (U.S. Census 2010).

Census blocks do not follow the boundaries of the floodplain, SLOSH, or sea-level rise scenarios and can grossly over or under estimate the population exposed when using the centroid or the intersect of the Census block with these zones. The limitations of these analyses are recognized, and as such the results are only used to provide a general estimate. The calculation of the 0.2-percent annual chance flood event results is cumulative in nature, as the population exposed to the 1-percent flood event will also be exposed to the 0.2-percent annual chance flood event. The SLOSH and sea-level rise analyses for the exposure of population, general building stock, and critical facilities are also cumulative in nature. For example, if a Census block is located within the Category 1 SLOSH zone, it is also located within the Category 2 SLOSH zone. The assumption is that if a Census block is affected by a Category 1 storm it would also be affected by a Category 2 or 3 storm event. For this purposes of this assessment, the population/demographic data presented include only those Census blocks whose geometric centers fall within the identified hazard areas.

Using this approach, it is estimated that 10,565 people are located in the 1-percent annual chance event and 14,543 people are exposed to the 0.2-percent annual chance flood event. It is estimated that 6,230 people are located in the Category 1 SLOSH zone, 17,414 people are located in the Category 2 SLOSH zone, 30,835 people are located in the Category 3 SLOSH zone, and 43,833 people are located in the Category 4 SLOSH zone. There are an estimated 11,470 people who are located in the 2050 Intermediate-High sea-level rise scenario delineated area, and 13,566 people in the 2050 Highest sea-level rise scenario area. Refer to Table 5-15 and 5-16 and Figures 5-28 through 5-30 for the results by hazard.

Table 5-15. Estimated U.S. Census 2010 Population Exposure to All Hazard Areas

Hazard	Total Number Exposed	% of Total
1-percent Annual Chance Flood Event	10,565	14.1%
0.2% Annual Chance Flood Event	14,543	19.4%
SLOSH Category 1	6,230	8.3%
SLOSH Category 2	17,414	23.2%
SLOSH Category 3	30,835	41.1%
SLOSH Category 4	43,833	58.4%
2050 Intermediate-High Scenario Sea-Level Rise	11,470	15.3%
2050 Highest Scenario Sea-Level Rise	13,566	18.1%

Source: FEMA 2015, NJOEM 2013, NOAA 2012, US Census 2010
Note: % - Percent

Table 5-16. Estimated Population Over 65 and Low-Income Population Exposure to All Hazard Areas

Hazard	Total Elderly Population	Total Number Exposed	% of Total	Total Low-Income Population	Total Number Exposed	% of Total
1-percent Annual Chance Flood Event	13,468	1,958	14.5%	3,360	332	9.9%
0.2% Annual Chance Flood Event	13,468	2,429	18.0%	3,360	435	12.9%
SLOSH Category 1	13,468	1,186	8.8%	3,360	188	5.6%
SLOSH Category 2	13,468	2,830	21.0%	3,360	530	15.8%

Hazard	Total Elderly Population	Total Number Exposed	% of Total	Total Low-Income Population	Total Number Exposed	% of Total
SLOSH Category 3	13,468	5,043	37.4%	3,360	1,104	32.9%
SLOSH Category 4	13,468	7,133	53.0%	3,360	1,724	51.3%
2050 Intermediate-High Scenario Sea-Level Rise	13,468	1,918	14.2%	3,360	335	10.0%
2050 Highest Scenario Sea-Level Rise	13,468	2,143	15.9%	3,360	392	11.7%

Source: FEMA 2015, NJOEM 2013, NOAA 2012, US Census 2010
Note: % - Percent

Figure 5-28. Estimated Population Exposure to Flood Hazard Areas

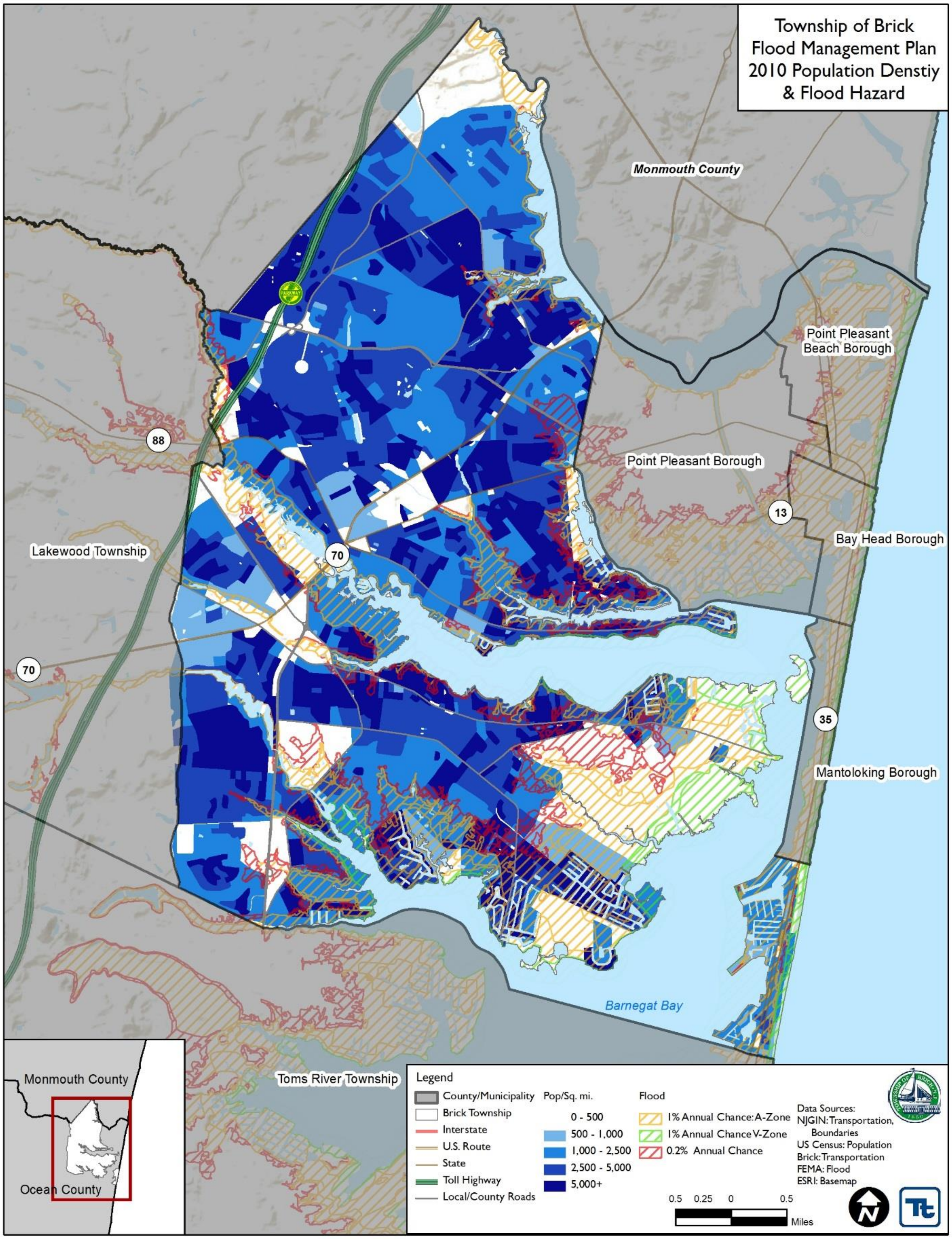


Figure 5-29. Estimated Population Exposure to SLOSH Hazard Areas

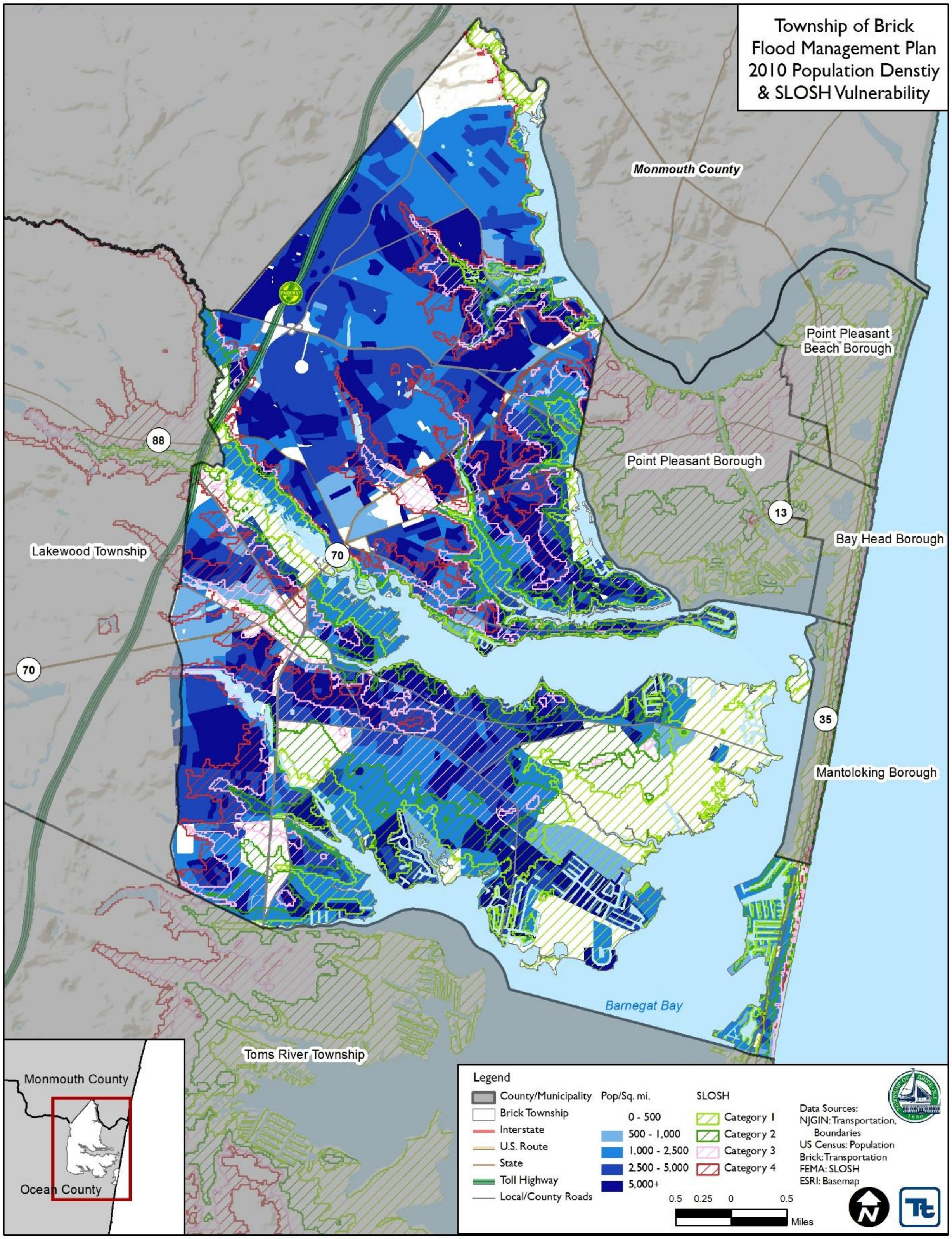
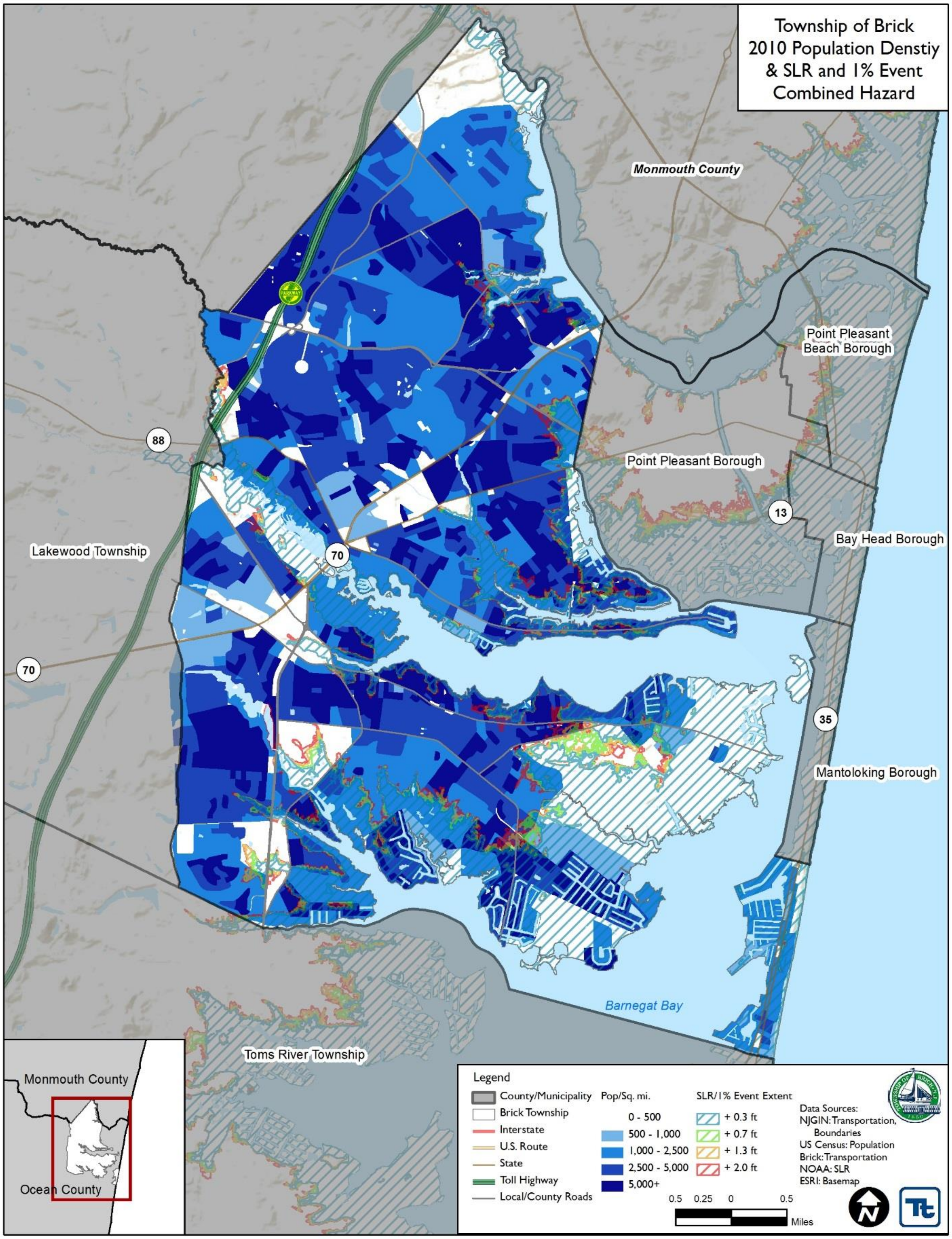


Figure 5-30. Estimated Population Exposure to Sea-Level Rise Hazard Areas



Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact to their family. The population over the age of 65 is also more vulnerable because they are more likely to seek or need medical attention which may not be available to due isolation during a flood event and they may have more difficulty evacuating. Special consideration should be taken when planning for disaster preparation, response, and recovery for these vulnerable groups.

Using 2010 U.S. Census data, HAZUS-MH 2.2 estimates the potential sheltering needs as a result of a 1-percent chance flood event. These statistics, by hazard, are presented in Table 5-17.

Table 5-17. Estimated Population Displaced or Seeking Short-Term Shelter by the 1-percent Annual Chance Event

Hazard	Displaced Households	Persons Seeking Short-Term Sheltering
1-percent Annual Chance Flood Event	11,443	9,807
SLOSH Category 1	7,549	6,529
SLOSH Category 2	17,331	14,865
SLOSH Category 3	31,530	27,838
SLOSH Category 4	43,477	38.998

Source: HAZUS-MH 2.2

The total number of injuries and casualties resulting from flooding is generally limited based on advance weather forecasting, blockades and warnings. Therefore, injuries and deaths generally are not anticipated if proper warning and precautions are in place. Ongoing mitigation efforts should help to avoid the most likely cause of injury, which results from persons trying to cross flooded roadways or channels during a flood.

5.8.7 Impact on General Building Stock

After considering the population exposed and potentially vulnerable to the hazard areas, the built environment was evaluated. Exposure includes those buildings located in the hazard areas. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content value.

Overall, there are a total of 40,489 structures in the Township with a total replacement cost value of greater than $18 billion and a total tax ratable amount of greater than $10 billion. To provide a general estimate of the building value exposed to the flood hazards, the 1- and 0.2-percent floodplain boundaries, SLOSH zones, and sea-level rise scenarios were overlaid upon the Township's updated building stock inventory at the structure level. The buildings with their centroid in the hazard areas were totaled. Table 5-18 and Table 5-19 and Figure 5-31 through Figure 5-33 summarize these results.

Table 5-18. Estimated General Building Stock Exposure to All Flood Hazard Areas

Hazard	Number of Structures Exposed	% of Total	Total RCV Exposed	% of Total	Total Tax Ratable Exposed	% of Total
1-percent Annual Chance Flood Event	7,488	18.5%	$3,481,039,250	18.6%	$1,418,745,677	13.2%
0.2% Annual Chance Flood Event	10,166	25.1%	$4,659,704,863	24.8%	$2,440,230,651	22.7%
SLOSH Category 1	5,005	12.4%	$2,313,165,139	12.3%	$917,559,002	8.5%
SLOSH Category 2	11,395	28.1%	$5,180,357,074	27.6%	$3,080,119,761	28.6%

Table 5-18. Estimated General Building Stock Exposure to All Flood Hazard Areas

Hazard	Number of Structures Exposed	% of Total	Total RCV Exposed	% of Total	Total Tax Ratable Exposed	% of Total
SLOSH Category 3	19,230	47.5%	$8,676,175,170	46.3%	$4,993,605,576	46.4%
SLOSH Category 4	25,494	63.0%	$11,221,622,025	59.8%	$6,422,371,185	59.7%
2050 Intermediate-High Scenario Sea-Level Rise	9,237	22.8%	$4,215,445,897	22.5%	$1,745,934,419	16.2%
2050 Highest Scenario Sea-Level Rise	10,105	25.0%	$4,581,928,097	24.4%	$2,222,444,719	20.7%

Source: FEMA 2015, NJOEM 2013, NOAA 2012, Brick Township
Note: % - Percent
RCV – Replacement Cost Value

Table 5-19. Estimated Number of Buildings Exposed by Occupancy Type to All Flood Hazard Areas

Hazard	Number of Residential Structures	Number of Commercial Structures	Number of Industrial Structures	Number of Governmen t Structures	Number of Education Structures	Number of Religion/ Non-Profit Structures
1-percent Annual Chance Flood Event	7,285	193	0	2	0	7
0.2% Annual Chance Flood Event	9,881	259	1	3	2	19
SLOSH Category 1	4,871	130	0	0	0	0
SLOSH Category 2	11,068	288	1	3	14	18
SLOSH Category 3	18,533	619	4	14	19	37
SLOSH Category 4	24,522	859	9	21	23	55
2050 Intermediate-High Scenario Sea-Level Rise	8,958	234	1	3	0	11
2050 Highest Scenario Sea-Level Rise	9,818	261	1	3	2	17

Source: FEMA 2015, NJOEM 2013, NOAA 2012, Brick Township

Figure 5-31. Estimated General Building Stock Exposure to Flood Hazard Areas

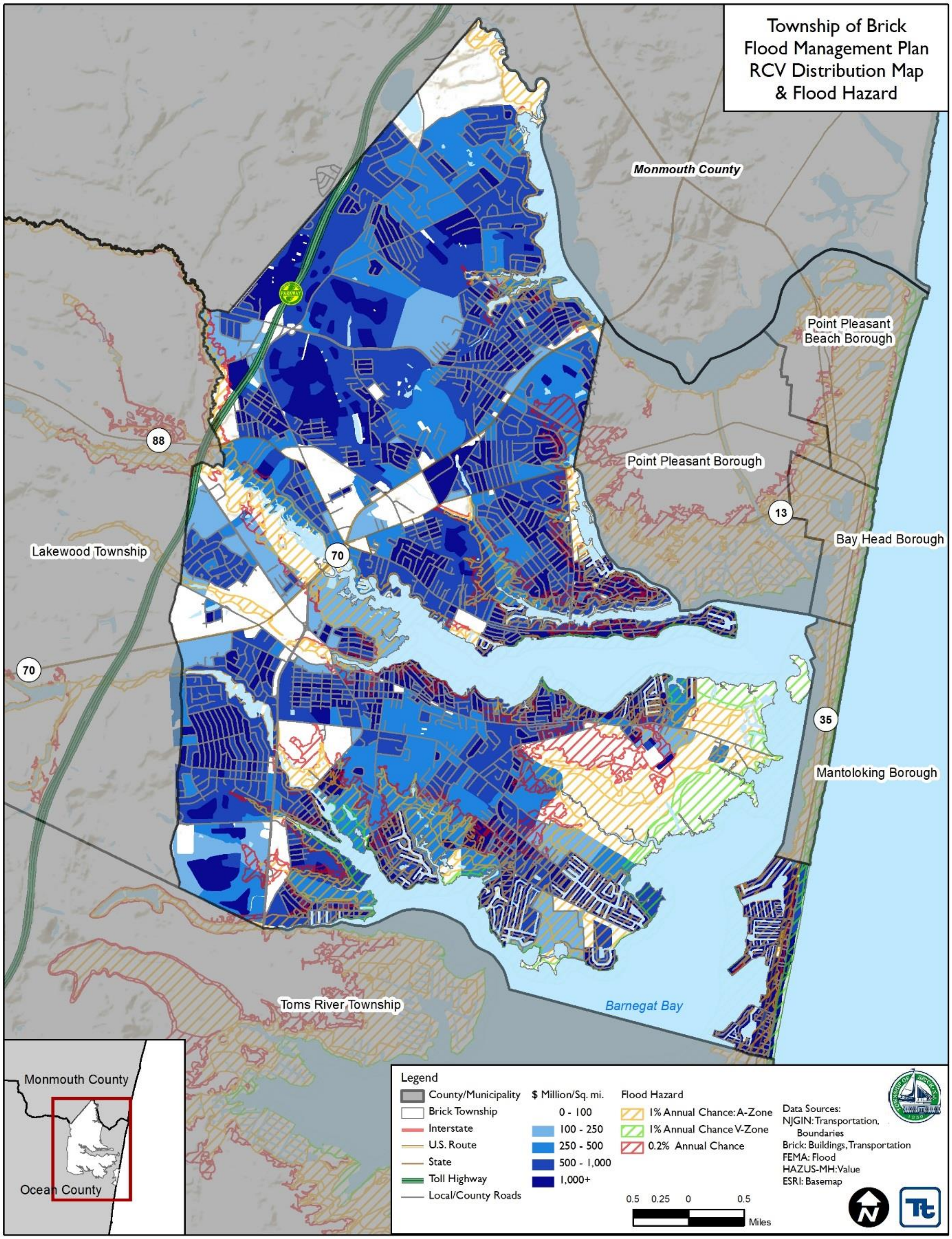


Figure 5-32. Estimated General Building Stock Exposure to SLOSH Hazard Areas

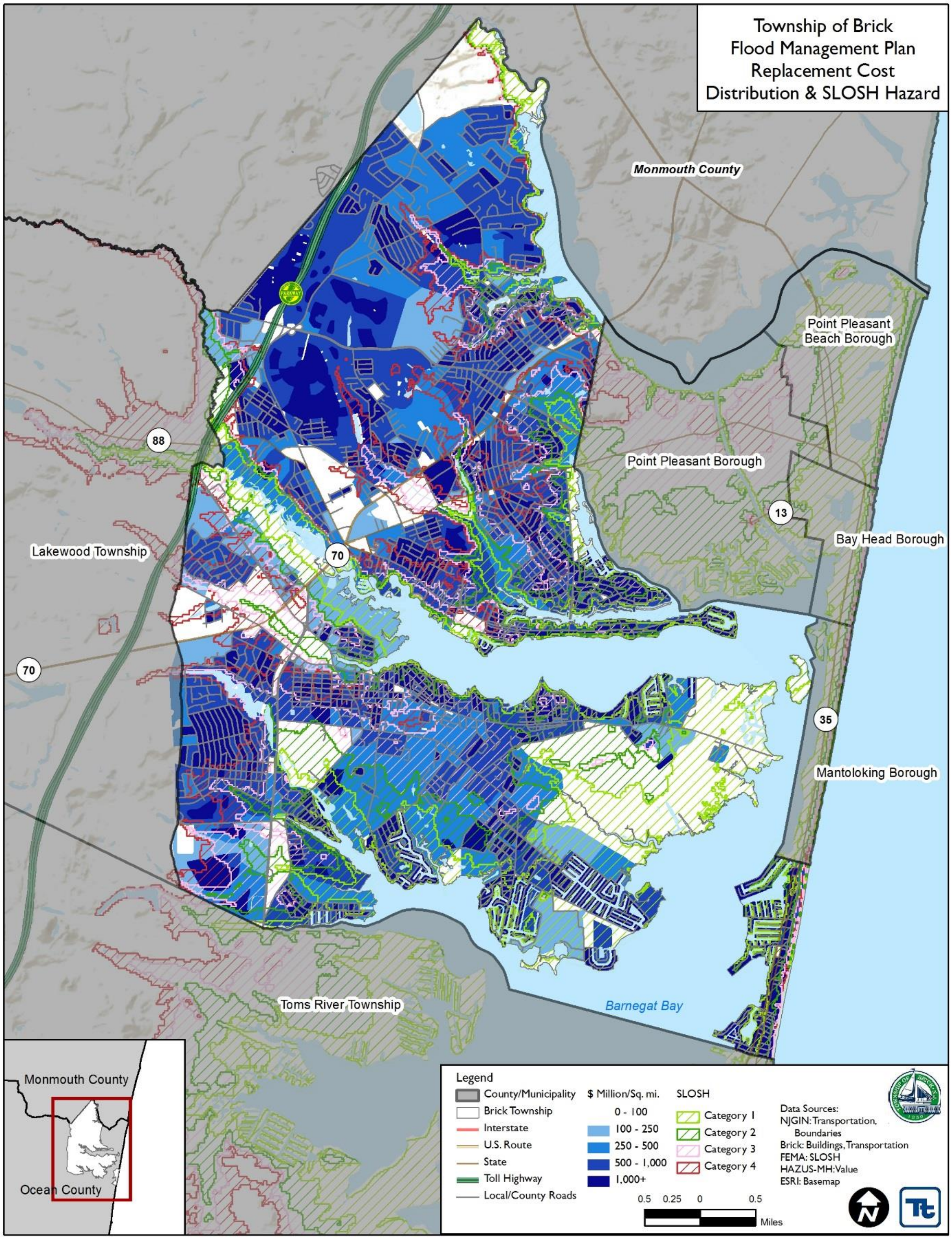
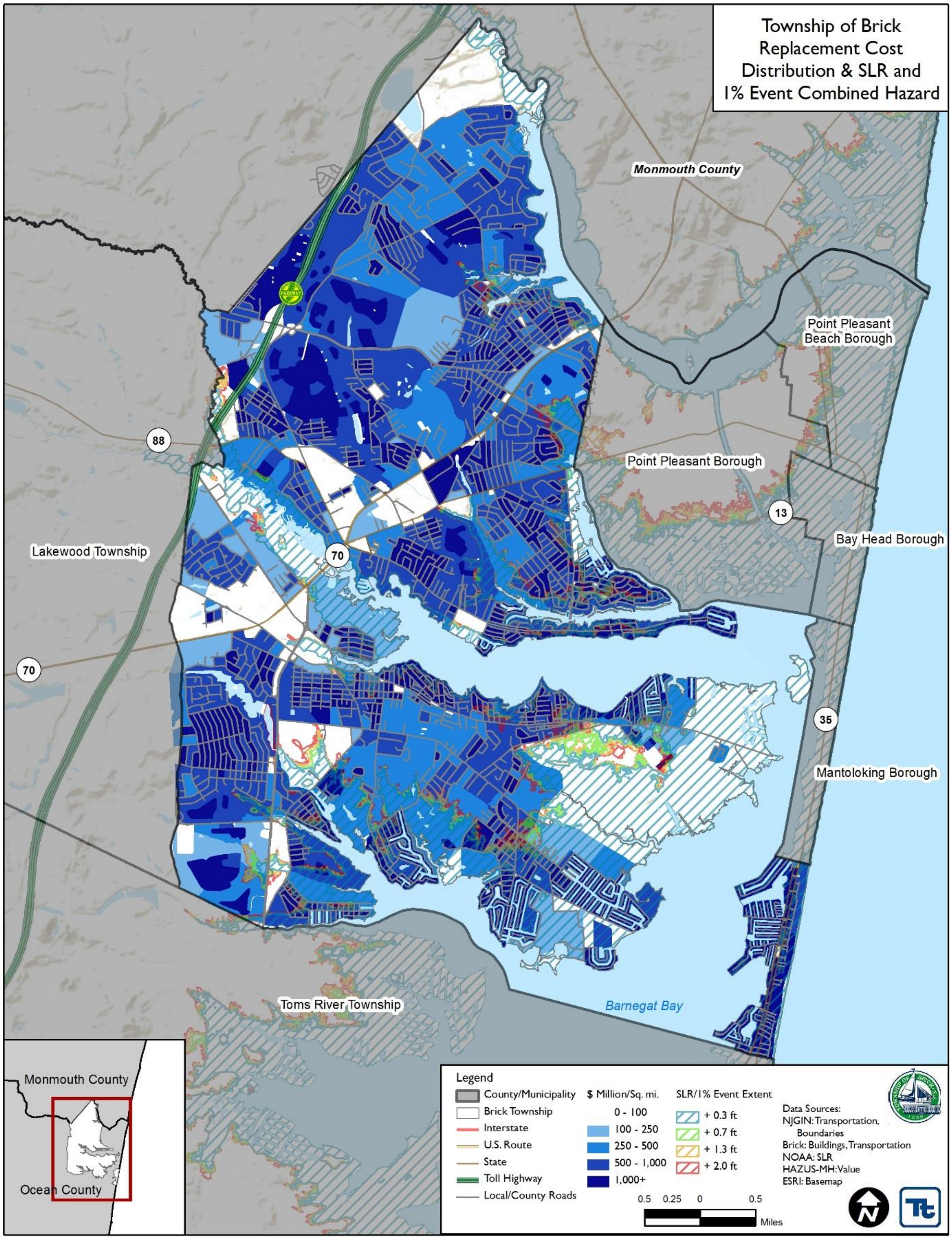


Figure 5-33. Estimated General Building Stock Exposure to Sea-Level Rise Hazard Areas



The HAZUS-MH model estimated potential damages to the buildings in the Township of Brick at the structure level using the custom Township structure inventory developed for this plan. The potential damage estimated by HAZUS-MH to the general building stock inventory associated with the 1-percent annual chance flood is approximately $497 million or 2.6-percent of the total building stock replacement cost value. HAZUS-MH also estimated 1-percent, 6.6-percent, 16.2-percent, and 26.2-percent of the Township's total building stock replacement cost value for the Category 1, Category 2, Category 3, and Category 4 inundation areas, respectively.

Table 5-20. Estimated General Building Stock Potential Loss to the 1-percent Annual Chance Flood Event

Occupancy Type	Total Replacement Cost Value	1-percent Annual Chance Event			
		Total Estimated Loss	Estimated Building Loss	Estimated Contents Loss	% of Total RCV
All Occupancies	$18,755,258,907	$496,762,914	$289,741,798	$207,021,116	2.6%
Residential	$15,766,432,088	$432,651,836	$275,517,431	$157,134,405	2.7%
Commercial	$2,131,577,543	$60,258,950	$13,718,257	$46,540,693	2.8%
Industrial, Religious, Education and Government	$857,249,277	$3,852,128	$506,110	$3,346,017	<1%

Source: HAZUS-MH 2.2
Note: % - Percent

Table 5-21. Estimated General Building Stock Potential Loss to the SLOSH Hazard for All Occupancy Classes

Hazard Area	Total Replacement Cost Value	Estimated Loss	Estimated Building Loss	Estimated Contents Loss	% of Total
SLOSH Category 1	$18,755,258,907	$188,238,930	$116,144,074	$72,094,856	1.0%
SLOSH Category 2	$18,755,258,907	$1,242,639,405	$701,930,535	$540,708,870	6.6%
SLOSH Category 3	$18,755,258,907	$3,029,459,417	$1,665,429,040	$1,364,030,377	16.2%
SLOSH Category 4	$18,755,258,907	$4,918,850,388	$2,766,282,412	$2,152,567,976	26.2%

Source: HAZUS-MH 2.2
Note: % - Percent

5.8.8 NFIP Policy, Claim and Repetitive Loss Statistics

In addition to total building stock modeling, individual data available on flood policies, claims, Repetitive Loss (RL) properties and severe RL (SRL) properties were analyzed. FEMA Region 2 provided a list of properties with NFIP policies, past claims and multiple claims (RL and SRLs). According to the metadata provided: "The (*sic* National Flood Insurance Program) NFIP Repetitive Loss File contains losses reported from individuals who have flood insurance through the Federal Government. A property is considered a repetitive loss property when there are two or more losses reported which were paid more than $1,000 for each loss. The two losses must be within 10 years of each other & be as least 10 days apart. Only losses from (*sic* since) 1/1/1978 that are closed are considered."

SRLs were then examined for the Township. According to section 1361A of the National Flood Insurance Act, as amended (NFIA), 42 U.S.C. 4102a, an SRL property is defined as a residential property that is covered under an NFIP flood insurance policy and:

- Has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or
- For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.
- For both of the above, at least two of the referenced claims must have occurred within any 10- year period, and must be greater than 10 days apart.

Table 5-22 and Table 5-23 summarize the NFIP policies, claims and repetitive loss statistics for Brick Township. Table 5-17 summarizes the occupancy classes of the RL properties in Brick Township. The majority of the RL occupancy class is comprised of single family residences (97.8 percent). This information was presented in the 2018 Ocean County Hazard Mitigation Plan.

The location of the properties with policies, claims and repetitive and severe repetitive flooding were geocoded by FEMA with the understanding that there are varying tolerances between how closely the longitude and latitude coordinates correspond to the location of the property address, or that the indication of some locations are more accurate than others.

Table 5-22. Occupancy Class of Repetitive Loss Structures in Brick Township

Occupancy Class	Total Number of Repetitive Loss Properties
Single Family	133
Condo	0
2-4 Family	1
Other Residential	0
Non-Residential	2
Brick Township	**136**

Source: Ocean County HMP 2018

Table 5-23. NFIP Policies, Claims and Repetitive Loss Statistics

Municipality	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)
Brick Township	4,129	3,940	$276,232,540	136

Source: Ocean County HMP 2018

5.8.9 Repetitive Loss Area Analysis (RLAA)

A repetitive loss area analysis was performed to enhance the information in this plan to support targeted outreach and more effective floodplain management for the community. The repetitive loss area includes both repetitive loss properties, as determined by FEMA, and properties that may undergo repetitive flood damage but are not technically considered repetitive loss properties by the NFIP. Properties that may undergo repetitive flood damage but are not classified as NFIP RLs or SRLs can occur for a variety of reasons, including the following:

- Property owners may not have flood insurance. Only properties within the floodplain and with a federally-backed mortgage are required to carry flood insurance.
- Owners of a flooded property may choose not to file a claim, even if the owner has flood insurance.

- The flood damage may not meet the minimum $1,000 threshold necessary for repetitive loss, but the property may still undergo recurring flood damage.

In the Township of Brick, the majority of repetitive loss properties are located in the floodplain. The cause of repetitive flooding at these properties is commensurate with the flood risk reflected on the current preliminary FIRM for the community. In many cases there are multiple causes of flooding as homes in the floodplain also experience stormwater flooding caused by inadequate flow with respect to issues related to local topography and drainage issues related to the low relative elevation of outfalls with respect to water surface elevations at high tide. In 2016, the Township has identified 27 repetitive loss areas including 2,799 structures. A 2021 update is currently underway.

5.8.10 Impact on Critical Facilities

HAZUS-MH was used to estimate the flood loss potential to critical facilities exposed to the flood hazard. Using depth-damage function curves, HAZUS estimates the percent of damage to the building and contents of critical facilities. Due to the sensitive nature of facility-specific information, the results of this detailed analysis is not included in the plan. Table 5-24 summarizes the number of critical facilities located in the hazard areas by type.

In cases where short-term functionality is impacted by a hazard, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce impact to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

Table 5-24. Number of Critical Facilities Located in the Hazard Areas

Facility Type	1-percent Annual Chance Event	0.2% Annual Chance Event	SLOSH Category 1	SLOSH Category 2	SLOSH Category 3	SLOSH Category 4	2050 Intermediate-High Scenario SLR	2050 Highest Scenario SLR
Bridge	10	10	6	8	9	11	7	7
County Building	2	2	-	1	3	3	1	1
Dam	1	2	1	2	3	3	-	1
EMS	-	1	-	1	1	2	1	1
EOC	1	1	-	1	1	3	1	1
Fire	1	2	-	2	5	5	2	2
Library	-	-	-	-	-	1	-	-
Police	1	1	-	1	1	2	1	1
Post Office	-	-	-	-	1	2	-	-
Potable Pump	3	3	3	3	4	4	2	3
School	-	1	-	2	7	14	1	1
Shelter	-	-	-	-	2	3	-	-
Substation	2	3	1	3	3	4	2	3
Potable Tank	-	-	-	1	2	2	-	-
Town Hall	-	-	-	-	-	1	-	-
Well	8	9	11	11	11	11	8	9

Table 5-24. Number of Critical Facilities Located in the Hazard Areas

Facility Type	1-percent Annual Chance Event	0.2% Annual Chance Event	SLOSH Category 1	SLOSH Category 2	SLOSH Category 3	SLOSH Category 4	2050 Intermediate-High Scenario SLR	2050 Highest Scenario SLR
Wastewater Pump	13	15	7	15	16	18	15	15
Wastewater Treatment Facility	-	-	-	-	1	1	-	-

Source: FEMA 2015, NJOEM 2013, NOAA 2012, Brick Township
Notes: Cumulative analysis conducted.

5.8.11 Impact on the Economy

For impact on economy, estimated losses from a flood event are considered. Losses include but are not limited to general building stock damages, business interruption, impacts to tourism and tax base to the Township. Estimated damages to the general building stock can be quantified using HAZUS-MH as discussed above. Other economic components such as loss of facility use, functional downtime and social economic factors are less measurable with a high degree of certainty.

Flooding can cause extensive damage to public utilities and disruptions to the delivery of services. Loss of power and communications may occur; and drinking water and wastewater treatment facilities may be temporarily out of operation. As indicated in Table 5-24, 42 facilities are located in the 1-percent annual chance flood hazard area, and eight (8) additional facilities in the 0.2% annual chance flood area. There are 29 facilities located in the Category 1 SLOSH inundation area, 51 facilities in the Category 2 SLOSH inundation area, 70 facilities in the Category 3 SLOSH inundation area, and 90 facilities in the Category 4 SLOSH inundation area; all of which are cumulative in nature.

In terms of sea level rise, there are 41 facilities located in both the intermediate-high and high sea-level rise scenario inundation areas, with four (4) additional facilities exposed to the highest sea-level rise scenario inundation area. In addition to critical facility potential damages and loss of function, flooded streets and road blocks make it difficult for emergency vehicles to respond to calls for service. Floodwaters can wash out sections of roadway and bridges (Foster, Date Unknown). In addition to travel along the roadways, public transit will be greatly impacted, causing problems for emergency responders.

Direct building losses are the estimated costs to repair or replace the damage caused to the building. Refer to the 'Impact on General Building Stock' subsection which discusses these potential losses. These dollar value losses to the Township's total building inventory replacement value, in addition to damages to roadways and infrastructure, would greatly impact the local economy.

HAZUS-MH estimates the amount of debris generated from the 1-percent annual chance flood event. The model breaks down debris into three categories: 1) finishes (dry wall, insulation, etc.); 2) structural (wood, brick, etc.) and 3) foundations (concrete slab and block, rebar, etc.). The distinction is made because of the different types of equipment needed to handle the debris. The HAZUS-MH Flood Model focuses on building-related debris and does not estimate debris generated for building contents such as household appliances (e.g., ovens or refrigerators), electronics and other personal items, or environmental (trees, shrubs, sediment etc.) debris. Table 5-20 summarizes the debris HAZUS-MH 2.2 estimates for these events. As a result of the 1-percent event, HAZUS-MH estimates a total of approximately 30,571 tons of debris will be generated. As a result of the Category 1 storm surge scenario, HAZUS-MH estimates approximately 5,062 tons of debris. HAZUS-MH also estimates approximately 53,692 tons, 249,871 tons, and 463,331 tons of debris as a results of the Category 2, Category 3, and Category 4 storm surge scenarios, respectively.

Please note this table only represents estimated debris generated by coastal flooding and does not include additional potential damage and debris which may be generated with the presence of wind.

Table 5-25. Estimated Debris Generated from the 1-Percent Flood Event and SLOSH Category 1-4 Scenarios

Hazard	1-percent Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
1-percent Annual Chance Event	30,571	20,564	6,083	3,924
SLOSH Category 1	5,062	4,081	602	380
SLOSH Category 2	53,692	31,780	13,425	8,487
SLOSH Category 3	249,871	72,165	103,917	73,788
SLOSH Category 4	463,331	109,826	203,772	149,732

Source: HAZUS-MH 2.2

5.8.12 Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such as flood events and hurricanes. While predicting changes of flood events and the prevalence or intensity of hurricanes under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2012).

5.8.13 Future Growth and Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the Township. Any areas of growth could be potentially impacted by the flood hazard if located within the identified hazard areas. It is the intention of the Township to discourage development in vulnerable areas or to encourage higher regulatory standards on the local level.

5.8.14 Additional Data and Next Steps

A HAZUS-MH flood analysis was conducted for the Township of Brick using the most current and best available data including updated building and critical facility inventories, and DFIRM. As additional FEMA Risk Mapping, Assessment, and Planning (Risk MAP) products become available, these may be used to further enhance this assessment (e.g. depth grids for additional recurrence intervals). Further, as additional climate change and sea-level rise scenarios and depth grids are generated, these may also be incorporated into HAZUS-MH and potential losses calculated.

Specific mitigation actions addressing improved data collection and further vulnerability analysis is included in Section 6 of this plan.