5.4.5 Flood

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

2021 HMP Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences (updated with events that occurred between 2016 and 2020), probability of future occurrence, and potential climate change impacts using best available data.
- A vulnerability assessment section was completed for the flood hazard that provides a more accurate estimated exposure and potential losses to Cape May County. The potential loss analysis was conducted using a custom County-wide building inventory with an estimated replacement cost value (structure and contents) for each structure; the replacement cost value was calculated using RS Means 2019 data. Using this updated building inventory, it was possible to calculate potential losses at the structure level. Additionally, hazard areas for the 1-percent annual chance flood event and 0.2-percent annual chance flood event were created using FEMA's October 4, 2017 Effective DFIRM and FEMA's June 30, 2014 Preliminary DFIRM data. A depth grid was created for the 1-percent annual chance flood event and integrated into the most current version of Hazus (v4.2), and the riverine and coastal models were run to estimate potential losses.

5.4.5.1 Profile

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.

Flooding in Cape May County is primarily attributed to coastal flooding from the Delaware Bay and the Atlantic Ocean (FEMA Preliminary FIS 2017). For the purpose of this HMP Update, and as deemed appropriate by the Planning Partnership, coastal flooding is the main flood type of concern that impacts Cape May County, followed by riverine (inland) flooding. The impacts of long term inundation as a result of sea level rise are discussed in Section 5.4.1 (Climate Change and Sea Level Rise) and Section 5.4.2 (Coastal Erosion).

Coastal Flooding

Coastal flooding occurs along the coasts of oceans, bays, estuaries, coastal rivers, and large lakes. Coastal floods are the submersion of land areas along the ocean coast and other inland waters caused by seawater over and above normal tide action. They are 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 Cape May County. 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

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

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

Riverine (Inland) and Flash Flooding

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

Flash floods are defined by the National Weather Service as "A flood caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through river beds, urban streets, or mountain canyons sweeping everything before them. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen, for instance after a levee or dam has failed, or after a sudden release of water by a debris or ice jam." (National Weather Service [NWS], n.d.).

Stormwater/Urban Flooding

Stormwater flooding described below is due to local drainage issues and high groundwater levels. Locally, heavy precipitation may produce flooding in areas other than delineated floodplains or along recognizable channels. If local conditions cannot accommodate intense precipitation through a combination of infiltration and

surface runoff, water may accumulate and cause flooding problems. During winter and spring, frozen ground and snow accumulations may contribute to inadequate drainage and localized ponding. Flooding issues of this nature generally occur in areas with flat gradients and generally increase with urbanization which speeds the accumulation of floodwaters because of impervious areas. Shallow street flooding can occur unless channels have been improved to account for increased flows (FEMA 1997). 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 streams. This bypasses the natural processes of water filtration through the ground, containment, and evaporation of excess water. Because drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding in those streams can occur more quickly and reach greater depths than prior to development in that area (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 1997).

Flood Protection Measures

Shore protection measures in the form of seawalls, stone revetments, bulkheads, jetties, and groins have been employed to prevent abnormally high tides from flooding and eroding the county's developed shoreline areas (FEMA Preliminary FIS 2017). The majority of flood protection measures in Cape May County are designed to reduce erosion and wave overwash but do provide some degree of flood protection as well.

In the Borough of Avalon, the northern portion of the community is protected by a series of bulkheads, revetments, groins, and jetties that span from the Townsend Inlet to the vicinity of 16th Street. For the community overall, especially south of 37th Street, the extensive dune system, consisting of primary and secondary dunes and thicket, serves as a protective barrier against the transmission of waves inland. The primary dunes, which are anchored by beach grass and lie closest to the shoreline, cannot be considered stable in nature. The secondary dunes further inland, are considered more stable as a consequence of their large spatial extent, the dissipation of wave energy attributable to the primary dunes or man-made structures, and the erosion protection afforded by the existence of vegetation (FEMA Preliminary FIS 2017).

The City of Cape May beachfront area is protected by a timber bulkhead (mostly on the southwestern end) and a stone seawall spanning most of the central beachfront and the western extremity (FEMA Preliminary FIS 2017). Both the bulkhead and seawall are protected by a seaward dune line.

In the Township of Lower, along the Delaware Bay shoreline, the Lower Township Planning Board is aware of the necessity to properly regulate development in areas prone to flooding and has employed ordinance controls to minimize potential damage to life and property (FEMA Preliminary FIS 2017).

In the City of Ocean City, bulkheads and dunes along the oceanfront and bulkheading along the bayfront offer modest flood protection.

In the City of North Wildwood, a stone and concrete seawall/revetment spans the shoreline along Hereford Inlet. Little to no beach exists to buffer the seawall from wave attack. The seawall's height is insufficient to prevent

wave overwash during runup, and may even allow the propagation of waves. The seawall's condition is suspect. It is, therefore, an ineffective barrier to wave attack during the 1-percent annual-chance storm. The timber bulkhead between 13th Street and 17th Street, and the boardwalk beginning south of 16th Street and continuing the length of North Wildwood, are also inadequate wave barriers during a 1-percent annual chance storm (FEMA Preliminary FIS 2017).

The City of Sea Isle City's beachfront area is protected by a series of dune formations in conjunction with a seawall, which contributes to the dissipation of wave energy. The fairly dense structural development, especially in the central and southern portions of the city, also impedes wave action (FEMA Preliminary FIS 2017).

The Borough of Stone Harbor's beachfront is protected by a continuous system of timber bulkheads, which spans from 80th Street south to the proposed location of 127th Street. Revetment has also been constructed from 80th Street to 114th Street (FEMA Preliminary FIS 2017).

In the Borough of West Cape May, the USACE developed a protection of the beach at South Cape May, which lies south of the borough. The plan included the construction and maintenance of groins, the establishment of a berm on the beach, and the periodic nourishment of the dune and beaches. This plan has been executed and the dune and sandy beach are formed to protect the beach (FEMA Preliminary FIS 2017).

In the Borough of Wildwood Crest, the bulkhead between Rambler Road and the corporate limit was found to be effective in protecting against wave action, although its height was considered to be inadequate to protect from overwash and spray (FEMA Preliminary FIS 2017).

Location

Cape May County is surrounded by tidally-influenced coastal and riverine waters, allowing for great susceptibility to flooding events. Cape May County forms the southern tip of the State of New Jersey and, excluding water bodies, includes approximately 267 square miles of area. The County is bounded to the east and west by large natural water bodies (Atlantic Ocean and the Delaware Bay) and on the north by two rivers (Tuckahoe Creek and Cedar Swamp Creek) and the Great Egg Harbor Inlet (Cape May County Planning Board 2005). In addition, the Crook Horn Creek, Flat Creek, Dennis Creek, Cape Island Creek and various other marshes, wetland preserves, channels and/or tributaries are present throughout the County. The County also consists of a canal, many bays, harbors, inlets and thoroughfares that create areas for additional flooding, including, but not limited to, the Cape May Canal, Cape May Harbor, Cape May Inlet, Jarvis Sound Thorofare, Grassy Sound, Richardson Sound, Hereford Inlet, Jenkins Sound, Upper Island Great Sound, Stites Sound, Townsends Inlet, Ludlums Thorofare, Ludlum Bay, Strathmere Thorofare, Corsons Inlet and Peck Bay.

> The State of New Jersey has 127 miles of coastline, encompassing portions of eight counties and 126 municipalities. Additionally, the coastal area of the State includes the Coastal Area Facility Review Act (CAFRA) zone and the New Jersey Meadowlands District. According to the NJDEP, portions of Cape May County are located in the CAFRA zone. For additional information regarding the coastal areas of Cape May County, refer to Section 5.4.1 (Climate Change and Sea Level Rise), Section 5.4.2 (Coastal Erosion), Section 5.4.6 (Hurricane and Tropical Storm), and Section 5.4.7 (Nor'Easter) of this 2021 Plan Update.

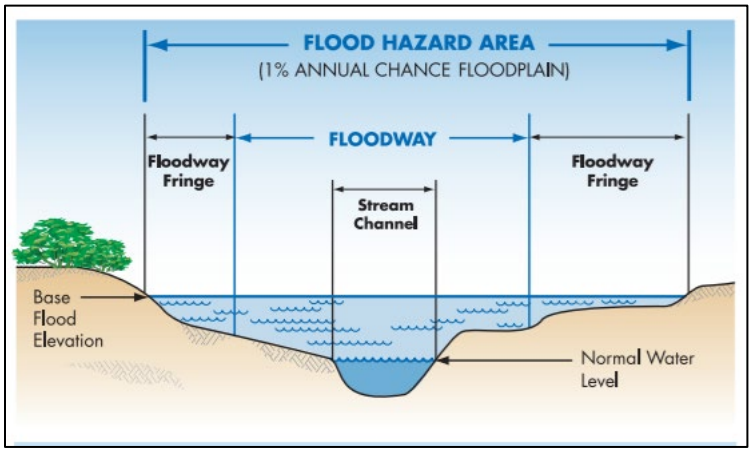
A number of man-made structures commonly called agricultural or salt-hay levees have been identified in this county. The inventory of these structures is detailed in a report (South Jersey Levee Inventory 2010) developed by the United States Department of Agriculture (USDA), National Resource Conservation Service (NRCS) for the New Jersey Department of Environmental Protection (NJDEP). However, these structures were studied and found to not provide protection from the 1-percent annual chance flood. There is a potential that these structures may increase local flood hazard due to higher velocity flows during a large flood event as they overtop, and may

lead to increased time of inundation by retaining flood waters for an extended period. Local conditions should be assessed for this potential for increased flood hazard and appropriate mitigation measures are recommended (FEMA Preliminary FIS 2017).

Floodplains

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. In Cape May County, floodplains line the rivers, streams, and coastal waters of the County. The boundaries of the floodplains are altered as a result of changes in land use, the amount of impervious surface, placement of obstructing structures in floodways, changes in precipitation and runoff patterns, improvements in technology for measuring topographic features, and utilization of different hydrologic modeling techniques. Figure 5.4.5-1 depicts the flood hazard area, the flood fringe, and the floodway areas of a floodplain.

Figure 5.4.5-1. Floodplain



Source: NJAFM Quick Guide

Flood hazard areas are identified as the Special Flood Hazard Area (SFHA). The SFHA is defined as the area that will be inundated by the flood event having a 1-percent chance of being equaled to or exceeded in any given year. The 1 percent annual chance flood is also referred to as the base flood or 100-year flood. A 100-year floodplain is not a flood that will occur once every 100 years; the designation indicates a flood that has a 1-percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. Similarly, the moderate flood hazard area (500-year floodplain) will not occur every 500 years but is an event with a 0.2-percent chance of being equaled or exceeded each year (FEMA 2020). The 1-percent annual chance floodplain establishes the area that has flood insurance and floodplain management requirements.

Flood Map Terms

- Flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA).
- SFHA = the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year.
- 1-percent annual chance flood = the base flood or 100-year flood.
- SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30.
- Zone B or Zone X (shaded) = Moderate flood hazard areas and are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood.
- Zone C or Zone X (unshaded) = Areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood, are labeled.

Coastal areas of New Jersey are particularly susceptible to a broad range of natural hazards. Many coastal areas are highly vulnerable to the effects of flooding, storm surge, episodic erosion, chronic erosion, sea level rise, and

extra-tropical storms (Nor'Easters, hurricanes and tropical storms) (NJDEP 2020). The shoreline of New Jersey is one of the most developed and densely populated shorelines in the United States and the population that resides in these areas are the most directly affected by these coastal hazards. FEMA identifies these areas as coastal shoreline counties which are defined as: (1) has a coastline bordering the open ocean or Great Lakes coasts (or associated sheltered water bodies); or (2) contains velocity zones (V Zones) or coastal high hazard areas. V zones are areas where wave heights more than three feet and/or high velocity water can cause structural damage in 1% annual chance flood zone. According to NOAA, Cape May County is a coastal shoreline county (NOAA 2013).

The NJDEP is mandated to delineate and regulate flood hazard areas pursuant to N.J.S.A. 58:16A-50 et seq., the Flood Hazard Area Control Act. This Act authorizes the DEP to adopt land use regulations for development within the flood hazard areas, to control stream encroachments and to integrate the flood control activities of the municipal, county, state and federal governments. The State's Flood Hazard Area delineations are defined by the New Jersey Flood Hazard Area Design Flood which is equal to a design flood discharge 25% greater in flow than the 1-percent annual chance flood. In addition, the floodway shall be based on encroachments that produce no more than a 0.2-foot water surface rise above the 1-percent annual chance flood.

Locations of flood zones in Cape May County as depicted on the FEMA preliminary Digital Flood Insurance Rate Map (DFIRM) are illustrated in Figure 5.4.5-2. Refer to Section 9 (Jurisdictional Annexes) for a map of each jurisdiction depicting the floodplains. The 1% annual chance of flood hazard zones (both A and V-zones) and 0.2% annual chance flood hazard zones throughout Cape May County are identified in Figure 5.4.5-2. The eastern and western coasts of Cape May County are located in the 1% annual chance flood hazard zones (both A and V). Several areas along the coastline are located within the 0.2% annual chance zone, while the majority of the 0.2% annual chance zone is located inland.

Historic Tide References

Tidal impact tables were developed by the National Weather Service (NWS) in Mount Holly, New Jersey in cooperation with local and county emergency managers and the Delaware Geological Survey. The tables attempt to correlate tide levels at select NOAA gages with their expected impact on local communities. By looking at historic coastal flooding events, a fairly reliable correlation has been developed between the tide levels and their expected impact on local communities. In Cape May County, the Cape May (Ferry Terminal) gage was used for this purpose. The tide gage is located along the Cape May Canal near the outlet to Delaware Bay. It is notable that the period of record for this tide gage is October 25, 1965 to present; therefore, it does not historic tide heights for events prior to October 25, 1965. The following table describes historic tide references for Cape May County, last updated in May 2016.

Table 5.4.5-1. Historic Tide References for Flooding in Cape May County

Tide Height (ft. above MLLW)	Flood Type	Location and/or Tidal Flooding Event Dates
9.0	Major	*Event:* January 23, 2016 (Winter Storm Jonas)
8.9	Major	*Event:* Post Tropical Cyclone Sandy (October 29, 2012)
8.8	Major	*Event:* Hurricane Gloria (September 27, 1985)
8.7	Major flooding begins	*Event:* October 25, 1980 and October 2011
8.6	Moderate	*Event:* December 11, 1992
8.5	Moderate	*Events:* January 4, 1992 and March 3, 1994
8.4	Moderate	*Events:* Hurricane Irene (August 27, 2011)
8.3	Moderate	*Event:* October 14, 1977
8.2	Moderate	*Events:* December 22, 1972; October 31, 1991; February 5, 1998 and June 4, 2012
8.1	Moderate	*Event:* March 29, 1984; October 17, 2009, November 13, 2009 and February 9, 2016
8.0	Moderate	*Events:* January 28, 1998; October 7, 2006, May 12, 2008 and October 2, 2015
7.9	Moderate	*Events:* December 2, 1974; January 2, 1987; March 19, 1996; January 25, 2000; May 25, 2005 and January 31, 2006
7.8	Moderate	*Events:* December 14, 1993, April 18, 2007 and December 9, 2014

Table 5.4.5-1. Historic Tide References for Flooding in Cape May County

Tide Height (ft. above MLLW)	Flood Type	Location and/or Tidal Flooding Event Dates
7.7	Moderate flooding begins	*Events:* December 9, 1973; November 15, 1981; December 13, 1996; November 14, 1997; January 3, 1999; June 13, 2007; June 22, 2009, April 16, 2011 and January 10, 2016
6.7	Minor flooding begins	

Source: NOAA 2016
Note: Figures based on NOAA tide gauge at Cape May Ferry Terminal

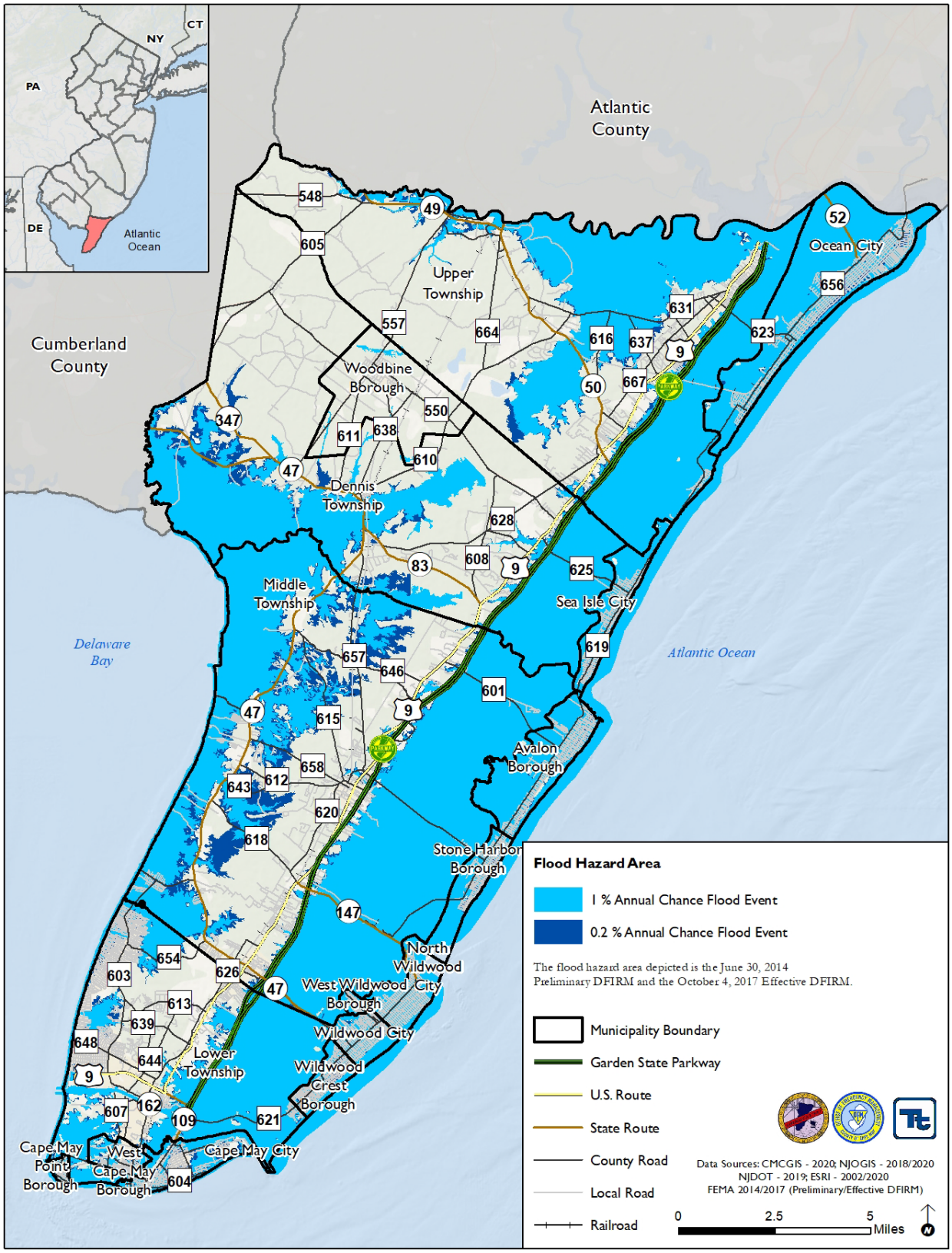
When tide heights reach 8.0 feet (moderate tidal flooding), flooding occurs along Dennis Creek around State Route 47 in Dennis Township and on Avalon Boulevard (County Route 601) near Garden State Parkway Interchange 13.

Moderate flooding begins when the tide height reaches 7.7 feet. This causes flooding in the following locations in the County: access roads to the Longport - Ocean City bridge; along Bay Avenue on the north end of Ocean City and along the NJ Route 52 causeway; on the access roads to the 34th Street bridge in Ocean City (Cape May County Route 623); in Ocean City from 34th Street to 55th Street; on Sea Isle Boulevard (Cape May County Route 625) leading into Sea Isle City; on the access roads to the Ocean Drive bridge between Wildwood Crest and Cape May (Cape May County Route 621); along Beach Avenue and New Jersey Avenue in Cape May; and around the Leaming Avenue - Elmira Street bridge between West Cape May and Cape May. When tide heights reach 7.5 feet, flooding begins in Strathmere and occurs along Landis Avenue in Sea Isle City (around 29th Street) and on the access roads to State Route 147 bridge into North Wildwood.

Tides measuring at 7.3 feet causes flooding to occur around the Townsends Inlet Bridge (Cape May County Route 619) between Sea Isle City and Avalon; in Avalon along Ocean and Dune Drives; around 96th Street in Stone Harbor; along Park Boulevard in Wildwood Crest; and around Yacht Avenue in Cape May. At 7.1 feet, flooding occurs on the access roads to the 9th Street bridge into Ocean City; in the Haven Avenue basin area of Ocean City (24th Street through 34th Street); along Ocean Drive (County Route 619) between Ocean City and Strathmere; and in West Wildwood. Flooding begins along the Delaware Bay shoreline from Reeds Beach to North Cape May when tides measure at 6.9 feet.

Minor flooding begins in Cape May County when tides reach 6.7 feet. When they reach this height, flooding occurs on the access roads to State Route 47 Bridge into Wildwood, including Rio Grande Avenue. At 6.5 feet, flooding occurs at the boat ramp in North Wildwood (bay end of 5th Avenue).

Figure 5.4.5-2. FEMA Flood Hazard Areas in Cape May County



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). 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)

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 NJDEP 2015 Land-Use Land-Cover data updated in 2019, the County has several floodplain areas that could serve natural and beneficial functions (Landscape Project contains the endangered species data). This information is summarized in Table 5.4.5-2 and Table 5.4.5-3; and wetland acreage is displayed on Table 5.4.5-2.

Table 5.4.5-2. Acreage of Wetlands by Municipality

Jurisdiction	Total Acres	Wetland Acres	Percentage of Wetlands
Avalon Borough	3,181	1,421	44.7%
Cape May City	1,845	470	25.5%
Cape May Point Borough	192	20	10.4%
Dennis Township	40,830	19,874	48.7%
Lower Township	19,852	7,853	39.6%
Middle Township	52,935	26,570	50.2%
North Wildwood City	1,593	149	9.3%
Ocean City	7,553	1,995	26.4%
Sea Isle City	1,762	574	32.6%
Stone Harbor Borough	1,480	236	15.9%
Upper Township	43,785	20,746	47.4%
West Cape May Borough	757	265	35.0%
West Wildwood Borough	233	44	19.0%
Wildwood City	1,058	18	1.7%
Wildwood Crest Borough	948	81	8.5%
Woodbine Borough	5,122	968	18.9%
Cape May County (Total)	**183,127**	**81,286**	**44.4%**

Source: NJDEP 2019/2015; Cape May County GIS 2020

Table 5.4.5-3. Natural and Beneficial Land in Cape May County

Wetland Type	Acres	Forest Type	Acres	Endangered Species Ranking	Suitable Habitat (Acres)
Agricultural Wetlands (Modified)	1	Coniferous Forest (>50% Crown Closure)	6	State Threatened	48,500
Atlantic White Cedar Wetlands	2	Coniferous Forest (10-50% Crown Closure)	1	State Endangered	147,847
Cemetery On Wetland	0	Deciduous Forest (>50% Crown Closure)	11	Federal Listed	13,248
Coniferous Scrub/Shrub Wetlands	1	Deciduous Forest (10-50% Crown Closure)	1	**Cape May County (Total)**	**209,596**
Coniferous Wooded Wetlands	5	Mixed Forest (>50% Coniferous With >50% Crown Closure)	10		
Deciduous Scrub/Shrub Wetlands	3	Mixed Forest (>50% Coniferous With 10-50% Crown Closure)	1		
Deciduous Wooded Wetlands	10	Mixed Forest (>50% Deciduous With >50% Crown Closure)	16		
Disturbed Tidal Wetlands	0	Mixed Forest (>50% Deciduous With 10-50% Crown Closure)	2		
Disturbed Wetlands (Modified)	0	**Cape May County (Total)**	**49**		
Former Agricultural Wetland (Becoming Shrubby, Not Built-Up)	0				
Freshwater Tidal Marshes	0				
Herbaceous Wetlands	2				
Managed Wetland In Built-Up Maintained Rec Area	0				
Managed Wetland In Maintained Lawn Greenspace	0				
Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	1				
Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	2				
Mixed Wooded Wetlands (Coniferous Dom.)	16				
Mixed Wooded Wetlands (Deciduous Dom.)	15				
Phragmites Dominate Coastal Wetlands	2				
Phragmites Dominate Interior Wetlands	1				
Phragmites Dominate Urban Area	0				
Saline Marsh (High Marsh)	2				
Saline Marsh (Low Marsh)	61				
Vegetated Dune Communities	1				
Saline Marsh (Low Marsh)	61				
Cape May County (Total)	**187**				

Source: NJDEP 2019/2015

Extent

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). The following describes the extent of the various types of flood in Cape May County.

Coastal Flooding

The extent of coastal flooding due to coastal storms (hurricanes, tropical storms and Nor'Easters) is determined by three factors: 1) the nature of the storm with respect to intensity, duration, and path; 2) astronomical tide conditions at the time the storm surge wave reaches the shore; and 3) the physical geometry and bathymetry of a particular area, which affects the time and passage of the surge wave.

> The NWS uses coastal flood watches, warnings and advisories to ensure that people know what to expect in the coming hours and days. Advisories are issued when minor tidal flooding is expected. Minor tidal flooding often results in some road closures and the usually the most vulnerable roadways will flood. Coastal flood watches are issued to inform the public and cooperating agencies that coastal flooding is possible approximately 12 to 36 hours after issuance time. They are issued when flooding with significant impact is possible. Coastal flood warnings are issued to warn the public and cooperating agencies that coastal flooding, posing a serious threat to life and property, is occurring, imminent, or highly likely to occur within the next 12 hours (NWS 2020).

Coastal flooding levels, categorized as minor, moderate, or major, are calculated based on the amount of water as it rises above the normal tide in a particular area. Minor flooding represents nuisance coastal flooding of locations adjacent to the shoreline. Minor beach erosion can be expected. Minor coastal flooding is not expected to close roads or do any major structural damage to homes and other buildings. Moderate coastal flooding is when more substantial coastal flooding occurs, threatening life and property. Some roads will likely become impassable and moderate beach erosion will occur. Some homes, businesses and other facilities will experience damage. Major coastal flooding represents a serious threat to both life and property. Many roads will likely become flooded and numerous homes and businesses along the coast will receive major damage. Major beach erosion is also expected (NWS n.d.). For details regarding the specific water levels for each type of coastal flooding in Cape May County, refer to the previous section "Historic Tide References".

As stated by the NWS, other important factors affecting the local severity, extent, and duration of coastal flooding include: (1) the various tidal cycles, (2) the persistence and behavior of the storm generating the flooding, (3) the topography, shoreline orientation, and bathymetry of the area, (4) the river stage or stream runoff in estuaries, and (5) the presence or absence of offshore reefs or other barriers. Coastal flooding intensities range from minor tidal overflow with little or no damage to a combination of the aforementioned causative factors resulting in extensive inundation and beach erosion (NWS 2020).

Riverine, Flash, and Stormwater Flooding

The frequency and severity of riverine 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 USGS National Water Information System (NWIS) collects surface water data from more than 850,000 stations across the country. The time-series data describes stream levels, streamflow (discharge), reservoir and lake levels, surface water quality, and rainfall. The data is collected by automatic recorders and manual field measurements at the gage locations. Cape May County does not have any active USGS stream gages.

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

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

Currently, there is no measurement used to further define the frequency and severity of urban flooding.

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with flooding throughout the State of New Jersey and Cape May County; therefore, the loss and impact information for many events varies depending on the source. The accuracy of monetary figures discussed is based only on the available information in cited sources.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2020, FEMA declared that the State of New Jersey experienced eight flood-specific disasters (DR) or emergencies (EM). Cape May County was included in seven of these flood declarations; refer to Table 5.4.5-4.

Table 5.4.5-4. Flood-Related Disaster (DR) and Emergency (EM) Declarations 1954-2020

Declaration	Event Date	Declaration Date	Event Description
DR-310	September 4, 1971	September 4, 1971	Heavy Rains & Flooding
DR-519	August 21, 1976	August 21, 1976	Severe Storms, High Winds, Flooding
DR-701	March 28-April 8, 1984	April 12, 1984	Coastal Storms & Flooding
DR-973	December 10-17, 1992	December 18, 1992	Coastal Storm, High Tides, Heavy Rain, & Flooding
DR-1206	February 4-8, 1998	March 3, 1998	Severe Winter Coastal Storm, High Winds, Flooding
DR-1867	November 11-15, 2009	December 22, 2009	Severe Storms and Flooding Associated with Tropical Storm Ida
DR-1897	March 12-April 15, 2010	April 2, 2010	Severe Storms And Flooding

Source: FEMA 2019

U.S. Department of Agriculture Disaster Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2016 and 2020, Cape May County was included in one USDA declaration involving excessive rainfall and cool spring temperatures (S4434 in 2018). However, flooding was not attributed to the disaster (USDA 2020).

The USDA crop loss data provide another indicator of the severity of previous events. Additionally, crop losses can have a significant impact on the economy by reducing produce sales and purchases. Such impacts may have long-term consequences, particularly if crop yields are low the following years as well. Between 2016 and 2020, Cape May County did not report any crop losses due to flooding (USDA 2020).

Previous Events

The National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Events database records and defines flood events as follows:

- Coastal Flooding is reported in the NOAA-NCEI database as flooding in coastal areas due to the vertical rise above normal water level caused by strong, persistent onshore wind, high astronomical tide, and/or low atmospheric pressure, resulting in damage, erosion, flooding, fatalities, or injuries. Coastal areas are defined as those portions of coastal land zones (coastal county/parish) adjacent to the waters, bays, and estuaries of the ocean.
- Flash Flood is reported in the NOAA-NCEI database for a life-threatening, rapid rise of water into a normally dry area beginning within minutes to multiple hours of the causative event (e.g., intense rainfall, dam failure, ice jam).
- Flood is reported in the NOAA-NCEI database for any high flow, overflow, or inundation by water which causes damage. In general, this would mean the inundation of a normally dry area caused by an increased water level in an established watercourse, or ponding of water, that poses a threat to life or property.

For the 2021 HMP update, known flood events that have impacted Cape May County between 2016 and 2020 are identified in Table 5.4.5-5. For events prior to 2016, refer to the Appendix E (Supplementary Data). Please see Section 9 for detailed information regarding impacts and losses to each municipality.

Table 5.4.5-5. Flood Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
January 22-24, 2016	Winter Storm & Coastal Flooding (Winter Storm Jonas)	DR-4264	Yes	Snow began to develop on January 22nd from south to north. Across the coastal regions, the snow changed over to rain which limited the totals for those areas. There were intense bands of snow with rates of two to four inches per hour in north-central New Jersey and the Lehigh Valley in Pennsylvania. In addition to snow, there were strong wind gusts that topped out between 30 and 50 mph for most of the region. At the airports, most flights were cancelled due to the storm. Travel became nearly impossible at times for most of the areas impacted. Moderate to major tidal flooding occurred along the New Jersey and Delaware beaches which resulted in severe beach erosion and some property damage in coastal communities. Snowfall totals ranged from two to 32 inches, with the highest totals from Berks, Pennsylvania northwest to Allentown (Pennsylvania) and then into north-central New Jersey. In Cape May County, snowfall totals ranged from seven inches in the City of Cape May to 11.3 inches in Wildwood Crest. Peak wind gusts ranged from 50 mph in Cape May Point to 64 mph in Strathmere. In addition to snow and wind, coastal flooding impacted the county. In Cape May, there was a record storm surge of 9.4 feet. The tides in the County were as high as 10 feet in some parts which flooded garages and ground floors of buildings. Flood damage was significant as water levels exceeded those observed during Sandy and ranked in the top 10 on record. Beach erosion was moderate to major. Major tidal flooding was reported at the Cape May tide gage – 8.98 feet above MLLW was recorded at 1:30pm on January 23rd (major tidal flooding starts at 8.7 feet above MLLW).
February 8-10, 2016	Nor'Easter & Coastal Flooding	N/A	N/A	A powerful Nor'Easter brought blizzard conditions to eastern Long Island and southeast New England and brought strong winds, rain and snow to the southern half of New Jersey. In Cape May County, snowfall totals were a minimum (0.2 inches in Middle Township and 0.6 inches in Cape May City). However, flooding was an issue in the County. The NWS issued a coastal flood warning for the county. During high tide, numerous streams were flooded and had to be closed. Moderate coastal flooding was reported at the Cape May tide gage – 8.159 feet above MLLW was recorded at 1:54pm on February 9th (moderate tidal flooding starts at 7.7 feet above MLLW).
May-5-7, 2016	Coastal Flooding	N/A	N/A	A Low pressure system slowly moved onshore on the 6th leading to a persistent period of onshore flow. Coupled with a New Moon cycle this led to abnormally high tidal levels and frequent minor to moderate coastal flooding corresponding to the high tides. The Low pressure system moved back offshore and out to sea by days end on the 7th. Minor to briefly moderate tidal flooding was recorded at the Cape May Ferry Terminal tidal gauge during the evening hours of the 5th.

Table 5.4.5-5. Flood Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
				A brief interval of minor tidal flooding occurred on the evening of the 7th in association with the high tide.
May 9, 2016	Coastal Flooding	N/A	N/A	A Low pressure system slowly moved onshore on the 6th leading to a persistent period of onshore flow. Coupled with a New Moon cycle this led to abnormally high tidal levels and frequent minor to moderate coastal flooding corresponding to the high tides. The Low pressure system moved back offshore and out to sea by days end on the 7th. A brief interval of minor tidal flooding occurred the evening of the 9th corresponding with the high tide and a departing low pressure system. Tidal flooding was spotty along the entire New Jersey coastline this night.
September 19, 2016	Flooding from Heavy Rain	N/A	N/A	The remnants of tropical storm Julia and a frontal boundary interacted leading to several rounds of rainfall over the region. This rainfall led to water pooling up to a foot deep in some streets in West Cape May. Haven Avenue in Ocean City was covered with water for a time period. Water was about a foot deep on 14th Street in North Wildwood.
March 14, 2017	Coastal Flood	N/A	N/A	Low pressure systems across the Ohio Valley and Carolinas phased. This led to a rapidly developing storm which tracked just offshore. Wind, coastal flooding, heavy rain and snow all occurred. Heavy rainfall in Southeast New Jersey ranged from 1-3 inches. Widespread roadway flooding accompanied the morning high tide in the coastal communities of Cape May county which led to road closures. George Redding Bridge into Wildwood was closed. Moderate beach erosion also occurred in Ocean City and Wildwood. Ocean city gauge reached 6.92 ft, moderate flooding begins at 6.5 ft. Sea Isle gauge reached 6.98 ft, moderate flooding begins at 6.9 feet.
May 13, 2017	Flooding from Heavy Rain	N/A	N/A	Heavy rain led to some localized flooding on the 13th in Cape May and Atlantic Counties with the aid of the high tide. Several streets were impassable due to the heavy rain and high tide. Ocean Drive in Avalon was flooded in spots, combination of heavy rain and high tide. Several roads flooded due to a combination of high tide and heavy rain in Sea Isle City.
May 25, 2017	Coastal Flood and Heavy Rain	N/A	N/A	Several clusters of showers and thunderstorms moved through the state in the afternoon and evening hours producing a few strong but sub-severe wind gusts and hail near severe limits. Heavy rainfall also fell across most of the state with several locations in

Table 5.4.5-5. Flood Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
				central New Jersey seeing over 2 inches of rain also extending into Bucks county PA. Moderate coastal flooding also occurred with the evening high tide. Moderate flooding occurred with the evening high tide at Cape May Harbor and at the ferry terminal with departures about a quarter of a foot into the moderate range. The southern tip of Cape May and the barrier islands saw the most impacts.
July 14, 2017	Flash Flood	N/A	N/A	A hot and humid airmass was present ahead of a frontal boundary which slowly moved southeast toward and then through the state. Several rounds of thunderstorms moved through the region ahead of this front over the course of a few days. Flooding took place at 79th and Landis near Townsends Inlet. Roadway flooding took place in Stone Harbor. In Sea Isle City, several cars were reported as being stuck in high water.
July 29, 2017	Coastal Flood and Heavy Rain	N/A	N/A	A rare summertime Nor'easter tracked just offshore producing heavy rain, thunderstorms and wind. Coastal flooding and beach erosion also occurred. Rainfall and high tide led to flooding on NJ 47 and West Rio Grand Avenue in Wildwood Crest. Flooding took place on NJ 47 at 5th street in Wildwood Gardens. Tides and rainfall led to street flooding in Stone Harbor. Street flooding was reported on Ocean Drive in Avalon. NJ 47 at CR 624 closed due to flooding in Wildwood. NJ 147 in North Wildwood was closed in both directions due to flooding and street flooding took place at 17th and North. Parts of Hudson Ave were flooded in North Wildwood. Street flooding occurred near the Inlet in Sea Isle City. Several inches of water were reported on roads in Avalon. Water was reported on roads in Ocean City from 24th to 33rd and on Haven Avenue.
August 7, 2017	Flash Flood	N/A	N/A	Thunderstorms developed along and ahead of a warm front. With a humid airmass in place, these storms produced heavy rain that led to flash flooding. Flooding took place in West Wildwood at 47 and 614. Street flooding took place in Ocean City on Haven Avenue.
September 19-20	Coastal Flood	N/A	N/A	Moderate coastal flooding affected eastern Cape May 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, which included John F. Kennedy Beach Drive in North Wildwood. The following tide gauges reached their moderate flooding threshold: Ocean City, Sea Isle City, Stone Harbor, Cape May Harbor, and Cape May Ferry Terminal.
October 29, 2017	Flooding from Heavy Rain	N/A	N/A	A strong low pressure system moved up the east coast producing heavy rain and strong winds. Power outages did occur as a result of downed trees and wires across the state.

Table 5.4.5-5. Flood Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
				Rainfall totals were over 2 inches in every county of New Jersey outside of the New York City area. The highest totals were at 5.42 inches in Princeton, 5.45 inches in Holiday City and 4.62 inches in Roebling. Thousands of people lost power due to the storm. Gusts in most locations topped out between 40 and 50 mph. Several gusts over 50 mph were reported in Ocean County near the shore and at High point. Low lying street flooding took place in Ocean City across the bay front that included Haven Ave.
March 4, 2018	Coastal Flood	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 move 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 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. Conversely, blowout tides occurred in portions of Delaware Bay late on March 2nd into the 3rd. Heavy rainfall occurred in New Jersey and Eastern Pennsylvania on March 1st and 2nd, with widespread rainfall amounts of 1 to 2 inches. 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. Moderate coastal flooding with a number of road closures in the coastal communities of Cape May County. The peak tide was 6.33 feet MLLW at Ocean City, 6.86 feet MLLW at Sea Isle City, 6.92 feet MLLW at Stone Harbor, and 7.78 feet MLLW at Cape May (ferry terminal).
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.

Table 5.4.5-5. Flood Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
				Moderate flooding occurred along the bays and other tidal waterways in Cape May County. The tide gauge at Ocean City reached 6.90 feet MLLW. The tide gauge at Sea Isle City reached 7.58 feet MLLW. The tide gauge at Stone Harbor reached 7.55 feet MLLW. The tide gauge at Cape May Harbor reached 7.70 feet MLLW. The tide gauge at the Cape May Ferry Terminal reached 8.44 feet MLLW. Many roads in Ocean City and Avalon became impassable. There was up to a foot of water on some streets in Stone Harbor. The George Redding Bridge into Wildwood was closed due to flooding. NJ Route 109 was under a foot of water near the bridge into Cape May. On the 10th, moderate flooding occurred along the bays and other tidal waterways in Cape May County. The tide gauge at Ocean City reached 6.35 feet MLLW. The tide gauge at Sea Isle City reached 6.87 feet MLLW. Widespread roadway flooding occurred. There was flooding along Central Avenue in Sea Isle City. The Townsend Inlet Bridge was closed due to high water and wave action.
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. Moderate coastal flooding occurred along the back bays, Delaware Bay and other tidal waterways in the county. There was widespread roadway flooding with water reaching some buildings. The tide gauge at Ocean City peaked at 7.25 feet MLLW. The tide gauge at the Sea Isle City peaked at 7.64 feet MLLW. The tide gauge at Stone Harbor peaked at 7.77 feet MLLW. The tide gauge at the Cape May Ferry Terminal peaked at 8.39 feet MLLW. The tide gauge at South Dennis peaked at 7.72 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. Moderate coastal flooding occurred on the evening of the 10th with numerous road closures. The tide gauge at Ocean City reached 6.53 feet MLLW, the tide gauge at Sea Isle City reached 7.12 feet MLLW, the tide gauge at Stone Harbor reached 7.25 feet MLLW, the tide gauge at Cape May Harbor reached 7.39 feet MLLW, the tide gauge at the Cape May Ferry Terminal reached 7.95 feet MLLW, and the tide gauge at South Dennis reached 7.65 feet MLLW. Moderate coastal flooding occurred on the evening of the 11th with numerous road closures. The tide gauge at Ocean City reached 6.64 feet MLLW, the tide gauge at Sea Isle City reached 7.15 feet MLLW, the tide gauge at Stone Harbor reached 7.26 feet MLLW, the tide gauge at Cape May Harbor reached 7.46 feet MLLW, the tide gauge at

Table 5.4.5-5. Flood Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
				the Cape May Ferry Terminal reached 7.99 feet MLLW, and the tide gauge at South Dennis reached 7.76 feet MLLW.
July 10, 2020	Tropical Storm Fay	N/A	N/A	Tropical Storm Fay made landfall near the border or Cape May and Atlantic County resulting in minor tidal flooding and heavy rain.

Source: NOAA NCEI 2020; FEMA 2020

Probability of Future Occurrences

Cape May County is expected to continue experiencing direct and indirect impacts of flooding in the future. Table 5.4.5-6 summarizes data regarding the probability of occurrences of flood events in Cape May County based on the historic record. The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results.

Table 5.4.5-6. Probability of Future Occurrences

Event Type	Number of Incidents (1950 to 2020)	% Chance of Occurrence in Any Given Year
Coastal Flooding	72	100
Flash Flood	12	16.90
Flood	30	42.25
Total	**114**	**100**

Source: NOAA-NCEI 2020
Note: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected flood events since 1968. Due to limitations in data, not all flood events occurring between 1950 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.

In Section 5.3, the identified hazards of concern for Cape May County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for flood in the County is considered 'frequent' (100% annual chance of occurring; occurring multiple times a year).

Climate Change Impacts

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).

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% increase. By 2050, annual precipitation in New Jersey could increase by 4% to 11% (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).

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).

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). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and

on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71% (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017). 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 five 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).

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). Rising sea levels will increase the frequency and severity of coastal flooding events.

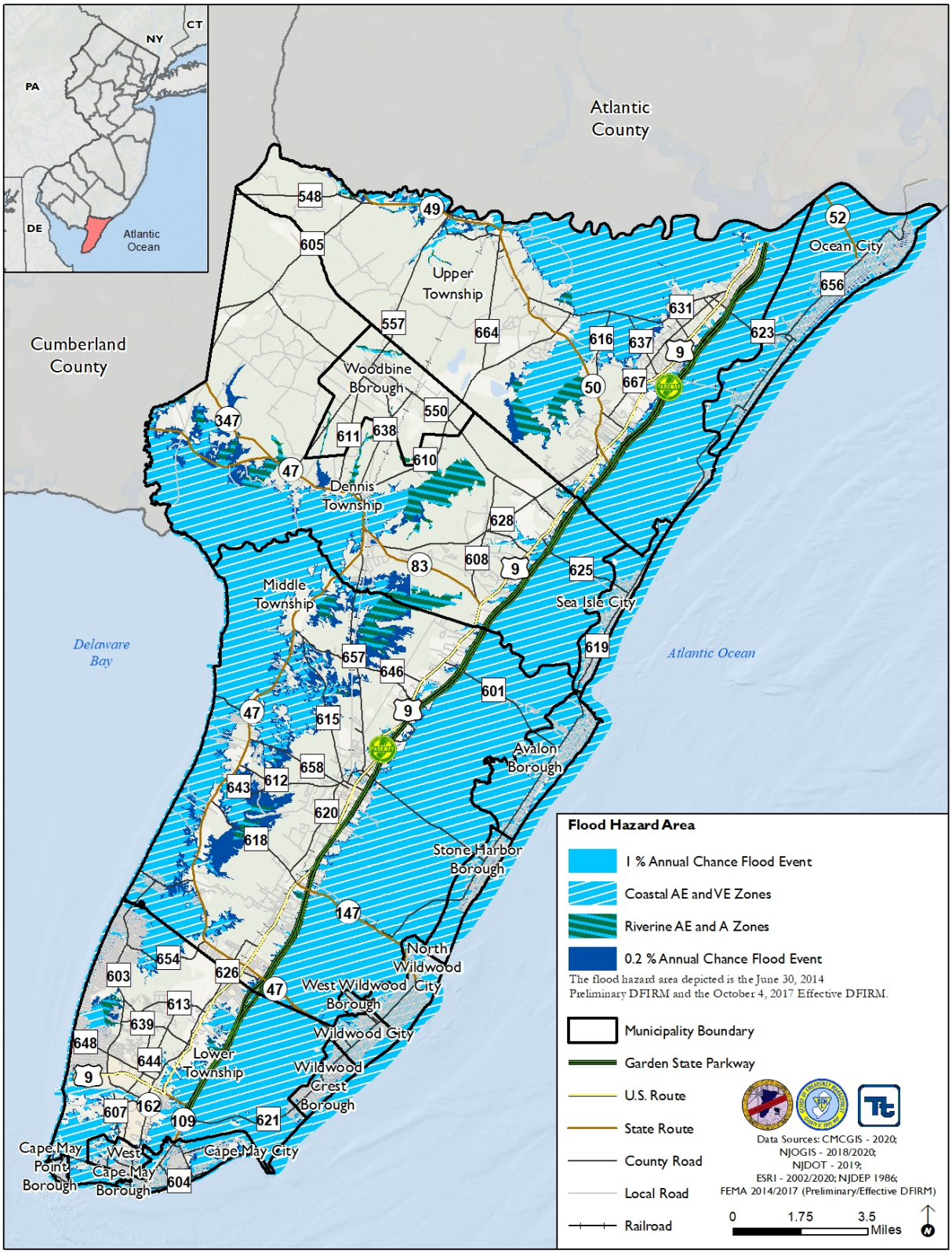
Impacts of climate change can lead to shoreline erosion, coastal flooding, and water pollution; affecting man-made coastal infrastructures and coastal ecosystems. Coastal areas may be impacted by climate change in different ways. These areas are sensitive to sea level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures (USEPA 2017). Temperatures are predicted to increase in Cape May County and ocean temperatures are forecast to continue to increase, which may lead to an increase in intensity and frequency of hurricanes and other coastal storms. It remains to be seen if other factors such as steering currents, atmospheric sheer, and the presence of Saharan dust will be impacted in ways which increase or decrease the risk of hurricanes in Cape May County.

For details regarding climate change and sea level rise, refer to Section 5.4.1 (Climate Change and Sea Level Rise).

5.4.5.2 Vulnerability Assessment

To assess Cape May County's risk to the flood hazard, a spatial analysis was conducted using the best available spatially-delineated flood hazard areas. The 1- and 0.2-percent annual chance flood events depicted on the FEMA 2014 Preliminary and 2017 Effective DFIRMs were examined to determine the assets located in the hazard areas and to estimate potential loss using the FEMA Hazus riverine and coastal flood models. The coastal hazard area includes VE and coastal AE zones. Coastal AE zones were determined using the head of tide points for watercourses from New Jersey Department of Environmental Protection to delineate the coastal AE zones on the seaward side of the head of tide locations versus the riverine AE zones on the landward side of the head of tide locations. The riverine hazard area includes riverine AE zones and A zones. Figure 5.4.5-3 displays the 1-percent annual chance flood event coastal and riverine hazard areas. Refer to Section 5.1 (Methodology and Tools) for additional details on the methodology used to assess flood risk.

Figure 5.4.5-3. Coastal and Riverine Flood Hazard Areas in Cape May County



Impact on Life, Health and Safety

The impact of flooding on life, health and safety is dependent upon several factors including the severity of the event and whether adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. However, exposure is not limited to persons who reside in a defined hazard zone, but includes all individuals who may be affected by the effects 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). The degree of that impact will vary and is not strictly measurable.

Based on the spatial analysis, there are an estimated 37,983 people living in the SFHA, or 1-percent annual chance event floodplain, and an estimated 44,368 people residing in the 0.2-percent annual chance floodplain (refer to Table 5.4.5-7). These estimates are based on the U.S. Census data and do not account for fluctuations in seasonal population.

The analysis also reviewed the number of persons living in the coastal 1-percent annual chance flood event boundary and number of persons living in the riverine 1-percent annual chance flood event boundary. Persons living in the coastal flood hazard area are more likely to experience greater impacts from flooding due to additional coastal hazards such as storm surge and wave height.

Generally, all residents living in the floodplain may displaced due to their homes flooding, requiring them to seek temporary shelter with friends and family or in emergency shelters. Based on the spatial analysis, three jurisdictions in Cape May County have 100-percent of their community living in the 1-percent annual chance flood boundary and five of the jurisdictions have 100-percent of their community living in the 0.2-percent annual chance flood boundary. Additionally, Ocean City has the greatest number of persons living in the 1-percent annual chance flood event and 0.2-percent annual chance flood event boundaries (i.e., 10,616 persons or 94.8-percent of its total population and 11,201 persons or 100-percent of its total population). For this project, the estimated potential population exposed is used as a guide for planning purposes.

Table 5.4.5-7. Estimated Population Exposed to the Flood Hazard Areas

Jurisdiction	American Community Survey (2014-2018) Total Population	Estimated Population Exposed					
		1-Percent Annual Chance Flood Event				0.2-percent Annual Chance Flood Event	
		Total Number of Persons Exposed to Hazard Area	Percent of Total	Total Number of Persons Exposed to Coastal Hazard Area Only	Total Number of Persons Exposed to Riverine Hazard Area Only	Total Number of Persons Exposed to Hazard Area	Percent of Total
Avalon Borough	1,409	1,308	92.8%	1,308	0	1,401	99.4%
Cape May City	3,491	2,101	60.2%	2,101	0	2,654	76.0%
Cape May Point Borough	188	152	80.9%	152	0	178	94.7%
Dennis Township	6,244	95	1.5%	88	7	286	4.6%
Lower Township	21,838	3,875	17.7%	3,873	1	5,907	27.0%
Middle Township	18,492	3,236	17.5%	3,081	155	4,900	26.5%
North Wildwood City	3,849	3,849	100.0%	3,849	0	3,849	100.0%
Ocean City	11,202	10,616	94.8%	10,616	0	11,201	100.0%
Sea Isle City	1,955	1,895	97.0%	1,895	0	1,948	99.7%

Table 5.4.5-7. Estimated Population Exposed to the Flood Hazard Areas

Jurisdiction	American Community Survey (2014-2018) Total Population	Estimated Population Exposed					
		1-Percent Annual Chance Flood Event				0.2-percent Annual Chance Flood Event	
		Total Number of Persons Exposed to Hazard Area	Percent of Total	Total Number of Persons Exposed to Coastal Hazard Area Only	Total Number of Persons Exposed to Riverine Hazard Area Only	Total Number of Persons Exposed to Hazard Area	Percent of Total
Stone Harbor Borough	955	808	84.6%	808	0	935	97.9%
Upper Township	11,909	1,526	12.8%	1,519	6	1,797	15.1%
West Cape May Borough	1,103	491	44.5%	491	0	732	66.3%
West Wildwood Borough	376	376	100.0%	376	0	376	100.0%
Wildwood City	5,073	5,073	100.0%	5,073	0	5,073	100.0%
Wildwood Crest Borough	3,131	2,582	82.5%	2,582	0	3,131	100.0%
Woodbine Borough	2,490	0	0.0%	0	0	0	0.0%
Cape May County (Total)	**93,705**	**37,983**	**40.5%**	**37,813**	**170**	**44,368**	**47.3%**

Sources: FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM; Cape May County GIS 2020; American Community Survey (ACS) 2018
Notes: Coastal hazard areas include coastal AE zones and VE zones. Riverine hazard areas include riverine AE zones and A zones.

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This is due to many factors including their physical and financial ability to react or respond during a hazard. Of the population exposed, the most vulnerable include the economically disadvantaged and the population over age 65. Economically disadvantaged populations may be more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on net economic impacts on their families. The population over age 65 is also more vulnerable because they are more likely to seek or need medical attention that may not be available due to isolation during a flood event, and they may have more difficulty evacuating. According to the 2018 5-year American Community Survey population estimates, within Cape May County there are approximately 23,572 people over the age of 65 and 10,140 people below the poverty level. The five jurisdictions with the greatest percent of its population in the 0.2-percent annual chance flood hazard inundation area also have more than 20-percent of its population over 65 years old.

The Centers for Disease Control and Prevention (CDC) 2016 Social Vulnerability Index (SVI) ranks U.S. Census tracts on socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Cape May County's overall score is 0.3438, indicating that its communities have low to moderate levels of vulnerability (CDC 2016). According to the CDC map, which shows the County's social vulnerability by tract, the County's greatest concentration of vulnerability is in the southern jurisdictions (i.e., Cape May Point Borough, West Cape May Point Borough, Cape May City, Lower Township, Wildwood City, and West Wildwood City).

Using 2010 U.S. Census data, Hazus estimates the potential sheltering needs as a result of a 1-percent annual chance flood event. For the 1-percent flood event, Hazus estimates 27,107 households will be displaced, and 1,245 people will seek short-term sheltering. Majority of the persons displaced or seeking short-term sheltering are in the coastal AE and VE zones 1-percent annual chance flood event boundary. These statistics, by

jurisdiction, are presented in Table 5.4.5-8. The estimated displaced households and number of persons seeking short-term sheltering differs from the number of persons exposed to the 1-percent annual chance flood, because the displaced population numbers take into consideration that not all residents will be significantly impacted enough to be displaced or to require short-term sheltering during a flood event.

Table 5.4.5-8. Estimated Population Displaced or Seeking Short-Term Shelter From the 1-Percent Annual Chance Flood Event

Jurisdiction	American Community Survey (2014-2018) Total Population	1-Percent Annual Chance Event (Total)		1-Percent Annual Chance Event (Riverine Only)		1-Percent Annual Chance Event (Coastal Only)	
		Displaced Population	Persons Seeking Short-Term Sheltering	Displaced Population	Persons Seeking Short-Term Sheltering	Displaced Population	Persons Seeking Short-Term Sheltering
Avalon Borough	1,409	1,189	30	0	0	1,189	30
Cape May City	3,491	0	0	0	0	0	0
Cape May Point Borough	188	0	0	0	0	0	0
Dennis Township	6,244	293	8	23	0	270	8
Lower Township	21,838	42	1	42	1	0	0
Middle Township	18,492	1,053	39	15	0	1,038	39
North Wildwood City	3,849	3,947	194	0	0	3,947	194
Ocean City	11,202	10,574	431	74	3	10,500	428
Sea Isle City	1,955	2,014	81	0	0	2,014	81
Stone Harbor Borough	955	688	12	0	0	688	12
Upper Township	11,909	1,049	40	6	0	1,043	40
West Cape May Borough	1,103	0	0	0	0	0	0
West Wildwood Borough	376	601	28	0	0	601	28
Wildwood City	5,073	5,150	343	0	0	5,150	343
Wildwood Crest Borough	3,131	483	38	0	0	483	38
Woodbine Borough	2,490	24	0	24	0	0	0
Cape May County (Total)	**93,705**	**27,107**	**1,245**	**184**	**4**	**26,923**	**1,241**

Source: HAZUS V4.2; American Community Survey 2018 5-year Estimates; US Census Bureau 2010; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM
**Note: Population results are referencing 2010 Census population statistics. Results may be under-estimated. Coastal hazard areas include coastal AE zones and VE zones. Riverine hazard areas include riverine AE zones and A zones.*

Total number of injuries and casualties resulting from typical riverine and tidal flooding are generally limited based on advance weather forecasting, blockades, and warnings. Injuries and deaths generally are not anticipated if proper warning and precautions occur. In contrast, warning time for flash flooding is limited. These events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event are highly vulnerable to this hazard.

Cascading impacts may also include exposure to pathogens such as mold. After flood events, excess moisture and standing water contribute to the growth of mold in buildings. Mold may present a health risk to building occupants, especially those with already compromised immune systems such as infants, children, the elderly and pregnant women. The degree of impact will vary and is not strictly measurable. Mold spores can grow in as short a period as 24-48 hours in wet and damaged areas of buildings that have not been properly cleaned. 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 (CDC 2019).

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.

Impact on General Building Stock

Buildings located in the coastal flood zones are exposed to not only the flood hazard, but also storm surge, wave run-up, and hurricane force winds (FEMA 2020, FEMA 2018). As a result, potential damages to structures in the coastal AE and VE flooding zones are greater than for those structures in riverine AE and A flooding zones. Hazus flood depth damage models for coastal flooding were applied to the structures built in FEMA's coastal flood hazard areas. The modeled loss is based upon the exposed inventory measure by structural and content replacement cost value.

There are an estimated 57,603 buildings located in the coastal SFHA with a value of approximately $55.4 billion of building and contents (based on replacement cost value). This represents approximately 61.4-percent of the County's total general building stock inventory replacement cost value (approximately $90.3 billion). Refer to Table 5.4.5-6 for the total number of buildings located in the coastal 1-percent annual chance floodplain by jurisdiction. Overall, Ocean City has the greatest number of structures exposed to the coastal 1-percent annual chance flood event boundary (i.e., 17,230 buildings), which is a replacement cost value of approximately $16.1 billion.

Of the structures exposed to the coastal 1-percent annual chance flood event boundary, Hazus estimates that 3,122 will experience damages, which is approximately $189.9 million in replacement cost value (refer to Table 5.4.5-9 and Table 5.4.5-10, respectively). Ocean City will experience the greatest amount of damages from the coastal AE and VE flood event (i.e., 1,033 structures with building loss totaling approximately $69.7 million in replacement cost value). Throughout the entire County, Hazus estimates that residential structures will be the most impacted by the coastal 1-percent annual chance flood event.

Table 5.4.5-9. Estimated General Building Stock Exposure to the Coastal 1-Percent Annual Chance Flood Event

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Flood Hazard Area 1-Percent Annual Chance Flood Event	
			Number of Buildings Exposed to Coastal Zones	Total Replacement Cost Value Exposed to Coastal Zones
Avalon Borough	5,867	$8,232,959,879	5,451	$7,603,419,933
Cape May City	4,234	$5,153,049,612	2,532	$3,206,575,131
Cape May Point Borough	785	$663,183,164	636	$557,657,620
Dennis Township	7,301	$3,813,425,173	100	$78,528,248
Lower Township	19,597	$9,950,232,225	3,533	$1,965,917,992
Middle Township	18,197	$11,557,342,752	2,948	$1,356,596,187
North Wildwood City	4,729	$4,423,365,953	4,729	$4,423,365,953
Ocean City	18,172	$17,100,920,036	17,230	$16,086,133,609
Sea Isle City	6,712	$7,663,928,227	6,503	$7,447,300,295
Stone Harbor Borough	3,836	$3,291,756,871	3,252	$2,793,486,256
Upper Township	9,627	$6,506,171,365	1,080	$790,346,986
West Cape May Borough	1,623	$1,178,516,373	671	$512,013,774
West Wildwood Borough	805	$459,103,094	805	$459,103,094
Wildwood City	3,679	$4,379,038,844	3,679	$4,379,038,844
Wildwood Crest Borough	5,410	$4,552,156,876	4,454	$3,740,296,052
Woodbine Borough	1,416	$1,335,589,432	0	$0
Cape May County (Total)	**111,990**	**$90,260,739,877**	**57,603**	**$55,399,779,973**

Sources: FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM; Cape May County GIS 2020; RS Means 2019
Notes: Coastal hazard areas include coastal AE zones and VE zones. Riverine hazard areas include riverine AE zones and A zones.

Table 5.4.5-10. Estimated Number of Structures with Damages Caused by the Coastal 1-Percent Annual Chance Flood Event Boundary

Jurisdiction	Total Number of Buildings	1-Percent Annual Chance Flood Event (Coastal Only)		
		All Occupancies Estimated Number of Buildings with Damages in Flood Hazard Area	Residential Estimated Number of Buildings with Damages in Flood Hazard Area	Commercial Estimated Number of Buildings with Damages in Flood Hazard Area
Avalon Borough	5,867	103	97	5
Cape May City	4,234	144	139	3
Cape May Point Borough	785	5	5	0
Dennis Township	7,301	3	3	0
Lower Township	19,597	167	139	27
Middle Township	18,197	210	185	20
North Wildwood City	4,729	400	337	54
Ocean City	18,172	1,033	900	113
Sea Isle City	6,712	219	212	6

Table 5.4.5-10. Estimated Number of Structures with Damages Caused by the Coastal 1-Percent Annual Chance Flood Event Boundary

Jurisdiction	Total Number of Buildings	1-Percent Annual Chance Flood Event (Coastal Only)		
		All Occupancies Estimated Number of Buildings with Damages in Flood Hazard Area	Residential Estimated Number of Buildings with Damages in Flood Hazard Area	Commercial Estimated Number of Buildings with Damages in Flood Hazard Area
Stone Harbor Borough	3,836	141	138	3
Upper Township	9,627	80	63	15
West Cape May Borough	1,623	15	15	0
West Wildwood Borough	805	277	260	8
Wildwood City	3,679	323	234	62
Wildwood Crest Borough	5,410	2	2	0
Woodbine Borough	1,416	0	0	0
Cape May County (Total)	**111,990**	**3,122**	**2,729**	**316**

Sources: Hazus v4.2, FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM; Cape May County GIS 2020
Notes: Coastal hazard areas include coastal AE zones and VE zones. Riverine hazard areas include riverine AE zones and A zones.

Table 5.4.5-11. Estimated Loss for Structures Impacted by the Coastal 1-Percent Annual Chance Flood Event Boundary

Jurisdiction	Total Replacement Cost Value (RCV)	1-Percent Annual Chance Flood Event (Coastal Only)		
		All Occupancies Estimated Loss	Residential Estimated Loss	Commercial Estimated Loss
Avalon Borough	$8,232,959,879	$4,058,416	$3,898,087	$18,249
Cape May City	$5,153,049,612	$7,346,695	$6,715,111	$575,734
Cape May Point Borough	$663,183,164	$10,773	$10,773	$0
Dennis Township	$3,813,425,173	$1,276,184	$1,276,184	$0
Lower Township	$9,950,232,225	$7,105,489	$4,637,054	$2,362,405
Middle Township	$11,557,342,752	$11,793,714	$11,043,537	$456,075
North Wildwood City	$4,423,365,953	$9,962,697	$5,446,752	$2,917,322
Ocean City	$17,100,920,036	$69,697,762	$64,607,793	$4,449,084
Sea Isle City	$7,663,928,227	$13,142,866	$12,650,040	$484,728
Stone Harbor Borough	$3,291,756,871	$4,695,575	$4,667,106	$28,469
Upper Township	$6,506,171,365	$6,824,673	$4,920,849	$1,232,270
West Cape May Borough	$1,178,516,373	$98,978	$98,978	$0
West Wildwood Borough	$459,103,094	$27,863,245	$26,702,586	$582,141
Wildwood City	$4,379,038,844	$26,056,594	$11,361,847	$6,497,089
Wildwood Crest Borough	$4,552,156,876	$8,996	$8,996	$0
Woodbine Borough	$1,335,589,432	$0	$0	$0
Cape May County (Total)	**$90,260,739,877**	**$189,942,657**	**$158,045,693**	**$19,603,566**

Sources: Hazus v4.2, FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM; Cape May County GIS 2020; RS Means 2019
Notes: Coastal hazard areas include coastal AE zones and VE zones. Riverine hazard areas include riverine AE zones and A zones.

Cape May County also has buildings located in the riverine AE and A flood zones. The impacts of riverine flooding will vary with terrain (FEMA 2013). For example, flat areas like Cape May County may experience longer and more shallow flood events because the water moves slower across the landscape. Hazus flood depth damage models for riverine flooding were applied to the structures built in FEMA's riverine flood hazard areas. The modeled loss is based upon the exposed inventory measure by structural and content replacement cost value.

There are an estimated 135 buildings located in the riverine SFHA with a value of approximately $25.3 million of building and contents (based on replacement cost value). This is less than 1-percent of the County's total general building stock inventory replacement cost value (approximately $90.3 billion). Refer to Table 5.4.5-12 for the total number of buildings located in the riverine 1-percent annual chance floodplain by jurisdiction. Overall, Middle Township has the greatest number of structures exposed to the riverine 1-percent annual chance flood event boundary (i.e., 121 buildings), which is a replacement cost value of approximately $15.8 million.

Of the structures exposed to the riverine 1-percent annual chance flood event boundary, Hazus estimates that one residential structure in Middle Township will experience damages, which is approximately $7,861 in replacement cost value.

Table 5.4.5-12. Estimated General Building Stock Exposure to the Riverine 1-Percent Annual Chance Flood Event

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Flood Hazard Area 1-Percent Annual Chance Flood Event	
			Number of Buildings Exposed to Riverine Zones	Total Replacement Cost Value Exposed to Riverine Zones
Avalon Borough	5,867	$8,232,959,879	0	$0
Cape May City	4,234	$5,153,049,612	0	$0
Cape May Point Borough	785	$663,183,164	0	$0
Dennis Township	7,301	$3,813,425,173	8	$5,812,804
Lower Township	19,597	$9,950,232,225	1	$39,020
Middle Township	18,197	$11,557,342,752	121	$15,809,792
North Wildwood City	4,729	$4,423,365,953	0	$0
Ocean City	18,172	$17,100,920,036	0	$0
Sea Isle City	6,712	$7,663,928,227	0	$0
Stone Harbor Borough	3,836	$3,291,756,871	0	$0
Upper Township	9,627	$6,506,171,365	5	$3,682,069
West Cape May Borough	1,623	$1,178,516,373	0	$0
West Wildwood Borough	805	$459,103,094	0	$0
Wildwood City	3,679	$4,379,038,844	0	$0
Wildwood Crest Borough	5,410	$4,552,156,876	0	$0
Woodbine Borough	1,416	$1,335,589,432	0	$0
Cape May County (Total)	**111,990**	**$90,260,739,877**	**135**	**$25,343,685**

Sources: FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM; Cape May County GIS 2020; RS Means 2019
Notes: Coastal hazard areas include coastal AE zones and VE zones. Riverine hazard areas include riverine AE zones and A zones.

Additionally, an exposure analysis estimated the total number of structures that would be impacted by the 0.2-percent annual chance flood event boundary. There are 65,698 buildings located in the 0.2-percent annual chance floodplain with approximately $61.8 billion of building and contents in replacement cost value (or 68.5-percent of the County's total replacement cost value). One hundred percent of buildings within five jurisdictions are exposed to the 0.2-percent annual chance flood event (i.e., North Wildwood City, Ocean City, West Wildwood Borough, Wildwood City, Wildwood Crest Borough). Overall, Ocean City has the greatest number of structures exposed to the 0.2-percent annual chance flood event (i.e., 18,170 structures, or approximately $17.1 billion in replacement cost value). Refer to Table 5.4.5-13 for the total number of buildings exposed to the 0.2-percent annual chance flood event inundation.

Table 5.4.5-13. Estimated General Building Stock and Replacement Cost Value Exposed to the 0.2-Percent Annual Chance Flood Event

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Flood Hazard Area 0.2-Percent Annual Chance Flood Event			
			Number of Buildings Exposed	Percent of Total	Total Replacement Cost Value Exposed	Percent of Total
Avalon Borough	5,867	$8,232,959,879	5,835	99.5%	$8,162,379,575	99.1%
Cape May City	4,234	$5,153,049,612	3,196	75.5%	$4,037,627,980	78.4%
Cape May Point Borough	785	$663,183,164	744	94.8%	$628,974,860	94.8%
Dennis Township	7,301	$3,813,425,173	307	4.2%	$197,062,701	5.2%
Lower Township	19,597	$9,950,232,225	5,301	27.1%	$2,734,754,110	27.5%
Middle Township	18,197	$11,557,342,752	4,730	26.0%	$2,518,831,249	21.8%
North Wildwood City	4,729	$4,423,365,953	4,729	100.0%	$4,423,365,953	100.0%
Ocean City	18,172	$17,100,920,036	18,170	100.0%	$17,097,349,504	100.0%
Sea Isle City	6,712	$7,663,928,227	6,686	99.6%	$7,644,261,453	99.7%
Stone Harbor Borough	3,836	$3,291,756,871	3,757	97.9%	$3,210,020,843	97.5%
Upper Township	9,627	$6,506,171,365	1,367	14.2%	$981,230,626	15.1%
West Cape May Borough	1,623	$1,178,516,373	982	60.5%	$758,177,553	64.3%
West Wildwood Borough	805	$459,103,094	805	100.0%	$459,103,094	100.0%
Wildwood City	3,679	$4,379,038,844	3,679	100.0%	$4,379,038,844	100.0%
Wildwood Crest Borough	5,410	$4,552,156,876	5,410	100.0%	$4,552,156,876	100.0%
Woodbine Borough	1,416	$1,335,589,432	0	0.0%	$0	0.0%
Cape May County (Total)	**111,990**	**$90,260,739,877**	**65,698**	**58.7%**	**$61,784,335,221**	**68.5%**

Sources: FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM; Cape May County GIS 2020; RS Means 2019
Notes: Coastal hazard areas include coastal AE zones and VE zones. Riverine hazard areas include riverine AE zones and A zones.

NFIP Statistics

FEMA Region 2 provided a list of NFIP policies, past claims, and repetitive loss properties (RL) in Cape May County. According to FEMA, a RL property is a NFIP-insured structure that has had at least two paid flood losses of more than $1,000 in any 10-year period since 1978. A SRL property is a NFIP-insured structure that has had four or more separate claim payments made under a standard flood insurance policy, with the amount of each claim exceeding $5,000 and with the cumulative amount of such claims payments exceeding $20,000; or at least two separate claims payments made under a standard flood insurance policy with the cumulative

amount of such claim payments exceed the fair market value of the insured building on the day before each loss (FEMA 2018). Table 5.4.5-14 through Table 5.4.5-16 and Figure 5.4.5-4 summarize the NFIP policies, claims and repetitive loss statistics for Cape May County.

FEMA provided the location of the properties with policies, claims and repetitive flooding 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. The structures reported were assessed using the Community Name and numbers provided by FEMA.

Table 5.4.5-14. Occupancy Class of NFIP Repetitive Loss Structures in Cape May County

Occupancy Class	Total Number of NFIP Repetitive Loss Properties (excludes Severe Repetitive Loss Properties)	Total Number of NFIP Severe Repetitive Loss Properties (excludes Repetitive Loss Properties)	Total Number of NFIP Repetitive Loss Properties and Severe Repetitive Loss Properties
Single Family	1,266	279	1,545
Assumed Condo	0	0	0
2-4 Family	592	137	729
Other Residential	116	22	138
Non-Residential	259	81	340
Cape May County (Total)	**2,233**	**519**	**2,752**

Source: FEMA Region 2 2020
NFIP = National Flood Insurance Program
Note: The total number of repetitive loss properties does not include the severe repetitive loss properties. The severe repetitive loss property totals only include validated properties.

Table 5.4.5-15. Occupancy Class of NFIP Repetitive Loss Structures in Cape May County by Jurisdiction

Jurisdiction	Total Number of NFIP Repetitive Loss Properties (excludes Severe Repetitive Loss Properties)					Total Number of NFIP Severe Repetitive Loss Properties (excludes Repetitive Loss Properties)				
	Single Family	Assumed Condo	2-4 Family	Other Residential	Non-Residential	Single Family	Assumed Condo	2-4 Family	Other Residential	Non-Residential
Avalon Borough	99	0	21	0	26	18	0	3	1	12
Cape May City	87	0	14	9	19	4	0	1	0	3
Cape May Point Borough	12	0	4	0	0	0	0	0	0	0
Dennis Township	1	0	0	0	0	0	0	0	0	0
Lower Township	4	0	2	0	0	1	0	0	0	1
Middle Township	77	0	1	0	1	13	0	1	0	0
North Wildwood City	249	0	132	12	60	48	0	26	5	16
Ocean City	233	0	201	62	58	37	0	14	9	9
Sea Isle City	64	0	106	15	23	13	0	27	5	9
Stone Harbor Borough	88	0	15	5	29	13	0	10	2	13
Upper Township	26	0	8	0	2	5	0	2	0	0
West Cape May Borough	11	0	2	0	1	0	0	1	0	0
West Wildwood Borough	186	0	34	1	7	92	0	25	0	1
Wildwood City	15	0	4	2	2	1	0	2	0	1
Wildwood Crest Borough	114	0	48	10	31	34	0	25	0	16
Woodbine Borough	0	0	0	0	0	0	0	0	0	0
Cape May County (Total)	**1,266**	**0**	**592**	**116**	**259**	**279**	**0**	**137**	**22**	**81**

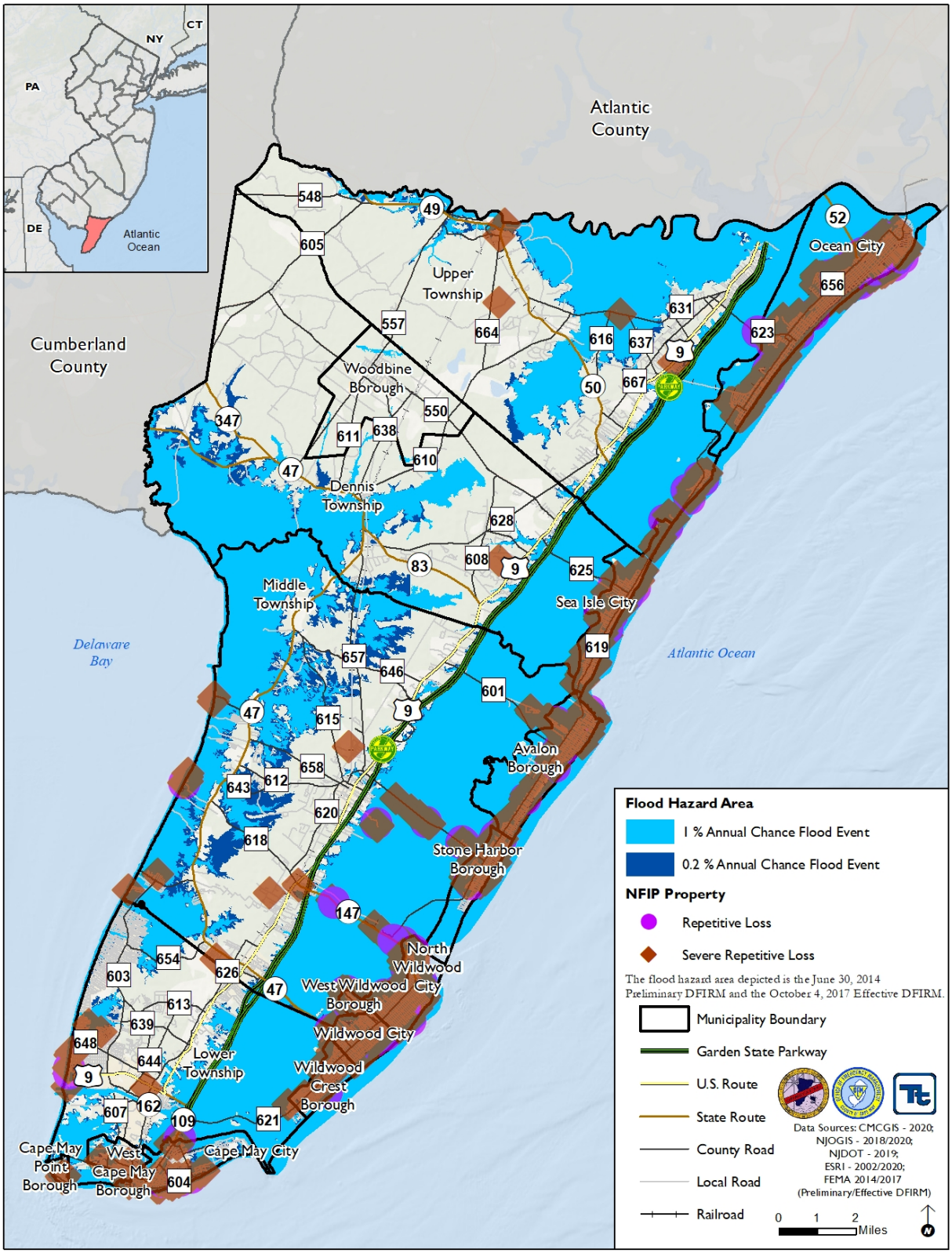
Source: FEMA Region 2 2020
Note: NFIP = National Flood Insurance Program. The total number of repetitive loss properties does not include the severe repetitive loss properties. The severe repetitive loss property totals only include validated properties.

Table 5.4.5-16. National Flood Insurance Program Policies, Claims, and Repetitive Loss Statistics by Jurisdiction.

Jurisdiction	NFIP Number of Policies	NFIP Number of Claims	NFIP Payments	Number of NFIP Repetitive Loss Properties (Excludes Severe Repetitive Loss Properties)	Number of NFIP Severe Repetitive Loss Properties (Excludes Repetitive Loss Properties)	Number of Mitigated Repetitive Loss/Severe Repetitive Properties
Avalon Borough	3,797	1,939	$26,664,883	146	34	80
Cape May City	1,666	1,118	$9,262,941	129	8	81
Cape May Point Borough	392	102	$839,631	16	0	8
Dennis Township	46	14	$1,035,224	1	0	0
Lower Township	1,454	207	$3,942,373	6	2	4
Middle Township	920	757	$9,372,842	79	14	21
North Wildwood City	2,483	3,345	$40,614,548	453	95	12
Ocean City	9,843	8,343	$85,589,583	554	69	81
Sea Isle City	3,274	2,567	$232,281	208	54	74
Stone Harbor Borough	1,959	1,334	$388,798	137	38	44
Upper Township	435	384	$352,650	36	7	13
West Cape May Borough	344	99	$2,298	14	1	1
West Wildwood Borough	404	2,133	$213,797	228	118	36
Wildwood City	1,603	2,111	$608,827	23	4	4
Wildwood Crest Borough	1,965	299	$31,243	203	75	51
Woodbine Borough	1	0	$0	0	0	0
Cape May County (Total)	**30,586**	**24,752**	**$179,151,918**	**2,233**	**519**	**510**

Source: FEMA Region 2 2020
Note: The total number of repetitive loss properties does not include the severe repetitive loss properties. The severe repetitive loss property totals only include validated properties.

Figure 5.4.5-4. NFIP Repetitive Loss Areas in Cape May County



Impact on Land Uses

An exposure analysis was completed to determine the number of acres residential, non-residential, and natural land use types are exposed to the flood hazard areas. To estimate exposure the floodplain boundaries were overlaid upon the 2015 NJDEP land use land cover data and a county boundary provided by Cape May County.

Table 5.4.5-17 summarizes the county-wide assessment that evaluated the number of acres land use types are exposed to the 1-percent and 0.2-percent annual chance flood events, where the land use types are aggregated into residential, non-residential, and natural land use categories (refer to Table 5.4.5-17). Overall, natural land use types are most exposed to the flood hazard area.

Additionally, the number of acres by land use type exposed to the 1-percent and 0.2-percent annual chance flood event were also determined for each jurisdiction (refer to Table 5.4.5-16). Middle Township has the greatest number of acres exposed to the 1-percent and 0.2-percent annual chance flood event boundaries (i.e., 31,163 acres and 35,634 acres, respectively). West Wildwood Borough has the greatest proportion of its land area exposed to the 1-percent annual chance flood event (i.e., 99.7-percent of total land area). Two jurisdictions are 100-percent exposed to the 0.2-percent annual chance flood event (i.e., West Wildwood Borough and Wildwood Crest Borough).

Table 5.4.5-17. Land Use Types Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

Land Use Type	Total Acres of Land Use Type Category in Cape May County	Land Use Types Exposed to the 1-percent Annual Chance Flood Event	Percent of Total Acres of Land Use Type	Land Use Types Exposed to the 0.2-percent Annual Chance Flood Event	Percent of Total Acres of Land Use Type
Residential Land Use Type	22,296	6,799	30.5%	8,297	37.2%
Non-Residential Land Use Type	160,338	86,820	54.1%	94,419	58.9%
Natural Land Use Type	139,026	82,930	59.7%	89,009	64.0%
Cape May County (Total)	**182,633***	**93,619**	**51.3%**	**102,716**	**56.2%**

Source: NJDEP 2019/2015; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM
**Acres is based upon the NJDEP 2015 boundary, which could over or underestimate the number of acres of land area compared to the County boundary provided by the County*

Table 5.4.5-18. Acres of Land Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

Jurisdiction	Total Acres*	Total Acres Exposed to the 1-percent Annual Chance Flood Event	Percent of Total	Total Acres Exposed to the 0.2-percent Annual Chance Flood Event	Percent of Total
Avalon Borough	3,181	3,052	96.0%	3,137	98.6%
Cape May City	1,845	1,232	66.8%	1,518	82.3%
Cape May Point Borough	192	155	80.7%	179	93.2%
Dennis Township	40,830	14,528	35.6%	16,261	39.8%

Table 5.4.5-18. Acres of Land Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

Jurisdiction	Total Acres*	Total Acres Exposed to the 1-percent Annual Chance Flood Event	Percent of Total	Total Acres Exposed to the 0.2-percent Annual Chance Flood Event	Percent of Total
Lower Township	19,852	9,854	49.6%	10,733	54.1%
Middle Township	52,935	31,163	58.9%	35,634	67.3%
North Wildwood City	1,593	1,467	92.1%	1,470	92.3%
Ocean City	7,553	7,318	96.9%	7,505	99.4%
Sea Isle City	1,762	1,715	97.3%	1,741	98.8%
Stone Harbor Borough	1,480	1,278	86.4%	1,364	92.1%
Upper Township	43,785	19,710	45.0%	20,765	47.4%
West Cape May Borough	757	422	55.8%	519	68.6%
West Wildwood Borough	233	233	99.7%	233	100.0%
Wildwood City	1,058	1,046	98.8%	1,053	99.5%
Wildwood Crest Borough	948	787	83.1%	948	100.0%
Woodbine Borough	5,122	129	2.5%	129	2.5%
Cape May County (Total)	**183,127**	**94,089**	**51.4%**	**103,188**	**56.3%**

Source: Cape May County GIS 2020; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM
Note: The county boundary includes waterways
**Acres is based upon the data provided by the County, which could over or underestimate the number of acres of land area because it includes waterways*

Impact on Critical Facilities and Lifelines

It is important to determine the critical facilities, lifelines and infrastructure that may be at risk to flooding, and who may be impacted should damage occur. Critical services during and after a flood event may not be available if critical facilities and community lifelines are directly damaged or transportation routes to access them are impacted. Roads that are blocked or damaged can isolate residents and can prevent access throughout the planning area to many service providers needing to reach vulnerable populations or to make repairs to critical infrastructure and lifelines.

Critical facility and lifeline exposure to the flood hazard was examined. In addition, Hazus was used to estimate the flood loss potential to critical facilities located in the FEMA-mapped floodplains which is summarized by jurisdiction in the Jurisdictional Annexes (Section 9). Table 5.4.5-19 and Table 5.4.5-20 summarize the number of critical facilities and lifelines located in the 1-percent and 0.2-percent annual chance flood inundation areas by jurisdiction, respectively. Table 5.4.5-21 through Table 5.4.5-24 summarize the distribution of the exposed facilities by type and jurisdiction. Table 5.4.5-25 summarizes the number of lifelines categorized by the FEMA lifelines that are exposed to the 1-percent and 0.2-percent annual chance flood event boundaries. Overall, 354 and 403 critical facilities are exposed to the 1-percent and 0.2-percent annual chance flood event boundaries, respectively. Of these critical facilities exposed to these flood boundaries, respectively, 350 and 399 are considered lifelines for the County. Most of the facilities exposed to the flood hazard areas are wastewater pump stations. One hundred percent of critical facilities in three jurisdictions are exposed to the 1-percent annual chance flood event boundary (i.e., North Wildwood City, Sea Isle City, and Wildwood City). One hundred percent exposure increases to eight jurisdictions for the 0.2-percent annual chance flood event boundary (i.e., Avalon Borough, North Wildwood City, Ocean City, Sea Isle City, Stone Harbor Borough, West Wildwood Borough, Wildwood City, and Wildwood Crest Borough).

Table 5.4.5-19. Number of Critical Facilities and Lifelines Located in the 1-Percent Annual Chance Flood Boundary

Jurisdiction	Total Critical Facilities	Total Lifelines	1-Percent Annual Chance Flood Event			
			Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total
Avalon Borough	30	30	29	96.7%	29	96.7%
Cape May City	32	32	19	59.4%	19	59.4%
Cape May Point Borough	10	10	6	60.0%	6	60.0%
Dennis Township	60	60	8	13.3%	8	13.3%
Lower Township	111	111	44	39.6%	44	39.6%
Middle Township	181	181	34	18.8%	34	18.8%
North Wildwood City	30	29	30	100.0%	29	100.0%
Ocean City	59	58	57	96.6%	56	96.6%
Sea Isle City	26	26	26	100.0%	26	100.0%
Stone Harbor Borough	26	26	19	73.1%	19	73.1%
Upper Township	73	68	19	26.0%	19	27.9%
West Cape May Borough	10	10	3	30.0%	3	30.0%
West Wildwood Borough	8	8	7	87.5%	7	87.5%
Wildwood City	39	37	39	100.0%	37	100.0%
Wildwood Crest Borough	23	23	14	60.9%	14	60.9%
Woodbine Borough	21	21	0	0.0%	0	0.0%
Cape May County (Total)	**739**	**730**	**354**	**47.9%**	**350**	**47.9%**

Source: Cape May County GIS 2020; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM

Table 5.4.5-20. Number of Critical Facilities and Lifelines Located in the 1-Percent Annual Chance Flood Boundary

Jurisdiction	Total Critical Facilities	Total Lifelines	0.2-Percent Annual Chance Flood Event			
			Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total
Avalon Borough	30	30	30	100.0%	30	100.0%
Cape May City	32	32	22	68.8%	22	68.8%
Cape May Point Borough	10	10	9	90.0%	9	90.0%
Dennis Township	60	60	11	18.3%	11	18.3%
Lower Township	111	111	49	44.1%	49	44.1%
Middle Township	181	181	45	24.9%	45	24.9%
North Wildwood City	30	29	30	100.0%	29	100.0%
Ocean City	59	58	59	100.0%	58	100.0%
Sea Isle City	26	26	26	100.0%	26	100.0%
Stone Harbor Borough	26	26	26	100.0%	26	100.0%

Table 5.4.5-20. Number of Critical Facilities and Lifelines Located in the 1-Percent Annual Chance Flood Boundary

Jurisdiction	Total Critical Facilities	Total Lifelines	0.2-Percent Annual Chance Flood Event			
			Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total
Upper Township	73	68	22	30.1%	22	32.4%
West Cape May Borough	10	10	4	40.0%	4	40.0%
West Wildwood Borough	8	8	8	100.0%	8	100.0%
Wildwood City	39	37	39	100.0%	37	100.0%
Wildwood Crest Borough	23	23	23	100.0%	23	100.0%
Woodbine Borough	21	21	0	0.0%	0	0.0%
Cape May County (Total)	**739**	**730**	**403**	**54.5%**	**399**	**54.7%**

Source: Cape May County GIS 2020; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM

Table 5.4.5-21. Distribution of Critical Facilities (Category Names Starting with 'A' through 'L') in the 1-Percent Annual Chance Floodplain by Type and Jurisdictions

Jurisdiction	Critical Facilities Exposed to the 1-Percent Annual Chance Flood Event																
	Airport	Bridge	Bus Station	Communications Facility	Communications Tower	County Facilities	Dams	DPW	Education	Electric Substation	EMS	EOC	Ferry Facilities	Fire Stations	Grocery/Food Processing	Health Services	Library
Avalon Borough	0	3	0	0	1	0	0	0	0	0	1	1	0	1	0	0	2
Cape May City	0	1	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0
Cape May Point Borough	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Dennis Township	0	0	0	0	3	0	2	0	0	0	0	0	0	0	0	0	0
Lower Township	0	3	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0
Middle Township	0	9	0	0	2	3	2	0	0	0	0	0	0	1	0	0	0
North Wildwood City	0	0	0	0	6	2	0	1	0	0	1	1	0	3	1	0	0
Ocean City	1	7	0	0	1	0	0	0	0	0	0	1	1	3	0	0	0
Sea Isle City	0	2	0	0	0	1	0	0	0	0	1	1	0	1	0	0	1
Stone Harbor Borough	0	2	0	2	3	1	0	0	0	0	0	0	0	0	0	0	1
Upper Township	0	5	0	1	0	1	3	0	0	0	0	0	0	1	0	0	1
West Cape May Borough	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Wildwood Borough	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wildwood City	0	1	1	0	0	0	0	2	1	1	0	0	0	3	1	1	0
Wildwood Crest Borough	0	0	0	1	7	0	0	0	0	0	1	0	0	1	0	0	0
Cape May County (Total)	**1**	**34**	**1**	**4**	**23**	**9**	**7**	**5**	**1**	**1**	**5**	**4**	**1**	**15**	**4**	**1**	**5**

Source: Cape May County GIS 2020; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM

Table 5.4.5-22. Distribution of Critical Facilities (Category Names Starting with 'M' through 'W') in the 1-Percent Annual Chance Floodplain by Type and Jurisdictions

Jurisdiction	Critical Facilities Exposed to the 1-Percent Annual Chance Flood Event																
	Marinas	Medical Clinics	Municipal Facilities	Natural Gas Facility	Police Stations	Polling Places	Potable Water Facilities	Potable Water Tower	Primary Education	Recreation	Secondary Education	Senior Facility	Shelters	Superfund Sites	Wastewater Facilities	Wastewater Pump Station	Well
Avalon Borough	4	0	2	0	1	0	0	0	1	0	0	0	0	0	0	12	0
Cape May City	2	0	0	0	0	2	1	1	0	0	0	0	0	1	0	5	3
Cape May Point Borough	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	3	0
Dennis Township	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lower Township	16	1	0	0	0	0	0	0	0	0	0	0	0	1	0	17	3
Middle Township	8	0	0	0	0	0	0	0	0	0	1	0	0	1	1	3	3
North Wildwood City	1	1	1	1	2	1	0	0	2	1	0	1	0	0	0	4	0
Ocean City	6	1	2	0	1	7	0	1	3	1	0	3	0	3	1	14	0
Sea Isle City	3	0	1	0	1	2	0	1	0	0	0	0	0	1	0	7	3
Stone Harbor Borough	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	4	3
Upper Township	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
West Cape May Borough	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
West Wildwood Borough	3	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0
Wildwood City	3	5	1	2	1	1	1	2	3	2	0	1	1	2	0	3	0
Wildwood Crest Borough	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	0
Cape May County (Total)	**55**	**9**	**10**	**4**	**7**	**15**	**2**	**5**	**11**	**4**	**1**	**5**	**1**	**9**	**2**	**75**	**18**

Source: Cape May County GIS 2020; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM

Table 5.4.5-23. Distribution of Critical Facilities (Category Names Starting with 'A' through 'L') in the 0.2-Percent Annual Chance Floodplain by Type and Jurisdictions

Jurisdiction	Critical Facilities Exposed to the 0.2-Percent Annual Chance Flood Event																
	Airport	Bridge	Bus Station	Communications Facility	Communications Tower	County Facilities	Dams	DPW	Education	Electric Substation	EMS	EOC	Ferry Facilities	Fire Stations	Grocery/Food Processing	Health Services	Library
Avalon Borough	0	3	0	0	1	0	0	0	0	0	1	1	0	1	0	0	2
Cape May City	0	1	0	0	0	0	0	2	0	0	1	0	0	1	0	0	0
Cape May Point Borough	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
Dennis Township	0	0	0	0	3	0	4	0	0	0	0	0	0	0	0	0	0
Lower Township	0	3	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0

Table 5.4.5-23. Distribution of Critical Facilities (Category Names Starting with 'A' through 'L') in the 0.2-Percent Annual Chance Floodplain by Type and Jurisdictions

Jurisdiction	Critical Facilities Exposed to the 0.2-Percent Annual Chance Flood Event																
	Airport	Bridge	Bus Station	Communications Facility	Communications Tower	County Facilities	Dams	DPW	Education	Electric Substation	EMS	EOC	Ferry Facilities	Fire Stations	Grocery/Food Processing	Health Services	Library
Middle Township	0	9	0	0	3	5	2	0	0	0	0	0	0	2	0	0	0
North Wildwood City	0	0	0	0	6	2	0	1	0	0	1	1	0	3	1	0	0
Ocean City	1	7	0	0	2	0	0	0	0	0	0	1	1	3	0	0	0
Sea Isle City	0	2	0	0	0	1	0	0	0	0	1	1	0	1	0	0	1
Stone Harbor Borough	0	2	0	2	3	1	0	0	0	0	1	0	0	1	0	0	1
Upper Township	0	5	0	1	0	1	3	0	0	0	0	0	0	1	0	0	1
West Cape May Borough	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Wildwood Borough	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Wildwood City	0	1	1	0	0	0	0	2	1	1	0	0	0	3	1	1	0
Wildwood Crest Borough	0	0	0	1	13	0	0	0	0	0	1	0	0	1	0	0	0
Cape May County (Total)	**1**	**34**	**1**	**4**	**31**	**12**	**9**	**5**	**1**	**1**	**6**	**4**	**1**	**19**	**4**	**1**	**5**

Source: Cape May County GIS 2020; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM

Table 5.4.5-24. Distribution of Critical Facilities (Category Names Starting with 'M' through 'W') in the 0.2-Percent Annual Chance Floodplain by Type and Jurisdictions

Jurisdiction	Critical Facilities Exposed to the 0.2-Percent Annual Chance Flood Event																	
	Marinas	Medical Clinics	Municipal Facilities	Natural Gas Facility	Police Stations	Polling Places	Potable Water Facilities	Potable Water Tower	Primary Education	Recreation	Secondary Education	Senior Facility	Shelters	Superfund Sites	TRI Sites	Wastewater Facilities	Wastewater Pump Station	Well
Avalon Borough	4	0	2	0	1	1	0	0	1	0	0	0	0	0	0	0	12	0
Cape May City	2	0	0	0	0	2	1	1	0	0	0	0	0	2	1	0	5	3
Cape May Point Borough	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	4	0
Dennis Township	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Lower Township	16	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	20	4
Middle Township	8	0	0	0	0	0	0	0	2	0	2	0	0	2	0	1	3	6
North Wildwood City	1	1	1	1	2	1	0	0	2	1	0	1	0	0	0	0	4	0
Ocean City	6	1	2	0	1	8	0	1	3	1	0	3	0	3	0	1	14	0

Table 5.4.5-24. Distribution of Critical Facilities (Category Names Starting with 'M' through 'W') in the 0.2-Percent Annual Chance Floodplain by Type and Jurisdictions

Jurisdiction	Critical Facilities Exposed to the 0.2-Percent Annual Chance Flood Event																	
	Marinas	Medical Clinics	Municipal Facilities	Natural Gas Facility	Police Stations	Polling Places	Potable Water Facilities	Potable Water Tower	Primary Education	Recreation	Secondary Education	Senior Facility	Shelters	Superfund Sites	TRI Sites	Wastewater Facilities	Wastewater Pump Station	Well
Sea Isle City	3	0	1	0	1	2	0	1	0	0	0	0	0	1	0	0	7	3
Stone Harbor Borough	1	0	2	0	1	1	0	0	1	0	0	0	0	0	0	0	4	5
Upper Township	5	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	2
West Cape May Borough	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
West Wildwood Borough	3	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0
Wildwood City	3	5	1	2	1	1	1	2	3	2	0	1	1	2	0	0	3	0
Wildwood Crest Borough	1	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	2	0
Cape May County (Total)	**55**	**9**	**12**	**4**	**9**	**20**	**2**	**7**	**14**	**4**	**2**	**6**	**1**	**12**	**2**	**2**	**79**	**24**

Source: Cape May County GIS 2020; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM

Table 5.4.5-25. Lifelines Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Events

FEMA Lifeline Categories	Total Lifelines in County	1-Percent Annual Chance Flood Event Exposure	0.2-Percent Annual Chance Flood Event Exposure
Communication	70	27	35
Energy	9	5	5
Food, Water, Shelter	206	107	119
Hazardous Materials	27	9	14
Health and Medical	39	15	16
Safety and Security	281	95	118
Transportation	98	92	92
Cape May County (Total)	**730**	**350**	**399**

Source: FEMA 2020; Cape May County GIS 2020; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM

Moreover, the miles of evacuation routes that intersect the 1-percent and 0.2-percent annual chance flood events was determined (refer to Table 5.4.5-26). Overall, 36.4-percent and 45-percent of evacuation routes are built within the 1-percent and 0.2-percent annual chance flood events, respectively. The roadways that intersect the flood hazard areas include:

- State Road 50
- State Road 52
- State Road 49
- State Road 83
- State Road 109
- US Route 9
- Bay Ave
- Bayshore & Jonathan Hoffman Rd
- Avalon Blvd
- Delaware Ave

- Ocean Dr
- Madison Ave
- Lafayette Ave
- Stone Harbor Blvd
- Sea Shore Rd & Railroad Ave
- Marshallville & Mill Rd
- Goshen Rd & Mechanic St
- North Wildwood Blvd
- Beach Ave
- Sunset Blvd
- Delsea Dr
- East Creek Mill Rd
- Pittsburgh & Texas Ave
- Sea Isle & JFK Blvd
- Roosevelt Blvd, and
- Garden State Parkway

Flooded roadways, whether from flood events or nuisance/urban flooding can delay evacuation, isolate populations, hinder emergency services and lead to economic impacts due to commuter delays and business closings because they are inaccessible. In addition to roads, other infrastructure such as bridges may be impacted, washed out or blocked by flood waters or debris. Debris from flood events may also affect culverts and sewer systems by creating bottlenecks in the wastewater system, which could not only cause or exacerbate localized urban flooding, but also cause wastewater to spill into homes and neighborhoods or contaminate local rivers and streams.

In cases where short-term functionality is impacted by a hazard, critical 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. Actions addressing shared services agreements are included in Section 9 (Jurisdictional Annexes) of this plan.

Table 5.4.5-26. Estimated Number of Miles of Evacuation Routes Built Within the 1-Percent and 0.2-Percent Annual Chance Flood Event Boundaries

Total Miles of Evacuation Routes in County	Hazard Area Type	Total Miles of Evacuation Routes Built Within the Flood Hazard Areas	Percent of Total
224	1-percent Annual Chance Flood Event	81	36.4%
	0.2-percent Annual Chance Flood Event	101	45.0%

Source: Cape May County GIS 2020; FEMA Effective 2017 DFIRM; FEMA Preliminary 2014 DFIRM; Cape May County Planning Department 2011

Impact on the Economy

Flood events can significantly impact the local and regional economy. This includes but is not limited to general building stock damages and associated tax loss, impacts to utilities and infrastructure, business interruption, and impacts on tourism. In areas that are directly flooded, renovations of commercial and industrial buildings may be necessary, disrupting associated services. Tourism in the County may be greatly impacted by flooding if businesses are shut down because they are damaged from flooding or roadways connecting businesses are impassable due to flood events. In addition, secondary homes, hotels, and rental properties may be negatively impacted by the occurrence of flooding and could be damaged in more severe flooding events. Refer to the 'Impact on Buildings' subsection earlier which discusses direct impacts to buildings in Cape May County.

Debris management may also be a large expense after a flood event. Hazus estimates the amount of structural debris generated during a 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.).

These distinctions are necessary because of the different types of equipment needed to handle debris. Table 5.4.5-27 summarizes the countywide debris estimates for the entire 1-percent annual chance flood event. This table only estimates structural debris generated by flooding and does not include non-structural debris or additional potential damage and debris possibly generated by wind that may be associated with a flood event or storm that causes flooding. Hazus estimates that Ocean City will have the greatest amount of debris generated from a 1-percent annual chance flood event.

Table 5.4.5-27. Estimated Debris Generated from the 1-Percent Annual Chance Flood Event

Jurisdiction	1-Percent Annual Chance Flood Event (Total)			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Avalon Borough	46,239	28,545	10,337	7,357
Cape May City	18,588	13,681	2,970	1,936
Cape May Point Borough	1,729	1,685	27	17
Dennis Township	740	642	60	38
Lower Township	8,466	5,505	1,699	1,262
Middle Township	9,617	5,796	2,200	1,621
North Wildwood City	31,772	27,295	2,695	1,782
Ocean City	94,144	75,164	11,386	7,594
Sea Isle City	54,451	44,720	5,711	4,020
Stone Harbor Borough	34,390	15,737	10,872	7,781
Upper Township	10,511	5,073	3,268	2,169
West Cape May Borough	2,659	1,972	420	268
West Wildwood Borough	7,138	6,539	352	247
Wildwood City	17,681	17,234	269	178
Wildwood Crest Borough	6,016	5,914	62	40
Woodbine Borough	2	2	0	0
Cape May County (Total)	**344,143**	**255,504**	**52,329**	**36,311**

Impact on the Environment

As Cape May County County and its jurisdictions grow, flood events may increase in frequency and/or severity as land use changes, more structures are built, and impervious surfaces expand. Furthermore, flood extents for the 1-percent and 0.2-percent annual flood events will continue to evolve alongside natural occurrences such as sea level rise, climate change, and/or severity of coastal storms. These flood events will inevitably impact Cape May County's natural and local environment. The acreage of natural land accounts for 76-percent of the County's total land area. Additionally, wetlands make up 44.4-percent of the County's land use area, which is an important landscape for ecosystem services, coastal erosion control, and flood management (refer to Table 5.4.5-28 and Figure 5.4.5-5).

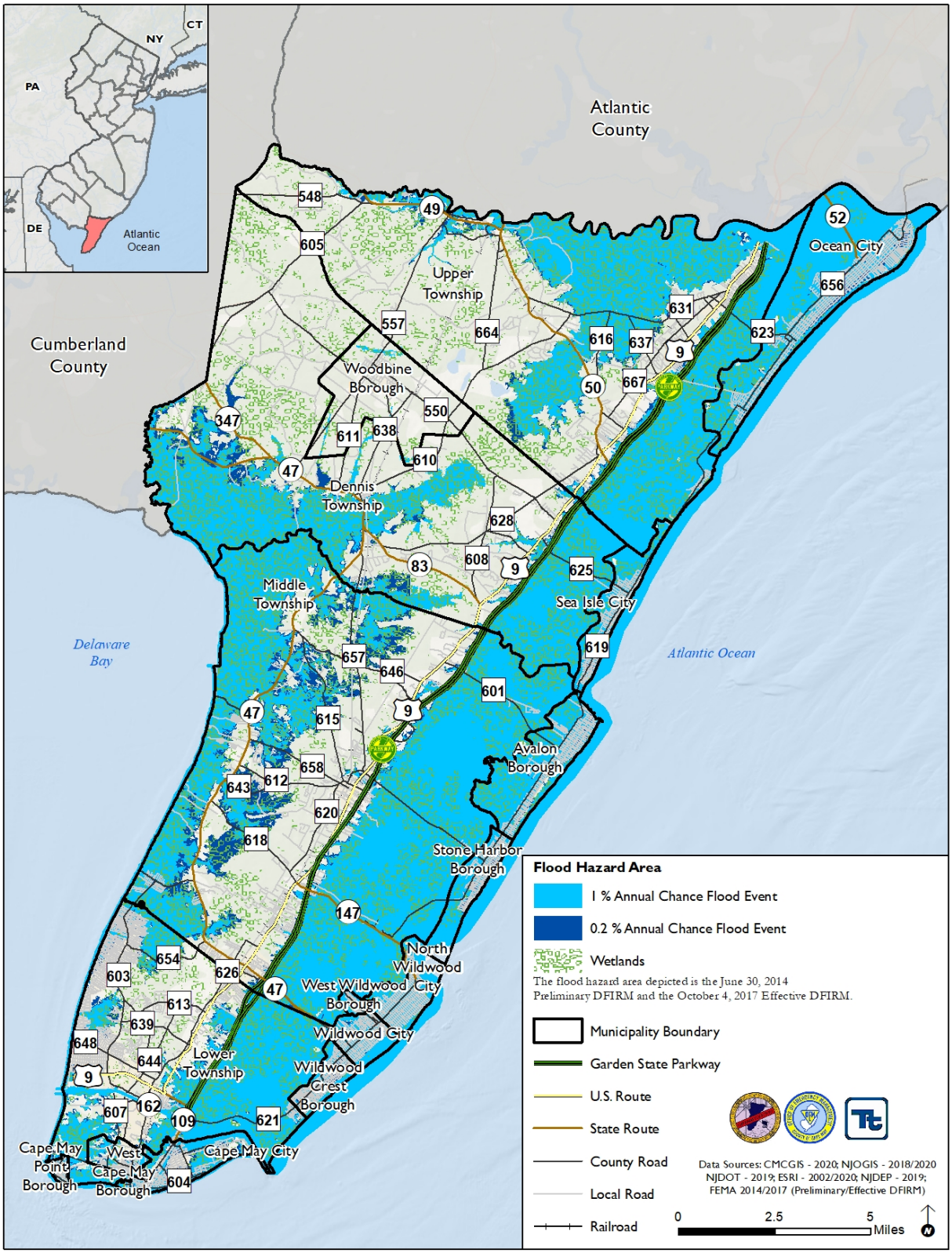
Table 5.4.5-28. Acres of Wetlands in Cape May County by Jurisdiction

Jurisdiction	Total Acres	Wetland Acres	Percentage of Wetlands
Avalon Borough	3,181	1,421	44.7%
Cape May City	1,845	470	25.5%
Cape May Point Borough	192	20	10.4%

Jurisdiction	Total Acres	Wetland Acres	Percentage of Wetlands
Dennis Township	40,830	19,874	48.7%
Lower Township	19,852	7,853	39.6%
Middle Township	52,935	26,570	50.2%
North Wildwood City	1,593	149	9.3%
Ocean City	7,553	1,995	26.4%
Sea Isle City	1,762	574	32.6%
Stone Harbor Borough	1,480	236	15.9%
Upper Township	43,785	20,746	47.4%
West Cape May Borough	757	265	35.0%
West Wildwood Borough	233	44	19.0%
Wildwood City	1,058	18	1.7%
Wildwood Crest Borough	948	81	8.5%
Woodbine Borough	5,122	968	18.9%
Cape May County (Total)	**183,127**	**81,286**	**44.4%**

Severe flooding cannot only influence the habitat of these natural land areas, it can be disruptive to species that reside in these natural habitats. Refer to Table 5.4.5-28 for the number of acres natural land use types are exposed to the 1-percent and 0.2-percent annual chance flood inundation areas.

Figure 5.4.5-5. Wetlands in Cape May County



Cascading Impacts on Other Hazards

Flood events can exacerbate the impacts of coastal erosion and disease outbreak. Flooding may cause a loss in protective shoreline dunes, loss of stabilizing plant material caused by inundation, and erosion (New York State 2019). Furthermore, flooding may increase the transmission of water-borne diseases such as typhoid fever, cholera, and hepatitis A (World Health Organization 2020). Flooding that causes contamination of drinking water facilities, including groundwater drinking water sources, may enhance the risk of disease outbreaks based on the number of persons that come in contact with these resources, particularly those with open wounds. Standing water that occurs as a result of a flood event may become a breeding site for vector-borne diseases, like West Nile virus (World Health Organization 2020). More information about these hazards of concern can be found in Section 5.4.1 (Climate Change and Sea Level Rise) and Section 5.4.3 (Disease Outbreak).

Future Changes That May Impact Vulnerability

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the County. Any areas of growth located in the FEMA delineated floodplains could be potentially impacted by flooding. It is recommended that the County and municipal partners implement design strategies that mitigate against the risk of flooding.

Projected Changes in Population

According to the U.S. Census Bureau, 2018 American Community Survey 5-Year Estimate, estimates Cape May County's population is approximately 93,705, which is a decrease in population since 2010, or a 5.4-percent decrease. Despite this decrease in the overall population, seasonal population changes that occur because of tourism can alter the number of persons impacted by flooding. Further, any change in population density in the flood hazard boundaries will also alter the number of persons impacted by flooding. Overall, Cape May County has experienced a small but steady population decline since 2000. Cape May County's population decline is reflected by declines in eleven of the County's sixteen municipalities. Between 2000 and 2010, the County lost nearly five percent of its population. Between 2010 and 2020, the County is expected to have experienced a similar decrease, owing to an aging population and a lack of young families moving to the region. Refer to Section 4 (County Profile) which includes a discussion on population trends for the County.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. Annual precipitation amounts in the region are projected to increase, primarily in the form of heavy rainfalls, which have the potential to increase the risk to flash flooding and riverine flooding, and flood critical transportation corridors and infrastructure. Increases in precipitation may alter and expand the floodplain boundaries and runoff patterns, resulting in the exposure of populations, buildings, and critical facilities and infrastructure that were previously outside the floodplain. This increase in exposure would result in an increased risk to life and health, an increase in structural losses, a diversion of additional resources to

response and recovery efforts, and an increase in business closures affected by future flooding events due to loss of service or access.

Furthermore, impacts from changes in climate such as the frequency and intensity of weather events have an impact on the flood extents in Cape May County. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such as flood events. While predicting changes of flood events 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.

Change of Vulnerability Since the 2016 HMP

This hazard mitigation plan includes population spatial data referencing the 5-Year 2014-2018 American Community Survey population estimates; an updated general building stock using tax assessor data provided by the County and its municipalities supplemented with 2013 MOD-IV parcel data, building footprints data from the County, and 2019 RS Means replacement cost values for buildings and content in the County; and an updated critical facility dataset provided by the County. Furthermore, FEMA's 2014 Preliminary DFIRM and 2017 Effective DFIRM data were used to create depth grids of the 1-percent and 0.2-percent annual chance flood event boundaries to assess the County's flood inundation risk. A damage analysis was performed in Hazus-MH v4.2 using the riverine and coastal 1-percent annual chance flood event depth grid, updated building stock, and updated critical facility data. This data is an update compared to the 2010 U.S. Census population and 2015 Preliminary DFIRM used in the 2016 hazard mitigation plan. The 2016 plan also used an older version of Hazus (version 3.0) to assess the flood loss for the County.

Overall, this vulnerability assessment provides the County an estimated exposure assessment and damage estimate for the flood hazard.