5.1 METHODOLOGY AND TOOLS

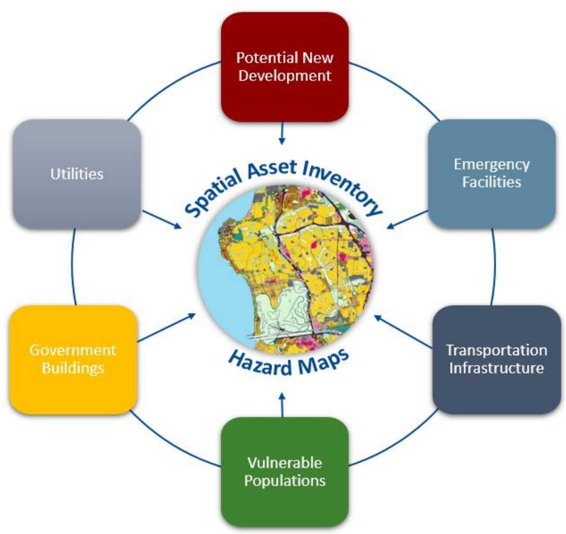
2021 HMP Update Changes

- The risk assessment was updated using best available information.
  - Hazard events and associated impacts were researched and summarized from 2013 to 2020
  - 2014-2018 American Community Survey 5-year estimates were utilized.
  - For this update, a customized general building stock was created using building footprints and parcel data from the County, which was supplemented with 2013 MOD-IV tax assessor data and 2019 RS Means replacement cost value for building and content replacement costs. This data was used to develop a structure-level building inventory and estimate replacement cost value for each building to value exposure and losses to the hazards of concern.
  - A critical facility inventory was created using data from Cape May County and County jurisdictions. Attribute information (e.g., back-up power, ownership, structure type, etc.) for each critical facility provided by the County was referenced and supplemented with default attributes defined by regional assumptions provided by Hazus.
  - Lifelines were identified in the critical facility inventory to align with FEMA's lifeline definition.
  - Hazus-MH v4.2 was used to estimate potential impacts to the flood, wind and seismic hazards.
  - Best available hazard data was used as described in this section.

The following summarizes the asset inventories, methodology and tools used to support the risk assessment process.

5.1.1 Asset Inventories

Cape May County assets were identified to assess potential exposure and loss associated with the hazards of concern. For the HMP update, Cape May County assessed exposure vulnerability of the following types of assets: population, buildings and critical facilities/infrastructure, new development, and the environment. Some assets may be more vulnerable because of their physical characteristics or socioeconomic uses. To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual personal or public properties.



The risk assessment included the collection and use of an expanded and enhanced asset inventory to estimate hazard exposure and vulnerability.

Population

Total population statistics from the 2014-2018 American Community Survey 5-year estimate were used to estimate the exposure and potential impacts to the County's population in place of the 2010 U.S. Census block estimates. Population counts at the jurisdictional level were averaged among the residential structures in each jurisdiction of the County to estimate the population at the structure level. This estimate is a more precise distribution of population across the County compared to only using the Census block or Census tract boundaries. Limitations of these analyses are recognized, and thus the results are used only to provide a general estimate for planning purposes.

As discussed in Section 4 (County Profile), research has shown that some populations are at greater risk from hazard events because of decreased resources or physical abilities. Vulnerable populations in Cape May County included in the risk assessment are children, elderly, population below the poverty level, non-English speaking individuals, and persons institutionalized with a disability.

Buildings

The updated building stock inventory was created using building footprints and parcel data from the County, which was supplemented with 2013 MOD-IV tax assessor data and 2019 RS Means replacement cost value for building and content replacement costs. Attributes provided in the spatial files were used to further define each structure in terms of occupancy class, construction type, year built, foundation type, etc. Default information was used to fill in the gaps for buildings that could not be assigned attributes from the assessor's data or from the data provided by the County and jurisdictions. The centroid of each building footprint was used to estimate the building location. If a building footprint was not located due to limited spatial data, parcels that had assessor's information supporting the presence of a building were given a centroid to represent the location of a structure. Structural and content replacement cost values (RCV) were calculated for each building utilizing available assessor data and RS Means 2019 values; a regional location factor for Cape May County was applied (1.12 for non-residential structures and 1.2 for residential structures). Replacement cost value is the current cost of returning an asset to its pre-damaged condition, using present-day cost of labor and materials. Total replacement cost value consists of both the structural cost to replace a building and the estimate value of contents of a building. The occupancy classes available in Hazus were condensed into the following categories (residential, commercial, industrial, agricultural, religious, governmental, and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single-family dwellings.

Critical Facilities and Lifelines

A **lifeline** provides indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety, or economic security (FEMA).

An updated critical facility inventory was created for this hazard mitigation plan, which includes essential facilities, utilities, transportation features and user-defined facilities. The critical facility dataset was reviewed by the County and jurisdictions for accuracy, additions or deletions of new/moved critical assets, identification of backup power for each asset (if known) and whether the critical facility is considered a lifeline in accordance with FEMA's definition; refer to Appendix J (Critical Facilities). To protect individual privacy and the security of assets, information is presented in aggregate, without details about specific individual properties or facilities.

Environment and Land Use Area

National land use land cover data updated by the New Jersey Department of Environmental Protection (NJ DEP) in 2019 was used to assess land use characteristics of the County. This land use land cover data represents land use land cover in 2015, and is updated from the 2012 dataset. This dataset helped to inform spatial areas of residential, non-residential, and natural land use areas.

The residential land use category included the following land use types: mixed residential; residential, high density or multiple dwelling; residential, rural, single unit; residential, single unit, low density; and residential, single unit, medium density. The non-residential land use category included all other land use types.

The natural land use category was created using a sub-group of the non-residential land use category, including the following land use types: artificial lakes; Atlantic ocean; Atlantic white cedar wetlands; bare exposed rock,

rock slides, etc.; beaches; coniferous brush/shrubland; coniferous forest (>50% crown closure); coniferous forest (10-50% crown closure); coniferous scrub/shrub wetlands; coniferous wooded wetlands; deciduous brush/shrubland; deciduous forest (>50% crown closure); deciduous forest (10-50% crown closure); deciduous scrub/shrub wetlands; deciduous wooded wetlands; disturbed tidal wetlands; disturbed wetlands (modified); freshwater tidal marshes; herbaceous wetlands; managed wetland in built-up maintained rec area; managed wetland in maintained lawn greenspace; mixed deciduous/coniferous brush/shrubland; mixed forest (>50% coniferous with >50% crown closure); mixed forest (>50% coniferous with 10-50% crown closure); mixed forest (>50% deciduous with >50% crown closure); mixed forest (>50% deciduous with 10-50% crown closure); mixed scrub/shrub wetlands (coniferous dom.); mixed scrub/shrub wetlands (deciduous dom.); mixed wooded wetlands (coniferous dom.); mixed wooded wetlands (deciduous dom.); natural lakes; old field (< 25% brush covered); open tidal bays; phragmites dominate coastal wetlands; phragmites dominate interior wetlands; phragmites dominate old field; saline marsh (high marsh); saline marsh (low marsh); streams and canals; tidal mud flat; tidal rivers, inland bays, and other tidal waters; undifferentiated barren lands; upland rights-of-way undeveloped; and wetland rights-of-way.

New Development

In addition to assessing the vulnerability of the built environment, Cape May County examined recent development over the last 5 years and anticipated new development in the next 5 years. Each jurisdiction was asked to provide a list by parcel ID or address of major development that has taken place within these timeframes.

New development was separated by anticipated in the next five years and recently developed over the last five years. An exposure analysis was conducted in GIS to determine hazard exposure to these development sites. Projects that are built on multiple parcels were assessed as one unit, so if one parcel identified within the project boundary intersected a spatial hazard layer, the entire project was considered 'exposed' to the hazard area of concern.

Identifying these changes and integrating new development into the risk assessment provides communities information to consider when developing the mitigation strategy to reduce these vulnerabilities in the future. The identified new development is listed in Section 4 (County Profile) and hazard exposure analysis results are presented in Section 9 (Jurisdictional Annexes) as a table in each annex.

5.1.2 Methodology

To address the requirements of the DMA 2000 and better understand potential vulnerability and losses associated with hazards of concern, Cape May County used standardized tools, combined with local, state, and federal data and expertise to conduct the risk assessment. Three different levels of analysis were used depending upon the data available for each hazard as described below. Table 5.1-1 summarizes the type of analysis conducted by hazard of concern.

(1) Historic Occurrences and Qualitative Analysis – This analysis includes an examination of historic impacts to understand potential impacts of future events of similar size. In addition, potential impacts and losses are discussed qualitatively using best available data and professional judgement.
(2) Exposure Assessment – This analysis involves overlaying available spatial hazard layers, or hazards with defined extent and locations, with assets in GIS to determine which assets are located in the impact area of the hazard. The analysis highlights which assets are located in the hazard area and may incur future impacts.
(3) Loss estimation — The FEMA Hazus modeling software was used to estimate potential losses for the following hazards: flood, earthquake, hurricane. In addition, an examination of historic impacts and an exposure assessment was conducted for these spatially-delineated hazards.

Table 5.1-1. Summary of Risk Assessment Analyses

Hazard	Population	General Building Stock	Critical Facilities	New Development
Climate Change and Sea Level Rise	E	E	E	E
Coastal Erosion	E	E	E	E
Disease Outbreak	Q	Q	Q	E
Drought	Q	Q	Q	E
Flood	E, H	E, H	E, H	E
Hurricane and Tropical Storm	E, H	E, H	E, H	E
Nor'Easter	Q	Q	Q	E
Severe Weather	Q	Q	Q	E
Severe Winter Weather	Q	Q	Q	E
Tsunami	Q	Q	Q	E
Wildfire	E	E	E	E

E – Exposure analysis; H – HAZUS analysis; Q – Qualitative analysis

Hazards U.S. – Multi-Hazard (Hazus-MH)

In 1997, FEMA developed a standardized model for estimating losses caused by earthquakes, known as Hazards U.S. or Hazus. Hazus was developed in response to the need for more effective national-, state-, and community-level planning and the need to identify areas that face the highest risk and potential for loss. Hazus was expanded into a multi-hazard methodology, Hazus-MH with new models for estimating potential losses from wind (hurricanes) and flood (riverine and coastal) hazards. Hazus is a Geographic Information System (GIS)-based software tool that applies engineering and scientific risk calculations, which have been developed by hazard and information technology experts, to provide defensible damage and loss estimates. These methodologies are accepted by FEMA and provide a consistent framework for assessing risk across a variety of hazards. The GIS framework also supports the evaluation of hazards and assessment of inventory and loss estimates for these hazards.

Hazus uses GIS technology to produce detailed maps and analytical reports that estimate a community's direct physical damage to building stock, critical facilities, transportation systems and utility systems. To generate this information, Hazus uses default Hazus provided data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. Damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements, and economic impact) depending on the hazard and available local data. Hazus-MH's open data architecture can be used to manage community GIS data in a central location. The use of this software also promotes consistency of data output now and in the future and standardization of data collection and storage. More information on Hazus-MH is available at http://www.fema.gov/hazus.

In general, modeled losses were estimated in the program using user-defined flood depth grids for the flood analysis (e.g. 1-percent and 0.2-percent annual chance flood events) and probabilistic analyses were performed to develop expected/estimated distribution of losses (mean return period losses) for hurricane wind and seismic hazards. The probabilistic model generates estimated damages and losses for specified return periods (e.g., 100- and 500-year). Table 5.1-2 displays the various levels of analyses that can be conducted using the Hazus-MH software.

Table 5.1-2. Summary of Hazus-MH Analysis Levels

HAZUS-MH Analysis Levels	
Level 1	Hazus-MH provided hazard and inventory data with minimal outside data collection or mapping.
Level 2	Analysis involves augmenting the Hazus-MH provided hazard and inventory data with more recent or detailed data for the study region, referred to as "local data"

HAZUS-MH Analysis Levels	
Level 3	Analysis involves adjusting the built-in loss estimation models used for the hazard loss analyses. This Level is typical done in conjunction with the use of local data.

Climate Change and Sea Level Rise

All of Cape May County is impacted by climate change. A qualitative analysis assessed the impacts of climate change referencing sources from the U.S. Climate Resilience Toolkit, NOAA, New Jersey Climate Adaptation Alliance, and the 2019 New Jersey State Hazard Mitigation Plan.

In addition, projected sea level rise 2017 data (in one-foot increments) available from the NOAA Office of Coastal Management (https://coast.noaa.gov/slrdata/) was used to understand the assets at risk of future sea level rise per each jurisdiction. Please note these sea level rise projections do not include additional storm surge due to a hurricane or Nor'easter. Sea level rise 1-foot through 4-foot hazard area extents were referenced in the exposure analysis. Asset data (population, building stock, critical facilities, and new development) were used to support an evaluation of assets exposed and potential impacts and losses. To determine what assets are exposed to sea level rise, the County's assets were overlaid with the hazard area. Assets with their centroid located in the hazard area were totaled to estimate the number and values exposed to sea level rise.

Coastal Erosion

Best available data was used to assess Cape May County's vulnerability to coastal erosion. To help understand the geographic distribution of coastal risk, the Limit of Moderate Wave Action (LiMWA) boundary was referenced from FEMA's 2014 Preliminary DFIRM and 2017 Effective DFIRM flood data. The LiMWA boundary was selected to assess coastal erosion because it represents land area that is susceptible to wave action. Wave action can be a driver for coastal erosion in Cape May County. Asset data (population, building stock, critical facilities, and new development) were used to support an evaluation of assets exposed and potential impacts and losses. To determine what assets are exposed to coastal erosion, the County's assets were overlaid with the hazard area. Assets with their centroid located in the hazard area were totaled to estimate the number and values exposed to coastal erosion.

Disease Outbreak

Disease outbreak is a new hazard of concern for Cape May County. All of Cape May County is exposed to disease outbreak events. A qualitative assessment was conducted for the disease outbreak hazard. Research from the Centers for Disease Control and Prevention and the State of New Jersey was utilized to qualitatively assess the most recent COVID-19 outbreak.

Drought

Drought is a new hazard of concern for Cape May County. To assess the vulnerability of Cape May County to drought and its associated impacts, a qualitative assessment was conducted. The United States Department of Agriculture (USDA) Census of Agriculture 2017 was used to estimate economic impacts. Information regarding the number of farms, land area in farms, etc. was extracted from the report and summarized in the vulnerability assessment. Additional resources from several scientific studies, the Office of the New Jersey State Climatologist, and the Intergovernmental Panel on Climate Change (IPCC) were used to assess the potential impacts to the population from a drought event.

Flood

The 1-percent and 0.2-percent chance flood events were examined to evaluate Cape May County's risk and vulnerability to the coastal and riverine flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as the NFIP.

The effective Cape May County FEMA Digital Flood Insurance Rate Map (DFIRM) published in 2017 and the preliminary DFIRM published in 2014 was used to evaluate exposure and determine potential future losses. A depth grid for the 1-percent annual chance flood event was generated using the effective and preliminary DFIRMs and the 2014 post Sandy 1-meter resolution Digital Elevation Model (DEM). The DEM tiles were mosaiced and the holes where existing water surfaces occur (i.e., water bodies and streams/rivers) were filled in using a value of zero. The depth grid was separated by the coastal hazard area and the riverine hazard area, which were defined by the 1986 New Jersey Department of Environmental Protection, Office of Environmental Analysis, and the Coast Survey Limited head of tide points. The head of tide points split AE zones into coastal and riverine zones where the AE zone on the inland side of the head of tide is characterized as the riverine hazard area and the AE zone on the seaward side of the head of tide is characterized as the coastal hazard area. All A zones depicted in the preliminary and effective DFIRMs are characterized as riverine hazard areas. Additionally, VE and AO zones are characterized as coastal hazard areas. The final depth grid was integrated into the Hazus-MH v4.2 coastal flood model used to estimate potential losses for the 1-percent annual chance flood event.

To estimate exposure to the 1-percent and 0.2-percent annual chance flood events, the DFIRM flood boundaries were overlaid on centroids of updated assets (population, building stock, critical facilities, and new development). Centroids that intersected the flood boundaries were totaled to estimate the building replacement cost value and population vulnerable to the flood inundation areas. A Level 2 Hazus coastal and riverine flood analysis was performed. Both the critical facility and building inventories were formatted to be compatible with Hazus and its Comprehensive Data Management System (CDMS). Once updated with the inventories, the Hazus coastal and riverine flood models were run to estimate potential losses in Cape May County for the 1-percent annual chance flood event. A user-defined analysis was also performed for the building stock. Buildings located within the floodplain were imported as user-defined facilities to estimate potential losses to the building stock at the structural level. Hazus calculated the estimated potential losses to the population (default 2010 U.S. Census data), potential damages to the general building stock, and potential damages to critical facility inventories based on the coastal and riverine depth grids generated and the default Hazus damage functions in the flood model.

Furthermore, locations identified as repetitive loss properties were provided by FEMA Region 2 and summarized to obtain an understanding of repetitive flood loss areas. These repetitive loss properties were geocoded using Geocodio and displayed on maps in the flood section and Jurisdictional Annexes (Volume II Section 9). FEMA Region 2 also provided a summary of the number of NFIP policies and claims for each jurisdiction.

Hurricane and Tropical Storm

A Hazus probabilistic analysis was performed to analyze the wind hazard losses for Cape May County for the 100- and 500-year mean return period events. The probabilistic Hazus hurricane model activates a database of thousands of potential storms that have tracks and intensities reflecting the full spectrum of Atlantic hurricanes observed since 1886 and identifies those with tracks associated with Cape May County. Hazus contains data on historic hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Default demographic and updated building and critical facility inventories in Hazus were used for the analysis. Although damages are estimated at the census tract level, results were presented at the municipal level. Since there are multiple census tracts that contain more than one jurisdiction, a density analysis was used to extract the percent of building structures that fall within each tract and jurisdiction. The percentage was multiplied against the results calculated for each tract and summed for each jurisdiction.

In addition to estimating potential losses due to wind, an exposure analysis was conducted using the 2014/2016 Sea – Lake Overland Surge from Hurricanes – SLOSH Model, which represents potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide. Please note these inundation zones do not include riverine flooding caused by hurricane surge or inland freshwater flooding. The model, developed by the NOAA Office for Coastal Management forecast surges that occur from wind and pressure forces of hurricanes, considers only storm surge height, and does not consider the effects of waves. The SLOSH spatial data includes boundaries for Category 1 through Category 4 hurricane events.

Asset data (population, building stock, critical facilities, and new development) were used to support an evaluation of assets exposed and potential impacts and losses associated with this hazard. To determine what assets are exposed to storm surge, the County's assets were overlaid with the SLOSH hazard area. Assets with their centroid located in the hazard area were totaled to estimate the replacement cost value (structure and content) and population exposed to the hazard.

Nor'Easter

All of Cape May County is exposed to Nor'Easters. A qualitative assessment was conducted for the Nor'Easter hazard with supporting information discussed in other hazard sections (e.g., Hurricane, Severe Weather). Information from the NOAA, the EPA, and Cape May County were used to assess the potential impacts to the County's assets.

Severe Weather

All of Cape May County is exposed to severe weather events. A qualitative assessment was conducted for the severe storm hazard with supporting information discussed in other hazard sections (e.g., Flood, Hurricane). Information from several research articles, the National Weather Service, and Cape May County were used to assess the potential impacts to the County's assets.

Severe Winter Weather

All of Cape May County is exposed and vulnerable to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. A percentage of the custom-building stock structural replacement cost value was utilized to estimate damages that could result from winter storm conditions (i.e., 1-percent, 5-percent, and 10-percent of total replacement cost value). Given professional knowledge and currently available information, the potential losses for this hazard are considered to be overestimated; hence, providing a conservative estimate for losses associated with winter storm events.

Tsunami

All of Cape May County is exposed and vulnerable to the tsunami hazard. A qualitative assessment was conducted for the tsunami hazard with supporting information discussed in other hazard sections (e.g., Flood, Hurricane). Information from the Caribbean Disaster Emergency Agency, International Tsunami Information Center, NOAA, and several research articles were used to assess the potential impacts to the County's assets.

Wildfire

The New Jersey Department of Environmental Protection (NJ DEP) and the New Jersey Forest Fire Service (NJFFS) 2009 high, very high, and extreme wildfire fuel hazard area boundaries and the 2010 Wildland-Urban Interface/Intermix obtained through the SILVIS Laboratory, Department of Forest Ecology and Management, University of Wisconsin – Madison, was referenced to delineate wildfire hazard areas. The NJ DEP and NJFFS wildfire high, very high, and extreme fuel hazard areas were aggregated into one location. The University of Wisconsin – Madison wildland fire hazard areas are based on the 2010 Census and 2006 National Land Cover Dataset and the Protected Areas Database. For this risk assessment, the high-, medium-, and low-density interface areas were combined and used as the "Interface" hazard area, and the high-, medium-, and low-density intermix areas were combined and used as the "Intermix" hazard areas.

Asset data (population, building stock, critical facilities, and new development) were used to support an evaluation of assets exposed and potential impacts and losses associated with this hazard. To determine what assets are exposed to wildfire, available and appropriate GIS data were overlaid with the hazard area; Assets with their centroid located in the hazard area were totaled to estimate the totals and values exposed to a wildfire event.

Considerations for Mitigation and Next Steps

The following items are to be discussed for considerations for the next plan update to enhance the vulnerability assessment:

- All Hazards
  - Utilize updated and current demographic data. If 2020 U.S. Census demographic data is available at the U.S. Census block level during the next plan update, use the census block estimates and residential structures for a more precise distribution of population, or the current American Community Survey 5-Year Estimate populations counts at the Census tract level.
- Climate Change and Sea Level Rise
  - Implement climate risk models into the next plan update to project changes such as plant density, water quality/quantity, or carbon emissions.
  - Implement updated sea level rise data to assess the future flood hazard risk for structures along the coast.
- Coastal Erosion
  - If available during the next plan update, update the risk assessment using a comprehensive coastal erosion hazard area map.
  - Collect data on historic costs incurred to reconstruct buildings, cultural resources and/or infrastructure due to coastal erosion impacts.
- Disease Outbreak
  - Assess trends in outbreaks and review the monetary impacts COVID-19 had on Cape May County.
- Drought
  - If available during the next plan update, update agricultural USDA data using more recent information.
- Flood
  - The general building stock inventory can be updated to include attributes regarding first floor elevation and foundation type (basement, slab on grade, etc.) to enhance loss estimates.
  - Conduct a Hazus-MH loss analysis for more frequent flood events (e.g., 10 and 50-year flood events).
  - Use FEMA's Flood Assessment Structure Tool (FAST) tool for a quicker, simpler flood analysis at the structure level.
  - Further refine the repetitive loss area analysis.
  - Continue to expand and update urban flood areas to further inform mitigation.
- Hurricanes and Tropical Storms
  - The general building stock inventory can be updated to include attributes regarding protection against strong winds, such as hurricane straps, to enhance loss estimates.
  - Estimate storm surge related losses using the Hazus flood model if the data is available.
  - If available during the next plan update, update the risk assessment using a comprehensive coastal erosion hazard area map and updated sea level rise inundation areas.

- Collect data on historic costs incurred to reconstruct buildings, cultural resources and/or infrastructure due to coastal erosion impacts.
- Integrate evacuation route data that is currently being developed.

- Tsunami
  - If the tsunami model in Hazus-MH is updated for the East Coast, use Hazus-MH to assess the tsunami hazard of concern for the County.
- Wildfire
  - General building stock inventory can be updated to include attributes such as roofing material or fire detection equipment or integrate distance to fuels as another measure of vulnerability.

5.1.3 Data Source Summary

Table 5.1-3 summarizes the data sources used for the risk assessment for this plan.

Table 5.1-3. Risk Assessment Data Documentation

Data	Source	Date	Format
Population data	U.S. Census Bureau; American Community Survey 5-Year Estimates	2010; 2018	Digital (GIS) format
Building footprints	Cape May County	2020	Digital (GIS) format
Tax Assessor data	Cape May County; MOD-IV	2020/2013	Digital (GIS/Tabular) format
Critical facilities	Cape May County Steering Committee and Planning Committee	2020	Digital (GIS) format
Post Sandy 1-meter resolution Digital Elevation Model (DEM)	NOAA	2014	Digital (GIS) format
1-Percent and 0.2-Percent Annual Chance Flood Event	FEMA Preliminary/Effective DFIRMs	2014/2017	Digital (GIS) format
Coastal Hazard Area	FEMA Preliminary/Effective DFIRM LiMWA Lines	2014/2017	Digital (GIS) format
Wildfire Fuel Hazard; Wildland-Urban Interface/Intermix	NJDEP NFFS; University of Wisconsin - Madison	2009/2010	Digital (GIS) format
Census of Agriculture	USDA	2017	Digital (PDF Report) format
Sea Level Rise Hazard Area	NOAA	2017	Digital (GIS) Format
Sea-Lake Overland Surge from Hurricanes (SLOSH) Model	NOAA	2014/2016	Digital (GIS) Format
New Development Data	Cape May County Coastal Resilience Initiative/Cape May County Planning Department	2020	Digital (GIS) Format

Limitations

Loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

1) Approximations and simplifications necessary to conduct such a study
2) Incomplete or dated inventory, demographic, or economic parameter data
3) The unique nature, geographic extent, and severity of each hazard
4) Mitigation measures already employed by the participating municipalities
5) The amount of advance notice residents have to prepare for a specific hazard event

6) Uncertainty of climate change projections

These factors can result in a range of uncertainty in loss estimates, possibly by a factor of two or more. Therefore, potential exposure and loss estimates are approximate. These results do not predict precise results and should be used to understand relative risk. Over the long term, Cape May County will collect additional data to collect additional data, update and refine existing inventories, to assist in estimating potential losses.

Potential economic loss is based on the present value of the general building stock utilizing best available data. The County acknowledges significant impacts may occur to critical facilities and infrastructure as a result of these hazard events causing great economic loss. However, monetized damage estimates to critical facilities and infrastructure, and economic impacts were not quantified and require more detailed loss analyses. In addition, economic impacts to industry such as tourism and the real-estate market were not analyzed.

5.2 IDENTIFICATION OF HAZARDS OF CONCERN

2021 HMP Update Changes

- The 2021 HMP flood hazard includes more discussion of urban flooding.
- The 2021 HMP tsunami hazard includes discussion of meteotsunamis.
- The 2021 HMP includes two new hazard profiles: disease outbreak and drought.

Hazards of Concern are defined as those hazards that are considered most likely to impact a community. These are identified using available data and local knowledge.

To provide a strong foundation for mitigation strategies considered in Section 6 (Mitigation Strategy), Cape May County considered a full range of natural hazards that could impact the area, and then identified and ranked those hazards that presented the greatest concern. The natural hazard of concern identification process incorporated input from the County and participating jurisdictions; review of the State of New Jersey Hazard Mitigation Plan (NJ HMP) and previous hazard identification efforts; research and local, state, and federal information on the frequency, magnitude, and costs associated with the various hazards that have previously, or could feasibly, impact the region; and qualitative or anecdotal information regarding natural hazards and the perceived vulnerability of the study area's assets to them. Table 5.2-1 documents the process of identifying the natural hazards of concern for further profiling and evaluation.

For the purposes of this planning effort, the Planning Partnership chose to group some natural hazards together, based on the similarity of hazard events, their typical concurrence or their impacts, consideration of how hazards have been grouped in FEMA guidance documents (FEMA 386-1, "Understanding Your Risks, Identifying Hazards and Estimating Losses; FEMA's "Multi-Hazard Identification and Risk Assessment – The Cornerstone of the National Mitigation Strategy"), and consideration of hazard grouping in the NJ HMP.

Table 5.2-1. Identification of Natural Hazards of Concern for Cape May County

Hazard	Is this a hazard that may occur in Cape May County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
Avalanche	No	No	• The NJ HMP does not identify avalanche as a hazard of concern for New Jersey. • The topography and climate of Cape May County does not support the occurrence of an avalanche event. • New Jersey in general has a very low occurrence of avalanche events based on statistics provided by the American Avalanche Association (AAA) between 1950 and 2014.	• NJ HMP • Review of NAC-AAA database • Steering and Planning Committee Input
Climate Change and Sea Level Rise	Yes	Yes	• Numerous studies and reports are available documenting the occurrence and risks associated with climate change and sea level rise, on global, regional, state and even local scales. • While climate change and sea level rise act as exacerbating conditions for the primary hazards of concern (flood, severe storm, wildfire, etc.), the Steering Committee has elected to develop a separate hazard profile for climate change and sea level rise for this update.	• Various studies and reports from Federal and State agencies and other interested • Steering Committee Input
Coastal Erosion	No	No	• The NJ HMP identifies coastal erosion as a hazard of concern for New Jersey. Counties bounded by coastal waters are most affected by coastal erosion. • A majority of Cape May County is bounded by coastal waters; therefore, coastal erosion was identified as a hazard of concern by the Steering Committee. • Coastal Cape May municipalities have a long history of coastal erosion.	• FEMA FIRMs • NJ HMP • NOAA • Stockton CRC • Steering and Planning Committee Input
Coastal Storm	Yes	Yes	• The NJ HMP identifies hurricanes/tropical storms and nor'easters as hazards of concern for New Jersey. • Due to its proximity to the Atlantic Ocean, Cape May County is susceptible to hurricanes, tropical storms, and Nor'Easters. • For the purpose of this HMP Update, hurricanes and tropical storms will be included in 'Hurricanes/Tropical Storms' and Nor'Easters will be included separately in 'Nor'Easters'. Please see those sections for information regarding hurricanes, tropical storms, and Nor'Easters in Cape May County.	• NJ HMP • FEMA • NOAA • NOAA-NCEI Storm Database • Steering and Planning Committee Input
Dam Failure	Yes	No	• The NJ HMP identifies dam failure as a hazard of concern for New Jersey. • According to NJDEP, there are 11 dams located in Cape May County; however, none of these dams are identified as high hazard dams and there have been no incidents recorded at these dams. • The Steering Committee did not identify dam failure as a hazard of concern for Cape May County.	• NJ HMP • NJ DEP • Steering and Planning Committee Input

Table 5.2-1. Identification of Natural Hazards of Concern for Cape May County

Hazard	Is this a hazard that may occur in Cape May County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
Disease Outbreak	Yes	Yes	• The NJ HMP identifies pandemic as a hazard of concern for New Jersey. • According to the NJ HMP, New Jersey's geographic and demographic characteristics make it particularly vulnerable to importation and spread of infectious diseases. All 21 counties in New Jersey have experienced the effects of a pandemic or disease outbreak. • Cape May County has been impacted by mosquito and tick-borne diseases, food-borne illness and most recently the COVID-19 pandemic. • Cape May County was part of a statewide emergency declaration for West Nile Virus in 2000 (EM-3156) and the DR-4488/EM-3451 for COVID-19.	• NJ HMP • FEMA • Steering and Planning Committee Input
Drought	Yes	Yes	• The NJ HMP identifies drought as a hazard of concern for New Jersey. • Since 1954, Cape May County has been included in two drought related federal disaster or emergency management declarations; EM-3083 and DR-205. Both events were for water shortage. • Since 2012, the USDA has included Cape May County in three agriculture disaster declarations related to drought, between 2012 and 2020: ○ S3487 - June-November 2012 ○ S3932 – July-September 2015 ○ S34071 – April-September 2016 • Cape May County is located in the Southern and Coastal Climate Divisions. According to the NRCC, these climate divisions has been impacted by the following periods of severe and extreme drought: ○ December 1930 – February 1931 ○ November 1931 – February 1932 ○ November 1949 – February 1950 ○ July-November 1957 ○ October-December 1964 ○ May 1965 – June 1966 ○ July-August 1977 ○ March-June 1985 ○ May-June 1986 ○ September-October 1986 ○ January-May 1992 ○ November-December 1998 ○ July-August 1999 ○ November 2001 – September 2002 ○ August-September 2010	• NJ HMP • FEMA • USGS • NRCC • NOAA • NOAA-NCEI Storm Database • Steering and Planning Committee Input

Table 5.2-1. Identification of Natural Hazards of Concern for Cape May County

Hazard	Is this a hazard that may occur in Cape May County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
			○ November-December 2010 • Drought is considered a hazard of concern due to the impact on drinking water resources, agriculture, and potential to accelerate saltwater intrusion.	
Earthquake	Yes	No	• The NJ HMP identifies earthquake as a hazard of concern for New Jersey. Although they are known to occur on a regular basis, records indicate that no major earthquakes have struck the state since the establishment of historical record-keeping (1500's). Between 1783 and 2017, there have been 204 earthquakes recorded for New Jersey. One of these events have been epicentered in Cape May County. • Cape May County is located in an area with less than 2%g (peak acceleration) and has relatively low seismic risk. • The Steering Committee did not identify earthquake as a hazard of concern for Cape May County.	• NJ HMP • NJDEP • NJGWS • USGS • Steering and Planning Committee Input
Expansive Soils	No	No	• The NJ HMP does identify expansive soils as a hazard of concern for New Jersey; however, the Planning Committee did not identify this as a hazard of concern for Cape May County. • Soils that expand (swell) as they become wet and contract (shrink) as they dry are called expansive soils. This change can cause the ground to move up and down several inches during a cycle of wetting and drying. Expansive soils that are predominately clay minerals have the ability to absorb water. • In Cape May County, the entire area is underlain by soils with little to no swelling clays.	• NJ HMP • USGS 1989 Swelling Clays Map of the Conterminous U.S. • Steering and Planning Committee Input
Extreme Temperature	Yes	Yes	Please see Severe Weather	
Flood (Riverine, Flash Flooding, Urban Flooding)	Yes	Yes	• The NJ HMP identifies flooding as a hazard of concern in New Jersey. • The County has 30,586 NFIP policies There has been a total of over $179 million paid claims in Cape May County. • There are 2,233 repetitive loss properties and 519 severe repetitive loss properties in the County. • The 2017 FEMA DFIRMs indicate over 51.4% of the County is located in the 1-percent annual chance floodplain; and 56.3% of the County is located in the 0.2-percent annual chance floodplain.	• NJ HMP • FEMA • FEMA FIS • NFIP • NOAA-NCEI Storm Database • Steering and Planning Committee Input
Geological Hazards	Yes	No	• The NJ HMP identifies geological hazards as a hazard of concern for New Jersey.	• NJ HMP • NJGWS

Table 5.2-1. Identification of Natural Hazards of Concern for Cape May County

Hazard	Is this a hazard that may occur in Cape May County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
			• According to NJGWS, Cape May County does not have a history of landslide occurrences. • Cape May County is located within a low susceptibility and low incidence landslide areas. Additionally, the County is not underlain by carbonate rock. • The Steering and Planning Committees did not identify geological hazards as a hazard of concern for Cape May County.	• NJDEP • Steering and Planning Committee Input
Hailstorm	Yes	Yes	Please see Severe Weather	
Hazardous Materials	Yes	No	• The NJ HMP identifies geological hazards as a hazard of concern for New Jersey. • Several major transportation routes are located in Cape May County and pose a threat to spills, accidents, and incidents. • The Steering and Planning Committees did not identify hazardous materials as a hazard of concern for Cape May County.	• NJ HMP • Steering and Planning Committee Input
Hurricane (and other Tropical Cyclones)	Yes	Yes	• The NJ HMP identifies hurricanes and tropical storms as hazards of concern for New Jersey. • According to FEMA, between 2009 and 2020, Cape May County was included in three declarations associated with hurricanes and tropical storms. ○ November 11-15, 2009 – FEMA-DR-1867 – Severe Storms and Flooding Associated with Tropical Storm Ida and a Nor'Easter ○ August 26-September 5, 2011 – FEMA-DR-4021 – Hurricane Irene ○ October 26-November 8, 2011 – FEMA-DR-4086 – Hurricane Sandy • Since 2016, there have been two tropical cyclones that tracked within 65 nautical miles of Cape May County. Tropical cyclones beyond 65 nautical miles have impacted the County through large swells, rip currents, and coastal erosion. • The Steering and Planning Committees identified hurricanes and tropical storms as a hazard of concern for Cape May County.	• NJ HMP • NOAA – NCEI • NHC • FEMA • Steering and Planning Committee Input
Ice Storm	Yes	Yes	Please see Severe Winter Weather	
Land Subsidence	Yes	No	Please see Geological Hazards	
Landslide	Yes	No	Please see Geological Hazards	
Nor'Easters	Yes	Yes	• The NJ HMP identifies Nor'Easters as hazards of concern for New Jersey. • According to FEMA, between 2009 and 2020, Cape May County was included in two declarations associated with Nor'Easters.	• NJ HMP • NOAA – NCEI • FEMA

Table 5.2-1. Identification of Natural Hazards of Concern for Cape May County

Hazard	Is this a hazard that may occur in Cape May County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
			○ November 11-15, 2009 – FEMA-DR-1867 – Severe Storms and Flooding Associated with Tropical Storm Ida and a Nor'Easter ○ October 29, 2011 – FEMA-DR-4048 – Severe Weather (snowstorm/Nor'Easter) ○ March 12, 2016 – FEMA-DR-4264 – Severe Winter Storm and Snowstorm • The Steering and Planning Committees identified Nor'Easter events as a hazard of concern for Cape May County.	• Steering and Planning Committee Input
Severe Weather (Windstorms, Thunderstorms, Hail, Lightning, Extreme Temperature, and Tornadoes)	Yes	Yes	• The NJ HMP identifies thunderstorms, lightning, tornadoes, extreme winds and extreme temperature as hazards of concern for New Jersey. • According to FEMA, between 2009 and 2020, Cape May County was included in three declarations associated with severe weather events. ○ November 11-15, 2009 – FEMA-DR-1867 – Severe Storms and Flooding Associated with Tropical Depression Ida and a Nor'Easter ○ March 12-April 15, 2010 – FEMA-DR-1897 - Severe Storms and Flooding ○ October 29, 2011 – FEMA-DR-4048 – Severe Weather • Cape May has experienced nine tornadoes between 1950 and 2020. • NOAA's NCDC storm events database indicates that Cape May County was impacted by approximately 151 severe weather events between 2009 and 2020 causing a total of over $214 million in property damages. • The Steering and Planning Committees identified severe weather (windstorms, thunderstorms, hail, lightning, extreme temperatures, and tornadoes) as a hazard of concern for Cape May County.	• NJ HMP • NOAA – NCEI • FEMA • NJ OEM • Steering and Planning Committee Input
Severe Winter Weather (Heavy Snow, Blizzards, Freezing Rain/Sleet, Ice Storms)	Yes	Yes	• The NJ HMP identifies severe winter weather as a hazard of concern for New Jersey and includes snow, blizzards, and ice storms. For the purpose of this HMP update, Cape May County is including blizzards, heavy snow, and ice storms under the severe winter weather hazard. • According to FEMA, between 2009 and 2020, Cape May County was included in three declarations associated with severe winter weather events. ○ February 5-6, 2010 – FEMA-DR-1889 – Severe Winter Storm and Snowstorm ○ December 26-27, 2010 – FEMA-DR-1954 – Severe Winter Storm and Snowstorm ○ March 12, 2016 – FEMA-DR-4264 – Severe Winter Storm and Snowstorm	• NJ HMP • FEMA • NOAA – NCEI Storm Database • ONJSC • Steering and Planning Committee Input

Table 5.2-1. Identification of Natural Hazards of Concern for Cape May County

Hazard	Is this a hazard that may occur in Cape May County?	If yes, does this hazard pose a significant threat to the County?	Why was this determination made?	Source(s)
			• NOAA-NCDC has indicated that Cape May County has experienced the impacts of 25 winter storm events between 2009 and 2015 causing a total of over $ 101 million in property damages. • Based on the history of occurrences and losses, and based on input from the Planning and Steering Committees, Cape May County identified severe winter weather as a hazard of concern.	
Tornado	Yes	Yes	Please see Severe Weather	
Tsunami	Yes	Yes	• The NJ HMP does not identify tsunami as a hazard of concern for New Jersey. • Cape May County exposure and vulnerability to coastal flooding is well recognized, as documented in the associated hazard profiles in this update to the HMP. • The impact and rate of occurrence of meteotsunamis has recently become better understood in the region. Meteotsunamis have been identified as a threat to Cape May County. • The Cape May County Steering Committee identified tsunami as a hazard of concern for the County in the 2010 HMP and recognizes it as an ongoing risk during this update process. As with earthquake risk in many parts of the state, while the probability of tsunami occurrence is believed to be very low, even a moderate tsunami would have vast impacts throughout the County.	• NJ HMP • NOAA – NCEI Storm Database • Steering and Planning Committee Input
Volcano	No	No	• The NJ HMP does not identify volcano as a hazard of concern for New Jersey.	• NJ HMP
Wildfire	Yes	Yes	• The NJ HMP identifies wildfire as a hazard of concern for New Jersey. • In Cape May County, 61.8 square miles are located in the high to extreme wildfire fuel zones according to the New Jersey Forest Fires Service. • According to the NJ Forest Fire Service, between 2010 and 2019, there have been 381 wildfire incidents in Cape May County. • Based on input from the Planning Committee, wildfire is considered a hazard of concern for Cape May County due to the large areas of State forests and development proximate to these areas.	• NJ HMP • NOAA – NCEI Storm Events Query • USGS • NJFFS • Steering and Planning Committee Input
Windstorm	Yes	Yes	Please see Severe Weather	

DIR *Drought Impact Reporter*
DR *Presidential Disaster Declaration Number*
EM *Presidential Disaster Emergency Number*
FEMA *Federal Emergency Management Agency*

HMP	*Hazard Mitigation Plan*
K	*Thousands ($)*
M	*Millions ($)*
NJ	*New Jersey*
NJDEP	*New Jersey Department of Environmental Protection*
NJDOH	*New Jersey Department of Health*
NJFFS	*New Jersey Forest Fire Service*
NJGS	*New Jersey Geological Survey (as part of the NJDEP)*
NOAA	*National Oceanic and Atmospheric Administration*
NRCC	*Northeast Regional Climate Center*
NWS	*National Weather Service*
OEM	*Office of Emergency Management*
ONJSC	*Office of New Jersey State Climatologist*
PHSMA	*Pipeline and Hazardous Materials Safety Administration*
SPC	*Storm Prediction Center*
USEPA	*United States Environmental Protection Agency*
USGS	*U.S. Geologic Survey*

According to input from the County, and review of all available resources, a total of 11 hazards of concern were identified as significant hazards affecting the entire planning area, to be addressed at the county level in this plan:

Hazards of Concern

- Climate Change and Sea Level Rise
- Coastal Erosion
- Disease Outbreak
- Drought
- Flood (including riverine, flash, sea level rise, urban flooding)
- Hurricane and Tropical Storms
- Nor'Easter
- Severe Weather (High Winds, Tornadoes, Thunderstorms, Hail, Extreme Temperatures)
- Severe Winter Storm (Heavy Snow, Blizzards, Ice Storms)
- Tsunami
- Wildfire

Other natural and human-caused hazards of concern have occurred within Cape May County but have a low potential to occur and/or result in significant impacts within the County. Therefore, these hazards will not be further addressed within this version of the HMP. However, if deemed necessary by the County, these hazards may be considered in future HMP updates.

5.3 HAZARD RANKING

2021 HMP Changes

- The 2021 update hazard ranking methodology was expanded to include adaptive capacity and climate change.
- The probability of occurrence category was adjusted to include the benchmark value 'rare', and modifications to the remaining categories so that 'frequent' aligned with an event that has an annual probability.
- The following hazards of concern's ranking changed from 2016 to 2021: the climate change and sea level rise hazard increased in rank from medium to high and the tsunami hazard increased in rank from medium to high.
- The disease outbreak hazard and drought hazards are new hazards of concern for 2021.

A comprehensive range of hazards that pose a significant risk to Cape May County were selected and considered during the development of this plan; see Section 5.2 (Identification of Hazards of Concern). However, each community has differing levels of exposure and vulnerability to each of these hazards. It is important for each community participating in this plan to recognize those hazards that pose the greatest risk to their community and direct their attention and resources accordingly to manage risk and reduce losses most effectively and efficiently. The hazard ranking for the county and each participating jurisdiction can be found in their jurisdictional annexes in Volume II, Section 9 of this plan.

To this end, a hazard risk ranking process was conducted for Cape May County and its municipalities using the method described below. This method includes four risk assessment categories—probability of occurrence, impact (population, property and economy), adaptive capacity, and changing future conditions (i.e., climate change). Each was assigned a weighting factor to calculate an overall ranking value for each hazard of concern. Depending on the calculation, each hazard was assigned a high, medium, or low ranking. Details regarding each of these categories is described below.

5.3.1 Hazard Ranking Methodology

Estimates of hazard risk for the County were developed using methodologies promoted by FEMA's hazard mitigation planning guidance, generated by FEMA's HAZUS-MH risk assessment tool, and input from Cape May County and participating jurisdictions.

As described in Section 5.1 (Methodology), three different levels of analysis were used to estimate potential impacts: 1) historic loss/qualitative analysis; 2) exposure analysis; and 3) loss estimation. All three levels of analysis are suitable for planning purposes; however, with any risk analysis, there is underlying uncertainty resulting from assumptions used to describe and assess vulnerability and the methodologies available to model impacts. Impacts from any hazard event within the County will vary from the analysis presented here based on the factors described for each hazard of concern; namely location, extent, warning time, and mitigation measures in place at the time of an event.

The hazard ranking methodology for some hazards of concern is based on a scenario event, while others are based on the potential vulnerability to the County as a whole. In order to account for these differences, the quantitative hazard ranking methodology was adjusted using professional judgement and subject-matter input; assumptions are included, as appropriate, in the following subsections. The limitations of this analysis are recognized given the all scenarios do not have the same likelihood of occurrence; nonetheless, there is value in summarizing and comparing the hazards using a standardized approach to evaluate relative risk. The following categories were considered when evaluating the relative risk of the hazards of concern.

- **Probability of Occurrence**—The probability of occurrence of the scenario evaluated was estimated by examining the historic record and/or calculating the likelihood of annual occurrence. When no scenario was assessed, an examination of the historic record and judgement was used to estimate the probability of occurrence of an event that will impact the County.
- **Impact**—The following three hazard impact subcategories were considered: impact to people; impact to assets and the economy; and impact to environmental resources and cultural assets. The results of the updated risk assessment and/or professional judgement were used to assign the numeric values for these three impact subcategories. A factor was applied to each subcategory, giving impact on population the greatest weight.
    - Population—Numeric value x 3
    - Buildings—Numeric value x 2
    - Economy—Numeric value x 1
- **Adaptive Capacity**—Adaptive capacity describes a jurisdiction's current ability to protect from or withstand a hazard event. This includes capabilities and capacity in the following areas: administrative, technical, planning/regulatory and financial. Mitigation measures already in place increases a jurisdiction's capacity to withstand and rebound from events (e.g. codes/ordinances with higher standards to withstand hazards due to design or location; deployable resources; or plans and procedures in place to respond to an event). In other words, assigning 'weak' for adaptive capacity means the jurisdiction does not have the capability to effectively respond, which increases vulnerability; whereas 'strong' adaptive capacity means the jurisdiction does have the capability to effectively respond, which decreases vulnerability.

  These ratings were assigned using the results of the core capability assessment with subject-matter input from each jurisdiction.
- **Climate Change (Changing Future Conditions) -** Current climate change projections were considered as part of the hazard ranking to ensure the potential for an increase in severity/frequency of the hazard was included. This was important to Cape May County to include because the hazard ranking helps guide and prioritize the mitigation strategy development, which should have a long-term future vision to mitigate the hazards of concern. The potential impacts climate change may have on each hazard of concern is discussed in Sections 5.4.1 through 5.4.11. The benchmark values in the methodology are similar to confidence levels outlined in the National Climate Assessment 2017.

Hazard Ranking Equation

[Probability of Occurrence x 0.30] + [(Impact on Population x 3) + (Impact on Property x 2) + (Impact on Economy x 1) x 0.30] + [Adaptive Capacity x 0.3] + [Climate Change x 0.10]

Table 5.3-1 summarizes the categories, benchmark values, and weights used to calculate the risk factor for each hazard. Using the weighting applied, the highest possible risk factor value is 9.0. The higher the number, the greater the relative risk. Based on the total for each hazard, a priority ranking is assigned to each hazard of concern (high, medium, or low). The rankings were categorized as follows: Low = Values less than or equal to 3.8; Medium = Values between 3.9 and 4.9; High = Values greater than 4.9.

Table 5.3-1. Summary of Hazard Ranking Approach

Category		Level / Category	Degree of Risk / Benchmark Value	Numeric Value	Weighted Value
Probability of Occurrence		Unlikely	A hazard event is not likely to occur or is unlikely to occur with less than a 1% annual chance probability.	0	30%
		Rare	Between 1 and 10% annual probability of a hazard event occurring.	1	
		Occasional	Between 10 and 100% annual probability of a hazard event occurring.	2	
		Frequent	100% annual probability; a hazard event may occur multiple times per year.	3	
Impact (Sum of all 3)	Population (Numeric Value x 3)	Low	14% or less of your population is exposed to a hazard with potential for measurable life safety impact, due to its extent and location.	1	30%
		Medium	15% to 29% of your population is exposed to a hazard with potential for measurable life safety impact, due to its extent and location.	2	
		High	30% or more of your population is exposed to a hazard with potential for measurable life safety impact, due to its extent and location.	3	
	Property (Numeric Value x 2)	Low	Property exposure is 14% or less of the total number of structures for your community.	1	
		Medium	Property exposure is 15% to 29% of the total number of structures for your community.	2	
		High	Property exposure is 30% or more of the total number of structures for your community.	3	
	Economy (Numeric Value x 1)	Low	Loss estimate is 9% or less of the total replacement cost for your community.	1	
		Medium	Loss estimate is 10% to 19% of the total replacement cost for your community.	2	
		High	Loss estimate is 20% or more of the total replacement cost for your community.	3	
Adaptive Capacity		Weak	Weak/outdated/inconsistent plans, policies, codes/ordinances in place; no redundancies; limited to no deployable resources; limited capabilities to respond; long recovery.	3	30%
		Moderate	Plans, policies, codes/ordinances in place and meet minimum requirements; mitigation strategies identified but not implemented on a widespread scale; county/jurisdiction can recover but needs outside resources; moderate county/Jurisdiction capabilities.	2	
		Strong	Plans, policies, codes/ordinances in place and exceed minimum requirements; mitigation/protective measures in place; county/jurisdiction has ability to recover quickly because resources are readily available, and capabilities are high.	1	
Climate Change		Low	No local data is available; modeling projections are uncertain on whether there is increased future risk; confidence level is low (inconclusive evidence).	1	10%
		Medium	Studies and modeling projections indicate a potential for exacerbated conditions due to climate change; confidence level is medium to high (suggestive to moderate evidence).	2	
		High	Studies and modeling projections indicate exacerbated conditions/increased future risk due to climate change; very high confidence level (strong evidence, well documented and acceptable methods).	3	

Note: A numerical value of zero is assigned if there is no impact.

**For the purposes of this exercise, "impacted" means exposed for population and property and estimated loss for economy. For non-natural hazards, although they may occur anywhere in the County, an event will not likely cause countywide impacts; therefore, impact to population was scored using an event-specific scenario.*

In an attempt to summarize the confidence level regarding the input utilized to populate the hazard ranking, a gradient of certainty was developed. A certainty factor of high, medium or low was selected and assigned to each hazard to provide a level of transparency and increased understanding of the data utilized to support the resulting ranking. The following scale was used to assign a certainty factor to each hazard:

- High—Defined scenario/event to evaluate; probability calculated; evidenced-based/quantitative assessment to estimate potential impacts through hazard modeling.
- Moderate—Defined scenario/event or only a hazard area to evaluate; estimated probability; combination of quantitative (exposure analysis, no hazard modeling) and qualitative data to estimate potential impacts.
- Low—Scenario or hazard area is undefined; there is a degree of uncertainty regarding event probability; majority of potential impacts are qualitative.

Table 5.3-2 summarizes the hazard scenario or hazard area evaluated; highlights key impacts to population, buildings/critical assets and the economy; and lists the associated certainty factor assigned for each hazard to convey the level of confidence in the data used. This table is not intended to be a complete and comprehensive list of all hazard impacts determined in the risk assessment and considered for the hazard ranking exercise. Refer to Sections 5.4.1 to 5.4.11 for a complete summary of all estimated impacts for each hazard.

Table 5.3-2. Overview of the Hazard Scenario and Associated Estimated Impacts Considered in the Hazard Ranking

<table>
<tr><th>Hazard of Concern</th><th>Hazard/ Scenario Area Evaluated</th><th colspan="2">Population</th><th colspan="2">Buildings</th><th colspan="2">Economy[a]</th><th>Certainty Factor</th></tr>
<tr><td>Climate Change and Sea Level Rise</td><td>Impact of climate change and the areas exposed to 1, 2, 3, and 4 feet of sea level rise.</td><td colspan="2">Entire population exposed to climate change impacts. Population located in sea level rise inundation zones are exposed.</td><td colspan="2">Building stock located in the sea level rise inundation zones.</td><td colspan="2">Economic impacts depend upon the degree of impact.</td><td>Low</td></tr>
<tr><td>Coastal Erosion</td><td>Coastal erosion hazard area established by the Limit of Moderate Wave Action seaward.</td><td>Population located in the established coastal erosion hazard area</td><td>1,268</td><td>Buildings located in the established coastal erosion hazard area</td><td>1,891</td><td>Replacement cost value of buildings located in the hazard area:</td><td>$2,017,140,222</td><td>Low</td></tr>
<tr><td>Disease Outbreak</td><td>Disease Outbreaks which include: West Nile Virus, Eastern Equine Encephalitis virus, Lyme disease, Influenza, Ebola virus, and Coronavirus.</td><td colspan="2">Population impacted is dependent on the disease and severity of the outbreak; in some cases, immuno-compromised persons are more vulnerable.</td><td colspan="2">Structural impacts due to disease outbreak would be limited.</td><td colspan="2">Economic losses can include County financial impacts to monitor/address outbreaks; lost wages or commercial interruptions; depends on the severity and type of disease outbreak.</td><td>Low</td></tr>
<tr><td>Drought</td><td>Prolonged drought event - The County is serviced by water supplies who primarily get water from unconfined groundwater sources.</td><td colspan="2">Entire population exposed. Population on surface water supplies may be impacted first; water restrictions/contamination; increased wildfire risk.</td><td colspan="2">Droughts are not expected to cause direct damage to buildings.</td><td colspan="2">Losses include aesthetic, landscape/nursery/agricultural industry impacts, cost of desalinization tied to increased saltwater intrusion</td><td>Low</td></tr>
<tr><td rowspan="3">Flood*</td><td rowspan="3">100- and 500-Year Mean Return Period Event</td><td rowspan="2">1% annual chance (100-year)</td><td rowspan="2">37,983</td><td>1% annual chance (100-year) coastal</td><td>3,122</td><td rowspan="3">1% annual chance (100-year)</td><td rowspan="3">$189,942,657</td><td rowspan="3">High</td></tr>
<tr><td>1% annual chance (100-year) riverine</td><td>135</td></tr>
<tr><td>0.2% annual chance (500-year)</td><td>44,368</td><td>0.2% annual chance (500-year)</td><td>65,698</td></tr>
<tr><td rowspan="2">Hurricane</td><td rowspan="2">100-Year and 500-Year Mean Return Period Events</td><td colspan="2" rowspan="2">Entire population exposed; the degree of impact to the population depends on the scale of the incident.</td><td colspan="2" rowspan="2">Entire building stock is exposed; The degree of impact depends on the scale of the incident.</td><td>100-Year MRP Estimated Damages</td><td>$415,738,054</td><td rowspan="2">High</td></tr>
<tr><td>500-Year MRP Estimated Damages</td><td>$3,164,253,276</td></tr>
<tr><td rowspan="2">Nor'Easter</td><td rowspan="2">100-Year and 500-Year Mean Return Period Events</td><td colspan="2" rowspan="2">Entire population exposed; the degree of impact to the population depends on the scale of the incident.</td><td colspan="2" rowspan="2">Entire building stock is exposed; The degree of impact depends on the scale of the incident.</td><td>100-Year MRP Estimated Damages</td><td>$415,738,054</td><td rowspan="2">High</td></tr>
<tr><td>500-Year MRP Estimated Damages</td><td>$3,164,253,276</td></tr>
<tr><td>Severe Weather*</td><td>Severe Weather Event</td><td colspan="2">Entire population exposed; the degree of impact to the population depends on the scale of the incident.</td><td colspan="2">Entire building stock is exposed; The degree of impact depends on the scale of the incident.</td><td colspan="2">Economic impacts depend upon the degree of impact.</td><td>Low</td></tr>
<tr><td>Severe Winter Weather</td><td>Severe Winter Weather Event</td><td colspan="2">All residents/commuters/visitors are exposed; socially-vulnerable populations may be at increased risk</td><td colspan="2">All buildings are exposed; the degree of impact depends on the scale of the incident.</td><td colspan="2">The cost of snow and ice removal and repair of roads/infrastructure can impact operating budgets.</td><td>Low</td></tr>
<tr><td>Tsunami</td><td>Tsunami Event</td><td colspan="2">Entire population exposed; the degree of impact to the population depends on the scale of the incident.</td><td colspan="2">Entire building stock is exposed; The degree of impact depends on the scale of the incident.</td><td colspan="2">Economic impacts depend upon the degree of impact.</td><td>Low</td></tr>
</table>

Hazard of Concern	Hazard/ Scenario Area Evaluated	Population		Buildings		Economy[a]		Certainty Factor
Wildfire	Wildfire Fuel Hazard areas (High, Very High, Extreme)	Population residing in the hazard area:	1,566	Number of buildings the hazard area:	1,530	Replacement cost value of buildings located in the hazard area:	$1,426,922,130	Moderate

Notes:
a Estimated loss in replacement cost values as available from HAZUS-MH.
b The impacts and vulnerability from a hazardous materials event are greatly dependent on the material and its physical and chemical properties, the quantity released, weather conditions, micro-meteorological effects of buildings and terrain, maintenance/mechanical failures, and distance and related response time for emergency response teams.
** HAZUS-MH estimated potential losses based on probabilistic models*
Exposed = This refers to the number of assets located in the hazard area; all of which may not incur losses as a result of the event.
SFHA = Special flood hazard area (1-percent annual chance flood event)
RCV = Replacement cost value based on 2019 RSMeans

Table 5.3-3 summarizes the projected changes in hazard event occurrences in terms of location, extent or intensity and frequency and/or duration. In addition, it lists the associated value assigned to each hazard in the risk factor calculation (i.e., confidence in changing future conditions). Refer to Sections 5.4.1 to 5.4.11 for a more detailed discussion of all factors of change discussed for each hazard of concern.

Table 5.3-3. Overview of Projected Future Changes for each Hazard of Concern

Hazard	Projected Change			Confidence in Changing Future Conditions [a]
	Location	Extent/ Intensity	Frequency/ Duration	
Climate Change and Sea Level Rise	↑	↑	↑	Highly Likely
Coastal Erosion	↑	↑	↑	Highly Likely
Disease Outbreak	↑	—	↑	Likely
Drought	—	↑	↑	Likely
Flood	↑	↑	↑	Highly Likely
Hurricane and Tropical Storm	—	—	—	Uncertain
Nor'Easter	↑	↑	↑	Likely
Severe Weather	↑	↑	↑	Highly Likely
Severe Winter Weather	—	↓	↓	Likely
Tsunami	—	—	—	Uncertain
Wildfire	↑	↑	↑	Likely

Notes:
Arrow direction indicates a projected increase or decrease based on literature review as described in Sections 5.4.1 through 5.4.11
— *Straight line indicates uncertain and/or no change known at this time.*
a Similar to confidence levels outlined in the National Climate Assessment 2018

- *Highly Likely = Studies and modeling projections indicate exacerbated conditions/increased future risk due to climate change; very high confidence level (strong evidence, well documented and acceptable methods).*
- *Likely = Studies and modeling projections indicate a potential for exacerbated conditions due to climate change; confidence level is medium to high (suggestive to moderate evidence).*
- *Uncertain = No local data is available; modeling projects are uncertain on whether there is increased future risk; confidence level is low (inconclusive evidence).*
- *No Change = Studies and modeling projections indicate there is no evidence at this time to indicate conditions may change in the future.*

5.3.2 Hazard Ranking Results

Using the process described above, the risk ranking for the identified hazards of concern was determined for Cape May County (refer to Table 5.3-4). The hazard ranking is detailed in the subsequent tables that present the step-wise process for the ranking. The countywide risk ranking includes the entire planning area and may not reflect the highest risk indicated for any of the participating jurisdictions. The resulting ranks of each municipality indicate the differing degrees of risk exposure and vulnerability. The results support the appropriate selection and prioritization of initiatives to reduce the highest levels of risk for each municipality. Both the county and the participating jurisdictions have applied the same methodology to develop the countywide risk and local rankings to ensure consistency in the overall ranking of risk; jurisdictions had the ability to alter rankings based on local knowledge and experience in handling each hazard.

This hazard ranking exercise serves four purposes: 1) to describe the probability of occurrence for each hazard; 2) to describe the impact each would have on the people, property, and economy; 3) to evaluate the capabilities a community has with regards to the hazards of concern; and 4) to consider changing future conditions (i.e., climate change) in Cape May County.

Table 5.3-4. Ranking for Hazards of Concern for Cape May County

Hazard of Concern	Probability		Impact										Adaptive Capacity	Climate Change
			Population			Property			Economy			Total Impact Value		
	Category	Numeric Value	Impact	Numeric Value	Weighted Value (x3)	Impact	Numeric Value	Weighted Value (x2)	Impact	Numeric Value	Weighted Value (x1)			
Climate Change and Sea Level Rise	Frequent	3	H	3	9	L	1	2	L	1	1	12	2	3
Coastal Erosion	Frequent	3	M	2	6	L	1	2	L	1	1	9	2	3
Disease Outbreak	Frequent	2	M	2	6	L	1	2	H	3	3	11	2	2
Drought	Occasional	2	L	1	3	L	1	2	H	3	3	8	2	3
Flood	Frequent	3	H	3	9	H	3	6	L	1	1	16	2	3
Hurricane and Tropical Storm	Occasional	2	H	3	9	H	3	6	H	3	3	18	2	3
Nor'Easter	Frequent	3	H	3	9	M	2	4	M	2	2	15	2	2
Severe Weather	Frequent	3	H	3	9	H	3	6	L	1	1	16	2	3
Severe Winter Weather	Frequent	3	H	3	9	L	1	2	L	1	1	12	1	2
Tsunami	Rare	1	M	2	6	M	2	4	L	1	1	11	2	1
Wildfire	Occasional	2	M	2	6	L	1	2	L	1	1	9	2	2

H = High; L = Low; M = Medium

Table 5.3-5 presents the total calculations for each hazard ranking value for the hazards of concern.

Table 5.3-5. Total Hazard Ranking Values for the Hazards of Concern for Cape May County

Hazard of Concern	Probability x 30%	Total Impact x 30%	Adaptive Capacity x 30%	Changing Future Conditions x 10%	Total Hazard Ranking Value
Climate Change and Sea Level Rise	0.9	4.0	0.6	0.3	**5.4**
Coastal Erosion	0.9	3.0	0.6	0.3	**4.5**
Disease Outbreak	0.6	3.0	0.6	0.2	**4.7**
Drought	0.6	2.0	0.6	0.3	**3.9**
Flood	0.9	5.0	0.6	0.3	**6.6**
Hurricane and Tropical Storm	0.6	5.0	0.6	0.3	**6.9**
Nor'Easter	0.9	5.0	0.6	0.2	**6.2**
Severe Weather	0.9	5.0	0.6	0.3	**6.6**
Severe Winter Weather	0.9	4.0	0.3	0.2	**5.0**
Tsunami	0.3	3.0	0.6	0.1	**4.3**
Wildfire	0.6	3.0	0.6	0.2	**4.1**

Low = Values less than or equal to 3.8; Medium = Values between 3.9 and 4.9; High = Values greater than or equal 5.0.

These rankings have been used as one of the bases for identifying the jurisdictional hazard mitigation strategies included in Section 9 (Jurisdictional Annexes) of this plan. The summary rankings for the County reflect the results of the vulnerability analysis for each hazard of concern and vary from the specific results of each jurisdiction. For example, the severe storm hazard may be ranked low in one jurisdiction, but due to the exposure and impact countywide, it is ranked as a high hazard and is addressed in the County's mitigation strategy accordingly. Jurisdictional ranking results are presented in each local annex in Section 9 (Jurisdictional Annexes) of this plan.

5.4.1 Climate Change and Sea Level Rise

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

2021 Plan Update Changes

- New and updated figures from federal and state agencies are incorporated.
- A vulnerability assessment was conducted using best available data from NOAA Office for Coastal Management 2017 sea level rise 1 through 4-foot scenarios, 2020 tax assessor data from Cape May County's jurisdictions, and Cape May County GIS 2020 building and critical facility data, supplemented with 2013 MOD-IV tax assessor data[1] where parcel information was missing.

5.4.1.1 Profile

Hazard Description

Climate Change

Climate change refers to any significant change in the measures of climate lasting for an extended period of time. Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature since the end of the 1890s (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). Due to continuing increases in greenhouse gas concentrations, 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). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70% of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). 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). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020).

[1] Please note that the 2013 MOD-IV tax assessor data is the most recent data published for Cape May County.

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 carbon dioxide concentrations in the atmosphere increase, the chemistry of the ocean will change. Carbon dioxide dissolves in seawater, beginning a chain reaction leading to more acidic conditions. Since the Industrial Revolution, the ocean has become 30% more acidic and ocean pH levels will continue to decline along the coast of New Jersey, causing shellfish and coral species to build weaker shells. Ocean acidification also affects the success of hatching, larval development, organ development, immune response, metabolic processes, and olfaction (smell) in marine species. New Jersey is at increased risk to the effects of ocean acidification due to its economic dependence on shellfish harvests, with southern New Jersey counties ranking second in the United States in economic dependence on shelled mollusks (NRDC 2015). While New Jersey is not predicted to see unfavorable acidification conditions for shellfish until 2100, given the State's dependence on shellfish resources, there could be high social and economic impacts (NRDC 2015, Ekstrom et al. 2015).

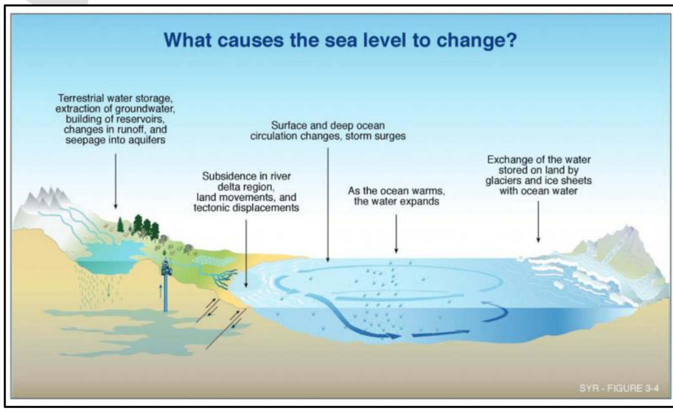
The changing climate impacts populations and ecosystems in numerous ways. For the purpose of this HMP update, this profile will include climate change and sea level rise in Cape May County. Each of the hazard profiles (Section 5.4.2 through Section 5.4.11) discuss the impacts of climate change on each of the hazards of concern for the County.

Sea Level Rise

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

There are two types of sea level: global and relative. Global sea level rise refers to the increase currently observed in the average global sea level trend (primarily attributed to changes in ocean volume due to ice melt and thermal expansion). The melting of glaciers and continental ice masses can contribute significant amounts of freshwater input to the earth's oceans. In addition, a steady increase in global atmospheric temperature creates an expansion of salt water molecules, increasing ocean volume. Figure 5.4.1-1 illustrates the causes of sea level change.

Figure 5.4.1-1. Causes of Sea Level Change



Source: U.S. Climate Resilience Toolkit 2019

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

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

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

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. All of these factors change during extreme weather and climate events (NOAA 2012). Other secondary hazards that could occur along the mid-Atlantic coast in response to sea level rise:

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

An increase in sea level will cause further issues as stormwater recharge is challenged as sea-levels submerge discharge points, resulting in increases in flooding (Kopp et al. 2019).

Location

Climate change is a concern for the entire United States and it will impact all areas of the country. Sea level rise is associated with climate change and has been experienced by coastal communities for the past 100 years. In New Jersey, coastal communities include any land adjacent to a tidally influenced waterway and includes the Atlantic Coast and the Delaware Bayshore (Kopp et al. 2019). Cape May County is located in the coastal areas of New Jersey and is vulnerable to both climate change and sea level rise. According to Table 5.4.1-1 and Figure 5.4.1-2, sea level rise of just one foot will impact nearly half of Cape May County.

Table 5.4.1-1. Total Land Area Affected by Sea Level Rise Hazard Areas

Total Acres in County	Hazard Area Type	Number of Acres Exposed to the Sea Level Rise Hazard Areas	Percent of Total
183,127	Sea Level Rise +1 foot	65,049	35.5%
	Sea Level Rise +2 foot	71,860	39.2%
	Sea Level Rise +3 foot	77,002	42.0%
	Sea Level Rise +4 foot	83,098	45.4%

Source: Cape May County GIS 2020; NOAA 2017
Notes: Acres of County does include waterways within county boundary; % = Percent

Extent

The extent (or severity) of climate change and sea level rise may pose a significant threat to the people, homes, businesses, and infrastructure of Cape May County. The following provides a description of the extent for climate change and sea level rise.

Climate Change

Each day, thousands of land and ocean temperatures are recorded around the world. This includes measurements from climate reference stations, weather stations, ships, buoys and autonomous gliders in the oceans. The surface measurements are also supplemented with satellite measurements. The global surface temperature is based on air temperature data over land and sea surface temperatures observed from ships, buoys, and satellites. Based on these measurements, there is a clear long-term global warming trend. In the United States, surface temperatures averaged across the country have also risen (NOAA NCDC 2020).

The U.S. Climate Extremes Index (CEI) was developed to quantify observed changes in climate within the contiguous United States. The CEI is the average of five indicators of the percentage of the specific area in the United States. These five indicators include:

1) The sum of (a) percentage of the United States with maximum temperatures much below normal and (b) percentage of the United States with maximum temperatures much above normal;

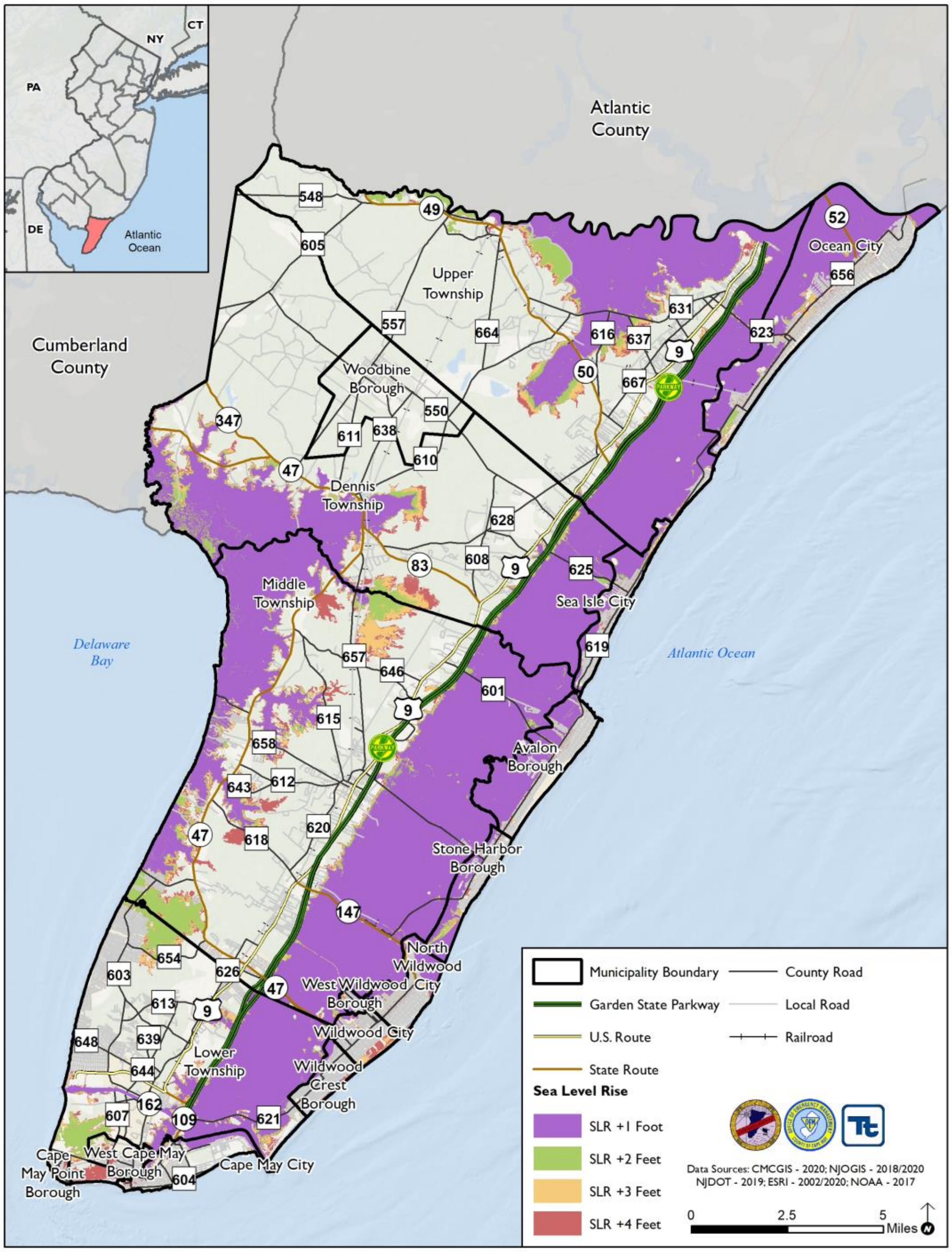
2) The sum of (a) percentage of the United States with minimum temperatures much below normal and (b) percentage of the United States with minimum temperatures much above normal;

3) The sum of (a) percentage of the United States in severe drought (equivalent to the lowest tenth percentile) based on the PDSI and (b) percentage of the United States with severe moisture surplus (equivalent to the highest tenth percentile) based on the PDSI;

4) Twice the value of the percentage of the United States with a much greater than normal proportion of precipitation derived from extreme (equivalent to the highest tenth percentile) 1-day precipitation events; and

5) The sum of (a) percentage of the United States with a much greater than normal number of days with precipitation and (b) percentage of the United States with a much greater than normal number of days without precipitation

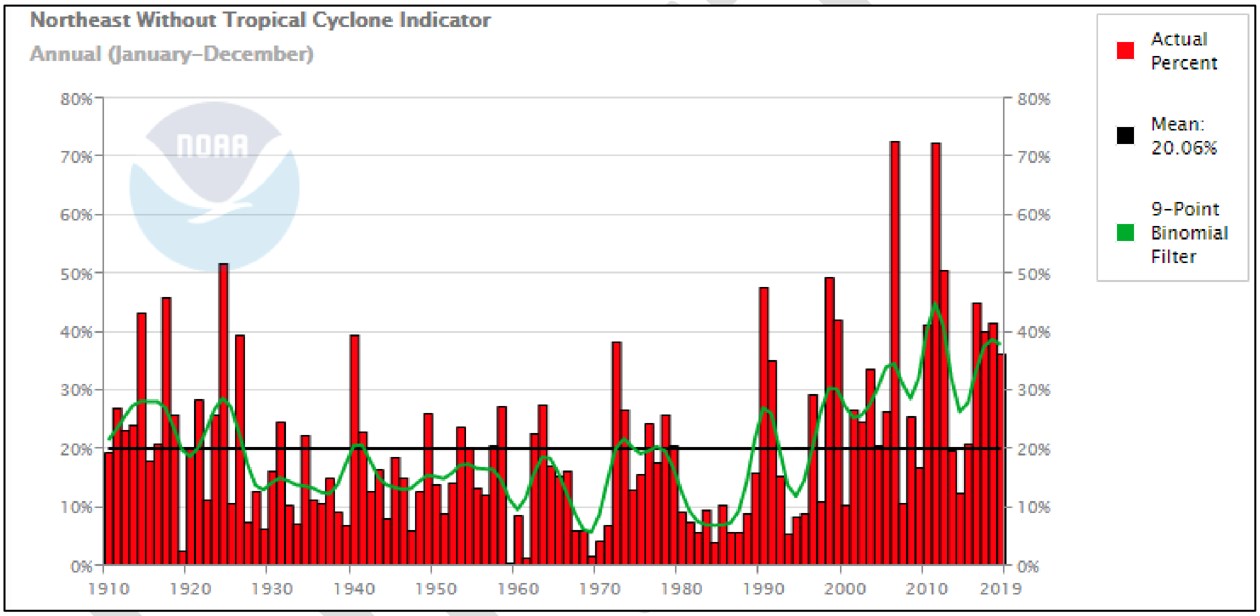
Figure 5.4.1-2. Sea Level Rise Scenarios for Cape May County



There is a sixth indicator (the sum of squares of U.S. landfalling tropical storm and hurricane wind velocities scaled to the mean of the first five indicators); however, it is only used when the period of interest includes months with significant tropical activity. The figure below shows the CEI graph for the northeast United States, which includes New Jersey and Cape May County. A value of 0% for the CEI indicates that no portion of the period of record was subject to any extremes of temperature or precipitation considered in the index. A value of 100% means that the entire country had extreme conditions throughout the year for each of the indicators. Therefore, observed CEI values of more than 20 percent indicate "more extreme" conditions than average, and CEI values less than 20 percent indicate "less extreme" conditions than average.

The figure below (Figure 5.4.1-3) shows the CEI for the northeast United States, from 1910 to 2019. According to this figure, in the last 30 years, the northeast has experienced extreme conditions for the indicators of the CEI (NOAA NCDC 2020).

Figure 5.4.1-3. Northeast CEI, 1910-2019



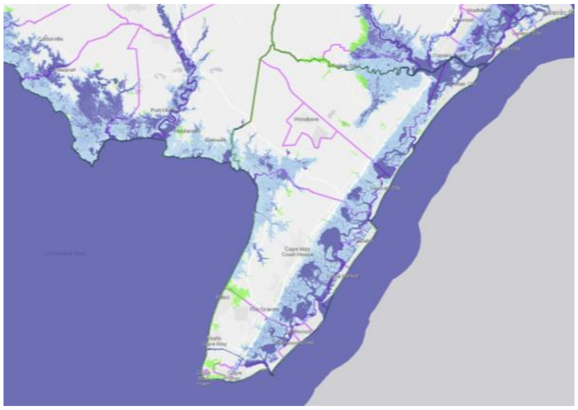
Source: NOAA NCDC 2020

Sea Level Rise

For New Jersey, Rutgers University, in partnership with other academic, local, federal and state agencies and programs, has developed online tools that help provide an understanding of how climate change is affecting and will continue to affect the State. With the interactive, user-centered NJFloodmapper web tool, New Jersey decision-makers can visualize flood risk due to sea level rise and extreme storms to aid resilience and hazard mitigation planning efforts. NJFloodmapper streamlines the latest spatial data and decision-support tools into a single resource that provides current, accessible, science-based and state-specific data and visualizations.

NJFloodmapper offers a unique Total Water Level approach to flood risk visualization that reflects user-defined combinations of sea level rise and flood conditions, providing flexibility to evaluate a range of flood conditions and time horizons for planning. NJFloodmapper also includes enhanced data layers that show physical infrastructure, evacuation routes, land uses, and socio-demographics to give a fuller picture of community vulnerability. Users can choose hazard overlays including Total Water Level, SLOSH for Categories 1-4, Sea Level Rise for 1-10 feet, FEMA Flood Zones, and Sandy Surge Extent. After creating a map, users can share a link or create a pdf for further use (Figure 5.4.1-4).

Figure 5.4.1-4. Screenshot of NJFloodMapper



NJFloodmapper also includes Municipal Snapshots that provide easy access to information about the people, places, and assets that are at risk from coastal flood hazards in each of New Jersey's municipalities. The mapping portal is found here: https://www.njfloodmapper.org/. In addition, Cape May County has its own flood tool located at https://cmcgis.maps.arcgis.com/apps/MapSeries/index.html?appid=dfc9972f2f8f4c92bce2187194d81ff5.

The global sea level trend has been recorded by satellite altimeters since 1992 and the latest calculation can be obtained from NOAA's Laboratory for Satellite Altimetry. The University of Colorado's Sea Level Research Group compares global sea level rates calculated by different research organizations and provides detailed explanations about the issues involved (NOAA 2020). A map of regional MSL in the United States can be found here: http://tidesandcurrents.noaa.gov/sltrends/slrmap.htm. The map provides an overview of variations in the rates of relative local MSL at long-term tide stations. The variations in sea level trends primarily reflect differences in rates and sources of vertical land motion. Areas that experienced little-to-no change in MSL are shown in green, including stations consistent with average global sea level rise rate of 1.7 to 1.8 mm/year. These stations do not experience significant vertical land motion. Stations that experienced positive sea level trends (yellow to red) experience both global sea level rise and lowering or sinking of the local land, causing an apparent exaggerated rate of relative sea level rise. Stations that are blue to brown have experienced global sea level rise and a greater vertical rise in local land, causing an apparent decrease in relative sea level. The rates of relative sea level rise reflect actual observations and must be accounted for in any coastal planning or engineering applications (NOAA 2020).

Figure 5.4.1-5. Mean Sea Level Trends in New Jersey

Source: NOAA 2020

There are three NOAA tide gauge stations located in New Jersey. This is where tide gauge measurements are made with respect to a local fixed reference level on land. Figure 5.4.1-4 shows these changes for Atlantic City, Sandy Hook, and Cape May. Table 5.4.1-2 presents the history and MSL trends at the three New Jersey stations, which show the result of a combination of the global sea level rate and the local vertical land motion.

Table 5.4.1-2. Linear MSL Trends and 95% Confidence Intervals

Station Name	First Year	Year Range	For all data to 2019 MSL Trend (inches/year)
Atlantic City	1911	108	0.16
Cape May	1965	54	0.19
Sandy Hook	1932	87	0.16

Source: NOAA 2020
MSL Mean Sea Level

Additionally, in an article titled "A geological perspective on sea level rise and its impacts along the U.S. mid-Atlantic coast" written by Kenneth Miller, Robert Kopp, Benjamin Horton, James Browning, and Andrew Kemp, an analysis of geological and historical sea level records was done. This showed a significant rate of increase in sea level rise since the 19th century. It was stated that in New Jersey, it is extremely likely that sea level rise in the 20th century was faster than during any century in the last 4,300 years. Based on the findings of this article and the 2019 update of the initial study, it is anticipated that the arrival of one foot of sea level rise will be experienced before 2050. As sea level rise is expected to accelerate in this century, three feet of sea level rise is very likely before 2100. The table below (Table 5.4.1-3) shows the "low", "high", and "best" estimates for sea level rise projects in New Jersey for the years 2050 and 2100. "Best" refers to a 50% likelihood of that level of sea level rise occurring.

Table 5.4.1-3. Sea Level Rise Projections for New Jersey (ft. above year 2000 average sea level) for New Jersey From 2030 to 2150 Under Low, Moderate and High Emissions Scenarios.

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

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

Looking at Figure 5.4.1-2, just one foot of sea level rise will inundate the eastern coast of Cape May County, which is dominated by salt marsh, including northern sections of Upper Township, portions of Dennis Township, and the western border of Middle Township along the Delaware Bay.

Previous Occurrences and Losses

Climate change and sea level rise have been documented since the 19th century. 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). This warming trend is expected to continue. 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. Data has shown that mean sea level rise in Cape May County is 0.19 inches/year. Since the turn of the twentieth century, sea level has risen approximately 16 inches along the Jersey Shore.

One method assessing impacts from climate change and sea level rise is through measuring the persistence of high tide flooding. NOAA defines high tide flooding as the inundation that occurs when ocean waters reach 0.5 m to 0.65 m (1.64 ft to 2.13 ft) above daily average high tide (mean higher high water) and begin to bubble up from storm drains and spill onto streets. According to a 2019 report by the National Weather Service, 2009 was the year of record for high tide flooding (14 days). The number of days with high tide flooding per year has increased from three in 2000 to seven in 2019 and is projected to increase to 15-30 by 2030 and 55-135 by 2050 (NOAA 2019).

Specific financial losses due to climate change and sea level rise are not easily quantifiable. However, sea level rise has likely contributed to flood damages experienced in the last century by increasing the overall elevation of flood waters and contributing to the climatic conditions that cause storms to develop.

Probability of Future Occurrences

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes. Impacts of climate change on coastal communities in New Jersey, like Cape May County, will primarily result from sea level rise and extreme storm events.

Sea level has been gradually rising for the past 100 years and the rate of sea level rise is predicted to accelerate as a result of climate change (refer to the Extent section of this profile). Rising sea levels will continue to increase occurrences of inundation and erosion along the coastal areas of Cape May County. Coastal communities in the County may also see an increase risk of flood-related damages to homes, businesses and infrastructure. An increase in sea level also implies that storm surges will operate from an elevated base, so severe coastal flooding may be more frequent in the future (NJ Climate Adaptation Alliance 2016).

Based on information provided earlier in this profile, Cape May County will experience the effects of a changing climate in the future. These effects may include an increase in a number of severe weather events, erosion along the coastline, and an increase in the degree of damage as a result of storms and flooding. Refer to the other hazard profiles (Section 5.4.2-10) for the probability of future occurrence for coastal erosion, disease outbreak, flood, hurricanes/tropical storms, Nor'Easters, severe weather, severe winter weather, tsunami, and wildfire.

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 climate change and sea level rise in the County is considered ‘frequent' (100% chance of occurring, occurs multiple times a year).

5.4.1.2 Vulnerability Assessment

To assess Cape May County’s risk to climate change and sea level rise, a qualitative review of climate impacts in the County was assessed in addition to a spatial analysis that was conducted using the best available spatially-delineated sea level rise data from NOAA. Sea level rise 2017 data was used to conduct an exposure analysis for the 1- through 4-foot inundation areas. These results are summarized below. Refer to Section 5.1 (Methodology and Tools) for additional details on the methodology used to assess the County’s risk to climate change and sea level rise.

Impact on Life, Health and Safety

The entire population of Cape May County is exposed to potential impacts from warmer temperatures and severe weather events associated with climate change. For more detailed discussion on the impacts of extreme temperature and severe weather events, refer to the Severe Weather profile (Section 5.4.8).

People living and working in the sea level rise hazard area may be displaced as homes and businesses become flooded and permanently lost. To estimate population exposed and vulnerable to the sea level rise hazards, a spatial analysis was conducted using the NOAA sea level rise inundation areas; refer to Table 5.4.1-4. This table summarizes the impacts of sea level rise for the 1-foot through 4-foot scenarios by Cape May County's municipalities. Please note the limitations of this analysis are recognized and the results should only be used as an estimate.

The analysis estimates that 508 persons living in the sea level rise +1 foot hazard area and up to 15,738 persons living in the sea level rise +4 foot hazard area. Overall, West Wildwood Borough has the greatest proportion of its population in the sea level rise hazard areas that may be displaced (i.e., 26.8-percent in the +1 foot hazard area and up to 99.2-percent in the +4 foot hazard area). Additionally, Middle Township has the greatest number of persons residing in the +1 foot and +2 foot sea level rise hazard areas that may be displaced (i.e., 191 and 457 persons, respectively), and Ocean City has the greatest number of persons residing in the +3 foot and +4 foot sea level rise hazard areas that may be displaced (i.e., 2,086 and 4,579 persons, respectively).

Table 5.4.1-4. Estimated Population Exposed to the Sea Level Rise Hazard Areas

Jurisdiction	American Community Survey (2014-2018) Total Population	Estimated Population Exposed: Number of Persons Exposed to Sea Level Rise +1 foot	Percent of Total	Number of Persons Exposed to Sea Level Rise +2 foot	Percent of Total	Number of Persons Exposed to Sea Level Rise +3 foot	Percent of Total	Number of Persons Exposed to Sea Level Rise +4 foot	Percent of Total
Avalon Borough	1,409	1	0.1%	3	0.2%	64	4.6%	322	22.9%
Cape May City	3,491	14	0.4%	22	0.6%	64	1.8%	409	11.7%
Cape May Point Borough	188	0	0.0%	0	0.0%	0	0.0%	59	31.5%
Dennis Township	6,244	2	0.0%	7	0.1%	16	0.3%	34	0.5%
Lower Township	21,838	80	0.4%	127	0.6%	524	2.4%	1,160	5.3%
Middle Township	18,492	191	1.0%	457	2.5%	985	5.3%	1,738	9.4%
North Wildwood City	3,849	14	0.4%	165	4.3%	1,215	31.6%	2,236	58.1%
Ocean City	11,202	53	0.5%	343	3.1%	2,086	18.6%	4,579	40.9%
Sea Isle City	1,955	4	0.2%	10	0.5%	147	7.5%	772	39.5%
Stone Harbor Borough	955	0	0.0%	4	0.4%	90	9.4%	273	28.6%
Upper Township	11,909	6	0.1%	59	0.5%	277	2.3%	623	5.2%
West Cape May Borough	1,103	0	0.0%	4	0.4%	19	1.8%	243	22.0%
West Wildwood Borough	376	101	26.8%	294	78.2%	363	96.4%	373	99.2%
Wildwood City	5,073	41	0.8%	236	4.6%	1,441	28.4%	2,536	50.0%
Wildwood Crest Borough	3,131	1	0.0%	13	0.4%	74	2.3%	381	12.2%
Woodbine Borough	2,490	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Cape May County (Total)	**93,705**	**508**	**0.5%**	**1,742**	**1.9%**	**7,366**	**7.9%**	**15,738**	**16.8%**

Source: American Community Survey 2018; NOAA 2017
Notes: % = Percent

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. Within Cape May County, there are approximately 23,572 people over the age of 65 and 10,140 people below the poverty level (American Community Survey 2018). In the three jurisdictions where the most persons or highest proportion of persons are within the sea level rise hazard areas (i.e., West Wildwood Borough, Middle Township, and Ocean City), persons over 65 years old make up 39.9-percent, 21.3-percent, and 31.6-percent of the municipality's total population (American Community Survey 2018).

The New Jersey 2019 Hazard Mitigation Plan suggests that changes in sea level rise will be a key indicator to understanding the impacts climate change is having on the State (State of New Jersey 2019). Based on the projections provided in the state hazard mitigation plan, climate change may exacerbate the effects of sea level rise in the State. Persons that are living in the projected inundation areas caused by future sea level rise may experience greater risk due to the fluctuations in climate and areas bordering inundation areas may be at higher risk to flooding events.

Impact on General Building Stock

The County's entire building stock is exposed to potential impacts from warmer temperatures and severe weather events associated with climate change. For more detailed discussion on the impacts of extreme temperature and severe weather events, refer to the Severe Weather profile (Section 5.4.8).

Structures and land may become permanently inundated due to sea level rise over time. Exposure to the sea level rise hazard areas was determined using NOAA's 2017 1-foot increment spatial data and updated building stock data for Cape May County. Up to 19.8-percent of the County's total replacement cost value and up to 20.4-percent of the County's total building stock is estimated to be located in the +4 foot sea level rise hazard area and at risk to permanent inundation. This is a value of approximately $17.9 billion in building and content costs for the County. Overall, West Wildwood Borough and Ocean City have the greatest number of buildings and replacement cost value located in the +1 through +4 foot sea level rise hazard areas (i.e., 215 and 626 buildings in West Wildwood Borough for the +1 and +2 foot sea level rise hazard areas; 3,443 and 7,496 buildings in Ocean City for the +3 and +4 foot sea level rise hazard areas). Refer to Table 5.4.1-5 and Table 5.4.1-6 for a breakdown of general building stock exposure summarized by municipality. It is important to keep in mind that there are impacts not reported in these results due to the unpredictable changes in climate that could exacerbate the impacts sea level rise on the building stock in the County.

Table 5.4.1-5. Estimated General Building Stock and Replacement Cost Value Exposed to the +1 foot and +2 foot Sea Level Rise Hazard Areas

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Sea Level Rise Hazard Areas							
			Number of Buildings Exposed - Sea Level Rise + 1 foot	Percent of Total	Total Replacement Cost Value Exposed - Sea Level Rise + 1 foot	Percent of Total	Number of Buildings Exposed - Sea Level Rise + 2 foot	Percent of Total	Total Replacement Cost Value Exposed - Sea Level Rise + 2 foot	Percent of Total
Avalon Borough	5,867	$8,232,959,879	7	0.1%	$6,461,488	0.1%	13	0.2%	$8,777,953	0.1%
Cape May City	4,234	$5,153,049,612	18	0.4%	$22,892,723	0.4%	28	0.7%	$31,609,249	0.6%
Cape May Point Borough	785	$663,183,164	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Dennis Township	7,301	$3,813,425,173	3	0.0%	$1,992,275	0.1%	7	0.1%	$3,272,619	0.1%
Lower Township	19,597	$9,950,232,225	71	0.4%	$25,189,189	0.3%	118	0.6%	$50,011,925	0.5%
Middle Township	18,197	$11,557,342,752	167	0.9%	$49,746,146	0.4%	480	2.6%	$139,022,281	1.2%
North Wildwood City	4,729	$4,423,365,953	18	0.4%	$11,571,932	0.3%	193	4.1%	$116,604,672	2.6%
Ocean City	18,172	$17,100,920,036	90	0.5%	$60,287,388	0.4%	574	3.2%	$417,034,339	2.4%
Sea Isle City	6,712	$7,663,928,227	14	0.2%	$8,751,675	0.1%	36	0.5%	$27,611,556	0.4%
Stone Harbor Borough	3,836	$3,291,756,871	0	0.0%	$0	0.0%	14	0.4%	$14,833,423	0.5%
Upper Township	9,627	$6,506,171,365	8	0.1%	$6,706,164	0.1%	45	0.5%	$32,596,816	0.5%
West Cape May Borough	1,623	$1,178,516,373	0	0.0%	$0	0.0%	7	0.4%	$2,075,913	0.2%
West Wildwood Borough	805	$459,103,094	215	26.7%	$87,268,313	19.0%	626	77.8%	$312,631,574	68.1%
Wildwood City	3,679	$4,379,038,844	30	0.8%	$27,100,287	0.6%	157	4.3%	$102,222,691	2.3%
Wildwood Crest Borough	5,410	$4,552,156,876	1	0.0%	$286,221	0.0%	22	0.4%	$19,015,605	0.4%
Woodbine Borough	1,416	$1,335,589,432	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Cape May County (Total)	**111,990**	**$90,260,739,877**	**642**	**0.6%**	**$308,253,801**	**0.3%**	**2,320**	**2.1%**	**$1,277,320,617**	**1.4%**

Source: Cape May County GIS 2020; MOV-ID 2013; RS Means 2019; NOAA 2017
Notes: % = Percent

Table 5.4.1-6. Estimated General Building Stock and Replacement Cost Value Exposed to the +3 foot and +4 foot Sea Level Rise Hazard Areas

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Sea Level Rise Hazard Areas							
			Number of Buildings Exposed - Sea Level Rise + 3 foot	Percent of Total	Total Replacement Cost Value Exposed - Sea Level Rise + 3 foot	Percent of Total	Number of Buildings Exposed - Sea Level Rise + 4 foot	Percent of Total	Total Replacement Cost Value Exposed - Sea Level Rise + 4 foot	Percent of Total
Avalon Borough	5,867	$8,232,959,879	275	4.7%	$317,084,954	3.9%	1,349	23.0%	$1,628,907,915	19.8%
Cape May City	4,234	$5,153,049,612	82	1.9%	$83,895,405	1.6%	500	11.8%	$478,848,397	9.3%
Cape May Point Borough	785	$663,183,164	0	0.0%	$0	0.0%	245	31.2%	$227,712,035	34.3%
Dennis Township	7,301	$3,813,425,173	17	0.2%	$8,545,966	0.2%	39	0.5%	$24,021,383	0.6%
Lower Township	19,597	$9,950,232,225	481	2.5%	$221,234,057	2.2%	1,102	5.6%	$510,881,744	5.1%
Middle Township	18,197	$11,557,342,752	1,010	5.6%	$320,887,172	2.8%	1,723	9.5%	$652,416,848	5.6%
North Wildwood City	4,729	$4,423,365,953	1,431	30.3%	$916,458,803	20.7%	2,699	57.1%	$1,891,479,570	42.8%
Ocean City	18,172	$17,100,920,036	3,443	18.9%	$2,467,888,642	14.4%	7,496	41.3%	$5,905,104,782	34.5%
Sea Isle City	6,712	$7,663,928,227	506	7.5%	$475,890,037	6.2%	2,657	39.6%	$2,822,880,368	36.8%
Stone Harbor Borough	3,836	$3,291,756,871	364	9.5%	$295,168,367	9.0%	1,104	28.8%	$894,135,788	27.2%
Upper Township	9,627	$6,506,171,365	192	2.0%	$104,930,344	1.6%	431	4.5%	$262,359,973	4.0%
West Cape May Borough	1,623	$1,178,516,373	31	1.9%	$15,698,589	1.3%	328	20.2%	$228,347,465	19.4%
West Wildwood Borough	805	$459,103,094	772	95.9%	$428,876,311	93.4%	794	98.6%	$447,868,047	97.6%
Wildwood City	3,679	$4,379,038,844	940	25.6%	$610,413,671	13.9%	1,690	45.9%	$1,339,903,138	30.6%
Wildwood Crest Borough	5,410	$4,552,156,876	125	2.3%	$99,942,236	2.2%	653	12.1%	$537,611,026	11.8%
Woodbine Borough	1,416	$1,335,589,432	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Cape May County (Total)	**111,990**	**$90,260,739,877**	**9,669**	**8.6%**	**$6,366,914,554**	**7.1%**	**22,810**	**20.4%**	**$17,852,478,479**	**19.8%**

Source: Cape May County GIS 2020; MOV-ID 2013; RS Means 2019; NOAA 2017
Notes: % = Percent

Impact on Critical Facilities

All of the County's critical facilities are exposed to potential impacts from warmer temperatures and severe weather events associated with climate change. For more detailed discussion on the impacts of extreme temperature and severe weather events, refer to the Severe Weather profile (Section 5.4.8).

Sea level rise may potentially impact critical facilities identified within the County. Critical services may not be available if critical facilities are directly damaged or transportation routes to access these critical facilities are permanently inundated by sea level rise. Residual impacts from sea level rise include increased frequency of coastal flooding events and coastal erosion. Flooding could disrupt utilities that are not protected with berms or other flood-proof measures. Coastal erosion may destabilize the roadways leading to facilities or destroy the foundation that supports the critical facilities along the shoreline.

Overall, most of the critical facilities within the sea level rise hazard areas are marinas. Bridges and wastewater pump stations are the second most exposed categories of critical facilities for the County. Middle Township and Lower Township have the greatest number of critical facilities located in the +1 and +2 foot sea level rise hazard areas, whereas Ocean City has the greatest number of critical facilities located in the +3 and +4 foot sea level rise hazard areas. Nearly 30-percent of the County's critical facilities are built in the projected +4 foot sea level rise hazard area, (i.e., 218 total). Of the total critical facilities exposed to the +4 foot sea level rise hazard area, 217 are considered lifelines for the County. Refer to Table 5.4.1-7 and Table 5.4.1-8 for a summary of critical facilities and lifelines exposed to the sea level rise hazard areas for each municipality. Table 5.4.1-9 through Table 5.4.1-12 show the distribution of exposed critical facilities by type in each municipality.

Table 5.4.1-7. Critical Facilities and Lifelines Exposed to the +1 foot and +2 foot Sea Level Rise Hazard Areas

Jurisdiction	Total Critical Facilities	Total FEMA Lifelines	+ 1 foot Sea Level Rise				+ 2 foot Sea Level Rise			
			Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total	Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total
Avalon Borough	30	30	6	20.0%	6	20.0%	6	20.0%	6	20.0%
Cape May City	32	32	9	28.1%	9	28.1%	9	28.1%	9	28.1%
Cape May Point Borough	10	10	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Dennis Township	60	60	1	1.7%	1	1.7%	2	3.3%	2	3.3%
Lower Township	111	111	13	11.7%	13	11.7%	16	14.4%	16	14.4%
Middle Township	181	181	17	9.4%	17	9.4%	18	9.9%	18	9.9%
North Wildwood City	30	29	0	0.0%	0	0.0%	2	6.7%	2	6.9%
Ocean City	59	58	10	16.9%	10	17.2%	17	28.8%	17	29.3%
Sea Isle City	26	26	3	11.5%	3	11.5%	4	15.4%	4	15.4%
Stone Harbor Borough	26	26	1	3.8%	1	3.8%	1	3.8%	1	3.8%
Upper Township	73	68	7	9.6%	7	10.3%	9	12.3%	9	13.2%
West Cape May Borough	10	10	1	10.0%	1	10.0%	1	10.0%	1	10.0%
West Wildwood Borough	8	8	4	50.0%	4	50.0%	6	75.0%	6	75.0%
Wildwood City	39	37	2	5.1%	2	5.4%	5	12.8%	5	13.5%
Wildwood Crest Borough	23	23	1	4.3%	1	4.3%	1	4.3%	1	4.3%
Woodbine Borough	21	21	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Cape May County (Total)	**739**	**730**	**75**	**10.1%**	**75**	**10.3%**	**97**	**13.1%**	**97**	**13.3%**

Source: Cape May County GIS 2020; NOAA 2017
Notes: % = Percent

Table 5.4.1-8. Critical Facilities and Lifelines Exposed to the +3 foot and +4 foot Sea Level Rise Hazard Areas

Jurisdiction	Total Critical Facilities	Total FEMA Lifelines	+ 3 foot Sea Level Rise				+ 4 foot Sea Level Rise			
			Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total	Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total
Avalon Borough	30	30	13	43.3%	13	43.3%	23	76.7%	23	76.7%
Cape May City	32	32	9	28.1%	9	28.1%	12	37.5%	12	37.5%
Cape May Point Borough	10	10	0	0.0%	0	0.0%	1	10.0%	1	10.0%
Dennis Township	60	60	4	6.7%	4	6.7%	4	6.7%	4	6.7%
Lower Township	111	111	25	22.5%	25	22.5%	28	25.2%	28	25.2%
Middle Township	181	181	20	11.0%	20	11.0%	23	12.7%	23	12.7%
North Wildwood City	30	29	4	13.3%	4	13.8%	17	56.7%	16	55.2%
Ocean City	59	58	31	52.5%	31	53.4%	43	72.9%	43	74.1%
Sea Isle City	26	26	8	30.8%	8	30.8%	16	61.5%	16	61.5%
Stone Harbor Borough	26	26	4	15.4%	4	15.4%	8	30.8%	8	30.8%
Upper Township	73	68	10	13.7%	10	14.7%	13	17.8%	13	19.1%
West Cape May Borough	10	10	2	20.0%	2	20.0%	3	30.0%	3	30.0%
West Wildwood Borough	8	8	6	75.0%	6	75.0%	6	75.0%	6	75.0%
Wildwood City	39	37	9	23.1%	9	24.3%	17	43.6%	17	45.9%
Wildwood Crest Borough	23	23	1	4.3%	1	4.3%	4	17.4%	4	17.4%
Woodbine Borough	21	21	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Cape May County (Total)	**739**	**730**	**146**	**19.8%**	**146**	**20.0%**	**218**	**29.5%**	**217**	**29.7%**

Source: Cape May County GIS 2020; NOAA 2017
Notes: % = Percent

Table 5.4.1-9. Distribution of Critical Facilities Exposed to the +1 foot Sea Level Rise Hazard Area

Jurisdiction	Critical Facilities Exposed to +1 foot Sea Level Rise									
	Bridge	Dams	DPW	Marinas	Municipal Facilities	Potable Water Facilities	Superfund Sites	Wastewater Facilities	Wastewater Pump Station	Well
Avalon Borough	3	0	0	3	0	0	0	0	0	0
Cape May City	1	0	2	1	0	1	1	0	0	3
Dennis Township	0	1	0	0	0	0	0	0	0	0
Lower Township	3	0	0	9	0	0	0	0	1	0
Middle Township	9	0	0	7	0	0	0	0	1	0
Ocean City	4	0	0	4	0	0	0	1	1	0
Sea Isle City	2	0	0	1	0	0	0	0	0	0
Stone Harbor Borough	1	0	0	0	0	0	0	0	0	0
Upper Township	4	0	0	3	0	0	0	0	0	0
West Cape May Borough	1	0	0	0	0	0	0	0	0	0
West Wildwood Borough	0	0	0	3	1	0	0	0	0	0
Wildwood City	0	0	0	2	0	0	0	0	0	0
Wildwood Crest Borough	0	0	0	1	0	0	0	0	0	0
Cape May County (Total)	**28**	**1**	**2**	**34**	**1**	**1**	**1**	**1**	**3**	**3**

Source: Cape May County GIS 2020; NOAA 2017
Notes: % = Percent

Table 5.4.1-10. Distribution of Critical Facilities Exposed to the +2 foot Sea Level Rise Hazard Area

Jurisdiction	Critical Facilities Exposed to +2 foot Sea Level Rise														
	Bridge	Communications Tower	Dams	DPW	Marinas	Medical Clinics	Municipal Facilities	Police Stations	Polling Places	Potable Water Facilities	Senior Facility	Superfund Sites	Wastewater Facilities	Wastewater Pump Station	Well
Avalon Borough	3	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Cape May City	1	0	0	2	1	0	0	0	0	1	0	1	0	0	3
Dennis Township	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Lower Township	3	0	0	0	12	0	0	0	0	0	0	0	0	1	0
Middle Township	9	0	0	0	8	0	0	0	0	0	0	0	0	1	0
North Wildwood City	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Ocean City	4	0	0	0	4	0	0	0	0	0	1	2	1	5	0
Sea Isle City	2	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Stone Harbor Borough	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Township	5	0	0	0	3	0	0	0	0	0	0	0	0	0	1
West Cape May Borough	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
West Wildwood Borough	0	0	0	0	3	0	1	1	1	0	0	0	0	0	0
Wildwood City	0	0	0	0	3	1	0	0	0	0	0	0	0	1	0
Wildwood Crest Borough	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Cape May County (Total)	**29**	**2**	**1**	**2**	**39**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**1**	**10**	**4**

Source: Cape May County GIS 2020; NOAA 2017
Notes: % = Percent

Table 5.4.1-11. Distribution of Critical Facilities Exposed to the +3 foot Sea Level Rise Hazard Area

Jurisdiction	Critical Facilities Exposed to +3 foot Sea Level Rise																		
	Airport	Bridge	Communications Facility	Communications Tower	Dams	DPW	Fire Stations	Marinas	Medical Clinics	Municipal Facilities	Police Stations	Polling Places	Potable Water Facilities	Primary Education	Senior Facility	Superfund Sites	Wastewater Facilities	Wastewater Pump Station	Well
Avalon Borough	0	3	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	6	0
Cape May City	0	1	0	0	0	2	0	1	0	0	0	0	1	0	0	1	0	0	3
Dennis Township	0	0	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Lower Township	0	3	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	6	2
Middle Township	0	9	0	1	0	0	0	8	0	0	0	0	0	0	0	0	1	1	0
North Wildwood City	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0
Ocean City	1	6	0	0	0	0	0	4	0	1	0	1	0	2	1	3	1	11	0
Sea Isle City	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	4	0
Stone Harbor Borough	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Upper Township	0	5	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	1
West Cape May Borough	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
West Wildwood Borough	0	0	0	0	0	0	0	3	0	1	1	1	0	0	0	0	0	0	0
Wildwood City	0	1	0	0	0	0	0	3	2	0	0	0	1	0	0	0	0	2	0
Wildwood Crest Borough	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Cape May County (Total)	**1**	**32**	**1**	**4**	**2**	**2**	**1**	**46**	**3**	**2**	**1**	**2**	**2**	**3**	**1**	**4**	**2**	**31**	**6**

Source: Cape May County GIS 2020; NOAA 2017
Notes: % = Percent

Table 5.4.1-12. Distribution of Critical Facilities Exposed to the +4 foot Sea Level Rise Hazard Area

Jurisdiction	Critical Facilities Exposed to +4 foot Sea Level Rise																												
	Airport	Bridge	Communications Facility	Communications Tower	County Facilities	Dams	DPW	Education	Electric Substation	EMS	EOC	Ferry Facilities	Fire Stations	Library	Marinas	Medical Clinics	Municipal Facilities	Natural Gas Facility	Police Stations	Polling Places	Potable Water Facilities	Primary Education	Recreation	Secondary Education	Senior Facility	Superfund Sites	Wastewater Facilities	Wastewater Pump Station	Well
Avalon Borough	0	3	0	1	0	0	0	0	0	0	0	0	0	2	4	0	2	0	1	0	0	1	0	0	0	0	0	9	0
Cape May City	0	1	0	0	0	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	1	0	2	3
Cape May Point Borough	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Dennis Township	0	0	0	1	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower Township	0	3	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	1	0	7	3
Middle Township	0	9	0	1	0	1	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	1	0	0	1	1	1
North Wildwood City	0	0	0	2	1	0	0	0	0	1	1	0	3	0	1	0	0	1	0	1	0	2	1	0	1	0	0	2	0
Ocean City	1	6	0	0	0	0	0	0	0	0	0	1	2	0	6	1	1	0	1	3	0	2	0	0	1	3	1	14	0
Sea Isle City	0	2	0	0	0	0	0	0	0	0	1	0	0	1	2	0	0	0	0	1	0	0	0	0	0	1	0	7	1
Stone Harbor Borough	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2	1
Upper Township	0	5	0	0	0	0	0	0	0	0	0	0	1	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1
West Cape May Borough	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	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	3	0	1	0	1	1	0	0	0	0	0	0	0	0	0
Wildwood City	0	1	0	0	0	0	1	1	1	0	0	0	0	0	3	2	0	2	0	1	1	2	0	0	0	0	0	2	0
Wildwood Crest Borough	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Cape May County (Total)	**1**	**32**	**1**	**8**	**1**	**3**	**3**	**1**	**1**	**1**	**2**	**1**	**6**	**4**	**51**	**4**	**4**	**4**	**3**	**7**	**2**	**8**	**1**	**1**	**2**	**6**	**2**	**48**	**10**

Source: Cape May County GIS 2020; NOAA 2017
Notes: % = Percent

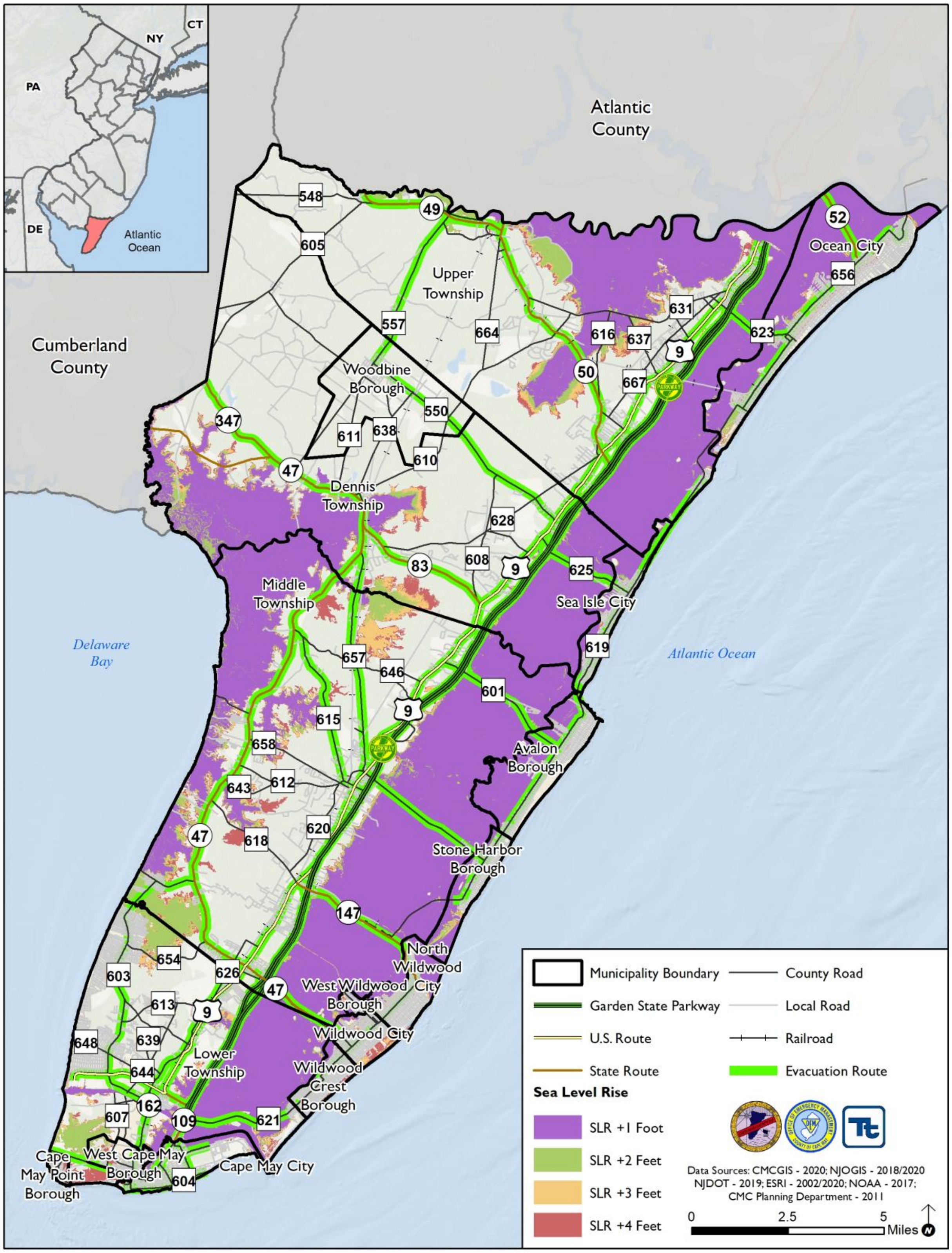
Additionally, sea level rise can have a major impact on transportation routes in the County, particularly roadways that serve as evacuation routes for the community. Evacuation routes in the County are at risk of becoming breached with rising tide or erosion along the shoreline caused by sea level rise. If these routes become inoperable from flooding or the infrastructure becomes unstable from erosion and/or permanent inundation, these communities can become isolated during an evacuation event. Overall, out of the 224 miles of evacuation routes in the County, approximately 15-percent will become inundated by the projected +4 foot sea level rise hazard area (refer to Table 5.4.1-13). Roadways at risk of sea level rise inundation include: State Road 109, State Road 49, State Road 50, State Road 52, North Wildwood Blvd, Delsea Dr, Avalon Blvd, Bayshore & Jonathan Hoffman Rd, Sunset Blvd, Goshen Rd & Mechanic St, Ocean Dr, Pittsburgh & Texas Ave, Roosevelt Blvd, Sea Isle & JFK Blvd, Sea Shore Rd & Railroad Ave, Lafayette Ave, Delaware Ave, Bay Ave, Stone Harbor Blvd, and Garden Statement Parkway. Refer to Figure 5.4.1-5 for the estimated number of miles evacuation routes in Cape May County will be exposed to the projected sea level rise hazard areas.

Table 5.4.1-13. Miles of Evacuation Routes Exposed to the Sea Level Rise Hazard Areas

Total Miles of Evacuation Routes in County	Sea Level Rise Hazard Area	Total Miles of Evacuation Routes Exposed to the Sea Level Rise Hazard Areas	Percent of Total
224	Sea Level Rise +1 foot	3	1.5%
	Sea Level Rise +2 foot	6	2.5%
	Sea Level Rise +3 foot	20	8.7%
	Sea Level Rise +4 foot	33	14.9%

Source: Cape May County GIS 2020; NOAA 2017; Cape May County Planning Department 2011
Notes: % = Percent

Figure 5.4.1-6. Evacuation Routes Exposed to Sea Level Rise in Cape May County



Impact on the Economy

Vulnerability to sea level rise is assessed as the potential permanent loss of land and assets. This permanent loss will severely impact the economy given the presence of major infrastructure and residential and commercial properties associated with the tourism industry along the coast in Cape May County. In addition, the densely developed coast has high property values and contributes to the tax base, as well as local and regional economies. The total replacement cost value of structures located in the +1 foot through +4 foot sea level rise inundation areas are $308.3 million, $1.3 billion, $6.4 billion, and $17.9 billion, respectively.

Additionally, disruption to business operations can occur in cases where infrastructure is breached by erosion caused by sea level rise. Loss of income may occur as a secondary impact if businesses are closed under repairs due to this breaching. To prevent these potential business losses, public expenditures may need to be spent to implement shoreline stabilizers and to protect key infrastructure like highways and interstates that follow along the coastline.

For discussion on the impacts of climate change influenced extreme temperature and severe weather events on the economy, refer to the Severe Weather profile (Section 5.4.8).

Impact on Land Use Types and the Environment

According to the State of New Jersey 2019 Hazard Mitigation Plan, sea level rise exacerbates coastal erosion and shoreline destabilization. Erosion would inhibit these natural landscapes to perform important ecosystem services such as buffering against future land loss, filtering pollutants, and maintaining a livable habitat that enhances the aesthetics of these coastal environments. Consequentially, natural habitats that would mitigate and protect the coastline become unstable and require replenishment actions (State of New Jersey 2019). The 2019 State Hazard Mitigation Plan references a 2016 report by Rutgers University Science and Technical Advisory Panel (STAP), which projects a 50-percent probability that:

- By 2030, sea level rise will meet or exceed 0.8 feet;
- By 2050, sea level rise will meet or exceed 1.4 feet;
- By 2100, sea level rise will meet or exceed 2.3 feet.

It should be noted that while the current State Hazard Mitigation Plan references the Rutgers STAP projections, at this time, there is no agreed upon model across agencies in the State to project sea level rise. The STAP report was updated in 2019 to slightly increase the expected sea level rise likely to occur in 2100 (3.3 feet in a moderate emissions scenario).

In addition, an exposure analysis utilizing the NOAA 2017 sea level rise projections and the acreage of land use types were assessed for Cape May County's updated hazard mitigation plan. Residential, non-residential, and natural land use types were assessed using the 2015 NJDEP land use land cover data for Cape May County. Overall, natural land use types are the most exposed to the sea level rise hazard areas (up to 55.9-percent). Refer to Table 5.4.1-14.

Table 5.4.1-14. Land Use Types Exposed to the Sea Level Rise Hazard Areas

Land Use Type	Total Acres of Land Use Type Category in Cape May County	Land Use Types Exposed to Sea Level Rise + 1 foot Hazard Area	Percent of Total Acres of Land Use Type	Land Use Types Exposed to Sea Level Rise + 2 foot Hazard Area	Percent of Total Acres of Land Use Type	Land Use Types Exposed to Sea Level Rise + 3 foot Hazard Area	Percent of Total Acres of Land Use Type	Land Use Types Exposed to Sea Level Rise + 4 foot Hazard Area	Percent of Total Acres of Land Use Type
Residential Land Use Type	22,296	142	0.6%	566	2.5%	1,744	7.8%	3,311	14.9%
Non-Residential Land Use Type	160,338	64,865	40.5%	71,214	44.4%	75,060	46.8%	79,469	49.6%
Natural Land Use Type	139,026	64,731	46.6%	70,815	50.9%	74,068	53.3%	77,683	55.9%
Cape May County (Total)	**182,633****	**65,008**	**35.6%**	**71,780**	**39.3%**	**76,804**	**42.1%**	**82,781**	**45.3%**

Sources: NJDEP 2015; NOAA 2017

Notes:

Residential land use types from the 2015 land use land cover data include mixed residential, residential high density or multiple dwelling, residential rural single unit, residential single unit low density, and residential single unit medium density.

Non-residential land use types include: agricultural wetlands (modified), airport facilities, altered lands, artificial lakes, athletic fields (schools), Atlantic Ocean*, bare exposed rock, rock slides, etc*, beaches*, bridge over water, commercial/services, coniferous brush/shrubland*, coniferous forest (>50% crown closure)*, coniferous forest (10-50% crown closure)*, coniferous scrub/shrub wetlands*, coniferous wooded wetlands*, cropland and pastureland, deciduous brush/shrubland*, deciduous forest (>50% crown closure)*, deciduous forest (10-50% crown closure)*, deciduous scrub/shrub wetlands*, deciduous wooded wetlands*, disturbed tidal wetlands*, disturbed wetlands (modified)*, dredged lagoon, former agricultural wetland (becoming shrubby, not built-up), herbaceous wetlands*, industrial, major roadway, managed wetland in built-up maintained rec area*, managed wetland in maintained lawn greenspace*, military installations, mixed deciduous/coniferous brush/shrubland*, mixed forest (>50% coniferous with >50% crown closure)*, mixed forest (>50% coniferous with 10-50% crown closure)*, mixed forest (>50% deciduous with >50% crown closure)*, mixed forest (>50% deciduous with 10-50% crown closure)*, mixed scrub/shrub wetlands (coniferous dom.)*, mixed scrub/shrub wetlands (deciduous dom.)*, mixed urban or built-up land, mixed wooded wetlands (coniferous dom.)*, mixed wooded wetlands (deciduous dom.)*, natural lakes*, old field (< 25% brush covered)*, open tidal bays*, orchards/vineyards/nurseries/horticultural areas, other urban or built-up land, phragmites dominate coastal wetlands*, phragmites dominate interior wetlands*, phragmites dominate old field*, railroads, recreational land, saline marsh (high marsh)*, saline marsh (low marsh)*, stadium, theaters, cultural centers and zoos, stormwater basin, streams and canals*, tidal mud flat*, tidal rivers, inland bays, and other tidal waters*, transitional areas, transportation/communication/utilities, upland rights-of-way undeveloped*, vegetated dune communities, and wetland rights-of-way*.*

Please note, natural land areas are a sub-section of non-residential land use types and are referenced with an asterisk (*).

***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*

For more detailed discussion on the impacts of climate change influenced extreme temperature and severe weather events on land use and the environment, refer to the Severe Weather (Section 5.4.8).

Cascading Impacts on Other Hazards

Sea level rise and climate change can exacerbate the impacts of coastal erosion, drought, flooding, hurricanes, tropical storms, Nor'Easters, severe weather, severe winter weather, tsunamis, and wildfires. However, truly understanding the future impacts sea level rise and climate change will have on other hazards is challenging. As discussed in earlier sections, sea level rise projections show that coastal areas will become inundated. This inundation may cause a loss in protective shoreline dunes and stabilizing plant material. Further, the level of inundation will vary along the shoreline, which will change the flood dynamics of the coastal communities. Climate change will have an effect on all natural hazards of concern for the County and are discussed in Section 5.4.2 (Coastal Erosion), Section 5.4.4 (Drought), Section 5.4.5 (Flood), Section 5.4.6 (Hurricane and Tropical Storms), Section 5.4.7 (Nor'Easter), Section 5.4.8 (Severe Weather), Section 5.4.9 (Severe Winter Weather), Section 5.4.10 (Tsunami), and Section 5.4.11 (Wildfire).

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 (County Profile), areas targeted for future growth and development have been identified across Cape May County. Any areas of growth located in the projected sea level rise hazard areas may become permanently inundated. It is recommended that the County and municipal partners implement design strategies that mitigate against the risk of sea level rise and climate change or avoid development in potential sea level rise inundation areas.

Cape May County has already begun mitigation projects to help reduce the future impacts sea level rise will have on future development. The New Jersey State Hazard Mitigation Plan lists several projects that have been proposed, are ongoing, or have been complete in Cape May County such as a beach nourishment projects, inlet flood reduction projects, and coastal habitat restoration and protection projects (State of New Jersey 2019).

Projected Changes in Population

Cape May County has experienced population declines since 2010. However, the County has a highly variable seasonal population that is estimated to be an eight-fold increase from its year-round population. These population increases are most noticeable in barrier island communities such as Ocean City, where the Census population of 11,701 people in 2010 explodes to an estimated 147,612 people when factoring day-trippers, marina slips, and hotel/motel units. Increases in seasonal population will increase the overall number of persons at risk to the impacts of future climate change and sea level rise.

Climate Change

Impacts of climate change can lead to shoreline erosion, coastal flooding, and water pollution, affecting man-made coastal infrastructure and coastal ecosystems. Coastal areas may be impacted by climate change in different ways. Coastal areas are sensitive to sea level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures. Additionally, oceans are absorbing more carbon dioxide from the rising atmospheric concentrations of the gas, resulting in oceans becoming more acidic. This could have significant impacts on coastal and marine ecosystems (NOAA 2020). As the coastline recedes inland as a result of climate change and sea level rise, the County's vulnerability to other hazards, including hurricanes and coastal erosion, may increase.

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, NOAA's 2017 modeled 1-foot increment sea level rise data was also used to assess potential change in future flood inundation risk. This data is an update compared to the 2010 U.S. Census population and 2012 NOAA sea level rise inundation polygon data used in the 2016 hazard mitigation plan.

Overall, this vulnerability assessment provides the County an estimated exposure assessment for the sea level rise hazard.

5.4.2 Coastal Erosion

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

2021 Plan Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences (updated with events that occurred between 2016 and 2020), probability of future occurrence, and potential climate change impacts using best available data.
- A vulnerability assessment section was completed for the coastal erosion hazard that provides a more accurate estimated exposure and potential losses to Cape May County.

5.4.2.1 Profile

Hazard Description

Along with flooding, coastal erosion is one of the primary coastal hazards leading to loss of lives or damage to property and infrastructure in damaged coastal areas. Erosion is the process of the wearing away of beaches and bluffs along the coastline by large storms, flooding, strong wave action, sea level rise, and human activities. Erosion occurs when the waves and currents remove sand from the beach system. The loss of sand causes the beach to become narrower and lower in elevation. During storms, waves carry the sand offshore, depositing and storing the sediment in large sandbars. In weeks and months following the storm, the sand is returned to the beach by calmer waves (CRS Coordinator's Manual 2017). However, transfer of sand down the beach due to longshore currents may result in a net loss of sand to a beach if new sand does not migrate into the area to offset the longshore losses.

> Coastal erosion is a complex physical process shaped by both natural processes and human activity. Natural factors include the sand supply; changes in sea level or the water level in the Great Lakes; geologic characteristics of the shore; the effects of waves, currents, tides, and wind; and the bathymetry of the offshore sea bottom. Human activity may have direct or indirect effects on the coastal areas (USGS 2015).

Many natural factors affect erosion of the shoreline, including shore and nearshore morphology, shoreline orientation, and the response of these factors to storm frequency and sea level rise. Coastal shorelines change constantly in response to wind, waves, tides, sea-level fluctuation, seasonal and climatic variations, human alteration, and other factors that influence the movement of sand and material within a shoreline system.

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

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

Sandy barrier/bluff coastlines are constantly changing as the result of wind, currents, storms, and sea level rise. Because of this, developed sandy shorelines are often stabilized with hardened structures (seawalls, bulkheads, revetments, rip-rap, gabions, and groins) to protect coastal properties from erosion. While hardened structures typically prove to be beneficial in reducing property damage, the rate of coastal erosion usually increases near stabilization structures. Shore protection structures such as seawalls and revetments tend to eliminate natural wave run-up and sand deposition processes and can increase reflected wave action and currents at the waterline. Increased wave action can cause localized scour in front of structures and prevent settlement of suspended sediment (FEMA 1996). This increased erosion impacts natural habitats, spawning grounds, recreational activity areas, and public access (Frizzera 2011). According to the NJDEP, Cape May County has a number of shoreline structures that includes one breakwater structure, 94 groins, eight jetties, four revetments, and three seawalls (NJDEP 1993).

Coastal erosion can be classified as short-term or long-term. The long-term changes of shoreline may not be evident on a day-to-day or even year-to-year basis. They occur over a period of decades, over which short-term changes tend to average out to the underlying erosion or accretion trend. However, short-term changes due to storm events are immediately noticed. Short-term changes occur over periods ranging from a few days to a few years. They can be highly variable in direction and magnitude.

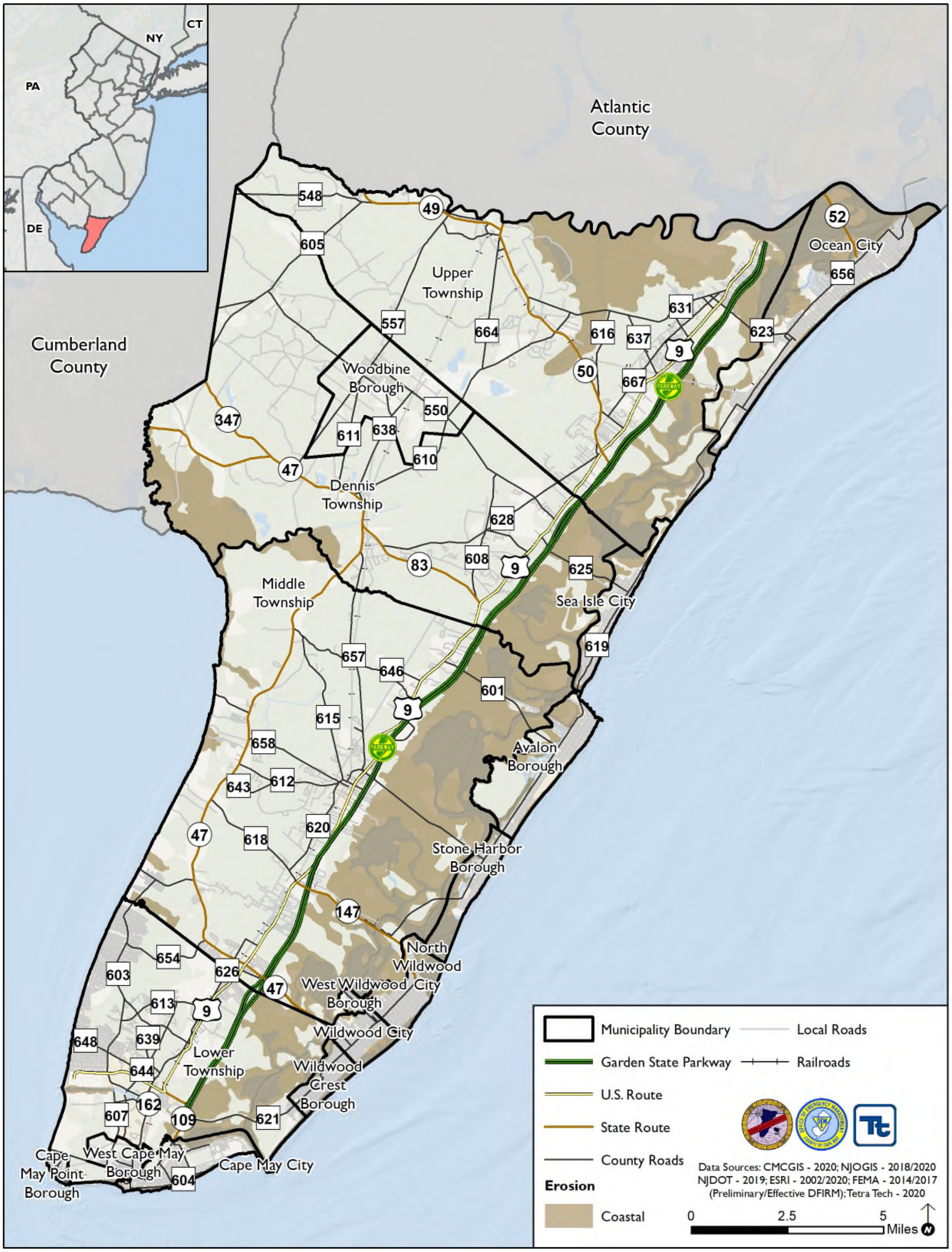
Coastal erosion is typically a sporadic event and most typically associated with another hazard event, such as a hurricane. Additionally, erosion rates are influenced by local geographic features and man-made structures. Although most typically associated with flooding, coastal erosion can also be caused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

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

Location

NJDEP defines ‘coastal’ as any land adjacent to a tidally influenced waterway. New Jersey has three primary coastal regions: the Atlantic Coast which includes communities along the Atlantic Ocean and communities that lie inland of the Atlantic coast barrier islands; the Delaware Bayshore; and the urban coast which includes communities such as Jersey City and Hoboken that lie along the tidal portion of the Hudson River (Rutgers 2014). The coastal area includes coastal waters to the limit of tidal influence including: the Atlantic Ocean (to the limit of New Jersey's seaward jurisdiction); Upper New York Bay, Newark Bay, Raritan Bay and the Arthur Kill; the Hudson, Raritan, Passaic, and Hackensack Rivers, and the tidal portions of the tributaries to these bays and rivers. The Delaware River and Bay and other tidal streams of the Coastal Plain are also in the coastal area, as is a narrow band of adjacent uplands in the Waterfront Development area beyond the CAFRA area (NJDEP 2014). As previously stated, a coastal area is any land adjacent to a tidally influenced waterway; therefore, Cape May County is considered a coastal county because nearly all its municipalities lie along the tidal portion of the Delaware Bay or the Atlantic Ocean. Figure 5.4.2-1 illustrates the coastal areas of Cape May County.

Figure 5.4.2-1. Coastal Erosion Hazard Area in Cape May County



Catastrophic events can alter the natural features of the shoreline, such as beaches, dunes, and wetlands, and threaten people and property. The prediction of a rising sea level and an increase in storm frequency and intensity, will result in the exacerbation of vulnerability to the risks of coastal hazards (NJDEP 2020).

New Jersey Beach Profile Network

In 1986, The Richard Stockton College Coastal Research Center (CRC) established the New Jersey Beach Profile Network (NJBPN) for the purpose of monitoring shoreline conditions along New Jersey's coast. NJBPN consists of over 100 beach profile sites along the entire shoreline of New Jersey, including the Raritan and Delaware Bays. The profile sites are spaced approximately one mile apart, with at least one site located in each oceanfront municipality. The dune, beach, and nearshore are surveyed at each profile site twice a year (fall and spring), and analyzed for seasonal and multiyear changes in shoreline position and sand volume. Reports on all beach profiles are published annually (Stockton University 2020).

There are 31 NJBPN survey sites along the beaches of Cape May County, consisting of a combination of barrier islands, coastal headlands, and the Delaware Bay shore. There are 27 sites along the Atlantic Ocean and four set along the Delaware Bay of western Cape May County. The profile sites are located in the following municipalities of the County: Ocean City, Strathmere (Upper Township), Sea Isle City, Avalon Borough, Stone Harbor Borough, City of North Wildwood, City of Wildwood, Lower Township, City of Cape May and the Borough of Cape May Point. The four Delaware Bay profiles are located in Reeds Beach (Middle Township), Villas (Lower Township), North Cape May (Lower Township), and Higbee Beach State Park.

Delaware Bay Shoreline of Western Cape May County

During 2013 and 2014, habitat restoration work commenced through an umbrella of conservation groups funded with National Fish & Wildlife Foundation Hurricane Sandy recovery money. Sandy destroyed or severely damaged 70 percent of known horseshoe crab spawning habitat on the New Jersey Delaware Bay shoreline. These marsh edge beaches consist of thin veneers of coarse sand supporting spawning activity each May of the largest population of horseshoe crabs worldwide. Sandy's storm surge and waves inundated and over-washed these low elevation beaches removing the thin veneer of sand exposing the salt marsh below, leaving an inhospitable shoreline for horseshoe crab spawning and successful egg production. Attention initially focused on restoring the western shoreline of Cape May County (Pierces Point – Reeds Beach) and included Moore's Beach in eastern Cumberland County. This stretch of post Sandy degraded shoreline was determined as critical habitat and targeted for immediate restoration based on documented reliance on the region for spawning and subsequent migratory shorebird foraging. Red Knots and other northbound migratory shorebirds depend on the horseshoe crab eggs as a major source of nutrients during their stopover along the Delaware Bay, adding critical weight needed to complete their long flight from South America to the Artic breeding grounds each spring. Sand for restoration was supplied from Cape May County quarries and the beaches engineered to have a steeper sloping beachface with a beach berm elevation just above normal mean higher high water. Restoration work expanded during 2015 westward along the Delaware Bay shoreline into Cumberland County (Fortescue, Thompson Beach and Dyer Cove (2016)) restoring additional sandy beach habitats suitable for horseshoe crab spawning damaged by Hurricane Sandy (Stockton 2019).

Other efforts focused on sediment distribution budgets and documentation of wave energy flux (heights, periods and direction of travel) along the lower Delaware Bay NJ shoreline. Installation of various structure types supporting oyster growth and development is providing interesting data on wave energy reduction at the sand beach. The structures act as nearshore oyster reefs to attenuate wave energy, reduce erosion rates and prolong the stability of the rebuilt beaches. Local oystermen are interested in this and similar approaches to oyster propagation as aquaculture opportunities especially viable along the bay front in Cape May County. Structures range from natural shell to "oyster castle" concrete shapes and timber and rebar platforms placed nearshore in water depths that expose the structures at low tide, but covers them completely during the higher tide cycle. Wave measurements have shown a reduction in incident wave energy at the beach landward of the structures versus open approach sections of the coastline. The combined efforts and methodologies helped restore the degraded shoreline and assist the migratory shorebirds including the Red Knot that depends on nutrients from horseshoe crab eggs to gain weight to complete their migration and for successful breeding (Stockton 2019).

Marsh restoration is being incorporated into the Maurice River delta area to convert extensive mud flats back into viable marsh habitat. In addition, the USACE completed a feasibility study to use dredged sands from Delaware Bay to reduce coastal storm risks in three bayshore communities. Potential sources of sand are from maintenance of the Delaware River Main Channel-Lower Reach E or from the Buoy 10 open water disposal site located one mile east of the Delaware Main Channel. In March 2018, the Township of Lower submitted a proposal to the US Army Corps of Engineers (Section 1122 of the Water Resources Development Act) for the use of this source of dredged material to improve shore protection (Stockton 2019).

Cape May City

Cape May City beaches continue to shed sand into the "Cove" beach belonging to The Nature Conservancy. These losses are remedied during the US Army Corps of Engineers work between Cold Spring Inlet and Cape May Point. Added studies were approved by the City in 2016 to better understand the beach configuration and seaward slope data following a number of injury complaints alleged to be the result of a too steep a beach and enhanced wave breaking at the beach. However, an administration change in the fall of 2016 election resulted in suspending this municipal study (Stockton 2019).

The Wildwoods

The North Wildwood beaches continue to lose sand primarily at the northeastern end of the island at Hereford Inlet. The North Wildwood situation appears to be the most troublesome concern in Cape May County with serious beach loss driving the municipality to undertake multiple emergency construction projects in the absence of the final USACE shore protection project (Stockton 2020). Sand back-passing from Wildwood City has been quite successful in holding the shoreline without returning to the ebb-tidal delta deposit in Hereford Inlet (Stockton 2019).

Work by the Philadelphia District USACE continues toward an approved design document for the Wildwoods that includes sand harvesting from Wildwood and Wildwood Crest and passing it back north to the erosion zone in North Wildwood instead of pumping in new sand from offshore or from the Hereford Inlet tidal shoals. The City of North Wildwood conducted sand harvesting work as well transferring 200,000 cy of Wildwood sand north in early 2017 and again by May 24, 2018. Interactions with the Department of the Interior regarding use of Hereford Inlet's ebb-tidal delta as a sand source produced agreement from the Department Secretary to allow access to the authorized borrow zone for hydraulic dredging for beach nourishment. This use was allowed under the exceptions to employing federal funding within the NJ Coastal Barrier Resource Unit #9 (Hereford Inlet) (Stockton 2019).

Avalon & Stone Harbor

These two communities have been leaders in shore protection by having successfully managed to have Federal shore protection projects constructed and, for years, have promoted wider, higher dunes with coordinated development of pedestrian access pathways that do not make a breach easier at street end access points. The US Army Corps of Engineers completed a project restoration from the 8th Street jetty to 31st Street in Avalon and from 70th Street in Avalon south to the terminal groin south of 123rd Street in Stone Harbor. This work was completed under PL 113-2 Emergency Restoration funds for Hurricane Sandy damage to the federal project. Since that was completed in early 2013, erosion claimed the sand to the revetment rocks at 12th Street in Avalon. The Borough conducted its individual beach project in 2015 adding 740,000 cy between 9th and 25th Streets.

The USACE returned in 2017 adding over 900,000 cubic yards (cy) to the Avalon beach. Currently a sand back-passing operation is underway to move sand from the mid-island borrow zone beaches to the erosional part of the island. Stone Harbor's southern oceanfront has suffered severe loss rates culminating in NE storm damage in early 2016 that were addressed in 2017 with some Hereford Inlet sand. Sand was also pumped from Townsend's Inlet ebb-tidal delta to Stone Harbor due to issues related to Hereford Inlet being located within a unit of the Coastal Barrier Resource System (CBRS) that prohibits federal funds for use to promote "development" within or for extraction of sediment out of the CBRS unit. This prohibition was lifted by the Department of the Interior Secretary in the fall of 2019 (Stockton 2019).

Sea Isle City & Strathmere

A 2009 NJ State and locally sponsored shore protection project saved these two communities from substantial damage from Hurricane Sandy with about 230,000 cubic yards of sand lost that was replaced starting April 17, 2015 in Ocean City under a federal responsibility for Ludlam Island. This project covered from 42nd Street to 59th Street in Ocean City and extended from Seaspray Avenue south to 93rd Street in Stone Harbor and was accomplished using sand from offshore borrow sites previously defined. Sand was added first in Ocean City, then starting in Strathmere and working south finishing at 93rd Street in Sea Isle City. Over 3.4 million cubic yards of new sand was pumped onto this island from offshore borrow sites by 2016 (Stockton 2019).

The Corson's Inlet State Park shoreline south of development in Ocean City suffered dune loss of considerable magnitude during Hurricane Sandy. Since sand moves south naturally under wave dominance from the northeast, this shoreline should benefit from any sand losses in Ocean City's part of the new project. The dune will need fencing to encourage reconstruction as the beach widens. The position of the main tidal channel in Corson's Inlet has been monitored because it's position vis-à-vis the Strathmere inlet shoreline is critical to the rates of erosion observed on the southern shoreline. Restoration work was recently completed at the Strathmere side and north of the State Park on the Ocean City side of Corson's Inlet using ebb-tidal delta sand and appears to be stable (Stockton 2019, 2020).

Ocean City

The Ludlam Island project also included 1.5 million cubic yards of sand for the southern shoreline of Ocean City that was damaged by Hurricane Sandy due to low, narrow dunes. This places the shoreline between Great Egg Inlet in Ocean City and Hereford Inlet in Stone Harbor under USACE project jurisdiction with a 3 to 5-year expectancy of maintenance work on restoring these beaches to the design specifications (Stockton 2019).

Ocean City continues to lose sand south to 12th Street with the middle section of the City remaining stable (Stockton 2020).

For details regarding the restoration and/or beach nourishments efforts within the County, please refer to the NJBPN Annual Reports found here: https://www.stockton.edu/coastal-research-center/njbpn/reports.html

Extent

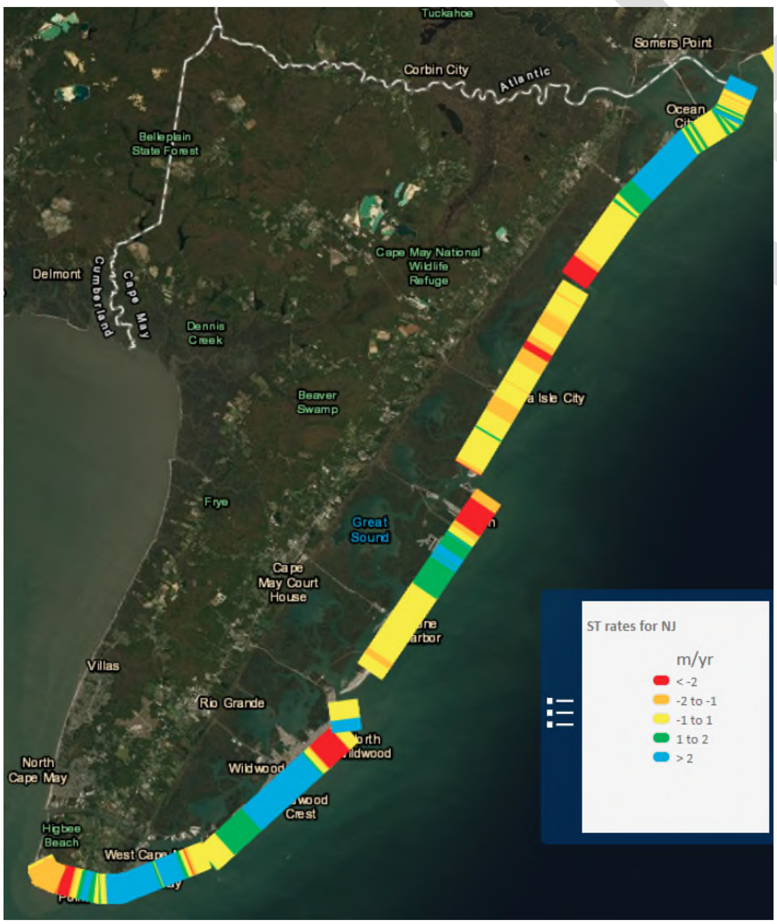
All beaches are affected by storms and other natural events that cause erosion; however, the extent and severity of erosion differs across the United States. It may be intensified by activities such as boat wakes, shoreline hardening, or dredging. Natural recovery after erosive episodes can take months or years. If a dune or beach does not recover quickly enough via natural processes, coastal and upland property may be exposed to further damage in subsequent events. Coastal erosion can cause the destruction of buildings and infrastructure (FEMA 1996).

Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a period of time. Geologists measure the severity of erosion in two ways -- as a rate of linear retreat (feet of shoreline recession per year) and volumetric loss (cubic yards of eroded sediment per linear foot of shoreline frontage per year) (NYC Emergency Management 2019).

Coastal erosion can be rapid or can occur gradually. However, measuring gradual (or long-term) erosion is often difficult, because the extent of natural erosion in a specific shoreline varies significantly from year to year. If choices are made to dredge or nourish beaches along particular parts of the coast, it can be difficult to determine how much beach is being lost or gained through natural processes and how much is being affected by human activities (NYC Emergency Management 2019). Coastal erosion may also be exacerbated by human activities, such as boat wakes, shoreline hardening, and dredging (FEMA 1996). In barrier islands and barrier spits, severe erosion can result in the formation of tidal inlets.

The USGS Coastal Change Hazards Portal hosts a short-term (30 years) change mapper, which displays the rate of average shoreline change on coastal shorelines. The Portal indicates that, over the past 30 years, Cape May County had various rates shoreline change ranging from >2 meters added per year to <2 meters lost per year on the Atlantic Coast. Figure 5.4.2-2 displays short-term shoreline change rates for Cape May County's Atlantic Coast.

Figure 5.4.2-2. Shoreline Change Rates for Cape May County



Source: USGS 2020

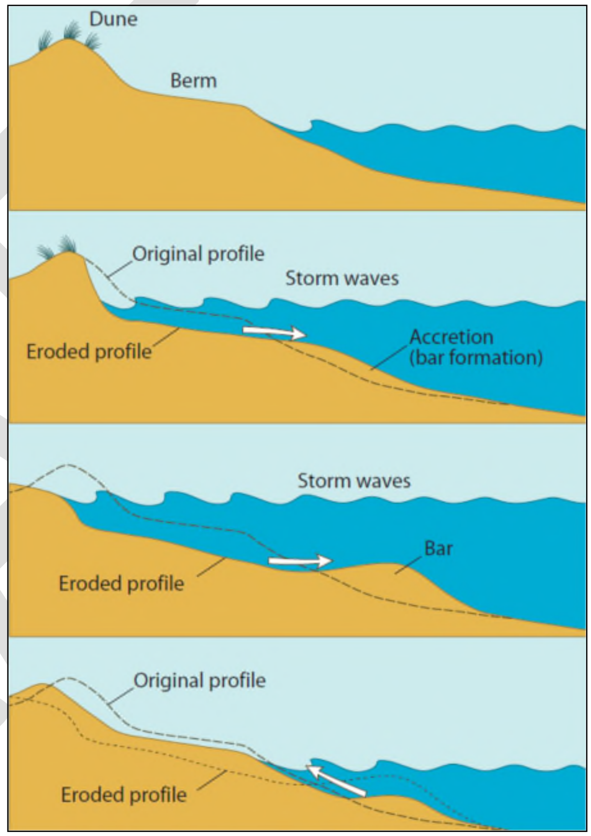
A number of factors determine whether a community exhibits greater long-term erosion or accretion:

- Exposure to high-energy storm waves,

- Sediment size and composition of eroding coastal landforms feeding adjacent beaches,
- Near-shore bathymetric variations which direct wave approach,
- Alongshore variations in wave energy and sediment transport rates,
- Relative sea level rise,
- Frequency and severity of storm events, and
- Human interference with sediment supply (e.g. revetments, seawalls, jetties) (Woods Hole Sea Grant 2003).

Beaches constantly change from day-to-day, week-to-week, month-to-month, and year-to-year, primarily in response to waves. The size and presence of any part of a beach, at a given time, is influenced by a number of factors: size and direction of the waves, size and shape of sand grains on the beach, the level of water at the time waves strike, and the initial shape of the beach. Waves play a major role in controlling the form, position and size of the beach. Waves are responsible for picking up and moving sand along the coast. The beach responds quickly to changes in wave energy. Very large, choppy waves tend to pick up and remove sand from the beach berm. This lowers the elevation which flattens the beach profile and causes the berm and shoreline to move landward. The material picked up from the waves can move in many directions depending on numerous factors. Most frequent, material is moved offshore and is deposited in a bar during storms. As the bar grows, it causes larger waves to break and dissipate their energy before they reach the landward berm, all which help the beaches protect themselves. In calmer weather, long, gentle waves can pick up much of the sand and bring it back onshore, building up the berm, raising the height of the backshore and moving the beach berm and shoreline back seaward. This creates a cycle where the beach erodes and builds back up in response to wave action. Over the course of a year, beaches can move back and forth by as much as 270 feet (Tanski 2012). Figure 5.4.2-3 illustrates the beach response to waves.

Figure 5.4.2-3. Beach Response to Waves



Source: Tanski 2012

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with coastal erosion 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.

Although many factors contribute to the natural coastal erosion of Cape May County shorelines; historical hurricanes, tropical storms and Nor'Easter events have significantly increased coastal erosion processes throughout Cape May County. Because Cape May County is primarily surrounded by coastal waters, most tropical and extra-tropical events that commonly occur within the area result in significant losses and temporary or permanent changes to the County's shorelines. Details regarding Hurricane and Nor'Easter events that have impacted Cape May County are presented earlier in Section 5.4.5 and Section 5.4.6, respectively.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2020, the State of New Jersey was included in nine FEMA coastal erosion-related disasters (DR) or emergencies (EM), classified as one or a combination of the following event types: severe storm, flood, coastal storm, high tides, heavy rain, Nor'Easter, tropical storm, and hurricane. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Of those eight declarations, Cape May County was included in seven of the declarations (Table 5.4.2-1) (FEMA 2020).

Table 5.4.2-1. Coastal Erosion-Related FEMA DR and EM Declarations for Cape May County

FEMA Declaration Number	Date(s) of Event	Event Type	Location
DR-973	December 10-17, 1992	Coastal Storm, High Tides, Heavy Rain, Flooding	Atlantic, Bergen, Cape May, Cumberland, Essex, Hudson, Middlesex, Monmouth, Ocean, Salem, Somerset, Union
DR-1206	February 4-8, 1998	Coastal Storm	Atlantic, Cape May and Ocean
DR-1867	November 11-19, 2009	Severe Storms and Flooding Associated with Tropical Depression Ida and a Nor'Easter	Atlantic, Cape May and Ocean
DR-4021	August 26 – September 5, 2011	Hurricane Irene	Twenty-one Counties in New Jersey including Cape May County
DR-4048	October 29, 2011	Severe Storm	Bergen, Cape May, Essex, Hunterdon, Middlesex, Morris, Passaic, Somerset, Sussex, Union, Warren
DR-4086	October 26 – November 8, 2012	Hurricane Sandy	Twenty-one Counties in New Jersey including Cape May County
DR-4264	January 22-24, 2016	March 14, 2016	Severe Storm(s): Severe Winter Storm and Snowstorm

Source: FEMA 2020

U.S. Department of Agriculture Disaster Declarations

Between 2016 and 2020, the period for which data was available, Cape May County was not included in any declarations related to coastal erosion.

Previous Events

For this 2021 Plan Update, known coastal erosion events that have impacted Cape May County between 2016 and 2020 are identified are identified in Table 5.4.2-2. For events prior to 2016, refer to Appendix E (Risk Assessment Supplementary Data).

Table 5.4.2-2. Coastal Erosion Events in Cape May County, 2016 to 2020

Dates of Event	Event Type	FEMA Declaration Number	Cape May County Designated?	Location	Losses / Impacts
January 22-24, 2016	Winter Storm & Coastal Flooding (Winter Storm Jonas), Coastal Erosion	DR-4264	Yes	Cape May County	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. A 64 MPH wind gust was recorded on the 23rd near Strathmere (Cape May). At one point during the storm, up to 270,000 customers were without power. Outages were concentrated closer to the coast where the strongest winds occurred. New Jersey Governor Chris Christie declared a State of Emergency on Friday, January 22nd for the duration of the event. Schools and many businesses recessed early on Friday afternoon in anticipation of the storm. 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. The New Jersey Department of Transportation spent approximately $25 million dollars to clear and maintain the state's highways and roadways. In seeking federal disaster aid, Governor Chris Christie announced the storm cost the state of New Jersey $82.6 million in damages and expenses. 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).
September 3-6, 2016	Coastal Erosion, Tropical Storm Hermine	N/A	N/A	Cape May County	Slow moving tropical cyclone Hermine caused several days of 8 to 12 feet of surf breaking on Atlantic Ocean shorelines. Cape May County beaches experienced moderate erosion.

Dates of Event	Event Type	FEMA Declaration Number	Cape May County Designated?	Location	Losses / Impacts
March 14, 2017	Coastal Erosion, Coastal Flood	N/A	N/A	Ocean City, Wildwood	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.
July 29, 2017	Coastal Flood and Heavy Rain	N/A	N/A	Cape May County	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.
September 19-20, 2017	Coastal Erosion, Tropical Storm Jose	N/A	N/A	North Wildwood, Ocean City	Tropical cyclone Jose tracked north and east along the Mid Atlantic coast Tuesday September 19th, eventually passing well offshore of Cape May County. Tidal flooding and erosion occurred. According to eyewitnesses and video, storm surge pounded the seawall at Third Avenue and Kennedy Boulevard, pouring over the top of the seawall in North Wildwood. Ocean City's north end experienced heavy erosion.
October 20-21, 2019	Coastal Erosion, Subtropical Storm Melissa	N/A	N/A	Sea Isle City, North Wildwood and Ocean City	Subtropical Storm Melissa caused erosion on Cape May Beaches. Most of the towns that saw the worst were in Cape May and Atlantic counties, including parts of Atlantic City, Sea Isle City, North Wildwood and Ocean City. North Wildwood was one of the hardest hit. There, surveyors recorded 40 feet of erosion on the beach, up to four feet in height, between 2nd and 7th Avenues. Five blocks of beach had 12-foot high scarps, according to the survey from the DEP's Division of Coastal Engineering. North Wildwood Mayor Patrick Rosenello estimated the city lost a total of 500,000 cubic yards of sand from the storm. In May, the city placed 200,000 cubic yards onto its beaches-- all of which was lost due to Melissa. In Ocean City, Subtropical Storm Melissa created scarps up to five feet high in the northern part of the island and wiped out dunes a few blocks from the Ocean City Music Pier, according to a DEP survey.

Dates of Event	Event Type	FEMA Declaration Number	Cape May County Designated?	Location	Losses / Impacts
May 22-24, 2020	Coastal Erosion	N/A	N/A	Cape May County	Northeast winds contributed to mild coastal erosion over the course of three days.
July 2, 2020	Coastal Erosion	N/A	N/A	Sea Isle City	A rapid erosion event at Townsend Inlet Beach was caused by a unique combination of beach profile and tidal currents. The event was not storm related, but due to oversteepening of the channel margin by scour. Video of the event went viral on social media platforms.
July 9, 2020	Coastal Erosion, Tropical Storm Fay	N/A	N/A	Cape May County	Tropical Storm Fay made landfall at the border of Ocean and Atlantic County bringing heavy rain and flash flooding. Significant erosion occurred in portions of the County including Cape May City.

Source: *NOAA-NCEI 2020; FEMA 2020, NHC 2020, Press of Atlantic City 2016, Cape May County Herald. 2017, Press of Atlantic City 2019, Press of Atlantic City 2020, CBSN Philly 2020.*

Probability of Future Occurrences

Long-term coastal erosion is a continuous and dynamic process, impacting the coastal counties along the Atlantic Ocean. It is anticipated that coastal erosion will continue due to the predicted increase in sea level rise and storm frequency and intensity. In New Jersey, coastal erosion will continue to be an on-going problem along many areas of coastline. It is difficult to assign a probability to the near constant small on-going erosion that may occur over a continuous period of time. However, a probability can be assigned to larger storm events such as Nor'easters and hurricanes, which can result in significant, rapid coastal erosion. The period of time suggest the probability of coastal erosion will be about the same in the future, with year-to-year variations. For information on the probability of coastal storms, refer to the Hurricane and Tropical Storm (Section 5.4.5) and Nor'Easter (Section 5.4.6) hazard profiles.

For Cape May County, impacts will vary from place to place along the surge-impacted areas of the County. As temperatures increase (see climate change impacts), the probability for future events will likely increase as well. It is estimated that Cape May County will continue to experience direct and indirect impacts of coastal erosion on occasion.

In Section 5.3, the identified hazards of concern for the County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Partnership, the probability of occurrence for coastal erosion in the County is considered 'frequent' (100% chance of occurring in any given year, 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).

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

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

in many locations. Assessments of shoreline change on barrier islands have shown that barrier island narrowing has been observed on some islands over the last 100 years (Gutierrez et al. 2007).

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). 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).

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).

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). As noted above, temperatures are predicted to increase in Cape May County, which lead to an increase in intensity and frequency of severe storm. This increase may lead to more weather patterns that cause coastal erosion events. Rising sea levels will also exacerbate erosional issues.

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

5.4.2.2 Vulnerability Assessment

To assess Cape May County's risk to the coastal erosion hazard, a spatial analysis was conducted using the best available spatially-delineated coastal erosion hazard areas. To determine the geographic distribution of coastal risk, the Limit of Moderate Wave Action (LiMWA) boundary was referenced from FEMA's 2014 Preliminary DFIRM and 2017 Effective DFIRM flood data. The LiMWA boundary was selected to assess coastal erosion because it represents land area that is susceptible to wave action. Wave action can be a driver for coastal erosion in Cape May County. Refer to Section 5.1 (Methodology and Tools) for additional details on the methodology used to assess coastal erosion risk.

Coastal erosion is a significant concern because of the large number of communities and cultural resources located along the coast in Cape May County. Beach dunes and other protective measures like sea walls serve as a buffer and protect the built environment and other natural resources on the mainland from coastal storm events such as hurricanes, tropical storms, and nor'easters, which can cause shoreline erosion or accretion. A changing climate and rising sea levels will have devastating impacts on New Jersey's economy, the health of its residents, the State's natural resources, and the extensive infrastructure system that provides transportation services, energy and clear water to millions of people in New Jersey (Rutgers University 2014). Please refer to Section 5.4.1 (Climate Change and Sea Level Rise) and Section 5.4.5 (Flood) for more information on the County's vulnerability to sea level rise and coastal flood hazards.

Impact on Life, Health and Safety

Coastal erosion is not generally considered an imminent threat to public safety when the changes are gradual over many years. However, drastic changes to the shoreline may occur as a result of a single storm event which can threaten homes and public safety. The population exposed, or located in the estimated hazard area, is also considered vulnerable to this hazard. The analysis indicates that 1,268 people are located in the estimated coastal erosion hazard area. Please note this table (Table 5.4.2-3) does not account for an increase in seasonal population along the County's coastal shores.

Table 5.4.2-3. Estimated Population Exposed to the Coastal Erosion Hazard

Jurisdiction	American Community Survey (2014-2018) Total Population	Estimated Population Exposed	
		Number of Persons Exposed to the Coastal Erosion Hazard Area	Percent of Total
Avalon Borough	1,409	11	0.8%
Cape May City	3,491	48	1.4%
Cape May Point Borough	188	0	0.3%
Dennis Township	6,244	15	0.2%
Lower Township	21,838	156	0.7%
Middle Township	18,492	438	2.4%
North Wildwood City	3,849	9	0.2%
Ocean City	11,202	257	2.3%
Sea Isle City	1,955	11	0.5%
Stone Harbor Borough	955	60	6.3%
Upper Township	11,909	139	1.2%
West Cape May Borough	1,103	0	0.0%
West Wildwood Borough	376	71	18.8%
Wildwood City	5,073	20	0.4%
Wildwood Crest Borough	3,131	34	1.1%
Woodbine Borough	2,490	0	0.0%
Cape May County (Total)	**93,705**	**1,268**	**1.4%**

Impact on General Building Stock

To estimate the general building stock exposed to coastal erosion, the updated building inventory was used. The total number of buildings with their centroid in the estimated hazard area were determined in GIS for each municipality. It is estimated that 1,891 buildings accounting for approximately $2 billion of replacement cost value are located in the estimated coastal erosion hazard area (Table 5.4.2-4). As mentioned above, please note the limitations of this analysis are recognized and the results should only be used as an estimate.

Table 5.4.2-4. Estimated Buildings Exposed to the Coastal Erosion Hazard

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed			
			Number of Buildings Exposed to the Coastal Erosion Hazard Area	Percent of Total	Total Replacement Cost Value Exposed to the Coastal Erosion Hazard Area	Percent of Total
Avalon Borough	5,867	$8,232,959,879	48	0.8%	$91,054,166	1.1%
Cape May City	4,234	$5,153,049,612	60	1.4%	$75,412,227	1.5%
Cape May Point Borough	785	$663,183,164	2	0.3%	$1,510,014	0.2%
Dennis Township	7,301	$3,813,425,173	14	0.2%	$11,197,921	0.3%
Lower Township	19,597	$9,950,232,225	196	1.0%	$205,465,667	2.1%
Middle Township	18,197	$11,557,342,752	352	1.9%	$177,157,079	1.5%
North Wildwood City	4,729	$4,423,365,953	74	1.6%	$155,942,162	3.5%
Ocean City	18,172	$17,100,920,036	432	2.4%	$440,783,157	2.6%
Sea Isle City	6,712	$7,663,928,227	37	0.6%	$62,845,017	0.8%
Stone Harbor Borough	3,836	$3,291,756,871	242	6.3%	$241,642,763	7.3%
Upper Township	9,627	$6,506,171,365	103	1.1%	$115,671,014	1.8%
West Cape May Borough	1,623	$1,178,516,373	0	0.0%	$0	0.0%
West Wildwood Borough	805	$459,103,094	159	19.8%	$92,051,909	20.1%
Wildwood City	3,679	$4,379,038,844	112	3.0%	$288,871,025	6.6%
Wildwood Crest Borough	5,410	$4,552,156,876	60	1.1%	$57,536,103	1.3%
Woodbine Borough	1,416	$1,335,589,432	0	0.0%	$0	0.0%
Cape May County (Total)	**111,990**	**$90,260,739,877**	**1,891**	**1.7%**	**$2,017,140,222**	**2.2%**

Impact on Critical Facilities

Coastal erosion can also impact critical facilities and lifelines. There are 76 critical facilities, 74 of which are identified as lifelines, located in the coastal erosion hazard area. Refer to Table 5.4.2-5 for these results by municipality and Table 5.4.2-6 for these results by municipality and critical facility type.

Table 5.4.2-5. Critical Facilities and Lifelines Located in the Estimated Coastal Erosion Hazard Area

Jurisdiction	Total Critical Facilities	Total Lifelines	Coastal Erosion Hazard Area			
			Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total
Avalon Borough	30	30	4	13.3%	4	13.3%
Cape May City	32	32	1	3.1%	1	3.1%
Cape May Point Borough	10	10	0	0.0%	0	0.0%
Dennis Township	60	60	1	1.7%	1	1.7%
Lower Township	111	111	17	15.3%	17	15.3%
Middle Township	181	181	15	8.3%	15	8.3%
North Wildwood City	30	29	2	6.7%	2	6.9%

Jurisdiction	Total Critical Facilities	Total Lifelines	Coastal Erosion Hazard Area			
			Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total
Ocean City	59	58	15	25.4%	15	25.9%
Sea Isle City	26	26	4	15.4%	4	15.4%
Stone Harbor Borough	26	26	2	7.7%	2	7.7%
Upper Township	73	68	6	8.2%	6	8.8%
West Cape May Borough	10	10	0	0.0%	0	0.0%
West Wildwood Borough	8	8	2	25.0%	2	25.0%
Wildwood City	39	37	6	15.4%	4	10.8%
Wildwood Crest Borough	23	23	1	4.3%	1	4.3%
Woodbine Borough	21	21	0	0.0%	0	0.0%
Cape May County (Total)	**739**	**730**	**76**	**10.3%**	**74**	**10.1%**

Table 5.4.2-6. Critical Facilities by Type Located in the Estimated Coastal Erosion Hazard Area

Jurisdiction	Critical Facilities in the Coastal Erosion Hazard Area											
	Airport	Bridge	Communications Tower	County Facilities	Grocery/ Food Processing	Marinas	Polling Places	Primary Education	Recreation	Superfund Sites	Wastewater Pump Station	Well
Avalon Borough	0	0	0	0	0	3	0	0	0	0	1	0
Cape May City	0	0	0	0	0	0	0	0	0	1	0	0
Dennis Township	0	0	1	0	0	0	0	0	0	0	0	0
Lower Township	0	1	0	0	0	14	0	0	0	0	0	2
Middle Township	0	7	1	0	0	6	0	0	0	0	1	0
North Wildwood City	0	0	0	1	1	0	0	0	0	0	0	0
Ocean City	1	4	0	0	0	4	1	1	0	1	3	0
Sea Isle City	0	2	0	0	0	2	0	0	0	0	0	0
Stone Harbor Borough	0	1	0	0	0	1	0	0	0	0	0	0
Upper Township	0	3	0	0	0	3	0	0	0	0	0	0
West Wildwood Borough	0	0	0	0	0	2	0	0	0	0	0	0
Wildwood City	0	0	0	0	0	2	1	0	2	1	0	0
Wildwood Crest Borough	0	0	0	0	0	1	0	0	0	0	0	0
Cape May County (Total)	**1**	**18**	**2**	**1**	**1**	**38**	**2**	**1**	**2**	**3**	**5**	**2**

Impact on Economy

Coastal erosion can also impact roads and infrastructure. As coastline evolution continues, evacuation and emergency routes need to be considered. Cape May County includes many significant roadways used for daily travel and hurricane evacuation routes. Using the hurricane evacuation routes for New Jersey spatial dataset, the exposure of these roadways to coastal erosion is evident. Evacuation routes that may be impacted by coastal erosion include State Road 109, State Road 50, State Road 52, US Rt 9, Garden State Parkway, North Wildwood Blvd, Delsea Dr, Avalon Blvd, Bayshore & Jonathan Hoffman Rd, Beach Ave, Sunset Blvd, Ocean Dr, Roosevelt Blvd, Sea Isle & JFK Blvd, Delaware Ave, Bay Ave, Stone Harbor Blvd. Of the 224 total miles of evacuation routes in the County, 15 miles are exposed to the coastal erosion hazard are (Table 5.4.2-7).

Table 5.4.2-7. Coastal Erosion Vulnerability for Hurricane Evacuation Routes

Total Miles of Evacuation Routes in the County	Total Miles of Evacuation Routes Exposed to the Coastal Erosion Hazard Area	Percent of Total
224	15	6.6%

Impact on the Environment

Coastal erosion is a natural process which defines and shapes coastal ecosystems. While disruptive, some species rely on the impacts of coastal erosion such as numerous nesting shorebirds. Severe coastal erosion events can lead to the destruction of current ecosystems. However, the destruction of one ecosystem leads to the creation of a different ecosystem (i.e. dune systems convert to sand flats or overwash fans). Negative overall impacts to the environment occur when coastal erosion eliminates critical habitat that is unlikely to be restored over time. Elimination of critical habitat is more likely to occur when shore-parallel structures like seawalls obstruct the natural evolution of shoreline ecosystems.

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 and sea level rise

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 defined coastal erosion hazard areas could be potentially impacted by coastal erosion similar to those that currently exist within the County. Of the areas of new development identified during the HMP update, only one recently completely commercial property in Wildwood is located in the coastal erosion hazard area.

Projected Changes in Population

The 2010 Census data indicates a County population of 97,265. However, more current data, according to U.S. Census Bureau, 2018 American Community Survey 5-Year Estimate, estimates a County population of approximately 93,705, which is a decrease in population since 2010. According to the South Jersey Transportation Planning Organization Regional Transportation Plan’s Demographic Forecast, it is likely that the current decline in population will be reversed but growth will be minimal through 2040 (SJTPO 2012). For more information on projected changes in population, refer to the County Profile (Section 4).

Climate Change

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

Impacts of climate change can lead to shoreline erosion, coastal flooding, and water pollution, affecting man-made coastal infrastructure and coastal ecosystems. Coastal areas may be impacted by climate change in different ways. Coastal areas are sensitive to sea-level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures. Additionally, oceans are absorbing more carbon dioxide from the rising atmospheric concentrations of the gas, resulting in oceans becoming more acidic. This could have significant impacts on coastal and marine ecosystems (EPA 2017). As previously stated, warmer temperatures may lead to an increase in frequency of storms, thus leading to more weather events with potentially increased severity, that cause coastal erosion.

Change of Vulnerability Since 2016 HMP

Since the 2016 analysis, population statistics have been updated using the 2014-2018 American Community Survey. The updated building stock inventory was created using building footprints and parcel data from the County, which was supplemented with 2013 MOV-ID tax assessor data and 2019 RS Means replacement cost value for building and content replacement costs. This provides an up-to-date look at the entire building stock for Cape May County and gives more accurate results for the exposure and loss estimation analysis.

Since 2016, ongoing coastal erosion mitigation projects have occurred including beach replenishment, replacement of bulkheading, and dredging of nearshore waterways. As the majority of these actions are continuations or restorations of protections in place prior to 2016, the changes in vulnerability to coastal erosion as a result of mitigation projects are not considered to be significant.

5.4.3 Disease Outbreak

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 disease outbreak hazard in Cape May County.

5.4.3.1 Profile

Hazard Description

An outbreak or an epidemic occurs when new cases of a certain disease, in a given population, substantially exceed what is expected. An epidemic may be restricted to one locale, or it may be global, at which point it is called a pandemic. Pandemic is defined as a disease occurring over a wide geographic area and affecting a high proportion of the population. A pandemic can cause sudden, pervasive illness in all age groups on a local or global scale. A pandemic is a novel virus to which humans have no natural immunity that spreads from person-to-person. A pandemic will cause both widespread and sustained effects and is likely to stress the resources of both the State and federal government (NJOEM 2019). The most recent occurrence of a pandemic is the novel Coronavirus, also known as COVID-19 which has exacerbated communities across the nation. While the pandemic has primarily affected areas with high population, Cape May County has also experienced significant impacts from this pandemic.

A disease outbreak is the occurrence of disease cases in excess of normal expectancy. The number of cases varies according to the disease-causing agent, and the size and type of previous and existing exposure to the agent. Disease outbreaks are usually caused by an infection, transmitted through person-to-person contact, animal-to-person contact, or from the environment or other media (WHO 2020).

Of particular concern in Cape May County are arthropod-borne viruses (arboviruses), which are viruses that are maintained in nature through biological transmission between susceptible hosts (mammals) and blood-feeding arthropods (mosquitos and ticks). More than 100 arboviruses can cause disease in humans; over 30 have been identified as human pathogens in the western hemisphere (New Jersey Department of Health and Senior Services 2008). New Jersey has been impacted by various past and present infestations including: high population of mosquitoes (mosquito-borne diseases) and deer ticks (tick-borne diseases).

Mosquito-borne diseases are diseases that are spread through the bite of an infected female mosquito. The three most common mosquito-borne diseases in New Jersey are: West Nile Virus (WNV), Eastern equine encephalitis (EEE) virus, and St. Louis encephalitis (SLE) virus. These diseases rely on mosquitos to spread. They become infected by feeding on birds carrying the virus; and then spread to humans and other animals when the mosquito bites them (New Jersey Department of Health 2013).

Tick-borne diseases are bacterial illnesses that spread to humans through infected ticks. The most common tick-borne diseases in New Jersey are: Lyme disease, Ehrlichiosis, Anaplasmosis, Rocky Mountain Spotted Fever, and Babesiosis. These types of diseases rely on ticks for transmission. Ticks become infected by micro-organisms when feeding on small infected mammals (mice and voles). Different tick-borne diseases are caused by different micro-organisms, and it is possible to be infected with more than one tick-borne disease at a time. Anyone who is bitten by an infected tick may get a tick-borne disease. People who spend a lot of time outdoors have a greater risk of becoming infected. The three types of ticks in New Jersey that may carry disease-causing micro-organisms are the deer tick, lone star tick, and the American dog tick (New Jersey Department of Health 2013b).

For the purpose of this HMP update, the following arboviruses will be discussed in further detail: West Nile Virus, Eastern equine encephalitis virus, Lyme disease, and Ebola virus. Influenza will also be discussed due to several outbreaks in the past five years. In addition, due to the COVID-19 pandemic that emerged during the development of this plan update, a brief description is described in this section.

West Nile Virus

West Nile Virus (WNV) encephalitis is a mosquito-borne viral disease, which can cause an inflammation of the brain. WNV is commonly found in Africa, West Asia, the Middle East and Europe. For the first time in North America, WNV was confirmed in the New York metropolitan area during the summer and fall of 1999. WNV successfully over-wintered in the northeastern U.S. and has been present in humans, horses, birds, and mosquitoes since that time. WNV is spread to humans by the bite of an infected mosquito. A mosquito becomes infected by biting a bird that carries the virus (New Jersey Department of Health 2014).

Eastern Equine Encephalitis

Eastern equine encephalitis (EEE) is a virus disease of wild birds that is transmitted to horses and humans by mosquitoes. It is a rare but serious viral infection. EEE is most common in the eastern half of the U.S. and is spread by the bite of an infected mosquito. EEE can affect humans, horses, and some birds. The risk of getting this virus is highest from late July through early October (New Jersey Department of Health 2012a). New Jersey represents a major focus for the infection with some form of documented viral activity nearly every year. Horse cases are most common in the southern half of New Jersey because the acid water swamps that produce the major mosquito vectors are especially prevalent on the southern coastal plain (Crans 2013).

Lyme Disease

Lyme disease is an illness caused by infection with the bacterium *Borrelia burgdorferi*, which is carried by ticks. The infection can cause a variety of symptoms and, if left untreated, can be severe. Lyme disease is spread to people by the bite of an infected tick. In New Jersey, the commonly infected tick is the deer tick. Immature ticks become infected by feeding on infected white-footed mice and other small mammals. Deer ticks can also spread other tick-borne diseases. Anyone who is bitten by a tick carrying the bacteria can become infected (New Jersey Department of Health 2012b).

Influenza

The risk of a global influenza pandemic has increased over the last several years. This disease is capable of claiming thousands of lives and adversely affecting critical infrastructure and key resources. An influenza pandemic has the ability to reduce the health, safety, and welfare of the essential services workforce; immobilize core infrastructure; and induce fiscal instability. Densely populated areas will spread diseases quicker than less densely populated areas (NJOEM 2019).

Pandemic influenza is different from seasonal influenza (or "the flu") because outbreaks of seasonal flu are caused by viruses that are already among people. Pandemic influenza is caused by an influenza virus that is new to people and is likely to affect many more people than seasonal influenza. In addition, seasonal flu occurs every year, usually during the winter season, while the timing of an influenza pandemic is difficult to predict. Pandemic influenza is likely to affect more people than the seasonal flu, including young adults. A severe pandemic could change daily life for a time, including limitations on travel and public gatherings (Barry-Eaton District Health Department 2013).

At the national level, the CDC’s Influenza Division has a long history of supporting the World Health Organization (WHO) and its global network of National Influenza Centers (NIC). With limited resources, most international assistance provided in the early years was through hands-on laboratory training of in-country staff, the annual provision of WHO reagent kits (produced and distributed by CDC), and technical consultations for vaccine strain selections. The Influenza Division also conducts epidemiologic research including vaccine studies and serologic assays and provided international outbreak investigation assistance (CDC 2010).

Ebola Virus

Ebola, previously known as Ebola hemorrhagic fever, is a rare and deadly disease caused by infection with one of the Ebola virus strains. According to the CDC, the 2014 Ebola epidemic is the largest in history affecting multiple countries in West Africa. Two imported cases, including one death, and two locally-acquired cases in healthcare workers have been reported in the United States. CDC and partners are taking precautions to prevent the further spread of Ebola in the United States (CDC, 2014).

Coronavirus

Coronavirus disease (COVID-19) is an infectious disease first identified in 2019. The virus rapidly spread into a global pandemic by spring of 2020. The elderly and those with underlying medical conductions such as cardiovascular disease, diabetes, chronic respiratory disease, and cancer are more likely to develop serious illness (WHO 2020). With the virus being relatively new, information regarding transmission and symptoms of the virus is emerging from the research. The COVID-19 virus spreads primarily through droplets of saliva or discharge from the nose when an infected person coughs or sneezes. Reported illnesses have ranged from mild symptoms to severe illness and death. Reported symptoms include trouble breathing, persistent pain or pressure in the chest, new confusion or inability to arouse, and bluish lips or face. Symptoms may appear 2-14 days after exposure to the virus (based on the incubation period of MERS-CoV viruses) (CDC 2020).

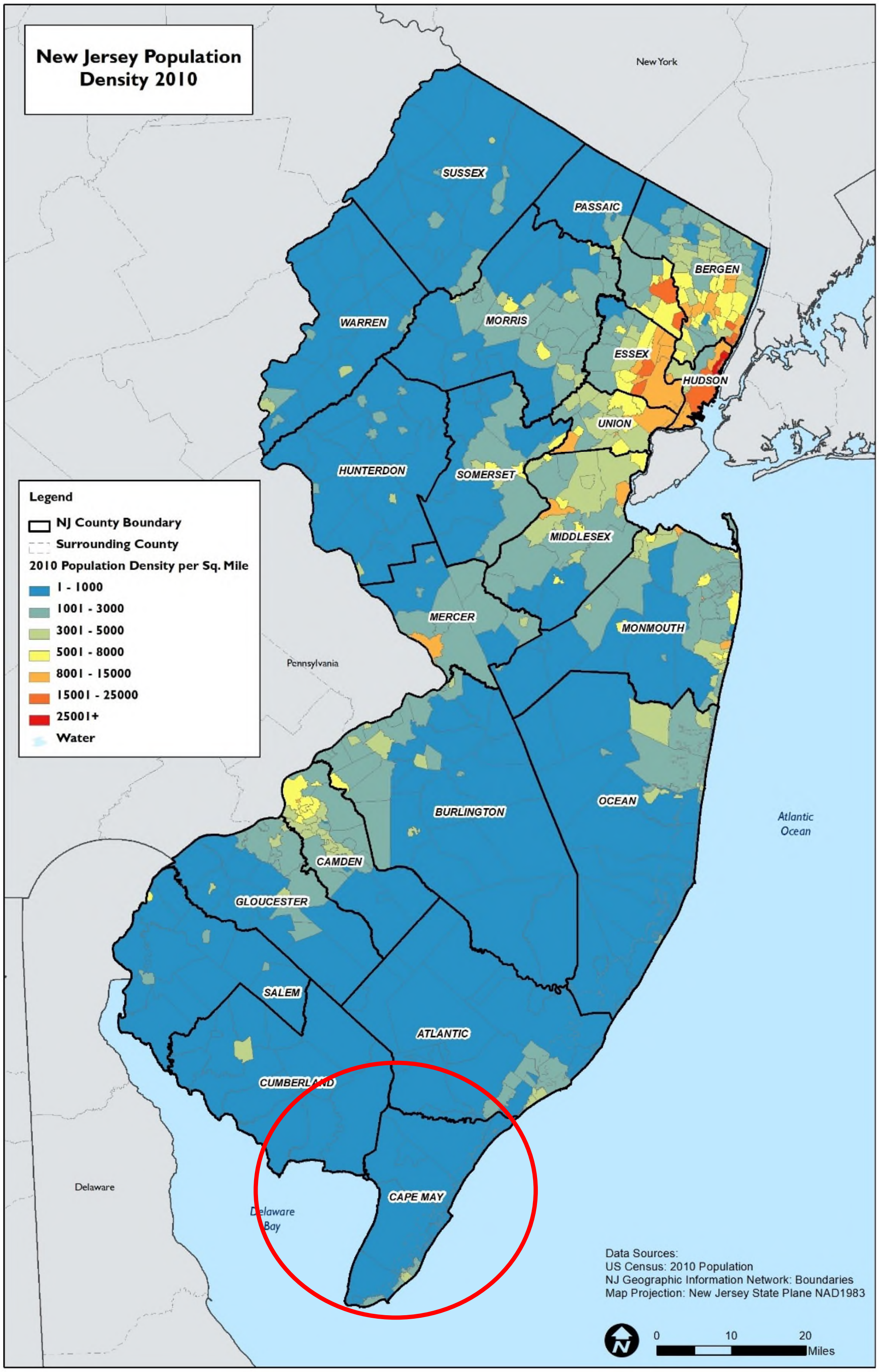
In an effort to slow the spread of the virus, the federal government and States have urged the public to avoid touching of the face, properly wash hands often, and use various social distancing measures. At the time of this plan update, there are no specific vaccines or treatments for COVID-19. However, there are many ongoing clinical trials evaluating potential treatments (WHO 2020).

Location

New Jersey's geographic and demographic characteristics make it particularly vulnerable to importation and spread of infectious diseases. All 21 counties in New Jersey have experienced the effects of a pandemic or disease outbreak. In terms of pandemic influenza, all counties may experience pandemic influenza outbreak caused by factors such as population density and the nature of public meeting areas. In Cape May County, transient visitor populations and high utility of public spaces such as beaches, boardwalks, restaurants, and amusements can accelerate the spread of diseases.

Densely populated areas will spread diseases quicker than less densely populated areas. Figure 5.4.3-1 shows population density throughout the State. Though Cape May County appears less dense than other counties in the State, it should be noted that the County's barrier islands are densely developed and have high seasonal populations. As a result, Census population figures do not capture the density of the County's beachfront resorts. Additionally, much of the State can experience other diseases such as WNV due to the abundance of water bodies throughout the State, which provide a breeding ground for infected mosquitos. In Cape May County, the prevalence of wetland areas and poor drainage reported in many locations can increase the risk of disease spread of mosquito-borne diseases.

Figure 5.4.3-1. New Jersey Population Density (United States Census 2010)



Source: United States Census 2010; New Jersey Geographic Information Network (NJGIN)
Note: Cape May is circled in red.

Extent

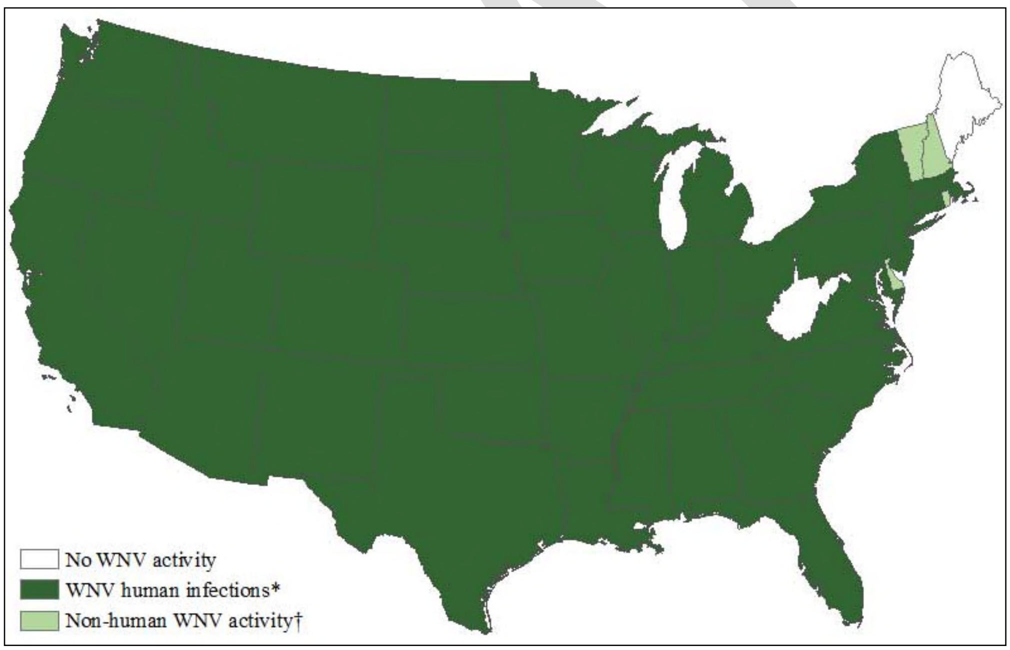
The exact size and extent of an infected population depends on how easily the illness is spread, the mode of transmission, and the amount of contact between infected and uninfected individuals. The transmission rates of pandemic illnesses are often higher in more densely populated areas. The transmission rate of infectious diseases will depend on the mode of transmission of a given illness.

The extent and location of disease outbreaks depends on the preferred habitat of the species, as well as the species' ease of movement and establishment. The magnitude of disease outbreaks species ranges from nuisance to widespread. The threat is typically intensified when the ecosystem or host species is already stressed, such as periods of drought. The already weakened state of the ecosystem causes it to more easily be impacted to an infestation. The presence of disease-carrying mosquitoes and ticks has been reported throughout most of New Jersey and Cape May County.

West Nile Virus

Since it was discovered in the western hemisphere, WNV has spread rapidly across North America, affecting thousands of birds, horses and humans. As of January 2020, every state in the continental United States aside from Maine and West Virginia has WNV activity with Delaware, Rhode Island, Vermont, and New Hampshire only being impacted by non-human WNV activity. Figure 5.4.3-2 shows the activity of WNV by state. The figure shows that Cape May County has had reported WNV human infections.

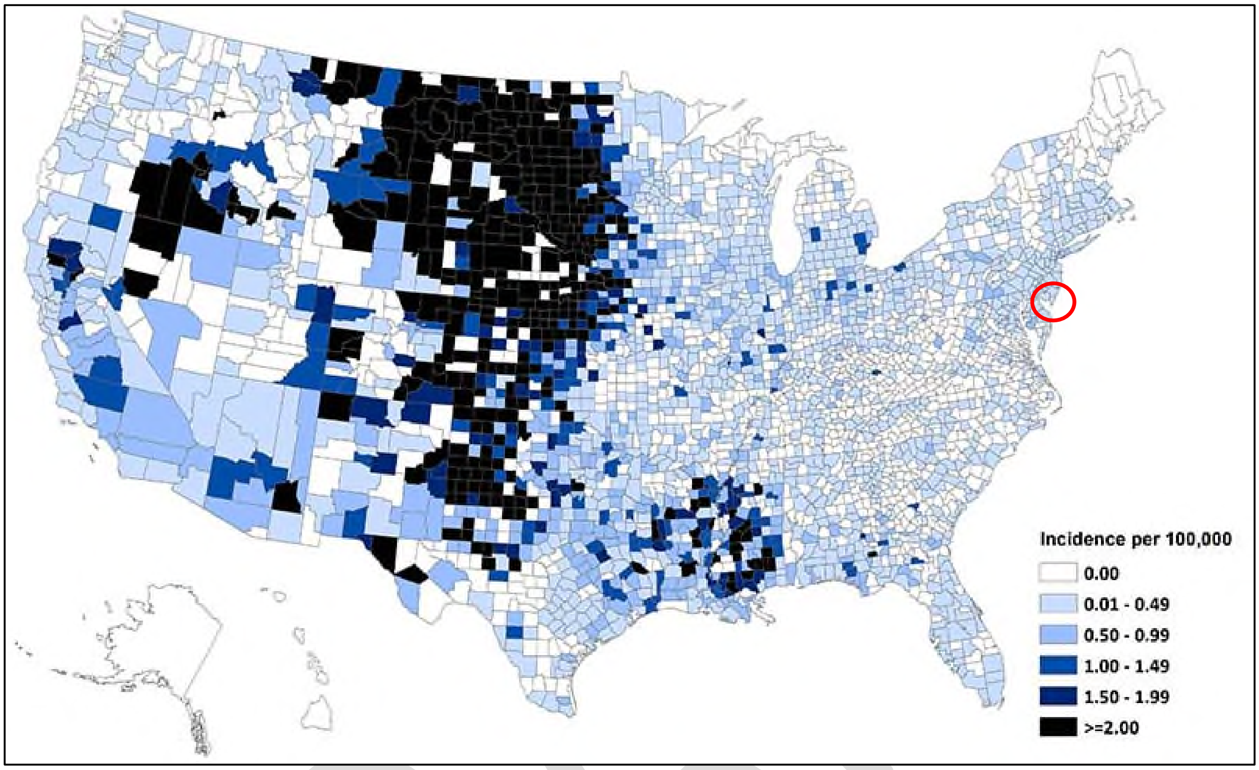
Figure 5.4.3-2. WNV Activity by State 2019



Source: CDC 2020

The CDC has a surveillance program for WNV. Data is collected on a weekly basis and reported for five categories: wild birds, sentinel chicken flocks, human cases, veterinary cases and mosquito surveillance (CDC 2019). Figure 5.4.3-3 illustrates WNV activity in the U.S. from 1999-2018. This figure shows that Cape May County has an average annual incidence rate of 0.01-0.49 .

Figure 5.4.3-3. Average Annual Incidence of West Nile Virus Neuroinvasive Disease Reported to CDC by County, 1999-2018



Source: *CDC 2019*
Note: *The circle indicates the approximate location of Cape May County.*

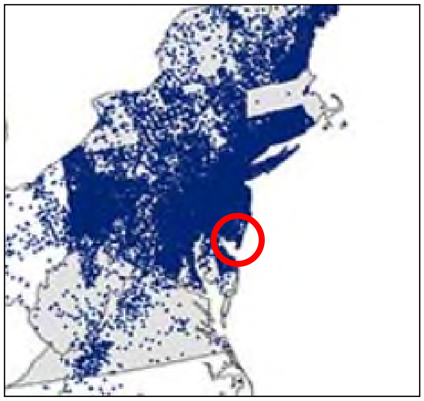
Eastern Equine Encephalitis

In the State of New Jersey, there has been five cases of EEE from 2010-2019 (CDC 2019.) According to the New Jersey Department of Health, no cases of EEE have been reported in Cape May County between 2010 and 2019 (NJ DOH 2019).

Lyme Disease

Lyme disease is the most commonly reported vector borne illness in the U.S. Between 2014 and 2018, there were 111 confirmed cases of Lyme disease in Cape May County (NJ DOH 2019). Figure 5.4.3-4 shows the reported cases of Lyme disease in the northeast U.S. for 2018 and shows that Cape May County has had reported cases.

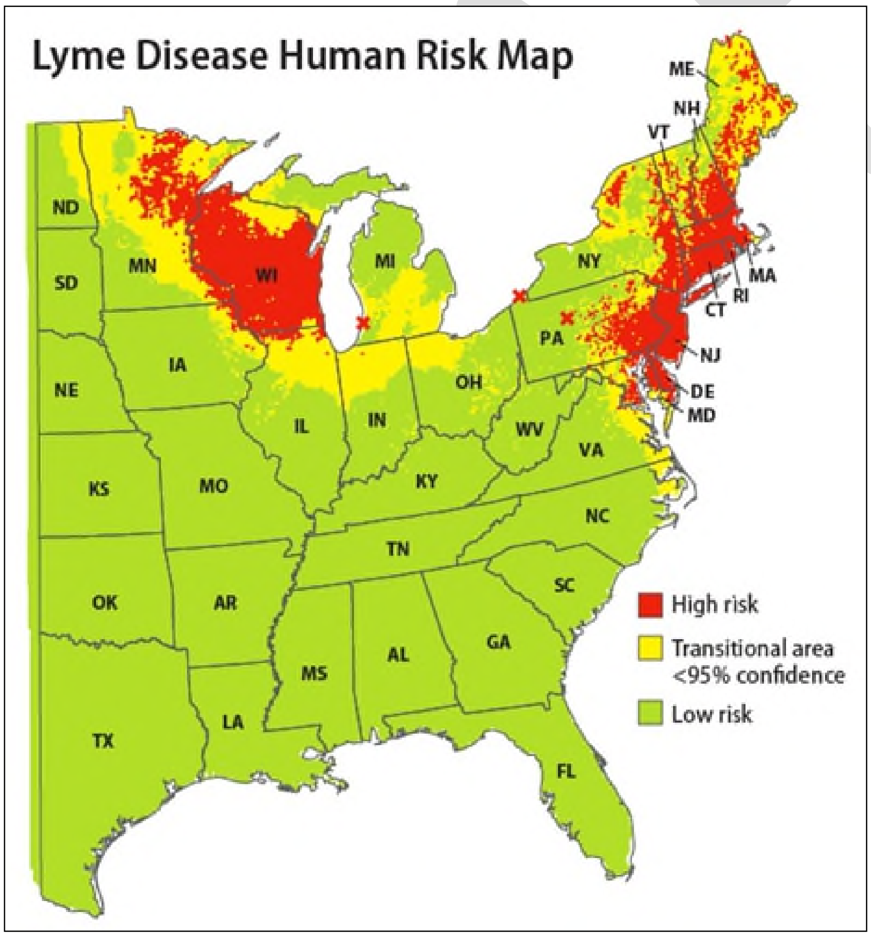
Figure 5.4.3-4. 2018 Reported Cases of Lyme Disease in the Northeast U.S.



Source: CDC 2019
Note: The red circle indicates the approximate location of Cape May County.

Figure 5.4.3-5 shows the risk of Lyme disease in the northeastern U.S. The figure indicates that Cape May County is located in a high-risk area.

Figure 5.4.3-5. Lyme Disease Human Risk Map in the Northeast U.S.

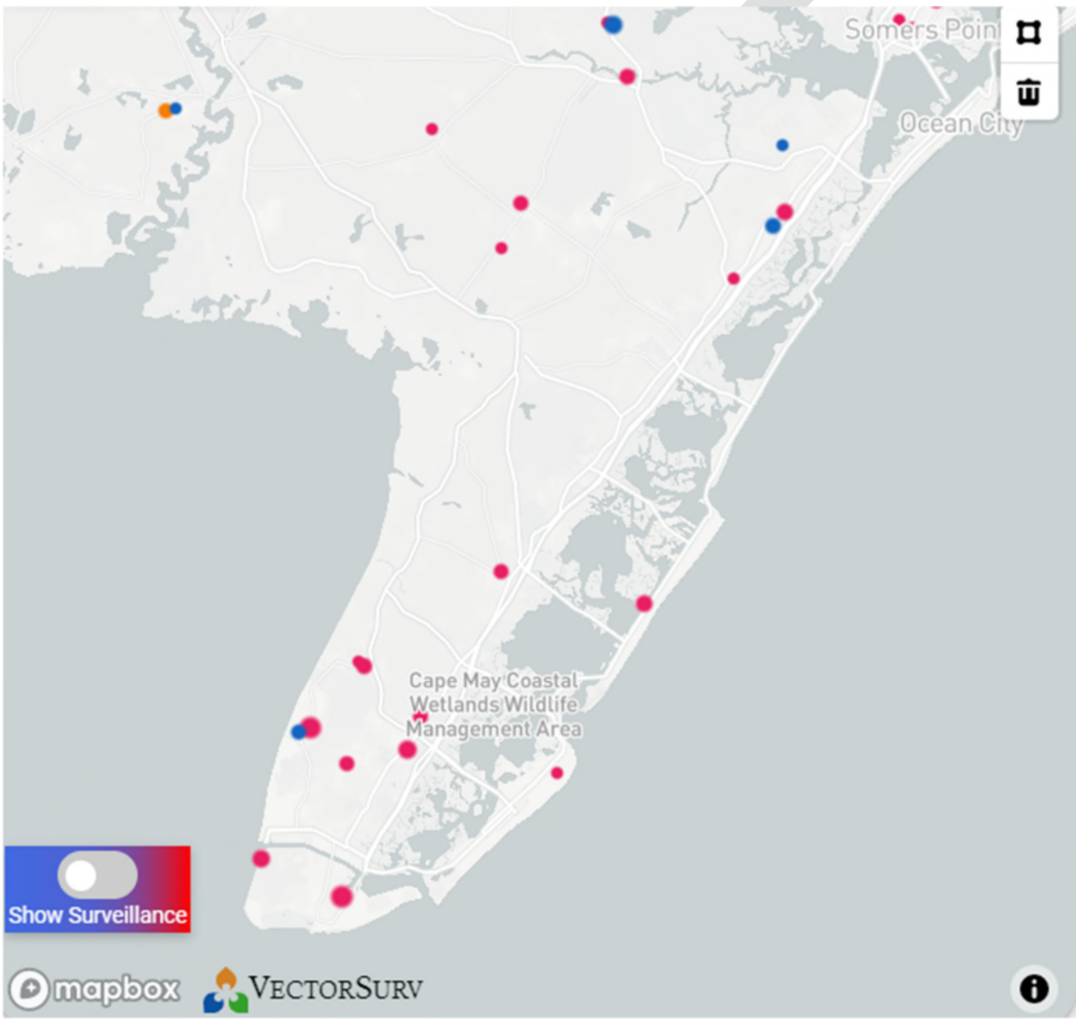


Source: Yale School of Public Health, 2013
Note (1): Cape May County is in a high risk or transitional area.

The CDC Division of Vector Borne Diseases (DVBD) indicated in 2018 that New Jersey was the state with the second-highest number of confirmed Lyme disease cases, totaling approximately 4,000 cases. For total number of cases between 2007 and 2017, New Jersey ranked third highest for the number of confirmed Lyme disease cases, totaling approximately 32,731 (12.4% of the total reported cases in the U.S.) New Jersey is also considered a High Incidence State for Lyme Disease, with the average incidence of at least 10 confirmed cases per 100,000 persons for three reporting years (CDC 2018).

Figure 5.4.3-6 below shows reports of arbovirus in Cape May County between January 2003 and the present. The red dots are for locations of mosquitos with West Nile Virus, whereas blue dots show the location of mosquitos carrying Eastern Equine Encephalitis.

Figure 5.4.3-6. Arbovirus Reports in Cape May County (January 2003-Present)

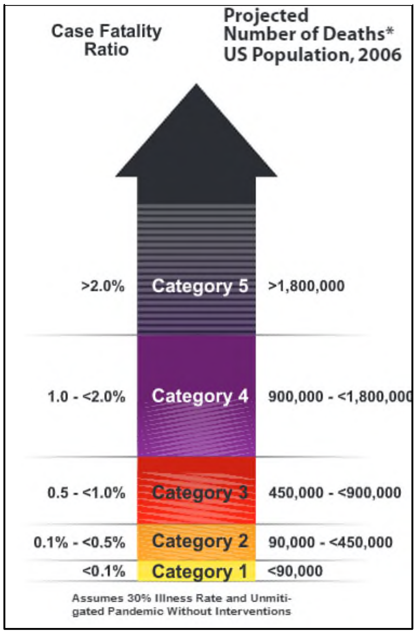


Source: VectorSurv; NJDOH

Influenza, Ebola and Coronavirus

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

Figure 5.4.3-7. Pandemic PSI



Source: NJDOH 2017

The CDC and Prevention Community Strategy for Pandemic Influenza Mitigation guidance introduced a Pandemic Severity Index (PSI), which uses the case fatality ratio as the critical driver for categorizing the severity of a pandemic. The index is designed to estimate the severity of a pandemic on a population to allow better forecasting of the impact of a pandemic, and to enable recommendations on the use of mitigation interventions that are matched to the severity of influenza pandemic. Pandemics are assigned to one of five discrete categories of increasing severity (Category 1 to Category 5) (New Jersey Department of Health 2015). Figure 5.4.3-7 illustrates the five categories of the Pandemic Severity Index (PSI).

In 1999, the WHO Secretariat published guidance for pandemic influenza and defined the six phases of a pandemic. Updated guidance was published in 2005 to redefine these phases. This schema is designed to provide guidance to the international community and to national governments on preparedness and response for pandemic threats and pandemic disease. Compared with the 1999 phases, the new definitions place more emphasis on pre-pandemic phases when pandemic threats may exist in animals or when new influenza virus subtypes infect people but do not spread efficiently. Because recognizing that distinctions between the two interpandemic phases and the three pandemic alert phases may be unclear, the WHO Secretariat proposes that classifications be determined by assessing risk based on a range of scientific and epidemiological data (WHO 2009). The WHO pandemic phases are outlined in Table 5.4.3-1.

Table 5.4.3-1. WHO Global Pandemic Phases

Phase	Description
Preparedness	
Phase 1	No viruses circulating among animals have been reported to cause infections in humans.
Phase 2	An animal influenza virus circulating among domesticated or wild animals is known to have caused infection in humans, and is therefore considered a potential pandemic threat.
Phase 3	An animal or human-animal influenza reassortment virus has caused sporadic cases or small clusters of disease in people, but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks. Limited human-to-human transmission may occur under some circumstances, for example, when there is close contact between an infected person and an unprotected caregiver. However, limited transmission under such restricted circumstances does not indicate that the virus has gained the level of transmissibility among humans necessary to cause a pandemic.
Response and Mitigation Efforts	
Phase 4	Human infection(s) are reported with a new subtype, but no human-to-human spread or at most rare instances of spread to a close contact.
Phase 5	Characterized by human-to-human spread of the virus into at least two countries in one WHO region. While most countries will not be affected at this stage, the declaration of Phase 5 is a strong signal that a pandemic is imminent and that the time to finalize the organization, communication, and implementation of the planned mitigation measures is short.
Phase 6	The pandemic phase, is characterized by community level outbreaks in at least one other country in a different WHO region in addition to the criteria defined in Phase 5. Designation of this phase will indicate that a global pandemic is under way.

Source: WHO 2009

In New Jersey, health and supporting agency responses to a pandemic are defined by the WHO phases and federal pandemic influenza stages, and further defined by New Jersey pandemic situations. The State's situations are similar, but not identical to the United States Department of Homeland Security federal government response stages. Transition from one situation to another indicates a change in activities of one or more New Jersey agencies. Table 5.4.3-2 compares the federal and New Jersey pandemic influenza phases and situations.

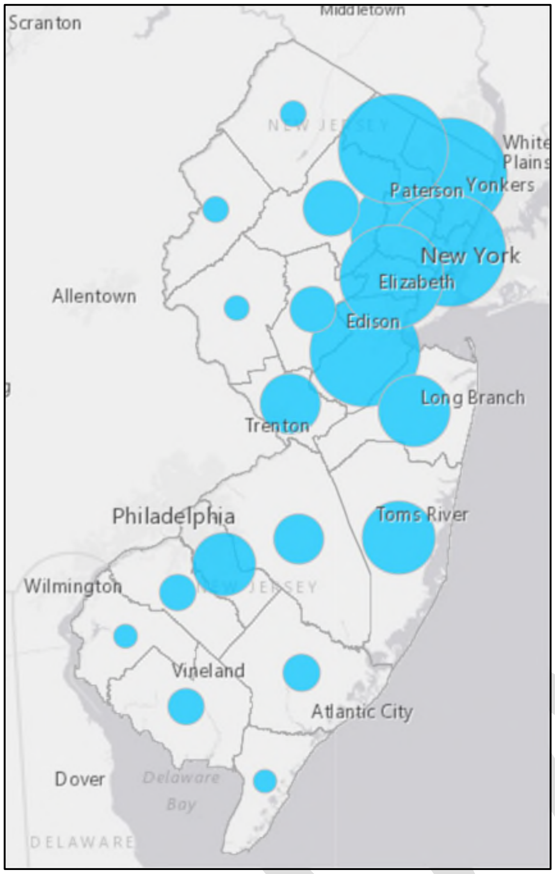
Table 5.4.3-2. Federal and New Jersey Pandemic Phases and Situations

Federal Pandemic Influenza Stage		New Jersey Situations	
0	New domestic outbreak in at-risk country (WHO Phase 1, 2, or 3)	1	Novel (new) influenza virus in birds or other animals outside the U.S.
		2	Novel (new) influenza virus in birds or other animals in the U.S./NJ
1	Suspected human outbreak overseas (WHO Phase 3)	3	Human case of novel (new) influenza virus outside of the U.S.
2	Confirmed human outbreak overseas (WHO Phase 4 or 5)	4	Human-to-human spread of novel (new) influenza outside the U.S. (no widespread human transmission)
		5	Clusters of human cases outside the U.S.
3	Widespread human outbreak in multiple locations overseas (WHO Phase 6)		
4	First human case in North America (WHO Phase 6)	6	Human case of novel (new) influenza virus (no human spread) in the U.S./NJ
5	Spread in the U.S. (WHO Phase 6)	7	First case of human-to-human spread of novel (new) influenza in the U.S./NJ
		8	Clusters of cases of human spread in the U.S./NJ
		9	Widespread cases of human-to-human spread of novel (new) influenza outside the U.S./NJ
6	Recovery and preparation for subsequent waves (WHO Phase 5 or 6)	10	Reduced spread of influenza or end of pandemic

Source: NJOEM 2019
NJ New Jersey
U.S. United States
WHO World Health Organization

As of August 2020, Cape May County was experiencing impacts due to the COVID-19 pandemic. Figure 5.4.3-8 illustrates the number of positive cases in the County as of August of that year.

Figure 5.4.3-8. Number of Positive COVID-19 Cases in New Jersey



Source: State of New Jersey Department of Health 2020 (as of August 17, 2020)

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with disease outbreak events throughout New Jersey and Cape May County.

FEMA Disaster Declarations

Between 1954 and 2020, the State of New Jersey was included in two disease outbreak-related emergency (EM) declarations, classified as a virus threat for West Nile Virus (EM-3156, May – November 2000) and COVID-19 (EM-3451, January 2020-Present). Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Cape May County was included in both declarations (FEMA 2020).

Table 5.4.3-3. Disease Outbreak-Related FEMA Declarations for Cape May County, 1954 to 2020

FEMA Declaration Number	Date(s) of Event	Date of Declaration	Event Type
EM-3156	May 30-November 1,2000	April 2, 2010	West Nile Virus
DR-4488 / EM-3451	January 20,2000 to present	March 25, 2020	New Jersey COVID-19 Pandemic

Source: FEMA 2020

Previous Events

For this 2021 HMP update, known disease outbreak events that have impacted Cape May County between 2014 and 2020, with the exception of COVID-19, are identified in the following tale, which shows infection counts for diseases of concern in Cape May County. With disease outbreak documentation for New Jersey and Cape May County being so extensive, not all sources have been identified or researched. Therefore, Table 5.4.3-4 may not include all events that have occurred in the County.

Table 5.4.3-4. Infectious Disease Rates for Selected Diseases

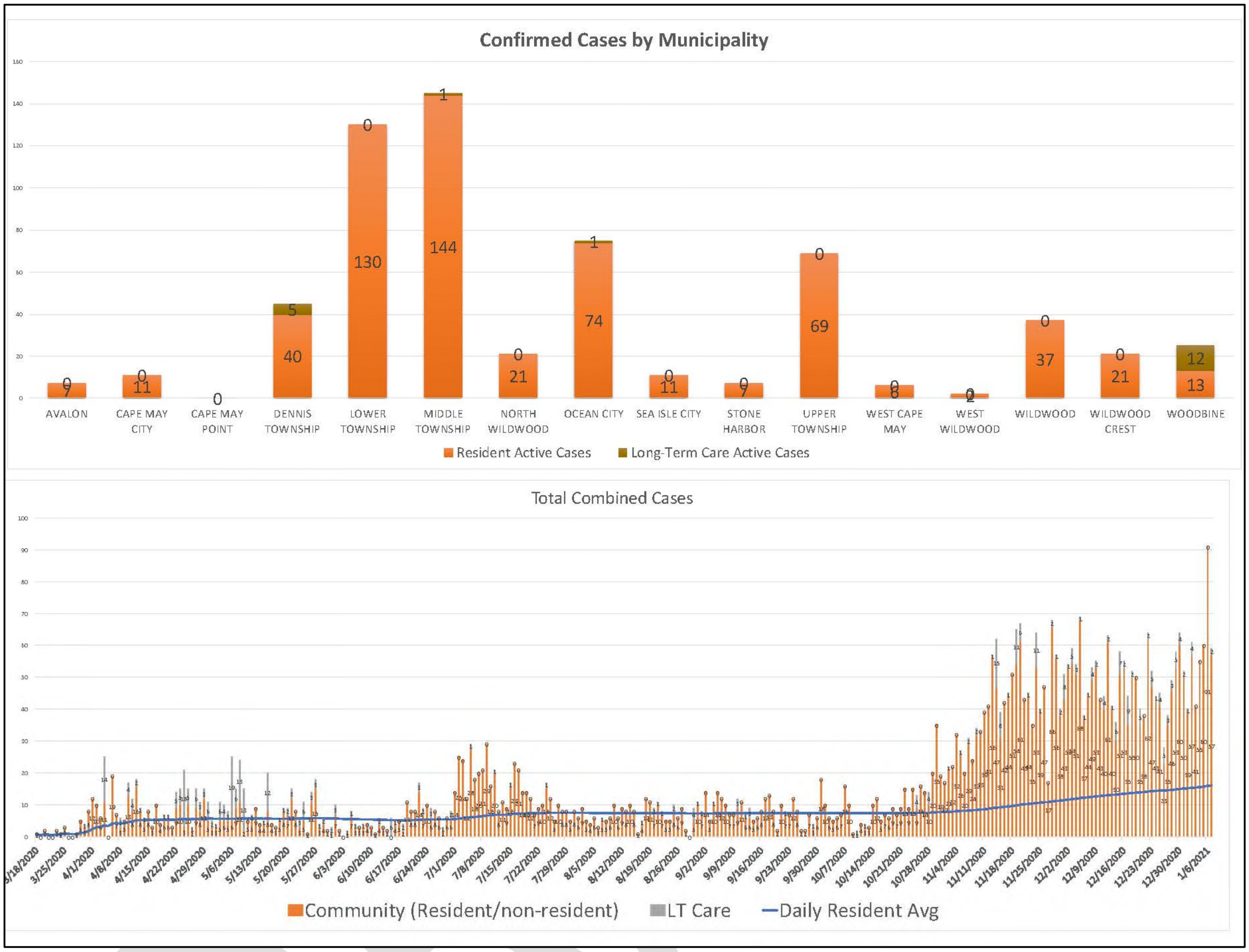
	Influenza (All Types)	Lyme Disease	West Nile Virus
2014	36	12	0
2015	23	27	0
2016	24	19	0
2017	77	22	1
2018	487	31	2

Source: New Jersey Department of Health 2020
N/A Not Available
WNV West Nile Virus

The most notable recent incidence of widespread disease outbreak in Cape May County is COVID-19, known as the novel coronavirus. As of August 17, 2020, the County reported 49 active resident case and 37 non-resident active cases. To date, the County has reported 1,038 total cases, 26 community fatalities, and 57 fatalities of long-term care facility residents.

The first reported case of COVID-19 in the County occurred in mid-March 2020 from an out-of-state visitor (Cape May County Herald, 2020). The number of confirmed cases continue to grow the spring before decreasing in the early summer and increasing again in the fall. As New Jersey advanced its economic reopening in May, Cape May County prepared to welcome tourists and seasonal residents. Despite the influx of visitors and increase of the seasonal population, the virus's spread in the summer of 2020 among residents remained low relative to the initial outbreak. Beginning in the fall of 2020, COVID-19 infection rates began increasing significantly as part of a nationwide surge. As of January 2021, COVID-19 infections remain at their highest point since the County's first infection. Vaccine distribution has been initiated in the County, with vaccines first being distributed to long-term care facility residents and medical workers.

Figure 5.4.3-9. Lab-Confirmed COVID-19 Cases in Cape May County



Source: Cape May County Health Department

Probability of Future Occurrences

It is difficult to predict when the next disease outbreak will occur and how severe it will be because viruses are always changing. The Department of Health and Human Services and others are developing supplies of vaccines and medicines. In addition, the United States has been working with the WHO and other countries to strengthen detection of disease and response to outbreaks. Preparedness efforts are ongoing at the national, State, and local level (NJOEM 2019). The Cape May County Health Department is leading the effort in coordination with the Cape May County Emergency Management and other departments on the COVID-19 response.

In Cape May County, the probability for a future disease outbreak event is dependent on several factors. One factor that influences the spread of disease is population density. Populations that live close to one another are more likely to spread diseases. All of the critical components necessary to sustain the threat of mosquito-borne disease in Cape May County have been clearly documented. Instances of the WNV have been generally decreasing because of aggressive planning and eradication efforts, but some scientists suggest that as global temperatures rise and extreme weather conditions emerge from climate change, the range of the virus in the United States will grow (Epstein, 2001). While instances of Zika have decreased since the outbreak in 2016, there is still the possibility of an outbreak occurring in the future. Therefore, based on all available information and available data regarding mosquito populations, it is anticipated that mosquito-borne diseases will continue to be a threat to Cape May County.

Disease-carrying ticks will continue to inhabit the northeast, including Cape May County, creating an increase in Lyme disease and other types of infections amongst the county population if not controlled or prevented. Ecological conditions favorable to Lyme disease, the steady increase in the number of cases, and the challenge of prevention predict that Lyme disease will be a continuing public health concern. Personal protection measures, including protective clothing, repellents or acaricides, tick checks, and landscape modifications in or near residential areas, may be helpful. However, these measures are difficult to perform regularly throughout the summer. Attempts to control the infection on a larger scale by the eradication of deer or widespread use of acaricides, which may be effective, have had limited public acceptance. New methods of tick control, including host-targeted acaricides against rodents and deer, are being developed and may provide help in the future (Steere, Coburn, and Glickstein, 2004).

Currently and in the future, control of Lyme disease will depend primarily on public and physician education about personal protection measures, signs and symptoms of the disease, and appropriate antibiotic therapy. Based on available information and the ongoing trends of disease-carrying tick populations, it is anticipated that Lyme disease infections will continue to be a threat to Cape May County.

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 Steering and Planning Committees, the probability of occurrence for disease outbreaks in the County is considered 'frequent' (100% annual chance of occurring, occurring multiple times a year) with a range of impacts which depend upon the outbreak.

Climate Change Impacts

The relationship between climate change and increase in infectious diseases is difficult to predict with certainty, there are scientific linkages between the two. Increased rainfall and heavy rainfalls increase the chances of standing water where mosquitos breed. As warm habitats that host insects such as mosquitoes increase, more of the population becomes exposed to potential virus threats (*The Washington Post*, 2017). The notion that rising temperatures will increase the number of mosquitoes that can transmit diseases such as WNV and Zika among humans (rather than just shift their range) has been the subject of debate over the past decade. Some believe that climate change may affect the spread of disease, while others are not convinced. However, many researchers point out that climate is not the only force at work in increasing the spread of infectious diseases into the future (NJOEM 2019). Increased sea levels and rainstorms contribute to flooding and poor drainage in Cape May County. As flooding events increase in the County owing to climate change, water-borne and vector-borne diseases (particularly those associated with mosquitos) may similarly increase owing to the prevalence of standing water over long periods (World Health Organization).

5.4.3.1 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable to the identified hazard. The following discusses Cape May County's vulnerability, in a qualitative nature, to the disease outbreak hazard.

Impact on Life, Health and Safety

The entire population of Cape May County is vulnerable to the disease outbreak hazard. Due to a lack of quantifiable loss information, a qualitative assessment was conducted to evaluate the assets exposed to this hazard and the potential impacts associated with this hazard.

Maintaining certain key functions is important to preserve life and decrease societal disruption during pandemic. Heat, clean water, waste disposal, and corpse management all contribute to public health. Ensuring functional transportation systems also protects health by making it possible for people to access medical care and by transporting food and other essential goods. Critical infrastructure groups have a responsibility to maintain public health, provide public safety, transport medical supplies and food, implement a pandemic response, and maintaining societal functions. If these workers were absent due to pandemic outbreak, these systems will fail (Global Security, 2011).

Healthcare providers and first responders have an increased risk of exposure due to their frequent contact with infected populations. Areas with a higher population density also have an increased risk of exposure or transmission of disease due to their proximity to potentially infected people. Further, the elderly and immunocompromised individuals may have increased vulnerability to becoming infected or experience exacerbated impacts depending upon the disease. Refer to Section 4 (County Profile) for summary of the vulnerable populations in Cape May County.

Impact on General Building Stock

No structures are anticipated to be directly affected by disease outbreaks.

Impact on Critical Facilities

While the actual structures of County and municipal buildings, lifelines, and infrastructure will not be impacted by a pandemic or disease outbreak, the effect of absenteeism on workers will impact local government services. The most significant impact on lifelines would be the increase in hospitalization and emergency room visits that would take place as a result of the outbreak. This would create a greater demand on these lifelines, their staff, and resources. According to the US Department of Homeland Security, a severe influenza pandemic may result in up to 6.5 million hospitalizations over the course of a pandemic, with 2.3 million requiring intensive care unit (ICU) treatment. In addition to hospital shortages, labor shortages of Tier 1 critical workers would result from such a pandemic (US Department of Homeland Security, 2015). The US Department of Homeland Security also found potential impacts to Energy and Water/Wastewater lifelines owing to absenteeism and cascading incidents.

Mortuary services could be substantially impacted due to the anticipated increased numbers of deaths. The timely, safe, and respectful disposition of the deceased is an essential component of an effective response. Pandemic influenza may quickly rise to the level of a catastrophic incident that results in mass fatalities, which will place extraordinary demands (including religious, cultural, and emotional burdens) on local jurisdictions and the families of the victims (Global Security 2011).

The US Department of Homeland Security anticipates that the Healthcare and Public Health and Emergency Service sectors will experience the "greatest and most immediate impact and face the significant prospect of being overwhelmed" resulting from pandemics.

Impact on Economy

The impact disease outbreaks have on the economy and estimated dollar losses are difficult to measure and quantify. Activities and programs implemented by the County may be disrupted as a result of a disease outbreak and impact the local economy. Cape May County's tourism industry is heavily dependent on outdoor activities, and the County's prevailing wetlands and forest cover intermixed with dense urban settlement in low-lying topography provides ideal breeding ground for mosquitos. Outbreaks of mosquito-borne diseases would have substantial impacts on the County's economy because it would increase disease exposure from outdoor activity, including beachgoing, boating, walking, and biking.

In Cape May County, the Department of Mosquito Control, founded in 1915, uses an integrated control approach for mosquito populations. The County uses intensive surveying and monitoring to determine the number and types of mosquito species (Cape May County Mosquito Control 2020). The Division of Mosquito Control was allotted an annual fund in 2019 of $1.5 million according to Cape May County's annual operating budget (Cape May County 2020).

In addition to the direct economic impacts posed by exposure to diseases pertaining to the County's natural environment, efforts to mitigate disease outbreaks can also cause major economic impacts. Lockdowns, closures of non-essential businesses, and diminished capacity to operating non-essential businesses caused major economic impacts to the County in 2020 resulting from the response to the COVID-19 pandemic. Economic impacts to the 2020 tourist season have not yet been fully determined (Caffrey 2020).

The Cape May County Health Department, in coordination with the Cape May County Department of Emergency Management are working to respond to the COVID-19 pandemic. Their activity requires additional costs from the State and County to manage COVID-19 in communities.

Impact on Environment

Disease outbreaks may have an impact on the environment if the outbreaks are caused by invasive species. Invasive species tend to be competitive with native species and their habitat. One study has shown that invasive mosquitos such as the Asian tiger mosquito, a common invasive mosquito found in New Jersey, have "desiccation-resistant eggs," which means that they have enhanced survival in inhospitable environments (Juliano and Lounibos 2005). This species are considered competitive predators, and will prey on other species of mosquitos and a range of insects disrupting the natural food chain. Invasive species of mosquitos can be the major transmitters of disease like Zika, dengue, and yellow fever (Placer Mosquito and Vector Control District 2019).

Secondary impacts from mitigating disease outbreaks could also have an impact on the environment. Pesticides used to control disease carrying insects like mosquitos have been reviewed by the EPA and department of health. The use of integrated pest management entails the use of both water management (e.g. marsh ditching), biological control, and chemical control (Cape May County 2020). Each of these methods entails human intervention in the natural environment that impact the County's ecology.

Future Changes that May Impact Vulnerability

Understanding future changes that may impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The county considered the following factors 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 and Change in Population

Any areas of growth could be potentially impacted by the disease outbreak hazard because the entire planning area is exposed. Additional development of structures near waterbodies or areas with high population density are at an increased risk to certain types of diseases (e.g., mosquito-borne diseases).

In Cape May County, the population of those over the age of 65 has increased by 5.7% between 2010 and 2018 whereas the overall population has decreased by 4.1% during the same time. Further, as the elderly population increases there may be increased risk to this demographic. Older adults and people who have severe underlying medical conditions like heart or lung disease or diabetes seem to be at higher risk for developing more serious complications from certain diseases, such as COVID-19.

Long-term care facilities have been shown to be an acute vulnerability for disease outbreak. As of 2020, Cape May County is home to nine long-term care facilities, two of which are long-term care facilities (New Jersey Department of Health 2020). Two of these facilities are located in Ocean City, one is located in Dennis Township, two are located in Lower Township, and four are located in Middle Township. As of November 2, 2020, COVID-19 has caused 18 outbreaks at these facilities resulting in 274 resident cases, 251 staff cases, and 59 resident deaths. Resident deaths to COVID-19 in Cape May County have accounted for more than half of all probable and confirmed deaths due to the pandemic in the County. In addition, the State-operated Woodbine Developmental Center in Woodbine has reported eight resident deaths and 45 cases among residents and 110 cases among staff as of November 2, 2020.

The aging of the County's population presents major repercussions for disease spread. In New Jersey. The percentage of residents over the age of 65 is 15.5% as of 2018. In Cape May County, this figure was over 25%. In both Avalon and Cape May Point, more than half of residents are over the age of 65. In Sea Isle City, Stone Harbor, and West Wildwood, more than 40% of residents are over the age of 65.

Climate Change

As discussed earlier in this section, the relationship between climate change and increase in infectious diseases is difficult to predict with certainty, however there may be linkages between the two. Changes in the environment may create a more livable habitat for vectors carrying disease as suggested by the Centers for Disease Control and Prevention (CDC n.d.). Localized changes in climate and human interaction may also be a factor in the spread of disease.

Change of Vulnerability Since the 2016 HMP

Disease outbreak is a new hazard for the 2021 Hazard Mitigation Plan Update. Overall, the County's vulnerability has not changed, and the entire County will continue to be exposed and vulnerable to disease outbreak events.

5.4.4 Drought

This section provides a hazard profile and vulnerability assessment for the drought hazard in Cape May County.

2021 HMP Update Changes

- The drought hazard profile is a new hazard profile for this 2021 HMP update.

5.4.4.1 Profile

Hazard Description

Drought is a period characterized by long durations of below normal precipitation. Drought conditions occur in virtually all climatic zones, yet characteristics of drought vary significantly from one region to another, relative to normal precipitation within respective regions. Drought can affect agriculture, water supply, aquatic ecology, wildlife, and plant life. Drought is a temporary irregularity in typical weather patterns and differs from aridity, which reflects low rainfall within a specific region and is a permanent feature of the climate of that area.

Saltwater Intrusion

Drought can exacerbate the rate of saltwater intrusion. Saltwater intrusion is a type of natural groundwater contamination, where the natural balance between freshwater and saltwater in coastal aquifers is disturbed by groundwater withdrawals and other human activities that lower groundwater levels, reduce fresh groundwater flow to coastal waters, and ultimately cause saltwater to intrude into the coastal aquifers making those aquifers no longer available for use. Other hydraulic stresses that reduce freshwater flow in coastal aquifers, such as lowered rates of groundwater recharge in sewered or urbanized areas, also can lead to saltwater intrusion, but the impact of such stresses on saltwater intrusion, at least currently, likely is small in comparison to pumping and land drainage (Kumar, 2016).

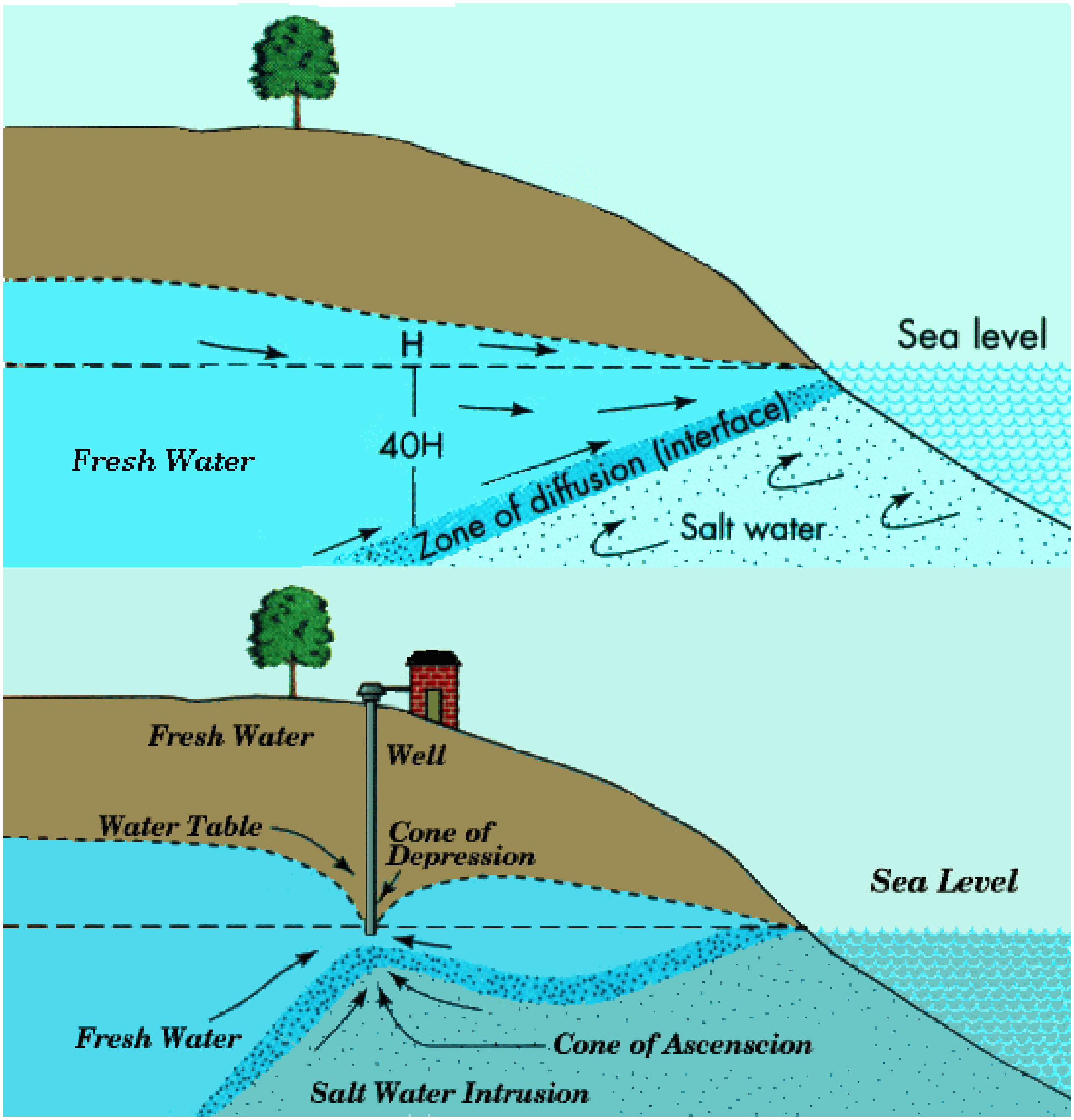
Saltwater intrusion is a natural process, but it becomes an environmental problem when excessive pumping of freshwater from an aquifer changes the water pressure and intensifies the effect, drawing saltwater into new areas. When freshwater levels drop, the intrusion can proceed further inland until reaching a pumped well. Then one may get saltwater out of the pump, which becomes no longer available for drinking or irrigation (Ranjan, 2007). When one pumps out freshwater rapidly, one lowers the height of the freshwater in the aquifer forming a cone of depression. The saltwater rises 40 feet for every 1 foot of freshwater depression and forms a cone of ascension (see Figure 5.4.4-1). Intrusion can affect the quality of water not only at the pumping well sites, but also at other well sites, and in undeveloped portions of an aquifer (Lenntech, 2020).

Location

Climate divisions are regions within a state that are climatically homogenous. The National Oceanic and Atmospheric Administration (NOAA) has divided the U.S. into 35 climate divisions. The boundaries of these divisions typically coincide with the county boundaries, except in the western U.S., where they are based largely on drainage basins. According to NOAA, New Jersey is made up of three climate divisions: Northern, Southern, and Coastal (NOAA 2012). Cape May County is located in the Coastal Climate Division.

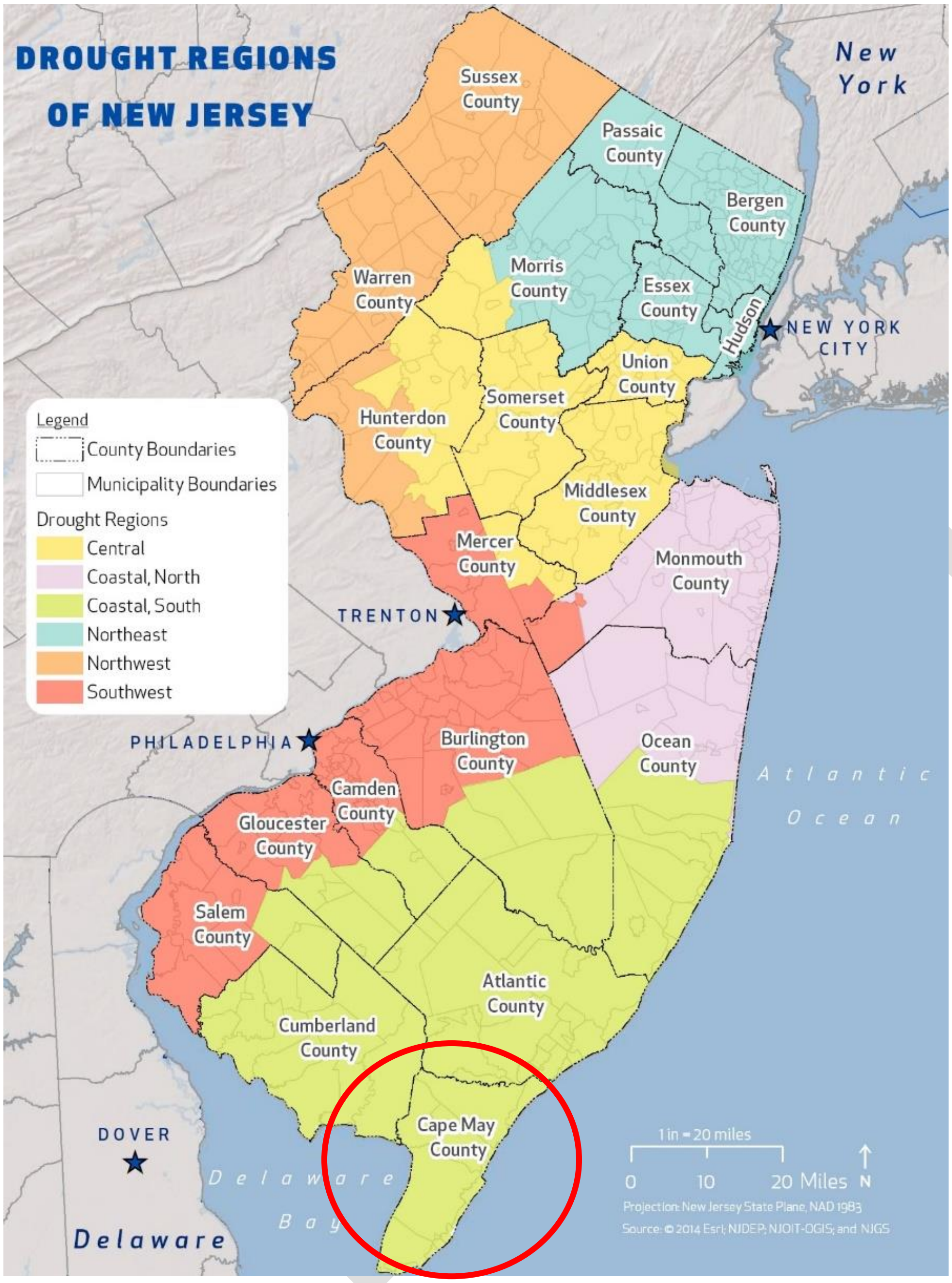
Drought regions allow New Jersey to respond to changing conditions without imposing restrictions on areas not experiencing water supply shortages. New Jersey is divided into six drought regions that are based on regional similarities in water supply sources and rainfall patterns (Hoffman and Domber, 2003). These regions were developed based upon hydro-geologic conditions, watershed boundaries, municipal boundaries, and water supply characteristics. Drought region boundaries are contiguous with municipal boundaries because during a water emergency, the primary enforcement mechanism for restrictions is municipal police forces. Figure 5.4.4-2 shows the drought regions of New Jersey. Cape May County is mainly located in the Coastal, South Drought Region.

Figure 5.4.4-1. Salt Water Intrusion Process



Source: Lenntech, 2020

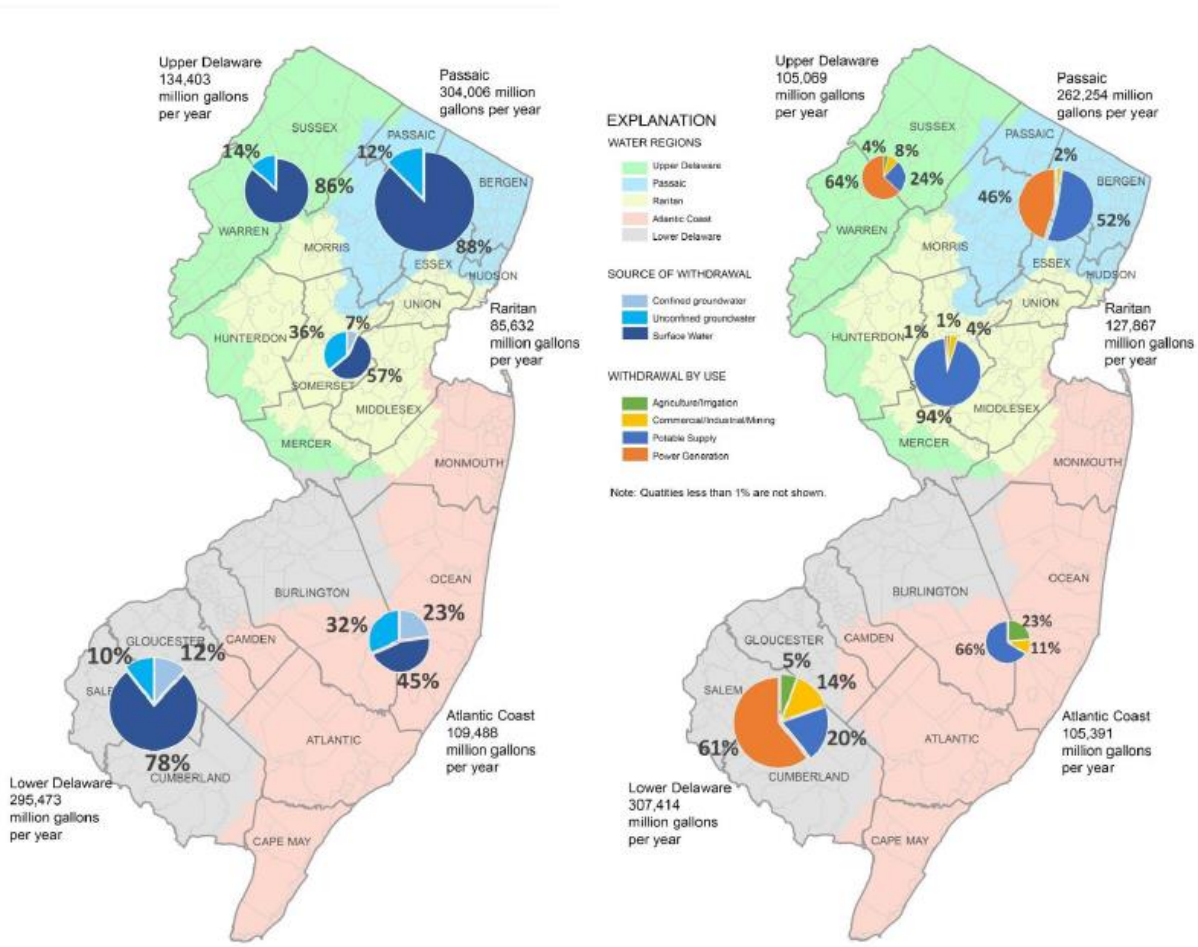
Figure 5.4.4-2. Drought Regions of New Jersey



Source: NJOEM (State HMP) 2019
Note: The red circle indicates the location of Cape May County

There are five water regions across the State (compiled from HUC11 Watershed Management Areas). Cape May County is located in the Atlantic Coast water region; refer to Figure 5.4.4-3. In terms of annual water withdrawal by sector, the majority is for potable water supply, followed by agricultural irrigation, then commercial/industrial/mining. Water use trends, like withdrawal trends, vary from month to month with water use typically peaking during summer months when outdoor and irrigation demands are high (New Jersey Department of Environmental Protection, 2017).

Figure 5.4.4-3. Water Regions, Sources and Withdrawal by Sector in New Jersey



Source: NJDEP 2017

Saltwater Intrusion

Saltwater intrusion has mostly impacted water supplies at the southern end of Cape May County. A reverse osmosis desalinization facility serves the City of Cape May. The facility was completed in 1998 due to saltwater intrusion of the City's wells (Cape May County Herald 2015).

Extent

The severity of a drought depends on the degree of moisture deficiency, the duration, and the size and location of the affected area. The longer the duration of the drought and the larger the area impacted, the more severe the potential impacts. The State of New Jersey uses a multi-index system that takes advantage of some of these indices to determine the severity of a drought or extended period of dry conditions.

Palmer Drought Severity Index

The Palmer Drought Severity Index is commonly used by drought monitoring agencies for drought reporting. The PDSI is primarily based on soil conditions. Soil with decreased moisture content is the first indicator of an overall moisture deficit. Table 5.4.4-1 lists the PDSI classifications. At the one end of the spectrum, 0 is used as normal and drought is indicated by negative numbers. For example, -2 is moderate drought, -3 is severe drought, and -4 is extreme drought. The PDSI also reflects excess precipitation using positive numbers; however, this is not shown in Table 5.4.4-1 (National Drought Mitigation Center [NDMC] 2013).

Table 5.4.4-1. Palmer Drought Category Descriptions

Category	Description	Possible Impacts	Palmer Drought Index
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting and growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.	-1.0 to -1.99
D1	Moderate drought	Some damage to crops and pastures; fire risk high; streams, reservoirs, or wells low; some water shortages developing or imminent; voluntary water-use restrictions requested.	-2.0 to -2.99
D2	Severe drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed.	-3.0 to -3.99
D3	Extreme drought	Major crop or pasture losses; extreme fire danger; widespread water shortages or restrictions.	-4.0 to -4.99
D4	Exceptional drought	Exceptional and widespread crop/pasture losses; exceptional fire risk; shortages of water in reservoirs, streams, and wells, creating water emergencies.	-5.0 or less

Source: NDMC 2013

Watches, Warnings and Emergencies

The Division of Water Supply and Geoscience within the NJDEP, regularly monitors various water supply conditions within the state based on the different Water Supply Regions. The water supply conditions aid the Department in declaring the regions as being within one of the four stages of water supply drought, Normal, Drought Watch, Drought Warning, and Drought Emergency.

- A ***Drought Watch*** is an administrative designation made by the Department when drought or other factors begin to adversely affect water supply conditions. A Watch indicates that conditions are dry but not yet significantly so. During a drought Watch, the Department closely monitors drought indicators (including precipitation, stream flows and reservoir and ground water levels, and water demands) and consults with affected water suppliers.
- A ***Drought Warning*** represents a non-emergency phase of managing available water supplies during the developing stages of drought and falls between the Watch and Emergency levels of drought response. The aim of a Drought Watch is to avert a more serious water shortage that would necessitate declaration of a water emergency and the imposition of mandatory water use restrictions, bans on water use, or other potentially drastic measures.
- A ***Drought Emergency*** can only be declared by the governor. While drought warning actions focus on increasing or shifting the supply of water, efforts initiated under a water emergency focus on reducing water demands. During a water emergency, a phased approach to restricting water consumption is typically initiated. Phase I water use restrictions typically target non-essential, outdoor water use (NJDEP Division of Water Supply and Geoscience 2018).

Saltwater Intrusion

The extent of saltwater intrusion depends, among other factors, on the rate of freshwater discharge to the sea. Other factors include the total rate of groundwater that is withdrawn compared to the total freshwater recharge to the aquifer, the distance of the stresses (wells and drainage canals) from the source (or sources) of saltwater, the geologic structure and distribution of hydraulic properties of the aquifer, and the presence of confining units that may prevent saltwater from moving vertically toward or within the aquifer. Moreover, the time required for saltwater to move through an aquifer and reach a pumping well can be quite long. The depth of the aquifer at the seaside, through which the saltwater intrudes the aquifer, also has a major effect on the degree of intrusion.

Depending on the location and lateral width of the transition zone, many years may pass before a well that is unaffected by saltwater intrusion suddenly becomes contaminated (Barlow and Wild, 2002). This makes saltwater intrusion a management problem since the freshwater discharge to the sea is the sum of the natural and the artificial recharge minus pumping. However, controlling saltwater intrusion is costly and/or management intensive. Extensive studies have been carried out in many parts of the world to clarify the mechanism of saltwater intrusion and to control it from better exploitation of coastal aquifers (Goosen and Shayya, 1999).

More than 100 water wells have already been abandoned on the Cape May peninsula of southern New Jersey because of saltwater intrusion (Hurdle 2020).

Previous Occurrences and Losses

Precipitation variability, coupled with concentrated population centers, can produce wide fluctuations in water availability and demands. The State and County have experienced several episodes of drought that have resulted in water shortages of varying degrees (e.g., mid-1960's, early to mid-1980's and 2001-2002) (NJDEP 2017).

FEMA Declarations

Between 1954 and 2020, the State of New Jersey experienced two FEMA declared drought-related disasters (DR) or emergencies (EM) classified as a water shortage. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Of those two declarations, Cape May County has been included in both declarations (FEMA 2020), as shown in Table 5.4.4-2.

Table 5.4.4-2. FEMA DR and EM Declarations for Drought Events in Cape May County, 1954 to 2020

FEMA Declaration Number	Date(s) of Event	Date of Declaration	Event Type
EM-3083	October 19, 1980	October 19, 1980	Water Shortage
DR-205	August 18, 1965	August 18, 1965	Water Shortage

Source: FEMA 2020

USDA Declarations

Agriculture-related drought disasters are quite common. One-half to two-thirds of the counties in the U.S. have been designated as disaster areas in each of the past several years. The USDA Secretary of Agriculture 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 2012 and 2020, Cape May County has been included in three USDA declarations related to drought as summarized in Table 5.4.4-3 (USDA 2020). Although USDA disasters were declared, there are no USDA records for historical losses from 2012-2020 (USDA 2020).

Table 5.4.4-3. USDA Disaster Declarations for Cape May County 2012-2020

Declaration	Event Date	Declaration Date	Event Description
S3487	June 28, 2012	November 8, 2012	The combined effects of drought, high winds (Derecho), hail, excessive heat, excessive rain, flash flooding, Hurricane Sandy, snowstorm, and Nor'easter
S3932	July 16, 2015	September 29, 2015	Excessive Heat and Drought
S34071	April 1, 2016	September 19, 2016	Combined effects of freeze, excessive heat, and drought

Source: USDA 2020

Previous Events

For the 2021 HMP update, known drought events that have impacted Cape May County between 2010 and 2020 are identified in Table 5.4.4-4.

Table 5.4.4-4. Drought Incidents in Cape May County, 2010 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
October 2000	Drought	N/A	N/A	October 2000 was one of the driest Octobers on record in New Jersey and in a few locations, the driest month ever on record. On a county weighted average, monthly precipitation total was 0.1 inches in Atlantic and Cape May Counties Normal monthly precipitation is around 3.4 inches. At the Atlantic City Marina, the monthly precipitation total of 0.01 inches was not only the driest October on record, but also tied September 1941 as the driest month on record. Records within Atlantic City go back to 1874. At the Atlantic City International Airport, the monthly precipitation total of 0.06 inches was not only the driest October on record, but also the driest month on record ever. Records at the airport go back to 1943. In Cape May City, the monthly precipitation total of 0.34 inches was the third driest October on record. Records have been kept since 1888. While the dry weather did not cause any appreciable agricultural damage, the falling leaves left the state susceptible to forest and brush fires.
November 7 – 13, 2000	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from November 7 – 13, 2000. Unseasonably dry weather continued through November of 2001. On a statewide average the preliminary monthly precipitation total for November was 1.03 inches, the 6th driest November on record. The combination preliminary statewide average of 2.06 inches for both October and November was the driest on record dating back to 1895. The continued dry weather, the drop in stream flow and groundwater levels and the reduced levels in the New York State reservoirs prompted the New Jersey State Department of Environmental Protection to upgrade the drought watch to a drought warning for counties in the Delaware River Basin and southern New Jersey on November 21st. The drought warning included all or part of the following counties: Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Hunterdon, Mercer, Monmouth, Ocean, Salem, Sussex and Warren. The drought warning gives the state Department of Environmental Protection (DEP) greater authority to control water distribution and transfers among the major reservoir systems and to temporarily modify water allocation permits. Individual municipalities can also set their own restrictions. The DEP asked residents to use good water conservation practices but there were no mandatary restrictions unless required by an individual township. The lack of adequate precipitation became more apparent as the month went along. On November 13th, the Great Egg Harbor, was at record low levels for the date. The same was true for about one quarter of all the rivers and streams in the state. The state forestry service banned all ground level campfires in wooded areas. Winter crops such as rye and grasses were struggling. On a county weighted average, the monthly precipitation total was 0.7 inches in Cape May County. Normal county averages are around 3.6 inches. The November monthly precipitation total at the Atlantic City International Airport was 1.06 inches, the fifth driest on record. At the Marina within Atlantic City, the monthly precipitation total of 0.85 inches was the 6th driest on record.
August 7 – 13, 2000	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from August 7 – 13, 2000.

Table 5.4.4-4. Drought Incidents in Cape May County, 2010 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
September 4, 2001 – December 16, 2002	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from September 1 – October 29, 2001; D1 or "moderate drought" status from October 30 – December 17, 2001; D2 or "severe drought" from December 18, 2001 – February 18, 2002; D3 or "extreme drought" from February 19 – April 22, 2002; D2 or "severe drought" from April 23 – June 10, 2002; D1 or "moderate drought" from June 11 – July 22, 2002; D2 or "severe drought" from July 23 - August 19, 2002; D3 or "extreme drought" from August 20 – September 2, 2002; D2 of "severe drought" from September 3 – October 7, 2002; D3 or "extreme drought" from October 8 – October 14, 2002; D1 or "moderate drought" from October 15 – November 4, 2002; D0 or "abnormally dry" from November 5 – December 16, 2002. October 2001 was an unseasonably dry month across the state of New Jersey. The ongoing dry weather prompted the state Environmental Protection Commissioner to issue a drought watch for the entire state on October 30th. The declaration called on residents to voluntarily conserve water. By the end of the month, new Jersey reservoirs were about 10 percent below normal with groundwater levels declining and many streams approaching record low stream flow levels. The state also prohibited campfires in wooded areas (of state owned parks) unless they were kept in an elevated fireplace, grill or stove that was one foot above ground level. Other than Atlantic, Burlington and Ocean Counties, all of the other counties in the state had less than half their normal precipitation with the least precipitation in northwest New Jersey. The dry weather also led to wildfires. During the last weekend in October (the 27th and 28th), 69 wildfires burned 125 acres of forest. The monthly precipitation total of 1.00 inch at the Atlantic City International Airport was the 8th driest on record. The 0.99 inches of rain that fell at the Marina within Atlantic City was the 10th driest on record. Records at the Marina date back to 1874. Unseasonably dry weather continued through November of 2001. On a statewide average the preliminary monthly precipitation total for November was 1.03 inches, the 6th driest November on record. The combination preliminary statewide average of 2.06 inches for both October and November was the driest on record dating back to 1895. The continued dry weather, the drop in stream flow and groundwater levels and the reduced levels in the New York State reservoirs prompted the New Jersey State Department of Environmental Protection to upgrade the drought watch to a drought warning for counties in the Delaware River Basin and southern New Jersey on November 21st. The drought warning included Cape May. The drought warning gives the state Department of Environmental Protection (DEP) greater authority to control water distribution and transfers among the major reservoir systems and to temporarily modify water allocation permits. Individual municipalities can also set their own restrictions. The DEP asked residents to use good water conservation practices but there were no mandatary restrictions unless required by an individual township. The lack of adequate precipitation became more apparent as the month went along. On November 13th, the Great Egg Harbor River was at record low levels for the date. The same was true for about

Table 5.4.4-4. Drought Incidents in Cape May County, 2010 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
				one quarter of all the rivers and streams in the state. The state forestry service banned all ground level campfires in wooded areas. Unseasonably dry weather continued across New Jersey during the month of December. While more precipitation fell during December than either October or November, it was still drier than normal. On a county weighted average, the monthly precipitation total was 1.6 inches in Cape May County. Signs of the drought were apparent across the state. On December 3rd, 20 percent of all streams were at record low flow for the calendar day. Another 40 percent were threatening record lows. Unseasonably dry weather continued across New Jersey during the month of January. While more precipitation fell during January than any month since last September, it was still drier than normal. Unseasonably dry weather intensified across New Jersey during the month of February. It was the driest February on record across the state. Farmers stated that the winter wheat crop was struggling. They expected a reduced yield. One stated that this was the driest the fields in February have been in his 49 years of farming. Christmas tree farms were also suffering as were other evergreens at nurseries. Irrigation ponds were well below normal (3 to 4 feet) for February. Another result of the drought was increased bear sightings and nuisance calls in the northwest part of the state. New Jersey entered March 2002 with considerably dry conditions and a drought warning in effect for most of the state. Most of the state's shallow groundwater wells were at the lowest levels ever for this time of year. Most of the surface streams and rivers were flowing at only about 25 percent of normal. There was a record number (500) of wells being replaced throughout the state through early March. All precipitated Governor Jim McGreevey to declare a drought emergency for the state of New Jersey on March 4th. The drought emergency placed an immediate ban on non-essential use of water. Water could be served in restaurants only be request. Vehicles and boats could only be washed commercially. Grass watering was banned. There was a limit to the amount of watering for newly seeded or sodded grass. Gardens, trees and shrubs could only be watered using a hose or watering can. Golf courses must cut back usage by 50 percent. Athletic fields could only be watered overnight. Washing of streets, roads, sidewalks, driveways, garages, parking areas and patios with potable water was banned. Only commercial power washing of surfaces permitted. Running water through fountains, artificial waterfalls and reflection pools were prohibited except to support wildlife. Flushing of sewer lines with potable water was banned. The spring allergy season started earlier and stronger because of the dry, warm weather. New Jersey entered April 2002 with a drought emergency in effect for the entire state with mandatory watering restrictions in place. Water usage statewide was down about 5 to 10 percent. March 2002 was the first month since June of 2001 where the statewide average precipitation was wetter than normal.

Table 5.4.4-4. Drought Incidents in Cape May County, 2010 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
				New Jersey entered May 2002 with a drought emergency in effect for the entire state with mandatory watering restrictions in place. Water usage statewide was down about 5 to 10 percent. New Jersey entered June 2002 with a drought emergency in effect for the entire state with mandatory watering restrictions in place. Water usage statewide was down by as much as 20 percent. In response to the improving conditions, some of the watering restrictions were relaxed. The unseasonably warm and dry month of July intensified drought conditions across the state. In spite of mandatory restrictions, water usage increased as the month wore on. Water usage statewide was down by as much as 20 percent in May and June. The unseasonably warm and dry month of August intensified drought conditions across the state. In fact very little precipitation fell across the state between August 2nd and the 24th. September began with drought conditions intensifying across New Jersey. The month though saw a return of near normal precipitation. This was too late for farmers. On the 3rd, Governor James McGreevey requested to Congress a federal farm disaster declaration. It was estimated that the drought will cost farmers about $125 million in revenue. October 2002 saw the return of well above normal precipitation to New Jersey. It was also the first month since June that precipitation was above normal in every county. An unseasonably wet November ended the meteorological drought across New Jersey.
September 6 – 12, 2005	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Cape May County from September 6 – 12, D1 or “moderate drought” from September 13 – October 10, and D0 or “abnormally dry” from October 11 – 17, 2005. September 2005 was an unseasonably warm and dry month across the state of New Jersey. The unseasonably dry weather began for most in mid-August and continued throughout the month. The lack of rain affected both the agriculture and water supplies. Acting Governor Richard Codey declared a drought watch on September 13th and called for voluntary conservation methods. Residents were urged to limit lawn watering, to only run their washers and dishwashers with full loads and to purchase and install water saving shower heads and faucets. The state's Forestry Service also prohibited the creating of recreational fires that burn directly on the ground and in all wooded areas. Because of the higher cost for fuel, irrigation costs increased. Another problem with the drought affected power lines near the coast. The lack of rain permitted salt to build on power lines. When it rained at the end of the month, blown fuses, arcing wires and pole fires occurred. About 9,000 homes and businesses mainly in Atlantic and Cape May Counties lost power.
March 21 – June 26, 2006	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or “abnormally dry” status across Cape May County from March 21 – April 10, D1 or “moderate drought” from April 11 – April 24, and D0 or “abnormally dry” from April 25 – June 26, 2006.

Table 5.4.4-4. Drought Incidents in Cape May County, 2010 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
August 22 – 28, 2006	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from August 22 – 28, 2006.
July 17, 2007 – March 10, 2008	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from July 17 – August 13, D1 or "moderate drought" from August 14 – October 29, and D0 or "abnormally dry" from October 30, 2007 – March 10, 2008
July 22 – December 1, 2008	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from July 22 – September 1, D1 or "moderate drought" from September 2 – 8, and D0 or "abnormally dry" from September 9 – December 1, 2008. An unseasonably dry August occurred across the state of New Jersey with the greatest departures from normal in the central part of the state. This exacerbated crop damage that was already inflicted by the heat and the large hail storm in the southern part of the state on August 10th. The combination of the June heat and the August hail storm and drought led the United States Secretary of Agriculture Edward Schafer to declare ten central and southern New Jersey Counties a natural disaster. Cape May County was included in the declaration.
March 24 – May 4, 2009	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from March 24 – May 4, 2009.
June 29 – October 25, 2010	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from June 29 – July 12, D1 or "moderate drought" status from July 13 – October 4, and D0 or "abnormally dry" status from October 5 – October 25, 2010. On September 8, 2010, the New Jersey Department of Environmental Protection extended a drought watch throughout the entire state. The Department of Environmental Protection asked all state residents to voluntarily conserve water. The hot and dry summer taxed reservoir stream and groundwater levels. Shallow groundwater (private) wells were also starting to show stress. September was another unseasonably warm month in New Jersey. Statewide it was the 4th warmest September on record since 1895 with an average temperature of 69.2 degrees. Because of the heavy rain on the last day of the month, September averaged closer to normal rainfall. It was the 7th warmest (71.0 degrees) September on record at the Atlantic City International Airport and the warm season as a whole established a new record for the number of days that the maximum temperature reached or exceeded 90 degrees (46 days). The wet weather on September 30th and October 1st started to recharge water supplies in the state of New Jersey. On October 26th, the New Jersey Department of Environmental Protection cancelled the drought watch for Cape May County. The summer drought took its toll on New Jersey farmers and the United States Secretary of Agriculture Thomas Vilsack declared all counties in southern, central and northwest New Jersey natural disaster areas in November. The declaration made farm operators eligible for assistance from

Table 5.4.4-4. Drought Incidents in Cape May County, 2010 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Description
				the Farm Service Agency. The assistance included low interest loans which could cover up to 100 percent of the dollar value of the crop losses.
June 7 – July 11, 2011	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from June 7 – July 11, 2011.
August 2 – 22, 2011	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from August 2 – 22, 2011.
January 31 – July 23, 2012	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from January 31– April 2, 2012, D1 or "moderate drought" status from April 3 – June 18, 2012, and D0 or "abnormally dry" status from June 19 – July 23, 2012.
August 21 – October 29, 2012	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from August 21 – October 29, 2012.
May 26 -June 1, 2015	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from May 26 – June 1, 2015.
September 1 – October 5, 2015	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from September 1 – October 5, 2015
August 2 – August 22, 2016	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from August 2 – August 22, 2016.
September 13 – 19, 2016	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from September 13 – 29, 2016.
December 6, 2016 – March 13, 2017	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from December 6, 2016 – March 13, 2017.
July 17 - 23, 2018	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from July 17 - 23, 2018.
September 17 – December 9, 2019	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from September 17 – October 14, D1 or "moderate drought" status from October 15 - 21, and D0 or "abnormally dry" status from October 22 – December 9, 2019.
June 30 – July 13, 2020	Drought	N/A	N/A	According to the U.S. Drought Monitor, conditions held at a D0 or "abnormally dry" status across Cape May County from June 30 – July 13, 2020

Source: NOAA NCEI 2020. USDA 2020, NDMC 2020

Probability of Future Occurrences

Based upon risk factors for and past occurrences, it is likely that droughts will occur across New Jersey and Cape May County in the future. In addition, as temperatures increase (see climate change impacts), the probability for future droughts will likely increase as well. Therefore, it is likely that droughts will occur in New Jersey of varied severity in the future.

It is estimated that Cape May County will continue to experience direct and indirect impacts of drought and its impacts on occasion, with the secondary effects causing potential disruption or damage to agricultural activities and creating shortages in water supply within communities.

In Section 5.3 (Hazard Ranking), 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 Steering Committee and Planning Committee, the probability of occurrence for drought in the County is considered 'occasional' (between 10% and 100% annual chance of occurring).

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

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). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70% of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). 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). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011).

Sea level has been gradually rising for the past 100 year and the rate of sea level rise is predicted to accelerate as a result of climate change (refer to the Extent section of this profile). Rising sea levels will continue to increase occurrences of inundation and erosion along the coastal areas of Cape May County. Coastal communities in the County may also see an increase risk of flood-related damages to homes, businesses and infrastructure. An increase in sea level also implies that storm surges will operate from an elevated base, so severe coastal flooding may be more frequent in the future (NJ Climate Adaptation Alliance 2016). Increased sea levels are connected to saltwater intrusion.

5.4.4.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. The following discusses Cape May County's vulnerability, in a qualitative nature, to the drought hazard.

Impact on Life, Health and Safety

The entire population of Cape May County is exposed to drought events. The population is estimated to be 93,705 people as of 2018 and is anticipated to be several times higher during the summer season. Drought conditions can cause a shortage of potable water for human consumption, both in quantity and quality. A decrease in available water may also impact power generation and availability to residents.

Surface water supplies are affected more quickly during droughts than groundwater sources; however, groundwater supplies generally take longer to recover. Droughts can also lead to reduced local firefighting capabilities. The drought hazard is a concern for Cape May County because the County's water is supplied by groundwater.

Public health impacts may include an increase in heat-related illnesses, waterborne illnesses, recreational risks, limited food availability, and reduced living conditions. Vulnerable populations could be particularly susceptible to the drought hazard and cascading impacts due to age, health conditions, and limited ability to mobilize to shelter, cooling and medical resources. Other possible impacts to health due to drought include increased recreational risks; effects on air quality; diminished living conditions related to energy, air quality, and sanitation and hygiene; compromised food and nutrition; and increased incidence of illness and disease. Health implications of drought are numerous. Some drought-related health effects are short-term while others can be long-term (CDC 2020).

The Centers for Disease Control and Prevention's (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 social vulnerability and impacts from a drought event may be exacerbated (CDC 2016).

Impact on General Building Stock

No structures are anticipated to be directly affected by a drought event. However, droughts contribute to conditions conducive to wildfires and reduce fire-fighting capabilities. Risk to life and property is greatest in those areas where forested areas adjoin urbanized areas (high density residential, commercial and industrial) also known as the wildfire urban interface (WUI). Therefore, all assets in and adjacent to, the WUI zone, including population, structures, critical facilities, lifelines, and businesses are considered vulnerable to wildfire. Refer Section 5.4.11 for the Wildfire risk assessment.

Impact on Critical Facilities

As mentioned, drought events generally do not impact buildings; however, droughts have the potential to impact agriculture-related facilities and critical facilities that are associated with water supplies such as potable water used with fire-fighting services. Critical facilities in and adjacent to the wildfire hazard areas are considered vulnerable to wildfire.

Water systems and thus distribution to the population may also be impacted by other hazards such as extreme weather events. For example, storm surge from Superstorm Sandy damaged critical water supply infrastructure along the coast and high winds impacted energy distribution across the State which in turn impacted the ability to supply water. As a result, NJDEP has developed new guidance aimed to ensure that repairs, reconstruction, new facilities and operations/maintenance are focused on enhancing the resilience of critical infrastructure (NJDEP 2017).

Impact on the Economy

Drought can produce a range of impacts that span many economic sectors and can reach beyond an area experiencing physical drought. As previously discussed, water withdrawals are not only used for potable water but for use in the commercial/industrial/mining sectors and power generation. When a state of water emergency is declared by the Governor (when a potential or actual water shortage endangers the public health, safety and welfare), the NJDEP may impose mandatory water restrictions and require specific actions to be taken by water suppliers. According to the New Jersey Water Supply Plan, a water emergency seeks to cause as little disruption as possible to commercial activity and employment (NJDEP 2017).

A prolonged drought can have a serious economic impact on a community. One impact of drought is its impact on water supply. When drought conditions persist with little to no relief, water restrictions may be put into place by local or state governments. These restrictions may include placing limitations on when or how frequent lawns can be watered, car washing services, or any other recreational/commercial outdoor use of water supplies. In exceptional drought conditions, watering of lawns and crops may not be an option. If crops are not able to receive water, farmland will dry out and crops will die. This can lead to crop shortages, which, in turn, increases the price of food.

Increased demand for water and electricity can also result in shortages and higher costs for these resources. Industries that rely on water for business could be impacted the most (e.g., landscaping businesses). Although most businesses will still be operational, they may be impacted aesthetically. These aesthetic impacts are most significant within the recreation and tourism industry. Moreover, droughts within another area could impact the food supply and price of food for residents within the county.

Direct impacts of drought include reduced crop yield, increased fire hazard, reduced water levels, and damage to wildlife and fish habitat. The many impacts of drought can be listed as economic, environmental, or social. Direct and indirect losses include the following:

- Damage to crop quality and crop losses.
- Insect infestation leading to crop and tree losses.
- Plant diseases leading to loss of agricultural crops and trees.
- Reduction in outdoor activities.
- Increased risk of brush fires and wildfires due to dried crops, grasses, and dying trees.

When a drought occurs, the agricultural industry is most at risk in terms of economic impact and damage. For example, crops may not mature leading to undernourished livestock and wildlife, decreased crop yield, declining land values, and financial losses to farmers (Western Drought Coordination Council, 1998). Based on the 2017 Census of Agriculture, there were 164 farms in Cape May County, a 7.8% increase from the 2012 reports. The average farm size was 50 acres. The County farms had a total market value of products sold of $9.8 million in crop sales and $1 million in livestock-related sales. Table 4.3.4-6 summarizes the acreage of agricultural land exposed to the drought hazard.

Table 5.4.4-5. Agricultural Land in Cape May County in 2017

Number of Farms	Land in Farms (acres)	Total Cropland (acres)	Harvested Cropland (acres)	Irrigated Land (acres)
164	8,135	3,823	3,086	1,433

Source: USDA 2017

Impact on the Environment

Droughts can impact the environment because these events can trigger wildfires, increase insect infestations, and exacerbate the spread of disease (NOAA 2020). Droughts will also impact water resources that are relied upon by aquatic and terrestrial species. Ecologically sensitive areas, such as wetlands, can be particularly vulnerable to drought periods because they are dependent on steady water levels and soil moisture availability to sustain growth. As a result, these types of habitats can be negatively impacted after long periods of dryness (NJDEP 2017). Nearly two-thirds of Cape May County's land area is forest or wetlands. Though freshwater wetlands are not as prevalent as saltwater wetlands in the County, the sensitive ecosystems remain vulnerable to drought.

Droughts also have the potential to lead to water pollution due to the lack of rainwater to dilute any chemicals in water sources. Contaminated water supplies may be harmful to plans and animals. If water is not getting into the soils, the ground will dry up and become unstable. Unstable soils increase the risk of erosion and loss of topsoil (North Carolina State University 2013).

Future Changes That May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. 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 (County Profile), areas targeted for future growth and development have been identified across Cape May County. The New Jersey Water Supply Plan indicates seasonal outdoor water use is rising and is attributable to continued suburbanization and increases in residential and commercial lawn and landscape maintenance. Changes in water demands by commercial/industrial users will depend on future development of this water type use and how effectively efficiency techniques are implemented (NJDEP 2017).

Projected Changes in Population

Potable water use is the second largest water use sector and largest consumptive use in New Jersey. As such, population projections, per capital water use and percent non-residential water use by water system are important factors to consider when assessing future water needs. Cape May County has experienced population declines since 2010. Moreover, the County has a highly variable seasonal population that is estimated to be an eight-fold increase from its year-round population. These population increases are most noticeable in barrier island communities such as Ocean City, where the Census population of 11,701 people in 2010 explodes to an estimated 147,612 people when factoring day-trippers, marina slips, and hotel/motel units. Increases in seasonal population may create greater strain on water resources in those communities, throughout Cape May County and the region as a whole (Cape May County 2020).

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures. Additionally, the State is projected to experience more frequency droughts which may affect the availability of water supplies, primarily placing an increased stress on the population and their available potable water. Agricultural needs may increase if the climate grows warmer but may decrease if more efficient irrigation techniques are adopted broadly or if precipitation increases. A decrease in water supply, or increase in water supply demand, may increase the County's vulnerability to structural fire and wildfire events. Critical water-related service sectors may need to adjust management practices and actively manage resources to accommodate for future changes.

Change of Vulnerability Since the 2016 HMP

Drought is a new hazard for the 2021 Hazard Mitigation Plan Update. Overall, the County's vulnerability has not changed, and the entire County will continue to be exposed and vulnerable to drought events.

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.

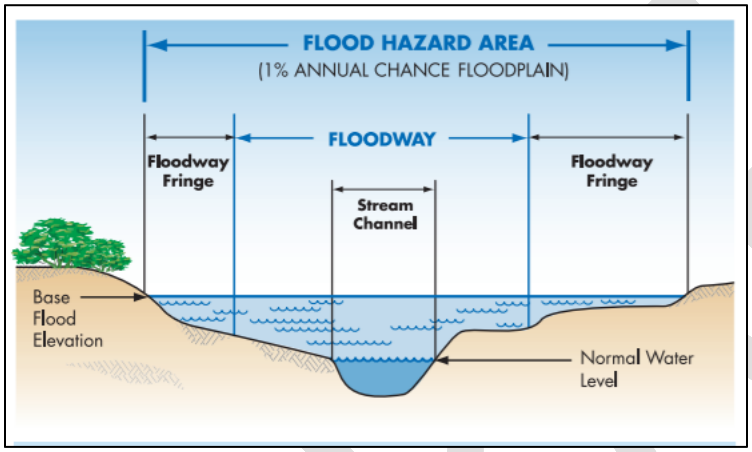
> The State of New Jersey has 127 miles of coastline, encompassing portions of eight counties and 126 municipalities. Additionally, the coastal area of the State includes the Coastal Area Facility Review Act (CAFRA) zone and the New Jersey Meadowlands District. According to the NJDEP, portions of Cape 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

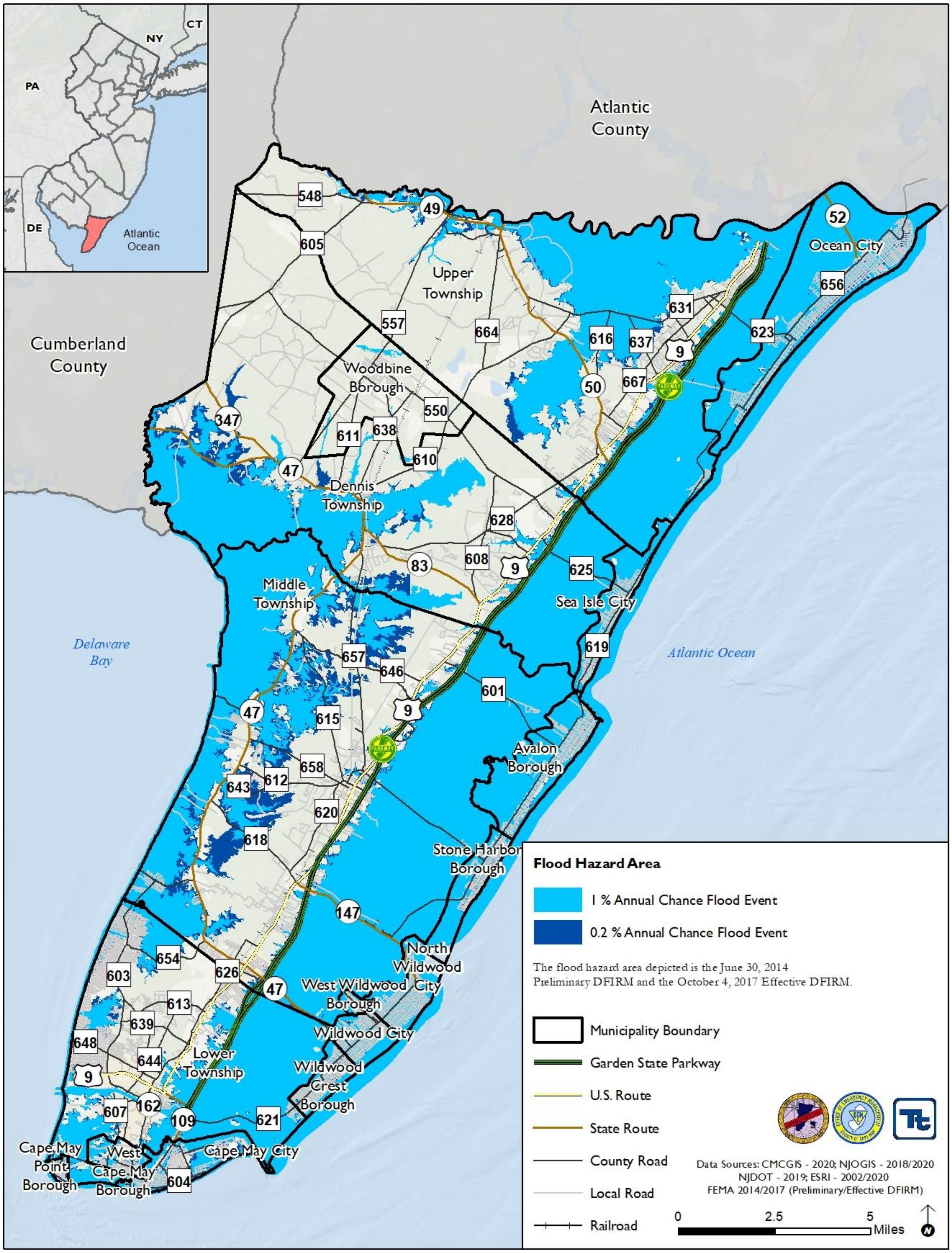
When tide heights reach 8.0 feet (moderate tidal flooding), flooding occurs along Dennis Creek around State Route 47 in Dennis Township and on Avalon Boulevard (County Route 601) near Garden State Parkway Interchange 13.

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.

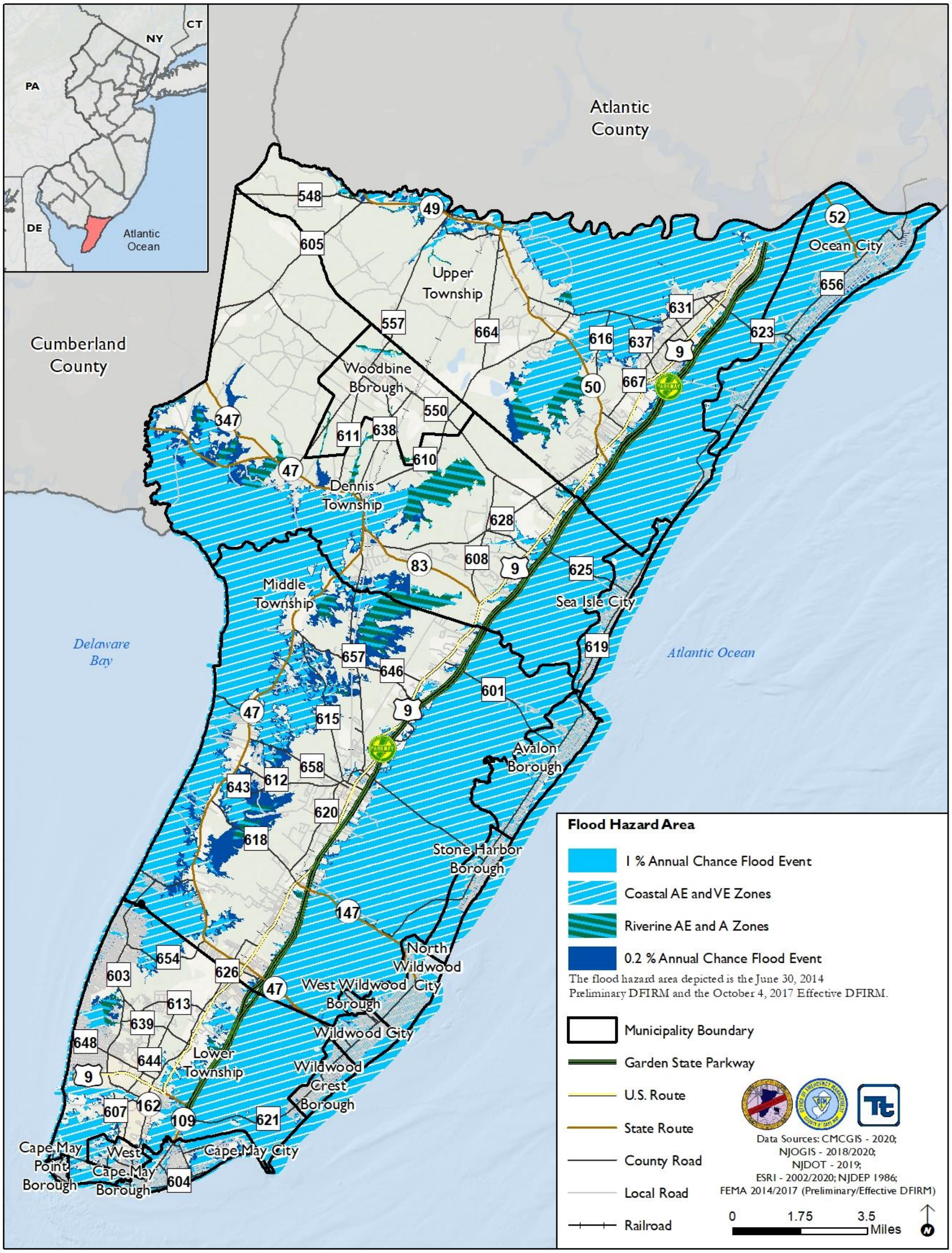
Impacts of climate change can lead to shoreline erosion, coastal flooding, and water pollution; affecting man-made coastal infrastructures and coastal ecosystems. Coastal areas may be impacted by climate change in different ways. These areas are sensitive to sea level rise, changes in the frequency and 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

		Estimated Population Exposed					
		1-Percent Annual Chance Flood Event				0.2-percent Annual Chance Flood Event	
Jurisdiction	American Community Survey (2014-2018) Total Population	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: 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	0.2-percent Annual Chance Flood Event: 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	Estimated Building Stock Exposed to the Flood Hazard Area 1-Percent Annual Chance Flood Event 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	1-Percent Annual Chance Flood Event (Coastal Only) Residential Estimated Number of Buildings with Damages in Flood Hazard Area	1-Percent Annual Chance Flood Event (Coastal Only) 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**

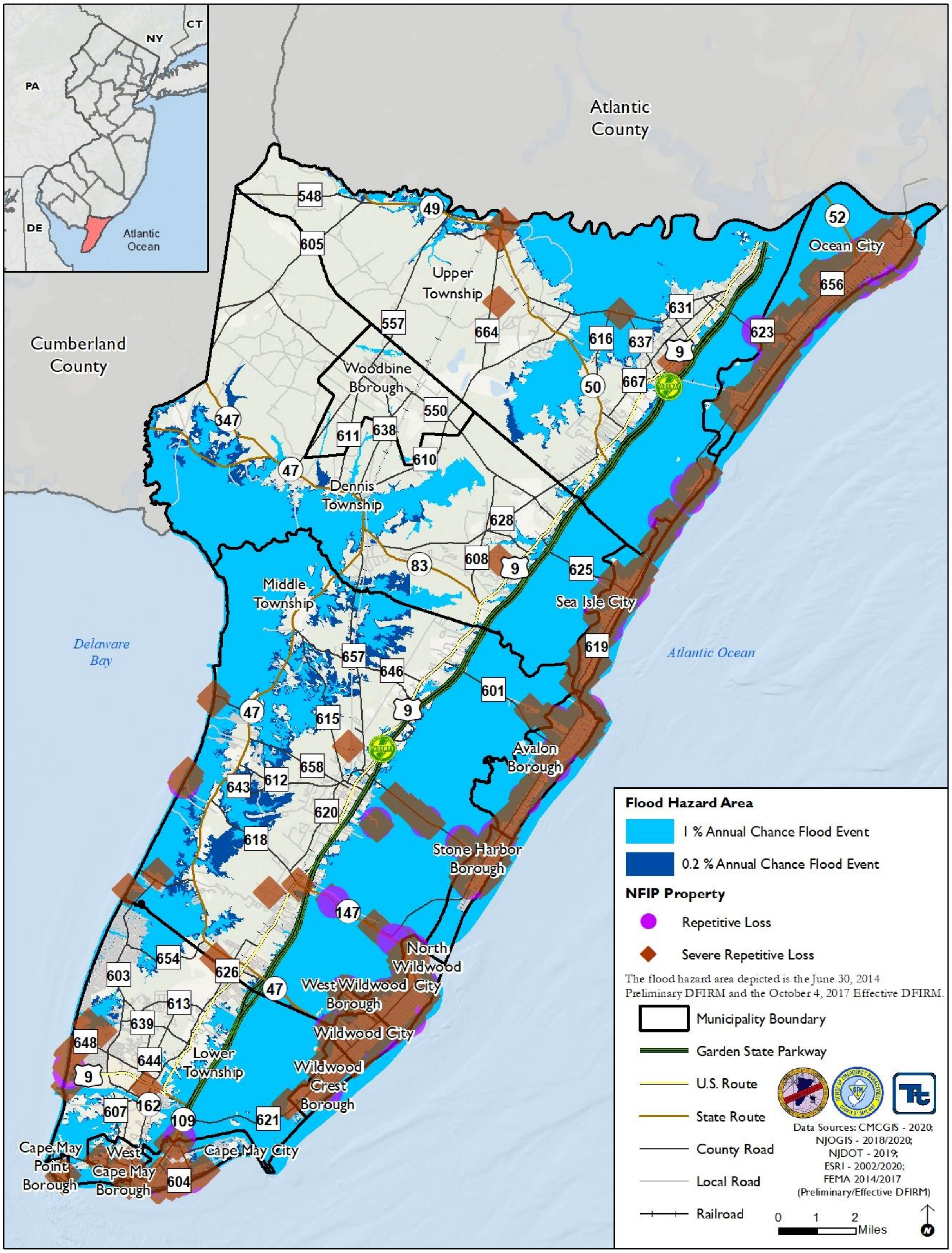
Source: FEMA Region 2 2020
Note: NFIP = National Flood Insurance Program. The total number of repetitive loss properties does not include the severe repetitive loss properties. The severe repetitive loss property totals only include validated properties.

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).

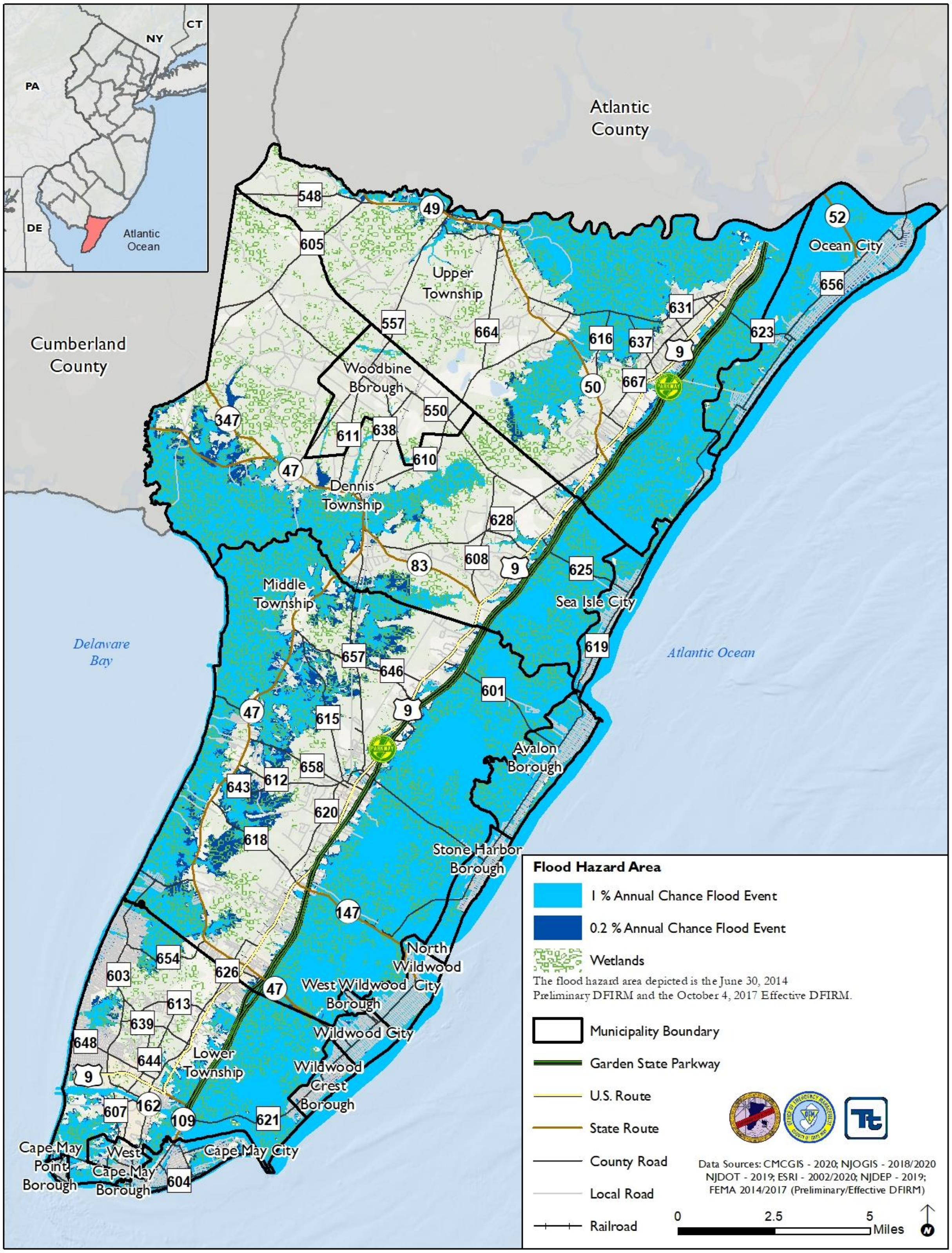
Table 5.4.5-28. Acres of Wetlands in Cape May County by Jurisdiction

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.

5.4.6 Hurricane and Tropical Storm

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 hurricane and tropical storm hazard in Cape May County.

2021 HMP Update Changes

- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2016 and 2020.
- A vulnerability assessment section was completed for the hurricane and tropical storm 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. A probabilistic assessment for the 100-year and 500-year Mean Return Periods (MRPs) was performed using the most current version of Hazus (v4.2) to estimate potential losses.

5.4.6.1 Profile

Hazard Description

A tropical cyclone is a rotating, organized system of clouds and thunderstorms that originates over tropical or sub-tropical waters and has a closed low-level circulation. Tropical depressions, tropical storms, and hurricanes are all considered tropical cyclones. These storms rotate counterclockwise around the center in the northern hemisphere and are accompanied by heavy rain and strong winds (NWS 2013a). Almost all tropical storms and hurricanes in the Atlantic basin (which includes the Gulf of Mexico and Caribbean Sea) form between June 1 and November 30 (hurricane season). August and September are peak months for hurricane development (NOAA 2013a).

Over a two-year period, the U.S. coastline is struck by an average of three hurricanes, one of which is classified as a major hurricane. Hurricanes, tropical storms, and tropical depressions pose a threat to life and property. These storms bring heavy rain, storm surge, and flooding (NOAA 2013b). The cooler waters off the coast of New Jersey can diminish the energy of storms that have traveled up the eastern seaboard. However, historical data show that a number of hurricanes/tropical storms have impacted New Jersey, often as the remnants of a larger storm hitting the Gulf or Atlantic Coast hundreds of miles south of New Jersey. These storms maintain sufficient wind and precipitation to cause substantial damage to the state.

For the purpose of this HMP update, this hazard profile will include hurricanes and tropical storms. Detailed information regarding these hazards in Cape May County are discussed further in this section.

Hurricanes and Tropical Storm

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, therefore categorized as a tropical storm instead of a hurricane). Tropical storms strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. They are fueled by a different heat mechanism than other cyclonic windstorms such as Nor'Easters and polar lows. The characteristic that separates tropical cyclones from other cyclonic systems is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings; a phenomenon called "warm core" storm systems (NOAA 2013c).

A hurricane is a tropical storm that attains hurricane status when its wind speed reaches 74 or more miles per hour (mph). Tropical systems may develop in the Atlantic between the Lesser Antilles and the African coast, or may develop in the warm tropical waters of the Caribbean and Gulf of Mexico. These storms may move up the Atlantic Coast of the United States and impact the Eastern Seaboard, or move into the United States through the states along the Gulf Coast, bringing wind and rain as far north as New England, before moving offshore and heading east.

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

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

Hurricanes and tropical storms often occur at the same time. Because of this, officials assign short, distinctive names to the storms to avoid confusion among weather stations, coastal bases, and ships at sea. Since 1953, Atlantic tropical storms have been named from lists originated by the National Hurricane Center. Currently, they are maintained and updated by the World Meteorological Organization. The list of names in the table below are used in rotation and recycled every 6 years. The only time there is a change in the list is if the named storm was so costly or deadly that the future use of it would be inappropriate. If that occurs, the World Meteorological Organization committee will select a new name to replace the one removed from the list. If all the names in a season's list have been used, later storms are named for Greek letters, in alphabetical order. A storm is given a name once its winds reach a speed of 40 mph. In addition to the Atlantic list of names, there are ten other lists corresponding to other storm-prone regions of the world (NOAA NHC 2020). Table 5.4.6-1 lists the tropical cyclone names for 2013 through 2018.

Table 5.4.6-1 Tropical Cyclone Names for the Atlantic

2020	2021	2022	2023	2024	2025
Arthur	Ana	Alex	Arlene	Alberto	Andrea
Bertha	Bill	Bonnie	Bret	Beryl	Barry

2020	2021	2022	2023	2024	2025
Cristobal	Claudette	Colin	Cindy	Chris	Chantal
Dolly	Danny	Danielle	Don	Debby	Dorian
Edouard	Elsa	Earl	Emily	Ernesto	Erin
Fay	Fred	Fiona	Franklin	Francine	Fernand
Gonzalo	Grace	Gaston	Gert	Gordon	Gabrielle
Hanna	Henri	Hermine	Harold	Helene	Humberto
Isaias	Ida	Ian	Idalia	Isaac	Imelda
Josephine	Julian	Julia	Jose	Joyce	Jerry
Kyle	Kate	Karl	Katia	Kirk	Karen
Laura	Larry	Lisa	Lee	Leslie	Lorenzo
Marco	Mindy	Martin	Margot	Milton	Melissa
Nana	Nicholas	Nicole	Nigel	Nadine	Nestor
Omar	Odette	Owen	Ophelia	Oscar	Olga
Paulette	Peter	Paula	Philippe	Patty	Pablo
Rene	Rose	Richard	Rina	Rafael	Rebekah
Sally	Sam	Shary	Sean	Sara	Sebastien
Teddy	Teresa	Tobias	Tammy	Tony	Tanya
Vicky	Victor	Virginie	Vince	Valerie	Van
Wilfred	Wanda	Walter	Whitney	William	Wendy

Source: NOAA 2020

Storm Surge

Storm surges inundate coastal floodplains by dune overwash, tidal elevation rise in inland bays and harbors, and backwater flooding through coastal river mouths. Strong winds can increase in tide levels and water-surface elevations. Storm systems generate large waves that run up and flood coastal beaches. The combined effects create storm surges that affect the beach, dunes, and adjacent low-lying floodplains. Shallow, offshore depths can cause storm-driven waves and tides to pile up against the shoreline and inside bays.

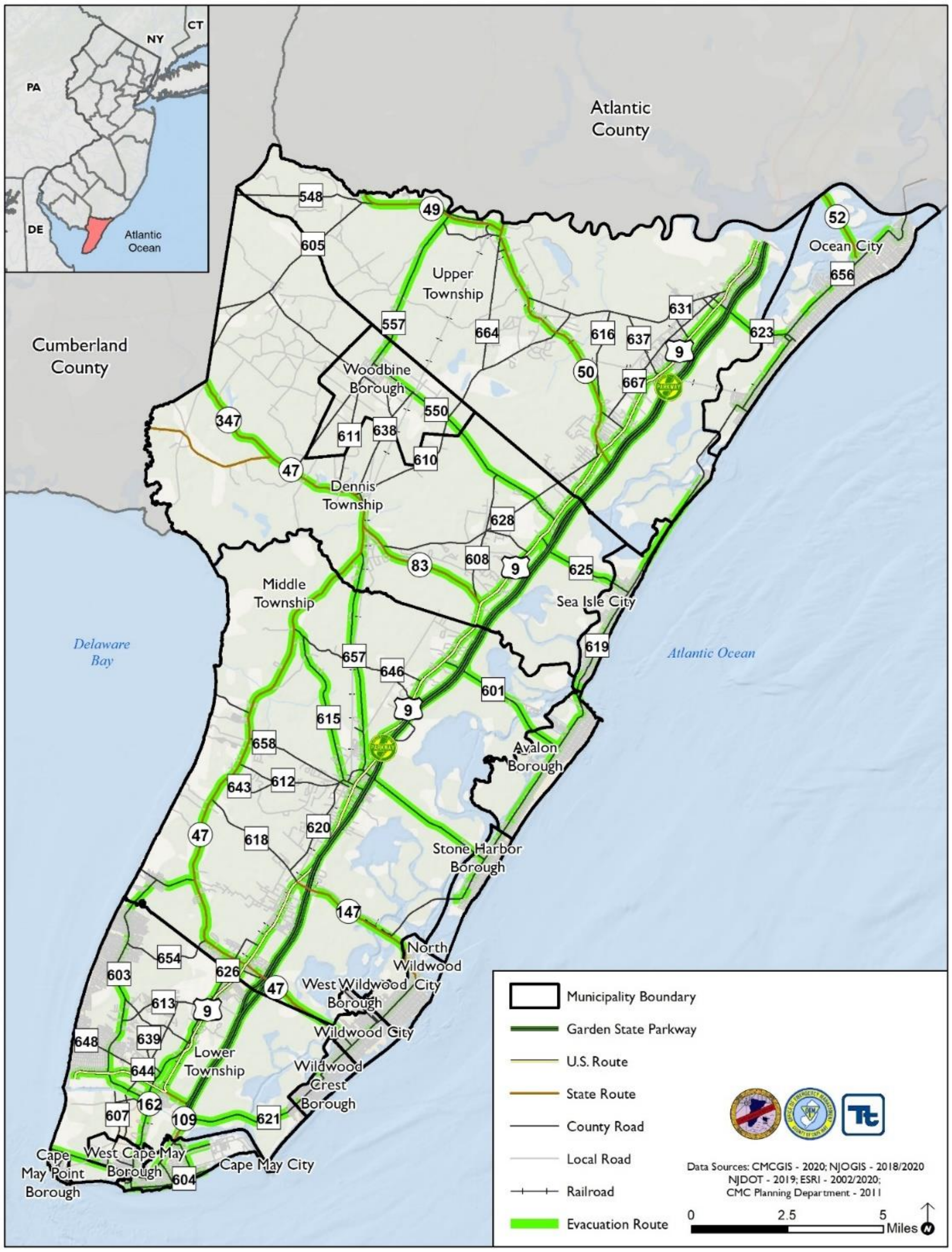
Based on an area's topography, a storm surge may inundate only a small area (along sections of the northeast or southeast coasts) or storm surge may inundate coastal lands for a mile or more inland from the shoreline. Storm surge is further discussed in Section 5.4.5 (Flood).

Location

The entire Cape May County Planning Area is vulnerable to coastal storms; however, where the storms impact depends on the storm's track. All of Cape May County is surrounded by coastal waters and susceptible to damage caused by the combination of both high winds and tidal surge. See Section 5.4.2 (Coastal Erosion) for detailed information regarding the coastline in Cape May County. Refer to Section 9 (Jurisdictional Annexes) for detailed maps that display the 1-percent annual chance event floodplains and Sea, Lake and Overland Surge from Hurricanes (SLOSH) inundation areas in each municipality.

The State of New Jersey has identified State roads as potential evacuation routes for coastal emergencies such as approaching tropical storms or hurricanes. When local, county or state officials order an evacuation, they will provide specific information about the roads that should be taken. Police and first responders will be posted in the communities being evacuated to direct traffic and block unsafe roadways. Figure 5.4.6-1 illustrates the state road evacuation routes in Cape May County.

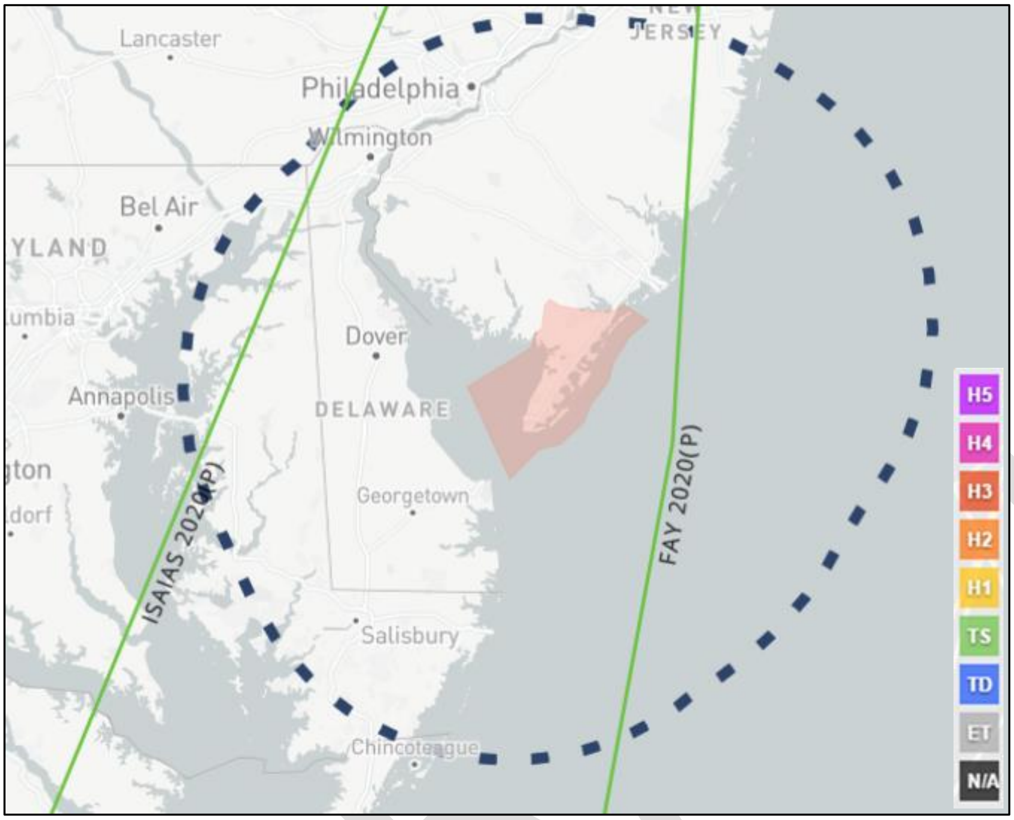
Figure 5.4.6-1. Coastal Evacuation Routes in Cape May County



Tropical Storm and Hurricane Tracks

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool catalogs tropical cyclones that have occurred from 1842 to 2020 (latest date available from data source). Between 1842 and 2020, 59 tropical cyclones tracked within 65 nautical miles of Cape May County. Figure 5.4.6-2 displays tropical cyclone tracks for Cape May County that tracked with 65 nautical miles between 2016 and 2020. Refer to the "Previous Events and Losses" section for further information regarding hurricane and tropical storm events that impacted Cape May County.

Figure 5.4.6-2. Historical Tropical Storm and Hurricane Tracks 2016 to 2020



Source: NOAA 2020

Extent

The extent of a hurricane is categorized in accordance with the Saffir-Simpson Hurricane Scale. The Saffir-Simpson Hurricane Wind Scale is a 1-to-5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous and require preventative measures (NHC 2013).

Figure 5.4.6-3. Saffir-Simpson Scale

Source: NWS 2020

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, a MRP is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. MRP is the average period of time, in years, between occurrences of a particular hazard event, equal to the inverse of the annual frequency of exceedance (Dinicola 2009).

Figure 5.4.6-4 and Figure 5.4.6-5 show the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP events. These peak wind speed projections were generated using FEMA's Hazus wind model. The maximum 3-second gust wind speeds for Cape May County range from 81 mph to 95 mph for the 100-year MRP event (Category 1). The maximum 3-second gust wind speeds for Cape May County range from 87 mph to 123 mph for the 500-year MRP event (Category 1 to Category 3). The storm tracks for the 100- and 500-year event were not available in Hazus. The associated impacts and losses from these 100-year and 500-year MRP hurricane events are discussed later in the Vulnerability Assessment subsection.

Figure 5.4.6-4. Wind Speeds for the 100-Year Mean Return Period Event

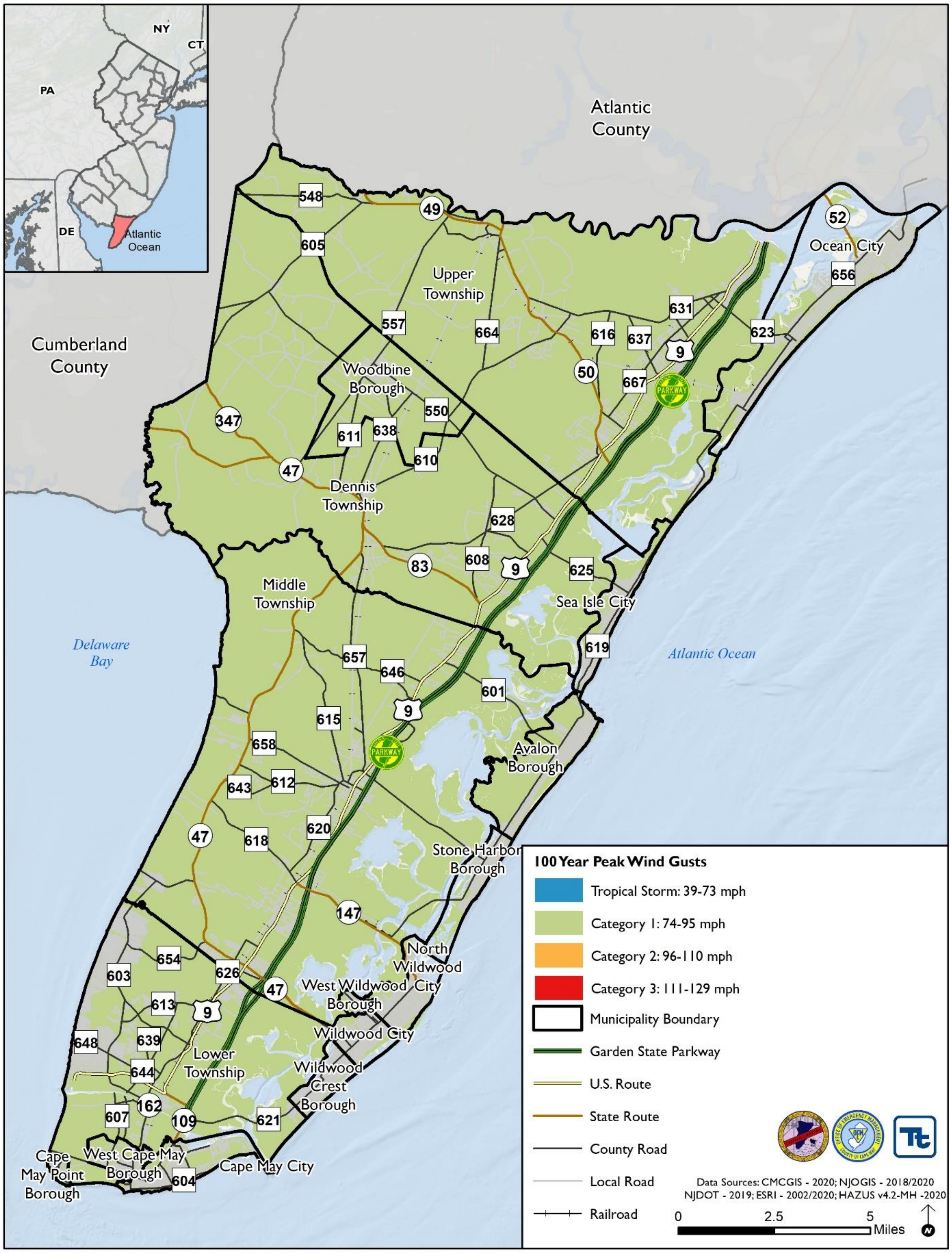
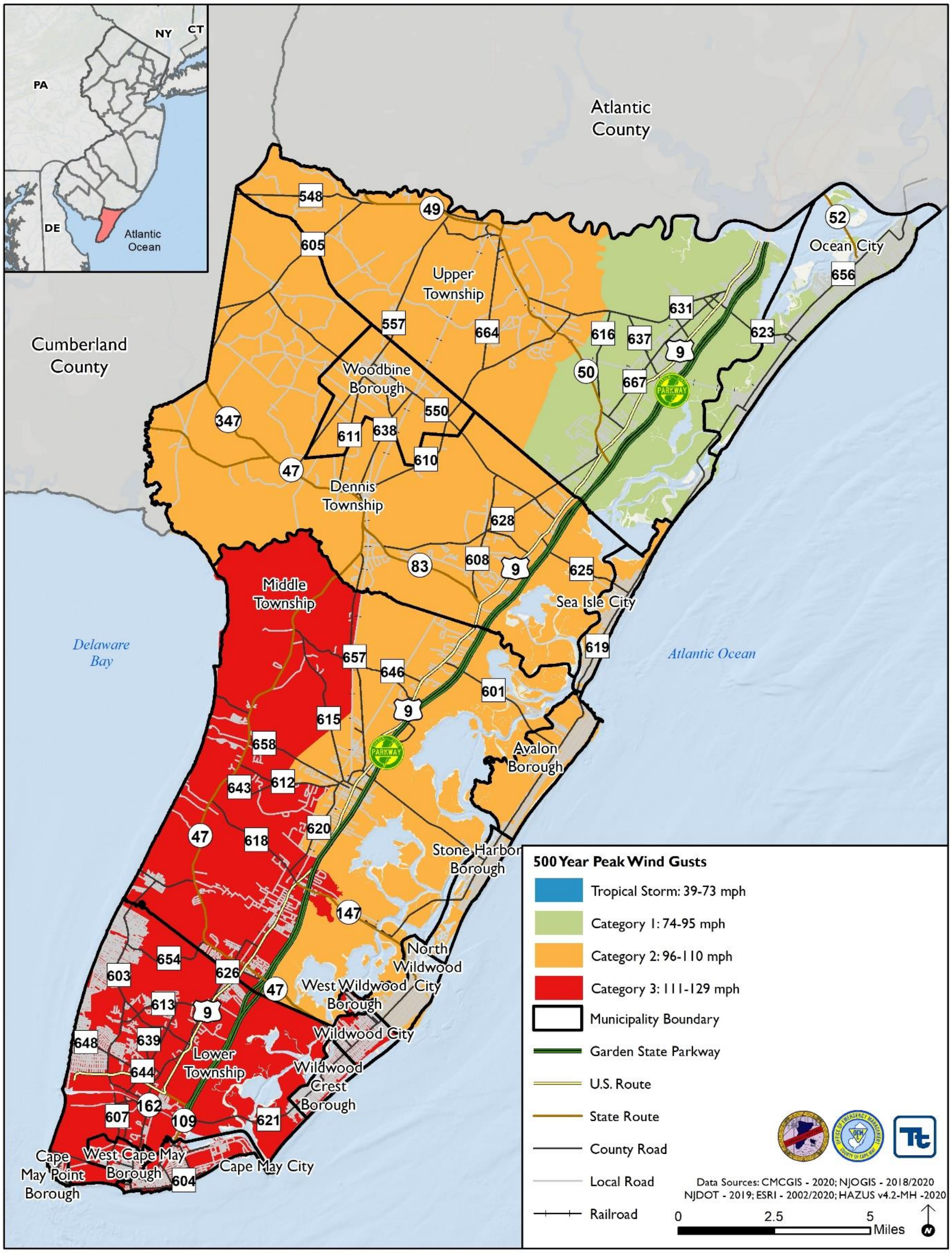


Figure 5.4.6-5. Wind Speeds for the 500-Year Mean Return Period Event



Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with hurricane and tropical storm 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 issued a disaster (DR) or emergency (EM) declaration for the State of New Jersey for eight tropical cyclone-related events, classified as one or a combination of the following disaster types: one or a combination of the following disaster types: hurricane, tropical storm, severe storms, flooding, and tropical depression. Of those events, Cape May County has been included in seven hurricane and tropical storm-related declarations (EM and DR) (FEMA 2020). Table 5.4.6-2 lists FEMA DR and EM declarations for the County.

Table 5.4.6-2. Hurricane and Tropical Storm-Related FEMA Declarations for Cape May County

FEMA Declaration Number	Date(s) of Event	Date of Declaration	Event Type
DR-749	September 27, 1985	October 15, 1985	Hurricane Gloria
EM-3148	September 16-18, 1999	September 17, 1999	Hurricane Floyd
DR-1867	November 11-19, 2009	December 22, 2009	Severe Storms and Flooding Associated with Tropical Depression Ida and a Nor'Easter
EM-3332	August 26 – September 5, 2011	August 27, 2011	Hurricane Irene
DR-4021	August 26 – September 5, 2011	August 31, 2011	Hurricane Irene
EM-3354	October 26 – November 8, 2012	October 28, 2012	Hurricane Sandy
DR-4086	October 26 – November 8, 2012	October 30, 2012	Hurricane Sandy

Source: FEMA 2020

USDA Declarations

Between 2016 and 2020, the period for which data was available, Cape May County was not included in any USDA agricultural disasters relating to hurricanes or tropical storms.

Previous Events

For this 2021 Plan Update, known hurricane and tropical storm events that have impacted Cape May County between 2016 and 2020 are identified are identified in Table 5.4.6-3. With documentation of hurricanes and tropical storms for the State of New Jersey and Cape May County being extensive, not all sources have been identified or researched. Therefore, Table 5.4.6-3 may not include all events that occurred in the County. For events prior to 2016, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 5.4.6-3. Hurricane and Tropical Storm Cape May County, 2016-2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Location	Description
September 3-6, 2016	Tropical Storm Hermine, High Surf	N/A	N/A	Cape May County	Slow moving tropical cyclone Hermine caused several days of 8 to 12 feet of surf breaking on Atlantic Ocean shorelines. Cape May County beaches experienced moderate erosion.
September 19-20, 2017	Tropical Storm Jose, High Surf	N/A	N/A	Cape May County	Tropical cyclone Jose tracked north and east along the Mid Atlantic coast Tuesday September 19th, eventually passing well offshore of Cape May County. Tidal flooding and erosion occurred. According to eyewitnesses and video, storm surge pounded the seawall at Third Avenue and Kennedy Boulevard, pouring over the top of the seawall in North Wildwood. Heavy erosion was also witnessed in Ocean City.
October 20-21, 2019	Subtropical Storm Melissa	N/A	N/A	Cape May County	Subtropical Storm Melissa caused erosion on Cape May Beaches. Most of the towns that saw the worst were in Cape May and Atlantic counties, including parts of Atlantic City, Sea Isle City, North Wildwood and Ocean City. North Wildwood was one of the hardest hit. There, surveyors recorded 40 feet of erosion on the beach, up to four feet in height, between 2nd and 7th Avenues. Five blocks of beach had 12-foot high scarps, according to the survey from the NJ DEP's Division of Coastal Engineering. North Wildwood Mayor Patrick Rosenello estimated the city lost a total of 500,000 cubic yards of sand from the storm. In May, the city placed 200,000 cubic yards onto its beaches-- all of which was lost due to Melissa. In Ocean City, Subtropical Storm Melissa created scarps up to five feet high in the northern part of the island and wiped out dunes a few blocks from the Ocean City Music Pier, according to a DEP survey.
July 10, 2020	Tropical Storm Fay	N/A	N/A	Cape May County	Tropical Storm Fay made landfall near the border of Ocean and Atlantic County bringing heavy rain and flash flooding. Significant erosion occurred in portions of the County including Cape May City.
August 4, 2020	Tropical Storm Isaias	N/A	N/A	Cape May County	Tropical Storm Isaias tracked to the west of Cape May County, bringing tropical downpours, heavy winds, and spawning tornadoes across the region, including one that left a path of destruction in Upper Township. NWS reporting found up to an inch of rainfall. 1.3 million customers in NJ lose power with up to 30% of properties in the County experiencing power outages.

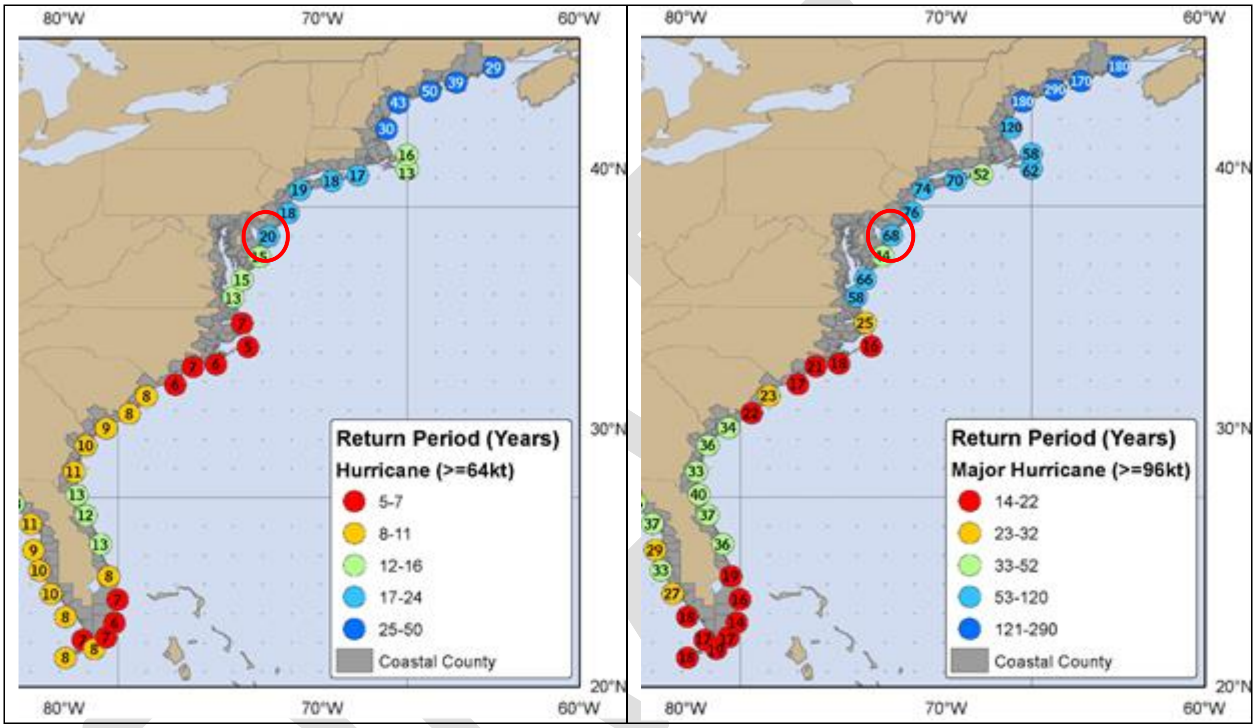
Sources: NOAA-NCEI 2020, FEMA 2020, NHC 2020, Press of Atlantic City 2016, Cape May County Herald. 2017, Press of Atlantic City 2019, Press of Atlantic City 2020
Note: Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table

DR	*Federal Major Disaster Declaration*	*M*	*Million ($)*
EM	*Federal Emergency Declaration*	*Mph*	*Miles Per Hour*
FEMA	*Federal Emergency Management Agency*	*NCEI*	*National Centers for Environmental Information*
HMP	*Hazard Mitigation Plan*	*NOAA*	*National Oceanic Atmospheric Administration*
K	*Thousand ($)*	*NWS*	*National Weather Service*

Probability of Future Occurrences

It is estimated that Cape May County will continue to experience direct and indirect impacts of hurricane and tropical storms annually that may induce secondary hazards such as flooding, extreme wind, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents, and inconveniences. Figure 5.4.6-1 illustrates the return period for hurricanes and major hurricanes along the eastern seaboard. According to these maps, Cape May County can expect a hurricane ever 20 years and a major hurricane ever 68 years.

Figure 5.4.6-6. Return Period in Years for Hurricanes and Major Hurricanes



Source: NHC 2011
Note: The return period of hurricanes based on historical data. Cape May County circled in red. The information on return period is generated with the 1987 HURISK program, but uses data through 2010.

Historical records from the National Hurricane Center can also be used to calculate the probability of future occurrences of hurricane and tropical storm events. Table 5.4.6-4 summarizes data regarding the probability of occurrences of hurricane and tropical storm events in Cape May County based on these historical records.

Table 5.4.6-4. Probability of Future Occurrences of Hurricane/Tropical Storm Events

Hazard Type	Number of Occurrences Between 1950 and 2020	% Chance of Occurring in Any Given Year
Tropical Depression	5	7.04
Tropical Storm	19	26.76
Hurricane	8	11.27
Total	27	38.03

Source: NHC 2021
Note: Event totals include tropical cyclones paths that have traveled within 65 nautical miles of Cape May County. This distance represents a buffer of a distance where impacts would likely be felt even if direct landfall over the county did not occur. The total number of events is less than the total for all hazard types due to some individual storms transitioning from a higher category to a lower category within the buffer zone.

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 hurricane and tropical storms in the county is considered "occasional" (between 10 and 100% annual chance of occurring).

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).

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 severity of coastal flooding events caused by storm surge.

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. 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).

5.4.6.2 Vulnerability Assessment

A probabilistic assessment was conducted for the 100- and 500-year MRPs through a Level 2 analysis in Hazus-MH v4.2 to analyze the wind hazard associated with hurricanes and tropical storms and provide a range of loss estimates due to wind impacts. Storm surge was also assessed using 2014 SLOSH data from NOAA's National Hurricane Center. Refer to Section 4.2 (Methodology and Tools) for additional details on the methodology used to assess hurricane and tropical storm risk.

Impact on Life, Health, and Safety

The impact of a hurricanes and tropical storms on life, health, and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. All Cape May County residents are exposed to a hurricane storm and tropical storm hazard; however 36.9-percent, 57.2-percent, 78.3-percent, and 90.8-percent of the population is exposed to the SLOSH Category 1, Category 2, Category 3, and Category 4 inundation areas, respectively (2018 American Community Survey 5-year Estimate). Refer to Table 5.4.6-5 and Table 5.4.6-6 for a summary of the number of persons exposed to the SLOSH Categories 1 through 4 by jurisdiction. Overall, Ocean City has the greatest number of persons exposed to the SLOSH Category 1 and Category 2 inundation areas. Lower Township has the greatest number of persons exposed to the SLOSH Category 3 and Category 4 inundation areas. One hundred percent of the population for three of the jurisdictions are exposed to the SLOSH Category 4 inundation area (i.e., Cape May Point Borough, West Cape May Borough, and Wildwood Crest Borough).

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. Economically disadvantaged populations are vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate. The population over the age of 65 is also vulnerable and, physically, they may have more difficulty evacuating. Additionally, the elderly are considered vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention which may not be available due to isolation during a storm event. According to the 5-year population estimates from the American Community Survey, Cape May County has a total of 10,140 persons living in poverty and 23,572 over the age of 65 years old. Please refer to Section 4 (County Profile) for the statistics of these populations.

Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Hazus estimates that 59 and 1,122 households will be displaced during the 100-year and 500-year MRP hurricane wind events, respectively. Hazus also estimates that 30 and 615 persons will be seeking short-term shelter during the 100-year and 500-year MRP hurricane wind events, respectively. Refer to Table 5.4.6-7 for a summary of the displaced households by jurisdiction. Please note that estimates are only based on wind speed and do not account for sheltering needs associated with flooding and storm surge that may accompany hurricane and tropical storm events.

Table 5.4.6-5. Estimated Population Exposed to the Hurricane Storm Surge SLOSH Category 1 and Category 2 Hurricane Inundation Hazard Areas

		Estimated Population Exposed to the Hurricane and Tropical Storm Hazard Areas			
Jurisdiction	American Community Survey (2014-2018) Population	Number of Persons Exposed to Category 1 SLOSH	Percent of Total	Number of Persons Exposed to Category 2 SLOSH	Percent of Total
Avalon Borough	1,409	1,222	86.7%	1,401	99.4%
Cape May City	3,491	2,012	57.6%	3,362	96.3%
Cape May Point Borough	188	76	40.6%	187	99.6%
Dennis Township	6,244	82	1.3%	1,074	17.2%
Lower Township	21,838	3,035	13.9%	9,213	42.2%
Middle Township	18,492	2,934	15.9%	8,020	43.4%
North Wildwood City	3,849	3,841	99.8%	3,844	99.9%
Ocean City	11,202	9,359	83.5%	11,175	99.8%
Sea Isle City	1,955	1,765	90.3%	1,943	99.4%
Stone Harbor Borough	955	763	79.9%	950	99.5%
Upper Township	11,909	1,324	11.1%	2,820	23.7%
West Cape May Borough	1,103	512	46.4%	1,046	94.8%
West Wildwood Borough	376	373	99.2%	374	99.4%
Wildwood City	5,073	5,053	99.6%	5,055	99.6%
Wildwood Crest Borough	3,131	2,234	71.4%	3,131	100.0%
Woodbine Borough	2,490	0	0.0%	0	0.0%
Cape May County (Total)	**93,705**	**34,585**	**36.9%**	**53,595**	**57.2%**

Source: American Community Survey 5-year Estimate (2013-2017); NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-6. Estimated Population Exposed to the Hurricane Storm Surge SLOSH Category 3 and Category 4 Hurricane Inundation Hazard Areas

		Estimated Population Exposed to the Hurricane and Tropical Storm Hazard Areas			
Jurisdiction	American Community Survey (2014-2018) Population	Number of Persons Exposed to Category 3 SLOSH	Percent of Total	Number of Persons Exposed to Category 4 SLOSH	Percent of Total
Avalon Borough	1,409	1,402	99.5%	1,403	99.6%
Cape May City	3,491	3,476	99.6%	3,478	99.6%
Cape May Point Borough	188	188	100.0%	188	100.0%
Dennis Township	6,244	2,833	45.4%	4,819	77.2%
Lower Township	21,838	16,271	74.5%	20,816	95.3%
Middle Township	18,492	15,983	86.4%	18,393	99.5%
North Wildwood City	3,849	3,843	99.8%	3,841	99.8%

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Population Exposed to the Hurricane and Tropical Storm Hazard Areas			
		Number of Persons Exposed to Category 3 SLOSH	Percent of Total	Number of Persons Exposed to Category 4 SLOSH	Percent of Total
Ocean City	11,202	11,183	99.8%	11,186	99.9%
Sea Isle City	1,955	1,943	99.4%	1,943	99.4%
Stone Harbor Borough	955	947	99.2%	950	99.5%
Upper Township	11,909	5,679	47.7%	8,301	69.7%
West Cape May Borough	1,103	1,103	100.0%	1,103	100.0%
West Wildwood Borough	376	375	99.6%	374	99.4%
Wildwood City	5,073	5,050	99.5%	5,053	99.6%
Wildwood Crest Borough	3,131	3,131	100.0%	3,130	100.0%
Woodbine Borough	2,490	2	0.1%	60	2.4%
Cape May County (Total)	**93,705**	**73,409**	**78.3%**	**85,039**	**90.8%**

Source: American Community Survey 5-year Estimate (2013-2017); NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-7. Estimated Number of Displaced Households and Number of Persons Seeking Shelter During a 100-Year and 500-Year MRP Hurricane Wind Event

Jurisdiction	American Community Survey (2014-2018) Population	Hurricane Wind 100-Year Mean Return Period		Hurricane Wind 500-Year Mean Return Period	
		Displaced Households*	People Requiring Short-Term Shelter*	Displaced Households*	People Requiring Short-Term Shelter*
Avalon Borough	1,409	1	0	5	2
Cape May City	3,491	2	1	136	85
Cape May Point Borough	188	0	0	22	10
Dennis Township	6,244	0	0	6	3
Lower Township	21,838	1	0	492	257
Middle Township	18,492	1	1	126	73
North Wildwood City	3,849	8	4	57	27
Ocean City	11,202	27	13	15	7
Sea Isle City	1,955	2	1	6	3
Stone Harbor Borough	955	1	0	9	3
Upper Township	11,909	0	0	4	3
West Cape May Borough	1,103	0	0	46	21
West Wildwood Borough	376	2	1	16	11
Wildwood City	5,073	7	5	86	58
Wildwood Crest Borough	3,131	7	4	91	48
Woodbine Borough	2,490	0	0	4	4
Cape May County (Total)	**93,705**	**59**	**30**	**1,122**	**615**

Source: Hazus-MH v4.2; U.S. Census Bureau 2010
*Notes: *Number of persons may be over or underestimated because Hazus uses 2010 Census Bureau population statistics.*

Impact on General Building Stock

Wind-Only Impacts

Damage to buildings is dependent upon several factors, including wind speed, storm duration, and path of the storm track. Building construction also plays a major role in the extent of damage resulting from a coastal storm. Due to differences in construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Mobile/manufactured homes, and structures constructed of wood and masonry buildings, in general, tend to experience more damage than concrete or steel buildings.

To better understand these risks, Hazus was used to estimate the expected wind-related building damages. Specific types of wind damages are also summarized in Hazus at the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.6-8 summarizes the definition of the damage categories. Table 5.4.6-9 summarizes the damage states estimated for structures during the 100-year and 500-year MRP hurricane wind events by occupancy class. Hazus estimates that zero structures will experience complete damage during the 100-year MRP event and approximately 1.5-percent of residential structures will experience complete damage during the 500-year MRP event.

Table 5.4.6-8. Description of Damage Categories

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
No Damage or Very Minor Damage Little or no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof over, with no or very limited water penetration.	≤2%	No	No	No	No	No
Minor Damage Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair.	>2% and ≤15%	One window, door, or garage door failure	No	<5 impacts	No	No
Moderate Damage Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.	>15% and ≤50%	> one and ≤ the larger of 20% & 3	1 to 3 panels	Typically 5 to 10 impacts	No	No
Severe Damage Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	>50%	> the larger of 20% & 3 and ≤50%	>3 and ≤25%	Typically 10 to 20 impacts	No	No
Destruction Complete roof failure and/or, failure of wall frame. Loss of more than 50% of roof sheathing.	Typically >50%	>50%	>25%	Typically >20 impacts	Yes	Yes

Source: Hazus-MH Hurricane Technical Manual

Table 5.4.6-9. Damage States for Structures Impacted by the 100-Year and 500-Year MRP Hurricane Wind Events

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	100-year		500-year	
			Building Count	Percent Buildings in Occupancy Class	Building Count	Percent Buildings in Occupancy Class
Residential Exposure (Single and	100,196	None	92,971	92.8%	64,340	64.2%
		Minor	6,731	6.7%	25,227	25.2%
		Moderate	460	0.5%	7,541	7.5%
		Severe	15	0.0%	1,580	1.6%

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	100-year Building Count	100-year Percent Buildings in Occupancy Class	500-year Building Count	500-year Percent Buildings in Occupancy Class
Multi-Family Dwellings)		Complete Destruction	19	0.0%	1,508	1.5%
Commercial Buildings	9,077	None	8,697	95.8%	6,219	68.5%
		Minor	351	3.87%	1,674	18.44%
		Moderate	28	0.3%	877	9.7%
		Severe	1	<0.1%	307	3.4%
		Complete Destruction	0	0.0%	0	0.0%
Industrial Buildings	37	None	36	97.3%	28	75.7%
		Minor	1	2.7%	5	13.5%
		Moderate	0	0.0%	3	8.1%
		Severe	0	0.0%	1	2.7%
		Complete Destruction	0	0.0%	0	0.0%
Government, Religion, Agricultural, and Education Buildings	2,680	None	2,577	96.2%	1,738	64.9%
		Minor	96	3.6%	628	23.4%
		Moderate	7	0.3%	251	9.4%
		Severe	0	0.0%	62	2.3%
		Complete Destruction	0	0.0%	1	<0.1%

Source: Hazus-MH 4.2

Table 5.4.6-10 summarizes the replacement cost value of building and content damages estimated for the 100- and 500-year MRP hurricane wind-only events. Table 5.4.6-11 summarizes the replacement cost value of building and content damages estimated for the 100-year and 500-year MRP hurricane wind-only events for residential and commercial occupancy classes. Less than 1% of the entire building stock may anticipate damages caused by the 100-year hurricane wind event and approximately 3.5-percent of the entire building stock may anticipate damages caused by the 500-year hurricane wind event. The total damage for all occupancy types across the County is estimated to be $415.7 million for the 100-year MRP wind-only event, and approximately $3.2 billion for the 500-year MRP wind-only event. The majority of these losses are to residential structures.

Table 5.4.6-10. Estimated Losses for the 100-Year and 500-Year MRP Hurricane Wind Events

Jurisdiction	Total Replacement Cost Value (All Occupancies)	Estimated Total Damages 100-Year	Percent of Total	500-Year	Percent of Total
Avalon Borough	$8,232,959,879	$45,556,435	0.6%	$142,708,862	1.7%
Cape May City	$5,153,049,612	$18,709,280	0.4%	$568,267,358	11.0%
Cape May Point Borough	$663,183,164	$2,636,428	0.4%	$79,830,434	12.0%
Dennis Township	$3,813,425,173	$12,131,107	0.3%	$48,012,984	1.3%
Lower Township	$9,950,232,225	$37,563,079	0.4%	$908,850,173	9.1%
Middle Township	$11,557,342,752	$35,443,035	0.3%	$344,730,436	3.0%
North Wildwood City	$4,423,365,953	$17,664,110	0.4%	$121,635,223	2.7%
Ocean City	$17,100,920,036	$101,779,622	0.6%	$73,718,096	0.4%
Sea Isle City	$7,663,928,227	$52,396,504	0.7%	$100,586,788	1.3%
Stone Harbor Borough	$3,291,756,871	$18,644,314	0.6%	$98,106,713	3.0%
Upper Township	$6,506,171,365	$27,896,296	0.4%	$49,218,071	0.8%
West Cape May Borough	$1,178,516,373	$5,450,858	0.5%	$165,050,693	14.0%
West Wildwood Borough	$459,103,094	$3,482,377	0.8%	$30,428,039	6.6%

Jurisdiction	Total Replacement Cost Value (All Occupancies)	Estimated Total Damages			
		100-Year	Percent of Total	500-Year	Percent of Total
Wildwood City	$4,379,038,844	$14,497,979	0.3%	$132,807,464	3.0%
Wildwood Crest Borough	$4,552,156,876	$19,719,858	0.4%	$286,440,410	6.3%
Woodbine Borough	$1,335,589,432	$2,166,772	0.2%	$13,861,534	1.0%
Cape May County (Total)	**$90,260,739,877**	**$415,738,054**	**0.5%**	**$3,164,253,276**	**3.5%**

Source: Hazus-MH 4.2
Notes: MRP = Mean return period
**The Total Damages column represents the sum of damages for all occupancy classes (residential, commercial, industrial, agricultural, educational, religious, and government) based on replacement cost value.*

Table 5.4.6-11. Estimated Losses for the 100-Year and 500-Year MRP Hurricane Wind Events – Residential and Commercial Occupancy Classes Only

Jurisdiction	Total Replacement Cost Value (All Occupancies)	Estimated Residential Damages		Estimated Commercial Damages	
		100-Year	500-Year	100-Year	500-Year
Avalon Borough	$8,232,959,879	$45,190,035	$140,894,777	$230,473	$1,309,504
Cape May City	$5,153,049,612	$18,049,569	$507,722,125	$218,154	$30,837,925
Cape May Point Borough	$663,183,164	$2,594,254	$75,810,523	$19,291	$2,146,092
Dennis Township	$3,813,425,173	$11,679,936	$44,268,035	$368,777	$2,436,579
Lower Township	$9,950,232,225	$36,618,753	$844,633,376	$390,377	$34,220,708
Middle Township	$11,557,342,752	$32,817,186	$282,423,878	$1,397,197	$41,348,277
North Wildwood City	$4,423,365,953	$17,092,538	$113,342,260	$304,222	$5,335,252
Ocean City	$17,100,920,036	$100,158,864	$72,898,618	$667,728	$336,658
Sea Isle City	$7,663,928,227	$52,092,081	$99,785,698	$239,376	$640,909
Stone Harbor Borough	$3,291,756,871	$18,527,867	$96,888,250	$89,307	$1,011,580
Upper Township	$6,506,171,365	$26,929,953	$47,165,017	$754,219	$1,455,976
West Cape May Borough	$1,178,516,373	$5,363,662	$156,739,463	$39,885	$4,437,080
West Wildwood Borough	$459,103,094	$3,206,241	$24,275,327	$185,311	$4,981,102
Wildwood City	$4,379,038,844	$13,554,445	$110,141,124	$635,767	$18,031,181
Wildwood Crest Borough	$4,552,156,876	$19,390,664	$277,565,903	$208,662	$6,193,297
Woodbine Borough	$1,335,589,432	$2,003,563	$10,472,374	$31,017	$545,842
Cape May County (Total)	**$90,260,739,877**	**$405,269,612**	**$2,905,026,748**	**$5,779,762**	**$155,267,962**

Source: Hazus-MH 4.2
Notes: MRP = Mean return period

Storm Surge Impacts on Buildings

To estimate potential building exposure, the SLOSH inundation zones were overlaid upon the building stock created for Cape May County. The estimated total number of buildings and replacement cost value located in Categories 1 through 4 SLOSH inundation zones are summarized in Table 5.4.6-12 through Table 5.4.6-15 by municipality. Overall, 52,612, 74,656, 93,640, and 105,238 buildings are exposed to the SLOSH Category 1, Category 2, Category 3, and Category 4 inundation hazard areas, respectively. Up to 94-percent of the total building stock in the County is exposed to the Category 4 inundation area, which is equal to approximately $85.7 billion.

Table 5.4.6-12. Number of Buildings in the SLOSH Category 1 and Category 2 Hurricane Inundation Hazard Areas

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Hurricane and Tropical Storm Hazard Areas			
			Number of Buildings Exposed - Category 1 SLOSH	Percent of Total	Number of Buildings Exposed - Category 2 SLOSH	Percent of Total
Avalon Borough	5,867	$8,232,959,879	5,087	86.7%	5,832	99.4%
Cape May City	4,234	$5,153,049,612	2,420	57.2%	4,049	95.6%
Cape May Point Borough	785	$663,183,164	317	40.4%	782	99.6%
Dennis Township	7,301	$3,813,425,173	92	1.3%	1,128	15.4%
Lower Township	19,597	$9,950,232,225	2,833	14.5%	8,213	41.9%
Middle Township	18,197	$11,557,342,752	2,884	15.8%	7,700	42.3%
North Wildwood City	4,729	$4,423,365,953	4,719	99.8%	4,723	99.9%
Ocean City	18,172	$17,100,920,036	15,193	83.6%	18,127	99.8%
Sea Isle City	6,712	$7,663,928,227	6,061	90.3%	6,671	99.4%
Stone Harbor Borough	3,836	$3,291,756,871	3,067	80.0%	3,817	99.5%
Upper Township	9,627	$6,506,171,365	943	9.8%	2,207	22.9%
West Cape May Borough	1,623	$1,178,516,373	694	42.8%	1,536	94.6%
West Wildwood Borough	805	$459,103,094	792	98.4%	794	98.6%
Wildwood City	3,679	$4,379,038,844	3,666	99.6%	3,667	99.7%
Wildwood Crest Borough	5,410	$4,552,156,876	3,844	71.1%	5,410	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**	**52,612**	**47.0%**	**74,656**	**66.7%**

Source: Cape May County GIS 2020; RS Means 2019; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-13. Total Replacement Cost Value of Buildings in the SLOSH Category 1 and Category 2 Hurricane Inundation Hazard Areas

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Hurricane and Tropical Storm Hazard Areas			
			Total Replacement Cost Value Exposed - Category 1 SLOSH	Percent of Total	Total Replacement Cost Value Exposed - Category 2 SLOSH	Percent of Total
Avalon Borough	5,867	$8,232,959,879	$6,913,855,160	84.0%	$8,173,584,260	99.3%
Cape May City	4,234	$5,153,049,612	$3,057,996,783	59.3%	$4,685,540,368	90.9%

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Hurricane and Tropical Storm Hazard Areas			
			Total Replacement Cost Value Exposed - Category 1 SLOSH	Percent of Total	Total Replacement Cost Value Exposed - Category 2 SLOSH	Percent of Total
Cape May Point Borough	785	$663,183,164	$284,202,393	42.9%	$660,042,234	99.5%
Dennis Township	7,301	$3,813,425,173	$71,048,250	1.9%	$552,380,903	14.5%
Lower Township	19,597	$9,950,232,225	$1,513,858,697	15.2%	$4,103,712,899	41.2%
Middle Township	18,197	$11,557,342,752	$1,401,878,198	12.1%	$4,450,058,370	38.5%
North Wildwood City	4,729	$4,423,365,953	$4,417,365,798	99.9%	$4,421,076,932	99.9%
Ocean City	18,172	$17,100,920,036	$13,457,420,404	78.7%	$17,053,274,649	99.7%
Sea Isle City	6,712	$7,663,928,227	$6,817,291,009	89.0%	$7,629,205,372	99.5%
Stone Harbor Borough	3,836	$3,291,756,871	$2,561,803,050	77.8%	$3,277,884,115	99.6%
Upper Township	9,627	$6,506,171,365	$674,165,922	10.4%	$1,558,257,463	24.0%
West Cape May Borough	1,623	$1,178,516,373	$542,087,166	46.0%	$1,149,594,226	97.5%
West Wildwood Borough	805	$459,103,094	$451,077,421	98.3%	$453,814,284	98.8%
Wildwood City	3,679	$4,379,038,844	$4,284,578,173	97.8%	$4,374,419,436	99.9%
Wildwood Crest Borough	5,410	$4,552,156,876	$3,008,761,830	66.1%	$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**	**$49,457,390,253**	**54.8%**	**$67,095,002,387**	**74.3%**

Source: Cape May County GIS 2020; RS Means 2019; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-14. Number of Buildings in the SLOSH Category 3 and Category 4 Hurricane Inundation Hazard Areas

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Hurricane and Tropical Storm Hazard Areas			
			Number of Buildings Exposed - Category 3 SLOSH	Percent of Total	Number of Buildings Exposed - Category 4 SLOSH	Percent of Total
Avalon Borough	5,867	$8,232,959,879	5,838	99.5%	5,843	99.6%
Cape May City	4,234	$5,153,049,612	4,214	99.5%	4,216	99.6%
Cape May Point Borough	785	$663,183,164	785	100.0%	785	100.0%
Dennis Township	7,301	$3,813,425,173	3,567	48.9%	5,829	79.8%
Lower Township	19,597	$9,950,232,225	14,591	74.5%	18,734	95.6%
Middle Township	18,197	$11,557,342,752	15,301	84.1%	18,114	99.5%
North Wildwood City	4,729	$4,423,365,953	4,722	99.9%	4,719	99.8%
Ocean City	18,172	$17,100,920,036	18,137	99.8%	18,144	99.8%
Sea Isle City	6,712	$7,663,928,227	6,670	99.4%	6,672	99.4%

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Hurricane and Tropical Storm Hazard Areas			
			Number of Buildings Exposed - Category 3 SLOSH	Percent of Total	Number of Buildings Exposed - Category 4 SLOSH	Percent of Total
Stone Harbor Borough	3,836	$3,291,756,871	3,805	99.2%	3,818	99.5%
Upper Township	9,627	$6,506,171,365	4,518	46.9%	6,845	71.1%
West Cape May Borough	1,623	$1,178,516,373	1,623	100.0%	1,623	100.0%
West Wildwood Borough	805	$459,103,094	796	98.9%	795	98.8%
Wildwood City	3,679	$4,379,038,844	3,662	99.5%	3,667	99.7%
Wildwood Crest Borough	5,410	$4,552,156,876	5,410	100.0%	5,408	100.0%
Woodbine Borough	1,416	$1,335,589,432	1	0.1%	26	1.8%
Cape May County (Total)	**111,990**	**$90,260,739,877**	**93,640**	**83.6%**	**105,238**	**94.0%**

Source: Cape May County GIS 2020; RS Means 2019; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-15. Total Replacement Cost Value of Buildings in the SLOSH Category 3 and Category 4 Hurricane Inundation Hazard Areas

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Hurricane and Tropical Storm Hazard Areas			
			Total Replacement Cost Value Exposed - Category 3 SLOSH	Percent of Total	Total Replacement Cost Value Exposed - Category 4 SLOSH	Percent of Total
Avalon Borough	5,867	$8,232,959,879	$8,199,965,751	99.6%	$8,201,005,027	99.6%
Cape May City	4,234	$5,153,049,612	$5,123,527,706	99.4%	$5,127,245,204	99.5%
Cape May Point Borough	785	$663,183,164	$663,183,164	100.0%	$663,183,164	100.0%
Dennis Township	7,301	$3,813,425,173	$1,789,222,608	46.9%	$3,135,453,246	82.2%
Lower Township	19,597	$9,950,232,225	$7,333,958,354	73.7%	$9,453,910,981	95.0%
Middle Township	18,197	$11,557,342,752	$9,684,807,237	83.8%	$11,487,391,738	99.4%
North Wildwood City	4,729	$4,423,365,953	$4,420,064,860	99.9%	$4,416,767,820	99.9%
Ocean City	18,172	$17,100,920,036	$17,061,314,149	99.8%	$17,070,398,742	99.8%
Sea Isle City	6,712	$7,663,928,227	$7,626,018,533	99.5%	$7,628,559,959	99.5%
Stone Harbor Borough	3,836	$3,291,756,871	$3,276,825,740	99.5%	$3,275,647,952	99.5%
Upper Township	9,627	$6,506,171,365	$3,101,293,501	47.7%	$4,683,127,959	72.0%
West Cape May Borough	1,623	$1,178,516,373	$1,178,516,373	100.0%	$1,178,516,373	100.0%
West Wildwood Borough	805	$459,103,094	$455,561,326	99.2%	$452,869,810	98.6%
Wildwood City	3,679	$4,379,038,844	$4,364,378,962	99.7%	$4,374,151,274	99.9%
Wildwood Crest Borough	5,410	$4,552,156,876	$4,552,156,876	100.0%	$4,551,120,707	100.0%

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to the Hurricane and Tropical Storm Hazard Areas: Total Replacement Cost Value Exposed - Category 3 SLOSH	Percent of Total	Total Replacement Cost Value Exposed - Category 4 SLOSH	Percent of Total
Woodbine Borough	1,416	$1,335,589,432	$114,556	0.0%	$11,861,609	0.9%
Cape May County (Total)	**111,990**	**$90,260,739,877**	**$78,830,909,696**	**87.3%**	**$85,711,211,564**	**95.0%**

Source: Cape May County GIS 2020; RS Means 2019; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

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 hurricane SLOSH inundation hazard areas. To estimate exposure the SLOSH Category 1 through Category inundation areas were overlaid upon the 2015 NJDEP land use land cover data and a county boundary provided by Cape May County.

Table 5.4.6-16 summarizes the county-wide assessment of the number of acres that are exposed to the SLOSH Category 1 through Category 4 inundation areas. Table 5.4.6-17 and Table 5.4.6-18 summarize the assessment that evaluated the number of acres land use types are exposed to the SLOSH Category 1 through Category 4 inundation areas, where the land use types are aggregated into residential, non-residential, and natural land use categories. The residential land use category included the following land use types: mixed residential; residential, high density or multiple dwelling; residential, rural, single unit; residential, single unit, low density; and residential, single unit, medium density. The non-residential land use category included all other land use types. The natural land use category was created using a sub-group of the non-residential land use category, including the following land use types: artificial lakes; Atlantic Ocean; Atlantic White Cedar wetlands; bare exposed rock, rock slides, etc; beaches; coniferous brush/shrubland; coniferous forest (>50% crown closure); coniferous forest (10-50% crown closure); coniferous scrub/shrub wetlands; coniferous wooded wetlands; deciduous brush/shrubland; deciduous forest (>50% crown closure); deciduous forest (10-50% crown closure); deciduous scrub/shrub wetlands; deciduous wooded wetlands; disturbed tidal wetlands; disturbed wetlands (modified); freshwater tidal marshes; herbaceous wetlands; managed wetland in built-up maintained rec area; managed wetland in maintained lawn greenspace; mixed deciduous/coniferous brush/shrubland; mixed forest (>50% coniferous with >50% crown closure); mixed forest (>50% coniferous with 10-50% crown closure); mixed forest (>50% deciduous with >50% crown closure); mixed forest (>50% deciduous with 10-50% crown closure); mixed scrub/shrub wetlands (coniferous dom.); mixed scrub/shrub wetlands (deciduous dom.); mixed wooded wetlands (coniferous dom.); mixed wooded wetlands (deciduous dom.); natural lakes; old field (< 25% brush covered); open tidal bays; phragmites dominate coastal wetlands; phragmites dominate interior wetlands; phragmites dominate old field; saline marsh (high marsh); saline marsh (low marsh); streams and canals; tidal mud flat; tidal rivers, inland bays, and other tidal waters; undifferentiated barren lands; upland rights-of-way undeveloped; and wetland rights-of-way.

Table 5.4.6-16. Total Acres of Cape May County Exposed to the SLOSH Category 1 through Category 4 Hurricane Inundation Hazard Areas

Total Acres in County*	Hazard Area Type	Number of Acres Exposed to the Coastal Storm Hazard Areas	Percent of Total
183,127	Category 1 SLOSH	66,587	36.4%
	Category 2 SLOSH	91,154	49.8%

	Category 3 SLOSH	116,812	63.8%
	Category 4 SLOSH	133,098	72.7%

Source: Cape May County GIS 2020; RS Means 2019; NOAA 2014; NJDEP 2019/2015
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes; 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*

Table 5.4.6-17. Land Use Types Exposed to the SLOSH Category 1 and Category 2 Hurricane Inundation Hazard Areas

Land Use Type	Total Acres of Land Use Type Category in Cape May County	Land Use Types Exposed to Category 1 SLOSH Hazard Area	Percent of Total Acres of Land Use Type	Land Use Types Exposed to Category 2 SLOSH Hazard Area	Percent of Total Acres of Land Use Type
Residential Land Use Type	22,296	6,319	28.3%	10,600	47.5%
Non-Residential Land Use Type	160,338	59,835	37.3%	80,018	49.9%
Natural Land Use Type	139,026	56,183	40.4%	71,937	51.7%
Cape May County (Total)	**182,633***	**66,154**	**36.2%**	**90,619**	**49.6%**

Source: Cape May County GIS 2020; RS Means 2019; NOAA 2014; NJDEP 2019/2015
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes
**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 5.4.6-18. Land Use Types Exposed to the SLOSH Category 3 and Category 4 Hurricane Inundation Hazard Areas

Land Use Type	Total Acres of Land Use Type Category in Cape May County	Land Use Types Exposed to Category 3 SLOSH Hazard Area	Percent of Total Acres of Land Use Type	Land Use Types Exposed to Category 4 SLOSH Hazard Area	Percent of Total Acres of Land Use Type
Residential Land Use Type	22,296	16,235	72.8%	19,696	88.3%
Non-Residential Land Use Type	160,338	100,059	62.4%	112,893	70.4%
Natural Land Use Type	139,026	87,160	62.7%	96,047	69.1%
Cape May County (Total)	**182,633***	**116,294**	**63.7%**	**132,590**	**72.6%**

Source: Cape May County GIS 2020; RS Means 2019; NOAA 2014; NJDEP 2019/2015
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes
**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*

Impact on Critical Facilities

Critical facilities are at risk of being impacted by high winds associated with structural damage, or falling tree limbs/flying debris, which can result in the loss of power. Power loss can greatly impact households, business operations, public utilities, and emergency personnel. For example, vulnerable populations in Cape May County are at risk if power loss results in interruption of heating and cooling services, stagnated hospital operations, and potable water supplies. Emergency personnel such as police, fire, and EMS will not be able to effectively respond in a power loss event to maintain the safety of its citizens.

Hazus estimates that critical facilities in Cape May have a low percent probability of sustaining minor to moderate damages from the 100-year MRP hurricane wind event. Hazus also estimates that there are critical facilities that have a 17.8-percent probability of sustaining severe damage from the 500-year MRP hurricane wind event. These probabilities can be found in Table 5.4.6-19 and Table 5.4.6-20 by facility type.

The critical facilities and utilities located in the Category 1 through 4 inundation zones are summarized Table 5.4.6-21 and Table 5.4.6-22 by municipality. Up to 82.9-percent of the critical facilities in Cape May County are exposed to the Category 4 SLOSH inundation area. Table 5.4.6-23 summarizes the number of lifelines categorized by FEMA lifeline categories that are exposed to the Category 1 through 4 SLOSH inundation areas. Overall, critical facilities that provide food, water, and shelter services and provide safety and security are the most exposed to the SLOSH inundation areas. Moreover, the distribution of the critical facilities exposed to the SLOSH Category 1 through Category 4 are summarized in Table 5.4.6-24 through Table 5.4.6-31 by jurisdiction.

Table 5.4.6-19. Estimated Impacts to Critical Facilities for the 100-Year MRP Hurricane Wind Event

		100-Year Event			
		Percent-Probability of Sustaining Damage			
Facility Type	Loss of Days	Minor	Moderate	Severe	Complete
EOC	0	1.7%-9.2%	0.0%-2.3%	<0.1%	0.0%
Medical	0	1.5%-7.0%	0.0%-2.7%	<0.1%	0.0%
Police	0	2.0%-9.2%	0.0%-2.3%	<0.1%	0.0%
Fire	0	0.6%-5.0%	0.0%-1.1%	<0.1%	0.0%
Schools	0	1.0%-7.4%	0.0%-4.3%	<0.1%	0.0%

Source: Hazus-MH v4.2

Table 5.4.6-20. Estimated Impacts to Critical Facilities for the 500-Year MRP Hurricane Wind Event

		500-Year Event			
		Percent-Probability of Sustaining Damage			
Facility Type	Loss of Days	Minor	Moderate	Severe	Complete
EOC	0	3.6%-22.1%	0.1%-29.1%	0.0%-17.8%	0.0%
Medical	0-3	3.8%-15.3%	0.6%-38.6%	0.0%-10.5%	0.0%-0.6%
Police	0	3.6%-23.8%	0.2%-29.1%	0.0%-17.8%	0.0%
Fire	0	1.6%-15.1%	0.1%-23.9%	0.0%-10.9%	0.0%-0.6%
Schools	0-24	3.5%-12.0%	0.7%-46.0%	0.0%-14.7%	<0.1%

Source: Hazus-MH v4.2

Table 5.4.6-21. Critical Facilities and Lifelines Exposed to the SLOSH Category 1 and Category 2 Hurricane Inundation Hazard Areas

Jurisdiction	Total Critical Facilities	Total Lifelines	Category 1 SLOSH				Category 2 SLOSH			
			Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total	Number of Critical Facilities Exposed	Percent of Total	Number of Lifelines Exposed	Percent of Total
Avalon Borough	30	30	20	66.7%	20	66.7%	25	83.3%	25	83.3%
Cape May City	32	32	16	50.0%	16	50.0%	19	59.4%	19	59.4%
Cape May Point Borough	10	10	3	30.0%	3	30.0%	10	100.0%	10	100.0%
Dennis Township	60	60	5	8.3%	5	8.3%	12	20.0%	12	20.0%
Lower Township	111	111	31	27.9%	31	27.9%	48	43.2%	48	43.2%
Middle Township	181	181	18	9.9%	18	9.9%	81	44.8%	81	44.8%
North Wildwood City	30	29	30	100.0%	29	100.0%	30	100.0%	29	100.0%
Ocean City	59	58	48	81.4%	48	82.8%	51	86.4%	50	86.2%
Sea Isle City	26	26	24	92.3%	24	92.3%	24	92.3%	24	92.3%
Stone Harbor Borough	26	26	18	69.2%	18	69.2%	24	92.3%	24	92.3%
Upper Township	73	68	9	12.3%	9	13.2%	18	24.7%	17	25.0%
West Cape May Borough	10	10	2	20.0%	2	20.0%	9	90.0%	9	90.0%
West Wildwood Borough	8	8	5	62.5%	5	62.5%	5	62.5%	5	62.5%
Wildwood City	39	37	36	92.3%	34	91.9%	37	94.9%	35	94.6%
Wildwood Crest Borough	23	23	12	52.2%	12	52.2%	22	95.7%	22	95.7%
Woodbine Borough	21	21	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Cape May County (Total)	**739**	**730**	**277**	**37.5%**	**274**	**37.5%**	**415**	**56.2%**	**410**	**56.2%**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-22. Critical Facilities and Lifelines Exposed to the SLOSH Category 3 and Category 4 Hurricane Inundation Hazard Areas

Jurisdiction	Total Critical Facilities	Total Lifelines	Category 3 SLOSH Number of Critical Facilities Exposed	Category 3 SLOSH Percent of Total	Category 3 SLOSH Number of Lifelines Exposed	Category 3 SLOSH Percent of Total	Category 4 SLOSH Number of Critical Facilities Exposed	Category 4 SLOSH Percent of Total	Category 4 SLOSH Number of Lifelines Exposed	Category 4 SLOSH Percent of Total
Avalon Borough	30	30	25	83.3%	25	83.3%	24	80.0%	24	80.0%
Cape May City	32	32	29	90.6%	29	90.6%	29	90.6%	29	90.6%
Cape May Point Borough	10	10	10	100.0%	10	100.0%	10	100.0%	10	100.0%
Dennis Township	60	60	25	41.7%	25	41.7%	47	78.3%	47	78.3%
Lower Township	111	111	70	63.1%	70	63.1%	93	83.8%	93	83.8%
Middle Township	181	181	160	88.4%	160	88.4%	164	90.6%	164	90.6%
North Wildwood City	30	29	30	100.0%	29	100.0%	30	100.0%	29	100.0%
Ocean City	59	58	52	88.1%	51	87.9%	51	86.4%	50	86.2%
Sea Isle City	26	26	24	92.3%	24	92.3%	24	92.3%	24	92.3%
Stone Harbor Borough	26	26	24	92.3%	24	92.3%	24	92.3%	24	92.3%
Upper Township	73	68	32	43.8%	31	45.6%	42	57.5%	40	58.8%
West Cape May Borough	10	10	9	90.0%	9	90.0%	9	90.0%	9	90.0%
West Wildwood Borough	8	8	5	62.5%	5	62.5%	5	62.5%	5	62.5%
Wildwood City	39	37	37	94.9%	35	94.6%	37	94.9%	35	94.6%
Wildwood Crest Borough	23	23	22	95.7%	22	95.7%	22	95.7%	22	95.7%
Woodbine Borough	21	21	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Cape May County (Total)	**739**	**730**	**554**	**75.0%**	**549**	**75.2%**	**611**	**82.7%**	**605**	**82.9%**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-23. FEMA Lifelines Exposed to the SLOSH Category 1 through 4 Hurricane Inundation Hazard Areas

FEMA Lifeline Categories	Total Lifelines in County	Number of Lifelines Exposed to SLOSH 1	Number of Lifelines Exposed to SLOSH 2	Number of Lifelines Exposed to SLOSH 3	Number of Lifelines Exposed to SLOSH 4
Communication	70	21	39	59	64
Energy	9	5	7	7	8
Food, Water, Shelter	206	101	141	168	187
Hazardous Materials	27	7	16	19	21
Health and Medical	39	16	24	30	34
Safety and Security	281	92	153	234	259
Transportation	98	32	30	32	32
Cape May County (Total)	**730**	**274**	**410**	**549**	**605**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-24. Distribution of Critical Facilities (Critical Facility Type Starting With 'A' Through 'L') Exposed to the Category 1 SLOSH Hurricane Inundation Hazard Area

	Critical Facilities Exposed to Category 1 SLOSH																
Jurisdiction	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	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	2
Cape May City	0	0	0	0	0	0	0	2	0	0	0	0	0	1	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	1	0	2	0	0	0	0	0	0	0	0	0	0
Lower Township	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0
Middle Township	0	1	0	0	2	3	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	3	0	0	1	0	0	0	0	0	0	1	1	3	0	0	0
Sea Isle City	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	1
Stone Harbor Borough	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0
Upper Township	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1
West Cape May Borough	0	0	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	0	5	0	0	0	0	0	1	0	0	1	0	0	0

Jurisdiction	Critical Facilities Exposed to Category 1 SLOSH																
	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
Cape May County (Total)	**1**	**5**	**1**	**3**	**18**	**7**	**5**	**5**	**1**	**1**	**4**	**4**	**2**	**18**	**3**	**1**	**4**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-25. Distribution of Critical Facilities (Critical Facility Type Starting With 'M' Through 'W') Exposed to the Category 1 SLOSH Hurricane Inundation Hazard Area

Jurisdiction	Critical Facilities Exposed to Category 1 SLOSH																
	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	1	0	2	0	1	0	0	0	1	0	0	0	0	0	0	10	0
Cape May City	1	0	0	0	0	2	1	1	0	0	0	0	0	0	0	5	3
Cape May Point Borough	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
Dennis Township	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Lower Township	7	1	0	0	0	0	0	0	0	0	0	0	0	1	0	16	3
Middle Township	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2	3
North Wildwood City	1	1	1	1	2	1	0	0	2	1	0	1	0	0	0	4	0
Ocean City	3	1	2	0	1	7	0	1	2	0	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	1	0	0	0	1	0	0	0	0	0	0	4	5
Upper Township	3	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	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0
Wildwood City	1	5	1	2	1	0	1	2	3	2	0	1	1	2	0	3	0
Wildwood Crest Borough	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	2	0
Cape May County (Total)	**23**	**9**	**10**	**4**	**9**	**14**	**2**	**5**	**10**	**3**	**1**	**6**	**1**	**7**	**2**	**69**	**19**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-26. Distribution of Critical Facilities (Critical Facility Type Starting With 'A' Through 'L') Exposed to the Category 2 SLOSH Hurricane Inundation Hazard Area

Jurisdiction	Critical Facilities in Category 2 SLOSH																	
	Airport	Bridge	Bus Station	Communications Facility	Communications Tower	County Facilities	Dams	Day Care	DPW	Education	Electric Substation	EMS	EOC	Ferry Facilities	Fire Stations	Grocery/Food Processing	Health Services	Library
Avalon Borough	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	2
Cape May City	0	0	0	0	0	0	0	0	2	0	0	1	0	0	1	0	0	0
Cape May Point Borough	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0
Dennis Township	0	0	0	0	4	0	3	0	0	0	0	0	0	0	0	0	0	0
Lower Township	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	0
Middle Township	0	1	0	0	5	29	2	0	0	0	0	1	0	0	2	0	2	0
North Wildwood City	0	0	0	0	6	2	0	0	1	0	0	1	1	0	3	1	0	0
Ocean City	1	3	0	0	2	0	0	0	0	0	0	0	1	1	3	0	0	0
Sea Isle City	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	1
Stone Harbor Borough	0	0	0	2	3	1	0	0	0	0	0	1	0	0	1	0	0	1
Upper Township	0	0	0	1	1	1	3	1	0	0	1	0	0	0	1	0	0	1
West Cape May Borough	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
West Wildwood Borough	0	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	0	2	1	1	0	0	0	3	1	1	0
Wildwood Crest Borough	0	0	0	1	13	0	0	0	0	0	0	1	0	0	1	0	0	0
Cape May County (Total)	**1**	**5**	**1**	**4**	**35**	**37**	**8**	**1**	**5**	**1**	**3**	**7**	**4**	**2**	**21**	**3**	**3**	**5**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-27. Distribution of Critical Facilities (Critical Facility Type Starting With 'M' Through 'W') Exposed to the Category 2 SLOSH Hurricane Inundation Hazard Area

Jurisdiction	Critical Facilities in Category 2 SLOSH																	
	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	2	0	2	0	1	1	0	0	1	0	0	0	0	0	0	0	12	0

Jurisdiction	Critical Facilities in Category 2 SLOSH																	
	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
Cape May City	1	0	0	0	0	2	1	1	0	0	0	0	0	1	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	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2
Lower Township	5	1	0	0	0	2	0	0	0	0	0	0	1	1	0	2	22	10
Middle Township	1	2	0	0	0	2	0	0	4	0	2	4	1	5	0	2	8	8
North Wildwood City	1	1	1	1	2	1	0	0	2	1	0	1	0	0	0	0	4	0
Ocean City	2	1	2	0	1	8	0	1	3	1	0	3	0	3	0	1	14	0
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	3	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	2
West Cape May Borough	0	1	1	1	0	1	0	0	2	0	0	0	0	0	0	0	0	1
West Wildwood Borough	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0
Wildwood City	1	5	1	2	1	1	1	2	3	2	0	1	1	2	0	0	3	0
Wildwood Crest Borough	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	2	0
Cape May County (Total)	**21**	**11**	**13**	**4**	**9**	**24**	**2**	**7**	**17**	**4**	**2**	**10**	**3**	**14**	**2**	**5**	**87**	**34**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-28. Distribution of Critical Facilities (Critical Facility Type Starting With ‘A’ Through ‘L’) Exposed to the Category 3 SLOSH Hurricane Inundation Hazard Area

	Critical Facilities Exposed to Category 3 SLOSH																		
Jurisdiction	Airport	Bridge	Bus Station	Communications Facility	Communications Tower	County Facilities	Cultural Building	Dams	Day Care	DPW	Education	Electric Substation	EMS	EOC	Ferry Facilities	Fire Stations	Grocery/Food Processing	Health Services	Library
Avalon Borough	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	2
Cape May City	0	0	0	0	2	0	0	0	0	2	0	0	2	1	0	2	0	0	0
Cape May Point Borough	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0
Dennis Township	0	0	0	0	6	0	0	3	0	0	0	0	0	0	0	2	0	0	0
Lower Township	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1	1	1	0	2
Middle Township	0	1	0	0	17	54	2	2	0	4	0	0	2	0	0	5	1	3	2
North Wildwood City	0	0	0	0	6	2	0	0	0	1	0	0	1	1	0	3	1	0	0
Ocean City	1	3	0	0	2	0	0	0	0	0	0	0	0	1	1	3	0	0	0
Sea Isle City	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	1
Stone Harbor Borough	0	0	0	2	3	1	0	0	0	0	0	0	1	0	0	1	0	0	1
Upper Township	0	1	0	1	5	1	0	3	1	0	0	1	1	1	0	1	0	0	3
West Cape May Borough	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
West Wildwood Borough	0	0	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	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	0	0	1	0	0	1	0	0	0
Cape May County (Total)	**1**	**6**	**1**	**4**	**55**	**62**	**2**	**8**	**1**	**10**	**1**	**3**	**11**	**6**	**2**	**27**	**4**	**4**	**11**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-29. Distribution of Critical Facilities (Critical Facility Type Starting With 'M' Through 'W') Exposed to the Category 3 SLOSH Hurricane Inundation Hazard Area

Jurisdiction	Critical Facilities Exposed to Category 3 SLOSH																		
	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	Veterinary Services	Wastewater Facilities	Wastewater Pump Station	Well
Avalon Borough	2	0	2	0	1	1	0	0	1	0	0	0	0	0	0	0	0	12	0
Cape May City	1	0	1	0	1	2	1	1	2	0	0	1	0	1	1	0	0	5	3
Cape May Point Borough	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0
Dennis Township	1	0	1	0	0	2	0	0	2	0	0	1	0	0	0	0	0	1	6
Lower Township	5	1	1	0	0	3	0	0	4	0	1	0	1	1	0	0	2	27	16
Middle Township	1	2	1	0	1	8	0	0	8	0	3	6	2	8	0	0	2	10	15
North Wildwood City	1	1	1	1	2	1	0	0	2	1	0	1	0	0	0	0	0	4	0
Ocean City	3	1	2	0	1	8	0	1	3	1	0	3	0	3	0	0	1	14	0
Sea Isle City	3	0	1	0	1	2	0	1	0	0	0	0	0	1	0	0	0	7	3
Stone Harbor Borough	1	0	2	0	1	1	0	0	1	0	0	0	0	0	0	0	0	4	5
Upper Township	3	1	1	0	0	0	0	1	1	0	0	0	0	1	1	1	0	0	3
West Cape May Borough	0	1	1	1	0	1	0	0	2	0	0	0	0	0	0	0	0	0	1
West Wildwood Borough	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Wildwood City	1	5	1	2	1	1	1	2	3	2	0	1	1	2	0	0	0	3	0
Wildwood Crest Borough	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	2	0
Cape May County (Total)	**22**	**12**	**18**	**4**	**11**	**33**	**2**	**7**	**30**	**4**	**4**	**13**	**4**	**17**	**2**	**1**	**5**	**94**	**52**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-30. Distribution of Critical Facilities (Critical Facility Type Starting With ‘A’ Through ‘L’) Exposed to the Category 4 SLOSH Hurricane Inundation Hazard Area

Jurisdiction	Critical Facilities Exposed to Category 4 SLOSH																			
	Airport	Bridge	Bus Station	Commercial Facility	Communications Facility	Communications Tower	County Facilities	Cultural Building	Dams	Day Care	DPW	Education	Electric Substation	EMS	EOC	Ferry Facilities	Fire Stations	Grocery/Food Processing	Health Services	Library
Avalon Borough	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	2
Cape May City	0	0	0	0	0	2	0	0	0	0	2	0	0	2	1	0	2	0	0	0
Cape May Point Borough	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0
Dennis Township	0	0	0	2	0	8	0	0	3	0	0	0	0	0	0	0	3	0	0	0
Lower Township	2	0	0	0	0	0	4	0	0	0	1	0	0	2	0	1	3	1	0	2
Middle Township	0	1	0	0	0	19	54	2	2	0	4	0	0	2	0	0	6	1	3	2
North Wildwood City	0	0	0	0	0	6	2	0	0	0	1	0	0	1	1	0	3	1	0	0
Ocean City	1	3	0	0	0	2	0	0	0	0	0	0	0	0	1	1	3	0	0	0
Sea Isle City	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	1
Stone Harbor Borough	0	0	0	0	2	3	1	0	0	0	0	0	0	1	0	0	1	0	0	1
Upper Township	0	1	0	0	2	5	1	0	3	2	1	0	2	1	1	0	3	0	0	3
West Cape May Borough	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
West Wildwood Borough	0	0	0	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	0	0	0	2	1	1	0	0	0	3	1	1	0
Wildwood Crest Borough	0	0	0	0	1	13	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Cape May County (Total)	**3**	**6**	**1**	**2**	**5**	**59**	**65**	**2**	**8**	**2**	**11**	**1**	**4**	**12**	**6**	**2**	**33**	**4**	**4**	**11**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Table 5.4.6-31. Distribution of Critical Facilities (Critical Facility Type Starting With 'M' Through 'W') Exposed to the Category 4 SLOSH Hurricane Inundation Hazard Area

Jurisdiction	Critical Facilities Exposed to Category 4 SLOSH																		
	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	Veterinary Services	Wastewater Facilities	Wastewater Pump Station	Well
Avalon Borough	1	0	2	0	1	1	0	0	1	0	0	0	0	0	0	0	0	12	0
Cape May City	1	0	1	0	1	2	1	1	2	0	0	1	0	1	1	0	0	5	3
Cape May Point Borough	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	4	0
Dennis Township	1	0	1	0	0	4	0	0	4	0	0	2	0	0	0	0	0	1	18
Lower Township	5	1	1	0	1	6	0	0	6	0	1	2	1	3	0	0	3	30	17
Middle Township	1	2	1	0	1	8	0	0	8	0	3	6	2	8	0	0	2	10	16
North Wildwood City	1	1	1	1	2	1	0	0	2	1	0	1	0	0	0	0	0	4	0
Ocean City	2	1	2	0	1	8	0	1	3	1	0	3	0	3	0	0	1	14	0
Sea Isle City	3	0	1	0	1	2	0	1	0	0	0	0	0	1	0	0	0	7	3
Stone Harbor Borough	1	0	2	0	1	1	0	0	1	0	0	0	0	0	0	0	0	4	5
Upper Township	3	1	1	0	0	2	0	1	1	0	0	0	0	1	1	2	0	0	4
West Cape May Borough	0	1	1	1	0	1	0	0	2	0	0	0	0	0	0	0	0	0	1
West Wildwood Borough	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0
Wildwood City	1	5	1	2	1	1	1	2	3	2	0	1	1	2	0	0	0	3	0
Wildwood Crest Borough	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	2	0
Cape May County (Total)	**20**	**12**	**18**	**4**	**12**	**40**	**2**	**7**	**34**	**4**	**4**	**16**	**4**	**19**	**2**	**2**	**6**	**97**	**67**

Source: Cape May County GIS 2020; NOAA 2014
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

At this time, HAZUS-MH v4.2 does not estimate losses to transportation lifelines and utilities as part of the hurricane model. Transportation lifelines are not considered particularly vulnerable to the wind hazard; they are more vulnerable to cascading effects such as flooding, falling debris etc. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs. Furthermore, evacuation routes are vulnerable to coastal storm surge events and hurricane wind events. Evacuation routes generated by the Cape May Planning Department were reviewed for level of exposure to the SLOSH Categories 1 through 4 inundation extents. Table 5.4.6-32 summarizes the number of miles evacuation routes are exposed.

Table 5.4.6-32. Number of Miles Evacuation Routes Are Exposed to the SLOSH Category 1 Through 4 Hurricane Inundation Hazard Areas

Total Miles of Evacuation Routes in County	Hazard Area Type	Total Miles of Evacuation Routes Exposed to the Coastal Storm Hazard Areas	Percent of Total
224	Category 1 SLOSH	87	38.9%
	Category 2 SLOSH	143	63.9%
	Category 3 SLOSH	189	84.6%
	Category 4 SLOSH	208	93.2%

Source: Cape May County GIS 2020; NOAA 2014; Cape May County Planning Department 2011
Notes: SLOSH = Sea – Lake Overland Surge from Hurricanes

Impact on Economy

Damage to structures from flooding and wind can be the most immediate result of coastal storm events; however, this damage can have long-lasting impacts on the economy. When a business is closed during storm recovery, there is lost economic activity in the form of day-to-day business and wages to employees. Overall, economic impacts include the loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, wage loss and rental loss due to the repair/replacement of buildings. As evidenced by Hurricane Sandy, the State of New Jersey, including Cape May County, lost millions of dollars in wages and economic activity.

Hazus estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the "Impact on General Building Stock" section discussed earlier. Business interruption losses are the losses associated with the inability to operate a business because of the wind damage sustained during the storm or the temporary living expenses for those displaced from their home because of the event.

For the 100-year MRP wind event, Hazus estimates $22.8 million in business interruption costs (income loss, relocation costs, rental costs, and lost wages). For the 500-year MRP wind-only event, Hazus estimates approximately $387.2 million in business interruption losses for the County which includes loss of income, relocation costs, rental costs, and lost wages.

Debris management can be costly and may also impact the local economy. Hazus estimates the amount of building and tree debris that may be produced as result of the 100- and 500-year MRP wind events. Because the estimated debris production does not include flooding, this is likely a conservative estimate and may be higher if multiple impacts occur. According to the Hazus Hurricane User Manual, estimates of weight and volume of eligible tree debris consist of downed trees that would likely be collected and disposed at public expense. Refer to the User Manual for additional details regarding these estimates. Table 5.4.6-33 summarizes debris production estimates for the 100- and 500-year MRP wind events.

Table 5.4.6-33. Debris Production for the 100-Year and 500-Year MRP Hurricane Wind Events

Jurisdiction	Brick and Wood (tons)		Concrete and Steel (tons)		Tree (tons)		Eligible Tree Volume (cubic yards)	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Avalon Borough	3,432	10,725	0	0	157	314	797	1,594
Cape May City	1,272	35,696	0	381	683	3,338	4,211	20,585
Cape May Point Borough	128	5,096	0	43	418	2,460	1,035	6,094
Dennis Township	521	3,228	0	0	14,941	53,452	11,097	34,859
Lower Township	2,007	65,364	0	542	7,400	38,578	22,737	123,870
Middle Township	2,017	25,299	0	121	22,493	81,381	33,112	122,370
North Wildwood City	1,636	10,137	0	39	0	0	0	0
Ocean City	10,947	7,520	3	1	313	313	1,499	1,499
Sea Isle City	5,456	10,301	0	0	140	210	962	1,443
Stone Harbor Borough	1,622	8,160	0	23	134	313	919	2,145
Upper Township	1,415	2,981	0	0	17,192	36,884	24,197	43,507
West Cape May Borough	265	10,536	0	88	864	5,086	2,140	12,600
West Wildwood Borough	457	2,861	0	12	19	88	156	704
Wildwood City	1,849	12,406	0	53	93	365	741	2,903
Wildwood Crest Borough	1,931	23,248	1	261	53	232	99	437
Woodbine Borough	100	926	0	4	1,795	6,417	2,743	9,800
Cape May County (Total)	**35,055**	**234,485**	**4**	**1,567**	**66,696**	**229,431**	**106,445**	**384,410**

Source: Hazus-MH 4.2
Notes: MRP = Mean Return Period

Impact on the Environment

According to the State of New Jersey 2019 Hazard Mitigation Plan, coastal storms can impact various natural land resources that can be easily uprooted by major wind events and storm surge. Extreme winds from coastal storms may create several tons of debris because the wind tears apart foliage and trees in Cape May County. Plants along waterways may be uprooted from surge causing even further instability and alterations of the shoreline. Consequentially, natural habitat that shelters the County from wind and storm surge can be destroyed, impacting future mitigation (State of New Jersey 2019).

Cascading Impacts on Other Hazards

Hurricanes can escalate the impacts of flooding and coastal erosion. Storm surge may increase erosion along the shoreline, which alters the extent of flooding. The structures most at risk of coastal erosion and flooding can be reviewed in Section 5.4.1 and Section 5.4.5, respectively.

Future Changes That May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures.

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 along the coastline where storm surge is a larger risk could be impacted. It is recommended that the County and municipal partners implement design strategies that mitigate against the risk of impacts from hurricane and tropical storm hazards.

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. 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. An increase in temperatures may also lead to an increase in the frequency and intensity of coastal storms. More frequent and severe storms will increase the County's vulnerability to both wind-related and storm surge impacts.

The New Jersey Protecting Against Climate Threats Program has been implemented to minimize the impact of climate related changes (NJDEP 2020). This PACT highlights a series of regulatory action and goals that the State has set for its jurisdictions. Some of the resolutions relate to coastal storms including, issuing sea level rise guidance frameworks, reforming coastal zone management rules, freshwater wetlands rules, and flood hazard control rules.

Furthermore, the New Jersey Science and Technical Advisory Panel (STAP) on Sea-Level Rise and Coastal Storms published a report in 2019 that found New Jersey coastal areas have at least a 66-percent chance of experiencing sea level rise increasing 0.5 to 1.1 feet between 2000 and 2030, but less than 5-percent change of sea level rise exceeding 2.6 feet by 2050 (Rutgers University 2019). However, the study also found that these sea level rise predictions are extremely dependent on future greenhouse gas emissions. If emissions increase, sea level rise will also increase, which can have an impact on coastal communities in New Jersey. Consequentially, sea level rise will affect the baseline for flooding from high tides and coastal storms (Climate Change Institute 2020). This will exacerbate coastal storm impacts on Cape May County.

Climate is defined not simply as average temperature and precipitation but also by the type, frequency, and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of events like hurricanes. While predicting changes to the prevalence or intensity of hurricanes and the events affects 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 (USEPA 2020).

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, NOAA 2014 SLOSH Category 1 through Category 4 inundation areas were used to assess the County's hurricane and tropical storm surge inundation risk. An aggregated damage analysis at the census tract level was performed in Hazus-MH v4.2 using the probabilistic 100-year and 500-year MRP hurricane wind events, updated building stock, and updated critical facility data. This data is an update compared to the 2010 U.S. Census population and Hazus version 3.0 hurricane storm information used in the 2016 HMP.

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

5.4.7 Nor'Easter

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 Nor'Easter hazard in Cape May County.

2021 Plan Update Changes

- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2016 and 2020.

5.4.7.1 Profile

Hazard Description

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

In order to be called a Nor'Easter, a storm must have the following conditions, as per the Northeast Regional Climate Center (NRCC):

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

A Nor'Easter event can cause storm surges, waves, heavy rain, heavy snow, wind, and coastal flooding. Nor'Easters have diameters that can span 1,200 miles, impacting large areas of coastline. The forward speed of a Nor'Easter is usually much slower than a hurricane, so with the slower speed, a Nor'Easter can linger for days and cause tremendous damage to those areas impacted. Approximately 20 to 40 Nor'Easters occur in the northeastern United States every year, with at least two considered severe (Storm Solution 2014). New Jersey can be impacted by 10 to 20 Nor'Easters each year, with approximately five to 10 of those having significant impact on the State. The intensity of a Nor'Easter can rival that of a tropical cyclone in that, on occasion, it may flow or stall off the mid-Atlantic coast resulting in prolonged episodes of precipitation, coastal flooding, and high winds.

For the purpose of this HMP, only Nor'Easter events are being further discussed within this hazard profile, due to their significant historical impact on Cape May County. For information on coastal flooding and surge related to Nor'Easters, refer to Section 5.4.5 (Flood) and Section 5.4.6 (Hurricane). For information on severe winter storms, refer to Section 5.4.9.

Location

The entire State of New Jersey is susceptible to the effects of Nor'Easters; however, coastal communities and other low-lying areas, such as Cape May County, are particularly vulnerable. Nor'Easters usually form off the east coast near the Carolinas, and then follow a track northwards along the coast until they blow out to sea.

Because Cape May County is primarily surrounded by coastal waters, Nor'Easters affect the entire area, particularly communities along the eastern shores of the County. The County has felt the direct and indirect landward effects, including high winds, heavy rains, flash and coastal flooding, and beach erosion associated with Nor'Easters.

Extent

The magnitude or severity of a severe winter storm or Nor'Easter depends on several factors including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and time of occurrence during the day (e.g., weekday versus weekend), and time of season.

The extent of a Nor'Easter can be classified by meteorological measurements and by evaluating its societal impacts. NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCDC 2011). Table 5.4.7-1 presents the five RSI ranking categories.

Table 5.4.7-1. RSI Ranking Categories

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

Source: NOAA-NCDC 2011
Note: RSI = Regional Snowfall Index

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with Nor'Easters 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 included the State of New Jersey in seven Nor'Easter-related major disaster (DR) or emergency (EM) declarations classified as one or a combination of the following disaster types: severe storm, high tides, flooding, coastal storm, coastal flooding, or tropical depression. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Cape May County has been included in five Nor'Easter-related declarations. Table 5.4.7-2 lists FEMA DR and EM declarations for Cape May County.

Table 5.4.7-2. FEMA Declarations for Nor'Easter Events in Cape May County

FEMA Declaration Number	Date(s) of Event	Event Type
DR-973	December 10-17, 1992	Coastal Storm, High Tides, Heavy Rain, Flooding
DR-1206	February 4-8, 1998	Coastal Storm
DR-1867	November 11-15, 2009	Severe Storms and Flooding Associated with Tropical Depression Ida and a Nor'Easter
DR-4048	October 29, 2011	Severe Weather (Snowstorm / Nor'Easter)
DR-4264	March 14, 2016	Severe Winter Storm and Snowstorm

Source: FEMA 2020; NJ HMP 2019

U.S. Department of Agriculture Declared Disasters

Cape May County was not included in any USDA declarations related to Nor'Easters.

Previous Events

For this 2021 HMP update, known Nor'Easter events that have impacted Cape May County between 2016 and 2020 are identified in Table 5.4.7-3. For events prior to 2016, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 5.4.7-3. Nor'Easter Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Location	Description
January 22-24, 2016	Winter Storm & Coastal Flooding (Winter Storm Jonas)	DR-4264	Yes	Cape May County	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. A 64 MPH wind gust was recorded on the 23rd near Strathmere (Cape May). At one point during the storm, up to 270,000 customers were without power. Outages were concentrated closer to the coast where the strongest winds occurred. New Jersey Governor Chris Christie declared a State of Emergency on Friday, January 22nd for the duration of the event. Schools and many businesses recessed early on Friday afternoon in anticipation of the storm. 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. The New Jersey Department of Transportation spent approximately $25 million dollars to clear and maintain the state's highways and roadways. In seeking federal disaster aid, Governor Chris Christie announced the storm cost the state of New Jersey $82.6 million in damages and expenses. 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	Cape May County	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).

Table 5.4.7-3. Nor'Easter Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Location	Description
January 23, 2017	Nor'Easter & Coastal Flooding	N/A	N/A	Cape May County	Heavy rain and powerful northeast winds combined to create a coastal flooding reaching the moderate threshold.
February 9, 2017	Winter Storm	N/A	N/A	Cape May County	Low pressure developed along a cold front over the Middle Atlantic early Thursday, February 9th. The low rapidly intensified as it moved off the Delmarva coast in the morning and then to the south and east of Long Island late morning into the afternoon. The low brought heavy snow and strong winds to portions of Northeast New Jersey. Numerous flights were cancelled or delayed at Newark Airport
March 14, 2017	Coastal Flood	N/A	N/A	Cape May County	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.
July 29, 2017	Coastal Flood and Heavy Rain	N/A	N/A	Cape May County	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 Avenue 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.
March 1-3, 2018	Nor'Easter	N/A	N/A	Cape May County	At the Jersey Shore, the storm caused minor flooding and road closures during the high tide on the morning of March 2. Atlantic City Electric reported 29,111 customers without power and PSE&G reported tens of thousands of customers without power. New Jersey Transit cancelled some service.
March 7, 2018	Nor'Easter	N/A	N/A	Cape May County	Two to three feet of snow fell from New Jersey to New England. At least one person died from the storm. This was the second of three Nor'easters to hit the east coast in a two-week span. The third Nor'easter on 3/13 did not significantly impact New Jersey.
March 21, 2018	Winter Storm	N/A	N/A	Cape May County	A complex area of low pressure over the middle Atlantic, which involved several individual centers, slowly consolidated off the Virginia Capes Tuesday morning, March 20th into Wednesday March 21st

Table 5.4.7-3. Nor'Easter Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Location	Description
					along a frontal boundary. This primary low, the fourth nor'easter of March, gradually moved northeast Wednesday night, to a position southeast of the benchmark on Thursday morning. Rain developed across far southern New Jersey on Tuesday morning, March 20th. As this precipitation moved northward into a colder air mass, snow and sleet developed across the remainder of southern New Jersey during the afternoon hours. Northeast winds increased throughout Tuesday, and gusted 40 to 50 mph along the Atlantic coast from Tuesday afternoon into Wednesday morning. Minor coastal flooding occurred along the New Jersey oceanfront around the times of high tide Tuesday night, Wednesday morning, and again Wednesday night. During Tuesday evening, a mixed bag of precipitation developed, with freezing rain, sleet, and snow, except rain closer to the coast. Freezing rain lead to ice accretion up to 0.20 inches across portions of southern New Jersey, causing downed trees and limbs, which impacted power lines, and led to power outages. Meanwhile, higher elevations of eastern Pennsylvania and northwest New Jersey remained dry through the overnight hours of Tuesday into Wednesday. A change over to snow progressed southeast across New Jersey by late morning on Wednesday, March 21st, with the exception of Cape May County NJ, where it did not occur until the early to mid-afternoon. Moderate to heavy snowfall developed, and gradually overspread New Jersey, from Wednesday morning into the evening. Snowfall rates, particularly outside of the higher elevations of northern New Jersey were around one inch per hour at times. The snow gradually ended from west to east around midnight, except late night closer to the New Jersey shore. Across New Jersey, snowfall amounts varied from less than 3 inches in portions of northern Sussex County and Cape May County, with a general 6 to 12 inches elsewhere, with the exception of portions of Monmouth, Ocean, and Burlington Counties, where some areas received 12 to 15 inches. The weight of the heavy, wet snow brought down trees, limbs, and power lines across portions of southern New Jersey, which led to power outages. In fact, portions of Monmouth, southeast Burlington, Ocean, and Atlantic Counties in New Jersey were particularly hard hit with numerous trees and power lines down.
November 16, 2018	Nor'Easter and Coastal Flooding	N/A	N/A	Cape May County	A coastal storm brought strong northeast winds, peaking at 48 mph for about 12 hours resulting in more than 2.5 feet of surge.

Table 5.4.7-3. Nor'Easter Events in Cape May County, 2016 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Cape May County Designated?	Location	Description
October 9-12, 2019	Nor'Easter and Coastal Flooding	N/A	N/A	Cape May County	A distant but stalled coastal storm generates a week of strong north/northeast winds but no rain. High tides flood streets over the course of four days, reaching the moderate threshold on two days.

Source: NOAA NCEI 2020, NJ HMP 2019, SHELDUS, Ocean City 2020

Probability of Future Occurrences

Cape May County will continue to experience the direct and indirect impacts of Nor'Easters. Secondary hazards may include flooding, extreme wind, erosion, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents, and inconveniences.

As with any weather phenomenon, it is nearly impossible to assign probabilities to Nor'Easters, except over the long-term. High activity seasons are when storm activity exceeds the historical 75th percentile. This means that seasons with this number of storms are expected to occur during one out of four years. Lower activity seasons are defined as when storm activity falls below the historical 75th percentile; meaning this number of storms are expected to occur during three out of four years (East Coast Winter Storms 2013).

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 Partnership, the probability of occurrence for Nor'Easters in the County is considered 'frequent' (100 percent chance of event occurring; occurs 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).

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).

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 severity of coastal flooding events caused by storm surge.

Some climatologists believe that climate change may play a role in the frequency and intensity of Nor'Easters. Two ingredients are needed to produce strong Nor'Easters and intense snowfall: (1) temperatures which are just below freezing, and (2) massive moisture coming from the Gulf of Mexico. When temperatures are far below freezing, snow is less likely. As temperatures increase in the winter months they will be closer to freezing rather than frigidly cold. Climate change is expected to produce more moisture, thus increasing the likelihood that these two ingredients (temperatures just below freezing and intense moisture) will cause more intense snow events.

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

5.4.7.2 Vulnerability Assessment

A qualitative assessment was conducted to analyze the Nor'Easter hazard for Cape May County. Quantified residual impacts from Nor'Easters such as flooding can also be reviewed in Section 5.4.5 (Flood). Refer to Section 5.1 (Methodology and Tools) for additional details on the methodology used to assess severe weather risk.

Impact on Life, Health and Safety

The impact of a Nor'Easter on life, health and safety is dependent upon several factors including the severity of the event and whether adequate warning time was provided to residents. The entire population of Cape May County (93,705) is exposed to this hazard (2014-2018 American Community Survey 5-Year Population Estimate).

Typically, a Nor'Easter has a longer duration (potentially lasting days) than a hurricane or tropical storm event, which normally pass through an area in a matter of hours. It is assumed that the entire County's population could be exposed to this hazard (wind and rain/snow and secondary impacts discussed earlier). Further, residents may be displaced or require temporary to long-term sheltering. Refer to Figures 5.4.6-3 and 5.4.6-4 in Section 5.4.6 (Hurricane and Tropical Storm) which display the peak gust wind speeds of the 100- and 500-year mean return period probabilistic wind events modeled in HAZUS-MH. In addition, Nor'Easter events may bring large volumes of precipitation (e.g., rain or snow). Refer to Section 5.4.9 for further discussion on the Severe Winter Weather hazard.

Impact on General Building Stock, Critical Facilities, and the Economy

The entire County's building stock and critical facilities are exposed to the wind and/or rain/snow from the Nor'Easter hazard. Nor'Easter events can greatly impact the economy, including: loss of business function, damage to inventory (utility outages), relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Damages to buildings can impact a community's economy and tax base. In addition, damages to buildings and critical infrastructure, as well as road closures, can delay emergency response services during these events. Refer to Sections 5.4.5 (Flood) and 5.4.6 (Hurricanes and Tropical Storms), and 5.4.9 (Severe Winter Weather) for estimated potential loss statistics by municipality as a result of flood, wind, and winter weather events, respectively.

Impact on Economy

Damages to buildings and infrastructure, utility outages, and roadways impassable due to snow or flood/surge can lead to closures of municipal or County buildings. These closures impact the services they provide and hinder response time for critical emergency services. Refer to Section 5.4.6 (Hurricanes and Tropical Storms) for a detailed discussion on potential losses to County buildings, critical facilities, and infrastructure due to winds and storm-surge flooding.

Impact on the Environment

Nor'Easters can cause significant impacts to the environment and natural resources. Flood/surge can cause beach and dune erosion, wetland loss, and barrier island breaching that disrupts coastal habitats and migration patterns of species (NYC 2019). Flooding caused by surge may breach structures containing hazardous wastes, which can contaminate water resources and soil resources. Debris caused by surge may also be hazardous to aquatic habitats and species.

Cascading Impacts on Other Hazards

Nor'Easters can escalate the impacts of flooding and coastal erosion. Storm surge may increase erosion along the coastline, which alters the extent of flooding. Further, the associated high winds, snow and ice may impact the continuity of utility services. The structures most at risk of coastal erosion and flooding can be reviewed in Section 5.4.2 (Coastal Erosion) and Section 5.4.5 (Flood).

Future Changes That May Impact Vulnerability

Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. 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.

Project Development

As discussed in Sections 4 and 9, areas targeted for future growth and development have been identified across Cape May County. Any areas of growth could be potentially impacted by the Nor'Easter hazard because the entire planning area is exposed and vulnerable. Please refer to the specific areas of development indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Projected Changes in Population

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. It is expected that in the next 20 years, population growth will be relatively stagnant (U.S. Census Bureau 2020, SJTPO). Overall, aging infrastructure may result in increased stress on existing infrastructure and related services. Although overall County growth is not expected, individual municipalities that experience increases in population may require utility system upgrades to keep up with utility demands (e.g., water, electric) during Nor'Easter events to prevent increased stresses on these systems. Refer to Section 4 (County Profile) for a detailed discussion on population change in Cape May County.

Climate Change

Climatologists predict that climate change may play a role in the frequency and intensity of Nor'easters. Two ingredients are needed to produce strong Nor'easters and intense snowfall: (1) temperatures which are just below freezing, and (2) massive moisture coming from the Gulf of Mexico. When temperatures are far below freezing, snow is less likely. As temperatures increase in the winter months they will be closer to freezing rather than frigidly cold. Future climate change has been predicted to produce more moisture, thus increasing the likelihood that these two ingredients (temperatures just below freezing and intense moisture) will cause more intense snow events (State of New Jersey HMP 2019).

Change in Vulnerability Since 2016 HMP

Overall, the County's vulnerability has not changed; the entire County continues to be exposed and potentially vulnerable to the Nor'Easter hazard.

5.4.8 Severe Weather

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 severe weather hazard in Cape May County.

2021 HMP Update Changes

- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2016 and 2020.
- A vulnerability assessment was conducted for the severe weather hazard using a more accurate and updated building inventory.

5.4.8.1 Profile

Hazard Description

For the purpose of this HMP Update and as deemed appropriated by the Cape May County Hazard Mitigation Planning Committee, the severe weather hazard includes high winds, tornadoes, thunderstorms and lightning, derechos, hail, and extreme temperatures (heat and cold), which are defined below. While hurricanes, tropical storms and Nor'Easters are all types of severe weather, they are included as separate hazards. Refer to Section 5.4.6 (Hurricane and Tropical Storm) and Section 5.4.7 (Nor'Easter).

Thunderstorms

> Thunderstorms can lead to flooding, landslides, strong winds, and lightning. Roads could become impassable from flooding, downed trees or power lines, or a landslide. Downed utility poles can lead to utility losses, such as electricity, phone, and water (from loss of pumping and filtering capabilities).

A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (NWS 2009d). A thunderstorm forms from a combination of moisture, rapidly rising warm air, and a force capable of lifting air, such as a warm and cold front, a sea breeze, or a mountain. Although thunderstorms generally affect a small area when they occur, they have the potential to become dangerous due to their ability in generating tornadoes, hailstorms, strong winds, flash flooding, and lightning. The NWS considers a thunderstorm *severe* only if it produces damaging wind gusts of 58 mph or higher, large hail one-inch (quarter size) in diameter or larger, or tornadoes (NWS 2020).

Lightning

Lighting is a bright flash of electrical energy produced by a thunderstorm. The resulting clap of thunder is the result of a shock wave created by the rapid heating and cooling of the air in the lightning channel. All thunderstorms produce lightning and are very dangerous. Lightning ranks as one of the top weather killers in the United States, killing approximately 50 people and injuring hundreds each year. Lightning can occur anywhere there is a thunderstorm. Lightning can be cloud to air, cloud to cloud, and cloud to ground.

> Lightning can damage homes and injure people. In the United States, an average of 300 people are injured and 80 people are killed by lightning each year. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. An estimated 100,000 thunderstorms occur each year in the United States, with approximately 10 percent of them classified as severe. During the warm season, thunderstorms are responsible for most of the rainfall.

High Winds

Wind begins with differences in air pressures. It is rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the earth (Rosenstiel School of Marine & Atmospheric Science 2005). High winds are often associated by other severe weather events such as thunderstorms, tornadoes, hurricanes, and tropical storms.

Tornadoes

A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 250 miles per hour (mph). Damage paths can be greater than 1 mile wide and 50 miles long. Tornadoes typically develop from either a severe thunderstorm or hurricane as cool air rapidly overrides a layer of warm air. Tornadoes typically move at speeds between 30 and 125 mph and can generate combined wind speeds (forward motion and speed of the whirling winds) exceeding 300 mph. The lifespan of a tornado rarely is longer than 30 minutes (FEMA 1997). Tornadoes can occur at any time of the year, with peak seasons at different times for different states (NSSL 2013).

> In Cape May County, ten tornadoes were reported between 1950 and September 2020. Upper Township was the site of the County's most recent tornado, which was spawned in the wake of Tropical Storm Isaias in August 2020. The tornado caused significant damage in the Marmora section of the Township.

Derechos

A derecho is a long-lived windstorm that is associated with a rapidly moving squall line of thunderstorms. It produces straight-line wind gusts of at least 58 mph and often has isolated gusts exceeding 75 mph. This means that trees generally fall and debris is blown in one direction. To be considered a derecho, these conditions must persist along a path of at least 240 miles. Derechos are more common in the Great Lakes and Midwest regions of the United States, though on occasion can persist into the Mid-Atlantic and Northeast (ONJSC 2013a).

Hailstorms

Hail forms inside a thunderstorm where there are strong updrafts of warm air and downdrafts of cold water. If a water droplet is picked up by the updrafts, it can be carried well above the freezing level. Water droplets freeze when temperatures reach 32 °F or colder. As the frozen droplet begins to fall, it might thaw as it moves into warmer air toward the bottom of the thunderstorm, or the droplet might be picked up again by another updraft and carried back into the cold air to re-freeze. With each trip above and below the freezing level, the frozen droplet adds another layer of ice. The frozen droplet, with many layers of ice, falls to the ground as hail.

Extreme Cold

Extreme cold events occur when temperatures drop significantly below normal in an area for an extended period of time. In New Jersey, no specific definition or thresholds exist for Extreme Cold. Extreme cold events may be due to winter storms, which can cause hazardous travel conditions or power outages. Prolonged exposure to cold can lead to serious or life-threatening health conditions (NJ OEM 2019).

Extreme Heat

Extreme heat is defined as temperatures which hover 10 degrees or more above the average high temperature for a region and that last for several weeks (CDC 2016). An extended period of extreme heat of three or more consecutive days is typically called a heat wave and is often accompanied by high humidity (NWS 2013d). Humid or muggy conditions occur when a *dome* of high atmospheric pressure traps hazy, damp air near the ground. There is no universal definition of a heat wave because the term is relative to the usual weather in a particular area. The term heat wave is applied both to routine weather variations and to extraordinary spells of heat which may occur only once a century (Meehl and Tebaldi 2004).

Location

All of Cape May County is exposed to high wind, tornadoes, thunderstorms and lightning, derechos, hailstorms, and extreme temperatures. Additionally, all of the County is subject to high winds from severe weather events. According to the FEMA Winds Zones of the United States map, Cape May County is located in Wind Zone II. In this zone, wind speeds can reach up to 160 mph. Additionally, the County is located within a "Hurricane Susceptible Region", meaning Cape May County is susceptible to hurricanes and other tropical cyclone events.

Extent

The extent (severity or magnitude) of a severe storm is largely dependent upon the most damaging aspects of each type of severe weather. This section describes the extent of thunderstorms, lighting, hail, windstorms, and tornadoes in Cape May. Historical data presented in Table 5.4.8-1 shows the most powerful severe weather records in Cape May County.

Table 5.4.8-1. Severe Storm Extent in Cape May County (1950-2020)

Extent of Severe Storms in Cape May County	
Largest Hailstone on Record	1.75 inches
Strongest Tornado on Record	EF-2
Highest Wind Speed on Record	78 knots

Source: NOAA-NCEI 2020

High Winds

The following table provides the description of winds used by the NWS during wind-producing events.

Table 5.4.8-2. NWS Wind Descriptions

Descriptive Term	Sustained Wind Speed (mph)
Strong, dangerous, or damaging	≥40
Very windy	30-40
Windy	20-30
Breezy, brisk, or blustery	15-25
None	5-15 or 10-20
Light or light and variable wind	0-5

Source: NWS 2015

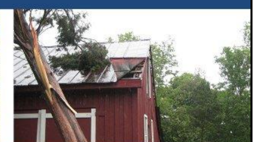
NWS issues advisories and warnings for winds, which are normally site-specific. High wind advisories, watches, and warnings are issued by the NWS when wind speeds may pose a hazard or may be life threatening. The criterion for each of these varies from state to state. Wind warnings and advisories for New Jersey are as follows:

- *High Wind Warnings* are issued when sustained winds of 40 mph or greater are forecast for 1 hour or longer, or wind gusts of 58 mph or greater are forecast for any duration.
- *Wind Advisories* are issued when sustained winds of 30 to 39 mph are forecast for one 1 hour or longer, or wind gusts of 46 to 57 mph are forecast for any duration (NWS 2015).

Tornadoes

The magnitude or severity of a tornado is categorized using the Enhanced Fujita Tornado Intensity Scale (EF Scale). This is the scale now used exclusively for determining tornado ratings by comparing wind speed and actual damage. Figure 5.4.8-1 illustrates the relationship between EF ratings, wind speed, and expected tornado damage.

Figure 5.4.8-1. Explanation of EF-Scale Ratings

EF Rating	Wind Speeds	Expected Damage		
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.		
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.		
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.		
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.		
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.		
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.		

Thunderstorms and Lightning

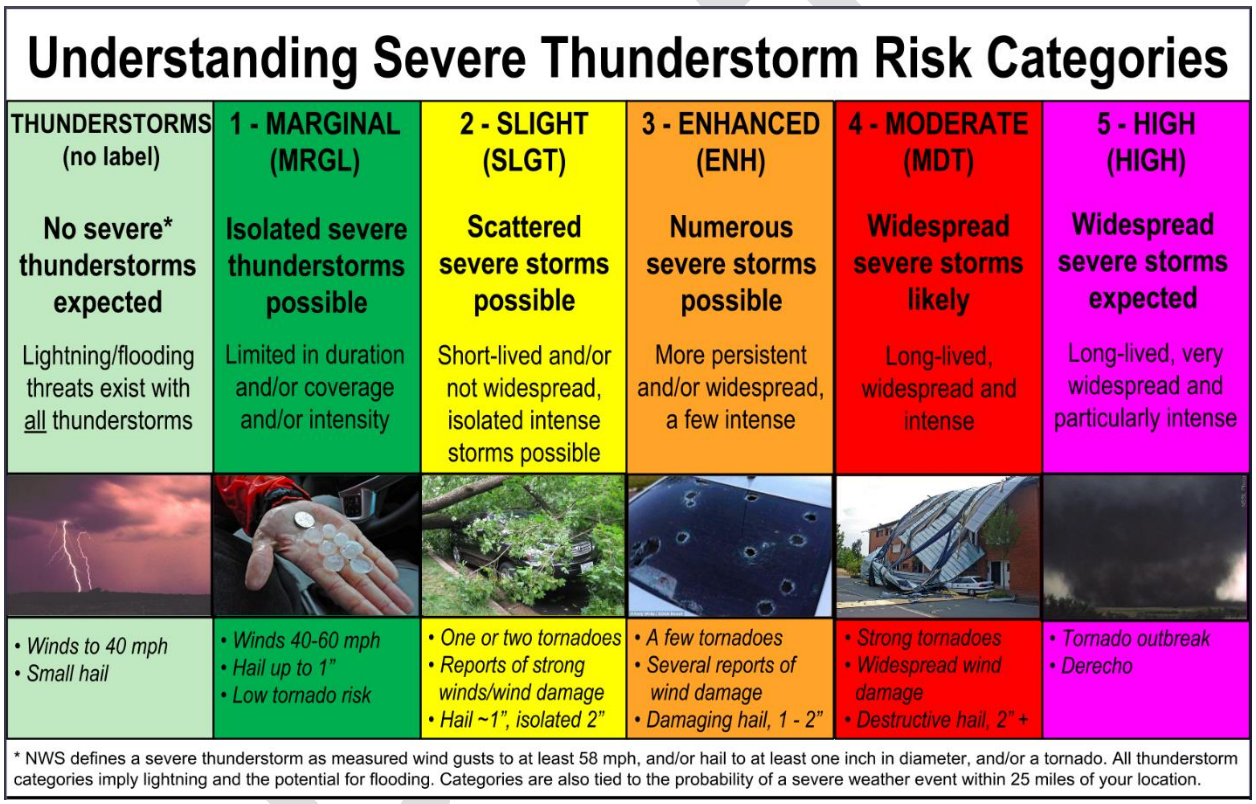
Severe thunderstorm watches and warnings are issued by the local NWS office and SPC. The NWS and SPC will update the watches and warnings and will notify the public when they are no longer in effect. Watches and warnings for tornadoes in New Jersey are as follows:

- Severe Thunderstorm Warnings are issued when there is evidence based on radar or a reliable spotter report that a thunderstorm is producing, or forecast to produce, wind gusts of 58 mph or greater, structural wind damage, and/or hail one-inch in diameter or greater. A warning will include where the storm was located, what municipalities will be impacted, and the primary threat associated with the severe thunderstorm warning. After it has been issued, the NWS office will follow up periodically with Severe Weather Statements which contain updated information on the severe thunderstorm and will let the public know when the warning is no longer in effect (NWS 2010c).

- Severe Thunderstorm Watches are issued by the SPC when conditions are favorable for the development of severe thunderstorms over a larger-scale region for a duration of at least three hours. Tornadoes are not expected in such situations, but isolated tornado development may also occur. Watches are normally issued well in advance of the actual occurrence of severe weather. During the watch, the NWS will keep the public informed on what is happening in the watch area and also let the public know when the watch has expired or been cancelled (NWS 2010c).
- Special Weather State for Near Severe Thunderstorms are issued for strong thunderstorms that are below severe levels, but still may have some adverse impacts. Usually, they are issued for the threat of wind gusts of 40 to 58 mph or small hail less than one-inch in diameter (NWS 2010c).

In addition, the SPC issues severe thunderstorm risk maps based on the likelihood of different severities of thunderstorms. Figure 5.4.8-2 shows the SPC's severe thunderstorm risk categories.

Figure 5.4.8-2. Severe Thunderstorm Risk Categories



Source: NOAA SPC 2017

Lightning is associated with moderate to severe thunderstorms. Lightning severity is determined by the frequency of lightning strikes during a storm.

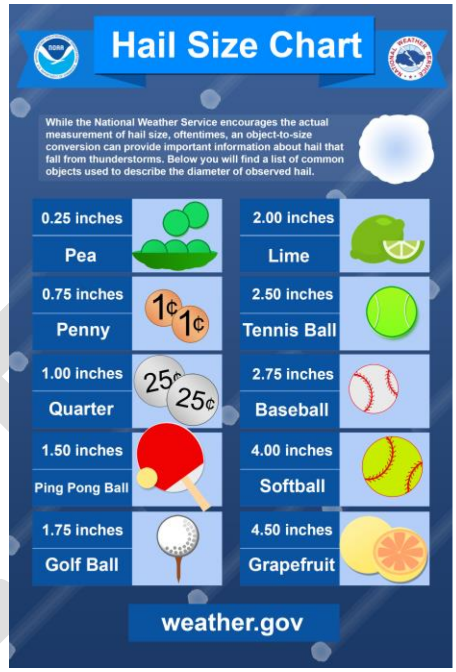
Derechos

In order for an event to be identified as a derecho, it must have wind gusts of at least 58 mph or greater along most of its length. While derecho winds typically are less than 100 mph, gusts as high as 130 mph have been recorded. Winds associated with derechos are not constant and may vary considerably along the path of the derecho. Any derecho below 57 mph is considered below severe limits and anything from 75 mph or greater is considered very strong (SPC 2015).

Hailstorms

Duration, hail size, and geographic extent determine hailstorm severity. Hail can exhibit a variety of sizes, though only the very largest hail stones pose serious risk to people, if exposed (NYS DHSES 2019). The size of hail is estimated by comparing it to a known object. Figure 5.4.8-3 shows the different sizes of hail and the comparison to real-world objects.

Figure 5.4.8-3. Hail Size Chart



Extreme Heat

NOAA's heat alert procedures are based mainly on Heat Index values. The Heat Index is given in degrees Fahrenheit. The Heat Index is a measure of how hot it really feels when relative humidity is factored in with the actual air temperature. To find the Heat Index temperature, the temperature and relative humidity need to be known. Once both values are known, the Heat Index will be the corresponding number with both values. The Heat Index indicated the temperature the body feels. It is important to know that the Heat Index values are devised for shady, light wind conditions. Exposure to full sunshine can increase heat index values by up to 15°F. Strong winds, particularly with very hot dry air, can also be extremely hazardous (NWS 2013d).

Figure 5.4.8-4. NWS Heat Index Chart

NWS Heat Index

Temperature (°F)

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

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: NWS 2020

The NWS station in Mount Holly (which covers Cape May County) provides alerts when Heat Indices approach hazardous levels. Table 5.4.8-3 explains these alerts.

Table 5.4.8-3. National Weather Service Alerts for Extreme Heat Events

Alert	Criteria
Heat Advisory	A period of excessive heat is expected. The combination of hot temperatures and high humidity will create a situation in which heat related illnesses are possible. A Heat Advisory is issued when heat indices are expected to reach at least 100 degrees, except at least 105 degrees over Delmarva and far southern New Jersey (Salem, Cumberland, Cape May, and Atlantic Counties). The aforementioned heat index values must be reached for at least two hours; typically a single day event.
Excessive Heat Watch	A prolonged period of dangerous excessive heat is possible within about 48 hours.
Excessive Heat Warning	A prolonged period of dangerous excessive heat is expected within about 24 hours. The combination of hot temperatures and high humidity will create a dangerous situation in which heat related illnesses are likely. An Excessive Heat Warning is issued when heat indices are expected to reach at least 105 degrees, except at least 110 degrees over Delmarva and far southern New Jersey (Salem, Cumberland, Cape May, and Atlantic Counties). The aforementioned heat index values must be reached for at least two hours per day; typically for a multi-day event.

Source: NWS, 2020

In New Jersey, average days per year where temperatures reach 90°F or higher range from five days to over 30 days, depending on location. Cape May County has an average of 12 to 22 days of temperatures in excess of 90°F; 2 or 4 days of temperatures in excess of 95°F; and 0.1 to 0.2 days of temperatures in excess of 100°F (ONJSC 2013b).

Wind Chill
At a Glance

The wind chill is how cold it feels on your skin when the wind is factored in.
It may also be referred to as the "feels-like" temperature.
Bitterly cold wind chills increase your risk of developing frostbite and hypothermia.

Source: The Weather Channel (2019)

Extreme Cold

The extent (severity or magnitude) of extreme cold temperatures generally are measured through the Wind Chill Temperature (WCT) Index. The WCT Index uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from wind chill. For details regarding the WCT Index, refer to: http://www.nws.noaa.gov/om/winter/windchill.shtml. The WCT Index is presented in Figure 5.4.8-5.

The National Weather Service (NWS) provides alerts when Wind Chill indices approach hazardous levels. Table 5.4.8-4 explains these alerts.

Table 5.4.8-4. National Weather Service Alerts for Extreme Cold

Alert	Criteria
Wind Chill Advisory	NWS issues a wind chill advisory when seasonably cold wind chill values, but not extremely cold values are expected or occurring.
Wind Chill Watch	NWS issues a wind chill watch when dangerously cold wind chill values are possible.
Wind Chill Warning	NWS issues a wind chill warning when dangerously cold wind chill values are expected or occurring.

Source: NWS 2018b

Average days per year when temperatures reached less than 32°F in New Jersey range from six days in the southern part of the State to over 45 days in northern New Jersey. Cape May County has an average of six (northern Cape May County) to 10 (southern Cape May County) days of temperatures below 32°F; 0.1 (southern Cape May County) to 1 (northern Cape May County) days of temperatures below 0°F (ONJSC 2013b).

Figure 5.4.8-5. WCT Index

Wind Chill Chart

Temperature (°F)

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

Frostbite Times: 30 minutes / 10 minutes / 5 minutes

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

Where, T= Air Temperature (°F) V= Wind Speed (mph) *Effective 11/01/01*

Source: NWS 2020

Warning Time

Meteorologists can accurately forecast extreme temperature event development and the severity of the associated conditions with several days lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations. For heat events, the NWS issues excessive heat outlooks when the potential exists for an excessive heat event in the next three to seven days. Watches are issued when conditions are favorable for an excessive heat event in the next 24 to 72 hours. Excessive heat warning/advisories are issued when an excessive heat event is expected in the next 36 hours. Winter temperatures may fall to extreme cold readings with no wind occurring. Currently, the only way to headline very cold temperatures is with the use of the NWS-designated Wind Chill Advisory or Warning products. When actual temperatures reach Wind Chill Warning criteria with little to no wind, extreme cold warnings may be issued (NWS n.d.).

Previous Occurrences and Losses

Numerous sources provided historical information regarding previous occurrences and losses associated with severe weather events affecting Cape May County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events may vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2020, the State of New Jersey was included in 28 FEMA declared severe weather-related disasters (DR) or emergencies (EM) classified as one or a combination of the following hazards: coastal storms, severe storm, straight-line winds, heavy rains, flooding, hail, tornadoes, and high wind. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Of those declarations, Cape May County has been included in six declarations (FEMA 2020). Table 5.4.8-5 lists FEMA DR and EM declarations for Cape May County.

Table 5.4.8-5. FEMA DR and EM Declarations since 2010 for Severe Weather Events in Cape May County

FEMA Declaration Number	Date(s) of Event	Date of Declaration	Event Type
DR-3005	December 24, 1974	December 24, 1974	New Jersey Severe Storms, High Winds & High Tides
DR-936	January 4, 1992	March 3, 1992	Severe Coastal Storm
DR-1206	February 4, 1998 - February 8, 1998	March 3, 1998	New Jersey Coastal Storm
DR-1867	November 11, 2009 - November 15, 2009	December 22, 2009	New Jersey Severe Storms And Flooding Associated With Tropical Depression Ida And A Nor'easter
DR-1897	March 12 – April 15, 2010	April 2, 2010	Severe Storms and Flooding
DR-4048	October 29, 2011	November 30, 2011	Severe Weather

Source: FEMA 2020

U.S. Department of Agriculture Disaster Declarations

Between 2016 and 2020, the period for which data was available, Cape May County was included in two USDA Disaster Declarations:

- S4071 – April 1-September 19th, 2016 – combined effects of freeze, excessive heat, and drought
- S4424 – May 1st-June 30th, 2018 – excessive rainfall and cool spring temperatures

Previous Events

For this 2021 Plan Update, known severe weather events, including FEMA disaster declarations, which have impacted Cape May County between 2016 and 2020 are identified in Table 5.4.8-6. With documentation of severe weather for the State of New Jersey and Cape May County being extensive, not all sources have been identified or researched. Therefore, Table 5.4.8-6 may not include all events that occurred in the County. For events prior to 2016, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 5.4.8-6. Severe Weather Events in Cape May County, 2016 to April 2020

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Event Details*
January 23, 2016	High Winds	No	N/A	Strong winds up to 56 mph were reported from a nor'easter passing along the coast.
April 2-3, 2016	Thunderstorm Wind	No	N/A	A strong cold front moved into the region overnight, bringing strong winds and causing widespread power outages. Wind gusts up to 63 mph were reported in the County.
June 8, 2016	Thunderstorm Wind	No	N/A	A fast-moving line of thunderstorms produced widespread wind damage and gusts up to 52 mph.
June 21, 2016	Thunderstorm Wind	No	N/A	Widespread power outages and wind speeds up to 61 mph were reported from thunderstorms developing from a stalled frontal boundary.

Table 5.4.8-6. Severe Weather Events in Cape May County, 2016 to April 2020

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Event Details*
August 21, 2016	Thunderstorm Wind	No	N/A	Thunderstorms producing lightning, heavy rain, and strong winds (up to 52 mph) were reported in the County.
September 19-20, 2016	Heavy Rain	No	N/A	Cape May County was inundated with several rounds of rainfall owing to remnants of Tropical Storm Julia.
September 29, 2016	Heavy Rain	No	N/A	Cape May County saw heavy rainfall due to a stalled frontal boundary.
October 9, 2016	Strong Winds; Heavy Rain	No	N/A	Hurricane Matthew interacted with a cold front, bringing rains and winds to the County.
January 23, 2017	High Winds	No	N/A	An incoming nor'easter brought strong winds (up to 53 mph), power outages, high tides, and mixed precipitation. Ocean City and Wildwood school districts were closed. The Cape May-Lewes Ferry ceased operations for the day.
February 9, 2017	High Winds	No	N/A	A strong cold front caused high winds, with gusts up to 53 mph.
February 13, 2017	High Winds	No	N/A	Wind speeds up to 54 mph were reported in Cape May, leading to downed power lines and wires.
March 1, 2017	Thunderstorm Wind	No	N/A	Unseasonably warm air maintained a line of thunderstorms along a pre-frontal trough. A gust of wind in Ocean City reached 60 mph and more than 2,500 customers lost power in the region.
June 19, 2017	Thunderstorm Wind	No	N/A	Wind damage was reported from a complex of thunderstorms that moved into the region. Wind speeds up to 51 mph were reported.
July 24, 2017	Heavy Rain; Lightning	No	N/A	Multiple rounds of thunderstorms were reported due to a frontal boundary moving through the area.
July 29, 2017	Heavy Rain	No	N/A	Heavy rain, thunderstorms, and winds were reported resulting from a summertime nor'easter.
August 7, 2017	Heavy Rain	No	N/A	Heavy rain and flash flooding were reported following thunderstorms that developed along a cold front.
December 25, 2017	High Wind	No	N/A	Winds up to 50 mph and power outages were reported following a strong wind event.
March 2, 2018	High Wind	No	N/A	Strong winds and flooding causing $100,000 in damage resulted from a stalled cold front from a deep area of low pressure. Recorded wind speeds were up to 71 mph.
February 24-25, 2019	High Wind	No	N/A	High winds with gusts up to 50 mph caused power outages, downed trees, and some structural damage.
April 26, 2019	Thunderstorm Wind	No	N/A	A funnel cloud and 52 mph winds were reported resulting from a severe thunderstorm generated by
June 29, 2019	Thunderstorm Wind	No	N/A	Severe thunderstorms generating 51 mph formed from a stalled frontal boundary that over the mid-Atlantic that left the region during the day and then returned.
July 23, 2019	Thunderstorm Wind	No	N/A	A stalled frontal boundary generated and upper level trough spurred severe weather with wind speeds of 51mph recorded in the County.
August 7, 2019	Thunderstorm Wind	No	N/A	Damaging winds up to 50 mph were reported in the County following a cold front entering the area with a robust shortwave trough. Downed power lines and a transformer fire were reported in Dennis Township (Martucci 2019).
February 7, 2020	Thunderstorm Wind	No	N/A	Wind speeds up to 63mph were recorded following an explosively intensifying area of low pressure moving in to the region from the southeast. Power outages were reported in Middle Township and Dennis Township (Davis 2020).
April 13, 2020	Thunderstorm Wind; High Wind	No	N/A	A warm front moved through the mid-Atlantic, mixing with a low level jet with strong wind gusts, particularly near the coast. Later in the day, a strong cold front entered the region,

Table 5.4.8-6. Severe Weather Events in Cape May County, 2016 to April 2020

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Event Details*
				bringing extreme wind shear. Heating produced strong to severe thunderstorms and 70 mph winds. In Wildwood, a section of the Boardwalk near the Convention Center was destroyed and historic Congress Hall in Cape May experienced roof damage.
April 21, 2020	Thunderstorm Wind; Hail	No	N/A	An unseasonable strong cold front brought a squall line through the region. Destabilized air masses brought 60 mph winds and a tornado off the coast. In West Cape May, a pole struck by lightning caught fire and downed wires and power lines were reported in Cape May. Dime-sized hail was reported in Tuckahoe of Upper Township, and multiple trees were reported down with power outages in Seaville (Martucci 2020a).
July 1, 2020	Hail	No	N/A	A severe thunderstorm moving through northern Cape May County brought significant wind, flood, and hail. Golf ball-sized hail was reported in Erma and 1.75-inch hail was reported in the Petersburg section of Upper Township. Ocean City and Marmora saw smaller hail.
August 4, 2020	Tropical Storm; Tornado	No	N/A	Remnants of Tropical Storm Isaias came onshore, bringing rains and high winds and causing considerable damage but no casualties. A waterspout spawned near Strathmere and came onshore the mainland at Marmora near Garden State Parkway milemarker 24.3-24.4. The EF-1 tornado caused significant damage to the Pine Hill Mobile Home Park, Coca-Cola facility, and the vicinity along Route 9. The tornado tracked for over five miles. High winds caused widespread power outages in the region, with outages in Marmora being particularly prolonged (Hartman and Brooks 2020; Martucci 2020b).

Source(s): FEMA 2020; NOAA-NCEI 2020; NJ HMP 2019

** Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table*

FEMA Federal Emergency Management Agency
HMP Hazard Mitigation Plan
NCDC National Climatic Data Center
NOAA National Oceanic and Atmospheric Administration
NWS National Weather Service

Probability of Future Occurrences

Predicting future severe weather events in a constantly changing climate has proven to be a difficult task. Predicting extremes in New Jersey and Cape May County is particularly difficult because of their geographic location. Both are positioned roughly halfway between the equator and the North Pole and are exposed to both cold and dry airstreams from the south. The interaction between these opposing air masses often leads to turbulent weather across the region (Keim 1997).

Table 5.4.8-7 summarizes data regarding the probability of occurrences of severe weather 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 and FEMA disaster declarations.

Table 5.4.8-7. Probability of Future Occurrences of Severe Weather Events

Hazard Type	Number of Occurrences Between 1950 and 2020	% Chance of Occurring in Any Given Year
Cold/Wind Chill	48	67.61%
Excessive Heat	23	32.39%
Extreme Cold/Wind Chill	4	5.63%
Funnel Cloud	3	4.23%
Hail	30	42.25%
Heat	94	100%
Heavy Rain	306	100%
High Wind	109	100%
Lightning	18	25.35%
Strong Wind	275	100%
Thunderstorm Wind	124	100%
Tornado	9	12.68%
Total	**1,043**	**100%**

Source: NOAA-NCEI 2020

Note: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected storm events since 1968. Due to limitations in data, not all severe weather events occurring between 1954 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.

It is estimated that Cape May County will continue to experience direct and indirect impacts of severe weather events annually that may induce secondary hazards such as flooding, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences. Extreme temperatures are expected to occur more frequently as part of regular seasons. Specifically, extreme heat will continue to impact New Jersey and its counties and, based upon data presented, will increase in the next several decades. As previously stated, several extreme temperature events occur each year in Cape May County. It is estimated that the County will continue to experience these events annually.

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 severe weather events in the County is considered ‘frequent’ (100% chance of event occurring; occurs multiple times a year).

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. 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). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70% of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). 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). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020).

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).

5.4.8.2 Vulnerability Assessment

A probabilistic assessment was conducted for the 100- and 500-year MRPs through a Level 2 analysis in HAZUS-MH to analyze the severe weather hazard and provide a range of loss estimates due to wind impacts. A qualitative assessment was conducted to analyze the other severe weather hazards for Cape May County. Quantified residual impacts from severe weather such as flooding can also be reviewed in Section 5.4.5 (Flood). Refer to Section 5.1 (Methodology and Tools) for additional details on the methodology used to assess severe weather risk.

Impact on Life, Health, Safety

The impact of a severe weather on life, health and safety is dependent upon several factors including the severity of the event and whether adequate warning time was provided to residents. The entire population of Cape May County (93,705) is exposed to this hazard (2014-2018 American Community Survey 5-Year Population Estimate).

Lightning can be responsible for deaths, injuries, and property damage. Lightning-based deaths and injuries typically involve heart damage, inflated lungs, or brain damage, as well as loss of consciousness, amnesia, paralysis, and burns, depending on the severity of the strike. Additionally, most people struck by lightning survive, although they may have severe burns and internal damage. People located outdoors (i.e., recreational activities and farming) are considered most vulnerable to hailstorms, thunderstorms, and tornadoes because there is little to no warning, and shelter might not be available. Moving to a lower risk location will decrease a person's vulnerability.

As a result of severe weather events, residents can be displaced or require temporary to long-term sheltering. The HAZUS-MH results for the 100-year and 500-year MRP hurricane wind events are able to show displaced households and people requiring short-term sheltering. 59 households will be displaced, and 30 people will require short-term sheltering in the 100-year event. 1,122 households will be displaced, and 615 people will require short-term sheltering in the 500-year event.

Table 5.4.8-8. Displaced Households and Short-Term Sheltering

Jurisdiction	American Community Survey (2014-2018) Population	Hurricane Wind 100-Year Mean Return Period		Hurricane Wind 500-Year Mean Return Period	
		Displaced Households	People Requiring Short-Term Shelter	Displaced Households	People Requiring Short-Term Shelter
Avalon Borough	1,409	1	0	5	2
Cape May City	3,491	2	1	136	85
Cape May Point Borough	188	0	0	22	10
Dennis Township	6,244	0	0	6	3
Lower Township	21,838	1	0	492	257
Middle Township	18,492	1	1	126	73
North Wildwood City	3,849	8	4	57	27
Ocean City	11,202	27	13	15	7
Sea Isle City	1,955	2	1	6	3
Stone Harbor Borough	955	1	0	9	3
Upper Township	11,909	0	0	4	3
West Cape May Borough	1,103	0	0	46	21
West Wildwood Borough	376	2	1	16	11
Wildwood City	5,073	7	5	86	58
Wildwood Crest Borough	3,131	7	4	91	48
Woodbine Borough	2,490	0	0	4	4
Cape May County (Total)	**93,705**	**59**	**30**	**1,122**	**615**

Source: Hazus-MH 4.2

Downed trees, damaged buildings, and debris carried by high winds from hurricanes, tropical storms, or tornadoes can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on several factors, including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing.

Economically disadvantaged populations are more vulnerable because they often evaluate evacuation needs and make decisions based on the economic impact to their family. The population over the age of 65 (23,572) is also vulnerable, can physically have difficulty evacuating, and are more likely to seek or need medical attention, which may not be available due to isolation during a storm event (2014-2018 American Community Survey 5-Year Population Estimate). Section 4 (County Profile) provides for the statistics for these populations in Cape May County.

Extreme temperature events have potential health impacts including injury and death. According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include the following: 1) the elderly, who are less able to withstand extreme temperatures due to their age, health conditions and limited mobility to access shelters; 2) infants and children up to four years of age; 3) individuals with chronic medical conditions (e.g., heart disease or high blood pressure); 4) low-income persons that cannot afford proper heating and cooling; and 5) the general public who may overexert during work or exercise during extreme heat events or experience hypothermia during extreme cold events (CDC 2016).

Risk of structural fire in the winter months is elevated with approximately 30 percent of all deaths caused by fire occurring in the winter months. Cooking and heat sources too close to combustible materials are leading factors in winter home fires. Often times, power outages occur during extreme cold events. Individuals powering their homes with generators are subjected to carbon monoxide poisoning if proper ventilation procedures are not followed. Improperly connected portable generators are capable of 'back feeding' power lines which may cause injury or death to utility works attempting to restore power and may damage house wiring and/or generators (NJOEM 2019).

Meteorologists can accurately forecast extreme heat and cold event development and the severity of the associated conditions with several days of lead time. These forecasts provide an opportunity for public health and other officials to notify vulnerable populations, implement short-term emergency response actions, and focus on surveillance and relief efforts on those at greatest risk. Adhering to extreme temperature warnings can significantly reduce the risk of temperature-related deaths.

Impact on General Building Stock and Critical Facilities

Wind-Only Impacts

Damage to buildings is dependent upon several factors, including wind speed, storm duration, and path of the storm track. Building construction also plays a major role in the extent of damage resulting from a storm. Due to differences in construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings, in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings.

To better understand these risks, Hazus was used to estimate the expected wind-related building damages. Specific types of wind damages are also summarized in Hazus at the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.8-9 summarizes the definition of the damage categories. Table 5.4.8-10 summarizes the damage states estimated for structures during the 100-year and 500-year MRP hurricane wind events by occupancy class. Hazus estimates that zero structures will experience complete damage during the 100-year MRP event and approximately 1.5-percent of residential structures will experience complete damage during the 500-year MRP event.

Table 5.4.8-9. Description of Damage Categories

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
No Damage or Very Minor Damage Little or no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof over, with no or very Limited water penetration.	≤2%	No	No	No	No	No
Minor Damage Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair.	>2% and ≤15%	One window, door, or garage door failure	No	<5 impacts	No	No
Moderate Damage Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some	>15% and ≤50%	> one and ≤ the larger of 20% & 3	1 to 3 panels	Typically 5 to 10 impacts	No	No

Table 5.4.8-9. Description of Damage Categories

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
resulting damage to interior of building from water.						
Severe Damage Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	>50%	> the larger of 20% & 3 and ≤50%	>3 and ≤25%	Typically 10 to 20 impacts	No	No
Destruction Complete roof failure and/or, failure of wall frame. Loss of more than 50% of roof sheathing.	Typically >50%	>50%	>25%	Typically >20 impacts	Yes	Yes

Source: HAZUS-MH Hurricane Technical Manual

Table 5.4.8-10 summarizes the replacement cost value of building and content damages estimated for the 100- and 500-year MRP hurricane wind-only events. Table 5.4.8-11 summarizes the replacement cost value of building and content damages estimated for the 100-year and 500-year MRP hurricane wind-only events for residential and commercial occupancy classes. Less than 1% of the entire building stock may anticipate damages caused by the 100-year hurricane wind event and approximately 3.5-percent of the entire building stock may anticipate damages caused by the 500-year hurricane wind event. The total damage for all occupancy types across the County is estimated to be $415.7 million for the 100-year MRP wind-only event, and approximately $3.2 billion for the 500-year MRP wind-only event. The majority of these losses are to residential structures.

Table 5.4.8-10. Estimated Losses for the 100-Year and 500-Year MRP Hurricane Wind Events

Jurisdiction	Total Replacement Cost Value (All Occupancies)	Estimated Total Damages 100-Year	Percent of Total	500-Year	Percent of Total
Avalon Borough	$8,232,959,879	$45,556,435	0.6%	$142,708,862	1.7%
Cape May City	$5,153,049,612	$18,709,280	0.4%	$568,267,358	11.0%
Cape May Point Borough	$663,183,164	$2,636,428	0.4%	$79,830,434	12.0%
Dennis Township	$3,813,425,173	$12,131,107	0.3%	$48,012,984	1.3%
Lower Township	$9,950,232,225	$37,563,079	0.4%	$908,850,173	9.1%
Middle Township	$11,557,342,752	$35,443,035	0.3%	$344,730,436	3.0%
North Wildwood City	$4,423,365,953	$17,664,110	0.4%	$121,635,223	2.7%
Ocean City	$17,100,920,036	$101,779,622	0.6%	$73,718,096	0.4%
Sea Isle City	$7,663,928,227	$52,396,504	0.7%	$100,586,788	1.3%
Stone Harbor Borough	$3,291,756,871	$18,644,314	0.6%	$98,106,713	3.0%
Upper Township	$6,506,171,365	$27,896,296	0.4%	$49,218,071	0.8%
West Cape May Borough	$1,178,516,373	$5,450,858	0.5%	$165,050,693	14.0%
West Wildwood Borough	$459,103,094	$3,482,377	0.8%	$30,428,039	6.6%
Wildwood City	$4,379,038,844	$14,497,979	0.3%	$132,807,464	3.0%
Wildwood Crest Borough	$4,552,156,876	$19,719,858	0.4%	$286,440,410	6.3%
Woodbine Borough	$1,335,589,432	$2,166,772	0.2%	$13,861,534	1.0%
Cape May County (Total)	**$90,260,739,877**	**$415,738,054**	**0.5%**	**$3,164,253,276**	**3.5%**

Source: Hazus-MH 4.2
Notes: MRP = Mean return period

**The Total Damages column represents the sum of damages for all occupancy classes (residential, commercial, industrial, agricultural, educational, religious, and government) based on replacement cost value.*

Table 5.4.8-11. Estimated Losses for the 100-Year and 500-Year MRP Hurricane Wind Events – Residential and Commercial Occupancy Classes Only

Jurisdiction	Total Replacement Cost Value (All Occupancies)	Estimated Residential Damages		Estimated Commercial Damages	
		100-Year	500-Year	100-Year	500-Year
Avalon Borough	$8,232,959,879	$45,190,035	$140,894,777	$230,473	$1,309,504
Cape May City	$5,153,049,612	$18,049,569	$507,722,125	$218,154	$30,837,925
Cape May Point Borough	$663,183,164	$2,594,254	$75,810,523	$19,291	$2,146,092
Dennis Township	$3,813,425,173	$11,679,936	$44,268,035	$368,777	$2,436,579
Lower Township	$9,950,232,225	$36,618,753	$844,633,376	$390,377	$34,220,708
Middle Township	$11,557,342,752	$32,817,186	$282,423,878	$1,397,197	$41,348,277
North Wildwood City	$4,423,365,953	$17,092,538	$113,342,260	$304,222	$5,335,252
Ocean City	$17,100,920,036	$100,158,864	$72,898,618	$667,728	$336,658
Sea Isle City	$7,663,928,227	$52,092,081	$99,785,698	$239,376	$640,909
Stone Harbor Borough	$3,291,756,871	$18,527,867	$96,888,250	$89,307	$1,011,580
Upper Township	$6,506,171,365	$26,929,953	$47,165,017	$754,219	$1,455,976
West Cape May Borough	$1,178,516,373	$5,363,662	$156,739,463	$39,885	$4,437,080
West Wildwood Borough	$459,103,094	$3,206,241	$24,275,327	$185,311	$4,981,102
Wildwood City	$4,379,038,844	$13,554,445	$110,141,124	$635,767	$18,031,181
Wildwood Crest Borough	$4,552,156,876	$19,390,664	$277,565,903	$208,662	$6,193,297
Woodbine Borough	$1,335,589,432	$2,003,563	$10,472,374	$31,017	$545,842
Cape May County (Total)	**$90,260,739,877**	**$405,269,612**	**$2,905,026,748**	**$5,779,762**	**$155,267,962**

Source: Hazus-MH 4.2
Notes: MRP = Mean return period

Since 1950, nearly $219 million damages to property has been reported to the NWS in Cape May County due to severe weather events including high wind, thunderstorm wind, strong wind, tornados, lightning, heavy rain, winter storm, hail, and extreme temperature events (NOAA NCEI 2020). High wind events created the greatest value of property damage out of this total ($215.5 million). Table 5.4.8-12 outlines the severe weather events that have reported property damages in Cape May County.

Table 5.4.8-12. Historical Severe Weather Events That Occurred in Cape May County with Recorded Property Damages

Type of Event	Number of Times Event Occurred (1950 – 2020)	Total Value of Losses
Cold/Wind Chill	48	$0
Excessive Heat	23	$0
Extreme Cold/Wind Chill	4	$0
Funnel Cloud	3	$0
Hail	30	$0
Heat	94	$0
Heavy Rain	309	$150,000
High Wind	109	$215,535,000
Lightning	18	$119,020
Strong Wind	275	$1,031,000
Thunderstorm Wind	124	$1,260,000
Tornado	9	$802,750

Type of Event	Number of Times Event Occurred (1950 – 2020)	Total Value of Losses
Total	**1,043**	**$218,897,770**

Source: NOAA NCEI 2020

All buildings are exposed to the extreme temperature hazard. Extreme heat generally does not impact buildings; however, elevated summer temperatures increase the energy demand for cooling. Losses can be associated with the overheating of heating, ventilation, and air conditioning (HVAC) systems. Extreme cold temperature events can damage buildings through freezing/bursting pipes and freeze/thaw cycles, as well as increasing vulnerability to home fires. Additionally, manufactured homes (mobile homes) and antiquated or poorly constructed facilities can have inadequate capabilities to withstand extreme temperatures.

Impact on Critical Facilities

Critical facilities are at risk of being impacted by high winds associated with structural damage, or falling tree limbs/flying debris, which can result in the loss of power. Power loss can greatly impact households, business operations, public utilities, and emergency personnel. Emergency personnel such as police, fire, and EMS will not be able to effectively respond in a power loss event to maintain the safety of its citizens unless backup power and fuel sources are available. Loss of power can impact other public utilities, including potable water, wastewater treatment, and communications. In addition to public water services, property owners with private wells might not have access to potable water until power is restored.

All critical facilities in the County are exposed to the extreme temperature hazard with similar risks as discussed for the general building stock. It is essential that critical facilities remain operational during natural hazard events. Extreme heat events can sometimes cause short periods of utility failures, commonly referred to as "brown-outs", due to increased usage from air conditioners, appliances, etc. Similarly, heavy snowfall and ice storms, associated with extreme cold temperature events, can cause power interruption as well. Backup power is recommended for critical facilities and infrastructure. Where backup power is needed for critical facilities that provide essential services, municipalities identified mitigation actions in Section 9 (Jurisdictional Annexes).

Hazus estimates that critical facilities in Cape May have a low percent probability of sustaining minor to moderate damages from the 100-year MRP hurricane wind event. Hazus also estimates that there are critical facilities that have a 17.8-percent probability of sustaining severe damage from the 500-year MRP hurricane wind event. These probabilities can be found in Table 5.4.8-13 and **Table 5.4.8-14** by facility type.

Table 5.4.8-13. Estimated Impacts to Critical Facilities for the 100-Year MRP Hurricane Wind Event

	100-Year Event				
		Percent-Probability of Sustaining Damage			
Facility Type	Loss of Days	Minor	Moderate	Severe	Complete
EOC	0	1.7%-9.2%	0.0%-2.3%	<0.1%	0.0%
Medical	0	1.5%-7.0%	0.0%-2.7%	<0.1%	0.0%
Police	0	2.0%-9.2%	0.0%-2.3%	<0.1%	0.0%
Fire	0	0.6%-5.0%	0.0%-1.1%	<0.1%	0.0%
Schools	0	1.0%-7.4%	0.0%-4.3%	<0.1%	0.0%

Source: Hazus-MH v4.2

Table 5.4.8-14. Estimated Impacts to Critical Facilities for the 500-Year MRP Hurricane Wind Event

Facility Type	Loss of Days	500-Year Event Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
EOC	0	3.6%-22.1%	0.1%-29.1%	0.0%-17.8%	0.0%
Medical	0-3	3.8%-15.3%	0.6%-38.6%	0.0%-10.5%	0.0%-0.6%
Police	0	3.6%-23.8%	0.2%-29.1%	0.0%-17.8%	0.0%
Fire	0	1.6%-15.1%	0.1%-23.9%	0.0%-10.9%	0.0%-0.6%
Schools	0-24	3.5%-12.0%	0.7%-46.0%	0.0%-14.7%	<0.1%

Source: Hazus-MH v4.2

Impact on Economy

Severe weather events can have short- and long-lasting impacts on the economy. When a business is closed during storm recovery, there is lost economic activity in the form of day-to-day business and wages to employees. Overall, economic impacts include the loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, wage loss and rental loss due to the repair/replacement of buildings. As evidenced by Hurricane Sandy, the State of New Jersey, including Cape May County, lost millions of dollars in wages and economic activity.

Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting and goods transport) transportation needs. Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage and impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to the population.

HAZUS-MH estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the "Impact on General Building Stock" section discussed earlier. Business interruption losses are the losses associated with the inability to operate a business because of the wind damage sustained during the storm or the temporary living expenses for those displaced from their home because of the event.

For the 100-year MRP wind event, Hazus estimates $22.8 million in business interruption costs (income loss, relocation costs, rental costs, and lost wages). For the 500-year MRP wind-only event, Hazus estimates approximately $387.2 million in business interruption losses for the County which includes loss of income, relocation costs, rental costs, and lost wages.

Debris management can be costly and may also impact the local economy. Hazus estimates the amount of building and tree debris that may be produced as result of the 100- and 500-year MRP wind events. Because the estimated debris production does not include flooding, this is likely a conservative estimate and may be higher if multiple impacts occur. According to the Hazus Hurricane User Manual, estimates of weight and volume of eligible tree debris consist of downed trees that would likely be collected and disposed at public expense. Refer to the User Manual for additional details regarding these estimates. Table 5.4.8-15 summarizes debris production estimates for the 100- and 500-year MRP wind events.

Table 5.4.8-15. Debris Production for the 100-Year and 500-Year MRP Hurricane Wind Events

Jurisdiction	Brick and Wood (tons)		Concrete and Steel (tons)		Tree (tons)		Eligible Tree Volume (cubic yards)	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Avalon Borough	3,432	10,725	0	0	157	314	797	1,594
Cape May City	1,272	35,696	0	381	683	3,338	4,211	20,585
Cape May Point Borough	128	5,096	0	43	418	2,460	1,035	6,094
Dennis Township	521	3,228	0	0	14,941	53,452	11,097	34,859
Lower Township	2,007	65,364	0	542	7,400	38,578	22,737	123,870
Middle Township	2,017	25,299	0	121	22,493	81,381	33,112	122,370
North Wildwood City	1,636	10,137	0	39	0	0	0	0
Ocean City	10,947	7,520	3	1	313	313	1,499	1,499
Sea Isle City	5,456	10,301	0	0	140	210	962	1,443
Stone Harbor Borough	1,622	8,160	0	23	134	313	919	2,145
Upper Township	1,415	2,981	0	0	17,192	36,884	24,197	43,507
West Cape May Borough	265	10,536	0	88	864	5,086	2,140	12,600
West Wildwood Borough	457	2,861	0	12	19	88	156	704
Wildwood City	1,849	12,406	0	53	93	365	741	2,903
Wildwood Crest Borough	1,931	23,248	1	261	53	232	99	437
Woodbine Borough	100	926	0	4	1,795	6,417	2,743	9,800
Cape May County (Total)	**35,055**	**234,485**	**4**	**1,567**	**66,696**	**229,431**	**106,445**	**384,410**

Source: Hazus-MH 4.2
Notes: MRP = Mean Return Period

According to the State of New Jersey 2019 HMP, hail alone causes $2 billion worth of crop and property damage on an annual basis in the United States (State of NJ 2019). Even though New Jersey is estimated to experience an average of two hailstorm events per year, the outcome of these events could be detrimental depending on the cost it would take for the community to recover from the damages. Likewise, these costs can add up for other severe weather events such as tornados destroying key infrastructure and level local businesses, or extreme rain events flooding out shopping centers or transportation hubs.

Extreme temperature events also have impacts on the economy, including loss of business function and damages to inventory. Business-owners may be faced with increased financial burdens due to unexpected repairs caused to the building (e.g., pipes bursting), higher than normal utility bills (e.g., less efficient heating or cooling systems overexerting power based on temperature extremes) or business interruption due to power failure (i.e., loss of electricity, telecommunications). In general, the agricultural industry is most at risk in terms of economic impact and damage due to extreme temperature events. Extreme heat events can result in drought and dry conditions and directly impact livestock and crop production. More information about the impacts of drought on the agricultural industry is discussed in Section 5.4.4 (Drought).

Impact on the Environment

The impact of severe weather events on the environment varies, but researchers are finding that the long-term impacts of more severe weather can be destructive to the natural and local environment. National organizations such as USGS and NOAA have been studying and monitoring the impacts of extreme weather phenomena as it impacts long term climate change, streamflow, river levels, reservoir elevations, rainfall, floods, landslides, erosion, etc. (USGS 2017). For example, severe weather that creates longer periods of rainfall can erode natural banks along waterways and degrade soil stability for terrestrial species. Tornadoes can tear apart habitats causing fragmentation across ecosystems. Researchers also believe that a greater number of diseases will spread across ecosystems because of impacts that severe weather and climate change will have on water supplies (NOAA 2013c). Overall, as the physical environment becomes more altered, species will begin to contract or migrate in response, which may cause additional stressors to the entire ecosystem within Cape May County. Refer to Sections 5.4.3 (Disease Outbreak) for more information about these stressors.

Extreme weather events can have a major impact on the environment. For example, freezing and warming weather patterns create changes in natural processes. An excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources (USGS nd). Likewise, rain-on-snow events also exacerbate runoff rates with warming winter weather.

Future Changes that May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. Cape May 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 (County Profile), areas targeted for future growth and development have been identified across Cape May County. Any areas of growth could be potentially impacted by the severe weather hazard because the entire County is exposed and vulnerable. However, due to increased standards and codes, new development may be less vulnerable to the severe weather hazard compared with the aging building stock in the County. The ability of new development to withstand extreme temperature impacts lies in sound land use practices, building design considerations (e.g. Leadership in Energy and Environmental Design [LEED]), and consistent enforcement of codes and regulations for new construction. New development will change the landscape where buildings, roads, and other infrastructure potentially replace open land and vegetation. Surfaces that were once permeable and moist are now impermeable and dry. These changes cause urban areas to become warmer than the surrounding areas forming (heat islands as described above). Specific areas of recent and new development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 (Jurisdictional Annexes) of this plan.

Projected Changes in Population

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. It is expected that in the next 20 years, population growth will be relatively stagnant (U.S. Census Bureau 2020, SJTPO). Overall, aging infrastructure may result in increased stress on existing infrastructure and related services. Although overall County growth is not expected, individual municipalities that experience increases in population may require utility system upgrades to keep up with utility demands (e.g., water, electric) during extreme temperature events to prevent increased stresses on these systems. Refer to Section 4 (County Profile) for a detailed discussion on population change in Cape May County.

Climate Change

As discussed earlier, studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. More frequent and severe storms will increase the County's vulnerability to each of the identified severe weather hazards. Section 5.4.5 (Flood) provides a discussion related to the impact of climate change due to increases in rainfall resulting from severe storms. Changes in the climate could alter the frequency of extreme temperature events that occur in the County, resulting in even hotter or colder events. As a result, vulnerable populations could be at risk for experiencing a greater number of illnesses associated with extreme temperature events, such as heatstroke and cardiovascular and kidney disease. Additionally, if temperatures become more extreme, a greater number of buildings, facilities, and infrastructure systems may exceed their ability to cope with these extremes.

Change of Vulnerability Since the 2016 HMP

Overall, the County's vulnerability has not changed, and the entire County will continue to be exposed and vulnerable to severe weather events. As existing development and infrastructure continue to age, they can be at increased risk to failed utility and transportation systems if they are not properly maintained and do not adapt to the changing environment.

5.4.9 Severe Winter Weather

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 severe winter weather hazard in Cape May County.

2021 Plan Update Changes

- New and updated figures from federal and state agencies are incorporated.
- A new table explaining prior severe winter weather events was added.
- Previous occurrences were updated with events that occurred between 2016 and 2020.
- A vulnerability assessment was conducted for the severe winter weather hazard using a more accurate and updated building inventory.

5.4.9.1 Profile

Hazard Description

A winter storm is a weather event in which the main types of precipitation are snow, sleet, or freezing rain. They can be a combination of heavy snow, blowing snow, and dangerous wind chills. According to the National Severe Storms Laboratory (n.d.), the three basic components needed to make a winter storm include the following:

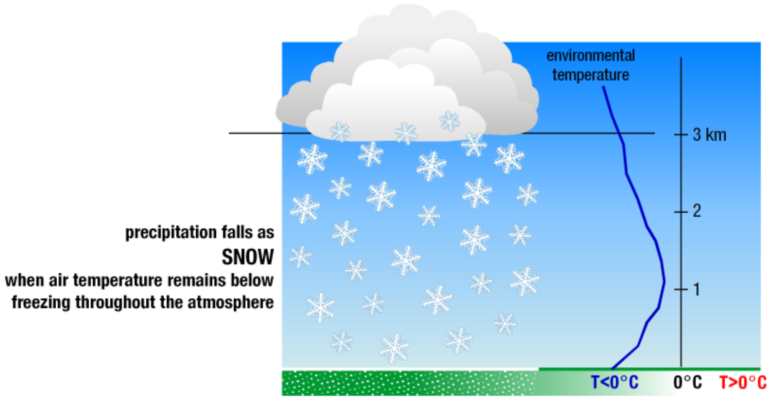
- Below freezing temperatures (cold air) in the clouds and near the ground to make snow and ice.
- Lift, something to raise the moist air to form clouds and cause precipitation, such as warm air colliding with cold air and being forced to rise over the cold dome or air flowing up a mountainside (oliographic lifting).
- Moisture to form clouds and precipitation, such as air blowing across a large lake or the ocean.

Some winter storms can immobilize an entire region, while others might only affect a single community. Winter storms typically are accompanied by low temperatures, high winds, freezing rain or sleet, and heavy snowfall. The aftermath of a winter storm can have an impact on a community or region for days, weeks, or even months; potentially causing cold temperatures, flooding, storm surge, closed and blocked roadways, downed utility lines, and power outages. Cape May County's winter weather events include blizzards, snow storms, Nor'Easters, and ice storms. For details regarding Nor'Easters, refer to Section 5.4.7.

Heavy Snow

According to the National Snow and Ice Data Center (NSIDC), snow is precipitation in the form of ice crystals. It originates in clouds when temperatures are below the freezing point (32 °F) and water vapor in the atmosphere condenses directly into ice without going through the liquid stage. Once an ice crystal has formed, it absorbs and freezes additional water vapor from the surrounding air, growing into snow crystals or a snow pellet, which then falls to the earth. Snow falls in different forms: snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud. Figure 5.4.9-1 depicts snow creation.

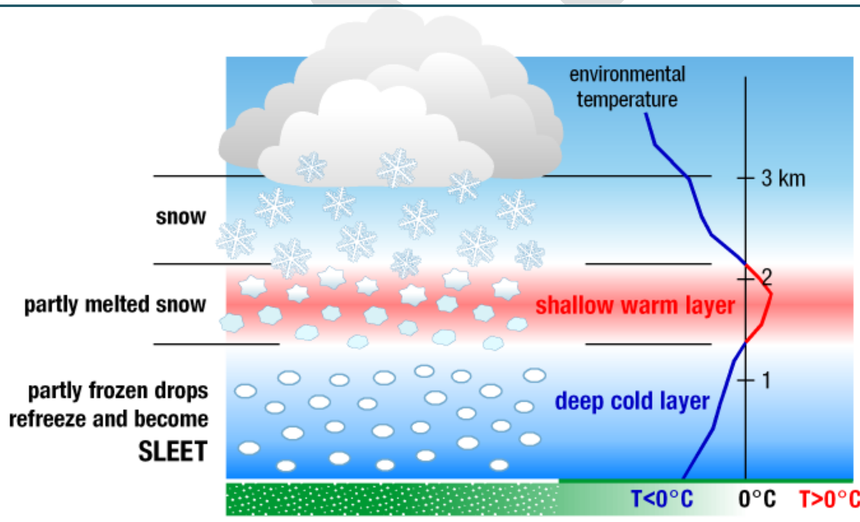
Figure 5.4.9-1. Snow Creation



Source: NOAA-NSSL, 2015

Snow pellets are opaque ice particles in the atmosphere. They form as ice crystals fall through super-cooled cloud droplets, which are below freezing but remain a liquid. The cloud droplets then freeze to the crystals. Sleet is made up of drops of rain that freeze into ice as they fall through colder air layers (see Figure 5.4.9-2). They are usually smaller than 0.30 inches in diameter (NSIDC 2020).

Figure 5.4.9-2. Sleet Creation



Source: NOAA-NSSL 2020

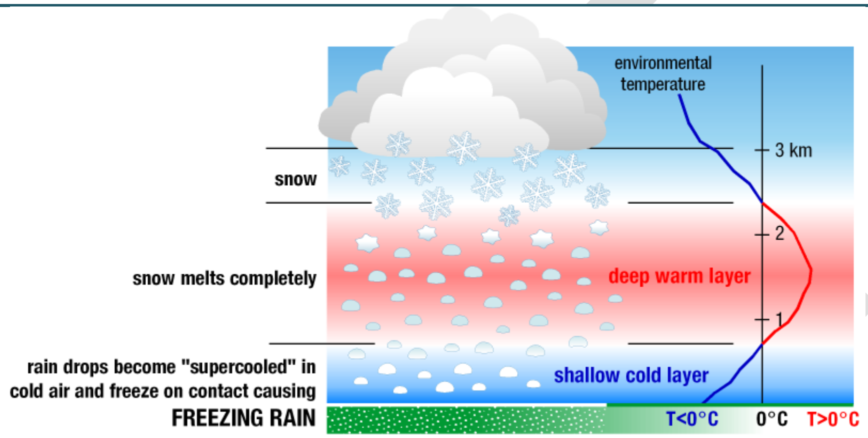
Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 miles per hour (mph) or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile, as the predominant conditions over a 3-hour period. Extremely cold temperatures often are associated with blizzard conditions but are not a formal part of the definition. The hazard, created by the combination of snow, wind, and low visibility, significantly increases when temperatures are below 20°F. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero. Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm, moister air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions caused by the blowing snow (Dolce 2018).

Ice Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations typically are accumulations of 0.25-inches or greater (NWS 2013). Heavy accumulations of ice can bring down trees, power lines, utility poles, and communication towers. Ice can disrupt communications and power for days. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians (Dolce 2018).

Figure 5.4.9-3. Freezing Rain Creation



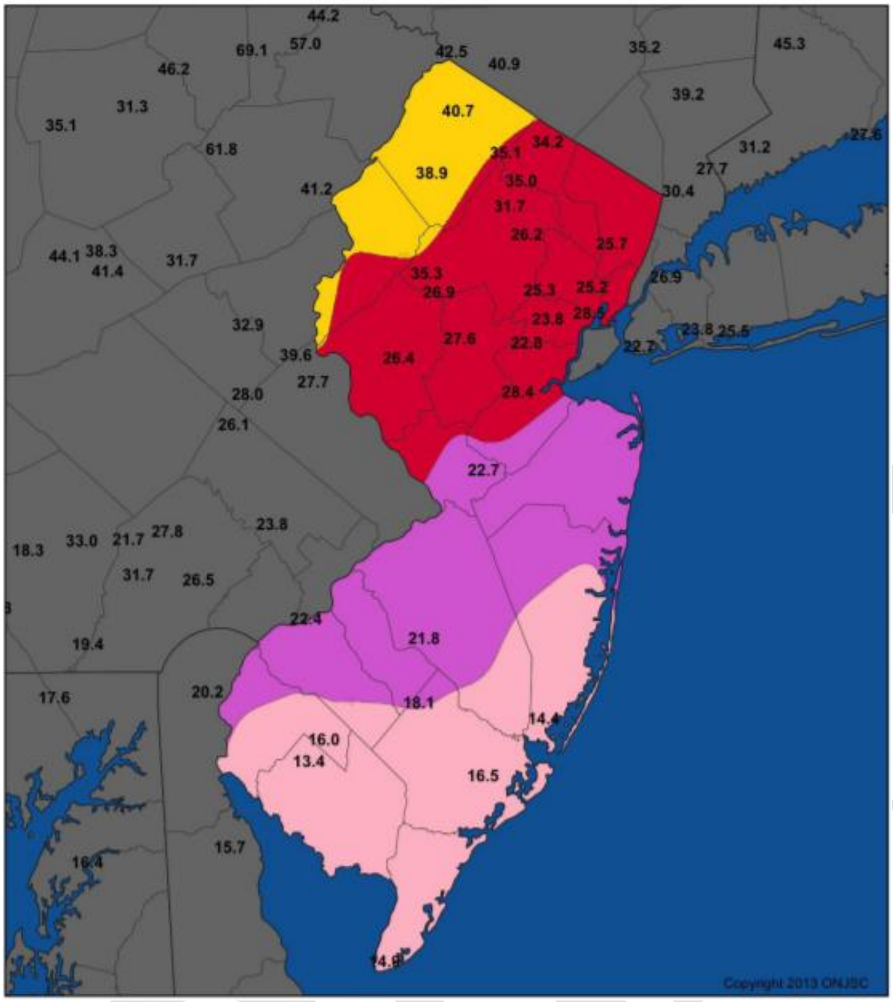
Source: NOAA-NSSL 2020

Location

Snow and Blizzards

Heaviest snowfall from winter storms is typically within a 150-mile wide swath to the northwest of what are generally southwest to northeast moving storms. The trajectory of the snowstorm will determine the location of heaviest snowfalls. Typical seasonal snowfall in New Jersey ranges from 14.9 inches annually in Cape May County to more than 40 inches in Sussex County. However, there is great variability from year to year. For example, the winter of 2019-2020 yielded 0.9 inches of accumulation total in Cape May County. The prior year (2018-2019) saw 10.5 inches of snow fall, whereas the 2017-2018 season saw 19.5 inches. The highest seasonal snowfall on record for the County was during the 2009-2010 season, when 54.2 inches of snow fell. The 2019-2020 season saw among the five lowest seasonal snowfall totals on record (ONJSC 2020). The following map displays normal seasonal snowfall totals between 1981 and 2019.

Figure 5.4.9-4. NJ Normal Seasonal Snowfall Totals (1981-2019)



Ice Storms

Cape May County, like all regions of New Jersey, are subject to ice storms. The distribution of ice storms often coincides with general distribution of snow within several zones in the State. A cold rain may be falling over the southern portion of the State, freezing rain over the central region, and snow over the northern counties as a coastal storm moves northeastward offshore. A locality's distance to the passing storm center is often the crucial factor in determining the temperature and type of precipitation during a winter storm.

Extent

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

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population based on the 2010 Census. The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA 2015). Table 5.4.9-1 presents the five RSI ranking categories.

Table 5.4.9-1. RSI Ranking Categories

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

Source: NOAA 2015
Note: RSI = Regional Snowfall Index

The NWS operates a widespread network of observing systems such as geostationary satellites, Doppler radars, and automated surface observing systems that feed into the current state-of-the-art numerical computer models to provide a look into what will happen next, ranging from hours to days. The models are then analyzed by NWS meteorologists who then write and disseminate forecasts.

The NWS uses winter weather watches, warnings and advisories to ensure that people know what to expect in the coming hours and days. A winter storm watch means that severe winter conditions (heavy snow, ice, etc.) may affect a certain area, but its occurrence, location and timing are uncertain. A watch is issued to provide 12 to 48 hour notice of the possibility of severe winter weather. A watch is upgraded to a winter storm warning when hazardous winter weather, in the form of heavy snow, heavy freezing rain or heavy sleet, is imminent or occurring. They are usually issued 12 to 24 hours before the event is expected to begin. Winter weather advisories inform people that winter weather conditions are expected to cause significant inconveniences that may be hazardous. The NWS may also issue a blizzard warning when snow and strong winds combine and produce a blinding snow, deep drifts, and wind chill (NWS 2013).

Previous Occurrences and Losses

Numerous sources provided winter storm information regarding previous occurrences and losses associated with winter storm events throughout Cape May County. Loss and impact information for many events could not be determined or may vary. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

FEMA Disaster Declarations

Between 1954 and 2020, FEMA declared that the State of New Jersey experienced eight winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe winter storm, severe storm, snowstorm, blizzard, and ice conditions. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Cape May County was included in six of these declarations. **Table 5.4.9-2** lists FEMA DR and EM declarations that included Cape May County.

Table 5.4.9-2. FEMA Declarations for Severe Winter Weather Events in Cape May County

FEMA Declaration Number	Date(s) of Event	Event Type	Counties Included
DR-528	February 8, 1977	Ice Conditions	Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Middlesex, Monmouth, Ocean, and Salem

Table 5.4.9-2. FEMA Declarations for Severe Winter Weather Events in Cape May County

FEMA Declaration Number	Date(s) of Event	Event Type	Counties Included
EM-3106	March 13-17, 1993	Severe Blizzard	All 21 Counties in New Jersey
DR-1088	January 7-12, 1996	Blizzard of '96 (severe snow storm)	All 21 Counties in New Jersey
DR-1206	February 4-8, 1998	Severe Winter Coastal Storm, High Winds, Flooding	Atlantic, Cape May, and Ocean
DR-1889	February 5-6, 2010	Severe Winter Storm and Snowstorm	Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester and Salem
DR-1954	December 26-27, 2010	Severe Winter Storm and Snowstorm	Atlantic, Bergen, Burlington, Cape May, Cumberland, Essex, Hudson, Mercer, Middlesex, Monmouth, Morris, Ocean, Passaic, Somerset, and Union
DR-4264	January 22-24, 2016	Severe Winter Storm and Snowstorm	Atlantic, Bergen, Burlington, Camden, Cape May, Cumberland, Essex, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Ocean, Somerset, Union and Warren

Source: FEMA 2020

U.S. Department of Agriculture Disaster Declarations

Between 2016 and 2020, the period for which data was available, Cape May County was not included in any winter weather-related USDA declarations.

Previous Events

For this 2021 Plan update, winter weather events were summarized from 2016 to 2020. For information regarding severe winter weather events prior to 2016, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (jurisdictional annexes).

Table 5.4.9-3. Severe Winter Weather Events in Cape May County, 2016 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
January 17, 2016	Winter Weather	N/A	No	Southern and Coastal New Jersey were impacted by one to three inches of winter precipitation, resulting in vehicular accidents in some areas.
January 22, 2016	Winter Storm	DR-4264	Yes	A storm impulse from the west coast developed into a nor'easter over the Carolinas, resulting in blizzard conditions to the County. Approximately one foot of snow fell, and wind gusts up to 64 mph were recorded in the County. The storm, known as Jonas, caused widespread power failures and flooding throughout the County.
February 5, 2016	Winter Weather	N/A	No	Shore areas of New Jersey saw heavy, wet snow following a north-moving low pressure system located offshore.
February 15, 2016	Winter Weather	N/A	No	A low pressure system from the Tennessee River Valley brought early snow followed by freezing rain and rain.
March 3, 2016	Winter Storm	N/A	No	Southern New Jersey saw high accumulations of snow resulting from an intensifying low-pressure system off the coast of North Carolina.
April 9, 2016	Winter Weather	N/A	No	Late-season snow brought approximately three inches to the County. The snow was followed by low temperatures, which caused localized plant damage.
December 17, 2016	Winter Weather	N/A	No	Cape May County saw a wintry mix of precipitation, resulting in a small amount of snowfall and ice glaze.

Table 5.4.9-3. Severe Winter Weather Events in Cape May County, 2016 to 2020

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
January 5, 2017	Winter Weather	N/A	No	The region received snowfall resulting from a clipper system combining with a northeast-moving low pressure system.
January 7, 2017	Winter Storm	N/A	No	Cape May County saw approximately eight inches of snow resulting from a strengthening low-pressure system located off the coast.
February 9, 2017	Winter Weather	N/A	No	Rain and minor slow accumulations were experienced in the region, followed by gusty winds following a strong cold front.
December 8, 2017	Winter Weather	N/A	No	Approximately three inches of snow were recorded in the coastal and southwestern sections of New Jersey following a low pressure system moving up the coast. Some mixed precipitation was recorded.
January 4, 2018	Blizzard	N/A	No	Blizzard conditions – with winds up to 40 mph – were experienced in Cape May County, resulting in a State of Emergency. The blizzard was followed by protracted cold conditions, leading to Code Blue operations and the closure of the Cape May Lewes Ferry.
March 7, 2018	Winter Weather	N/A	No	A low pressure system deepened as it passed east of the New Jersey Shore, causing mixed precipitation and then predominantly snow. A number of downed trees were recorded resulting from wet, heavy snow. Smaller amounts of precipitation were recorded in Cape May County.
March 21, 2018	Winter Storm	N/A	No	Cape May County saw minor coastal flooding and mixed precipitation following a complex area of low pressure moving into the region. Snow developed in Cape May County relatively later, resulting in only three inches of snow, which was wet and heavy in character.
December 5, 2018	Winter Weather	N/A	No	Localized snowfall was recorded due to a Norlun Trough, resulting in up to four inches of snow, with higher totals recorded in the northern portion of the Country.
January 12, 2019	Winter Weather	N/A	No	Cape May County was struck by a weekend winter storm, yielding approximately 4.7 inches of snow.
February 1, 2019	Winter Weather	N/A	No	Cape May County experienced light snow during an Arctic airmass outbreak.
February 10, 2019	Winter Weather	N/A	No	Light snow was recorded in the southern mid-Atlantic region, which was followed by the second part of the storm that brought wintry mix and rain.
February 20, 2019	Winter Weather	N/A	No	Mixed precipitation amounting to several inches of snow and freezing rain was recorded in the region following a complex area of low pressure.
March 1, 2019	Winter Weather	N/A	No	Two to four inches fell over a three-hour period during a brief but intense winter weather event.

Sources: FEMA 2020; NOAA-NCEI 2020; SPC 2020; NJOSC 2020
* *Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table*
DR Major Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph Miles per Hour
NCEI National Centers for Environmental Information
NJOSC New Jersey State Climatologist
NOAA National Oceanic and Atmospheric Administration
N/A Not Applicable

Probability of Future Occurrences

Severe winter weather is a common occurrence each winter season in New Jersey. The majority of the State will receive at least one measurable snow event during the winter months. The months of January, February, March, April, October, November and December are typically when a vast majority of New Jersey has been observed to receive measurable snow. Generally, counties in the northern region experience more snow events than those in the southern region. It is estimated that Cape May County will continue to experience the direct and indirect impacts of severe winter weather events annually that many induce secondary hazards such as: structural damage (snow and ice load), wind damage, impact to life safety, disruption of traffic, loss of productivity, economic impact, loss of ability to evacuate, taxing first-responder capabilities, service disruption (power, water, etc.), and communication disruption.

Table 5.4.9-4 summarizes data regarding the probability of occurrences of severe winter weather events in Cape May County based on the historic record. To calculate the probability, the NOAA-NCEI database was queried for all winter weather-related events in Cape May County. Table 5.4.9-4 shows the number of occurrences and the percent chance of the event occurring in any given year. The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results.

Table 5.4.9-4. Probability of Future Occurrence of Severe Winter Weather Events

Hazard Type	Number of Occurrences Between 1950 and 2020	% Chance of Occurring in Any Given Year
Blizzard	3	4.2
Ice Storm	0	0
Heavy Snow	23	33
Winter Storm	20	28.5
Winter Weather	82	100%
Total	**128**	**100%**

Source: NOAA-NCEI 2020

Note: Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected storm events since 1950. Due to limitations in data, not all severe winter weather 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 Partnership, the probability of occurrence for severe winter weather in the County is considered 'frequent' (100% chance occurring each year, occurring multiple times a year).

Climate Change Impacts

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. 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). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70% of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the

New Jersey State Climatologist 2020). 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).

5.4.9.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the severe winter weather hazard, all of Cape May County has been identified as the hazard area. Therefore, all assets in the County (population, structures, critical facilities and lifelines), as described in the County Profile (Section 4), are vulnerable to a winter weather event.

Impact on Life, Health and Safety

The entire population of Cape May County (93,705 people) is exposed to severe winter weather events (U.S. Census, 2018). According to the NOAA National Severe Storms Laboratory (NSSL); every year, winter weather indirectly and deceptively kills hundreds of people in the U.S., primarily from automobile accidents, overexertion and exposure. Winter storms are often accompanied by strong winds creating blizzard conditions with blinding wind-driven snow, drifting snow and extreme cold temperatures and dangerous wind chill. They are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. People can die in traffic accidents on icy roads, heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold (NSSL 2020).

The homeless and elderly are considered most susceptible to this hazard. The elderly are considered susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice. According to the 2018 American Community Survey 5-Year population estimate, there are 23,572 persons over 65 years old that reside in the County that are considered vulnerable to severe winter weather. In addition, severe winter weather can reduce the ability of these populations to access emergency services.

Additionally, the homeless and residents below the poverty level may not have access to housing or their housing could be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). Residents with low incomes might not have access to housing or their housing can be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). In Cape May County, the Borough of Woodbine has the highest population below the poverty level (i.e., 690 persons). Refer to Section 4 (County Profile) that displays the distribution of low-income populations in Cape May County.

Impact on General Building Stock

The entire general building stock inventory is exposed and vulnerable to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Table 5.4.9-5 presents the total exposure value for general building stock for each participating municipality.

Current modeling tools are not available to estimate specific losses for this hazard. As an alternate approach, this plan considers percentage damages that could result from severe winter storm conditions. Table 5.4.9-5 below summarizes percent damages that could result from severe winter storm conditions for the Planning Area's total general building stock. Given professional knowledge and the currently available information, the potential loss for this hazard is considered to be overestimated because of varying factors (building structure type, age, load distribution, building codes in place, etc.). Therefore, the following information should be used as estimates only for planning purposes with the knowledge that the associated losses for severe winter weather events vary greatly.

Table 5.4.9-5. General Building Stock Exposure and Estimated Losses from Severe Winter Weather Events

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	1-Percent of Total Replacement Cost Value	5-Percent of Total Replacement Cost Value	10-Percent of Total Replacement Cost Value
Avalon Borough	5,867	$8,232,959,879	$82,329,599	$411,647,994	$823,295,988
Cape May City	4,234	$5,153,049,612	$51,530,496	$257,652,481	$515,304,961
Cape May Point Borough	785	$663,183,164	$6,631,832	$33,159,158	$66,318,316
Dennis Township	7,301	$3,813,425,173	$38,134,252	$190,671,259	$381,342,517
Lower Township	19,597	$9,950,232,225	$99,502,322	$497,511,611	$995,023,223
Middle Township	18,197	$11,557,342,752	$115,573,428	$577,867,138	$1,155,734,275
North Wildwood City	4,729	$4,423,365,953	$44,233,660	$221,168,298	$442,336,595
Ocean City	18,172	$17,100,920,036	$171,009,200	$855,046,002	$1,710,092,004
Sea Isle City	6,712	$7,663,928,227	$76,639,282	$383,196,411	$766,392,823
Stone Harbor Borough	3,836	$3,291,756,871	$32,917,569	$164,587,844	$329,175,687
Upper Township	9,627	$6,506,171,365	$65,061,714	$325,308,568	$650,617,137
West Cape May Borough	1,623	$1,178,516,373	$11,785,164	$58,925,819	$117,851,637
West Wildwood Borough	805	$459,103,094	$4,591,031	$22,955,155	$45,910,309
Wildwood City	3,679	$4,379,038,844	$43,790,388	$218,951,942	$437,903,884
Wildwood Crest Borough	5,410	$4,552,156,876	$45,521,569	$227,607,844	$455,215,688
Woodbine Borough	1,416	$1,335,589,432	$13,355,894	$66,779,472	$133,558,943
Cape May County (Total)	**111,990**	**$90,260,739,877**	**$902,607,399**	**$4,513,036,994**	**$9,026,073,988**

Source: Cape May County GIS 2020; RS Mean 2019

A specific area that is vulnerable to the severe winter weather hazard is the floodplain. Severe winter storms can cause flooding through blockage of streams or through snow melt. At-risk residential infrastructures are presented in the flood hazard profile (Section 5.4.5). Generally, losses resulting from flooding associated with severe winter storms should be less than that associated with a 100-year flood. Please refer to the Hurricanes and Tropical Storms (Section 5.4.6) profile and Nor'Easter (Section 5.4.7) profile for losses resulting from high winds which may also accompany severe winter weather.

Impact on Critical Facilities

Full functionality of critical facilities such as police, fire and medical facilities is essential for response during and after a severe winter weather event. These critical facility structures are largely constructed of concrete and masonry; therefore, they should only suffer minimal structural damage from severe winter weather events. Because power interruption can occur, backup power is recommended. Infrastructure at risk for this hazard includes roadways that could be damaged due to the application of salt and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires the clearing roadways and alerting citizens to dangerous conditions; following the winter season, resources for road maintenance and repair are required (NSSL 2020).

> Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL 2020).

Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. Another impact on the economy includes impacts on commuting into, or out of, the area for work or school. The loss of power and closure of roads prevents the commuter population traveling to work within and outside of the County.

Impact on the Environment

Severe winter weather can have a major impact on the environment. Not only does winter weather create changes in natural processes, the residual impacts of a community's methods to maintain its infrastructure through winter weather maintenance may also have an impact on the environment. For example, an excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources (USGS 2020). Rain-on-snow events can also exacerbate runoff rates with warming winter weather. Consequentially, these flow rates and excess volumes of water can erode banks, tear apart habitat along the banks and coastline, and disrupt terrestrial plants and animals. Road-salt runoff can cause groundwater salinization, modify the soil structure, and result in loss or reduction in lake turnover. Additionally, road salt can cause changes in the composition of aquatic invertebrate assemblages and pose threats to birds, roadside vegetation, and mammals (Tiwari and Rachlin).

> Chemically based winter maintenance practices have its own effect on the natural environment. Melting snow and ice that carry de-icing chemicals onto vegetation and into soils can contaminate the local waterways. Elevated salt levels may hinder vegetation from absorbing nutrients, slowing plant growth.

Cascading Impacts on Other Hazards

Severe winter weather events may exacerbate flooding. As discussed, the freezing and thawing of snow and ice associated with winter weather events can create major flooding issues in the County. Maintaining winter weather hazards through snow and ice removal could minimize the potential risk of flooding during a warming period. Refer to 5.4.5 (Flood) for more information about the flood hazard of concern.

Future Changes That May Impact Vulnerability

Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. 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.

Project Development

As discussed in Sections 4 and 9, areas targeted for future growth and development have been identified across Cape May County. Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire planning area is exposed and vulnerable. Please refer to the specific areas of development indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Projected Changes in Population

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. It is expected that in the next 20 years, population growth will be relatively stagnant (U.S. Census Bureau 2020, SJTPO). Overall, aging infrastructure may result in increased stress on existing infrastructure and related services. Although overall County growth is not expected, individual municipalities that experience increases in population may require utility system upgrades to keep up with utility demands (e.g., water, electric) during winter weather events to prevent increased stresses on these systems. Refer to Section 4 (County Profile) for a detailed discussion on population change in Cape May County.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such winter storms. While predicting changes of winter storm 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 (U.S. Environmental Protection Agency [EPA] 2016).

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

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

Change of Vulnerability Since 2016 HMP

The entire County continues to be vulnerable to the severe winter weather hazard. The 2010 HMP used default general building stock data from HAZUS-MH MR4. The 2016 HMP update provided damage estimates using an updated custom building stock based on 2015 MODIV tax assessment data. The 2021 updated vulnerability assessment provides a more current and accurate assessment for the County.

5.4.10 Tsunami

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 tsunami hazard in Cape May County.

2021 Plan Update Changes

- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2016 and 2020.

5.4.10.1 Profile

Hazard Description

Tsunamis are a series of enormous waves created by an underwater disturbance (for example, earthquake, landslide, volcanic eruptions, or meteorite). They can move hundreds of miles per hour in the open ocean and crash into land with waves as high as 100 feet or more. From the area where the tsunami originates, waves travel outward in all directions (International Tsunami Information Center 2020).

A tsunami consists of a series of high-energy waves that travel outward, like pond ripples, from the area in which the tsunami originated. The sequence of tsunami waves arrives at the shoreline over an extended period of time and builds height as it get closer (FEMA 2007). A tsunami approaching the shoreline may take three forms:

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

There are three types of tsunamis: local, regional, and distant. A locally generated tsunami is a tsunami where its destructive effects are experienced on coasts within 100 km from the source of the tsunami. In such cases, the travel time for the tsunami is generally less than one (1) hour. A local tsunami is usually generated by an earthquake, but can also be caused by a landslide or a pyroclastic flow from a volcanic eruption. Locally generated tsunamis are especially dangerous. This type of tsunami may reach a nearby shore in less than ten minutes. In such cases, there is not sufficient time for a Tsunami Warning Center or for local authorities to issue an official tsunami warning. Coastal residents and users should therefore take life-saving action as indicated on the sign based on the shaking of the ground, which is a warning that a tsunami may be imminent (CDEMA 2010).

A regional tsunami is a tsunami capable of destruction in a particular area which lies between 100 km - 1,000 km form the source of the tsunami. Regional tsunamis can take between 1-3 hours to reach the affected shoreline. The most destructive tsunamis can be classified as local or regional (CDEMA 2010).

Also referred to as a tele-tsunami or ocean-wide tsunami, distant tsunamis originate from a faraway source (more than 1000 km away) and generally take more than 3 hours to arrive at affected coasts. When a tsunami is formed, the waves generally radiate and move in opposite directions. In this case, a local tsunami can impact on coastlines which are close to the tsunami source. The waves which are moving in other directions away from the source of the tsunami, can continue to travel across entire ocean basins as distant tsunamis with sufficient energy to cause additional casualties and destruction on far away shores (CDEMA 2010).

The first indication of a tsunami may be a rise in water level. An advancing tsunami may initially resemble a strong surge increasing the sea level, similar to a rising tide, but a tsunami surge rises faster and does not stop at the shoreline. Even if the wave height appears to be small, for example three to six feet, the strength of the accompanying surge can be deadly. Waist-high surges can cause strong currents that float cars, small structures, and other debris (Humboldt County Hazard Mitigation Plan 2008).

All tsunamis are potentially dangerous, even though they may not damage every coastline they strike. A tsunami can strike anywhere along most of the United States coastline. The most destructive tsunamis have occurred along the coasts of California, Oregon, Washington, Alaska, and Hawaii (International Tsunami Information Center 2020).

Since the beginning of the 20th century, tsunami events have caused more than 700 deaths and over $200 million in damages to the U.S. coastal states and territories. More than 50-percent of the U.S. population lives in coastal communities and may be at risk for tsunami impacts (Dunbar and Weaver 2008).

While traditional tsunamis are caused by geological triggers, a more common tsunami on the east coast of the United States is the meteotsunami, a tsunami triggered by atmospheric forcing. Meteotsunamis are still being studied to better understand their causes and potential impacts. Meteotsunamis are typically caused by moving atmospheric disturbances such as sharp pressure gradients and/or changes in wind speed associated with a range of underlying atmospheric conditions, such as frontal passages, convective systems, squall lines, tropical cyclones, or nor'easters. The initial ocean wave caused by the atmospheric disturbance is typically quite small on the order of centimeters. However, through resonance achieved within the basin it moves through, the wave can reach a larger open sea height on the order of tens of centimeters prior to reaching the coast. Further amplification of the wave can occur due to harbor resonance, in which the shape of the harbor or estuary is such that oscillations reach an even greater and potentially destructive height (Dusek et. al. 2019). While meteotsunamis may be more common, they are much smaller and less likely to cause damage than geologically triggered tsunamis. The largest east coast meteotsunami found by a 2019 study of the past 22 years of events was 1.19 meters. Globally, however, meteotsunamis have been recorded up to 6 meters. Additional research is necessary to determine the true risks associated with meteotsunamis in Cape May County.

Location

Tsunamis impact areas along the coastline; therefore, all coastal areas of Cape May County are exposed to the threat of a tsunami. However, the tsunami threat level for the east and Gulf coasts of the United States, which includes Cape May County, has a relatively low threat to tsunamis (NOAA National Tsunami Warning Center 2016).

Extent

NOAA issues tsunami warnings in the United States and has two Tsunami Warning Centers: the West Coast and Alaska Tsunami Warning Center (WC/ATWC) located in Palmer, Alaska and the Pacific Tsunami Warning Center (PTWC) located in Ewa Beach, Hawaii. WC/ATWC issues information to all states except Hawaii, U.S. territories in the Caribbean, and Canada. PTWC is responsible for Hawaii, U.S. territories in the Pacific, and international recipients in the Pacific and Indian Oceans, and the Caribbean Sea.

The Warning Centers monitor a worldwide network of seismic and sea level stations, providing a basis for which tsunami warnings, advisories, providing the basis for which tsunami warnings, advisories, watches, and information statements are issued. There are four types of tsunami messages issued by the Warning Centers and are as follows:

- Warnings are initially based solely on seismic data and are issued as quickly as possible indicating that a significant inundation may occur. They can be cancelled or downgraded to an advisory.
- Advisories indicate potential beach and harbor danger due to strong currents; however, significant widespread inundation is not expected.
- Watches indicate that a potentially dangerous distant event has occurred and the area needs to be alert for more information (NOAA 2016).

Previous Occurrences and Losses

Due to the fact there are no major subduction zones in the Atlantic Ocean, with the exception of where it borders the Caribbean Sea, there has been a relatively low frequency of tsunamis along the East Coast, including Cape May County. The tsunamis that have been recorded along the East Coast have been associated with earthquakes in the Caribbean and Puerto Rico.

According to NOAA and USGS, the State of New Jersey has had eight tsunami events with run-up (a measurement of the height of the water onshore observed above a reference sea level). Three of these tsunami events had undetermined run-up heights; three events had run-ups of between 0.03 and 1.6 feet; and two events had a run-up of between 1.67 and 3.2 feet (NOAA 2020).

One of the six tsunamis in New Jersey was caused by an earthquake-triggered landslide; three of the six tsunamis were caused by a Caribbean earthquake; one of the six tsunamis was caused by a non-Atlantic earthquake; one of the six tsunamis was caused by an underwater landslide, and one event was caused by meteorological conditions and was classified as a meteotsunami (Dunbar and Weaver 2008, NOAA 2020).

FEMA Disaster Declarations

Between 1954 and 2020, New Jersey and Cape May County were not included in any Federal Emergency Management Agency (FEMA) declared tsunami specific disasters (DR) or emergency declarations (EM).

U.S. Department of Agriculture Disaster Declarations

Between 2016 and 2020, the period for which data was available, Cape May County was not included in any tsunami-related USDA declarations.

Tsunami Events

For this 2021 Plan update, tsunami events were summarized from 2016 to 2020. According to record keeping by NOAA, no tsunami events have impacted Cape May County between 2016 and 2020. However, one event was recorded that impacted the northeast on July 15, 2018. Classified as a meteotsunami, a 0.15 meter wave runup was recorded at the Atlantic City tide gauge. The event was not recorded at the Cape May gauge but it is possible that the event did impact Cape May County as other locations throughout the mid-Atlantic and northeast recorded the event and meteotsunamis are known to be very location dependent (NOAA 2020, Dusek et al. 2019). For information regarding tsunami events prior to 2016, refer to Appendix E.

Probability of Future Events

The probability of tsunamis is related to the probability of the events that cause them, so it is similar to that of seismic activities or landslides. Using the NOAA National Geophysical Data Center / World Data Service (NGDC/WDS) tsunami database, it was found that there have been tsunami-related events (waves, runups, etc.) that have occurred along the coastline of New Jersey. Based on this data and assuming that a tsunami impacting New Jersey would also impact Cape May, Cape May County has a 4.96% chance of a tsunami or tsunami-related event impacting the county. The table below shows these statistics, as well as the annual average number of events and the estimated percent chance of the event occurring in a given year (NOAA 2020).

A total of 548 meteotsunami events were detected on the U.S. East Coast from 1996 to 2017, for an average of about 25 events per year (Dusek et. al. 2019). Additional research of these events is necessary to determine the frequency of meteotsunami events in Cape May County.

Using the history of tsunami events recorded in Cape May County, Table 5.4.10-1 provides the probability of tsunamis occurring each year in Cape May County. Based on the information researched, the County has a 4.96 percent chance of a tsunami, of any magnitude, occurring each year.

Table 5.4.10-1. Probability of Future Occurrences of Tsunamis

Event Type	Number of Incidents (1900 to 2020)	% Chance of Occurrence in Any Given Year
Tsunami	6	4.96

Source: NOAA National Centers for Environmental Information (NCEI) 2020, NOAA 2020

Earlier in this HMP, 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 ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for tsunami events in Cape May County is considered 'rare' (between 1 and 10% annual chance of occurring).

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).

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). Stronger and more frequent storms could result in an increase in the frequency of meteotsunamis.

As stated earlier in this profile, tsunamis can be caused by: the down drop or upthrust of the earth's crust which results in an earthquake; an undersea landslide; a submarine volcanic eruption; or a large meteor impact at sea.

Therefore, climate change impacts on these natural hazards should be referenced to determine how climate change may impact tsunami.

The potential impacts of global climate change on earthquake probability are unknown. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the Earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. National Aeronautics and Space Administration (NASA) and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes (New Jersey State HMP 2019).

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). Higher sea levels could increase the severity of tsunami events.

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

5.4.10.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable to the identified hazard. For the tsunami hazard, all of Cape May County has been identified as the hazard area. Therefore, all assets in the County (population, structures, critical facilities and lifelines), as described in the County Profile (Section 4), are exposed and potentially vulnerable to a tsunami.

Impact on Life, Health and Safety

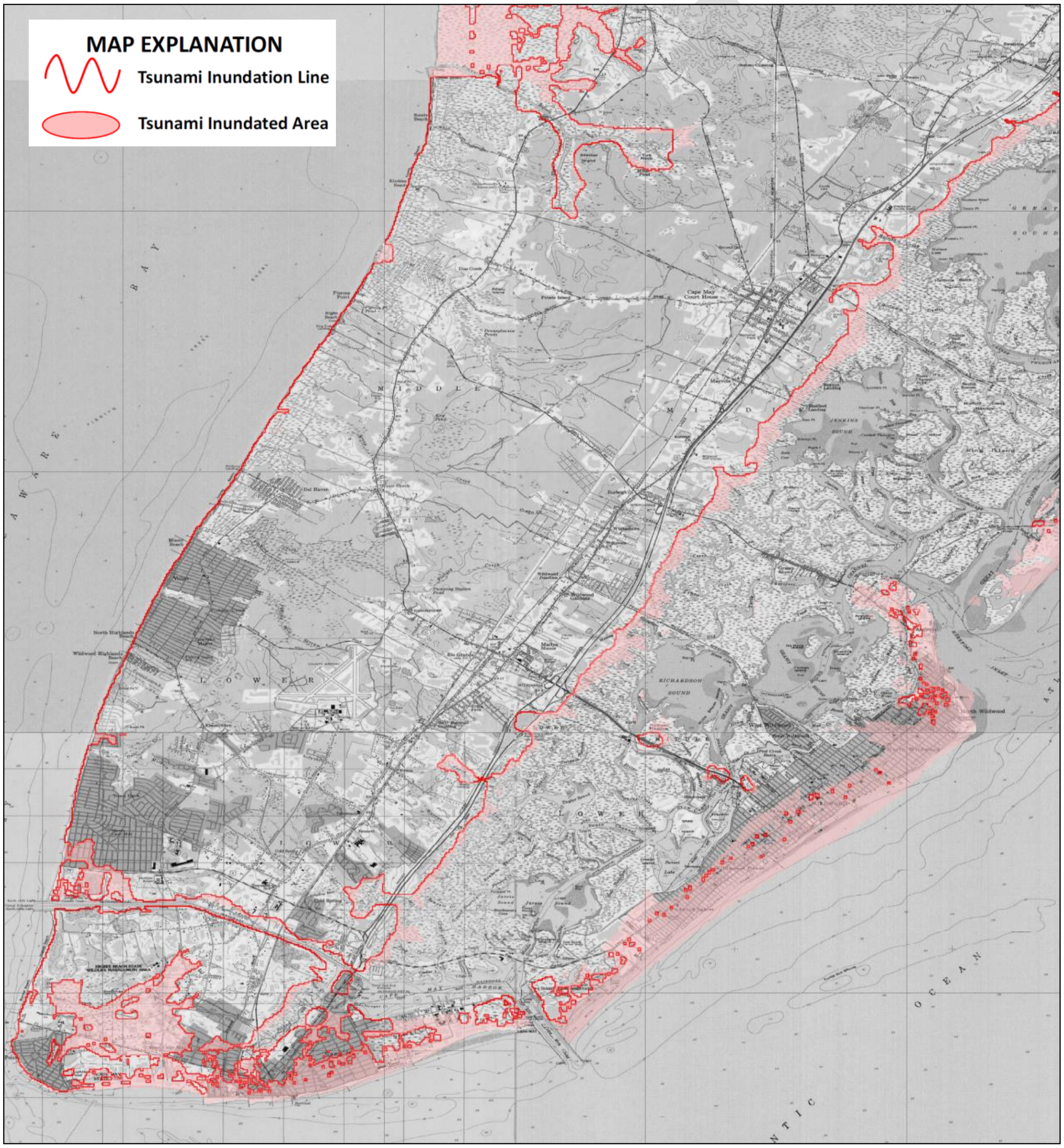
The impact of a tsunami on life, health and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. The populations in Cape May County that would be most exposed to this type of hazard are those along beaches and low lying coastal areas. In the event of a local tsunami in or near the planning area, there would be little warning time.

Currently, the Center for Applied Coastal Research, University of Delaware, and the Department of Ocean Engineering, University of Rhode Island are collaborating on a project to create flood inundation maps appropriate for both the public and emergency management personnel, pertaining to modeled runs of tsunami waves off the mid-Atlantic coast. Detailed inundation studies are being conducted for highest-risk East Coast communities, and results of these studies will be used to construct a first-generation of tsunami inundation maps for the chosen communities. The tsunami inundation maps are being prepared to help coastal communities identify their tsunami hazard. The maps were created using the best available data and portray the worst case scenario. Funding for this project is from the NOAA National Tsunami Hazard Mitigation Program (NTHMP).

In Cape May County, tsunami inundation maps have been created for portions of the County including the Borough of Avalon and Ocean City. These figures show inundation lines which represent the maximum tsunami runup extent and the tsunami inundation areas which show the areas in which be impacted if a tsunami were to occur. The figures indicate that the coastal areas of these communities have the potential to inundate if a tsunami were to occur. For details of these figures, refer to: http://www.udel.edu/kirby/nthmp/maps/

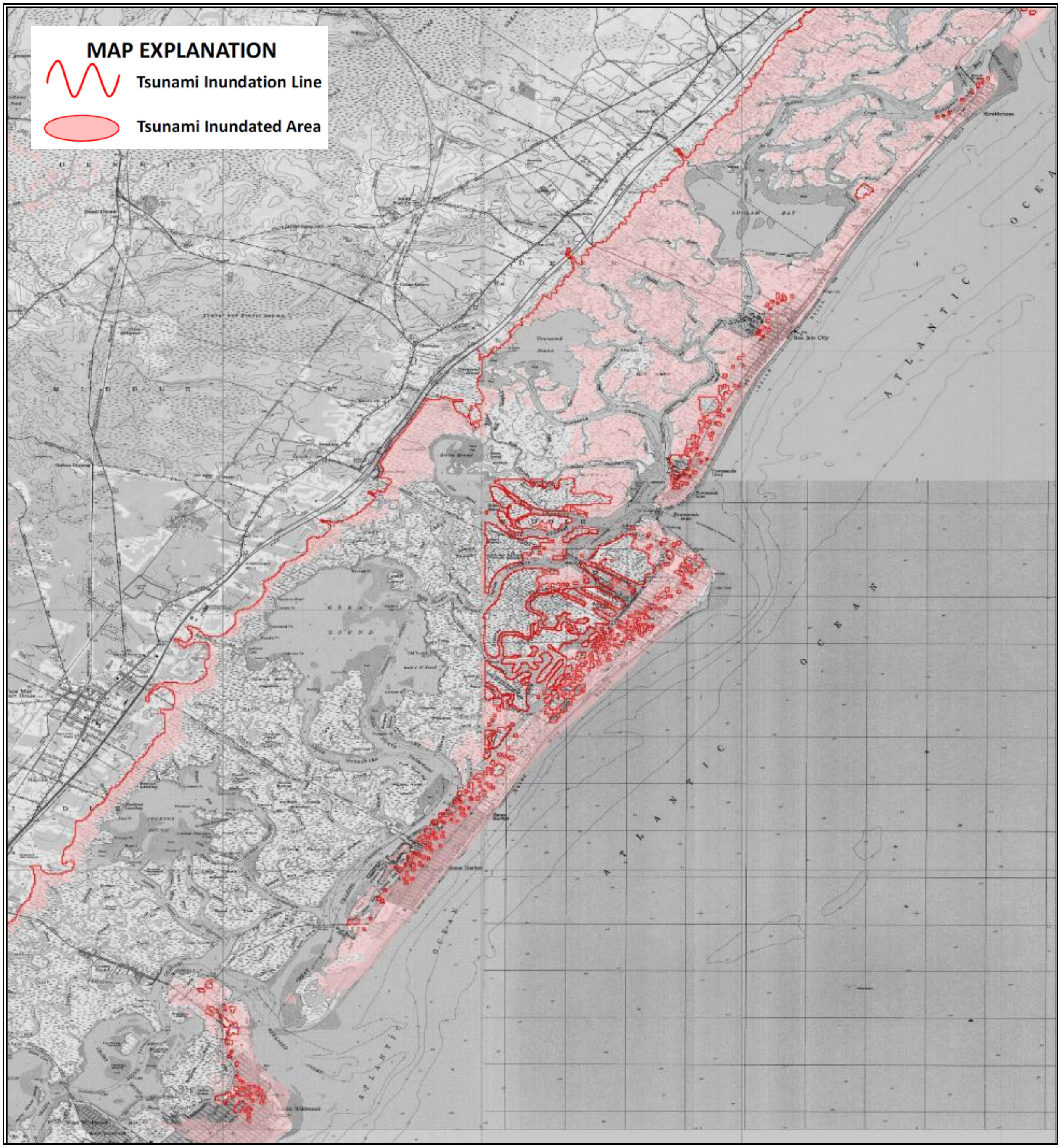
Based on the research conducted for this planning process, there are tsunami inundation areas developed for portions of Cape May County. For the areas that have been mapped, the mapping portrays the maximum tsunami runup extent utilizing a number of extreme, but scientifically realistic tsunami sources. For the purposes of this plan, as a conservative approach, it is assumed that the entire County population (permanent and seasonal) is exposed to the tsunami hazard. The greatest vulnerability would exist along the eastern shores of the County, due to greater exposure to tsunami events. Development of tsunami inundation or hazard areas can be used to conduct a spatial analysis to identify the most vulnerable residents living in the tsunami hazard zone and can be used to focus public education and outreach efforts on these communities.

Figure 5.4.10-1. Tsunami Inundation Map for Cape May



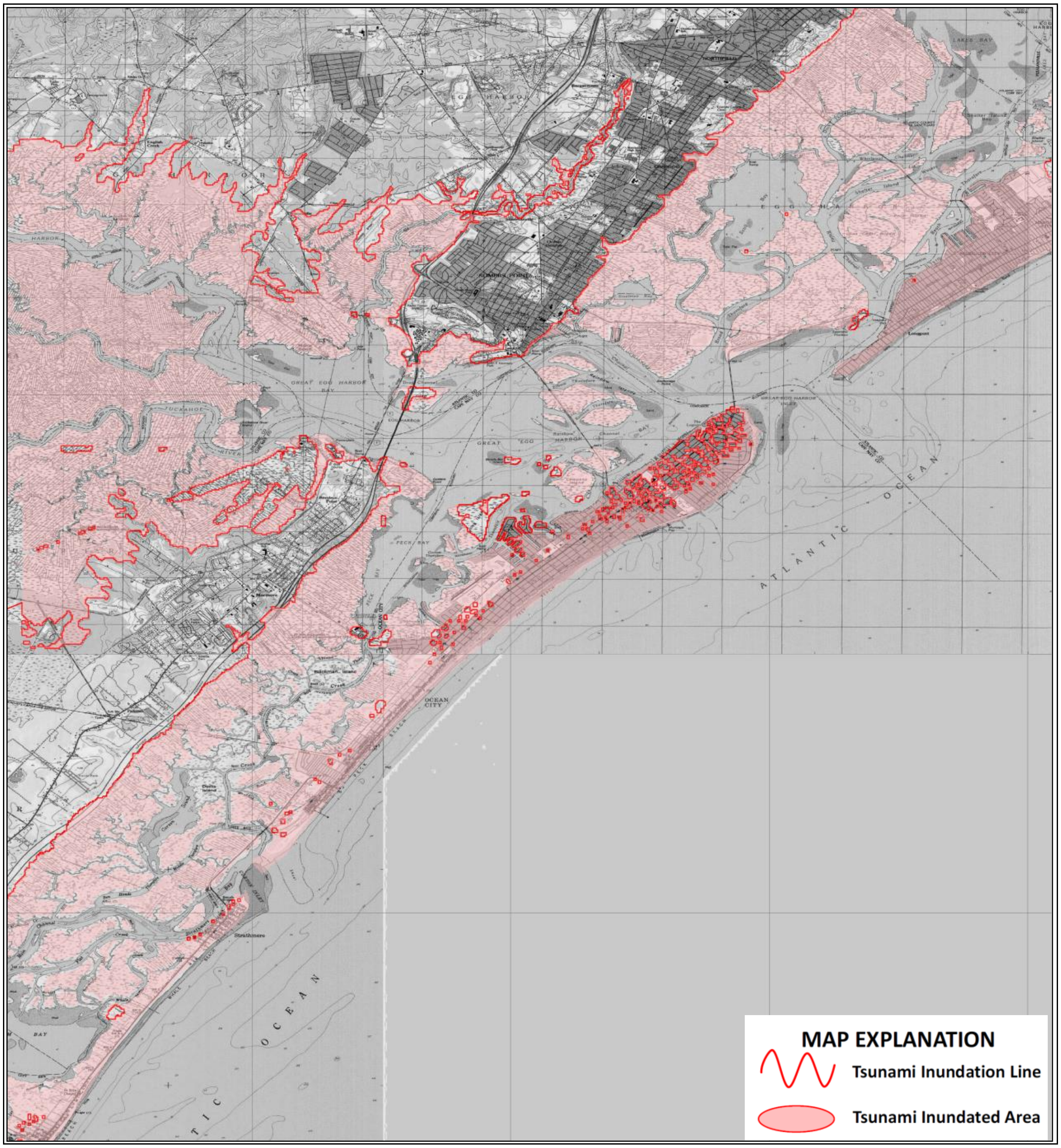
Source: University of Delaware 2015

Figure 5.4.10-2. Tsunami Inundation Map for Avalon Borough



Source: University of Delaware 2015

Figure 5.4.10-3. Tsunami Inundation Map for Ocean City



Source: University of Delaware 2015

Impact on General Building Stock, Critical Facilities, and the Economy

Similar to the population exposed, for the purposes of this planning effort, all general building stock, critical facilities and infrastructure are considered vulnerable to the tsunami hazard. However, the areas with the highest vulnerability are those areas that are low-lying along the coastline located on the eastern shores of Cape May County. The impact of the waves and the scouring associated with debris that may be carried in the water could be very damaging to structures located in the tsunami's path. Structures that would be most vulnerable are those located in the front line of tsunami impact and those that are structurally unsound (Humboldt County Hazard Mitigation Plan 2008).

Roads are the primary resource for evacuation to higher ground before and during the course of a tsunami event. Flooding caused by a tsunami will greatly impact this important component in the management of tsunami related emergencies. Bridges exposed to tsunami events can be extremely vulnerable due to the forces transmitted by the wave run up and by the impact of debris carried by the wave action. The forces of tsunami waves can also impact above ground utilities by knocking down power lines and radio/cellular communication towers. Power generation facilities can be severely impacted by both the velocity impact of the wave action and the inundation of floodwaters (Humboldt County Hazard Mitigation Plan 2008).

Tsunamis may induce secondary hazards such as water quality and supply concerns, and public health concerns. Impacts on the economy are difficult to quantify. As discussed above, losses include but are not limited to general building stock damages, business interruption/closure, impacts to tourism and tax base to Cape May County.

Future Changes that May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. Cape May 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 (County Profile), areas targeted for future growth and development have been identified across Cape May County. Any areas of growth along the coastline of Cape May County could be potentially impacted by a tsunami because the entire coastline is exposed and vulnerable. Specific areas of recent and new development are indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 (Jurisdictional Annexes) of this plan.

Project Changes in Population

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. It is expected that in the next 20 years, population growth will be relatively stagnant (U.S. Census Bureau 2020 SJTPO). Any population growth in the coastal communities of Cape May County could be impacted by a tsunami in the future. Refer to Section 4 (County Profile) for a detailed discussion on population change in Cape May County.

Climate Change

As discussed earlier, studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. As stated earlier in this profile, tsunamis can be caused by: the down drop or upthrust of the earth's crust which results in an earthquake; an undersea landslide; a submarine volcanic eruption; or a large meteor impact at sea. None of these events are likely to be influenced by climate change. However, as noted previously, meteotsunami events are influenced by severe weather events and climate change could increase the frequency and severity of weather events that spawn meteotsunamis.

Change of Vulnerability Since the 2016 HMP

Overall, the County's vulnerability has not changed; the entire County continues to be exposed and vulnerable to tsunami.

5.4.11 Wildfire

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 wildfire hazard in Cape May County.

2021 HMP Update Changes

- New and updated figures from federal, state, and county agencies are incorporated. New Jersey Forest Fire Service (NJFFS) Wildfire Fuel Hazard data was used to identify wildfire events.
- Previous occurrences were updated with events that occurred between 2010 and 2020.

5.4.11.1 Profile

Hazard Description

Wildfires are any non-structural fire that occurs in the wildland. Three distinct types of wildfires have been defined and include: naturally occurring wildfire, human-caused wildfire, and prescribed fire. Many of these are highly destructive and can be difficult to control. They occur in forested, semi-forested, or less developed areas. Wildland fires can be caused by lightning, human carelessness, and arson. Most frequently, wildland fires in the State of New Jersey are caused by humans. Wildfires result in the uncontrolled destruction of forests, brush, field crops, grasslands, real estate, and personal property, and have secondary impacts on other hazards such as flooding, by removing vegetation and destroying watersheds.

Wildfires can increase the probability of other natural disasters, specifically floods and mudflows. Wildfires, particular large-scale fires, can dramatically alter the terrain and ground conditions, making land already devastated by fire susceptible to floods. Lands impacted by wildfire increase the risk of flooding and mudflow in those areas impacted by wildfire. Normally, vegetation absorbs rainfall, reducing runoff. However, wildfires leave the ground charred, barren, and unable to absorb water; thus, creating conditions perfect for flash flooding and mudflows. Flood risk in these impacted areas remain significantly higher until vegetation is restored, which can take up to five years after a wildfire (FEMA 2012).

Flooding after a wildfire is often more severe, as debris and ash left from the fire can form mudflows. During and after a rain event, as water moves across charred and denuded ground, it can also pick up soil and sediment and carry it in a stream of floodwaters. These mudflows have the potential to cause significant damage to impacted areas. Areas directly affected by fires and those located below or downstream of burn areas are most at risk for flooding (FEMA 2013). For detailed information regarding flooding, see Section 5.4.5 (Flood).

The height of wildland fire season in New Jersey is typically in spring (March through May) and culminates in early May, corresponding with the driest live fuel moisture periods of the year. Although the spring months are the most severe, the summer and fall months may also experience extensive fires in the state. While the spring season is historically the period in which wildfire danger is the highest, wildland fires can occur every month of the year. Drought, snow pack, and local weather conditions can expand the length of the fire season. The early and late shoulders of the fire season usually are associated with human-caused fires. Lightning generally is the cause of most fires in the peak season.

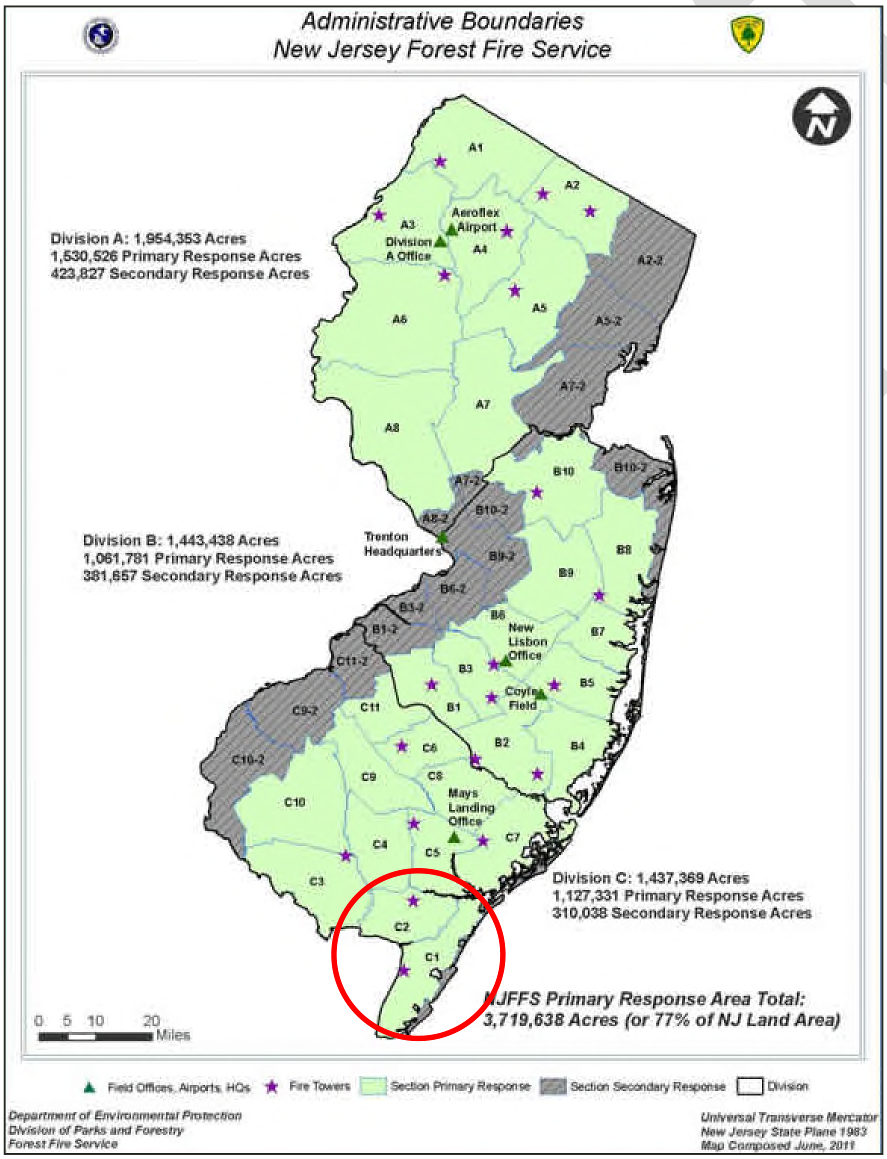
In the State of New Jersey, each year, an average of 1,500 wildfires damage or destroy 7,000 acres of the state's forests. Wildfires not only damage woodlands, but threaten homeowners who live within or adjacent to forest environments. From January 1, 2020, to August 13, 2020, there were 853 wildfires in New Jersey that burned 4,695 acres (New Jersey Forest Fire Service [NJFFS] 2020).

Location

NJFFS, a division of NJDEP, is responsible for protecting the 3.15 million acres of public and private wildland in the state. NJFFS is under the direction of the state fire warden and is headquartered in Trenton. NJFFS has 85 full-time employees that provide an array of services including staffing the state's 21 fire towers, which are operational during the months of March, April, May, October, and November.

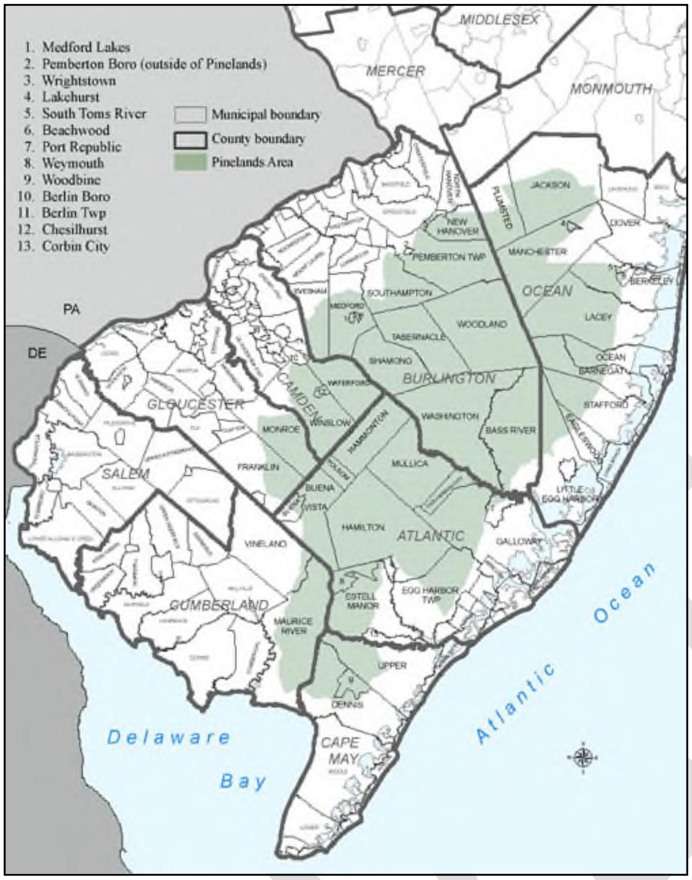
The NJFFS is broken up into three divisions (A, B, C). Each division is responsible for responding to wildfire events within their boundaries. Cape May County is located in Division C. All of Cape May County is susceptible to wildfires and they can occur anywhere and at any time. Additionally, a portion of Cape May County is located within the New Jersey Pine Barrens. The Townships of Upper and Dennis and the Borough of Woodbine are all located in the Pine Barrens (Figure 5.4.11-2).

Figure 5.4.11-1. Fire Divisions of New Jersey



Source: NJDEP 2013
Note: The red circle indicates the location of Cape May County. The County is located in Fire Division C.

Figure 5.4.11-2. Municipalities of the New Jersey Pine Barrens



Source: Piney Power 2013

The Pine Barrens is one of the most fire-prone areas in the United States due to the type of vegetation found there. Each year, wildfires burn portions of the Pine Barrens. These fires are important for the land's ecology; however, it also poses a threat to life and property to those in and around the Pine Barrens. With the northwest portion of Cape May County located within the Pine Barrens, wildfire risk for that area may be increased.

NJFFS has developed Wildfire Fuel Hazard data for the state based upon NJDEP's 2002 Land Use/Land Cover (LU/LC) datasets and NJDEP's 2002 10-meter Digital Elevation Grid datasets. For details of these figures, please refer to: http://www.state.nj.us/dep/parksandforests/fire/wildfire_hazard_mitigation.htm. Wildfire fuel hazard for Cape May County ranges from low to extreme and are spread evenly throughout the County. There are more concentrated areas of extreme fuel hazard areas in the northern section of the County. As for wildfire risk, the portion of the County that is located in the Pine Barrens has the highest risk and the central and southern portions of Cape May County have low to moderate fire risk. Table 5.4.11-1 indicates the amount of land in each of the wildfire fuel hazard ranking zones for Cape May County. Table 5.4.11-2 explains the approximate area in the NJFFS risk areas in the County. According to these tables, the Townships of Dennis, Lower, Middle, and Upper and the Borough of Woodbine have the highest percentage of land in the high to extreme fuel hazard areas.

Table 5.4.11-1. Approximate Area in the Wildfire Fuel Hazard Areas in Cape May County

Hazard Area	Area (Square Miles)
Extreme	18.7

Table 5.4.11-1. Approximate Area in the Wildfire Fuel Hazard Areas in Cape May County

Hazard Area	Area (Square Miles)
Very High	7.5
High	35.5
Moderate	90.1
Low	47.7

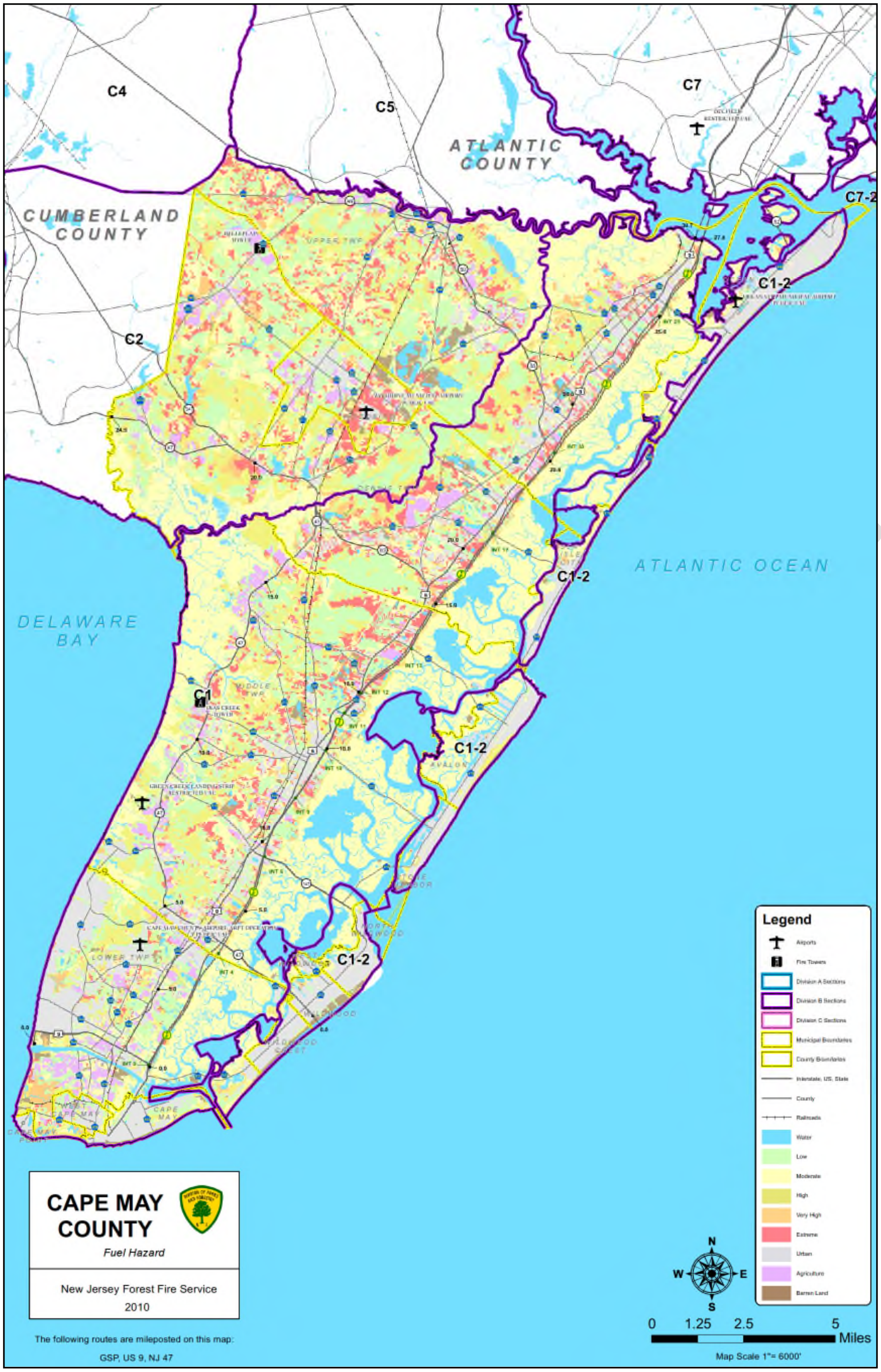
Source: NJFFS 2010

Table 5.4.11-2. Approximate Area in Wildfire Fuel Hazard Areas in Cape May County

Municipality	Total Area (Square Miles)	New Jersey Forest Fire Service Fuel Hazard Areas			
		Low to Moderate	% in Hazard Area	High to Extreme	% in Hazard Area
Avalon Borough	4.9	2.1	42.9%	0.3	6.1%
Cape May City	2.7	0.6	22.2%	0.2	7.4%
Cape May Point Borough	0.3	0	0.0%	0	0.0%
Dennis Township	63.8	34.8	54.5%	19.3	30.3%
Lower Township	30.9	12.5	40.5%	4.9	15.9%
Middle Township	82.7	43	52.0%	16	19.3%
North Wildwood City	2.2	0.3	13.6%	0.1	4.5%
Ocean City	11.8	2.9	24.6%	0.4	3.4%
Sea Isle City	2.7	0.8	29.6%	0.2	7.4%
Stone Harbor Borough	2.2	0.2	9.1%	0.1	4.5%
Upper Township	68.4	36.5	53.4%	17.2	25.1%
West Cape May Borough	1.2	0.4	33.3%	0.1	8.3%
West Wildwood Borough	0.4	0.1	25.0%	0	0.0%
Wildwood City	1.6	0.1	6.3%	0	0.0%
Wildwood Crest Borough	1.5	0.1	6.7%	0	0.0%
Woodbine Borough	8.0	3.4	42.5%	2.7	33.8%
Cape May County (Total)	**285.2**	**137.8**	**48.3%**	**61.8**	**21.7%**

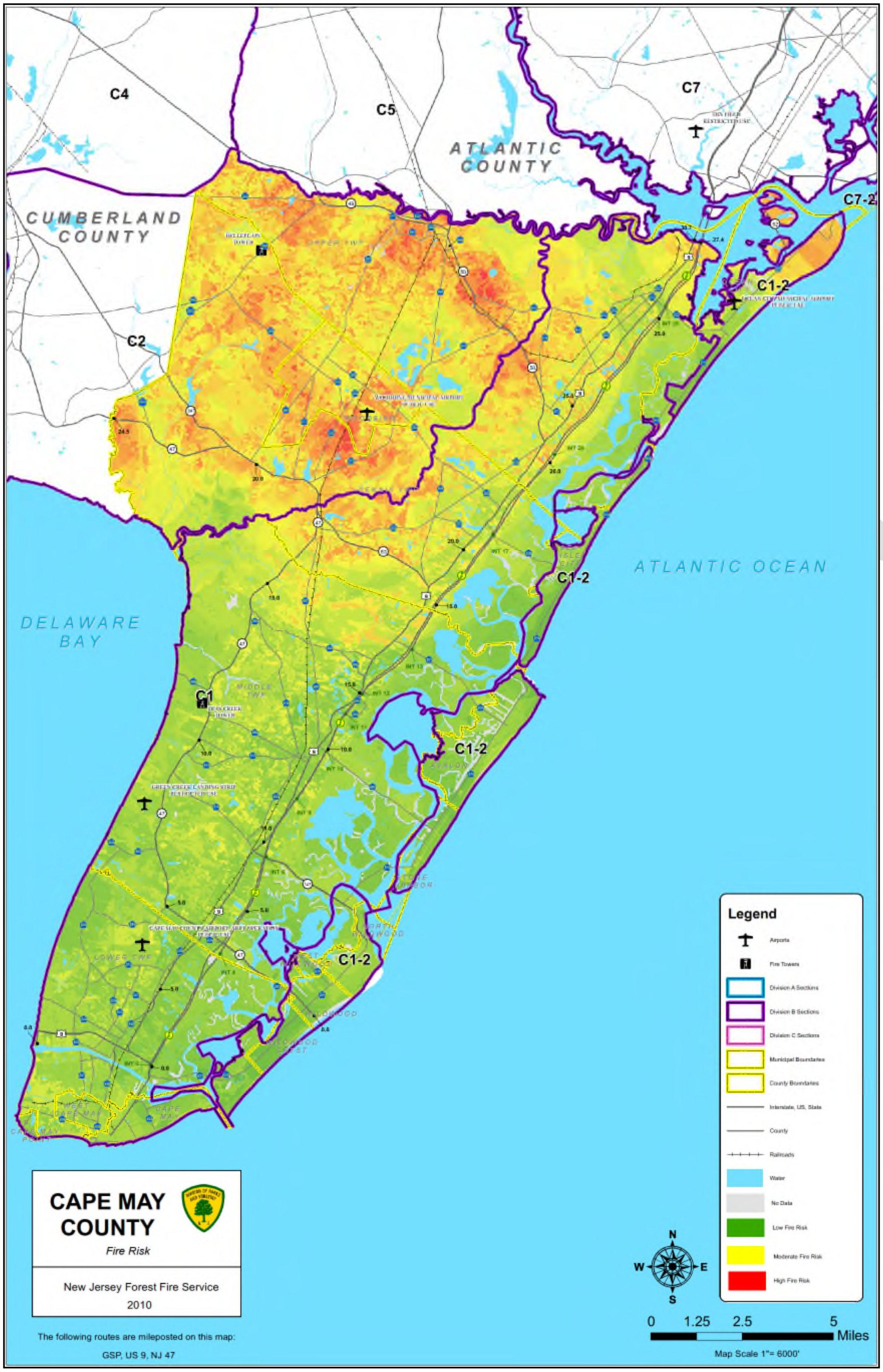
Source: NJFFS 2010

Figure 5.4.11-3. Wildfire Fuel Hazard for Cape May County



Source: New Jersey Forest Fire Service 2010

Figure 5.4.11-4. Wildfire Risk for Cape May County



Source: *New Jersey Forest Fire Service 2010*

Extent

The extent (that is, magnitude or severity) of wildfires depends on weather and human activity. NJFFS uses two indices to measure and monitor dryness of forest fuels and the possibility of fire ignitions becoming wildfires. These indices include the National Fire Danger Rating System's (NFDRS) Buildup Index (BUI), and the Keetch-Byram Drought Index (KBDI). Both are used for fire preparedness planning, which includes the following: campfire and burning restrictions, fire patrol assignments, fire lookout tower staffing, and readiness status for both observation and firefighting aircraft (NJFFS 2015).

The **Buildup Index (BUI)** is a number that reflects the combined cumulative effects of daily drying and precipitation in fuels with a 10-day time lag constant. The BUI can represent three to four inches of compacted litter or can represent up to six inches or more of loose litter (North Carolina Forest Service 2009).

The **Keetch-Byram Drought Index (KBDI)** is a drought index designed for fire potential assessment as defined by the U.S. Forest Service (USFS). It is a number representing the net effect of evapotranspiration and precipitation in producing cumulative moisture deficiency in deep duff and upper soil layers. It is a continuous index, relating to the flammability of organic material in the ground. The KBDI attempts to measure the amount of precipitation necessary to return the soil to full field capacity. It is a closed system ranging from 0 to 800 units and represents a moisture regime from 0 to 8 inches of water through the soil layer. Zero is the point of no moisture deficiency and 800 is the maximum drought that is possible. At any point along the scale, the index number indicates the amount of net rainfall that is required to reduce the index to 0, or saturation (USFS-Wildland Fire Assessment System [WFAS] 2015; Florida Forest Service N.D.).

Additionally, the NFDRS is used to provide a measure of the relative seriousness of burning conditions and threat of fire throughout the United States. It allows fire managers to estimate the day's fire danger for a given area. The NFDRS uses a five color-coded system to help the public understand fire potential; this color scale has been adapted slightly for NJFFS purposes. The NFDRS (with the NJFFS color scheme) is as follows:

Table 5.4.11-3. Fire Danger Rating and Color Code

Fire Danger Rating and Color Code	Description
Low (L) (Green)	Fuels do not ignite readily from small firebrands although a more intense heat source, such as lightning, may start fires in duff or punky wood. Fires in open cured grasslands may burn freely a few hours after rain, but woods fires spread slowly by creeping or smoldering, and burn in irregular fingers. There is little danger of spotting.
Moderate (M) (Blue)	Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low. Fires in open-cured grasslands will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and control is relatively easy.
High (H) (Yellow)	All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High-intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and their control difficult unless they are attacked successfully while small.
Very High (VH) (Orange)	Fires start easily from all causes and, immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high-intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels.
Extreme (E) (Red)	Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high-intensity burning will usually be faster and occur from smaller fires than in the very high fire danger class. Direct attack is rarely possible and may be dangerous except immediately after ignition. Fires that develop headway in heavy slash (trunks, branches, and tree

Table 5.4.11-3. Fire Danger Rating and Color Code

Fire Danger Rating and Color Code	Description
	tops) or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions the only effective and safe control action is on the flanks until the weather changes or the fuel supply lessens.

Source: NJFFS 2015, WFAS 2015

Previous Occurrences and Losses

Many sources provided wildfire information regarding previous occurrences and losses associated with wildfire throughout New Jersey and Cape May County. With many sources reviewed for the purpose of this HMP Update, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP update.

FEMA Major Disasters and Emergency Declarations

Between 1954 and 2020, New Jersey was included in two FEMA fire management assistance (FMA) declarations. Generally, these disasters cover a wide range of the State; therefore, the disaster may have impacted many counties. Cape May County was not included in either declaration.

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 2015 and 2020, Cape May County was included in two USDA disaster declarations (S4071 and S4424), neither of which were due to wildfire conditions.

Wildfire Events

Based on information provided by NJFFS, Cape May County has experienced 381 wildfire incidents between 2010 and 2019, burning 139 acres in total. Over the past ten years, Middle Township has seen the greatest frequency of incidents (143) and acreage burned (43.5), followed by Lower Township, Upper Township, and Dennis Township respectively. Wildfires typically impact mainland communities with significant forest and vegetation cover as opposed to barrier island communities that are significantly more developed. Acreage and incident counts are shown in the following table.

Table 5.4.11-4. Wildfire Incidents in Cape May County by Municipality, 2010-2019

Municipality	Number of Incidents	Acreage Burned
Middle Twp.	143	43.5
Lower Twp.	88	33
Upper Twp.	69	29.75
Dennis Twp.	66	25
Woodbine	12	4.75
Cape May City	1	1.25
West Cape May	1	1
North Wildwood	1	0.75
Total	381	139

Source: NJ Forest Fire Service, 2020

On a Countywide average, approximately 14 acres are burned in wildfires each year since 2010. 2010 saw the highest number of fires (65) and acres burned (23). Since 2015, both the number of fires and acreage burned has fluctuated. In 2018, an increase in brush fires in Upper Township led to an increase in acres burned.

Table 5.4.11-5. Wildfire Events in Cape May County (2015-2019)

	2015		2016		2017		2018		2019	
	Number of Events	Acres Burned	Number of Events	Acres Burned	Number of Events	Acres Burned	Number of Events	Acres Burned	Number of Events	Acres Burned
Cape May City	0	0	1	1.25	0	0	0	0	0	0
Dennis Twp	9	2.25	3	1	6	2.25	4	1	13	3.5
Lower Twp	6	1.5	5	3.5	7	3.25	6	2.75	3	1
Middle Twp	11	3.5	9	3.5	15	3.75	12	3.75	16	4
Upper Twp	5	3	2	1.75	8	3	10	8.25	5	1.75
West Cape May	0	0	0	0	1	1	0	0	0	0
Woodbine	1	0.25	3	2	1	0.25	0	0	0	0
County Totals	**32**	**10.5**	**23**	**13**	**38**	**13.5**	**32**	**15.75**	**37**	**10.25**

Source: NJ Forest Fire Service, 2020

Probability of Future Occurrences

Estimating the approximate number of wildfires to occur in Cape May County is difficult to predict in a probabilistic manner. This is because a number of variable factors impact the potential for a fire to occur and because some conditions (for example, ongoing land use development patterns, location, fuel sources, and construction sites) exert increasing pressure on the wildfire fuel and risk zones. Based on available data, wildfires will continue to present a risk to Cape May County. Given the numerous factors that can impact wildfire potential, the likelihood of a fire event starting and sustaining itself should be gauged by professional fire managers on a daily basis. Although a definite prediction of future wildfire events cannot be noted, an analysis of the frequency of past occurrences can give professionals a rough guide as to how many potential events may occur each year if current trends continue.

In order to determine the probability of wildfire occurrences in Cape May County, the New Jersey Forest Fire Service and online searches were used to identify previous events. Please note that information regarding previous events and losses, wildfire occurrences that were readily available via online research were used and that events prior to 2009 were not examined. Therefore, the probability calculations does not include all wildfire events that occurred in the County. Based on the number of events found, Cape May County has a 100 percent chance of a wildfire occurring in any given year.

Table 5.4.11-6. Probability of Future Occurrence of Wildfire Events

Hazard Type	Number of Occurrences Between 2010 and 2019	% Chance of Occurring in Any Given Year
Wildfire	381	100

Source: New Jersey Forest Fire Service, 2020

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 ranking hazards. Based on historical records and input from the Planning Partnership, the probability of occurrence for wildfire in the County is considered 'occasional' (between 10 and 100% chance of occurring in any given year). Though brush fires occur frequently in certain portions of the County, they are rare events in the County's densest areas.

Climate Change Impacts

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. 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). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70% of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). 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). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011).

A gradual change in temperatures will alter the growing environment of many tree species throughout the United States and New Jersey, reducing the growth of some trees and increasing the growth of others. Tree growth and regeneration may be affected more by extreme weather events and climatic conditions than by gradual changes in temperature or precipitation. While an increase in annual precipitation is expected, warmer temperatures may lead to longer dry seasons and multi-year droughts, creating triggers for wildfires, insects, and invasive species. Increased temperature and change in precipitation will also affect fuel moisture during wildfire season and the length of time during while wildfires can burn during a given year (U.S. Department of Agriculture [USDA] 2012). Climate change may also increase the frequency of lightning strikes. A warmer atmosphere holds more moisture which is one of the key items for triggering a lightning strike. Lightning strikes cause approximately half the wildfires in the United States. If the frequency of lightning strikes increases, the potential for wildfires from these strikes also increases (Lee 2014). Wildfire incidents are predicted to increase throughout the United States due to climate change, causing at least a doubling of areas burned within the next century (USDA 2012).

As stated above, according to the temperature projections Cape May County can expect warmer conditions with drier conditions likely to occur in the summer months which may increase the frequency and intensity of wildfires. Higher temperatures are expected to increase the amount of moisture that evaporates from land and water. These changes have the potential to lead to more frequent and severe droughts, which, in turn, increases the likelihood of wildfires (U.S. EPA 2009).

Sea level rise is expected to accelerate in rate of increase in the future. Rising sea levels will inundate inland areas that are currently dry coastal uplands. Additionally, natural and man-made topographic features prevent flooded upland areas from discharging floodwaters after periods of flooding. This was observed in the wake of Superstorm Sandy, when standing pools of water killed inland trees and vegetation throughout the Jersey Shore. In Dennis Township, historic sea level rise has contributed to the phenomenon of "ghost forests", where stands of dead trees result from saltwater infiltration. An increase in sea level also implies that storm surges will operate from an elevated base, so severe coastal flooding may be more frequent in the future (NJ Climate Adaptation Alliance 2016). Increased sea levels are connected to saltwater intrusion. Continued flooding and infiltration will result in dead vegetation that serves as fuel for wildfire.

5.4.11.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the wildfire hazard, the Wildland-Urban Interface (Interface and Intermix) obtained through the SILVIS Laboratory, Department of Forest Ecology and Management, University of Wisconsin – Madison, was referenced to delineate wildfire hazard areas. The University of Wisconsin – Madison wildland fire hazard areas are based on the 2010 Census and 2006 National Land Cover Dataset and the Protected Areas Database. For this risk assessment, the high-, medium-, and low-density interface areas were combined and used as the "Interface" hazard area, and the high , medium-, and low-density intermix areas were combined and used as the "Intermix" hazard areas.

Impact on Life, Health and Safety

Wildfires have the potential to impact human health and life of residents and responders, structures, infrastructure, and natural resources. The most vulnerable populations include emergency responders and those within a short distance of the interface between the built environment and the wildland environment. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. **Table 5.4.11-7** summarizes the estimated population exposed to the wildfire hazard by municipality.

Based on the analysis, an estimated 1,566 residents, or 1.7-percent of the County's population, are located in the extreme, high, and very high wildfire hazard areas. Overall, the Middle Township has the greatest number of individuals located in the "extreme," "very high," and "high" hazard areas (i.e., 998 persons).

Of the population exposed, the most vulnerable include the economically disadvantaged and the population over age 65. Economically disadvantaged populations are 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 wildfire event, and they may have more difficulty evacuating. In Cape May County, there are 10,140 persons in poverty and 23,572 persons over 65 years old.

Table 5.4.11-7. Estimated Vulnerable Population

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Number of Persons Exposed to Wildland-Urban Interface/Intermix Areas				Estimated Number of Persons Exposed to Wildfire Fuel Hazard Area	
		Number of Persons Exposed to Wildland-Urban Interface Area	Percent of Total	Number of Persons Exposed to Wildland-Urban Intermix Area	Percent of Total	Number of Persons Exposed to Wildfire Fuel Extreme, Very High, and High Hazard Area	Percent of Total
Avalon Borough	1,409	274	19.4%	0	0.0%	0	0.0%
Cape May City	3,491	0	0.0%	68	1.9%	0	0.0%
Cape May Point Borough	188	0	0.0%	0	0.0%	1	0.4%
Dennis Township	6,244	2,164	34.6%	3,566	57.1%	136	2.2%

Table 5.4.11-7. Estimated Vulnerable Population

Jurisdiction	American Community Survey (2014-2018) Population	Estimated Number of Persons Exposed to Wildland-Urban Interface/Intermix Areas				Estimated Number of Persons Exposed to Wildfire Fuel Hazard Area	
		Number of Persons Exposed to Wildland-Urban Interface Area	Percent of Total	Number of Persons Exposed to Wildland-Urban Intermix Area	Percent of Total	Number of Persons Exposed to Wildfire Fuel Extreme, Very High, and High Hazard Area	Percent of Total
Lower Township	21,838	10,728	49.1%	1,623	7.4%	125	0.6%
Middle Township	18,492	8,898	48.1%	9,057	49.0%	998	5.4%
North Wildwood City	3,849	0	0.0%	0	0.0%	0	0.0%
Ocean City	11,202	3,999	35.7%	73	0.7%	6	0.1%
Sea Isle City	1,955	1,858	95.0%	51	2.6%	1	0.0%
Stone Harbor Borough	955	0	0.0%	0	0.0%	0	0.0%
Upper Township	11,909	7,910	66.4%	3,771	31.7%	250	2.1%
West Cape May Borough	1,103	0	0.0%	26	2.3%	4	0.4%
West Wildwood Borough	376	0	0.0%	0	0.0%	0	0.0%
Wildwood City	5,073	0	0.0%	0	0.0%	0	0.0%
Wildwood Crest Borough	3,131	0	0.0%	0	0.0%	0	0.0%
Woodbine Borough	2,490	1,242	49.9%	1,126	45.2%	46	1.9%
Cape May County (Total)	**93,705**	**37,072**	**39.6%**	**19,362**	**20.7%**	**1,566**	**1.7%**

Impact on General Building Stock

Buildings located within the NJFFS identified extreme, very high or high fuel hazard areas are exposed and considered vulnerable to the wildfire hazard. Buildings constructed of wood or vinyl siding are generally more likely to be impacted by the fire hazard than buildings constructed of brick or concrete. Table 5.4.11-8 summarizes the estimated building stock inventory located in the hazard area by municipality. Less than 2% ($1.4 billion) of the County's building replacement cost value is located in the extreme/very high/high hazard area. Middle Township has the greatest number of buildings located in the extreme/very high/high hazard area (850 structures – 4.7% of its total) and has the greatest replacement cost value located in the hazard area ($858 million – 7.4% of its total).

All state and federal park areas in the County are under the control of state and federal agencies. The NJFFS conducts brush maintenance in state parks to reduce the risks which includes prescribed burns, clearing underbrush, etc. At a local level, municipalities supply water and manpower to assist during a brush fire.

Table 5.4.11-8. Building Stock Replacement Cost Value Located in Wildfire Fuel Hazard Ranking Zones

Jurisdiction	Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Exposed to Wildland-Urban Interface/Intermix Areas								Estimated Building Stock Exposed to Wildfire Fuel Hazard Area			
			Number of Buildings Exposed to Wildland-Interface Area	Percent of Total	Total Replacement Cost Value Exposed to Wildland-Interface Area	Percent of Total	Number of Buildings Exposed to Wildland-Intermix Area	Percent of Total	Total Replacement Cost Value Exposed to Wildland-Intermix Area	Percent of Total	Number of Buildings Exposed to Wildfire Fuel Extreme, Very High, and High Hazard Area	Percent of Total	Total Replacement Cost Value Exposed to Wildfire Fuel Extreme, Very High, and High Hazard Area	Percent of Total
Avalon Borough	5,867	$8,232,959,879	1,125	19.2%	$1,862,679,796	22.6%	0	0.0%	$0	0.0%	5	0.1%	$10,012,829	0.1%
Cape May City	4,234	$5,153,049,612	0	0.0%	$0	0.0%	85	2.0%	$135,204,722	2.6%	2	0.0%	$1,002,611	0.0%
Cape May Point Borough	785	$663,183,164	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	3	0.4%	$4,651,609	0.7%
Dennis Township	7,301	$3,813,425,173	2,040	27.9%	$1,134,008,537	29.7%	4,586	62.8%	$2,373,007,081	62.2%	288	3.9%	$171,673,821	4.5%
Lower Township	19,597	$9,950,232,225	9,323	47.6%	$3,912,810,869	39.3%	1,708	8.7%	$836,435,323	8.4%	124	0.6%	$107,028,377	1.1%
Middle Township	18,197	$11,557,342,752	7,659	42.1%	$4,978,808,236	43.1%	9,259	50.9%	$4,508,725,296	39.0%	850	4.7%	$858,500,905	7.4%
North Wildwood City	4,729	$4,423,365,953	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	1	0.0%	$876,400	0.0%
Ocean City	18,172	$17,100,920,036	6,375	35.1%	$4,666,412,341	27.3%	116	0.6%	$79,665,674	0.5%	15	0.1%	$19,117,926	0.1%
Sea Isle City	6,712	$7,663,928,227	6,358	94.7%	$7,273,680,056	94.9%	172	2.6%	$217,581,345	2.8%	4	0.1%	$3,229,626	0.0%
Stone Harbor Borough	3,836	$3,291,756,871	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	1	0.0%	$535,656	0.0%
Upper Township	9,627	$6,506,171,365	5,947	61.8%	$4,116,504,194	63.3%	3,385	35.2%	$2,116,086,539	32.5%	203	2.1%	$218,154,552	3.4%
West Cape May Borough	1,623	$1,178,516,373	0	0.0%	$0	0.0%	61	3.8%	$65,172,492	5.5%	7	0.4%	$6,196,622	0.5%
West Wildwood Borough	805	$459,103,094	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Wildwood City	3,679	$4,379,038,844	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Wildwood Crest Borough	5,410	$4,552,156,876	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%	1	0.0%	$418,569	0.0%
Woodbine Borough	1,416	$1,335,589,432	657	46.4%	$465,543,808	34.9%	567	40.0%	$290,704,047	21.8%	26	1.8%	$25,522,628	1.9%
Cape May County (Total)	**111,990**	**$90,260,739,877**	**39,484**	**35.3%**	**$28,410,447,837**	**31.5%**	**19,939**	**17.8%**	**$10,622,582,518**	**11.8%**	**1,530**	**1.4%**	**$1,426,922,130**	**1.6%**

Impact on Critical Facilities

It is recognized that a number of critical facilities are located in the wildfire hazard area, and are also vulnerable to the threat of wildfire. Many of these facilities are the locations for vulnerable populations (i.e., schools, senior facilities) and responding agencies to wildfire events (i.e., fire, police). Table 5.4.11-9 through Table 5.4.11-11 summarize the critical facilities located within the wildfire fuel hazard ranking zones by jurisdiction.

Table 5.4.11-9. Facilities in High Wildfire Fuel Hazard Ranking Zone in Cape May County

Jurisdiction	Critical Facilities Exposed to the Wildfire Fuel High Hazard Area							
	Communications Tower	Dams	Marinas	Recreation	Secondary Education	Superfund Sites	Wastewater Facilities	Wastewater Pump Station
Avalon Borough	0	0	0	0	0	0	0	2
Lower Township	0	0	0	0	1	0	0	0
Middle Township	1	0	0	0	0	1	0	1
Ocean City	0	0	0	1	0	0	1	0
Sea Isle City	0	0	1	0	0	0	0	0
Upper Township	0	1	1	0	0	0	0	0
Cape May County (Total)	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**3**

Table 5.4.11-10. Facilities in Very High Fuel Hazard Ranking Zone in Cape May County

Jurisdiction	Critical Facilities Exposed to the Wildfire Fuel Very High Hazard Area				
	Communications Tower	County Facilities	EMS	Wastewater Facilities	Wastewater Pump Station
Lower Township	0	0	0	0	1
Middle Township	0	0	0	1	0
Upper Township	1	1	1	0	0
Cape May County (Total)	**1**	**1**	**1**	**1**	**1**

Table 5.4.11-11. Facilities in Extreme Fuel Hazard Ranking Zone in Cape May County

Jurisdiction	Critical Facilities Exposed to the Wildfire Fuel Extreme Hazard Area						
	Communications Tower	Day Care	Potable Water Tower	Primary Education	Superfund Sites	Wastewater Pump Station	Well
Dennis Township	2	0	0	1	0	0	1
Middle Township	1	0	0	0	0	1	0
Upper Township	1	1	1	0	0	0	0
Woodbine Borough	0	0	0	0	1	0	0
Cape May County (Total)	**4**	**1**	**1**	**1**	**1**	**1**	**1**

Impact on Economy

Wildfire events can have major economic impacts on a community from the initial loss of structures and the subsequent loss of revenue from destroyed business and decrease in tourism. Wildfires can cost thousands of taxpayer dollars to suppress and control and involve hundreds of operating hours on fire apparatus and thousands of volunteer man hours from the volunteer firefighters. There are also many direct and indirect costs to local businesses that excuse volunteers from working to fight these fires.

Impact on the Environment

According to the USGS, post-fire runoff polluted with debris and contaminates can be extremely harmful to ecosystem and aquatic life (USGS 2018). Studies show that urban fires in particular are more harmful to the environment compared to forest fires (USGS 2018). The age and density of infrastructure within Cape May County can exacerbate consequences of fires on the environment because of the increased amount of chemicals and contaminates that would be released from burning infrastructure. These chemicals, such as iron lead, and zinc, may leach into the storm water, contaminate nearby streams, and impair aquatic life.

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 defined wildfire hazard areas could be potentially impacted by wildfire similar to those that currently exist within the County. Refer to the jurisdictional annexes in Volume II of this HMP. It is anticipated that any new development and new residents in the extreme, very high or high fuel hazard areas will be exposed to the wildfire hazard.

Projected Changes in Population

The 2010 Census data indicates a county population of 97,265. However, more current data, according to U.S. Census Bureau, 2018 American Community Survey 5-Year Estimate, estimates a County population of approximately 93,705, which is a decrease in population since 2010. It is likely that a slight decrease in population will continue to occur in the near future.

Climate Change

According to the U.S. Fire Service (USFS), climate change will likely alter the atmospheric patterns that affect fire weather. Changes in fire patterns will, in turn, impact carbon cycling, forest structure, and species composition. Climate change associated with elevated greenhouse gas concentrations may create an atmospheric and fuel environment that is more conductive to large, severe fires (USFS 2020). Under a changing climate, wildfires are expected to increase by 50 percent across the United States (USFS 2020).

Fire interacts with climate and vegetation (fuel) in predictable ways. Understanding the climate/fire/vegetation interactions is essential for addressing issues associated with climate change that include:

- Effects on regional circulation and other atmospheric patterns that affect fire weather
- Effects of changing fire regimes on the carbon cycle, forest structure, and species composition, and
- Complications from land use change, invasive species and an increasing wildland-urban interface (USFS 2020).

It is projected that higher summer temperatures will likely increase the high fire risk by 10 to 30-percent. Fire occurrence and/or area burned could increase across the U.S. due to the increase of lightning activity, the frequency of surface pressure and associated circulation patterns conductive to surface drying, and fire-weather conditions, in general, which is conductive to severe wildfires. Warmer temperatures will also increase the effects of drought and increase the number of days each year with flammable fuels and extending fire seasons and areas burned (USFS 2020).

Future changes in fire frequency and severity are difficult to predict. Global and regional climate changes associated with elevated greenhouse gas concentrations could alter large weather patterns, thereby affecting fire-weather conducive to extreme fire behavior (USFS 2020).

Change of Vulnerability Since 2016 HMP

Since the 2016 analysis, population statistics have been updated using the 2014-2018 American Community Survey. The updated building stock inventory was created using building footprints and parcel data from the County, which was supplemented with 2013 MOV-ID tax assessor data and 2019 RS Means replacement cost value for building and content replacement costs. This provides an up-to-date look at the entire building stock for Cape May County and gives more accurate results for the exposure and loss estimation analysis.

The NJFFS Wildfire Fuel Hazard spatial layer has not been updated since the last HMP; therefore, changes and increases in overall wildfire hazard exposure are attributed to increases in population and new development.