4.3.8 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 Sussex County.

2020 HMP CHANGES

- Previous occurrences were updated with events that occurred between 2016 and 2020.
- A vulnerability assessment was conducted for the hurricane and tropical storm hazard using a more accurate and updated building inventory.

Profile

Hazard Description

A tropical cyclone is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain. Tropical depressions, tropical storms, and hurricanes are all considered tropical cyclones. Tropical cyclones strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. These storms rotate counterclockwise in the northern hemisphere around the center and are accompanied by heavy rain and strong winds (NOAA 2020a). 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 2020a).

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

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.

Location

All of Sussex County is vulnerable and at risk to flooding due to heavy rains and winds produced by hurricanes and tropical storms.

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 1861 and 2020, 32 events classified as either a hurricane, tropical storm, or tropical depression tracked within 65 nautical miles of Sussex County. Figure 4.3.8-1 displays tropical cyclone tracks that tracked with 65 nautical miles of Sussex County between 2015 and 2020 (only two events – Tropical Storm Fay and Tropical Storm Isaias in 2020). Refer to the "Previous Occurrences and Losses" section for further information regarding hurricane and tropical storm events that impacted Sussex County.

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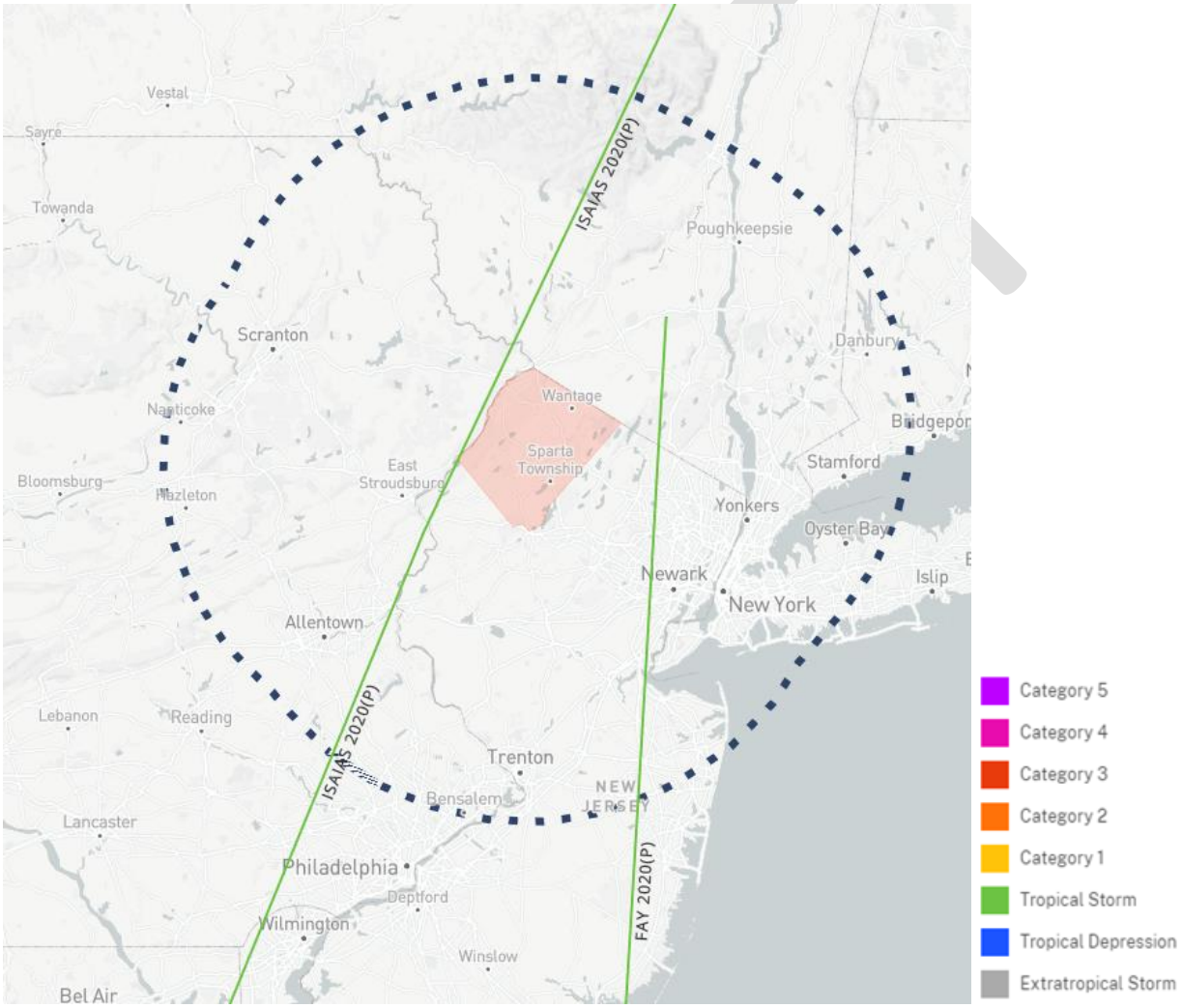
Extent

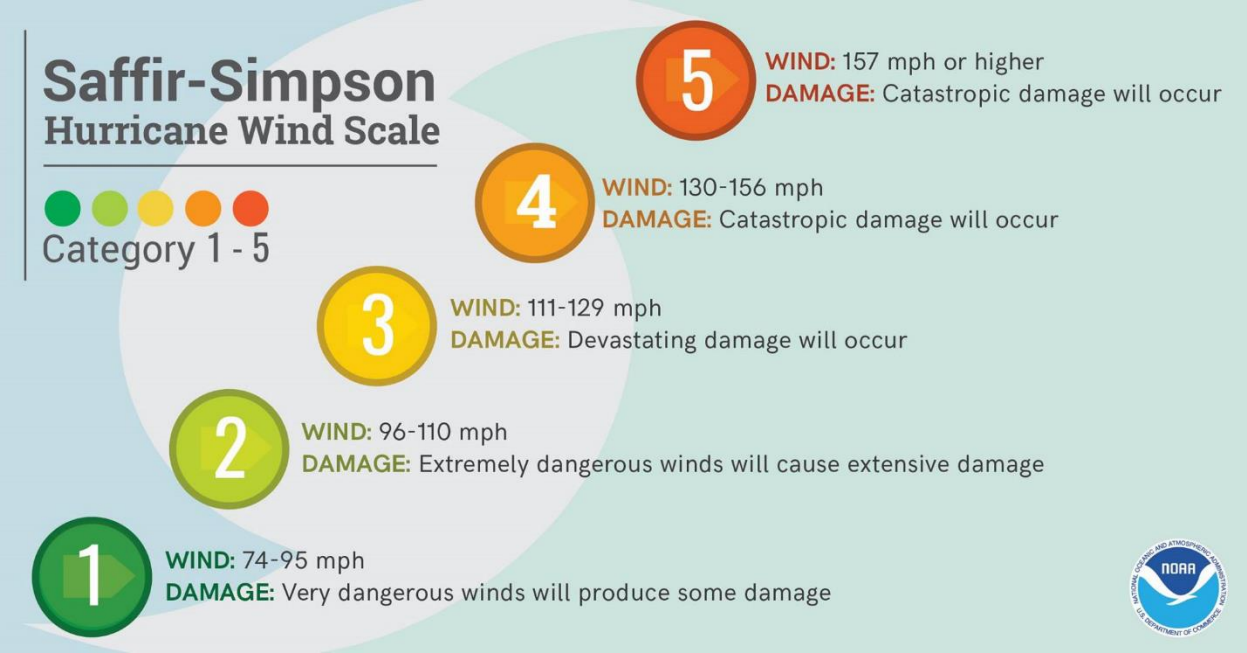
The extent of a hurricane is categorized in accordance with the Saffir-Simpson Hurricane Scale. The Saffir-Simpson Hurricane Wind Scale is a 1-to-5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered 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 (NOAA 2013b). Table 4.3.8-1 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes landfall.

Figure 4.3.8-1. Historical Tropical Storm and Hurricane Tracks 2015 to 2020



Source: NOAA 2021

Figure 4.3.8-2. Saffir-Simpson Scale



Source: NWS 2020

The 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 2013).

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 4.3.8-3 and Figure 4.3.8-4 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-MH v4.2 wind model. The estimated hurricane track used for the 100- and 500-year event is also shown. The maximum 3-second gust wind speeds for Sussex County are 59-64 mph (Tropical Storm), for the 100-year MRP event (tropical storm). The maximum 3-second gust wind speeds for Sussex County are 75-80 mph (Category 1 hurricane) for the 500-year MRP event. The associated impacts and losses from these 100-year and 500-year MRP hurricane event model runs are discussed in the Vulnerability Assessment subsection.

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Figure 4.3.8-3. Wind Speeds for the 100-Year Mean Return Period Event

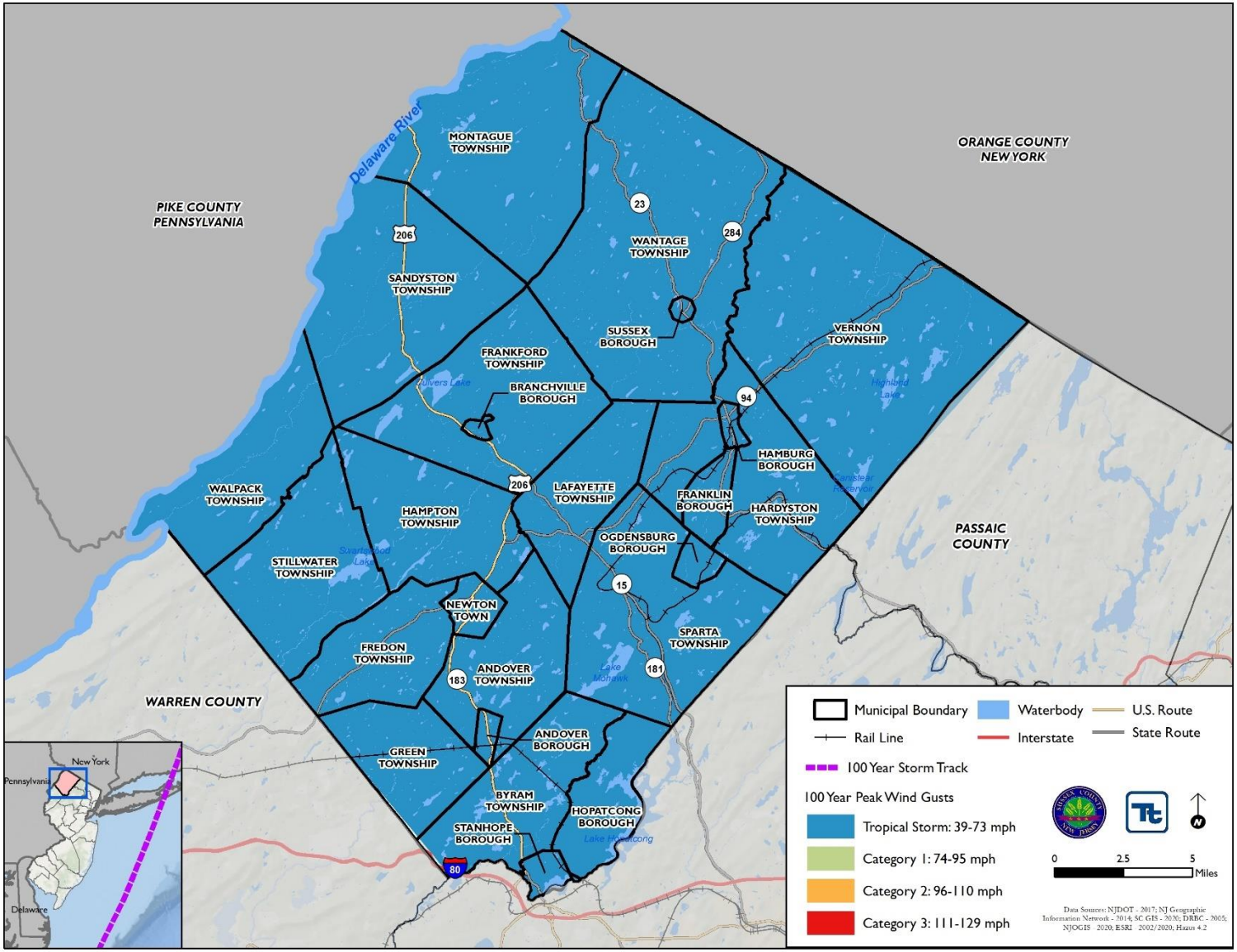
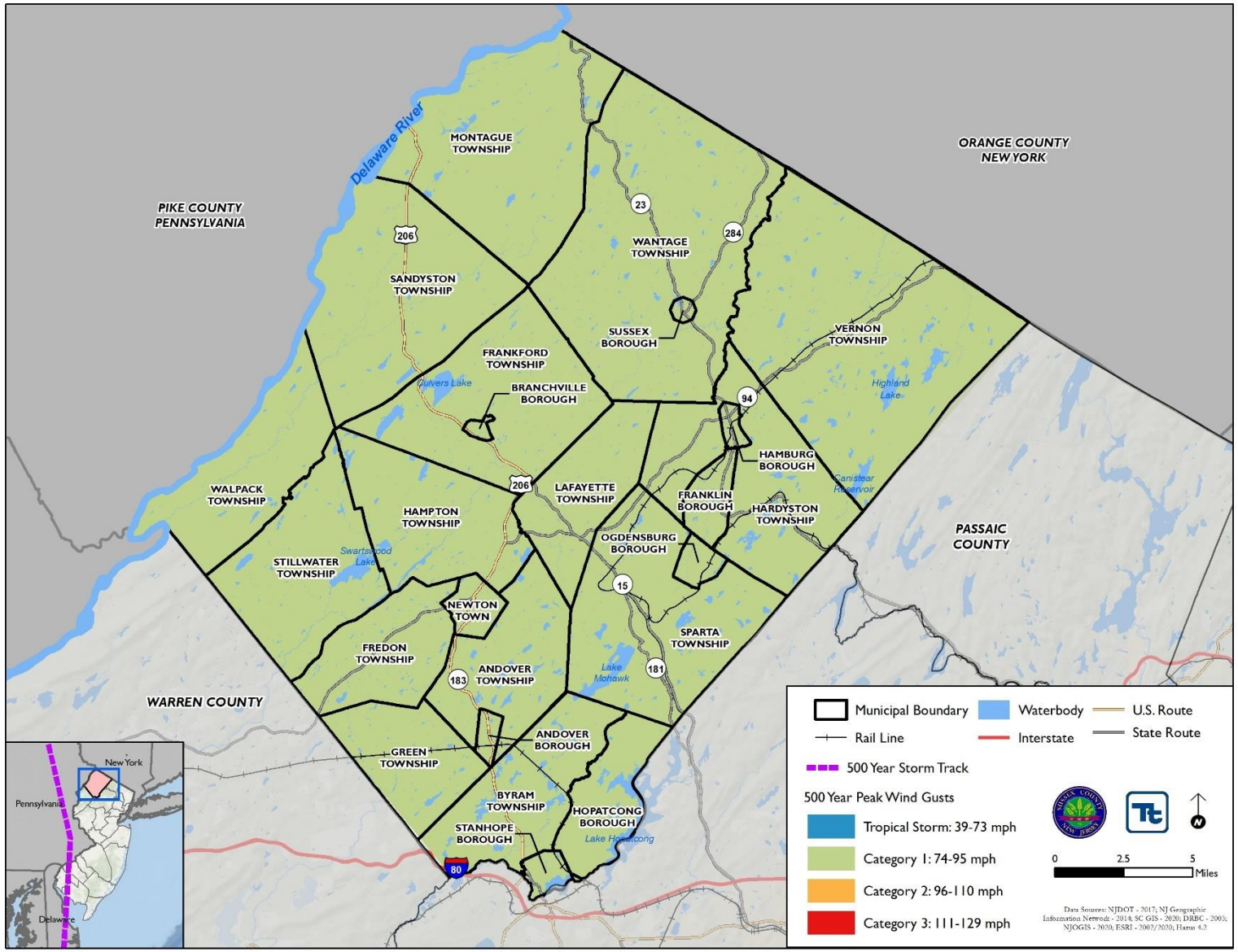


Figure 4.3.8-4. Wind Speeds for the 500-Year Mean Return Period Event



Previous Occurrences and Losses

Between 1954 and 2020, Sussex County was included in six declarations for hurricane and tropical storm-related events; refer to Table 4.3.8-1. Hurricane and tropical storm events that have impacted Sussex County between 2015 and 2020 are identified in Table 4.3.8-2 with associated impacts. 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, the period for which data was available, Sussex County was not included in any USDA agricultural disasters relating to hurricanes or tropical storms.

Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality. For events prior to 2015, refer to the Appendix E (Risk Assessment Supplement).

Table 4.3.8-1. Hurricane-Related Disaster (DR) and Emergency (EM) Declarations 1954-2020

Declaration	Event Date	Declaration Date	Event Description
EM-3148	September 16-18, 1999	September 17, 1999	Hurricane Floyd Emergency Declarations
DR-1295	September 16-18, 1999	September 17, 1999	Hurricane Floyd Major Disaster Declarations
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

Table 4.3.8-2. Hurricane and Tropical Storm Events in Sussex County, 2015 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
July 10, 2020	Tropical Storm	N/A	TBD, pending	Sussex County	Tropical Storm Fay moved northward along the coasts of Delaware and New Jersey on the afternoon and evening of July 10. The storm produced rainfall totals up to 3 to 6 inches in New Jersey, with the highest totals occurring in the southern part of the state. Some areas also experienced a period of tropical storm force winds, especially near the coast. Overall impacts from wind were limited.
August 4, 2020	Tropical Storm	N/A	TBD, pending	Sussex County	Tropical Storm Isaias brought high winds, heavy rain, several tornadoes, and coastal flooding to the mid-Atlantic region, becoming the most impactful tropical cyclone to impact most of the region since Sandy in 2012.

Source: FEMA 2020; NOAA-NCEI 2020; NWS 2020; SPC 2020; NJOEM 2019

Note: Not all events that have occurred in Sussex County are included due to the extent of documentation and the fact that not all sources have been identified or researched.

K: Thousand

DR Disaster Declaration (FEMA)

FEMA Federal Emergency Management Agency

Mph miles per hour

N/A Not Applicable

Probability of Future Occurrences

Hurricane return periods are the frequency at which a certain intensity of hurricane can be expected within a given distance of a given location. For example, a return period of 20 years for a major hurricane means that on average during the previous 100 years, a Category 3 or greater hurricane passed within 58 miles of a specific location approximately 5 times. The return period of hurricanes for Sussex County was not calculated – however, the return period for surrounding counties is 18 to 19 years for a hurricane (greater than 64 mph winds) and 74 to 76 years for a major hurricane (greater than 110 mph winds) (NOAA 2013).

In order to determine the recurrence interval and the average annual number of events, data from 1950 to 2020 was looked at using NOAA's Historical Hurricane Tracks tool. A 65 nautical mile radius was used to identify any hurricane and tropical storm events Sussex County. Based on this data, 18 hurricanes, tropical storms, tropical depressions or extra-tropical storms passed within 100 nautical miles of Sussex County. The table below shows these statistics, as well as the annual average number of events and the estimated percent change of an event occurring in a given year (NHC 2021).

Table 4.3.8-3. Probability of Future Hurricane and Tropical Storm Events

Hazard Type	Number of Occurrences Between 1950 and 2020	Rate of Occurrence or Annual Number of Events (average)	Recurrence Interval (in years) (# Years/Number of Events)	Probability of Event in any given year	Percent chance of occurrence in any given year
Tropical Depression	2	0.03	35.5	0.03	2.8
Tropical Storm	14	0.20	5.1	0.20	19.7
Hurricanes (all categories)	2	0.03	35.5	0.03	2.8
Total	**18**	**0.26**	**3.9**	**0.25**	**25.4**

Source: NHC 2021

It is estimated that Sussex County will continue to experience direct and indirect impacts of hurricane and tropical storms 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.

In Section 4.4, the identified hazards of concern for Sussex 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 'frequent' (100 percent annual probability; a hazard event may occur multiple times per year, as presented in Table 4.4-1). The ranking of the hurricane and tropical storm hazard for individual municipalities is presented in the jurisdictional annexes.

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).

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).

Climate change may result in changes to the frequency of coastal storms. 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).

Temperatures are predicted to increase in Sussex 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 Sussex County.

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 estimate potential losses associated with high-wind events. The impacts on population, existing structures, critical facilities and the economy are presented below.

Impact on Life, Health and Safety

The impact of a hurricane or tropical storm 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. For the purposes of this HMP, the entire population of Sussex County (142,298 people) is exposed to hurricanes and tropical storm events (U.S. Census, American Community Survey 5-year Population Estimates 2018). Residents might be displaced or require temporary to long-term sheltering as a result of these events. 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 several 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 no households will be displaced and temporary shelter will not be required as a result of the 100 or 500-year MRP events.

Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and might lack funds to evacuate. The population over the age of 65 is also more vulnerable and might physically have more difficulty evacuating. The elderly is considered most vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention that might not be available due to isolation during a storm event. The 2018 American Community Survey population estimates indicate there were 22,889 persons over 65 years old and 7,191 living below the poverty level in Sussex County. Section 3 (County Profile) provides statistics of these populations.

Secondary flooding associated with the torrential downpours during hurricanes/tropical storms is also a primary concern in the County (refer to the flooding discussion in Section 4.3.5 - Flood).

Impact on General Building Stock

It is assumed that the entire County's general building stock is exposed to the hurricane and tropical storm hazard ($60.0 billion). Building construction plays a major role in the extent of damage resulting from a storm event. 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. High-rise buildings are also very vulnerable structures. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

The Hazus wind model was run to estimate potential losses to buildings. Expected building damage was evaluated across the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction; Table 4.3.8-4 summarizes the definition of the damage categories.

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Table 4.3.8-4 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 cover, 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

According to the Hazus wind model, most Sussex structures would experience no damage with a small number experiencing minor damage. Table 4.3.8-5 indicates the number and type of buildings for each damage category.

Table 4.3.8-5 Expected Damages from 100 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 Multi-Family Dwellings)	62,429	None	62,419	>99.9%	61,852	>99.9%
		Minor	10	<0.1%	570	<0.1%
		Moderate	0	0.0%	7	<0.1%
		Severe	0	0.0%	0	0.0%
		Complete Destruction	0	0.0%	0	0.0%
Commercial Buildings	3,304	None	3,297	>99.9%	3,279	>99.9%
		Minor	7	<0.1%	25	<0.1%
		Moderate	0	0.0%	0	0.0%

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
		Severe	0	0.0%	0	0.0%
		Complete Destruction	0	0.0%	0	0.0%
Industrial Buildings	258	None	257	>99.9%	255	>99.9%
		Minor	1	<0.1%	3	<0.1%
		Moderate	0	0.0%	0	0.0%
		Severe	0	0.0%	0	0.0%
		Complete Destruction	0	0.0%	0	0.0%
Government, Religion, Agricultural, and Education Buildings	6,030	None	6,027	>99.9%	6,004	>99.9%
		Minor	3	<0.1%	25	<0.1%
		Moderate	0	0.0%	1	<0.1%
		Severe	0	0.0%	0	0.0%
		Complete Destruction	0	0.0%	0	0.0%

Source: Hazus-MH v4.2

Table 4.3.8-6 and Table 4.3.8-7 summarize the replacement cost value damage estimated for the 100- and 500-year MRP wind-only events.

The total estimated damage to buildings for all occupancy types across Sussex County is estimated to be approximately $10.0 and $67.4 million for the 100- and 500-year MRP wind-only events, respectively. Most of these losses are to residential buildings. Due to differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. The damage counts include buildings damaged at all severity levels from minor damage to destruction. Total dollar damage reflects the overall impact to buildings at an aggregate level. The Township of Vernon is estimated to experience the greatest damage in a 100-year MRP event, approximately $2.1 million. The Township of Sparta is estimated to experience the greatest damage in a 500-year event, losing $9.9 million. Damages to buildings is a direct result of wind speeds, direction and duration; which is dependent upon the storm's intensity and track.

Table 4.3.8-6. Estimated Building Value Damaged by the 100 and 500-Year MRP Hurricane-Related Winds (Building Structure and Content)

Jurisdiction	Total Replacement Cost Value (All Occupancies)	Estimated Total Damages		Percent of Total Building and Contents Replacement Cost Value	
		100-Year	500-Year	100-Year	500-Year
Andover (B)	$628,463,030	$65,969	$482,051	<0.1%	0.1%
Andover (Twp)	$3,609,679,724	$402,887	$3,444,722	<0.1%	0.1%
Branchville (B)	$532,377,368	$49,511	$465,331	<0.1%	0.1%
Byram (Twp)	$2,746,550,446	$158,478	$1,713,526	<0.1%	0.1%

Jurisdiction	Total Replacement Cost Value (All Occupancies)	Estimated Total Damages		Percent of Total Building and Contents Replacement Cost Value	
		100-Year	500-Year	100-Year	500-Year
Frankford (Twp)	$3,129,888,305	$371,869	$3,658,865	<0.1%	0.1%
Franklin (B)	$1,921,211,856	$331,708	$1,932,696	<0.1%	0.1%
Fredon (Twp)	$1,372,050,934	$231,557	$2,088,224	<0.1%	0.2%
Green (Twp)	$1,598,635,804	$314,315	$2,917,436	<0.1%	0.2%
Hamburg (B)	$1,588,049,291	$274,204	$1,408,409	<0.1%	0.1%
Hampton (Twp)	$2,196,131,598	$304,221	$2,943,964	<0.1%	0.1%
Hardyston (Twp)	$3,183,033,542	$872,641	$4,516,987	<0.1%	0.1%
Hopatcong (B)	$2,888,571,676	$385,082	$3,109,993	<0.1%	0.1%
Lafayette (Twp)	$1,958,174,065	$223,659	$1,759,760	<0.1%	0.1%
Montague (Twp)	$1,459,611,020	$244,371	$1,842,918	<0.1%	0.1%
Newton (T)	$5,093,275,807	$277,957	$3,312,499	<0.1%	0.1%
Ogdensburg (B)	$819,879,629	$175,178	$1,046,811	<0.1%	0.1%
Sandyston (Twp)	$1,212,626,664	$158,825	$1,136,422	<0.1%	0.1%
Sparta (Twp)	$9,070,094,285	$1,619,592	$9,875,755	<0.1%	0.1%
Stanhope (B)	$1,051,183,581	$283,585	$1,946,102	<0.1%	0.2%
Stillwater (Twp)	$1,417,579,398	$226,775	$2,263,005	<0.1%	0.2%
Sussex (B)	$1,945,578,916	$87,646	$692,029	<0.1%	0.0%
Vernon (Twp)	$5,658,971,163	$2,106,600	$9,190,004	<0.1%	0.2%
Walpack (Twp)	$63,691,550	$5,301	$37,930	<0.1%	0.1%
Wantage (Twp)	$4,877,543,885	$781,076	$5,623,717	<0.1%	0.1%
Sussex County (Total)	**$60,022,853,539**	**$9,953,005**	**$67,409,158**	**<0.1%**	**0.1%**

Source: Hazus-MH 4.2; Sussex County GIS 2020; RS Means 2020
Notes: B – Borough; Twp. – Township; T = Town; % - Percent
**The Estimated 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.*

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Table 4.3.8-7. Estimated Building Value of Residential, Commercial, and Other Occupancy Types Damaged by the 100-Year and 500-Year MRP Event Winds

Jurisdiction	Total Replacement Cost Value (All Occupancies)	Estimated Residential Damages		Estimated Commercial Damages		Estimated Damages for All Other Occupancies	
		100-Year MRP Event	500-Year MRP Event	100-Year MRP Event	500-Year MRP Event	100-Year MRP Event	500-Year MRP Event
Andover (B)	$628,463,030	$65,969	$455,728	$0	$22,504	$0	$3,819
Andover (Twp)	$3,609,679,724	$402,618	$3,187,863	$202	$210,672	$67	$46,187
Branchville (B)	$532,377,368	$49,511	$442,963	$0	$18,977	$0	$3,392
Byram (Twp)	$2,746,550,446	$158,207	$1,531,548	$206	$159,144	$65	$22,834
Frankford (Twp)	$3,129,888,305	$371,869	$3,544,452	$0	$96,755	$0	$17,658
Franklin (B)	$1,921,211,856	$302,956	$1,823,447	$19,117	$83,222	$9,635	$26,027
Fredon (Twp)	$1,372,050,934	$231,557	$2,039,186	$0	$10,674	$0	$38,364
Green (Twp)	$1,598,635,804	$314,315	$2,857,242	$0	$15,510	$0	$44,684
Hamburg (B)	$1,588,049,291	$246,517	$1,326,939	$15,786	$68,616	$11,901	$12,854
Hampton (Twp)	$2,196,131,598	$304,221	$2,860,242	$0	$61,615	$0	$22,107
Hardyston (Twp)	$3,183,033,542	$861,208	$4,414,884	$9,780	$81,912	$1,653	$20,191
Hopatcong (B)	$2,888,571,676	$357,459	$2,995,325	$16,750	$84,711	$10,873	$29,957
Lafayette (Twp)	$1,958,174,065	$223,505	$1,651,470	$116	$53,334	$38	$54,956
Montague (Twp)	$1,459,611,020	$244,371	$1,815,035	$0	$19,505	$0	$8,378
Newton (T)	$5,093,275,807	$277,957	$2,926,377	$0	$294,308	$0	$91,814
Ogdensburg (B)	$819,879,629	$165,127	$1,000,351	$3,533	$32,841	$6,518	$13,619
Sandyston (Twp)	$1,212,626,664	$158,825	$1,112,355	$0	$11,590	$0	$12,477
Sparta (Twp)	$9,070,094,285	$1,459,587	$9,303,493	$131,331	$486,978	$28,674	$85,284
Stanhope (B)	$1,051,183,581	$266,003	$1,893,816	$6,868	$29,462	$10,715	$22,824
Stillwater (Twp)	$1,417,579,398	$226,775	$2,244,493	$0	$13,995	$0	$4,517
Sussex (B)	$1,945,578,916	$87,646	$530,262	$0	$145,944	$0	$15,823
Vernon (Twp)	$5,658,971,163	$2,051,946	$9,109,822	$26,780	$49,910	$27,874	$30,272
Walpack (Twp)	$63,691,550	$5,301	$37,127	$0	$387	$0	$416
Wantage (Twp)	$4,877,543,885	$780,919	$5,502,893	$157	$87,011	$0	$33,813
Sussex County (Total)	**$60,022,853,539**	**$9,614,367**	**$64,607,314**	**$230,624**	**$2,139,577**	**$108,014**	**$662,267**

Source: Hazus-MH 4.2; Sussex County GIS 2020; RS Means 2020
Notes: B – Borough; Twp. – Township; T = Town; % - Percent

Impact on Critical Facilities and Lifelines

Utility infrastructure could suffer damage from high winds associated with falling tree limbs or other debris, resulting in the loss of power. Loss of service can impact residents and business operations alike. Interruptions in heating or cooling utilities can affect populations such as the young and elderly, who are particularly vulnerable to temperature-related health impacts. 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 due to pump failure until power is restored. Lack of power to emergency facilities, including police, fire, EMS, and hospitals, will inhibit a community's ability to effectively respond to an event and maintain the safety of its citizens.

Overall, all critical facilities and lifelines are exposed to the wind hazard. Hazus estimates the probability that critical assets (i.e., medical facilities, fire/EMS, police, EOC, schools, and user-defined facilities such as shelters and municipal buildings) could sustain damage as a result of 100-year and 500-year MRP wind events. Additionally, Hazus estimates the loss of use for each facility in number of days. Due to the sensitive nature of this dataset, individual facility estimated loss is not provided.

No critical facilities would experience damage as the result of the 100-year MRP event. Table 4.3.8-8 summarizes the percent probability that each facility type may experience damage as a result of the 500-year MRP event.

Table 4.3.8-8. Estimated Impacts to Critical Facilities for the 500-Year Mean Return Period Winds

Facility Type	Loss of Days	Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
EOC	0	1.0%	0.0%	0.0%	0.0%
Medical	0	0%-1.0%	0.0%	0.0%	0.0%
Police	0	1.0%	0.0%	0.0%	0.0%
Fire	0	0%-1.0%	0.0%	0.0%	0.0%
Schools	0	1.0%	0.0%	0.0%	0.0%

Source: Hazus-MH v4.2; Sussex County GIS 2020

Impact on Economy

Damage to structures from flooding and wind can be the most immediate result of hurricane and tropical 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 Sussex County, lost millions of dollars in wages and economic activity.

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. Refer to Table 4.3.8-9 which summarizes the economic losses estimated by Hazus.

Table 4.3.8-9. Estimated Economic Losses for the 100-Year and 500-Year Mean Return Period Hurricane Wind Events

Mean Return Period (MRP)	Inventory Loss	Relocation Loss	Building and Content Losses	Wages Losses	Rental Losses	Income Losses
100-year MRP	$0	$10	$9,953,000,000	$0	$0	$0
500-year MRP	$210,000	$506,040,000	$67,409,160,000	$0	$161,230,000	$0

Source: Hazus-MH v4.2; Sussex County GIS 2020; RS Means 2020

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 heating or cooling provisions to the population.

Debris management can be costly and impact the local economy. Hazus estimates the amount of debris that might be produced as result of the 100- and 500-year MRP wind events. Table 4.3.8-10 summarizes the estimated debris by municipality, which should be considered a lower-bound analysis. Because the estimated debris production does not include debris generated by flooding, this is likely a conservative estimate and could be higher if multiple impacts occur.

Table 4.3.8-10. Debris Production for 100- and 500-Year Mean Return Period Event Winds

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
Andover (B)	0	18	0	0	64	257	115	458
Andover (Twp)	0	171	0	0	639	2,554	853	3,415
Branchville (B)	0	23	0	0	156	624	153	610
Byram (Twp)	0	147	0	0	1	715	6	1,293
Frankford (Twp)	0	159	0	0	993	3,970	1,162	4,650
Franklin (B)	1	106	0	0	148	589	549	2,196
Fredon (Twp)	0	103	0	0	572	2,286	500	2,000
Green (Twp)	0	133	0	0	520	2,080	513	2,054
Hamburg (B)	1	68	0	0	76	193	609	1,525
Hampton (Twp)	0	100	0	0	810	3,240	958	3,831
Hardyston (Twp)	0	161	0	0	1,036	4,145	1,202	4,808
Hopatcong (B)	8	265	0	0	1	298	2	770
Lafayette (Twp)	0	112	0	0	570	2,280	401	1,604
Montague (Twp)	0	53	0	0	1,472	4,416	938	2,815
Newton (T)	0	237	0	0	117	569	567	2,819
Ogdensburg (B)	0	44	0	0	73	299	276	1,110
Sandyston (Twp)	0	35	0	0	2,081	6,244	1,015	3,044
Sparta (Twp)	14	480	0	0	828	3,717	1,909	8,122
Stanhope (B)	0	64	0	0	70	349	358	1,789
Stillwater (Twp)	0	55	0	0	916	3,662	997	3,989
Sussex (B)	0	65	0	0	22	108	148	737
Vernon (Twp)	0	277	0	0	1,514	5,320	2,740	9,736

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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
Walpack (Twp)	0	1	0	0	69	208	34	102
Wantage (Twp)	0	240	0	0	2,158	7,552	1,774	6,379
Sussex County (Total)	**24**	**3,120**	**0**	**0**	**14,906**	**55,675**	**17,779**	**69,856**

Source: Hazus-MH 4.2; Sussex County GIS 2020
Notes: B – Borough; T – Town; Twp. – Township; % - Percent

Impact on the Environment

The impacts of hurricane related winds on the environment typically take place over a larger area. Where these events occur, widespread, severe damage to tree and plant species is likely. This includes uprooting or destruction of trees and an increased threat of wildfire in areas where dead trees are not removed. Section 4.3.5 (Flood) provides additional environmental impacts due to flooding from heavy rainfalls.

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. 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

Understanding future changes that impact vulnerability in the Sussex County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. It is anticipated that any new development and new residents will be exposed to the hurricane and tropical storm hazard. However, due to increased standards and codes, new development might be less vulnerable to wind-related hazards compared to the aging building stock.

Projected Changes in Population

Sussex County has experienced a population decline since 2010. According to the U.S. Census Bureau, the County's population has decreased 4.7-percent between 2010 and 2018 (U.S. Census Bureau 2020). The Township of Walpack and the Borough of Sussex have experienced the greatest decline with a decrease of 62.5-percent and 13.0-percent, respectively. The population is expected to continue to decrease as residents move away from the suburbs and towards urban centers (Stirling 2018).

Even though the population has decreased over the past decade, any changes in the density of population can impact the number of persons exposed to hurricanes and tropical storms. As the population changes, so will the number of people impacted by this hazard.

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 heavy rain impacts.

The northeast region of the United States has experienced a greater increase in extreme precipitation than any other region in the U.S. between 1958 and 2010, the Northeast experienced more than 70% increase in the amount of precipitation falling in rain events (Global Change 2014). Refer to Section 4.3.5 (Flood) for a discussion related to the impact of climate change due to increases in rainfall. An increase in storms will produce more wind events and may increase tornado activity. With an increased likelihood of strong winds and tornado events, all the County's assets will experience additional risk for losses as a result of extreme wind events.

Vulnerability Changes Since the 2016 HMP

Since the 2016 analysis, population statistics have been updated using the 2014-2018 American Community Survey. The Hazus wind analysis was performed in Hazus-MH v4.2 for Sussex County and was based on the most current and best available data, including building and critical facility inventories. The general building stock was also updated using RS Means 2020 building valuations that estimated replacement cost value for each building in the inventory. This provides an up-to-date look at the entire building stock for Sussex County and gives more accurate results for the exposure and loss estimation analysis.

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