4.3.11 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 Mercer County.

2021 HMP UPDATE CHANGES

- All subsections have been updated using best available data.
- Previous occurrences were updated with events that occurred between 2015 and 2020.
- The vulnerability assessment was conducted using updated population, building and critical facility/lifeline data. These wind-related results are discussed in greater detail in Section 4.3.8 (Hurricane).

Profile

Hazard Description

For the purpose of this HMP update and as deemed appropriated by the Mercer County Planning Committee, the severe weather hazard includes high winds, tornadoes, thunderstorms and lightning, extreme temperatures, and hail, which are defined below.

Thunderstorms

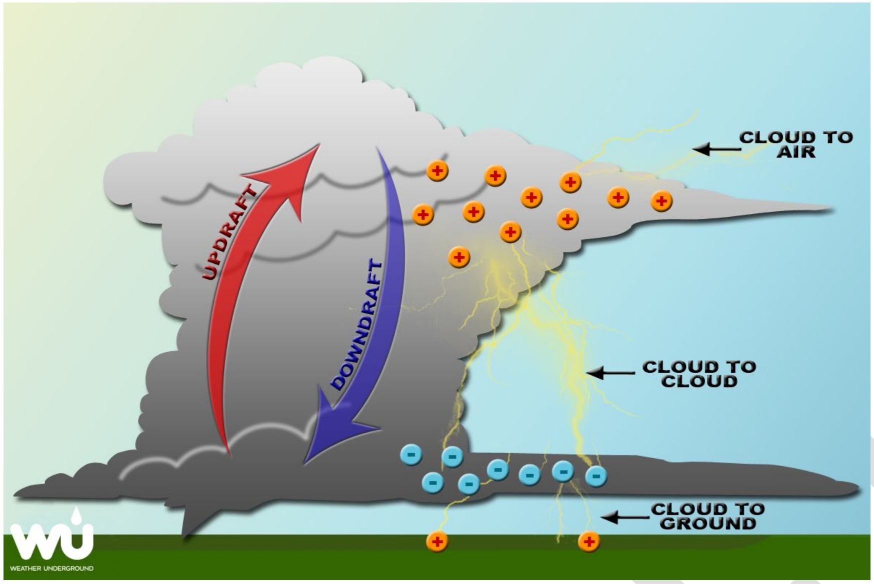
A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (National Weather Service [NWS] 2009a). A thunderstorm forms from a combination of moisture; rapidly rising warm air; and a force capable of lifting air, such as a warm front, cold front, a sea breeze, or a mountain. Thunderstorms form from the equator to as far north as Alaska. Although thunderstorms generally affect a small area when they occur, they have the potential to become dangerous due to their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and lightning.

Thunderstorms can lead to heavy rain induced flooding, landslides, strong winds, and lightning. Roads may become impassable from flooding, downed trees or power lines, or a landslide. Downed power lines can lead to loss of utility services, such as water, phone, and electricity. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. During the summer, thunderstorms are responsible for most of the rainfall.

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. Figure 4.3.11-1 demonstrates the variety of lightning types.

Figure 4.3.11-1. Types of Lightning

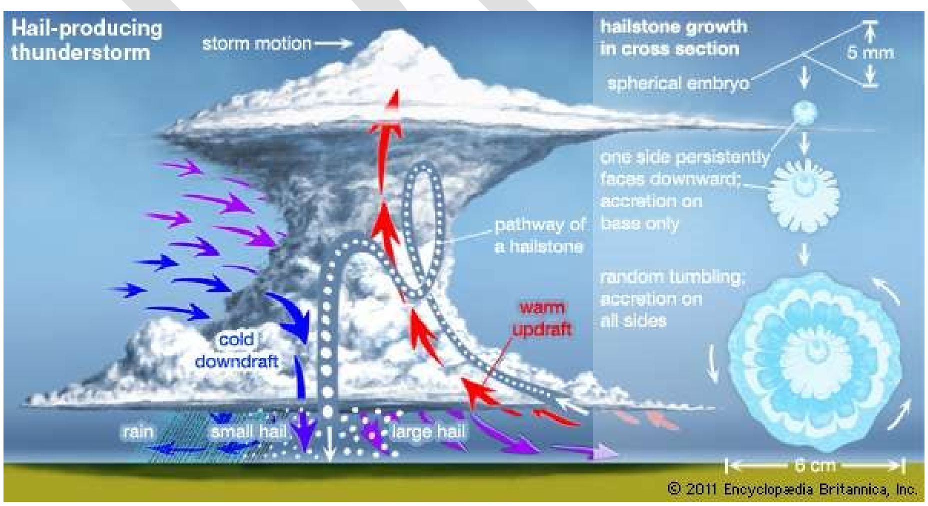


Source: Weather Underground date unknown

Hailstorms

Hail forms inside a thunderstorm or other storms with 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 degrees Fahrenheit (°F) or colder. As the frozen droplet begins to fall, it may thaw as it moves into warmer air toward the bottom of the thunderstorm. However, the droplet may be picked up again by another updraft and carried back into the cold air and 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. Most hail is small and typically less than 2 inches in diameter (NWS 2010). Figure 4.3.11-2 shows how hail is formed in thunderstorms.

Figure 4.3.11-2. Hail Formation in Thunderstorms



Source: Encyclopedia Britannica 2011

Windstorms

Wind begins with differences in air pressures and occurs through 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. High winds are often associated with other severe weather events such as thunderstorms, tornadoes, nor'easters, hurricanes, and tropical storms.

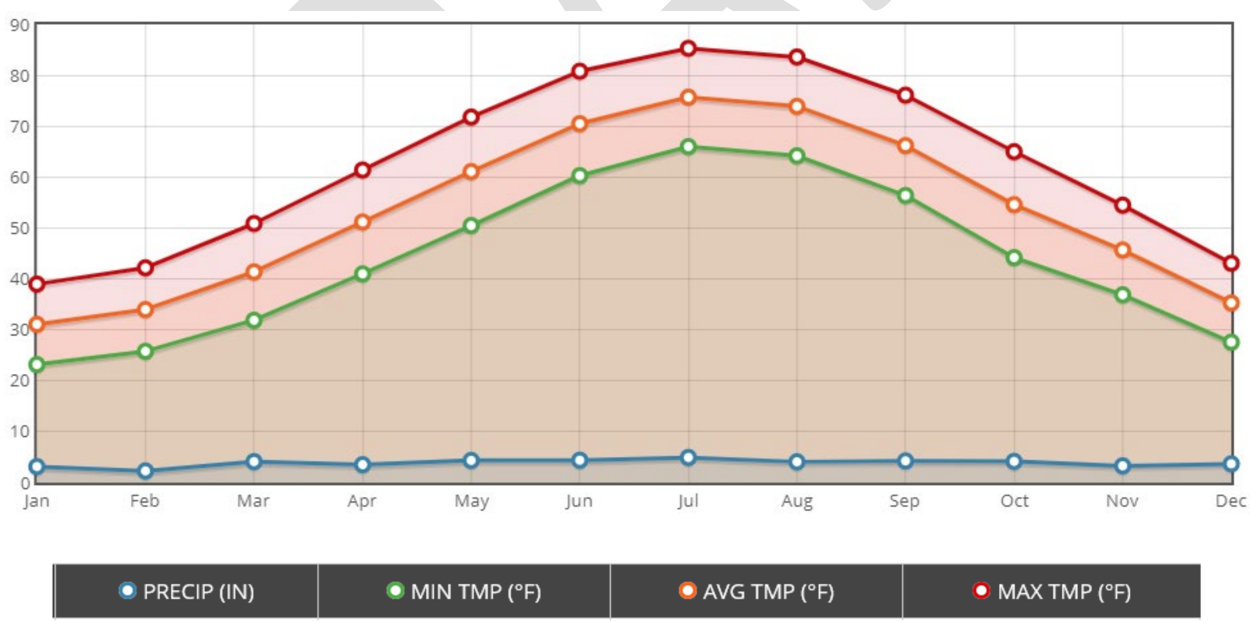
Tornadoes

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 (National Severe Storms Laboratory [NSSL] 2013).

Extreme Temperatures

Extreme temperature includes both heat and cold events that can have significant direct impacts to human health and commercial/agricultural businesses and primary and secondary effects on infrastructure (e.g., burst pipes and power failure). Distinguishing characteristics of "extreme cold" or "extreme heat" vary by location, based on the conditions to which the population is accustomed. Figure 4.3.11-3 shows the average low and high temperatures each month at the Trenton Mercer Airport station in Mercer County.

Figure 4.3.11-3. Average Temperatures at Trenton Mercer Airport



Source: NWS 2021

Extreme Cold

Extreme cold events are when temperatures drop well below normal in an area. In regions relatively unaccustomed to winter weather, near freezing temperatures are considered "extreme cold." Extreme cold temperatures are generally characterized in temperate zones by the ambient air temperature dropping to approximately 0ºF or below (Centers of Disease Control and Prevention [CDC] 2007). Extremely cold temperatures often accompany a winter storm, which can cause power failures and icy roads. Although staying indoors as much as possible can help reduce the risk of car crashes and falls on the ice, individuals may also face indoor hazards. Many homes will be too cold—either due to a power failure or because the heating system is not adequate for the weather. The use of space heaters and fireplaces to keep warm increases the risk of household fires and carbon monoxide poisoning (CDC 2007).

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 (Centers for Disease Control and Prevention [CDC] 2016). A heat wave is defined as a period of abnormally and uncomfortably hot and unusually humid weather. Typically, a heat wave lasts two or more days. (NWS 2009b). 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).

Urbanized areas and urbanization creates an exacerbated type of risk during an extreme heat event, compared to rural and suburban areas. As defined by the U.S. Census, urban areas are classified as all territory, population, and housing units located within urbanized areas and urban clusters. The term urbanized area denotes an urban area of 50,000 or more people. Urban areas under 50,000 people are called urban clusters. The U.S. Census delineates urbanized area and urban cluster boundaries to encompass densely settled territory, which generally consists of:

- A cluster of one or more block groups or census blocks each of which has a population density of at least 1,000 people per square mile at the time.
- Surrounding block groups and census blocks each of which has a population density of at least 500 people per square mile at the time.
- Less densely settled blocks that form enclaves or indentations or are used to connect discontiguous areas with qualifying densities (U.S. Census 2010).

As these urban areas develop and change, so does the landscape. Buildings, roads, and other infrastructure 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. This forms an 'island' of higher temperatures (EPA 2009).

The term 'heat island' describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with more than one million people can be between 1.8 ºF and 5.4ºF warmer than its surrounding areas. In the evening, the difference in air temperatures can be as high as 22ºF. Heat islands occur on the surface and in the atmosphere. On a hot, sunny day, the sun can heat dry, exposed urban surfaces to temperatures 50ºF to 90ºF hotter than the air. Heat islands can affect communities by increasing peak energy demand during the summer, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and death, and water quality degradation (EPA 2010 and 2011).

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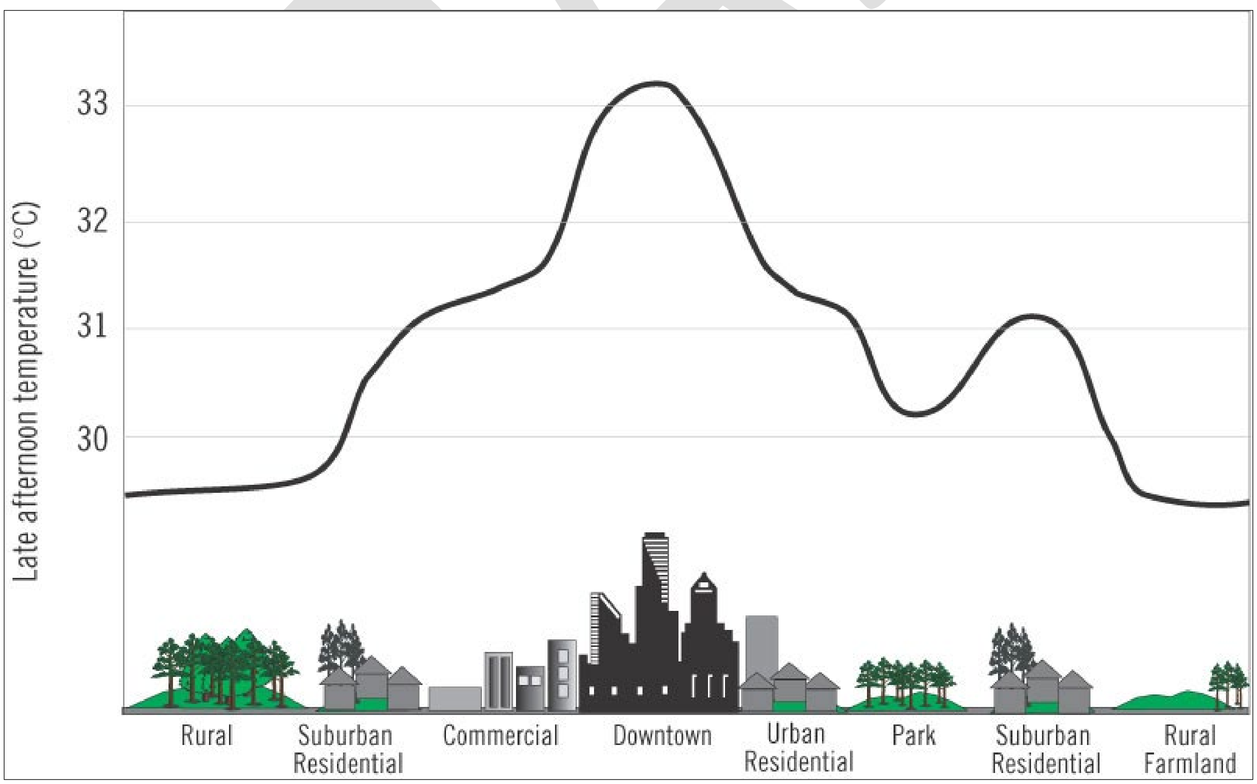
Figure 4.3.11-4 below illustrates an urban heat island profile. The graphic demonstrates that heat islands are typically most intense over dense urban areas. Further, vegetation and parks within a downtown area may help reduce heat islands (EPA 2019).

Figure 4.3.11-4. Urban Heat Island Profile

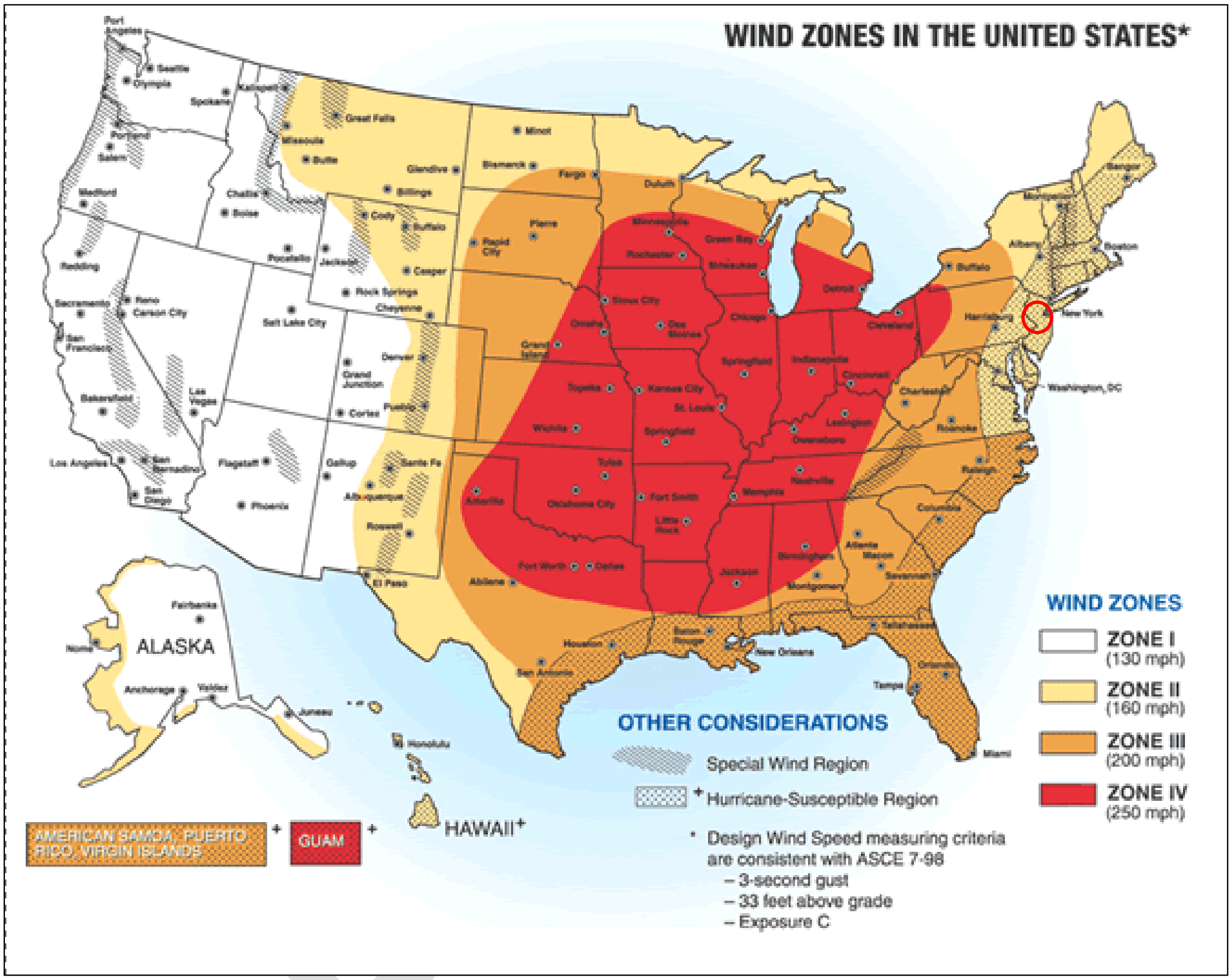


Source: *EPA 2019*
ºC *degrees Celsius*

Location

All of Mercer County is exposed to severe weather. According to the FEMA Winds Zones of the United States map, Mercer County is located in Wind Zone II, where wind speeds can reach up to 160 mph and is part of the hurricane susceptible region. Figure 4.3.11-5 illustrates wind zones across the United States, which indicate the impacts of the strength and frequency of wind activity per region. The information on the figure is based on 40 years of tornado data and 100 years of hurricane data collected by FEMA.

Figure 4.3.11-5. Wind Zones in the United States



Source: FEMA 2012
Note: The red circle indicates the approximate location of Mercer County.

According to the ONJSC, New Jersey has five distinct climate regions. Elevations, latitude, distance from the Atlantic Ocean, and landscape (e.g. urban, sandy soil) produce distinct variations in the daily weather between each of the regions. The five regions include: Northern, Central, Pine Barrens, Southwest, and Coastal (ONJSC Rutgers University n.d.). Figure 4.3.11-6 depicts these regions. Mercer County is located within the Central Climate Region with a small area in the northwest edge of the County located in the Northern Climate Region.

The Central Climate Zone has a northeast to southwest orientation, running from New York Harbor and the Lower Hudson River to the great bend of the Delaware River in the vicinity of Trenton. This region has many urban locations with large amounts of pollutants produced by the high volume of automobile traffic and industrial processes. The concentration of buildings and paved surfaces serve to retain more heat, thereby affecting the local temperatures in the previously discussed "heat island" effect (ONJSC Rutgers University n .d.).

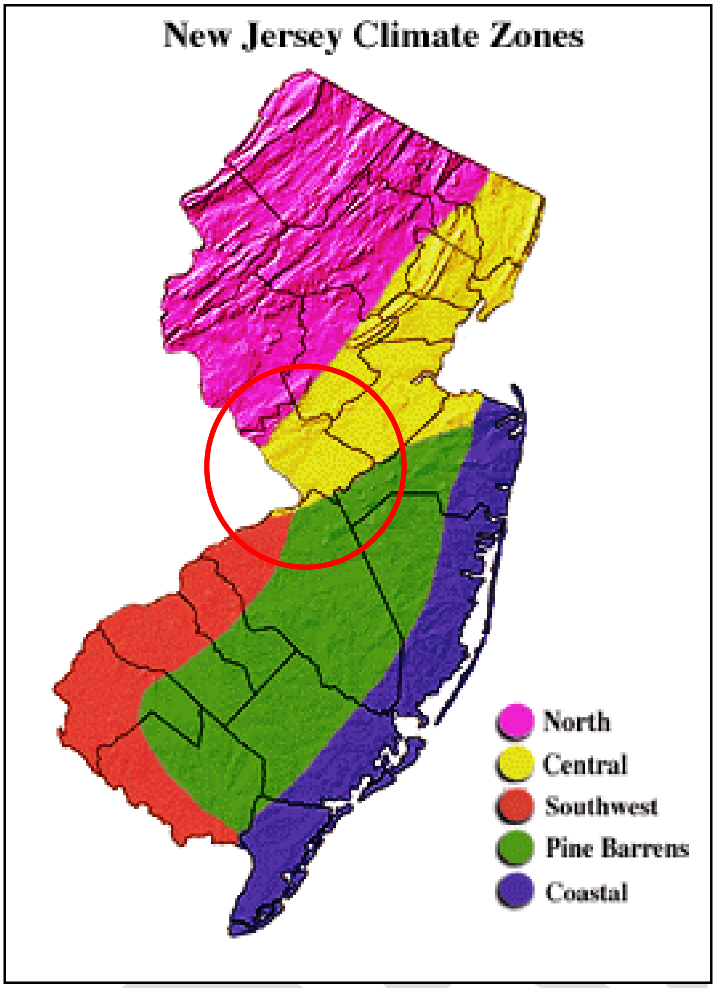
The northern edge of the Central Zone is often the boundary between freezing and non-freezing precipitation during wintertime. In summer, the northern reaches often mark the boundary between comfortable and uncomfortable sleeping conditions. Areas to the south of the Central Zone tend to have nearly twice as many days with temperatures above 90 degrees F than the 15-20 commonly observed in the central portion of the state (ONJSC Rutgers University n .d.).

The Northern Climate Zone covers about one-quarter of New Jersey and consists mainly of elevated highlands and valleys which are part of the Appalachian Uplands. Surrounded by land, this region can be characterized as having a continental type of climate with minimal influence from the Atlantic Ocean, except when the winds contain an easterly component. Prevailing winds are from the southwest in summer and from the northwest in winter. Being in the northernmost portion of the state, and with small mountains up to 1800 feet in elevation, the Northern Zone normally exhibits a colder temperature regime than other climate regions of the State. This difference is most dramatic in winter when average temperatures in the Northern Zone can be more than ten degrees Fahrenheit cooler than in the Coastal Zone (ONJSC Rutgers University n.d.).

A storm track extending from the heart of the Mississippi Valley, over the Great Lakes, and along the St. Lawrence Valley is a major source of precipitation for this region. Coastal storms add to the precipitation totals. During the warm season, thunderstorms are responsible for most of the rainfall. Cyclones and frontal passages are less frequent during this time. Thunderstorms spawned in Pennsylvania and New York State often move into northern New Jersey, where they often reach maximum development in the evening. This region has about twice as many thunderstorms as the coastal zone, where the nearby ocean helps stabilize the atmosphere (ONJSC Rutgers University n.d.).

The Northern Climate Zone usually has the shortest growing season, about 155 days. The average date for the last killing Spring frost is May 4. The first frost in Fall is around October 7. The exact dates vary significantly within the region as well as from year to year. Some valley locations have observed killing frost in mid-September and as late as mid-June (ONJSC Rutgers University n.d.).

Figure 4.3.11-6. Climate Regions of New Jersey



Source: ONJSC Rutgers University n.d.
Note: The red circle indicates the location of Mercer County.

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 Mercer County. Historical data presented in Table 4.3.11-1 shows the most powerful severe weather records in Mercer County.

Table 4.3.11-1. Severe Storm Extent in Mercer County (1950-2021)

Extent of Severe Storms in Mercer County	
Largest Hailstone on Record	1.75 inches
Strongest Tornado on Record	F-2
Highest Wind Speed on Record	63 knots

Source: NOAA-NCEI 2021

Thunderstorms

NWS considers a thunderstorm severe if it produces damaging wind gusts of 58 mph or higher, hail 1 inch (quarter size) in diameter or larger, or tornadoes (NWS 2010b). Severe thunderstorm watches and warnings are issued by the local NWS office and NOAA's Storm Prediction Center (SPC). 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 thunderstorms in New Jersey are defined as follows:

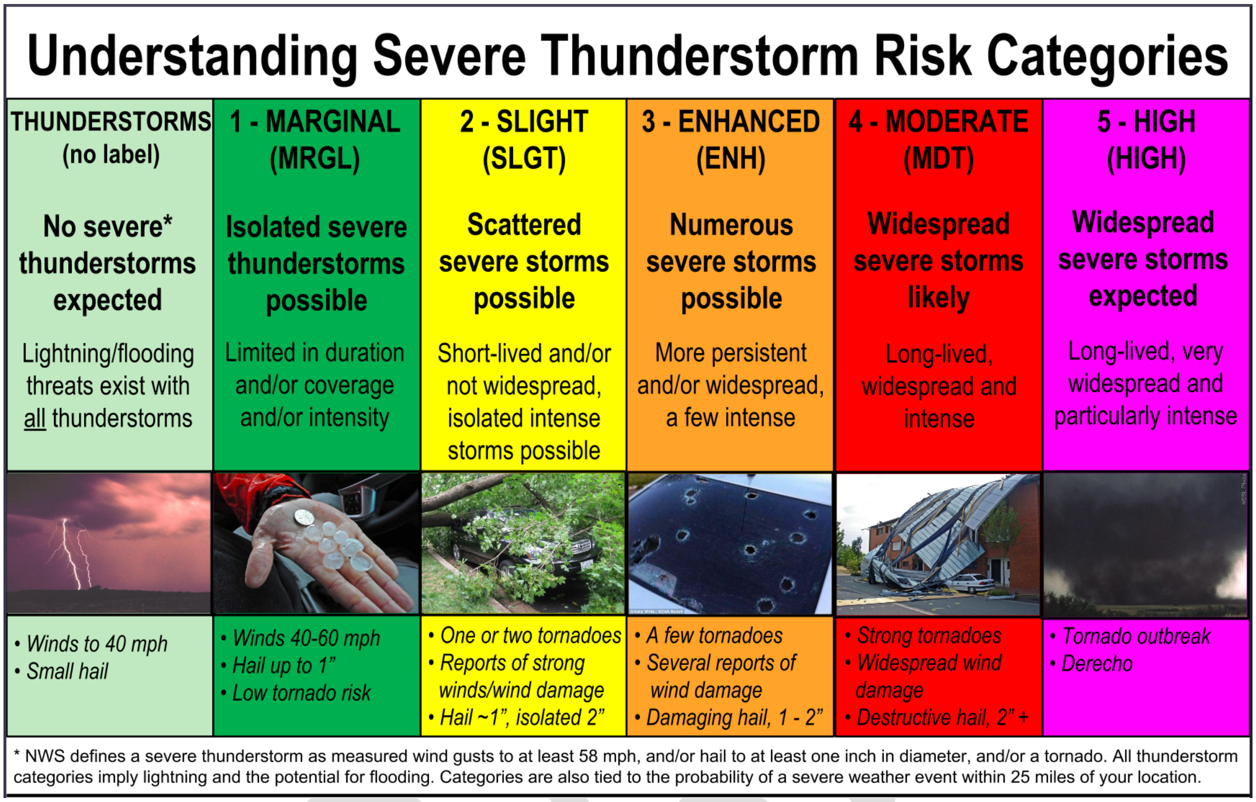
- *Severe Thunderstorm Warnings* are issued when there is evidence based on radar or a reliable spotter report that a thunderstorm is producing (or is forecast to produce) wind gusts of 58 mph or greater, structural wind damage, and hail 1 inch in diameter or greater. A warning will include the location of the storm, the municipalities that are expected to 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 2010).

- *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 3 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, NWS will keep the public informed on developments happening in the watch area and will also notify the public when the watch has expired or been cancelled (NWS 2010).

- *Special Weather State for Near Severe Thunderstorms* bulletins 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 (1) inch in diameter (NWS 2010).

In addition, the SPC issues severe thunderstorm risk maps based on the likelihood of different severities of thunderstorms. Figure 4.3.11-7 shows the SPC's severe thunderstorm risk categories.

Figure 4.3.11-7. Severe Thunderstorm Risk Categories



Source: NOAA SPC 2017

Lightning

Lightning is most often associated with moderate to severe thunderstorms. The severity of lightning refers to the frequency of lightning strikes during a storm. Multiple devices are available to track and monitor the frequency of lightning.

Hail

The severity of a hailstorm is measured by duration, hail size, and geographic extent. Most hail stones from hailstorms are made up of variety of sizes. The size of hail is estimated by comparing it to a known object. Table 4.3.11-2 describes the different sizes of hail as compared to real-world objects and lists approximate measurements.

Table 4.3.11-2. Hail Size

Description	Diameter (in inches)
Pea	0.25
Marble or mothball	0.50
Penny or dime	0.75
Nickel	0.88

Description	Diameter (in inches)
Golf ball	1.75
Hen's egg	2.00
Tennis ball	2.5
Baseball	2.75

Description	Diameter (in inches)	Description	Diameter (in inches)
Quarter	1.00	Tea cup	3.00
Half dollar	1.25	Grapefruit	4.00
Walnut or ping pong ball	1.50	Softball	4.50

Source: NOAA 2012

Windstorms

Table 4.3.11-3 lists the NWS descriptions of winds during wind-producing events.

Table 4.3.11-3. 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 2015a).

Tornado

The magnitude or severity of a tornado is categorized using the Enhanced Fujita Tornado Intensity Scale (EF Scale). Figure 4.3.11-8 illustrates the relationship between EF ratings, wind speed, and expected tornado damage.

Figure 4.3.11-8. Enhanced Fujita Tornado Intensity Scale Ratings, Wind Speeds, and Expected Damage

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.		

Source: NWS 2018

Tornado watches and warning are issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly, that little, if any, advance warning is possible (NOAA 2011).

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 (Figures 4.3.11-9 and 4.3.11-10). 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 2013).

Figure 4.3.11-9. NWS Heat Index Chart

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 2015b
°F degrees Fahrenheit
% percent

Figure 4.3.11-10. Adverse Effects of Prolonged Exposures to Heat on Individuals

Category	Heat Index	Health Hazards
Extreme Danger	130 °F – Higher	Heat Stroke / Sunstroke is likely with continued exposure.
Danger	105 °F – 129 °F	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Extreme Caution	90 °F – 105 °F	Sunstroke, muscle cramps, and/or heat exhaustions possible with prolonged exposure and/or physical activity.
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity.

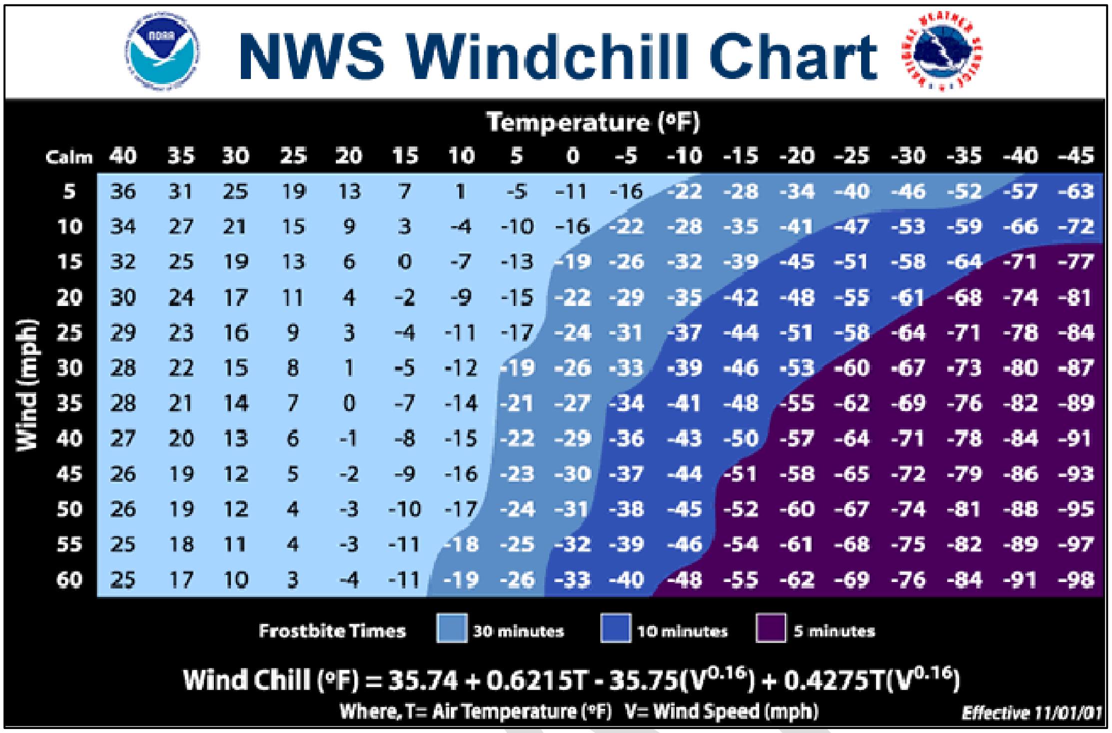
Source: NWS 2009c
°F degrees Fahrenheit

Extreme Cold

The extent (severity or magnitude) of extreme cold temperatures are generally measured through the Wind Chill Temperature (WCT) Index. Wind Chill Temperature is the temperature that people and animals feel when outside and it is based on the rate of heat loss from exposed skin by the effects of wind and cold. As the wind increases, the body is cooled at a faster rate causing the skin's temperature to drop (NWS n.d.).

On November 1, 2001, the NWS implemented a new WCT Index. It was designed to more accurately calculate how cold air feels on human skin. The table below shows the new WCT Index. The WCT Index includes a frostbite indicator, showing points where temperature, wind speed, and exposure time will produce frostbite to humans. Figure 4.3.11-11 shows three shaded areas of frostbite danger. Each shaded area shows how long a person can be exposed before frostbite develops (NWS n.d.).

Figure 4.3.11-11. NWS Wind Chill Index



NWS Windchill 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 n.d.
°F degrees Fahrenheit
mph miles per hour

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

Many sources provided historical information regarding previous occurrences and losses associated with severe weather events throughout Mercer 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.

Federal Disaster Declarations

Between 1954 and 2021, Mercer County has been included in six declarations for severe storm-related events classified as severe storm (FEMA 2021). Table 4.3.11-4 lists these events.

Table 4.3.11-4. Severe Storm-related FEMA Disaster Declarations

Declaration	Event Date	Declaration Date	Event Description
DR-1563	September 18 - October 1, 2004	October 1, 2004	Severe Storms and Flooding
DR-1588	April 1-3, 2005	April 19, 2005	Severe Storms and Flooding
DR-1653	June 23 - July 10, 2006	July 7, 2006	Severe Storms and Flooding
DR-1694	April 14-20, 2007	April 26, 2007	Severe Storms and Inland and Coastal Flooding
DR-1897	March 12-April 15, 2010	May 7, 2010	Severe Storms and Flooding
DR-4039	September 28 - October 6, 2011	October 14, 2011	Remnants of Tropical Storm Lee

Source: FEMA 2021

USDA Disaster Declarations

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. Mercer County was included in declarations related to severe weather in 2015 and 2016.

Table 4.3.11-5. USDA Agriculture Disaster Declarations, 2015 to 2021

Year	Designation number	Description	Losses
2015	S3930	Excessive Heat and Drought	$80,491.80 for All Other Crops
2016	S4071	Combined effects of freeze, excessive heat, and drought	$7,908 for Corn $98,079.75 for Soybeans

Source: USDA 2021a, b

Severe Weather Events

Severe weather events that have impacted Mercer County between 2015 and 2021 are identified in Table 4.3.11-6. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

Table 4.3.11-6. Severe Weather Events in Mercer County, 2015 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
June 12, 2015	Heat	N/A	N/A	Mercer County	An unseasonably hot and humid air mass caused high temperatures to reach the lower to mid 90s in southwest New Jersey on the 12th. Combined with relatively high dew points, peak hourly heat index values reached the upper 90s. The heat forced some schools, especially those without air conditioning, to dismiss children early. Actual high temperatures included 95 degrees at the Philadelphia International Airport, 94 degrees in Haddonfield (Camden County), 93 degrees in South Harrison (Gloucester County), 92 degrees at the South Jersey Regional Airport (Burlington County) and Trenton (Mercer County) and 91 degrees in Woodstown (Salem County). While humid weather continued beyond the 12th, a weak back door cold front brought in a slightly cooler air mass into New Jersey on the 13th.
July 19-20, 2015	Excessive Heat	N/A	N/A	Mercer County	Unseasonably hot and humid weather affected most of New Jersey on the 19th and 20th. High temperatures in most areas reached into the lower to mid 90s both days. The 19th was slightly hotter and more humid overall. The combination of heat and humidity brought afternoon heat index values as high as 100F to 105F on the 19th. These were some of the highest heat index values of the entire summer. A dissipating cold front on the 20th brought slightly drier air into the region during the afternoon of the 20th and heat index values peaked around 100F . A re-enforcing cold frontal passage on the 21st brought even cooler and drier air into the area and by the 22nd all high temperatures were less than 90 degrees in New Jersey. To combat the heat, many counties, cities and municipalities opened cooling centers. The hours of air-conditioned senior citizen centers were extended. In Camden County, free fans were distributed to senior citizens. Highest temperatures included 96 degrees in Hamilton (Mercer County County).

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
August 20, 2015	Thunderstorm Wind	N/A	N/A	Ewing Township	An approaching cold front coupled with a warm, moist airmass triggered scattered showers and thunderstorms across southeastern Pennsylvania and into central and southern New Jersey during the late evening of the 20th through the early morning of the 21st. The thunderstorms were accompanied by heavy rainfall, leading to areas of flash flooding. In addition, isolated wind damage also occurred. A thunderstorm wind gust knocked down a 40 foot section of a tree and a telephone pole in Ewing Township at 12:35 a.m. EDT on the 21st resulting in $500 in damage.
February 14, 2016	Cold/Wind Chill	N/A	N/A	Mercer County	Bitter cold temperatures and strong northwest winds associated with an Arctic outbreak combined to create dangerous wind chill temperatures across the entire northeast quadrant of the county beginning Saturday morning, February 13th into Sunday afternoon, February 14th. Many local governments across the area set up Code Blue shelters for the vulnerable population. The lowest wind chill values were reported at the following locations during the early morning hours of February 14th: 18 degrees below zero in Skillman, 12 degrees below zero in Edinburg, and 11 degrees below zero at Mercer County Airport.
February 24, 2016	Thunderstorm Wind	N/A	N/A	Princeton Township	A strong low pressure system moving north through the Great Lakes region, combined with its associated warm front and cold front, copious amounts of moisture, and low level jet, produced strong to severe thunderstorms, heavy rain, flash flooding, and stream flooding in New Jersey late Wednesday afternoon and evening, February 24th, with stream flooding continuing into Thursday, February 25th. Thousands were without power for a period across the state, focused in South Jersey. Thunderstorm wind gusts brought down wires and trees in Princeton.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
April 2, 2016	Hail	N/A	N/A	Lawrence Township	A strong cold front associated with a low pressure system moving through New York State swept across the area during the late evening hours of April 2nd and early morning hours of April 3rd, accompanied by thunderstorms, very strong convectively driven winds, and small hail. As colder air behind this front drained south, precipitation changed to snow, with up to three inches falling in the higher elevations of northwest New Jersey and lesser amounts in isolated spots through most of New Jersey. The parent low pressure system then quickly intensified as it continued to move northeast away from the area. The gradient between this low pressure system and incoming high pressure produced strong winds gusting over 60 MPH in some localities from late overnight through the morning hours of April 3rd. A reported peak wind gust of 51 MPH took place at Mercer County Airport at 0605EST (Mercer County). 81,000 were without power across the state. Thunderstorms associated with a strong cold front moving across the area during the early overnight hours on the 3rd produced three-quarter inch hail in Lawrence Township.
April 26, 2016	Hail	N/A	N/A	Robbinsville	A cold front in southern New York moved slowly south across the area during the late afternoon and evening hours on the 26th, producing thunderstorms with gusty winds, small hail, and heavy rain. Nickel size hail was reported in Robbinsville, NJ at 1745EST.
May 26, 2016	Excessive Heat	N/A	N/A	Trenton	A southwesterly flow produced the first 90-degree temperatures of the 2016 season on the 26th. These temperatures, in combination with high relative humidity, caused heat-related stress for more than a dozen middle school students from William Penn Middle School in Lower Makefield Township (Bucks County PA) while they were attending a Trenton Thunder baseball game at Arm and Hammer Park in Trenton. Many of these students started felling light-headed at the stadium, and were taken to a nearby

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					hospital for treatment for heat stroke. Other students were treated after they returned to their school during the early afternoon hours. The high temperature at Trenton on the 26th was 90 degrees.
June 21, 2016	Thunderstorm Wind	N/A	N/A	Groveville	A cold frontal boundary moved south into New Jersey during the morning hours of the 21st before stalling. This front served as a focal point for showers and thunderstorms to develop across the region. Some of the storms were severe particularly in the afternoon. More than 30,000 people lost power for a time. Several trees and wires were downed in Groveville due to thunderstorm winds.
July 9, 2016	Thunderstorm Wind	N/A	N/A	Trenton	A stationary frontal boundary remained in place with a sharp contrast in temperatures between the Jersey shore and areas further inland. This thermal difference along the front coupled with instability west of the front lead to the development of showers and thunderstorms across portions of the state. Several trees taken down due to thunderstorm winds in Trenton.
July 25, 2016	Thunderstorm Wind	N/A	N/A	Pennington, Washington Crossing	A trough of low pressure led to the development of afternoon and evening showers and thunderstorms which became severe in spots and produced locally heavy rains. 40,000 were left without power across the state. Trees were downed in Pennington due to thunderstorm winds. Several wires and trees downed due to thunderstorm winds on Route 29 near Washington Crossing.
January 23, 2017	Strong Wind	N/A	N/A	Hamilton Township	An area of low pressure over North Carolina on the 23rd strengthened and moved northeast to a location just off the New Jersey Coastline on the morning of the 24th. With a very tight pressure gradient, winds increased ahead of the storm reaching in excess of 50 mph that led to some damage reports. A few periods of heavy rainfall occurred. Excessive rainfall close to 2 inches was

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					focused in sections of Northern and Eastern New Jersey. Power outages from the storm were estimated at around 20,000. Numerous schools either dismissed early on the 23rd or had a delay/closing on the 24th. Transit services were interrupted both days. A tree was knocked due to wind in Hamilton Township resulting in $100 in damages.
June 19, 2017	Strong Wind	N/A	N/A	Mercer County	A complex of thunderstorms came through the region during the evening producing high winds and heavy rain. Wind damage occurred in several locations from the thunderstorms. A tree fell onto a towpath near Jacobs Creek Road. $100 in damages were reported.
June 24, 2017	Thunderstorm Wind	N/A	N/A	Pennington, East Windsor	A band of gusty convective showers moved through during the morning hours in association with the remnants of tropical storm Cindy. Several reports of damage were reported from the winds. Thousands lost power. Wires were reported down in Pennington and East Windsor
July 1, 2017	Thunderstorm Wind	N/A	N/A	White Horse	Strong to severe thunderstorms ahead of a cold front decayed as they moved east into New Jersey. Still some wind damage from thunderstorms occurred near Trenton. A large tree fell onto Lake Avenue which damaged two cars and a pair of jet skis.
July 20, 2017	Thunderstorm Wind	N/A	N/A	Pennington, Agasote	A complex of severe thunderstorms moved southeast across northern portions of state producing wind damage before weakening as it reached central portions of the state. Lightning struck several trees on the night of the 20th which created a 3,500 acre fire that burned for a few days. A tree was downed from thunderstorm winds along route 31 near Olden Avenue in Pennington.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
March 2, 2018	High Wind	N/A	N/A	Mercer County	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. Heavy rainfall occurred in New Jersey and Eastern Pennsylvania on March 1st and 2nd, with widespread rainfall amounts of 1 to 2 inches. In addition, areal and minor small stream flooding also occurred. As the rain changed to snow on the 2nd, localized heavy snowfall occurred, particularly over the higher elevations. Southeast of the New Jersey Turnpike and Interstate 95, up to around 3 inches of snowfall was observed. To the Northwest of the New Jersey Turnpike and Interstate 95, up to around 6 inches of snow was measured with localized amounts of around 9 inches. Higher elevations mainly to the north of Interstate 80 in New Jersey generally reported greater than 9 inches of snow, with amounts ranging from 10 to 18 inches generally around 1,000 feet and above. Downed trees and wires were reported throughout the county. A wind gust of 54 mph was recorded by the ASOS unit at Mercer County Airport at 1620EST on March 2nd. Another wind gust of 62 mph in Lawrenceville at 1700EST on March 2nd was reported on social media.
April 4, 2018	High Wind	N/A	N/A	Ewing Township	Low pressure developed over the Central Plains on April 3rd, deepening as it moved into the Saint Lawrence Valley on April 3rd and to Prince Edward Island on

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					April 4th, due to a significant contrast in air masses with Continental Polar air to the north and Maritime Tropical air to the south. This lead to a strong cold frontal passage across the region on April 4th. In the wake of this front, colder air moving into the area and a tight pressure gradient lead to widespread damaging west-northwest wind gusts in excess of 50 mph on April 4th. Law Enforcement reported a tree and wires down blocking a portion of Mountainview Road in Ewing.
May 15, 2018	Thunderstorm Wind	N/A	N/A	West Trenton	Severe thunderstorms moved across portions of northern New Jersey with hail and wind damage reported. A downed tree was reported on State Highway 29 near Upper Ferry Road in West Trenton which led to lane closures.
July 1-3, 2018	Excessive Heat	N/A	N/A	Mercer County	Temperatures in the middle to upper 90s and dew points in the upper 60s to lower 70s led to excessive heat across portions of southeastern Pennsylvania. Heat indices reached 108 degrees at the Trenton Airport ASOS on July 3rd.
October 2, 2018	Thunderstorm Wind	N/A	N/A	East Trenton, Ajax Park	Supercellular severe thunderstorms caused 2 tornadoes, wind damage, and hail across the region all part of a record breaking tornado outbreak across Pennsylvania. A tree was down at US 1 and Mulberry Street in East Trenton. A tree was uprooted onto a house on King Avenue in Ajax Park. Minor structural damage. Downed power lines in the area.
October 27, 2018	High Wind	N/A	N/A	Mercer County	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. Tree down on wires on Ridgeview Road between great road and Baldwin Lane forcing a road closure.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
February 24-25, 2019	High Wind	N/A	N/A	Princeton Township, Lawrence Township, Prospect Park	A departing very deep cyclone combined with strong high pressure to the west yielded a strong pressure gradient from the Plains eastward to the northern Mid-Atlantic and New England regions. High winds gusting 50-60 mph resulted in scattered power outages and trees down across the region. Some minor structural damage also occurred. A tree fell across I-195 blocking Eastbound lanes near Exit 3. Trees, utility poles, and power lines were down on Great Road in Princeton. A tree fell across US-206 closing all lanes in Lawrence Twp. A large tree fell through a fence in Prospect Park.
April 15, 2019	Thunderstorm Wind	N/A	N/A	White Horse, Robbinsville Township, East Trenton, Hamilton Square, East Windsor, White Horse	A severe weather outbreak impacted much of the East Coast, causing widespread straight line wind damage and a few tornadoes. An approaching frontal system with strong wind fields moving into an unusually moist April air mass contributed to the formation of a well organized line of severe convection. This line moved through the mid-Atlantic during the predawn hours of April 15. A number of thunderstorm related damage reports were received. A tree was downed on the exit ramp of Interstate 295 southbound at Exit 61. A tree was reported down near Robbinsville Township. Multiple large trees were reported down in East Trenton. A roof was blown off of a shed in Hamilton Square with several trees down, including one onto a vehicle. Several large trees were uprooted on Shagbark Lane in East Windsor. One tree fell onto a house causing considerable structural damage, including chimney collapse and a destroyed outer wall. A tree was down on I-295 Southbound ramp to Exit 61 (Arena Drive) in White Horse.
April 26, 2019	Thunderstorm Wind	N/A	N/A	Agasote	A strong low pressure system tracked through the eastern Great Lakes on April 26. A warm front moved through the mid-Atlantic that morning with an initial round of locally strong but sub-severe convection. That afternoon, an approaching cold front triggered

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					widespread severe thunderstorm development. Widespread wind damage occurred as initially semi-discrete storms merged into a squall line. No tornado touchdowns were confirmed, but at least one funnel cloud was observed. A large tree was reported down in a park.
May 29, 2019	Hail, Thunderstorm Wind	N/A	N/A	Hopewell Township, Groveville, North Crosswicks, Woodsville, Princeton Township	The second day of a three day outbreak of severe weather, numerous severe thunderstorms developed over the mid-Atlantic as a wave of low pressure tracked along a stalled frontal boundary. Widespread wind damage occurred along with areas of severe hail. 1-inch hail was reported in Hopewell Township. 1.25-inch hail was reported in Groveville. 0.88-inch hail was reported in North Crosswicks. Downed trees and wires were reported in Woodsville on NJ-31 in both directions north of CR-612, closing all lanes. A downed utility pole and wires were reported on NJ-27 in Princeton Township in both directions at CR-571 and Washington St. All lanes were closed.
June 20, 2019	Thunderstorm Wind	N/A	N/A	White Horse	A frontal boundary which had been positioned over the mid-Atlantic for several days finally pushed offshore on June 20. As it did so, a final round of showers and thunderstorms developed. A few of these storms became severe with damaging winds in addition to very heavy rainfall. A downed tree was reported on I-295 southbound north of Exit 57 and several trees were reported down near Exit 1 in White Horse caused lane restrictions on the interstate.
June 29, 2019	Thunderstorm Wind	N/A	N/A	Hopewell Township	A frontal boundary that had been stalled over the mid-Atlantic had lifted north of the region by the morning of June 29. Later that day and into the evening, the front

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					once again approached, this time as a strong cold front, as low pressure tracked through New England and began to intensify offshore in the Gulf of Maine. The combination of strong frontal forcing and a warm, unstable environment ahead of the front led to widespread severe thunderstorms developing. Numerous reports of damaging wind, as well as some hail, were received in association with these storms. In Hopewell Township, a large tree was reported down over a roadway with a limb on a car.
July 2, 2019	Thunderstorm Wind	N/A	N/A	Princeton Township	A warm and humid air mass combined with an approaching trough led to thunderstorm development over interior parts of the mid-Atlantic, with storms gradually propagating eastward. While a lack of wind shear limited the extent of severe weather, some storms did still become strong to severe and produced pockets of damaging wind. Wires were reported down near Princeton.
July 6, 2019	Thunderstorm Wind	N/A	N/A	Hopewell Township	A cold front and a weak upper level disturbance approached the mid-Atlantic on July 6. A hot and humid air mass was in place, with high temperatures well into the 90s. This led to significant instability, and combined with adequate shear and the forcing from the approaching disturbances, scattered strong to severe thunderstorms developed in the area. In Somerset, a tree was down on NJ-29 northbound near River Knoll Dr in Hopewell Township. All lanes were closed.
July 17, 2019	Thunderstorm Wind	N/A	N/A	Ewing Township, Princeton Township	The remnants of Hurricane Barry moved near and west of the mid-Atlantic on July 17, in tandem with a frontal system which was absorbing the former tropical cyclone. A hot air mass existed east of this system, and the tropical moisture associated with Barry combined with the heat to create an unstable environment primed for heavy rainfall and severe weather. Widespread

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					convection developed, with a number of storms producing damaging wind. In Ewing Township, a downed tree blocked a lane of NJ-31 northbound near CR-636. In Princeton Township, a downed tree blocked all lanes of NJ-27 southbound south of CR-605.
July 22, 2019	Thunderstorm Wind	N/A	N/A	Trenton, Mercerville, Robinsville, Dutch Neck, Princeton Junction	A frontal boundary stalled over the mid-Atlantic on July 22. An approaching upper level trough helped spur the development of a wave of low pressure along the front. A very favorable environment for convection and severe weather developed along and south of this boundary. Extremely high moisture content was present in the air mass, allowing moderate to strong instability to build during the heating of the day. The frontal boundary and developing low also helped to enhance both low level and deep layer shear to respectably strong values for midsummer. The result was a day of widespread severe weather. Discrete storms early in the afternoon gave way to a powerful mesoscale convective system in the evening which produced widespread damaging winds with considerable damage over a large area. Multiple trees were snapped in Trenton. Multiple small to medium size trees were downed in Mercerville with one house on Post Road damaged by a fallen tree. A tree was downed on I-195 eastbound approaching Exit 6 in Robinsville. A downed tree blocked Village Road East in Dutch Neck. Social media photos in the area showed trees blown down or uprooted in Princeton Junction.
August 7, 2019	Thunderstorm Wind, Hail, Tornado	N/A	N/A	East Windsor, Princeton Township, Rosedale, Hightstown	A cold front along with a robust shortwave trough gradually approached the eastern mid-Atlantic on August 7. A pre-frontal surface trough was also in place. Ahead of the front, a warm and moist air mass built through the day. Strong instability developed, along with moderate wind shear. Convection initially developed along the pre-frontal trough. Later, a squall line associated with the front and trough combination moved through the region. Given the strong instability and

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					adequate shear, numerous storms became severe, primarily producing damaging winds. In addition, low level shear was sufficient to help spawn a couple of brief tornadoes in New Jersey. Several reports of trees and limbs down in East Windsor. Nickel size hail was also reported. Downed power lines were reported in Princeton. A downed tree closed all lanes of US-206 northbound at CR-533. Some flooding also occurred on the roadway. Power lines were downed at Lawrenceville Road and Province Line Road in Rosedale. A weak tornado briefly touched down on the property of Voorhees Greenhouse in Hightstown, NJ on the afternoon of Wednesday, August 7. The tornado began near Sharon Road, where several trees and branches were downed. The most significant damage observed was to a greenhouse, whose glass roof was shattered. Shards of glass were blown for hundreds of yards, with many shards also piercing clean through the doors and walls of a nearby barn. A few metal support beams from the greenhouse were also tossed up to 200 yards from their original position, with a number of loose outdoor objects tossed about in a chaotic, yet circular manner often consistent with tornadic winds. Eyewitnesses working at the time reported seeing circulating winds and a possible condensation funnel as damage to the greenhouse was occurring. The tornado then passed over a barn, scattering shards of glass, flower planters, and support beams. Many of these objects were deposited on the other side of the barn into a nearby field. Several trees sustained damage to limbs and branches, but all were left upright. The tornado dissipated as it moved into a clearing beyond the wooded area. One woman received a minor cut from flying glass, but thankfully, no serious injuries occurred as a result of this tornado, which was especially fortunate given the large volume of broken glass strewn about the impacted property.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
October 31, 2019	Thunderstorm Wind	N/A	N/A	Washington Crossing, Princeton Township	A severe weather outbreak impacted the mid-Atlantic from the evening of October 31 through the pre-dawn hours of November 1. A strong area of low pressure moved through the eastern Great Lakes on the 31st. Ahead of it, strong southerly flow advected an unseasonably warm and moist air mass into the mid-Atlantic. This generated enough instability, combined with extremely strong wind fields, to produce a low topped line of severe convection which tracked across the entire region. Widespread damaging wind occurred as the squall line moved through, along with a couple of short lived embedded tornadoes. A tree was downed on NJ-29 between Washington Crossing Road and Valley Road in Washington Crossing. All lanes were closed. A tree was downed on NJ-64 southbound near Cranbury Road in Princeton Township. All lanes were closed.
February 7, 2020	Thunderstorm Wind	N/A	N/A	Trenton Mercer County Airport, Woodsville, Princeton Township, Rocky Hill	An area of low pressure moving out of the Southeast began to explosively intensify as it moved over the mid-Atlantic. On the morning of February 7, the eastern mid-Atlantic was briefly within the warm sector of the deepening low. An environment of extreme wind fields was present, and temperatures and dew points rose enough for sufficient instability to develop to sustain convection. A line of low topped but intense convection developed, and despite producing little thunder and lightning it produced a long swath of wind damage over the mid-Atlantic. A gust of 56 knots was reported at Trenton Mercer County Airport. A tree was downed on NJ-31 in both directions north of CR-612 in Woodsville. All lanes were closed and detoured. In Princeton Township, Great Road was closed between Stuart Road and Princeton Day School from a pole and wires down across the road. A tree and wires were downed near Window Drive in Rocky Hill.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
March 3, 2020	Lightning	N/A	N/A	Pennington Township	A warm front moved north through parts of the mid-Atlantic during the late morning and afternoon of March 3. A cold front followed closely behind it in association with strengthening low pressure moving through the eastern Great Lakes. An upper level shortwave was also approaching the area. The cold front moved rapidly through the region during the evening hours. Ahead of it, a weakly unstable but strongly forced and highly sheared environment existed. Widespread showers and some embedded thunder developed, and while lightning activity was limited the strength of the forcing and shear profiles allowed for some damaging wind gusts to occur. In Pennington Townhsip, lightning struck a large tree causing electrical damage to some neighboring homes.
April 21, 2020	Thunderstorm Wind	N/A	N/A	Clarksville, Agasote	Strong low pressure tracked through southern Canada on April 21. A warm front associated with the low moved through the mid-Atlantic during the morning hours, with a strong and fast moving cold front following closely behind for the afternoon. This was an unseasonably strong cold front which marked the leading edge of a much colder than average air mass moving into the region behind it. A strongly forced and highly sheared environment existed ahead of the front. Widespread morning cloudiness and rain showers limited instability, but a brief window of clearing allowed for heating and destabilization to occur. A severe squall line developed, producing considerable wind damage over eastern portions of the mid-Atlantic. A weak tornado also occurred along the New Jersey coast. In Clarksville, several trees were downed near Quaker Bridge Mall. In Agasote, power lines were downed from strong winds.
June 3, 2020	Thunderstorm Wind	N/A	N/A	Titusville, Hopewell Township, Trenton Mercer County Airport, Lawrenceville	A derecho developed just southeast of Lake Erie during the early morning hours of June 3, 2020, then moved rapidly southeast across Pennsylvania before exiting the central New Jersey coast during the early afternoon hours, approximately 130 PM. Damaging winds in

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
				Township, Hamilton Square	excess of 60 MPH were sporadic over western and central Pennsylvania, but as the thunderstorm complex moved into increasingly unstable air in the eastern part of the state just before noon, wind damage reports became more numerous and widespread. Most of these reports were confined within a 50-mile wide swath extending from Berks County eastward to the Philadelphia metro area, then further east to the Ocean County shoreline in New Jersey. Wind gust reports between 60 and 70 MPH were common within this swath. In addition to these destructive wind gusts, frequent to continuous cloud to ground lightning and heavy downpours were also reported throughout the area. Over 112,000 power outages were reported in southern New Jersey as a result of fallen trees on power lines. Some localities were without power for several days. Because this derecho moved off the coast by 200 PM, the warm afternoon sun was able to sufficiently destabilize the atmosphere for the formation of another round of severe thunderstorms over some of the same areas that experience them earlier in the day. Reported wind gusts associated with these thunderstorms generally ranged between 45 and 65 MPH, with a 65 MPH wind gust measured at the Philadelphia International Airport. The remaining thunderstorms then moved offshore by 1000 PM, which brought an end to the day's severe weather. Downed power poles and wires were reported on State Highway 29 north of Pleasant Valley Road near Titusville. A large tree damaged property in Hopewell Township. Trees were reported down in Lawrenceville. Large parts of trees were blown down in Hamilton Square. A gust of 50 knots was measured at Trenton Airport.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
June 27, 2020	Thunderstorm Wind	N/A	N/A	East Windsor	An upper level disturbance and associated trough of low pressure over northeast Pennsylvania and northern New Jersey, in conjunction with high dew point temperatures and instability, touched off showers and thunderstorms across the central and southern portions of the Garden State during the afternoon and evening hours. Several reports of downed power lines in the East Windsor Township area.
July 6, 2020	Hail	N/A	N/A	White Horse, Hamilton Square, Mercerville	A slow moving backdoor cold front drifted southwest through the mid-Atlantic region on July 6. Meanwhile, a shortwave vorticity impulse, one of several in a series, moved across the region during the day. A very hot and humid air mass was present ahead of the backdoor cold front, leading to the development of strong to extreme instability over the region. The approaching upper level disturbance allowed for the development of moderate wind shear over the region. Combined with the front, it also acted as a trigger mechanism for convection. Severe thunderstorms developed by early afternoon over eastern PA and southern and central New Jersey. These storms produced strong outflow boundaries which served to initiate additional severe convection. The result was a ring of fire in which outflow steadily propagated outward in all directions. This caused severe weather to spread radially outward from its origin near Philadelphia to much of New Jersey, other portions of eastern Pennsylvania, and Delmarva. Quarter sized hail was reported in White Horse. Mainly penny size hail was reported in Hamilton Square but a few hailstones to quarter size and ping pong sized. Hail fell for around 15 minutes. Quarter sized hail was reported in Mercerville.
July 22, 2020	Thunderstorm Wind	N/A	N/A	Washington Crossing, Hopewell Township, West Trenton	A slow moving frontal boundary was draped across upstate New York and southern New England on July 22 with multiple waves of low pressure tracking along it. The mid-Atlantic was left in a warm sector air mass south of this front. This led to a very hot and humid day

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					on July 22 with air temperatures rising into the 90s and dew point values near 70. This caused strong instability to develop. Shear values were not overly impressive, but an approaching shortwave disturbance from the Midwest did help to increase shear late in the day. This disturbance also served as forcing for convection to develop in the warm and unstable air mass. Widespread thunderstorm development occurred, with storms eventually developing into a mostly solid squall line. This line of storms produced numerous reports of wind damage across eastern Pennsylvania, New Jersey, and Delmarva. Trees and wires were downed near Maddock Road and River Road in Washington Crossing. Several reports of downed wires in the Hopewell area. There were several reports of wires down in West Trenton.
August 3, 2020	Thunderstorm Wind	N/A	N/A	West Windsor	A diffuse, slow moving frontal boundary was present over the mid-Atlantic on August 3 as an upper level trough also approached from the west. Meanwhile, Hurricane Isaias was steadily approaching from the south, with tropical moisture beginning to overspread the region. The result was a warm and humid day on August 3. This created an unstable environment, and forcing from the frontal boundary as well as the approaching trough helped to trigger afternoon thunderstorm development. Shear also increased as mid level winds increased ahead of the trough and Isaias. This led to a considerable severe weather event in advance of Isaias, with multiple clusters of thunderstorms producing scattered and in some cases significant wind damage over New Jersey. Trees and wires were downed near Hendrickson Drive in West Windsor.
August 28, 2020	Thunderstorm Wind	N/A	N/A	Trenton, Allentown	A quasi-stationary frontal boundary was located near the border region of the mid-Atlantic and New England for much of the day on August 28. South of the front, a hot and humid air mass developed. In addition, a fast

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					moving approaching shortwave disturbance caused shear to increase, creating an environment of moderate to strong shear and instability as well as high moisture. Forcing from the shortwave caused widespread convection to develop by early to mid afternoon. Significant storm organization occurred, particularly in association with a line of storms that impacted portions of Pennsylvania, New Jersey, and northern Delmarva. This mesoscale convective system (MCS) produced widespread wind damage, with a few other storms across the region also producing damaging winds. Tree limbs and wires were downed near Bunting Avenue in Trenton. Power lines were downed near Circle Drive in Allentown.
September 3, 2020	Thunderstorm Wind	N/A	N/A	Trenton, Hamilton Township	A frontal boundary stalled over the mid-Atlantic on the overnight of September 2 and lifted northward slightly during the day on September 3. A robust shortwave trough was also approaching during the day. This combination caused a high shear environment to develop, with good moisture also present. However, instability was marginal due to considerable cloud cover over the area. In addition, multiple rounds of storms associated with different sources of lift tended to work against each other, as storms generally struggled to organize and become dominant. However, given the high shear some storms still became strong to severe and produced instances of damaging wind. Downed trees, wires, and some minor roof damage were reported in a concentrated are in Hamilton Township, especially near Redfern Street.
November 15, 2020	Thunderstorm Wind	N/A	N/A	Titusville	Strong low pressure moved through the Great Lakes on November 15, 2020. As it did so, it pushed a warm front through the mid-Atlantic during the late morning and early afternoon hours, causing unseasonably warm conditions to develop. Strong mid and upper level dynamics associated with this low pressure caused linear convection to develop ahead of its associated cold front

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					early in the day. While instability ahead of the front was very limited, the strong frontal forcing combined with extreme wind fields allowed two primary lines of convection to form and produce severe convective wind gusts as they moved east. One of these lines tracked into the eastern mid-Atlantic and towards the coast during the evening hours. It produced widespread wind gusts of around 60 mph, with a number of reports of downed trees and power lines and localized property damage across the region. A downed power pole and wires closed all lanes of NJ-29 southbound near River Drive in Titusville.
November 30, 2020	Thunderstorm Wind	N/A	N/A	Woodsville	A complex storm system affected the mid-Atlantic on November 30, 2020. Developing low pressure over the Southeast US began to interact and phase with a clipper system over the Great Lakes, leading to a steadily intensifying low tracking northward along the Appalachians. This would become the primary low pressure system, which moved into Pennsylvania by the afternoon of the 30th. Ahead of the low, a warm front pushed through the mid-Atlantic and brought a period of rain with embedded thunder during the morning and early afternoon. By later in the day, a cold front began to approach. While increasing mid-level dry air was an inhibiting factor, the development of some sunshine after the earlier rain helped some modest instability to develop as surface temperatures rose well above seasonal normal. Combined with strong forcing and very strong wind fields in the narrow warm sector of the intensifying and highly dynamic low, convection developed ahead of the cold front. The combination of these factors led to a spatially limited but considerably impactful severe weather event over portions of eastern Pennsylvania, New Jersey, the Eastern Shore of Maryland, and northern Delaware. A number of instances of damaging wind as well as a couple of tornadoes occurred in the region.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Mercer County Designated?	Location	Description
					Trees and wires were downed near Harbourton Rocktown Road in Woodsville.

Source: FEMA 2021; NOAA-NCEI 2021; NWS 2021; SPC 2021; NJOEM 2019
DR Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph miles per hour
N/A Not Applicable

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 Mercer 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).

It is estimated that Mercer 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 Mercer County. It is estimated that the county will continue to experience these events annually.

According to the NOAA-NCEI storm events database, Mercer County has experienced 466 severe weather events between 1950 and 2021. This data was used to determine the recurrence interval and the average annual number of events for the county. The table below summarizes these statistics, as well as the annual average number of events and the estimated percent chance of an incident occurring in a given year (NOAA NCEI 2021).

Table 4.3.11-7. Probability of Future Severe Weather 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
Extreme Temperature	111	1.56	0.65	1.54	100%
Hail	35	0.49	2.06	0.49	48.6%
High/Strong Wind	123	1.73	0.59	1.71	100%
Lightning	32	0.45	2.25	0.44	44.4%
Thunderstorm Wind	154	2.17	0.47	2.14	100%
Tornado / Funnel Cloud	11	0.15	6.55	0.15	15.3%
Total	**466**	**6.56**	**0.15**	**6.47**	**100%**

Source: NOAA-NCEI 2021

In Section 4.4, the identified hazards of concern for Mercer 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 in the county is considered 'frequent'. The ranking of the severe weather 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 percent 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 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). 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 percent (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

Vulnerability Assessment

All of Mercer County is exposed to the severe weather hazard. A qualitative assessment is summarized below.

Impact on Life, Health and Safety

The entire population of Mercer County (367,922 people) is exposed to severe storm events (ACS 2019). Residents may be displaced or require temporary to long-term sheltering due to severe weather events. The number of households displaced by severe wind events is summarized in Section 4.3.8 (Hurricane and Tropical Storm). 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. Vulnerable populations include homeless persons, elderly (over 65 years old), low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads. According to the 2019 5-year ACS population data, there are 40,980 persons living below the poverty level and 59,941 persons over the age of 65 within Mercer County.

Additionally, people located outdoors (i.e., recreational activities and farming) are considered vulnerable to hailstorms, thunderstorms and tornadoes. This is because there is little to no warning and shelter may not be available. Moving to a lower risk location will decrease a person's vulnerability. Refer to Section 3 (County Profile) for population statistics for each participating jurisdiction.

Impact on General Building Stock

As discussed in Table 4.3.11-6, several thousand dollars of reported damages have occurred in Mercer County due to severe storm events. Damage to buildings is dependent upon several factors including wind speed, wind duration, presence of hail stones or lightning, and building construction. These wind-related damages are discussed further in Section 4.3.8 (Hurricane and Tropical Storm).

Impact on Critical Facilities and Lifelines

Critical facilities are at risk of being impacted by severe storm events, particularly events with high winds. High wind events are typically 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.

Impact on Economy

Severe storm 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.

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.

Section 4.3.8 (Hurricane and Tropical Storm) estimates the total economic loss caused by severe wind events. These losses include direct building losses and business interruption losses, which are the estimated costs to repair or replace the damage caused to the building and 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, respectively.

Impact on Environment

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 2020, NOAA n.d.). 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 (USGS 2020, NOAA n.d.). 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 Mercer County. Refer to Section 4.3.9 (Infestation and Invasive Species) for more information about these stressors.

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. Changes in the natural environment and built environment and how they interact can also provide insight about ways to plan for the future.

Projected Development and Changes in Population

As discussed in Section 3 (County Profile), areas targeted for future growth and development have been identified across Mercer County. Any areas of growth throughout the County are vulnerable to severe storm events. New development sites should adhere to the proper building codes to protect against severe storm event elements such as high wind protection and/or flood proofing measures.

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 of storm surge, and flood critical transportation corridors and infrastructure. Increases in precipitation may alter and expand the floodplain boundaries of storm surge areas 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, 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 severe storms 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] 2020).

Change of Vulnerability Since the 2016 HMP

As summarized above, changes in climate have and may continue to result in an increased frequency and intensity of severe weather events. The entire County continues to be exposed to the severe weather hazard.