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 Sussex County.

2021 HMP 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 spatial data to estimate potential losses from the wind hazard using the FEMA Hazus-MH hurricane model. These wind-related results are discussed in greater detail in Section 4.3.8 (Hurricane and Tropical storm).

Profile

Hazard Description

For the purpose of this HMP update and as deemed appropriated by the Sussex 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] 2009). 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 5.4.8-1 demonstrates the variety of lightning types.

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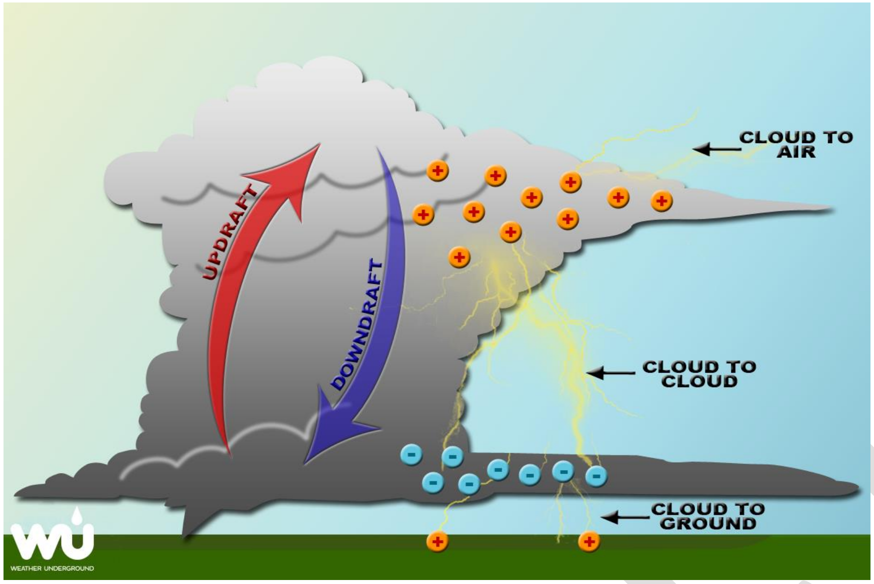
Figure 4.3.11-1. Types of Lightning

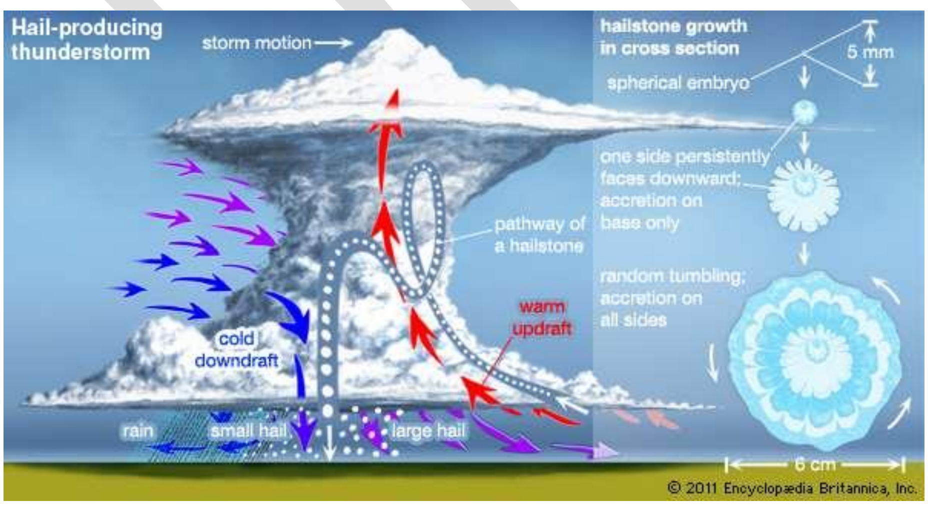


Source: Weather Underground date unknown

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 within 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.

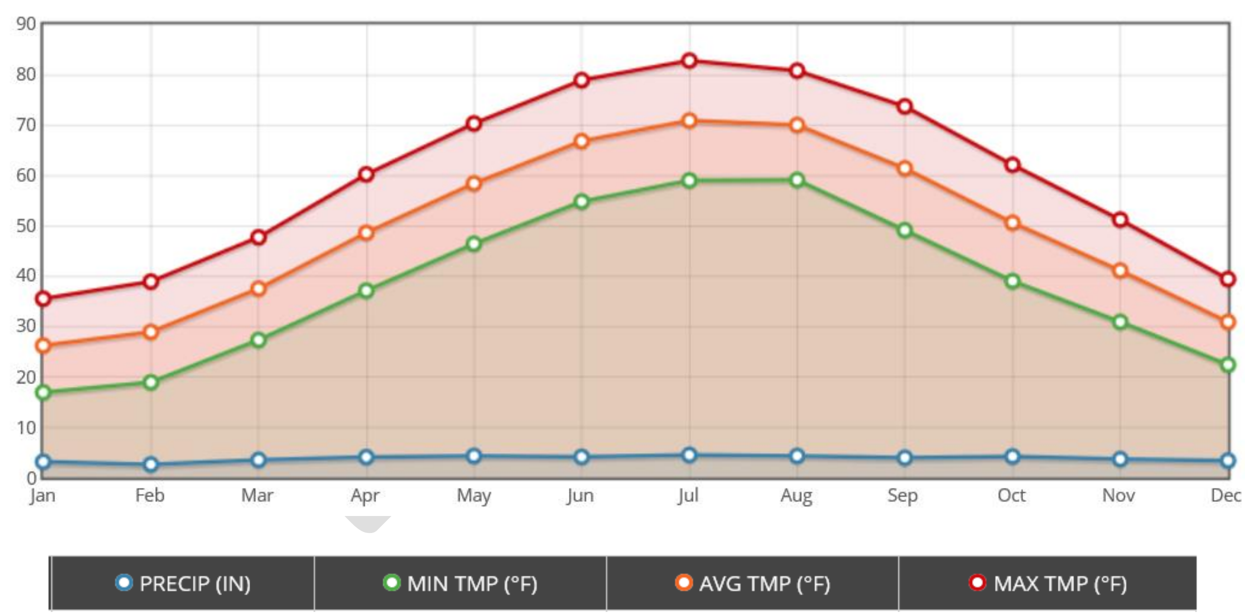
Tornadoes

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 Sussex Airport station in Sussex County.

Figure 4.3.11-3. Average Temperatures at Sussex Airport



Source: NWS 2020

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. (National Weather Service [NWS] 2009). 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 (U.S. Environmental Protection Agency [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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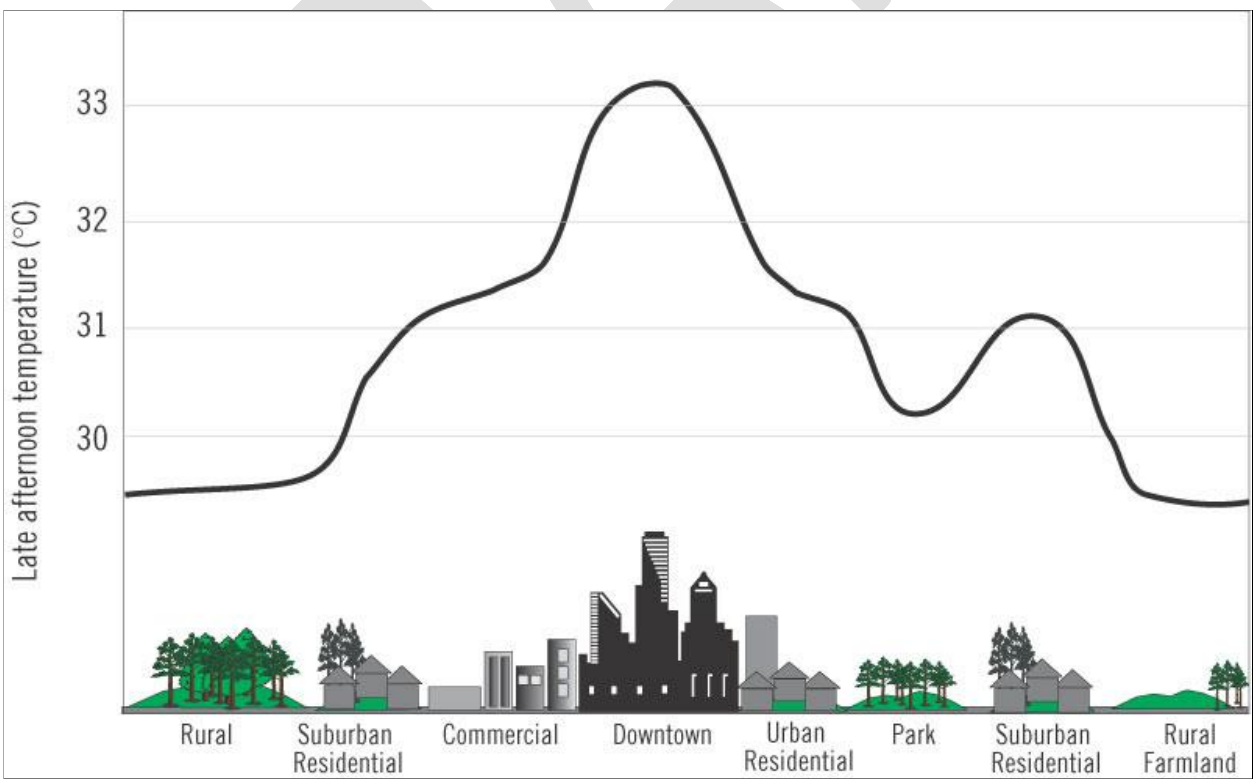
Figure 4.3.11-4 below illustrates an urban heat island profile. The graphic demonstrates that heat islands are typically most intense over dense urban areas. Further, vegetation and parks within a downtown area may help reduce heat islands (U.S. EPA 2019).

Figure 4.3.11-4. Urban Heat Island Profile

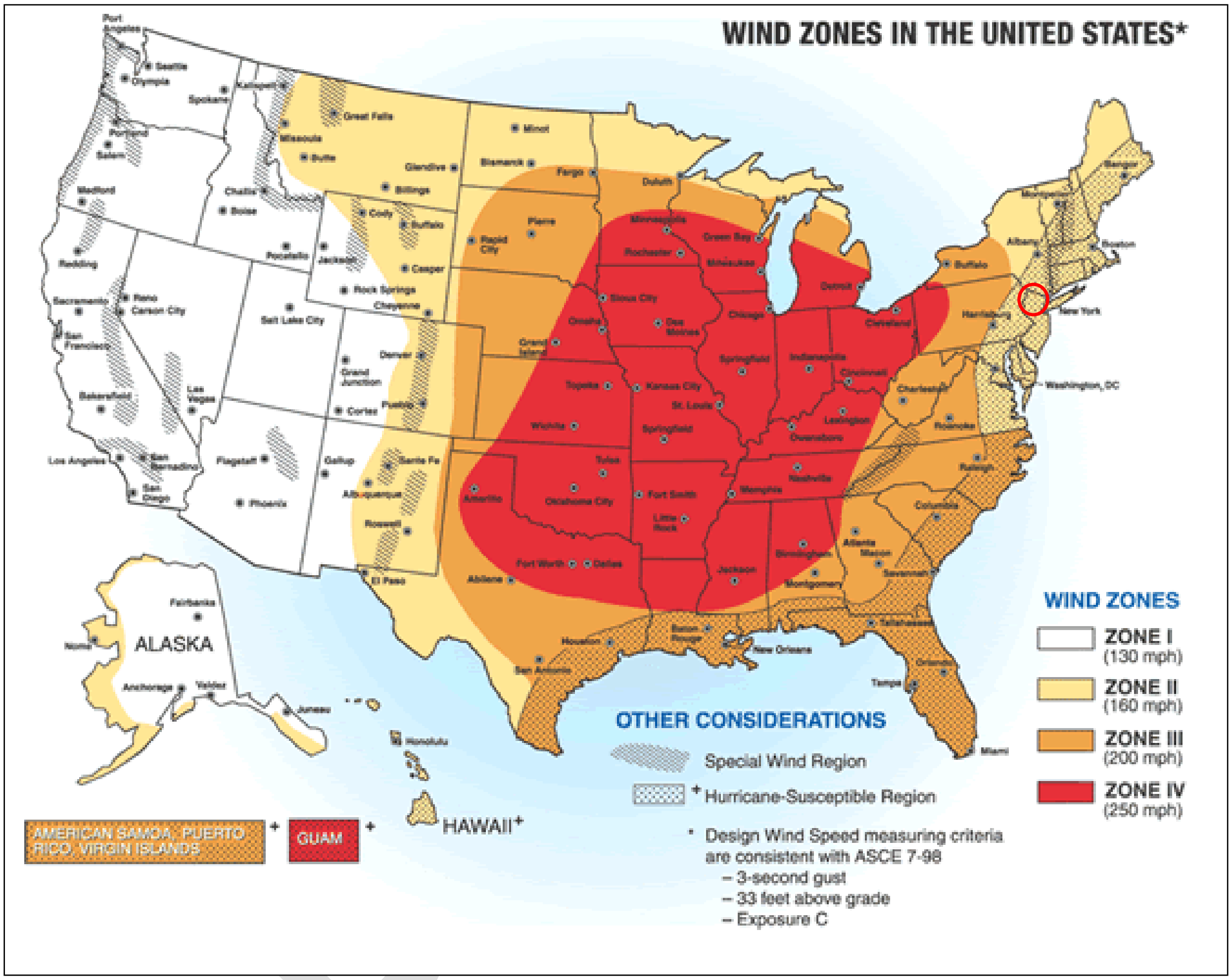


Source: EPA 2019
ºC degrees Celsius

Location

All of Sussex County is exposed to severe weather. According to the FEMA Winds Zones of the United States map, Sussex 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

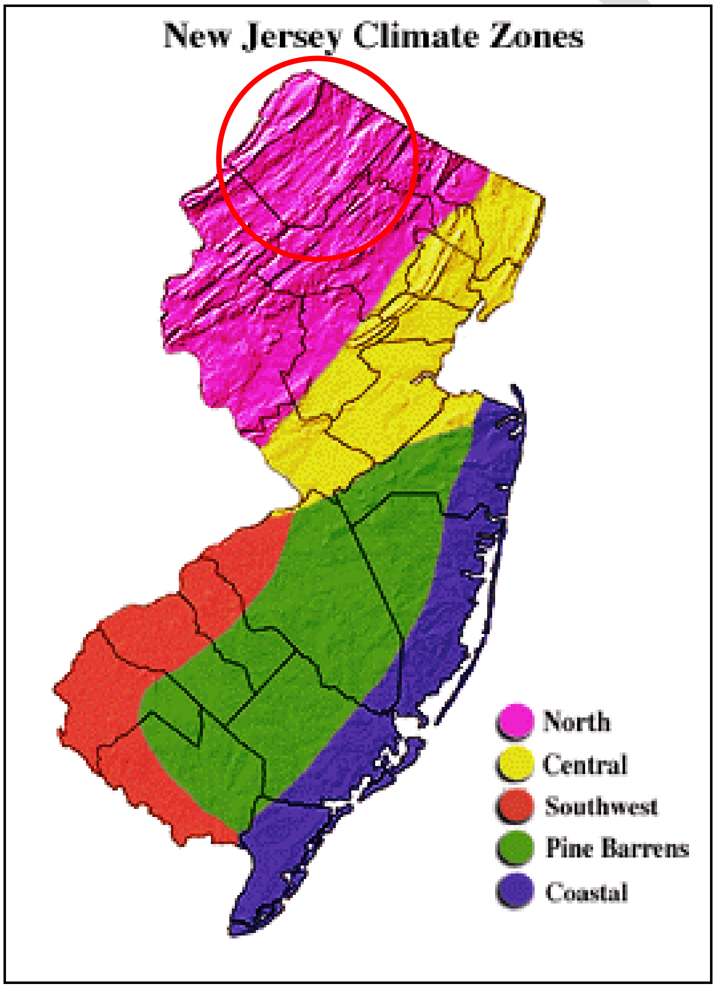


Source: FEMA 2012
Note: The red circle indicates the approximate location of Sussex County.

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. Sussex County is located within the Northern Climate Region.

The Northern Region 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. 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, with precipitation shields that reach well enough inland 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. 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 Sussex County. The County is located in the North Climate Zone of New Jersey.

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

Table 4.3.11-1. Severe Storm Extent in Sussex County (1950-2020)

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

Source: NOAA-NCEI 2019

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 2010). 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.

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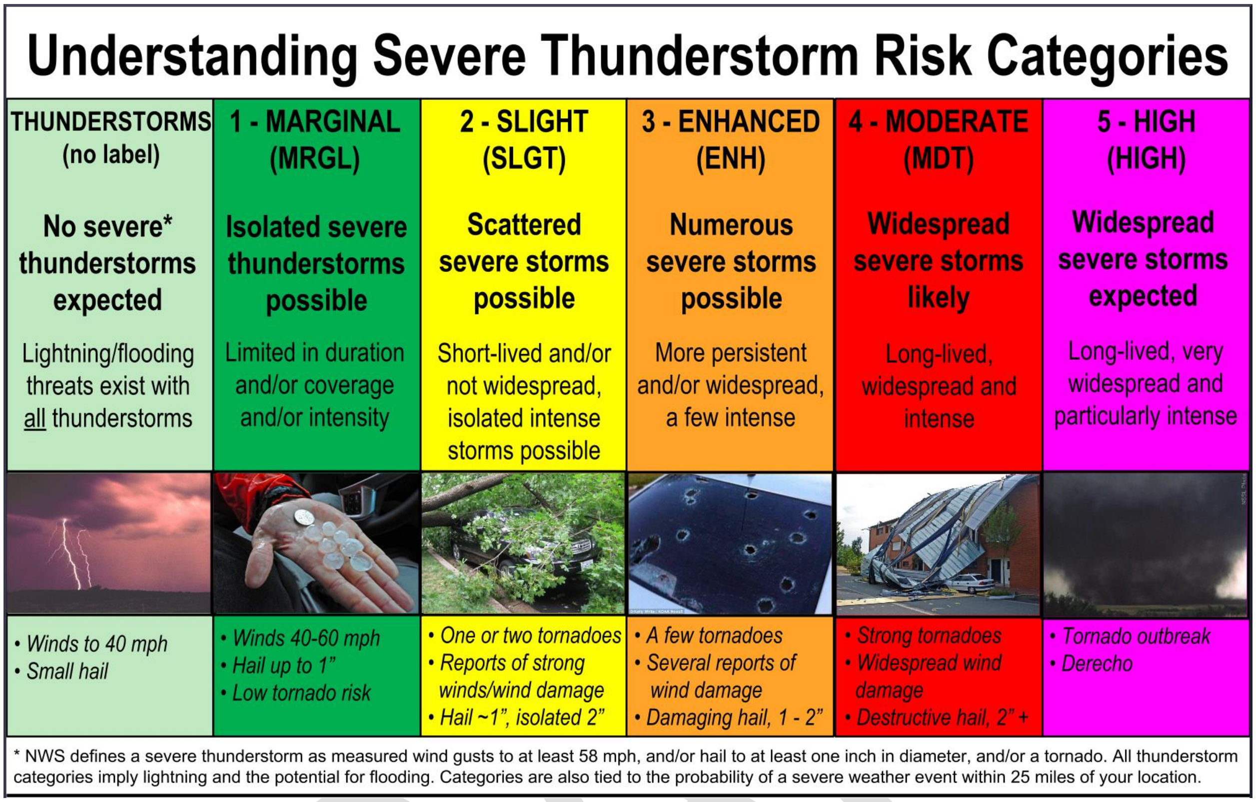
Figure 4.3.11-7. Severe Thunderstorm Risk Categories



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)	Description	Diameter (in inches)
Pea	0.25	Golf ball	1.75
Marble or mothball	0.50	Hen's egg	2.00
Penny or dime	0.75	Tennis ball	2.5
Nickel	0.88	Baseball	2.75
Quarter	1.00	Tea cup	3.00

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Description	Diameter (in inches)
Half dollar	1.25
Walnut or ping pong ball	1.50

Description	Diameter (in inches)
Grapefruit	4.00
Softball	4.50

Source: NOAA 2012

Windstorms

Table 4.3.11-3 provides 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 2015).

Tornado

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

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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 (Figure 5.4.8-1). 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 2015c
°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 2009
°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 5.4.8-3 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 4.3.11-10. 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

Between 1954 and 2020, Sussex County has been included in 15 declarations for severe storm-related events classified as severe storm (FEMA 2020). Severe weather events that have impacted Sussex County between 2015 and 2020 are identified in Tables 4.3.11-4 and 4.3.11-5. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2015 and 2020, Sussex County was included in two severe storm related agricultural disaster declarations. In 2019, Sussex County was included in declaration S4479 for excessive precipitation and S4455 for the combined effects of excessive rainfall, moisture, and storm-force winds from Hurricane Florence. In 2019, indemnities for moisture/precipitation/rain for all other crops totaled $43,692.

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

Declaration	Event Date	Declaration Date	Event Description
DR-1337	August 12-21, 2000	August 17, 2000	Severe Storms, Flooding & Mudslides
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-4039	September 28 - October 6, 2011	October 14, 2011	Remnants of Tropical Storm Lee
DR-4048	October 29, 2011	November 30, 2011	Severe Storm

Source: FEMA 2020

Table 4.3.11-5. Severe Weather Events in Sussex County, 2015 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
January 4, 2015	Strong Wind	N/A	N/A	Sussex County	A strong cold frontal passage brought strong winds in its wake into New Jersey during the evening and overnight on the 4th. The strongest winds occurred in eastern New Jersey and over the higher terrain of northwest New Jersey. Peak gusts in those locations averaged 50 to 55 mph, while elsewhere most peak gusts were between 40 and 45 mph. The strong winds knocked down weak tree limbs, trees and wires and caused isolated power outages. Peak wind gusts included 54 mph in High Point (Sussex County). $2K in property damage was reported.
January 7-8, 2015	Cold/Wind Chill	N/A	N/A	Sussex County	Narrative The arrival of an arctic air mass brought one of the coldest mornings of the month of January to most of New Jersey. Morning low temperatures were mainly in the single numbers above zero. In addition, gusty northwest winds continued into the morning and lowest hourly wind chill factors reached around degrees below zero throughout the state. Actual low temperatures included 2 degrees below zero in Walpack (Sussex County). Lowest hourly wind chill factors included 11 degrees below zero in Sussex (Sussex County).
February 2, 2015	Strong Wind	N/A	N/A	Sussex County	Strong, gusty northwest winds occurred in the wake of a departing and intensifying low pressure system during the late afternoon into the middle of the evening on the 2nd in New Jersey. Peak wind gusts average around 50 mph and knocked down weak trees, tree limbs and

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
					wires. Scattered power outages occurred. This was further exacerbated by snow and ice on tree limbs in the northwest part of the state. Peak winds included 56 mph in Wantage (Sussex County). $7K in property damage was reported.
February 12-13	Strong Wind, Cold/Wind Chill	N/A	N/A	Sussex County	Strong gusty northwest winds occurred behind a secondary cold frontal passage in New Jersey during the evening and overnight on the 12th. Peak wind gusts averaged around 55 mph over the higher terrain of Sussex County. $5K in property damage was reported. Northwest winds that persisted into the morning of the 13th combined with an arctic air mass to produce wind chill factors of around 10 degrees below zero and low temperatures in the positive single numbers throughout most of New Jersey. Actual morning low temperatures included zero in Walpack (Sussex County).
February 15, 2015	High Wind, Cold/Wind Chill	N/A	N/A	Sussex County	The increasing pressure difference (gradient) between a rapidly intensifying low pressure system offshore and an arctic high pressure system moving east from the Great Lakes caused strong to high damaging northwest winds to occur in New Jersey from the late evening of the 14th into the afternoon of the 15th. Strong wind gusts started late in the evening on the 14th, peaked during the morning of the 15th and continued into the afternoon of the 15th. The highest winds occurred in the southern half of the state and in the higher terrain of Sussex County. In these latter locations, peak wind gusts averaged around 60 mph. $10K in property damage was reported. The combination of strong to high winds and an approaching arctic air mass produced wind chill factors of 10 to 15 degrees below zero during the first half of the day on the 15th in New Jersey.
February 19-20, 2015	Cold/Wind Chill	N/A	N/A	Sussex County	The arrival of another arctic air mass brought some of the lowest wind chills as well as the lowest temperatures of the winter season to New Jersey on the 20th and 21st. As far as wind chill factors went, the first half of the day on the 20th was colder with wind chill factors as low as around 20 degrees below zero during the morning. Actual low temperatures were around zero. On the morning of the 21st, little, if any, wind was present as the arctic high pressure system was nearby.

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					Low temperatures in more rural inland areas were lower, many were below zero, some well below zero. But, because of the lack of wind, wind chill factors nearly matched the air temperatures and it felt relatively warmer on the morning of the 21st.
February 24, 2015	Cold/Wind Chill	N/A	N/A	Sussex County	The high pressure system responsible for third and last arctic blast of the month of February arrived in New Jersey on the morning of the 24th. Unlike the two previous arctic outbreaks earlier this month, this one was not accompanied by strong winds during the first half of the day. Air and wind chill temperatures were nearly the same. The calm conditions and snow cover combined to give many locations in northwest New Jersey the coldest morning of the winter season and comparably cold to the 20th and 21st weather in the rest of the state. Actual low temperatures included 19 degrees below zero in Walpack (Sussex County) and 15 degrees below zero in Sussex (Sussex County).
April 4, 2015	Strong Wind	N/A	N/A	Sussex County	Strong, gusty northwest winds circulating around an intensifying low pressure system and approaching high pressure system had the greatest impact across northern New Jersey and coastal southern New Jersey during the second half of the morning into the afternoon on the 4th. Peak wind gusts in these areas reached between 45 mph and 50 mph and knocked down weak tree limbs and wires. In the rest of the southern half of the state, while still windy, most peak wind gusts were less than 40 mph. Peak wind gusts included 48 mph in Wantage (Sussex County).
May 16, 2015	Thunderstorm Wind	N/A	N/A	Middleville	A lee side trough coupled with an unseasonably warm air mass helped trigger an area of showers and thunderstorms that moved through New Jersey during the very late afternoon and first half of the evening on the 16th. This included one severe thunderstorm in Sussex County. The thunderstorms caused outages to a couple of thousand homes and businesses, mainly in the northwest part of the state. Jersey Central Power and light reported that 1,600 of its customers were still without power at 11 p.m. EDT on the 16th.

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Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
					A severe thunderstorm knocked down large tree limbs and wires in Stillwater Township.
June 12, 2015	Thunderstorm Wind	N/A	N/A	Green Twp, Fredon Twp, Newton	A lee side trough preceding a cold front combined with an unseasonably hot and humid air mass to trigger scattered strong to locally severe thunderstorms in northwest New Jersey during the late afternoon and early evening of the 12th. A severe thunderstorm knocked down trees and wires in Green Township. The same severe thunderstorm knocked down multiple trees in Fredon Township. A severe thunderstorm also knocked down trees and wires in Newton.
June 21, 2015	Thunderstorm Wind	N/A	N/A	Wantage Twp	Scattered strong thunderstorms moved through western New Jersey during the afternoon and evening of the 21st. An isolated severe thunderstorm occurred in Sussex County. A severe thunderstorm tore down power lines in Wantage Township.
June 23, 2015	Thunderstorm Wind	N/A	N/A	Wantage Twp, Veron Twp	A severe thunderstorm knocked down a few trees along Central School Road in Wantage Township. A severe thunderstorm knocked down a few trees in Vernon Township.
July 19, 2015	Heat	N/A	N/A	Sussex 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.
January 4-5, 2016	Cold/Wind Chill	N/A	N/A	Sussex County	Northwest winds that persisted into the morning of the 5th, combined with an arctic air mass - the coldest of the season so far - produced wind chill factors between minus 10 and minus 30 degrees below zero. The coldest wind chill factors were located in the higher elevations

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
					where the wind was strongest and temperatures the lowest. The lowest hourly wind chill factor at High Point was minus 27 degrees, which occurred at 0310EST, and minus 15 degrees near Flatbrookville, which occurred at 0314EST. Actual morning low temperatures were in the above zero single numbers and included 4 degrees in Sussex, 5 degrees at Sussex Airport, and 6 degrees in Pelletown. The unseasonably cold arctic air mass and low wind chill factors were caused by the strong northwest wind flow over 30 MPH produced by a deepening mid-level trough over the eastern part of the country, and an arctic high pressure system moving east into the region. Cold temperatures were repeated the following night, but with less wind, wind chill factors were closer to the actual air temperatures.
February 13-14, 2016	Extreme Cold/Wind Chill	N/A	N/A	Sussex County	Wind Chill values dropped to 25 degrees below zero at 0553EST at Sussex County Airport, with northwest wind gusts as high as 25 MPH. The actual air temperature at this time was 6 degrees below zero. The highest wind gust reported at this station was 30 MPH at 1353EST Saturday, February 13th. A wind chill value of 46 degrees below zero was reported at a Safetynet site at Highpoint at 0530EST.
February 24, 2016	Strong Wind	N/A	N/A	Wantage	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. A 55 MPH thunderstorm wind gust was measured in Wantage.
April 3, 2016	High Wind	N/A	N/A	Sussex County	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

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					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. Numerous reports of downed trees and wires throughout the county due to high winds.
June 5, 2016	Thunderstorm Wind	N/A	N/A	Wantage, Fredon	A cold front moving into an unstable air mass over New Jersey set off numerous showers and thunderstorms during the late afternoon hours on the 5th. Lightning with these thunderstorms was somewhat limited, so straight-line winds and heavy downpours were the major threat as these storms moved through the area. Thousands of people lost power as a result of the storms. Many wind gusts from 60 to over 70 MPH were recorded across the region. The highest gust was in Gloucester TWP at 74 mph. Rainfall amounts across the northern parts of the state did surpass an inch with the highest total 1.58 inches in Wantage. Downed trees due to winds leading to road closures were reported in Wantage. Trees and branches were downed in Fredon.
July 25, 2016	Thunderstorm Wind	N/A	N/A	Five Points	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. Several trees downed due to thunderstorm winds in Five Points.
August 16, 2016	Thunderstorm Wind	N/A	N/A	Middleville, Montague, Five Points	Trees, poles and wires were taken down due to thunderstorm winds in Middleville Montague, and Five Points.
September 14, 2016	Thunderstorm Wind	N/A	N/A	Newton, Cranberry Lake, Hopatcong, Lake Mohawk, Sparta	A cluster of thunderstorms developed ahead of a cold front and moved across northern New Jersey during the late afternoon hours of the 14th. Some of the thunderstorms produced damaging winds. Trees were downed by thunderstorm wind gusts closing a few roads in Newton. Several trees were taken down due to thunderstorm winds in Cranberry

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Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
					Lake. One large tree fell onto and downed power lines. A 52 kt wind gust was recorded in Hopatcong. A 63 kt wind gust was reported in Lake Mohawk. Several trees taken down due to thunderstorm winds blocking access to the local marina. Two boats broke anchor as the attachment was torn off from thunderstorm winds. Several trees were taken down due to thunderstorm wind gusts in Sparta.
February 13, 2017	High Wind	N/A	N/A	Hopatcong, Byram Twp	High winds blew through the area after a cold frontal passage, enough to lead to downed trees and wires during the day of the 13th and from a severe squall line early on the 13th. Temperatures were also cold enough with the main low pressure system along the front to produce a wintry mix across northern portions of the state. In terms of freezing rain across northern portions of the state, accumulations were generally light with 0.01 inches at the Sussex ASOS. Winds behind the front were also gusty. Several thousand power outages were reported with some lasting 24 hours in Sussex and Morris counties. Wires taken down due to wind throughout the county. A tree fell across Mason Drive and a pole was taken down in Hopatcong on Brooklyn Stanhope Road. A tree fell onto route 613 in Byram Twp.
February 25, 2017	Thunderstorm Wind	N/A	N/A	Middleville, Branchville, Plumsock, Quarryville, Colesville	Several days of record warmth came to an abrupt end as a strong cold front moved through the state. Moisture and instability were sufficient to develop a line of showers and thunderstorms ahead of the front. These showers and thunderstorms produced damaging winds and hail across western portions of the state. The most noteworthy damage was in Sussex county at the Space farm zoo. Several thousand people lost power as well. In Middleville, a tree was downed due to thunderstorm winds onto a house with several trees uprooted as well due to thunderstorm winds. Several large trees were snapped and uprooted in Branchville. A Blacksmith Museum building was flattened and several trees were uprooted due to thunderstorm winds in Plumsock. Some other building had siding and roof damage as well. Trees and wires were downed in Quarryville

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					due to thunderstorm winds. A large pine tree was uprooted in Colesville due to thunderstorm winds. Two metal barn roofs were torn off in Quarryville due to thunderstorm winds.
March 2, 2017	High Wind	N/A	N/A	Sussex County	An unseasonably warm, very moist, and unstable air mass, characterized by temperatures in the 70s and Dew Points in the upper 50s to lower 60s, was conducive to maintaining a line of thunderstorms along a pre-frontal trough, as they crossed the Appalachians and moved through portions of southern NJ. Although there was little in the way of lightning associated with these storms, pockets of significant wind damage occurred. A large tree fell onto a house and fence.
March 14, 2017	High Wind	N/A	N/A	Sussex County	Low pressure systems across the Ohio Valley and Carolinas phased. This led to a rapidly developing storm which tracked just offshore. A wind gust of 51 kts was measured in Sussex County.
June 13, 2017	Hail	N/A	N/A	Maple Grange, Hamburg	A severe thunderstorm impacted Sussex County, NJ. This storm produced a 46 mph wind gust and nickel size hail. Lightning also downed a tree which landed on a house. Another tree was downed due to wind on highway 23. Hail lasted for roughly 5 minutes. Tree downed on highway 23 due to wind at the highway 94 intersection in Hamburg.
August 2, 2017	Thunderstorm Wind	N/A	N/A	Fredon	A hot and humid airmass with weak boundaries led to slow moving strong to severe thunderstorms with damaging winds, hail and flooding. Over 2,000 people lost power. Wires were down on Stillwater Road in Fredon.
October 24, 2017	Strong Wind	N/A	N/A	Pellettown	A strong low pressure system over the Great Lakes and a departing high pressure system to our east lead to a tight pressure gradient and a round of strong winds. Over 25,000 homes and businesses lost power. Several school districts had to close because of the power loss. A CWOP measured gust of 39 kts was reported just southeast of Pellettown.
January 4, 2018	High Wind	N/A	N/A	Sussex County	An area of low pressure tracked up the east coast interacting with a cold front which lead to rapid development of a winter storm across the state. This storm quickly moved out by the 5th. However, snowfall accumulations and gusty winds occurred with the storm. Blizzard

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					conditions occurred along many coastal locations. Top wind gusts were generally around 40 mph across the state. Snow amounts were highest in southern and coastal New Jersey with over 6 inches, totals were only a few inches further northwest. A state of Emergency was declared during the height of the storm. Several hundred vehicles were stranded and hundreds of thousands were without power at some point. Severe cold continued for the next week leading to many locations going to code blue operations and closing of the Cape May Lewes Ferry.
March 2, 2018	High Wind	N/A	N/A	Sussex County	Numerous trees and power lines were knocked down from strong winds. Nearly 30 roads throughout the county were closed because of downed trees. As of 10 PM Saturday, March 3rd, 23,503 customers were still without power. Free water and ice was provided to affected residents. A wind gust of 48 MPH was reported by a NJWXNET weather station at High Point Monument at 1125EST on March 2nd. A 41 year old man was killed on Friday evening at 1845EST when he came in contact with live wires on Lenape Avenue in Andover, NJ that had been knocked down by the strong winds. He was pronounced dead on the scene.
April 4, 2018	High Wind	N/A	N/A	Sussex County	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 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. A mesonet site in High Point Monument recorded a wind gust of 58 mph at 4 PM on April 4th.
July 1, 2018	Excessive Heat	N/A	N/A	Sussex 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 106 degrees at the Andover Airport AWOS on July 3rd.

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October 2, 2018	Thunderstorm Wind	N/A	N/A	Cranberry Lake, Branchville	Supercellular severe thunderstorms caused 2 tornadoes, wind damage, and hail across the region all part of a record breaking tornado outbreak across Pennsylvania. Cranberry Lake reported localized power outages and trees down. Branchville reported localized tree damage and power outages.
February 25, 2019	High Wind	N/A	N/A	Sussex County	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.
April 15, 2019	Thunderstorm Wind	N/A	N/A	Stillwater Township	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. Multiple trees and power lines were reported down in Stillwater Twp. The
May 19, 2019	Thunderstorm Wind	N/A	N/A	Sandyston Twp, Lake Owassa	A warm front moved through the mid-Atlantic on the morning of May 19. This set the stage for the warmest day of the year to that point for most of the region. The combination of daytime heating and a pre-frontal trough ahead of an approaching cold front led to thunderstorm development late in the day. Thunderstorms organized into a line which produced pockets of wind damage over eastern Pennsylvania and northern New Jersey. A brief tornado also occurred in Pennsylvania. With the loss of daytime heating, storms weakened as they moved to the northeast. A tree was reported down on Layton-Hainesville Rd. in Sandyston Twp. A tree was reported down on E Shore Rd. near Lake Owassa.
May 28, 2019	Thunderstorm Wind, Tornado	N/A	N/A	Hopatcong, Stanhope	Severe supercellular storms developed and moved into the region from the west during the mid to late afternoon hours. Storms produced large hail, damaging wind gusts, and 2 tornadoes. Tree reported down into a house on Helen Street in Hopatcong.

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Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
					A tornado touched down in Stanhope in Sussex County, New Jersey. Damage began near the Lenape Valley Regional High School. Here, several trees were snapped or uprooted. On a field in front of the school, a clear tornadic damage path was seen with three nearby trees snapped or uprooted in a cyclonic fashion. A small but anchored outbuilding was also lifted and flipped over. Further tree damage occurred at a residence across the street from the school. Damage then appeared to briefly abate, indicating the tornado likely lifted for a short time. However, a short distance further southeast, additional tornadic damage was observed with numerous trees snapped or uprooted and several homes and cars sustaining damage from falling trees on and around Unger Avenue. Including the brief time when it likely lifted, the tornado lasted approximately one to one and a half minutes. Thankfully, no injuries were reported as a result of this tornado.
June 29, 2019	Thunderstorm Wind	N/A	N/A	Cranberry Lake, Brookwood	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 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. Numerous trees and telephone poles and wires were reported down in the Cranberry Lake area. A tree fell on US-206 north of I-80, closing all lanes in Brookwood.
July 17, 2019	Thunderstorm Wind	N/A	N/A	Hampton Twp, Cranberry Lake, Branchville	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 convection developed, with a number of storms

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					producing damaging wind. A tree was reported down in Hampton Twp. Tree blown down on N Shore Rd in the Cranberry Lake area.
July 20, 2019	Thunderstorm Wind	N/A	N/A	Branchville, Frankford Twp	An excessively hot air mass was in place over the mid-Atlantic on July 20. While the air mass was hot, the environment was otherwise generally unfavorable for convection due to mid level capping. However, some thunderstorms did develop where the cap was weaker, especially in New York but also as far south as northern New Jersey. These isolated cells produced localized wind damage. Several downed trees blocked CR-519 near Branchville. Numerous trees and power lines were downed in and near Frankford Twp.
July 21, 2019	Thunderstorm Wind	N/A	N/A	Andover Airport, Hopatcong	A slow moving cold front was approaching a very hot air mass over the mid-Atlantic on July 21. Strong instability and high moisture levels were present ahead of the front. Relatively weak shear and some mid-level dry air were limiting factors, but the frontal forcing helped to trigger scattered thunderstorms, some of which became strong to severe and produced areas of wind damage. Downed trees and power lines were reported in the Andover and Hopatcong areas.
July 22, 2019	Thunderstorm Wind	N/A	N/A	Hopatcong	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. Trees and powerlines were downed throughout Hopatcong.

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Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
August 8, 2019	Thunderstorm Wind	N/A	N/A	Newton, Andover	Behind a cold front, an upper level trough moved over the mid-Atlantic on August 8. Multiple shortwave impulses rotated through the broader trough over the day. The upper level energy combined with daytime heating in an otherwise marginally favorable environment to produce scattered showers and thunderstorms. A few storms became strong to severe, producing gusty winds. Tree and wires downed on Swartswood Rd in Newton. Tree and wires downed on Crescent Dr in Andover.
October 31, 2019	Thunderstorm Wind	N/A	N/A	Hopatcong, Beaver Lake	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 photo in Hopatcong showed a large tree down on power lines. The report also indicated several additional trees down on power lines with multiple transformer fires in the area. A tree was downed on NJ-23 south of Beaver Lake Rd.
February 7, 2020	High Wind	N/A	N/A	Sussex County	Following a mid-morning severe weather outbreak, the weather remained active over the mid-Atlantic into the later morning and afternoon hours on February 7. Explosively intensifying low pressure began to pull away from the region to the north, leading to a cold frontal passage. Rapid height and pressure rises on the back side of the departing low led to a period of strong and in some cases damaging synoptic winds following the damaging convective winds from earlier in the day. Winds were strongest in coastal areas. Winds began to diminish late in the day as the low moved further away and the gradients relaxed.
June 3, 2020	Thunderstorm Wind	N/A	N/A	Libertyville	A derecho developed just southeast of Lake Erie during the early morning hours of June 3, 2020, then moved rapidly southeast across Pennsylvania before

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					exiting the central New Jersey coast during the early afternoon hours, approximately 130 PM. Downed trees and wires were reported near Route 519 and Neilson Road near Wantage. Several reports of tree limbs and power lines down near Route 515 and Vernon Crossing Road near Wawayanda State Park.
June 19, 2020	Thunderstorm Wind	N/A	N/A	Sparta	Several impulses of energy rotating within the flow of a mid-level low produced scattered thunderstorms over northern New Jersey during the mid to late evening hours. While most of these thunderstorms were sub-severe, one or two reports of isolated wind damage were reported. Reports of trees and wires down near Underrock Road near Sparta.
June 28, 2020	Hail, Thunderstorm Wind	N/A	N/A	Colesvile	A cold front approaching from the west, in combination with a pre-frontal lee-side trough parked over the mid-Atlantic region, sparked afternoon and evening thunderstorms across many parts of New Jersey. In addition to strong to severe winds and heavy rain, a few thunderstorms contained large hail. Dime to nickle size hail was reported on River Road in Montague. Several reports of power lines down and power outages in the Vernon Valley area northwest of Wawayanda State Park.
July 3, 2020	Thunderstorm Wind	N/A	N/A	Glenwood, Independence Corner, McAfee	A back door cold front moving south into very hot and moderately humid air touched off showers and thunderstorms, some of them severe. Wires were reported down on McAfee-Glenwood Road in Glenwood. Wires were down on Glenwood Road in Vernon Valley. Downed tree and wires near Tall Timbers Road near Wallkill Lake with power outages in the area. Downed tree on NJ-284 southbound near Layton Road northeast of Sussex. Lane restrictions were put in place. Downed tree into a trailer near Hemlock Drive in Vernon with power lines down in the area. Trees and wires down on Valley View Drive in McAfee.
July 22, 2020	Hail	N/A	N/A	Township of Montague, Colesville	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 on July 22 with air temperatures rising into

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					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. 1.25-1.50 inch hail was reported in Montague. 50 knot winds were reported. A large tree was split at a residence on Red Hill Road. A tree was downed on Deckerton Turnpike near the intersection with County Route 675. Several reports of downed trees and wires in Montague Township including near Clove Road and New Road. Reports of downed tree limbs and wires near Lake Marcia in Collesville.
August 18, 2020	Thunderstorm Wind, Hail	N/A	N/A	Township of Montague	A prefrontal trough ahead of a slow moving cold front led to a few thunderstorms developing on the afternoon of August 17. Moderate instability and weak shear generally limited storm coverage and severity, but a cluster of severe thunderstorms with damaging winds impacted portions of the Pennsylvania Poconos and northern New Jersey. Trees and wires were downed on Fox Hollow Rd near Montague.
August 25, 2020	Thunderstorm Wind	N/A	N/A	Colesville, Owens, Vernon	A strong cold front along with a mid-level shortwave trough approached the mid-Atlantic on August 25. Ahead of the disturbances, wind shear increased significantly and surface temperatures warmed, increasing instability. While some ingredients were in place for a major severe weather event, an offset in timing between the shortwave and the front, combined with greater than expected mid-level dry air, caused storms to generally struggle to develop over the mid-Atlantic. Greater storm coverage was found in more favorable environments over both New England and the Ohio Valley. However, the environment over the mid-Atlantic was still highly favorable for damaging winds, so the few

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Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
					storms that did develop produced some instances of wind damage. A wind gust of 53 knots was measured at High Point monument in Colesville. Several reports of downed trees and wires near Mount Salem Road and Moore Road in Quarryville. Several reports of downed trees and wires near Glenwood Mount Road in Owens. Trees and wires were downed near Pondeddy Road in Vernon.

Source: FEMA 2020; NOAA-NCEI 2020; NWS 2020; SPC 2020; NJOEM 2019; NHC 2020
DR Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph miles per hour
N/A Not Applicable

Probability of Future Occurrences

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

According to the NOAA National Climate Data Center (NCDC), Sussex County has experienced 402 severe weather events between 1950 and 2020. 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 NCDC 2020).

Table 4.3.11-6. 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	84	1.20	0.85	1.2	100%
Hail	32	0.46	2.2	0.45	45.1%
High/Strong Wind	137	1.96	0.52	1.9	100%
Lightning	19	0.27	3.7	0.27	26.8%
Thunderstorm Wind	134	1.91	0.53	1.9	100%
Tornado / Funnel Cloud	6	0.09	11.8	0.08	8.5%

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
Total	412	5.89	0.17	5.8	100%

Source: NOAA-NCEI 2020

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 severe weather 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 severe weather hazard for individual municipalities is presented in the jurisdictional annexes.

Climate Change Impacts

Climate change includes changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70% of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9% increase. By 2050, annual precipitation in New Jersey could increase by 4% to 11% (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020).

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71% (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

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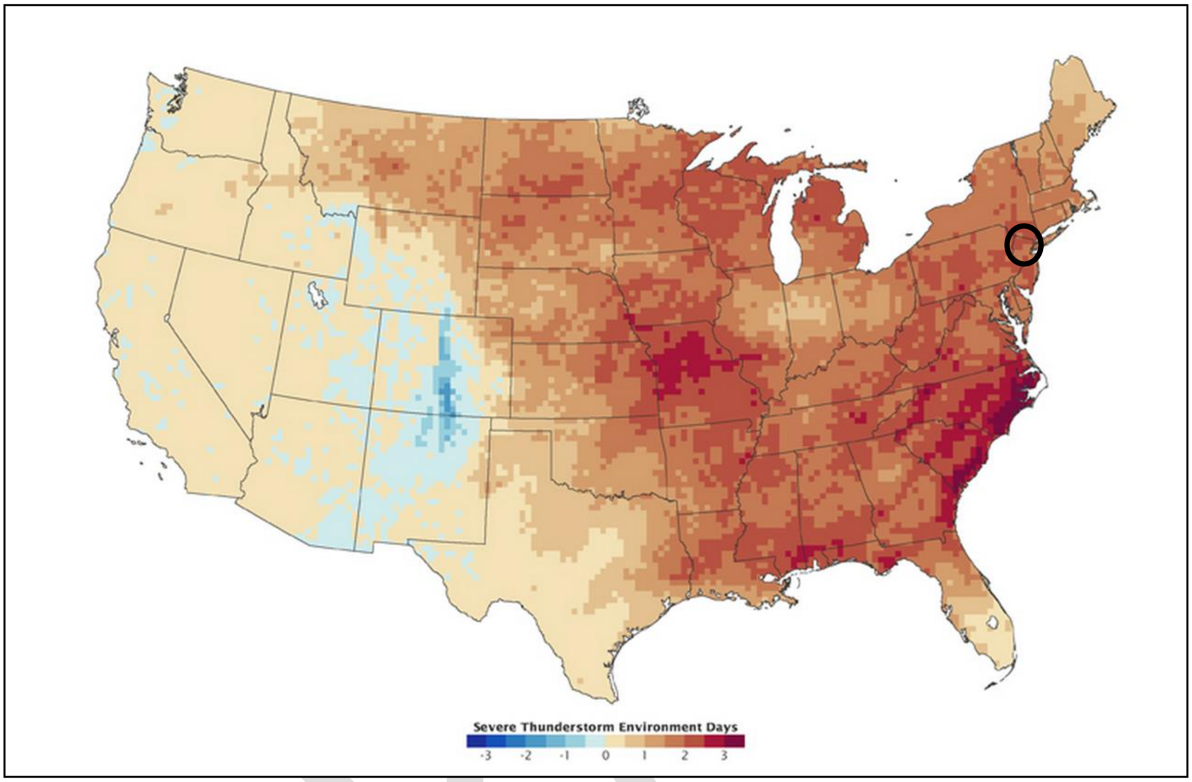
Figure 4.3.11-11 illustrates the predicted change in severe thunderstorm days; overall it is anticipated New Jersey will experience an increase.

Figure 4.3.11-5. Predicted Change in Severe Thunderstorm Environment Days from the 1962-1989 Period to the 2072-2099 Period



Source: Trapp et. al. 2007
Note: The approximate location of Sussex County is indicated by the black circle

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Vulnerability Assessment

A qualitative assessment was conducted to analyze the severe weather hazard for Sussex County. A probabilistic assessment was conducted for the 100- and 500-year MRPs to analyze the wind hazard and provide a range of loss estimates. These estimates are detailed in Section 4.3.8 (Hurricane and Tropical Storm).

Impact on Life, Health and Safety

The impact of severe weather events on life, health, and safety is dependent upon several factors including the severity of the event and whether adequate warning time was provided to residents. The entire population of Sussex County (142,298 people) is exposed to severe storm events (American Community Survey 2018). 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 Storms). 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 2018 5-year American Community Survey population data, there are 7,191 persons living below the poverty level and 22,889 persons over the age of 65 within Sussex County.

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

Impact on General Building Stock

Damage to buildings depends on several factors, including the type of event, wind speed, presence and size of hail, storm duration, path of the storm track or tornado, and distance from the tornado funnel. Several thousand dollars of reported damages have occurred in Sussex County due to severe storm events. Estimated wind-related building damages are discussed further in Section 4.3.8 (Hurricane and Tropical Storms).

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 or other utility service. Loss of service can impact residents, critical facilities, and business operations alike. Interruptions in heating or cooling utilities can affect populations, such the young and elderly, who are particularly vulnerable to temperature-related health impacts. Loss of power can also impact other public utilities, including potable water, wastewater treatment, and communications. 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 residents.

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. The longer the business is closed, the less likely they are to reopen. 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 Storms) 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

The impact of severe storm events on the environment varies, but researchers are finding that the long-term impacts of more severe weather can be destructive to the natural and local environment. National organizations such as USGS and NOAA have been studying and monitoring the impacts of extreme weather phenomena as it

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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 Sussex 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

As discussed in Section 4, areas targeted for future growth and development have been identified across the 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.

Projected Changes in Population

According to the 2018 5-year population estimates from the American Community Survey, the population of Sussex County (i.e., 142,298 persons) has decreased by approximately 4.7-percent since 2010. Even though the population has decreased, any changes in the density of population can create issues for local residents during evacuation of a natural hazard severe storm event. Historically, flooding and debris with associated severe storm events have severely impacted transportation corridors as well as infrastructure. Refer to Section 3 (County Profile), which includes a discussion on population trends for the County.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. Annual precipitation amounts in the region are projected to increase, primarily in the form of heavy rainfalls, which have the potential to increase the risk 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. EPA 2020).

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Change of Vulnerability Since the 2016 HMP

Overall, the County's vulnerability has not changed, and the entire County will continue to be exposed and vulnerable to severe weather events.

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