16. SEVERE WEATHER

16.1 HAZARD PROFILE

16.1.1 Hazard Description

For this HMP update, the severe weather hazard includes thunderstorms, lightning, hail, high winds, tornadoes, and extreme temperatures, as defined in the following sections.

Thunderstorms

A thunderstorm is a rain shower that features thunder and lightning. Thunderstorms form when warm, moist surface air rises, causing the water vapor in it to cool and condense into clouds. These clouds eventually grow upward into areas with temperatures below freezing. There, the condensed water vapor eventually builds up enough to fall as rain. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes (National Weather Service 1994).

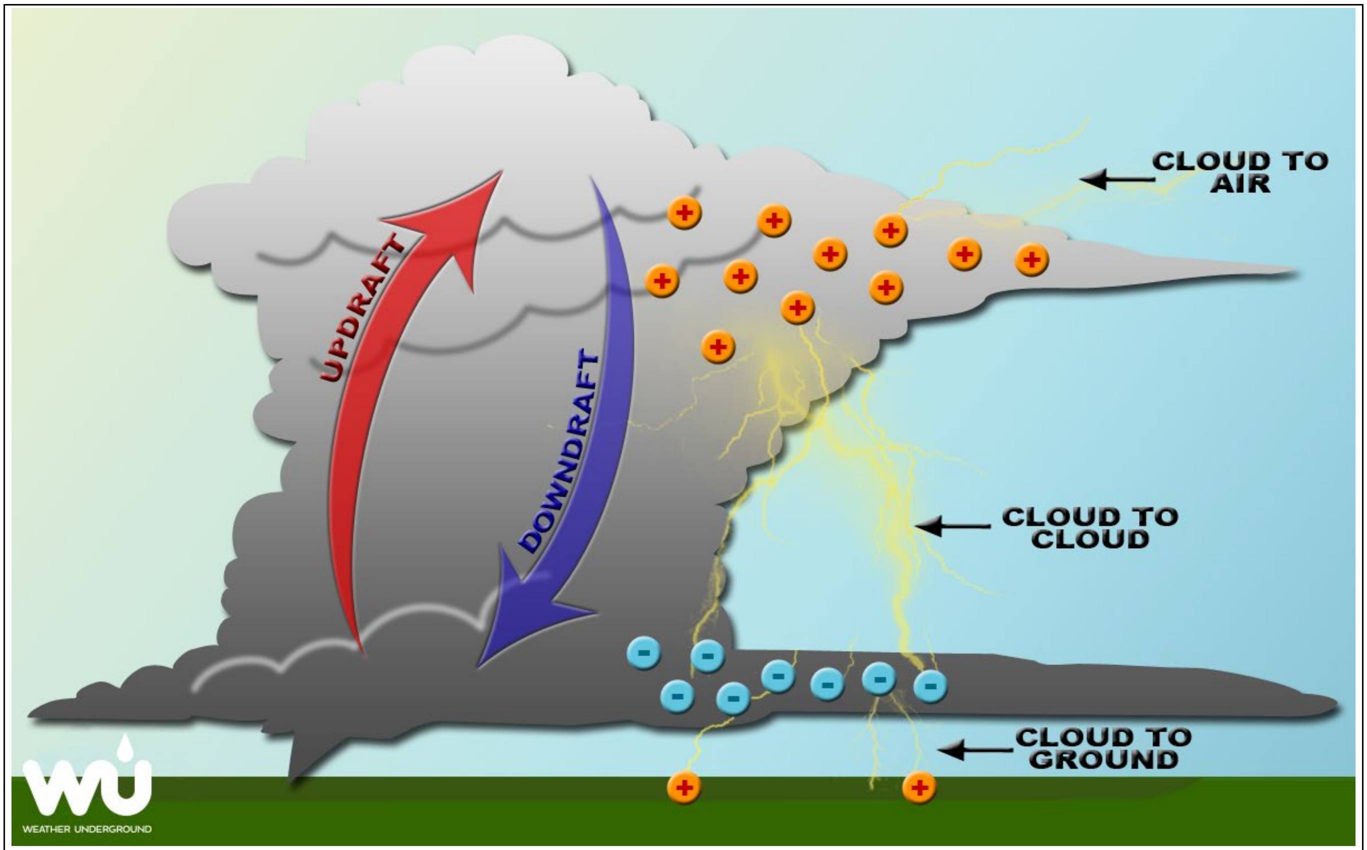
Lightning

Lighting is a bright flash of electrical energy produced by a thunderstorm. Inside the storm, when two water/ice particles collide, they bounce off each other. Many collisions by these particles build up regions of electric charges, causing bolts of lightning (National Oceanic and Atmospheric Administration 2023). The resulting clap of thunder is the result of a shockwave created by the rapid heating and cooling of the air around the electrical discharge. As shown in Figure 16-1, lightning can be produced wherever there are varying electrical charges, whether it be cloud to air, cloud to cloud, or cloud to ground (National Oceanic and Atmospheric Administration 2014, Royal Meteorological Society 2017):

- **Cloud-to-Ground Lightning** is the most common form of lightning. It occurs when a negative charge hits the ground. As the negative charge nears the ground, a positive charge (normally from taller objects in the area, such as a tree, house, or telephone pole) will connect, causing the powerful electric current.
- **Cloud-to-Air Lightning** refers to a discharge that jumps from a cloud into clear air and terminates abruptly.
- There are two forms of **Cloud-to-Cloud Lightning**:
    - **Intercloud lightning** refers to long, horizontal moving flashes often seen on the underside of stratiform clouds.
    - **Intracloud lightning** refers to lightning embedded within a single storm cloud, which jumps between different charge regions in the cloud.

Cloud-to-ground and intra-cloud lightning flashes are detected and mapped in real-time by two networks in the United States: National Lightning Detection Network (NLDN) and the Earth Networks Total Lightning Network. These systems detect radio waves emitted by fast electric currents within a cloud or in a channel to ground (National Oceanic and Atmospheric Administration n.d.)..

Figure 16-1. Types of Lightning



Source: Weather Underground n.d.

Hail

Hail forms inside a storm with strong updrafts of warm air. If a falling water droplet is picked up by the updrafts, it can be carried into higher air with temperatures below the freezing level. There the droplet freezes and begins to fall. At the bottom of the storm, the droplet may begin to thaw but then be picked up by another updraft and carried back into the cold air to re-freeze. With each trip above and below the freezing level, the frozen droplet adds another layer of ice. The frozen droplet, with many layers of ice, eventually falls to the ground as hail when it becomes heavy enough to overcome the strength of the thunderstorm updraft and is pulled to the earth by gravity.

High Winds

Wind is air movement caused by the differences in air pressure that result from 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, hurricanes, and tropical storms (National Weather Service 2012). The following are common types of high wind events (National Oceanic and Atmospheric Administration 2023).

- **Straight-line wind** refers to any thunderstorm wind that is not associated with rotation; this term is used mainly to differentiate from tornado winds.
- A **microburst** is a small, concentrated downburst that produces an outward burst of strong winds at or near the surface. Microbursts are typically less than 3 miles across and last only 5 to 10 minutes. Their maximum wind speeds sometimes exceed 100 miles per hour (mph). There are two kinds of microbursts:

  - A wet microburst is accompanied by heavy precipitation at the surface.
  - Dry microbursts occur with little or no precipitation at the ground.
- **Derechos** are widespread, long-lived windstorms that are associated with a band of rapidly moving showers or thunderstorms. A typical derecho consists of numerous microbursts, downbursts, and downburst clusters. A wind event may be classified as a derecho if the wind damage swath extends more than 240 miles and includes wind gusts of at least 58 mph along most of its length.

Tornadoes

A tornado is a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 250 mph. Damage paths can be greater than a 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 plus the speed of the whirling winds) exceeding 300 mph. The lifespan of a tornado rarely is longer than 30 minutes (National Weather Service 2010).

Extreme Temperatures

Extreme Cold

Extreme cold events occur when temperatures drop well below what is normal for an area. For example, near-freezing temperatures are considered extreme cold in regions unaccustomed to winter weather. In regions that are subjected to temperatures below freezing on a more regular basis, extreme cold might be used to describe temperatures below 0 °F. For the purposes of this HMP, extreme cold refers to ambient air temperature of about 0 °F or below (NWS n.d.).

Extreme cold temperatures in New Jersey generally accompany winter storm events. These conditions typically manifest when arctic air masses under high atmospheric pressure move southward from central Canada (Cornell University n.d.).

Extreme Heat

Extreme heat is defined as temperatures that remain 10 °F or more above the normal high temperature of a region for several weeks (Centers for Disease Control and Prevention 2016).

Heat Waves

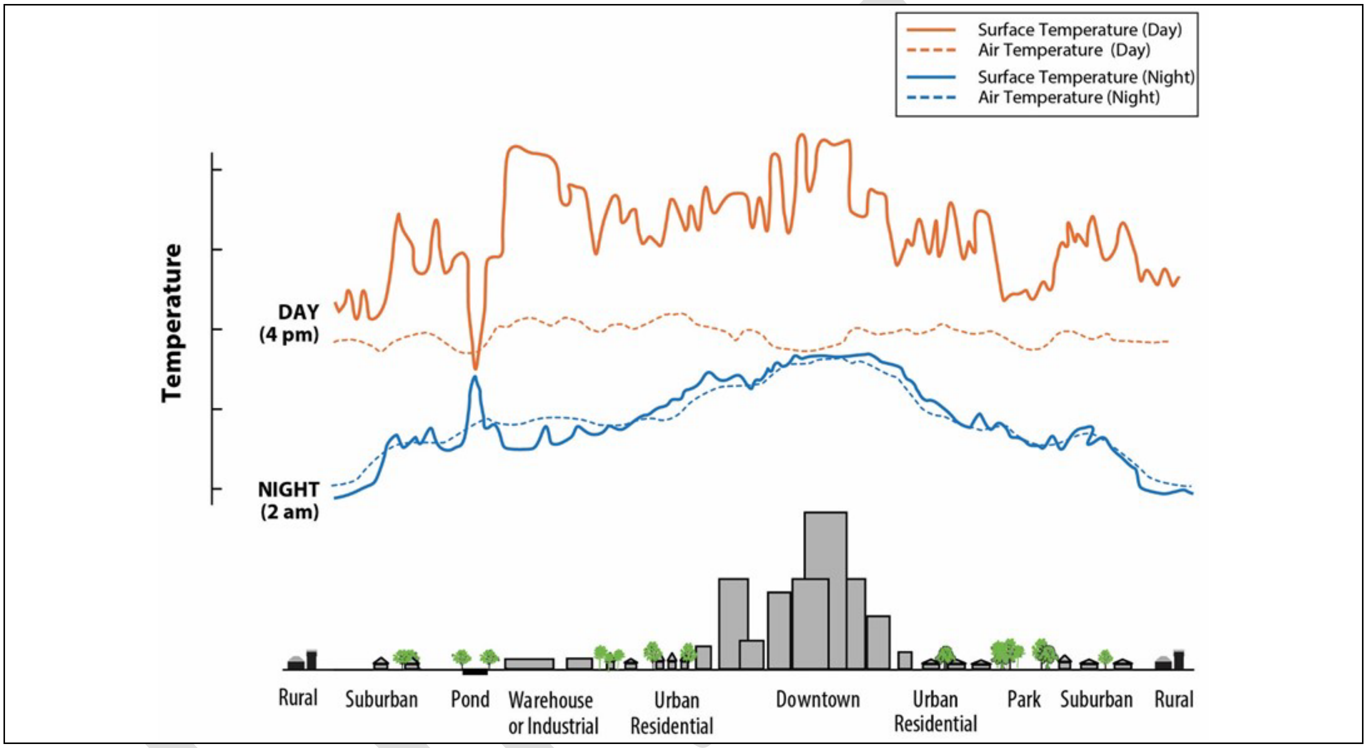
A heat wave is a period of abnormally and uncomfortably hot and unusually humid weather. Humid conditions occur when a dome of high atmospheric pressure traps hazy, damp air near the ground. A heat wave will typically last two or more days (National Oceanic and Atmospheric Administration 2009).

Heat Islands

Urbanized areas face increased risks related to extreme heat. As urban areas develop and change, buildings, roads, and other infrastructure replace open land and vegetation. Surfaces that were once permeable and moist become impermeable and dry, causing urban areas to be warmer than the surrounding areas. This process effectively forms a “heat island” of higher temperatures (United States Environmental Protection Agency 2019). Heat islands are areas that are hotter than nearby less developed areas.

Heat islands occur on the surface and in the atmosphere. The annual mean air temperature of a city with more than one million people can be between 1.8 ºF and 5.4 ºF warmer than its surrounding areas. In the evening, the difference in air temperatures can be as high as 22 ºF. On a hot, sunny day, the sun can heat dry, exposed urban surfaces to temperatures 50 ºF to 90 ºF hotter than the air. As shown in Figure 16-2, surface temperatures vary more than atmospheric air temperatures during the day, but they are generally similar at night. The dips and spikes in surface temperatures over the pond area in the figure show how water maintains a nearly constant temperature day and night because it does not absorb the sun’s energy the same way as buildings and paved surfaces. Parks, open land, and bodies of water can absorb more energy, creating areas that feel cooler throughout a city.

Figure 16-2. Urban Heat Island Profile



Source: US EPA 2023

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 (United States Environmental Protection Agency 2019).

16.1.2 Location

All of Sussex County is exposed to severe weather events (thunderstorms, lightning, hail, high winds, tornadoes, and extreme temperatures).

Thunderstorms

Thunderstorms affect relatively small, localized areas, rather than large regions like winter storms and hurricane events. They tend to take place in spring and summer and during the warmest times of the day (late afternoon and early evening) (National Oceanic and Atmospheric Administration n.d.). It is assumed for this HMP that the thunderstorm risk is the same everywhere in Sussex County.

Lightning

Severe storm events occur throughout the State of New Jersey and are not bound by geographic extent. The likelihood of these events affecting Sussex County depends on storm conditions. Lightning occurs with thunderstorms, so it is most likely during spring and summer, and during the warmest times of the day (National Oceanic and Atmospheric Administration n.d.). Figure 16-3 shows a relatively moderate Lightning Risk Index for Sussex County from FEMA's National Risk Index (FEMA 2019).

Figure 16-3. National Risk Index Lightning Risk

Source: FEMA 2019
Note: Sussex County is outlined in a blue border.

Hail

Hailstorms can form anywhere; however, they are more likely to fall in areas that have the most thunderstorms. Figure 16-4 shows a very low Hail Risk Index for Sussex County from FEMA's National Risk Index (FEMA 2019).

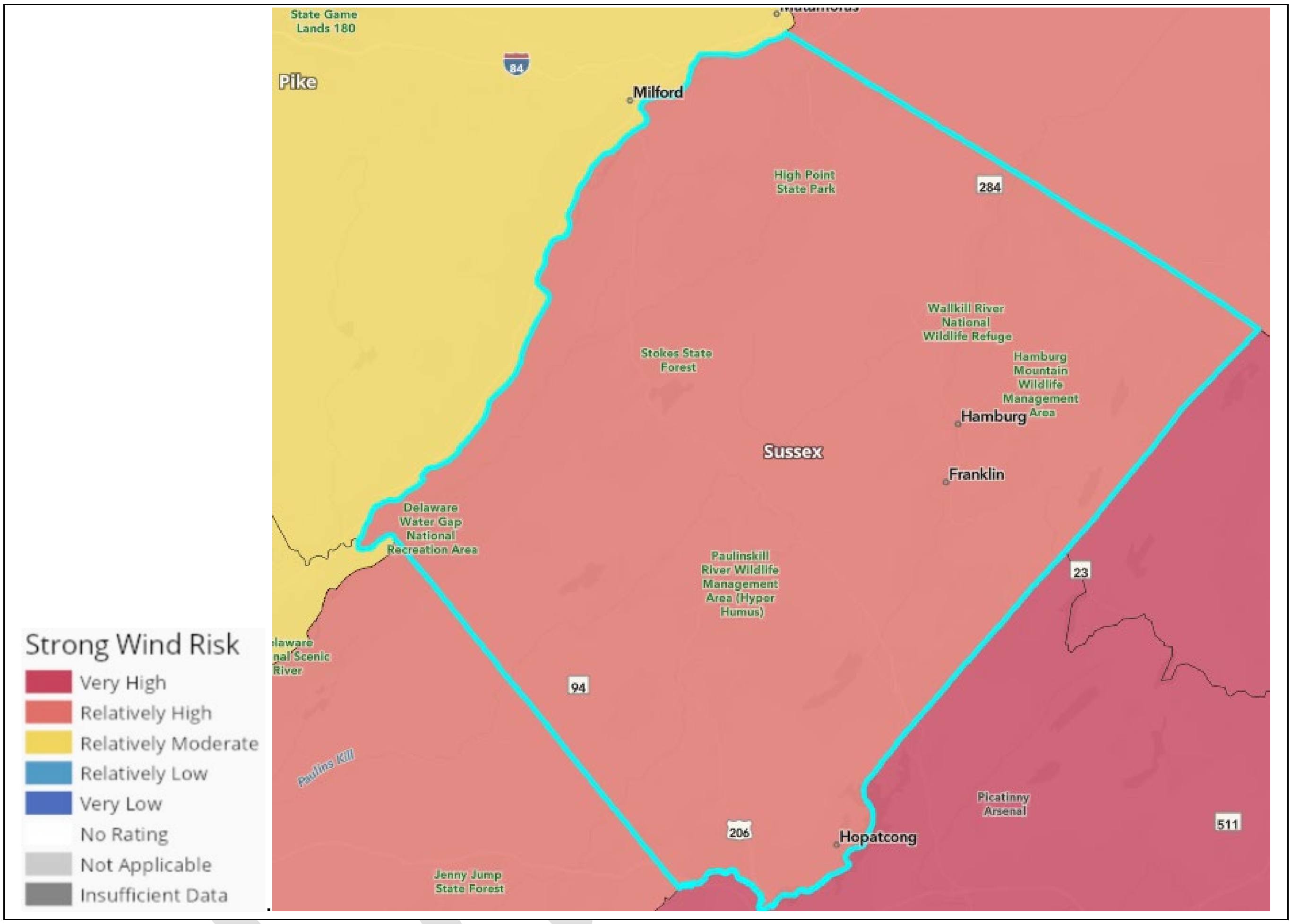
Figure 16-4. National Risk Index Hail Risk

Source: FEMA 2019
Note: Sussex County is outlined in a blue border.

High Winds

All of Sussex County is subject to high winds from severe weather events. Figure 16-5 shows a relatively high Strong Wind Risk Index for Sussex County from FEMA's National Risk Index (FEMA 2019).

Figure 16-5. National Risk Index Strong Wind Risk



Source: FEMA 2019
Note: Sussex County is outlined in a blue border.

Tornadoes

Like thunderstorms, tornadoes do not have any specific geographic boundary and can occur anywhere in Sussex County. Figure 16-6 shows a relatively low Tornado Risk Index for Sussex County from FEMA's National Risk Index (FEMA 2019).

Figure 16-6. National Risk Index Tornado Risk

Source: FEMA 2019
Note: Sussex County is outlined in a blue border.

Extreme Temperatures

Extreme Cold

Being in the northernmost portion of the state, and with small mountains up to 1,800 feet in elevation, Sussex County normally exhibits a colder temperature regime than other New Jersey counties. In winter, average temperatures in the County can be more than 10 °F cooler than in other parts of the state (Rutgers University 2019). Figure 16-7 shows a relatively low Extreme Cold, or Cold Wave, Risk Index for Sussex County from FEMA's National Risk Index (FEMA 2019).

Extreme Heat

Extreme heat events usually cover a large area, such as an entire county. However, there can be spot locations that are somewhat cooler (e.g., a shady park near a stream) or hotter (e.g., urban areas because their built environment holds heat). Figure 16-8 shows a relatively moderate Extreme Heat, or Heat Wave, Risk Index for Sussex County from FEMA's National Risk Index (FEMA 2019).

Figure 16-7. National Risk Index Cold Wave Risk

Source: FEMA 2019
Note: Sussex County is outlined in a blue border.

Figure 16-8. National Risk Index Heat Wave Risk

Source: FEMA 2019
Note: Sussex County is outlined in a blue border.

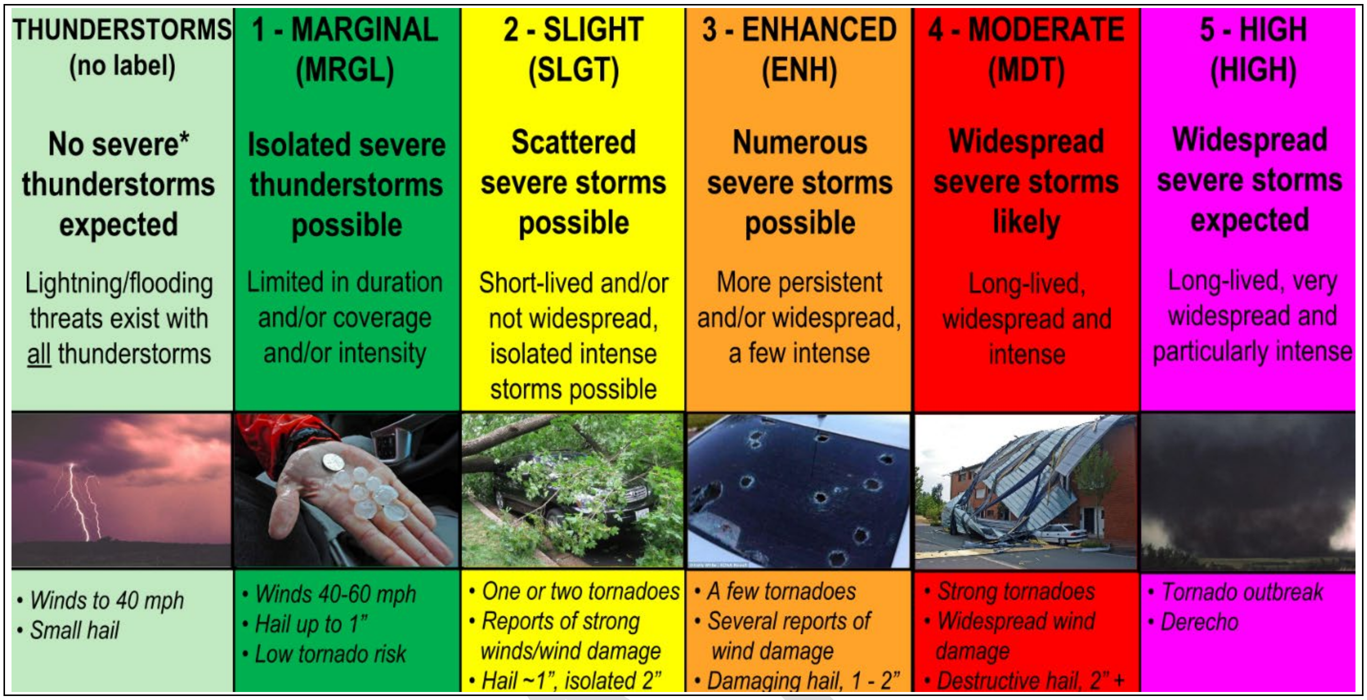
16.1.3 Extent

Thunderstorms

Thunderstorms are a common hazard for Sussex County and pose a wide variety of threats to affected communities, including rain-induced flooding, landslides, strong winds, and lightning. There have been reports of property damage, injury, and, in some cases, death caused by thunderstorms and lightning in the County.

When a thunderstorm features a tornado, wind gusts of 58 mph or more, or hail 1 inch or more in diameter, the National Weather Service (NWS) defines it as a severe thunderstorm. The NWS has five risk categories for severe thunderstorm—marginal, slight, enhanced, moderate, and high—as shown in Figure 16-9.

Figure 16-9. Severe Thunderstorm Risk Categories



Source: National Oceanic and Atmospheric Administration n.d.

The local NWS office and the Storm Prediction Center issue the following severe thunderstorm alerts (National Weather Service 2023):

- **Special Weather Statements** are issued for strong storms that are below severe levels but may have impacts. Usually reserved for the threat of wind gust of 40 to 57 mph or hail of 0.5 inches to 0.99 inches in diameter.
- **Severe Thunderstorm Watches** are issued when severe thunderstorms are possible in and near watch areas.
- **Severe Thunderstorm Warning** indicates a storm is imminent or occurring; it is either detected by weather radar or reported by storm spotters. A warning means to take shelter.

Lightning

Lightning ranks as one of the top weather killers in the United States, killing approximately 50 people and injuring hundreds each year (NWS n.d.). 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. Most people struck by lightning survive, although they may have severe burns and internal damage. Over 22,000 fires caused by lightning occurred annually throughout the U.S. between 2007 and 2011, which was valued at approximately $450 million of damages per year (National Fire Protection Association 2013).

Hail

As shown in Table 16-1, the NRI hail risk ranges from very low to relatively low at the census tract scale across Sussex County. The NRI identifies hail risk countywide as very low.

Most hailstorms are made up of a mix of different sizes, and only the very largest hail stones pose serious risk to people caught in the open (National Oceanic and Atmospheric Administration 2021). Large hail can damage aircraft, homes, or cars and can be deadly to livestock and people. Wind-driven hail can tear up siding on houses, break windows and blow into houses, break side windows on cars, and cause severe injury and/or death to people and animals. Hail size is often estimated by comparing the size of a single hailstone to a known object, as shown in Table 16-1.

Table 16-1. Hail Size

Description	Diameter (in inches)	Description	Diameter (in inches)
Pea	0.25	Golf ball	1.75
Marble or Mothball	0.50	Tennis ball	2.5
Penny or Dime	0.75	Baseball	2.75
Nickel	0.88	Tea cup	3.00
Quarter	1.00	Softball	4.00
Ping Pong Ball	1.25	Grapefruit	4.50

Source: National Oceanic and Atmospheric Administration 2023

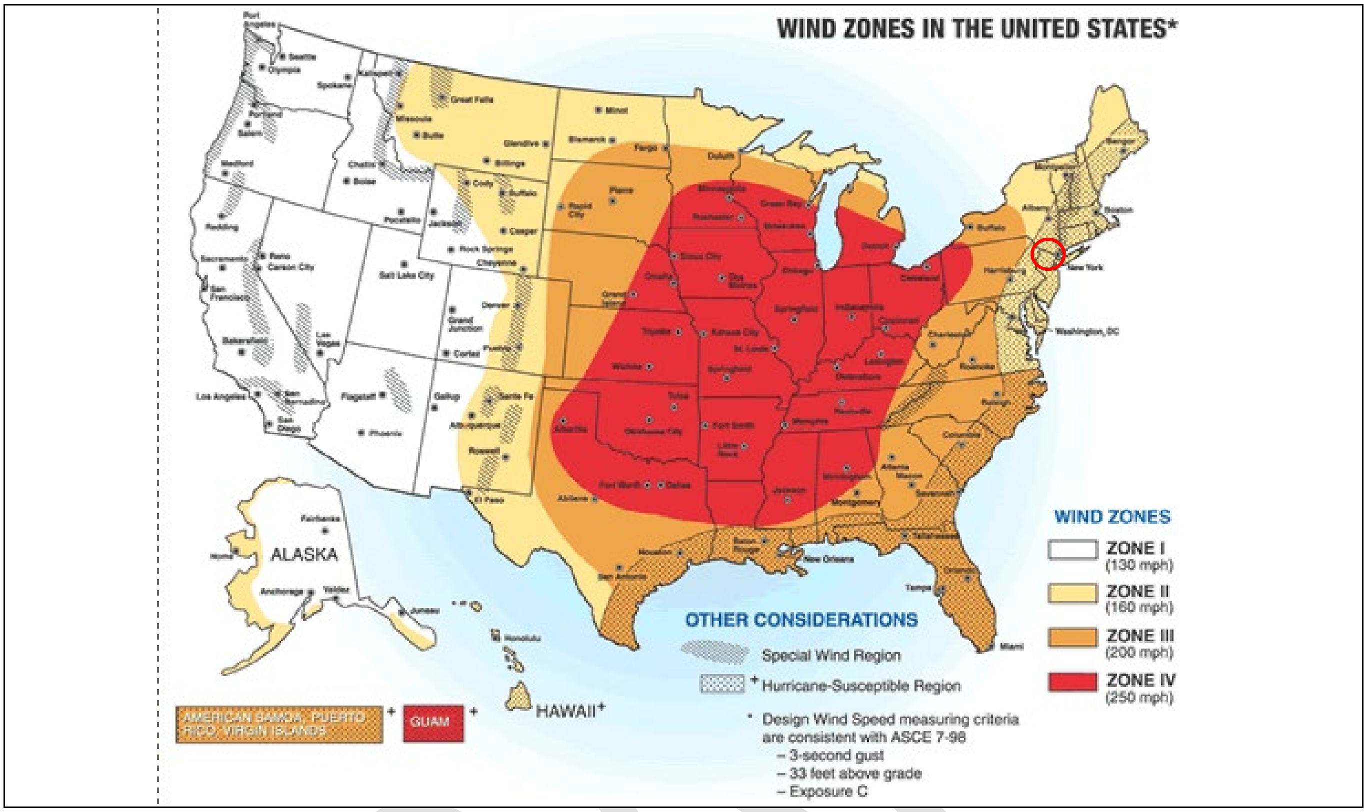
High Wind

As shown in **Error! Reference source not found.**, the NRI strong wind risk ranges from relatively moderate to very high at the census tract scale across Sussex County. The NRI identifies strong wind risk countywide as relatively high.

According to FEMA's "Winds Zones of the United States" map, Sussex County is located in Wind Zone II, where wind speeds can reach up to 160 mph (see Figure 16-10).

Table 16-2 provides the descriptions of winds and their associated sustained wind speed used by the NWS during wind-producing events. The Beaufort wind scale, developed in 1805, is also used today to classify wind conditions, and is provided in Appendix H (Supplementary Data).

Figure 16-10. Wind Zones in the United States



Source: National Institute of Standards and Technology 2011
Note: The red circle indicates the approximate location of Sussex County.

Table 16-2. NWS Wind Descriptions

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

Source: National Weather Service 2010

In New Jersey, NWS issues high wind alerts as follows when wind speeds may pose a hazard or may be life threatening (National Weather Service 2012):

- **Wind Advisories** are issued when sustained winds of 30 to 39 mph are forecast for one hour or longer, or wind gusts of 46 to 57 mph for any duration.
- **High Wind Watches** are issued when there is the possibility that high wind warning criteria may be met 24 to 48 hours out.
- **High Wind Warnings** are issued when sustained wind speeds of 40 mph or greater lasting for one hour or longer, winds of 58 mph or greater for any duration, or widespread damage are possible.

Tornado

As shown in **Error! Reference source not found.**, the NRI tornado risk ranges from very low to relatively moderate at the census tract scale across Sussex County. The NRI identifies tornado risk countywide as relatively low.

Tornadoes can disrupt daily activities of the public and service industries, causing injuries or damage to critical infrastructure and property. Most of the damage from tornadoes in Sussex County is caused by windblown debris.

The magnitude or severity of a tornado is categorized using the Enhanced Fujita Tornado Intensity Scale (EF Scale). This scale determines tornado ratings by comparing wind speed and actual damage. **Error! Reference source not found.** illustrates the relationship between EF ratings, wind speed, and expected tornado damage.

Figure 16-11. 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: National Weather Service 2015

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 (National Oceanic and Atmospheric Administration 2011).

Extreme Temperatures

Extreme Cold

Prolonged exposure to extreme cold temperatures can cause the following dangerous health conditions (Occupational Safety and Health Administration n.d.):

- **Frostbite** is damage to body tissue caused by extreme cold. A wind chill of -20 °F will cause frostbite in roughly 30 minutes. Frostbite can cause a loss of feeling and a white or pale appearance of exposed skin.
- **Hypothermia** is a condition brought on when the body temperature drops to less than 95 °F and is deadly. Warning signs of hypothermia include uncontrollable shivering, memory loss, disorientation, incoherence, slurred speech, drowsiness, and exhaustion.

The severity or magnitude of extreme cold temperatures is generally measured through the wind chill temperature (WCT) index. Wind chill temperature is the temperature that people and animals feel when outside, 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 (National Oceanic and Atmospheric Administration 2023). Figure 16-12 shows WCT based on temperature and wind speed. Three shaded areas of frostbite danger indicate how long a person can be exposed before frostbite develops (National Weather Service 2021).

Figure 16-12. NWS Wind Chill Index

Wind (mph)	Temperature (°F)																	
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

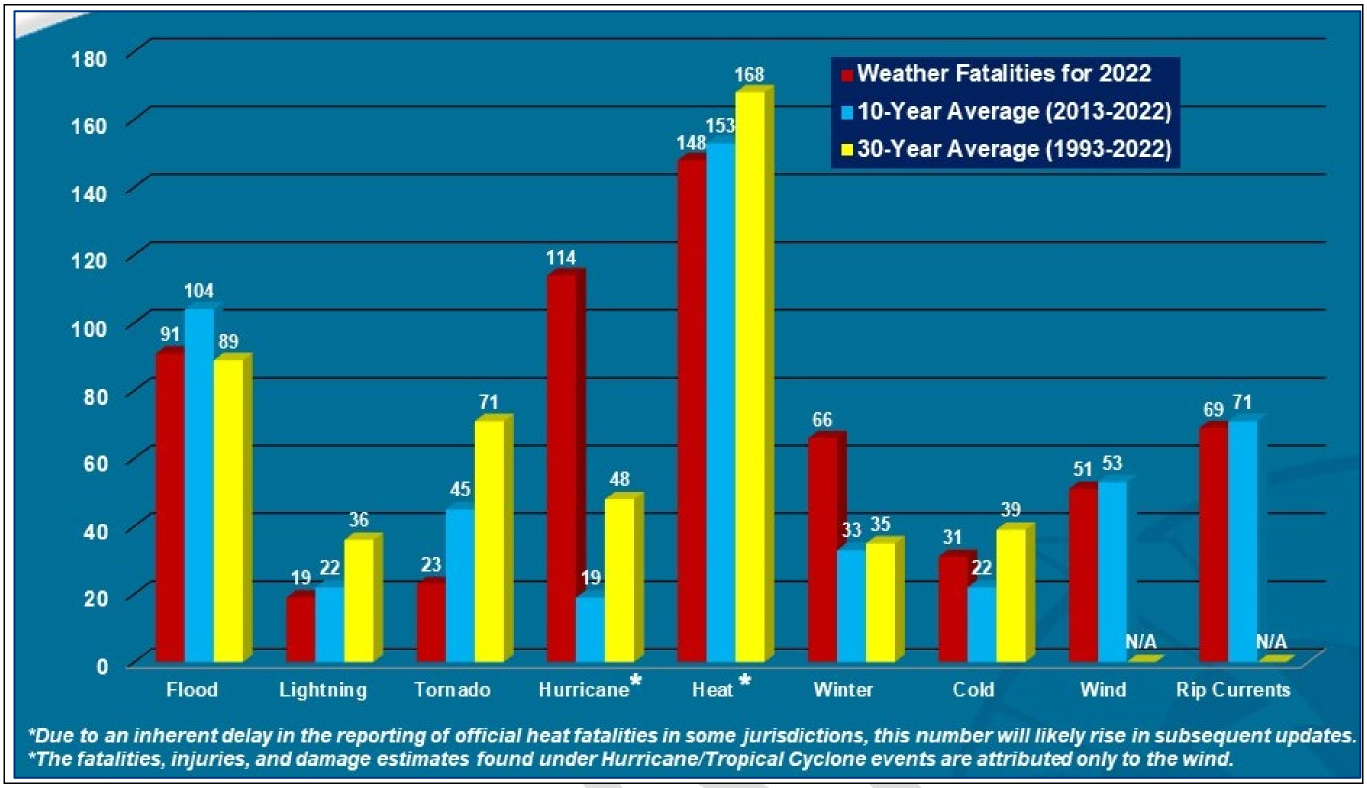
Frostbite Times: 30 minutes; 10 minutes; 5 minutes

Source: National Weather Service 2021

Extreme Heat

Extreme heat is the number one weather-related cause of death in the U.S. On average, about 150 people die each year in the United States from excessive heat (National Weather Service n.d.). In 2022, 148 people died from heat related illnesses as shown in **Error! Reference source not found.**.

Figure 16-13. Weather Related Fatalities in the United States in 2022



Source: National Weather Service n.d.

The following health hazards are related to extreme heat temperatures (FEMA 2024):

- **Heat exhaustion** is the body's response to an excessive loss of water and salt, usually through excessive sweating. Symptoms can include headache, cramping, dizziness, and weakness.
- **Heat stroke** is the most serious heat-related illness. It occurs when the body can no longer control its temperature: body temperature rises rapidly and the sweating mechanism fails. Body temperature can rise to 106 °F within 10 to 15 minutes. Heat stroke can cause permanent disability or death if the person does not receive emergency treatment.

Workers who are exposed to extreme heat or work in hot environments may be at risk of heat stroke, heat exhaustion, heat cramps, or heat rashes. Workers at greater risk of these conditions include those who are 65 years of age or older, are overweight, have heart disease or high blood pressure, or take medications that may be affected by extreme heat. Heat can also increase the risk of injuries in workers as it may result in sweaty palms, fogged-up safety glasses, and dizziness. Burns may occur as a result of accidental contact with hot surfaces (Centers for Disease Control and Prevention 2020, Centers for Disease Control and Prevention 2018).

The NWS heat index, shown in Figure 16-13, indicates apparent temperature of the air as it increases with relative humidity in shady, light wind conditions. This index provides a measure of how temperatures feel. **Error! Reference source not found.** denotes the effects of prolonged exposure to heat on the human body.

Figure 16-14. 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: National Weather Service 2023

Table 16-3. Adverse Effects of Prolonged Exposure to Heat

Category	Heat Index	Effects on the Body
Caution	80 °F – 90 °F	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	90 °F – 103 °F	Heat stroke, heat cramps, or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	103 °F – 124 °F	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	125 °F or higher	Heat stroke highly likely

Source: National Weather Service 2023

Extreme Temperature Alerts

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

The NWS issues the following freeze/cold alerts depending on the severity of the wind chill and the time of the year (National Weather Service 2021):

- **A Wind Chill Advisory** is issued when seasonably cold wind chill values, but not extremely cold values are expected or occurring.
- **A Wind Chill Watch** is issued when dangerously cold wind chill values are possible.

- **A Wind Chill Warning** is issued when dangerously cold wind chill values are expected or occurring.
- **A Frost Advisory** indicates that areas of frost are expected or occurring and are posing a threat to sensitive vegetation.
- **A Freeze Watch** is issued when there is a potential for significant, widespread freezing temperatures within the following 24 to 36 hours.
- **A Freeze Warning** is typically issued when temperatures are forecasted to go below 32 °F for a long period of time.
- **A Hard Freeze Warning** is issued when temperatures are expected to drop below 28 °F, which typically kills most commercial crops and residential plants.

The NWS issues the following heat alerts depending on the severity of the heat index (National Weather Service 2020):

- An **Excessive Heat Outlook** is issued when potential exists for an excessive heat event within the following three to seven days.
- A **Heat Advisory** is issued within 12 hours of the onset of extremely dangerous heat conditions. This advisory is typically issued when the maximum heat index temperature is expected to be 100 °F or higher for at least 2 days, and nighttime air temperatures will not drop below 75 °F.
- An **Excessive Heat Watch** is issued when conditions are favorable for an excessive heat event within the following 24 to 72 hours. This watch is typically issued when risk of a heat wave has increased, but the timing and occurrence is still uncertain.
- An **Excessive Heat Warning** is issued within 12 hours of the onset of extremely dangerous heat conditions. This warning is typically issued when the maximum heat index temperature is expected to be 105 °F or higher for two consecutive days with night temperatures not dropping below 75 °F.

16.1.4 Previous Occurrences

FEMA Major Disaster and Emergency Declarations

Between 1954 and 2024, Sussex County was included in seven major disaster (DR) or emergency (EM) declarations for severe weather-related events, as shown in Table 16-4. None of them occurred since the previous County HMP (FEMA 2024).

USDA Declarations

The U.S. Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans from the U.S. Department of Agriculture (USDA) to producers suffering losses in those counties and in contiguous counties. Since the previous Sussex County HMP, the County has not been included in any USDA severe weather-related agricultural disaster declarations.

Previous Events

Known hazard events that impacted Sussex County between January 2020 and June 2024 are listed in Table 16-5. For events prior to 2020, refer to the 2021 Sussex County HMP.

Table 16-4. FEMA Declarations for Severe Weather Events in Sussex County (1954 to 2024)

Event Date	Declaration Date	Declaration Number	Description
August 12 – August 21, 2000	August 17, 2000	DR-1337	Severe Storms, Flooding and Mudslides
September 18 – October 1, 2004	October 1, 2004	DR-1563	Tropical Depression Ivan
April 1-3, 2005	April 19, 2005	DR-1588	Severe Storms and Flooding
June 23 – July 10	July 7, 2006	DR-1653	Severe Storms and Flooding
April 14-20, 2007	April 26, 2007	DR-1694	Severe Storms and Inland and Coastal Flooding
September 28 – October 6, 2011	October 14, 2011	DR-4039	Remnants of Tropical Storm Lee
October 29, 2011	November 30, 2011	DR-4048	Severe Storm

Sources: FEMA 2024

Table 16-5. Severe Weather Events in Sussex County (2020 to 2024)

Event Date	FEMA Declaration or State Proclamation Number	Sussex County included in declaration?	Location Impacted	Description
February 7, 2020	N/A	N/A	Sussex County	Winds up to 62 mph occurred in areas of Sussex County.
June 3, 2020	N/A	N/A	Libertyville, Vernon	A derecho produced damaging winds in excess of 60 mph. Frequent cloud to ground lightning and heavy downpours were also reported throughout the area. Reported wind gusts associated with these thunderstorms generally ranged between 45 and 65 mph. Several reports of tree limbs and power lines down near Route 515, Vernon Crossing Road, Route 519, and Neilson Road.
June 19, 2020	N/A	N/A	Sparta	Scattered thunderstorms produced isolated wind damage. Reports of trees and wires down near Underrock Road near Sparta.
June 28, 2020	N/A	N/A	Colesville, Glenwood	Thunderstorms produced strong to severe winds and heavy rain; a few thunderstorms contained large hail. Dime to ping-pong ball sized hail was reported in Montague. Several reports of power lines down and power outages in the Vernon Valley area northwest of Wawayanda State Park.

Event Date	FEMA Declaration or State Proclamation Number	Sussex County included in declaration?	Location Impacted	Description
July 3, 2020	N/A	N/A	Glenwood, Independence Corner, McAfee	Severe thunderstorms and heavy rain showers developed. Wires down on McAfee-Glenwood Road and Glenwood Road. Trees and wires were downed near Tall Timbers Road, Valley View Drive, and Hemlock Drive where a tree fell on a trailer; power outages were reported in both areas. A downed tree on NJ-284 southbound cause lane restrictions to be put in place.
July 22, 2020	N/A	N/A	Montague, Colesville	Widespread thunderstorms developed into a squall line that produced numerous reports of wind damage. A large tree was split at a residence on Red Hill Road. Hail up to half dollar size was reported. A tree was downed on Deckerton Turnpike near the intersection with County Route 675. Several reports of downed trees and wires were made in Montague Twp. Downed tree limbs and wires were reported near Lake Marcia. Ping pong ball size hail fell in Montague.
August 18, 2020	N/A	N/A	Montague	A cluster of severe thunderstorms with damaging winds impacted portions of northern New Jersey. Trees and wires were downed on Fox Hollow Road near Montague.
August 25, 2020	N/A	N/A	Colesville, Quarryville, Owens, Vernon	Storms produced wind damage. Several reports were made of downed trees and wires near Mount Salem Road, Moore Road, Glenwood Mount Road, and Pondeddy Road.
November 15, 2020	N/A	N/A	Hardystonville, Highland Lakes	Storms produced widespread wind gusts of around 60 mph, with a number of reports of downed trees and power lines and localized property damage.
April 28, 2021	N/A	N/A	Sussex, McAfee	Storms produced damaging wind. Some trees were downed in the vicinity of Opsal Lane in Wantage Twp. and of Evergreen Trail in Vernon Twp. Power outages were reported.
June 4, 2021	N/A	N/A	Swartswood	Severe storms caused damaging winds and hail. Trees and wires were downed near West Shore Drive.
June 14, 2021	N/A	N/A	Andover, Franklin	Severe storms caused damaging winds and some hail. Trees and wires were downed near Tranquility Road in Andover. Wires were reported down near Franklin.
June 21, 2021	N/A	N/A	Hainesville, Yellow Frame, Fredon, Halsey, Newton, Beemerville	Severe storms produced damaging winds, with numerous reports of downed trees and power lines. Trees and power lines were downed on Flatbrook Road, Yellow Frame Road, Phil Hardin Road, Newton Swartswood Road, and Wantage Avenue.
July 6, 2021	N/A	N/A	Frankford Plain, Newton, Tranquility, Fredon, South Ogendensburg, Beaver Lake, Highland Lakes	Severe storms produced damaging winds, some hail, and prolific lightning. Multiple trees and wires were downed. Reports of hail up to quarter size were received.

Event Date	FEMA Declaration or State Proclamation Number	Sussex County included in declaration?	Location Impacted	Description
July 12, 2021	N/A	N/A	Highland Lakes, Lake Mohawk	Severe storms produced damaging wind. There was a report of a lightning strike to a house. Trees and wires were downed near Springbrook Trail.
July 16, 2021	N/A	N/A	Ownes, Vernon	Thunderstorms produced at least two strong microbursts. Many trees were snapped near Vernon due to what was likely a strong microburst. Power outages were also reported. Wind speeds were estimated to be 70 mph but may have been higher. This storm earlier produced a measured 64 mph wind gust with another microburst.
July 27, 2021	N/A	N/A	Libertyville, Independence Corner, Glenwood	Severe thunderstorms produced damaging wind. Tree limbs were downed onto wires with a fire reported on Armstrong Road. Several tree limbs were downed with lane blockages along Route 517 in Glenwood.
August 12, 2021	N/A	N/A	Five Points	Scattered thunderstorms produced instances of damaging winds. There were multiple reports of trees and wires down.
May 16, 2022	N/A	N/A	Quarryville	Severe storms produced a few instances of damaging winds up to 60 mph and hail.
July 12, 2022	N/A	N/A	Brookwood	A storm produced scattered wind damage along its path. There was a report of a downed tree and utility pole fire in Byram.
July 24, 2022	N/A	N/A	Five Points	Thunderstorms produced isolated wind damage. Tree and wires were blown down on Possum Hill Road.
December 23-24, 2022	N/A	N/A	Sussex County	Temperatures fell into the single digits and teens with wind chills ranging from -5 °F to -20 °F in New Jersey. The lowest wind chills occurred at the higher elevations of Sussex County.
February 3-4, 2023	N/A	N/A	Sussex County	Low temperatures and windy conditions resulted in dangerously low wind chills ranging from -10 °F to -20 °F. Temperatures fell into the lower single digits to just below zero across Sussex County.
March 7, 2023	N/A	N/A	Sussex County	Strong winds developed behind a storm system. A New Jersey Weather station at High Point measured a gust of 67 mph.
April 22, 2023	N/A	N/A	Montague	Showers and thunderstorms produced gusty winds and small to medium sized hail. The average hail size was 0.50 inches, and the largest was 0.75 inches.
June 26, 2023	N/A	N/A	Lafayette, Vernon	Storms moved over the region and multiple trees and wires were downed in Lafayette Township. Additional trees and wires were downed on New Jersey 94 at the intersection with Vernon Crossing Road.
July 13, 2023	N/A	N/A	Vernon	Severe thunderstorms produced damaging wind gusts up to 60 mph and hail up to 1 inch in diameter.
July 14, 2023	N/A	N/A	Brookwood	Severe thunderstorms produced damaging wind gusts up to 60 mph in parts of New Jersey, causing multiple wires to be blown down.

Event Date	FEMA Declaration or State Proclamation Number	Sussex County included in declaration?	Location Impacted	Description
July 16, 2023	N/A	N/A	Hopatcong	Slow-moving showers and thunderstorms produced damaging wind gusts across parts of New Jersey. A large tree fell down on Hopatchung Road.
July 25, 2023	N/A	N/A	Hamburg	Thunderstorms produced damaging winds of up to 60 mph across parts of New Jersey. Downed tree on NJ 94 northbound north of NJ 23 in Hardyston Twp.
July 29, 2023	N/A	N/A	Libertyville	Severe storms produced damaging wind gusts. There was a report of multiple 3- to 5-inch tree limbs broken with power lines down at intersection of Libertyville Road and County Route 519 in Wantage.

Source: FEMA 2023; NOAA NCEI 2023

16.1.5 Probability of Future Occurrences

Probability Based on Previous Occurrences

Information on previous severe weather occurrences in the County was used to calculate the probability of future occurrence of such events, as summarized in Table 16-6. Probability of Future Severe Weather Events in Sussex County

. Based on historical records and input from the Steering Committee, the probability of occurrence for severe weather in the County is considered “frequent.”

Effect of Climate Change on Future Probability

Projections of climate change for New Jersey predict higher temperatures, more intense rainfall events, and increases in total annual precipitation (see Section 3.3.4) (NJDEP 2020). A warmer atmosphere means storms have the potential to be more intense and occur more often. Most of these events occur in the warmer months between April and October. Extreme cold events might decrease in frequency, while extreme heat events might increase in frequency; the shift in temperatures could result in hotter extreme heat events.

Table 16-6. Probability of Future Severe Weather Events in Sussex County

Hazard Type	Number of Occurrences Between 1996[a] and 2024	Percent Chance of Occurring in Any Given Year
Cold/Wind Chill	32	100
Excessive Heat	8	28.57
Extreme Cold/Wind Chill	3	10.71
Hail	35	100
Heat	43	100
Heavy Rain	48	100
High/Strong Wind	138	100
Lightning	20	71.43
Thunderstorm Wind	152	100

Hazard Type	Number of Occurrences Between 1996[a] and 2024	Percent Chance of Occurring in Any Given Year
Tornado / Funnel Cloud	6	21.42
Total	**485**	**100**

Source: NOAA NCEI 2023

a. Events prior to 1996 are not included because sources of earlier data are not considered to be complete.

16.1.6 Cascading Impacts on Other Hazards

Direct and indirect impacts of severe weather events may induce secondary hazards such as flooding, dust storms, droughts, wildfires, water shortages, power outages, infrastructure deterioration or failure, utility failures, water quality and supply concerns, and transportation issues.

Severe winds can breach power lines and disconnect utility systems. Severe weather may carry extreme rainfall that exacerbates flooding. Fallen trees from severe weather events can contribute to an increase in fuel for wildfires. Fallen vegetation also reduces the soil stability of steep slopes, which can lead to an increased risk of landslides. Extreme heat contributes to the risk of drought conditions. The compounding impacts from extreme heat and drought make areas more susceptible to wildfires, which can be triggered by lightning.

16.2 VULNERABILITY AND IMPACT ASSESSMENT

For the severe weather hazard, all of Sussex County has been identified as at risk. Due to a lack of quantifiable loss information, a qualitative assessment was conducted to evaluate the assets exposed to this hazard and its potential impacts.

16.2.1 Life, Health, and Safety

Overall Population

The entire population of Sussex County (144,221 people) is exposed to severe weather events. Risks are particularly high for people who are outdoors during severe weather events, whether for work or recreation. These people are vulnerable to hailstorms, thunderstorms, and tornadoes because there is little to no warning, and shelter might not be available. Downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. People outdoors may overexert through work or exercise during extreme heat events or experience hypothermia during extreme cold events (CDC 2022, CDC 2005).

Heavy rain, lightning, hail, high winds, and extreme temperatures all can pose a greater threat to employees in the construction industry. Employers should prepare for the hazards associated with adverse weather conditions that may require special facilities and safety equipment being provided to employees who work outdoors, or in some instances, work stoppage to ensure the safety and health of workers (Hazwoper 2020).

Socially Vulnerable Population

Extreme cold can adversely affect susceptible populations, such as those without shelter or a vehicle, or those who live in a home that is poorly insulated or without heat (such as mobile homes) (CDC 2012). According to the Centers for Disease Control and Prevention, populations most at risk to extreme cold and heat events include the following (CDC 2022, CDC 2005):

- The elderly, who are less able to withstand temperature extremes due to their age, health conditions, and limited mobility to access shelters
- Infants and children up to 4 years of age
- Individuals with chronic medical conditions (e.g., heart disease, high blood pressure)
- Low-income persons that cannot afford proper heating and cooling.

Without a quantitative assessment of potential impacts of a severe weather on socially vulnerable populations, the Planning Partners can best assess mitigation options through an understanding of the general numbers and locations of such populations across Sussex County. Section 3.5.3 provides detailed data on socially vulnerable populations within the planning area. Table 16-7 summarizes highlights of this information. For planning purposes, it is reasonable to assume that percentages and distribution of socially vulnerable populations affected by a severe weather event will be similar to the countywide numbers.

Table 16-7. Distribution of Socially Vulnerable Populations by Municipality

Category	Sussex County Total		Municipality Highest in Category		Municipality Lowest in Category	
	Number	Percent	Number	Percent	Number	Percent
			Vernon (T)	Walpack (T)	Walpack (T)	Sparta (T)
Population Over 65	**25,451**	**17.65%**	**3,687**	**100.00%**	**7**	**13.38%**
			Sparta (T)	Lafayette (T)	Walpack (T)	Walpack (T)
Population Under 5	**6,500**	**4.51%**	**1,160**	**7.21%**	**0**	**0.00%**
Non-English-			Hopatcong (B)	Hamburg (B)	Andover, Frankford, Sandyston, Stanhope, Stillwater, Walpack	Andover, Frankford, Sandyston, Stanhope, Stillwater, Walpack
Speaking Population	**1,922**	**1.33%**	**339**	**10.17%**	**0**	**0.00%**
Population With			Vernon (T)	Franklin (B)	Walpack (T)	Walpack (T)
Disability	**15,697**	**10.88%**	**2,318**	**17.32%**	**0**	**0.00%**
Population Below			Vernon (T)	Sussex (B)	Walpack (T)	Walpack (T)
Poverty Level	**7,320**	**5.08%**	**877**	**18.03%**	**0**	**0.00%**
Households Below			Vernon (T)	Sussex (B0	Branchville (B)	Green (T)
ALICE Threshold	**14,428**	**21%**	1,833	**48%**	90	**14%**

16.2.2 General Building Stock

All buildings are exposed to severe weather hazards such as hailstorms and lightning strikes. Sussex County is estimated to have 71,937 buildings, with a total replacement cost value (structure and content) of approximately $68.5 billion (see Section 3.7.1).

While hailstorms are not frequently known to cause major damage in New Jersey, an extreme event can carry hail stones traveling at speeds greater than 100 miles per hour (National Weather Service 2019). This could cause structural damage for the general building stock in the County. Severe weather that causes lightning could be a threat to the County's general building stock if the lightning starts a fire.

Extreme heat generally does not impact buildings, but increased demand for cooling can cause damage from overheating of heating, ventilation, and air conditioning (HVAC) systems. Extreme cold temperatures can damage buildings through freezing/bursting of pipes and freeze/thaw cycles, as well as increasing vulnerability to home fires.

16.2.3 Community Lifelines and Other Critical Facilities

Critical facilities are at risk of being impacted by high winds associated with structural damage, or falling tree limbs/flying debris, which can result in the loss of power. Loss of power can impact public utilities, including potable water, wastewater treatment, and communications. Emergency personnel such as police, fire, and EMS will not be able to effectively respond in a power loss event to maintain public safety unless backup power and fuel sources are available.

All critical facilities in the County are exposed to the same extreme temperature risks as those discussed for the general building stock. Extreme heat can sometimes cause short periods of utility failures, commonly referred to as brownouts, due to increased usage from air conditioners, appliances, etc. Backup power is recommended for critical facilities and infrastructure. Where backup power is needed for critical facilities that provide essential services, municipalities identified mitigation actions in Volume II of this HMP.

16.2.4 Economy

Severe weather can have short- and long-lasting impacts on the economy. Hailstorms, tornados, high winds, and flooding due to extreme rainfall all have the potential to damage key infrastructure, shopping centers, or transportation hubs, with potentially high public or private costs for repair. When businesses close 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, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Impacts on transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting and goods transport) transportation needs. Weather-related loss of power can impact business operations and heating or cooling provision to the population.

Extreme temperature events also have impacts on the economy, including building damage requiring repairs (e.g., pipes bursting), higher than normal utility bills, or business interruption due to power failure (i.e., loss of electricity, telecommunications). Extreme heat and cold events can damage crops. Based on the 2017 Census of Agriculture, Sussex County farms had a total market value of $10.8 million in crop sales and $7.4 million in livestock sales (United States Department of Agriculture 2017).

In 2014, the State of New Jersey established the Energy Resilience Bank (ERB), to address significant energy infrastructure vulnerabilities arising in the aftermath of Superstorm Sandy. Utilizing $200 million through New Jersey's second Community Development Block Grant-Disaster Recovery (CDBG-DR) allocation, the ERB supports the development of distributed energy resources at critical facilities throughout the state that will enable them to remain operational during future outages.

16.2.5 Natural, Historic and Cultural Resources

Natural

Severe weather that includes heavy rainfall can erode natural banks along waterways and degrade soil stability for terrestrial species. Tornadoes can tear apart habitats, causing fragmentation across ecosystems (United States Environmental Protection Agency 2023). Freezing and warming weather patterns can create changes in natural processes. Extreme heat events can have negative impacts on aquatic systems, contributing to fish kills, aquatic plant die offs, and increased likelihood of harmful algal blooms. Extreme temperature events can also affect surrounding ecosystems, which can destroy food webs and deplete resources in the environment.

Historic

Winds associated with severe weather can cause damage or destruction to the County's historical assets, especially historical buildings not built to modern building code standards to withstand high winds. Historic buildings also may be susceptible to damage from extreme temperatures. Proper strategies help safeguard buildings and their contents. Sudden and dramatic fluctuations in heating or cooling should be minimized. Slower heating and cooling give building materials and stored contents time to acclimate to new temperatures in the building and corresponding new humidity levels (CCAHA 2019).

Extreme heat can increase the risk of ignition and propagation of fires. Under extreme heat, stones can face both macro (e.g., cracking of stones, soot accumulation, color change in stone containing iron) and micro degradation (e.g., mineralogical and textural changes), leading to structural instability. The long-term impacts include weakened stones and increased susceptibility to deterioration processes such as salt weathering and temperature cycling (Sesana, et al. 2021).

Cultural

Outdoor cultural events are likely to be postponed or cancelled as the result of severe weather conditions. Winds associated with severe weather can cause damage or destruction to the County's cultural assets, especially historical buildings not built to modern building code standards to withstand high winds.

16.3 CHANGE OF VULNERABILITY SINCE 2021 HMP

Overall, Sussex County's vulnerability to severe weather has not changed, and the entire County will continue to be exposed and vulnerable to severe weather events. Any perceived or actual changes in vulnerability may be attributed to changes in population numbers and density.

16.4 FUTURE CHANGES THAT MAY AFFECT RISK

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

16.4.1 Potential or Planned Development

The ability of new development to withstand severe weather hazard impacts lies in sound land use practices, building design considerations (e.g., Leadership in Energy and Environmental Design), and consistent enforcement of codes and regulations for new construction. New development will change the landscape where buildings, roads, and other infrastructure potentially replace open land and vegetation. Surfaces that were once permeable and moist will become impermeable and dry, potentially making them more susceptible to fires caused by lightning. These changes also cause urban areas to become warmer than the surrounding areas in the form of heat islands. Green space preservation will need to continue to be a priority to mitigate increased heat islands.

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

16.4.2 Projected Changes in Population

Changes in the density of population can impact the number of persons exposed to the severe weather hazard. Densely populated areas of the County may require utility system upgrades to keep up with utility demands (e.g., water, electric) during extreme temperature events to prevent increased stresses on these systems.

The New Jersey Department of Labor and Workforce Development produced population projections by County from 2014 to 2019, 2024, 2029, and 2034. According to these projections, Sussex County is projected to have a decrease in population in the upcoming years. These projection totals include a population of 140,400 by 2024, 137,300 by 2029, and 136,600 by 2034 (State of New Jersey 2017).

16.4.3 Climate Change

Climate change has the potential to alter the prevalence and severity of severe weather events. 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 flood critical transportation corridors and other infrastructure.

With increased temperatures, people could face increased health impacts. Additionally, as temperatures rise, more buildings, facilities, and infrastructure systems may exceed their ability to cope with the heat. Thus, building efficiency and upgrading heating and cooling technology/HVAC will become an increasingly important issue for businesses and homeowners over the coming years.

Researchers are finding that the long-term impacts of more severe weather can be destructive to the natural environment. For example, severe weather that creates longer periods of rainfall can erode natural banks along waterways and degrade soil stability for terrestrial species (United States Environmental Protection Agency 2023). 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 (United States Climate Resilience Toolkit 2016). 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.

Climate change is a potential threat to cultural heritage sites as it may aggravate the physical, chemical, and biological mechanisms causing degradation by affecting the structure or composition of building materials. Changes in temperature, precipitation, atmospheric moisture, and wind intensity, and the interaction between climatic changes and air pollution, have been identified as concerns by the United Nations (Sesana, et al. 2021).