4.3.12 SEVERE WINTER WEATHER

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the severe winter weather hazard in Sussex County.

2021 HMP Changes

- Previous occurrences were updated with events that occurred between 2015 and 2020.
- A vulnerability assessment was conducted for the severe winter weather hazard utilizing updated building data.

Profile

Hazard Description

A winter storm is considered a storm with significant snowfall, ice, and/or freezing rain. The quantity of precipitation varies by elevation. Heavy snowfall in non-mountainous areas is four inches or more in a 12-hour period, or six inches or more in a 24-hour period. In mountainous areas, heavy snowfall is considered 12 inches or more in a 12-hour period or 18 inches or more in a 24-hour period. Blizzards are storms with considerable falling and/or blowing snow combined with sustained winds or frequent wind gusts of 35 mph or greater that frequently reduce visibility to less than 0.25 mile for at least three hours.

Some winter storms are large enough to immobilize an entire region while others may only affect a single community. Winter storms are typically accompanied by low temperatures, high winds, freezing rain or sleet, and heavy snowfall. The aftermath of a winter storm can have an impact on a community or region for days, weeks, or even months; potentially causing cold temperatures, flooding, storm surge, closed and/or blocked roadways, downed utility lines, and power outages. In Sussex County, winter storms include blizzards, snowstorms, Nor'Easters and ice storms. Extreme cold temperatures, wind chills and Nor'Easters are also associated with winter storms; however, based on input from the Planning Committee, these events are further discussed in this plan in Section 4.3.10 (Nor'Easters) and Section 4.3.11 (Severe Weather).

Heavy Snow

According to the National Snow and Ice Data Center (NSIDC), snow is precipitation in the form of ice crystals. It originates in clouds when temperatures are below the freezing point (32 degrees Fahrenheit [°F]), when water vapor in the atmosphere condenses directly into ice without going through the liquid stage. Once an ice crystal has formed, it absorbs and freezes additional water vapor from the surrounding air, growing into snow crystals or snow pellets, which then fall to the earth. Snow falls in different forms, such as snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud. Snow pellets are opaque ice particles in the atmosphere. They form as ice crystals fall through super-cooled cloud droplets that are below freezing but remain a liquid. The cloud droplets then freeze to the crystals. A heavy snowstorm is defined as a snowstorm with accumulations of 4 inches or more of snow in a 6-hour period, or 6 inches of snow in a 12-hour period (NWS 2009).

Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 mph or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile. These conditions must be the predominant over a 3-hour period. Extremely cold temperatures are often associated with blizzard conditions, but are not a formal part of the definition. The hazard, created by the combination of snow, wind, and low visibility, significantly increases when temperatures are below 20°F. A severe blizzard is categorized as having

temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero. Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm, moister air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions caused by the blowing snow (The Weather Channel 2012).

Sleet

Sleet is made up of drops of rain that freeze into ice as they fall. They are usually smaller than 0.30 inch in diameter (NSIDC 2013). A sleet storm involves significant accumulations of solid pellets, which form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces, posing a hazard to pedestrians and motorists (NWS 2009).

Freezing Rain

Freezing rain occurs when rain falls into areas that are below freezing. In order for this to occur, ground-level temperatures must be colder than temperatures aloft. Freezing rain can also occur when the air temperature is slightly above freezing but the surface that the rain lands upon is still below freezing from prior cold air temperatures (NWS 2009).

An ice storm is an event caused by damaging accumulations of ice during freezing rain events. An ice storm involves significant accumulation of rain or drizzle freezing on objects (trees, power lines, roadways, etc.) as it strikes them, causing slippery surfaces and damage from sheer weight of ice accumulations (NWS 2009). Significant ice accumulations are typically 0.25 inch or greater (National Weather Service [NWS] 2013).

Location

Snow and Blizzards

The trajectory of the storm center—whether it passes close to the New Jersey coast or at a distance—largely determines both the intensity and the duration of the snowfall over the State. Winter storms tend to have the heaviest snowfall within a 150-mile wide swath to the northwest of what are generally southwest to northeast moving storms. Depending on whether all or a portion of New Jersey falls within this swath, the trajectory determines which portion of the State (or all of the State) receives the heaviest amount of snow. According to the ONJSC, normal seasonal snowfall in Sussex County is approximately 40 to 50 inches (ONJSC n.d).

Ice Storms

All regions of New Jersey are subject to ice storms. The distribution of ice storms often coincides with general distribution of snow within several zones in the State. A cold rain may be falling over the southern portion of the State, freezing rain over the central region, and snow over the northern counties as a coastal storm moves northeastward offshore. A locality's distance to the passing storm center is often the crucial factor in determining the temperature and type of precipitation during a winter storm. Based on data from 1948–2000, Sussex County can anticipate 5-6 days with freezing rain per year (Changnon & Karl. 2003). Based on data from 1932–2001, the County can anticipate 9-12 total hours of freezing rain per year (Changnon 2004).

Extent

The magnitude or severity of a severe winter storm depends on several factors, including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day (for example, weekday versus weekend), and time of season. While sleet accumulation is measured and tracked in a method similar to snow

events, the extent or severity of freezing rain or an ice storm requires a different and sometimes more challenging process. According to NWS, ice accumulation does not coat the surface of an object evenly, as gravity typically forces rainwater to the underside of an object before it freezes. Wind can also force rainwater downward prior to freezing, resulting in a thicker coating of ice on one side of the object than the other side. Ice mass is then determined by taking the average from the thickest and thinnest portions of ice on the sample used for measurement.

NOAA's National Climatic Data Center (NCDC) produces the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from Category 1 to 5, which is similar to the Enhanced Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes. RSI is based on the spatial extent of the storm, the amount of snowfall, and the combination of the extent and snowfall totals with population (based on the 2000 Census). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCEI 2018). Table 4.3.12-1 presents the five RSI ranking categories.

Table 4.3.12-1. RSI Ranking Categories

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

Source: NOAA-NCEI 2018
Note: RSI = Regional Snowfall Index

The NWS operates a widespread network of observing systems such as geostationary satellites, Doppler radars, and automated surface observing systems that feed into the current state-of-the-art numerical computer models to provide a look into what will happen next, ranging from hours to days. The models are then analyzed by NWS meteorologists who then write and disseminate forecasts (NWS 2013). While winter weather is normal during the winter season for Sussex County, the NWS uses winter weather watches, warnings, and advisories to help people anticipate what to expect in the days and hours prior to an approaching storm.

- A ***winter storm watch*** is issued when severe winter conditions (heavy snow, ice, etc.) may affect a certain area, but its occurrence, location, and timing are uncertain. A watch is issued to provide 24 to 72 hours of notice of the possibility of severe winter weather.
- A ***winter storm warning*** is issued when hazardous winter weather, in the form of heavy snow, heavy freezing rain, or heavy sleet, is imminent or occurring. A warning is usually issued 12 to 24 hours before the event is expected to begin.
- A ***winter weather advisory*** is issued when a hazardous winter weather event is occurring, is imminent, or has a greater than 80 percent chance of occurrence. Advisories are used to inform people that winter weather conditions are expected to cause significant inconveniences and that conditions may be hazardous. These conditions may refer to sleet, freezing rain, or ice storms, in addition to snow events.

NWS may also issue a ***blizzard warning*** when snow and strong winds combine to produce the potential for blinding snow, deep drifts, and wind chill (NWS n.d.).

Previous Occurrences and Losses

The NOAA NCEI Storm Events database records and defines severe winter storm events as follows:

- Blizzard is reported in the NOAA-NCEI database when a winter storm which produces the following conditions for 3 consecutive hours or longer: (1) sustained winds or frequent gusts 30 knots (35 mph) or greater, and (2) falling and/or blowing snow reducing visibility frequently to less than 1/4 mile.
- Heavy snow is reported in the NOAA-NCEI database whenever snow accumulation meets or exceed locally/regionally defined 12 and/or 24 hour warning criteria.
- Ice storm is reported in the NOAA-NCEI database when ice accretion meets or exceed locally/regionally defined warning criteria (typical value is 1/4 or 1/2 inch or more).
- Sleet is reported in the NOAA-NCEI database whenever sleet accumulations meet or exceed locally/regionally defined warning criteria (typical value is ½ inch or more).
- Winter storm is reported in the NOAA-NCEI database whenever a winter weather event has more than one significant hazard (i.e., heavy snow and blowing snow; snow and ice; snow and sleet; sleet and ice; or snow, sleet and ice) and meets or exceeds locally/regionally defined 12 and/or 24 hour warning criteria for at least one of the precipitation elements.
- Winter weather is reported in the NOAA-NCEI database when a winter precipitation event causes a death, injury, or a significant impact to commerce or transportation, but does not meet locally/regionally defined warning criteria.

Between 1954 and 2020, FEMA declared that the State of New Jersey experienced six winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe winter storm, severe storm, snowstorm, blizzard, and ice conditions. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Sussex County was included in three of these declarations.

Agriculture-related drought disasters are quite common. 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. From 2015-2020, Sussex County was not included in any USDA disaster declarations for winter storm events (USDA 2020, USDA 2020a).

For this 2021 HMP update, winter weather events were summarized from 2015 to 2020. For information regarding severe winter weather events prior to 2015, refer to the Appendix E (Risk Assessment Supplement). For detailed information on damages and impacts to each municipality, refer to Section 9 (jurisdictional annexes).

Table 4.3.12-2. Winter Weather Related Disaster (DR) and Emergency (EM) Declarations 1954-2020

Declaration	Event Date	Declaration Date	Event Description
EM-3106	March 13-17, 1993	March 17, 1993	Severe Blizzard
DR-1088	January 7-12, 1996	January 13, 1996	Blizzard of 96 (Severe Snowstorm)
EM-3181	February 16-17, 2003	March 20, 2003	Snow

Source: FEMA 2020

Table 4.3.12-3. Severe Winter 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 24, 2015	Heavy Snow	N/A	N/A	Sussex County	A winter storm dropped heavy snow in Northwest New Jersey and a mixture of snow, sleet and freezing rain in the central and southwest part of New Jersey on the evening of the 23rd into the morning of the 24th. Overall less wintry precipitation (a faster switch to rain) occurred progressively farther to the south and southeast in the state. Snowfall averaged 5 to 9 inches in northwest New Jersey; 2 to 5 inches in central New Jersey and less than two inches across southwest New Jersey. No snow fell in southeast New Jersey. Ice accumulations were generally around a trace. The snow caused traveling difficulties as well as postponement of social activities on the 24th. There were over 100 reported accidents in the state. The snow and accidents caused about 2,000 homes and businesses to lose power. New Jersey Transit cross-honored all commuting tickets. The onshore flow from the winter storm also caused minor tidal flooding in southern New Jersey during the morning high tide cycle on the 24th. Precipitation started as snow on the evening of the 23rd from southwest New Jersey northward between 9 p.m. EST and Midnight EST. In Northwest New Jersey, the snow fell at its heaviest during the pre-dawn hours on the 24th and ended between 8 a.m. EST and 10 a.m. EST on the 24th. In the Raritan Valley, snow also fell at its heaviest during the pre-dawn hours on the 24th, but then changed to freezing rain and sleet between 4 a.m. EST and 6 a.m. EST on the 24th. Precipitation in some areas changed to plain rain before ending later that morning. In the central third of New Jersey, a change to rain (with some sleet at the transition time) worked its way to the northwest from coastal areas and occurred between 1 a.m. EST and 5 a.m. EST on the 24th and remained rain until it ended around 8 a.m. EST on the 24th. Throughout the state, about 20 high schools postponed SAT testing. Representative snowfall included 9.0 inches in Highland Lakes (Sussex County).
February 1-2, 2015	Winter Storm	N/A	N/A	Sussex County	A winter storm brought a heavy mixture of snow, some sleet and freezing rain to the Raritan Valley and northwest New Jersey with less of a wintry impact to the rest of central and southwest New Jersey on the first into the second. The storm greatly impacted the morning commute on the 2nd in the northwest part of the state. Precipitation started as snow throughout the northern half and southwest part of New Jersey during the evening of the 1st.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
					Precipitation fell as rain in the southeast part of the state throughout the event. In southwest New Jersey, the snow transitioned briefly to sleet and then rain early on the 2nd. The rain briefly changed to snow before ending in the mid afternoon on the 2nd. In the Raritan Valley and in Mercer and Monmouth Counties, precipitation transitioned to rain during the early morning on the 2nd and then changed back to freezing rain, then sleet and ultimately snow during the second half of the morning and early afternoon. The snow ended during the mid afternoon on the 2nd. In northwest New Jersey including the Passaic Basin, the snow transitioned to a sleet and/or freezing rain mixture during the morning of the 2nd, then changed back to snow by early afternoon and ended during the middle of the afternoon on the 2nd. Speed restrictions were in place on most major roadways in central and northern New Jersey on the 2nd. Many schools in northwest New Jersey were closed on the 2nd. Representative snowfall included 8.0 inches in Montague (Sussex County).
January 22-24, 2016	Winter Storm	DR-4264	No	Sussex County	An impulse from the west coast traversed the midsection of the country, then developed into a low pressure system as it tracked across the Gulf states before intensifying along the Carolina coast into a major nor'easter, producing record snowfall in parts of New Jersey on January 23rd. It then moved out to sea after passing by the mid-Atlantic coast early on January 24th. Snow began falling during the Friday afternoon commute on January 22nd, then continued, heavy at times, Friday night into early Sunday morning. Wind gusts up to 60 MPH produced blizzard conditions as visibilities dropped to one-quarter mile or less in spots. Representative snowfall totals include 16.0 inches in Stockholm (Sussex).
November 20, 2016	Heavy Snow	N/A	N/A	Sussex County	An area of low pressure near James Bay Canada lead to a strong cold frontal passage across the middle Atlantic Saturday evening November 19. Northwesterly winds increased substantially immediately following the cold frontal passage, with several reports of gusts generally in the 45 to 55 mph range over New Jersey. These strong wind gusts persisted around 48 hours, through Monday November 21. The High Point, NJ mesonet site recorded a peak wind gust of 60 mph at 14:40EST on November 21. Following the cold frontal passage Saturday evening November 19, low pressure developed over New England, and provided a sufficiently cold and moist air mass to produce the seasons first significant snowfall. Snow overspread portions of the middle Atlantic late Saturday evening November 19, shortly after the cold frontal passage. By 01:00EST Sunday November 20, some of the higher terrain of northern New Jersey received around two inches of snowfall. The highest amount as of this time was 2.0 inches in Highland Lakes, New Jersey. The snow continued to fall into Sunday morning November 20. Around 08:00EST, amounts up to around 6 inches were observed across the higher terrain of Sussex county New Jersey.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
February 9, 2017	Winter Storm	N/A	N/A	Sussex County	A strong cold front moved through the region with a temperature drop from the 50's and 60's all the way down close to freezing. Low pressure developed along the front with precipitation northwest of the boundary. The precipitation changed to snow across most of the state. Northern locations had all snow with higher totals. Further south the precipitation was mainly rain for an extended period resulting in much lower accumulations. Gusty winds also occurred as the low departed the region. Some higher snowfall amounts include 11.1 inches in Highland Lakes, 10.3 inches in Wantage, 10.0 inches in Vernon, and 9.0 inches in Stockholm.
March 14, 2017	Blizzard	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. Wind and a foot of snow were reported across Sussex County.
January 17, 2018	Winter Storm	N/A	N/A	Sussex County	Several inches of snow fell across the northern portions of the state. Snowfall averaged around 6 inches of snow in Sussex county. Further south, across most of Northern Jersey totals ranged from 3-5 inches with totals closer to an inch in southern portions of the state. Several area schools closed due to the storm. A few hundred people also lost power in Sussex county. Snowfall averaged around 6 inches in the county.
March 2, 2018	Winter Storm	N/A	N/A	Sussex County	A heavy, wet snow accumulated to a depth of over 16 inches in the higher elevations of the county, and around 6 inches or so in the valleys. Some snowfall totals include 16.5 inches in Branchville, 14.0 inches in Highland Lakes, 13.5 inches at High Point, 8 inches near Wantage, 7.0 inches in Stockholm, and 2.3 inches near Sussex. A wind gust of 48 MPH was reported at High Point Monument at 1125EST on the 2nd. Blowing and drifting snow made travel hazardous Friday afternoon and evening. Numerous power outages, some lasting over two weeks, were widespread throughout the county due to tree and wire damage. Warming centers were established around the county for affected residents.
March 7, 2018	Winter Storm	DR-4368	No	Sussex County	Narrative A broad area of low pressure extending from the Ohio Valley to the Piedmont of South Carolina consolidated off the Virginia Capes during the early morning of March 7th. This new primary low moved northeast and gradually deepened as it passed east of the Delaware and New Jersey coasts on March 7th. The snow contained large amounts of liquid, making it heavy and wet. This resulted in downed trees, limbs, and wires, leading to numerous power outages across portions of New Jersey, especially where the heaviest snow was reported. Many customers were still without power from the previous storm when this storm struck. Governor Murphy estimated about 350,000 customers state-wide lost power as a result of this second storm. Although all portions of the county experienced significant snowfall from this event, the higher amounts occurred over the central and eastern portions of the county which were closer to the low pressure system. Some reported snowfall totals include: 21.0 inches in Highland Lakes, 17.0 inches in Stockholm, 16.0

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
					inches in Sparta, 15.5 inches in Hardyston Township, 15.0 inches in Vernon, 13.5 inches in Wantage, 12.7 inches in Montague, and 12.0 inches in Newton.
March 21-22, 2018	Winter Storm	N/A	N/A	Sussex County	A complex area of low pressure over the middle Atlantic, which involved several individual centers, slowly consolidated off the Virginia Capes Tuesday morning, March 20th into Wednesday March 21st along a frontal boundary. This primary low, the fourth nor'easter of March, gradually moved northeast Wednesday night, to a position southeast of the 40 North/70 West Benchmark coordinates on Thursday morning. Precipitation began as a wet, heavy snow during the evening hours on March 20th. After a lull during the overnight hours, a drier snow began falling, heavy at times, during the afternoon and evening hours on March 21st. The heaviest snow from this event fell in the southern one-half of the county, with a sharp drop off in the far north. Some snowfall reports include: 10.0 inches in both Stockholm and Byram Township, 9.5 inches in Fredon, 8.5 inches in both Hardyston Township and Newton, 7.0 inches in Ogdensburg, 7.0 inches in Andover, Sparta, and Franklin, 2.5 inches in Vernon Valley, 1.3 inches in Sussex, 1.1 inches in Wantage, and 0.2 inches in Montague.
April 2, 2018	Winter Storm	N/A	N/A	Sussex County	Despite high temperatures in the 50's and 60's across the region on April 1st, a cold front moving though the area during the morning gradually brought in colder air, which moved into the region by April 2nd. Meanwhile, a weak wave of low pressure developed along this front, and tracked south of the area. To the north of this low and where temperatures were cold enough, snow accumulated, especially near the Interstate 195 corridor and points north. The snow began after midnight on April 2nd and continued into the mid-morning hours. Snowfall amounts ranged from 4 to around 8 inches north of the Interstate 78 corridor. South of here, 1 to 4 inch amounts were common to the Interstate 195 corridor. To the south of the Interstate 195 corridor, amounts tapered down from 1 inch in a southerly direction, with Atlantic City New Jersey reporting a Trace of snowfall. A trained spotter reported 7.4 inches of snow in Highland Lakes. An NWS employee reported 5.5 inches of snow 4 miles southwest of Wantage.
November 15-16, 2018	Winter Storm	N/A	N/A	Sussex County	Early season winter storm. Additional trace amounts of snow were reported in Cape May County. Totals ranged from 12.6 in Montague to 6.5 in Sparta Township.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Sussex County Designated?	Location	Description
February 12-13, 2019	Winter Storm	N/A	N/A	Sussex County	This event was the second part of a multi-day storm that impacted the region with light snow changing to a wintry mix and then to rain. Snow and ice totals were less across Delmarva than other locations farther north and west. A trained spotter reported 3.0 of snow in Lebanon. 0.04 of ice was reported at the Sussex County Airport.
March 3-4, 2019	Winter Storm	N/A	N/A	Sussex County	An offshore low pressure system brought a period of heavy precipitation to the mid-Atlantic. A mix of rain, sleet, and snow was observed, with snow confined mainly to interior areas and sleet and rain more abundant near the coast. Snowfall totals inland approached 10, with snowfall rates exceeding one inch per hour for several hours. A sharp gradient in snowfall with a steep drop in snow totals was observed just west of the Interstate 95 corridor. A trained spotter in Highland Lakes reported 8.2 inches of snow.
December 1-3, 2019	Winter Storm	N/A	N/A	Sussex County	A complex, long duration winter storm impacted parts of the mid-Atlantic over the first three days of December. Impacts from the storm came mainly in two phases. Initially, weakening low pressure moved into the Midwest and Great Lakes region on December 1, bringing a widespread area of overrunning precipitation to the mid-Atlantic. Cold air in place ahead of the precipitation led to heavy mixed precipitation in interior areas, with most though not all areas eventually seeing a gradual change to rain. On December 2nd, developing secondary low pressure brought additional precipitation to the region, which took the form of rain changing to snow. The rapidly strengthening secondary low finally pulled away from the area during the early hours of December 3rd. A heavy mix of snow, sleet, and freezing rain occurred. The highest snowfall report was 14.3 inches in Highland Lakes, with a widespread 8 to 12 inches of snow throughout the county. Up to a third of an inch of glaze ice also fell. The Sussex Airport ASOS (KFWN) measured 0.32 inches of glaze ice. Widespread power outages occurred with a number of downed trees and wires, including the KFWN ASOS which failed late in the storm's duration due to loss of power.
December 16-17, 2019	Winter Storm	N/A	N/A	Sussex County	Low pressure developed along a stationary boundary over the Southeast US on December 16. The low pressure tracked into the Appalachians before beginning to develop near the southern New Jersey coast early on December 17. This brought widespread precipitation to the mid-Atlantic. Surface temperatures were initially cold enough for frozen precipitation in some areas, but a surge of low level warm air caused most of the frozen precipitation to fall as sleet and freezing rain, with most areas eventually seeing a change to all rain. In some places, impacts due to icing were significant. The Sussex, NJ Airport ASOS (KFWN) measured 0.44 inches of ice accretion. Some sleet also occurred. A number of reports of downed trees and power lines were received.

Source: NOAA-NCDC 2020; NJOEM 2019; NWS 2020; FEMA 2020
DR Disaster Declaration
FEMA Federal Emergency Management Agency
N/A Not Applicable

NCDC *National Climatic Data Center*
NOAA *National Oceanic and Atmospheric Administration*
NWS *National Weather Service*

Probability of Future Occurrences

Severe winter weather is a common occurrence each winter season in New Jersey. The majority of the State will receive at least one measurable snow event during the winter months. The months of January, February, March, April, October, November and December are typically when a vast majority of New Jersey has been observed to receive measurable snow. Generally, counties in the northern region experience more snow events than those in the southern region. It is estimated that Sussex County will continue to experience the direct and indirect impacts of severe winter weather events annually that many induce secondary hazards such as: structural damage (snow and ice load), wind damage, impact to life safety, disruption of traffic, loss of productivity, economic impact, loss of ability to evacuate, taxing first-responder capabilities, service disruption (power, water, etc.), and communication disruption.

According to the NOAA NCEI storm events database, Sussex County has been impacted by 135 severe winter storm events between 1950 and 2020 (Table 4.3.12-4). While no events resulted in deaths or crop damage, $3.65M in property damages and four injuries were reported.

Table 4.3.12-4. Probability of Future Occurrence of Severe Winter Weather Events

Hazard Type	Number of Occurrences Between 1950 and 2020	Annual Number of Events (average)	Recurrence Interval* (in years)	Probability of Event Occurring in Any Given Year	Percent Chance of Occurring in Any Given Year
Blizzard	2	0.03	35.5	0.03	2.8%
Heavy Snow	47	0.67	1.51	0.66	66.2%
Ice Storm	10	0.14	7.10	0.14	14.1%
Sleet	4	0.06	17.9	0.06	5.6%
Winter Storm	72	1.03	0.99	1.01	100%
Total	**135**	**1.9**	**0.53**	**1.90**	**100%**

Note: Not all events that have occurred in Sussex County are included due to the extent of documentation and the fact that not all sources have been identified or researched.
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 winter 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 winter weather hazard for individual municipalities is presented in the jurisdictional annexes.

Climate Change Impacts

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey

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

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

Vulnerability Assessment

All of Sussex County is vulnerable to severe winter storm events. The following subsections discuss Sussex County's vulnerability, in a qualitative nature, to the severe winter weather hazard.

Impact on Life, Health and Safety

According to the NOAA National Severe Storms Laboratory (NSSL); every year, winter weather indirectly and deceptively kills hundreds of people in the U.S., primarily from automobile accidents, overexertion and exposure (NSSL 2020). Winter storms are often accompanied by strong winds creating blizzard conditions with blinding wind-driven snow, drifting snow and extreme cold temperatures and dangerous wind chill. They are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. People can die in traffic accidents on icy roads, heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold. Heavy accumulations of ice can bring down trees and power lines, disabling electric power and communications for days or weeks. Heavy snow can immobilize a region and paralyze a city, shutting down all air and rail transportation and disrupting medical and emergency services. Storms near the coast can cause coastal flooding and beach erosion as well as sink ships at sea. The economic impact of winter weather each year is huge, with costs for snow removal, damage and loss of business in the millions (NOAA 2017).

The entire population of Sussex County (149,265 people) is exposed to severe winter storm events (U.S. Census, 2010). Snow accumulation and frozen/slippery road surfaces increase the frequency and impact of traffic accidents for the general population, resulting in personal injuries.

The homeless and residents below the poverty level may not have access to housing or their housing could be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). Residents with low incomes might not have access to housing or their housing can be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). In Sussex County, area with the highest concentration of population below the poverty level are located in Newton (10% of the total population). Refer to Section 3 (County Profile) that displays the densities of low-income populations in Sussex County.

Impact on General Building Stock

The entire general building stock inventory is exposed and vulnerable to the severe winter storm hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. As an alternate approach, this plan

considers percentage damages that could result from severe winter storm conditions. Table 4.3.12-5 summarizes percent damages to buildings that could result from severe winter storm conditions. Given professional knowledge and the currently available information, the potential loss for this hazard is many times considered to be overestimated because of varying factors (building structure type, age, load distribution, building codes in place, etc.). Therefore, the following information should be used as estimates only for planning purposes with the knowledge that the associated losses for severe winter storm events vary greatly.

Table 4.3.12-5 General Building Stock Exposure and Estimated Losses from Severe Winter Storm Events

Municipality	Total (All Occupancies)	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Borough of Andover	$110,720,294	$1,107,202.94	$5,536,014.70	$11,072,029.40
Township of Andover	$797,432,934	$7,974,329.34	$39,871,646.70	$79,743,293.40
Borough of Branchville	$105,787,947	$1,057,879.47	$5,289,397.35	$10,578,794.70
Township of Byram	$1,001,139,850	$10,011,398.50	$50,056,992.50	$100,113,985.00
Township of Frankford	$1,028,566,798	$10,285,667.98	$51,428,339.90	$102,856,679.80
Borough of Franklin	$555,083,580	$5,550,835.80	$27,754,179.00	$55,508,358.00
Township of Fredon	$524,017,917	$5,240,179.17	$26,200,895.85	$52,401,791.70
Township of Green	$617,892,936	$6,178,929.36	$30,894,646.80	$61,789,293.60
Borough of Hamburg	$478,777,394	$4,787,773.94	$23,938,869.70	$47,877,739.40
Township of Hampton	$898,127,786	$8,981,277.86	$44,906,389.30	$89,812,778.60
Township of Hardyston	$1,058,804,064	$10,588,040.64	$52,940,203.20	$105,880,406.40
Borough of Hopatcong	$1,459,447,874	$14,594,478.74	$72,972,393.70	$145,944,787.40
Township of Lafayette	$484,326,532	$4,843,265.32	$24,216,326.60	$48,432,653.20
Township of Montague	$550,631,281	$5,506,312.81	$27,531,564.05	$55,063,128.10
Town of Newton	$926,551,970	$9,265,519.70	$46,327,598.50	$92,655,197.00
Borough of Ogdensburg	$250,464,374	$2,504,643.74	$12,523,218.70	$25,046,437.40
Township of Sandyston	$359,643,031	$3,596,430.31	$17,982,151.55	$35,964,303.10
Township of Sparta	$3,083,993,131	$30,839,931.31	$154,199,656.55	$308,399,313.10
Borough of Stanhope	$557,098,000	$5,570,980.00	$27,854,900.00	$55,709,800.00
Township of Stillwater	$581,254,607	$5,812,546.07	$29,062,730.35	$58,125,460.70
Borough of Sussex	$259,651,457	$2,596,514.57	$12,982,572.85	$25,965,145.70
Township of Vernon	$3,063,072,948	$30,630,729.48	$153,153,647.40	$306,307,294.80
Township of Walpack	$8,710,816	$87,108.16	$435,540.80	$871,081.60
Township of Wantage	$1,396,272,081	$13,962,720.81	$69,813,604.05	$139,627,208.10
Sussex County (Total)	**$20,157,469,603**	**$201,574,696.03**	**$1,007,873,480.15**	**$2,015,746,960.30**

Source: Sussex County GIS 2020; RS Means 2020
Values represent estimated replacement cost.

A specific area that is vulnerable to the severe winter storm hazard is the floodplain. Severe winter storms can cause flooding through blockage of streams or through snow melt. At-risk residential infrastructures are presented in the flood hazard profile (Section 4.3.5). Generally, losses resulting from flooding associated with severe winter storms should be less than that associated with a 100-year flood. Please refer to the Severe Weather (Section 4.3.11) profile for losses resulting from high winds which may also accompany severe winter weather.

Impact on Critical Facilities and Lifelines

Full functionality of critical facilities such as police, fire and medical facilities is essential for response during and after a severe winter storm event. These critical facility structures are largely constructed of concrete and masonry; therefore, they should only suffer minimal structural damage from severe winter storm events. Because power interruption can occur, backup power is recommended. Infrastructure at risk for this hazard includes roadways that could be damaged due to the application of salt and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires the clearing roadways and alerting citizens to dangerous conditions; following the winter season, resources for road maintenance and repair are required.

Heavy snow can immobilize a region and paralyze a city, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL 2020).

Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. Another impact on the economy includes impacts on commuting into, or out of, the area for work or school. The loss of power and closure of roads prevents the commuter population traveling to work within and outside of the County. During the 2019-2020 winter season, the State of New Jersey Department of Transportation has budgeted winter maintenance expenditures at $36.9 million, which includes costs for salt (124,911 tons), liquid calcium chloride (247,424 gallons), and brine (270,820 gallons) (NJDOT 2020).

Impact on the Environment

Severe winter weather can have a major impact on the environment. Not only does winter weather create changes in natural processes, the residual impacts of a community's methods to maintain its infrastructure through winter weather maintenance may also have an impact on the environment. For example, an excess amount of snowfall and earlier warming periods may affect natural processes such as flow within water resources. Rain-on-snow events can also exacerbate runoff rates with warming winter weather. Consequentially, these flow rates and excess volumes of water can erode banks, tear apart habitat along the banks and coastline, and disrupt terrestrial plants and animals.

Furthermore, chemically based winter maintenance practices have its own effect on the natural environment. Melting snow and ice that carry deicing chemicals onto vegetation and into soils can contaminate the local waterways. Elevated salt levels may hinder vegetation from absorbing nutrients, slowing plant growth (UMass Extension 2020).

Future Growth and Development

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensure that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that can affect hazard vulnerability:

- Potential or projected development.
- Projected changes in population.
- Other identified conditions as relevant and appropriate, including the impacts of climate change.

Projected Development

As discussed in Sections 3 and 9, areas targeted for future growth and development have been identified across Sussex County. Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire planning area is exposed and vulnerable. However, due to increased standards and codes, new development may be less vulnerable to the severe winter weather hazard compared with the aging building stock in the County.

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 severe winter storm event. Furthermore, if the density or number of persons over 65 increases in the County, more persons will be vulnerability to severe winter weather events. Refer to Section 3 (County Profile), which includes a discussion on population trends for the County.

Climate Change

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such winter storms. While predicting changes of winter storm events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2020).

Both northern and southern New Jersey have become wetter over the past century. In terms of long-term changes in snowfall and ice storms in New Jersey, there is a lack of quantitative data to predict how future climate change will affect this hazard. It is likely that the number of winter weather events may decrease, and the winter weather season may shorten; however, it is also possible that the intensity of winter storms may increase. The exact effect on winter weather is still highly uncertain.

An increase in the frequency and severity of severe winter storms could result in an increase of snow loads on the County's building stock and infrastructure, putting each building at risk to structural damage. More frequent and severe events also will result in increased resources spent to prepare for and clean-up after an event. However, as winter temperatures continue to rise, climate projections indicate the increase in precipitation is likely to occur during the winter months as rain. Increased rain on snowpack or frozen or saturated soils can lead to increased flooding and related impacts on the County's assets.

Change of Vulnerability

Overall, the County's exposure and vulnerability have not changed, and the entire County will continue to be exposed and vulnerable to severe winter storm events.