# 12. SEVERE WINTER WEATHER

## 12.1 HAZARD PROFILE

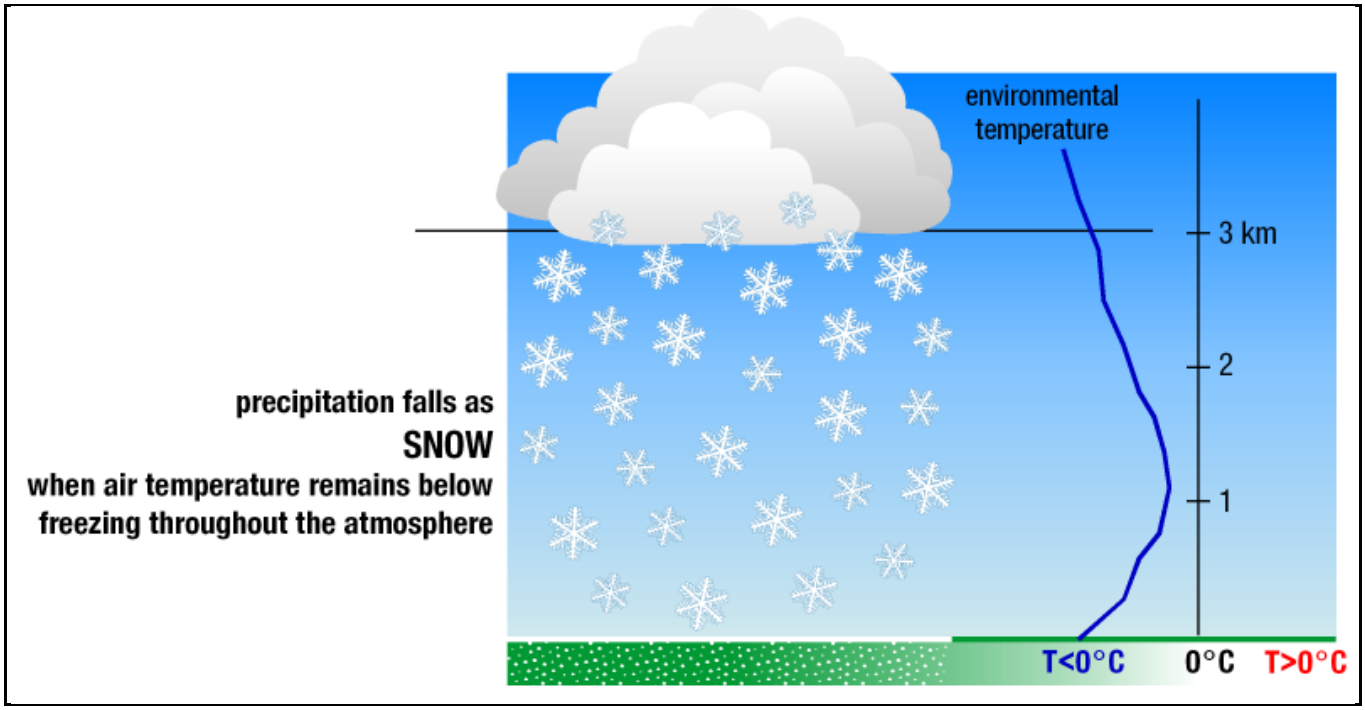
### 12.1.1 Hazard Description

The severe winter weather hazard for this HMP includes extreme events involving snow, sleet, or freezing rain, often in combination with dangerous wind chills and low temperatures. Some winter weather events can immobilize an entire region, while others might only affect a single community. Such events can result in cold temperatures, flooding, storm surge, closed or blocked roadways, downed utility lines, and power outages. The aftermath of a severe winter weather event can impact a community or region for days, weeks, or even months. The types of severe winter weather addressed in this HMP are heavy snow, blizzards, sleet, ice storms, and nor'easters.

#### Heavy Snow

Snow is precipitation in the form of ice crystals (NSIDC 2024). It originates in clouds when temperatures are below the freezing point (32 °F) and 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, which then fall to the earth. Snowflakes are clusters of ice crystals that form from a cloud. Figure 12-1 depicts snow creation.

Figure 12-1. Snow Creation




*Source: NOAA 2023*

## Blizzards

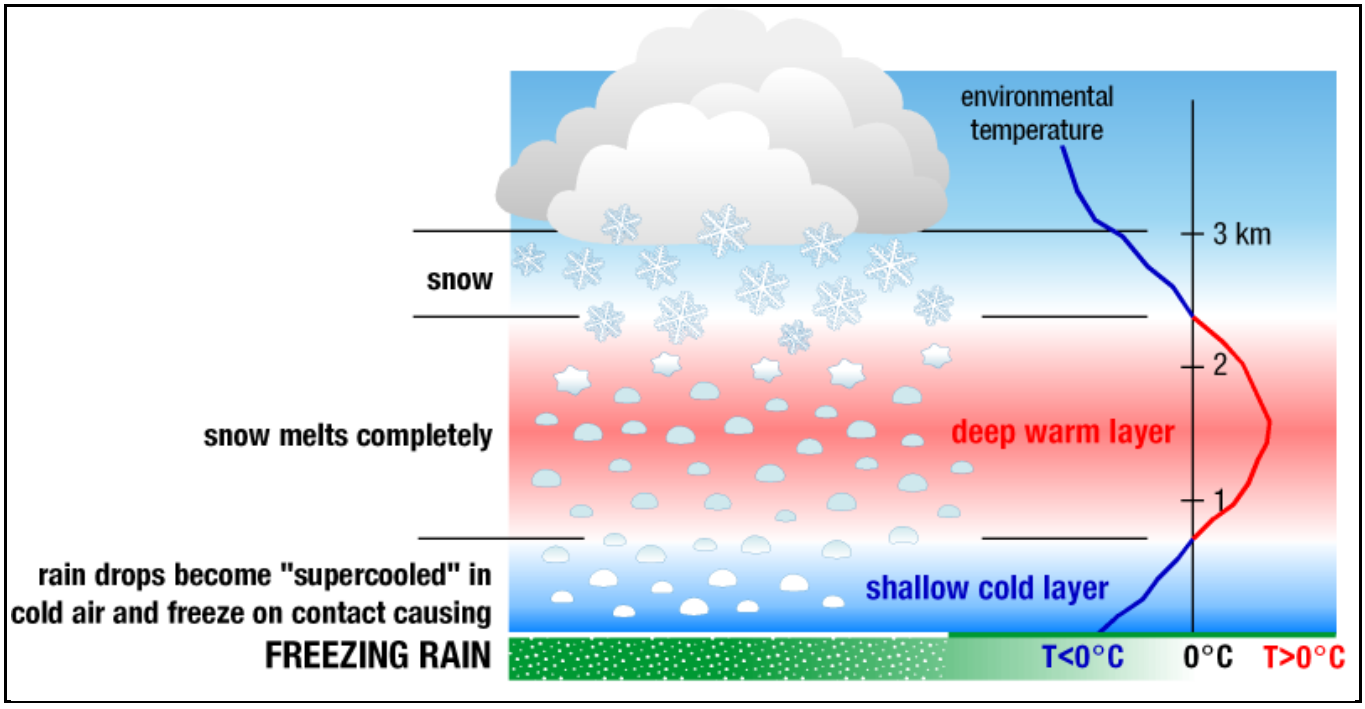
A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 miles per hour (mph) or more, accompanied by falling or blowing snow reducing visibility to 0.25 miles or less, as the predominant conditions over a three-hour period (NOAA NWS n.d.). Extremely cold temperatures often are associated 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 (NOAA NWS n.d.).

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 (Lam 2019).

## Ice Storms

An ice storm consists of damaging accumulations of ice (typically 0.25 inches or greater) during freezing rain situations (NOAA n.d.). Heavy accumulations of ice can bring down trees, power lines, utility poles, and communication towers. Ice can disrupt communications and power for days. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians (NWS 2019). Figure 12-2 depicts the creation of freezing rain that leads to an ice storm.

Figure 12-2. Freezing Rain Creation

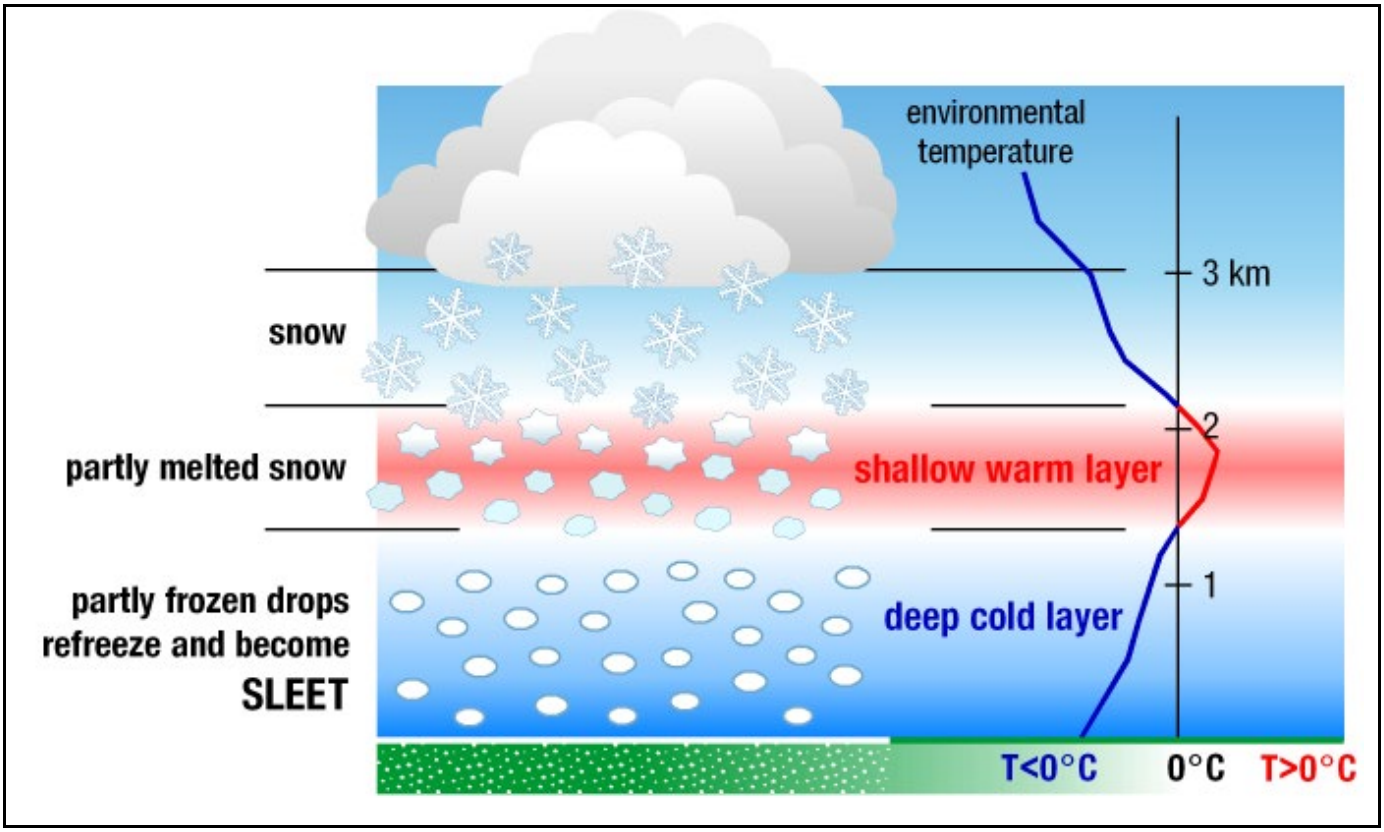



*Source: NOAA 2023*

## Sleet

Sleet is made up of drops of rain that freeze into ice as they fall. They are usually smaller than 0.30 inches in diameter (NSIDC 2024). 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 (NSIDC 2024). Figure 12-3 depicts sleet creation.

Figure 12-3. Sleet Creation




*Source: NOAA 2023*

## Nor'easter

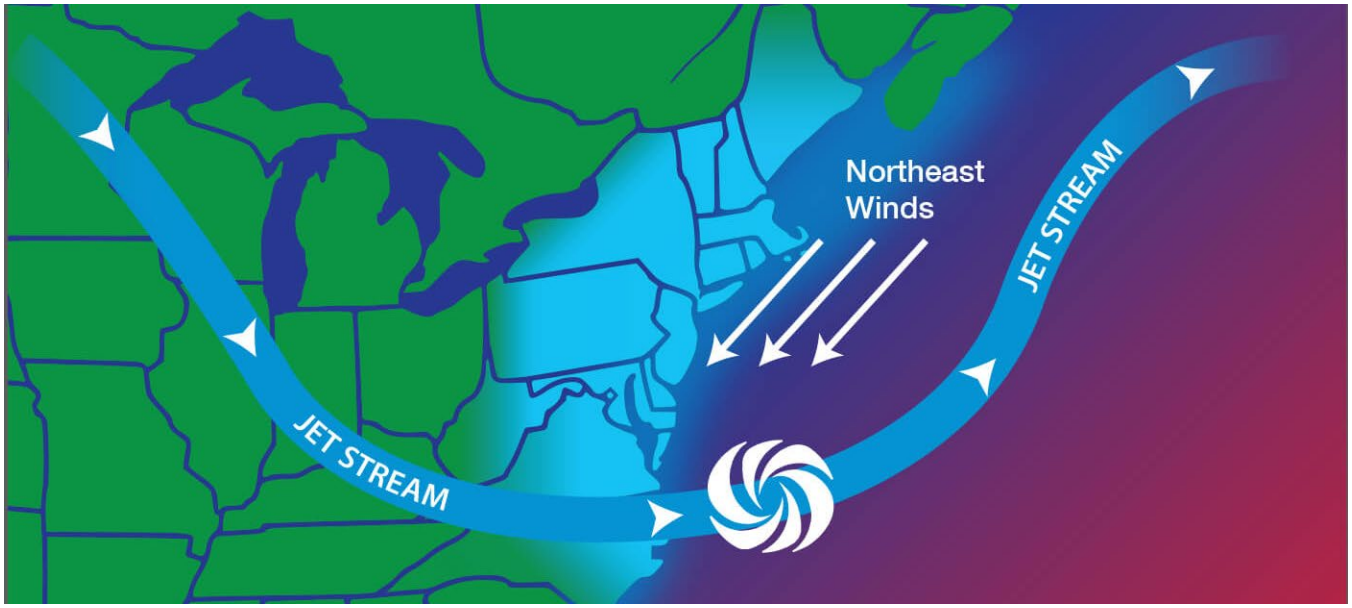
A nor'easter is a cyclonic storm that moves along the east coast of North America. It is called a nor'easter because the damaging winds over coastal areas blow from a northeasterly direction. Nor'easters are most frequent and strongest between September and April. These storms usually develop between Georgia and New Jersey within 100 miles of the coastline and typically move from southwest to northeast along the Atlantic Coast (NWS n.d.). Nor'easters can span thousands of miles, impacting large areas of coastline. To be classified a nor'easter, a storm must have the following conditions (NJOEM 2024):

- Persists for at least a 12-hour period
- Has a closed circulation
- Shows general movement from the south-southwest to the north-northeast
- Contains wind speeds greater than 23 miles per hour (mph)

A nor'easter event can cause heavy rain, heavy snow, and wind, with storm surges, waves, and coastal flooding in areas along the coast. With a forward speed much slower than that of a hurricane, a nor'easter can linger for days and cause tremendous damage to affected areas. Approximately 20 to 40 nor'easters occur in the northeastern United States every year (NPS 2023). New Jersey can experience 10 to 20 nor'easters each year, with five to 10 of those having significant impact on the state (NJOEM 2024).

The intensity of a nor'easter can rival that of a tropical cyclone in that, on occasion, it may flow or stall off the mid-Atlantic coast resulting in prolonged episodes of precipitation, coastal flooding, and high winds. Figure 12-4 displays the formation of a Nor'easter.

Figure 12-***4***. Formation of a Nor'easter




*Source: NOAA 2023*

## 12.1.2 Location

### Heavy Snow, Blizzards, and Sleet

Snow and sleet events can impact the entire county. The trajectory of the storm center largely determines the intensity and duration of snowfall over the state. The heaviest snowfall often occurs within a 150-mile-wide swath to the northwest of what are generally southwest to northeast moving storms. Whether all or a portion of New Jersey falls within this swath determines which portion of the state receives the heaviest amount of snow. Between 1945 and 2006 (the most recently available record), Passaic County received 25.9 inches of snow on average every year, based on totals measured at Wanaque Raymond Dam (ONJSC 2006).

### Ice Storms

All regions of the state are subject to ice storms. The distribution of ice storms often coincides with general distribution of snow within several zones in the state (NJOIT 2024). As a coastal storm moves northeastward offshore, a cold rain may fall over the southern portion of the state, with freezing rain over the central region and snow over the northern counties. A locality's distance from the storm center is often the crucial factor in determining the temperature and type of precipitation during a winter storm.

### Nor'easter

Several nor'easters have impacted New Jersey. Nor'easters can occur any time of the year but are most frequent and strongest between September and April (NWS n.d.). The entire State of New Jersey is susceptible to the effects of these storms, depending on the storm's track. However, coastal communities and other low-lying areas of the state are particularly vulnerable. Most of the damage following these storms often results from residual wind damage.

## 12.1.3 Extent

### Heavy Snow, Blizzards, Ice Storms, and Sleet

The severity of severe winter weather is defined by snowfall rates, snowfall amounts, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day and week (e.g., weekday versus weekend), and time of season.

The National Oceanic and Atmospheric Administration's (NOAA) 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 1 to 5, based on the spatial extent of the storm, the amount of snowfall, and the interaction of the storm with population. The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA n.d.). Table 12-1 presents the five RSI ranking categories.

Table 12-1. Regional Snowfall Index 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 n.d.*

The NWS uses the following alerts to help people anticipate upcoming severe winter weather conditions:

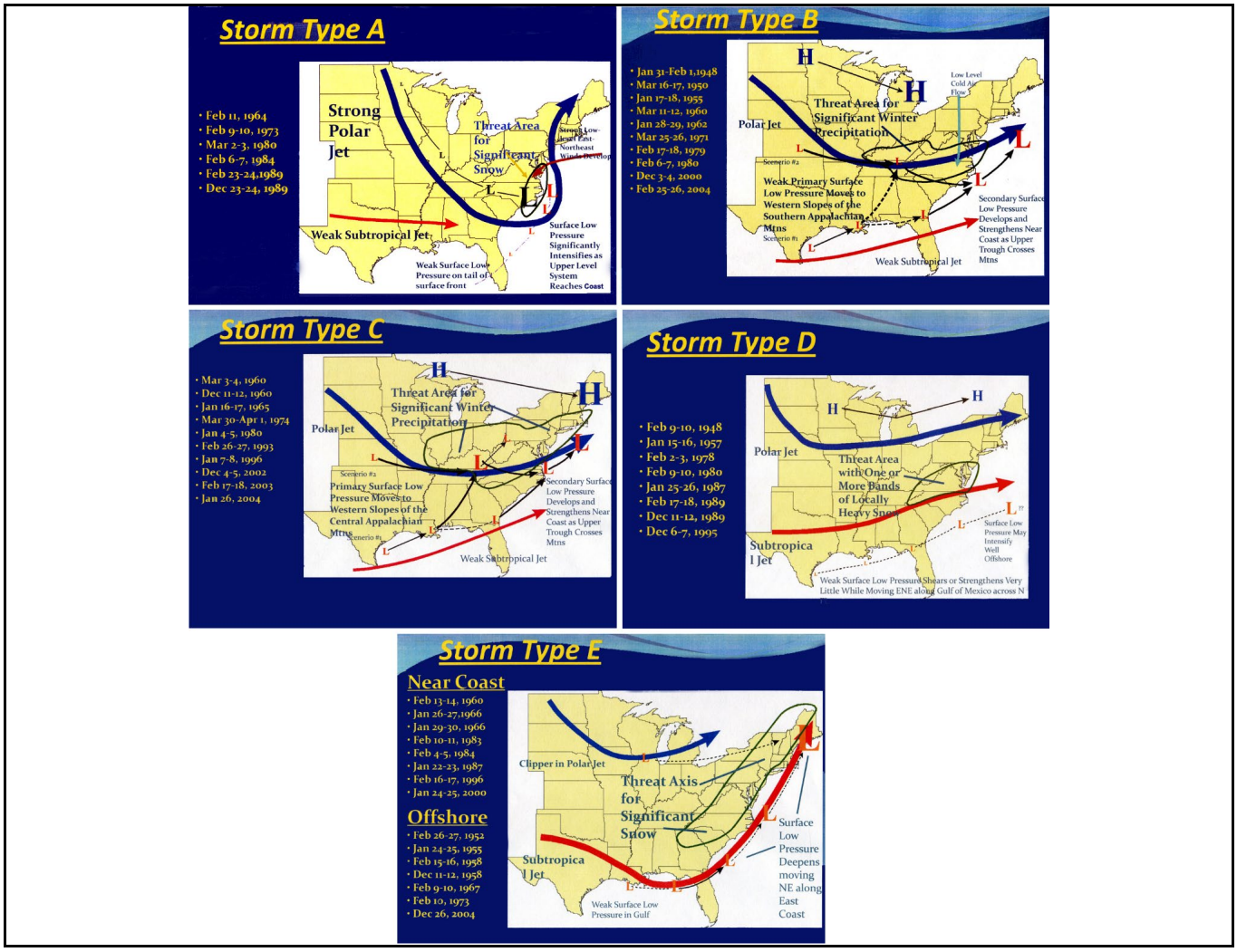
- A **winter storm watch** is issued when severe winter conditions (heavy snow, ice, etc.) may affect a certain area, but its occurrence, location, and timing are uncertain. A watch is issued to provide 24 to 72 hours of notice of the possibility of severe winter weather.
- A **winter storm warning** 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 n.d.).

## Nor'easter

Nor'easters have the potential to impact society to a greater extent than hurricanes and tornadoes. These storms often have a diameter three to four times larger than a hurricane and therefore impact much larger areas. More homes and properties become susceptible to damage as the size and strength of a nor'easter intensifies (NWS n.d.). Most of the damage from a nor'easter is caused by wind.

The severity of a nor'easter depends on snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, time of occurrence during the day (e.g., weekday versus weekend), and season. Nor'easters were classified in 1946 into two major categories. The most common are Miller Type A nor'easters, which form in the Gulf of Mexico and develop into full-fledged storms that move along the East Coast. Miller Type B nor'easters originate as low-pressure systems in the U.S. Midwest. These less-common systems diminish after crossing the Appalachian Mountains and reform into nor'easters on the East Coast (National Geographic 2022). A 2004 study added classification types C through E onto the Miller Classification after identifying five predominant patterns that produce 4 inches or more of snowfall across the Mid-Atlantic (Siebers n.d.). Figure 12-5 describes the five categories.

Figure 12-5. Nor'easter Miller Classifications




*Source: Siebers n.d.*

## 12.1.4 Previous Occurrences

### FEMA Major Disaster and Emergency Declarations

Passaic County has been included in four major disaster (DR) or emergency (EM) declarations for severe winter weather-related events (FEMA 2023). Table 12-2 lists these declarations.

Table 12-2. FEMA Declarations for Severe Winter Weather Events in Passaic County (1954 to 2023)

| Event Date | Declaration Date | Declaration Number | Description |
|---|---|---|---|
| March 13, 1993 | March 17, 1993 | EM-3106-NJ | Severe Blizzard |
| January 7, 1996 | January 13, 1996 | DR-1088-NJ | Severe Blizzard of '96 |
| February 16, 2003 | March 20, 2003 | EM-3181-NJ | Blizzard and Coastal Flooding |
| December 26, 2010 | February 4, 2011 | DR-1954-NJ | Severe Blizzard |

*Source: NOAA-NCEI 2023; FEMA 2023*

### 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. Between 2019 and 2023, Passaic County was included in two USDA severe winter weather-related agricultural disaster declarations, as listed in Table 12-4 (USDA 2024).

Table 12-3. USDA Declarations for Severe Winter Weather Events in Passaic County (2019 to 2023)

| Event Date | USDA Declaration Number | Description |
|---|---|---|
| April 6 to May 15, 2020 | S4748 | Freeze and Frost |
| May 17 to 18, 2023 | S5644 | Freeze and Frost |

*Source: USDA 2024*

### Previous Events

Known hazard events that impacted Passaic County between August 2019 and December 2023 are listed in Table 12-4. For events prior to 2019, refer to the 2019 Passaic County HMP.

Table 12-4. Severe Winter Weather Events in Passaic County (August 2019 to December 2023)

| Event Date | FEMA Declaration Number | Passaic County Included in Declaration? | Location Impacted | Description |
|---|---|---|---|---|
| December 1-3, 2019 | N/A | N/A | County-wide | Observers reported 4 to 6 inches of snow in Eastern Passaic County and 7 to 9 inches of snow in Western Passaic County. |
| December 16-17, 2020 | N/A | N/A | County-wide | Weather observers measured 6 to 8 inches of snow. The nearby Teterboro Airport measured a 38 mph wind at 6:51 a.m. on December 17. |

| Event Date | FEMA Declaration Number | Passaic County Included in Declaration? | Location Impacted | Description |
|---|---|---|---|---|
| February 1-3, 2021 | N/A | N/A | County-wide | Trained spotter reported 15 inches of snow in Wayne, 26.2 inches of snow in Bloomingdale, and 24.7 inches in West Milford. The nearby Newark Liberty International Airport measured a 41-mph wind gust on February 1. |
| February 7, 2021 | N/A | N/A | County-wide | Snowfall rates within a low-pressure band were up to 2 inches per hour at times. Snowfall accumulation ranged from 4 to 8 inches. |
| February 18-19, 2021 | N/A | N/A | County-wide | A brief period of moderate to heavy snowfall occurred during the morning and early afternoon on February 18. A trained spotter in Wayne reported 5 inches of snow. |
| February 22, 2021 | N/A | N/A | County-wide | A brief period of moderate to locally heavy snow transitioned to rain during the afternoon as temperatures rose above freezing. Spotters reported 4.8 inches of snowfall and a trace of freezing rain in Bloomingdale and 5 inches of snowfall in Wayne. |
| January 6-7, 2022 | N/A | N/A | Eastern Passaic County | Moderate snowfall occurred across most portions of northeastern New Jersey. A spotter measured 4.3 inches in Wayne. |
| January 16-17, 2022 | N/A | N/A | County-wide | Snow accumulated across northern and northwestern New Jersey. Radar indicated 2 to 4 inches of snow across Eastern Passaic County and 2 to 5 inches in Western Passaic County before a changeover to freezing rain, then rain, occurred. |
| January 28-29, 2022 | N/A | N/A | County-wide | A nor'easter brought snow and gusty winds. Wind gusts of 40 mph were reported across eastern parts of northeastern New Jersey. Snowfall ranged from 3.3 to 5.1 inches across Passaic County. |
| February 13, 2022 | N/A | N/A | Western Passaic County | Trained spotters reported 3.7 inches of snow at 5 N West Milford and 3.1 inches at 1 NE West Milford. |
| February 27-28, 2023 | N/A | N/A | County-wide | Heavy snow fell across the western portion of the county and carried into the morning commute. The public reported 6.0 inches in Bloomingdale. Wet snow fell across the eastern half of the county. Snowfall amounts ranged generally from 3 to 5 inches across this portion of the County. |

*Source: FEMA 2023; NOAA NCEI 2023*

## 12.1.5 Probability of Future Occurrences

### Probability Based on Previous Occurrences

Information on previous severe winter weather occurrences in the County was used to calculate the probability of future occurrence of such events, as summarized in Table 12-5. Based on historical records and input from the Steering Committee, the probability of occurrence for severe winter weather in the County is considered “occasional.”

Table 12-5. Probability of Future Severe Winter Weather Events in Passaic County

| Hazard Type | Number of Occurrences Between 1996 and 2023 | Percent Chance of Occurring in Any Given Year |
|---|---|---|
| Blizzard | 2 | 7% |
| Heavy Snow | 27 | 100% |
| Sleet | 1 | 4% |
| Ice Storm | 11 | 41% |
| Winter Storm* | 1 | 4% |
| Total | 42 | 100% |

*Source: NOAA NCEI 2024*
*Note: Nor'easter events are not tracked in the NCEI database but are often recorded as winter storms.*

Table 12-5 does not include the annual probability of nor'easters or freezing rain because these events are not discretely recorded in the National Centers for Environmental Information (NCEI) database. Because of limitations in classifying and tracking nor'easter events, it is difficult to assign probabilities to nor'easters, except over the long-term. High activity seasons are when storm activity exceeds the historical 75th percentile. Seasons with this number of storms are expected to occur during one out of four years. Lower activity seasons are when storm activity falls below the historical 75th percentile; meaning this number of storms are expected to occur during three out of four years (NWS n.d.).

Based on data from 1948 to 2000, Passaic County can anticipate three to four days with freezing rain per year (Changnon and Karl 2003). Based on data from 1932 to 2001, the County can anticipate six to nine total hours of freezing rain per year (S. Changnon 2004).

### Effect of Climate Change on Future Probability

There is a lack of quantitative data to predict how future climate change will affect snowfall and ice storms in New Jersey. It is likely that the number of winter weather events will decrease, and the winter weather season may shorten. However, it is also possible that when winter storms do occur, they will be more intense and severe than in the past.

Some climatologists predict that climate change may play a role in the frequency and intensity of nor'easters. Two ingredients are needed to produce strong nor'easters and intense snowfall: temperatures which are just below freezing, and massive moisture coming from the Gulf of Mexico. When temperatures are far below freezing, snow is less likely. As winter temperatures increase in the future, they will be closer to freezing rather than frigidly cold. Future climate change has been predicted to produce more moisture, thus increasing the likelihood that these two ingredients (temperatures just below freezing and intense moisture) will cause more intense snow events. However, the exact effect on winter weather remains uncertain (Sustainable Jersey Climate Change Adaptation Task Force 2011) Future enhancements in climate modeling will provide an improved understanding of how the climate will change and impact Passaic County.

## 12.1.6 Cascading Impacts on Other Hazards

Heavy precipitation and the freezing and thawing of snow and ice can create major flooding issues in the County. Nor'easter events can create coastal flooding, which can impact the southeastern portion of the County.

Severe winter weather events, especially nor'easters, often coincide with or are followed by extreme cold events and generate strong winds that create very low wind chills.

High winds and ice and snow accumulation can be destructive to the functionality of utilities by breaching power lines and disconnecting the utility systems. Severe winter weather could also result in falling trees and branches due to ice, snow, and strong winds. Fallen trees and branches increase available fuel for wildfires.

## 12.2 VULNERABILITY AND IMPACT ASSESSMENT

All of Passaic County is vulnerable to the winter storm hazard and its impacts. Current modeling tools are not available to estimate specific losses for this hazard. A qualitative analysis was conducted to assess the county's vulnerability to this hazard.

### 12.2.1 Life, Health, and Safety

#### Overall Population

The entire population of Passaic County (519,986) is exposed to severe winter weather events (US Census Bureau 2020). Likely impacts of this hazard include the following:

- Snow accumulation and frozen or slippery road surfaces increase the frequency and impact of traffic accidents for the general population, resulting in personal injuries or deaths.
- Winter weather indirectly and deceptively kills hundreds of people in the U.S. each year, primarily due to automobile accidents, overexertion, and exposure.
- These events are often accompanied by strong winds, creating blizzard conditions with blinding wind-driven snow, drifting snow, extreme cold temperatures, and dangerous wind chills.
- People can suffer heart attacks while shoveling snow or succumb to 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.

#### Socially Vulnerable Population

Without a quantitative assessment of potential impacts of severe winter 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 Passaic County. Section 3.6.3 provides detailed data on socially vulnerable populations within the planning area. Table 12-6 summarizes highlights of this information. For planning purposes, it is reasonable to assume that percentages and distribution of socially vulnerable populations affected by severe winter weather will be similar to the countywide numbers.

Table 12-6. 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 |
| | | | Paterson | North Haledon | Prospect Park | Passaic |
| Population Over 65 | **78,440** | **15.10%** | **18,141** | **24.6%** | **625** | **9.0%** |
| | | | Paterson | Passaic, Prospect Park | Bloomingdale | Bloomingdale |
| Population Under 5 | **33,502** | **6.40%** | **12,442** | **8.3%** | **247** | **3.2%** |
| Non-English-Speaking Population | **68,953** | **13.30%** | Paterson **34,885** | Passaic **22.4%** | Bloomingdale, Ringwood **104** | Ringwood **0.9%** |
| Population With Disability | **46,707** | **9.00%** | Paterson **12,756** | Prospect Park **14.3%** | Bloomingdale **588** | Pompton Lakes **7.2%** |
| Population Below Poverty Level | **68,995** | **13.30%** | Paterson **37,143** | Paterson **23.5%** | Ringwood **262** | Ringwood **2.2%** |
| Households Below ALICE Threshold | **62,752** | **35%** | Paterson **33,284** | Paterson **67%** | North Haledon **745** | Ringwood **22%** |

Particular impacts of this hazard on socially vulnerable populations are as follows (CDC 2022, CDC 2005):

- People 65 and older are susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice. This vulnerability is exacerbated by factors such as reduced mobility, chronic health conditions, and a diminished ability to regulate body temperature. In addition, severe winter weather events can reduce the ability of these populations to access emergency services.
- Children are at heightened risk due to their smaller body size, which makes them more susceptible to hypothermia, and their dependence on adults for appropriate winter clothing and shelter.
- Low-income individuals frequently lack access to adequate heating, proper winter attire, and safe housing, increasing their exposure to extreme cold.
- The homeless population faces significant risks due to prolonged exposure to the elements, limited access to warm shelters, and challenges in obtaining necessary resources to remain safe during harsh winter conditions.

## 12.2.2 General Building Stock

The entire general building stock inventory is vulnerable to severe winter weather hazards, with aging infrastructure being particularly at risk. Some building materials, such as wood, are more vulnerable to these conditions. In general, structural impacts include damage to roofs and building frames, rather than complete destruction of buildings or damage to building contents. Older buildings may be more susceptible due to less stringent building codes and the use of less resilient materials.

Particular impacts of this hazard on buildings are as follows:

- Extreme blizzards or snowstorms can carry and deposit significant amounts of snow, which can be heavy enough to damage roofs and aging buildings.
- High winds associated with winter storms can also cause structural damage.
- The freeze/thaw cycle can weaken building materials, leading to cracks and other forms of deterioration. Some building materials, such as wood, are more vulnerable to these conditions.

## 12.2.3 Community Lifelines and Other Critical Facilities

Full functionality of critical facilities such as police, fire and medical facilities is essential for response during and after a severe winter weather event. These critical facility structures are largely constructed of concrete and masonry; therefore, they should suffer only minimal structural damage from severe winter weather 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 (NWS 2019).

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 (NWS 2019).

## 12.2.4 Economy

The financial burden of snow and ice removal, roadway treatments (such as salt and brine), and road repairs from the freeze/thaw process and plowing can strain local resources. Additionally, severe winter weather disrupts commuting for work or school, as power outages and road closures prevent travel within and outside the County, potentially leading to a loss in economic productivity. The economic impact of winter weather each year is substantial, with costs for snow removal, damage, and business losses reaching millions of dollar (NOAA 2023).

According to FEMA's National Risk Index, Passaic County's expected annual losses from severe winter weather events are as follows (FEMA 2024):

- Ice Storm: $225,000
- Winter Weather: $831,000

## 12.2.5 Natural, Historic and Cultural Resources

### Natural

Excessive snowfall can significantly affect natural processes, such as surface water flows. Rain that falls onto an existing snowpack and freezes, forming an ice crust, can exacerbate runoff rates during warming winter weather. Increased flow rates and excess volumes of water can erode banks, tear apart habitat along the banks and coastline, and disrupt terrestrial plants and animals (Tiwari and Rachlin 2018).

Winter weather also has residual impacts on the environment due to the methods communities use to maintain their infrastructure during severe winter conditions (NSIDC n.d.). Road-salt runoff can cause groundwater salinization, modify the soil structure, and result in loss or reduction in lake turnover. Additionally, road salt can cause changes in the composition of aquatic invertebrate assemblages and pose threats to birds, roadside vegetation, and mammals (Tiwari and Rachlin 2018).

### Historic

Historic buildings may be susceptible to damage from severe winter weather conditions. 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).

Historic buildings, archaeological sites, and artifacts are vulnerable to severe winter weather due to several factors. Freeze-thaw cycles can cause significant damage as water seeps into cracks, freezes, expands, and then thaws, leading to the gradual breakdown of materials like stone, brick, and mortar. Snow and ice introduce moisture into structures and artifacts, which can freeze and cause expansion and cracking, while fluctuating humidity levels can deteriorate organic materials like wood and textiles.

### Cultural

The weight of accumulated snow and ice can stress roofs and other structural elements, potentially leading to collapses. Extreme cold makes materials more brittle and susceptible to cracking, and sudden temperature changes can cause thermal shock, damaging delicate artifacts. Additionally, severe winter weather can hinder access and maintenance, making it challenging to perform necessary upkeep and repairs (NPS 2016).

## 12.3 FUTURE CHANGES THAT MAY AFFECT RISK

### 12.3.1 Potential or Planned Development

Areas targeted for future growth and development have been identified across the County. As development and re-development increase, even less-intense storms may lead to costly storm damage. Potential or planned development can influence the risk and impact of severe winter weather in several ways. As development expands into previously undeveloped areas, more people and properties become exposed to the risks of severe winter weather, leading to higher potential for economic losses and disruptions.

Urbanization often leads to the creation of urban heat islands, which are warmer than their rural surroundings due to human activities and infrastructure. While this might reduce the severity of winter weather in urban areas, it can also lead to more significant temperature contrasts and potentially more intense weather events.

New developments might not always be designed with severe winter weather in mind, especially in regions that historically experience milder winters, increasing the vulnerability of buildings, roads, and utilities to damage from snow, ice, and freezing temperatures. Rapid development can also strain local resources and emergency services, making it more challenging to respond effectively to severe winter weather events

Additionally, development can alter natural landscapes, affecting local weather patterns and potentially increasing the frequency or severity of winter weather events. For example, deforestation and changes in land cover can influence local climate conditions.

## 12.3.2 Projected Changes in Population

An increase in population density can significantly hinder the ability of residents in the County to mobilize or receive essential services during severe winter weather events, as higher demand for resources and services can overwhelm infrastructure and emergency response systems.

The New Jersey Department of Labor and Workforce Development produced population projections by County for 2029 and 2034. According to these projections, Passaic County is projected to have an increase in population in the upcoming years. These projections include a population of 536,100 by 2029 and 542,500 by 2034 (State of New Jersey 2017).

## 12.3.3 Climate Change

Winter temperatures in the Northeast have increased by 4 °F since 1970, leading to less intense cold waves, fewer sub-freezing days, and less snow accumulation. As temperatures rise, the atmosphere can hold more water vapor, increasing precipitation potential. The state's annual precipitation has slightly increased, with projections of a 4 percent to 11 percent rise by 2050.

While quantitative data on future snowfall and ice storms in the State of New Jersey is lacking, it is likely that winter weather events may decrease in number but increase in intensity. This is because a warmer atmosphere can hold more moisture, leading to heavier precipitation. Any increased temperature contrast between warmer air masses and cold Arctic air can intensify storm systems. The projected increase in annual precipitation, primarily in the form of heavy rainfalls, can freeze into heavy snowfall and ice. This could lead to higher risks to life and health, increased structural losses, more resources needed for response and recovery, and more business closures due to severe winter events. (The Climate Reality Project 2022). Future climate modeling will enhance understanding of these changes.