5.4.8 Severe Winter Storm

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 storm hazard in Broome County.

5.4.8.1 Profile

Hazard Description

A winter storm is a weather event in which the main types of precipitation are snow, sleet, or freezing rain. They can be a combination of heavy snow, blowing snow, and dangerous wind chills. According to the National Severe Storms Laboratory (n.d.), the three basic components needed to make a winter storm include the following:

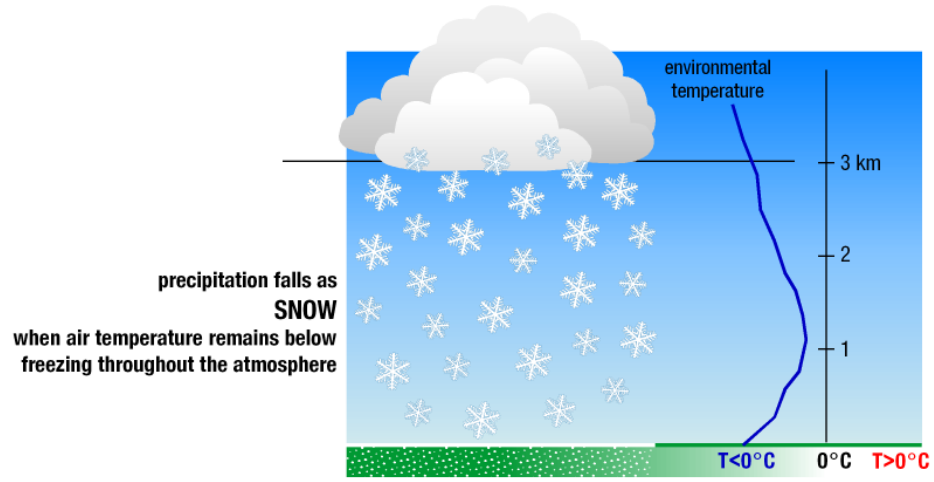
- Below freezing temperatures (cold air) in the clouds and near the ground to make snow and ice.
- Lift, something to raise the moist air to form clouds and cause precipitation, such as warm air colliding with cold air and being forced to rise over the cold dome or air flowing up a mountainside (oliographic lifting).
- Moisture to form clouds and precipitation, such as air blowing across a large lake or the ocean.

Some winter storms are large enough to immobilize an entire region while others might only affect a single community. Winter storms typically are 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 blocked roadways, downed utility lines, and power outages. In Broome County, winter storms include blizzards, snow storms, Nor'Easters, and ice storms. Extreme cold temperatures and wind chills are associated with winter storms.

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 °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 or a snow pellet, which then falls to the earth. Snow falls in different forms: snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud. Figure 5.4.8-1 depicts snow creation.

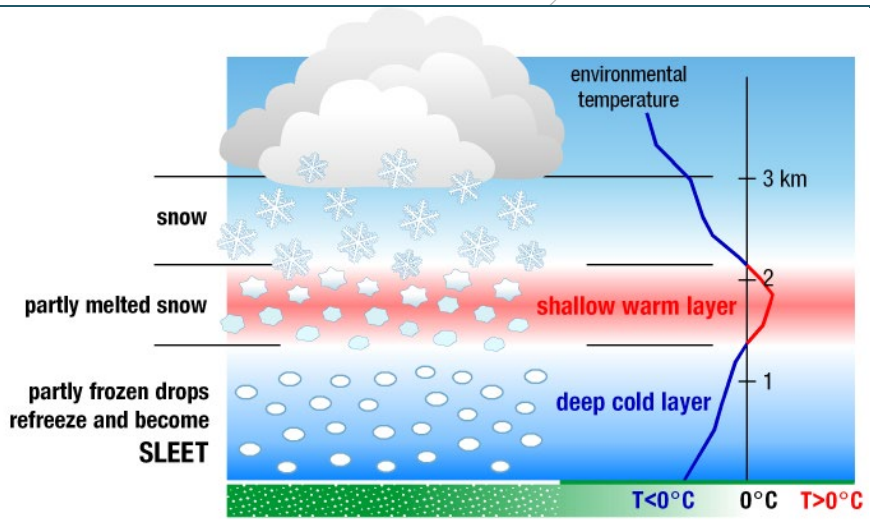
Figure 5.4.8-1. Snow Creation



Source: NOAA-NSSL, 2015

Snow pellets are opaque ice particles in the atmosphere. They form as ice crystals fall through super-cooled cloud droplets, which are below freezing but remain a liquid. The cloud droplets then freeze to the crystals. Sleet is made up of drops of rain that freeze into ice as they fall through colder air layers. They are usually smaller than 0.30 inches in diameter (NSIDC 2013).

Figure 5.4.8-2. Sleet Creation



Source: NOAA-NSSL 2015

Blizzards

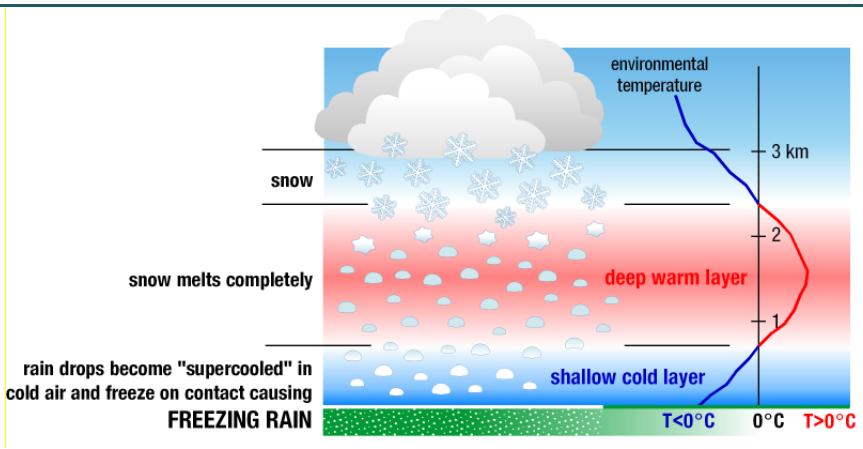
A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 miles per hour (mph) or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile, as the predominant conditions over a 3-hour period. Extremely cold temperatures often are associated with blizzard 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. 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).

Ice Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations typically are accumulations of 0.25-inches or greater (NWS 2013). 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 2008).

Figure 5.4.8-3. Freezing Rain Creation



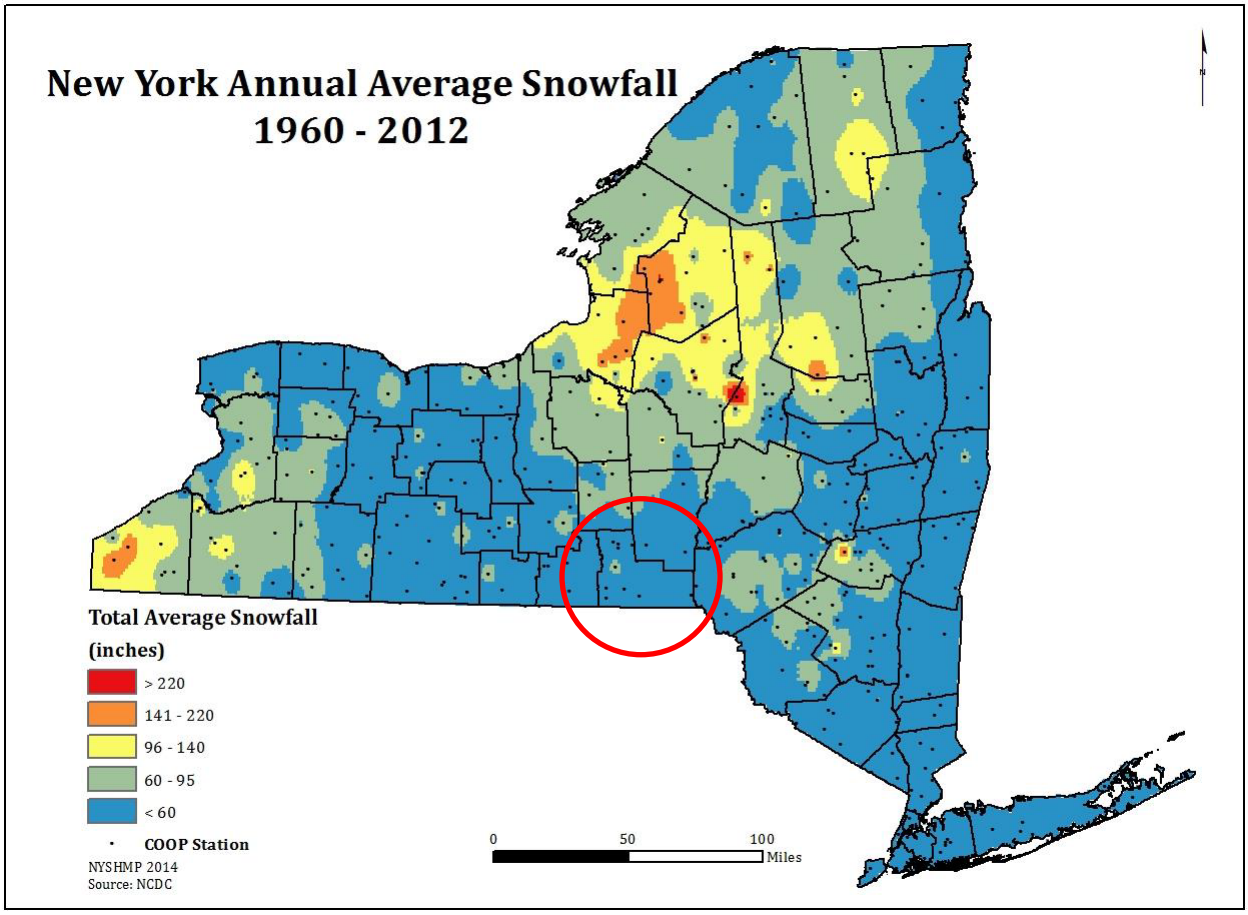
Source: NOAA-NSSL 2015

Location

Snow and Blizzards

On average, New York State receives more snowfall than any other state within the United States, with the easternmost and west-central portions of the state most likely to suffer under severe winter storm occurrences than the southern portion. Average snowfall in New York State is about 65 inches but varies greatly in the different regions of the state. Between 1960 and 2012, Broome County had a total average snowfall of less than 60 inches (New York State HMP 2014).

Figure 5.4.8-4. New York Annual Average Snowfall, 1960-2012



Source: NYSHMP 2014 NCDC
Note: The red circle indicates the location of Broome County.

Ice Storms

The Midwest and Northeast United States are prime areas for freezing rain and ice storm events. These events can occur anytime between November and April, with most events occurring during December and January. Based on data from 1948 to 2000, the average annual number of days with freezing rain for Broome County is six-seven days, and the average annual number of hours is 18–21 (Midwest Regional Climate Center 2018).

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 and week (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. The National Oceanic and Atmospheric Administration's (NOAA's) National Climatic Data Center (NCDC) is currently producing 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 and is based on the spatial extent of the storm, the amount of snowfall, and the interaction 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 2015). Table 5.4.8-1Table 5.4.8-1 presents the five RSI ranking categories.

Table 5.4.8-1. 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 2015
Note: RSI = Regional Snowfall Index

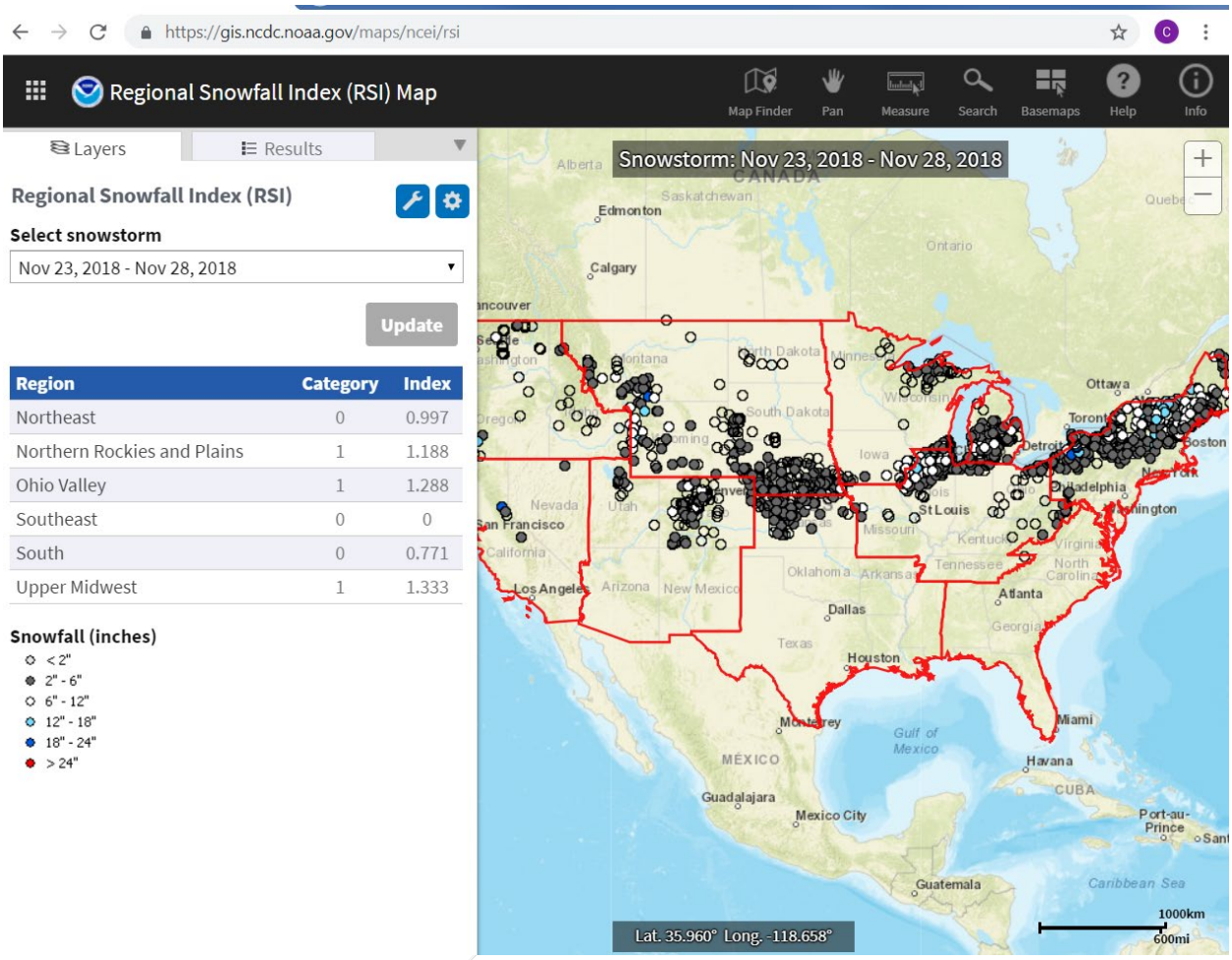
The NWS operates a widespread network of observing systems, such as geostationary satellites, Doppler radars, and automated surface observing systems that feed into the current state-of-the-art numerical computer models to provide a look into what will happen next, ranging from hours to days. The models are then analyzed by NWS meteorologists who then write and disseminate forecasts (NWS 2013).

According to NWS (2018), the magnitude of a severe winter storm can be qualified into five main categories by event type:

- Heavy Snowstorm – Accumulations of 4 inches or more of snow in a 6-hour period, or 6 inches of snow in a 12-hour period.
- Sleet Storm – Significant accumulations of solid pellets that form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces, posing a hazard to pedestrians and motorists.
- Ice Storm – Significant accumulation of rain or drizzle freezing on objects (trees, power lines, roadways) as it strikes them, causing slippery surfaces and damage from sheer weight of ice accumulations.
- Blizzard – Wind velocity of 35 mph or more, temperatures below freezing, considerable blowing snow with visibility frequently below one-quarter mile prevailing over an extended period.
- Severe Blizzard – Wind velocity of 45 mph, temperatures of 10 °F or lower, a high density of blowing snow with visibility frequently measured in feet prevailing over an extended period.

The NWS uses winter weather watches, warnings, and advisories to ensure that people know what to expect in the coming hours and days. A winter storm watch means that severe winter conditions (heavy snow, ice) might affect a certain area, but its occurrence, location, and timing are uncertain. A winter storm watch is issued when severe winter conditions (heavy rain or significant ice accumulations) are possible within in the next day or two. A winter storm warning is issued when severe winter conditions are expected (heavy snow 7 inches or greater in 12 hours or 9 inches or greater in 24 hours; ice storm with ½ inch or more). A winter weather advisory is used when winter conditions (i.e., snow, sleet, freezing rain, ice) are expected to cause significant inconvenience and could be hazardous (e.g., snow or sleet of 4–6 inches, freezing rain and drizzle in any accretion of ice on roads but less than ½ inch). A blizzard warning is issued when snow and strong winds will combine to produce a blinding snow, visibility near zero/whiteouts, and deep snow drifts (NWS, n.d.). Figure 5.4.8-5 depicts the NOAA National Centers for Environmental Information's Regional Snowfall Index.

Figure 5.4.8-5 NOAA NCEI Regional Snowfall Index



Previous Occurrences and Losses

Many sources have provided historical information regarding previous occurrences and losses associated with severe winter storm events in Broome County. According to the NOAA-NCEI storm events database, Broome County has been impacted by 79 winter weather events between 1950 and 2018, including 49 heavy snow events, 5 ice storms, 2 lake effect snow storms, 18 winter storms, and 5 winter weather events. Table 5.4.8-2 and Table 5.4.8-3 summarize these statistics, as well as the annual average number of events and the percent chance of these individual severe winter storm hazards occurring in Broome County in future years (NOAA NCEI 2018).

Table 5.4.8-2. Severe Winter Events 1950-2018

Hazard Type	Number of Occurrences Between 1950 and 2018	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Blizzard	0	0	0	$0	$0
Heavy Snow	49	0	0	$755,000	$0
Ice Storm	5	0	0	$205,000	$0
Lake Effect Snow	2	0	0	$0	$0
Sleet	0	0	0	$0	$0

Hazard Type	Number of Occurrences Between 1950 and 2018	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Winter Storm	18	0	0	$30,000	$0
Winter Weather	5	0	0	$20,000	$0
Total	**79**	**0**	**0**	**$1.01 million**	**$0**

Source: *NOAA-NCEI 2018; NHC 2018*
Note: *NOAA-NCEI database includes winter-related events starting in 1996. Events that occurred prior to 1996 are not included in the table.*

Between 1954 and October 2018, FEMA included New York State in 25 winter storm-related major disaster (DR) or emergency (EM) declarations classified as one or a combination of the following disaster types: severe winter storm, snowstorm, snow, ice storm, winter storm, blizzard, and flooding. Generally, these disasters cover a wide region of the state; therefore, they may have impacted many counties. Broome County was included in four of these declarations.

Table 5.4.8-3 FEMA Major Disasters and Emergency Declarations in Broome County

FEMA Declaration Number	Date(s) of Event	Event Type	Details
EM-3107	March 13–17, 1993	Snow	Severe Blizzard
EM-3173	December 25, 2002–January 4, 2003	Snow	Snowstorms
EM-3184	February 17–18, 2003	Snow	Snow
DR-4322	March 14–15, 2017	Snow	Severe Winter Storm and Snowstorm

Source: *FEMA 2018*
DR *Major Disaster Declaration (FEMA)*
EM *Emergency Declaration (FEMA)*
FEMA *Federal Emergency Management Agency*

Table 5.4.8-4 identifies the known severe winter storm events that impacted Broome County between 2012 and 2018. For events prior to 2012, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 5.4.8-4. Severe Winter Weather Events in Broome County, 2012 to 2018

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
December 26, 2012	Winter Storm	N/A	N/A	A low-pressure system tracked from the Tennessee Valley on Wednesday to just off the New Jersey coast on Thursday to the Canadian Maritimes on Friday. Northwest flow pulled cold and moist air behind the system with a widespread snow falling across central New York on Wednesday and Thursday. Snowfall amounts across the county ranged from 5–8 inches
December 29, 2012	Winter Storm	N/A	N/A	A low-pressure system tracked from the Midwest on Friday to the mid-Atlantic states on Saturday. Moisture and cold air associated with this system spread snow into portions of central New York on Saturday. Snowfall amounts across the county ranged from 5–8 inches.
February 8, 2013	Heavy Snow	N/A	N/A	A northern system passed over our region while merging with a coastal storm, yielding a period heavy snowfall across the region late February 8 into early February 9, 2013. Snow amounts generally ranged from 5–11 inches. A period of heavy snow

Table 5.4.8-4. Severe Winter Weather Events in Broome County, 2012 to 2018

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
				resulted in 5–10 inches accumulation. Highest amounts included 10.1 inches 5 miles southeast of Windsor and 9.0 inches in Tunnel.
December 14, 2013	Winter Storm	N/A	N/A	A low-pressure system developed over the southern Plains on December 13th and intensified as it headed toward the Northeast. A coastal low developed along the Atlantic seaboard on December 15th. Warm advection snow developed on the morning of Saturday. December 14th along a stationary boundary stretched across the Mason-Dixon line and dropped an initial 1–3 inches of snow. As the low-pressure system intensified, it produced moderate to heavy snowfall across the western Catskills and the upper Susquehanna Region of New York. Snowfall amounts ranged from 8–10 inches across the county. The highest amount of 10 inches fell in Vestal Center.
January 1, 2014	Winter Storm	N/A	N/A	A stalled frontal boundary across central New York resulted in light to moderate snowfall across central New York falling during the afternoon hours of Wednesday, January 1st. This snow intensified during the overnight and early morning hours of Thursday, January 2nd as a low-pressure system tracked through the Ohio Valley and re-developed off of the eastern seaboard. The highest snowfall totals occurred in the southern tier of New York into the upper Susquehanna Region with several reports of 13 inches. Snowfall amounts ranged from 8–12 inches across the county. The highest amount of 11.5 inches fell in Whitney Point. Windy conditions resulted in significant blowing snow and cold temperatures.
February 5, 2014	Winter Storm	N/A	N/A	A low-pressure system tracked through the Ohio Valley and re-developed off the eastern seaboard during the morning hours of Wednesday, February 5th. An intense snow band that developed produced as much as 1–3 inches of snow per hour during the early morning hours. Widespread snow amounts ranged from 6–15 inches, with the highest totals occurring across the southern tier of New York. Snowfall amounts ranged from 10–14 inches across the county. The highest amount of 14 inches fell in Castle Creek.
February 13, 2014	Winter Storm	N/A	N/A	A low-pressure system tracked out of the Gulf of Mexico and along the eastern seaboard on Thursday, February 13th bringing snowfall to the region. Widespread snow amounts ranged from 8–18 inches, with the highest totals occurring across Sullivan county, New York. Snowfall amounts ranged from 5–11 inches across the county. The highest amount of 11 inches fell in Windsor.
March 30, 2014	Winter Storm	N/A	N/A	A low-pressure system that moved up the eastern seaboard developed an intense narrow band of snow which was centered over the southern tier of New York State just east of Binghamton. This snow band produced tremendous snowfall rates of up to 3 inches per hour. Storm total snowfalls in a narrow 15-mile band ranged from 6–12 inches, including in a narrow strip across the eastern sections of Broome County. The highest snowfall total of 12 inches fell in Port Crane at an elevation of 1,460 feet.
November 26, 2014	Winter Storm	N/A	N/A	A low-pressure system developed over the northern Gulf of Mexico and intensified as it headed toward the Northeast. A coastal low developed along the Atlantic seaboard on November 26th. This system spread snow, heavy at times, into the western Catskills, Susquehanna Region, and southern tier of New York during the afternoon hours of Wednesday, November 26th. The highest snowfall totals were reported from a Cooperstown to Coventry to Binghamton line with double-digit snowfalls common along this route. Snowfall amounts ranged from 8–10.5 inches across the county. The highest amount of 10.5 inches fell in Chenango Forks.

Table 5.4.8-4. Severe Winter Weather Events in Broome County, 2012 to 2018

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Event Details*
February 1, 2015	Heavy Snow	N/A	N/A	A winter storm tracked from the central Plains on Sunday February 1st to the upper Ohio Valley and western Pennsylvania by Monday morning the 2nd. The storm then moved east off the New Jersey coast and out to sea by Monday evening. This storm spread snow to central New York during the evening hours of the 1st. The snow lasted through the overnight and tapered to snow showers by Monday afternoon. The winter storm brought a general 6 to 12 inches of snow to central New York with locally higher amounts. Snowfall of 6–10 inches occurred with this winter storm. The highest snowfall was recorded at the Greater Binghamton Airport with 10.5 inches.
March 18, 2015	Lake Effect Snow	N/A	N/A	A northwest flow of cold and moist air around an intense winter storm over the Maritimes combined with moisture from Lake Ontario distributed a band of locally heavy snow from the Finger Lakes Region southeast to the Binghamton area and western Catskills. The snow developed during the overnight hours on March 8th and ended by early afternoon. Snowfall accumulations generally ranged from 3–6 inches from the Finger Lakes to the Catskills with locally up to 8–10 inches from southern Cayuga County to northern Broome County in New York. Snowfall ranged up to around 8 inches in the northern part of Broome County. Lesser amounts fell to the south.
November 19, 2016	Lake Effect Snow	N/A	N/A	A strong cold front crossed central New York on Saturday afternoon of November 19th. Much colder air followed this front and was accompanied by several inches of snow, especially over the higher terrain. A slow-moving upper air low, which followed this front, slowly tracked across New York into northern New England from Sunday the 20th to Tuesday the 22nd. A northwest flow of cold moist air around this upper level low combined with moisture from the Great Lakes leading to a prolonged period of heavy lake effect snow. The lake effect snow affected an unusually large part of central New York including the southern tier counties, which typically do not see heavy lake effect snow. Record snowstorm at the Greater Binghamton Airport occurred over a 4-day period with a storm total snowfall of 27.6 inches. Much of Broome county saw between 1–2 feet of snow.
February 2, 2017	Heavy Snow	N/A	N/A	A winter storm tracked from the Ohio Valley across Pennsylvania to off the southern New England coast from the early morning hours of February 12th–13th. The storm brought heavy snow to portions of central and north central New York on the 12th with lake effect snow in its wake until the afternoon of the 13th. Snowfall accumulations ranged from 5–11 inches, with the highest amount at the Greater Binghamton Airport.
March 14, 2017	Heavy Snow	DR 4322	Yes	A major winter storm developed over eastern North Carolina during the early morning hours of March 14th. The winter storm tracked northeast during the day on the 14th, reaching the Gulf of Maine by the late evening of the 14th. This storm spread a heavy record-breaking snowstorm to a large part of central New York and northeast Pennsylvania with blizzard conditions from the Catskills in New York to the Poconos of northeast Pennsylvania and in the greater Scranton Wilkes-Barre area. Many municipalities and counties declared states of emergencies or travel bans or both. New York state also declared a state of emergency. A record snowfall of between 25–35 inches of snow fell. Snowfall rates reached up to 5 inches per hour especially during the onset of the storm. The Greater Binghamton Airport broke an all-time daily snowfall record with 32.4 inches and a 2-day snowfall record of 34.9 inches.

Sources: *FEMA 2018; NOAA-NCEI 2018; SPC 2018*
*** *Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table*
DR *Major Disaster Declaration (FEMA)*
FEMA *Federal Emergency Management Agency*
Mph *Miles per Hour*
NCEI *National Centers for Environmental Information*
NOAA *National Oceanic and Atmospheric Administration*
N/A *Not Applicable*

Climate Change Projections

New York State averages more than 40 inches of snow each year. Snowfall varies regionally, based on topography and the proximity to large lakes and the Atlantic Ocean. Maximum snowfall is more than 165 inches in parts of the Adirondacks and Tug Hill Plateau, as well as in the westernmost parts of the state. The warming influence of the Atlantic Ocean keeps snow in the New York City and Long Island areas below 36 inches each year (NYSERDA 2014).

Climate change is beginning to affect both people and resources in New York State, and these impacts are projected to increase. The impacts related to increasing temperatures and sea level rise are already causing complications in the state. *ClimAID: The Integrated Assessment for Effective Climate Change in New York State (ClimAID)* was undertaken to provide decision-makers with information on the state's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge (NYSERDA 2011).

Temperatures in New York State are warming, with an average rate of warming over the past century of 0.25° F per decade. Average annual temperatures are projected to increase across New York State by 2–3.4 °F by the 2020s, 4.1–6.8 °F by the 2050s, and 5.3–10.1 °F by the 2080s. By the end of the century, the greatest warming is projected to be in the northern section of the state (NYSERDA 2014).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Broome County is part of Region 3, Southern Tier, where temperatures are estimated to increase by 4.4–6.3 ºF by the 2050s and 5.7–9.9 ºF by the 2080s (baseline of 47.5 ºF, middle range projection). Precipitation totals are estimated to increase between 4–10 percent by the 2050s and 6–14 percent by the 2080s (baseline of 35.0 inches, middle range projection). Table 5.4.8-5 displays the projected seasonal precipitation change for Southern Tier ClimAID Region (NYSERDA 2014).

Table 5.4.8-5. Projected Seasonal Precipitation Change in Region 3, 2050s (% change)

Winter	Spring	Summer	Fall
+5 to +15	0 to +15	-10 to +10	-5 to +10

Source: *NYSERDA 2011*

New York State already is experiencing the effects of climate change during the winter season. Winter snow cover is decreasing, and spring comes, on average, about a week earlier than it did a few years ago. Nighttime temperatures are measurably warmer, even during the colder months. Overall winter temperatures in New York State are almost 5 degrees warmer than in 1970 (NYSERDA 2011; NYSDEC, n.d.). The state has experienced a decrease in the number of cold winter days (below 32 °F) and can expect to see a decrease in snow cover by as much as 25–50 percent by end of the next century. The lack of snow cover may jeopardize opportunities for skiing, snowmobiling, and other types of winter recreation; and natural ecosystems will be affected by the changing snow cover (Cornell University College of Agriculture and Life Sciences 2011). As the century progresses, snowfall is likely to become less frequent, with the snow season decreasing in length. It is uncertain if there will be changes in the intensity of snowfall during each storm; however, it is possible that higher

temperatures in colder parts of New York State could support higher snowfall totals during snowstorm events (NYSERDA 2014).

Some climatologists believe that climate change could play a role in the frequency and intensity of Nor'Easters. Two ingredients are needed to produce strong Nor'Easters and intense snowfall: (1) temperatures which are just below freezing and (2) massive moisture coming from the Gulf of Mexico. When temperatures are far below freezing, snow is less likely. As temperatures increase in the winter months, they will be closer to freezing rather than frigidly cold. Climate change is expected 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.

Probability of Future Occurrences

Table 5.4.8-6 summarizes data regarding the probability of occurrences of severe winter storm events in Broome County based on the historic record. Heavy snow events are the most common in Broome County, followed by winter storms. The information used to calculate the probability of occurrences is based solely on NOAA-NCEI storm events database results.

Table 5.4.8-6. Probability of Future Occurrence of Severe Winter Weather Events in Broome County

Hazard Type	Number of Occurrences Between 1950 and 2018	Rate of Occurrence or Annual Number of Events (average)	Recurrence Interval (in years) (# Years/Number of Events)	Probability of Event in any given year	% chance of occurrence in any given year
Blizzard	0	0	0	0	0
Heavy Snow	49	0.72	1.41	0.71	71.01
Ice Storm	5	0.07	13.80	0.07	7.25%
Lake Effect Snow	2	0.03	34.50	0.03	2.90%
Sleet	0	0	0	0	0%
Winter Storm	18	0.26	3.83	0.26	26.09%
Winter Weather	5	0.07	13.80	0.07	7.25%
Total	**79**	**1.16**	**0.87**	**1.14**	**100%**

Source: NOAA-NCEI 2018

Based on historical data from NYSERDA (2011), it is expected that the following will occur at least once per 100 years:

- Up to four inches of freezing rain in the ice band near central New York State of which between 1–2 inches of accumulated ice will occur over a 24-hour period.
- Up to two feet of accumulated snow in the snow band in northern and western New York State over a 48-hour period.

Based on geography, location, past event history, and climate projections, Broome county will continue to experience winter storm events. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings; refer to Section 5.3 (Hazard Ranking) for additional information on the hazard ranking methodology and probability criteria. The probability of occurrence for severe winter storms in the county is considered *frequent* (event has a 100 percent annual probability and might occur multiple times in the same year).

5.4.8.2 Vulnerability Assessment

All of Broome County is exposed to the severe winter storm hazard. The following summarizes the estimated potential impacts of severe winter storm events on the county.

Impact on Life, Health and Safety

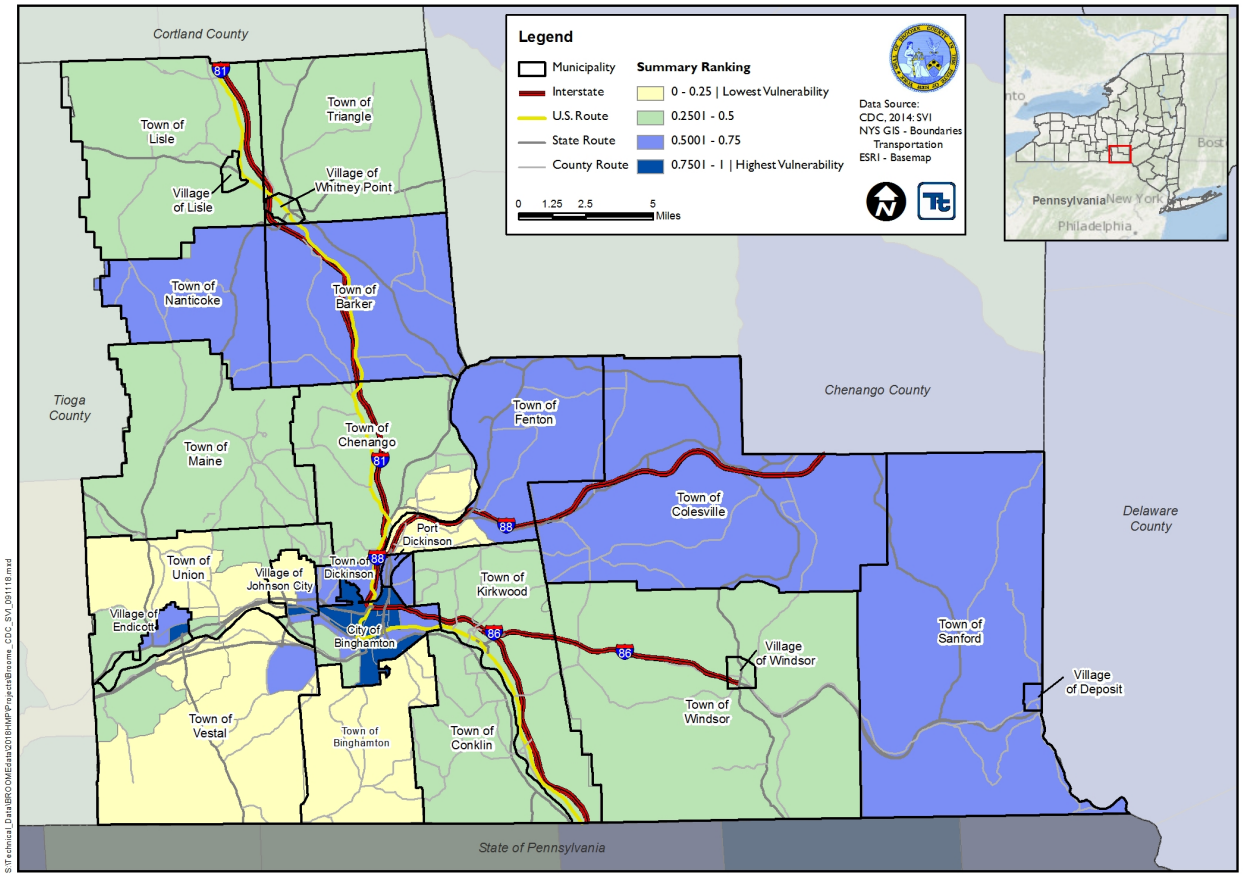
For the purposes of this HMP, the entire population of Broome County (197,381) is exposed to severe winter storm events (U.S. Census 2016 ACS 5-Year Population Estimate). The homeless and elderly are considered most susceptible to this hazard; the homeless due to their lack of shelter and the elderly due to their increased risk of injuries and death from falls and overexertion or hypothermia from attempts to clear snow and ice.

According to the 2016 ACS 5-Year Population Estimate, 17.6 percent of the population in Broome County is 65 and over. In addition, severe winter storm events can reduce the ability of these populations to access emergency services. In Broome County, the following areas have the highest concentration of elderly population: City of Binghamton and Villages of Deposit, Endicott, Johnson City, Port Dickinson, Whitney Point, and Windsor; locations of higher concentrations might also be present in areas throughout each of the county's towns. Refer to Figure 4-9 in Section 4 (County Profile) that displays the densities of populations over 65 in Broome County.

The homeless and residents with low incomes might 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). Refer to Figure 4-11 in Section 4 (County Profile) that displays the densities of low-income populations in Broome County. Additionally, homeless populations might not have access to housing or sheltering during a severe winter storm.

According to the Center for Disease Control and Prevention's (CDC) 2014 Social Vulnerability Index, Census Tracts 2, 5, 6, 11, 13, 17, and 18 in the City of Binghamton; Census Tracts 135 and 137 in the Village of Endicott; and Census Tract 139 in the Village of Johnson City are ranked in the highest vulnerability category, with values between 0.759 and 0.996. Census Tract 11 in the City of Binghamton has the highest social vulnerability with a ranking of 0.996. The vulnerable population located in these Census Tracts in the City of Binghamton and Villages of Endicott and Johnson City might be more susceptible to impacts from severe winter storms. Figure 5.4.8-6 below displays the CDC 2014 Social Vulnerability Index for Broome County.

Figure 5.4.8-6 CDC's Social Vulnerability Index 2014



Heavy snow can immobilize a region and paralyze a city. Additional impacts include stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Accumulations of snow can collapse buildings and knock down trees and power lines. In rural areas, homes and farms can be isolated for days, and unprotected livestock could be lost. In Broome County, the towns generally are rural compared with the villages and cities. In mountainous areas (Town of Windsor, Town of Sanford), heavy snow can lead to avalanches. The cost of snow removal, repairing damages, and loss of business can have large economic impacts on cities and towns (NSSL 2006)

Impact on General Building Stock

The entire general building stock inventory in Broome County is exposed and potentially vulnerable to the severe winter storm hazard; however, properties in poor condition or in particularly vulnerable locations may be at risk to the most damage. 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, the percent damage to structures that could result from severe winter storm conditions is considered. This allows planners and emergency managers to select a range of potential economic impact based on an estimate of the percent of damage to the general building stock. Table 5.4.8-7 summarizes the estimated loss to structures because of 1-, 5-, and 10-percent loss. Given professional knowledge and the currently available information, the potential loss for this hazard is considered to be overestimated because of varying factors (building structure type, age, load distribution, building codes in place). Therefore, the table's data should be

used as estimates only for planning purposes with the knowledge that the associated losses for severe winter storm events vary greatly.

Table 5.4.8-7. General Building Stock Exposure and Estimated Losses from Severe Winter Storm Events

County	Total (All Occupancies)	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Broome County	**$199,107,859,000**	**$1,991,078,590**	**$9,955,392,950**	**$19,910,785,900**

Source: Broome County GIS & Mapping Services

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 Section 5.4.4 (Flood Hazard Profile). Generally, losses resulting from flooding associated with severe winter storms should be less than that associated with a 1-percent annual chance flood event. In addition, coastal areas are at high risk during winter storm events that involve high winds, as presented in Section 5.4.6 (Severe Storm Profile) for losses resulting from wind.

Impact on Critical Facilities

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. Heavy accumulations of ice can bring down trees, electrical wires, telephone poles, utility 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 can cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL 2006). Because power interruption can occur, backup power is recommended.

Infrastructure at risk for this hazard includes roadways that could be damaged due to salt application 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.

Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. Impacts on the economy also include commuter difficulties into or out of the area for work or school. The loss of power and closure of roads prevent commuters within the county.

Future Changes that May Impact Vulnerability

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 4 (County Profile) and 9 (Jurisdictional Annexes), areas targeted for future growth and development have been identified across the county. Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire planning area is exposed and vulnerable. The ability of new development to withstand severe winter storm impacts lies in sound land use practices and consistent enforcement of codes and regulations for new construction.

Current New York State land use and building codes incorporate standards that address and mitigate snow accumulation. Some local municipalities in the county implemented the following activities to eliminate loss of life and property and infrastructure damages during winter storm events:

- Remove snow from roadways.
- Remove dead trees and trim trees/brush from roadways to lessen falling limbs and trees.
- Bury electrical and telephone utility lines to minimize downed lines.
- Remove debris/obstructions in waterways and develop routine inspections/maintenance plans to reduce potential flooding.
- Purchase and install backup generators in evacuation facilities and critical facilities to essential services to residents.

Projected Changes in Population

Between 2016 and 2017, the Greater Binghamton Area saw an increase of 121 percent in unsheltered homelessness and a decrease of 26 percent in family homelessness (BinghamtonHomepage.com 2017). The homeless population is vulnerable to extreme weather events inclusive of storms and extreme temperatures. According to population projections from the Cornell Program on Applied Demographics, Broome County will experience a continual population decrease through 2040 (an estimated decline of greater than 17,400 people by 2040). This decrease could reduce the overall vulnerability of the county's population over time; however, a closer examination of the age of the population, changes in their geography, and how climate change could alter the winter weather received (rain versus snow) will be important to continue to assess future changes in vulnerability.

Climate Change

As discussed earlier, it is uncertain how climate change will influence extreme winter storm events. With a potential for more frequent lake-effect snow events over the next two decades, the county's assets will be at risk to the impacts of more frequent severe winter storm events. 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 Since 2013 HMP

The Broome County Comprehensive Plan describes changes in the county's population from the 2000 to the 2010 U.S. Census. Overall, Broome County has experienced a decrease in population; however, there was an increase in the elderly population and unsheltered homelessness population (City of Binghamton), which are vulnerable to severe winter weather hazard. Further, the county has experienced an increase in population moving to more rural areas (Broome County Comprehensive Plan 2012). Rural areas could be hit hardest during

winter storm events because of geographical remoteness and increased additional winter weather preparedness measures. Overall, the entire county remains vulnerable to severe winter storm events.

Issues Identified

Important issues associated with a severe winter storm in the planning area include the following:

- Older building stock in Broome County might be more vulnerable to aftermath of a winter storm event. Heavy snow loads on the roofs of buildings might not be able to withstand the extra weight.
- Ice and freezing temperatures can lead to frost heaving, damaging roads, bridges, buildings, home foundations, and railroad tracks.
- The homeless population is rising in the City of Binghamton. During snow storms, this population is exposed and vulnerable to the health impacts of such events. In order to quantify the number of homeless, the Southern Tier Homeless Coalition does annual counts of the homeless in Broome and surrounding counties.
- The impacts of drought and invasive species can lead to dead or dying trees. These trees are more susceptible to falling during winter storm events from the weight of snow and ice causing power outages, closed roadways, and damage to buildings and property.
- Downed power lines from the weight of snow and ice lead to power outages, leaving many homes without a source of heat.