5.4.2 SEVERE WINTER STORM

This section provides a profile and vulnerability assessment for the severe winter storm hazard.

HAZARD PROFILE

This section provides profile information including description, extent, location, previous occurrences and losses and the probability of future occurrences.

Description

For the purpose of this HMP and as deemed appropriated by Delaware County, most severe winter storm hazards include heavy snow (snowstorms), blizzards, sleet, freezing rain, and ice storms. Since most extra-tropical cyclones (mid-Atlantic cyclones locally known as Northeasters or Nor'Easters), generally take place during the winter weather months (with some events being an exception), these hazards have also been grouped as a type of severe winter weather storm. According to the New York State Hazard Mitigation Plan (NYS HMP), winter storms are frequent events for the State of New York and occur from late October until mid-April. These types of winter events or conditions are further defined below.

Heavy Snow: According to the National Weather Service (NWS), heavy snow is generally snowfall accumulating to 4 inches or more in depth in 12 hours or less; or snowfall accumulating to six inches or more in depth in 24 hours or less. A snow squall is an intense, but limited duration, period of moderate to heavy snowfall, also known as a snowstorm, accompanied by strong, gusty surface winds and possibly lightning (generally moderate to heavy snow showers) (NWS, 2009). Snowstorms are complex phenomena involving heavy snow and winds, whose impact can be affected by a great many factors, including a region's climatologically susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and occurrence during the course of the day, weekday versus weekend, and time of season (Kocin and Uccellini, 2011).

Blizzard: Blizzards are characterized by low temperatures, wind gusts of 35 miles per hour (mph) or more and falling and/or blowing snow that reduces visibility to ¼-mile or less for an extended period of time (three or more hours) (NWS, 2009).

Sleet or Freezing Rain Storm: Sleet is defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes. These pellets of ice usually bounce after hitting the ground or other hard surfaces. Freezing rain is rain that falls as a liquid but freezes into glaze upon contact with the ground. Both types of precipitation, even in small accumulations, can cause significant hazards to a community (NWS, 2009).

Ice storm: An ice storm is used to describe occasions when damaging accumulations of ice are expected during freezing rain situations. Significant accumulations of ice pull down trees and utility lines resulting in loss of power and communication. These accumulations of ice make walking and driving extremely dangerous, and can create extreme hazards to motorists and pedestrians (NWS, 2009).

Extra-Tropical Cyclone: Extra-tropical cyclones, sometimes called mid-latitude cyclones, are a group of cyclones defined as synoptic scale, low pressure, weather systems that occur in the middle latitudes of the Earth. These storms have neither tropical nor polar characteristics and are connected with

fronts and horizontal gradients in temperature and dew point otherwise known as "baroclinic zones". Extra-tropical cyclones are everyday weather phenomena which, along with anticyclones, drive the weather over much of the Earth. These cyclones produce impacts ranging from cloudiness and mild showers to heavy gales and thunderstorms. Tropical cyclones often transform into extra-tropical cyclones at the end of their tropical existence, usually between 30 degrees (°) and 40° latitude, where there is sufficient force from upper-level shortwave troughs riding the westerlies (weather systems moving west to east) for the process of extra-tropical transition to begin. A shortwave trough is a disturbance in the mid or upper part of the atmosphere which induces upward motion ahead of it. During an extra-tropical transition, a cyclone begins to tilt back into the colder air mass with height, and the cyclone's primary energy source converts from the release of latent heat from condensation (from thunderstorms near the center) to baroclinic processes (Canadian Hurricane Centre [CHC], 2003).

Nor'Easter (abbreviation for North Easter): Nor'Easters are named for the strong northeasterly winds that blow in from the ocean ahead of the storm and over coastal areas. They are also referred to as a type of extra-tropical cyclones (mid-latitude storms, or Great Lake storms). A Nor'Easter is a macro-scale extra-tropical storm whose winds come from the northeast, especially in the coastal areas of the northeastern U.S. and Atlantic Canada. Wind gusts associated with Nor'Easters can exceed hurricane forces in intensity. Unlike tropical cyclones that form in the tropics and have warm cores (including tropical depressions, tropical storms and hurricanes); Nor'Easters contain a cold core of low barometric pressure that forms in the mid-latitudes. Their strongest winds are close to the earth's surface and often measure several hundred miles across. Nor'Easters may occur at any time of the year but are more common during fall and winter months (September through April) (NYCOEM, Date Unknown).

Nor'Easters can cause heavy snow, rain, gale force winds and oversized waves (storm surge) that can cause beach erosion, coastal flooding, structural damage, power outages and unsafe human conditions. If a Nor'Easter cyclone stays just offshore, the results are much more devastating than if the cyclone travels up the coast on an inland track. Nor'Easters that stay inland are generally weaker and usually cause strong winds and rain. The ones that stay offshore can bring heavy snow, blizzards, ice, strong winds, high waves, and severe beach erosion. In these storms, the warmer air is aloft. Precipitation falling from this warm air moves into the colder air at the surface, causing crippling sleet or freezing rain (McNoldy [Multi-Community Environmental Storm Observatory (MESO)], Date Unknown). While some of the most devastating effects of Nor'Easters are experienced in coastal areas (e.g. beach erosion, coastal flooding), the effects on inland areas, like Delaware County, may include heavy snow, strong winds and blizzards.

Winter storms can also generate coastal flooding, ice jams and snow melt, resulting in significant damage and loss of life. Coastal floods are caused when the winds generated from intense winter storms cause widespread tidal flooding and severe beach erosion along coastal areas. Ice jams are caused when long cold spells freeze up rivers and lakes. A rise in the water level or a thaw breaks the ice into large chunks. These chunks become jammed at man-made and natural obstructions. The ice jams act as a dam and result in flooding (NSSL, 2006).

Extent

The magnitude or severity of a severe winter storm depends on several factors including a region's climatologically susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and time of occurrence during the day (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements, such as those above, and by evaluating its societal impacts. The Northeast Snowfall Impact Scale (NESIS) categorizes snowstorms, including Nor'Easter events, in this manner. Unlike the Fujita Scale (tornado) and Saffir-Simpson Scale (hurricanes), there is no widely used scale to classify snowstorms. NESIS was developed by Paul Kocin of The Weather Channel and Louis Uccellini of the NWS to characterize and rank high-impact, northeast snowstorms. These storms have large areas of 10 inch snowfall accumulations and greater. NESIS has five ranking categories: Notable (1), Significant (2), Major (3), Crippling (4), and Extreme (5) (Table 5.4.2-1). The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus, NESIS gives an indication of a storm's societal impacts. This scale was developed because of the impact northeast snowstorms can have on the rest of the country in terms of transportation and economic impact (Kocin and Uccellini, 2011).

Table 5.4.2-1. NESIS Ranking Categories 1 - 5

Category	Description	NESIS Range	Definition
1	Notable	1.0 – 2.49	These storms are notable for their large areas of 4-inch accumulations and small areas of 10-inch snowfall.
2	Significant	2.5 – 3.99	Includes storms that produce significant areas of greater than 10-inch snows while some include small areas of 20-inch snowfalls. A few cases may even include relatively small areas of very heavy snowfall accumulations (greater than 30 inches).
3	Major	4.0 – 5.99	This category encompasses the typical major Northeast snowstorm, with large areas of 10-inch snows (generally between 50 and 150 × 103 mi^2—roughly one to three times the size of New York State with significant areas of 20-inch accumulations.
4	Crippling	6.0 – 9.99	These storms consist of some of the most widespread, heavy snows of the sample and can be best described as crippling to the northeast U.S, with the impact to transportation and the economy felt throughout the United States. These storms encompass huge areas of 10-inch snowfalls, and each case is marked by large areas of 20-inch and greater snowfall accumulations.
5	Extreme	10 +	The storms represent those with the most extreme snowfall distributions, blanketing large areas and populations with snowfalls greater than 10, 20, and 30 inches. These are the only storms in which the 10-inch accumulations exceed 200 × 103 mi^2 and affect more than 60 million people.

Source: Kocin and Uccellini, 2004

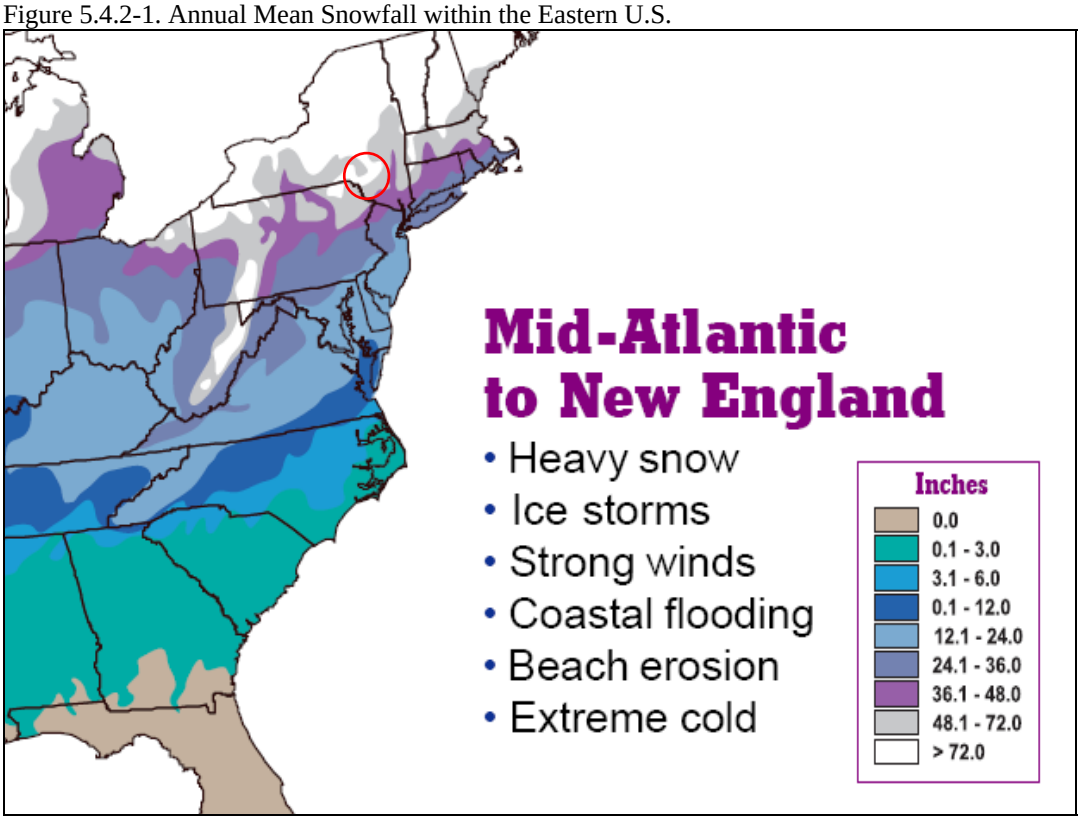
NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. These numbers are calculated into a raw data number ranking from "1" for an insignificant fall to over "10" for a massive snowstorm. Based on these raw numbers, the storm is placed into its decided category. The largest NESIS values result from storms producing heavy snowfall over large areas that include major metropolitan centers (Enloe, 2011).

Location

The climate of New York State is marked by abundant snowfall. Winter weather can reach New York State as early as October and is usually in full force by late November with average winter temperatures between 20 and 40° F. As indicated in the NYS HMP, communities in New York State receive more snow than most other communities in the nation. Although the entire State is subject to winter storms, the easternmost and west-central portions of the State are more likely to suffer under winter storm occurrences than any other location (New York State Disaster Preparedness Commission [NYSDPC],

2008). With the exception of coastal New York State, the State receives an average seasonal amount of 40 inches of snow or more. The average annual snowfall is greater than 70 inches over 60-percent of New York State's area; including Delaware County (Figure 5.4.2-1).

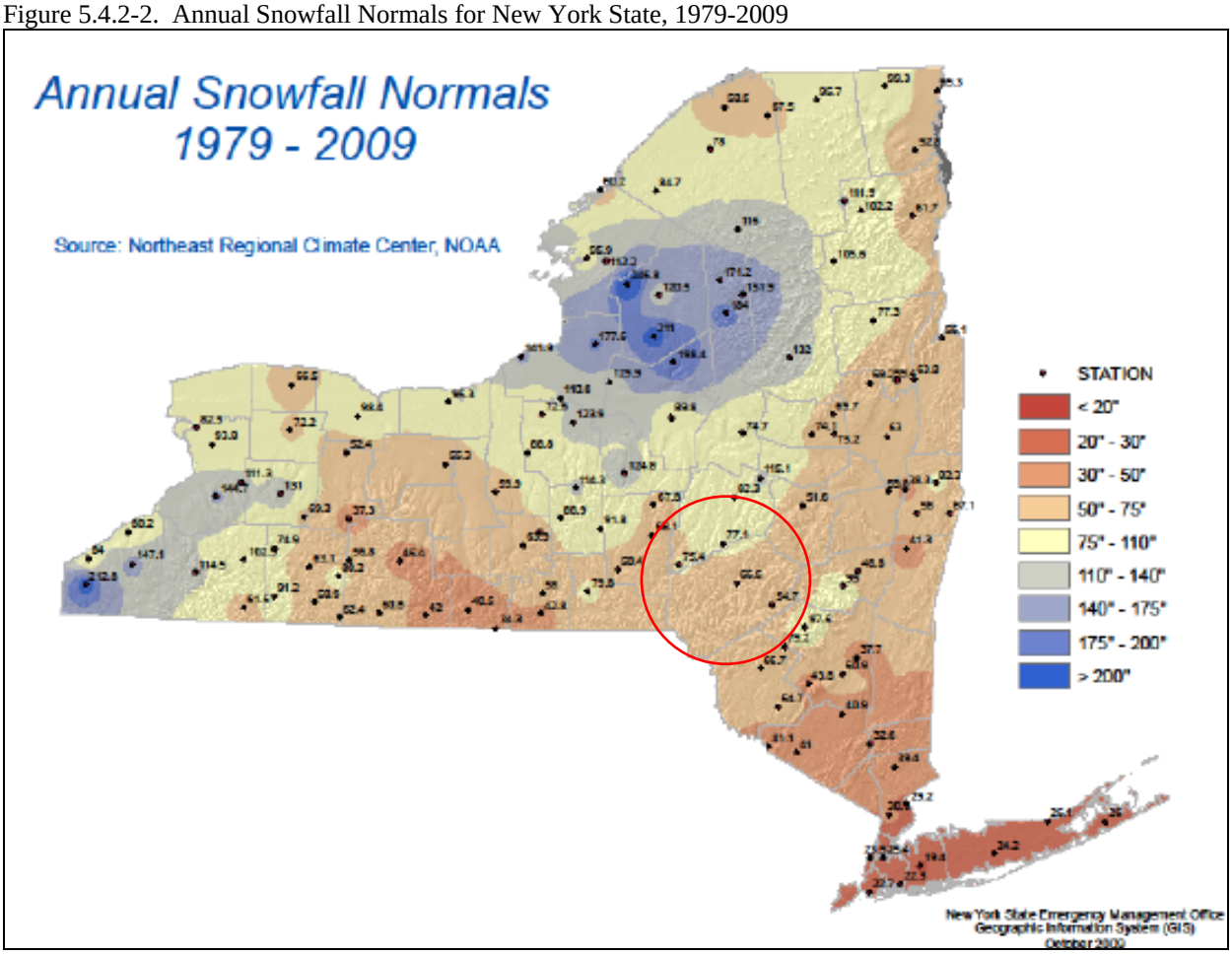
Figure 5.4.2-1. Annual Mean Snowfall within the Eastern U.S.



Source: NWS, 2011

Figure 5.4.2-2, an annual normal snowfalls map, illustrates the annual average snowfall totals over a 30 year period for New York State. The general indication of the average annual snowfall map shows areas that are subject to a consistent risk for large quantities of snow (NYS HMP, 2011).

Figure 5.4.2-2. Annual Snowfall Normals for New York State, 1979-2009

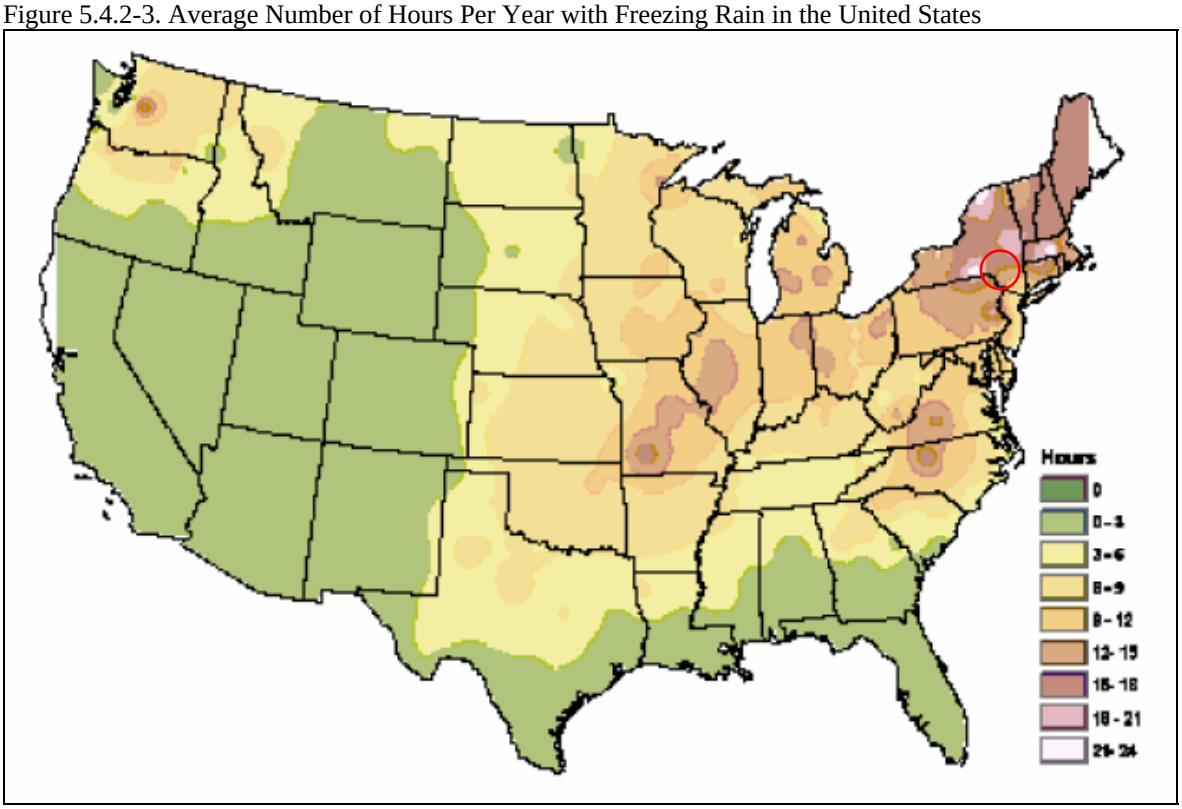


Source: NYS HMP, 2011
Note: Delaware County is indicated by a red circle with an average annual snow accumulation of 50 to 75-inches.

Figure 5.4.2-3 illustrates the average number of hours per year with freezing rain in the U.S. According to the figure, Delaware County experiences between 13 and 18 hours per year (NYS HMP, 2011).

The general indication of the average annual snowfall map shows areas that are subject to a consistent risk for large quantities of snow (NYS HMP, 2011).

Figure 5.4.2-3. Average Number of Hours Per Year with Freezing Rain in the United States



Source: NYS HMP, 2011
Note: Delaware County is indicated by a red circle with an average number of 13 to 18 hours of freezing rain each year.

Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with severe winter storms and extreme cold events throughout New York State and Delaware County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

The 2011 Draft New York State HMP rated each county in terms of their vulnerability to snow and ice storms hazards. Please refer to the NYS HMP for additional details on their point system. Table 5.4.2-2 and Table 5.4.2-3 summarize Delaware County's rating for both hazards.

Table 5.4.2-2. Delaware County's Vulnerability Rating for Snow Storms.

County Rating Score (Max 25)	Annual Average Snowfall (inches)	*Extreme Snowfall Potential (no/yes)	# of Snow Related Disasters Population Density (per square mile)	Population Density (per square mile)	Total # of Structures (HAZUS)
10	72.2	No	4	32.8	21,904

Source: NYS HMP, 2011 – need proper reference

Table 5.4.2-3. Delaware County's Vulnerability Rating for Ice Storms

County Rating Score	Related Disasters	Total # of Structures (HAZUS)
2	0	21,904

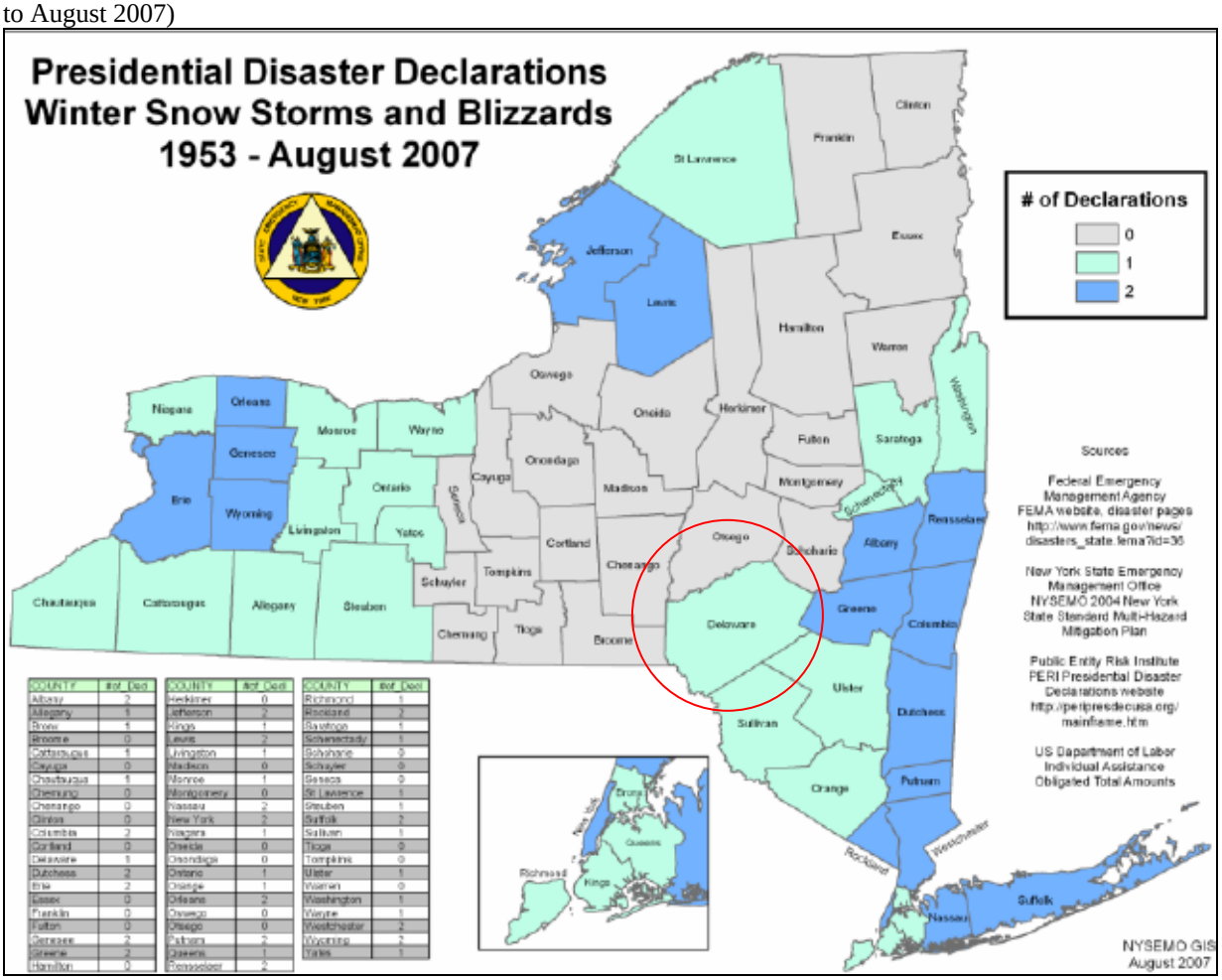
Source: NYS HMP, 2011 – need proper reference

According to NOAA's NCDC storm events database, Delaware County experienced 98 snow and ice storm events between April 30, 1950 and September 30, 2011. Total property damages, as a result of these winter storm events, were estimated at $28.12 million. This total also includes damages to other counties. According to the Hazard Research Lab at the University of South Carolina's Spatial Hazard Events and Losses Database for the U.S. (SHELDUS), between 1960 and 2007, 176 winter storm events occurred within the County. The database indicated that severe winter storm events and losses specifically associated with Delaware County and its municipalities totaled over $31.4 million in property damage. However, these numbers may vary due to the database identifying the location of the hazard event in various forms or throughout multiple counties or regions.

Between 1954 and 2012, FEMA declared that New York State experienced 23 winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: winter storms, severe storms, coastal storms, ice storm, blizzard, snow, snowstorm, Nor'Easter and flooding. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, the NYS HMP and other sources indicate that Delaware County has been declared as a disaster area as a result of six winter storm-related events (FEMA, 2012).

Figure 5.4.2-4 shows the FEMA disaster declarations (DR) for "winter storms" and "blizzards" in New York State, from 1953 to August 2007. This figure indicates that Delaware County was only included in one disaster declaration. Since the date of this figure, Delaware County has been included in one other FEMA disaster declaration. Figure 5.4.2-5 shows the FEMA disaster declarations (DR) for ice storms in New York State, from 1983 and August 2007. This figure indicates that Delaware County has not been included in any ice storm disaster declarations. Since the date of this figure, Delaware County has not been included in any other disaster declarations for ice storms.

Figure 5.4.2-4. Presidential Disaster Declarations in New York State from Winter Snow Storms and Blizzards (1953 to August 2007)

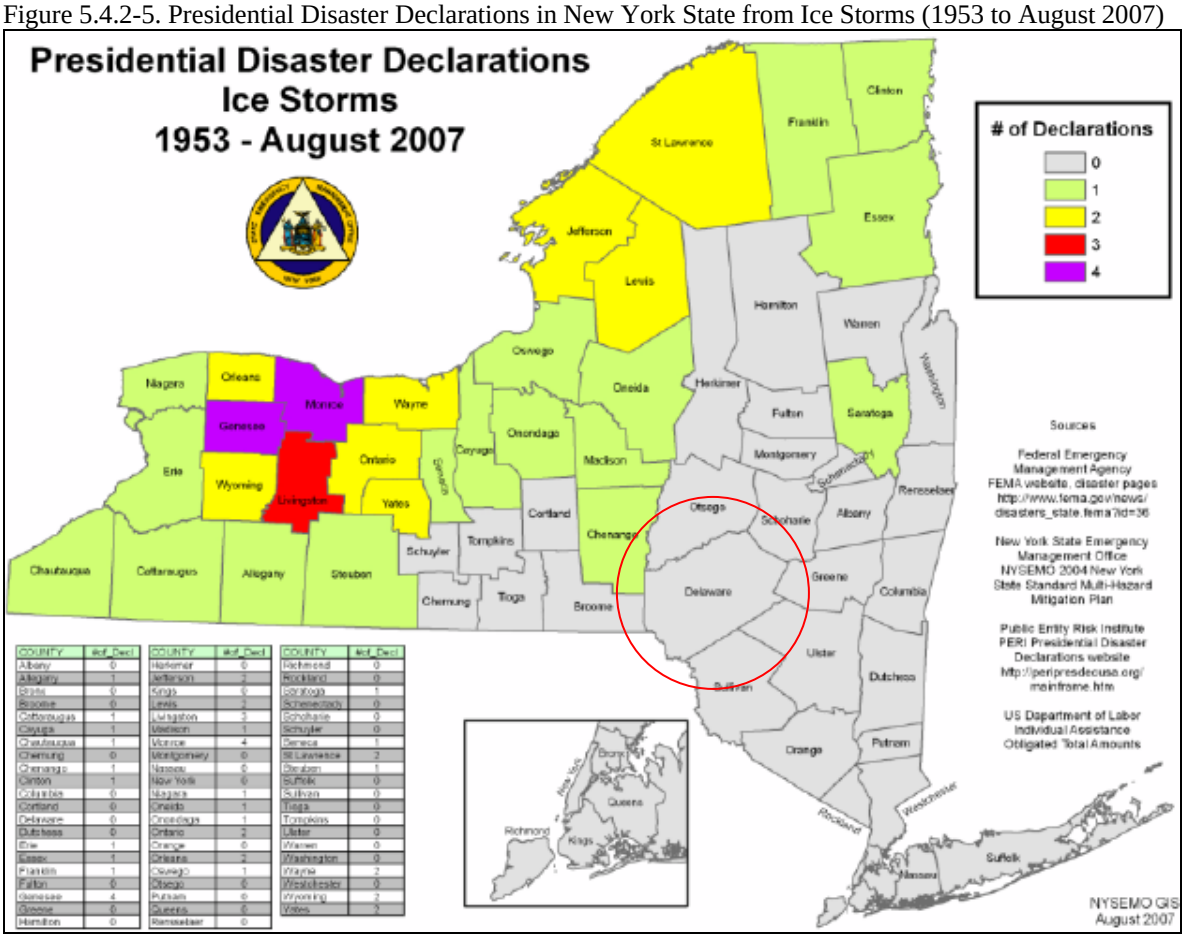


COUNTY	#of Decl	COUNTY	#of Decl	COUNTY	#of Decl
Albany	2	Herkimer	0	Richmond	1
Allegany	1	Jefferson	2	Rockland	2
Bronx	1	Kings	1	Saratoga	1
Broome	0	Lewis	2	Schenectady	1
Cattaraugus	1	Livingston	1	Schoharie	0
Cayuga	0	Madison	0	Schuyler	0
Chautauqua	1	Monroe	1	Seneca	0
Chemung	0	Montgomery	0	St Lawrence	1
Chenango	0	Nassau	2	Steuben	1
Clinton	0	New York	2	Suffolk	2
Columbia	2	Niagara	1	Sullivan	1
Cortland	0	Oneida	0	Tioga	0
Delaware	1	Onondaga	0	Tompkins	0
Dutchess	2	Ontario	1	Ulster	1
Erie	2	Orange	1	Warren	0
Essex	0	Orleans	2	Washington	1
Franklin	0	Oswego	0	Wayne	1
Fulton	0	Otsego	0	Westchester	2
Genesee	2	Putnam	2	Wyoming	2
Greene	2	Queens	1	Yates	1
Hamilton	0	Rensselaer	2		

Source: NYS HMP, 2011

Note: The red circle indicates the approximate location of Delaware County. Delaware County has been included in one winter storm/blizzard disaster declaration in New York State.

Figure 5.4.2-5. Presidential Disaster Declarations in New York State from Ice Storms (1953 to August 2007)



Source: NYS HMP, 2011

Note: The red circle indicates the approximate location of Delaware County. Delaware County has not included in any ice storm disaster declarations in New York State.

Based on all sources researched, known winter storm events that have affected Delaware County and its municipalities are identified in Table 5.4.2-4. With winter storm documentation for New York State being so extensive, not all sources have been identified or researched. Therefore, Table 5.4.2-4 may not include all events that have occurred throughout the County and region.

Table 5.4.2-4. Winter Storm Events Between 1950 and 2012.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
December 25, 2002 – January 4, 2003	Snowstorm	EM-3173 (PA)	Yes	Between December 25 and 26, a snowstorm moved into central New York State and brought freezing rain and snow. Snowfall totals in the area ranged between six inches and three feet. Due to snowfall amounts, the New York State Thruway was closed for parts of the evening. The snow caused power outages to 3,000 customers in the Catskills. Many counties declared a state of emergency. In Delaware County, snowfall totals ranged from 19 inches in the Town of Deposit to 33.2 inches in the Town of Walton. Between January 3 and 4, a slow moving Nor'easter moved into central New York State, spreading snow. The snow was heavy at times, with totals ranging between eight and 25 inches. At least 20,000 customers were without power, some without power for a week. Emergency shelters were set up in some areas. Snowfall totals in Delaware County ranged from 11 inches in the Town of Delhi to 24 inches in the Town of Franklin. Total property damages for Delaware County were $352,941.17. FEMA awarded Delaware County $523,858.32 in federal assistance for these two events.	FEMA, NOAA-NCDC, NWS, SHELDUS
February 16-18, 2003	Snowstorm	EM-3184 (PA)	Yes	A coastal storm moved up the east coast of the U.S. Snow fall spread into the southern Catskills and into the southern tier. At times, snow fell at rates of several inches an hour. Snowfall totals in the area ranged between 10 and 30 inches. Property damage from the storm was approximately $2.7 M. In Delaware County, between eight and 19.5 inches of snow fell, with 19.5 inches in the Town of Hancock. Property damage in the County was approximately $152 K.	FEMA, NOAA-NCDC, SHELDUS, NWS
February 13-14, 2007 (Valentine's Day Storm)	Severe Winter Storm	N/A	N/A	The Valentine's Day Storm was the largest to effect central New York State and northeast Pennsylvania during the 2006-2007 winter season. This storm was classified as "major" on the Northeast Snowfall Impact Scale. Snowfall totals in Delaware County ranged from 12 inches in the Village of Margaretville to 30 inches in the Town of Bovina.	NWS
February 22-23, 2007	Winter Storm	N/A	N/A	A strong cold front pushed through the region, accompanied by snow and wind. As the storm moved into New England, snow fall was heavy at times, affecting eastern New York State. In Delaware County, snowfall totals ranged between four and 11	NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
				inches, with 9 inches in the Town of Stamford and 11.1 inches in the Town of Roxbury.	
April 15-16, 2007	Winter Storm	N/A	N/A	A mix of light rain and snow fell over central New York State during the afternoon of the 15th. During the evening, precipitation changed back to snow north and west of the Catskills. The morning of the 16th, the snow became heavy and continued across central New York State. Snow totals across the state ranged from two inches to two feet. In Delaware County, snowfall totals ranged between 10 and 15 inches.	NOAA-NCDC
December 11-31, 2008	Severe Winter Storm (snow and ice)	EM-3299 / DR-1827 (PA)	Yes	Between December 11th and 12th, wintry precipitation fell in central New York State. A band of heavy snow developed across central New York State, from the Finger Lakes to Onondaga and Madison Counties, bringing between five and 10 inches of snow. Further east, in Chenango, Delaware and Otsego Counties, significant icing was experienced and more than a half inch of ice fell. Snowfall totals in Delaware County ranged between 7 and 10 inches. Another storm occurred December 18th. The storm brought snow across all of central New York State, with accumulations ranging from six to 11 inches. In Delaware County, snowfall amounts ranged between five and eight inches. As of June 10, 2009, Delaware County received $1,299,664 in assistance.	FEMA, NOAA-NCDC
February 23-24, 2010	Winter Storm	N/A	N/A	During the night of February 23rd, snow became heavy and tapered off the morning of the 24th. The heaviest snow fell in the higher elevations of the western Catskills. The snow caused many power outages in the area. In Delaware County, heavy snow fell in the eastern portions of the County. In the Town of Roxbury, 18.9 inches of snow fell. In the Hamlet of New Kingston, 11 inches of snow fell.	NOAA-NCDC
February 25-26, 2010	Winter Storm	N/A	N/A	During the afternoon of the 25th, snow became heavy and wind speeds ranged between 20 and 25 mph, with gusts of 35 mph. This caused near-blizzard conditions and state of emergencies were declared for several counties in central New York State. Snowfall totals ranged from 10 to 20 inches, with two to three feet in the Catskills. In Delaware County, heavy snow fell across the county, with amounts ranging between 10 and 19 inches.	NOAA-NCDC

Sources: NOAA-NCDC, FEMA, NWS, SHELDUS
Note: Monetary figures within this table were U.S. Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of inflation.

DR	Disaster Declaration
EM	Emergency 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
PA	Public Assistance
SHELDUS	Spatial Hazard Events and Losses Database for the United States

Probability of Future Events

Winter storm hazards in New York State are virtually guaranteed yearly since the State is located at relatively high latitudes resulting in winter temperatures that range between 0°F and 32 °F for a good deal of the fall through early spring season (late October until mid-April). In addition, the State is exposed to large quantities of moisture from both the Great Lakes and the Atlantic Ocean. While it is almost certain that a number of significant winter storms will occur during the winter and fall season, what is not easily determined is how many such storms will occur during that time frame (NYS HMP, 2011).

The New York State HMP includes a similar ranking process for hazards that affect the State. Based on historical records and input from the Planning Committee, the probability of at least one winter snow storm of emergency declaration proportions, occurring during any given calendar year is virtually certain in the State. Based on historical snow related disaster declaration occurrences, New York State can expect a snow storm of disaster declaration proportions, on average, once every 3 to 5 years. Similarly, for ice storms, based on historical disaster declarations, it is expected that on average, ice storms of disaster proportions will occur once every 7-10 years within the State (NYS HMP, 2011).

It is estimated that Delaware County will continue to experience direct and indirect impacts of severe winter storms annually. Table 5.4.2-5 summarizes the occurrences of winter storm events and their annual occurrence (on average).

Table 5.4.2-5. Occurrences of Severe Winter Storm Events in Delaware County, 1993 - 2011

Event Type	Total Number of Occurrences	Annual Number of Events (average)
Winter Storm	14	1.3
Snow / Heavy Snow	61	3.4
Winter Weather	2	0.1
Snow / Freezing Rain / Sleet	13	1.4
Ice Storm	10	1.8
Total:	**100**	**5.6**

Source: NOAA-NCDC, 2011
Note: On average, Delaware County experiences 5.6 winter storm events each year.

In Section 5.3, the identified hazards of concern for Delaware 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 storms in the County is considered 'Frequent' (likely to occur within 24 years, as presented in Table 5.3-6).

Climate Change Impacts

Climate change is beginning to affect both people and resources in New York State, and these impacts are projected to continue growing. Impacts related to increasing temperatures and sea level rise are already being felt 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 (New York State Energy Research and Development Authority [NYSERDA], 2011).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Delaware County is part of Region 2, Catskill Mountains and West Hudson River Valley. Some of the issues in this region, affected by climate change, include: the watershed for New York City's water supply, spruce/fir forests disappear from mountains, decline in popular apple varieties, winter recreation

declines/summer opportunities increase, Hemlock wooly adelgid destroys trees, and native brook trout decline and replaced by bass (NYSERDA, 2011).

Temperatures are expected to increase throughout the state, by 1.5 to 3ºF by the 2020s, 3 to 5.5ºF by the 2050s and 4 to 9ºF by the 2080s. The lower ends of these ranges are for lower greenhouse gas emissions scenarios and the higher ends for higher emissions scenarios. Annual average precipitation is projected to increase by up to five-percent by the 2020s, up to 10-percent by the 2050s and up to 15-percent by the 2080s. During the winter months is when this additional precipitation will most likely occur, in the form of rain, and with the possibility of slightly reduced precipitation projected for the late summer and early fall. Table 5.4.2-6 displays the projected seasonal precipitation change for the Catskill Mountains and West Hudson River Valley ClimAID Region (NYSERDA, 2011).

Table 5.4.2-6. Projected Seasonal Precipitation Change in Region 2, 2050s (% change)

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

Source: NYSERDA, 2011

It is uncertain how climate change will impact winter storms. Based on historical data, it is expected that the following will occur at least once per 100 years:

- Up to eight inches of rain fall in the rain band near the coast over a 36-hour period
- Up to four inches of freezing rain in the ice band near central New York State, of which between one and two inches of accumulated ice, 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 (NYSERDA, 2011)

New York State is already 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 (NYSDEC, Date Unknown). Overall winter temperatures in New York State are almost five degrees warmer than in 1970 (NYSDEC, Date Unknown). The State has seen 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 to 50% 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 (DeGaetano et al. [Cornell University], 2010).

VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For severe winter storm events, the entire County has been identified as the hazard area. Therefore, all assets in Delaware County (population, structures, critical facilities and lifelines), as described in the County Profile section (Section 4), are vulnerable. The following section includes an evaluation and estimation of the potential impact severe winter storm events have on Delaware County including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact, including: (1) impact on life, safety and health, (2) general building stock, (3) critical facilities (4) economy and (5) future growth and development
- Further data collections that will assist understanding of this hazard over time
- Overall vulnerability conclusion

Overview of Vulnerability

Severe winter storms are of significant concern to Delaware County because of their frequency and magnitude in the region. Additionally, they are of significant concern due to the direct and indirect costs associated with these events; delays caused by the storms; and impacts on the people and facilities of the region related to snow and ice removal, health problems, cascade effects such as utility failure (power outages) and traffic accidents, and stress on community resources.

Data and Methodology

National weather databases and local resources were used to collect and analyze severe winter storm impacts on Delaware County and the participating municipalities. The 2010 U.S. Census data and default HAZUS-MH 2.0 general building data was used to support an evaluation of assets exposed to this hazard and the potential impacts associated with this 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. 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 (NSSL, 2006).

Heavy snow can immobilize a region and paralyze a city, 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 may be isolated for days, and

unprotected livestock may be lost. In the mountains, 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).

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, 2006).

For the purposes of this HMP, the entire population of Delaware County (47,980 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. Refer to Table 4-3 in the County Profile for population statistics for each participating municipality.

The elderly are considered most 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. In addition, severe winter storm events can reduce the ability of these populations to access emergency services. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). Table 5.4.2-7 summarizes the population over the age of 65 and individuals living below the Census poverty threshold.

Table 5.4.2-7. Delaware County Population Statistics (2000 U.S. Census)

Municipality	HAZUS-MH Population Over 65 (Census 2000)	HAZUS-MH Population Below Poverty (Census 2000)*
Andes (T)	149	250
Bovina (T)	51	61
Colchester (T)	193	358
Davenport (T)	169	492
Delhi (T)	178	322
Delhi (V)	139	261
Deposit (T)	58	155
Deposit (V)	128	388
Fleischmanns (V)	34	59
Franklin (T)	167	302
Franklin (V)	32	79
Hamden (T)	107	214
Hancock (T)	134	385
Hancock (V)	129	257
Harpersfield (T)	98	168
Hobart (V)	23	45
Kortright (T)	124	247
Margaretville (V)	81	142
Masonville (T)	89	220
Meredith (T)	98	217

Municipality	HAZUS-MH Population Over 65 (Census 2000)	HAZUS-MH Population Below Poverty (Census 2000)*
Middletown (T)	306	555
Roxbury (T)	216	470
Sidney (T)	151	322
Sidney (V)	307	943
Stamford (T)	127	259
Stamford (V)	72	75
Tompkins (T)	84	178
Walton (T)	185	405
Walton (V)	233	737
Delaware County	**3,862**	**8,566**

Source: HAZUS 2.0
Note: * Households with an income of less than $25,000

Impact on General Building Stock

The entire general building stock inventory in Delaware County 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. Table 5.4.2-8 presents the total exposure value for general building stock for each participating municipality (structure only).

There was no historic information available that identified property damages within Delaware County due to a single severe winter storm event. 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 5.4.2-8 below summarizes percent damages that could result from severe winter storm conditions for the County's total general building stock (structure only). Given professional knowledge and information available, the potential losses for this hazard are considered to be overestimated; hence, conservative estimates for losses associated with severe winter storm events.

Table 5.4.2-8. General Building Stock Exposure (Structure Only) and Estimated Losses from Severe Winter Storm Events in Delaware County

Municipality	Total (All Occupancies) RV	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Andes (T)	$162,728,000	$1,627,280	$8,136,400	$16,272,800
Bovina (T)	$78,408,000	$784,080	$3,920,400	$7,840,800
Colchester (T)	$194,716,000	$1,947,160	$9,735,800	$19,471,600
Davenport (T)	$155,590,000	$1,555,900	$7,779,500	$15,559,000
Delhi (T)	$162,592,000	$1,625,920	$8,129,600	$16,259,200
Delhi (V)	$242,545,000	$2,425,450	$12,127,250	$24,254,500
Deposit (T)	$56,836,000	$568,360	$2,841,800	$5,683,600
Deposit (V)	$160,872,000	$1,608,720	$8,043,600	$16,087,200
Fleischmanns (V)	$40,650,000	$406,500	$2,032,500	$4,065,000
Franklin (T)	$146,876,000	$1,468,760	$7,343,800	$14,687,600
Franklin (V)	$26,316,000	$263,160	$1,315,800	$2,631,600
Hamden (T)	$105,619,000	$1,056,190	$5,280,950	$10,561,900
Hancock (T)	$183,818,000	$1,838,180	$9,190,900	$18,381,800

Municipality	Total (All Occupancies) RV	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Hancock (V)	$100,183,000	$1,001,830	$5,009,150	$10,018,300
Harpersfield (T)	$65,042,000	$650,420	$3,252,100	$6,504,200
Hobart (V)	$21,868,000	$218,680	$1,093,400	$2,186,800
Kortright (T)	$118,510,000	$1,185,100	$5,925,500	$11,851,000
Margaretville (V)	$53,624,000	$536,240	$2,681,200	$5,362,400
Masonville (T)	$88,390,000	$883,900	$4,419,500	$8,839,000
Meredith (T)	$113,294,000	$1,132,940	$5,664,700	$11,329,400
Middletown (T)	$302,907,000	$3,029,070	$15,145,350	$30,290,700
Roxbury (T)	$264,317,000	$2,643,170	$13,215,850	$26,431,700
Sidney (T)	$131,797,000	$1,317,970	$6,589,850	$13,179,700
Sidney (V)	$332,661,000	$3,326,610	$16,633,050	$33,266,100
Stamford (T)	$176,684,000	$1,766,840	$8,834,200	$17,668,400
Stamford (V)	$52,076,000	$520,760	$2,603,800	$5,207,600
Tompkins (T)	$80,248,000	$802,480	$4,012,400	$8,024,800
Walton (T)	$149,252,000	$1,492,520	$7,462,600	$14,925,200
Walton (V)	$236,431,000	$2,364,310	$11,821,550	$23,643,100
Delaware County	**$4,004,850,000**	**$40,048,500**	**$200,242,500**	**$400,485,000**

Source: HAZUS-MH 2.0

Notes: RV = Replacement Cost Value. The building values shown are building structure only because damage from the severe winter storm hazard generally impact structures such as the roof and building frame (rather than building content). The valuation of general building stock and the loss estimates determined in Delaware County were based on the default general building stock database provided in HAZUS-MH 2.0.

A specific area that is vulnerable to the severe winter storm hazard is the floodplain. At risk general building stock and infrastructure in floodplains are presented in the flood hazard profile (Section 5.4.3). Generally, losses from flooding associated with severe winter storms should be less than that associated with a 100-year or 500-year flood. In summary, snow and ice melt can cause both riverine and urban flooding. Estimated losses due to riverine flooding in Delaware County are discussed in Section 5.4.3.

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. Because power interruption can occur, backup power is recommended for critical facilities and infrastructure. 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 infrastructure to clear roadways, alert citizens to dangerous conditions, and following the winter requires resources for road maintenance and repair. Additionally, freezing rain and ice storms impact utilities (i.e., power lines and overhead utility wires) causing power outages for hundreds to thousands of residents.

Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. However, because severe winter storms are a regular occurrence in this area, Delaware County is generally well-prepared for snow and ice removal each season.

According to the Delaware County Department of Public Works, the 2012 budget for total road snow removal in the county is more than $1.8 Million (DC DPW, 2012). It is clear that the County is prepared for the severe winter storm hazard; however it is costly.

Future Growth and Development

As discussed and illustrated in Section 4, 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. For the severe winter storm hazard, the entire County has been identified as the hazard area. Please refer to Section 4 (County Profile) for a map that illustrates where potential new development is located.

Effect of Climate Change on Vulnerability

The potential effects of climate change on Delaware County's vulnerability to winter storms shall need to be considered as a greater understanding of regional climate change impacts develop.

Additional Data and Next Steps

The assessment above identifies vulnerable populations and economic losses associated with this hazard of concern. Historic data on structural losses to general building stock are not adequate to predict specific losses to this inventory; therefore, the percent of damage assumption methodology was applied. This methodology is based on FEMA's How to Series (FEMA 386-2), Understanding Your Risks, Identifying and Estimating Losses (FEMA, 2001) and FEMA's Using HAZUS-MH for Risk Assessment (FEMA 433) (FEMA, 2004). The collection of additional/actual valuation data for general building stock and critical infrastructure losses would further support future estimates of potential exposure and damage for the general building stock inventory.

Overall Vulnerability Assessment

Severe winter storms are common in the study area, often causing impacts and losses to the County and local roads, structures, facilities, utilities, and population. The overall hazard ranking determined for this HMP for the severe winter storm hazard is 'High', with a 'Frequent' probability of occurrence (hazard event is likely to occur within 25 years) (see Tables 5.3-3 through 5.3-6 in Section 5.3).

Existing and future mitigation efforts should continue to be developed and employed that will enable the study area to be prepared for these events when they occur. The cascade effects of severe winter storm events include utility losses and transportation accidents and flooding. Losses associated with the flood hazard are discussed in Section 5.4.3. Particular areas of vulnerability include low-income and elderly populations, mobile homes, and infrastructure such as roadways and utilities that can be damaged by such storms and the low-lying areas that can be impacted by flooding related to rapid snow melt.