5.4.4 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 appropriate by Cayuga 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).

Lake Effect Snow: Lake Effect Snow (LES) is named for the result of air above the relatively warm waters of the Great Lakes interacting with a movement of cold air, which can lead to weather events unique to the region during the late fall and winter. The cold air passing over the open waters of the Great Lakes transfers warmth and moisture to the lowest portion of the atmosphere, which then rises to the overriding cold air above. This layer of trapped moisture ultimately turns to cloudiness and snow on the leeward side of the region (Smith, 2012). On a more limited basis, the two largest Finger Lakes can also produce lake effect snowfalls.

LES often occurs in bands of intense snowfall and limited visibility; though any one LED event can be characterized by an extreme variability of weather conditions in short intervals of time and space. For instance, clear skies could turn to a snow squall in a given location within minutes, while a location nearby might not experience any snow at all (Smith, 2012).

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, 2008).

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)], 1998-2007). 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 much of Cayuga 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 5.4.4- 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 5.4.4- 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 × 10^3 square miles—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 × 10^3 square miles 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).

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 U.S. The RSI ranks snowstorm impacts on a scale from one to five, which is similar to the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes. The RSI differs from the NESIS because it includes population. RSI is based on the spatial extent of the storm, the amount of snowfall, and the combination of the extent and snowfall totals with population (based on the 2000 Census) (NOAA-NCDC, 2011). Table 5.4.4-2 explains the five categories:

Table 5.4.4-2. 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+

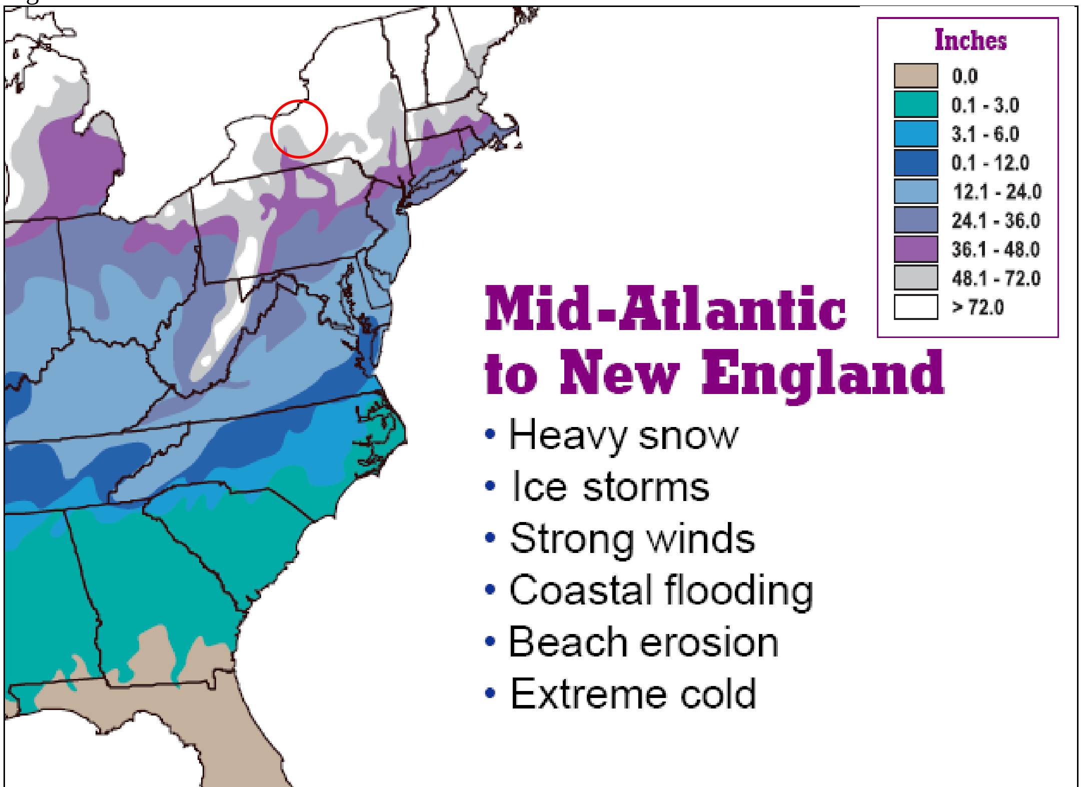
Source: NOAA-NCDC, 2011 (http://www.ncdc.noaa.gov/snow-and-ice/rsi/)

The indices for RSI are calculated similar to those for NESIS; however, the new indices require region-specific parameters and thresholds for the calculations. The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCDC, 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^{o} 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], 2011). 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 Cayuga County (Figure 5.4.4-1). The general indication of the average annual snowfall map shows areas that are subject to a consistent risk for large quantities of snow (Draft NYS HMP, 2011).

Figure 5.4.4-1 Annual Mean Snowfall within the Eastern U.S.

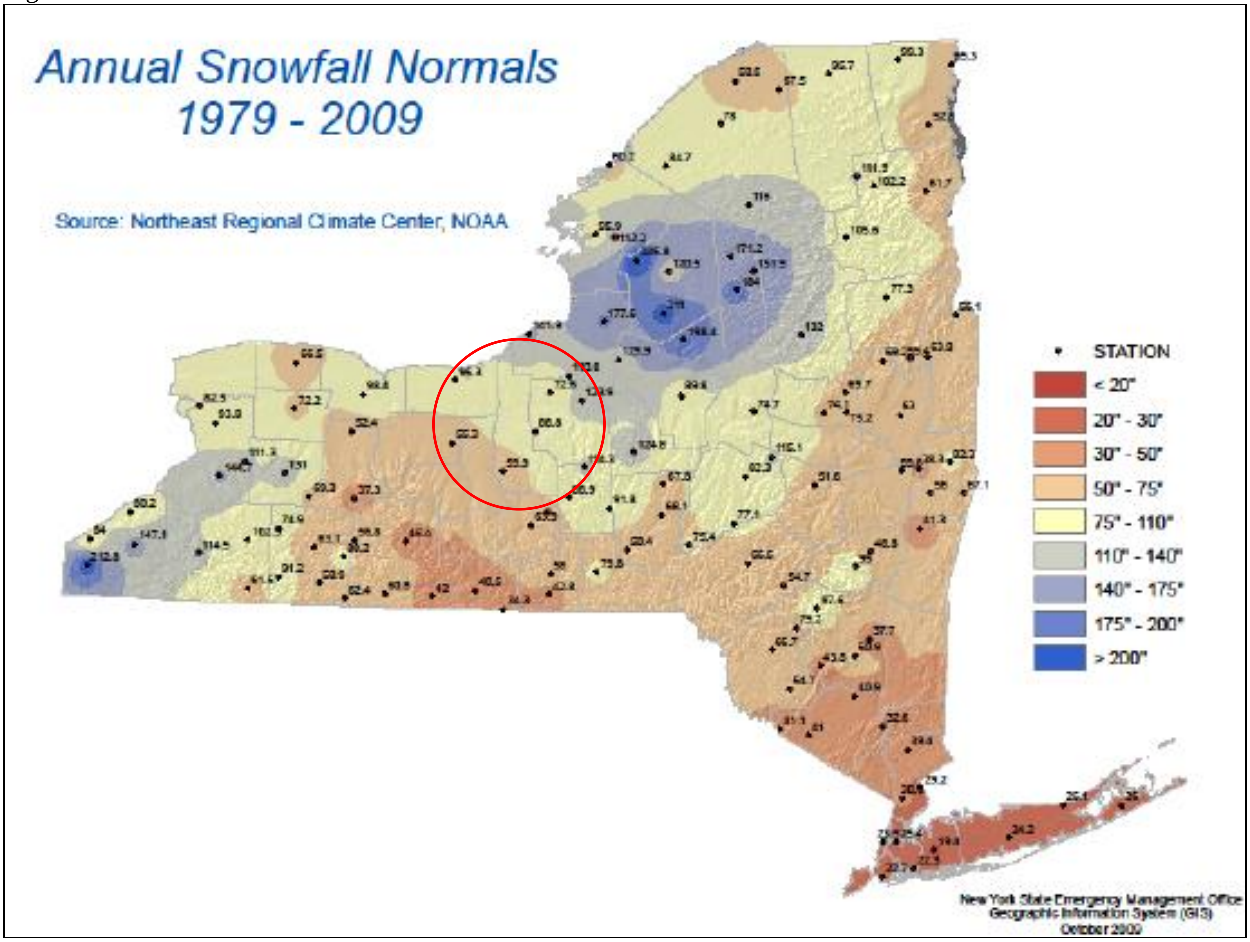


Source: NWS, 2001

Note: The circle indicates the approximate location of Cayuga County. Cayuga County receives an average of over 72 inches of snow annually.

Figure 5.4.4-2, 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, with the northernmost part of Cayuga County abutting Lake Ontario receiving the highest levels of snowfall annually (Draft NYS HMP, 2011).

Figure 5.4.4-2 Annual Snowfall Normals for New York State

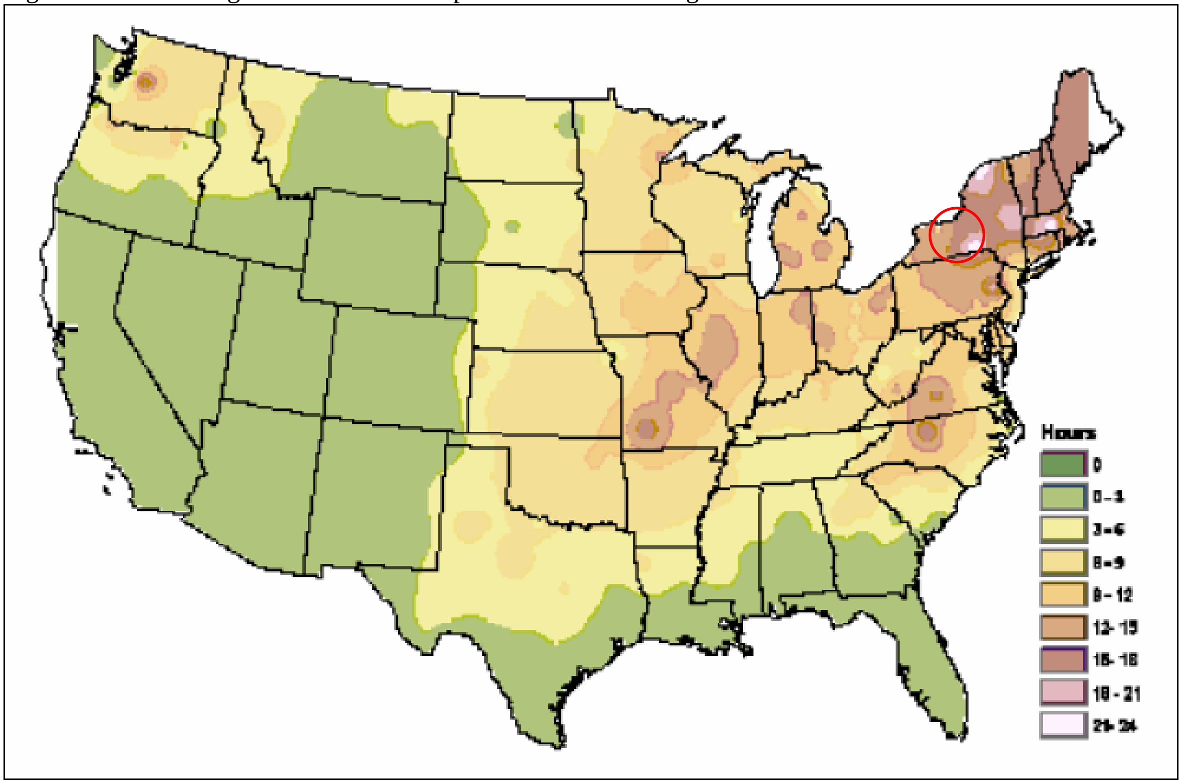


Source: Draft NYS HMP, 2011

Note: Cayuga County is indicated by a red circle with an average annual snow accumulation of 50 to 110-inches.

Figure 5.4.4-3 illustrates the average number of hours per year with freezing rain in the U.S. According to the figure, Cayuga County experiences between 15 to 21 hours per year (Draft NYS HMP, 2011).

Figure 5.4.4-3 Average Number of Hours per Year with Freezing Rain in the United States



Source: Draft NYS HMP, 2011

Note: Cayuga County is indicated by a red circle with an average number of 15 to 21 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 Cayuga 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 5.4.4-3 and Table 5.4.4- 4 summarize Cayuga County's rating for both hazards.

Table 5.4.4-3 Cayuga 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)
11	81.6	no	2	111.7	26,291

Source: Draft NYS HMP, 2011

Table 5.4.4- 4 Cayuga County's Vulnerability Rating for Ice Storms.

County Rating Score	Related Disasters	Total # of Structures (HAZUS)
6	1	26,291

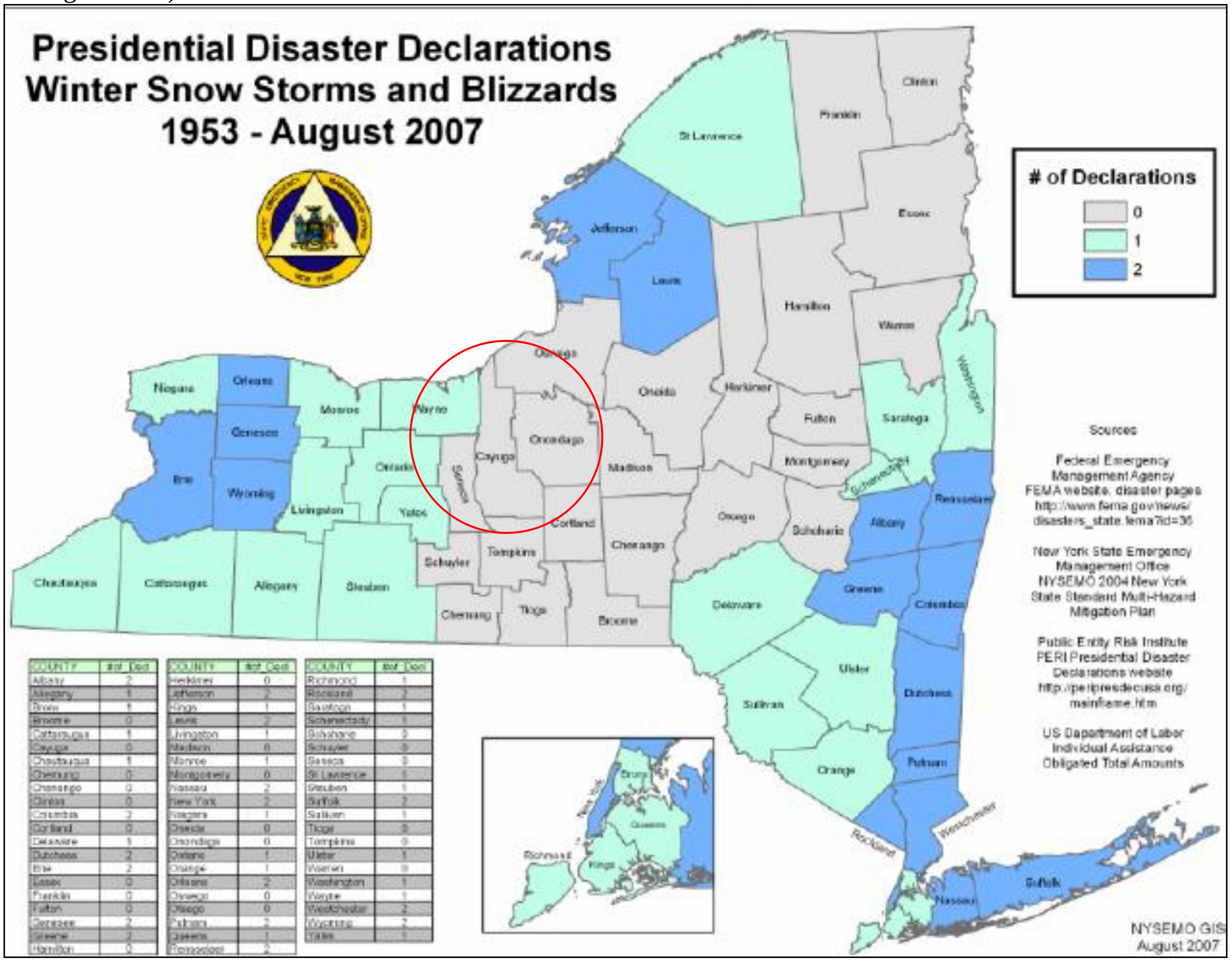
Source: Draft NYS HMP, 2011

According to NOAA's NCDC storm events database, Cayuga County experienced approximately 100 snow and ice storm events between 1950 and 2012. Total property damages, as a result of these winter storm events, were estimated at $48 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 2010, 289 winter storm events occurred within Cayuga County. The database indicated that severe winter storm events and losses specifically associated with Cayuga County and its municipalities totaled over $17.2 million in property damage and over $960,000 in crop 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 Cayuga County has been declared as a disaster area as a result of two winter storm-related events (FEMA, 2012).

Figure 5.4.4-4 shows the FEMA disaster declarations (DR) for "winter storms" and "blizzards" in New York State, from 1953 to August 2007. This figure indicates that Cayuga County has not been included in any disaster declarations. Since the date of this figure, Cayuga County has not been included in any other FEMA disaster declaration. Figure 5.4.4-5 shows the FEMA disaster declarations (DR) for ice storms in New York State, from 1983 and August 2007. This figure indicates that Cayuga County has been included in one ice storm disaster declaration. Since the date of this figure, Cayuga County has not been included in any other disaster declarations for ice storms.

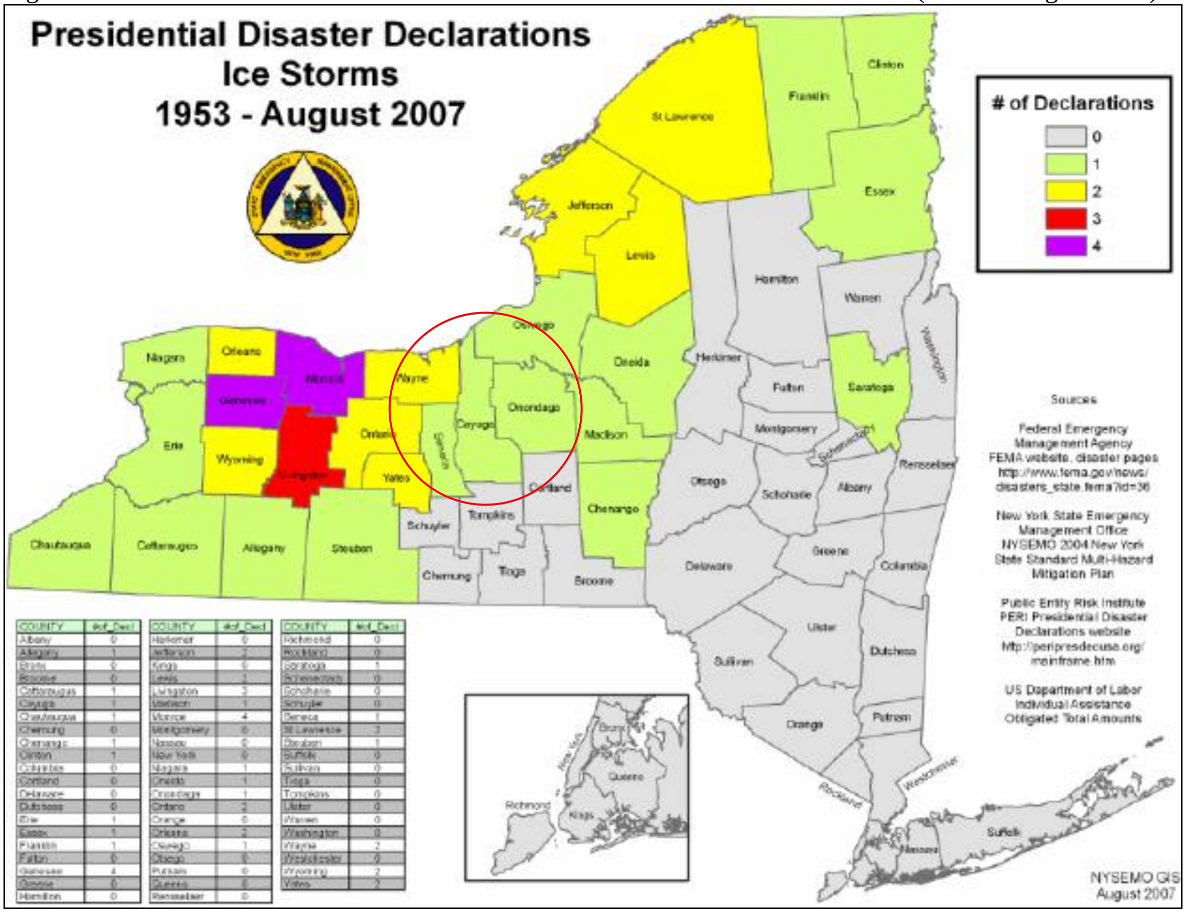
Figure 5.4.4-4 Presidential Disaster Declarations in New York State from Winter Snow Storms and Blizzards (1953 to August 2007)



Source: Draft NYS HMP, 2011

Note: The red circle indicates the approximate location of Cayuga County. Cayuga County has not been included any winter storm/blizzard disaster declarations in New York State.

Figure 5.4.4-5 Presidential Disaster Declarations in New York State from Ice Storms (1953 to August 2007)



Source: Draft NYS HMP, 2011

Note: The red circle indicates the approximate location of Cayuga County. Cayuga County has been included in one ice storm disaster declarations in New York State.

Based on all sources researched, known winter storm events that have affected Cayuga County and its municipalities are identified in Table 5.4.4-5. With winter storm documentation for New York State being so extensive, not all sources have been identified or researched. Therefore, Table 5.4.4-5 may not include all events that have occurred throughout Cayuga County and the region.

Table 5.4.4-5 Winter Storm Events Between 1950 and 2012.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
January 28 - February 1, 1977	Winter Weather	N/A	N/A	Cayuga County had over $2 M in damages due to a blizzard.	SHELDUS
February 27 - 29, 1984	Winter Weather	N/A	N/A	Cayuga County had over $150 K in damages due to snow.	SHELDUS
January 25, 1986	Winter Weather	N/A	N/A	Cayuga County had approximately $2 M in damages and one fatality due to a blizzard.	SHELDUS
March 13, 1993	Blizzard (“Storm of the Century”)	EM-3107	No	An intense storm tracked from the western Gulf of Mexico to the Florida panhandle and up the eastern seaboard to Massachusetts. Snowfall amounts from the event ranged to over 40 inches in New York State. Winds of up to 70 mph were common across the affected area, with snow drifts of up to 20 feet high. No specific snowfall amounts were available for Cayuga County. The storm caused nearly 300 deaths. Cayuga County had approximately $5 M in damages.	NOAA-NCDC
March 3, 1994	Heavy Snow	N/A	N/A	Low pressure off the New Jersey coast brought heavy snow to the Central Southern Tier Counties and Eastern Finger Lakes Region. The heaviest snowfall extended east of a line from Elmira to Ithaca to Syracuse. Specific snowfall reports ranged from 18 to 33 inches. No specific snowfall amounts were available for Cayuga County. Cayuga County had approximately $500,000 in damage.	NOAA-NCDC
January 6 - 8, 1999	Winter Weather, Heavy Snow / Winter Storm	N/A	N/A	Low pressure moving northeast across the region brought heavy snow and zero visibilities to the region. Numerous automobile accidents, several with injuries, were blamed on the heavy snow and reduced visibilities. It was the fourth significant lake effect event in two weeks. Snowfall amounts included 10 inches in southwest Oswego and 7 inches in the village of Fair Haven in Cayuga County and Mannsville in Jefferson County. Cayuga County had approximately $135K in damages.	SHELDUS, NOAA-NCDC
March 4 - 6, 1999	Winter Weather	N/A	N/A	Cayuga County had nearly $400 K in damages due to heavy snow over two days. One inch of snowfall was recorded at the Aurora Research Farm on March 6.	SHELDUS, NWS

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
November 20, 2000	Winter Weather	N/A	N/A	Cold air crossing the warm waters of Lakes Erie and Ontario resulted in lake effect squalls that dropped over two feet of snow downwind of the lakes. The storm moved northwest and then north late on the 22nd, and brought several inches of fluffy snow to the south shore of Lake Ontario. No specific snowfall amounts were available for Cayuga County. Cayuga County had approximately $3.3 M in damages due to heavy snow.	SHELDUS, NOAA-NCDC
March 4 - 5, 2001	Winter Weather	N/A	N/A	A storm developing from a complex low pressure system brought significant snowfall to western and central New York, as well as other parts of the Northeast U.S.. The snow in western New York came in two phases from Sunday night to early Monday morning (4th-5th) and again Monday night to Tuesday morning (5th-6th). In Cayuga County, 11 inches of snow was recorded in the Village of Aurora at the Musgrave Research Farm on March 5. Cayuga County had approximately $125 K in damages.	SHELDUS, NWS
January 30-31, 2002	Heavy Snow / Winter Weather	N/A	N/A	Three to five inches of snow fell overnight between the 30th and 31st, and turned to freezing rain during the morning hours. Ice accumulations of one-half to three-quarters of an inch occurred. Hundreds of thousands were left without power for up to 72 hours as the heavy ice build-up downed trees and power lines. Winds gusts were reported up to 55 mph. Trees and tree limbs fell blocking roads and damaging homes and automobiles. East of Lake Ontario snowfall amounts of six to eight inches were followed by one-quarter to one-half inch of ice. Cayuga County had approximately $900 K in damages.	NOAA-NCDC, SHELDUS
December 25, 2002	Heavy Snow / Winter Weather	EM-3173	No	A strong winter storm produced significant snowfall across parts of central New York State and northeast Pennsylvania. Eight to 12 inches of snow covered the area, with higher amounts generally over the Finger Lakes Region.	FEMA, NOAA-NCDC, SHELDUS, NWS
January 2-4, 2003				A strong storm system moved up the east coast and produced significant snowfall across central New York State. The weight of the snow combined with the weight of ice from the New Year's day storm caused additional power	

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
				outages. In Cayuga County, snowfall totals ranged from 8.6 inches to 12.1 inches in the City of Auburn to 14 inches in the Town of Locke. Cayuga County had over $6 million in property damage.	
February 17 - 18, 2003	Heavy Snow / Winter Weather	N/A	N/A	Snow spread into the southern Catskills of New York during the evening of the 16th. In Cayuga County, snowfall totals ranged from 5.2 inches in the City of Auburn to 11 inches in the Town of Locke. Accidents were fewer due to the Presidents Day holiday and due to the early start of the snow. Cayuga County had approximately $2.6 M in damages.	NOAA-NCDC, SHELDUS, NWS
April 3 - 5, 2003	Ice Storm, Winter Weather	DR-1467	Yes	A stationary front moved west to east across Pennsylvania during the 3rd and 4th of April, bringing precipitation to upstate New York. During the evening of the 4th, colder air brought freezing rain into the Finger Lakes and northern Susquehanna Region, especially at the higher elevations. Some of the freezing rain changed to snow, which accumulated up to five inches in some counties. Tens of thousands of electricity customers throughout the state were without power, some for up to a week. States of emergencies were declared for many counties, and a federal disaster was declared in Cayuga and other counties nearby. Cayuga County had up to $28.5 M in property damage and over $955 K in crop damage. This event caused three deaths in Cayuga County	FEMA, SHELDUS, NOAA-NCDC, County Input
December 14 - 15, 2003	Heavy Snow	N/A	N/A	This was a widespread event that brought between eight and 12 inches of snow across south-central New York State. Across central New York State, sleet and freezing rain mixed in with snow which lowered the total snowfall amounts. The snow caused numerous automobile accidents and many schools were closed. Cayuga County had over $500 K in property damage.	NOAA-NCDC
January 28 - 31, 2004	Snow	EM-3195	Yes	A band of storms drifted north into southern Lewis and extreme southern Jefferson Counties before moving back south across Monroe, Wayne, and northern Cayuga Counties on the 31st. The weight of the snow caused buildings to collapse. Because of the heavy lake effect	FEMA, NOAA-NCDC, NWS

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
				snow events throughout January, Oswego, Jefferson and Cayuga Counties were declared disaster areas. In Cayuga County, snowfall totals ranged from 4.7 inches in the City of Auburn to 9 inches in the Town of Locke. Cayuga County had approximately $450 K in property damage.	
February 3, 2004	Heavy Snow	N/A	N/A	Heavy snow caused numerous accidents during the afternoon and evening of February 4th. Snowfall totals in Cayuga County ranged from 3.7 inches in Auburn to 4 inches in Locke. Cayuga County had approximately $170 K in damages.	NOAA-NCDC, NWS
March 16 - 17, 2004	Heavy Snow	N/A	N/A	Snow began to fall during the morning on the 16th and was heaviest from late morning into the afternoon. The covered roadways disrupted commuters on their way home from work. In Cayuga County, snowfall totals ranged from 9 inches in Locke to 11.6 inches in Auburn. Cayuga County had approximately $340 K in property damage.	NOAA-NCDC, NWS, SHELDUS
January 22 - 23, 2005	Heavy Snow	N/A	N/A	A major winter storm moved east from the Ohio Valley to the mid-Atlantic coast, which then moved northeast up the coast. This event brought widespread snow between the 22nd and 23rd. Snowfall accumulation, combined with cold temperatures, caused major travel problems. In Cayuga County, over the two day period, snowfall totals included: 14.2 inches in Auburn, 12 inches in the Village of Fair Haven, 11 inches in the Village of Cayuga, and 7 inches in the Town of Locke. Cayuga County had approximately $480 K in property damages.	NOAA-NCDC, NWS
February 28 - March 1, 2005	Heavy Snow	N/A	N/A	A strong winter storm brought eight to 14 inches of snow to central New York State. The snow moved in from the south starting in the afternoon and early evening on February 28th. The snow continued through the night, heavy at times, before tapering off to light snow and flurries late in the morning on March 1st. In Cayuga County, snowfall totals for this event ranged from 7 inches at the Town of Cato and Village of Meridian border to 9 inches in the City of Auburn. Cayuga County had $360 K in property damage.	NOAA-NCDC, NWS

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
February 5 - 7, 2006	Heavy Snow	N/A	N/A	A cold front swept across the area causing lake effect snow to develop. Snowfall totals in the affected areas ranged from six to 33 inches. Cayuga County experienced approximately $120 K in property damage.	NOAA-NCDC
April 15-16, 2007	Severe Storms and Inland and Coastal Flood (also identified as a Nor'Easter)	DR-1692	No	A series of severe storms produced millions in damage across New York State, mostly due to flooding. FEMA gave out more than $61 million in assistance to affected counties within the State. In the Finger Lakes region, the storm produced unusually late season snow with total accumulations between 1 and 2 feet across much of the region. The snow was heavy and wet bringing down many trees and power lines causing scattered power outages. Snowfall totals of 4 inches on the 16th and 8 inches on the 17th were reported in the Village of Cayuga in Cayuga County. Cayuga County had an estimated $8K in damage.	NOAA-NCDC, NWS
December 3-5, 2007	Lake Effect Snow	N/A	N/A	A lake effect storm brought snow across central New York. In Cayuga County, 12 inches of snowfall was reported in the Village of Cayuga on the 4th and 9 inches fell between the 4th and 5th in the Town of Locke.	NOAA-NCDC, NWS
January 19-20, 2008	Lake Effect Snow	N/A	N/A	Lake effect snows developed off Lake Ontario, and fell from Saturday evening through Monday morning over western Oswego and Cayuga counties. Specific storm totals included 36 inches at the Village of Fair Haven in Cayuga County. Cayuga County reported $10k in damage.	NOAA-NCDC
February 26-28, 2008	Winter Storm	N/A	N/A	A low pressure system developed over the Central Plains and brought heavy snow accumulations to much of central New York. Snowfall amounts across Cayuga County ranged from 4 to 10 inches, including 5 inches in the Town of Locke on the 27th and 3 inches on the 28th.	NOAA-NCDC, NWS
November 18-19, 2008	Lake Effect Snow	N/A	N/A	Cold fronts off Lake Ontario brought up to a foot of snow over Cayuga County. Total snowfall ranged from 14 inches in the Village of Fair Haven to 2 inches in the Village of Aurora and 5.5 inches in the Town of Locke. Cayuga County had approximately $15K in property damage.	NOAA-NCDC, NWS
December 30-31, 2008	Winter Storm	N/A	N/A	Steady snowfall in the region deposited eight to fourteen inches of snow over the course of an eight hour storm. The	NOAA-NCDC, NWS

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
				strong winds produced areas of blowing and drifting snow resulting in significantly reduced visibilities. Snowfall reports for Cayuga County included 10 inches on the 31st in the Village of Aurora and 5 inches in the Town of Locke. Cayuga County had approximately $10K in property damage.	
January 27-28, 2009	Winter Storm	N/A	N/A	A winter storm brought snowfall amounts of 6 to 10 inches to the northern parts of Cayuga County, including 6 inches in the Village of Aurora and 6.5 inches in the Town of Locke.	NOAA-NCDC, NWS
February 19-20, 2009	Lake Effect Snow	N/A	N/A	Lake effect snowfall totals topped 1.5 feet in parts of northern Cayuga County. Specific snowfall amounts included 18 inches at the Village of Fair Haven and 1.5 inches in the Town of Locke. Cayuga County had approximately $10K in property damage.	NOAA-NCDC, NWS
December 4-8, 2010	Lake Effect Snow	N/A	N/A	A lake effect snow storm dropped between 1 and 2 feet of snow at locations across central New York, and brought heavy snow to much of Cayuga County. At the Binghamton Regional Airport, 21.7 inches of snow fell, which was the most snow from a lake effect snowstorm on record. Over a four day period, snowfall amounts ranged from over one foot to around 20 inches. The City of Auburn measured 20.3 inches, the Village of Cayuga recorded 16 inches, and the Town of Locke measured 13.3 inches.	NOAA-NCDC, NWS
December 14-16, 2010	Lake Effect Snow	N/A	N/A	A flow of very cold air coming across Lake Ontario produced another round of heavy lake effect snow through central New York, producing snowfalls ranging from 1 to 2 feet. Snowfall totals in the hardest hit areas of northern Cayuga County ranged from 8 to 18 inches. Over the two-day period, 6.6 inches of snow fell in the City of Auburn, and 10 inches in the Village of Cayuga.	NOAA-NCDC, NWS
January 5-6, 2011	Lake Effect Snow	N/A	N/A	Cold air moved west across the St. Lawrence Valley and brought heavy snowfall over northern and central New York. Specific snowfall totals included 1.6 inches in the City of Auburn, 1.5 inches in the Village of Cayuga, and 1.3 inches in the Town of Locke. Cayuga County had approximately $15K in damage.	NOAA-NCDC, NWS
January 21-22, 2011	Lake Effect Snow	N/A	N/A	This lake effect storm gave most of western and central New York several inches of snow overnight on the 20th-21st. Specific snowfall totals from the storm in Cayuga County included 5 inches in the Town of Locke, 3 inches in	NOAA-NCDC, NWS

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
				the Village of Cayuga, and 2.9 inches in the City of Auburn. Cayuga County had approximately $15K in damages.	
February 25, 2011	Winter Storm	N/A	N/A	Cold air moving east through Pennsylvania early on the 25th brought widespread snow to central New York throughout the day. Snowfall totals across Cayuga County ranged from 5 inches in the southern part of Cayuga County to nearly 11 inches in the north. From the 25th to the 26th, 6.1 inches fell in the City of Auburn, 6.5 inches in the Village of Cayuga, and 5.8 inches in the Town of Locke. Cayuga County had approximately $10K in damages.	NOAA-NCDC, NWS
March 6-7, 2011	Heavy Snow	N/A	N/A	A band of heavy snow developed during the evening hours of March 6th and remained over central New York and northeast Pennsylvania into the morning of March 7th. Snowfall totals across Cayuga County ranged generally from 13 inches in western parts of Cayuga County to nearly 22 inches in southern areas. Specific snowfall amounts include 11.2 inches in the City of Auburn, 8 inches in the Village of Cayuga, and 8 inches in the Town of Locke.	NOAA-NCDC, NWS

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	N/A	Not Applicable
EM	Emergency Declaration	NCDC	National Climatic Data Center
FEMA	Federal Emergency Management Agency	NOAA	National Oceanic and Atmospheric Administration
K	Thousand ($)	NWS	National Weather Service
M	Million ($)	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 (Draft 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 (Draft NYS HMP, 2011).

It is estimated that Cayuga County will continue to experience direct and indirect impacts of severe winter storms annually. Table 5.4.4-6 summarizes the occurrences of winter storm events and their annual occurrence (on average).

Table 5.4.4-6 Occurrences of Severe Winter Storm Events in Cayuga County, 1950 - 2012

Event Type	Total Number of Occurrences	Annual Number of Events (average)
Blizzard	1	0.02
Winter Storm	18	0.35
Heavy Snow/Snow Squall	62	1.19
Winter Weather	1	0.02
Lake Effect Snow	9	0.17
Ice Storm	6	0.12
(Other) Snow	3	0.06
Total:	**100**	**1.92**

Source: NOAA-NCDC, 2012

In Section 5.3, the identified hazards of concern for Cayuga 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 Cayuga County is considered 'Frequent' (likely to occur within 25 years, as presented in Table 5.3-3).

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. Cayuga County is part of Region 1, Western New York Great Lakes Plain. Some of the issues in this region, affected by climate change, include: agricultural revenue highest in the state; relatively low rainfall and increased summer drought risk; high value crops could need irrigation; and improved conditions for grapes projected (NYSERDA, 2011).

Temperatures are expected to increase throughout the state, and in the Western New York Great Lakes Plain region are expected to increase by 3.0 to 5.5ºF by the 2050s and 4.5 to 8.5ºF 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 5.4.4-7 displays the projected seasonal precipitation change for the Western New York Great Lakes Plain ClimAID Region (NYSERDA, 2011).

Table 5.4.4-7 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

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, including parts of southern Cayuga County, 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, including most of central and northern Cayuga County, 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 several decades ago. Nighttime temperatures are measurably warmer, even during the colder months (NYSDEC, Date Unknown), and 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).

Tree Vulnerability

Ice storms cause considerable damage every year to trees in urban and natural areas within the U.S. Ice storms vary in their severity and frequency and are one of the most devastating winter weather events. Within the eastern deciduous forests in North America, ice storms are among the most frequent forest disturbances. Ice storms result in the accumulation of freezing rain on surfaces such as tree branches and electrical wires. Accumulations of ice can increase the branch weight of trees by a factor of 10 to 100 times. Ice accumulations on stems generally range from a trace to one inch in diameter, and in extreme cases, up to eight inches of ice encasing the stem. The severity of damage increases with greater accumulations of ice. Accumulations between ¼- and ½- inch can cause small branches and weak limbs to break, whereas ½- to one- inch or greater accumulations can cause larger branches to break, resulting in extensive tree damage. Branch failures occur when loading from the weight of ice exceeds wood resistance to failure or when constant loading further stresses a weakened area in a branch. Ice accumulations, combined with strong winds, substantially increase the potential for damage. Residual damage from ice storms can occur several months to years later when wood of branches and trucks weakened by ice loading fails (Hauer et al, 2006).

Monetary losses to forests, individual trees, utility poles, agriculture, commerce, and property can be extensive after an ice storm. Between 1949 and 2000, insured property losses from freezing rain were $16.3 billion. Actual losses are even greater as this total excludes non-insured losses (Hauer et al, 2006).

The damage to trees from ice storms depends on several factors: amount and duration of accumulated ice, exposure to wind, and duration of the storm event. An increased susceptibility of tree species to ice storms involves tree characteristics: weak branch junctures indicated by included bark, decaying or dead branches, tree height and diameter, increased surface area of lateral branches, broad crowns, unbalanced crowns, restricted and unbalanced root systems, and shallow rooting habit. Included bark results from in-grown bark in branch junctures. This weak connection enhances a tree's susceptibility to breakage under ice loading. Decaying or dead branches already are weakened and have a greater probability of breaking when loaded with ice. Decay, in combination with included bark, further increases a tree's susceptibility to ice events (Hauer et al, 2006).

The location of a tree within a stand often influences its susceptibility to ice storms. Edge trees tend to have large, unbalanced crowns with longer, lower, and more branches on the open side. Interior trees, the crowns of which much compete for light, have small crowns with shorter main branches and fewer limbs and typically show less damage than edge trees. Edge trees will accumulate more ice on the open side, which can result in major branch failure, crown breakage, and uprooting. Trees on slopes tend to have greater damage because of imbalances in the crowns and roots. Vine growth on forest trees can increase susceptibility to ice storm damage by increases the surface area that accumulates ice. Tree species that have a shallow root system are more prone to tipping during ice storms (Hauer et al, 2006).

Trees also have characteristics that make them resistant to damages from ice storms. Trees that have conical branching patterns, strong branch attachments, flexible branches and low surface area of lateral branches are generally resistant to ice storms. A tree's seed source also influences ice storm resistance. Seed source variation in ice tolerance is due to natural selection, according to climate influences, of trees comprising populations and species. Tree species indigenous to areas subject to ice storms appear to have a greater resistance than those not from such areas. Table 5.4.4-8 shows the susceptibility of certain tree species during ice storms. According to Cayuga County, box elder and silver maple are typically the species damaged during ice events. The table indicates that red maple is susceptible to storms and the box elder has an intermediate susceptibility (Hauer et al, 2006).

Table 5.4.4-8 Ice Storm Susceptibility of Tree Species

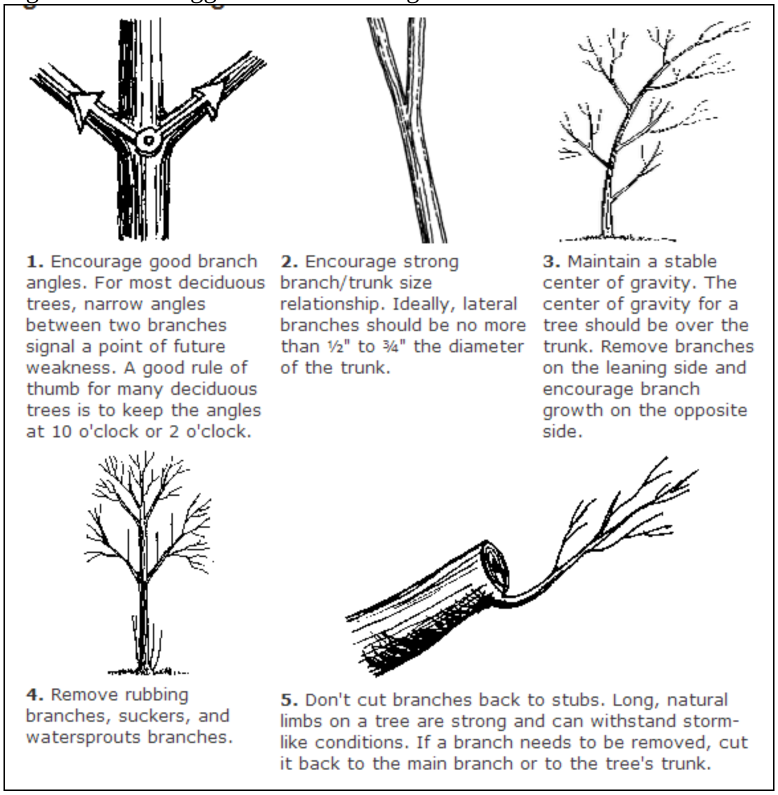
Susceptible	Intermediate	Resistant
American basswood	American beech	Amur maple
American elm	Box elder	Baldcypress
Bigtooth aspen	Chestnut oak	Balsam fir
Black ash	Choke cherry	Bitternut hickory
Black cherry	Douglas fir	Black walnut
Black locust	Eastern white pine	Blackgum
Bradford pear	Gray birch	Blue beech
Butternut	Green ash	Bur oak
Common hackberry	Japanese larch	Catalpa
Eastern cottonwood	Loblolly pine	Colorado blue spruce
Honey locust	Northern red oak	Crabapple
Jack pine	Paper birch	Eastern hemlock
Pin cherry	Pin oak	Eastern red cedar
Pitch pine	Red maple	European larch

Susceptible	Intermediate	Resistant
Quacking aspen	Red pine	Ginkgo
Red elm	Scarlet oak	Hophornbeam
River birch	Scotch pine	Horsechestnut
Siberian elm	Slash pine	Kentucky coffeetree
Silver maple	Sourwood	Littleleaf linden
Virginia pine	Sugar maple	Mountain ash
Willow	Sycamore	Northern white cedar
	Tamarack	Norway maple
	Tulip poplar	Norway spruce
	White ash	Ohio buckeye
	Yellow birch	Pignut hickory
		Shagbark hickory
		Swamp white oak
		Sweetgum
		White oak
		White spruce
		Witch hazel
		Yellow buckeye

Source: Hauer et al.
Note: For tree species not included in this table, resistance to ice accumulation can be estimated based on general tree characteristics.

Steps can be taken to manage and minimize ice storm damage to trees through tree selection, maintenance and recovery plans. It is a good idea to integrate ice storm and tree damage information into management plans and prepare in advance to mitigate and respond to storm damage. Selecting and planting tree species resistant to ice damage can reduce tree and property from ice events. Trees with a greater risk for failure, such as those with extensive decay and cavities in the trunk and major branches, should be removed promptly. Property tree placement and pruning on a regular cycle can reduce the potential for property damage and decrease a tree's susceptibility to ice damage. Trees located near homes and other structures should be evaluated for tree risk failure potential. Trees should not be planted where their growth may interfere with above-ground utilities (Hauer et al, 2006) (http://na.fs.fed.us/urban/inforesources/TreesIceStorms2ed.pdf). Figure 5.4.4-6 displays five suggestions for pruning a tree that will promote growth of strong branches.

Figure 5.4.4-6 Suggestions for Pruning Trees to Promote Growth of Strong Branches



Source: Minnesota Department of Natural Resources, 2013 (http://www.dnr.state.mn.us/treecare/maintenance/prevention.html)

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 Cayuga County (population, structures, critical facilities and lifelines), as described in Cayuga 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 Cayuga 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
- Effect of climate change on vulnerability
- Further data collections that will assist understanding of this hazard over time

Overview of Vulnerability

Severe winter storms are of significant concern to Cayuga 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 Cayuga County and the participating municipalities. The 2010 U.S. Census data and custom building inventory 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/weeks 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 Cayuga County (80,026 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 4-2 in Cayuga 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 5.4.4-9 summarizes the population over the age of 65 and individuals living below the Census poverty threshold.

Table 5.4.4-9 Cayuga County Population Statistics (2010 U.S. Census)

Municipality	2010 U.S. Census Population	HAZUS-MH Population (Census 2000)	HAZUS-MH Population Over 65 (Census 2000)	HAZUS-MH Population Below Poverty (Census 2000)*
Auburn (C)	27,687	28,574	5,128	3,862
Aurelius (T)	2,243	2,427	393	179
Aurora (V)	724	720	96	36
Brutus (T)	2,649	2,760	313	194
Cato (T)	2,020	2,166	227	145
Cato (V)	533	601	63	44
Cayuga (V)	549	509	84	39
Conquest (T)	1,819	1,925	167	111
Fair Haven (V)	703	884	150	74
Fleming (T)	2,636	2,647	423	153
Genoa (T)	1,935	1,914	243	107
Ira (T)	1,881	2,053	171	99
Ledyard (T)	1,158	1,112	139	38
Locke (T)	1,951	1,900	176	141
Mentz (T)	1,096	1,149	156	102
Meridian (V)	309	350	33	23
Montezuma (T	1,277	1,431	105	117
Moravia (T)	2,347	2,674	209	135
Moravia (V)	1,279	1,363	178	114

Municipality	2010 U.S. Census Population	HAZUS-MH Population (Census 2000)	HAZUS-MH Population Over 65 (Census 2000)	HAZUS-MH Population Below Poverty (Census 2000)*
Niles (T)	1,194	1,208	127	55
Owasco (T)	3,793	3,755	607	188
Port Byron (V)	1,282	1,297	193	117
Scipio (T)	1,713	1,537	166	95
Sempronius (T)	890	878	40	48
Sennett (T)	3,595	3,244	526	103
Springport (T)	1,176	1,202	148	73
Sterling (T)	2,337	2,548	295	199
Summerhill (T)	1,222	1,116	102	40
Throop (T)	1,990	1,824	273	77
Union Springs (V)	1,195	1,054	172	84
Venice (T)	1,368	1,286	140	68
Victory (T)	1,660	1,838	138	124
Weedsport (V)	1,815	2,017	261	125
Cayuga County	**80,026**	**81,963**	**11,642**	**7,109**

Source: HAZUS 2.1
Note: *Households with an income of less than $20,000

Impact on General Building Stock

The entire general building stock inventory in Cayuga 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 5.4.4-9 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 Cayuga 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 5.4.4-10 below summarizes percent damages that could result from severe winter storm conditions for Cayuga 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.

Table 5.4.4-10 General Building Stock Exposure (Structure Only) and Estimated Losses from Severe Winter Storm Events in Cayuga County

Municipality	Total (All Occupancies) RV	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Auburn (C)	$1,100,276,332	$11,002,763	$55,013,817	$110,027,633
Aurelius (T)	$134,125,275	$1,341,253	$6,706,264	$13,412,528
Aurora (V)	$47,018,098	$470,181	$2,350,905	$4,701,810
Brutus (T)	$86,375,939	$863,759	$4,318,797	$8,637,594
Cato (T)	$79,995,131	$799,951	$3,999,757	$7,999,513
Cato (V)	$15,985,164	$159,852	$799,258	$1,598,516
Cayuga (V)	$19,355,373	$193,554	$967,769	$1,935,537
Conquest (T)	$51,762,871	$517,629	$2,588,144	$5,176,287

Municipality	Total (All Occupancies) RV	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Fair Haven (V)	$50,655,432	$506,554	$2,532,772	$5,065,543
Fleming (T)	$145,054,479	$1,450,545	$7,252,724	$14,505,448
Genoa (T)	$97,772,321	$977,723	$4,888,616	$9,777,232
Ira (T)	$84,756,445	$847,564	$4,237,822	$8,475,644
Ledyard (T)	$75,499,466	$754,995	$3,774,973	$7,549,947
Locke (T)	$51,704,162	$517,042	$2,585,208	$5,170,416
Mentz (T)	$42,026,454	$420,265	$2,101,323	$4,202,645
Meridian (V)	$8,510,387	$85,104	$425,519	$851,039
Montezuma (T)	$32,245,260	$322,453	$1,612,263	$3,224,526
Moravia (T)	$81,617,008	$816,170	$4,080,850	$8,161,701
Moravia (V)	$63,302,852	$633,029	$3,165,143	$6,330,285
Niles (T)	$88,522,619	$885,226	$4,426,131	$8,852,262
Owasco (T)	$257,691,438	$2,576,914	$12,884,572	$25,769,144
Port Byron (V)	$43,185,772	$431,858	$2,159,289	$4,318,577
Scipio (T)	$70,839,247	$708,392	$3,541,962	$7,083,925
Sempronius (T)	$36,056,158	$360,562	$1,802,808	$3,605,616
Sennett (T)	$255,432,453	$2,554,325	$12,771,623	$25,543,245
Springport (T)	$66,000,942	$660,009	$3,300,047	$6,600,094
Sterling (T)	$70,728,520	$707,285	$3,536,426	$7,072,852
Summerhill (T)	$39,419,729	$394,197	$1,970,986	$3,941,973
Throop (T)	$77,080,272	$770,803	$3,854,014	$7,708,027
Union Springs (V)	$58,776,870	$587,769	$2,938,843	$5,877,687
Venice (T)	$55,882,599	$558,826	$2,794,130	$5,588,260
Victory (T)	$45,202,475	$452,025	$2,260,124	$4,520,247
Weedsport (V)	$74,889,699	$748,897	$3,744,485	$7,488,970
Cayuga County	**$3,507,747,242**	**$35,077,472**	**$175,387,362**	**$350,774,724**

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 Cayuga County were based on the default general building stock database provided in HAZUS-MH 2.1.

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 5.4.1). 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 Cayuga County are discussed in Section 5.4.1.

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, Cayuga County is generally well-prepared for snow and ice removal each season. The account total for snow removal in the City of Auburn is $322,962.

Future Growth and Development

As discussed in Sections 4 and 9, areas targeted for future growth and development have been identified across Cayuga County. Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire planning area is exposed and vulnerable. Please refer to the specific areas of development indicated in tabular form (subsection B) and/or on the hazard maps (subsection I) included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such winter storms. While predicting changes of winter storm events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2006).

The 2011 'Responding to Climate Change in New York State' report was prepared for New York State Energy Research and Development Authority to study the potential impacts of global climate change on New York State. According to the synthesis report, it is uncertain how climate change will influence extreme winter storm events. Winter temperatures are projected to continue to increase. In general, warmer winters may lead to a decrease in snow cover and an earlier arrival in spring; all of which have numerous cascading effects on the environment and economy. Annual average precipitation is also projected to increase. The increase in precipitation is likely to occur during the winter months as rain, with the possibility of slightly reduced precipitation projected for the late summer and early fall. Increased rain on snowpack may lead to increased flooding and related impacts on water quality, infrastructure, and agriculture in the State. Overall, it is anticipated that winter storms will continue to pass through New York State (NYSERDA, 2011). Future enhancements in climate modeling will provide an improved understanding of how the climate will change and impact the Northeast.

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.