



5.4.8 Severe Winter Storm

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

5.4.8.1 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 Monroe County, the severe winter storm hazard includes heavy snow (snowstorms), blizzards, sleet, freezing rain, and ice storms. According to the 2014 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 Snow and Ice Data Center, snow is precipitation in the form of ice crystals. It originates in clouds when temperatures are below the freezing point (32°F), when water vapor in the atmosphere condenses directly into ice without going through the liquid stage. Once an ice crystal has formed, it absorbs and freezes additional water vapor from the surrounding air, growing into snow crystals or snow pellets, which then fall to the earth. Snow falls in different forms: snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud. Snow pellets are opaque ice particles in the atmosphere. They form as ice crystals fall through super-cooled cloud droplets, which are below freezing but remain a liquid. The cloud droplets then freeze to the crystals. Sleet is made up of drops of rain that freeze into ice as they fall. They are usually smaller than 0.30 inch in diameter (NSIDC 2015).

Heavy snow accumulations can immobilize a region and paralyze a city, stranding commuters, stopping the flow of supplies, and disrupting emergency and medical services. Ice storms can be accompanied by high winds, and have similar impacts, especially to trees, power lines, and residential utility services. Because of its unique location at a climactic crossroads and distinctive geography, New York State experiences the full effect of all four seasons, and winter is no exception. Snowstorms are the most obvious manifestation of intense winter weather.

Blizzards

A blizzard is a winter snowstorm with sustained or frequent wind gusts of 35 miles per hour (mph) or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile. These conditions must be predominant over a 3-hour period to be considered a blizzard. Extremely cold temperatures are often associated with blizzard conditions, but are not a formal part of the definition. The hazard created by the combination of snow, wind, and low visibility significantly increases, however, with temperatures below 20°F. A severe blizzard is categorized as having temperatures near or below 10°F, winds exceeding 45 mph, and visibility reduced by snow to near zero. Storm systems powerful enough to cause blizzards usually form when the jet stream dips far to the south, allowing cold air from the north to clash with warm air from the south. Blizzard conditions often develop on the northwest side of an intense storm system. The difference between the lower pressure in the storm and the higher pressure to the west creates a tight pressure gradient, resulting in strong winds and extreme conditions caused by the blowing snow (The Weather Channel 2014).



Ice Storms

An ice storm is an event when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations are typically 1/4 inch or greater (NWS 2013). Heavy accumulations of ice can bring down trees, power lines, utility poles, and communication towers. Ice can disrupt communications and power for days. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians (NWS 2009).

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, time of occurrence during the day (e.g., weekday versus weekend), and time of season. The National Oceanic and Atmospheric Administration’s (NOAA) National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States.

The RSI ranks snowstorm impacts on a scale from 1 to 5, which is similar to the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes. The RSI differs from the Northeast Snowfall Impact Scale (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). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCDC Date Unknown). Table 5.4.8-1 explains the five categories:

Table 5.4.8-1. RSI Ranking Categories

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

Source: NOAA-NCDC, Date Unknown

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

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

The NWS uses winter weather watches, warnings and advisories to ensure that people know what to expect in the coming hours and days. A winter storm watch means that severe winter conditions (heavy snow, ice, etc.)



may affect a certain area, but its occurrence, location, and timing are uncertain. A watch is issued to provide 24 to 72 hours of notice of the possibility of severe winter weather. A watch is upgraded to a winter storm warning when hazardous winter weather, in the form of heavy snow, heavy freezing rain or heavy sleet, is imminent or occurring. They are usually issued 12 to 24 hours before the event is expected to begin. Winter weather advisories are issued when the hazardous winter weather event is occurring, is imminent, or has a greater than 80 percent chance of occurrences; advisories are used to inform people that winter weather conditions are expected to cause significant inconveniences, and that conditions may be hazardous. These conditions may refer to sleet, freezing rain, or ice storms, in addition to snow events. The NWS may also issue a blizzard warning when snow and strong winds combine and produce a blinding snow, deep drifts, and wind chill (NWS Date Unknown).

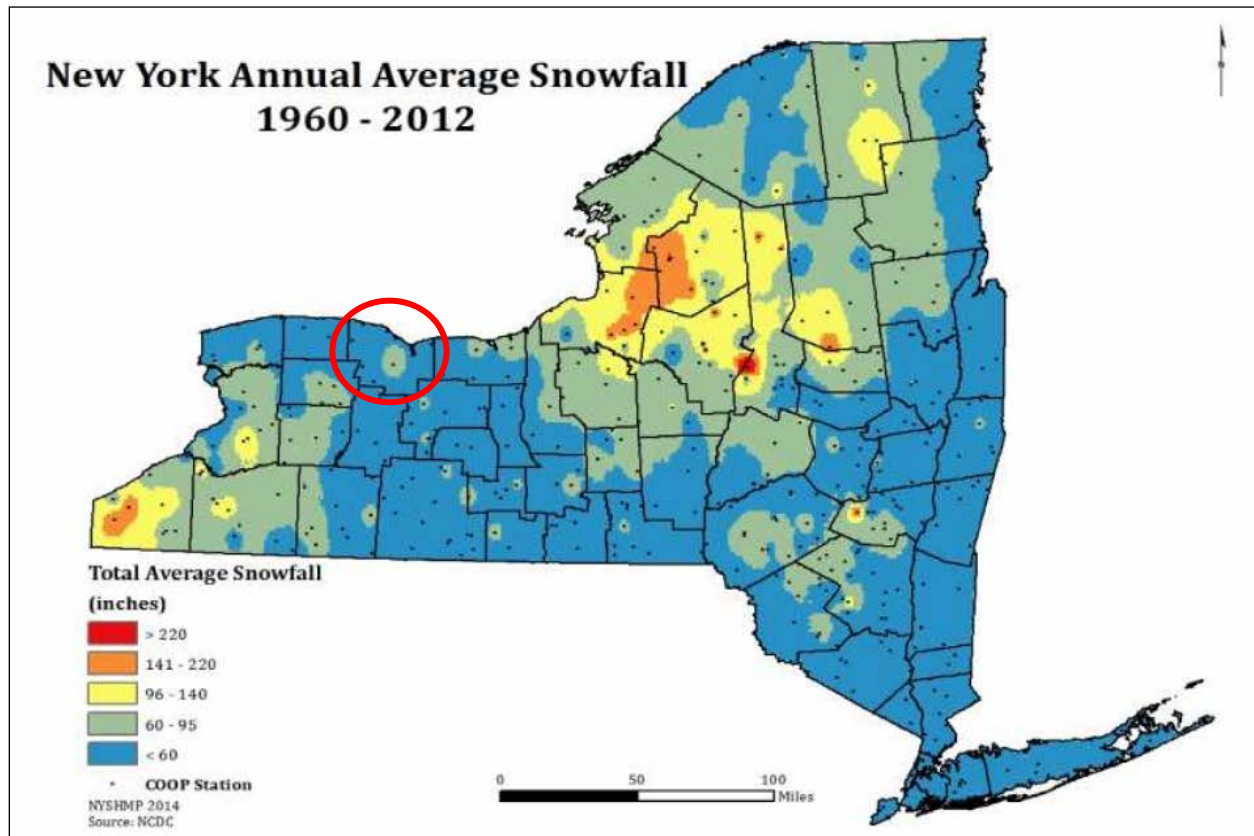
Location

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 2014 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 (NYS DHSES 2014). 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, with Monroe County's average over 72 inches annually. Albany, Syracuse, Buffalo and Rochester are typically in the top ten cities in the nation in annual snowfall (NYS DHSES 2014). According to the Northeast Regional Climate Center, average annual snowfall in Rochester is 93.4 inches (Northeast Regional Climate Center 2009).

Figure 5.4.8-1, an annual average snowfall map, illustrates the annual average snowfall totals over a 50-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 DHSES 2014).



Figure 5.4.8-1. Annual Average Snowfall for New York State



Source: NYS HMP, 2014

Note: Monroe County is indicated by a red circle with an annual average snow accumulation of either 60-95 inches, or less than 60”.

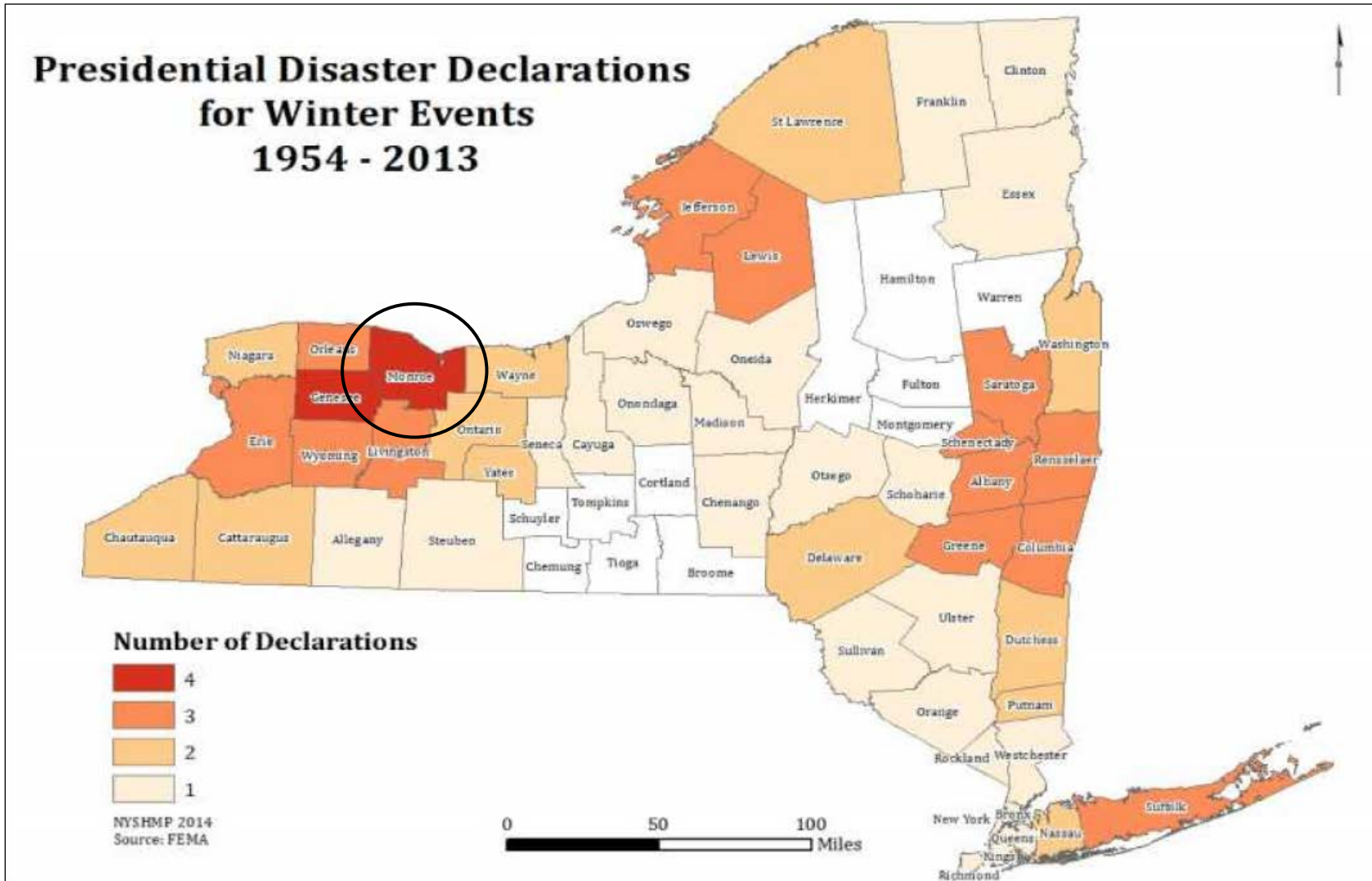
Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with severe winter storms and extreme cold events throughout New York State and Monroe County. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events 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.

Between 1954 and 2015, the Federal Emergency Management Agency (FEMA) declared that New York State experienced 22 winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: winter storm, severe storm, coastal storm, ice storm, blizzard, snow, snowstorm, 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 2014 NYS HMP and other sources indicate that Monroe and Genesee Counties have the highest number of winter declarations. Monroe County has been declared as a disaster area on four separate occasions resulting from winter storm-related events, as indicated by Figure 5.4.8-2, which shows Presidential (FEMA) disaster declarations for winter storms and blizzards in New York State from 1953 to 2013. However, the last time Monroe County was included in a severe winter storm disaster declaration was in 2003 (NYS DHSES 2014).



Figure 5.4.8-2. Presidential Disaster Declarations in New York State from Winter Snow Storms and Blizzards (1954 to 2013)



Source: NYS DHSES, 2014

Note: The black circle indicates the approximate location of Monroe County. Monroe County has been included in four winter storm/blizzard disaster declaration in New York State between 1954 and 2015.





The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. USDA records indicate that Monroe County has experienced crop losses from winter storm events. Between 2002 and 2015, USDA recorded nine recorded crop loss events in Monroe County which involved severe winter storms (USDA, 2015).

Table 5.4.8-2 presents USDA-declared snow events impacting Monroe County, along with other historical occurrences as reported by other sources. Details on these and other events are provided in Table 5.4.8-2 immediately below.

Table 5.4.8-3. USDA Crop Losses from Severe Winter Storms in Monroe County

Year	Crop Type	Cause of Loss	Losses
2014	Apples	Other (Snow-Lightning-Etc.)	\$ 17,701.00
2011	Sweet Corn	Other (Snow-Lightning-Etc.)	\$ 25,333.00
2010	Green Peas	Other (Snow-Lightning-Etc.)	\$ 5,588.00
2010	Green Peas	Other (Snow-Lightning-Etc.)	\$ 7,815.00
2005	All Other Crops	Other (Snow-Lightning-Etc.)	\$ 1,143.00
2002	All Other Crops	Other (Snow-Lightning-Etc.)	\$ 41,715.00
2002	All Other Crops	Other (Snow-Lightning-Etc.)	\$ 16,287.00
2002	All Other Crops	Other (Snow-Lightning-Etc.)	\$ 8,419.00
2002	All Other Crops	Other (Snow-Lightning-Etc.)	\$ 1,456.00

Source: USDA 2015

According to NOAA NCDC, there were 74 severe winter storm events in Monroe County between 1950 and 2015, classified as blizzard, heavy snow, ice storm, lake-effect snow, sleet, winter storm, or winter weather, resulting in \$17.5 million in property damage and \$1.5 million in crop damage (NOAA NCDC 2015). Other records of storm events show up to 189 events over that same period. For this 2017 HMP Update, known winter storm events that have impacted Monroe County between 2008 and 2015 are identified in Table 5.4.8-3. For events prior to 2008, refer to the 2011 Monroe County HMP. Because documentation for New York State and Monroe County winter storms is so extensive, not all sources have been identified or researched. Therefore, Table 5.4.8-3 may not include all events that have occurred in the county.



Table 5.4.8-4. Winter Storm Events Impacting Monroe County between 2008 and 2015

Date(s) of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
February 14, 2015	Winter Storm	N/A	No	A strong clipper crossed the Great Lakes and brought snow and blowing snow to the region and some of the coldest air of the season. The snowfall amounts were enhanced downwind of Lake Ontario and upslope east of Lake Erie where snowfall amounts around a foot were recorded. Gusty winds accompanied the system and produced reduced visibilities in blowing snow. On the back side of the system, temperatures plummeted and struggled to reach zero on February 15. Combined with the winds, wind chill temperatures of 25 to 35 degrees below zero were recorded.
February 8, 2015	Winter Storm	N/A	No	Low pressure moved across Ohio and Pennsylvania to the Virginia Coast. The system brought a light general snowfall to the area. The northerly flow crossing the warmer waters of Lake Ontario and higher elevations resulted in enhanced snowfall amounts across parts of the Genesee Valley and northern Finger Lakes. Given the harsh winter conditions, the effects of this storm on the region were generally minimal with just some delays and longer travel times. Specific snowfall reports included 14 inches near Rochester.
February 1, 2015	Winter Storm	N/A	No	Low pressure tracked across Ohio and Pennsylvania and brought a general 8 to 14 inches of snow to the entire region. Heaviest amounts were along the southern tier counties and over the counties along the south shore of Lake Ontario. Northeast winds became quite strong near Lake Ontario with near blizzard conditions occurring closer to the shore. While the snow did not result in many closings, the general snow across the entire region did result in many delays and late openings. Specific snowfall reports included 17 inches in the Town of Webster and 16 inches in the Town of Greece.
November 17-26, 2014	Severe Winter Storm, Snowstorm, and Flooding	DR-4204	No	Snowfall amounts of up to 4 feet impacted parts of Southern Erie County and Wyoming County on November 19th. The moderate to heavy snow extended east across Livingston and Ontario counties as well with accumulations approaching a foot over northern Livingston County. Millions of dollars were lost as area dairy farmers were unable to transport milk for processing. This event combined with the lake effect snow event following the next couple of days qualified the area for a Federal Disaster Declaration. Monroe County sent resources to Erie County to assist in the response to this storm. Assets were sent from County DOT, County Parks, County DES, County OEM, and County Fire Bureau. Costs incurred by Monroe County totaled \$28,304.81.
December 10, 2014	Winter Storm / Nor'Easter	N/A	No	Low pressure developed off the mid-Atlantic coast then lifted to southern New England. The Nor'Easter brought a blanket of heavy snow to much of the region. The highest amounts were in Cayuga, Jefferson, Oswego, Wayne, Monroe, and Ontario Counties where a band of moderate to heavy snow fell on December 10 in the afternoon, and then another snow in the evening. The snow resulted in travel disruptions. Several school districts in the hardest hit areas were forced to close. Specific snowfall amounts received included 14 inches in the Town of Webster and 11 inches at Rochester Airport. Property damage from the storm was estimated at \$40,000 in Monroe County.



Date(s) of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
March 29, 2014	Winter Storm	N/A	No	Low pressure moved across the Tennessee Valley to the Atlantic and then northeast along the coast. Precipitation began as rain across the region then changed to a brief period of freezing rain before changing to all snow. A blanket of four to seven inches of snow covered the entire region. Snowfall accumulations were greater across the higher elevations and downwind of Lakes Erie and Ontario. Specific snowfall amounts included 10 inches in the City of Rochester and 9 inches at Rochester Airport. Property damage from the storm was estimated at \$20,000 in Monroe County.
March 12, 2014	Blizzard	N/A	No	Low pressure moved across the Ohio Valley to the Mid-Atlantic coast then lifted northeast to the Canadian Maritimes. Snow began across the region during the pre-dawn hours of March 12. By morning, the combination of heavy snow and strong winds produced blizzard conditions across much of the region. Damage was mainly limited to economic loss of business and cost of cleanup as most businesses and schools announced closings early in the well forecast storm. The blizzard conditions led to cancellation of classes at the Rochester Institute of Technology (RIT) and closure of the university, and a power failure led to loss of service at a primary University data center, resulting in hardware and equipment damage. Sustained winds of 25 to 35 mph were accompanied by frequent gusts of 45 to 50 mph. Reported snowfall amounts included 19 inches at Hamlin Beach in the Town of Hamlin, 16.2 inches at Rochester Airport, and 14 inches in the Town of East Rochester. Property damage from the storm was estimated at \$42,000 in Monroe County, and Monroe County OEM had costs of \$628.93 related to food for EOC representatives.
December 21, 2013	Ice Storm	N/A	No	A surface front stalled across the region acted as a pathway for periods of heavy precipitation. To the north of the front, the precipitation fell as freezing rain. Ice coated trees, power lines and all exposed surfaces. Across the Niagara Frontier, ice accumulations of a half- to one-inch were reported. Across the north country, where the freezing rain persisted the longest, the ice accumulations ranged from one to two inches. The weight of the heavy ice brought down trees and power lines. Tens of thousands were left without power. In some cases, trees fell on homes, buildings and automobiles. At the RIT campus in the Town of Henrietta, cold temperatures and winds caused several pipes to burst in three apartment complexes. Total property damage on campus was \$67,000. Other property damage from the storm in Monroe County was estimated at \$50,000.
December 14, 2012	Winter Storm	N/A	No	Low pressure moved from the Ohio Valley to the East Coast and brought a general accumulating snow to much of the region. 6 to 10 inches of snow blanketed the region with the higher amounts across the higher elevations of the Eastern Lake Ontario region and areas south of Lake Ontario where lake enhancement occurred. The snow resulted in the usual traffic slowdowns and several accidents were blamed on the storm. Specific snowfall amounts that were reported included 7 inches in the City of Rochester.



Date(s) of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
November 26, 2013	Winter Storm	N/A	No	A strengthening area of low pressure moved north along the U.S. East Coast. The storm brought accumulating snow across western New York. Across parts of the North Country, the snow mixed with sleet and freezing rain. Although not exceptionally high snowfall totals, strong winds accompanying the system resulted in a considerable amount of blowing snow resulting in frequent white out conditions. Several counties issued travel advisories because of hazardous road conditions. The fact that the storm occurred close to Thanksgiving added to the impact of the storm. Specific snowfall reports included 7 inches in the Town of Greece. Property damage from the storm was estimated at \$20,000 in Monroe County.
January 22, 2013	Lake-Effect Snow	N/A	No	Lake snows persisted as a deep trough of low pressure became entrenched across the northeast United States. Off Lake Ontario, an intense band of lake-effect snow developed east of the lake late Monday Night and drifted slowly south across Oswego County on Tuesday producing more heavy snow along the way. Snowfall rates reached 3 to 5 inches per hour during this time. The band then settled along the south shore of the lake Tuesday Night with heavy snow along the entire south shore. Periodic bands of somewhat weaker lake effect snow then continued along the south shore of the lake through midweek. Specific snowfall reports included 11 inches at Hamlin Beach in the Town of Hamlin. Property damage from the storm was estimated at \$10,000 in Monroe County.
December 26, 2012	Winter Storm	N/A	No	Low pressure over the deep south lifted across the Tennessee Valley to the Delmarva coast. The low pressure spread about 12 to 18 inches of snow across the entire region. Winds increased to 20 to 30 mph, gusting at times to near 40 mph. The winds produced blowing snow and reduced visibilities. Numerous automobile accidents occurred because of the wintry conditions. Some holiday travel was disrupted at Buffalo and Rochester airports. Specific snowfall reports received included: 14 inches in the Town of Greece; 12 inches in the Town of Chili; and 11 inches at Rochester Airport. Property damage from the storm was estimated at \$15,000 in Monroe County.
February 12, 2012	Lake-Effect Snow	N/A	No	While this event proved to have minimal impact on the Rochester metropolitan area because it occurred over a weekend, it was the first significant lake-effect snowstorm of 12 inches or more for the major urban area in several years. A low pressure system situated over the southern half of Quebec brought cold, northwest winds to the region. Lake-effect snow developed off Georgian Bay into a band that gathered additional moisture off Lake Ontario as it curved more to the east across Monroe County. Moderate to heavy lake effect snow then fell across a large portion of Monroe County during the early morning hours of Sunday, February 12, with accumulations of 12 inches or more experienced by daybreak. Specific reported snowfall totals included: 12 inches in the City of Rochester and the Town of Greece. Property damage from the storm was estimated at \$15,000 in Monroe County.
February 25, 2011	Winter Storm	N/A	No	An intensifying area of low pressure moved across Pennsylvania then headed northeast across New England. The system brought a significant snowfall of 6 to 12 inches of snow to the entire area. A brisk northerly flow also resulted in a significant amount of blowing and drifting snow. Winds gusted to 40 mph along the Lake Erie Shore. A 30-mile stretch of the New York State Thruway was closed because of multiple accidents. There were several reports of building collapses throughout the region from the weight of the snow that had built up throughout the snowy winter. Property damage from the storm was estimated at \$15,000 in Monroe County.



Date(s) of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
December 13-14, 2010	Lake-Effect Snow	N/A	No	The fourth lake-effect event of the winter season followed on the heels of storm which brought a cold rain to most of the area. The event was long lasting and featured three sub-events. Most of the accumulation occurred during these three sub-event periods, the first of which was a north to northwest upslope flow from late December 13 through the morning of December 14, which brought 6 to 10 inches from Monroe to Wayne Counties and over 12 inches of snow in the Chautauqua ridge. The storm continued across the Niagara frontier during afternoon December 14 and then dropped 12 inches of snow over Oswego county Wednesday night to Thursday morning the 15th-16th. Lighter activity continued outside of these periods but accumulating snow fell at least until Friday. The 4-day totals topped more than 12 inches across the greater Rochester area. Reported totals included 18 inches in the City of Rochester. Property damage from the storm was estimated at \$25,000 in Monroe County.
December 5, 2010	Lake-Effect Snow	N/A	No	A strong northwest flow of arctic air produced long lasting lake-effect snow squalls to the southeast of Lakes Erie and Ontario. The event began on December 5 with strong bands off Lakes Huron and Ontario. The Ontario band worked across the Rochester area during the afternoon and then slowly settled south overnight, and combined with a Georgian Bay band to drop 4 to 8 inches around the City of Buffalo on Monday, December 6. This activity broke down later Monday but strong bands set up Monday night and continued through Wednesday night in an area from the City of Rochester to the City of Syracuse. Off Lake Ontario, reported snow totals included 24 inches in the City of Rochester. Property damage from the storm was estimated at \$10,000 in Monroe County.
February 25-26, 2010	Winter Storm	N/A	No	A deep storm system off Long Island strengthened and stalled off the New York/New Jersey coast. The system circulated Atlantic moisture back across western and north central New York. About 6 to 10 inches of snow fell across the region with higher amounts to the east (closer to the low center) and downwind of the Great Lakes (where lake enhancement occurred). Rochester received 10 to 16 inches. Many schools throughout the region were closed because of the snow. Numerous automobile accidents were blamed on the treacherous driving conditions. RG&E restored power to 1,311 customers in an hour when heavy snow dropped tree branches on a power line in Webster. Reported storm totals included: 22 inches in the Towns of Webster and Hamlin. Property damage from the storm was estimated at \$20,000 in Monroe County.
January 3-9, 2010	Winter Storm	N/A	No	Rochester Airport recorded 116 straight hours of snow, with an accumulation of 12.3 inches.
January 1, 2010	Lake Effect Snow	N/A	No	A strong cold front crossed the region on New Year's Day. A broad area of lake-effect snows develop along the south shores of Lakes Erie and Ontario late on the first, and impacted up to 20 miles inland. The activity continued through Saturday (January 3) and then strengthened in place Saturday night as a large area of moisture spiraled around a massive coastal storm off New England. About 12 to 24 inches fell over two days, with up to 18 inches in the Rochester area. Nine to 18 inches fell in Rochester (from north to south across the city). Property damage from the storm was estimated at \$20,000 in Monroe County.



Date(s) of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
December 10-12, 2009	Lake Effect Snow	N/A	No	Lake-effect snows developed off Lakes Erie and Ontario in a well-aligned, cold, unstable west to southwest flow. Strong winds allowed the snow bands to extend well inland, but produced significantly reduced visibilities in blowing and drifting snow. The Lake Erie snows produced significant accumulations well into the Rochester metro area. Off Lake Erie, the event began across northern Erie and southern Niagara counties, and then settled south into southern Erie and Wyoming counties by mid-morning Thursday (December 10) after dropping 2 to 4 inches. The storm then moved northward for several hours across the metro Buffalo area and across Genesee and Monroe counties, then settled slowly south and stalled out for many hours during the evening with very intense snowfall rates across the Buffalo south towns and Wyoming county. Areas immediately adjacent to the east shores of the lakes received up to 40 inches. An unusual wind shift above Lake Erie blew blizzard-like conditions into the Rochester area on December 10th, slowing the evening commute, and causing dozens of accidents. Specific snowfall amounts included 3 to 9 inches in the City of Rochester (from north to south). Property damage from the storm was estimated at \$15,000 in Monroe County.
December 31, 2008	Winter Storm	N/A	No	A deepening area of low pressure moved across the Ohio valley and Pennsylvania before moving off the southern New England Coast during the afternoon of December 31. Steady snow developed over the region and was accompanied by increasing northerly winds. Widespread snowfall amounts ranged from 8 to 14 inches during the 8-hour event. The strong winds produced areas of blowing and drifting snow and resulted in significantly reduced visibilities. Some of the highest snowfall reports included 9 inches in the Town of Greece and 8.9 inches at the Rochester Airport. Property damage from the storm was estimated at \$10,000 in Monroe County.
December 19, 2008	Winter Storm	N/A	No	Low pressure moved out of the central plains and moved across Pennsylvania. The low brought an 8- to 12-inch blanket of snow to the entire region on December 19. Across the western southern tier, snowfall amounts were slightly lower; the snow mixed with freezing rain and sleet across that area. Some of the highest snowfall amounts included 11 inches in the Town of Perinton, 9 inches at the Rochester Airport, and 10 inches in the City of Rochester. Innumerable automobile accidents were reported throughout the region as the roads became hard to navigate in the heavy snow and reduced visibilities. Schools shut down across the region and many municipalities suggested avoiding unnecessary travel if possible. Property damage from the storm was estimated at \$20,000 in Monroe County.



Date(s) of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
March 7-9, 2008	Winter Storm	N/A	No	<p>One of the worst storms of the 2007-2008 winter season occurred from March 7 through March 9. This was an extended two-part event, but totals of 1 to 2 feet of snow were common, with some isolated higher amounts. The storm occurred over a weekend so impact to daily activities (school and businesses) was minimal. Numerous automobile accidents were blamed on the slippery conditions and poor visibilities in falling and blowing snow. The storm dropped about 16 inches of snow on Rochester during a 36-hour period. RG&E reported 3,300 customers without power. Blowing and drifting snow caused whiteout conditions on roads and visibility at the Rochester Airport was 0.8 mile. Thunder and lightning accompanied bands of heavy snow the afternoon and evening of March 8</p> <p>Snowfall reports in Monroe County included 22 inches in the Town of Hamlin; 14 inches in the Town of Webster; and 13 inches in the Town of Greece. Property damage from the storm was estimated at \$25,000 in Monroe County.</p>
March 4, 2008	Winter Storm	N/A	No	<p>Low pressure developed over the lower Mississippi valley and lifted to the Ohio valley. The storm brought a mix of snow, sleet, and freezing rain to the region. About 4 to 6 inches blanketed the entire region and was followed by several inches of sleet and up to ½ inch of glaze from freezing rain. Schools were closed in many parts of the region. Some county officials declared a States of Emergency, while others recommended no unnecessary travel. Utility companies reported scattered power outages affected tens of thousands of customers across the region. Property damage from the storm was estimated at \$10,000 in Monroe County.</p>
February 10, 2008	Winter Weather	N/A	No	<p>An arctic front roared across the eastern lakes region on Sunday morning, February 10. Snow squalls accompanied the front, which was trailed by strong northwest winds. The strong winds blew about the freshly-fallen snow producing whiteout conditions and blowing snow on Interstate 390 in the Town of Gates. A 36-car accident occurred in which a 17-year old girl died, and nearly two dozen others taken to the hospital. Property damage from the storm was estimated at \$500,000 in Monroe County.</p>
February 1, 2008	Winter Storm	N/A	No	<p>Initially a snow storm, then a mix of snow, freezing rain and sleet, spread across parts of the region. Snowfalls in Monroe County ranged from 5 to 11 inches, followed by 1 to 2 inches of sleet or ice. Property damage from the storm was estimated at \$10,000 in Monroe County.</p>

Sources: NOAA-NCDC 2015; FEMA 2015

FEMA Federal Emergency Management Agency
 NCDC National Climatic Data Center
 NOAA National Oceanic and Atmospheric Administration
 RG&E Rochester Gas and Electric
 RIT Rochester Institute of Technology



Probability of Future Events

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 declarations, 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 to 10 years within the state (NYS DHSES 2014). It is estimated that Monroe County will continue to experience direct and indirect impacts of severe winter storms annually.

Table 5.4.8-5 provides the probability of occurrences of severe winter storm events. Based on historic occurrences, heavy storm events are the most common in Monroe County, followed by winter storm events. However, the information used to calculate the probability of occurrences is only based on using NOAA-NCDC storm events database results.

Table 5.4.8-6. Probability of Occurrence of Severe Storm Events

Hazard Type	Number of Occurrences Between 1950 and 2015	Probability of Occurrence	Annual Number of Events
Blizzard	2	3.03%	3.08%
Heavy snow	39	59.09%	60.00%
Ice storm	3	4.55%	4.62%
Lake-effect snow	9	13.64%	13.85%
Winter storm	20	30.30%	30.77%
Winter weather	1	1.52%	1.54%
Total	74	112.12%	113.85%

Source: NOAA-NCDC 2015

Note: Probability was calculated using the available data provided in the NOAA-NCDC storm events database.

In Section 5.3, the identified hazards of concern for Monroe County were ranked using a variety of parameters. 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” (event that will occur in 25 years) (see Section 5.3, Tables 5.3-1 and 5.3-3).

Climate Change Impacts

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

Climate change is beginning to affect both people and resources in New York State, and these impacts are projected to continue to grow. Impacts related to increasing temperatures and sea level rise are already being felt in the state. 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] 2014).



Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Monroe County is part of Region 1, which includes western New York and the Great Lakes plain. Some of the issues in this region affected by climate change include: highest agricultural revenue in the state; relatively low rainfall, increased summer drought risk; high value crops could need irrigation; improved condition for grapes projected (NYSERDA 2014).

Temperatures are expected to increase throughout the state, by two to 3.4 °F by the 2020s, 4.1° F to 6.8° F by the 2050s, and 5.3° F to 10.1° F by the 2080s. The lower ends of these ranges are for lower greenhouse gas emission scenarios and the higher ends for higher emission scenarios. Annual average precipitation is projected to increase by 1 to up to 8 percent by the 2020s, from 3 up to 12 percent by the 2050s, and from 4 up to 15 percent by the 2080s. By the end of the century, the greatest increases in precipitation are projected to be in the northern parts of the state. Although seasonal projections are less certain than annual results, this additional precipitation will most likely occur during the winter months, with the possibility of slightly reduced precipitation projected for the late summer and early fall. Table 5.4.8-5 displays the projected precipitation change for the Western New York Great Lakes ClimAID Region (NYSERDA 2014).

Table 5.4.8-7. Projected Seasonal Precipitation Change in Region 1, 2050s (% change)

Baseline (1971-2000) 34.0 inches	Low Estimate (10 th Percentile)	Middle Range (25 th to 75 th Percentile)	High Estimate (90 th Percentile)
2020s	0 percent	+ 2 to + 7 percent	+ 8 percent
2050s	+ 2 percent	+ 4 to + 10 percent	+ 12 percent
2080s	+ 1 percent	+ 4 to + 13 percent	+ 17 percent
2100	+ 3 percent	+ 4 to + 19 percent	+ 24 percent

Source: *NYSERDA 2014*

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 4 inches of freezing rain in the ice band near central New York State, consisting of between 1 and 2 inches of accumulated ice over a 24-hour period
- Up to 2 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. Annual ice cover has decreased 71 percent on the Great Lakes since 1973. This decrease may lead to increased lake-effect snow in the next couple of decades through greater moisture availability. By mid-century, however, lake-effect snow will generally decrease as temperatures below freezing become less frequent (NYSERDA 2014). Winter snow cover is decreasing and spring comes, on average, about a week earlier than it did a few years ago. Night-time temperatures are measurably warmer, even during the colder months (NYSDEC, Date Unknown). Overall winter temperatures in New York State are almost 5 degrees F 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 percent by end of the next century. The lack of snow cover may jeopardize winter sport businesses offering skiing, snowmobiling, and other types of winter recreation; and natural ecosystems will be affected by the changing snow cover (Cornell University College of Agriculture and Life Sciences 2011).



5.4.8.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the severe winter storm hazard, all of Monroe County has been identified as the hazard area. Therefore, all assets in the county (population, structures, critical facilities, and lifelines), as described in the County Profile (Section 4), are vulnerable to a winter storm event. The following text evaluates and estimates the potential impact of severe winter storm events on the county including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, health and safety of residents, (2) general building stock, (3) critical facilities, (4) economy, and (5) future growth and development
- Effect of climate change on vulnerability
- Change of vulnerability compared to the 2011 Monroe County Hazard Mitigation Plan
- Further data collections that will assist understanding this hazard over time

Overview of Vulnerability

Severe winter storms are of significant concern to the county because of the frequency and magnitude of these events in the region, 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

Updated population and general building stock data were used to support an evaluation of assets exposed to this hazard and the potential impacts associated with this hazard. Additionally, available economic losses were provided by the Planning Committee to support this vulnerability assessment.

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 United States, 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, extreme cold temperatures, and dangerous wind chill. They are considered deceptive killers because most deaths, impacts, or losses are indirectly related to the storm. People may die in traffic accidents on icy roads, from 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. The economic impact of winter weather each year is huge, with costs for snow removal, damage repair, and loss of business in the millions (NSSL 2006).

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.

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 Monroe County (744,344) is exposed to severe winter storm events (U.S. Census 2010). Snow accumulation and frozen or slippery road surfaces increase the frequency and impact of traffic accidents, which may result in personal injuries. Refer to the County Profile for population statistics for each participating municipality.

The elderly are considered most susceptible to this hazard because of their increased risk of injuries and death from falls, and overexertion 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).

Impact on General Building Stock

The entire general building stock inventory in Monroe 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 5.4.2-4 presents the total exposure value for general building stock for each participating municipality (structure only).

Current modeling tools are not available to estimate specific losses for this hazard. As an alternate approach, this HMP Update considers percentage damages that could result from severe winter storm conditions. Table 5.4.2-6 below summarizes percent damages that could result from severe winter storm conditions for the Planning Area’s total general building stock. Given professional knowledge and the currently available information, the potential loss for this hazard is many times considered to be overestimated because of varying factors (building structure type, age, load distribution, building codes in place, etc.). Therefore, the following information should be used as estimates only for planning purposes with the knowledge that the associated losses for severe winter storm events vary greatly.

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

Municipality	Total RCV (Structure only)	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Brighton (T)	\$10,405,472,959	\$104,054,730	\$520,273,648	\$1,040,547,296
Brockport (V)	\$1,163,162,254	\$11,631,623	\$58,158,113	\$116,316,225
Chili (T)	\$5,061,017,630	\$50,610,176	\$253,050,882	\$506,101,763
Churchville (V)	\$528,694,494	\$5,286,945	\$26,434,725	\$52,869,449
Clarkson (T)	\$1,109,338,986	\$11,093,390	\$55,466,949	\$110,933,899
East Rochester (V/T)	\$1,628,651,386	\$16,286,514	\$81,432,569	\$162,865,139
Fairport (V)	\$1,438,659,566	\$14,386,596	\$71,932,978	\$143,865,957
Gates (T)	\$5,543,044,232	\$55,430,442	\$277,152,212	\$554,304,423
Greece (T)	\$15,639,605,696	\$156,396,057	\$781,980,285	\$1,563,960,570
Hamlin (T)	\$1,109,833,295	\$11,098,333	\$55,491,665	\$110,983,330
Henrietta (T)	\$7,651,359,581	\$76,513,596	\$382,567,979	\$765,135,958
Hilton (V)	\$983,735,374	\$9,837,354	\$49,186,769	\$98,373,537
Honeoye Falls (V)	\$647,493,313	\$6,474,933	\$32,374,666	\$64,749,331
Irondequoit (T)	\$9,766,802,498	\$97,668,025	\$488,340,125	\$976,680,250
Mendon (T)	\$1,851,317,752	\$18,513,178	\$92,565,888	\$185,131,775
Ogden (T)	\$2,765,048,753	\$27,650,488	\$138,252,438	\$276,504,875
Parma (T)	\$1,663,300,448	\$16,633,004	\$83,165,022	\$166,330,045
Penfield (T)	\$8,737,396,946	\$87,373,969	\$436,869,847	\$873,739,695
Perinton (T)	\$10,681,192,459	\$106,811,925	\$534,059,623	\$1,068,119,246
Pittsford (T)	\$7,463,741,305	\$74,637,413	\$373,187,065	\$746,374,131
Pittsford (V)	\$1,168,490,910	\$11,684,909	\$58,424,546	\$116,849,091
Riga (T)	\$765,044,014	\$7,650,440	\$38,252,201	\$76,504,401
Rochester (C)	\$53,423,837,423	\$534,238,374	\$2,671,191,871	\$5,342,383,742





Municipality	Total RCV (Structure only)	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Rush (T)	\$878,802,934	\$8,788,029	\$43,940,147	\$87,880,293
Scottsville (V)	\$416,050,113	\$4,160,501	\$20,802,506	\$41,605,011
Spencerport (V)	\$1,050,247,411	\$10,502,474	\$52,512,371	\$105,024,741
Sweden (T)	\$1,075,937,877	\$10,759,379	\$53,796,894	\$107,593,788
Webster (T)	\$7,158,370,539	\$71,583,705	\$357,918,527	\$715,837,054
Webster (V)	\$1,016,484,474	\$10,164,845	\$50,824,224	\$101,648,447
Wheatland (T)	\$617,971,045	\$6,179,710	\$30,898,552	\$61,797,105
Monroe County (Total)	\$163,410,105,668	\$1,634,101,057	\$8,170,505,283	\$16,341,010,567

Source: Monroe County

Notes: RCV = Replacement Cost Value

C = City

T = Town

V = Village

A specific area that is vulnerable to the severe winter storm hazard is the floodplain. Severe winter storms can cause flooding through blockage of streams or through snow melt. At risk residential infrastructure are presented in the section for the flood hazard (Section 5.4.4). Generally, losses resulting from flooding associated with severe winter storms should be less than that associated with a 100-year flood. In addition, coastal areas are at high risk during winter storm events that involve high winds. Please refer to the severe storm profile for losses resulting from wind (Section 5.4.7).

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. Infrastructure at risk for this hazard includes roadways that could be damaged from the application of salt and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires clearing of roadways and alerting of citizens to dangerous conditions; following the winter season, resources for road maintenance and repair are required.

Impact on Economy

The cost of snow and ice removal, road repair due to the freeze/thaw process can drain local financial resources. The economy is also impacted by loss of commuters traveling into or out of the area for work or school. The loss of power and closure of roads prevents the commuter population from traveling to work within and outside of the county.

Future Growth and Development

As discussed in Sections 4 and 9 (Volume II), 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. Areas targeted for potential future growth and development in the next 5 years have been identified across the county at the municipal level. Refer to the jurisdictional annexes in Volume II of this HMP.

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

- Remove snow from roadways





- Remove dead trees and trim trees/brush from roadways to lessen falling limbs and trees
- Ensure proper road signs are visible and installed properly
- Bury electrical and telephone utility lines to minimize downed lines
- Remove debris and obstructions in waterways and develop routine inspections and maintenance plans to reduce potential flooding
- Replace substandard roofs of critical facilities to reduce exposure to airborne germs resulting from leakage
- Purchase and install backup generators in evacuation facilities and critical facilities offering essential services to residents
- Install cell towers in areas where limited telecommunication is available to increase emergency response and cell phone coverage (NYS DHSES 2014).

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 as winter storms. While predicting 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] 2013).

The 2011 “Responding to Climate Change in New York State” report was prepared by the 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 the state’s 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 portions of the country.

Change of Vulnerability

There was no quantitative vulnerability assessment conducted for the 2011 version of the HMP. For this update, the county’s building inventory is being used to estimate vulnerability to severe winter storms. Overall, the county’s vulnerability has not changed, and the entire county will continue to be exposed and vulnerable to severe winter storm events.



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 and 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. Mitigation strategies addressing early warning, dissemination of hazard information, provisions for snow removal, and backup power are included in Volume II, Section 9 of this plan.