5.4.5 Severe Winter Storm

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

5.4.5.1 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 Westchester County, most severe winter storm hazards include heavy snow (snowstorms), blizzards, sleet, freezing rain, ice storms, and Nor'Easters. 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 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 a snow crystals or snow pallet, which then falls to the earth. Snow falls in different forms: snowflakes, snow pellets, or sleet. Snowflakes are clusters of ice crystals that form from a cloud. 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 inches in diameter (NSIDC, 2014).

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 they have similar impacts, especially to trees, power lines, and residential utility services. 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 mph or more, accompanied by falling or blowing snow reducing visibility to or below 0.25 mile. These conditions must be the predominant over a 3-hour period. 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°. 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, 2012).

Sleet or Freezing Rain Storms

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 Storms

An ice storm describes those events when damaging accumulations of ice are expected during freezing rain situations. Significant ice accumulations are typically accumulations of ¼" or greater (NWS, 2009). Heavy accumulations of ice can bring down trees, power lines and 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, 2013).

Nor'Easter

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

Nor'Easters can cause heavy snow, rain, gale force winds and oversized waves (storm surge) that can cause beach erosion, coastal flooding, structural damage, power outages and unsafe human conditions. If a Nor'Easter cyclone stays just offshore, the results are much more devastating than if the cyclone travels up the coast on an inland track. Nor'Easters that stay inland are generally weaker and usually cause strong winds and rain. The ones that stay offshore can bring heavy snow, blizzards, ice, strong winds, high waves, and severe beach erosion. In these storms, the warmer air is aloft. Precipitation falling from this warm air moves into the colder air at the surface, causing crippling sleet or freezing rain.

If a significant pressure drop occurs within a Nor'Easter, this change can turn a simple extra-tropical storm into what is known as a "bomb". "Bombs" are characterized by a pressure drop of at least 24 millibars within 24 hours (similar to a rapidly-intensifying hurricane). Even though "bombs" occasionally share some characteristics with hurricanes, the two storms have several differences. "Bombs" are a type of Nor'Easter and are extra-tropical; therefore, they are associated with fronts, higher latitudes, and cold cores. They require strong upper-level winds, which would destroy a hurricane (McNoldy, Date Unknown).

Extent

The magnitude or severity of a severe winter storm depends on several factors including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, 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 and by evaluating its societal impacts. NOAA's National Climatic Data Center (NCDC) is currently producing the Regional

Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5. It is based on the spatial extent of the storm, the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCDC 2011). Table 5.4.5-1 presents the five RSI ranking categories.

Table 5.4.5-1. 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 2011*

Note: *RSI = Regional Snowfall Index*

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

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 12 to 48 hour 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 inform people that winter weather conditions are expected to cause significant inconveniences that may be hazardous. 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 2013).

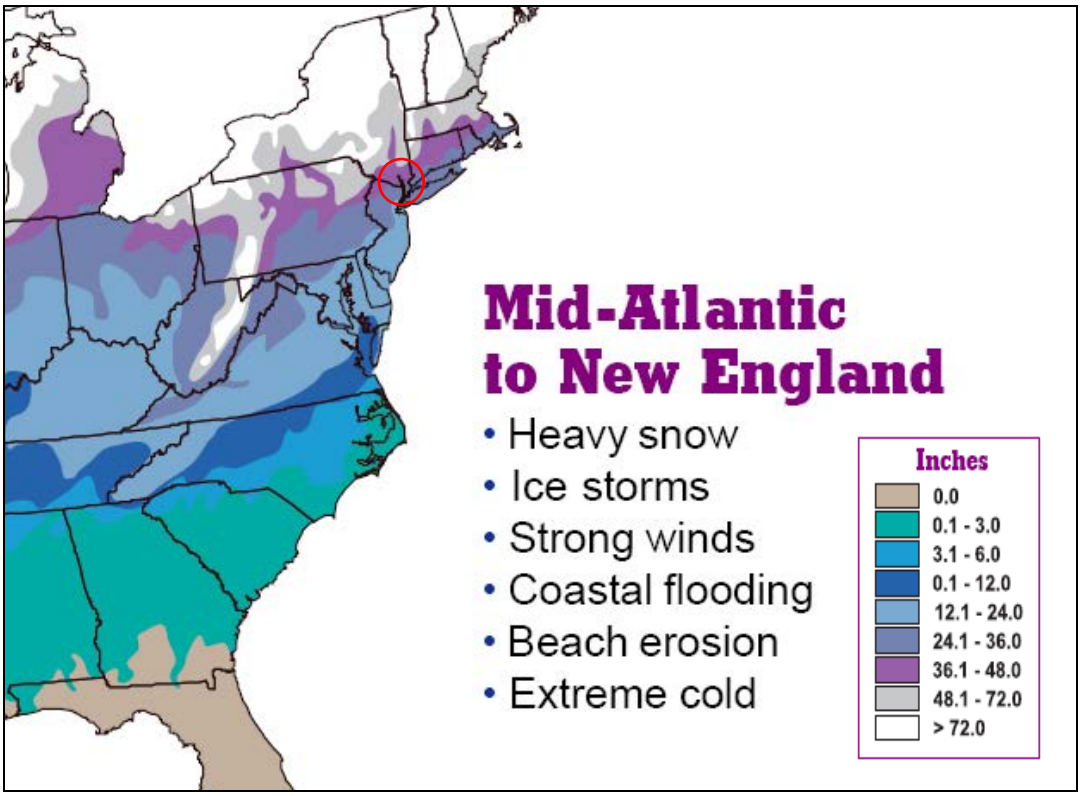
Location

The climate of New York State is marked by abundant snowfall. Winter weather can reach New York State as early as October and is usually in full force by late November with average winter temperatures between 20 and 40° F. As indicated in the NYS HMP, communities in New York State receive more snow than most other communities in the nation. Although the entire State is subject to winter storms, the easternmost and west-central portions of the State are more likely to suffer under winter storm occurrences than any other location (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 Westchester County's average between 24.1 and 48 inches (Figure 5.4.5-1). However, according to the New York State Climatologist (NYSC), normal seasonal snowfall in Westchester County is 30.5 inches (NYSC, 2014).

The New York City metropolitan area, which encompasses Westchester County, in comparison to the rest of the State, is milder in the winter. Due in part to its geography (proximity to the Atlantic Ocean and being shielded to the north and west by hillier terrain), the New York City metropolitan area usually sees far less snow than the rest of the State. Lake-effect snow rarely affects the New York City metropolitan area, except for its extreme northwestern suburbs. Winters also tend to be noticeably shorter here than the rest of the State.

Based on this information, all of Westchester County is susceptible to winter storms; however, most storms are not expected to be as severe as other locations of the State.

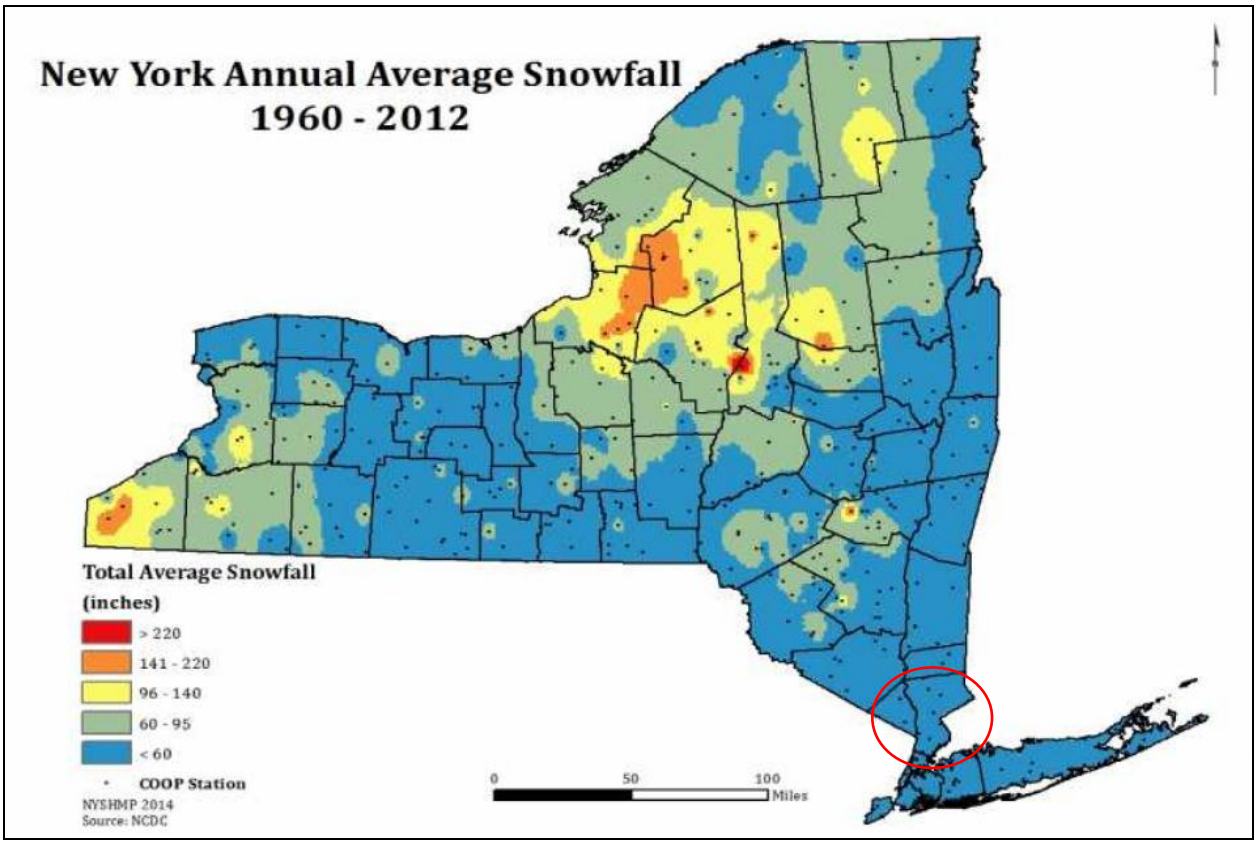
Figure 5.4.5-1. Annual Mean Snowfall within the Eastern U.S.



Source: NWS, 2001

Figure 5.4.5-2, 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 5.4.5-2. Annual Average Snowfall for New York State



Source: NYS DHSES, 2014
Note: Westchester County is indicated by a red oval with an annual average snow accumulation of greater than 60 inches.

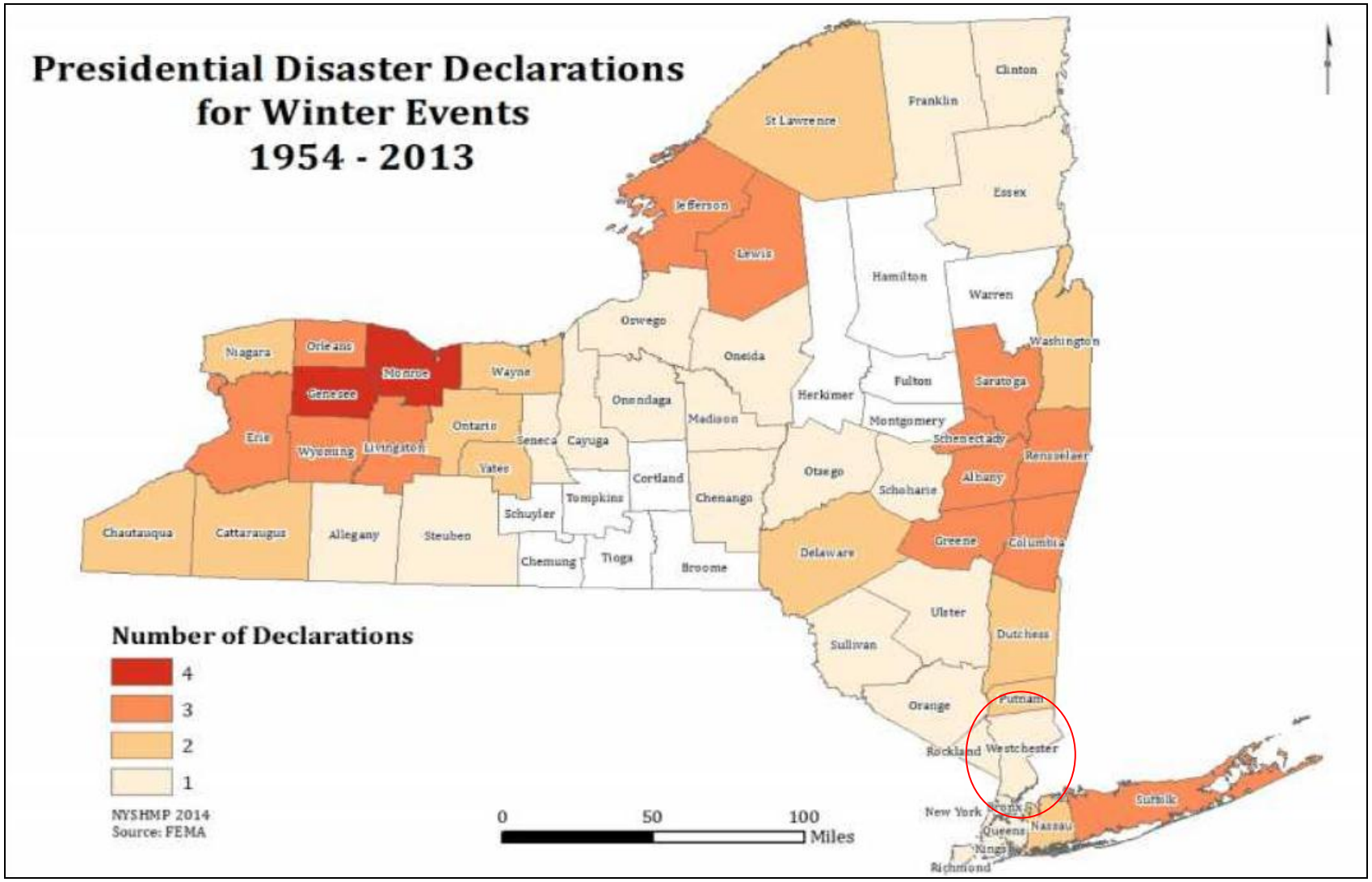
Previous Occurrences and Losses

Many sources provided historical information regarding previous occurrences and losses associated with severe winter storms and extreme cold events throughout New York State and Westchester 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.

Between 1954 and 2014, FEMA included New York State in 22 winter storm-related major disaster (DR) or emergency (EM) declarations classified as one or a combination of the following disaster types: ice storm, severe storm, flooding, snowstorm, severe winter storm, blizzard, and winter storm. 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 2014 Update, NYSDHSES and other sources indicate that Westchester County has been included in four winter storm-related disaster declarations (FEMA 2014; NYSHMP 2014; NYSDHSES 2014).

Figure 5.4.5-3 is a NYS DHSES figure that identifies the FEMA major disaster (DR) declarations for winter storms and blizzards in New York State, from 1953 to 2013. This figure indicates that Westchester County has been included in one disaster declaration. However, FEMA and NYSDHSES records indicate that the County has been included in five disaster declarations: DR-974 (Nor'Easter/Coastal Storm), EM-3107 (Blizzard), DR-1083 (Blizzard), EM-3184 (Snowstorm), and DR-1692 (Nor'Easter).

Figure 5.4.5-3. Presidential Disaster Declarations in New York State from Winter Snow Storms and Blizzards (1954 to 2013)



Source: *NYS DHSES, 2014*

Note: *The red circle indicates the approximate location of Westchester County. Westchester County has been included in one winter storm/blizzard disaster declaration in New York State between 1954 and 2013.*

In the previous Westchester County HMP, specific hazard events and losses were not discussed. Therefore, for the 2014 Plan Update, known severe winter storm events that have impacted Westchester County between 1990 and 2014 will be discussed. Known severe winter storm events that occurred during this time period are identified in Table 5.4.5-2. With severe winter storm documentation for New York State and Westchester County being so extensive, not all sources have been identified or researched. Therefore, Table 5.4.5-2 may not include all events that have occurred in the County.

Table 5.4.5-2. Winter Storm Events Between 1990 and 2014.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
December 11-14, 1992	Coastal Storm, High Tides, Heavy Rain, Flooding	DR-974	Yes	New York State experienced approximately $31.2 million in property damages, mostly due to flooding. Flooding in New York City and Boston was recorded between four and five feet. In Westchester County, between eight and 11 inches of rain, causing flooding. All public schools were closed. Several major roadways were closed due to flooding. Overall, Westchester County had approximately $7.1 million in flood damages. Over 20,000 power failures occurred throughout the County.
January 3, 1993	Freezing Rain	N/A	N/A	A combination of a cold surface and warm, moist air caused freezing rain and drizzle. This resulted in over 1,000 traffic accidents around the area. Many roadways were covered with a thin sheet of ice, which caused the traffic accidents. Westchester County was affected by this event and had approximately $5 million in property damages.
March 13-17, 1993	Blizzard	EM-3107	Yes	This blizzard resulted in total eligible damages of approximately $8.5 million through New York State. County-specific damage information was not available. Total snowfall accumulations for Westchester County were between 10 and 20 inches.
January 12, 1994	Snow/Ice Storm	N/A	N/A	Snowfall totals ranged between four and eight inches. A dangerous coating of ice followed as the snow changed to sleet and freezing rain before ending. Traffic throughout the area was significantly affected.
January 17, 1994	Heavy Snow	N/A	N/A	Accumulations ranged between six and 12 inches however some isolated amounts of 17 inches were reported. This brought traffic to a standstill throughout the area. In addition, trees and power lines were snapped from the weight of the snow. This closed roads and knocked power off to thousands of residents.
February 8, 1994	Snow/Ice Storm	N/A	N/A	After depositing between six and nine inches, the snow began to mix then change to sleet and freezing rain. This added a dangerous coating of ice which caused major transportation problems.
February 11, 1994	Snow/Ice Storm	N/A	N/A	Between six and 14 inches of snow accumulated before it mixed or changed to sleet and/or freezing rain in some locations. The wintery mix caused major transportation problems throughout the region.
February 23, 1994	Snow/Ice Storm	N/A	N/A	The region saw between three and five inches before a dangerous coating of ice was added as the snow changed to sleet and/or freezing rain. Major transportation problems developed.
March 3, 1994	Snow/Ice Storm	N/A	N/A	Strong northeasterly winds of between 35 and 40 mph prevailed for several hours along coastal sections. Several locations reported gust of around 60 mph. Downed trees and branches left thousands without power. In addition, snow and ice accumulated between five and eight inches. This caused significant transportation problems for trains, planes, and motorists.

Table 5.4.5-2. Winter Storm Events Between 1990 and 2014.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
February 27-28, 1995	Ice Storm	N/A	N/A	Numerous traffic accidents were reported as roadways became extremely hazardous due to ice. The ice also coasted trees and caused numerous branches to break off.
January 6-9, 1996	Blizzard	DR-1083	Yes	19 deaths were attributed to the storm; one in Westchester County (Yorktown). The major effects from this storm in New York State were felt across the southeastern sections of the State, resulting in property damages ranging from $21.3 to $70 million. Property damage information for Westchester County was not available.
March 7-8, 1996	Winter Storm	N/A	N/A	Ice accumulated on trees, power lines, and roadways. Total accumulations of sleet and snow caused tree branches to snap off, power lines to fall, and a significant increase in traffic accidents.
March 31, 1997	Winter Storm	N/A	N/A	Strong gusty winds (to at least 40 mph) combined with heavy wet snow caused numerous trees and power lines to fall. Many roads were closed due to fallen trees and power lines. Northern Westchester County, snowfall ranged from nine inches at Croton On Hudson to 16 inches at Yorktown Heights.
January 15, 1999	Winter Storm	N/A	N/A	Significant icing caused widespread disruptions to mass transit and traffic. Rte.22 in Bedford was forced to close due to significant icing. Icing downed scattered tree limbs across the region. Heavy rain showers along with wind gusts from 30 to 40 mph occurred along the Long Island Sound shore of Westchester County. This downed additional scattered ice-laden tree limbs that caused some power outages.
March 14-15, 1999	Heavy Snow	N/A	N/A	Heavy wet snow downed many tree limbs and power lines across the region. In Westchester County, snowfall amounts ranged from 6 inches at White Plains to 10 inches at Yorktown Heights.
January 25, 2000	Winter Storm	N/A	N/A	White-out conditions caused massive traffic interruptions. Light freezing rain fell along the coast with a mixture of freezing rain and sleet inland. Snowfall from 5.5 inches at Yorktown Heights to eight inches at White Plains.
February 18-19, 2000	Winter Storm	N/A	N/A	Snowfall amounts ranged from one to six inches across the Lower Hudson Valley. This first round of heavy precipitation was followed by up to a 1/8th-inch thick ice coating, which caused serious and widespread traffic disruptions. Snowfall amounts ranged from two inches at Yonkers to six inches at White Plains. Significant icing of roads occurred, which forced the closure of many metro roads overnight. Numerous traffic accidents occurred on ice-covered roads. One fatality was reported.
December 14, 2000	Ice Storm	N/A	N/A	A mixture of freezing rain and sleet created treacherous travel for the morning commute. In addition, power outages resulted as tree limbs fell due to significant ice accretion. Ice accumulated at least one quarter inch throughout the area, with some locations receiving up to one half inch of ice.

Table 5.4.5-2. Winter Storm Events Between 1990 and 2014.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
December 30, 2000	Heavy Snow	N/A	N/A	Snowfall totals ranged from 13 inches at Mount Kisco to 16.5 inches at Mamaroneck.
January 20-21, 2001	Winter Storm	N/A	N/A	Heavy snow occurred across Orange, Putnam, Rockland, and northern Westchester counties. Sleet and freezing rain produced ice accumulations of up to 0.20 inches. Ice accumulations ranged from 0.25 to 0.50 inches. This accretion of ice on tree limbs caused some tree branches to fall, and led to power outages. Snowfall ranged from 5 inches at Yorktown Heights to 7.3 inches measured at White Plains.
March 5-6, 2001	Winter Storm	N/A	N/A	The combination of very heavy wet snow and strong winds with this prolonged coastal storm produced scattered power outages across southeast New York. In addition, many schools and businesses were closed for several days due to the hazardous nature of this storm. Snowfall ranged from 5.5 inches at New Rochelle, to 9.5 inches at Yonkers.
December 25-26, 2002	Nor'Easter	N/A	N/A	Snowfall totals in Westchester County ranged from eight inches in Yorktown Heights to 11 inches in Tarrytown.
February 17-18, 2003	Heavy Snow (Presidents Day Snow)	EM-3184	Yes	Periods of light snow developed as northeast winds increased to around 15 mph across the New York City metropolitan area. Snow became widespread and heavy, falling at rates up to two to three inches per hour. Heavy snow blown by northeast winds 20 to 30 mph causing near blizzard conditions throughout the area. Record snowfall totals crippled mass transit. These conditions lead to many local emergency declarations throughout the region. In Westchester County, snowfall totals ranged from 14.5 inches in Croton-on-Hudson to 26 inches in Thornwood.
January 28, 2004	Heavy Snow	EM-3195	No	A light mixture of snow, sleet, and freezing rain spread north across the area. A light coating of ice on area roads made traveling extremely hazardous toward evening. Many traffic accidents occurred across the NYC Metropolitan Area during this time. Snowfall in the county ranged from 8.0 inches at Ossining and Yorktown Heights to 10.0 inches at Thornwood and Hasting-On-Hudson.
February 11-12, 2006	Blizzard	N/A	N/A	The storm rapidly intensified as it moved northeast just off the New England coast. Snow spread north across the area, falling steadily and heavily at times in many areas. During the event, many areas had snowfall rates of up to three and four inches an hour. Reports of thunderstorm were received. The highest totals fell across New York City and Westchester and Putnam Counties. Winds ranged from 10 to 20 mph with gusts of up to 30 mph. This created blizzard conditions with very hazardous driving conditions. In Westchester County, snowfall totals ranged from 16 inches in Croton-on-Hudson to 24.5 inches in New Rochelle.

Table 5.4.5-2. Winter Storm Events Between 1990 and 2014.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
February 13-14, 2007	Ice Storm	N/A	N/A	A significant accretion of ice, especially across the northern half of the county, where nearly half an inch of ice accumulated on tree limbs, power lines, and roadways. In addition, this was further compounded by one to two inches of accumulated sleet. This resulted in major mass transit problems.
April 15-16, 2007	Severe Storms and Inland and Coastal Flood (also identified as a Nor'Easter)	DR-1692	Yes	A Nor'Easter struck the area between the 15th and 16th, bringing heavy rains and high winds that caused widespread and significant river, stream and urban flooding. High winds downed many trees and power lines. The combination of high winds, heavy rain, and high water table produced widespread moderate tidal flooding across parts of New York City and Long Island Sound shores. Rainfall totals from this event ranged from 1.47 inches to 8.41 inches. Wind speed gusts ranged from 35 to 55 mph. New York State experienced millions in eligible damages. FEMA gave out more than $61 million in assistance to affected counties within the State. In Westchester County, rainfall totals ranged from 5.85 inches in Yorktown Heights to 8.22 inches in East White Plains. State Police reported flooding closures of Exit 7 of I-287, Exits 18A, 18B, and 22 of I-95, and I-95 southbound between exits 19 and 17. Roads were also closed along the Hutchinson River Parkway due to flooding at Linden Avenue in the Town of Harrison. The Bronx River Parkway was also closed in the City of White Plains. Private property losses in Westchester County were estimated at $83 million and public property losses were estimated at $2 million. Disaster assistance to the County totaled $30 million.
February 10, 2010	Snowstorm	N/A	N/A	Periods of heavy snow and strong winds impacted the New York City and Long Island area. The high winds caused blowing and drifting snow. Snowfall totals in Westchester County ranged from 8.5 inches in Armonk to 14 inches in Bronxville. A peak wind gust of 38 mph was recorded in White Plains.
February 25-26, 2010	Heavy Snow	N/A	N/A	A combination of heavy snow, heavy rain, coastal flooding and strong winds impacted the region. Up to three feet of snow fell across interior portions of the Lower Hudson Valley, one to two feet across the New York City metropolitan area, and six to 12 inches of snow across eastern Long Island. In Westchester County, snowfall totals ranged from 10 inches in Harrison to 25.4 inches in Ossining.
January 26-27, 2011	Heavy Snow	N/A	N/A	A very heavy snow band developed over the New York City metropolitan area, southern and eastern portions of the Lower Hudson Valley and northern and western Long Island. This band was responsible for snowfall rates of three to four inches per hour over a four to six hour period. In Westchester County, snowfall totals ranged from seven inches in Peekskill to 20 inches in Irvington. A peak wind gust of 43 mph was recorded at White Plains.
October 29-30, 2011	Heavy Snow	N/A	N/A	A historic and unprecedented winter storm impacted the area on October 29th bringing over a foot of heavy, wet snow to portions of northeast New Jersey, the Lower Hudson Valley, and southern Connecticut. Thousands of people lost power

Table 5.4.5-2. Winter Storm Events Between 1990 and 2014.

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
				during this event as heavy snow accumulated on trees causing the trees and limbs to fall, damaging power lines. Storm totals in Westchester County ranged from 6.5 inches in Hastings-on-Hudson to 12.5 inches in Armonk. A peak wind gust of 33 mph was recorded at White Plains. In addition to the snow, 1.1 inches of rain fell in the County.
December 26-27, 2011	Blizzard	N/A	N/A	This blizzard brought between 20 and 30 inches of snow to the New York City metropolitan area, northeast New Jersey and the Lower Hudson Valley. Winds from this storm ranged between 25 and 40 mph, with gusts exceeding 60 mph. 18 inches of snow fell in the Village of Hastings-on-Hudson, along with 63 mph wind gusts. This storm was declared a major disaster (DR) by FEMA: however, Westchester County was not included in this declaration.
February 8, 2013	Winter Storm	DR-4111	No	Spotters reported snowfall ranging from 17.2 inches in Mount Vernon, to 23.3 inches in Port Chester.
March 7, 2013	Heavy Snow	N/A	N/A	Spotters reported snowfall ranging from 7.5 inches in Ardsley and Eastchester to 10 inches in Port Chester and White Plains.
March 18, 2013	Winter Weather	N/A	N/A	Spotters reported between 4.0 and 6.5 inches of snow.
December 14, 2013	Winter Storm	N/A	N/A	Spotters reported widespread snowfall totals of 6 to 7.5 inches, followed by 1/10 to 1/4 inch ice accretion.
January 3-4, 2014	Snow	N/A	N/A	Snowfall totals in Westchester County ranged from 5.4 inches in New Rochelle to over 10 inches in Rye. Maximum wind gusts of 40 mph were recorded at the White Plains Airport.
February 13-14, 2014	Snow (Nor'Easter)	N/A	N/A	Snowfall totals ranged from 12 inches in White Plains to 16.5 inches in Hastings-on-Hudson in Westchester County. In Peekskill, 0.22 inches of ice fell.

Sources: NCDC, 2014; FEMA, 2014; Kocin & Uccellini, 2004; McFadden, 2006; Kennedy, 1996

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

DR – *Disaster Declaration*
EM – *Emergency Declaration*
FEMA – *Federal Emergency Management Agency*
HMP – *Hazard Mitigation Plan*
N/A – *Not Applicable*
NCDC – *National Climatic Data Center*
NOAA – *National Oceanic and Atmospheric Administration*
NWS – *National Weather Service*
PA – *Public Assistance*
SHELDUS – *Spatial Hazard Events and Losses Database for the United States*
TSTM – *Thunderstorm*

Probability of Future Events

Winter storm hazards in New York State are virtually guaranteed yearly since the State is located at relatively high latitudes resulting in winter temperatures that range between 0°F and 32 °F for a good deal of the fall through early spring season (late October until mid-April). In addition, the State is exposed to large quantities of moisture from both the Great Lakes and the Atlantic Ocean. While it is almost certain that a number of significant winter storms will occur during the winter and fall season, what is not easily determined is how many such storms will occur during that time frame (NYS DHSES, 2014).

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 three to five 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 seven to 10 years within the State (NYS DHSES, 2014). It is estimated that Westchester County will continue to experience direct and indirect impacts of severe winter storms annually.

In Section 5.3, the identified hazards of concern for Westchester County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for severe winter storms in the County is considered 'frequent' (event likely to occur within 25 years, as presented in Table 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 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 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. Westchester County is part of Region 5, East Hudson and Mohawk River Valleys. Some of the issues in this region, affected by climate change, include: more frequent heat waves and above 90°F days, more heat-related deaths, increased frequency of heavy precipitation and flooding, decline in air quality, etc. (NYSERDA, 2011).

Temperatures in New York State are warming, with an average rate of warming over the past century of 0.25° F per decade. Average annual temperatures are projected to increase across New York State by 2° F 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. By the end of the century, the greatest warming is projected to be in the northern section of the State (NYSERDA, 2014).

Regional precipitation across New York State is projected to increase by approximately one to eight-percent by the 2020s, three to 12-percent by the 2050s, and four to 15-percent by the 2080s. By the end of the century, the greatest increases in precipitation are projected to be in the northern areas of the State (NYSERDA, 2014).

In Region 5, it is estimated that temperatures will increase by 3.5ºF to 7.1ºF by the 2050s and 4.1ºF to 11.4ºF by the 2080s (baseline of 47.6ºF). Precipitation totals will increase between 2 and 15% by the 2050s and 3 to 17% by the 2080s (baseline of 38.6 inches). Table 5.4.5-3 displays the projected seasonal precipitation change for the East Hudson and Mohawk River Valleys ClimAID Region (NYSERDA, 2014).

Table 5.4.5-3. Projected Seasonal Precipitation Change in Region 5, 2050s (% change)

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

Source: NYSERDA, 2011

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

- Up to eight inches of rain fall in the rain band near the coast over a 36-hour period
- Up to four inches of freezing rain in the ice band near central New York State, of which between one and two inches of accumulated ice, over a 24-hour period
- Up to two feet of accumulated snow in the snow band in northern and western New York State over a 48-hour period (NYSERDA, 2011)

New York State is already experiencing the effects of climate change during the winter season. Winter snow cover is decreasing and spring comes, on average, about a week earlier than it did a few years ago. Nighttime temperatures are measurably warmer, even during the colder months (NYSDEC, Date Unknown). Overall winter temperatures in New York State are almost five degrees warmer than in 1970 (NYSDEC, Date Unknown). The State has seen a decrease in the number of cold winter days (below 32°F) and can expect to see a decrease in snow cover, by as much as 25 to 50% by end of the next century. The lack of snow cover may jeopardize opportunities for skiing, snowmobiling and other types of winter recreation; and natural ecosystems will be affected by the changing snow cover (Cornell University College of Agriculture and Life Sciences, 2011).

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

5.4.5.2 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 Westchester 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 as compared to that presented in the 2005 Westchester 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 Westchester 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

The custom general building stock generated for this HMP update was used to support an evaluation of assets exposed and the potential impacts associated with this hazard.

Impact on Life, Health and Safety

According to the NOAA National Severe Storms Laboratory (NSSL); every year, winter weather indirectly and deceptively kills hundreds of people in the U.S., primarily from automobile accidents, overexertion and exposure. Winter storms are often accompanied by strong winds creating blizzard conditions with blinding wind-driven snow, drifting snow and extreme cold temperatures and dangerous wind chill. They are considered deceptive killers because most deaths and other impacts or losses are indirectly related to the storm. People can die in traffic accidents on icy roads, heart attacks while shoveling snow, or of hypothermia from prolonged exposure to cold. Heavy accumulations of ice can bring down trees and power lines, disabling electric power and communications for days or weeks. Heavy snow can immobilize a region and paralyze a city, shutting down all air and rail transportation and disrupting medical and emergency services. Storms near the coast can cause coastal flooding and beach erosion as well as sink ships at sea. The economic impact of winter weather each year is huge, with costs for snow removal, damage and loss of business in the millions (NSSL, 2006).

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

Heavy accumulations of ice can bring down trees, electrical wires, telephone poles and lines, and communication towers. Communications and power can be disrupted for days while utility companies work to repair the extensive damage. Even small accumulations of ice may cause extreme hazards to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (NSSL, 2006).

For the purposes of this HMP, the entire population of Westchester County (949,113) is exposed to severe winter storm events (U.S. Census Bureau, 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 the County Profile for population statistics for each participating municipality.

The elderly are considered most susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice. In addition, severe winter storm events can reduce the ability of these populations to access emergency services. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply).

Impact on General Building Stock

The entire general building stock inventory in Westchester 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 5.4.5-4 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 plan considers percentage damages that could result from severe winter storm conditions. Table 5.4.5-4 below summarizes percent damages that could result from severe winter storm conditions for the County's total general building stock (structure only). Given professional knowledge and information available, the potential losses for this hazard are considered to be overestimated.

Table 5.4.5-4. General Building Stock Exposure (Structure Only) and Estimated Losses from Severe Winter Storm Events in Westchester County

Municipality	Total RV (Structure only)	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Ardsley (V)	$1,004,645,830	$10,046,458	$50,232,292	$100,464,583
Bedford (T)	$5,451,464,008	$54,514,640	$272,573,200	$545,146,401
Briarcliff Manor (V)	$2,194,162,224	$21,941,622	$109,708,111	$219,416,222
Bronxville (V)	$1,694,686,839	$16,946,868	$84,734,342	$169,468,684
Buchanan (V)	$1,944,545,818	$19,445,458	$97,227,291	$194,454,582
Cortlandt (T)	$6,989,473,890	$69,894,739	$349,473,695	$698,947,389
Croton-on-Hudson (V)	$2,119,932,123	$21,199,321	$105,996,606	$211,993,212
Dobbs Ferry (V)	$2,194,515,432	$21,945,154	$109,725,772	$219,451,543
Eastchester (T)	$3,609,064,266	$36,090,643	$180,453,213	$360,906,427
Elmsford (V)	$1,011,898,477	$10,118,985	$50,594,924	$101,189,848
Greenburgh (T)	$12,729,170,899	$127,291,709	$636,458,545	$1,272,917,090
Harrison (T)	$9,147,880,385	$91,478,804	$457,394,019	$914,788,039
Hastings-on-Hudson (V)	$1,527,655,704	$15,276,557	$76,382,785	$152,765,570
Irvington (V)	$1,660,776,222	$16,607,762	$83,038,811	$166,077,622
Larchmont (V)	$1,352,506,748	$13,525,067	$67,625,337	$135,250,675
Lewisboro (T)	$3,243,450,518	$32,434,505	$162,172,526	$324,345,052
Mamaroneck (T)	$2,505,216,282	$25,052,163	$125,260,814	$250,521,628
Mamaroneck (V)	$3,761,418,986	$37,614,190	$188,070,949	$376,141,899

Municipality	Total RV (Structure only)	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Mount Kisco (T)	$3,021,776,949	$30,217,769	$151,088,847	$302,177,695
Mount Pleasant (T)	$9,223,489,016	$92,234,890	$461,174,451	$922,348,902
Mount Vernon (C)	$10,513,643,877	$105,136,439	$525,682,194	$1,051,364,388
New Castle (T)	$5,730,848,942	$57,308,489	$286,542,447	$573,084,894
New Rochelle (C)	$14,173,804,740	$141,738,047	$708,690,237	$1,417,380,474
North Castle (T)	$5,688,857,022	$56,888,570	$284,442,851	$568,885,702
North Salem (T)	$1,600,118,414	$16,001,184	$80,005,921	$160,011,841
Ossining (T)	$1,395,190,504	$13,951,905	$69,759,525	$139,519,050
Ossining (V)	$3,475,001,257	$34,750,013	$173,750,063	$347,500,126
Peekskill (C)	$4,197,700,345	$41,977,003	$209,885,017	$419,770,035
Pelham (V)	$1,128,604,342	$11,286,043	$56,430,217	$112,860,434
Pelham Manor (V)	$1,313,019,752	$13,130,198	$65,650,988	$131,301,975
Pleasantville (V)	$1,538,985,095	$15,389,851	$76,949,255	$153,898,510
Port Chester (V)	$4,704,483,378	$47,044,834	$235,224,169	$470,448,338
Pound Ridge (T)	$1,678,304,487	$16,783,045	$83,915,224	$167,830,449
Rye (C)	$4,349,710,315	$43,497,103	$217,485,516	$434,971,032
Rye Brook (V)	$2,903,600,321	$29,036,003	$145,180,016	$290,360,032
Scarsdale (T)	$4,500,173,896	$45,001,739	$225,008,695	$450,017,390
Sleepy Hollow (V)	$1,761,996,250	$17,619,963	$88,099,813	$176,199,625
Somers (T)	$6,068,992,967	$60,689,930	$303,449,648	$606,899,297
Tarrytown (V)	$2,783,030,922	$27,830,309	$139,151,546	$278,303,092
Tuckahoe (V)	$1,006,691,887	$10,066,919	$50,334,594	$100,669,189
White Plains (C)	$16,704,710,777	$167,047,108	$835,235,539	$1,670,471,078
Yonkers (C)	$32,794,059,885	$327,940,599	$1,639,702,994	$3,279,405,989
Yorktown (T)	$8,358,614,593	$83,586,146	$417,930,730	$835,861,459
Westchester County (Total)	**$214,757,874,586**	**$2,147,578,746**	**$10,737,893,729**	**$21,475,787,459**

Source: Westchester County

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 presentation for the flood hazard. Generally, losses resulting from flooding associated with severe winter storms should be less than that associated with a 100-year flood. Please refer to the flood profile (Section 5.4.3). In addition, coastal areas are at high risk during winter storm events that involve high winds. Please refer to the Severe Storms profile for losses resulting from wind (Section 5.4.4).

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 due to the application of salt and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires the clearing roadways and alerting citizens to dangerous conditions; following the winter season, resources for road maintenance and repair are required.

Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. Another impact on the economy includes impacts on commuting into, or out of, the area for work

or school. The loss of power and closure of roads prevents the commuter population traveling to work within and outside of the County.

Future Growth and Development

As discussed in Sections 4 and 9, 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 five (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 activities to eliminate loss of life and property and infrastructure damages during winter storm events:

- Removal of snow from roadways
- Removal of 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
- Removal of debris/obstructions in waterways and develop routine inspections/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 to 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 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], 2013). Refer to the Climate Change Impacts section earlier in this profile for impacts to Westchester County.

Change of Vulnerability

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/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 back-up power are included in Volume II, Section 9 of this plan.