5.4.3 SEVERE WINTER STORM

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

HAZARD PROFILE

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

Description

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

Heavy Snow: According to the National Weather Service (NWS), heavy snow is generally snowfall accumulating to 4 inches or more in depth in 12 hours or less; or snowfall accumulating to six inches or more in depth in 24 hours or less. A snow squall is an intense, but limited duration, period of moderate to heavy snowfall, also known as a snowstorm, accompanied by strong, gusty surface winds and possibly lightning (generally moderate to heavy snow showers) (NWS, 2005). Snowstorms are complex phenomena involving heavy snow and winds, whose impact can be affected by a great many factors, including a region's climatologically susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and occurrence during the course of the day, weekday versus weekend, and time of season (Kocin and Uccellini, 2011).

Blizzard: Blizzards are characterized by low temperatures, wind gusts of 35 miles per hour (mph) or more and falling and/or blowing snow that reduces visibility to ¼-mile or less for an extended period of time (three or more hours) (NWS, 2005).

Sleet or Freezing Rain Storm: Sleet is defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes. These pellets of ice usually bounce after hitting the ground or other hard surfaces. Freezing rain is rain that falls as a liquid but freezes into glaze upon contact with the ground. Both types of precipitation, even in small accumulations, can cause significant hazards to a community (NWS, 2005).

Ice storm: An ice storm is used to describe occasions when damaging accumulations of ice are expected during freezing rain situations. Significant accumulations of ice pull down trees and utility lines resulting in loss of power and communication. These accumulations of ice make walking and driving extremely dangerous, and can create extreme hazards to motorists and pedestrians (NWS, 2005).

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

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

Nor'Easter (abbreviation for North Easter): Nor'Easters are named for the strong northeasterly winds that blow in from the ocean ahead of the storm and over coastal areas. They are also referred to as a type of extra-tropical cyclones (mid-latitude storms, or Great Lake storms). A Nor'Easter is a macro-scale extra-tropical storm whose winds come from the northeast, especially in the coastal areas of the northeastern U.S. and Atlantic Canada. Wind gusts associated with Nor'Easters can exceed hurricane forces in intensity. Unlike tropical cyclones that form in the tropics and have warm cores (including tropical depressions, tropical storms and hurricanes); Nor'Easters contain a cold core of low barometric pressure that forms in the mid-latitudes. Their strongest winds are close to the earth's surface and often measure several hundred miles across. Nor'Easters may occur at any time of the year but are more common during fall and winter months (September through April) (NYCOEM, 2008).

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

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 [Multi-Community Environmental Storm Observatory (MESO)], 1998-2007).

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

Extent

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

The extent of a severe winter storm can be classified by meteorological measurements, such as those above, and by evaluating its societal impacts. The Northeast Snowfall Impact Scale (NESIS) categorizes snowstorms, including Nor'Easter events, in this manner. Unlike the Fujita Scale (tornado) and Saffir-Simpson Scale (hurricanes), there is no widely used scale to classify snowstorms. NESIS was developed by Paul Kocin of The Weather Channel and Louis Uccellini of the NWS to characterize and rank high-impact, northeast snowstorms. These storms have large areas of 10 inch snowfall accumulations and greater. NESIS has five ranking categories: Notable (1), Significant (2), Major (3), Crippling (4), and Extreme (5) (Table 5.4.3-1). The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus, NESIS gives an indication of a storm's societal impacts. This scale was developed because of the impact northeast snowstorms can have on the rest of the country in terms of transportation and economic impact (Kocin and Uccellini, 2011).

Table 5.4.3-1. NESIS Ranking Categories 1 - 5

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

Source: Kocin and Uccellini, 2004

NESIS scores are a function of the area affected by the snowstorm, the amount of snow, and the number of people living in the path of the storm. These numbers are calculated into a raw data number ranking from "1" for an insignificant fall to over "10" for a massive snowstorm. Based on these raw numbers, the storm is placed into its decided category. The largest NESIS values result from storms producing heavy snowfall over large areas that include major metropolitan centers (Enloe, 2007). Storms that have occurred in the northeastern U.S. using this impact scale are listed in Table 5.4.3-5 in the "Previous Occurrences" section of this profile.

Nor'Easters

Though the occurrence of a Nor'Easter can be forecasted with some accuracy, predicting their impact can be a little more complex. The extent of a Nor'Easter can be categorized by the Dolan-Davis Nor'Easter Intensity Scale. In 1993, researchers Robert Davis and Robert Dolan created this Nor'Easter intensity scale, but it deals primarily with beach and coastal deterioration. This scale, presented as Table 5.4.3-2, categorizes or rates the intensity of Nor'Easters from 1 (weak) to 5 (extreme) based on their storm class. This is used to give an estimate of the potential beach erosion, dune erosion, overwash and property damages expected from a Nor'Easter (MESO, Date Unknown).

Table 5.4.3-2. The Dolan-Davis Nor'Easter Intensity Scale

Storm Class	Beach Erosion	Dune Erosion	Overwash	Property Damage
1 (*Weak*)	Minor Changes	None	No	No
2 (*Moderate*)	Modest; mostly to lower beach	Minor	No	Modest
3 (*Significant*)	Erosion extends across the beach	Can be significant	No	Loss of many structures at local level
4 (*Severe*)	Severe beach erosion and recession	Severe dune erosion or destruction	On low beaches	Loss of structures at community level
5 (*Extreme*)	Extreme beach erosion	Dunes destroyed over extensive areas	Massive in sheets and channels	Extensive at regional-scale; millions of dollars

Source: MESO, 2002

Dr. Gregory Zielinski, Maine state climatologist and an associate research professor at the University of Maine Institute for Quaternary and Climate Studies, developed a way to help weather forecasters and the public understand the likely impacts of winter storms. Dr. Zielinski applies his analysis mainly to two types of storms: Nor'Easters that often intensity in the mid-Atlantic region and move up the coast into New England; and storms that originate east of the Rocky Mountains and that move through the Great Lakes region or up the Ohio River valley. These storms are often called the Witches of November and have been responsible for shipwrecks on the Great Lakes (sinking of the Edmund Fitzgerald) (National Aeronautics and Space Administration [NASA], 2002).

In an article posted in the January 2002 issue of the Bulletin of the American Meteorological Society (BAMS), Dr. Zielinski explains: "My classification scheme allows forecasters and meteorologists to easily summarize the intensity of a winter storm by giving it an intensity index and placing it into its appropriate category on a 1-5 scale. The potential impact of the storm can then be passed on to public service officials so they may make plans for precipitation amounts, particularly snow, snowfall rates, wind speeds, drifting potential and overall impact on schools, businesses, travelers, and coastal communities" (NASA, 2002).

His approach to storms uses two features of a storm: air pressure and forward speed. Based on the calculations to determine the different characteristics of the storms (Dolan-Davis Nor'Easter Intensity Scale), which reflects the storm's strength, Dr. Zielinski places the storm into a category between one and five. Forward speed is important because even moderately intense storms can have a large impact if they move slowly (NASA, 2002).

In Dr. Zielinski's classification system, a second number reflecting forward speed is used together with the first number from the Dolan-Davis Nor'Easter Intensity Scale. Like the Intensity Scale, the second number of his scale ranges between one and five. A five would be the slowest moving and thus longest

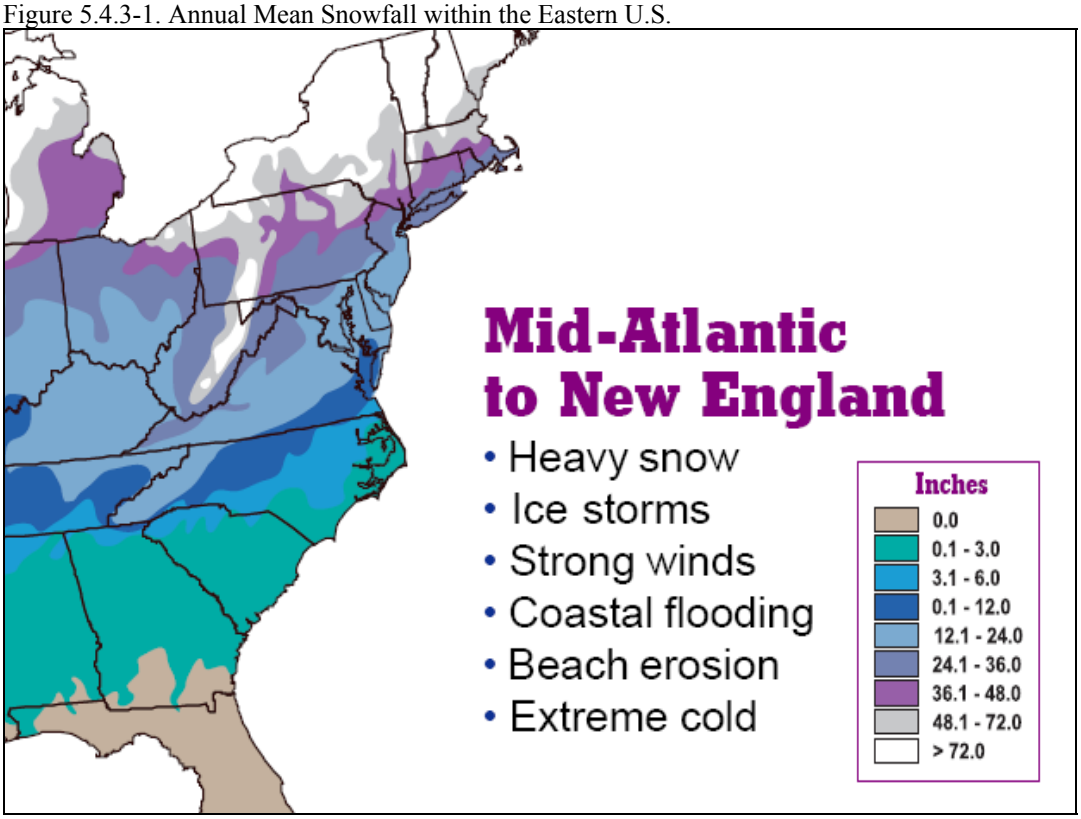
duration storm. A storm's category might be 2.4 or 4.3, reflecting intensity with the first digit and duration with the second (MESO, 2002; NASA, 2002).

Dr. Zielinski has used his system to classify more than 70 past storms. He has made over 550 individual classifications, looking at the March 1993 "Storm of the Century", the Great Arctic Outbreak of 1899, and Blizzard of 1888 and other storms that are a part of legendary U.S. weather (NASA, 2002).

Location

Winter weather, particularly snowstorm events, has historically affected many U.S. states, mainly in the Northeast and Midwest. 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. Syracuse, Buffalo, Rochester, and Albany are typically in the top 10 cities in the Nation in annual snowfall. These municipalities are located in Onondaga, Erie, Monroe, and Albany Counties. Although the entire State is subject to winter storms, the easternmost and west-Central portions of the State are more likely to suffer under winter storm occurrences than any other location (New York State Disaster Preparedness Commission [NYSDPC], 2008). With the exception of coastal New York State, the State receives an average seasonal amount of 40 inches of snow or more. The average annual snowfall is greater than 70 inches over 60-percent of New York State's area; however, this does not include Westchester County which receives between 24 and 48 inches (Figure 5.4.3-1).

Figure 5.4.3-1. Annual Mean Snowfall within the Eastern U.S.



Source: NWS, 2001

Topography, elevation and proximity to large bodies of water result in a great variation of snowfall in the State's interior, even within relatively short distances. Maximum seasonal snowfall, averaging more than 175 inches, occurs on the western and southwestern slopes of the Adirondacks and Tug Hill. A secondary maximum of 150 to 180 inches prevails in the southwestern highlands, approximately 10 to 30 miles inland from Lake Erie. Record heavy snow accumulations, averaging between 100 and 120 inches, occur within (1) the uplands of southwestern Onondaga County and adjoining counties; (2) the Cherry Valley section of northern Otsego and southern Herkimer Counties; and (3) the Catskill highlands in Ulster, Delaware and Sullivan counties. Minimum seasonal snowfall of 40 to 50 inches occurs upstate in (1) Niagara County, near the south shore of Lake Ontario, (2) the Chemung and mid-Genesee River Valleys of western New York, and (3) near the Hudson River in Orange, Rockland, and Westchester Counties upstream to the southern portion of Albany County (New York State Climate [NYSC] Office, Date Unknown).

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.

The NYSDPC and NYSEMO listed Westchester County as the 22nd county in the State most threatened by and vulnerable to snow and snow loss, with an annual average snowfall of 32.3 inches. Westchester County is also listed as the 31st county in New York State most threatened by and vulnerable to ice storms and ice storm loss (NYSDPC, 2008).

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.

The Northeast Snowfall Impact Scale was developed by Paul Kocin and Louis Uccellini of the National Weather Service. It characterizes and ranks high-impact Northeast snowstorms. These storms have large areas of snowfall accumulations of 10 inches and greater. Table 5.4.3-3 ranks 40 high-impact snowstorms that have affected the Northeast urban corridor. Although the severity of these events may vary throughout the State, many of these listed storms impacted Westchester County. This list does not represent all storms that may have impacted the northeastern U.S.

Table 5.4.3-3. Top 40 High-Impact Snowstorms that Affected the Northeast U.S. (Arranged by Rank/Category)

Rank	Dates	NESIS	Category	Description
1	12-14 March 1993	13.2	5	Extreme
2	6-8 January 1996	11.78	5	Extreme
3	2-5 March 1960	8.77	4	Crippling
4	15-18 February 2003 (preliminary)	8.13	4	Crippling
5	2-5 February 1961	7.06	4	Crippling

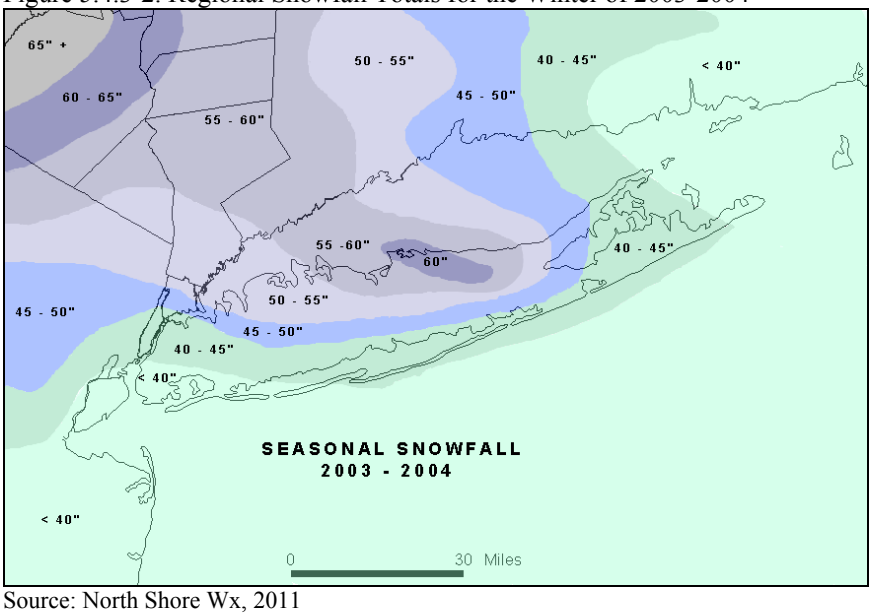
Rank	Dates	NESIS	Category	Description
6	11-14 January 1964	6.91	4	Crippling
7	21-24 January 2005	6.8	4	Crippling
8	19-21 January 1978	6.53	4	Crippling
9	25-28 December 1969	6.29	4	Crippling
11	14-17 February 1958	6.25	4	Crippling
10	10-12 February 1983	6.25	4	Crippling
12	29-31 January 1966	5.93	3	Major
13	5-7 February 1978	5.78	3	Major
14	12-15 February 2007	5.63	3	Major
15	21-23 January 1987	5.4	3	Major
16	8-12 February 1994	5.39	3	Major
17	23-28 February 2010 (preliminary)	5.11	3	Major
19	17-19 February 1979	4.77	3	Major
18	18-20 February 1972	4.77	3	Major
20	11-13 December 1960	4.53	3	Major
21	4-7 February 2010 (preliminary)	4.3	3	Major
22	22-28 February 1969	4.29	3	Major
23	12-13 February 2006	4.1	3	Major
24	18-21 January 1961	4.04	3	Major
25	18-21 December 2009 (preliminary)	4.03	3	Major
26	9-11 February 2010 (preliminary)	3.93	2	Significant
27	23-25 December 1966	3.81	2	Significant
29	8-10 February 1969	3.51	2	Significant
28	18-21 March 1958	3.51	2	Significant
30	5-8 February 1967	3.5	2	Significant
31	6-7 April 1982	3.35	2	Significant
32	15-18 March 2007 (preliminary)	2.55	2	Significant
33	24-26 January 2000	2.52	2	Significant
34	30-31 December 2000	2.37	1	Notable
35	31 March - 1 April 1997	2.29	1	Notable
36	18-19 March 1956	1.87	1	Notable
37	1-3 March 2009 (preliminary)	1.65	1	Notable
38	22-23 February 1987	1.46	1	Notable
39	2-4 February 1995	1.43	1	Notable

Rank	Dates	NESIS	Category	Description
40	25-26 January 1987	1.19	1	Notable

Source: Kocin and Uccellini, 2010

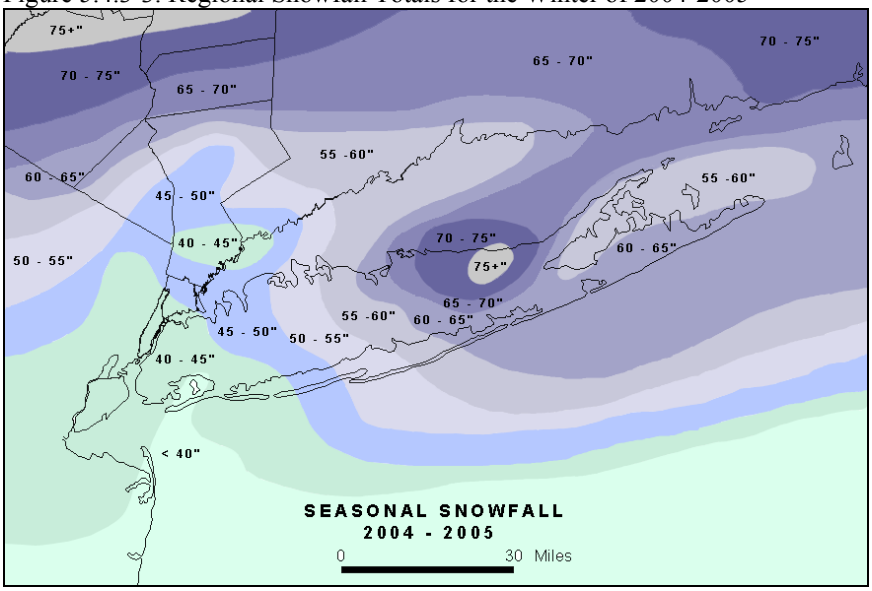
Figures 5.4.3-2 through 5.4.3-6 indicate the seasonal snow accumulations throughout southeastern New York State between 2003 and 2008. Based on these findings, the 2004-2005 winter season experienced the most snowfall averaging around 40 and 65 inches of snow throughout Westchester County. Between 40 and 50 inches accumulated within the vicinity of the Greater Greenburgh Planning Area (North Shore Wx, 2010).

Figure 5.4.3-2. Regional Snowfall Totals for the Winter of 2003-2004



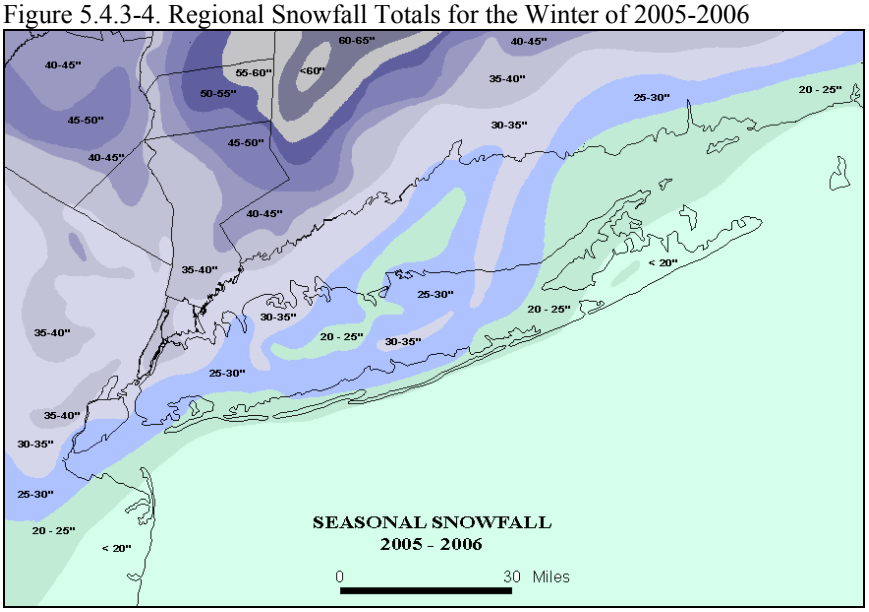
Source: North Shore Wx, 2011

Figure 5.4.3-3. Regional Snowfall Totals for the Winter of 2004-2005



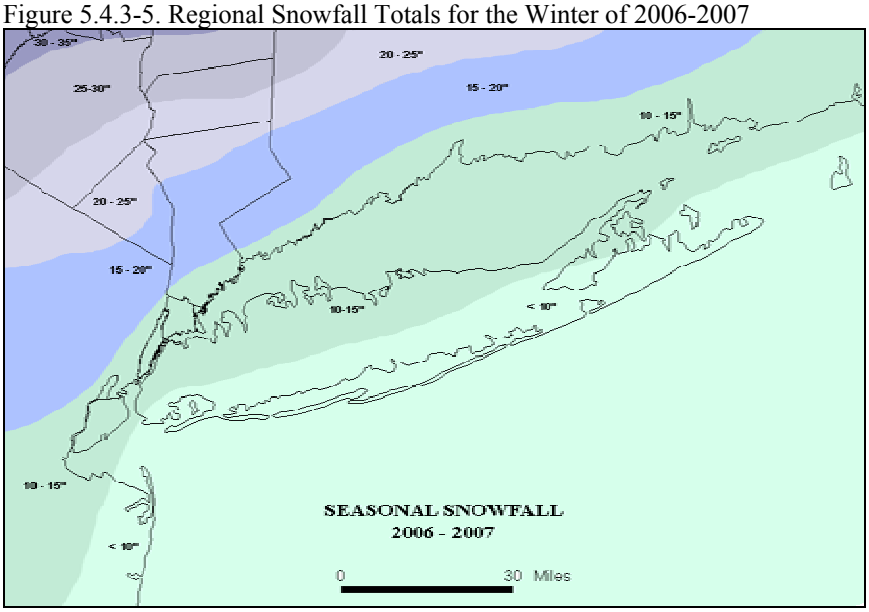
Source: North Shore Wx, 2011

Figure 5.4.3-4. Regional Snowfall Totals for the Winter of 2005-2006



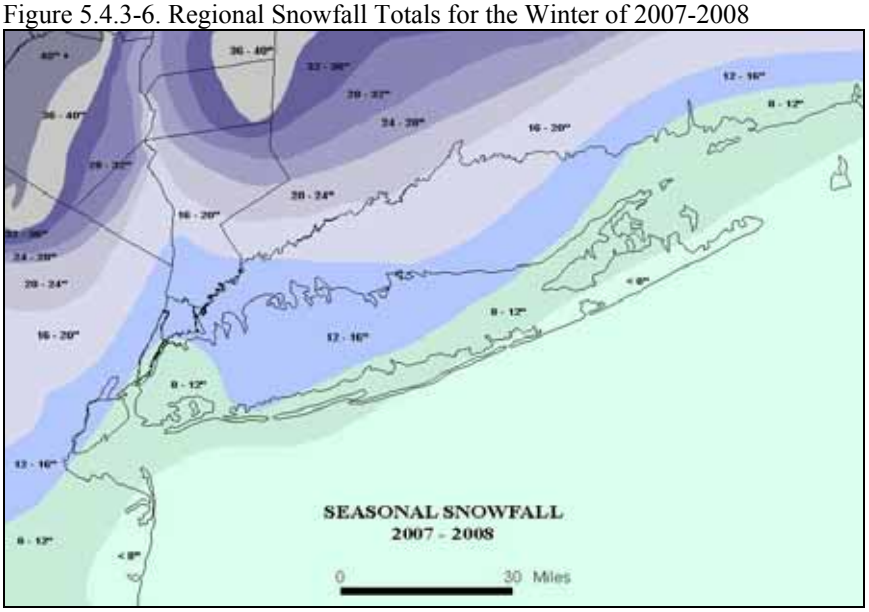
Source: North Shore Wx, 2011

Figure 5.4.3-5. Regional Snowfall Totals for the Winter of 2006-2007



Source: North Shore Wx, 2011

Figure 5.4.3-6. Regional Snowfall Totals for the Winter of 2007-2008



Source: North Shore Wx, 2011

Between 1954 and 2010, FEMA declared that New York State experienced 23 winter storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: winter storms, severe storms, coastal storms, ice storm, blizzard, snowstorm, Nor'Easter and flooding. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, the NYS HMP and other sources indicate that Westchester County has been declared as a disaster area as a result of five winter storm events (FEMA, 2010; NYSDPC, 2008). Table 5.4.3-4 summarizes the FEMA Presidential Disaster (DR) or Emergency (EM) Declarations for winter storm events for the County.

Table 5.4.3-4. Presidential Disaster / Emergency Declarations for Severe Winter Storm Events in Westchester County

Type of Event*	Date**	Declaration Number	Cost of Losses (approximate)***
Coastal Storm, High Tides, Heavy Rain, Flooding	December 11-12, 1992	DR-974	New York State experienced approximately $31.2 M 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 M in flood damages. Over 20,000 power failures occurred throughout the County. Estimated losses in the Greater Greenburgh Planning Area are unknown.
Severe Blizzard ("The Storm of the Century") (also identified as a Nor'Easter)	March 12-15, 1993	EM-3107	Listed as a top billion dollar weather disaster storm, impacting 26 states and resulted in approximately $3 B in damages. FEMA declared an EM in 17 states, including New York State. New York State experienced approximately $8.4 M in eligible damages. Westchester County received between 10 to 20 inches of snow from this event. In Westchester, there was 16.5 inches of snow in Croton Falls, 14.6 inches in Scarsdale and 13 inches in Yonkers. Estimated losses in the Greater Greenburgh Planning Area are unknown.

Type of Event*	Date**	Declaration Number	Cost of Losses (approximate)***
Blizzard	January 7-9, 1996	DR-1083	Heavy snow, combined with strong winds caused blizzard conditions in the New York City area. Approximately 21 inches of snow fell in Central Park in Manhattan. Local airports were closed for almost two days. A state of emergency was declared for several counties in New York State; however, Westchester County was not declared a state of emergency. Wind gusts reached more than 50 mph, causing widespread power outages, numerous fatalities and $1 B in damages from Washington, D.C. to Boston. Estimated losses in the Greater Greenburgh Planning Area are unknown.
Snowstorm	February 17-18, 2003	EM-3184	Multiple counties throughout New York State experienced an impact from this regional event. Almost two feet of snow fell in the New York City area. Nationwide, the storm killed 42 people. Major airports in the area were closed. Governor Pataki declared a snow emergency for New York City, Long Island and 12 other counties that were hit by the storm. Westchester County received between 14.5 and 26 inches of snow from this event and experienced approximately $1.8 M in property damages. Estimated losses in the Greater Greenburgh Planning Area are unknown.
Severe Storms and Inland and Coastal Flood (also identified as a Nor'Easter)	April 14-18, 2007	DR-1692	New York State experienced millions in eligible damages, mostly due to flooding. FEMA gave out more than $61 million in assistance to affected counties within the State. Private property losses in Westchester County were estimated at $83 M and public property losses were estimated at $2 M. Disaster assistance to the County totaled $30 M as of July 23, 2007. The flooding from this Nor'Easter damaged homes, business and public infrastructure that amounted to tens of millions of dollars in damage costs. Rainfall totals in the County ranged between 5.85 inches to 8.22 inches. Estimated losses in the Greater Greenburgh Planning Area are unknown.

Source: FEMA, 2011; NCDC, 2011; NYSEMO, 2011; Kocin and Uccellini, 2004

Note (1): DR-974 and DR-1692 were classified as Nor'Easters by various sources that produced significant flood impacts throughout the County; therefore, they are included with this hazard category but also mentioned in more detail in Section 5.4.2 Flood.

Note (2): Dollars rounded to nearest thousand. Recorded losses indicate the dollar value of covered losses paid, as available through the public records reviewed.

* The 'Type of Event' is the disaster classification that was assigned to the event by FEMA.

** Date of Incident

*** Flood impact or damage associated with any of these events are further discussed in Section 5.4.2

DR Major Disaster Declaration

EM Emergency Declaration

FEMA Federal Emergency Management Agency

K Thousand ($)

M Million ($)

Based on all sources researched, known winter storm and extreme cold events that have impacted the Greater Greenburgh Planning Area and its neighboring Towns and Villages (Mount Pleasant, White Plains, Scarsdale, Yonkers and Sleepy Hollow) are identified in Table 5.4.3-5. With winter storm documentation for New York State being so extensive, not all sources may have been identified or researched. Hence, Table 5.4.3-5 may not include all events that have occurred throughout the region.

Table 5.4.3-5. Severe Winter Events between 1983 and 2011

Event Date / Name	Location	Losses / Impacts	Source(s)
Great "Megalopolitan" Snowstorm February 11-12 1983	Countywide	Between February 11 and 12th, a snowstorm moved up the eastern coast of the U.S. Snow accumulations ranged from 12 inches to 30 inches. Between 10 and 20 inches of snow fell in Westchester County. Westchester County experienced approximately $63 K in property damages.	Hazards and Vulnerability Research Institute (SHELDUS), Gedzelman et al., NOAA
Flood / Nor'Easter December 11-12, 1992 (FEMA DR-974)	Multi-State	See FEMA Disaster Declarations (Table 5.4.3-4)	FEMA, NYSDPC, NYSEMO, New York Times, The Associated Press, McFadden
Freezing Rain January 3, 1993	Multi-County	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 M in property damages.	NOAA-NCDC
Blizzard "The Storm of the Century" March 12-15, 1993 (FEMA EM-3107)	Statewide	See FEMA Disaster Declarations (Table 5.4.3-4)	FEMA, Kocin and Ucceliini, NYSDPC, NWS, Steinberg (New York Times), Miller
Blizzard January 6-8, 1996 (FEMA DR-1083)	Multi-State	See FEMA Disaster Declarations (Table 5.4.3-4)	FEMA, NYSDPC, NYSEMO, Kocin and Uccellini
Snowstorm December 24-25, 2002 and January 3-4, 2003	Multi-County	Resulted in an Emergency Declaration for 18 New York State counties (EM-3173), however, it did not include Westchester County. Between December 24th and 25th, 11 inches of snow fell in the Village of Tarrytown.	FEMA, Kocin and Uccellini, NOAA-NCDC, Hazards and Vulnerability Research Institute (SHELDUS), NWS
Snowstorm "President's Day Storm" February 17-18, 2003 (FEMA DR-3184)	Multi-County	See FEMA Disaster Declarations (Table 5.4.3-4)	FEMA, NWS, NOAA-NCDC, NYSDPC, Hazards and Vulnerability Research Institute (SHELDUS), Kocin and Uccellini
Snowstorm December 4-7, 2003	Multi-County	Snowfall totals in Westchester County ranged from 11.0 inches at Armonk to 16.0 inches at Yorktown. In the Village of Tarrytown, 8.5 inches of snow fell. Some sources indicated that Westchester County received over 20 inches of snow during this event.	NOAA-NCDC, Grumm

Event Date / Name	Location	Losses / Impacts	Source(s)
Heavy Snow January 28, 2004	Multi-County	Snowfall totals for the Village of Hastings-on-Hudson was approximately 10 inches.	NWS
Snowstorm December 9, 2005	Multi-County	Snowfall totals in Westchester County ranged from 5.0 inches at New Rochelle to 10.0 inches at Milton.	NWS
Snowstorm February 12-13, 2006	Multi-State	The highest snowfall amounts fell across New York City and Westchester County with 15 to 27 inches. Snowfall totals in the Greater Greenburgh Planning Area included 20 inches in the Village of Hastings-on-Hudson	Kocin and Uccellini, NWS, Hauser (New York Times), McFadden, NOAA-NCDC
Severe Storm / Inland and Coastal Flooding April 14-17, 2007* (also identified as a Nor'Easter) (FEMA DR-1692)	Countywide	See FEMA Disaster Declarations (Table 5.4.3-4)	FEMA, Chas. H. Sells, Inc., The Associated Press, Fodero
Snowstorm February 22, 2008	Countywide	Snowfall totals in the Greater Greenburgh Planning Area include 8 inches in the Village of Hastings-on-Hudson and 8.4 inches in the Village of Ardsley.	NWS
Snowstorm February 10, 2010	Multi-State	Snowfall totals for the Greater Greenburgh Planning Area included 13.5 inches in the Village of Dobbs Ferry and 13 inches in the Village of Hastings-on-Hudson	NWS
Snowstorm February 25-27, 2010	Multi-State	In the Greater Greenburgh Planning Area, the Village of Hastings-on-Hudson had 20 inches of snow.	NWS
Blizzard December 26-27, 2011	Multi-State	A low pressure system passed through the Mid Atlantic coast, just east of Long Island from December 26th through the 27th. 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. In the Greater Greenburgh Planning Area, 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.	NWS, FEMA

Note (1): This table does not represent all events that may have occurred throughout the County due to a lack of detail and/or their minor impact upon the County. The NOAA NCDC storm query indicated that Westchester County has experienced 63 snow and ice storm events between January 1, 1950 and November 30, 2010. However, most events are regional events not specific to Westchester County alone. Therefore, not all of these events were identified in this table due to minimal information made available or their minor impact on the County.

Note (2): 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.

B Billion ($)

DR Federal Disaster Declaration

EM	Federal Emergency Declaration
FEMA	Federal Emergency Management Agency
K	Thousand ($)
M	Million ($)
NCDC	National Climate Data Center
NOAA	National Oceanic Atmospheric Administration
NWS	National Weather Service
NYSDEC	New York State Department of Environmental Conservation
NYSDPC	New York State Disaster Preparedness Commission
SHELDUS	Spatial Hazard Events and Losses Database for the United States

Further descriptions of particular severe winter storm and extreme cold events that have impacted Westchester County and the Greater Greenburgh Planning Area are provided below for selected events where details regarding their impact were available. These descriptions are provided to give the reader a context of the winter storm and extreme cold events that have affected the City and to assist local officials in locating event-specific data for their municipalities based on the time and proximity of these events.

Monetary figures within the event descriptions were U.S. Dollar (USD) figures calculated during or within the approximate time of the event (unless present day recalculations were made by the sources reviewed). If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of inflation.

March 12-15, 1993 ("Superstorm of 1993," "Storm of the Century" or "Great Storm of 1993") (FEMA EM-3107): This storm was identified as both a Nor'easter and a blizzard by many sources. It was a massive storm complex, affecting at least 26 states and much of eastern Canada. The March 1993 storm is listed among the NOAA Top Billion Dollar Weather Disasters (Miller, 1995-2007), reportedly causing a total of $6.6 billion in damages along the eastern coast of the U.S. and resulting in over 270 fatalities (23 fatalities in New York State) (Lott, 1993). According to NYS HMP and NYSEMO, this blizzard resulted in total eligible damages of approximately $8.5 million through New York State (NYSDPC, 2008; NYSEMO, 2006).

Achieving a NESIS rating of 12.52, the "Storm of the Century" ranks as an 'Extreme' snow event. With a total area impacting, at peak, from Maine to Florida, a final total 5 to 50 inches of snowfall, and hurricane force winds, this storm ground most of the Eastern seaboard to a halt for days. Total snowfall accumulations for Westchester County were between 10 and 20 inches (Kocin and Uccellini, 2004). In Westchester County, there was 16.5 inches of snow in Croton Falls, 14.6 inches in Scarsdale and 13 inches in Yonkers (Steinberg, 1993). Estimated losses for the Greater Greenburgh Planning Area were not available in the materials reviewed to develop this plan.

This storm resulted in a statewide FEMA Emergency Declaration (FEMA EM-3107) on March 17, 1993. Through this declaration, all counties were declared eligible for federal and State disaster public assistance funds (NYSEMO, 2006; FEMA, 2008). Disaster aid for Westchester County was not available in the materials reviewed to develop this plan.

January 6-9, 1996 (FEMA DR-1083) ("Blizzard of '96"): Much of the eastern U.S. seaboard, from Tennessee to Maine, was affected by this blizzard. Many areas received between 1 and 3 feet of snow during this storm. This blizzard achieved a NESIS rating of 11.54, placing the storm in the Extreme category. A total of 4 to 40 inches of snow fell along the storms path, with the highest accumulations in the States of Pennsylvania, New Jersey, New York, Maryland, Virginia and West Virginia (Kocin and Uccellini, 2004).

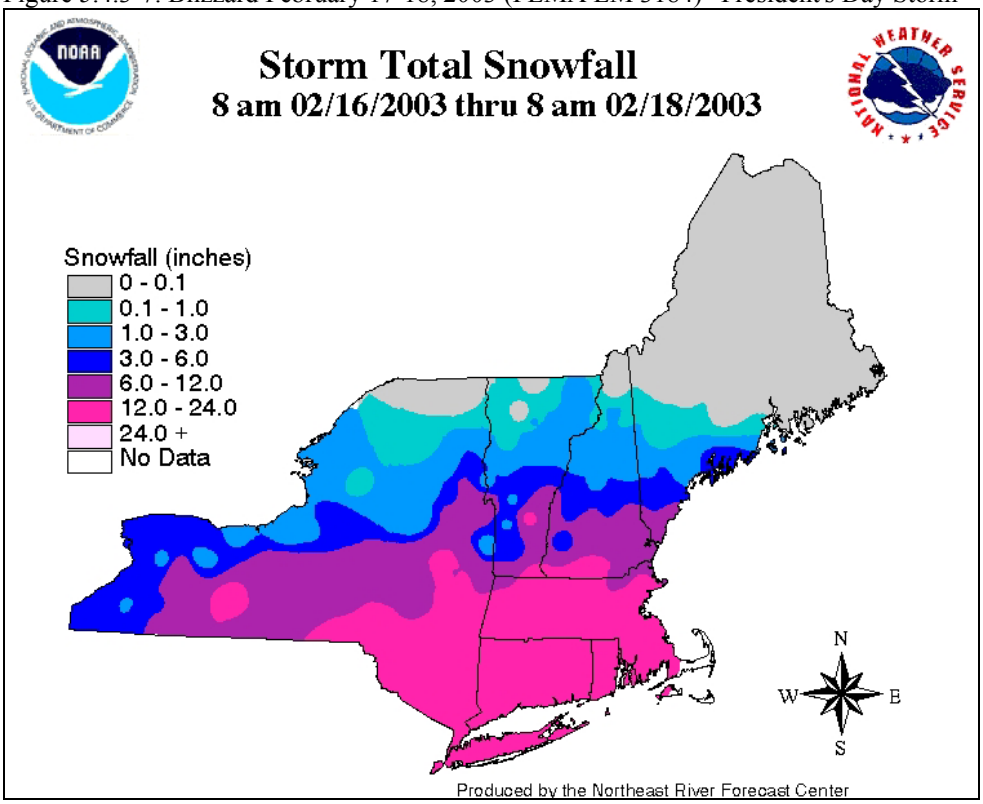
The major effects from this storm in New York State were felt across the southeastern sections of the State, resulting in property damages ranging from $21.3 to $70 million (NYSDPC, 2008; NWS, 1996). Many sources indicate that Westchester County experienced as much as 30 inches of snow during this blizzard (Kocin and Uccellini, 2004). Estimated losses for the Greater Greenburgh Planning Area were not available in the materials reviewed to develop this plan.

This storm resulted in a FEMA Disaster Declaration (FEMA DR-1083) on January 12, 1996. Through this declaration, the following Counties were declared eligible for federal and State disaster funds: Albany, Bronx, Columbia, Delaware, Dutchess, Greene, Kings, Nassau, New York, Orange, Putnam, Queens, Rensselaer, Richmond, Rockland, Suffolk, Sullivan, Ulster and Westchester (NYSEMO, 2006;

FEMA, 2008). Disaster aid for Westchester County was not available in the materials reviewed to develop this plan.

February 17-18, 2003 ("President's Day Storm") (FEMA EM-3184): This snowstorm, also known as the "President's Day Storm" was a coastal storm, resulting in heavy snowfall throughout the Mid-Atlantic states from Ohio to Maine. This storm achieved a NESIS rating of 8.91, placing the storm in the 'Crippling' category (Kocin and Uccellini, 2004). In New York State, snow accumulations ranged between 1 and 24 inches (Figure 5.4.3-7). Governor Pataki declared a snow emergency for Albany, Schenectady, Columbia, Greene, Suffolk, Nassau, Westchester, Rockland, Putnam, Orange, Sullivan, Dutchess, Ulster, and Delaware counties (Business Review, 2003). According to the NOAA-NCDC Storm Query, this event resulted in $20 million in property damages throughout New York State.

Figure 5.4.3-7. Blizzard February 17-18, 2003 (FEMA EM 3184) "President's Day Storm"



Source: NCDC, 2003

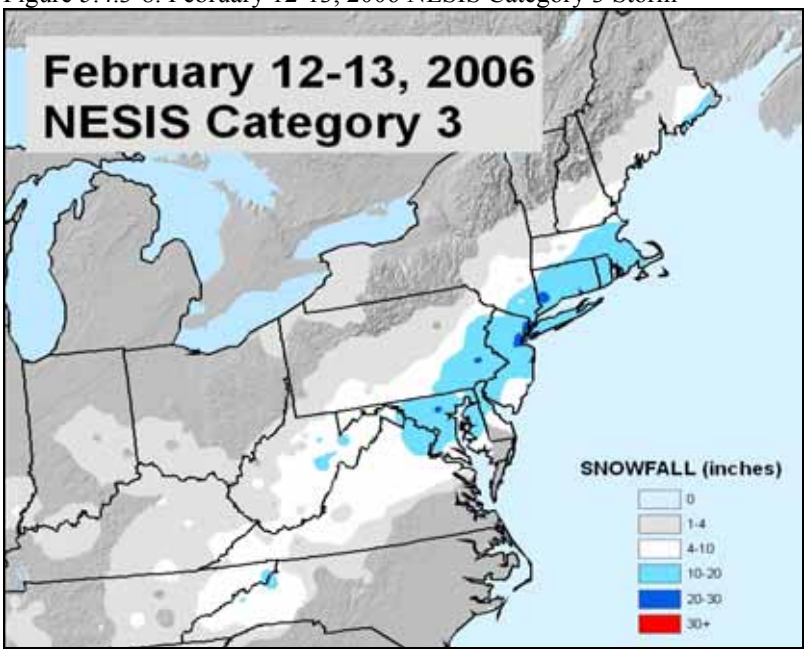
In Westchester County, snowfall totals during this event ranged between 10 and 30 inches and resulted in $1.8 million in damages (Hazards and Vulnerability Research Institute, 2007). Estimated losses for the Greater Greenburgh Planning Area were not available in the materials reviewed to develop this plan. Specific snowfall totals within Westchester County include:

- Thornwood (26.0 inches)
- Yorktown Heights (21.0 inches)
- Yonkers (19.0 inches)
- Mamaroneck (18.0 inches)
- White Plains (17.0 inches)
- Croton-On-Hudson (14.5 inches) (NWS, 2003).

This storm resulted in a FEMA Emergency Declaration (FEMA EM-3184) on March 27, 2003. Through this declaration, the following Counties were declared eligible for federal and State disaster funds: Albany, Bronx, Broome, Chenango, Columbia, Delaware, Dutchess, Greene, Kings, Nassau, New York, Orange, Putnam, Queens, Richmond, Rockland, Schenectady, Schoharie, Suffolk, Sullivan, Ulster and Westchester (FEMA, 2008). Disaster aid for Westchester County was not available in the materials reviewed to develop this plan.

February 11-12, 2006: This February 2006 snowstorm inundated the Northeast, closing regional airports, canceling hundreds of flights, and paralyzing normal traffic for city residents who took to the snow-caked streets in snowshoes and skis. The winter storm's high winds, icy snow, thunder and lightning hit much of the mid-Atlantic and New England region. A fairly large area was impacted, with snow accumulations of more than 20 inches in New York, New Jersey and Connecticut. The NWS described the weather conditions as "a major snowstorm" with winds up to 50 mph. Achieving a NESIS rating of 4.00, this event falls within the Major category (Figure 5.4.3-8) (Kocin and Uccellini, 2004).

Figure 5.4.3-8. February 12-13, 2006 NESIS Category 3 Storm



Source: Enloe, 2007

In Westchester County, snowfall totals during this event ranged between 10 and 30 inches. Estimated losses for the Greater Greenburgh Planning Area were not available in the materials reviewed to develop this plan. Specific snow totals throughout Westchester County include:

- New Rochelle (24.5 inches)
- Pound Ridge (24.0 inches)
- Yonkers (23.9 inches)
- Eastchester (23.2 inches)
- Katonah (22.0 inches)
- White Plains (21.5 inches)
- Hastings-On-Hudson (20.0 inches)
- Rye Brook (20.0 inches)
- Bronxville (19.8 inches)
- Mount Kisco (19.5 inches)
- North Salem (19.0 inches)
- Armonk (18.5 inches)
- Croton-On-Hudson (16.0 inches)
- Goldens Bridge (16.0 inches) (NWS, 2006)

April 14-18, 2007 (FEMA DR-1692): This Nor'Easter generally impacted the northeastern U.S. states of New York, New Jersey and Connecticut. The combined effects of high winds and heavy rainfall during this event led to flooding, storm damages, power outages, and evacuations, and disrupted traffic and commerce. Various counties in the eastern Catskills and Mid-Hudson Region of New York State were impacted by several inches of rain during this event (NWS, 2007). This event resulted in widespread flooding throughout the County; therefore, its flood impact is further mentioned in Section 5.4.2 (Flood).

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 winter temperatures range between 0°F and 32 ^{o}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 (NYSDPC, 2008).

In Section 5.3, the identified hazards of concern for the Greater Greenburgh Planning Area 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 Planning Area is considered 'frequent (likely to occur within 25 years, as presented in Table 5.3-6).

The New York State HMP includes a similar ranking process for hazards that affect the State. Based on historical records and input from the Planning Committee, the probability of at least one winter snow storm of emergency declaration proportions, occurring during any given calendar year is virtually certain in the State. Based on historical snow related disaster declaration occurrences, New York State can expect a snow storm of disaster declaration proportions, on average, once every 3 to 5 years. Similarly, for ice storms, based on historical disaster declarations, it is expected that on average, ice storms of disaster proportions will occur once every 7-10 years within the State (NYSDPC, 2008).

It is estimated that the Greater Greenburgh Planning Area will continue to experience direct and indirect impacts of severe winter storms annually. This may induce secondary hazards such as snow melt, flooding, and water quality and supply concerns and cause utility failures, power outages, transportation delays/accidents/inconveniences and public health concerns.

VULNERABILITY ASSESSMENT

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

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

Overview of Vulnerability

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

Data and Methodology

National weather databases and local resources were used to collect and analyze severe winter storm impacts on Westchester County and the participating municipalities. Default HAZUS-MH MR4 data was used to support an evaluation of assets exposed to this hazard and the potential impacts associated with this hazard.

Impact on Life, Health and Safety

According to the National Oceanic and Atmospheric Administration (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 in the Greater Greenburgh Planning Area (86,764 people) is exposed to severe winter storm events (U.S. Census, 2000). Snow accumulation and frozen/slippery road surfaces increase the frequency and impact of traffic accidents for the general population, resulting in personal injuries. Refer to Table 4-1 in the Region Profile for population statistics for each participating municipality. The elderly are considered most susceptible to this hazard due to their increased risk of injuries and death from falls and overexertion and/or hypothermia from attempts to clear snow and ice. In addition, severe winter storm events can reduce the ability of these populations to access emergency services. Residents with low incomes may not have access to housing or their housing may be less able to withstand cold temperatures (e.g., homes with poor insulation and heating supply). Table 5.4.3-6 summarizes the population over the age of 65 and individuals living below the Census poverty threshold.

Table 5.4.3-6. Greater Greenburgh Planning Area Population Statistics (2000 U.S. Census)

Municipality	Census/HAZUS-MH 2000 Population	HAZUS-MH Population Over 65	HAZUS-MH Population Below Poverty
Unincorporated Greenburgh	41,828	2,562	1,294
Village of Ardsley	4,269	295	40
Village of Dobbs Ferry	10,622	586	416
Village of Elmsford	4,676	259	187
Village of Hastings-on-Hudson	7,648	499	284
Village of Irvington	6,631	402	187
Village of Tarrytown	11,090	650	459
Planning Area Total	**86,764**	**5,253**	**2,867**

Source: Census 2000 (U.S. Census Bureau); HAZUS-MH MR4, 2009
Note: Pop. = Population
* Individuals below poverty level (Census poverty threshold for a 3-person family unit is approximately $15,000)
** Households with an income of less than $20,000

Impact on General Building Stock

The entire general building stock inventory in the Greater Greenburgh Planning Area 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 5.4.3-7 presents the total exposure value for general building stock for each participating municipality (structure only).

There was no historic information available that identified property damages within the Greater Greenburgh Planning Area due to a single severe winter storm event. Current modeling tools are not available to estimate specific losses for this hazard. As an alternate approach, this plan considers percentage damages that could result from severe winter storm conditions. Table 5.4.3-7 below summarizes percent damages that could result from severe winter storm conditions for the Planning Area's total general building stock (structure only). Given professional knowledge and information available, the potential losses for this hazard are considered to be overestimated; hence, conservative estimates for losses associated with severe winter storm events.

Table 5.4.3-7. General Building Stock Exposure (Structure Only) and Estimated Losses from Severe Winter Storm Events in the Greater Greenburgh Planning Area

Municipality	Total (All Occupancies) RV	1% Damage Loss Estimate	5% Damage Loss Estimate	10% Damage Loss Estimate
Unincorporated Greenburgh	$4,780,369,000	$47,803,690	$239,018,450	$478,036,900
Village of Ardsley	$537,732,000	$5,377,320	$26,886,600	$53,773,200
Village of Dobbs Ferry	$1,132,486,000	$11,324,860	$56,624,300	$113,248,600
Village of Elmsford	$594,852,000	$5,948,520	$29,742,600	$59,485,200
Village of Hastings-on-Hudson	$896,979,000	$8,969,790	$44,848,950	$89,697,900
Village of Irvington	$735,641,000	$7,356,410	$36,782,050	$73,564,100
Village of Tarrytown	$1,407,087,000	$14,070,870	$70,354,350	$140,708,700
Planning Area Total	**$10,085,146,000**	**$100,851,460**	**$504,257,300**	**$1,008,514,600**

Source: HAZUS-MH MR4

Notes: RV = Replacement Cost Value. The building values shown are building structure only because damage from the severe winter storm hazard generally impact structures such as the roof and building frame (rather than building content). The valuation of general building stock and the loss estimates determined in the Greater Greenburgh Planning Area were based on the default general building stock database provided in HAZUS-MH MR4. The general building stock valuations provided in HAZUS-MH MR4 are Replacement Cost Value from RSMeans as of 2006.

A specific area that is vulnerable to the severe winter storm hazard is the floodplain. At risk general building stock and infrastructure in floodplains are presented in the flood hazard profile (Section 5.4.2). Generally, losses from flooding associated with severe winter storms should be less than that associated with a 100-year or 500-year flood. In summary, snow and ice melt can cause both riverine and urban flooding. Estimated losses due to riverine flooding in the Greater Greenburgh Planning Area are discussed in Section 5.4.2.

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. The replacement value for each police station or fire station in the Planning Area ranges from approximately $714,000 to $5 Million. These critical facility structures are largely constructed of concrete and masonry; therefore, they should only suffer minimal structural damage from severe winter storm events. Because power interruption can occur, backup power is recommended for critical facilities and infrastructure. Infrastructure at risk for this hazard includes

roadways that could be damaged due to the application of salt and intermittent freezing and warming conditions that can damage roads over time. Severe snowfall requires infrastructure to clear roadways, alert citizens to dangerous conditions, and following the winter requires resources for road maintenance and repair. Additionally, freezing rain and ice storms impact utilities (i.e., power lines and overhead utility wires) causing power outages for hundreds to thousands of residents.

Impact on Economy

The cost of snow and ice removal and repair of roads from the freeze/thaw process can drain local financial resources. However, because severe winter storms are a regular occurrence in this area, Westchester County is well-prepared for snow and ice removal each season (Westchester County DPW, 2006).

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 and/or mass transportation prevents the large New York City commuter population from traveling to work. Specific information on the number of in- and out-commuters is available in the Westchester County Databook and indicates that in 2000, the total workers in Westchester County was approximately 400,000 and that 33 percent of these workers commuted from other areas (New York City, Bronx, CT, and others). Similarly in 2000, Westchester County included over 450,000 working residents, with 37 percent working out of the County, primarily community to New York City (75 percent of the residents commuting) and surrounding areas (Westchester County Databook, 2010).

Future Growth and Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the Planning Area. Any areas of growth could be potentially impacted by the severe winter storm hazard because the entire planning area is exposed and vulnerable. For the severe winter storm hazard, the entire Planning Area has been identified as the hazard area. Please refer to Section 4 (Region Profile) for a map that illustrates where potential new development is located.

Additional Data and Next Steps

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

Overall Vulnerability Assessment

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

Existing and future mitigation efforts should continue to be developed and employed that will enable the study area to be prepared for these events when they occur. The cascade effects of severe winter storm events include utility losses and transportation accidents and flooding. Losses associated with the flood hazard are discussed in Section 5.4.2. Particular areas of vulnerability include low-income and elderly populations, mobile homes, and infrastructure such as roadways and utilities that can be damaged by such storms and the low-lying areas that can be impacted by flooding related to rapid snow melt.