

5.4.1 SEVERE STORMS

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

HAZARD PROFILE

Hazard profile information is provided in this section, including information on description, extent, location, previous occurrences and losses and the probability of future occurrences within the Greater Greenburgh Planning Area.

Description

For the purpose of this HMP and as deemed appropriated by the Greater Greenburgh Planning Area, the severe storm hazard includes hailstorms, windstorms, lightning, thunderstorms, tornadoes, and tropical cyclones (e.g. hurricanes, tropical storms, and tropical depressions), which are defined below. Since most northeasters, (or Nor’Easters) a type of an extra-tropical cyclone, generally take place during the winter weather months, Nor’Easters have been grouped as a type of severe winter weather storm, further discussed in Section 5.4.3 (Severe Winter Storm).

Hailstorm: According to the National Weather Service (NWS), hail is defined as a showery precipitation in the form of irregular pellets or balls of ice more than five millimeters in diameter, falling from a cumulonimbus cloud (NWS, 2005). Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight; they fall as precipitation, in the form of balls or irregularly shaped masses of ice. The size of hailstones is a direct function of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth’s surface. Higher temperature gradients relative to elevation above the surface result in increased suspension time and hailstone size. Hailstorms are a potential damaging outgrowth of severe thunderstorms (Northern Virginia Regional Commission [NVRC], 2006). They cause over \$1 billion in crop and property damages each year in the U.S., making hailstorms one of the most costly natural disasters (Federal Alliance for Safe Homes, Inc., 2006).

Windstorm: According to the Federal Emergency Management Agency (FEMA), wind is air moving from high to low pressure. It is rough horizontal movement of air (as opposed to an air current) caused by uneven heating of the Earth’s surface. It occurs at all scales, from local breezes generated by heating of land surfaces and lasting tens of minutes to global winds resulting from solar heating of the Earth (FEMA, 1997). A type of windstorm that is experienced often during rapidly moving thunderstorms is a derecho. A derecho is a widespread and long-lived windstorm associated with thunderstorms that are often curved in shape (Johns et al., 2011). The two major influences on the atmospheric circulation are the differential heating between the equator and the poles, and the rotation of the planet. Windstorm events are associated with cyclonic storms (for example, hurricanes), thunderstorms and tornadoes (FEMA, 1997).

Lightning: According to the NWS, lightning is a visible electrical discharge produced by a thunderstorm. The discharge may occur within or between clouds or between a rain cloud and the ground (NWS, 2005). The discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm creates a “bolt” when the buildup of charges becomes strong enough. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit (°F). Lightning rapidly heats the sky as it flashes but the surrounding air cools following the bolt. This rapid heating and cooling of the

surrounding air causes thunder. Annually, on average, 300 people are injured and 89 people are killed due to lightning strikes in the U.S. (NVRC, 2006).

Thunderstorm: According to the NWS, a thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (NWS, 2005). A thunderstorm forms from a combination of moisture, rapidly rising warm air and a force capable of lifting air such as a warm and cold front, a sea breeze, or a mountain. Thunderstorms form from the equator to as far north as Alaska. These storms occur most commonly in the tropics. Many tropical land-based locations experience over 100 thunderstorm days each year (Pidwirny, 2007). Although thunderstorms generally affect a small area when they occur, they are very dangerous because of their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. A thunderstorm produces wind gusts less than 57 miles per hour (mph) and hail, if any, of less than 3/4-inch diameter at the surface. A severe thunderstorm has thunderstorm related surface winds (sustained or gusts) of 57 mph or greater and/or surface hail 3/4-inch or larger (NWS, 2005). Wind or hail damage may be used to infer the occurrence/existence of a severe thunderstorm (Office of the Federal Coordinator for Meteorology, 2001).

Tornado: A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. It is spawned by a thunderstorm (or sometimes as a result of a hurricane) and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. Tornado season is generally March through August, although tornadoes can occur at any time of year (FEMA, 2004). Tornadoes tend to strike in the afternoons and evening, with over 80 percent (%) of all tornadoes striking between noon and midnight (New Jersey Office of Emergency Management [NJOEM], 2007). The average forward speed of a tornado is 30 mph, but can vary from nearly stationary to 70 mph (NWS, 1995). The NOAA Storm Prediction Center (SPC) indicates that the total duration of a tornado can last between a few seconds to over one hour; however, a tornado typical lasts less than 10 minutes (Edwards, 2011). High-wind velocity and wind-blown debris, along with lightning or hail, result in the damage caused by tornadoes. Destruction caused by tornadoes depends on the size, intensity, and duration of the storm. Tornadoes cause the greatest damage to structures that are light, such as residential homes and mobile homes, and tend to remain localized during impact (NVRC, 2006).

Tropical Cyclone: Tropical cyclone is a generic term for a cyclonic, low-pressure system over tropical or sub-tropical waters (National Atlas, 2011); containing a warm core of low barometric pressure which typically produces heavy rainfall, powerful winds and storm surge (New York City Office of Emergency Management [NYCOEM], 2008). It feeds on the heat released when moist air rises and the water vapor in it condenses (Dorrego, Date Unknown). Depending on their location and strength, there are various terms by which tropical cyclones are known, such as hurricane, typhoon, tropical storm, cyclonic storm and tropical depression (Pacific Disaster Center, 2006). While tropical cyclones begin as a tropical depression, meaning the storm has sustained winds below 38 miles per hour (mph), it may develop into a tropical storm (with sustained winds of 39 to 73 mph) or a hurricane (with winds of 74 mph and higher).

Tropical Depression: A tropical depression is an organized system of clouds and thunderstorms with a defined surface circulation and maximum sustained winds of less than 38 mph. It has no “eye” (the calm area in the center of the storm) and does not typically have the organization or the spiral shape of more powerful storms (Emanuel, Date Unknown; Miami Museum of Science, 2000).

Tropical Storm: A tropical storm is an organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds between 39 and 73 mph (FEMA, 2007). Once a storm has reached tropical storm status, it is assigned a name. During this time, the storm itself becomes more organized and begins to become more circular in shape, resembling a hurricane. The rotation of a tropical storm is more recognizable than a tropical depression. Tropical storms can cause a lot of problems, even

without becoming a hurricane; however, most of the problems stem from heavy rainfall (University of Illinois, Date Unknown).

Hurricane: A hurricane is an intense tropical cyclone with wind speeds reaching a constant speed of 74 mph or more (FEMA, 2004). It is a category of tropical cyclone characterized by thunderstorms and defined surface wind circulation. They are caused by the atmospheric instability created by the collision of warm air with cooler air. They form in the warm waters of tropical and sub-tropical oceans, seas, or Gulf of Mexico (NWS, 2000). Most hurricanes evolve from tropical disturbances. A tropical disturbance is a discrete system of organized convection (showers or thunderstorms), that originate in the tropics or subtropics, does not migrate along a frontal boundary, and maintains its identity for 24 hours or more (NWS, 2004). Hurricanes begin when areas of low atmospheric pressure move off the western coast of Africa and into the Atlantic, where they grow and intensify in the moisture-laden air above the warm tropical ocean. Air moves toward these atmospheric lows from all directions and circulates clock-wise under the influence of the Coriolis effect, thereby initiating rotation in the converging wind fields. When these hot, moist air masses meet, they rise up into the atmosphere above the low pressure area, potentially establishing a self-reinforcing feedback system that produces weather systems known to meteorologists as tropical disturbances, tropical depressions, tropical storms, and hurricanes (Frankenberg, Date Unknown).

Almost all tropical storms and hurricanes in the Atlantic basin, which includes the Gulf of Mexico and Caribbean Sea, form between June 1st and November 30th. This time frame is known as hurricane season. August and September are peak months for hurricane development. The threats caused by an approaching hurricane can be divided into three main categories: storm surge, wind damage and rainfall/flooding:

- *Storm Surge* is simply water that is pushed toward the shore by the force of the winds swirling around the storm. This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase the mean water level 15 feet or more. Storm surge is responsible for nearly 90-percent of all hurricane-related deaths and injuries.
- *Wind Damage* is the force of wind that can quickly decimate the tree population, down power lines and utility poles, knock over signs, and damage/destroy homes and buildings. Flying debris can also cause damage to both structures and the general population. When hurricanes first make landfall, it is common for tornadoes to form which can cause severe localized wind damage.
- *Rainfall / Flooding* the torrential rains that normally accompany a hurricane can cause serious flooding. Whereas the storm surge and high winds are concentrated around the “eye”, the rain may extend for hundreds of miles and may last for several days, affecting areas well after the hurricane has diminished (Mandia, 2011).

Extent

The extent (that is, magnitude or severity) of a severe storm is largely dependent upon sustained wind speed. Straight-line winds, winds that come out of a thunderstorm, in extreme cases, can cause wind gusts exceeding 100 mph. These winds are most responsible for hailstorm and thunderstorm wind damage. One type of straight-line wind, the downburst, can cause damage equivalent to a strong tornado (NVRC, 2006).

Hail

Hail can be produced from many different types of storms. Typically, hail occurs with thunderstorm events. The size of hail is estimated by comparing it to a known object. Most hail storms are made up of a variety of sizes, and only the very largest hail stones pose serious risk to people, if exposed (NYSDFPC,

2008; NSSL, Date Unknown). Table 5.4.1-1 shows the different types of hail and the comparison to real-world objects.

Table 5.4.1-1. Hail Size

Description	Diameter (in inches)
Pea	0.25
Marble or mothball	0.50
Penny or dime	0.75
Nickel	0.88
Quarter	1.00
Half Dollar	1.25
Walnut or Ping Pong Ball	1.50
Golf ball	1.75
Hen's Egg	2.00
Tennis Ball	2.75
Baseball	2.75
Tea Cup	3.00
Grapefruit	4.00
Softball	4.50

Source: NYSDPC, 2008

Tornado

The magnitude or severity of a tornado was originally categorized using the Fujita Scale (F-Scale) or Pearson Fujita Scale introduced in 1971, based on a relationship between the Beaufort Wind Scales (B-Scales) (measure of wind intensity) and the Mach number scale (measure of relative speed). It is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure (Tornado Project, Date Unknown). The F-Scale categorizes each tornado by intensity and area. The scale is divided into six categories, F0 (Gale) to F5 (Incredible) (Edwards, 2011). Table 5.4.1-2 explains each of the six F-Scale categories.

Table 5.4.1-2. Fujita Damage Scale

Scale	Wind Estimate (MPH)	Typical Damage
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.

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Scale	Wind Estimate (MPH)	Typical Damage
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.

Source: SPC, Date Unknown

Although the F-Scale has been in use for over 30 years, there are limitations of the scale. The primary limitations are a lack of damage indicators, no account of construction quality and variability, and no definitive correlation between damage and wind speed. These limitations have led to the inconsistent rating of tornadoes and, in some cases, an overestimate of tornado wind speeds. The limitations listed above led to the development of the Enhanced Fujita Scale (EF Scale). The Texas Tech University Wind Science and Engineering (WISE) Center, along with a forum of nationally renowned meteorologists and wind engineers from across the country, developed the EF Scale (NOAA, 2007).

The EF Scale became operational on February 1, 2007. It is used to assign tornadoes a ‘rating’ based on estimated wind speeds and related damage. When tornado-related damage is surveyed, it is compared to a list of Damage Indicators (DIs) and Degree of Damage (DOD), which help better estimate the range of wind speeds produced by the tornado. From that, a rating is assigned, similar to that of the F-Scale, with six categories from EF0 to EF5, representing increasing degrees of damage. The EF Scale was revised from the original F-Scale to reflect better examinations of tornado damage surveys. This new scale has to do with how most structures are designed (NOAA, 2008). Table 5.4.1-3 displays the EF Scale and each of its six categories.

Table 5.4.1-3. Enhanced Fujita Damage Scale

F-Scale Number	Intensity Phrase	Wind Speed (mph)	Type of Damage Done
EF0	Light tornado	65–85	Light damage. Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	Moderate tornado	86-110	Moderate damage. Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	Significant tornado	111-135	Considerable damage. Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	Severe tornado	136-165	Severe damage. Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	Devastating tornado	166-200	Devastating damage. Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	Incredible tornado	>200	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 m (109 yd); high-rise buildings have significant structural deformation; incredible phenomena will occur.

Source: SPC, 2007

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In the Fujita Scale, there was a lack of clearly defined and easily identifiable damage indicators. The EF Scale takes into account more variables than the original F-Scale did when assigning a wind speed rating to a tornado. The EF Scale incorporates 28 DIs, such as building type, structures, and trees. For each damage indicator, there are eight DODs, ranging from the beginning of visible damage to complete destruction of the damage indicator. Table 5.4.1-4 lists the 28 DIs. Each one of these indicators has a description of the typical construction for that category of indicator. Each DOD in every category is given an expected estimate of wind speed, a lower bound of wind speed, and an upper bound of wind speed.

Table 5.4.1-4. EF Scale Damage Indicators

Number	Damage Indicator	Abbreviation	Number	Damage Indicator	Abbreviation
1	Small barns, farm outbuildings	SBO	15	School - 1-story elementary (interior or exterior halls)	ES
2	One- or two-family residences	FR12	16	School - jr. or sr. high school	JHSH
3	Single-wide mobile home (MHSW)	MHSW	17	Low-rise (1-4 story) bldg.	LRB
4	Double-wide mobile home	MHDW	18	Mid-rise (5-20 story) bldg.	MRB
5	Apt, condo, townhouse (3 stories or less)	ACT	19	High-rise (over 20 stories)	HRB
6	Motel	M	20	Institutional bldg. (hospital, govt. or university)	IB
7	Masonry apt. or motel	MAM	21	Metal building system	MBS
8	Small retail bldg. (fast food)	SRB	22	Service station canopy	SSC
9	Small professional (doctor office, branch bank)	SPB	23	Warehouse (tilt-up walls or heavy timber)	WHB
10	Strip mall	SM	24	Transmission line tower	TLT
11	Large shopping mall	LSM	25	Free-standing tower	FST
12	Large, isolated ("big box") retail bldg.	LIRB	26	Free standing pole (light, flag, luminary)	FSP
13	Automobile showroom	ASR	27	Tree - hardwood	TH
14	Automotive service building	ASB	28	Tree - softwood	TS

Source: SPC, Date Unknown



Since the EF Scale recently went into effect in February 2007, previous occurrences and losses associated with historic tornado events, described in the next section (Previous Occurrences and Losses) of this hazard profile, are based on the former Fujita Scale. Events after February 2007 are based on the Enhance Fujita Scale.

Hurricanes

The extent of a hurricane is categorized by the Saffir-Simpson Hurricane Scale. This scale categorizes or rates hurricanes from 1 (Minimal) to 5 (Catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline, in the landfall region (National Hurricane Center [NHC], 2010). Table 5.4.1-5 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes land fall.

Table 5.4.1-5. The Saffir-Simpson Scale

Category	Wind Speed (mph)	Storm Surge (above normal sea level)	Expected Damage
1	74-95	4 – 5 feet	<u>Minimal</u> : Damage is done primarily to shrubbery and trees, unanchored mobile homes are damaged, some signs are damaged, and no real damage is done to structures.
2	96-110	6 – 8 feet	<u>Moderate</u> : Some trees are toppled, some roof coverings are damaged, and major damage is done to mobile homes.
3	111-130	9 – 12 feet	<u>Extensive</u> : Large trees are toppled, some structural damage is done to roofs, mobile homes are destroyed, and structural damage is done to small homes and utility buildings.
4	131-155	13 – 18 feet	<u>Extreme</u> : Extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; and some curtain walls fail.
5	> 155	> 18 feet	<u>Catastrophic</u> : Roof damage is considerable and widespread, window and door damage is severe, there are extensive glass failures, and entire buildings could fail.
Additional Classifications			
Tropical Storm	39-73	0 - 3 feet	NA
Tropical Depression	< 38	0	NA

Source: FEMA, 2010

- mph = Miles per hour
- > = Greater than
- NA = not applicable or not available

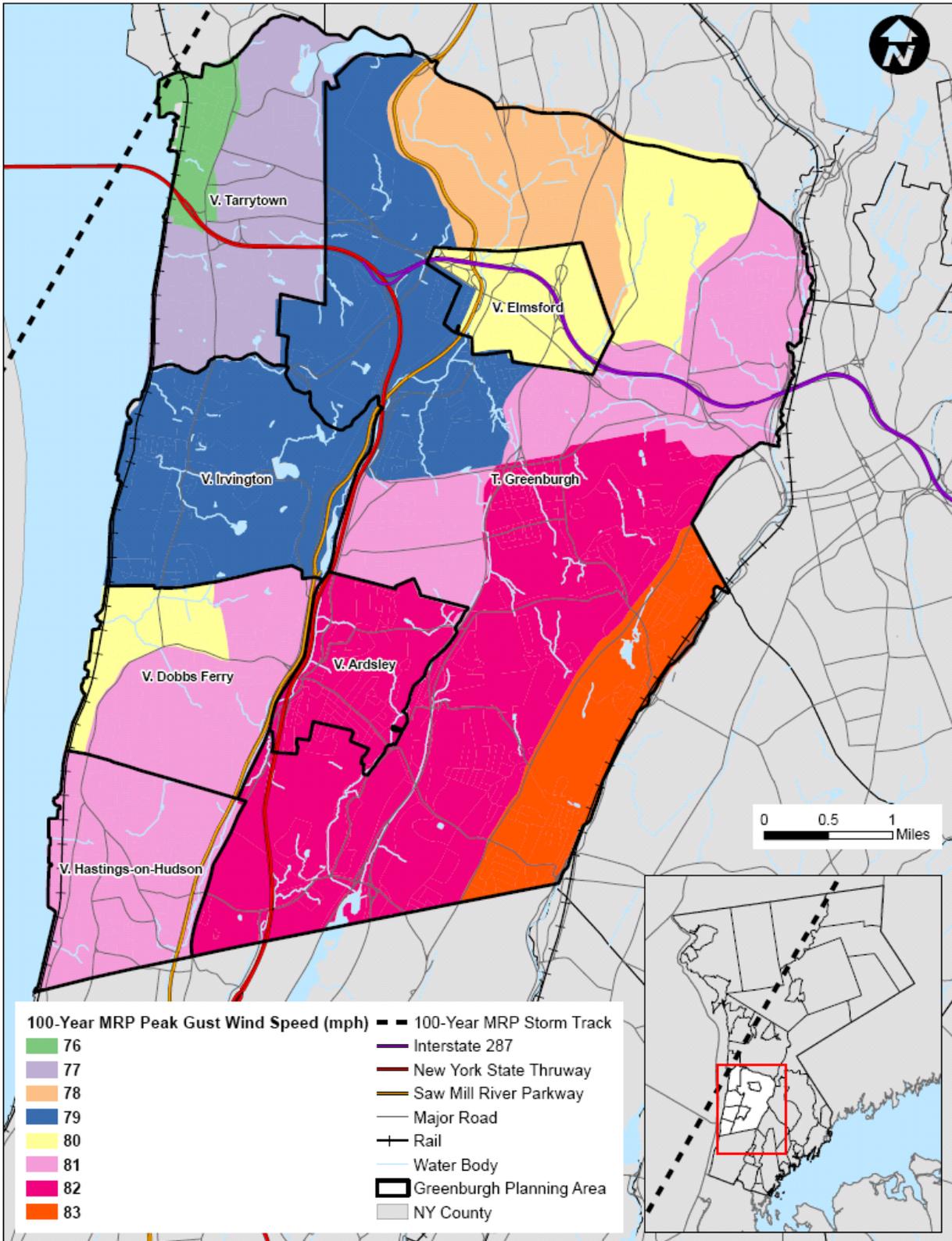
In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. MRP is the average period of time, in years, between occurrences of a particular hazard event (equal to the inverse of the annual frequency of exceedance). For example, a flood that has a 1-percent chance of being equaled or exceeded in any given year is also referred to as the base flood and has a MRP of 100. This is known as a 100-year flood. The term “100-year flood” can be

misleading; it is not the flood that will occur once every 100 years. Rather, it is the flood elevation that has a one-percent chance of being equaled or exceeded each year. Therefore, the 100-year flood could occur more than once in a relatively short period of time or less than one time in 100 years (Dinicola, 2009).

Figures 5.4.1-1 and 5.4.1-2 show the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP HAZUS-MH model runs. The estimated hurricane track for the 100- and 500-year event is also shown. For the 100-year MRP event, the maximum 3-second gust wind speeds for the Greater Greenburg Planning Area range from 76 to 83 mph. These are wind speeds characteristic of a Category 1 hurricane. For the 500-year MRP event, the maximum 3-second gust wind speeds for the Planning Area range from 102 to 104 mph, characteristic of a Category 2 hurricane. The associated impacts and losses from these 100-year and 500-year MRP hurricane event model runs are reported in the Vulnerability Assessment later in this section.

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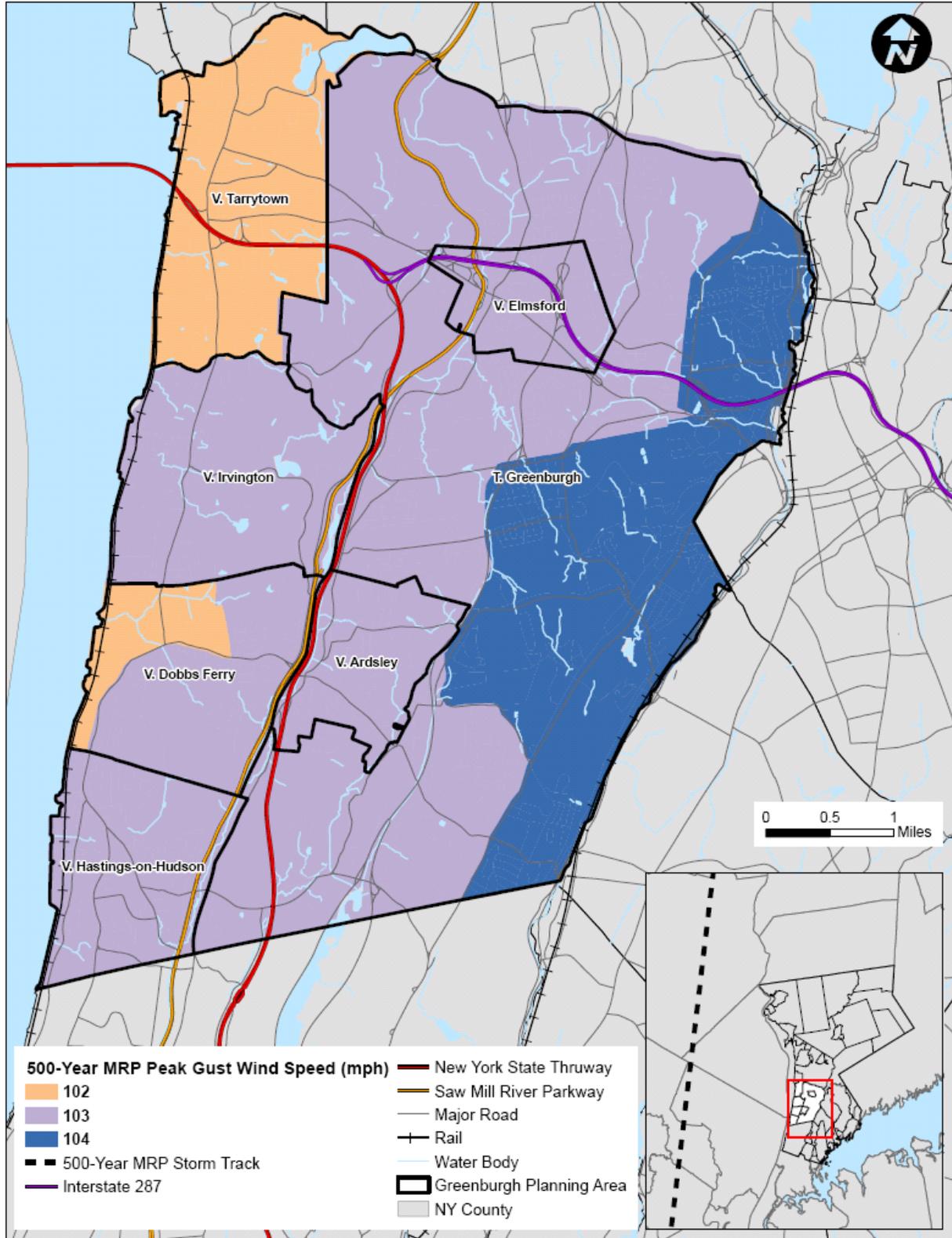
Figure 5.4.1-1. Peak Wind Speeds for 100-year Hurricane Severe Storm Event (Wind) in the Greater Greenburgh Planning Area



Source: HAZUS-MH MR4

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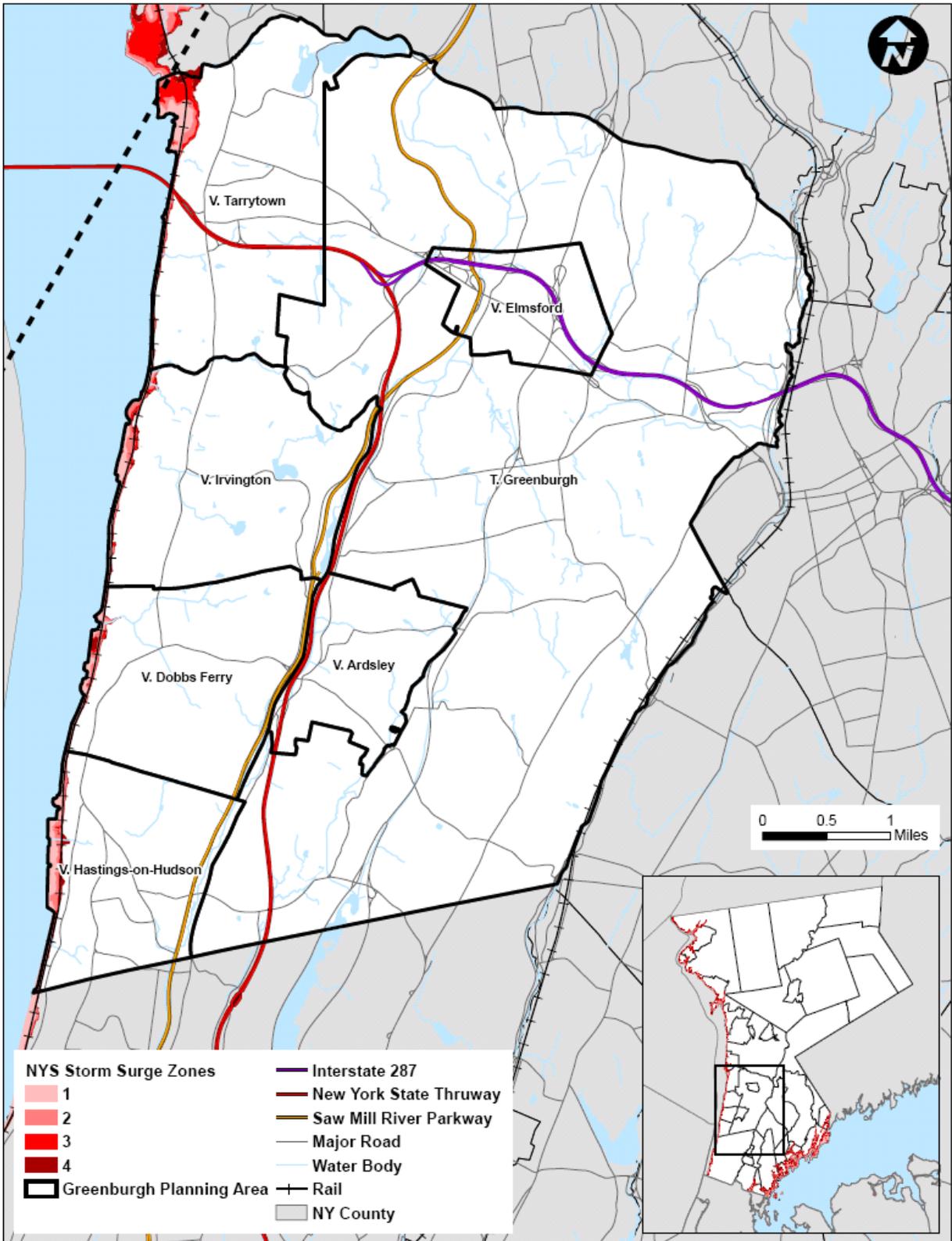
Figure 5.4.1-2. Peak Wind Speeds for 500-year Hurricane Severe Storm Event (Wind) in Greater Greenburgh Planning Area



Source: HAZUS-MH MR4

NYSOEM has made available hurricane storm surge zones based on NOAA's Sea, Lake and Overland Surge from Hurricanes (SLOSH) model projections of vertical surge heights associated with Saffir - Simpson scale category 1 - 4 storms. This data was developed to delineate hazard zones and assess risk from hurricane-related storm surges and to support hurricane evacuation planning. According to the metadata, 'Multiple storm landfall locations have been factored to produce a worst case flooding for any given area. Northwest direction storms which landfall at high tide are used as these storms produce the highest surge in this region'. The bands of color in Figure 5.4.1-3 indicate areas at risk from progressively stronger categories of storms. Areas with lighter shades are the first to flood. As storm intensities increase, flooding covers higher elevation areas, which are shaded more darkly on the maps. White areas farther away from the coast are outside of the storm surge inundation zones.

Figure 5.4.1-3. Potential Storm Surge Inundation Areas in the Greater Greenburgh Planning Area from a Hurricane



Source: NYSOEM

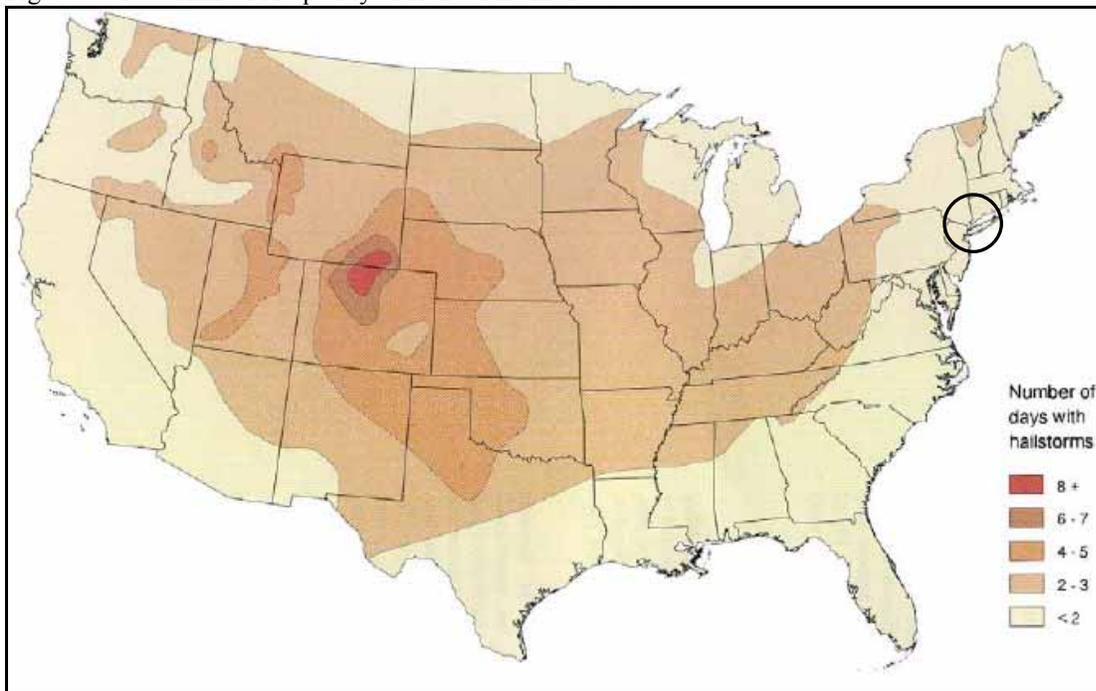
Location

Severe storms are a common natural hazard in New York State because the State exhibits a unique blend of weather (geographically and meteorological) features that influence the potential for severe storms and associated flooding. Factors include temperature, which is affected by latitude, elevation, proximity to water bodies and source of air masses; and precipitation which includes snowfall and rainfall. Precipitation intensities and effects are influenced by temperature, proximity to water bodies, and general frequency of storm systems. The Cornell Climate Report also indicates that the geographic position of the State (Northeast U.S.) makes it vulnerable to frequent storm and precipitation events. This is because nearly all storms and frontal systems moving eastward across the continent pass through, or in close proximity to New York State. Additionally, the potential for prolonged thunderstorms or coastal storms and periods of heavy precipitation is increased throughout the state because of the available moisture that originates from the Atlantic Ocean (NYSDPC, 2008).

Hailstorms

Hailstorms are more frequent in the southern and central plain states, where the climate produces violent thunderstorms. However, hailstorms have been observed in almost every location where thunderstorms occur (Federal Alliance for Safe Homes, Inc, 2006). Figure 5.4.1-4 illustrates that the Greater Greenburgh Planning Area and most of New York State experience less than two hailstorms per year.

Figure 5.4.1-4. Annual Frequency of Hailstorms in the U.S.



Source: NVRC, 2006

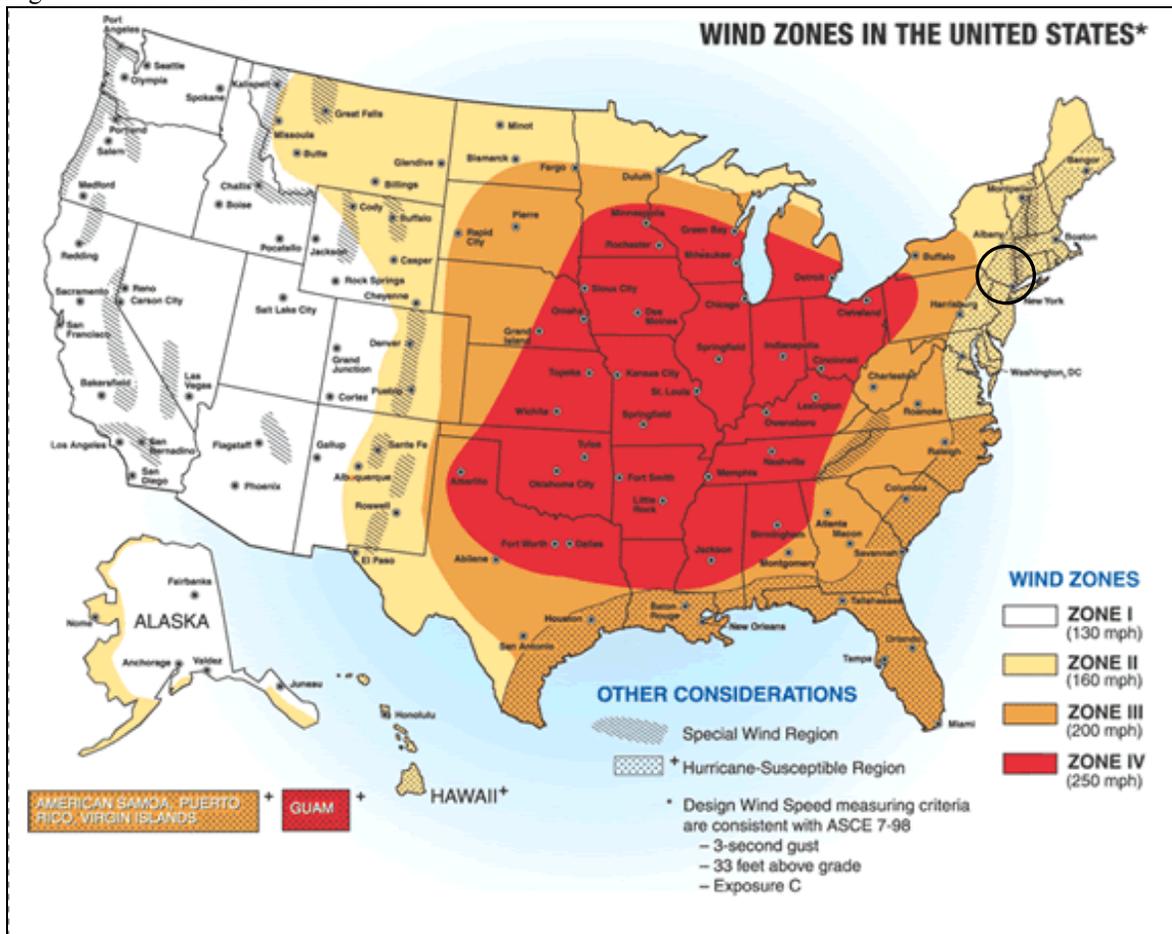
Note: The black circle indicates the approximate location of Westchester County and the Greater Greenburgh Planning Area.

Windstorms

Figure 5.4.1-5 indicates how the frequency and strength of windstorms impacts the U.S. and the general location of the most wind activity. This is based on 40 years of tornado history and 100 years of hurricane history, collected by FEMA. States located in Wind Zone IV have experienced the greatest number of tornadoes and the strongest tornadoes (NVRC, 2006). The Greater Greenburgh Planning Area

is located in Wind Zone II with speeds up to 160 miles per hour. The Planning Area is also located within the Hurricane Susceptibility Region, which extends along the northeastern coastline of the U.S. (FEMA, 2008). The New York State Hazard Mitigation Plan (NYS HMP) identifies counties most vulnerable to wind, as determined by a rating score. Counties accumulate points based on the value of each vulnerability indicator, the higher then indication for wind exposure the more points assigned, resulting in a final rating score. Westchester County was given a rating score of 17, a medium vulnerability to wind exposure (NYSDPC, 2008).

Figure 5.4.1-5. Wind Zones in the U.S.



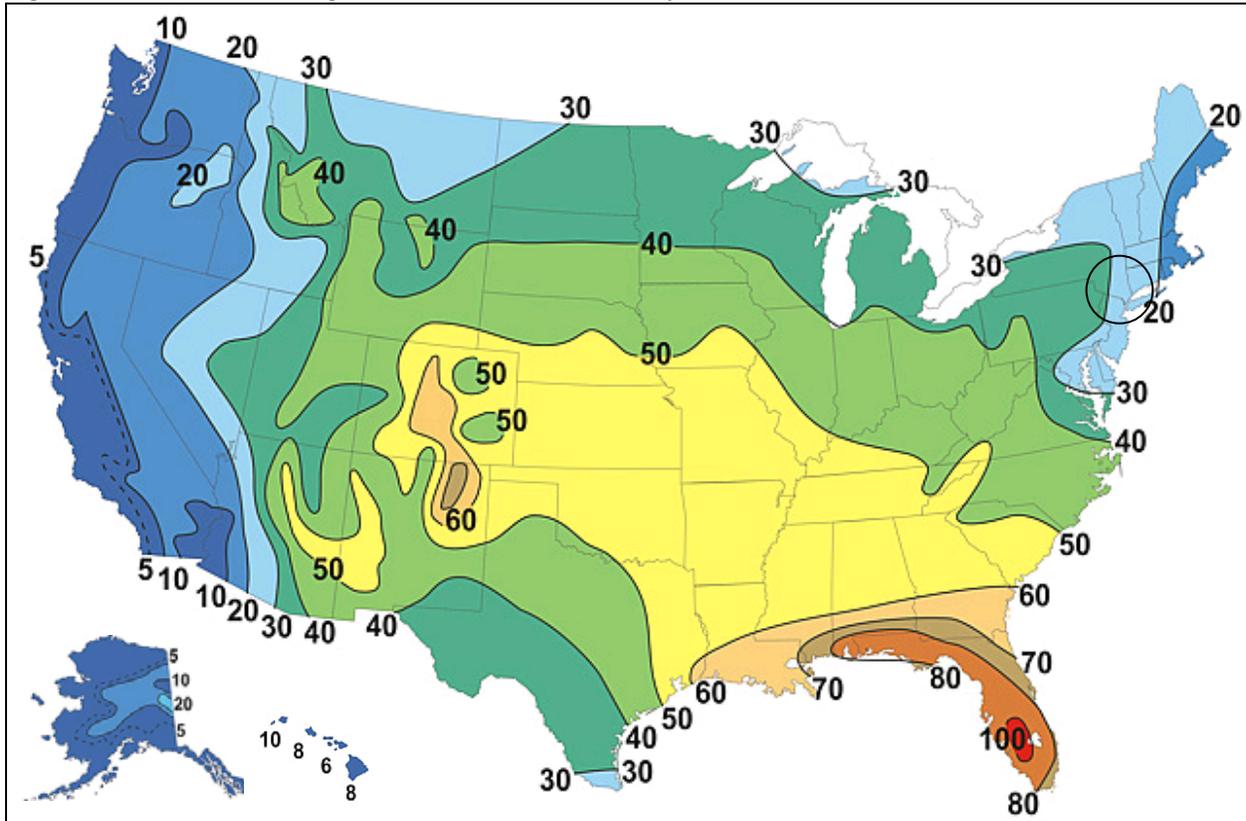
Source: FEMA, 2008

Note: The black circle indicates the approximate location of Westchester County and the Greater Greenburgh Planning Area.

Thunderstorms

Thunderstorms affect relatively small localized areas, rather than large regions much like winter storms, and hurricane events (NWS, 2005). Thunderstorms can strike in all regions of the U.S.; however, they are most common in the central and southern states. The atmospheric conditions in these regions of the country are most ideal for generating these powerful storms (NVRC, 2006). It is estimated that there are as many as 40,000 thunderstorms each day world-wide. Figure 5.4.1-6 shows the average number of thunderstorm days throughout the U.S. The most thunderstorms are seen in the southeast states, with Florida having the highest incidences (80 to over 100 thunderstorm days each year) (NWS, 2010). This figure indicates that Greater Greenburgh Planning Area experiences between 20 and 30 thunderstorm days each year.

Figure 5.4.1-6. Annual Average Number of Thunderstorm Days in the U.S.

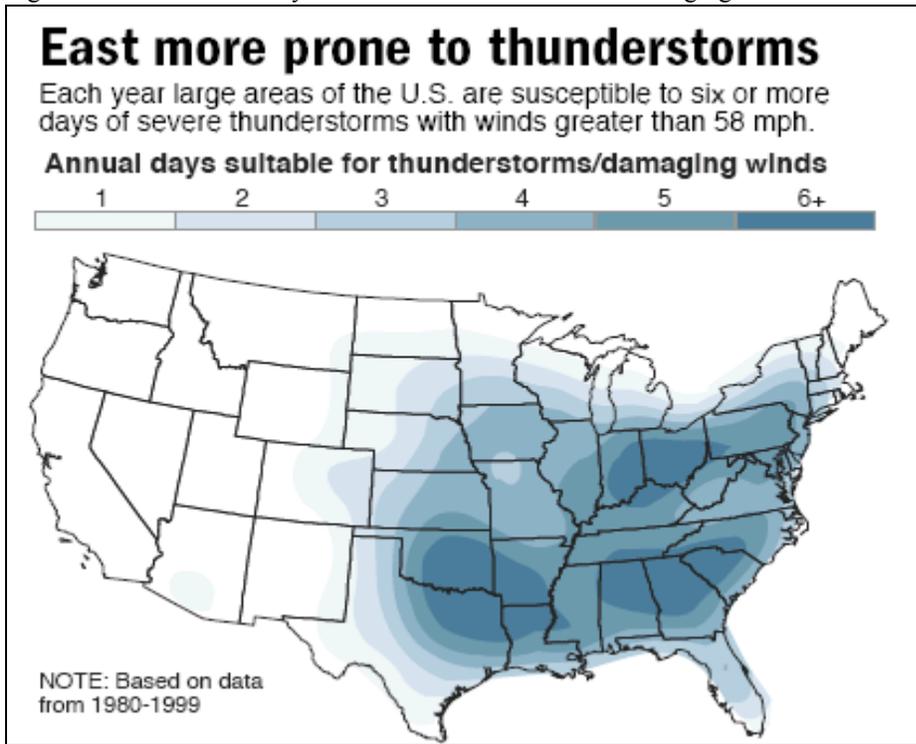


Source: NWS, 2010

Note: The black circle indicates the approximate location of Westchester County.

NASA scientists suggest that the U.S. will face more severe thunderstorms in the future, with deadly lightning, damaging hail and the potential for tornadoes in the event of climate change (Borenstein, 2007). A recent study conducted by NASA predicts that smaller storm events like thunderstorms will be more dangerous due to climate change (Figure 5.4.1-7). As prepared by the NWS, Figure 5.4.1-7 identifies those areas, particularly within the eastern U.S. that are more prone to thunderstorms, which includes New York State.

Figure 5.4.1-7. Annual Days Suitable for Thunderstorms/Damaging Winds

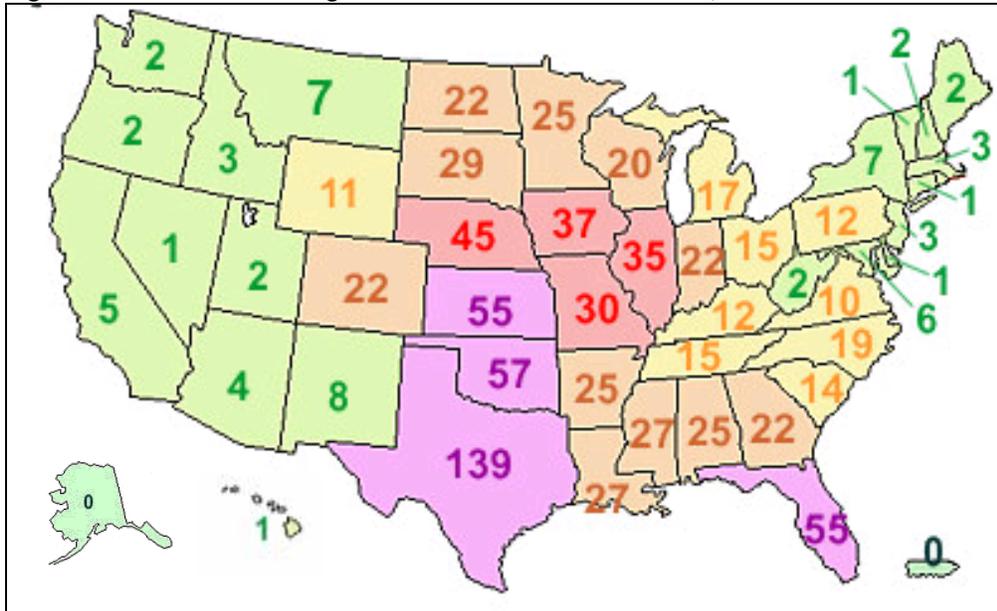


Source: MSNBC.com, 2007

Tornado

The U.S. experiences more tornadoes than any other country. In a typical year, approximately 1,000 tornadoes affect the U.S. The peak of the tornado season is April through June, with the highest concentration of tornadoes in the central U.S. Figure 5.4.1-8 shows the annual average number of tornadoes between 1953 and 2004 (NWS, 2010). New York State experienced an average of seven tornado events annually between 1953 and 2004.

Figure 5.4.1-8. Annual Average Number of Tornadoes in the U.S., 1953 to 2004

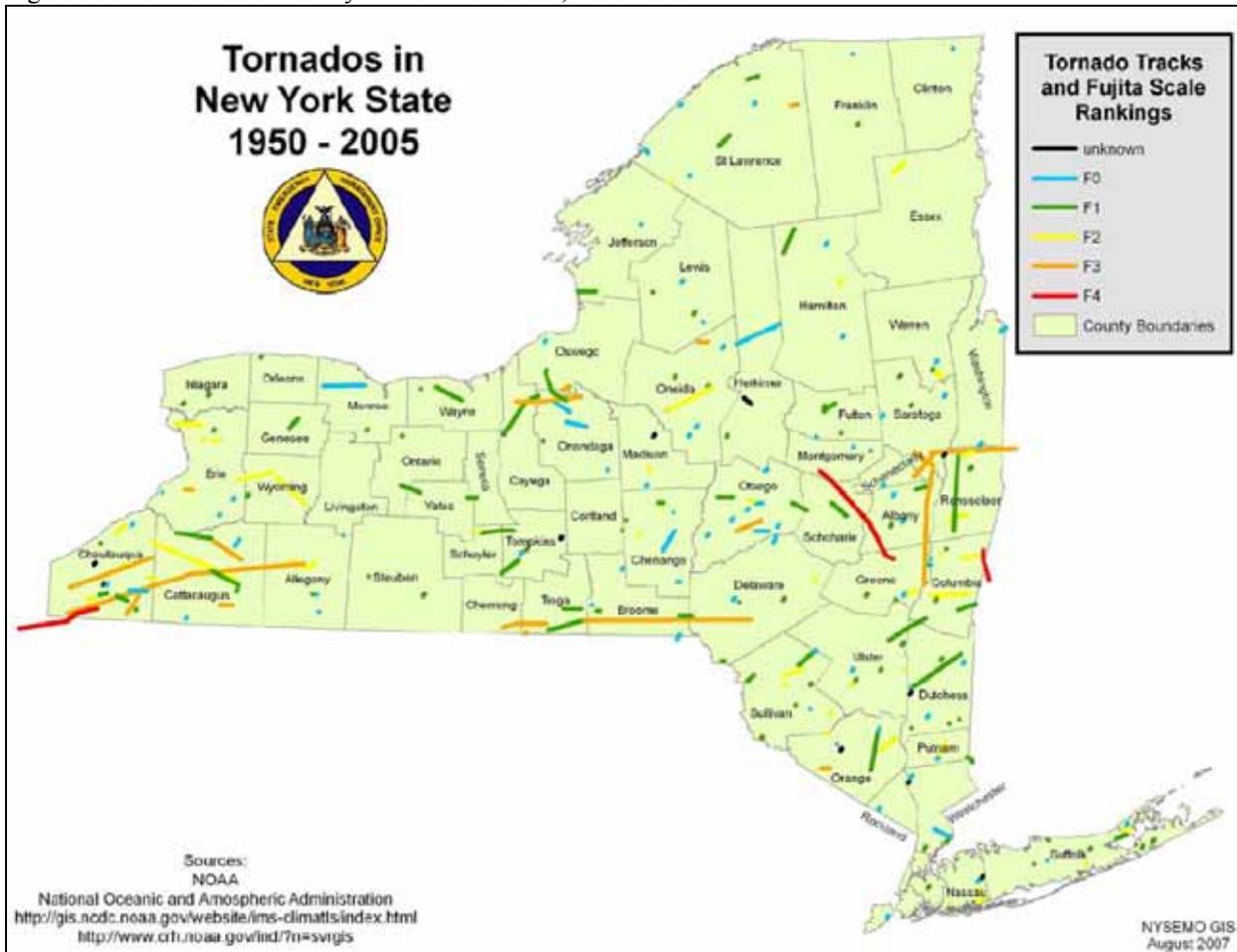


Source: NWS, 2010

Note: Between 1953 and 2004, New York State experienced an average of seven tornadoes each year.

New York State ranks 30th in the U.S. for frequency of tornadoes. When compared to other states on the frequency of tornadoes per square mile, the State ranks 35th (Pacific Disaster Center, 2006). New York State has a definite vulnerability to tornadoes and can occur, based on historical occurrences, in any part of the State. According to Figure 5.4.1-9, every county in New York State has experienced a tornado between 1950 and 2005 (NYSDPC, 2008).

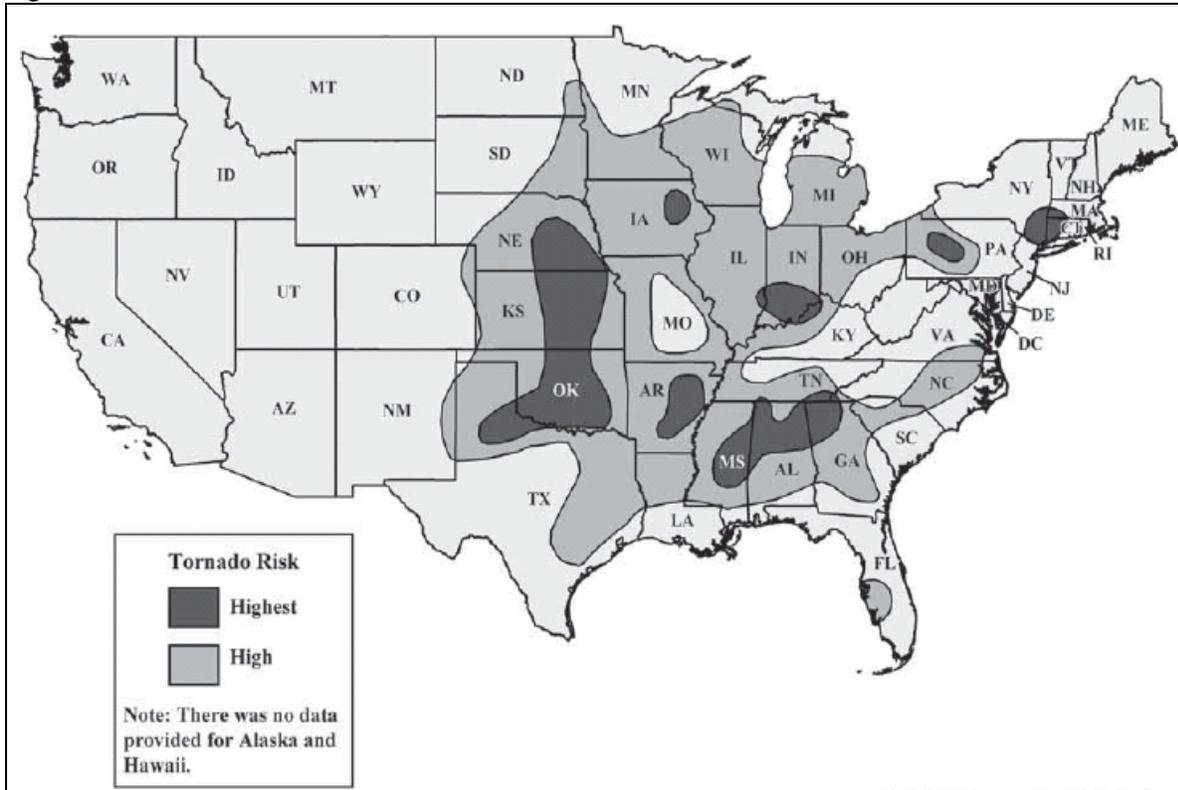
Figure 5.4.1-9. Tornado Activity in New York State, 1950-2005



Source: NYSDPC, 2008

Figure 5.4.1-10 indicates that a majority of the State, with the exception of the southeastern section (Mid-Hudson Region), has an overall low risk of tornado activity. The Greater Greenburgh Planning Area is located in southeastern New York State, which according to the figure, has the highest risk of tornadoes. Details regarding historical tornado events are discussed in the next section (Previous Occurrences and Losses) of this profile.

Figure 5.4.1-10. Tornado Risk in the U.S.



Source: NYSDPC, 2008

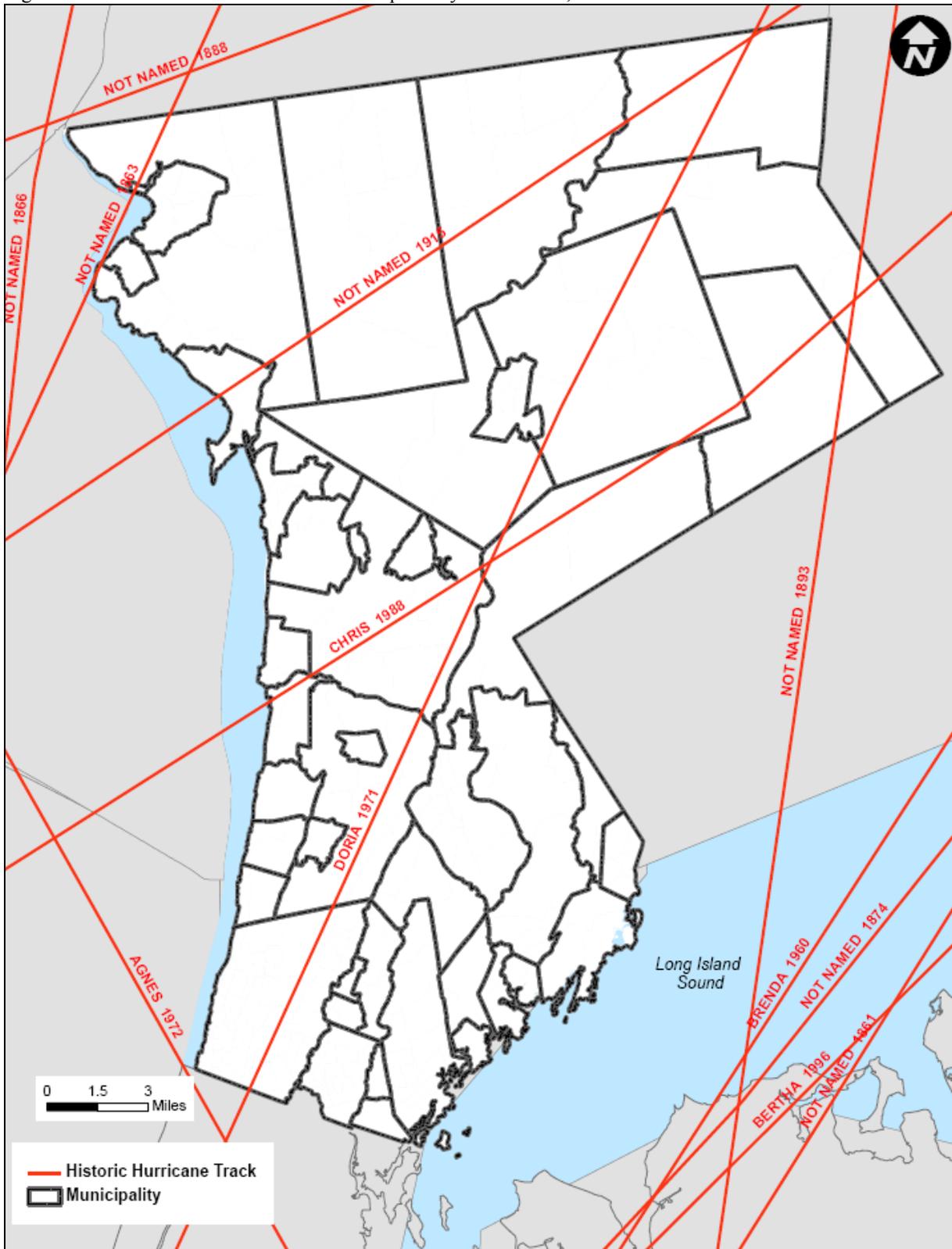
Note: Westchester County is shown has having the highest risk of tornado occurrences.

Hurricanes/Tropical Storms

Westchester County and the Greater Greenburgh Planning Area are vulnerable to hurricanes and tropical storms due to its extensive coastline along the Long Island Sound and Hudson River. Hurricanes are relatively rare to the County; however, tropical storms can strike and cause damage (Westchester County, 2011). As shown in Figure 5.4.1-5, the Greater Greenburgh Planning Area is located in Wind Zone II, with speeds up to 160 mph, and identified in the Hurricane Susceptibility Region which extends along the eastern and southern coastline of the U.S.

Hurricanes and tropical storms typically impact New York State between June and November, which is the official eastern U.S. hurricane season. Between late July and early October is the period hurricanes and tropical storms are most likely to impact the State, due to the coolness of the north Atlantic waters (NYSDPC, 2008). Figure 5.4.1-11 illustrates the historical hurricane tracks near Westchester County from 1851 to 2002.

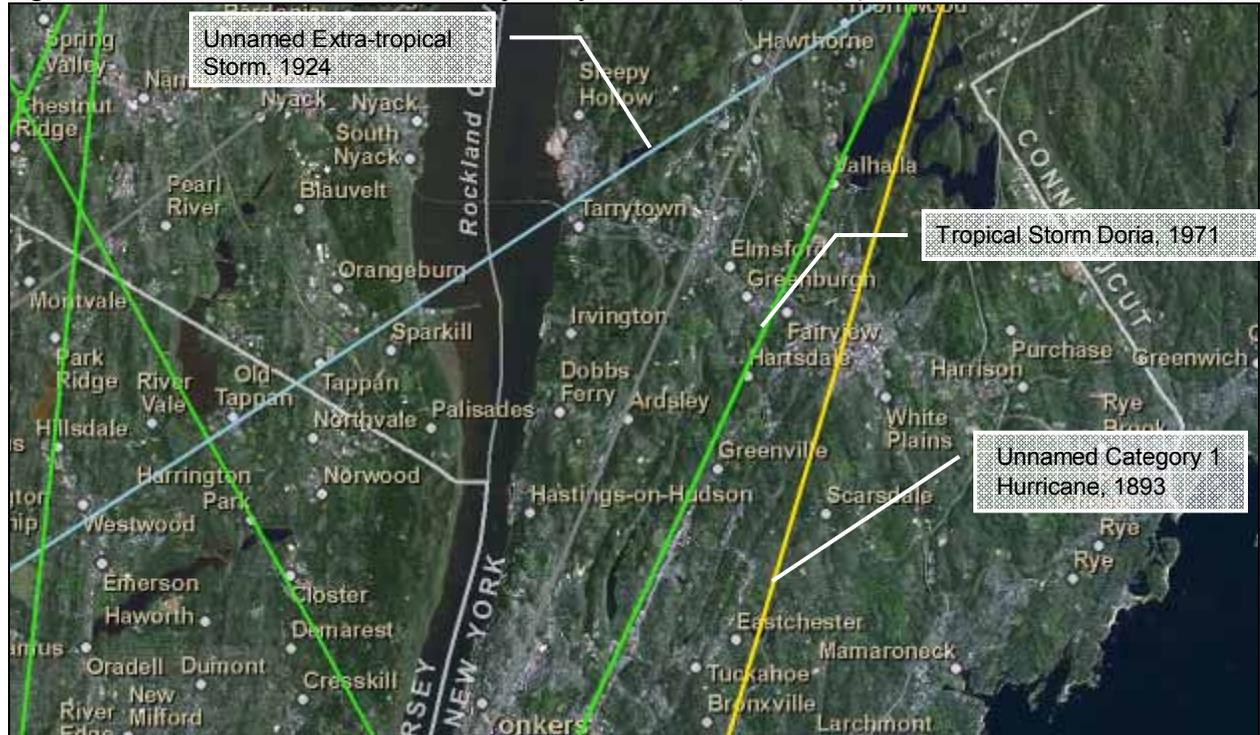
Figure 5.4.1-11. Historical North Atlantic Tropical Cyclone Tracks, 1851-2002



Source: NOAA, 2003

The Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from 1861 to 2008. Figure 5.4.1-12 displays tropical cyclone tracks for the Greater Greenburgh Planning Area; however, the associated names for some of these events are unknown. Between 1861 and 2008, the Greater Greenburgh Planning Area has experienced 36 tropical cyclone events. These events occurred within 65 nautical miles of the Planning Area (NHC, 2008).

Figure 5.4.1-12. Historical North Atlantic Tropical Cyclone Tracks (1861-2008)



Source: NOAA, 2011

Previous Occurrences and Losses

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

Between 1954 and 2010, FEMA declared that New York experienced 47 severe storm-related disasters classified as one or a combination of the following disaster types: severe storms, hurricane (Ida-2009, Ivan-2004, Floyd-1999, Bob-1991, Gloria-1985, Belle-1976, Agnes-1972), coastal storms, flooding, high tides and heavy rain (FEMA, 2010). Of those events, multiple sources, including FEMA, indicated that Westchester County was declared a disaster area as a result of 11 severe storm events. FEMA couples some disasters as severe storms and flooding events; therefore, those severe storm disasters that are also listed as flooding events have been discussed in Section 5.4.2 (Flood) as well. Table 5.4.1-6 summarizes the FEMA Presidential Disaster (DR) or Emergency Declarations (EM) for severe storm events in Westchester County.

SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Table 5.4.1-6. Presidential Disaster Declarations for Severe and Coastal Storm Events in Westchester County

Type of Event*	Date**	Declaration Number	Cost of Losses (approximate)
Severe Storms and Flooding (Tropical Storm Doria)	August 25-28, 1971	DR-311	This storm caused seven deaths and \$147.6 M in damage throughout its path. New York State experienced approximately \$7.4 M in total eligible damages. Westchester County experienced approximately \$29 K in property and crop damages. Approximately 6.86 inches of rain fell in the Greater Greenburgh Planning Area. Losses in the Planning Area are unknown.
Tropical Storm Agnes	June 20-25, 1972	DR-338	New York State experienced approximately \$703 M in total eligible damages. Storm either severely damaged or destroyed 5,000 homes and killed 24 people. Westchester County experienced approximately \$806 K in property and crop damages. Approximately 5.2 inches of rain fell within a 12 hour period in the Planning Area. The storm caused flooding along the Bronx River. Losses in the Planning Area are unknown.
Severe Storms, Heavy Rain, Landslides, Flooding (Hurricane Eloise)	September 25-27, 1975	DR-487	New York State experienced approximately \$25 M in property damages and two fatalities. Storm totals exceeded 10 inches within southeastern New York State, including Westchester County. Between nine and 10 inches of rain fell in the Planning Area over a four-day period. New York State Route 9A was flooded from Lamont Street to Fairview Park Drive. Residences along Babbitt Court were flooded. Losses in the Planning Area are unknown.
Coastal Storms and Flooding	April 5, 1984	DR-702	New York State experienced approximately \$11.9 M in property damages. In the Greater Greenburgh Planning Area, Route 9A and properties to the west were flooded after more than five inches of rain fell in one day. Losses in the Planning Area are unknown.
Coastal Storms, High Tides, Heavy Rain and Flooding	December 11-14, 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 Storms and Flooding	October 19-20, 1996	DR-1146	Coastal flooding event that caused over \$16.1 M in property damages throughout Westchester and Suffolk Counties. Approximately \$3.5 M in disaster aid to the two counties. Flooding caused the closures of the Hutchinson River Parkway between Wolfs Lane and East 3rd Street and the Bronx River Parkway between Sprain Brook Parkway and Scarsdale Road. Rainfall totals in Westchester County ranged from 2.37 inches at Ossining to 4.98 inches at Dobbs Ferry.

SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Type of Event*	Date**	Declaration Number	Cost of Losses (approximate)
Hurricane Floyd	September 14-17, 1999	DR-1296	New York State experienced approximately \$62.2 M in eligible damages as a result of property damage and debris accumulation (NYSDPC). The worst damage in the New York metropolitan region occurred in Rockland and Westchester Counties. Orange, Putnam, Rockland and Westchester Counties were declared disaster areas. NOAA-NCDC, SHELDUS and other sources indicated that Westchester County experienced between \$6.6 and \$14.6 million in damages. Many Westchester County officials proclaimed the storm as one of the worst storms ever to hit the area at that time, with the most rain ever recorded dropped on the county in 24 hours. Nearly all of the state-controlled parkways in Westchester County flooded during Floyd, causing about \$2.8 million in damage. As of December 6, 1999, FEMA indicated that the County was approved for over \$1.8 M in public assistance. Other sources indicate that Westchester municipalities were reimbursed about \$14 M by FEMA for damages; local businesses received \$2.3 M, and homeowners received approximately \$1.6 M. A total of 7.62 inches of rain fell and caused flooding in Unincorporated Greenburgh. The Saw Mill River near the Village of Elmsford was hit the hardest. Homes on Babbitt Court, south of the Village of Elmsford, were flooded. Debris was washed into the Town's storm system within the Saw Mill River watershed. Flooding occurred in the Troublesome Brook area near Claredon Place and Winthrop Lane. Edgemont Road was severely impacted due to a backup in the Bronx River. Manhattan Brook overflowed its banks along Randolph Road, Benedict Road, and County Center Road. Homes were flooded near the confluence of the Bronx River and Manhattan Brook. Flood levels in the Saw Mill River area reach 500-year inundation and the Bronx River reached the elevation of a 125-year flood. Damage to businesses alone exceeded \$1 M.
Severe Storms and Flooding	April 2-4, 2005	DR-1589	New York State experienced approximately \$66.2 M in eligible damages. FEMA approved more than \$5 M in disaster aid to the State to help fund recovery efforts in several counties and jurisdictions. In Westchester County, Unincorporated Greenburgh was reimbursed \$4,420 for debris removal. Total rainfall in New York State ranged between one and four inches. NOAA-NCDC and SHELDUS indicated that Westchester County experienced approximately \$4.3 M in flood damages.
Severe Storms and Flooding	June / July 2006	DR-1650	This event was the largest and most costly natural disaster that New York State encountered since Hurricane Agnes in 1972. Resulted in a Disaster Declaration for 19 New York State counties. New York State experienced approximately \$246.3 M in eligible damages. As of December 29, 2006, more than \$227 M in disaster aid was approved for the State.
Severe Storms and Inland and Coastal Flooding (also identified as a Nor'Easter)	April 14-18, 2007	DR-1692	New York State experienced millions in eligible damages. 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. Westchester County was one of the hardest hit counties in the area. In Unincorporated Greenburgh, along East Hartsdale Avenue, flooding was so severe, some businesses and homes were flooded with eight to nine feet of water. A few businesses had to close permanently.

SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Type of Event*	Date**	Declaration Number	Cost of Losses (approximate)
Severe Storms and Flooding	March 13-15, 2010	DR-1899	On April 16, 2010, FEMA announced that federal disaster aid was made available for the State of New York due to the severe storms and flooding that struck between March 13 and 15. Nassau, Orange, Richmond, Rockland, Suffolk and Westchester Counties were all included in this declaration (FEMA, 2010). This storm caused seven deaths in Northeast U.S. and more than 300,000 customers were without power. Hurricane-force winds knocked down trees and power lines. Heavy rain caused flooding across the region. Flood warnings were issued from northern Virginia to southern New Hampshire. Some coastal areas received more than six inches of rain. Con Ed reported that more than 86,000 customers were without power in New York City and Westchester County. Wind speeds reached 75 mph at JFK airport in New York City and 72 mph winds were reported in Atlantic City. In Westchester County, schools were closed. Unincorporated Greenburgh was one of the hardest hit areas in the County.

Source(s): FEMA, 2011; Hazards and Vulnerability Research Institute (SHELDUS), 2008; National Climatic Data Center (NCDC), 2011; NYSEMO, Date Unknown

Note (1): Dollars rounded to nearest thousand. Recorded losses indicate the dollar value of covered losses paid, as available through the public records reviewed. Some of these events overlap with events shown under the Flood and Severe Winter Storm hazard profiles of this Plan.

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

** Represents the date(s) of the event

DR Disaster Declaration

EM Emergency Declaration

M Million (\$)

SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Based on all sources researched, many coastal and severe storm events appear to have impacted Westchester County and the Greater Greenburgh Planning Area, as summarized in Table 5.4.1-7. With severe storm documentation for the State being so extensive, not all sources may have been identified or researched; therefore, Table 5.4.1-7 may not include all events that have occurred throughout the region.

Table 5.4.1-7. Severe and Coastal Storm Events between 1971 and 2010

Event Name / Date	Location	Losses / Impacts	Source(s)
Remnants of Tropical Storm Doria August 27-29, 1971 (FEMA DR-311)	Multi-State	See FEMA Disaster Declarations (Table 5.4.1-6)	Hazards and Vulnerability Research Institute (SHELDUS), FEMA, MARFC, Kocin, Sidney B. Bowne & Son
Remnants of Tropical Storm Agnes June 22-25, 1972 (FEMA DR-338)	Multi-State	See FEMA Disaster Declarations (Table 5.4.1-6)	FEMA, NOAA-HPC, NWS, Hazards and Vulnerability Institute (SHELDUS), Chartuk (NWS), Wilson, Sidney B. Bowne & Son
Heavy Rain / Flooding March 21, 1980	Greater Greenburgh Planning Area	Approximately 2.46 inches of rain fell in one day causing flooding near the Saw Mill River.	Sidney B. Bowne & Son
Heavy Rain / Flooding April 9 – 10, 1980	Greater Greenburgh Planning Area	Heavy rains flooded area parkways and Babbitt Court and businesses west of Route 9A. Almost two inches of rain fell on April 9 th and on April 10 th , more than three inches of rain fell, totaling over five inches of rain in two days.	Sidney B. Bowne & Son
Remnants of Hurricane Fausto September 16-17, 1996	Countywide	Storm produced heavy rain, strong gusty winds and minor to locally moderate coastal flooding. Rainfall amounts ranged between 2 and 4 inches over New York City, Long Island and the Lower Hudson Valley.	NOAA-NCDC
Remnants of Tropical Storm Josephine October 8-9, 1996	Countywide	Between 1 and 3 inches of rain fell across the area and caused localized flooding of streets and poor drainage areas. Wind gusts ranged between 40 and 50 mph in most of the affected areas.	NOAA-NCDC
Severe Storms / Flooding October 18-23, 1996 (FEMA DR-1146)	Multi-State	See FEMA Disaster Declarations (Table 5.4.1-6)	NOAA-NCDC, Associated Press, USGS, FEMA, Stuart et al., NYSDPC, Sidney B. Bowne & Son
Remnants of Hurricane/Tropical Storm Floyd September 16-18, 1999 (FEMA DR-1296)	Multi-State	See FEMA Disaster Declarations (Table 5.4.1-6)	FEMA, Pasch, Hazards and Vulnerability Institute (SHELDUS) , Sidney B. Bowne & Son
Remnants of Hurricane	Countywide	Remnants of Hurricane Isidore passed just west and	NOAA-NCDC

SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Event Name / Date	Location	Losses / Impacts	Source(s)
Isidore September 26-28, 2002		northwest of the New York City Metropolitan Area. This resulted in widespread rainfall. Westchester County and the Lower Hudson Valley received between 1.5 inches and 2 inches of rain. The storm also brought strong sustained winds between 20 and 30 mph, with gusts of 40 mph. Wind downed many trees.	
Severe Storm / Flooding April 1-4, 2005 (FEMA DR-1589)	Multi-State	See FEMA Disaster Declarations (Table 5.4.1-6)	FEMA, Hazards and Vulnerability Research Institute (SHELDUS), USACE, MARFC, NOAA-NCDC
Severe Storms and Flooding June / July 2006 (FEMA DR-1650)	Multi-State	See FEMA Disaster Declarations (Table 5.4.1-6)	FEMA, Hazards and Vulnerability Research Institute (SHELDUS), NOAA-NCDC
Remnants of Tropical Storm Ernesto September 2, 2006	Multi-County	Remnants of Tropical Storm Ernesto brought heavy rain and gusty winds across Long Island and Southeast New York State. This resulted in many trees and power lines down with hundreds of thousands of people without power. Westchester County had between 0.5 and 1 inches of rain, with wind gusts of up to 49 mph.	NOAA-NCDC
Severe Storm and Inland and Coastal Flooding April 14-17, 2007 (also identified as a Nor'Easter) (FEMA DR-1692)	Multi-State	See FEMA Disaster Declarations (Table 5.4.1-6)	FEMA, Chas. H. Sells, Inc., Associated Press
TSTMs May 16, 2007	Multi-State	Severe TSTMs hit the region, causing power outages to 30,000 people, including residents in the Town of Cortlandt. Estimated wind speeds were at least 70 mph.	Feurer, NWS
TSTM / Wind March 5, 2008	Multi-Jurisdictional	Severe thunderstorms moved across southeast New York State ahead of a cold front the morning of March 5th. The storms produced strong winds, with 58 mph winds reported in the Village of Hastings-on-Hudson. A downed tree was reported in the Village of Elmsford along the Saw Mill River Parkway.	NOAA-NCDC, NWS, USAToday.com
Severe Storms and Flooding	Multi-County	See FEMA Disaster Declarations (Table 5.4.1-6)	FEMA, CNN.com, Fox News, NOAA-NCDC



SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Event Name / Date	Location	Losses / Impacts	Source(s)
March 13-15, 2010 (also identified as a Nor'Easter) (FEMA DR-1899)			
Severe Storms March 29 – 31, 2010	Multi-State	A significant rain storm socked the region, causing widespread flooding. On Long Island, the Atlantic Ocean inundated a 20-mile stretch of an oceanfront road in Southampton. A mudslide in the Bronx interrupted service on the Metro-North commuter railroad. Flooding suspended service on part of the Staten Island railway. The Sheldrake River in the Village of Mamaroneck closed an exit off of I-95. In Westchester County, rainfall totals ranged between 3.20 inches and 4.83 inches.	NOAA-NCDC, NWS, NBC New York

Note (1): 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 Federal Disaster Declaration
- EM Federal Emergency Declaration
- FEMA Federal Emergency Management Agency
- HMP Hazard Mitigation Plan
- K Thousand (\$)
- M Million (\$)
- NCDC National Climate Data Center
- NOAA National Oceanic Atmospheric Administration
- NWS National Weather Service
- SHELDUS Spatial Hazard Events and Losses Database for the U.S.
- USDA U.S. Department of Agriculture
- USGS U.S. Geological Survey



Further descriptions of select severe storm events that have impacted the Greater Greenburgh Planning Area are provided below with details regarding their impact, where available. These descriptions are provided to give the reader a context of the coastal storm events that have affected the Planning Area and to assist local officials in locating event-specific data for their municipalities based on the time and proximity of these events. Many severe storm events resulted in major flooding throughout the Planning Area; therefore, the flood impacts of these events are further mentioned in Section 5.4.2 (Flood).

Monetary figures within the following 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 increased inflation.

September 16, 1999 (Hurricane/Tropical Storm Floyd) (FEMA DR-1296): According to the NOAA NHC, this event was a large and intense storm that pounded the central and northern Bahama islands, seriously threatened Florida, struck near the coast of North Carolina and moved up the east coast of the U.S. into New England as a tropical storm. It neared the threshold of a Category 5 on the Saffir/Simpson Hurricane Scale as it approached the Bahamas, and caused a flood disaster of immense proportions in the eastern U.S., particularly from the eastern coast of North Carolina through New Jersey (Pasch et al., 1999). Much of Floyd's impact was due to heavy rainfall, creating major losses from floodwaters throughout the eastern U.S. Common rainfall totals ranged between 4 and 12 inches (NWS, 1999). Ten states were declared major disaster areas, which included Connecticut, Delaware, Florida, Maryland, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, and Virginia (NCDC, 2000).

New York State experienced approximately \$62.2 million in property damages from this event (NYSDPC, 2008). The worst damage in the New York Metropolitan region reportedly occurred in Rockland and Westchester Counties (Chen, 1999). Many Westchester County officials proclaimed the storm as one of the worst storms ever to hit the area at that time, with the most rain ever recorded dropped on the County in a 24-hour period (Brenner, 1999). In Westchester County, rainfall totals ranged between 8 and 12 inches (NWS, 1999). The flood impact and losses of this event are further discussed in more detail in Section 5.4.2 (Flood).

This storm resulted in a FEMA Disaster Declaration (FEMA DR-1296) on September 19, 1999. Through this declaration, the following 15 counties were declared eligible for Federal and State disaster funds: Albany, Dutchess, Essex, Greene, Nassau, Orange, Putnam, Rensselaer, Rockland, Schenectady, Schoharie, Suffolk, Ulster, Warren and Westchester counties (NYSEMO, 2006; FEMA, 2008; NYSDPC, 2008). Disaster assistance for all counties affected in the State has not been clearly documented. As of December 6, 1999, 921 Disaster Housing grants totaling \$1,682,634 and 104 Individual and Family Grants (IFG) grants totaling \$114,902 were approved out of 1,859 total registrations from the County (FEMA, 1999). However, other sources indicate that Westchester County municipalities were reimbursed approximately \$14 million by FEMA for damages with local businesses receiving \$2.3 million from FEMA and homeowners receiving nearly \$1.6 million (Rubenstein, 2004).

April 2-4, 2005 (FEMA DR-1589): A slow moving storm moved up through the Appalachians and into the northeast U.S. Widespread heavy rain and thunderstorms occurred with this storm, bringing rainfall totals from one inch on parts of Long Island to almost four inches across parts of the Lower Hudson valley. Prior to this system, another storm brought two to three inches of rain across the region, causing widespread flooding.

New York State experienced approximately \$66.2 M in eligible damages during this event with the heaviest rain falling in Ulster and Greene Counties (NYSDPC, 2008). Total Rainfall amounts in New York State ranged from around 1 inch on parts of Long Island to nearly 4 inches across parts of the Lower

Hudson Valley. In Westchester County, NOAA-NCDC and SHELDUS indicated that the County experienced approximately \$4.3 million in flood damages (NCDC, 2008; Hazards and Vulnerability Research Institute, 2008). The flood impact and losses of this event are further discussed in more detail in Section 5.4.2 (Flood).

This storm resulted in a FEMA Disaster Declaration (DR-1589) on April 19, 2005. Through this declaration, the following 20 counties were declared eligible for Federal and State disaster funds: Broome, Cayuga, Chautauqua, Chenango, Columbia, Cortland, Delaware, Greene, Madison, Montgomery, Niagara, Orange, Otsego, Putnam, Rensselaer, Schoharie, Sullivan, Tioga, Ulster and Westchester (NYSDPC, 2008; FEMA, 2008). In a September 14, 2005 Press Release, FEMA indicated that nearly \$35 million in disaster aid was made available to all declared counties as result of this event. In this press release, FEMA approved \$76,136 in public assistance reimbursements for the County (FEMA, 2005).

April 14-18, 2007 (FEMA DR-1692): An intense and powerful Nor'Easter brought flooding rains and heavy wet snowfall to the northeast U.S. Rainfall totals of six to eight inches were reported across the eastern Catskill Mountains, mid-Hudson Valley and western New England, resulting in widespread flooding. Snowfall accumulations of one to one and a half feet were reported across the southern Adirondacks, eastern Catskills, Berkshires, and southern Green Mountains (NWS, Date Unknown). The combined effects of high winds and heavy rainfall during this event led to flooding, storm damages, power outages, 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, particularly in the southeastern section of the State (NOAA, 2008). Westchester County experienced between 4 and 8 inches of rainfall during this event. The heavy rains in Westchester County produced widespread flooding. The flood impacts and losses of this event are further discussed in more detail in Section 5.4.2 (Flood).

New York State experienced millions in damages from this event (NYSDPC, 2008). In Westchester County, private property losses were estimated at \$83 million and public property losses were estimated at \$2 million (Chas. H. Sells, Inc., 2007). Disaster assistance to the County totaled \$30 million as of July 23, 2007. Cost estimates of property damage in Westchester County and the Greater Greenburgh Planning Area were unavailable in the materials reviewed to develop this plan.

This Nor'Easter resulted in a FEMA Emergency Declaration (FEMA EM-1692) on April 24, 2007. Through this declaration, the following 13 Counties were declared eligible for Federal and State disaster funds: Albany, Columbia, Dutchess, Essex, Greene, Montgomery, Orange, Putnam, Rockland, Schoharie, Suffolk, Ulster and Westchester Counties (FEMA, 2008). As of August 13, 2007, FEMA indicated that nearly \$61 million in total disaster aid was made available to all declared counties as result of this event (FEMA, 2007). Earlier on July 30, 2007, FEMA approved over \$30 million in disaster assistance for Westchester County (FEMA, 2007). The monies include individual assistance (IA) grants, U.S. Small Business Administration (SBA) loans, and public assistance (PA) funding for damage sustained during the storm. The monies are broken down as follows:

- More than \$6.7 million was approved for 2,731 households through the FEMA Housing Program (HA).
- More than \$840,000 was approved for 599 households under the FEMA/State Other Needs Assistance Program (ONA).
- The SBA approved \$20,225,700 in low-interest disaster loans for 384 homeowners, renters and business owners.

- More than \$2.4 million was approved for public assistance (PA) funding (FEMA, 2007).

March 13-15, 2010 (FEMA DR-1899): A Nor’Easter affected the east coast of the U.S., which brought heavy rain, snow, sleet, ice, and wind to the area. Flooding, power outages, downed trees and storm surge all resulted from the storm. Over 300,000 customers were without power due to the hurricane-force winds. The heavy rain caused flooding across the northeast, with flood warnings in effect from northern Virginia to southern New Hampshire. Some coastal areas received over six inches of rain (Courson et al., 2010). In higher elevations, snow, sleet and freezing rain fell across the eastern Catskills, Helderbergs, southern Adirondacks, Berkshires, Litchfield Hills and southern Vermont (NOAA, 2010). This Nor’Easter caused seven deaths: two in New Jersey, one in Rhode Island, one in New Hampshire, one in Connecticut, one in West Virginia, and one in New York (Courson et al., 2010).

In the New York City area, Con Edison stated that more than 86,000 customers were without power in New York City and Westchester County. Long Island Power Authority said over 64,000 customers were without power on Long Island (Courson et al., 2010).

Unincorporated Greenburgh was one of the hardest hit areas in Westchester County (Wall Street Journal, 2010). Numerous downed trees, power lines and closed roads were reported in the Town (Feiner, 2010). The flood impacts and losses of this event are further discussed in more detail in Section 5.4.2 (Flood).

This Nor’Easter resulted in a FEMA Emergency Declaration (FEMA EM-1899) on April 16, 2010. Through this declaration, the following nine counties were declared eligible for Federal and State disaster funds: Nassau, Orange, Otsego, Richmond, Rockland, Schoharie, Suffolk, Warren and Westchester (FEMA, 2010). As of February 3, 2011, FEMA indicated that over \$83 million in total public assistance grants was made available for those counties included in the disaster declaration (FEMA, 2011).

Probability of Future Events

The NWS conducted a study of the frequency of storms in the Atlantic Ocean. Utilizing statistical data on the motion of tropical storms in the Atlantic Ocean, the NWS calculated the expected numbers of tropical storms and hurricanes per 100 year period impacting various locations along the east coast. The data was gathered and analyzed based on a grid system. The data presented in Table 5.4.1-8 is based on the grid that encompasses southeastern New York State, northern New Jersey, western Connecticut, and western Long Island. This grid also included the Greater Greenburgh Planning Area (Sidney B. Bowne & Son, 2001).

Table 5.4.1-8. Potential for Future Severe Storm Events

Expected Number of Tropical Storms	Expected Number of Hurricanes	Probability of at Least One Tropical Storm Over a 10 Year Period	Probability of at Least One Hurricane Over a 10 Year Period
19	7	0.85	0.50

Source: Sidney B. Bowne & Son, 2001

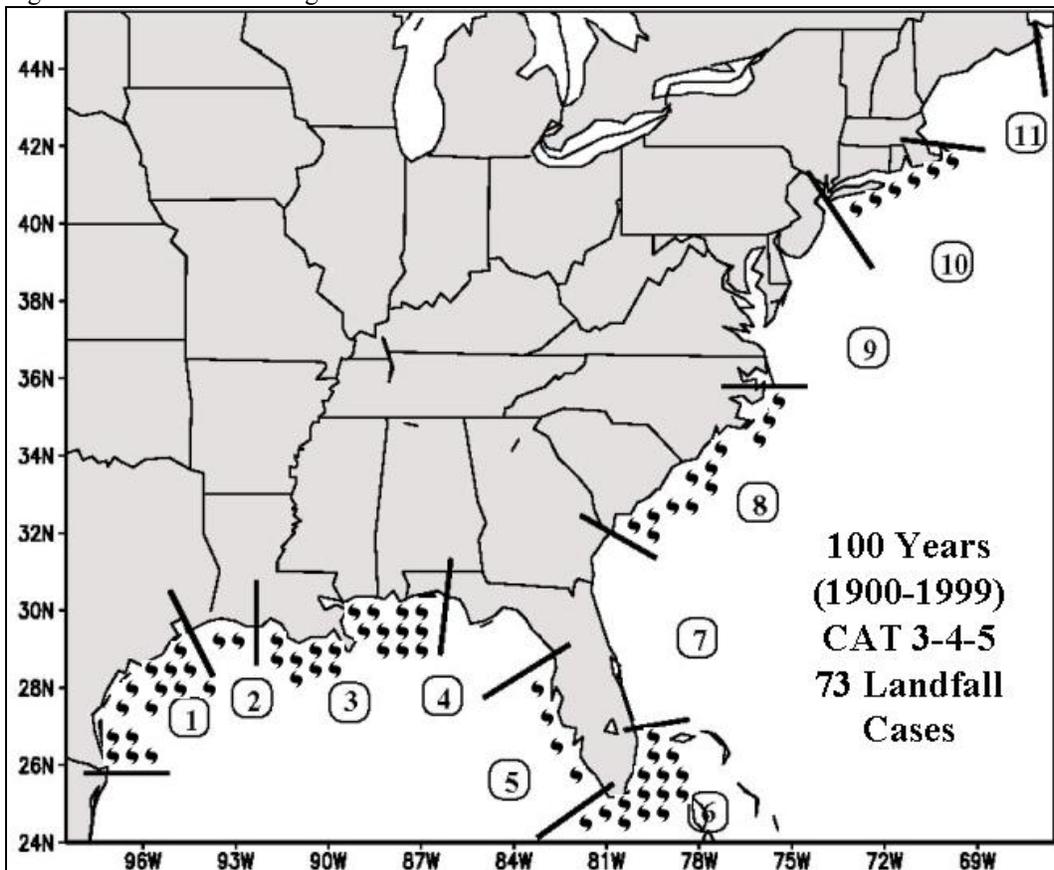
Predicting future severe storm events in a constantly changing climate has proven to be a difficult task. Predicting extremes in New England and New York State is particularly difficult because of the region’s geographic location. It is positioned roughly halfway between the equator and the North Pole and is exposed to both cold and dry airstreams from the south. The interaction between these opposing air masses often leads to turbulent weather across the region (Keim, 1997).

Hurricanes

Hurricane season starts in June and ends in November. It averages six hurricanes per year in the Atlantic Ocean. During the hurricane season, New York City is at highest risk between August and October because water temperatures are warm enough in the Northern Atlantic to develop and sustain a hurricane. According to a 1998 study by Colorado State University, New York City has a 0.9-percent chance of being hit by a Category 3 hurricane (NYC.gov, Date Unknown).

Tropical cyclone landfall and wind gust calculations have been made for eleven regions in the U.S., from Brownsville, Texas to Eastport, Maine. These regions were created based on frequency of intense or major hurricane (Category 3 through 5) landfalls between 1900 and 1999 (Klotzbach et al., Date Unknown). Westchester County is located in Region 10, which includes counties from New York State, Connecticut and Massachusetts. Figure 5.4.1-13 shows the regions along the east coast.

Figure 5.4.1-13. Coastal Regions for Landfall Probabilities



Source: Klotzbach et al., Date Unknown

According to the U.S. Landfalling Hurricane Probability Project, Region 10 has a 26.7-percent probability that a named storm will hit the Region in 2010. There is a 16.4-percent probability that Region 10 will be hit with a hurricane in 2010 and an 8-percent probability that Region will be hit with a major hurricane (Category 3 or higher) in 2010. For Westchester County, there is a 0.8-percent probability of a named storm making landfall in the County. There is a 0.4-percent probability of a hurricane making landfall and a 0.2-percent probability of a major hurricane making landfall (Klotzbach et al., Date Unknown; Mandia, 2010).

SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

NOAA’s National Hurricane Center Risk Analysis Program has calculated hurricane MRPs for the northeastern U.S. for the five hurricane categories (see Figure 5.4.1-14 for a Category 3 hurricane and Figure 5.4.1-15 for a Category 4 hurricane). Table 5.4.1-9 documents the return period for Categories 1 through 5 that may impact Westchester County and the Planning Area.

Figure 5.4.1-14. Return Period - Category 3 Hurricane

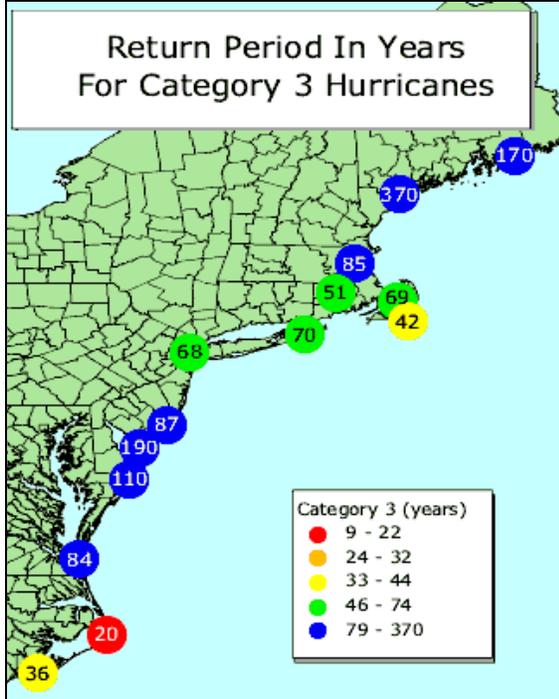
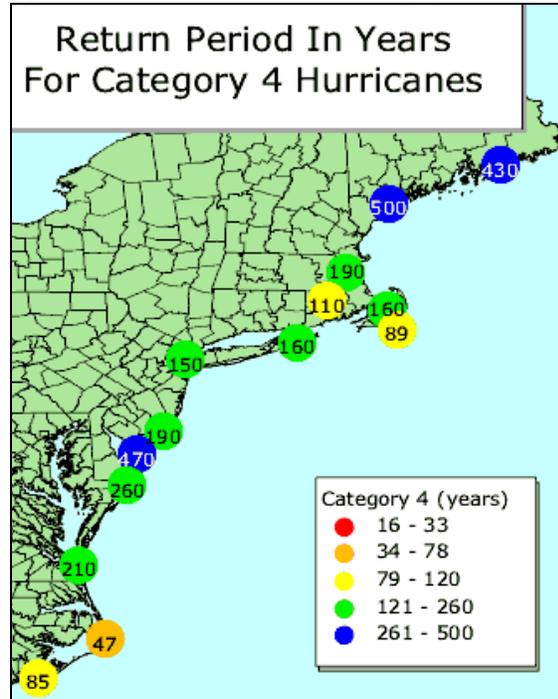


Figure 5.4.1-15. Return Period - Category 4 Hurricane



Source: NOAA National Hurricane Center, Date Unknown

Table 5.4.1-9. Return Period in Years for Hurricanes (by Category) for Westchester County

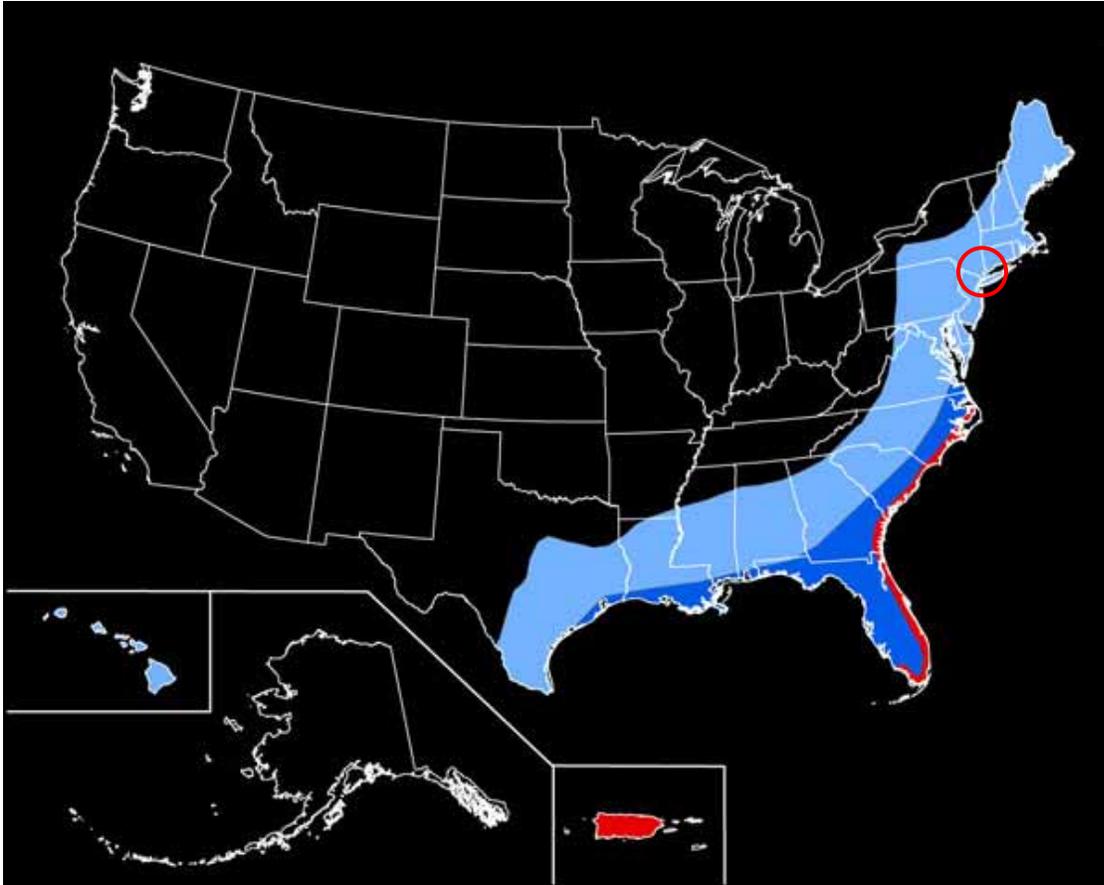
Return Period in Years for Hurricanes		
Category	Wind Speed	Return Period
1	74-95 mph	15-24 years
2	96-110 mph	31-62 years
3	111-130 mph	46-74 years
4	131-155 mph	121-260 years
5	156 + mph	251-370 years

Source(s): NHC, Date Unknown; NHC, 2010

Hurricane return periods are the frequency a certain category of hurricane can be expected within 75 nautical miles of a given location. A return period of 20 years for a Category 3 or greater hurricane means that on average during the previous 100 years, a Category 3 or greater hurricane passed within 75 nautical miles of the specific location approximately five times. It would be expected that on average an additional five Category 3 or greater hurricanes within the radius over the next 100 years (NHC, Date Unknown).

Figure 5.4.1-16 illustrates the number of hurricanes expected to occur during a 100-year period. According to this map, portions of New York State, including Westchester County, can expect between 20 and 40 hurricanes during a 100-year return period.

Figure 5.4.1-16. Number of Hurricanes for a 100-year Return Period



Source: USGS, 2007

Note: The number of hurricanes expected to occur during a 100-year MRP based on historical data—light blue area, 20 to 40; dark blue area, 40 to 60; red area, more than 60. Map not to scale.

Nor’Easters

Analysis of Nor’Easter frequency by researchers reveals that fewer Nor’Easters occurred during the 1980s. However, the frequency of major Nor’Easters (class 4 and 5 on the Dolan-Davis Scale) has increased in recent years. In the period of 1987 to 1993, at least one class 4 or 5 storm has occurred each year along the Atlantic coast, a situation duplicated only once in the last 50 years (North Carolina Division of Emergency Management, 2009).

According to the Cape Cod Commission’s Emergency Preparedness Handbook, unlike the relatively infrequent hurricane, the northeastern U.S. generally experiences at least one or two Nor’Easter events each year with varying degrees of severity. These storms have the potential to inflict more damage than many hurricanes because high winds can last from 12 hours to three days, while the duration of hurricanes ranges from six to 12 hours (Cape Cod Commission, 2007). Infrastructure, including critical facilities, may be impacted by these events, and power outages and transportation disruptions (for example: snow, heavy rain and/or debris impacted roads, as well as hazards to navigation and aviation) are often associated with Nor’Easters and other winter storms (Northeast States Emergency Consortium [NESEC],

Date Unknown). All areas of the Greater Greenburgh Planning Area are potentially at risk for property damage and loss of life due to Nor'easters; therefore, having a moderate to high probability for Nor'easters to occur.

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 ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for severe storms in the Planning Area is considered 'frequent' (likely to occur more than once every 25 years, as presented in Table 5.3-3); however, impacts only related to severe storms, excluding those associated with hurricanes, tropical storms, Nor'easters and flooding, are expected to be minimal.

It is estimated that the Greater Greenburgh Planning Area will continue to experience direct and indirect impacts of severe storms annually that may induce secondary hazards such as flooding, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences.

The Role of Global Climate Change on Future Probability

Global climate change poses risks to human health and to terrestrial and aquatic ecosystems. Important economic resources such as agriculture, forestry, fisheries, and water resources also may be affected. Warmer temperatures, more severe droughts, storms and floods, and sea level rise could have a wide range of impacts. All these stresses can add to existing stresses on resources caused by other influences such as population growth, land-use changes, and pollution.

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Human-induced climate change has the potential to alter the prevalence and severity of extremes such as heat waves, cold waves, severe storms, floods and droughts. Though predicting changes in these types of events under a changing climate is difficult, understanding vulnerabilities to such changes is a critical part of estimating future climate change impacts on human health, society and the environment.

It is important to understand that directly linking any one specific extreme event (for example, a severe hurricane) to climate change is not possible. However, climate change and global warming may increase the probability of some ordinary weather events reaching extreme levels or of some extreme events becoming more extreme (U.S. Environmental Protection Agency [USEPA], 2006). It remains very difficult to assess the impact of global warming on extreme weather events, in large part because this analysis depends greatly on regional forecasts for global warming. Global warming will almost certainly have different effects on different regions of the Earth, so areas will not be equally susceptible to increased or more intense extreme weather events. Although regional climate forecasts are improving, they are still uncertain (Climate Institute, Date Unknown). These many uncertainties may exist regarding magnitude or severity; however, many sources indicate that future weather patterns and increased intensities are anticipated as a result of climate change, along with atmospheric, precipitation, storm and sea level changes (USEPA, 2007).

VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For severe storms, the entire Greater Greenburgh Planning Area has been identified as the hazard area. Therefore, all assets in the Planning Area (population, structures, critical facilities and lifelines), as described in the Regional Profile section, are vulnerable. The following text evaluates and estimates the potential impact of severe storms on the Planning Area including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, safety and health of residents, (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

The high winds and air speeds of a hurricane or any severe storm often result in power outages, disruptions to transportation corridors and equipment, loss of workplace access, significant property damage, injuries and loss of life, and the need to shelter and care for individuals impacted by the events. A large amount of damage can be inflicted by trees, branches, and other objects that fall onto power lines, buildings, roads, vehicles, and, in some cases, people. Additionally, storms can cause storm surge related damages along the coast.

Due to the Greater Greenburgh Planning Area's proximity to the tidal Hudson River and Atlantic Ocean, the loss associated with severe storms is primarily associated with tropical storm/hurricane-related rains, storm surge and severe winds. The Planning Area has experienced flooding in association with severe storms in the past. Please refer to the flood hazard profile (Section 5.4.2) for more information on the Planning Area's vulnerability to this hazard.

The entire inventory of the Planning Area is at risk of being damaged or lost due to impacts of severe storms (severe wind). Certain areas, infrastructure, and types of building are at greater risk than others due to proximity to falling hazards and manner of construction.

HAZUS-MH MR4 estimates losses associated with hurricane-related winds. Potential losses associated with high wind events were calculated for the Greater Greenburgh Planning Area for two probabilistic hurricane events, the 100-year and 500-year MRP hurricane events. The impacts on population, existing structures and critical facilities on the Planning Area are presented below, following a summary of the data and methodology used.

Data and Methodology

After reviewing historic data, the HAZUS-MH methodology and model were used to analyze the severe storm hazard for the Greater Greenburgh Planning Area. Data used to assess this hazard include data available in the HAZUS-MH MR4 hurricane and flood models, professional knowledge, information provided by the Planning Committee and input from public citizens.

A probabilistic scenario was run for the Greater Greenburgh Planning Area for annualized losses and the 100- and 500-year MRPs were examined for the wind/severe storm hazard. Figures 5.4.1-1 and 5.4.1-2, earlier in this section, show the HAZUS-MH MR4 maximum peak gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP hurricane events. The estimated hurricane track for the 100- and 500-year events is also shown.

HAZUS-MH MR4 contains data on historic hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Hurricane and inventory data available in HAZUS-MH MR4 were used to evaluate potential losses from the 100- and 500-year MRP hurricane event (severe wind impacts). Locally available inventory data were reviewed to determine their appropriateness for inclusion. Other than data for critical facilities, the default data in HAZUS-MH MR4 was the best available for use in this evaluation. The 11 residential and 10 commercial occupancy classes available in HAZUS-MH were condensed into the following occupancy classes (residential, commercial, industrial, agricultural, religious, government, and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single family dwellings. In addition, impacts to critical facilities were evaluated for the 100-year and 500-year MRP events.

Hurricanes cause both wind and storm surge related damages. For the purposes of this Plan, exposure from storm surge is included below using the Sea – Lake Overland Surge from Hurricanes – SLOSH Model inundation areas provided by NYSOEM, however at this time, estimated losses from combined wind and storm surge are not reported.

Impact on Life, Health and Safety

The impact of a severe storm on life, health and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. It is assumed that the entire Planning Area's population (U.S. Census 2000 population of 86,764 people) is exposed to this storm hazard.

Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Table 5.4.1-10 lists the number of households HAZUS-MH MR4 estimates may be displaced and/or require temporary shelter due to a 100-year and 500-year MRP event. These figures are based on the 2000 U.S. Census. Please refer to Section 4 for a list of shelters in the Greater Greenburgh Planning Area.

SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Table 5.4.1-10. Sheltering Needs for 100-year and 500-year MRP Hurricane Events for the Greater Greenburgh Planning Area

Municipality	Displaced		Short-Term	
	100-Yr.	500-Yr.	100-Yr.	500-Yr.
Unincorporated Greenburgh	3	115	1	23
Village of Ardsley	0	0	0	0
Village of Dobbs Ferry	0	20	0	4
Village of Elmsford	0	3	0	0
Village of Hastings-on-Hudson	0	7	0	1
Village of Irvington	0	8	0	0
Village of Tarrytown	0	17	0	3
Planning Area Total	3	170	1	31

Source: HAZUS-MH MR4

Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate. The population over the age of 65 is also more vulnerable and, physically, they may have more difficulty evacuating. The elderly are considered most vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention which may not be available due to isolation during a storm event.

NYSOEM provided hurricane storm surge inundation zones for New York State. The inundation maps were based on surge height projections calculated by the National Weather Service’s “Sea – Lake Overland Surge from Hurricanes – SLOSH Model.” The surge heights were calculated for a number of Category 1 to 4 hurricanes. This data was developed to delineate hazard zones and assess risk from hurricane-related storm surges and to support hurricane evacuation planning. Please note, the real effects of a hurricane can depend on many factors, including the storm’s size, location of landfall and the tides. Refer to Figure 5.4.1-3 earlier in this profile for the hurricane storm surge inundation zones for the Greater Greenburgh Planning Area.

To estimate the population located in the hurricane inundation zones, the sum of the population in all Census Blocks with their centroid located in the SLOSH zone was calculated for the Region. Table 5.4.1-11 summarizes the approximate population located in the hurricane storm surge inundation zones based on 2000 Census data. See the Flood profile (Section 5.4.2) for the population located in the flood zones.

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Table 5.4.1-11. Approximate Population in the Hurricane Inundation Zones for the Greater Greenburgh Planning Area

Municipality	Total Population	CAT 1		CAT 2		CAT 3		CAT 4	
		Pop. in Zone	% of Total						
Unincorporated Greenburgh	41,828	0	0.0	0	0.0	0	0.0	0	0.0
Village of Ardsley	4,269	0	0.0	0	0.0	0	0.0	0	0.0
Village of Dobbs Ferry	10,622	0	0.0	379	3.6	379	3.6	379	3.6
Village of Elmsford	4,676	0	0.0	0	0.0	0	0.0	0	0.0
Village of Hastings-on-Hudson	7,648	53	0.7	53	0.7	53	0.7	53	0.7
Village of Irvington	6,631	0	0.0	0	0.0	85	1.3	85	1.3
Village of Tarrytown	11,090	278	2.5	278	2.5	672	6.1	672	6.1
Planning Area Total	86,764	331	0.4	710	0.8	1,189	1.4	1,189	1.4

Source(s): HAZUS-MH MR4; NYSOEM
 Notes: CAT = Category. Pop. = Population.

Impact on General Building Stock

After considering the population exposed to the severe storm hazard, the general building stock replacement value exposed to and damaged by 100- and 500-year MRP events was examined. Wind-only impacts from a severe storm are reported based on the probabilistic hurricane runs in HAZUS-MH MR4. Potential damage is the modeled loss that could occur to the exposed inventory, including damage to structural and content value based on the wind-only impacts associated with a hurricane (using the methodology described in Section 5.1).

It is assumed that the entire Planning Area’s general building stock is exposed to the severe storm wind hazard (nearly \$17 billion; refer to Section 4). However, severe storms also cause storm-surge related impacts. The SLOSH inundation areas were used to estimate the total number of buildings and general building stock replacement value exposed to hurricane storm surge. The SLOSH inundation areas were overlaid upon 2004 structure GIS layers provided by Westchester County GIS for each participating municipality in the Greater Greenburgh Planning Area. According to these 2004 datasets, there are 26,844 ‘buildings’ of the 27,159 structures in the Planning Area (antennas, tanks, towers, train stations, train platforms and miscellaneous structures were excluded). The buildings with their center located within the SLOSH zones were used to estimate the building count exposed to this hazard (Table 5.4.1-12). Because no other attribute data was provided with the building GIS layer, the number of buildings per occupancy class (i.e., residential, commercial, etc.) or the building/contents replacement values cannot be specified.

Table 5.4.1-12. Number of Buildings in the Hurricane Inundation Zones for the Greater Greenburgh Planning Area

Municipality	Total Number of Buildings	CAT 1		CAT 2		CAT 3		CAT 4	
		# in Zone	% of Total						
Unincorporated Greenburgh	13,049	0	0.0	0	0.0	0	0.0	0	0.0
Village of Ardsley	1,670	0	0.0	0	0.0	0	0.0	0	0.0
Village of Dobbs Ferry	2,859	7	0.2	13	0.5	17	0.6	18	0.6



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Municipality	Total Number of Buildings	CAT 1		CAT 2		CAT 3		CAT 4	
		# in Zone	% of Total	# in Zone	% of Total	# in Zone	% of Total	# in Zone	% of Total
Village of Elmsford	1,509	0	0.0	0	0.0	0	0.0	0	0.0
Village of Hastings-on-Hudson	2,813	21	0.7	27	1.0	29	1.0	39	1.4
Village of Irvington	2,063	3	0.1	11	0.5	16	0.8	25	1.2
Village of Tarrytown	2,881	27	0.9	44	1.5	69	2.4	78	2.7
Planning Area Total	26,844	58	0.2	95	0.4	131	0.5	160	0.6

Source: NYSOEM; Westchester GIS, 2004

Notes: CAT = Category.

To calculate the general building stock replacement value exposed, the sum of the general building stock replacement value (for all occupancy classes) in all Census Blocks with their centroid located in the SLOSH zone was calculated. Table 5.4.1-13 summarizes the approximate general building stock replacement value located in the hurricane storm surge inundation zones based on HAZUS-MH MR4 default data (replacement values based on RSMMeans as of 2006). See the Flood profile (Section 5.4.2) for the general building stock replacement value located in the flood zones.

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Table 5.4.1-13. Estimated Total General Building Stock Replacement Value in the Hurricane Inundation Zones

Municipality	Total GBS RV	CAT 1		CAT 2		CAT 3		CAT 4	
		GBS in Zone	% of Total	GBS in Zone	% of Total	GBS in Zone	% of Total	GBS in Zone	% of Total
Unincorporated Greenburgh	\$869,545,000	\$0	0.0	\$0	0.0	\$0	0.0	\$0	0.0
Village of Ardsley	\$1,890,873,000	\$0	0.0	\$0	0.0	\$0	0.0	\$0	0.0
Village of Dobbs Ferry	\$1,028,560,000	\$0	0.0	\$0	0.0	\$73,102,000	7.1	\$73,102,000	7.1
Village of Elmsford	\$7,923,763,000	\$0	0.0	\$0	0.0	\$0	0.0	\$0	0.0
Village of Hastings-on-Hudson	\$1,469,469,000	\$34,579,000	2.4	\$34,579,000	2.4	\$34,579,000	0.0	\$34,579,000	0.0
Village of Irvington	\$1,194,043,000	\$0	0.0	\$0	0.0	\$80,014,000	2.4	\$86,024,000	2.4
Village of Tarrytown	\$2,451,976,000	\$34,642,000	1.4	\$34,642,000	1.4	\$104,835,000	6.7	\$113,733,000	7.2
Planning Area Total	\$16,828,229,000	\$69,221,000	0.4	\$69,221,000	0.4	\$292,530,000	4.3	\$307,438,000	4.6

Source(s): HAZUS-MH MR4; NYSOEM

Notes:

CAT = Category. GBS = General Building Stock. RV = Replacement Value

Wind Only Hurricane Impacts

The entire study area is considered at risk to the severe storm wind hazard. Please refer to Section 4 (Region Profile) which presents the total exposure value for general building stock by occupancy class for the Greater Greenburgh Planning Area.

Expected building damage was evaluated by HAZUS across the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.1-14 summarizes the definition of the damage categories.

Table 5.4.1-14. Description of Damage Categories

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
No Damage or Very Minor Damage Little of no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof over, with no or very limited water penetration.	≤ 2%	No	No	No	No	No
Minor Damage Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair.	> 2% and ≤ 15%	One window, door, or garage door failure	No	< 5 Impacts	No	No
Moderate Damage Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.	> 15% and ≤ 50%	> the larger of 20% & 3 and ≤ 50%	1 to 3 Panels	Typically 5 to 10 Impacts	No	No
Severe Damage Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	> 50%	> one and ≤ the larger of 20% & 3	> 3 and ≤ 25%	Typically 10 to 20 Impacts	No	No
Destruction Complete roof failure and/or failure of wall frame. Loss of more than 50% of roof sheathing.	Typically > 50%	> 50%	> 25%	Typically > 20 Impacts	Yes	Yes

Source: HAZUS-MH Hurricane Technical Manual

The Greater Greenburgh Planning Area HAZUS-MH MR4 100- and 500-year MRP wind event model runs calculated the estimated expected building damage by general occupancy type of various severities for the wind-only analysis. These estimates are summarized for the Region in Table 5.4.1-15. In addition, the annualized losses were examined for the Greater Greenburgh Planning Area; see Table 5.4.1-16. Please note that annualized loss does not predict what losses will occur in any particular year.

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Table 5.4.1-15. Expected Building Damage by Occupancy Class for 100- and 500-Year Hurricane Events for the Greater Greenburgh Planning Area

Occupancy Class	Severity of Expected Damage	100-year		500-year	
		Building Count	Percent Buildings in Occupancy Class	Building Count	Percent Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	None	23,718	97.8%	18,108	74.7%
	Minor	491	2.0%	4,943	20.4%
	Moderate	47	< 1%	1,109	4.6%
	Severe	1	< 1%	56	< 1%
	Complete Destruction	0	0%	41	< 1%
Commercial Buildings	None	-	98.3%	-	78.4%
	Minor	-	< 1%	-	15.7%
	Moderate	-	< 1%	-	5.2%
	Severe	-	0%	-	<1%
	Complete Destruction	-	0%	-	0%

Source: HAZUS-MH MR4

Note: Only the residential category contains building counts because the residential sub-categories RES1 (single-family dwellings) and RES2 (manufactured houses) building counts are based on census housing unit counts. HAZUS-MH MR4 estimates 24,257 residential buildings in the Planning Area. All other occupancy class building counts are calculated in HAZUS-MH MR4 based on regional average square footage values for specific occupancy class/building types, and may significantly over- or under-estimate actual structure counts. Therefore, percent buildings are provided for the commercial occupancy classes in the table above to provide a general estimate of building damage.

Table 5.4.1-16. Summary of Estimated Annualized Wind General Building Stock Losses for the Greater Greenburgh Planning Area

Municipality	Total (Buildings + Contents)	Buildings	Contents
Unincorporated Greenburgh	\$1,349,072	\$953,633	\$255,749
Village of Ardsley	\$144,434	\$102,022	\$28,648
Village of Dobbs Ferry	\$285,568	\$201,601	\$52,866
Village of Elmsford	\$153,545	\$101,291	\$30,557
Village of Hastings-on-Hudson	\$229,342	\$163,802	\$42,663
Village of Irvington	\$189,499	\$136,162	\$35,130
Village of Tarrytown	\$295,765	\$206,821	\$52,891
Planning Area Total	\$2,647,223	\$1,865,331	\$498,504

Source: HAZUS-MH MR4

As noted earlier in the profile, the 100-year MRP wind speeds for the Greater Greenburgh Planning Area equate to a Category 1 hurricane. For the 100-year scenario, HAZUS-MH MR4 estimates zero-percent (0%) of the general building stock will be completely destroyed due to wind damage alone. Residential buildings comprise the majority of the building inventory and are estimated to experience the majority of building damage. Approximately 2% of the residential building stock is estimated to experience minor-to-moderate damage; however, nearly 98% of the residential building stock does not experience any damage.

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The 500-year MRP wind speeds for the Greater Greenburgh Planning Area equate to a Category 2 hurricane. Approximately 41 residential structures are estimated to be completely destroyed from wind damage alone, whereas the commercial buildings mainly experience zero to moderate damage.

Table 5.4.1-17 summarizes the building value (structure and contents) damage estimated for the 100- and 500-year MRP wind-only events.

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Table 5.4.1-17. Estimated Building Replacement Value (Structure and Content) Damaged by the 100-Year and 500-Year MRP Hurricane-Related Winds for All Occupancy Classes

Municipality	Total Building Damage		Residential Buildings		Commercial Buildings		Industrial Buildings	
	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year
Unincorporated Greenburgh	\$13,819,181	\$109,154,070	\$12,976,106	\$90,300,642	\$696,512	\$13,827,530	\$72,079	\$2,553,279
Village of Ardsley	\$1,312,338	\$10,700,114	\$1,248,712	\$8,996,187	\$46,203	\$1,221,699	\$1,586	\$51,579
Village of Dobbs Ferry	\$2,637,855	\$24,029,864	\$2,518,513	\$20,139,643	\$79,548	\$2,081,693	\$10,268	\$347,295
Village of Elmsford	\$1,051,553	\$12,412,295	\$938,930	\$8,351,562	\$94,367	\$3,061,222	\$11,414	\$597,238
Village of Hastings-on-Hudson	\$2,219,648	\$18,762,566	\$2,108,047	\$15,652,336	\$86,711	\$2,071,322	\$10,891	\$391,625
Village of Irvington	\$1,645,727	\$15,845,901	\$1,568,981	\$13,546,849	\$65,942	\$1,827,323	\$5,529	\$261,882
Village of Tarrytown	\$1,893,185	\$26,792,984	\$1,707,478	\$19,914,666	\$151,915	\$5,163,573	\$17,532	\$763,938
Planning Area Total	\$24,579,487	\$217,697,793	\$23,066,767	\$176,901,886	\$1,221,198	\$29,254,362	\$129,299	\$4,966,835

Municipality	Agriculture Buildings		Religious Buildings		Government Buildings		Education Buildings	
	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year
Unincorporated Greenburgh	\$12,043	\$467,543	\$39,334	\$882,849	\$5,345	\$580,245	\$17,761	\$541,980
Village of Ardsley	\$1,143	\$42,209	\$12,235	\$306,467	\$179	\$10,452	\$2,281	\$71,526
Village of Dobbs Ferry	\$1,157	\$48,104	\$8,425	\$225,920	\$442	\$65,754	\$19,500	\$1,121,457
Village of Elmsford	\$950	\$50,163	\$3,576	\$115,122	\$763	\$166,067	\$1,554	\$70,920
Village of Hastings-on-Hudson	\$945	\$38,752	\$6,308	\$150,340	\$2,210	\$321,955	\$4,536	\$136,238
Village of Irvington	\$252	\$14,721	\$2,216	\$79,090	\$159	\$13,416	\$2,648	\$102,621
Village of Tarrytown	\$302	\$30,207	\$10,315	\$446,631	\$2,192	\$300,848	\$3,451	\$173,131
Planning Area Total	\$16,791	\$691,700	\$82,409	\$2,206,419	\$11,291	\$1,458,735	\$51,731	\$2,217,874

Source: HAZUS-MH MR4; US Census Bureau Data, Census 2000 (as updated for HAZUS-MH most recent release).

Note (1): The valuation of general building stock and loss estimates are 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 RSMean as of 2006.

The total damage to buildings (structure and contents) for all occupancy types across the Planning Area is estimated to be nearly \$25 Million for the 100-year MRP wind-only event, and approximately \$217 Million for the 500-year MRP wind-only event. The majority of these losses are to the residential and commercial building category.

Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. The damage counts include buildings damaged at all severity levels from minor damage to total destruction. Total dollar damage reflects the overall impact to buildings at an aggregate level.

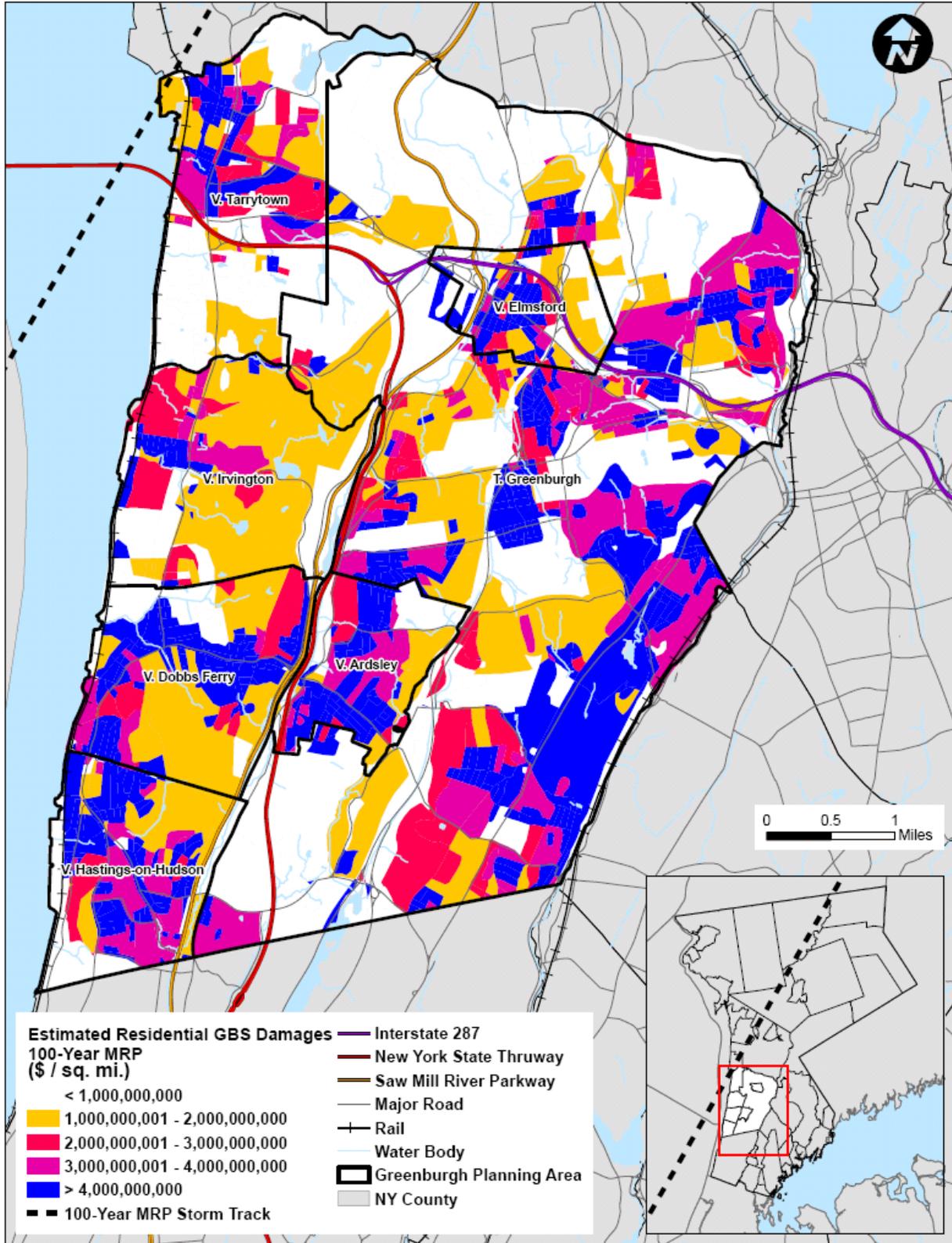
Of the \$11 billion in total residential replacement value (structure and contents) for the entire Planning Area (refer to Section 4), an estimated \$23 Million in residential building damage can be anticipated for the 100-year event and nearly \$177 Million in residential building damage can be anticipated for the 500-year event. Residential building damage accounts for 94-percent and 81-percent of total damages for the 100- and 500-year wind-only events, respectively. This illustrates that losses can be significant, especially to residential structures.

Figures 5.4.1-17 and 5.4.1-18 show the density of damage estimated for residential structures for the 100-year and 500-year MRP wind events run for the Planning Area as a whole. As can be seen from the figures, the density of loss to residential buildings is significant for the hurricane-related wind impact.

As noted earlier, total damage to buildings for combined wind and storm-surge cannot be estimated at this time. However, it is anticipated that the combination wind/surge impacts would increase these damage estimates.

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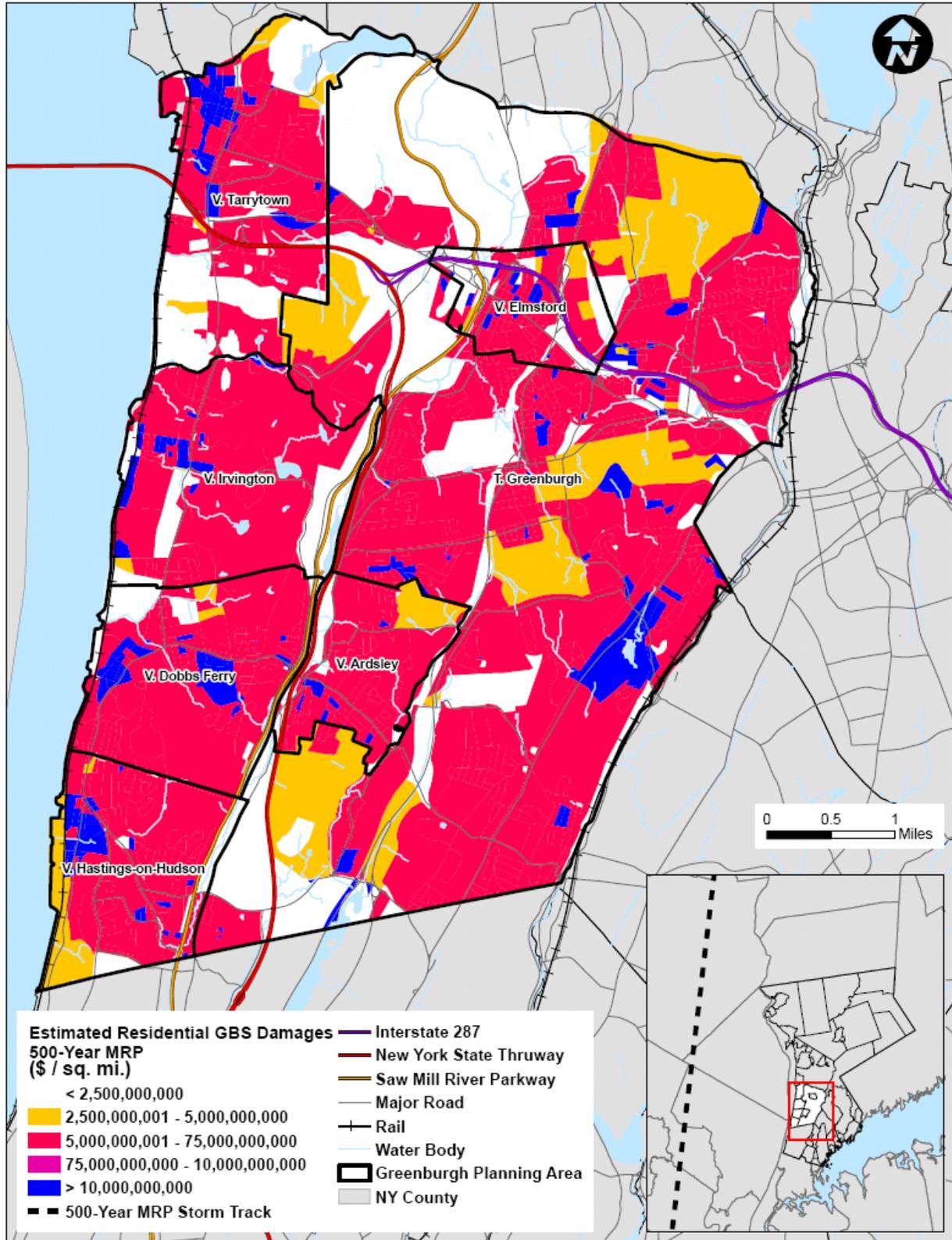
Figure 5.4.1-17. Density of Losses for Residential Structures (Structure and Content) for the Greater Greenburgh Planning Area 100-Year MRP Hurricane (Wind-Only) Event



Source: HAZUS-MH MR4

SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Figure 5.4.1-18. Density of Losses for Residential Structures (Structure and Content) for the Greater Greenburgh Planning Area 500-Year MRP Hurricane (Wind-Only) Event



Source: HAZUS-MH MR4

Impact on Critical Facilities

HAZUS-MH MR4 estimates the probability that critical facilities (i.e., medical facilities, fire/EMS, police, EOC, schools, and user-defined facilities such as shelters and municipal buildings) may sustain damage as a result of 100-year and 500-year MRP wind-only events. Additionally, HAZUS-MH MR4 estimates the loss of use for each facility in number of days.

Tables 5.4.1-18 and 5.4.1-19 list the estimated loss of use in days for each critical facility and the probability of sustaining the damage category as defined by the column heading, for the 100-year and 500-year wind-only events. The damage categories are defined in Table 5.4.1-14, under “Impact on General Building Stock”.

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Table 5.4.1-18. Estimated Impacts to Critical Facilities by the 100-Year MRP Hurricane Event (Wind Only)

100-Year Event							
Name	Municipality	Type	(Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Ardsley F.D.	Ardsley (V)	Fire	0	2.0	0.0	0.0	0.0
Ardsley EMS	Ardsley (V)	Fire	0	2.0	0.0	0.0	0.0
Ardsley P.D.	Ardsley (V)	Police	0	2.0	0.0	0.0	0.0
Ardsley High School	Ardsley (V)	School	0	2.0	0.0	0.0	0.0
Concord Road Elementary School	Ardsley (V)	School	0	2.0	0.0	0.0	0.0
Lyceum Kennedy School - French	Ardsley (V)	School	0	2.0	0.0	0.0	0.0
Ardsley Village Highway Garage	Ardsley (V)	User Defined	NA	2.0	0.0	0.0	0.0
Ardsley Community Center	Ardsley (V)	User Defined	NA	2.0	0.0	0.0	0.0
Ardsley Village Salt Shed	Ardsley (V)	User Defined	NA	2.0	0.0	0.0	0.0
Woodlands Senior Living Community	Ardsley (V)	User Defined	NA	2.0	0.0	0.0	0.0
Lincoln Rest Home	Ardsley (V)	User Defined	NA	2.0	0.0	0.0	0.0
Ardsley Senior Citizens Center	Ardsley (V)	User Defined	NA	2.0	0.0	0.0	0.0
Ardsley Village Hall	Ardsley (V)	User Defined	NA	2.0	0.0	0.0	0.0
Dobbs Ferry Hospital	Dobbs Ferry (V)	Medical	0	2.0	0.0	0.0	0.0
Dobbs Ferry F.D.	Dobbs Ferry (V)	Fire	0	1.0	0.0	0.0	0.0
Dobbs Ferry F.D.	Dobbs Ferry (V)	Fire	0	1.0	0.0	0.0	0.0
Dobbs Ferry VAC	Dobbs Ferry (V)	Fire	0	1.0	0.0	0.0	0.0
Dobbs Ferry P.D.	Dobbs Ferry (V)	Police	0	1.0	0.0	0.0	0.0
Dobbs Ferry Middle School	Dobbs Ferry (V)	School	0	1.0	0.0	0.0	0.0
Springhurst Elementary School	Dobbs Ferry (V)	School	0	2.0	0.0	0.0	0.0
St. Christopher's School (Special Ed.)	Dobbs Ferry (V)	School	0	1.0	0.0	0.0	0.0
Children's Village (Special Ed.)	Dobbs Ferry (V)	School	0	2.0	0.0	0.0	0.0
Mercy College	Dobbs Ferry (V)	School	0	1.0	0.0	0.0	0.0
Long Island University-Westchester Campus	Dobbs Ferry (V)	School	0	1.0	0.0	0.0	0.0
Masters School (The)	Dobbs Ferry (V)	School	0	2.0	0.0	0.0	0.0
Our Lady of Victory Academy	Dobbs Ferry (V)	School	0	1.0	0.0	0.0	0.0
Dobbs Ferry High School	Dobbs Ferry (V)	School	0	1.0	0.0	0.0	0.0
Sacred Heart Seniors/Church	Dobbs Ferry (V)	User Defined	NA	2.0	0.0	0.0	0.0
St. Cabrini Nursing Home	Dobbs Ferry (V)	User Defined	NA	2.0	0.0	0.0	0.0
Dobbs Ferry Village Hall	Dobbs Ferry (V)	User Defined	NA	1.0	0.0	0.0	0.0



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100-Year Event							
Name	Municipality	Type	(Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Respite of Dobbs Ferry	Dobbs Ferry (V)	User Defined	NA	1.0	0.0	0.0	0.0
Dobbs Ferry Senior Citizens Center	Dobbs Ferry (V)	User Defined	NA	1.0	0.0	0.0	0.0
Elmsford F.D.	Elmsford (V)	Fire	0	2.0	0.0	0.0	0.0
Elmsford F.D.	Elmsford (V)	Fire	0	2.0	0.0	0.0	0.0
Elmsford VFD Rescue	Elmsford (V)	Fire	0	2.0	0.0	0.0	0.0
Elmsford P.D.	Elmsford (V)	Police	0	2.0	0.0	0.0	0.0
Elmsford Village Civil Defense	Elmsford (V)	EOC	0	2.0	0.0	0.0	0.0
Our Lady of Mt. Carmel School	Elmsford (V)	School	0	2.0	0.0	0.0	0.0
Carl Dixson Elementary School	Elmsford (V)	School	0	2.0	0.0	0.0	0.0
Alice E. Grady Elementary School	Elmsford (V)	School	0	2.0	0.0	0.0	0.0
Alexander Hamilton High School	Elmsford (V)	School	0	2.0	0.0	0.0	0.0
Montefiore Westchester DIV	Elmsford (V)	User Defined	NA	1.0	0.0	0.0	0.0
Elmsford Senior Citizens	Elmsford (V)	User Defined	NA	1.0	0.0	0.0	0.0
Elmsford Village Hall	Elmsford (V)	User Defined	NA	2.0	0.0	0.0	0.0
Westchester Medical Center	Greenburgh (U)	Medical	0	2.0	0.0	0.0	0.0
Fairview F.D.	Greenburgh (U)	Fire	0	2.0	0.0	0.0	0.0
Fairview F.D.	Greenburgh (U)	Fire	0	2.0	0.0	0.0	0.0
Hartsdale F.D.	Greenburgh (U)	Fire	0	2.0	0.0	0.0	0.0
Hartsdale F.D.	Greenburgh (U)	Fire	0	2.0	0.0	0.0	0.0
Greenville F.D.	Greenburgh (U)	Fire	0	2.0	0.0	0.0	0.0
Greenburgh Police Dept.	Greenburgh (U)	Fire	0	2.0	0.0	0.0	0.0
Greenburgh P.D.	Greenburgh (U)	Police	0	2.0	0.0	0.0	0.0
Greenburgh Town Civil Defense	Greenburgh (U)	EOC	0	1.0	0.0	0.0	0.0
Greenburgh P.D.	Greenburgh (U)	EOC	0	2.0	0.0	0.0	0.0
Daytop Village Secondary School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Maria Regina High School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Sacred Heart School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Mohawk Country Home School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
NY School - Deaf	Greenburgh (U)	School	0	1.0	0.0	0.0	0.0
Ardsley Middle School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Woodlands Middle School/High School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0



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100-Year Event							
Name	Municipality	Type	(Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Greenburgh Early Childhood	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Highview Elementary School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Virginia Road Elementary School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Edgemont Middle School/High School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Greenville Elementary School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Seely Place Elementary School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Bailey Elementary School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Lee F. Jackson Elementary School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Empire State College (S.U.N.Y.) at Harts	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Westchester Community College	Greenburgh (U)	School	0	1.0	0.0	0.0	0.0
Solomon Schechter School	Greenburgh (U)	School	0	2.0	0.0	0.0	0.0
Greenburgh BOCES	Greenburgh (U)	School	0	1.0	0.0	0.0	0.0
Vaughn Glanton Employment Residence	Greenburgh (U)	User Defined	NA	3.0	0.0	0.0	0.0
Town Park Multi Purpose Center	Greenburgh (U)	User Defined	NA	3.0	0.0	0.0	0.0
Theodore D Young Comm Center	Greenburgh (U)	User Defined	NA	3.0	0.0	0.0	0.0
Greenburgh Town Garage	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Greenburgh Gas Storage	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Rangers Knicks Training Center	Greenburgh (U)	User Defined	NA	1.0	0.0	0.0	0.0
Radiation	Greenburgh (U)	User Defined	NA	1.0	0.0	0.0	0.0
Planned Parenthood	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Shooting Range	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Fairview-Greenburgh Community Center	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Sacred Heart Leisure Club	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Sprain Brook Manor Nursing Home	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Open Door Community Center	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Sprain Brook Manor	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Hebrew Hospital Home	Greenburgh (U)	User Defined	NA	1.0	0.0	0.0	0.0
Westchester Meadows	Greenburgh (U)	User Defined	NA	1.0	0.0	0.0	0.0
Manhattan Ave Senior Housing	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Greenburgh Town Hall	Greenburgh (U)	User Defined	NA	2.0	0.0	0.0	0.0
Hastings-on-Hudson F.D.	Hastings-On Hudson (V)	Fire	0	1.0	0.0	0.0	0.0



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100-Year Event							
Name	Municipality	Type	(Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Hastings-on-Hudson F.D.	Hastings-On Hudson (V)	Fire	0	1.0	0.0	0.0	0.0
Hastings-on-Hudson F.D.	Hastings-On Hudson (V)	Fire	0	2.0	0.0	0.0	0.0
Hastings-on-Hudson F.D.	Hastings-On Hudson (V)	Fire	0	2.0	0.0	0.0	0.0
Hastings-on-Hudson VFDAC	Hastings-On Hudson (V)	Fire	0	1.0	0.0	0.0	0.0
Hastings-On-Hudson P.D.	Hastings-On-Hudson (V)	Police	0	1.0	0.0	0.0	0.0
St Matthew's School	Hastings-On-Hudson (V)	School	0	1.0	0.0	0.0	0.0
Hillside Elementary School	Hastings-On-Hudson (V)	School	0	2.0	0.0	0.0	0.0
Farragut Middle School	Hastings-On-Hudson (V)	School	0	2.0	0.0	0.0	0.0
Hastings High School	Hastings-On-Hudson (V)	School	0	2.0	0.0	0.0	0.0
Graham - Martin Luther King JHS	Hastings-On-Hudson (V)	School	0	1.0	0.0	0.0	0.0
Orchard School	Hastings-On-Hudson (V)	School	0	2.0	0.0	0.0	0.0
Harmon Community Center	Hastings-on-Hudson (V)	User Defined	NA	1.0	0.0	0.0	0.0
Andrus on Hudson	Hastings-on-Hudson (V)	User Defined	NA	1.0	0.0	0.0	0.0
Hastings-on-Hudson Village Hall	Hastings-on-Hudson (V)	User Defined	NA	1.0	0.0	0.0	0.0
Irvington F.D.	Irvington (V)	Fire	0	1.0	0.0	0.0	0.0
Irvington VAC	Irvington (V)	Fire	0	1.0	0.0	0.0	0.0
Irvington P.D.	Irvington (V)	Police	0	1.0	0.0	0.0	0.0
Immaculate Conception School	Irvington (V)	School	0	1.0	0.0	0.0	0.0
Abbot School (Special Ed.)	Irvington (V)	School	0	1.0	0.0	0.0	0.0
Irvington High School	Irvington (V)	School	0	1.0	0.0	0.0	0.0
Irvington Middle School	Irvington (V)	School	0	1.0	0.0	0.0	0.0
Main Street School	Irvington (V)	School	0	1.0	0.0	0.0	0.0
Dows Lane Elementary School	Irvington (V)	School	0	1.0	0.0	0.0	0.0
Leisure Time Club	Irvington (V)	User Defined	NA	1.0	0.0	0.0	0.0
Irvington Village Hall	Irvington (V)	User Defined	NA	1.0	0.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	0	1.0	0.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	0	1.0	0.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	0	1.0	0.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	0	1.0	0.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	0	1.0	0.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	0	1.0	0.0	0.0	0.0



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100-Year Event							
Name	Municipality	Type	(Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Tarrytown VAC	Tarrytown (V)	Fire	0	1.0	0.0	0.0	0.0
N.Y.S.P.D. Troop T - Thruway	Tarrytown (V)	Police	0	1.0	0.0	0.0	0.0
Tarrytown P.D.	Tarrytown (V)	Police	0	1.0	0.0	0.0	0.0
Hackley School	Tarrytown (V)	School	0	1.0	0.0	0.0	0.0
John Paulding Elementary School	Tarrytown (V)	School	0	1.0	0.0	0.0	0.0
Tappan Hill Elementary School	Tarrytown (V)	School	0	1.0	0.0	0.0	0.0
Washington Irving Interm Middle School	Tarrytown (V)	School	0	1.0	0.0	0.0	0.0
E.F. Schools	Tarrytown (V)	School	0	1.0	0.0	0.0	0.0
St Jude Habilitation Institute	Tarrytown (V)	School	0	1.0	0.0	0.0	0.0
Transfiguration School	Tarrytown (V)	School	0	1.0	0.0	0.0	0.0
Tarrytown Library	Tarrytown (V)	User Defined	NA	1.0	0.0	0.0	0.0
Neighborhood House	Tarrytown (V)	User Defined	NA	1.0	0.0	0.0	0.0
Tarrytown Seniors	Tarrytown (V)	User Defined	NA	1.0	0.0	0.0	0.0
Church of the Transfiguration - Seniors	Tarrytown (V)	User Defined	NA	1.0	0.0	0.0	0.0
Tarrytown Hall Care Center	Tarrytown (V)	User Defined	NA	1.0	0.0	0.0	0.0
Tarrytown Village Hall	Tarrytown (V)	User Defined	NA	1.0	0.0	0.0	0.0
Tarrytown Public Works	Tarrytown (V)	User Defined	NA	1.0	0.0	0.0	0.0

Source: HAZUS-MH MR4; Greater Greenburgh Planning Area Committee, 2010

Notes: NA = Data not provided in HAZUS-MH MR4 output



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Table 5.4.1-19. Estimated Impacts to Critical Facilities by the 500-Year MRP Hurricane Event (Wind Only)

Name	Municipality	Type	(# of Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Ardsley F.D.	Ardsley (V)	Fire	4	16.0	6.0	0.0	0.0
Ardsley EMS	Ardsley (V)	Fire	4	16.0	6.0	0.0	0.0
Ardsley P.D.	Ardsley (V)	Police	4	16.0	6.0	0.0	0.0
Ardsley High School	Ardsley (V)	School	5	17.0	5.0	0.0	0.0
Concord Road Elementary School	Ardsley (V)	School	5	17.0	5.0	0.0	0.0
Lyceum Kennedy School - French	Ardsley (V)	School	5	17.0	5.0	0.0	0.0
Ardsley Village Highway Garage	Ardsley (V)	User Defined	NA	16.0	6.0	0.0	0.0
Ardsley Community Center	Ardsley (V)	User Defined	NA	16.0	6.0	0.0	0.0
Ardsley Village Salt Shed	Ardsley (V)	User Defined	NA	16.0	6.0	0.0	0.0
Woodlands Senior Living Community	Ardsley (V)	User Defined	NA	17.0	5.0	0.0	0.0
Lincoln Rest Home	Ardsley (V)	User Defined	NA	17.0	5.0	0.0	0.0
Ardsley Senior Citizens Center	Ardsley (V)	User Defined	NA	17.0	5.0	0.0	0.0
Ardsley Village Hall	Ardsley (V)	User Defined	NA	16.0	6.0	0.0	0.0
Dobbs Ferry Hospital	Dobbs Ferry (V)	Medical	5	17.0	7.0	0.0	0.0
Dobbs Ferry F.D.	Dobbs Ferry (V)	Fire	4	15.0	5.0	0.0	0.0
Dobbs Ferry F.D.	Dobbs Ferry (V)	Fire	4	15.0	5.0	0.0	0.0
Dobbs Ferry VAC	Dobbs Ferry (V)	Fire	4	15.0	5.0	0.0	0.0
Dobbs Ferry P.D.	Dobbs Ferry (V)	Police	4	15.0	5.0	0.0	0.0
Dobbs Ferry Middle School	Dobbs Ferry (V)	School	4	15.0	5.0	0.0	0.0
Springhurst Elementary School	Dobbs Ferry (V)	School	4	16.0	5.0	0.0	0.0
St. Christopher's School (Special Ed.)	Dobbs Ferry (V)	School	4	15.0	5.0	0.0	0.0
Children's Village (Special Ed.)	Dobbs Ferry (V)	School	4	16.0	5.0	0.0	0.0
Mercy College	Dobbs Ferry (V)	School	4	15.0	5.0	0.0	0.0
Long Island University-Westchester Campus	Dobbs Ferry (V)	School	4	15.0	5.0	0.0	0.0
Masters School (The)	Dobbs Ferry (V)	School	4	16.0	5.0	0.0	0.0
Our Lady of Victory Academy	Dobbs Ferry (V)	School	4	15.0	5.0	0.0	0.0
Dobbs Ferry High School	Dobbs Ferry (V)	School	4	15.0	5.0	0.0	0.0
Sacred Heart Seniors/Church	Dobbs Ferry (V)	User Defined	NA	16.0	5.0	0.0	0.0
St. Cabrini Nursing Home	Dobbs Ferry (V)	User Defined	NA	16.0	5.0	0.0	0.0
Dobbs Ferry Village Hall	Dobbs Ferry (V)	User Defined	NA	15.0	5.0	0.0	0.0
Respite of Dobbs Ferry	Dobbs Ferry (V)	User Defined	NA	16.0	4.0	0.0	0.0



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Name	Municipality	Type	(# of Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Dobbs Ferry Senior Citizens Center	Dobbs Ferry (V)	User Defined	NA	16.0	4.0	0.0	0.0
Elmsford F.D.	Elmsford (V)	Fire	5	17.0	6.0	0.0	0.0
Elmsford F.D.	Elmsford (V)	Fire	5	17.0	6.0	0.0	0.0
Elmsford VFD Rescue	Elmsford (V)	Fire	5	17.0	6.0	0.0	0.0
Elmsford P.D.	Elmsford (V)	Police	5	17.0	6.0	0.0	0.0
Elmsford Village Civil Defense	Elmsford (V)	EOC	5	17.0	6.0	0.0	0.0
Our Lady of Mt. Carmel School	Elmsford (V)	School	5	17.0	6.0	0.0	0.0
Carl Dixson Elementary School	Elmsford (V)	School	5	17.0	6.0	0.0	0.0
Alice E. Grady Elementary School	Elmsford (V)	School	5	17.0	6.0	0.0	0.0
Alexander Hamilton High School	Elmsford (V)	School	5	17.0	6.0	0.0	0.0
Montefiore Westchester DIV	Elmsford (V)	User Defined	NA	17.0	5.0	0.0	0.0
Elmsford Senior Citizens	Elmsford (V)	User Defined	NA	17.0	5.0	0.0	0.0
Elmsford Village Hall	Elmsford (V)	User Defined	NA	17.0	6.0	0.0	0.0
Westchester Medical Center	Greenburgh (U)	Medical	5	17.0	6.0	0.0	0.0
Fairview F.D.	Greenburgh (U)	Fire	5	17.0	6.0	0.0	0.0
Fairview F.D.	Greenburgh (U)	Fire	5	17.0	6.0	0.0	0.0
Hartsdale F.D.	Greenburgh (U)	Fire	4	17.0	6.0	0.0	0.0
Hartsdale F.D.	Greenburgh (U)	Fire	5	16.0	6.0	0.0	0.0
Greenville F.D.	Greenburgh (U)	Fire	4	15.0	5.0	0.0	0.0
Greenburgh Police Dept.	Greenburgh (U)	Fire	5	16.0	6.0	0.0	0.0
Greenburgh P.D.	Greenburgh (U)	Police	5	16.0	6.0	0.0	0.0
Greenburgh Town Civil Defense	Greenburgh (U)	EOC	4	15.0	5.0	0.0	0.0
Greenburgh P.D.	Greenburgh (U)	EOC	5	16.0	6.0	0.0	0.0
Daytop Village Secondary School	Greenburgh (U)	School	5	18.0	6.0	0.0	0.0
Maria Regina High School	Greenburgh (U)	School	5	17.0	5.0	0.0	0.0
Sacred Heart School	Greenburgh (U)	School	5	18.0	6.0	0.0	0.0
Mohawk Country Home School	Greenburgh (U)	School	5	17.0	5.0	0.0	0.0
NY School - Deaf	Greenburgh (U)	School	4	16.0	5.0	0.0	0.0
Ardasley Middle School	Greenburgh (U)	School	4	15.0	5.0	0.0	0.0
Woodlands Middle School/High School	Greenburgh (U)	School	5	17.0	6.0	0.0	0.0
Greenburgh Early Childhood	Greenburgh (U)	School	5	17.0	6.0	0.0	0.0
Highview Elementary School	Greenburgh (U)	School	5	18.0	6.0	0.0	0.0



SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Name	Municipality	Type	(# of Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Virginia Road Elementary School	Greenburgh (U)	School	5	17.0	5.0	0.0	0.0
Edgemont Middle School/High School	Greenburgh (U)	School	5	17.0	5.0	0.0	0.0
Greenville Elementary School	Greenburgh (U)	School	4	15.0	5.0	0.0	0.0
Seely Place Elementary School	Greenburgh (U)	School	5	17.0	5.0	0.0	0.0
Bailey Elementary School	Greenburgh (U)	School	5	17.0	5.0	0.0	0.0
Lee F. Jackson Elementary School	Greenburgh (U)	School	5	17.0	6.0	0.0	0.0
Empire State College (S.U.N.Y.) at Harts	Greenburgh (U)	School	5	17.0	6.0	1.0	0.0
Westchester Community College	Greenburgh (U)	School	4	15.0	5.0	0.0	0.0
Solomon Schechter School	Greenburgh (U)	School	5	17.0	6.0	0.0	0.0
Greenburgh BOCES	Greenburgh (U)	School	4	16.0	5.0	0.0	0.0
Vaughn Glanton Employment Residence	Greenburgh (U)	User Defined	NA	22.0	9.0	0.0	0.0
Town Park Multi Purpose Center	Greenburgh (U)	User Defined	NA	23.0	9.0	0.0	0.0
Theodore D Young Comm Center	Greenburgh (U)	User Defined	NA	23.0	9.0	0.0	0.0
Greenburgh Town Garage	Greenburgh (U)	User Defined	NA	15.0	5.0	0.0	0.0
Greenburgh Gas Storage	Greenburgh (U)	User Defined	NA	15.0	5.0	0.0	0.0
Rangers Knicks Training Center	Greenburgh (U)	User Defined	NA	16.0	4.0	0.0	0.0
Radiation	Greenburgh (U)	User Defined	NA	15.0	5.0	0.0	0.0
Planned Parenthood	Greenburgh (U)	User Defined	NA	17.0	5.0	0.0	0.0
Shooting Range	Greenburgh (U)	User Defined	NA	16.0	4.0	0.0	0.0
Fairview-Greenburgh Community Center	Greenburgh (U)	User Defined	NA	18.0	6.0	0.0	0.0
Sacred Heart Leisure Club	Greenburgh (U)	User Defined	NA	18.0	6.0	0.0	0.0
Sprain Brook Manor Nursing Home	Greenburgh (U)	User Defined	NA	16.0	4.0	0.0	0.0
Open Door Community Center	Greenburgh (U)	User Defined	NA	18.0	6.0	0.0	0.0
Sprain Brook Manor	Greenburgh (U)	User Defined	NA	16.0	4.0	0.0	0.0
Hebrew Hospital Home	Greenburgh (U)	User Defined	NA	16.0	4.0	0.0	0.0
Westchester Meadows	Greenburgh (U)	User Defined	NA	16.0	4.0	0.0	0.0
Manhattan Ave Senior Housing	Greenburgh (U)	User Defined	NA	18.0	6.0	0.0	0.0
Greenburgh Town Hall	Greenburgh (U)	User Defined	NA	16.0	6.0	0.0	0.0
Hastings-on-Hudson F.D.	Hastings-On Hudson (V)	Fire	3	13.0	4.0	0.0	0.0
Hastings-on-Hudson F.D.	Hastings-On Hudson (V)	Fire	3	13.0	4.0	0.0	0.0
Hastings-on-Hudson F.D.	Hastings-On Hudson (V)	Fire	4	15.0	5.0	0.0	0.0
Hastings-on-Hudson F.D.	Hastings-On Hudson (V)	Fire	4	15.0	5.0	0.0	0.0



SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Name	Municipality	Type	(# of Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Hastings-on-Hudson VFDAC	Hastings-On Hudson (V)	Fire	3	13.0	4.0	0.0	0.0
Hastings-On-Hudson P.D.	Hastings-On-Hudson (V)	Police	3	13.0	4.0	0.0	0.0
St Matthew's School	Hastings-On-Hudson (V)	School	3	14.0	4.0	0.0	0.0
Hillside Elementary School	Hastings-On-Hudson (V)	School	4	16.0	5.0	0.0	0.0
Farragut Middle School	Hastings-On-Hudson (V)	School	4	16.0	5.0	0.0	0.0
Hastings High School	Hastings-On-Hudson (V)	School	4	16.0	5.0	0.0	0.0
Graham - Martin Luther King JHS	Hastings-On-Hudson (V)	School	3	14.0	4.0	0.0	0.0
Orchard School	Hastings-On-Hudson (V)	School	4	16.0	5.0	0.0	0.0
Harmon Community Center	Hastings-on-Hudson (V)	User Defined	NA	14.0	3.0	0.0	0.0
Andrus on Hudson	Hastings-on-Hudson (V)	User Defined	NA	14.0	3.0	0.0	0.0
Hastings-on-Hudson Village Hall	Hastings-on-Hudson (V)	User Defined	NA	13.0	4.0	0.0	0.0
Irvington F.D.	Irvington (V)	Fire	4	15.0	5.0	0.0	0.0
Irvington VAC	Irvington (V)	Fire	4	15.0	5.0	0.0	0.0
Irvington P.D.	Irvington (V)	Police	4	15.0	5.0	0.0	0.0
Immaculate Conception School	Irvington (V)	School	4	16.0	5.0	0.0	0.0
Abbot School (Special Ed.)	Irvington (V)	School	4	16.0	5.0	0.0	0.0
Irvington High School	Irvington (V)	School	4	16.0	5.0	0.0	0.0
Irvington Middle School	Irvington (V)	School	4	16.0	5.0	0.0	0.0
Main Street School	Irvington (V)	School	4	16.0	5.0	0.0	0.0
Dows Lane Elementary School	Irvington (V)	School	4	16.0	5.0	0.0	0.0
Leisure Time Club	Irvington (V)	User Defined	NA	16.0	4.0	0.0	0.0
Irvington Village Hall	Irvington (V)	User Defined	NA	15.0	5.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	3	13.0	3.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	4	14.0	4.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	4	14.0	4.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	4	14.0	4.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	4	14.0	4.0	0.0	0.0
Tarrytown F.D.	Tarrytown (V)	Fire	3	13.0	3.0	0.0	0.0
Tarrytown VAC	Tarrytown (V)	Fire	4	14.0	4.0	0.0	0.0
N.Y.S.P.D. Troop T - Thruway	Tarrytown (V)	Police	4	14.0	4.0	0.0	0.0
Hackley School	Tarrytown (V)	School	3	13.0	3.0	0.0	0.0
John Paulding Elementary School	Tarrytown (V)	School	4	14.0	4.0	0.0	0.0



SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Name	Municipality	Type	(# of Days)	Percent Probability of Sustaining Damage			
			Loss Of Use	Minor	Moderate	Severe	Complete
Tappan Hill Elementary School	Tarrytown (V)	School	3	13.0	3.0	0.0	0.0
Washington Irving Interm Middle School	Tarrytown (V)	School	4	14.0	4.0	0.0	0.0
E.F. Schools	Tarrytown (V)	School	3	13.0	3.0	0.0	0.0
St Jude Habilitation Institute	Tarrytown (V)	School	3	13.0	3.0	0.0	0.0
Transfiguration School	Tarrytown (V)	School	4	14.0	4.0	0.0	0.0
Tarrytown Library	Tarrytown (V)	User Defined	NA	15.0	4.0	0.0	0.0
Neighborhood House	Tarrytown (V)	User Defined	NA	15.0	4.0	0.0	0.0
Tarrytown Seniors	Tarrytown (V)	User Defined	NA	15.0	4.0	0.0	0.0
Church of the Transfiguration - Seniors	Tarrytown (V)	User Defined	NA	15.0	4.0	0.0	0.0
Tarrytown Hall Care Center	Tarrytown (V)	User Defined	NA	15.0	4.0	0.0	0.0
Tarrytown Village Hall	Tarrytown (V)	User Defined	NA	14.0	4.0	0.0	0.0
Tarrytown Public Works	Tarrytown (V)	User Defined	NA	15.0	4.0	0.0	0.0

Source: HAZUS-MH MR4; Greater Greenburgh Planning Area Committee, 2010

Notes: NA = Data not provided in HAZUS-MH MR4 output



As listed in Tables 5.4.1-18 and 5.4.1-19, there are numerous critical facilities impacted by the wind hazard. At this time, HAZUS-MH MR4 does not estimate losses to transportation lifelines and utilities as part of the hurricane model. Transportation lifelines are not considered particularly vulnerable to the wind hazard; they are more vulnerable to cascading effects such as flooding, storm surge, falling debris etc. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs.

Utility structures could suffer damage associated with falling tree limbs or other debris. Such impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to citizens (including the young and elderly, who are particularly vulnerable to temperature-related health impacts).

Impact on Economy

Severe storms also impact the economy, including: loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, wage loss and rental loss due to the repair/replacement of buildings. HAZUS-MH estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the “Impact on General Building Stock” section discussed earlier. Business interruption losses are the losses associated with the inability to operate a business because of the wind damage sustained during the storm or the temporary living expenses for those displaced from their home because of the event.

HAZUS-MH estimates approximately \$1.5 Million in business interruption losses for the Planning Area as a result of the 100-year MRP wind-only event. A majority of these losses is sustained by residential occupancies (approximately \$1.4 Million) in terms of relocation and rental costs. Losses to the commercial occupancy result from relocation and rental costs, as well as income and lost wages.

For the 500-year MRP wind only event, HAZUS-MH estimates greater than \$25 Million in business interruption losses for the Planning Area. A majority of these losses is sustained by residential and commercial occupancies (approximately \$22 Million); mainly of relocation and rental cost losses for the residential occupancy and relocation, rental, income and lost wages to the commercial occupancy. Losses to other occupancies result from relocation and rental costs, as well as income and lost wages.

As noted earlier, total damage to buildings and the economy for combined wind and storm-surge cannot be estimated at this time. However, it is anticipated that the combination wind/surge impacts would increase these damage estimates.

HAZUS-MH MR4 also estimates the amount of debris that may be produced a result of the 100- and 500-year MRP wind events. Table 5.4.1-20 estimates the debris produced. Because the estimated debris production does not include storm surge or flooding, this is likely a conservative estimate and may be higher if multiple impacts occur.

SECTION 5.4.1: RISK ASSESSMENT – SEVERE STORM

Table 5.4.1-20. Debris Production for 100- and 500-Year MRP Hurricane-Related Winds

Municipality	Brick and Wood		Concrete and Steel		Tree	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Unincorporated Greenburgh	1,531	12,091	0	44	3,287	13,053
Village of Ardsley	94	999	0	5	377	1,167
Village of Dobbs Ferry	353	2,983	0	6	367	1,644
Village of Elmsford	138	1,442	0	2	132	796
Village of Hastings-on-Hudson	246	2,137	0	5	368	1,435
Village of Irvington	174	1,812	0	10	351	1,875
Village of Tarrytown	254	3,363	0	1	591	2,493
Planning Area Total	2,790	24,827	0	73	5,473	22,463

Source: HAZUS-MH MR4

It is estimated that the impact to the economy, as a result of a severe storm event, would be considered “medium” in accordance with the risk ranking shown in Table 5.3-4.

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 storm hazard because the entire planning area is exposed and vulnerable to the wind hazard associated with severe storms. Table 5.4.1-21 summarizes the potential new development approximate locations in the hurricane inundation areas (SLOSH zones).

Table 5.4.1-21. Potential New Development Located in SLOSH Zones

Address	Project	Type	Number of Potential Structures	CAT	CAT	CAT	CAT
				1	2	3	4
Village of Dobbs Ferry – Waterfront	Waterfront Revitalization Project	Public	Not applicable	X	X	X	X
Village of Hastings on Hudson – Southern portion of the property to the west of the Metro-North railroad tracks	The Mobil / Uhlich Site (Tappan Terminal) (includes the Pioneer Boat Club)	Commercial	Not available	X	X	X	X
Village of Hastings on Hudson - Southside Avenue	Zinsser Parking Lot (Metro-North commuter lot)	Commercial	Not available	X	X	X	X
Village of Hastings on Hudson – River Street	MacEachron Waterfront Park	Zoned MW	Not available	X	X	X	X
Village of Hastings on Hudson – River Street	Tower Ridge Yacht Club	Commercial	Not available	X	X	X	X
Village of Hastings on Hudson - Border on Yonkers	Palisade Boat Club	Commercial	Not available	X	X	X	X
Village of Tarrytown	Hudson Harbor	Commercial	Not available	X	X	X	X

Source: NYSEMO; Westchester County, 2010; Planning Committee, 2011.

Additional Data and Next Steps

Over time, the Planning Area will obtain additional data to support the analysis of this hazard. Data that will support the analysis would include additional detail on past hazard events and impacts, specific

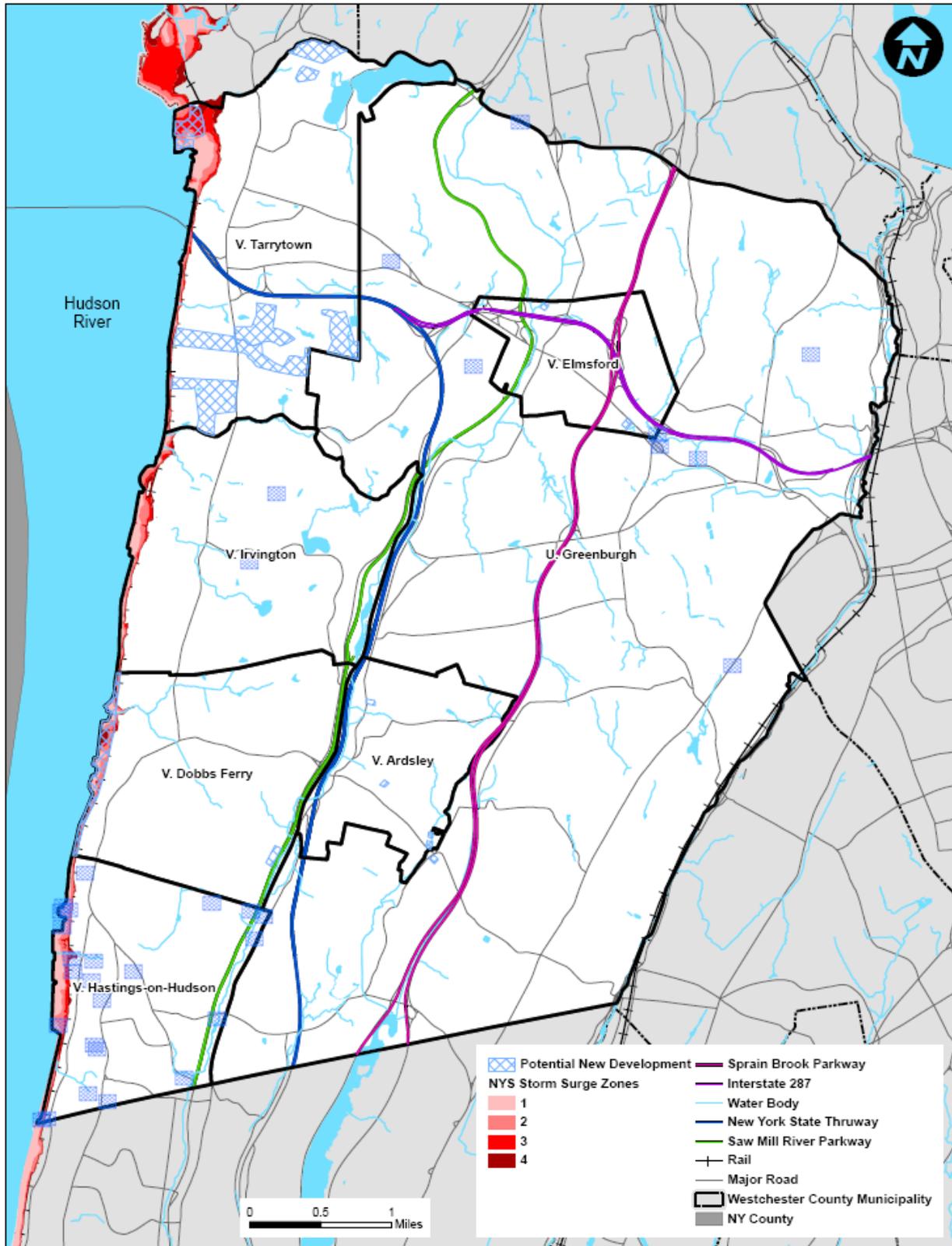
building information such as first floor elevation, type of construction, foundation type and details on protective features (for example, hurricane straps). In addition, information on particular buildings or infrastructure age or year built would be helpful in future analysis of this hazard.

In time, HAZUS-MH will be released with modules that address hurricane wind and associated flooding as one model. As this version of HAZUS-MH is released, the Greater Greenburgh Planning Area can run analyses for an overall picture of the hurricane-associated wind and flood damages.

Overall Vulnerability Assessment

The Greater Greenburgh Planning Area is highly vulnerable to severe storm events which can cause significant impacts and losses to the area's structures, facilities, utilities, and population. 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 overall hazard ranking determined by the Planning Committee for this hazard is "high" with a "frequent" probability of occurrence (see Tables 5.3-3 through 5.3-6 in Section 5.3).

Figure 5.4.1-19. Potential Development and Hurricane Storm Surge Inundation Areas for the Greater Greenburgh Planning Area



Source: NYSOEM; Planning Committee