5.0 Hazard Data and Profiles

Detailed profiles of hazards identified in the previous section as worthy of further evaluation in the overall risk assessment are provided in this section. The hazards chosen by the participating jurisdictions in this plan were done so with an eye toward future impacts made possible by sea level rise and increased chances of flash flooding brought on by climate change. This is why hazards such as landslides are listed in certain areas despite no documented past occurrences. Each hazard profile includes a description of the hazard and its causes and impacts, the location and extent of areas subject to the hazard, known historical occurrences, and the probability of future occurrences. The level of detail included for each hazard was limited by the amount of historical data and prior cost and damage estimates available. The profiles also include specific information noted by members of the Steering Committee and jurisdiction representatives, including unique observations or relevant anecdotal information regarding individual historical hazard occurrences and individual jurisdictions.

5.1 Extreme Temperatures

Extreme temperatures principally affect the health and safety of the human population, although they can also impact livestock, agricultural crops, and may also cause damage to infrastructure and property. This section provides detailed profiles of both extreme high and extreme low temperatures.

5.1.1 Description

An extreme temperature event was determined to occur if an event lasted for at least 3 days with a temperature colder than -10 degrees Fahrenheit (cold wave) or hotter than 95 degrees Fahrenheit (heat wave). This hazard is defined by extended periods of excessive cold or hot weather with a serious impact on human and/or animal populations, particularly elderly and/or persons with respiratory ailments. People living in urban environments may be at greater risk from the effects of prolonged heat wave than those living in rural areas due to the "urban heat island effect."

5.1.2 Location and Extent

Orange County is located in a region of the country that is susceptible to extreme heat and extreme cold. During periods of extreme temperature conditions the effects will be felt over widespread geographic areas, and it is generally assumed that Orange County and all of its municipalities are uniformly exposed to extreme heat and extreme cold. The effects of extreme temperatures will be primarily limited to the elderly and homeless populations, those with pre-existing medical conditions, with occasionally minor, sporadic property damages (i.e., bursting pipes) and damages to crops and other vegetation.

5.1.3 Historical Occurrences

Recent notable extreme temperature events in the Orange County region, as reported by the National Climatic Data Center (NCDC) at the National Oceanic and Atmospheric Administration (NOAA), include:

Extreme Heat:

July 4-6, 1999: An extremely hot and humid air mass covered the southeastern New York State region from July 4 through July 6. On Sunday July 4, temperatures soared into the mid and upper 90s. The combination of high temperatures and moderate humidity caused most heat indices to range from 100 to 105 degrees. However, at Central Park, the Heat Index peaked at 110 degrees around 4 p.m. On Monday July 5, many new maximum temperature records were set. Heat indices peaked from 110 to 115 degrees. Heat indices peaked around 110 degrees. Widespread blackouts occurred across the New York City Metro area, including Westchester County's sound shore from Pelham Manor to Port Chester. This heat wave was directly responsible for killing 33 people in the New York City Metro area.

August 8-10, 2001: A Bermuda high pressure system sent hot temperatures and high humidity levels across the region. Heat indices peaked across the entire region on August 9 between 105 and 110 degrees. Heat indices were also quite high on August 10, reaching 105 to 110 degrees, as humidity levels increased, despite slightly lower temperatures. On August 6, high temperatures ranged from 90 degrees at White Plains to 94 degrees at Central Park. As temperatures rose higher each day, demand for electricity increased. Scattered power outages first occurred in urban areas on August 7, then spread across the suburbs on August 8 and became more widespread on August 9 and 10. Excessive heat caused a portion of Sunrise Highway at Exit 40 (near Route 231) to buckle, which caused road closures. There were also four deaths in New York City attributed to the heat.

August 1-3, 2006: An oppressive air mass moved slowly east across the region from August 1 to August 3. This was preceded by a hot dry air mass, when temperatures reached at least 90 degrees for five consecutive days at LaGuardia Airport (New York City). Excessive heat occurred mainly from noon to midnight each day for three consecutive days. High temperatures ranged mainly from the upper 90s to around 100 degrees. With surface dew point temperatures in the mid-70s, heat indices ranged from 105 to 115 degrees. Excessive heat resulted in 42 deaths and scattered power outages that lead to business losses. In southeast New York, the excessive heat was responsible for 42 deaths, of which 40 were in New York City.

July 6-8, 2010: Temperatures reached 98-100 degrees with heat indices topping 100 degrees. Due to increased demand for electricity for air conditioning, there were 17 incidents of downed wires or transformer malfunctions resulting in over 47 homes losing power (mostly in the Town of Newburgh) and 3 instances of heat exposure. There were also 16 brushfires that sparked during the event. Cooling center operations were engaged across Orange County.

July 22, 2011: An oppressive hot and humid air mass produced excessive heat that resulted in day time temperatures 95 to 105 degrees with night time lows in the 70s and 80s. Heat indices peaked around 115 degrees during Friday afternoon, July 22nd. Prolonged excessive heat led to the death of at least 20 people in Southeast, NY; 19 in New York City 7 in Brooklyn, 6 in the Bronx, 4 in Manhattan, and 2 in Queens) and 1 in Orange County. Excessive heat between 95 and 105 degrees, along with heat indices in excess of 105 degrees occurred for a couple of days. The heat index was as high as 115 degrees at Stewart International Airport (KSWF), located in the Towns of New Windsor and Newburgh, at 1 p.m. and 2 p.m. on July 22.

June 20-21, 2012: The Orange County Emergency Operations Center was mobilized – on a "limited activation" status – to monitor conditions related to a heat wave. On June 20, temperatures were forecast to reach 97 degrees in Goshen with the Heat Index Value expected to reach 103 degrees. Temperatures at Thomas Bull Memorial Park in the Town of Hamptonburgh reached 100 degrees.

Source: 2011 Orange County HMP

July 18, 2012: High pressure remained over the western Atlantic as a cold front approached from the west. The heat index reached or exceeded 107 degrees at Stewart International Airport.

July 19, 2013: A large area of high pressure remained nearly stationary to the south for almost a week. This resulted in a prolonged period of high to excessive heat across the area. The combination of high heat and humidity resulted in heat index values between 105 and 110 degrees for a few hours during the afternoon at the Orange County Airport (KMGJ), located in the Town of Montgomery, and at Stewart International Airport.

Extreme Cold:

February 1-2, 1993: An Arctic high pressure center descended from the Upper Great Lakes Region and moved into northern New York early on February 2. A strong pressure gradient which was set up across the area on the first of February produced northerly winds of 15 to 30 mph. The strong winds coupled with temperatures between 5 below zero and 10 above zero resulted in wind chill readings of 30 to 40 below zero in many areas. Temperatures fell so fast in the Mohawk Valley that transmission lines snapped leaving 10,000 customers without power.

January 17-18, 2000: An arctic cold front swept across the region during January 16th. Strong and gusty northwest winds combined with well below normal temperatures and produced extremely low wind chill values mainly on January 17 and January 18. On January 17, wind speeds from 15 to 20 mph combined with temperatures from five (5) to 10 degrees above zero, produced wind chill values from 15 to around 20 degrees below zero in New York City and from 20 to 30 degrees below zero across the Lower Hudson

Valley. On January 18, wind chills across the Lower Hudson Valley were 30 to 35 degrees below zero. Three people died in New York City from exposure to extremely low wind chill values and extremely cold temperatures.

January 21, 2000: The combination of a quickly intensifying low pressure system off the New England Coast and a strong high pressure system west of the Great Lakes caused strong and gusty northwest winds. Northwest winds averaged 25 to 35 mph with gusts from 38 mph at Orange County Airport in the Town of Montgomery to 52 mph at LaGuardia Airport from around 2 p.m. to 8 p.m. As temperatures fell to around 10 degrees, wind chill values plummeted from 20 to 30 degrees below zero along the coast and to 25 to 35 degrees below zero inland.

January 15-16, 2004: An arctic cold front swept southeast across the region during, January 13. Extremely cold air followed this front through January 14. As an Alberta Clipper passed south of Long Island, it rapidly intensified as it moved northeast. The large difference in pressure between a strong low pressure system northeast of New England and a strong arctic high pressure system in Southeast Canada resulted in the combination of extremely low temperatures, high winds, and extremely low wind chill index values from sunset Thursday evening through sunrise Friday morning, January 16. On January 16, a record low temperature of 1 degree above zero was set at John F. Kennedy Airport in New York City. On January 16, low temperatures reached 3 degrees below zero at Orange County Airport in Montgomery. Wind Chill Index temperature values reached 26 degrees below zero at Westchester County Airport with a sustained wind speed of 30 mph. Peak wind gusts were between 30 and 40 mph. In Orange County, loss of heat in the County Mental Health Building caused significant damage when pipes froze.

February 15, 2015: Strong northwest winds and frigid air in the wake of an intense storm over the Canadian Maritimes combined to produce dangerous wind chills across parts of interior southeast New York. Wind chills fell to 26 degrees below zero at 6 a.m. at both the Orange County Airport and Stewart International Airport.

5.1.4 Historical Cost and Damage Estimates

The NCDC captures extreme temperature event data for Orange County starting in February 1993. According to this database, Orange County has been included in the area affected by 15 serious extreme temperature events between February 1993 and April 2015. Of these, nine were extreme heat events and six were extreme cold events. These events resulted in one fatality. All six extreme cold events occurred in either January or February, the time of year when extreme cold events are most common in the area. The nine extreme heat events predominantly occurred in either July or August. New York State has received no Federal Disaster or Emergency Declarations due solely to extreme temperature events.

Most concern related to extreme heat events occur when people or animals are overexposed to heat and have over-exercised for their age and/or physical condition. Older adults, young children, and those who are sick or overweight are more likely to experience the adverse effects of extreme heat. Similarly, cold events have a greater potential to affect elderly populations.

Historically, Orange County has opened cooling centers at various designated venues across the county to provide heat relief to the public, especially vulnerable populations.

5.1.5 Future Potential Impacts

Extreme temperature events will remain a very frequent occurrence in Orange County, and the probability of future occurrences in Orange County is certain (somewhat higher for extreme heat than extreme cold).

Based on historical records from the NCDC over the last 15 years (2000-2015), in New York State, extreme temperature events of all types can be expected to occur approximately 15.1 times per year. Of these anticipated yearly occurrences, 9.7 are likely to be extreme cold events, and 5.4 are likely to be extreme heat events, making extreme cold events more likely to occur in any given year with over double the frequency of occurrence when compared to extreme heat events. This trend is different in Orange County, where, based on NCDC records collected over the last 15 years, extreme temperature events have occurred approximately 0.40 times per year, with extreme heat to be expected approximately 0.27 times per year.

The impact of such occurrences on people and property is typically minimal. Furthermore, such events are not expected to pose a significant threat to human lives and safety due to relatively low percentages of young children and elderly populations (combined) in many of Orange County's municipal jurisdictions (ranging from a minimum of 10.5 percent in the Town of Highlands to 24.4 percent in the Village of Kiryas Joel, with an overall county-wide average of 18.3 percent). "Young children" are considered to be those less than five years old while the "elderly" population is defined as those over the age of 65.

5.2 Severe Thunderstorm/Wind/Tornado

5.2.1 Description

Severe storms include hail storms, windstorms, and severe thunderstorms (with associated severe wind events such as derechos, gustnados, and downbursts). The National Weather Service (NWS) defines a severe storm as one with a tornado and/or surface hail ¾" or greater and/or wind gusts 50 knots (58 mph) or greater. Such storms can cause damage from wind, hail, heavy rainfall, and/or lightning strikes.

Thunderstorms: The National Weather Service (NWS) estimates that over 100,000 thunderstorms occur each year on the U.S. mainland. Approximately 10 percent are classified as "severe." Thunderstorms can produce deadly and damaging tornadoes, hailstorms, intense downburst and microburst winds, lightning, and flash floods. Thunderstorms spawn as many as 1,000 tornadoes each year as well. On average, 300 people are injured and 80 people are killed each year by lightning in the United States. Flash flooding is responsible for more fatalities – more than 140 annually—than any other thunderstorm-associated hazard.[1]

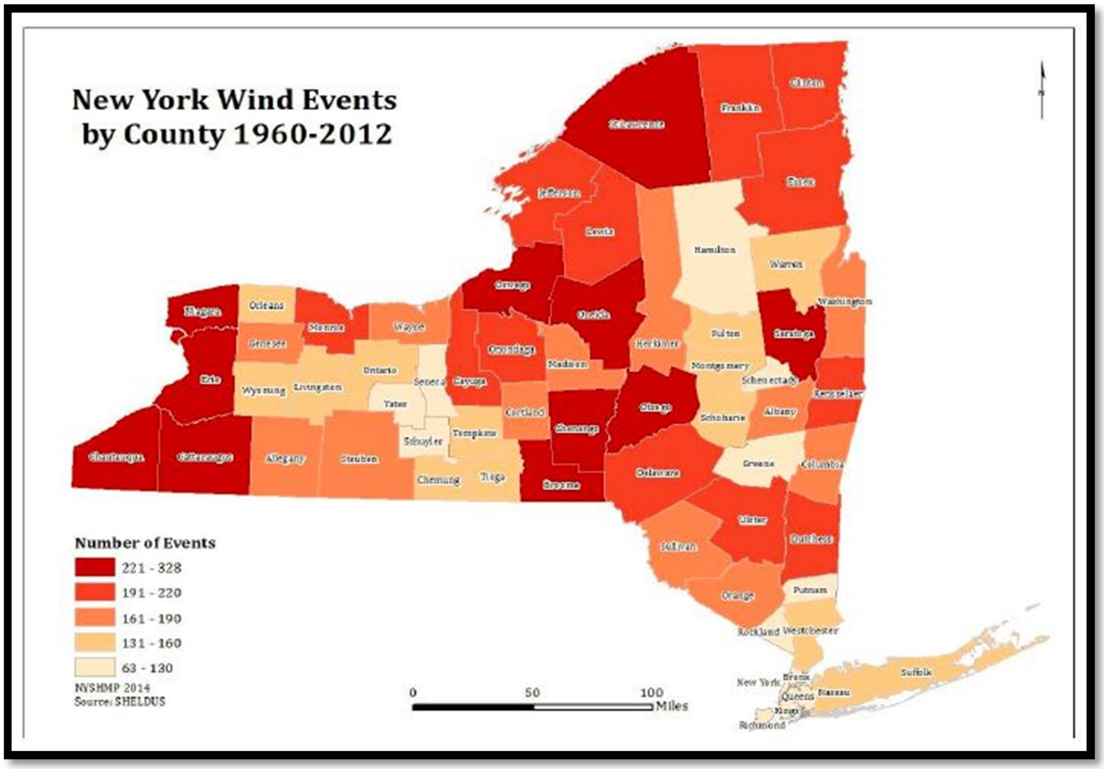
[1] https://www.fema.gov/media-library-data/20130726-1545-20490-4583/mhira_n1.pdf - pg. 28

The duration of a thunder event is determined by measuring the time between the first peal of thunder and the last. The last peal of thunder is defined to be that which is followed by a period of at least 15 minutes without an additional peal. A "thunder day" is defined as any day in which at least one thunder peal is heard. Downburst winds are strong, concentrated, straight-line winds created by falling rain and sinking air that can reach speeds of 125 mph (200 km/h). Microburst winds are more concentrated than downbursts, with speeds up to 150 mph (240 km/h). Severe damage can result from the spreading out of downbursts and microbursts, which generally last five to seven minutes. Due to wind shear and detection difficulties, they pose the biggest threat to aircraft departures and landings.

Lightning, which occurs during all thunderstorms, can strike anywhere. Generated by the buildup of charged ions in a thundercloud, the discharge of a lightning bolt interacts with the best conducting object or surface on the ground. The air in the channel of a lightning strike reaches temperatures higher than 50,000ºF. The NWS classifies a thunderstorm as severe if its winds reach or exceed 58 mph (km/h), produces a tornado, or drops surface hail at least 0.75 in (1.91 cm) in diameter (FEMA, MHIRA, 1997). According to lightning fatality data collected by NOAA, 139 fatalities occurred in New York State between 1959 and 2013 that are attributable to lightning strikes (Vaisala, Inc., 2014). Only four lightning deaths occurred in New York State from 2005 to 2014 (Vaisala, Inc., 2015). On average, lightning strikes are fatal to about 10 percent of people who are struck (The Weather Channel, 2015).

For reference, a derecho is a widespread and long-lived wind storm that is associated with a band of rapidly moving showers or thunderstorms (Storm Prediction Center, “About Derechos”). A typical derecho consists of numerous microbursts, downbursts, and downburst clusters. A gustnado is a short-lived, ground-based vortex that develops on a gust front associated with either showers or thunderstorms (National Weather Service, 2009).

Figure 5.2a: Number of High Wind Events Reported for
New York State Between 1960 and 2012
(NYS DHSES, 2014)



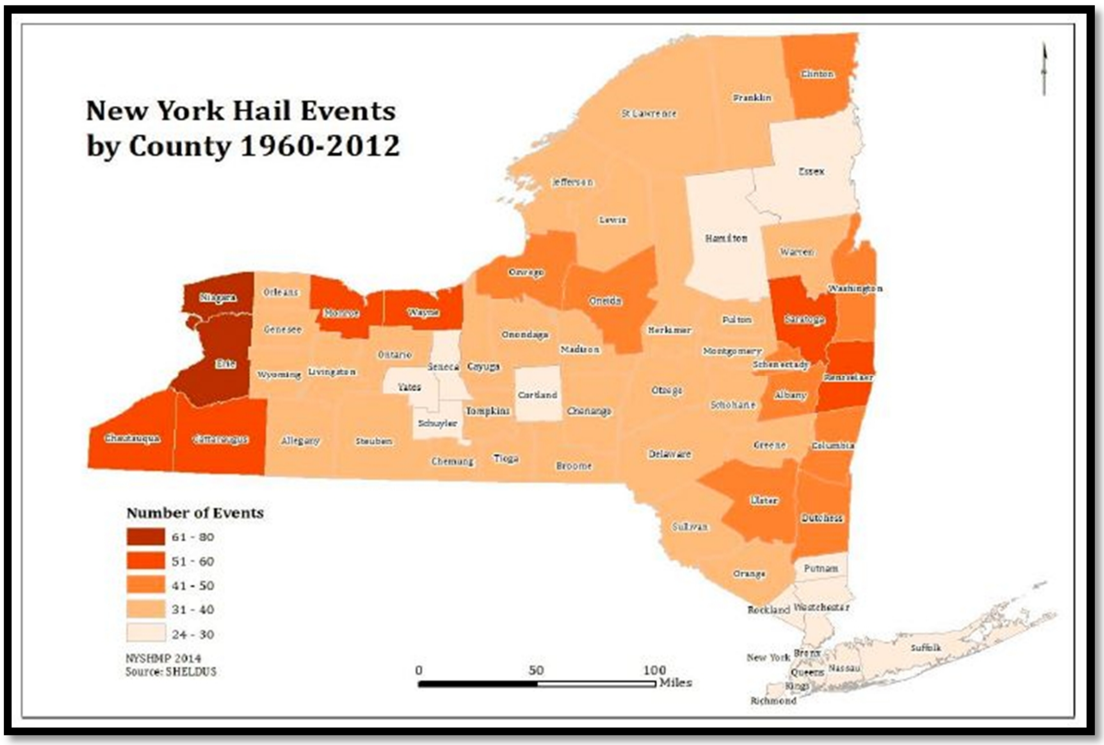
Windstorms: Wind is defined as the motion of air relative to the earth's surface. The horizontal component of the three-dimensional flow and the near-surface wind phenomenon are the most significant aspects of the hazard. Extreme windstorm events are associated with tropical cyclones, winter cyclones, and severe thunderstorms. Winds vary from zero at ground level to 200 mph (89 m/s) in the upper atmospheric jet stream at six to eight (6 to 8) mi (10 to 13 km) above the earth's surface. Large-scale extreme wind phenomena are experienced over every region of the United States and its territories. The number of high wind events in NYS by County between 1960 and 2012 is shown above in Figure 5.2a. Orange County falls into the "161-190" bracket.

Hailstorms: Hailstorms are often associated with severe thunderstorms. Hailstorms are characterized by the balls or irregularly shaped lumps of ice greater than 0.75 in (1.91 cm) in diameter which fall with rain. Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to warm air rising rapidly into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until they reach a certain weight, after which they fall as precipitation. The size of hailstones is a direct function of the severity and size 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 temperatures at the surface increase the suspension time of hail in the thunderclouds and increase the size of the hailstones themselves (FEMA, MHIRA, 1997).

Peak periods for hailstorms are late spring and early summer, the time of year when the jet stream migrates northward across the U.S. Hailstorms can extensively damage agriculture crops, particularly those that are herbaceous and long-stemmed. Severe hailstorms can also cause damage to buildings and automobiles, but rarely cause fatalities or serious injury.

Figure 5.2b is located on the following page and illustrates the number of hail wind events reported in NYS between 1960 and 2012. Orange County is shown in the "31-40" event category.

Figure 5.2b: Number of Hail Wind Events Reported for
New York State Between 1960 and 2012
(NYS DHSES, 2014)



Tornadoes: Tornadoes are described as local atmospheric storms, generally of short duration, formed by winds rotating at very high speeds, usually in a counter-clockwise direction. The vortex of the tornado can be up to several hundred yards wide and is visible to the observer as a whirlpool-like column of winds rotating about a hollow cavity or funnel. Tornado winds have exceeded 300 miles per hour. (FEMA, 1997, Multi-Hazard Identification and Risk Assessment)

The National Weather Service describes tornadoes as violently rotating columns of air that come in contact with the ground and extend from the base of a cumuliform cloud. A condensation funnel does not need to reach to the ground for a tornado to be present; a debris cloud underneath a thunderstorm is all that is needed to confirm the presence of a tornado, even in the absence of a condensation funnel. Tornadoes always start as funnel clouds and may be accompanied by a loud roaring noise.

The most destructive and deadly tornados occur from supercells, which area described as rotating thunderstorms with a well-defined radar circulation called a mesocyclone. Supercells are also capable of producing damaging hail, severe winds, frequent lightning, and flash flooding.

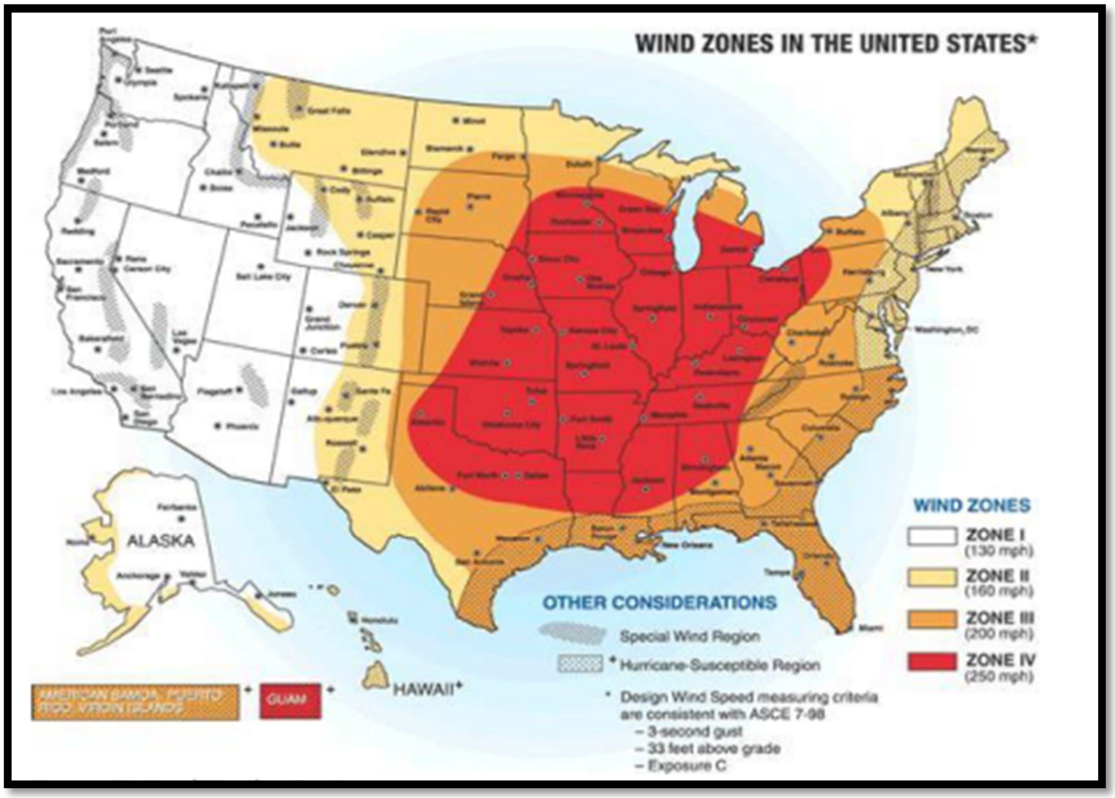
Waterspout: A waterspout is a tornado over water. Waterspouts can happen over seas, bays, and lakes, and are most common in the U.S. along the southeast coast. Although waterspouts are tornadoes by definition, they do not officially count in tornado records unless they hit land. Waterspouts can overturn boats, damage larger ships, cause significant damage when they hit land, and can cause casualties, much like a regular land-based tornado. The NWS often issues special marine warnings when waterspouts are likely or have been sighted over coastal waters.

Multi-Vortex Tornado: A multi-vortex tornado contains two or more small, intense subvortices orbiting the center of the larger tornado. When a tornado does not contain too much dust and debris, the multiple vortices may be visible. These vortices may form and die within a few seconds and can happen in all sorts of tornado sizes. Subvortices are the cause of most of the narrow, short, extreme swaths of damage that sometimes arc through larger tornado paths.

5.2.2 Location

Extreme wind events are experienced in every region of the United States. A useful tool for determining the location of the extreme wind hazard area in a jurisdiction is depicted in Figure 5.2c - Wind Zones in the United States. This map of design wind speeds was developed by the American Society of Civil Engineers. It divides the United States into four wind zones, geographically representing frequency and magnitude of potential extreme wind events. The figure shows that a single wind zone covers Orange County and its jurisdictions; Zone II, with a design wind speed for shelters of 160 mph. Orange County is additionally mapped in the Hurricane-Susceptible Region.

Figure 5.2c: Wind Zones in the United States
(Source: National Weather Service, 2014 NYS Hazard Mitigation Plan)



5.2.3 Extent

The severity of a severe wind event depends upon the maximum sustained winds experienced in any given area. Extreme winds pose a significant threat to lives, property and infrastructure due to direct wind forces but also flying debris, such as rocks, lumber, fuel drums, sheet metal and loose gear of any type that can be picked up by the wind and hurled with great force. Extreme winds also down trees and power lines that often result in power outages across an affected area. Table 5.2a illustrates the severity and typical effects of various wind speeds, as obtained from the NOAA NCDC website (2016).

Table 5.2a: Severity and Typical Effects of Various Speed Winds
(NOAA, NCDC, 2016)

Maximum Wind Speeds	Equivalent Saffir-Simpson Scale* (Hurricanes)	Equivalent Fujita Scale (Tornadoes)	Severity	Typical Effects
40-72 mph *(35-62 kt)*	Tropical Storm = 39-73 mph	F0	Minimal	Some damage to chimneys; breaks twigs and branches off tress; pushes over shallow-rooted trees; damages signboards; some windows broken; hurricane wind speed begins at 73 mph.
73-112 mph *(63-97 kt)*	Cat 1 = 74-95mph Cat 2 = 96-110 mph Cat 3 = 111-130 mph	F1	Moderate	Peels surfaces off roofs; mobile homes pushed off foundations or overturned; outbuildings demolished; moving autos pushed off the roads; trees snapped or broken.
113-157 mph *(98-136 kt)*	Cat 3 = 111-129 mph Cat 4 = 130-156 mph Cat 5 > 155 mph	F2	Considerable	Roofs torn off frame houses; mobile homes demolished; frame houses with weak foundations lifted and moved; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
158-206 mph *(137-179 kt)*	Cat 5 > 157 mph or higher	F3	Severe	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forests uprooted; heavy cars lifted off the ground and thrown; weak pavement blown off roads.
207-260 mph *(180-226 kt)*	Cat 5 > 157 mph or higher	F4	Devastating	Well-constructed homes leveled; structures with weak foundations blown off some distance; cars thrown and disintegrated; large missiles generated; trees in forest uprooted and carried some distance away. The max. wind speeds of hurricanes are not likely to reach this level.
261-318 mph *(227-276 kt)*	N/A	F5	Incredible	Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 300 ft (100 m); trees debarked; incredible phenomena will occur. The max. wind speeds of hurricanes are not expected to reach this level.
Greater than 319 mph *(277 kt)*	N/A	F6	N/A	The max. wind speeds of tornadoes are not expected to reach this level. The max. wind speeds of hurricanes are not expected to reach this level.

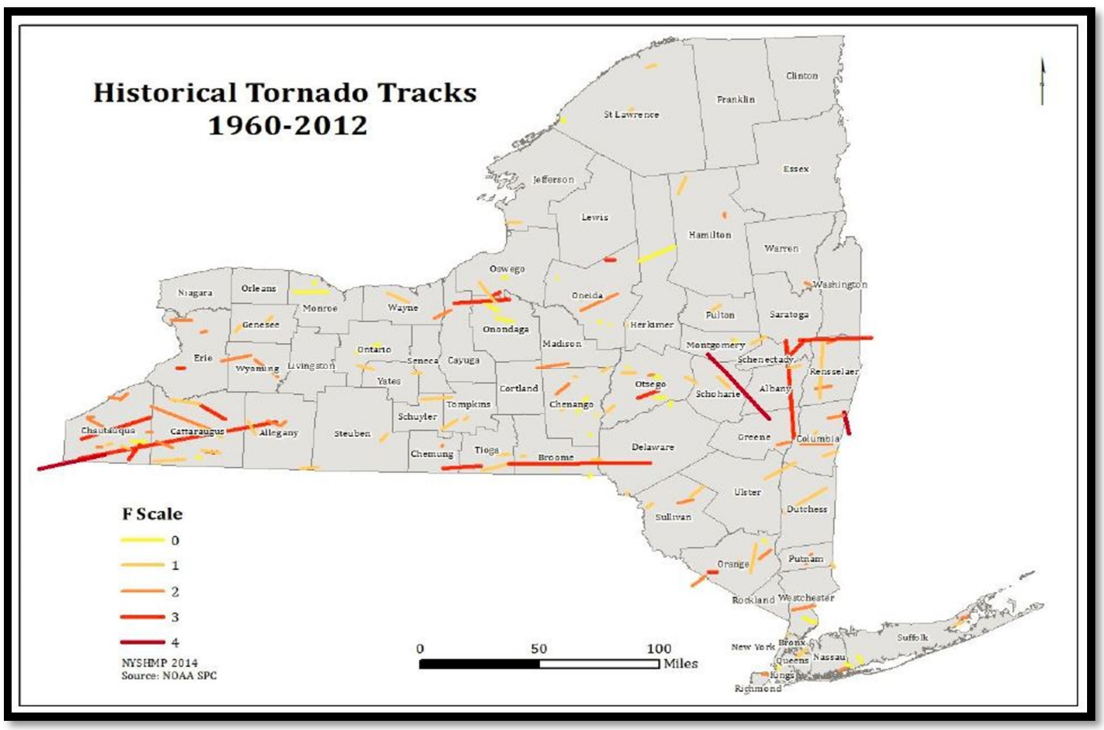
** The Saffir-Simpson Scale is a five-category wind speed/storm surge classification scale used to classify Atlantic hurricane intensities. The Saffir-Simpson values range from Category 1 to Category 5. The strongest SUSTAINED hurricane wind speeds correspond to a strong F3 (Severe Tornado) or possibly a weak F4 (Devastating Tornado) value. Whereas the highest wind gusts in Category 5 hurricanes correspond to moderate F4 tornado values, F5 tornado wind speeds are not reached in hurricanes.*

5.2.4 Historical Occurrences

Orange County's CEPA Program results identified Severe Thunderstorm/Wind/Tornado as having a medium likelihood of occurrence and a medium level of consequence (Orange County, 2014), which resulted in a 'Low' ranking.

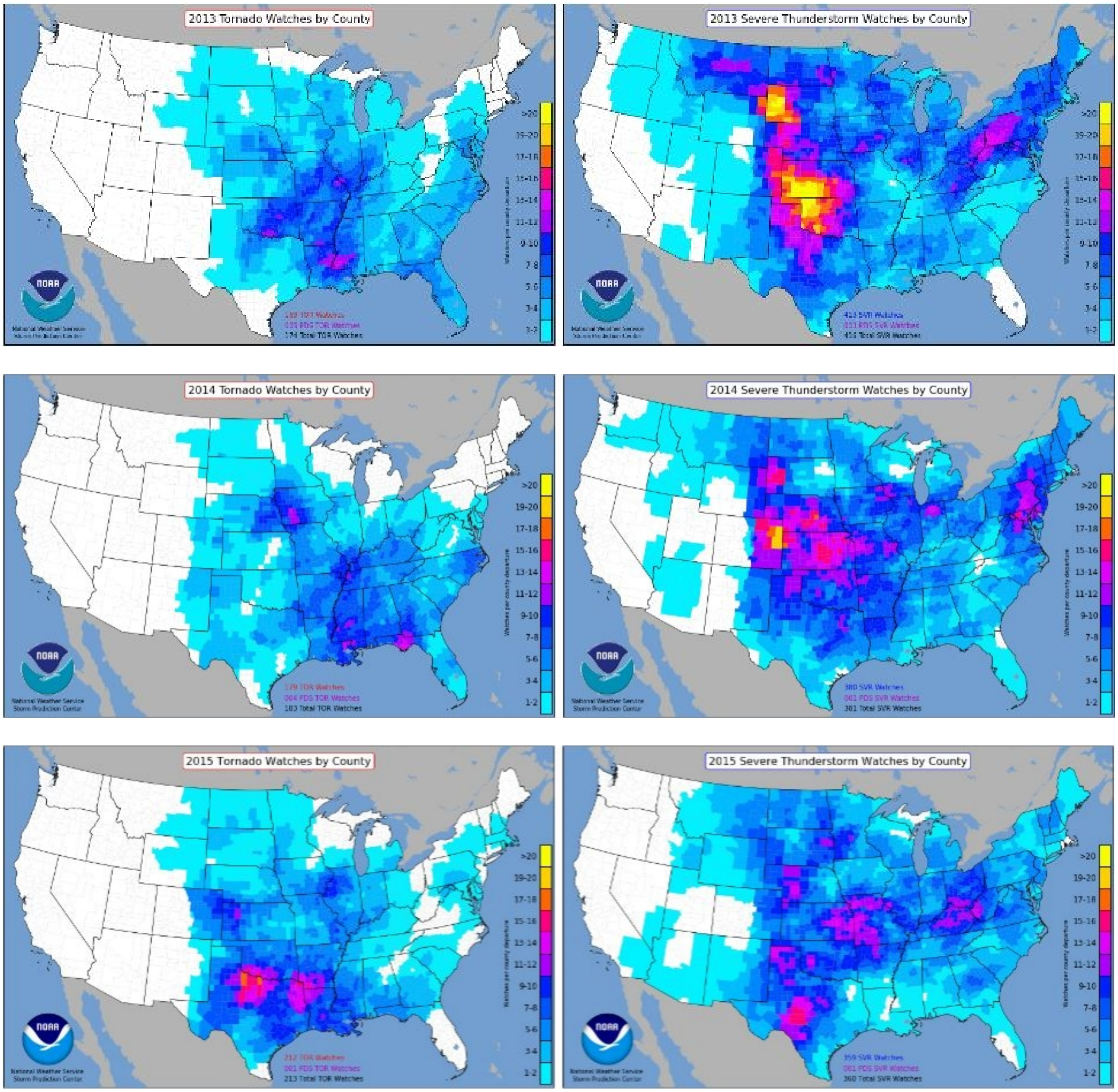
As shown on Figure 5.2a, Orange County has experienced 171 high wind events between 1960 and 2012. During the same date range, 32 hail events have also been documented within Orange County (Figure 5.2b). According to the 2014 NYS Hazard Mitigation Plan, five tornados touched down in Orange County between 1960 and 2012 (Figure 5.2d); however, none of these events were included in a Presidential Disaster Declaration. Out of these five tornado events, the occurrence that received the highest F scale designation, an F-3, occurred on July 14, 1988, and resulted in one injury. The tornado event that resulted in the largest number of fatalities in Orange County is described as an undeclared historical tornado event, documented on November 16, 1989 at 12:05 p.m. Nine children were killed and many more were injured when a cafeteria wall at the East Coldenham Elementary School in the Town of Newburgh was blown over by high winds (NYS DHSES, 2014 and McFadden, 1989).

Figure 5.2d: New York State Historical Tornado Paths, 1960-2012
(NYS DHSES, 2014)



The three sets of images below, Figure 5.2e, illustrate the total tornado and severe thunderstorm watches issued for the United States in 2013, 2014, and 2015. In 2013 and 2015, Orange County was included in one tornado watch, while no tornado watches were issued for New York State in 2014. The rate of severe thunderstorm watches for Orange County totaled 9 to 10 in 2013 and 2014, but dropped to a rate of one to two for 2015 (NOAA Storm Prediction Center).

Figure 5.2e: Storm Prediction Center's Tornado and Severe Thunderstorm Watch Frequency Maps – 2013, 2014, & 2015
(NOAA SPC, 2016)



A list of some more recent and notable severe thunderstorm, high wind, and tornado events to have affected Orange County include the following:

November 16, 1989: A line of tornados of magnitude F0 and F1 are recorded touching down in the Village of Monroe and traveling approximately 14 miles north in the vicinity of the Town of Monroe, Blooming Grove, New Windsor and Newburgh. The villages or hamlets affected included South Blooming Grove, Washingtonville, Little Britain and East Coldenham. This line of tornados is recorded as causing $ 25 million dollars in damages. The most significant damages are at the East Coldenham Elementary School, 286 State Route 17K, Newburgh, NY 12550; located in the Town of Newburgh and part of the Valley Central School District. Nine students are killed and 18 students are injured as the tornado blew in the cafeteria wall and the wall collapsed on the students eating their lunches at tables below.

July 8, 1996: Clusters of strong thunderstorms developed in a moist unstable air mass ahead of a slow moving cold front. As thunderstorms moved east southeast at speeds averaging 20 mph, they produced high winds, large hail and torrential rain. Trees were knocked down and a building collapsed at the intersection of Jersey and Front Streets in the City of Port Jervis.

June 26, 1997: A line of scattered severe thunderstorms developed in a moist unstable air mass ahead of an approaching cold front. These storms produced high winds and hail. High winds downed several trees and power lines in several areas. High winds also downed trees and power lines in the Village of Greenwood Lake and the Town of Chester. These storms resulted in vehicle accidents, causing seven injuries to people in Newburgh. A driver and passenger were injured in the Town of Newburgh when a tree fell across NYS Route 52 and landed on their car.

May 31, 1998: Severe thunderstorms formed in lines and clusters and moved over the Lower Hudson Valley of New York. Severe thunderstorms produced high winds, large hail, torrential rain, and frequent lightning. High winds downed many trees onto power lines, into houses, and onto cars. Spotters reported funnel clouds five miles south of the Harriman Tolls on Interstate-87 and near Stewart International Airport. There were significant interruptions of power for up to 48 hours following these storms**.**

June 30, 1998: On June 30, two waves of severe weather occurred: the first during the morning and the second during the evening. The first wave included a line of thunderstorms that moved east across Orange County. These thunderstorms produced high winds that downed trees in the communities of Goshen and Chester. The second wave included lines of severe thunderstorms that produced high winds, large hail, and frequent lightning. This second series of storms resulted in widespread damage across the region. In Orange County, high winds downed many trees and power lines. Significant damage to trees and houses occurred in the Towns of Monroe and Newburgh. High winds also blew a trailer upside down on Bark Lane, off Big Island Road in the Town of Florida. Four people were injured and required medical treatment at the Arden Hill Hospital in the Village of Goshen, which has since been permanently closed. Lightning struck a house in the Town of Crawford, which ignited a fire and caused structural damage.

June 2, 2000: Lines of severe thunderstorms swept southeast across the region. In Orange County, a 60 mph wind gust was reported at the Plattekill Service Area along the NYS Thruway, just north of the Town of Newburgh. There were numerous reports of wires down, trees down on houses and cars, and trees blocking roads in the vicinity of the City of Middletown and Towns of Wawayanda, Cornwall, Goshen, Chester, and Newburgh.

December 12, 2000: High winds developed rapidly in an unstable air mass following the passage of a strong cold front across the area. Several measured peak wind gusts were at least 58 mph. High winds downed many trees onto houses, cars, power lines, and streets. In urban areas, high winds downed signs, collapsed scaffolds, and caused five partial building collapses. These storms caused significant property damage and power outages. In Orange County, a spotter in Warwick reported a peak measured wind gust of 64 mph. Peak wind gusts measured by the Automated Surface Observing Systems were 53 mph at Stewart International Airport and 50 mph at the Orange County Airport.

September 23, 2003: As a severe thunderstorm moved from northern New Jersey into Orange County, New York, it produced damaging winds that knocked numerous wires down, resulting in the loss of power for portions of Slate Hill, a hamlet located in the Town of Wawayanda.

September 23, 2003: A severe thunderstorm produced high winds and heavy rain that downed trees and power lines from New City to Congers in Rockland County. The Orange and Rockland County Utilities reported that 1,423 customers lost electricity for an unspecified duration at this time.

November 13, 2003: High winds downed numerous trees and power lines, which resulted in widespread power outages throughout the area. In Orange County, Town of Montgomery police said a 46-year-old Newburgh man was killed after being blown off the roof of a makeshift, canvas-covered garage on which he was working. Police stated that he fell 20 feet to the ground and suffered massive head trauma. Schools in Goshen, along with the Orange County Government Center and 400 nearby homes and businesses, were without power for two hours, after a falling tree severed power lines on Scotchtown Road, according to the NCDC. At the Orange County Airport, the highest sustained wind speed was 48 mph and the highest gust was 58 mph.

May 23, 2004: As a severe thunderstorm moved east, it produced high winds that damaged the roof of an inn, downed power lines, and blew over trees. The most significant structural damage was reported at the American Budget Inn off NYS Route 17 in the Village of Harriman. About 70 percent of the inn's roof was dragged off by the violent winds and then tossed across the eastbound lanes of NYS Route 17. In addition, trees were downed along several streets in the Village of Harriman.

November 25, 2004: Thunderstorm winds brought down trees and billboards on NYS Route 17 and Harriman Drive in Goshen. Reports of damage to commercial buildings were also received. About 3 miles west of Goshen, in the Town of Wawayanda, the same line of thunderstorms tore apart a small barn owned by a farmer, and scattered the pieces 100 yards from where the barn originally stood. Several large trees were uprooted in the Town of Wawayanda as well. About 3,300 customers in central Orange County experienced power outages due to the thunderstorm's winds.

July 31, 2009: A cold front transiting the Tri-State area triggered multiple severe thunderstorms across southeastern New York State, especially across the northern portions of the Lower Hudson Valley and Eastern Long Island. In Orange County, a barn roof was damaged on the Karsten Family Farm along South Kaisertown Road in the Town of Montgomery.

February 19, 2011: A strong low pressure system and its associated cold front tracked across the Orange County area resulting in high winds across portions of the region. A Skywarn spotter reported a wind gust up to 58 mph in Warwick at 1:42 p.m. These winds resulted in downed trees or tree limbs across portions of the entire area and $100,000 in property damage.

August 28, 2011: Hurricane Irene – to be further detailed in Section 5.3: Hurricanes and Tropical Storms

September 9, 2011: Tropical Storm Lee – to be further detailed in Section 5.4: Hurricanes and Tropical Storms

October 29, 2012: Hurricane Sandy – to be further detailed in Section 5.4: Hurricanes and Tropical Storms

April 19, 2013: A line of strong to isolated severe thunderstorms formed ahead of a cold front that moved across Orange County during the evening. In the Town of Wawayanda, a tree was downed on Jogee Road by 52 knot winds, causing $100,000 in property damage. In the City of Port Jervis, another large tree limb was blocking Canal Street at Hamilton Street, causing another $100,000 in property damage.

5.2.5 Historical Cost and Damage Estimates

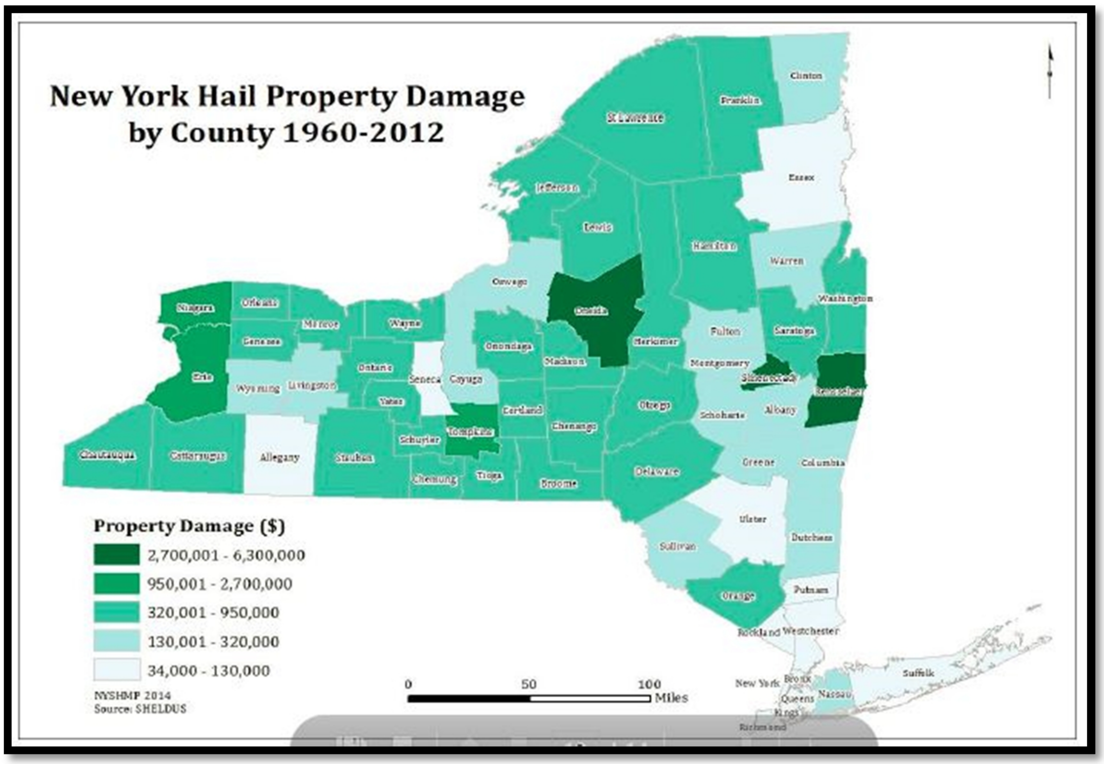
Orange County has experienced numerous types of damaging extreme wind events in the past including severe thunderstorms, tornadoes, hurricanes, tropical storms and nor'easters, not all of which are included in this hazard profile.

Within New York State, Orange County has the highest fatality rate attributed to high wind hazard events (NYS DHSES, 2014). According to the NOAA's NCDC, 197 recorded high wind events have affected Orange County between January 1950 and July 2015 (data includes wind events greater than 50 knots (57.5 mph), with the exception of tornado events. Within Orange County, there were 4 deaths, 20 injuries, and $2,673,000 worth of property damage attributed to these events (NOAA NCDC, 2015).

As shown on Figure 5.2a, Orange County has experienced 171 high wind events between 1960 and 2012. These events have resulted in 19 fatalities, 57 injuries, over $13.8 million in property damage, and over $600,000 in crop damage. Thirty-eight high wind events were documented in Orange County from 2010 to 2012, resulting in only one injury and $556,000 worth of property damage (NYS DHSES, 2014). Orange County experienced an average annual loss of $113,262 resulting from hail events between 1960 and 2012 (NYS DHSES, 2014). Figure 5.2f, below, illustrates that Orange County experienced a total of between $320,001 and $950,000 in property damage from hail events that occurred between 1960 and 2012.

Impacts to public utilities are commonly reported as a result of severe storm events. Such impacts require an immediate response by utility company personnel and are often fixed quickly. Hail events can cause minimal damage to private property, especially vehicles, but often do not result in an increased need for County emergency services or other resources. After a severe storm event ends, the County and municipal public works departments are sometimes called upon to clean up debris or fix infrastructure damage that may have occurred.

Figure 5.2f: Hail Property Damage in New York State, 1960-2012
(NYS DHSES, 2014)



5.2.6 Future Potential Impacts

Extreme wind events will remain a very frequent occurrence in Orange County, and the probability of future occurrences in Orange County is certain. The entire planning area is susceptible to a wide variety of recurring events that cause extreme wind conditions including severe thunderstorms (most frequent), tornadoes, hurricanes, tropical storms and nor'easters.

Since 2000, there have been 152 high wind events (50+ mph winds of any event type except tornadoes) in Orange County according to NOAA's NCDC storm event database. This reduces to just over ten events per year (10.13), with data available only through June 2015.

Extreme winds are a probabilistic natural phenomenon: it is impossible to predict in what years windstorms will occur or how severe the winds will be. Wind hazards are often expressed in terms of wind frequencies or recurrence intervals, such as a 10-year wind or a 100-year wind.

A "100-year wind" means that there is a one percent chance in any given year of a wind at the 100-year or higher wind speed. A 10-year wind means that there is a 10 percent chance in any given year of a wind at the 10-year or higher wind speed. Wind recurrence intervals don't mean that windstorms occur exactly at these intervals; rather, they express probabilities of winds. Thus, a given location may experience two 100-year windstorms in a short time period or go several decades without experiencing a 10-year windstorm.

Extreme winds can occur during tornadoes, hurricanes, tropical cyclones, extra-tropical cyclones (northeasters), destructive wind, and thunderstorms, but can also occur in their absence as mere "windstorms." Extreme winds have a history of occurrence throughout Orange County, and are highly likely to occur in the future.

5.3 Hurricanes and Tropical Storms

5.3.1 Hazards Associated with Hurricane and Tropical Storm Events

Hurricanes and tropical storms are particular types of events. The hazards associated with a hurricane or tropical storm event are: high winds, flooding (including storm surge), coastal erosion, and wave action. Each of the unique hazards associated with hurricane and tropical storm events are summarized briefly below, and addressed specifically elsewhere in the plan. Hurricane and tropical storm events are discussed in the remainder of this section.

Winds: After making landfall, hurricane winds can remain at or above hurricane force well inland (sometimes more than 100 miles). In addition, hurricanes can also spawn tornadoes. Typically, the more intense a hurricane is, the greater the tornado threats. High winds are addressed separately in this document.

Flooding: Upon making landfall, a hurricane rainfall can be as high as 20 inches or more in a 24-hour period, with amounts in the 10 to 15 inch range being most common. If the storm is large and moving slowly, the rainfall amounts can be much higher. Heaviest rainfall tends to be along the coastline, but sometimes there is a secondary maximum further inland. Following a hurricane, inland streams and rivers can flood and trigger landslides. Flooding can also be caused when drainage system capacities are exceeded. Flooding is addressed separately in this document.

Storm Surge: Even more dangerous than the high winds of a hurricane is the storm surge, a dome of ocean water that is basically pushed ashore by the hurricane winds. Hurricane storm surge can be as much as 20 feet at its peak and 50 to 100 miles wide, depending on hurricane strength and depth of offshore waters. Generally, the stronger the hurricane and the shallower the offshore water depths, the higher the storm surge. Most hurricane fatalities and coastal damages are attributable to storm surge, as opposed to hurricane winds. Storm surge can cause the most damage when it occurs during high tides. Storm surge can come ashore as much as five hours in advance of the time that a hurricane makes landfall.

Coastal Erosion: The currents created by the tide and storm surge, combined with wave action, can severely erode coastlines. Many buildings withstand hurricane force winds until their foundations, undermined by erosion, are weakened and fail.

Wave Action: Hurricanes and tropical storms are also associated with significant wave action, which can damage not only buildings but infrastructure and protective features along ocean shorelines.

5.3.2 Description

A hurricane is a severe tropical cyclone with winds that have reached a constant speed of 74 miles per hour or more. Hurricane winds blow in a large spiral around a relative calm center known as the "eye." The "eye" is generally 20 to 30 miles wide, and the system can extend outward from the eye by up to 400 miles. In the Northern Hemisphere, circulation is in a counterclockwise motion around the eye. These storms are usually short in duration but are extremely powerful and cause the greater amount of damage due to significant storm surges and high winds. If these systems have wind speeds of between 39 and 73 miles per hour, they are classified as tropical storms.

In the Atlantic basin, hurricanes and tropical storms are most likely to occur between June 1 and November 30, with the peak number of events typically occurring between mid-August and late October.

5.3.3 Location

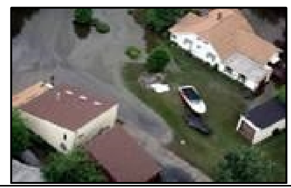
Most hurricanes that reach the New York State area are likely to become downgraded to tropical storms if they move any distance inland. Given its geographic position within the state, Orange County is more likely than most counties to experience the impacts of tropical systems, with the southeastern areas of the County at greater risk because of their more immediate proximity to the Atlantic coast.

Because of the size of hurricane and tropical storm systems, areas within Orange County can still be affected even when the eye makes landfall outside of Orange County. The hazards associated with hurricane and tropical storm events have distinct hazard area locations. For Orange County, these include wind and flood hazards.

5.3.4 Extent

The magnitude or severity of hurricanes is categorized by the Saffir-Simpson Scale. The Saffir-Simpson Scale is a five-category wind speed/storm surge classification scale used to classify Atlantic hurricane intensities. The scale is used to give an estimate of the potential property damage and flooding that can be expected. The Saffir-Simpson values range from Category 1 to Category 5, as shown in Table 5.3a. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf in the landfall region.

Note that, for tropical storms (not represented on the scale), winds are between 39 and 73 miles per hour and typical effects include breakage of twigs and branches off tress, toppling of shallow-rooted trees, and some damage to signboards and windows.

Table 5.3a: Saffir-Simpson Hurricane Scale *(FEMA, 2008)*				
Category	Wind Speed (miles per hour)	Storm Surge (feet above normal sea level)	Expected Damage	Photo Example
1	74-96 mph	4-5 ft	Minimal: Damage is done primarily to shrubbery and trees, unanchored mobile homes are damaged, some signs are damaged, no real damage is done to structures	
2	96-110 mph	6-8 ft	Moderate: Some trees are toppled, some roof coverings are damaged, and major damage is done to mobile homes.	
3	111-129 mph	9-12 ft	Extensive: 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	130-156 mph	13-18 ft	Extreme: Extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; some curtain walls fail.	
5	157 mph or higher	Greater than 18 ft	Catastrophic: Roof damage is considerable and widespread, window and door damage is severe, there are extensive glass failures, and entire buildings could fail.	

** Source: FEMA's How-To #2, page 2-23*

The magnitude or severity of hurricane and tropical storm events will increase under the following conditions:

- as the storm category increases;
- as the diameter of the storm system increases;
- as the system's forward speed decreases;
- as rainfall amounts increase; and
- as the quantity of people, structures and infrastructure in the affected areas increases.

For the sake of clarity, it should also be noted that, for communities with mapped erosion, surge, or wave action zones, the magnitude or severity will also increase with increasing degree of erosion, surge and/or wave action. While waves are discussed in the state plan under flood hazard, damage-causing waves are considered a coastal phenomenon, and since Orange County is located more than 30 miles from the nearest coastline likely to be affected by wave action, they are not regarded as a hazard for the purposes of this plan.

5.3.5 Historical Occurrences

Selected events for which some details or descriptions are available are as follows:

June 23, 1972: Orange County was included in areas eligible for both Individual and Public Assistance under Disaster Declaration DR-0338, following the impacts of the impact of Tropical Storm Agnes. Heavy rainfall caused riverine flooding and an estimated $750 million in damage and 24 deaths in New York State.

July 13, 1996: Hurricane Bertha originally made landfall in North Carolina, but had weakened to a Tropical Storm by the time it reached the New York City area. It passed Long Island, producing torrential rain and strong gusty winds. Torrential rain caused flooding of low lying and poor drainage areas, streams, and rivers across the area. The heaviest rain fell in a band to the northwest of Bertha's track over the Lower Hudson Valley. Rainfall amounts recorded in Orange County ranged from 3.3 inches at Ridgebury to 4.5 inches at the Village of Greenwood Lake.

September 16, 1999: The remnants of Hurricane Floyd passed over Long Island from 7 p.m. to 9 p.m. on September 16. Serious widespread flooding of low-lying and poor drainage areas resulted in the closure of many roads and basement flooding across the entire region. Orange, Putnam, Rockland, and Westchester Counties were declared disaster areas, under Disaster Declaration DR-1296. For these four counties, the initial cost estimates were $14.6 million. These figures represent "eligible" costs for disaster payments, and were provided by the New York State Emergency Management Office. Sample County records from this event show post-disaster repairs of County roads and the Harriman Waste Water Treatment Plant totaling $295,000. Rainfall amounts recorded in Orange County ranged from 4.46 inches in the City of Middletown to 8.25 inches at West Point. Impacts recorded in Orange County included damages to County Roads 9 and 65.

September 18, 2004: The remnants of Hurricane Ivan reached the region as a tropical depression and produced torrential rains across southeast New York. Orange County became eligible for both Public and Individual Assistance under Disaster Declarations DR-1564 and DR-1565. Torrential rains resulted in flash flooding on nearly all roads in the City of Port Jervis. A local state of Emergency was declared by the Mayor. Sample County records from this event show post-disaster repairs to the Delaware and Hudson Canal costing $46,000.

September 6, 2008: Tropical Storm Hanna impacted southeast New York, making landfall near the Nassau/Suffolk County border around 10:35 p.m. on September 6. Storm total rainfall ranged from 1.66 inches at the City of Port Jervis to 5.92 inches at New City in Rockland County. State Highway 218 was closed in both directions between the Town of Cornwall and West Point due to flooding.

It should be noted that the damage cost figures discussed above do not include any damages addressed by private insurance, which may mean that the cost of the events were significantly higher.

August 28, 2011: Hurricane Irene produced torrential rains, high winds and flooding from the Bahamas all the way to northern New England. Orange County reported between six and more than ten inches of rain. Irene made landfall locally as a tropical storm around 9:00 a.m. August 28, 2011 over New York City. Irene then moved across southeast New York and western Connecticut before dissipating over northern New England near the Canadian border later that evening. Copious amounts of tropical moisture within the storm produced extended periods of heavy rainfall, which resulted in widespread moderate to major flooding across the area.

September 9, 2011: The remnants of Tropical Storm Lee brought a new round of flooding and misery Thursday for people still trying to cope with damage from Hurricane Irene. Heavy rain started to fall across the region by 2:00 a.m., adding two to four inches of precipitation to sodden ground, strained infrastructure and swollen waterways. The Village of Washingtonville was again cut off from all routes except Route 208, and officials were evacuating the Brookside Acres and Washingtonville Manor mobile home parks. Schools were closed or dismissed early across the region as municipalities declared states of emergency, most of them for a second time in as many weeks. The Orange County Government Center, which just reopened Tuesday after being closed the previous week because of damage from Hurricane Irene, shut down again Thursday afternoon.

October 29, 2012: Post-Tropical Storm Sandy was the costliest natural disaster in southeast New York. Tropical Storm Sandy formed in the Caribbean Sea on October 22. After drifting slowly southwest on October 23, Sandy turned to the north and intensified to a hurricane on October 24, just before making landfall in Jamaica. Hurricane Sandy continued to the north and intensified to a strong Category 2 hurricane before making landfall again in Cuba shortly after 12:00 a.m. on October 25.

As Sandy continued to move northwest and interact with the mid-latitude trough, its interaction continued to make it less tropical, but did not weaken it much. Sandy continued to make a harder turn to the left (west) and made landfall in Atlantic County as a post tropical storm at 7:30 p.m. on October 29. Record breaking high tides and wave action was combined with sustained winds of 40 to 60 mph and wind gusts of 80 to 90 mph.

These extreme conditions resulted in at least 60 deaths and widespread property damage of at least 42 billion dollars. Emergency managers recommended mandatory evacuations of more than 1/2 million people that lived in low lying areas. Widespread significant power outages of more than two million lasted up to two weeks.

Locally, a wind gust up to 61 mph was reported in Orange Lake in the Town of Newburgh at 7:45 p.m., and winds of 58 mph were reported at the Orange County Airport at 7:40 p.m.

5.3.6 Historical Cost and Damage Estimates

Hurricanes and tropical storms have impacted Orange County and its component jurisdictions in the past, and will continue to do so in the future.

Orange County has an active history of hurricanes and tropical storms. According to NOAA historical records, 18 hurricane or tropical storm tracks have passed within 65 miles of the Orange County seat at Goshen since 1861. This includes two Category 1 hurricanes and 16 tropical storms. Of these 18 recorded hurricane or tropical storm events, five tracks traversed directly through Orange County: Tropical Storms Agnes in 1972 and Able in 1952, and three unnamed tropical storms between 1866 and 1893. Tropical Storm Irene tracked just to the east of the county in 2011.

Orange County has also been significantly impacted by hurricanes and tropical storm events which passed the County at a greater distance: for example the remnants of Hurricane Floyd in September 1999, Hurricane Ivan in September 2004, and Tropical Storm Hanna in September 2008, all of which were tropical depressions by the time they reached the Orange County area. More recently, Tropical Storm Lee (September 2011) and Hurricane Sandy (October 2012) prompted emergency response measures and caused significant damage across the metropolitan New York City area.

According to EMMIE data from FEMA, Hurricane Irene produced over $30,000,000 in damages in Orange County alone while the remnants of Tropical Storm Lee caused over $9,000,000 in damages in the county just a week and a half later. EMMIE figures for Hurricane Sandy are estimated at $15 billion among Bronx, Kings, Nassau, New York, Orange, Putnam, Queens, Richmond, Rockland, Suffolk, Sullivan, Ulster, and Westchester Counties. .

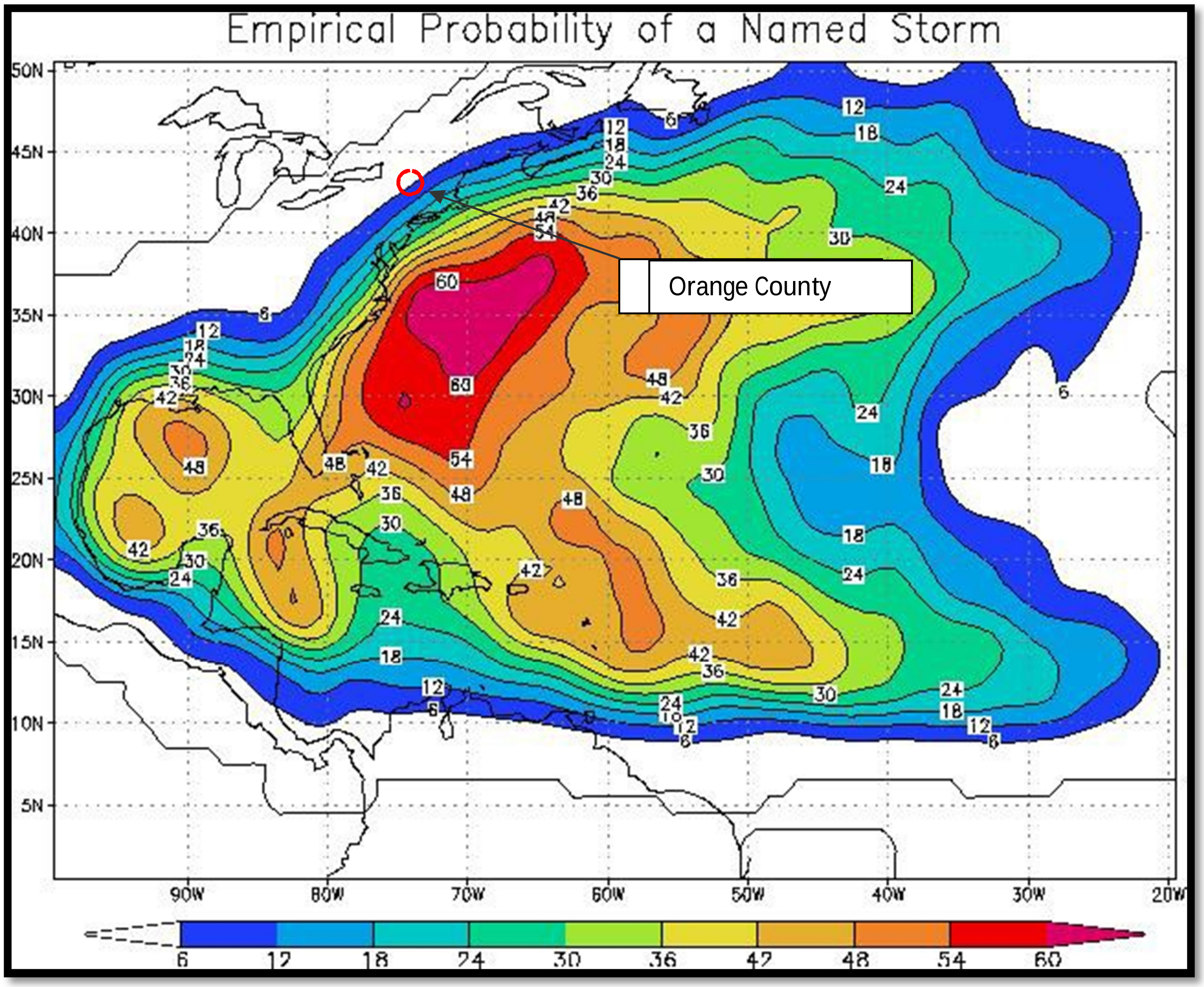
Figure 5.3b graphically represents the paths of tropical and extratropical storms across the State from 1960-2011. Orange County was crossed directly by Tropical Storms Beryl and Agnes.

Figure 5.3a: Historical Storm Tracks 1960-2011
(NYS DHSES, 2014)

5.3.7 Future Potential Impacts

Internet resources on NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) website were researched to gain an understanding of the relative likelihood of Orange County being impacted by a coastal storm as compared to other locations in the Atlantic Basin (see Figure 5.3c). The data indicates that Orange County and its jurisdictions have roughly a 12 percent chance of being impacted by a named storm in any given year.

Figure 5.3b: Probability of a Named Storm in the Atlantic Basin
(NOAA, 2016)



NOAA has additionally derived expected return periods for the various categories of hurricane directly impacting the New York City and Lower Hudson Valley area, as follows:

Category 1	17 Years, or approximately a 6% chance in any given year
Category 2	39 Years, or approximately a 2.5% chance in any given year
Category 3	68 Years or approximately a 1.5% chance in any given year
Category 4	150 years or approximately a 0.7% chance in any given year
Category 5	370 years or approximately a 0.3% chance in any given year

5.4 Floods

5.4.1 Description

Floods are natural events for rivers and streams where excess water from snowmelt, rainfall, or storm surges accumulates and overflows onto the banks and adjacent floodplains of these waterbodies. Floodplains are lowland areas located adjacent to waterbodies that are subjected to recurring flood events.

Several factors determine the severity of floods, including intensity and duration of rainfall or other water sources. A large amount of rainfall over a short period can result in flash flood conditions. Even a small amount of precipitation can result in flood events in locations where the soil is already saturated or in areas with large amounts of impervious surfaces (i.e., large parking lots, roadways, developments, etc.). Topographic and cover type characteristics are also factors that contribute to the severity of flood events. Water runoff is greater in areas with steep slopes and little or no vegetative ground cover. Frequency of inundation depends on the climate, soil, and channel slope of a particular area.

Waterbody impoundment, such as dams, poses additional, man-made hazards. Failure of this infrastructure cascades into aforementioned flooding hazards for communities downgrade from the impoundment. In Orange County, there are 268 dams according to NYSDEC. Of these, 197 are categorized as “low hazard,” 48 as “intermediate hazard”, 22 as “high hazard”, and one (1) as unclassified. More information on dams and other high impact facilities in the County can be found in Section 2.8.

Flash Flooding: Flash floods can develop very quickly, often in just a few minutes and without any visible signs of rain. Flash floods are known to have a high velocity of water that carries rocks, mud, and other debris with it and can sweep away most items in its path (FEMA, Flood, 2009). Flash flood damage tends to occur in areas immediately adjacent to a stream or arroyo (gulch that temporarily fills with water after a heavy rain), due to a combination of heavy rain, dam failure, levee failure, rapid snowmelt, and ice jams. Additionally, heavy rain falling on steep terrain can weaken soil and cause debris flow, damaging homes, roads, and property.

Mountains and steep hills produce rapid runoff and quick stream response. Rocks and clay soils do not allow much water to infiltrate the ground. Steep narrow valleys generate rapid flowing waters that can rise quickly to a considerable depth. Saturated soil also can lead rapidly to flash flooding. Other high risk areas include canyons, low water crossings, recent burn areas in mountains, and developed areas from pavement and roofs which concentrate rainfall runoff (NOAA, NWS, 2005).

National Flood Insurance Program: The Federal Emergency Management Agency (FEMA), which is the government entity that administers the National Flood Insurance Program (NFIP), has mapped the known floodplains within much of the United States. When a flood study is completed for the NFIP, the information and maps are assembled into a Flood Insurance Study (FIS). A FIS compiles flood risk data for specific waters or hazard areas within specific communities and includes the main causes of flooding in these areas. The FIS delineates Special Flood Hazard Areas (SFHAs), designates flood risk zones, and establishes base flood elevations (BFEs) within certain areas. BFEs are based on the flood event that has a one percent chance of occurring annually, or the 100-year flood. At present, every individual municipality in Orange County is an active member of the NFIP except for the Village of Otisville and the Town of Woodbury (See Table 8.2a).

100-year Floodplain: The 100-year floodplain designates an area that has, on average, a one percent chance of flooding in any given year. It is important to note that a 100-year flood could occur during subsequent years or once every 10 years. The 100-year flood, or base flood, is the standard that has been adopted for use in the NFIP. As indicated on Federal Insurance Rate Maps (FIRMs), base flood elevations (BFEs) indicate the elevation of surface water resulting from a flood that has a one percent chance of occurring in any given year. The BFE is the height of the base flood, normally in feet, relative to the geographic datum referenced in the FIS report (i.e., National Geodetic Vertical Datum (NGVD) of 1929, North American Vertical Datum (NAVD) of 1988, etc.)

5.4.2 Location and Extent

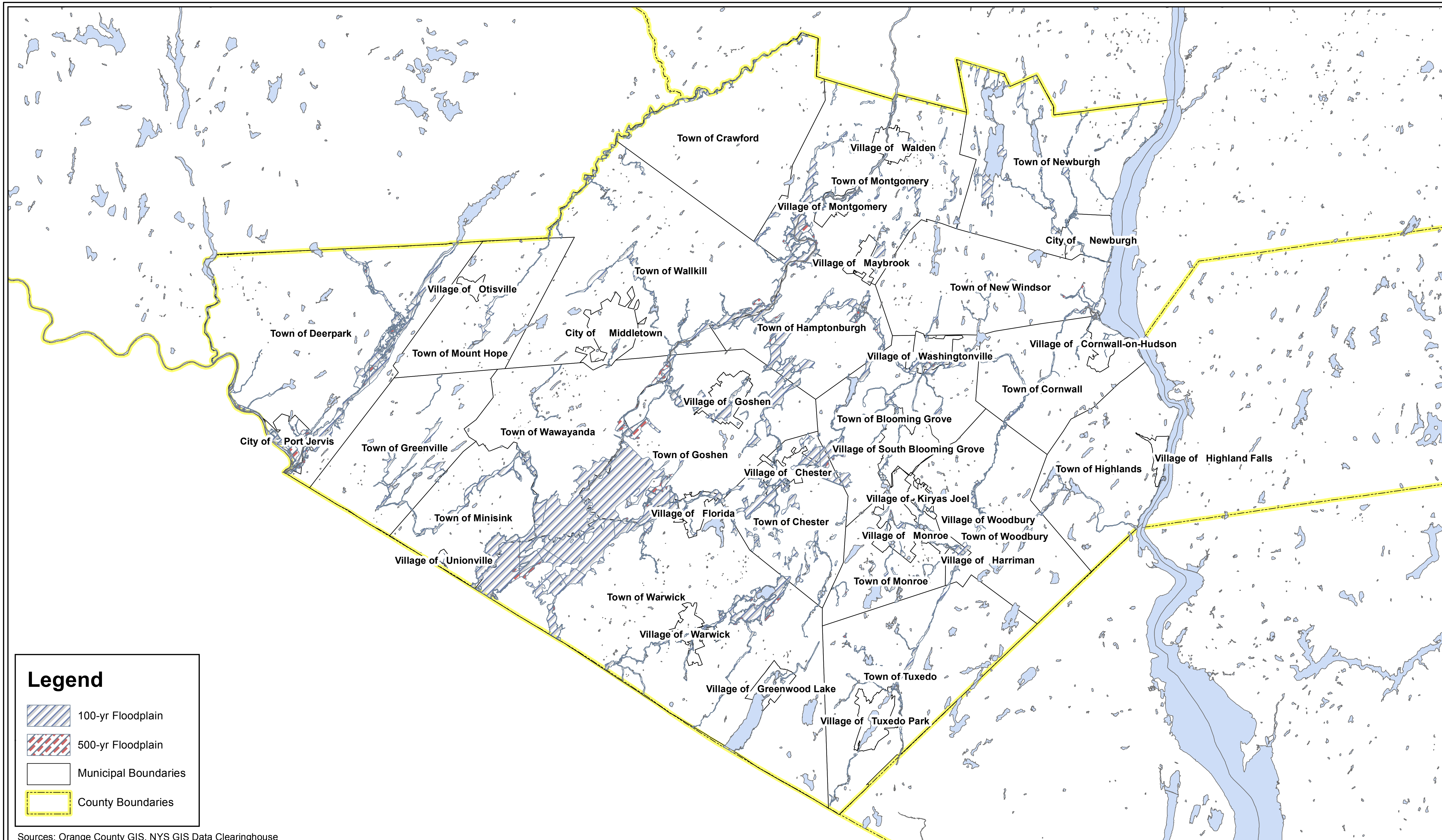
Orange County and its jurisdictions experience several types of flooding. While the Hudson River is tidally influenced, Orange County is sufficiently far from the open ocean to be essentially unaffected by coastal flooding. Basically, flooding in Orange County is caused by from riverine flooding, shallow flooding resulting from urban drainage issues, and occasional ice jams.

Orange County has experienced flooding on many of the County's roadways. Flooding has also impacted County parks, sewer treatment facilities, and pump stations throughout Orange County. The County is located within the Hudson River Basin and the Delaware River Basin.

The county is divided into seven primary watersheds, which include the Delaware River, Wallkill River, Moodna Creek, Ramapo River, Wanaque River, Upper Hudson River, and Lower Hudson River basins. The eastern portion of the County drains into the Hudson River, the Wallkill River drains the central and northern section, the Delaware River drains western Orange County, while the County's southern corner drains into the Passaic River in New Jersey via the Ramapo and Wanaque Rivers. There are dozens of sub-watersheds in each of the river basins.

The extent of flooding associated with a one percent probability of occurrence – the "100-year flood" or "base flood" – is used as regulatory boundaries by a number of federal, state and local agencies. Also referred to as the "special flood hazard area", this boundary is a convenient tool for assessing vulnerability and risk in flood prone. FEMA's DFIRM data was used to identify the location of flood hazard areas in Orange County. According to the FIRM data, high/moderate flood risk zones exist in all Orange County Municipalities. Figure 5.4a illustrates the mapped flood risk using FEMA zone designations, which are explained in more detail below:

The FEMA Flood Insurance Rate Map (FIRM) for Orange County became effective on August 3, 2009. This data uses advanced engineering and refined standards to improve data quality and is regarded as FEMA's most reliable flood hazard data.



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Engineers • Environmental Scientists • Planners • Landscape Architects

N S W E

1 inch = 20,000 feet

Orange County

Floodplains

Orange County December 2015 New York

Figure

-

Project No. 1724.002

FEMA's DFIRM mapping was overlaid upon the Orange County GIS Base Map to summarize the flood mapping and flood risk areas for all municipalities in Orange County, and the collated data is presented in Tables 5.4a and 5.4b.

In total only 11% of the County area lies within high or moderate flood risk zones, according to current FIRM data. The Village of Greenwood Lake has the highest proportion of its area within a high flood risk zone, followed by the Town of Goshen. The City of Port Jervis has the highest proportion of land within moderate flood risk zones, followed by the Village of Washingtonville.

According to the current flood mapping, no land areas within the Village of Otisville are identified as lying within any identified floodplain, and this municipality is one of two in the County which does not currently participate in the NFIP. While the Town of Woodbury also does not currently participate in the NFIP, the Village of Woodbury, which largely shares the same land area, has been involved since 1974.

Table 5.4a: Summary of Land Areas in Flood Hazard Areas
(Source: FEMA DFIRM Data, 2016)

Municipality	Total Land Area (Acres)	High Flood Risk (Acres)	Moderate Flood Risk (Acres)	Low Flood Risk (Acres)	Land in High Flood Risk %	Land in Moderate Flood Risk %
		A, AE, AH, AO	X500	X	A, AE, AH, AO	X500
Blooming Grove, Town of	21,051	1,854	277	18,919	9%	1%
Chester, Town of	14,698	2,405	213	12,079	16%	1%
Chester, Village of	1,393	897	42	1,022	64%	3%
Cornwall, Town of	16,446	892	83	15,447	5%	1%
Cornwall-on-Hudson, Village of	1,565	304	3	1,258	19%	0%
Crawford, Town of	25,696	388	76	25,097	2%	0%
Deerpark, Town of	43,382	3,395	416	39,433	8%	1%
Florida, Village of	1,175	164	21	990	14%	2%
Goshen, Town of	25,990	7,144	642	18,204	27%	2%
Goshen, Village of	2,032	365	20	1,647	18%	1%
Greenville, Town of	19,449	783	30	18,635	4%	0%
Greenwood Lake, Village of	1,388	387	0	1,001	28%	0%
Hamptonburgh, Town of	17,063	3,087	536	13,439	18%	3%
Harriman, Village of	638	153	31	454	24%	5%
Highland Falls, Village of	695	24	0	670	3%	0%
Highlands, Town of	20,740	1,700	0	18,996	8%	0%
Kiryas Joel, Village of	727	36	0	691	5%	0%
Maybrook, Village of	828	649	0	179	78%	0%
Middletown, City of	3,171	31	43	3,098	1%	1%

Table 5.4a: Summary of Land Areas in Flood Hazard Areas *(Source: FEMA DFIRM Data, 2016)*						
	Total Land Area (Acres)	High Flood Risk (Acres)	Moderate Flood Risk (Acres)	Low Flood Risk (Acres)	Land in High Flood Risk %	Land in Moderate Flood Risk %
Municipality		A, AE, AH, AO	X500	X	A, AE, AH, AO	X500
Minisink, Town of	14,847	1,559	316	12,959	11%	2%
Monroe, Town of	10,410	393	147	9,869	4%	1%
Monroe, Village of	2,211	267	59	1,884	12%	3%
Montgomery, Town of	29,670	3,156	435	26,037	11%	1%
Montgomery, Village of	932	179	39	714	19%	4%
Mount Hope, Town of	15,901	502	0	15,392	3%	0%
New Windsor, Town of	23,742	1,426	84	22,229	6%	0%
Newburgh, City of	3,034	661	41	2,302	22%	1%
Newburgh, Town of	30,144	4,701	93	25,302	16%	0%
Otisville, Village of	417	0	0	417	0%	0%
Port Jervis, City of	1,716	425	262	1,010	25%	15%
South Blooming Grove, Village of*	Data not available	Data not available	Data not available	Data not available	Data not available	Data not available
Tuxedo, Town of	29,206	994	80	28,130	3%	0%
Tuxedo Park, Village of	2,076 1,960	1,822 850	1 101	253 28,089	88% 3%	0% 0%
Unionville, Village of	171	4	0	168	2%	0%
Walden, Village of	1,259	73	4	1,182	6%	0%
Wallkill, Town of	40,070	4,736	351	34,922	12%	1%
Warwick, Town of	63,531	9,992	750	52,625	16%	1%
Warwick, Village of	1,384	157	25	1,203	11%	1%
Washingtonville, Village of	1,636 2,293	240 321	150 141	1,246 1,181	15% 20%	9% 9%
Wawayanda, Town of	22,520	3,541	322	18,658	16%	1%
Woodbury, Town and Village	23,404 23,511	676 771	66 79	22,662 22,594	3% 3%	0% 0%
Orange County Total	*536,408*	*62,104*	*5,979*	*522,287*	*12%*	*1%*

*The Village of South Blooming Grove was established after FEMA compiled the most recent data.

Table 5.4b: Summary of Improved Values in Flood Hazard Areas (Source: FEMA DFIRM Data, Orange County Real Property, 2016)							
Municipality	Total Improved Value	Improved Value in High Flood Risk Areas Zones A, AE, AH, AO		Improved Value in Moderate Flood Risk Areas Zone X500		Improved Value in Low Flood Risk Areas Zone X	
		$	%	$	%	$	%
Blooming Grove, Town of	$1,518,225,074	$180,829,863	12%	$171,325,901	11%	$1,166,069,310	77%
Chester, Town of	$1,747,842,949	$451,473,007	26%	$173,039,888	10%	$1,123,330,054	64%
Chester, Village of	$1,077,375,658	$428,417,400	40%	$454,008,858	42%	$194,949,400	18%
Cornwall, Town of	$1,579,952,280	$79,888,462	5%	$72,610,200	5%	$1,427,453,618	90%
Cornwall-on-Hudson, Village of	$603,393,591	$39,139,700	6%	$5,412,800	1%	$558,841,091	93.0%
Crawford, Town of	$1,656,829,358	$45,369,677	3%	$30,730,848	2%	$1,580,728,833	95%
Deerpark, Town of	$1,154,522,117	$329,356,035	29%	$142,368,850	12%	$682,797,232	59%
Florida, Village of	$430,314,934	$31,283,900	7%	$27,425,867	6%	$371,605,167	86%
Goshen, Town of	$2,221,930,996	$522,368,078	24%	$235,616,109	11%	$1,463,946,809	66%
Goshen, Village of	$1,235,894,280	$257,691,038	21%	$29,807,300	2%	$948,395,942	77%
Greenville, Town of	$506,025,959	$40,021,800	8%	$8,310,800	2%	$457,693,359	90%
Greenwood Lake, Village of	$437,701,567	$99,564,600	23%	$0	0%	$338,136,967	77%
Hamptonburgh, Town of	$1,469,012,700	$246,653,000	17%	$226,452,400	15%	$995,907,300	68%
Harriman, Village of	$546,800,400	$111,397,100	20%	$85,750,800	16%	$349,652,500	64%
Highland Falls, Village of	$478,055,001	$50,110,498	10%	$0	0%	$427,944,503	90%
Highlands, Town of	$428,407,352	$36,145,358	8%	$0	0%	$392,261,994	92%
Kiryas Joel, Village of	$604,989,203	$53,892,233	9%	$0	0%	$551,096,970	91%
Maybrook, Village of	$16,245,200	$0	0%	$0	0%	$16,245,200	100%
Middletown, City of	$2,669,850,991	$254,743,900	10%	$134,695,100	5%	$2,280,411,991	85%
Minisink, Town of	$622,312,400	$74,397,300	12%	$64,905,200	10%	$483,009,900	78%
Monroe, Town of	$1,745,902,809	$99,541,200	6%	$54,159,300	3%	$1,592,202,309	91%
Monroe, Village of	$1,379,302,405	$122,102,500	9%	$129,616,700	9%	$1,127,583,205	82%
Montgomery, Town	$2,252,774,427	$250,927,500	11%	$1,861,732,327	83%	$140,114,600	6%

Table 5.4b: Summary of Improved Values in Flood Hazard Areas (Source: FEMA DFIRM Data, Orange County Real Property, 2016)							
		Improved Value in High Flood Risk Areas Zones A, AE, AH, AO		Improved Value in Moderate Flood Risk Areas Zone X500		Improved Value in Low Flood Risk Areas Zone X	
Municipality	Total Improved Value	$	%	$	%	$	%
Montgomery, Village of	$451,808,300	$33,341,700	7%	$30,995,000	7%	$387,471,600	86%
Mount Hope, Town of	$1,568,367,606	$80,535,584	5%	$820,200	0%	$1,487,011,822	95%
New Windsor, Town of	$3,034,886,997	$140,822,280	5%	$37,745,000	1%	$2,856,319,717	94%
Newburgh, City of	$1,770,065,120	$187,149,750	11%	$153,014,400	9%	$153,014,400	9%
Newburgh, Town of	$4,057,973,972	364,280,996	9%	$146,008,638	4%	$3,547,684,338	87%
Otisville, Village of	$18,434,147	$0	0%	$0	0%	$18,434,147	100%
Port Jervis, City of	$749,932,929	$173,876,774	23%	$230,214,818	31%	$345,841,337	46%
South Blooming Grove, Village of	$355,649,153	$30,323,900	9%	$39,946,900	11%	$285,378,353	80%
Tuxedo, Town of	$2,154,634,232	$345,809,538	16%	$265,115,922	12%	$1,543,708,772	72%
Tuxedo Park, Village of	$75,764,300	$11,995,400	16%	$0	0%	$63,768,900	84%
Unionville, Village of	$63,762,900	$7,300,000	11%	$0	0%	$56,462,900	89%
Walden, Village of	$562,132,000	$38,440,000	7%	$5,893,500	1%	$517,798,500	92%
Wallkill, Town of	$4,852,726,776	$451,701,974	9%	$697,326,712	14%	$3,703,698,090	76%
Warwick, Town of	$4,282,219,148	$507,560,765	12%	$345,964,900	8%	$3,428,693,483	80%
Warwick, Village of	$1,054,106,301	$93,157,766	9%	$105,358,600	10%	$855,589,935	81%
Washingtonville, Village of	$653,163,432	$106,611,700	16%	$123,024,700	19%	$423,527,032	65%
Wawayanda, Town of	$949,951,457	$77,674,816	8%	$22,907,100	2%	$849,369,541	89%
Woodbury, Town and Village	$3,370,777,742	$442,779,342	13%	$98,238,025	3%	$2,829,760,375	84%
Orange County Total	*$56,410,018,163*	*$6,898,676,434*	*12%*	*$6,210,543,663*	11%	*$42,023,911,496*	74%

5.4.3 Historical Occurrences

Floods have occurred in Orange County's communities in the past, and will continue to do so in the future. Orange County and its component municipalities have generally been impacted by riverine flooding and shallow flooding. A picture of the flooding history of Orange County in terms of damage to private property over the last three decades or so can be derived from the recorded flood losses and payments data from the NFIP. This data is presented in Section 8.0, along with the total number of current policies and the total coverage values. At the time of writing, none of the municipalities in Orange County were eligible for participation in FEMA's Community Rating System (CRS), under which municipalities implementing and enforcing floodplain management measures above and beyond the NFIP minimum requirements are rewarded with discounted flood insurance premiums.

There are two non-participating communities in the County; the Village of Otisville and the Town of Woodbury. The Village of Otisville contains no significant watercourses considered to be a potential source of flooding and there are no reported localized drainage issues. The Village of Woodbury was incorporated in 2006 and covers all of the Town of Woodbury except for a portion within the Village of Harriman. On incorporation, the Village of Woodbury assumed the Town's obligations and authority over local building and zoning, as well as the administration of the Floodplain Management Ordinance and other responsibilities associated with NFIP membership. Hence there would be little benefit in the Town also joining the NFIP since this would result in the duplication of existing efforts.

Tables 8.2a and 8.2b show that Orange County NFIP insured flood losses have totaled just over $23.5 million since 1978, or over $600,000 per year. This figure experienced a significant jump since the 2011 Orange County Hazard Mitigation Plan, when the average annual NFIP payment to Orange County was approximately $300,000. It was found that approximately $14 million in NFIP losses were incurred in Orange County between September 2010 and July 2015. Actual property flood losses community-wide are likely to be higher, since this value only includes NFIP claims for which payments were made and does not include losses incurred on properties the owners of which do not participate in the NFIP, losses for which a claim was not submitted, or losses for which payment on a claim was denied.

The average NFIP payment for the County overall was approximately $13,000 per individual loss. Over 40% of all NFIP losses in Orange County (in terms of dollar loss amounts) have occurred in three municipalities – the Town of Deerpark, the Town of Blooming Grove, and the Village of Washingtonville. The highest average payment per loss in any single municipality is in the Town of Tuxedo, where payments have been nearly $40,000 per loss. Of the 41 municipalities participating in the NFIP, only the Town of Greenville has not experienced any flood damage resulting in NFIP payments.

5.4.4 Repetitive Losses

FEMA defines a Repetitive Loss (RL) property as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. A repetitive loss property may or may not be currently insured by the NFIP. A listing of repetitive and severe repetitive loss properties across Orange County can be found in Section 8.2.

5.4.5 Flood Disaster Declarations

The New York State Emergency Management Office reports Orange County as having been affected by 13 Presidential Disaster Declarations specifically due to flooding or due to weather events which are recorded as having caused serious flooding. Table 5.4c summarizes the occurrence and causes of these disaster declarations, including total damages (where recorded) and which form of post-disaster assistance the County became eligible for after the declaration.

Through the Public Assistance (PA) Program, FEMA provides supplemental Federal disaster grant assistance for debris removal, emergency protective measures, and the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain Private Non-Profit (PNP) organizations. The Individual Assistance Program (IA) provides money or direct assistance to individuals and families in an area whose property has been damaged or destroyed and whose losses are not covered by insurance. It is meant to assist with critical expenses that cannot be covered in other ways, rather than to restore damaged property to its condition before the disaster.

Table 5.4c: Flood-Related Disaster Declarations Affecting Orange County
(Source: NYSDHSES, 2015)

Disaster #	Description[1]	Declared Date (and Incident Period)	Damages[2]
DR-0311	Severe storms and flooding: Orange County: PA only	9/13/1971	Not recorded
DR-0338	Tropical Storm Agnes: Orange County: PA and IA	6/23/1972 (6/20/72 – 6/25/72)	$703m
DR-0702	Flooding – Southeastern NY: Orange County – PA and IA	4/17/1984	$11.9m
DR-1095	Flooding: Orange County – PA and IA	1/24/1996 (1/19/1996 – 1/30/1996)	$160m
DR-1296	Hurricane Floyd: Orange County: PA & IA	9/19/1999 (9/15/99 – 9/18/99)	$62.2m
DR-1564	Severe Storms: Orange County – PA and IA	10/1/2004 (8/13/2004 – 9/16/2004)	$18 m
DR-1565	Tropical Depression: Orange County – PA and IA	10/1/2004 (9/16/2004 – 9/24/2004)	$15.1m
DR-1589	Severe Rains/Floods: Orange County – PA and IA	4/19/2005 (4/2/2005 – 4/4/2005)	$66.2m
DR-1650	Severe Storms/Flooding: Orange County – IA only	7/1/2006 (6/29/2006 – 7/10/2006)	$246.3m
DR-1692	Nor'easter: Orange County: PA & IA	4/27/2007 (4/14/07 – 4/18/07)	$12.8 m
DR-4020	Hurricane Irene: Orange County – PA and IA	8/31/2011 (8/26/11 – 9/5/11)	$637 m
DR-4031	Remnants of Tropical Storm Lee: Orange County: PA & IA	9/13/2011 (9/7/11 – 9/11/11)	$352 m
DR-4085	Hurricane Sandy: Orange County: PA & IA	10/30/2012 (10/27/12 – 11/9/12)	$10.8 b

[1] As given by NYSDHSES [2] Includes damages in areas outside Orange County

The NCDC database records flood events in Orange County from January 2000 to December 2017, and there have been 75 recorded flood events affecting Orange County in this period, causing reported damages totaling more than $30.9 million, including damages incurred outside Orange County. Table 5.4d presents selected significant flood events recorded for Orange County in the NCDC database for which some detailed information was available. Some events that caused significant flooding have been described in the hurricane and tropical storms and nor'easter hazard profiles. In some cases additional information has been supplied by Orange County staff.

Agriculture-related flood disasters are quite common. The Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans (EM) to producers suffering losses in those counties and in counties that are contiguous to a designated county. Table 5.4d summarizes the USDA disaster designations for flood-related events (USDA, 2016). Table 5.4e lists recent flood events in Orange County recorded by the NOAA's National Climate Data Center.

Table 5.4d: USDA Disaster Designations for Orange County (2007-2015)
Updated for the 2018 Orange County Multi-Jurisdiction HMP

Incidence Period	Event Type	USDA Declaration Number	Losses/Impacts
April 14-18, 2007	Severe storms and inland and coastal flooding, excessive rain, flash flood and flooding	M1692, S2528	Production and physical losses were attributed to excessive rain, flash flooding and flooding
May 1-3, May 16, May 20, and June 16, 2008	Excessive rain, high winds, flooding, flash flooding, hail and lightning	S2725, S2724, S2827	The U.S. Department of Agriculture designated 19 counties in New York as primary natural disaster areas because of losses resulting from extreme weather which occurred during the period of May 1-3, 2008, and continuing. Production losses were attributed to multiple extreme weather events from May 1 to June 13, 2008.
May 16 2009	Excessive rain, flash flooding, hail, high winds	S2929	Production losses were attributed to excessive rain, flooding, flash flooding, hail and high winds.
March 13-15, 2010	Severe storms and flooding	M1899	Production and physical losses were attributed to severe storms and flooding.
April 1-June 15, 2011	Excessive rain, high winds, and hail	S3160	Production and physical losses were attributed to excessive rain, high winds, and hail.
July 10-August 25, 2011	Excessive heat and excessive rain	S3204, S3202	Production and physical losses were attributed to excessive heat and excessive rain, and the combined effects of excessive rain, flooding, flash flooding, hail, high winds, below normal temperatures and tornadoes.
August 26, September 5, 2011	Tropical Storm /Hurricane Irene	M4020	Production and physical losses were attributed to the effects of Tropical Storm and Hurricane Irene.

Table 5.4d: USDA Disaster Designations for Orange County (2007-2015) Updated for the 2018 Orange County Multi-Jurisdiction HMP			
Incidence Period	Event Type	USDA Declaration Number	Losses/Impacts
October 28-31, 2012	Hurricane Sandy	M4085, N1114	Production and physical damages and losses were attributed to the combined effects of high winds excessive rain, and flash flooding associated with Hurricane Sandy.
May 1, 2013-ongoing	Excessive rain and related flooding, high winds and hail	S3593	Production losses were attributed to excessive rain, hail, high winds and flooding.
April 1, 2014-July 8, 2014	Flood, excessive rain, hail, high winds,	S3747	Production and physical damages and losses were attributed to the combined effects of flooding, high winds, hail, and excessive rain.
May 1, 2015-July 14, 2015	Excessive rainfall, hail, high winds, tornadoes, lighting	S3885	Production and physical damages and losses were attributed to the combined effects of excessive rain, hail, high winds, tornadoes, and lightning.
M Presidential Major Disaster Declaration N Administrative Physical Loss Notification S Secretarial National Disaster Determination USDA United State Department of Agriculture			

Table 5.4e: Selected Flood Events in Orange County
(Source: NOAA NCDC)

Date	Affected Areas[1]	Description	Reported Property Damage[2]
4/16/1993	Not recorded	Showers and thunderstorms deposited between one and two inches of rain across the area. Localized but significant urban flooding resulted from these torrential rains.	Not recorded
1/28/1994	Not recorded	Melting the snow and heavy rains caused significant and widespread urban flooding across the area. Many roads were closed for hours during this event. Numerous cars stalled attempting to cross some of these flooded roads and several drivers had to be rescued from their vehicles.	Not recorded
1/24/1996	Countywide	Orange County was among the Counties in New York State that became eligible for Individual and Public Assistance under Federal Disaster Declaration DR-1095, which resulted from the occurrence of severe storms and flooding across the region. Sample County records from this event show post- disaster repairs of County roads at 32 locations with costs totaling almost $330,000. Other major post- disaster costs included in these records were $473,000 for repairs of the Delaware and Ohio Canal, $149,000 for the repair of a sewage pumping station, and $19,000 for debris removal at four locations.	$1.07 million
7/13/1996	New Windsor	As Tropical Storm Bertha moved northeast, passing east of Atlantic City, NJ it produced torrential rain and strong gusty winds. The rain caused flooding of low lying and poor drainage areas, streams, and rivers across the area. The heaviest rain fell in a band to the northwest of Bertha's track over the Lower Hudson Valley. Measured rainfall totals in Orange County included 3.3 inches at Ridgebury and 4.5 inches at Greenwood Lake.	Not recorded
7/25/1996	Goshen, Washingtonville	Clusters of strong thunderstorms deposited from two to four inches of rain across central parts of Orange County. Torrential rain caused flash flooding of numerous roads, small streams, and basements throughout this area. Total rainfall of four inches was measured in Goshen, where significant basement flooding occurred.	Not recorded
9/8/1996	Port Jervis	Thunderstorms produced torrential rain that caused significant flash flooding of low lying and poor drainage areas, including many streets.	Not recorded
10/19/1996	Cornwall, Highland Falls	Heavy rains along with minor to major coastal flooding occurred. More than three inches of rain fell, with 3.5 inches measured at Port Jervis. The rain caused serious widespread street and poor drainage flooding: Route 218 between Cornwall and Highland Falls was closed due to flooding.	Not recorded
5/10/1998	Monroe	With wet antecedent conditions during the previous 11 days, bands of heavy rainfall caused flash flooding. In Orange County, the police reported flooded basements and roads countywide, and a Section of Route 17M in Monroe was closed by flooding.	Not recorded
5/31/1998	Countywide	Severe thunderstorms formed in lines and clusters moved over the Lower Hudson Valley. They produced high winds, large hail, torrential rain, and frequent lightning. Up to six inches of rain caused flash flooding of roads and basements across Orange County, resulting in $200K in property damage.	$200,000
9/16/1999	Countywide	Torrential record rainfall, which caused serious widespread urban, small stream, and river flooding, preceded the remnants of Hurricane Floyd. Orange, Putnam, Rockland, and Westchester Counties were declared disaster areas.	$1.7 million
		For these four counties, the damage estimates were $14.6 million dollars. These figures represent eligible costs for disaster payments, and represent a "fraction" of the costs that were actually incurred. Serious widespread flooding of low-lying and poor drainage areas resulted in the closure of many roads and basement flooding across the entire region. Several roads were closed due to flooding and the Grove Drive Bridge in Tuxedo Park was overtopped by floodwaters.	

Table 5.4e: Selected Flood Events in Orange County *(Source: NOAA NCDC)*			
Date	Affected Areas[1]	Description	Reported Property Damage[2]
8/3/2000	Western and Northern Orange County	A slow moving thunderstorm produced torrential rain. Rainfall rates estimated by radar from 2.5 to 3 inches per hour caused a creek in Deerpark to overflow and flood Peenpack Trail Road, just north of Port Jervis. A line of thunderstorms also produced torrential rain that caused localized flooding of low- lying and poor drainage areas across Northern Orange County.	Not recorded
9/1/2000	Cornwall, Highland Falls	Slow moving thunderstorms produced periods of torrential rain that caused flash flooding of many low- lying and poor drainage areas. Staff from The Times Herald Record reported significant serious street flooding along with some basement flooding in Cornwall. A spotter from New Windsor measured 2.75 inches of rainfall and. National Weather Service radar estimated up to six inches of rain fell in the vicinity of Highland Falls, where numerous reports of flash flooding were received. At least 94 of 100 houses surveyed showed at least minor flood damage. There were many flash flooding reports of basements, low-lying and poor drainage areas, and small streams.	$500,000
12/17/2000	Crawford, Port Jervis, Blooming Grove	Heavy rain caused significant flooding in Orange and Rockland Counties. The axis of the heaviest rain extended from Western New Jersey northeast across Orange County, where 3 to 4 inches of rain fell, mainly across Western and Northern Orange County. Widespread flash flooding of low lying and poor drainage areas occurred at several locations throughout Orange County. In Orange County, rainfall amounts ranged from 2.11 inches at Gardnerville to 2.8 inches at Sterling Forest. In Pine Bush, 15 cars had to be moved when the back parking lot of the Schuyler Crossing Senior Citizen Complex flooded. In Port Jervis, flooding caused the closure of Jersey Avenue between Owen and Cole Streets. Serious flooding occurred in parts of Mountain Lodge Park in Blooming Grove, where some trails partially washed away.	Not recorded
5/28/2002	New Windsor	Slow moving clusters of heavy showers and thunderstorms produced widespread flash flooding of poor drainage areas and streets in New Windsor.	Not recorded
8/22/2003	Harriman	Scattered showers and thunderstorms developed along a pre-frontal trough and moved east across the region, producing areas of torrential rain resulting in flash flooding as well as wind damage from a severe thunderstorm. The Harriman Police Department reported significant street flooding and several knocked down trees in Harriman.	Not recorded
8/11/2003	Goshen, Montgomery	Heavy showers developed in response to a persistent trough of low pressure. Radar estimated maximum rainfall rates of two to three inches in three hours between Montgomery and Maybrook. The heavy rainfall resulted in street flooding in Goshen and along Interstate 84 in Montgomery.	Not recorded
9/23/2003	Goshen, Florida	Widespread heavy rain of between one to two inches created flooding problems across the lower Hudson Valley and several roads became impassable due to flooding and had to be at least partially closed. These included the Pine Island Turnpike in Orange County, which was partially washed out near Goshen and Florida.	Not recorded
8/30/2004	Port Jervis, Deerpark	The remnants of a tropical system combined with a stalled frontal boundary acted to ignite slow moving thunderstorms over Western Orange County for several hours. Hourly radar rainfall estimates in the 3-5" range were observed at times. The hardest hit areas were Port Jervis and Deerpark, where flooding was severe enough to initiate states of emergencies. Houses were damaged, roads were destroyed, and buildings collapsed throughout Western Orange County. Damage estimates were $2.2 million in public and $1.8 million in private property.	$4 million

Table 5.4e: Selected Flood Events in Orange County *(Source: NOAA NCDC)*			
Date	Affected Areas[1]	Description	Reported Property Damage[2]
9/8/2004	Deerpark	The remnants of Hurricane Frances produced torrential rainfall across Southeastern New York The rains caused flash flooding in areas of Cuddebackville including Deerpark manor. Firefighters and other volunteers spent hours laying sandbags to protect homes from the floodwaters. Rainfall amounts ranging from an inch to up to 6 inches were common across the area. This caused extensive flash flooding across the region, resulting in rescues of people from homes and cars.	Not recorded
9/18/2004	Port Jervis	The remnants of Hurricane Ivan produced torrential rains across Southeast New York. Storm total rainfall reports added up to over five inches in some areas. This caused extensive flash flooding of roads and highways across the region. The rains resulted in flash flooding on nearly all roads in Port Jervis, where a state of Emergency was declared by the Mayor.	Not recorded
4/2/2005	Port Jervis Deerpark	Widespread heavy rain along with embedded heavy showers and thunderstorms occurred, causing widespread urban flooding. Most small streams and rivers overflowed their banks, and the Delaware River flooded in the Port Jervis-Deerpark area, The Orange County Division of Emergency Management reported 100 basements flooded ($1 million in damage) in Port Jervis and 160 houses damaged ($16 million) in Deerpark. Port Jervis officials issued a mandatory evacuation for people living along the Delaware River. The Town of Deerpark was placed under a State of Emergency.	$17 million
6/16/2005	Newburgh	Flash flooding closed many roads in the Newburgh area as torrential rain from thunderstorms occurred. Several streets were closed, some of which were inundated by four feet of water.	Not recorded
10/8/2005	Highlands, Highland Falls, Monroe	Heavy rain fell north of New York City and across the Lower Hudson Valley. The rain resulted in significant flooding on some rivers, most small brooks and streams, and throughout urban areas in low lying and poor drainage areas. More than 12 inches of rain was recorded at New Windsor. Spotters reported flash flooding of many roads throughout Orange County. A state of emergency was declared for the Town of Highlands, where up to four feet of water covered Routes 293 and 9W.	Not recorded
10/28/2006	Middletown	Heavy rain caused flash flooding of urban areas with poor drainage, and numerous basements were flooded in Howells in the Town of Wallkill, where more than 2.5 inches of rain was recorded.	Not recorded
4/15/2007	Countywide	High winds, heavy rain, and high water tables produced widespread flooding across parts of the New York City region. Orange County rainfall ranged from 4.26 inches in Westtown to 8.00 inches at Cornwall. The Orange County Department of Emergency Services reported emergency declarations in the towns of Deerpark and Blooming Grove and in the villages of Washingtonville, Greenwood Lake, and South Blooming Grove. Many road closures were reported in the towns of Newburgh, Blooming Grove, Cornwall, Crawford, Deerpark, Walkill, and many other towns and villages throughout the county. Evacuations occurred in the towns of Woodbury, Tuxedo, Deerpark, and Washingtonville. Among the highways closed by flooding were County Roads 26, 53, and 67.	Not recorded
3/8/2008	Middletown, Washingtonville	Numerous flooded basements had to be pumped out in residential areas of Middletown and Washingtonville. Route 78 near Aspin Rd/Wisner Avenue was also closed due to flooding.	Not recorded
7/23/2008	Cornwall-on-Hudson	The combination of several waves of low pressure interacting with a tropical air mass led to torrential rainfall and flash flooding. A car was submerged in water on Hudson Street (Rte. 218) in Cornwall on Hudson. A water rescue was performed by the local fire department.	Not recorded
8/11/2008	Warwick	An anomolous low pressure system over southeast New York produced numerous thunderstorms with torrential rainfall which led to flash flooding in the Lower Hudson Valley. Main St. and Railroad Ave. in Warwick were impassable due to flooding.	Not recorded

Table 5.4e: Selected Flood Events in Orange County *(Source: NOAA NCDC)*			
Date	Affected Areas[1]	Description	Reported Property Damage[2]
9/6/2008	Cornwall	Periods of torrential rain from heavy showers and thunderstorms caused flash flooding in many locations, which included urban, small stream and river flooding. Storm total rainfall ranged from 1.66 inches at Port Jervis to 5.92 inches at New City. State Highway 218 was closed in both directions between Cornwall and West Point due the concern that the heavy rain would cause rock slides.	Not recorded
7/26/2009	Goshen	A cluster of thunderstorms producing heavy rainfall moved across Orange County during the late evening hours which resulted in flash flooding. Route 17 in Goshen was closed due to flooding.	Not recorded
8/12/2009	Cornwall-on-Hudson	Slow moving thunderstorms developed in a tropical air mass, which resulted in very heavy rain and flash flooding in Orange County. All lanes were closed southbound on NY 218 between Cornwall-on- Hudson and West Point due to the concern that the heavy rain would cause rock slides.	Not recorded
3/7/2011	Tuxedo Park, Washingtonville	Several waves of low pressure tracked north along a slow moving cold front that extended from the Gulf Coast to Maine. The combination of this slow moving boundary and a sub-tropical moisture feed aided in the production of heavy rainfall that resulted in moderate to major flooding across portions of Southeast New York. Moodna Creek overflowed its banks causing flooding of first floor residents and businesses on Route 208 as well as Route 94 near Washingtonville High School.	Not recorded
3/11/2011	Huguenot, Otisville, Deer Park, Port Jervis	Low pressure over the upper mid-west slowly tracked across the Great Lakes into southeast Canada. Very wet antecedent conditions were already in place from heavy rain a few days earlier. This in combination with a slow moving frontal boundary and a sub-tropical moisture feed from a deep southerly wind flow aided in the production of more heavy rainfall that resulted in widespread flooding across the Lower Hudson Valley. Route 17 between the Harriman Train Station and the NY State Thruway in Tuxedo Park was impassable due to flooding. In Otisville, US 209 was closed in both directions at Oakland Valley Rd. due to flooding. Evacuations were performed due to flooding on Hobson Rd. in the Deer Park community of Port Jervis.	Not recorded
8/28/2011	County-wide	Hurricane Irene produced torrential rains, high winds and flooding from the Bahamas all the way to northern New England. Orange County reported between 6 and more than 10 inches of rain.	Not recorded
9/8/2011	Country-wide	The combination of showers and thunderstorms in association with a slow moving cold front and deep tropical moisture moving up the east coast from the remnants of Tropical Storm Lee, produced a prolonged period of rainfall, which led to flooding across portions of the Lower Hudson Valley. Cardinal Dr. was closed at Peacock Circle in Washingtonville due to flooding. In Mt. Hope, Seybolt Ave. was washed out and two ft. of water infiltrated numerous homes in the Hidden Valley development off of Guymard Turnpike. Property damage amount is estimated. Total reported rainfall amounts in Orange County ranged from 4.56 inches in Port Jervis to 8.30 inches in Warwick.	$6.3 million
12/8/2011	Chester, Newburgh, Harriman	Exit 127 on Rt. 17 in Sugar Loaf was closed due to flooding. Storm total measured rainfall amounts ranged from 1.22 inches in Newburgh to 3.25 inches in Harriman. Several waves of low pressure tracked south to north along a slow moving frontal boundary, which led to a prolonged period of heavy rain and resulted in widespread flooding across the Lower Hudson Valley.	Not recorded
7/15/2012	Crawford	Cransmill Rd. in Pine Bush was closed due to a sinkhole created from a flash flood. The combination of an upper level shortwave trough and a surface trough produced scattered showers and thunderstorms across the area. Some thunderstorms produced torrential rainfall which resulted in flash flooding in Orange County.	Not recorded

Table 5.4e: Selected Flood Events in Orange County
(Source: NOAA NCDC)

Date	Affected Areas[1]	Description	Reported Property Damage[2]
7/28/2012	Newburgh, New Windsor	A stream overflowed its banks which resulted in swift moving water rushing down Union Ave. in New Windsor. A few weak areas of low pressure moved along a nearly stationary frontal boundary just south of Long Island. This in combination with an upper level trough also tracking through the area resulted in scattered thunderstorms which produced heavy rainfall and flash flooding in Orange, Putnam and Suffolk counties.	Not recorded
9/4/2012	Port Jervis	Heavy rain resulted in ponding of water 1 1/2 to 2 1/2 ft. high in the streets of the 4th ward of Port Jervis, which caused basement flooding in several homes. The department of public works reported 3.25 inches of rainfall in an hour. Low pressure and its attending warm front moved through the region, producing torrential rain over a short period of time, which resulted in flash flooding in western Orange County.	Not recorded
10/29/2012	County-wide	Hurricane Sandy produced torrential rains, high winds and flooding from the Bahamas all the way to northern New England. Orange County reported between 2 and more than 4 inches of rain. Damages are presently being assessed.	$200,000
6/24/2013	Woodbury	Water rescues were performed on Interstate 87 near Mile Marker 49.7 in Highland Mills. The combination of a trough of low pressure stalled over the region and a passing upper level disturbance triggered a line of severe thunderstorms, which passed across Orange and Putnam Counties. This line produced heavy rainfall, which resulted in flash flooding in Orange county.	Not recorded
7/1/2013	Port Jervis, Deerpark, Tuxedo Park	The intersection of Reservoir Ave. and Orange St. in Port Jervis was closed due to flooding. Route 17 in Tuxedo Park was closed due to flooding. A large upper level low encompassing the Mississippi Valley resulted in a moisture feed up the east coast from the Gulf of Mexico. A stationary boundary just to the west of New York City was the focus for training showers and thunderstorms and resulted in heavy rain and flash flooding in the Lower Hudson Valley.	Not recorded
8/9/2013	Wawayanda, Newburgh, Goshen, Hamptonburgh, Middletown	Vehicle rescues were performed by local responders after becoming trapped in flood waters on Dolsontown Road in Middletown. Eight inches of water was flowing down Union Ave. in Gardnertown. In New Hampton, I-84 was closed at Dolson Ave. due to flooding. Additionally, a portion of Dolson Ave. was closed due to flooding, including the intersection of Dolsontown Rd. and Dolson Avenue. Basement flooding was also reported in Middletown. A lake on Carmelite Dr. in Middletown overflowed resulting in six inches of water flowing across the roadway. Basement flooding was reported on Murray Ave. in Goshen. The southbound lanes of Rt. 300, Union Ave., in Newburgh were closed near I-84 due to flooding. A pre-frontal trough triggered scattered heavy showers and thunderstorms with heavy rainfall that resulted in flash flooding in Orange County.	Not recorded
8/21/2014	Port Jervis, Deerpark	Main Street in Port Jervis was flooded and impassable. The bridge over the Neversink River was closed to traffic due to the flood waters. An upper level trough pivoting through the Northeast triggered scattered evening showers and thunderstorms, with an isolated severe thunderstorm and flash flooding in Orange County.	Not recorded
7/25/2015	Tuxedo Park	Village Road was closed at Highway 17 in Tuxedo Park due to flash flooding. A slow moving shortwave trough crossed the region in the afternoon, producing slow moving showers and thunderstorms that resulted in isolated flash flooding in Orange and Rockland counties.	Not recorded
6/13/2017	Woodbury	Lent Drive and Schunnemunk Road at Ridge Road were closed due to flooding in Highland Mills. A cold front moved slowly across the area during the afternoon and evening hours, sparking scattered thunderstorms that resulted in isolated flash flooding across Orange County. One spotter in the Highland Mills area reported over one inch of rain in 30 minutes, with over 2 inches falling in the span of 45 minutes.	Not recorded

Table 5.4e: Selected Flood Events in Orange County
(Source: NOAA NCDC)

Date	Affected Areas[1]	Description	Reported Property Damage[2]
6/19/2017	Middletown	The intersection of Wickham Avenue and Wisner Avenue was closed due to flooding in Middletown. A cold front crossing the area during the afternoon and evening produced numerous showers and thunderstorms, some of which resulted in flash flooding across parts of the Lower Hudson Valley and New York City. These storms developed in an environment with precipitable water values of around 2 inches. Rainfall totals ranged from 1-3 inches across the area, with 2.45 reported by a trained spotter in Middletown, NY.	Not recorded
8/2/2017	Walden	East Main Street in Walden was closed due to flooding. An approaching upper level disturbance combined with increasing instability resulted in the development of afternoon showers and thunderstorms. With weak steering flow and precipitable water values of 1.5 or greater, these storms produced isolated flash flooding across parts of New York City and the Lower Hudson Valley.	Not recorded

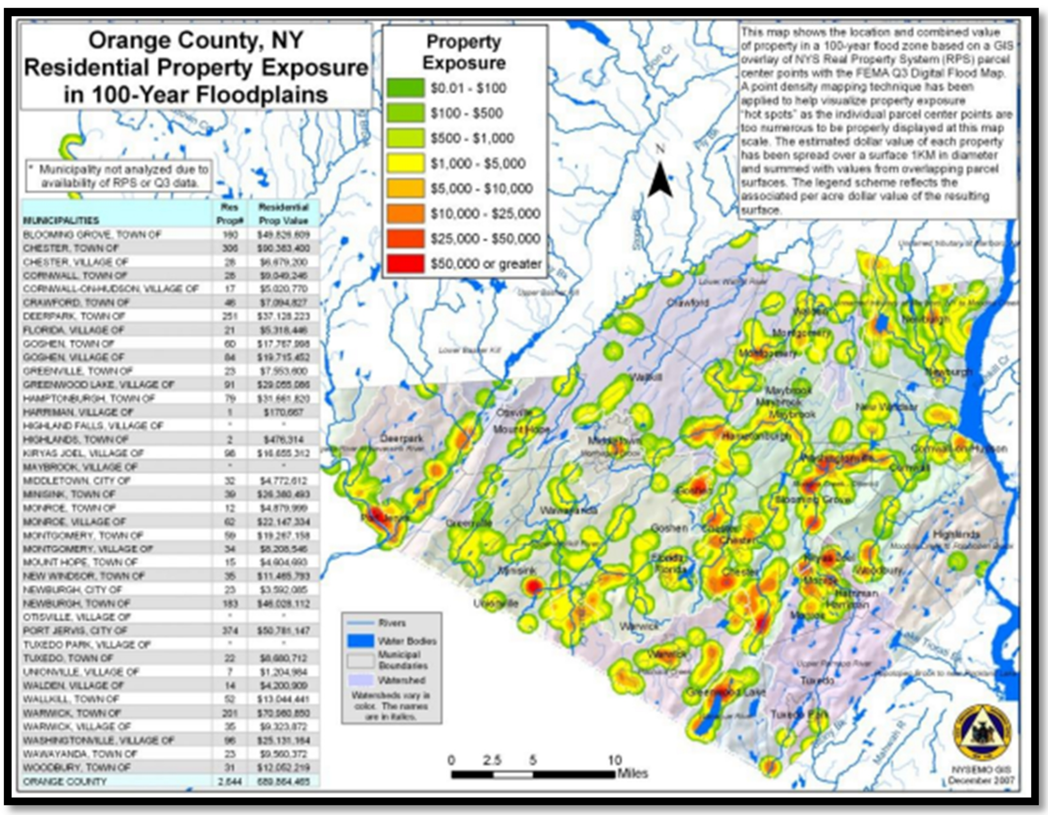
[1] Where specific flood impacts are mentioned by NCDC
[2] NCDC indicates these damages occurred wholly in Orange County

5.4.6 Future Potential Impacts

The probability of occurrence of a flood at a given location (the odds of being flooded) is expressed in percentages as the chance of a flood of a specific magnitude occurring in any given year. The "100-year flood" has a 1% chance of occurring in any given year. The 100-year flood is often also referred to as the "base flood". This probability of occurrence might imply that a 100-year flood would reoccur only once every 100 years; in reality, this is not the case. A 100-year flood can happen multiple times in a single year, or not at all for more than 100 years. Properties located in FEMA-mapped A- and V-Zones are within the footprint of the 100-year floodplain. FEMA A-Zones represent the 100-year floodplain.

For all floodplains, there is an associated water surface elevation. This elevation is unique to any given location on the map (in other words, 100-year flood levels vary from one community to the next throughout Orange County, and also within individual communities). Figure 5.4b depicts residential property exposure in the 100-year floodplain across communities in Orange County

Figure 5.4b: Orange County, NY Residential Property Exposure in 100-year Floodplains
(NYSDHSES, 2007)



Within the 100-year floodplain, flooding can occur at less than the 100-year flood level, and also more than the 100-year flood level. The 100-year flood represents a flood of high magnitude – it is a deep and widespread event. The 500-year flood is of a greater magnitude, and would be deeper and more widespread than a 100-year event. However, it is not as likely to occur. Smaller floods, with magnitudes of 10-years or 50-years for example, are also possible within the

100-year floodplain. These are not as deep or as widespread as a 100-year flood would be, however, they are much more likely to occur.

The term "100-year flood" can often be confusing to someone not intimately familiar with flooding or statistics. FEMA's *NFIP Floodplain Management Requirements: a Study Guide and Desk Reference for Local Officials* (FEMA-480), suggests that another way to look at flood risk is to think of the odds that a 100-year flood will happen sometime during the life of a 30-year mortgage of a home in the floodplain. Figure 5.4c illustrates these odds, over various time periods for different size floods. In any given year, a property in the 100-year floodplain has a 10 percent chance of being flooded by a 10-year flood, and a 1 percent chance of being flooded by a 100-year flood. While it may seem insignificant, over a 30–year period, that same location has a 96 percent chance of being flooded by a 10-year flood and a 26 percent chance of being flooded by a 100-year flood.

Figure 5.4c: The Odds of Being Flooded
(NFIP, FEMA-430, 2004)

WHAT ARE THE ODDS OF BEING FLOODED?

The term "100-year flood" has caused much confusion for people not familiar with statistics. Another way to look at flood risk is to think of the odds that a 100-year flood will happen sometime during the life of a 30-year mortgage—a 26% chance for a structure located in the SFHA.

Chance of Flooding over a Period of Years

Time Period	Flood Size 10-year	25-year	50-year	100-year
1 year	10%	4%	2%	1%
10 years	65%	34%	18%	10%
20 years	88%	56%	33%	18%
30 years	96%	71%	45%	26%
50 years	99%	87%	64%	39%

Even these numbers do not convey the true flood risk because they focus on the larger, less frequent, floods. If a house is low enough, it may be subject to the 10- or 25-year flood. During a 30-year mortgage, it may have a 26% chance of being hit by the 100-year flood, but the odds are 96% (nearly guaranteed) that it will be hit by a 10-year flood. Compare those odds to the only 1-2% chance that the house will catch fire during the same 30-year mortgage.

5.5 Drought

5.5.1 Description

A drought is a prolonged period of time with little or no rain – particularly during the planting and growing season in agricultural areas. Limited winter precipitation accompanied by moderately long periods during the spring and summer months can also lead to drought conditions (2014 NYS HMP). An absolute drought consists of a period of at least 15 consecutive days where none of the days experience 0.01 inches of rain or greater. A partial drought is a period of at least 20 consecutive days where the mean daily rainfall does not exceed 0.01 inches. A dry spell consists of a period of at least 15 consecutive days where none of the days experience 0.04 inches or more of rainfall (USGS, 2009).

Four types of drought are generally recognized by the climatological community (NOAA, NCDC, 2016):

1. ***Meteorological drought:*** occurs when dry weather patterns dominate the area;
2. ***Hydrological drought:*** occurs when low water supply becomes evident, especially in streams, reservoirs, and groundwater levels, usually after many months of meteorological drought;
3. ***Agricultural drought:*** occurs when crops become affected; and
4. ***Socioeconomic drought:*** relates the supply and demand of various commodities to drought.

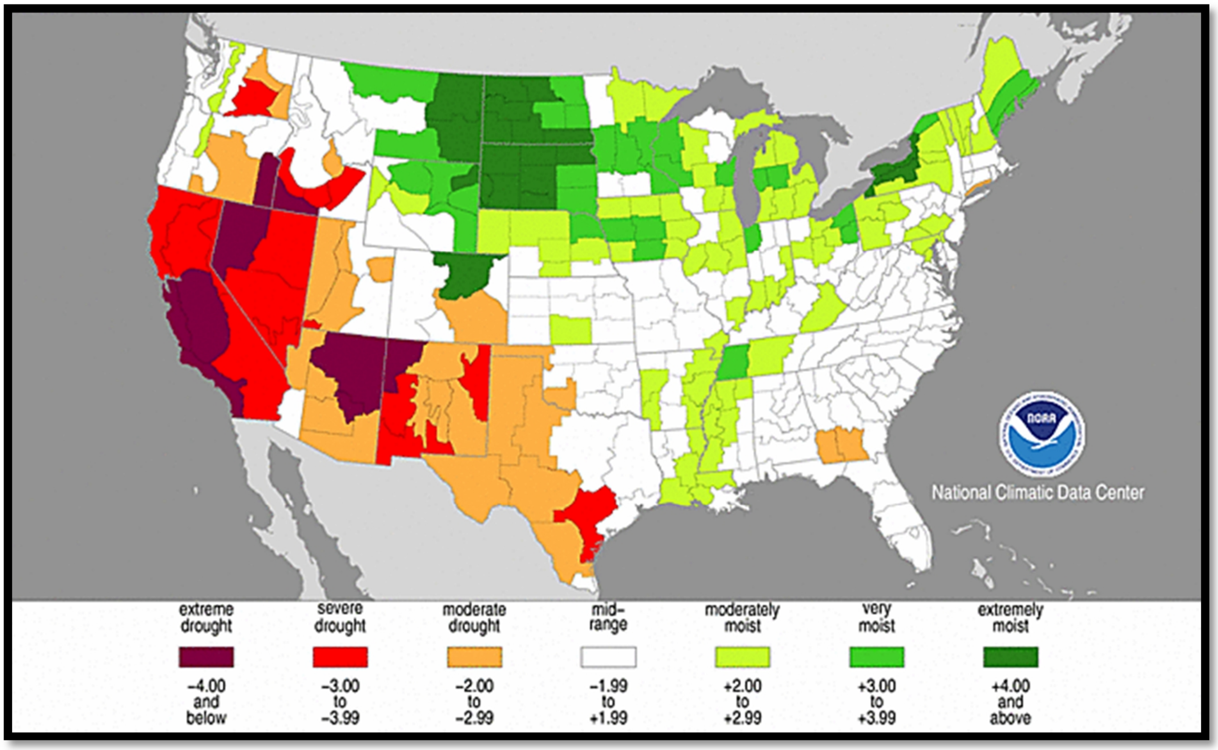
Drought is often referred to as a “creeping disaster” in which its exact onset and end are often difficult to pinpoint until long after the event has passed (NOAA, NCDC, 2016).

5.5.2 Location and Extent

Droughts occur in all parts of the country and at any time of year, depending on temperature and precipitation over time. Arid regions are more susceptible to long-term or extreme drought conditions, while other areas (including Orange County) tend to be more susceptible to short-term, less severe droughts.

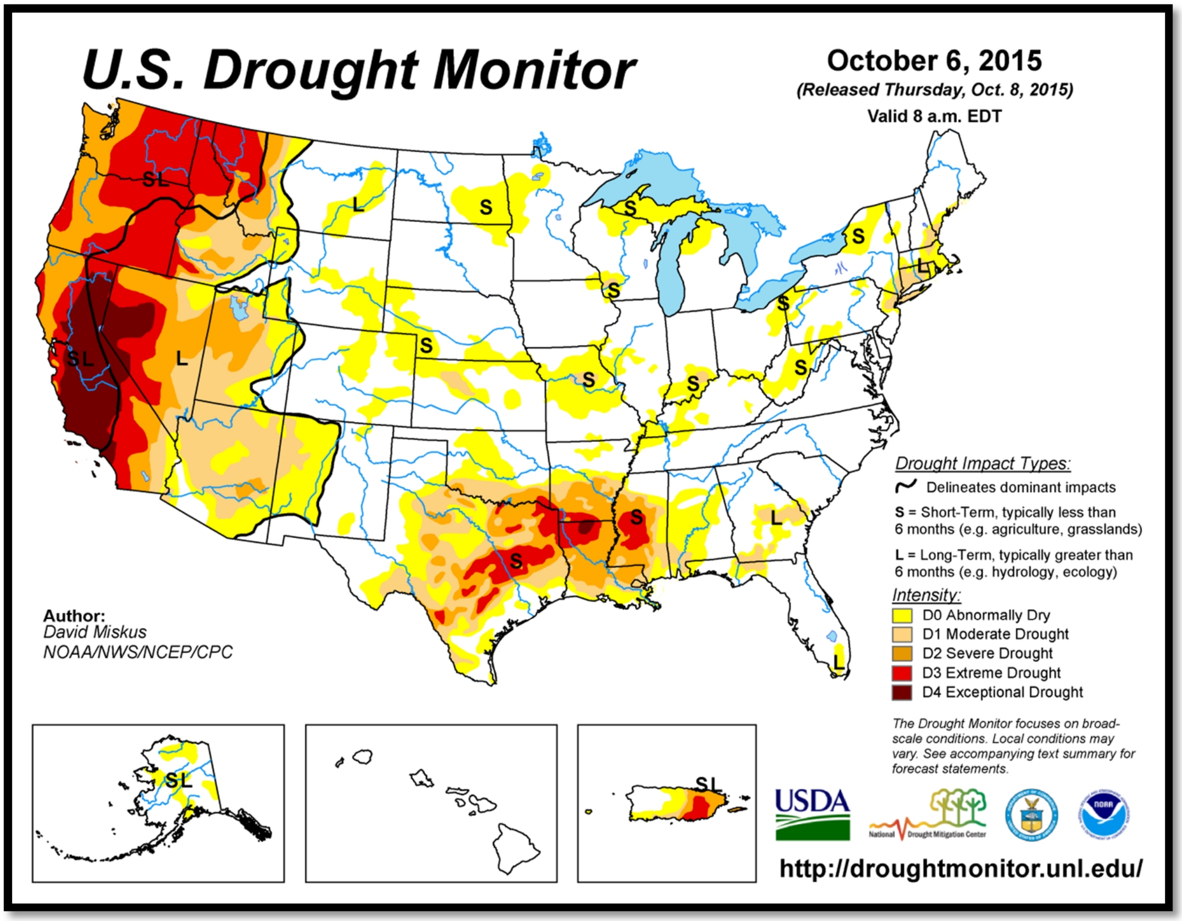
The Palmer Drought Severity Index (PDSI) attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. Since weather patterns can change almost literally overnight from a long-term drought pattern to a long-term wet pattern, the PDSI can respond fairly rapidly. The following map depicts the PDSI in August 2014, indicating that Orange County is in the mid-range of drought vs. moist conditions.

Figure 5.5a: Palmer Drought Severity Index, August 2014
(NCDC, 2015)



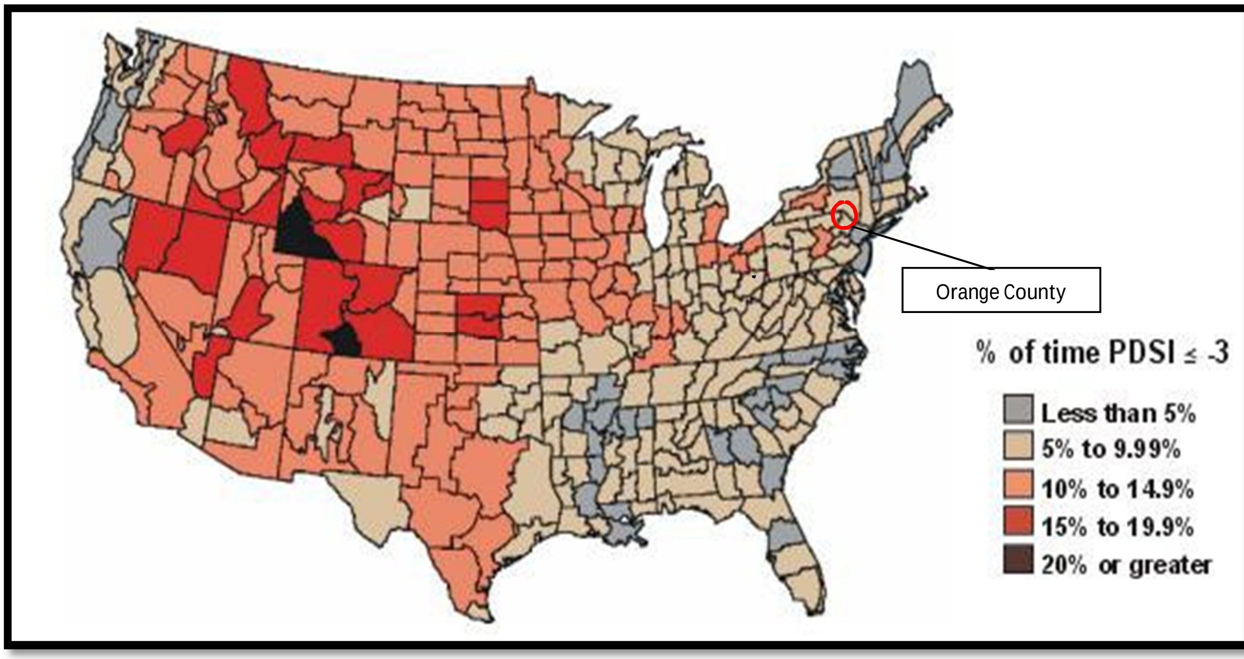
The U.S. Drought Monitor graphic as of October 6, 2015 shows that drought conditions have increased in the Orange County area, but only to an "abnormally dry" category.

Figure 5.5b: U.S. Drought Monitor, October 6, 2015
(NOAA, NWS, 2015)



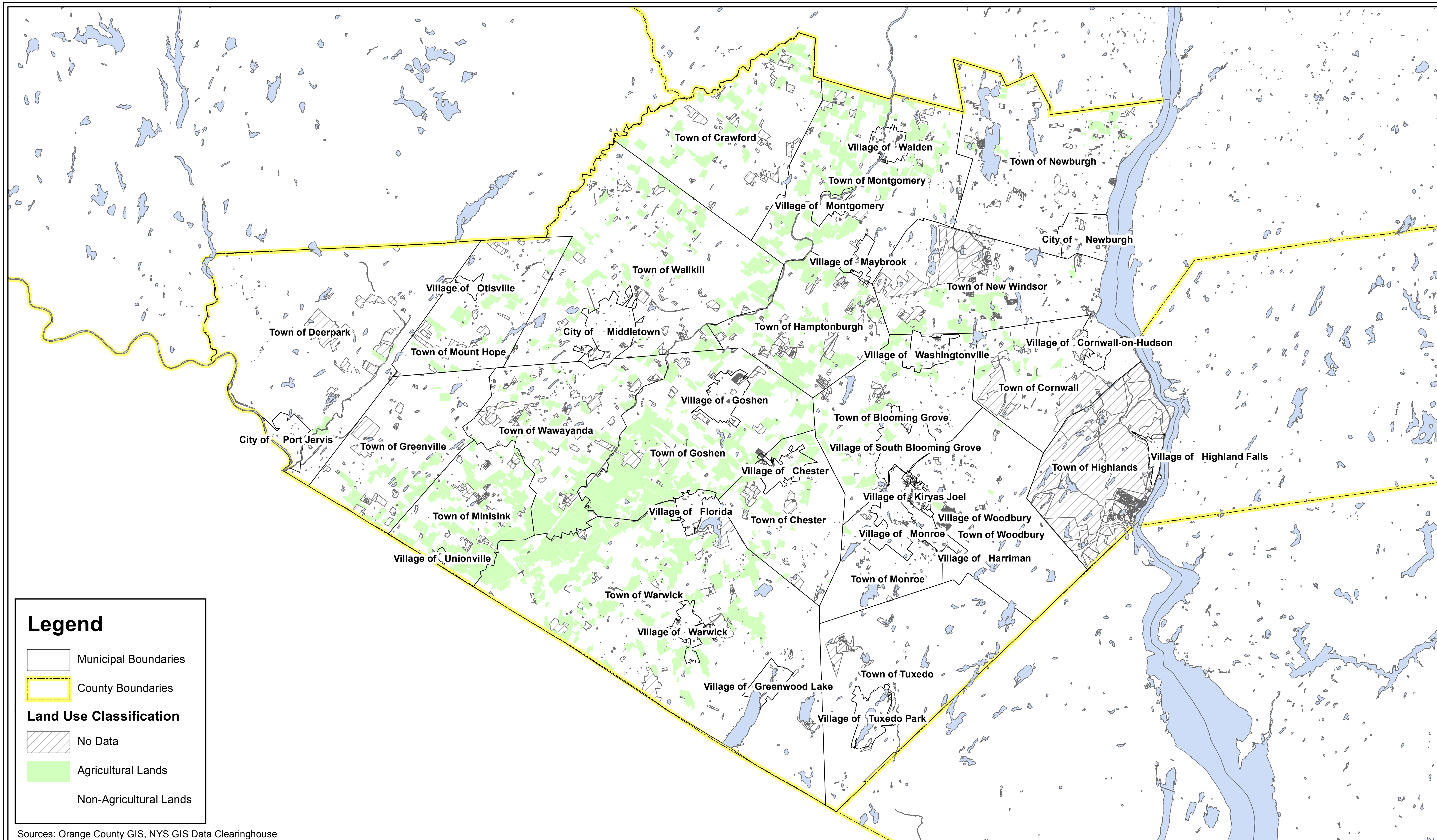
To illustrate long term trends, Figure 5.5c on the following page shows the Palmer Drought Severity Index (PDSI) Summary Map for the United States from 1895 to 1995. PDSI drought classifications are based on observed drought conditions and will range from -0.5 (incipient dry spell) to -4.0 (extreme drought). According to the PDSI map, Orange County is in a zone that experienced severe drought conditions between five (5) and ten (10) percent of the 100-year period during 1895 to 1995, meaning that severe drought conditions are a relatively low risk for Orange County. However, short term droughts of less severity are more common and may occur several times in a decade.

Figure 5.5c: Palmer Drought Severity Index (PDSI) Summary Map for the United States



While the extent of drought impacts for Orange County may include all of the issues listed above, some of the most immediately quantifiable effects of drought in the County are likely to be experienced by farmers, who can suffer heavy financial losses due to crop damage or loss. Figure 5.5d shows the extent, location and distribution of agricultural land across Orange County, and Table 5.5a presents a breakdown of agricultural land by municipality, based on Orange County GIS land use data. It is evident from the figure that a significant proportion of municipality areas in the southwest of the County are devoted to agriculture in some form.

According to the USDA Agricultural Census of 2012, there are 658 farms in Orange County, with a market production value of more than $100.7 million. About 72% of this value is accounted by crop sales, with livestock and poultry products accounting for about 28%. The County's 658 farms occupy approximately 80,000 acres (16.5% of the County area), of which 46,000 are classified cropland by the USDA Agricultural Census.



Sources: Orange County GIS, NYS GIS Data Clearinghouse

Barton & Loguidice, D.P.C.
Engineers • Environmental Scientists • Planners • Landscape Architects

1 inch = 20,000 feet

Orange County
Agricultural Lands
Orange County December 2015 New York

Figure -
Project No. 1724.002

Table 5.5a: Distribution of Agricultural Land in Orange County *(Orange County GIS, 2016)*			
Municipality	Total Area (Acres)	Total Agricultural Land (Acres)	Total Agricultural Land %
Blooming Grove, Town of	18,437	2,564	13.9%
Chester, Town of	16,606	3,069	18.5%
Chester, Village of	1,253	210	16.8%
Cornwall, Town of	14,385	765	5.3%
Crawford, Town of	26,417	3,733	14.1%
Deerpark, Town of	42,586	460	1.1%
Goshen, Town of	36,686	13,698	37.3%
Greenville, Town of	19,016	2,623	13.8%
Hamptonburgh, Town of	17,283	4,811	27.8%
Maybrook, Village of	1,191	370	31.1%
Minisink, Town of	16,493	7,070	42.9%
Monroe, Town of	10,779	69	0.6%
Montgomery, Town of	34,804	10,710	30.8%
Mount Hope, Town of	16,999	2,594	15.3%
New Windsor, Town of	26,948	2,356	8.7%
Newburgh, Town of	30,805	1,028	3.3%
South Blooming Grove, Village of	3,086	148	4.8%
Wallkill, Town of	41,758	5,850	14.0%
Warwick, Town of	62,823	13,863	22.1%
Warwick, Village of	1,373	3	0.2%
Washingtonville, Village of	2,293	106	4.6%
Wawayanda, Town of	23,250	5,555	23.9%
Woodbury, Town and Village of	23,511	164	0.7%
Orange, County of	519,482	81,819	15.8%

Figure 5.5d, Table 5.5a, and Table 2.5b (Section 2.5) indicate that the impact of drought would be experienced most significantly for crop farmers in the southwestern portion of the County, particularly in the Black Dirt Region, where several municipalities have 25-45% of their land areas given over to agriculture. For dairy farmers, the impact would also be significant in the northern portions of the County where the Towns of Crawford and Montgomery have over 10% of their land given over to pastureland.

For residences, businesses, and institutions in Orange County, water is mostly sourced from groundwater aquifers: according to the Orange County Water Master Plan (August 2010), 56% of Orange County water supplies serving residences and businesses come from groundwater, with 33% from surface water and the remaining 11% from the New York City aqueduct system. The majority of the County water supply is provided by 161 community water supply systems drawing from reservoirs (29) and aquifers (132). Three municipalities in the County draw their supplies from the Catskill Aqueduct (with another able to draw water from this source under emergency conditions), one municipality draws water from the Delaware Aqueduct, and 80% of the County land area is serviced by individually-owned wells. The County is served by 63 water districts, some of which cross municipal boundaries.

5.5.3 Historical Occurrences

Historical occurrences of drought in Orange County have been identified using the NOAA NCDC database. The NCDC database records the following significant drought events which specifically list Orange County as an affected area since August 1993, the point at which NCDC drought records begin for Orange County:

> **May 1964 – September 1966:** Orange County was part of the area that suffered what the New York Times called 20 years later the most prolonged drought in New York State History. Just prior to the start of the drought in March 1964 local reservoirs were at around 69% of capacity but had dropped to 38% of capacity within a year, and reached 25% before the end of the drought, while under normal operating conditions they are filled to 80-90% of capacity. Many crop yields were significantly reduced, with wheat crops being particularly affected. According to the Northeast Regional Climate Center at Cornell University, the PDSI (see above) reached -6.66 in November 1964. The New York State Emergency Management Office website reports that Orange County was included in the area covered by Disaster Declaration Dr-0204, which was declared in August 1965 due to the ongoing drought. Under this declaration, Orange County was eligible for both Public and Individual Assistance.
>
> **August – December 1993:** A prolonged period of drought during the summer of 1993 decimated much of the agriculture in southeast New York. A drought alert advisory was issued on August 5, 1993 by the New York State Drought management Task Force for Delaware, Dutchess, Sullivan and Ulster Counties. Other counties hit hard by drought included Albany, Rensselaer, Columbia and Greene. Estimates of feed grain losses in affected counties were well over 40 percent and in some cases nearly 100 percent.
>
> Especially hard hit were hay and corn crops as well as other fruits and vegetables. In November 1993 the drought alert advisory was upgraded to a drought warning by the New York State Drought Management Task Force for Delaware, Dutchess, Greene, Otsego, Schoharie, Sullivan, and Ulster Counties. Further, the Delaware River Basin Commission continued the drought warning for the basin which includes small sections of Broome, Chenango, Greene, Schoharie and Ulster Counties and much of Delaware and Sullivan Counties.
>
> **November 2001 – October 2002:** A second straight month of extremely dry weather worsened drought conditions across the region. The combined storage in the New York City water supply reservoir system at the end of the month was 45.3 percent of capacity. Normal for this period is 71.2 percent of capacity. Stream flow and groundwater conditions at USGS sites monitored around the region were consistently in the deficit range. As a consequence of declining water levels, on November 5th, the New York

State Department of Environmental Conservation issued a Drought Watch for Orange, Putnam, Rockland, and Westchester Counties. As a consequence of continually declining water levels, on December 3rd, 2001, the New York State Department of Environmental Conservation (NYSDEC) upgraded the drought watch to a drought warning for Orange, Putnam, Rockland, and Westchester Counties. The drought warning remained in place for New York City, Rockland, and Westchester Counties through October 31st, 2002. According to the *New York Times*, Orange County officials said that this was the worst drought there in almost 30 years. According to the Northeast Regional Climate Center at Cornell University, the PDSI reached -3.6 in February 2002.

June 2010 – August 2010: Several water restrictions were issued across Orange County from June 16, 2010 through July 9, 2010 during a period of drought conditions.

June 2012 – October 2012, Winter 2013: A pair of USDA-declared droughts occurred in Orange County in recent years, which is documented in the Town of Blooming Grove Hazard Mitigation Plan (2013). The impact of these droughts was felt, in particular, by the agricultural sector. These droughts occurred from June 1 to October 24, 2012 and over the winter of 2013.

5.5.4 Future Potential Impacts

Based on NCDC records, Orange County has directly experienced two (2) significant droughts during the 15 year period from 2000 through 2015 for which the NCDC keeps detailed records, or an average of 0.133 drought events per year. This is consistent with Figures 5.5a and 5.5b illustrate that Orange County is less prone to drought conditions than other parts of the country. However, Orange County may experience an increase in the frequency of drought conditions in the foreseeable future if some of the current predictions regarding climate change prove to be accurate.

5.6 Landslides

5.6.1 Description

Landslides are defined as the downward and outward movement of slope-forming materials reacting to the force of gravity. Slide materials may be composed of natural rock, soil, artificial fill, or combinations of these materials. Landslide is a general term that can include rock falls, rockslides, creep, block glides, debris slides, earth-flow, and slump. During a landslide event, masses of rock, earth, or debris move down a slope. These events vary in speed of occurrence and how large of an area is impacted.

Landslides are activated by storms, earthquakes, volcanic eruptions, fires, alternate freezing or thawing, and steepening of slopes by erosion or human modification. Landslide problems can be caused by land mismanagement, especially in mountainous and coastal regions. In areas with high landslide potential, land-use zoning, professional inspections, and proper design can minimize many landslide, mudflow, and debris flow problems.

5.6.2 Location and Extent

Areas that are commonly considered to be safe from landslides include areas that have not experienced landslides in the past, areas of minimal slope, and areas set back from the tops of slopes. Conversely, areas that are commonly considered to be more prone to landslides tend to be areas where a landslide has occurred in the past, bases of steep slopes or drainage channels, and developed hillsides where leach field septic systems are used.

The potential for landslides exists across the whole of New York State, although according to USGS and NYGS the vast majority of the state (80%) has a low susceptibility to landslide hazard. Landslide hazard mapping has been completed for New York State. In general the highest potential for landslides can be found along major river and lake valleys that were formerly occupied by glacial lakes resulting in glacial lake deposits (glacial lake clays) and usually associated with steeper slopes, such as the Hudson River valley. USGS landslide susceptibility mapping uses three basic classifications to communicate the risk, in conjunction with three further classifications to communicate the combinations of susceptibility and incidence:

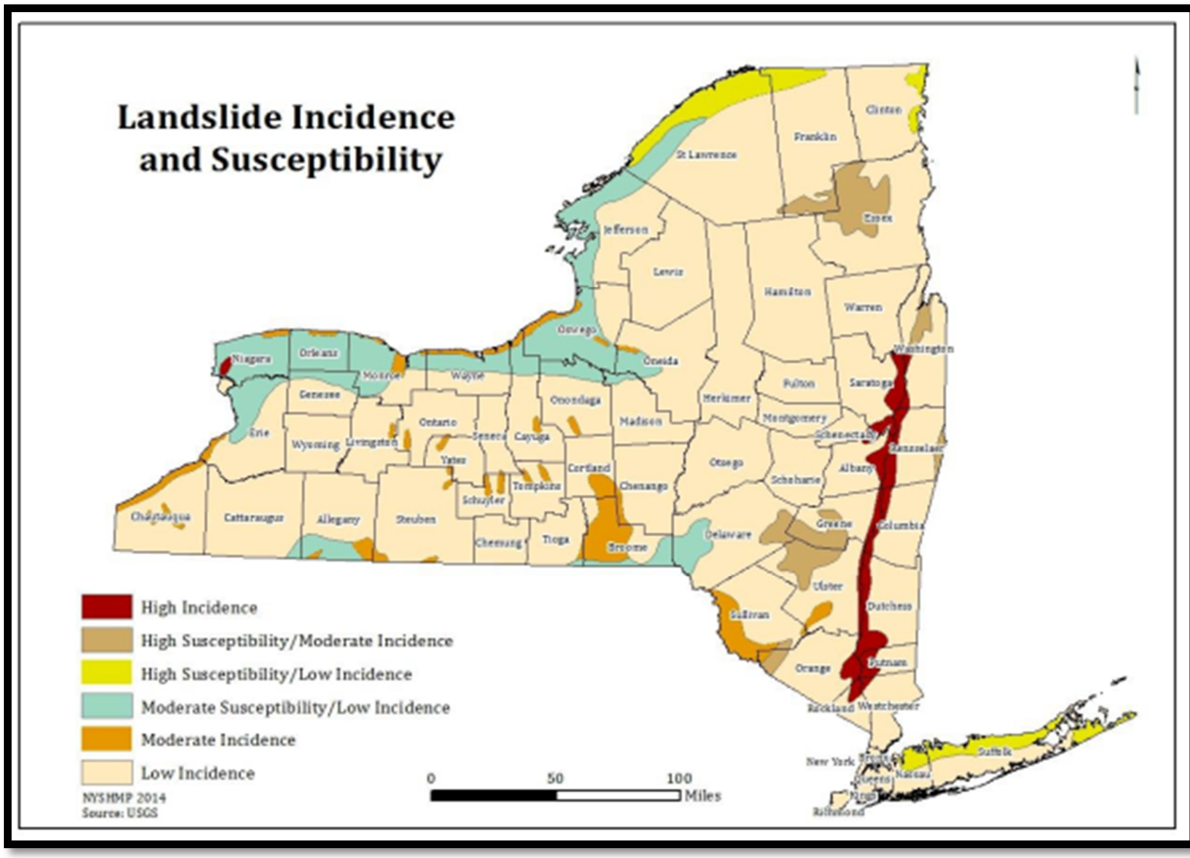
- High incidence (Greater than 15 % of the area involved)
- Moderate incidence (1.5% - 15% of the area involved)
- Low incidence (Less than 1.5% of the area involved)
- High susceptibility/moderate incidence
- High susceptibility/low incidence
- Moderate susceptibility/low incidence

The USGS provides the following supporting narrative for the landslide hazard classifications:

> *"Susceptibility not indicated where same or lower than incidence. Susceptibility to land sliding was defined as the probably degree of response of [the areal] rocks and soils to natural or artificial cutting or loading of slopes, or to anomalously high precipitation. High, moderate, and low susceptibility are delimited by the same percentages used in classifying the incidence of land sliding. Some generalization was necessary at this scale, and several small areas of high incidence and susceptibility were slightly exaggerated."*

USGS landslide susceptibility mapping for NYS is presented in Figure 5.6a. The map shows that there are two main areas in the County which may be considered to have a significant landslide risk. The westernmost corner of the county has been identified as being of moderate incidence and moderate incidence/high susceptibility to landslides, while an area in the east of the county adjacent to the Hudson River has been identified as being of high landslide incidence. With the exception of a small area of high incidence in the north east of the county adjacent to the Hudson River, the remainder of the County is classified as "Low Incidence".

Figure 5.6a: Landslide Incidence and Susceptibility in NYS
(USGS, NYSDHSES 2014)



The severity of a landslide depends in large part on the degree of development in the area in which it occurs and the geographic area of slide itself. Generally speaking, landslides often result in devastating consequences, but only in very localized areas. A landslide occurring in an undeveloped area would be less severe because lives and property would not be affected; the only impacts would be to land, vegetation, and possibly some wildlife. On the contrary, a landslide occurring in a developed area could have devastating effects, ranging from structure and infrastructure damage to injury and/or loss of life. Structures or infrastructure built on susceptible land would likely collapse as their footings slide downhill, while those below the land failure would likely be crushed. Landslides in the area of roadways could have the potential to fall and damage or destroy vehicles, and force other drivers to have accidents.

Figures 5.6b and 5.6c identify the locations of individual landslide events that have been recorded by the New York State Geological survey by County from 1960 – 2012 and their estimated damage totals. Orange County has had one such event amounting to less than $25,000 in damage.

Figure 5.6b: NYS Landslide Events by County 1960-2012
(NYSDHSES, 2014)

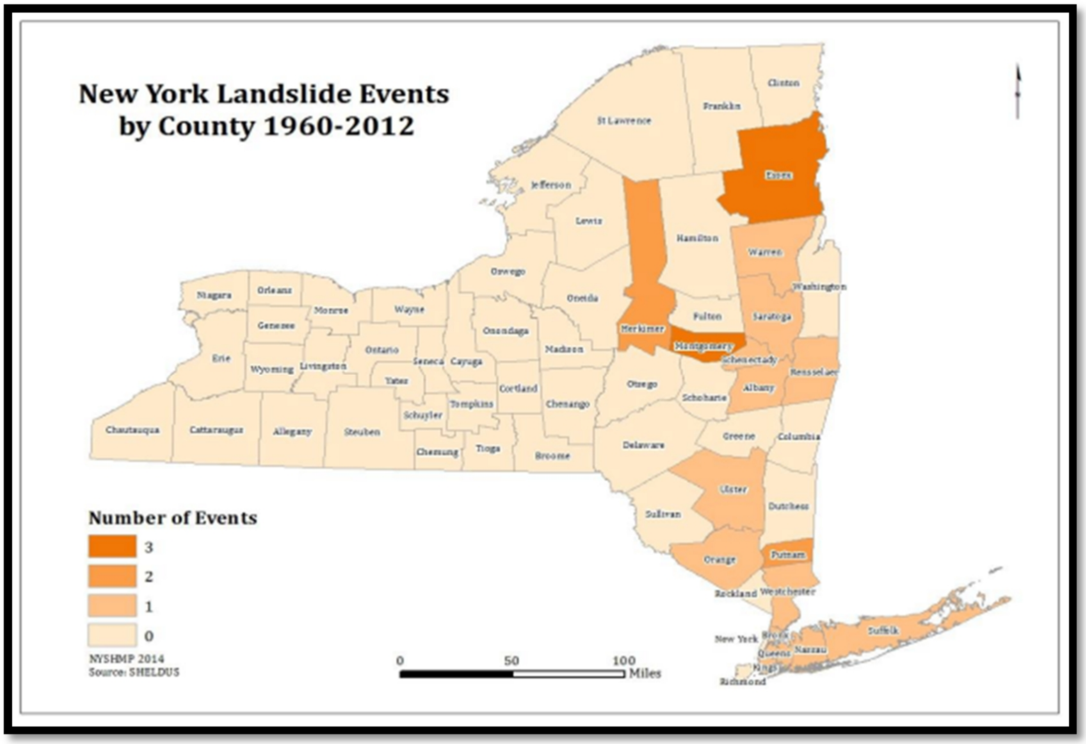
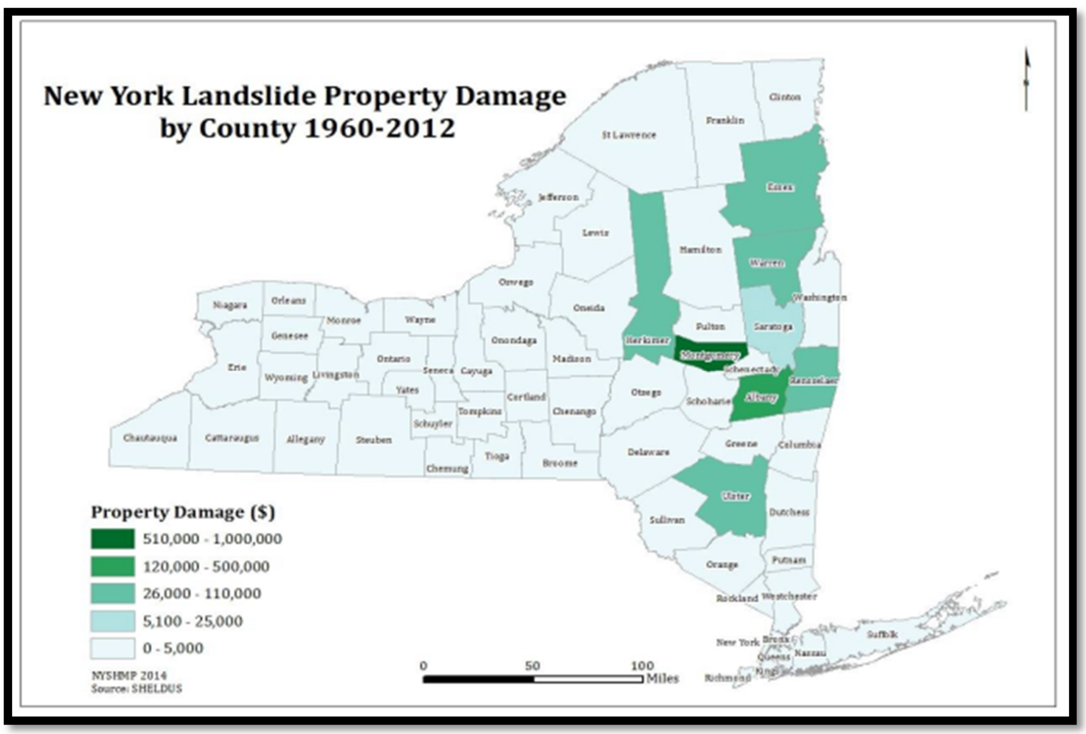


Figure 5.6c: NYS Landslide Property Damage by County 1960-2012
(NYSDHSES, 2014)



5.6.3 Historical Occurrences

The New York State Geological Survey records a total of 329 significant landslide events that have occurred in New York State between 1837 and 2007. Of these, the New York State Plan records that three occurred in Orange County, but gives details for only one event, which caused three fatalities in 1934. Mapping and other information supplied by the New York State Geological Survey included limited details for an additional 11 events listed as landslides in Orange County:

1916: Soil slumps/landslides were recorded along river banks in the Town of New Windsor in the area west of Stewart Airport.

April 8, 1934: A debris flow down Storm King Mountain onto New York State Route 218 north of the US Military Academy in the Town of Highlands engulfed three automobiles, causing three fatalities. The cause was attributed to loosening of earth and boulders by winter frosts and rain. Numerous other minor slides were reported in the vicinity in the preceding winter.

1983: A rock slid/toppled onto Route 97 Hawks Nest Road east of Mongaup in the Town of Deerpark. The road was closed for several months for repairs and slope stabilization.

Date Not Recorded:*

- Exfoliation and frost wedging caused a 150 foot high granite rock slide on NY Route 218 south of the Town of Cornwall. The cost of stabilizing the remaining slope was estimated at $200,000.
- A rock slide occurred near the West Point Interchange in the Village of Highland Falls.
- A rock slide occurred onto Route 84 east of City of Port Jervis in the Town of Greenville.
- Numerous rock falls onto the pavement of I-87 between exits 15 and 16, mile markers 34.0 – 34.7, 35.0 – 35.7 and 36.2 – 36.6 in the Town of Tuxedo. One rock slide crossed two lanes of the highway.
- Rock slides across two lanes of I-87 between mileposts 41.4 and 41.9 in the Town of Tuxedo.
- Soil/debris toppled onto County Road 32 near Orrs Mill in the Town of Cornwall. A portion of this road was rerouted in 1966 following an evaluation by the County Engineering Department of slope recession since the 1950s.
- Soil erosion continued due to steep side slopes south of the Quaker Road/County Route 107 intersection in the Town of Cornwall. Corrective action by the County failed to stabilize the slopes.

- Severe soil erosion occurred due to stream undercutting in the Wallkill River channel near County Road 37 in the Town of Wawayanda. Corrective action was taken by the Town and the U.S. Army Corps of Engineers.
- Severe undercutting of County Road 7 by the Neversink River in the Town of Deerpark.
- Section of pavement lost on US Route 6 east of the NY State Thruway near the Village of Harriman in the Town of Woodbury.

(*Note: No dates were recorded on the NYSGS landslide data sheets for these incidents.)

In addition to reports of actual events, State Route 18 between the Village of Cornwall-on-Hudson and West Point is considered by OCDES personnel to be vulnerable to rockslides during heavy rain, and this section of highway is occasionally closed to traffic during heavy rain events.

5.6.4 Historical Cost and Damage Estimates

Though landslide events documented within Orange County are not significant events, this hazard has been determined to have a medium probability of occurrence compared with the rest of New York State. Landslide events are most common on vacant properties. Localized areas are most often damaged by landslide events, which do not result in extensive damage to existing infrastructure. The need to collect more detailed data on annual occurrences and damages that result from landslide events has been identified.

5.6.5 Future Potential Impacts

While it is certainly possible for landslides to occur within Orange County, the current readily available data regarding historic occurrences does not permit any estimation of the frequency of future occurrences. While the overall probability of future occurrence is assumed to be low for most of the County, there are significant portions (including highly developed areas) and locally important highways in the Towns of Woodbury, Highlands, Cornwall, and New Windsor, and the Villages of Cornwall-on-Hudson and Highland Falls, as well as several high value individual properties in the Town and City of Newburgh located within high landslide risk areas.

Based on overall landslide susceptibility and the number of historic events, Orange County is ranked in the New York State Plan as the 14th most threatened by landslides out of the 62 counties in the state (2014 NYS HMP).

The vulnerability of local critical facilities as it relates to landslides is depicted in each jurisdiction annex in their respective Hazard Vulnerabilities and Ranking sections.

5.7 Earthquakes

5.7.1 Description

An earthquake is a sudden motion or trembling that is caused by a release of strain accumulated within or along the edge of Earth's tectonic plates. The effects of an earthquake can be felt at distances beyond its actual occurrence, though the effects are less severe as the distance increases. Earthquakes often occur without warning and can quickly cause extensive damage and extensive casualties. Common effects of earthquakes include ground motion and shaking, surface fault ruptures, and ground failure (NYSDHSES, 2016).

The U.S. Geological Society describes and defines a list of hazards resulting from earthquakes. These are as follows:

- Surface Faulting: Displacement that reaches the earth's surface during slip along a fault. Commonly occurs with shallow earthquakes, those with an epicenter less than 20 kilometers (12.43 miles).
- Ground Motion (Shaking): The movement of the earth's surface from earthquakes or explosions. Ground motion or shaking is produced by waves that are generated by sudden slip on a fault or sudden pressure at the explosive source and travel through the earth and along its surface.
- Landslide: A movement of surface material down a slope.
- Liquefaction: A process by which water-saturated sediment temporarily loses strength and acts as a fluid, like when you wiggle your toes in the wet sand near the water at the beach. This effect can be caused by earthquake shaking.
- Tectonic Deformation: A change in the original shape of a material due to stress and strain.
- Tsunami: A sea wave of local or distant origin that results from large-scale seafloor displacements associated with large earthquakes, major submarine slides, or exploding volcanic islands.
- Seiche: The sloshing of a closed body of water from earthquake shaking (USGS, 2012).

As noted in the 2014 SHMP, earthquake intensity and classification are commonly measured using two different scales, the Maximum Modified Mercalli Intensity Scale (MMI) and the Richter Magnitude Scale (often shortened to Richter Scale). The MMI Scale estimates the shaking strength of an earthquake at a specific location, such as the epicenter, or over a specific area by considering its effects on people, objects, and buildings. The strength reduces as the distance from the epicenter increases. The Richter scale uses whole numbers and decimal fractions to quantify the energy released during an earthquake. This determination is based on logarithms from the amplitude of waves recorded by seismographs. Table 5.7a, found below, provides ranking and classification definitions for the two scales.

Table 5.7a: Modified Mercalli Scale vs. Richter Scale
(NYSDHSES, 2016)

Modified Mercalli Scale vs. Richter Scale

Category	Effects	Richter Scale (approximate)
I. Instrumental	Not felt	1-2
II. Just perceptible	Felt by only a few people, especially on upper floors of tall buildings	3
III. Slight	Felt by people lying down, seated on a hard surface, or in the upper stories of tall buildings	3.5
IV. Perceptible	Felt indoors by many, by few outside; dishes and windows rattle	4
V. Rather strong	Generally felt by everyone; sleeping people may be awakened	4.5
VI. Strong	Trees sway, chandeliers swing, bells ring, some damage from falling objects	5
VII. Very strong	General alarm; walls and plaster crack	5.5
VIII. Destructive	Felt in moving vehicles; chimneys collapse; poorly constructed buildings seriously damaged	6
IX. Ruinous	Some houses collapse; pipes break	6.5
X. Disastrous	Obvious ground cracks; railroad tracks bent; some landslides on steep hillsides	7
XI. Very disastrous	Few buildings survive; bridges damaged or destroyed; all services interrupted (electrical, water, sewage, railroad); severe landslides	7.5
XII. Catastrophic	Total destruction; objects thrown into the air; river courses and topography altered	8

Source: http://www.sms-tsunami-warning.com/pages/mercalli-scale

5.7.2 Location and Extent

Earthquakes are possible within any of Orange County's communities. Figures 5.7a and 5.7b show the earthquake hazard maps for the conterminous United States and also New York State, which are prepared by the USGS Earthquake Hazards Program. It shows that the earthquake hazard in New York State is low relative to other parts of the country (for example the west coast of the USA), but the possibility for noticeable earthquakes does exist in the State.

Figure 5.7a: US 2014 Earthquake Hazard Map (PGA, 2% in 50 years)
(USGS, 2016)

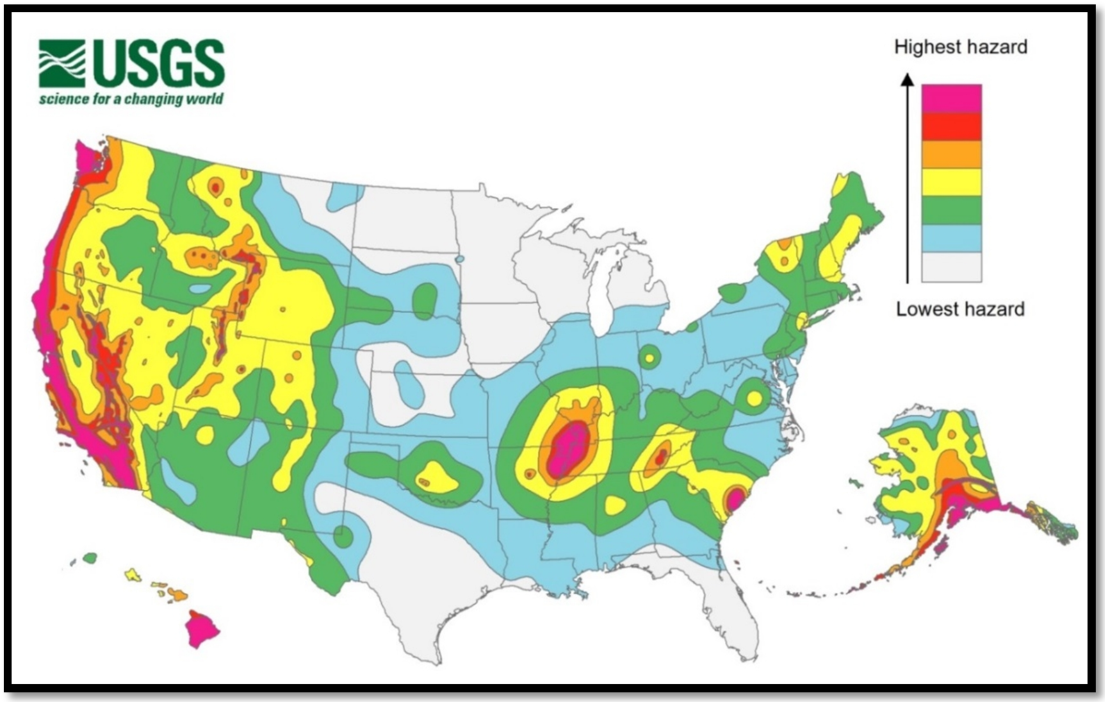
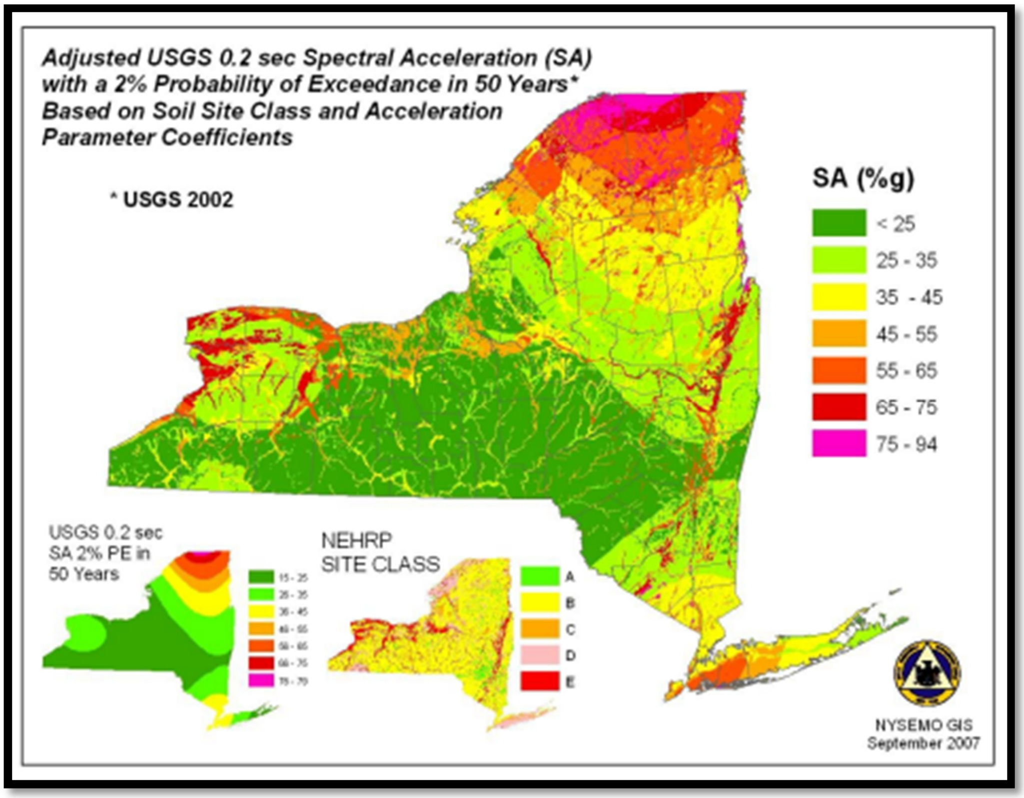
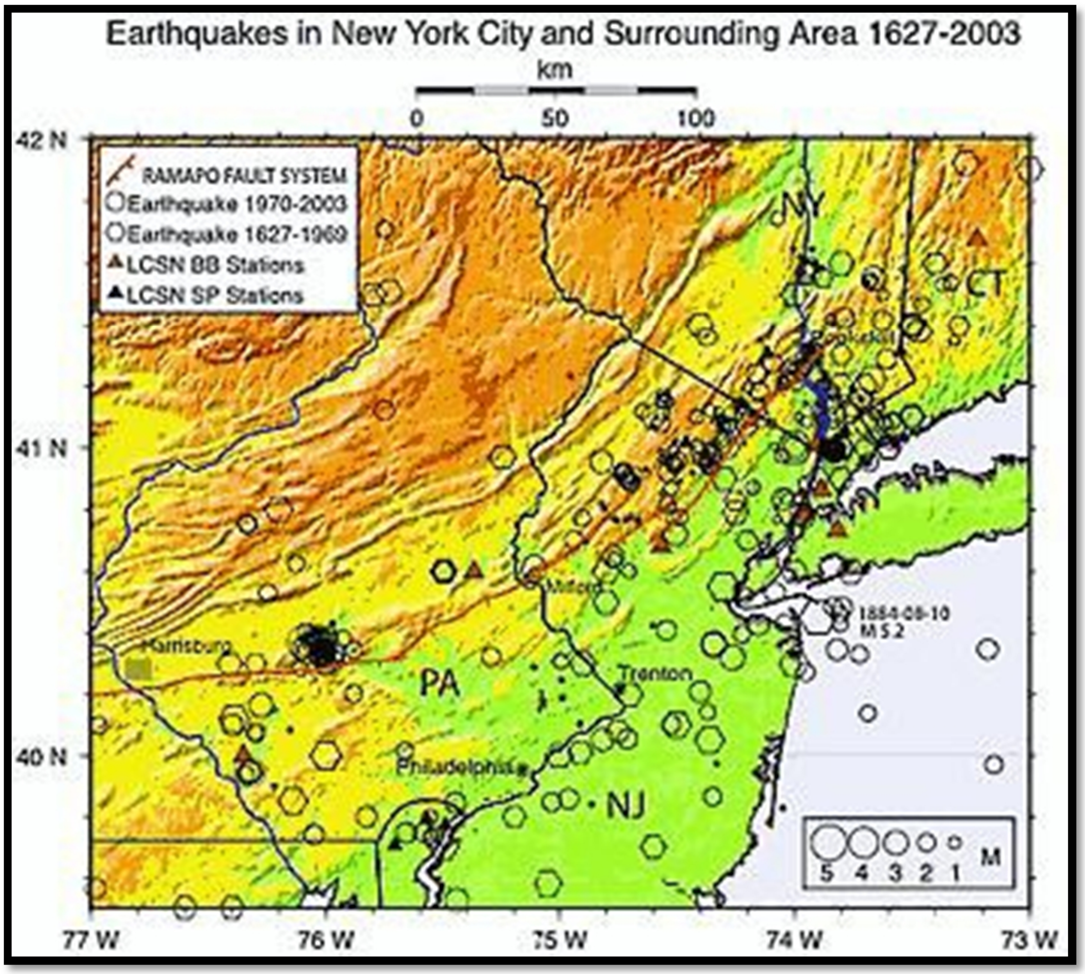


Figure 5.7b: NYS 2002 Earthquake Hazard Map (SA 2% in 50 years)
(USGS, NYSDHSES, 2002)



Of particular interest to this hazard mitigation plan is the Ramapo Fault, part of a system of northeast striking, southeast-dipping faults, which have been mapped from southeastern New York State to eastern Pennsylvania and beyond. These faults were particularly active at different times during the evolution of the Appalachians, especially in the Mesozoic Era when they served as border faults to the Newark Basin and other extensional basins formed by the opening of the Atlantic Ocean approximately 200 million years ago. The Ramapo Fault crosses the southern and eastern edge of Orange County, running approximately parallel to the boundary with Rockland County. The epicenters of earthquakes recorded between 1627 and 2003 have generally tended to be clustered around the line of this fault, as illustrated in Figure 5.7c (in which the fault is shown as a red line).

Figure 5.7c: The Ramapo Fault

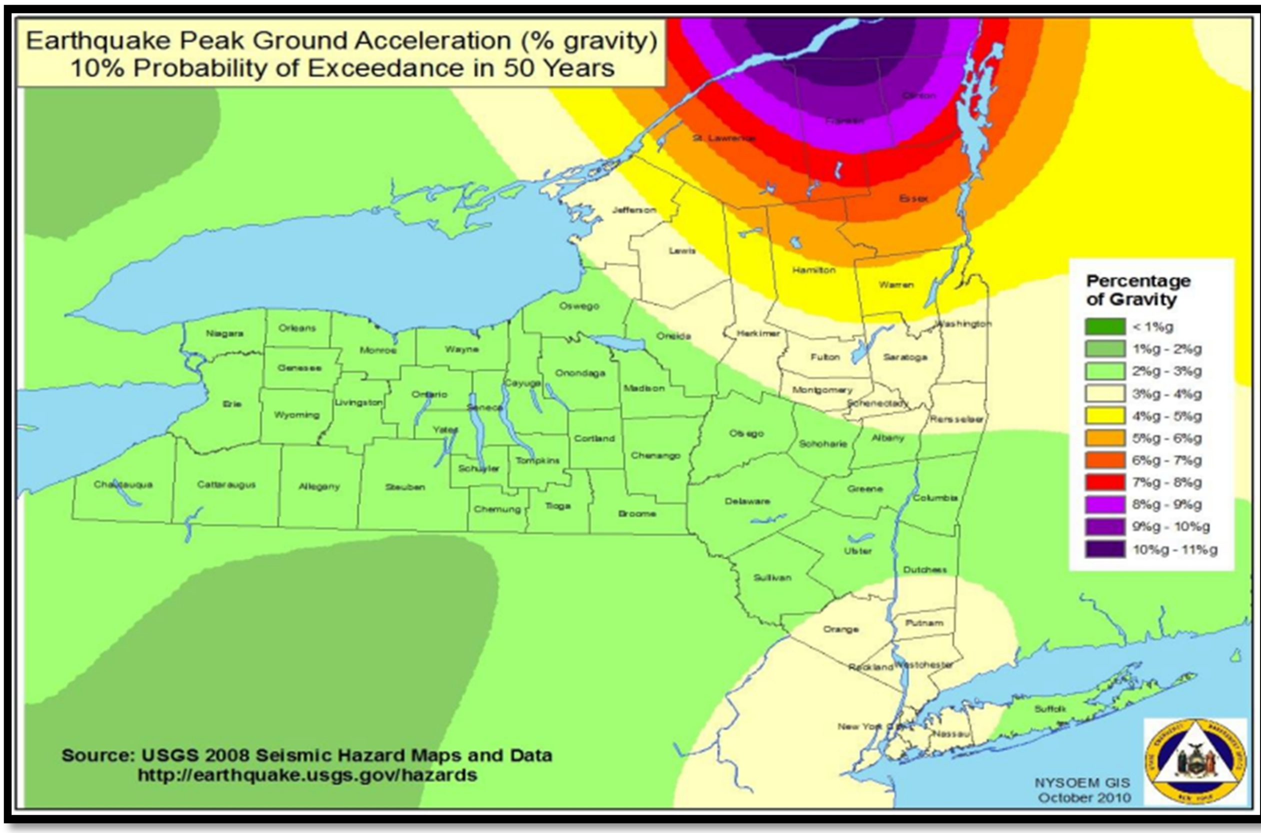


The severity of an earthquake at a given location depends on the amount of energy released at the epicenter, and the location's distance from the epicenter. The terms "magnitude" and "intensity" are two terms used to describe the severity of an earthquake. An earthquake's "magnitude" is a measurement of the total amount of energy released while its "intensity" is a measure of the effects of an earthquake at a particular place.

Another way to express an earthquake's severity is to compare its acceleration to the normal acceleration due to gravity. Earthquake hazard maps – sometimes referred to as "PGA maps" – are used as a tool to project the likelihood of a various intensity quake being exceed at a certain location over a given period of time. Peak Ground Acceleration (PGA) measures the rate of change in motion of the earth's surface and expresses it as a percent of the established rate of acceleration due to gravity (9.8 m/sec2).

Figure 5.7d shows that, for Orange County, PGA values of between 3 and 4%-g have a 10 percent chance of being exceeded over 50 years. All of Orange County has some degree of exposure to the earthquake hazard.

Figure 5.7d: PGA % Seismic Hazard Map
(USGS 2008 Seismic Hazard Map, NYSDHSES)



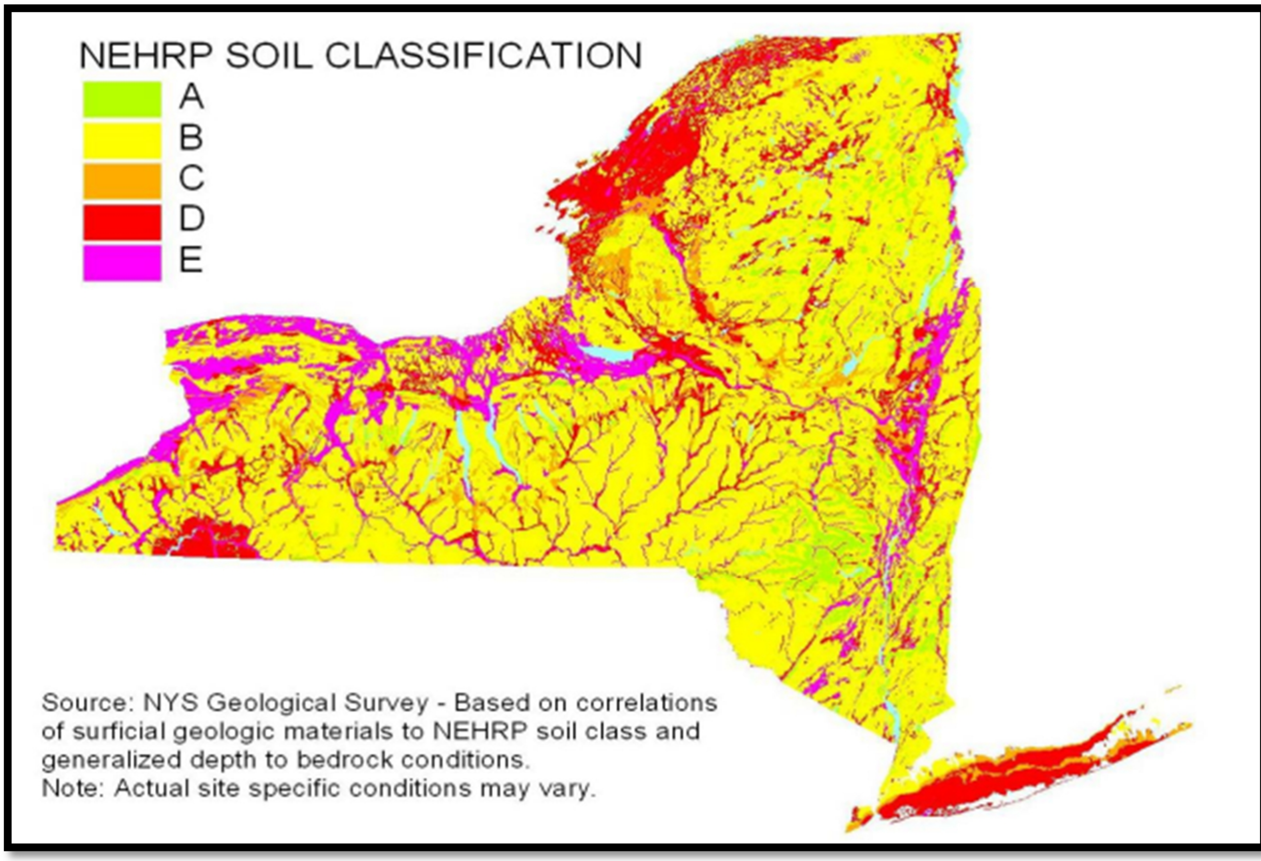
An approximate relationship between PGA, magnitude, and intensity is shown in Table 5.7b below. Using Table 5.7b, one can approximate that, for an earthquake of expected severity for the majority of Orange County (PGA values of 3 to 4%-g), perceived shaking would be light to moderate (depending upon the distance from the epicenter) and potential damage could range from none to very light (also depending upon the distance from the epicenter).

Table 5.7b: Modified Mercalli Intensity (MMI) and PGA Equivalents *(USGS 2013, NYSDHSES, 2014)*			
MMI	Acceleration (%g)(PGA)	Perceived Shaking	Potential Damage
I	<.17	Not Felt	None
II	.17 – 1.4	Weak	None
III	.17 – 1.4	Weak	None
IV	1.4 – 3.9	Light	None
V	3.9 – 9.2	Moderate	Very Light
VI	9.2 – 18	Strong	Light
VII	18 – 34	Very Strong	Moderate
VIII	34 – 65	Severe	Moderate to Heavy
IX	65 – 124	Violent	Heavy
X	>124	Extreme	Very Heavy
XI	>124	Extreme	Very Heavy
XII	>124	Extreme	Very Heavy

An earthquake with a 10 percent chance of exceedance over 50 years in Orange County would have a PGA of 3 to 4%-g and an intensity ranging from only IV to V, which would result in light to moderate perceived shaking, and damages ranging from none to very light. For comparison purposes, an earthquake of Intensity IV on the Modified Mercalli Scale would most likely cause vibrations similar to heavy trucks driving over roads, or the sensation of a jolt. Hanging objects would swing; standing cars would rock; windows, dishes and doors would rattle; and, in the upper ranges of Intensity IV, wooden walls and frames would creak. An earthquake of Intensity V on the Modified Mercalli Scale would be felt outdoors, awaken sleepers, disturb or spill liquids, displace small unstable objects, swing doors, and cause shutters and pictures to move.

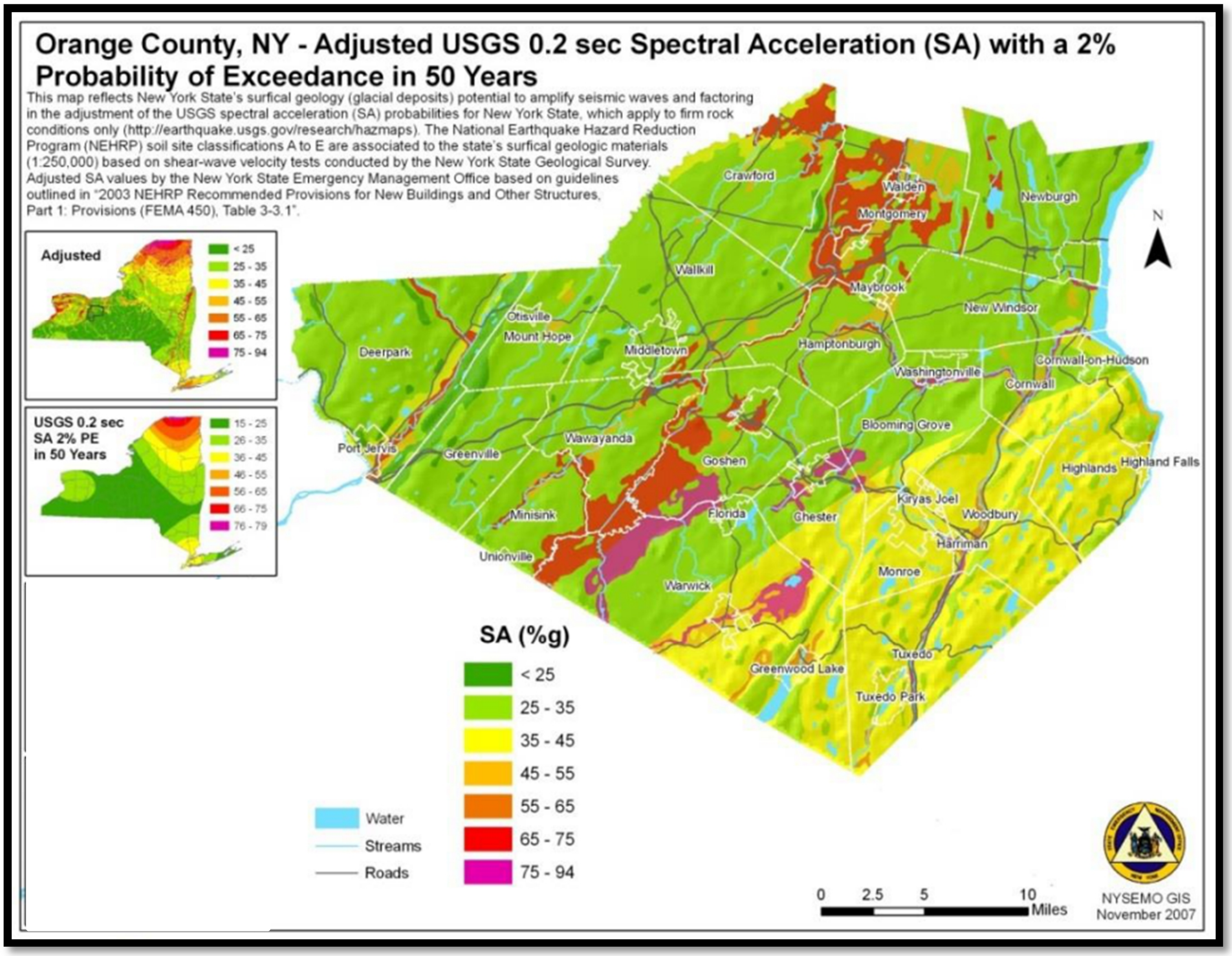
As noted in the 2014 New York State Hazard Mitigation Plan, soil type can have an impact on the severity of an earthquake at a given location. For example, soft soils (i.e., fill, sand) are more likely to amplify ground motion during an earthquake. Liquefaction is also more likely to occur in areas of soft soils. In contrast, harder soils (i.e., granite) tend to reduce ground motion during an earthquake. Figure 5.7e was developed by the National Earthquake Hazard Reduction Program (NEHRP) and NYS Geological Survey. It shows soil types in five basic categories with varying degrees in likelihood of amplifying the effects of an earthquake, with Category A being far less likely to amplify the seismic motion than Category E.

Figure 5.7e: NEHRP Soil Classification in NYS
(NEHRP, NYS Geological Survey, NYSDHSES, 2014)



The soil types and surficial materials have been combined with the baselines seismic hazards by NYSDHSES/NYSGS in Figure 5.7f (2014 New York State Hazard Mitigation Plan) to provide an adjusted, more refined picture of the earthquake hazard in terms of earthquake spectral acceleration, which is a better indicator of damage to buildings. While PGA (Peak Ground Acceleration) is what is experienced by a particle on the ground, SA (Spectral Acceleration) is an approximation of what is experienced by a building, as modeled by a particle on a massless vertical rod having the same natural period of vibration as the building, according to the USGS definition.

Figure 5.7f: Orange County, NY Adjusted Spectral Acceleration with a 2% Probability of Exceedance in 50 Years *(NYSDHSES, 2007)*



5.7.3 Historical Occurrences

As noted in the 2014 New York State Mitigation Plan, although the probability of damaging earthquakes in New York State is low, earthquakes do occur on a regular basis in New York.

Figure 5.7g on the following page shows historical earthquake events and the associated magnitude for the New York State. During the period of 1973 to 2012, there were eight events of Magnitude 4 or higher.

Figure 5.7g: New York State Historical Earthquakes 1972 – 2012
(USGS Global Earthquake Search, NYSDHSES 2014)

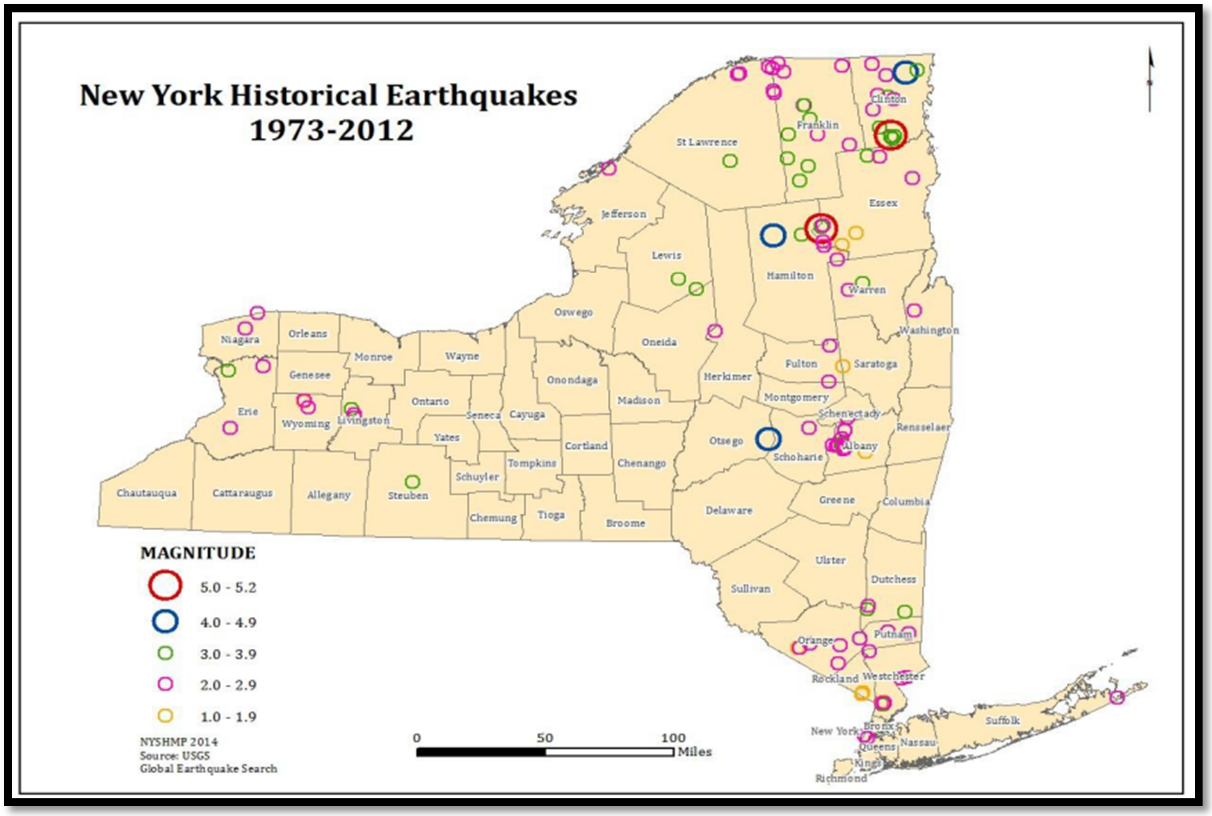


Table 5.7c presents details for earthquakes recorded in New York State since 1737 that were recorded in the 2006 NYS statistical yearbook and indicated in the 2014 NYS HMP. The list records two seismic events in neighboring Rockland County: an earthquake of Intensity V in the vicinity of Rockland Lake in the Town of Clarkstown in September 1948, and an earthquake of Magnitude 3.6 which was recorded in the Bear Mountain area of Rockland County in September 1951. While no records of damages are available for either event, it is possible that some impacts were felt in Orange County.

As recently as 2010, a reported 5.5 magnitude earthquake in Quebec, Canada prompted numerous reports of tremors in the Hudson Valley, including one at 18 Seward Avenue, Middletown, NY. The Orange County Emergency Operations Center opened in response to the possibility of aftershocks. No injuries or damages were reported in Orange County.

Table 5.7c: Earthquake History Throughout New York State (1737 – 2005) *(Source: NYSDHSES/NYS Statistical Yearbook 2006)*			
Date	Location	Size	Damage Description
December 18, 1737	New York City	5.2	Bells rang, several chimneys fell
January 16, 1840	Herkimer	3.7	No reference and/or No damage reported
September 2, 1847	Offshore NYC	3.5	No reference and/or No damage reported
September 9, 1848	Rockland Lake	V	Felt by many
March 12, 1853	Lowville	VI	Machinery knocked over
February 7, 1855	Saugerties	VI	Cryoseism
October 23, 1857	Buffalo (Lockport)	4.0	Bells rang, crocks fell from shelves
December 18, 1867	Canton	4.7	Sleepers awakened
December 11, 1874	Tarrytown	3.4	No reference and/or No damage reported
November 4, 1877	Lyon Mountain	VII	Chimneys down, walls cracked, window damaged, crocks overturned
August 10, 1884	New York Bight (NYC)	5.2	Chimneys and bricks fell, walls cracked
May 28, 1897	Dannemora	4.5	No reference and/or No damage reported
February 3, 1916	Schenectady	3.8	Broke windows, people thrown out of bed
March 18, 1928	Saranac Lake	4.0	No reference and/or No damage reported
August 12, 1929	Attica	5.2	250 chimneys fell, brick buildings damaged, Attica prison walls, wells went dry
April 20, 1931	Warrensburg	4.8	Chimneys fell, church spire twisted
April 15, 1934	Dannemora	3.9	House shifted
July 9, 1937	Brooklyn	3.5	No reference and/or No damage reported
September 5, 1944	Cornwall, Ontario/Massena, NY	5.8	Nearly all chimneys fell, buildings damaged, $2 million damage
September 5, 1944	Cornwall, Ontario/Massena, NY	4.5	Chimneys destroyed, houses damaged
September 3, 1951	Rockland County	3.6	No reference and/or No damage reported
January 1, 1966	Attica	4.7	Chimneys and walls damaged
June 13, 1967	Attica	3.9	Chimneys and walls damaged
May 23, 1971	Blue Mountain Lake	4.1	No reference and/or No damage reported
May 23, 1971	Blue Mountain Lake	3.5	No reference and/or No damage reported
June 7, 1974	Wappingers Falls	3.0	Windows broken
June 9, 1975	Plattsburgh (Altona)	3.5	Chimneys and fireplaces cracked
November 3, 1975	Raquette Lake	4.0	No reference and/or No damage reported
February 2, 1983	Scarsdale-Lagrangeville	3.0	Chimneys cracked
October 7, 1983	Goodnow, Adirondack Mountains	5.1	Tombstones rotated, some cracked chimneys, windows broken, walls damaged
October 19, 1985	Ardsley	4.0	Windows broken, walls damaged
June 17, 1991	Richmondville	4.0	No reference and/or No damage reported
March 10, 1992	East Hampton, Suffolk County	4.1	No reference and/or No damage reported
April 20, 2000	Newcomb	3.8	No damage reported

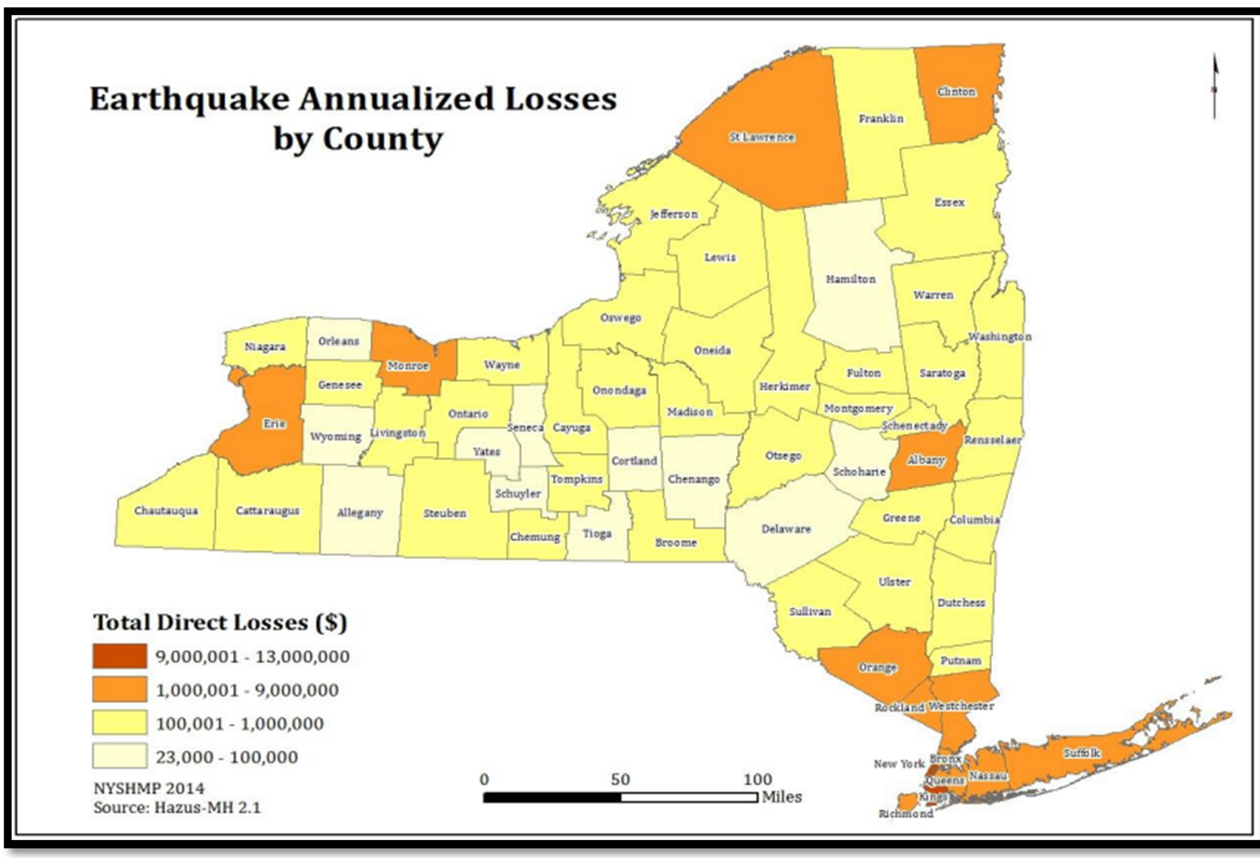
Table 5.7c: Earthquake History Throughout New York State (1737 – 2005) *(Source: NYSDHSES/NYS Statistical Yearbook 2006)*			
Date	Location	Size	Damage Description
April 20, 2002	Au Sable Forks	5.1	Cracked walls, chimneys fell, road collapsed, power outages
May 24, 2002	Au Sable Forks	3.1	Aftershock of the April 20, 2002 event, no damage reported

There has been one Federally-declared disaster in New York State due to an earthquake, following an event of Magnitude 3.1 that occurred in the far north eastern part of the state in April 2002 (with aftershocks in May 2002). Orange County was not affected by this event.

5.7.4 Historical Cost and Damage Estimates

The NYS Hazard Mitigation Plan (2014) has modeled potential loss to earthquakes by County. This information, depicted by Figure 5.7h, used surficial geology and soils data to estimate earthquake risk and potential loss if such a hazard event were to occur. This mapping illustrates that damages reported within Orange County could range from $1,000,001 to $9,000,000.

Figure 5.7h: New York State Estimated Earthquake Annualized Losses by County
(NYSDHSES, HAZUS-MH 2.1, 2014)



Additional earthquake damage potential and loss estimation data is included in the state plan. According to the NYS Hazard Mitigation Plan (2014) HAZUS – MH software estimates that out of the 62 counties in the State, Orange County ranks 15th in terms of exposure to earthquake hazard events. The annualized value of facilities, infrastructure, and property within the County that is potentially vulnerable to such a hazard event is estimated at $1,165.

5.7.5 Future Potential Impacts

Earthquakes cannot be predicted. They strike without warning, at any time of the year, and at any time of the day or night. According to USGS, there are an estimated 700 shocks each year with the capability of shaking homes, rattling windows, displacing objects, or even strong enough to cause property damage, death, and injury. It is fortunate that many of these shocks occur in unpopulated areas.

Forecasting earthquakes is often a difficult task. However, historical occurrences indicate that NYS experiences damaging earthquake events once every 22 years, on average. Lower magnitude earthquakes are more common. (NYSDHSES, 2014) Overall, the frequency of damaging earthquakes within and in the immediate vicinity of Orange County is low relative to other parts of the country and the world.

5.8 Winter Storm/Ice Storm

5.8.1 Hazards Associated with Winter Storm/Ice Storm

A severe winter storm is described as a storm system that develops in late fall to early spring and deposits wintry precipitation, such as snow, sleet, or freezing rain, with a significant impact on transportation systems and public safety.

5.8.2 Description

Extreme cold and heavy snowfall can immobilize the entire state causing road closures, power outages, disruption in communication services, and no heat for several days, under the most severe circumstances. Severe storms can require persons to abandon their homes and seek shelter. (2014 NYS HMP)

The severity or magnitude of a severe winter storm depends on several factors including a region’s climatological susceptibility to snowstorms, snowfall amounts and rates, wind speeds, temperatures, visibility, storm duration, topography, time, day of the week, and season (2014 NYS HMP).

Ice storms are characterized by freezing rain which accumulates in a substantial glaze layer of ice resulting in serious disruptions of normal transportation and possible downed power lines. The NWS uses the term “ice storm” to describe occasions when damaging accumulations of ice are expected during freezing rain situations. Significant accumulations of ice pull down trees and utility lines resulting in the loss of power and communications. Such accumulations of ice pose a risk to walking and driving. Damage from such events could include structural damage, utility failures, and tree damage as a result of excessive weight.

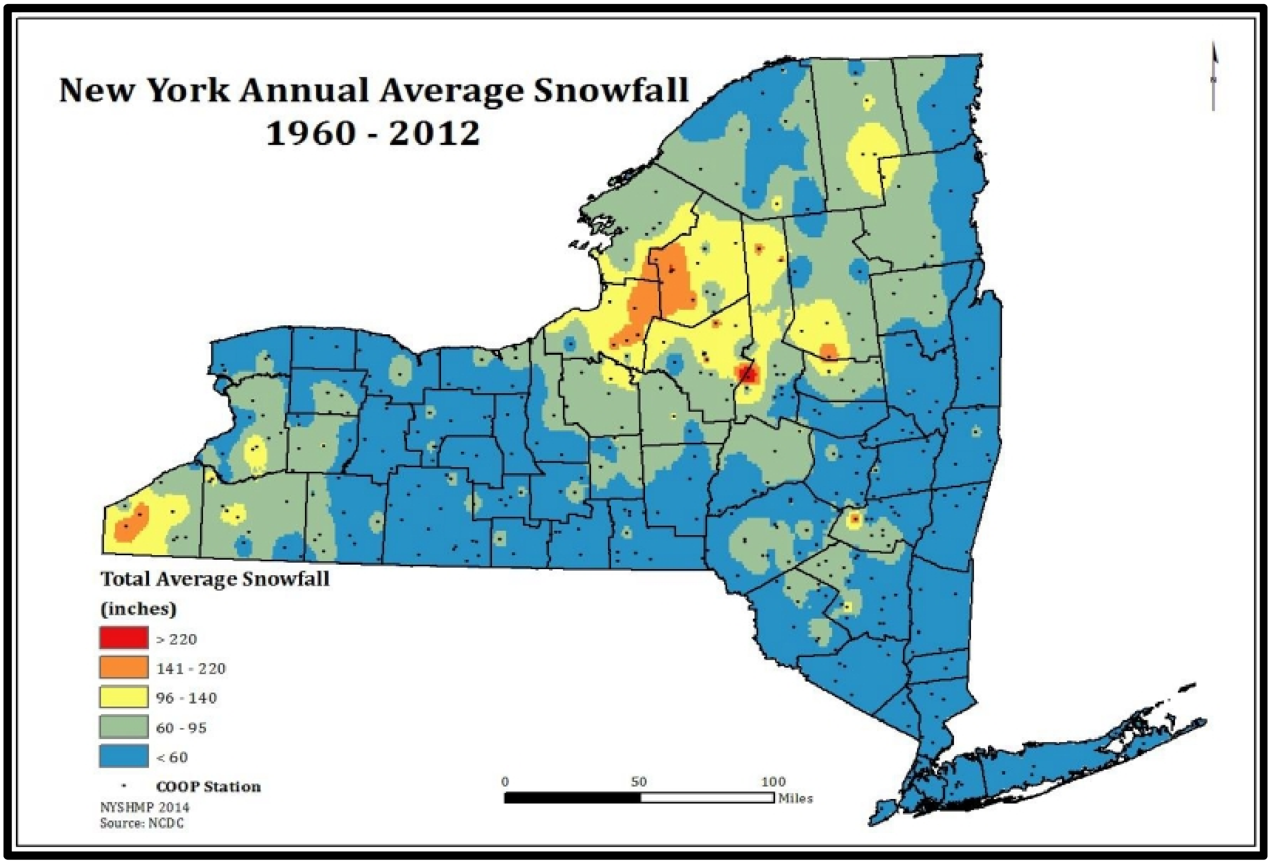
The 2014 NYS Hazard Mitigation Plan describes the Northeast Snowfall Impact Scale (NESIS) as a way to classify the extent of a severe winter storm by meteorological measurements and by evaluating its societal impacts. These storms have large areas of 10 inch snowfall accumulations and greater. NESIS has five ranking categories: Notable (1), Significant (2), Major (3), Crippling (4), and Extreme (5). Table 5.8a identifies and describes each ranking. The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus, NESIS gives an indication of a storm's societal impacts. This scale was developed because of the impact northeast snowstorms can have on the rest of the country in terms of transportation and economic impact (Kocin and Uccellini, 2011).

Table 5.8a: Northeast Snowfall Impact Scale (NESIS) Ranking Categories
(Kocin and Ullenini, 2004; NYSDHSES, 2014)

Category	Description	NESIS Range	Definition
1	Notable	1.0 – 2.49	These storms are notable for their large areas of 4-inch accumulations and small areas of 10-inch snowfall.
2	Significant	2.5 – 3.99	Includes storms that produce significant areas of greater than 10-inch snows while some include small areas of 20-inch snowfalls. A few cases may even include relatively small areas of very heavy snowfall accumulations (greater than 30 inches).
3	Major	4.0 – 5.99	This category encompasses the typical major Northeast snowstorm, with large areas of 10-inch snows (generally between 50 and 150 x 103 mi2 – roughly one to three times the size of New York State with significant areas of 20-inch accumulations.
4	Crippling	6.0 – 9.9	These storms consist of some of the most widespread, heavy snows of the sample and can be best described as crippling to the northeast U.S. with the impact to transportation and the economy felt throughout the United States. These storms encompass huge areas of 10-inch snowfalls, and each case is marked by large areas of 20-inch and greater snowfall accumulations.
5	Extreme	10+	The storms represent those with the most extreme snowfall distributions, blanketing large areas and populations with snowfalls greater than 10, 20, and 30 inches. These are the only storms in which the 10-inch accumulations exceed 200 x 103 mi2 and affect more than 60 million people.

Statewide, according to NOAA data average annual snowfall ranges from a low of approximately 10 – 20 inches in the New York City/Long Island area, to over 200 inches in the north of the State, in the Adirondack Mountains. For Orange County, average annual snowfall ranges from 30 to 50 inches per year, although the 2014 NYSHMP reports that the average annual snowfall for the County is 40 inches, as depicted in Figure 5.8a. This can vary greatly from one year to the next, particularly if several major extended-period storms impact the area (during which snowfall totals can approach or exceed annual averages), and considering Orange County's vulnerability to nor'easters along the Atlantic coast.

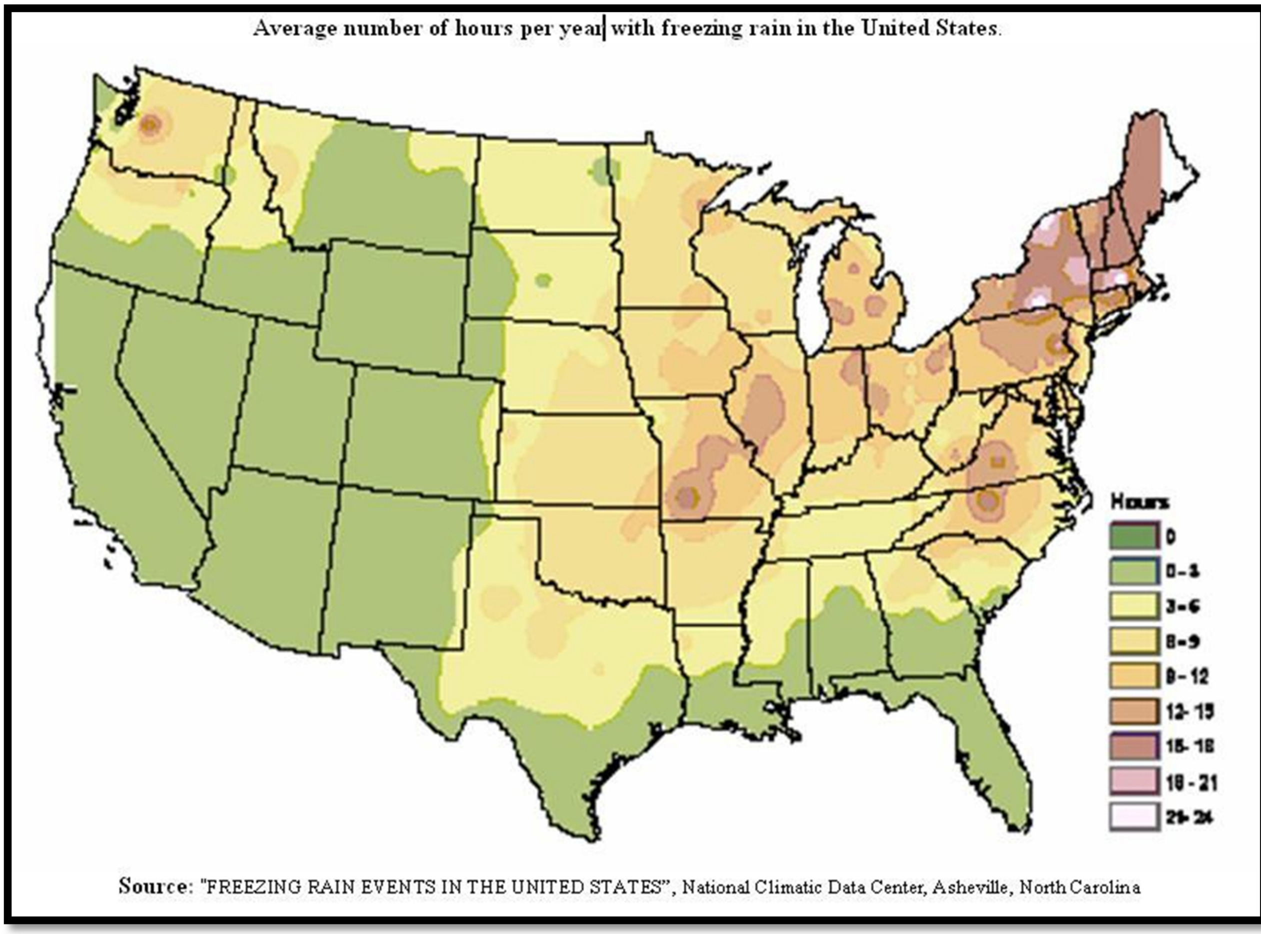
Figure 5.8a: New York State Annual Average Snowfalls 1960 – 2012
(NCDC, NYSDHSES, 2014)



Sleet is defined as pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes. These pellets of ice usually bounce after hitting the ground or other hard surfaces. Freezing rain is rain that falls as a liquid but freezes into glaze upon contact with the ground. Both types of precipitation, even in small accumulations, can cause significant hazards to a community (NWS, 2009).

Orange County lies within an area of the country which experiences averages of eight to twelve hours of freezing rain per year, while much of New York State further north experiences even greater amounts per year (See Figure 5.8b). Freezing rain is comparatively uncommon in the USA outside the northeastern states.

Figure 5.8b: Freezing Rain Zones Nationwide
(NCDC, NYSDHSES, 2014)



5.8.3 Location

A severe winter storm can affect a small or large region of the County or the entire County at one time. A single storm can also move from one area to another and back again, making the exact locations of impact nearly impossible to predict. Severe winter storms have the ability to immobilize an entire portion of the County, severely limiting the ability of emergency agencies to respond to local emergencies. Orange County is susceptible to coastal nor'easter snow events, which often result in high precipitation totals and/or temporarily produce white-out conditions.

5.8.4 Extent

A severe winter storm can adversely affect roadways, utilities, business activities and can cause loss of life, frostbite, or freezing. The severity of the effects of winter storms and ice storms increases as the amount and rate of precipitation increase. In addition, storms with a low forward velocity are in an area for a longer duration and become more severe in their affects. Storms that are in full force during the morning or evening rush hours tend to have their affects magnified because more people are out on the roadways and directly exposed. Storms that arrive at high tide can also have exacerbated affects in coastal areas.

The magnitude of a severe winter storm or ice storm can be qualified into five main categories by event type, as shown below:

- **Heavy Snowstorm:** Accumulations of four inches or more of snow in a six-hour period, or six inches or more of snow in a twelve-hour period.
- **Sleet Storm:** Significant accumulations of solid pellets which form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces posing hazards to pedestrians and motorists.
- **Ice Storm:** Significant accumulations of rain or drizzle freezing on objects (tress, power lines, roadways, etc.) as it strikes them, causing slippery surfaces and damage from the sheer weight of ice accumulation.
- **Blizzard:** Wind velocity of 35 miles per hour or more, temperatures below freezing, considerable blowing snow with visibility frequently below one-quarter mile prevailing over an extended period of time.
- **Severe Blizzard:** Wind velocity of 45 miles per hour, temperatures of 10 degrees Fahrenheit or lower, a high density of blowing snow with visibility frequently measured in feet prevailing over an extended period of time.

5.8.5 Historical Occurrences

In Orange County, severe winter snow and ice storms are normal and expected. A review of the New York State Hazard Mitigation Plan in conjunction with data from NOAA and FEMA shows that Orange County has been specifically included in one snow-related declared disaster in the last 30 years (DR-1083, 1/12/1996) and three snow-related emergency declaration (EM-3173, 2/25/2003, EM-3184, 3/27/2003, and EM-3299, 12/18/2008).

In addition to this information, the NCDC database holds snow and ice events for Orange County from January 2000 to June 2015, and a review of the NCDC database yielded 70 significant snow and ice events reported as having affected Orange County during this period. Details and descriptions for some of these events are as follows:

> **December 30, 2000:** A low pressure system rapidly intensified and moved north along the Mid-Atlantic coast during Saturday December 30. This produced a wide swath of heavy snow to the northwest of the storm track. Snow fell at intense rates right from the start, and rates of one to two inches per hour were common. There were also numerous reports of thunder and lightning accompanying the most intense snow bands. Winds also began to increase later Saturday morning, causing some blowing and drifting of snow, which reduced visibilities significantly, and created near blizzard conditions at times in some areas. Subfreezing temperatures and gusty winds lingered behind the storm system. Specific snowfall totals in Orange County ranged from 14 inches at Harriman to 21 inches at Warwick and Rock Tavern.

February 5, 2001: A developing low pressure system off the North Carolina coast moved northeast to a position off eastern Long Island, sending several bands of snow across central and eastern Long Island and portions of the lower Hudson Valley. This second band of snow then moved east and produced additional snow across portions of the New York City area and Long Island. Due to the rapid rate at which the snow fell, hazardous travel resulted across much of the New York City region. Specific snowfall totals for this snow event in Orange County ranged from 12 inches at Walden and Newburgh to 22 inches at Monroe.

February 25, 2001: Snow and sleet developed into freezing rain, with up to ¼ to 1/3-inch of ice accumulated on roads, trees, and power lines, which resulted in some power outages. In Middletown, a blown transformer on Wawayanda Avenue, near the Mount Carmel School, took out power in much of downtown. Several traffic accidents were reported along Route 17 in Orange County.

December 26, 2002: An area of low pressure caused light freezing rain over the Lower Hudson Valley, changing to snow as the storm moved east. Snowfall amounts in Orange County ranged from 10 to 20 inches.

February 17-18, 2003: Known as the Presidents Day Storm, this event resulted in Declared Emergency EM-3184, which specifically included Orange County: With an exceptionally strong high pressure system over New England, a low pressure system developed off the Mid Atlantic Coast. Periods of light snow developed as northeast winds increased to around 15 mph across the NYC Metro area Sunday afternoon, February 16th. Snow became widespread and heavy, falling at rates up to 2 to 3 inches per hour Sunday night and Monday, February 17th. Heavy snow blown by northeast winds 20 to 30 mph caused near blizzard conditions throughout the area. Record heavy snowfalls crippled mass transit. These extremely hazardous weather conditions led to local emergency declarations throughout the region. In Orange County Total Snowfall ranged from 14 inches at Port Jervis to 28 inches at Tuxedo.

December 5, 2003: A low pressure system moving up from the south caused heavy snowfalls, wind gusts up to 35 mph and whiteout conditions that disrupted transport across the NYC region. Snowfalls in Orange County ranged from six inches at Port Jervis to 25 inches at Chester.

February 6, 2004: Snow spread across, changing to freezing rain. From around 2 to 4 inches of snow was followed by from 0.33 to 0.5 inches of freezing rain. Significant ice accumulations on the wet snow pack led to hazardous road conditions and many traffic accidents across the region. At Orange County Airport in Montgomery, 3 inches of snow was followed by 0.53 inches of freezing rain. A spotter in Circleville reported 3.5 inches of snow followed by 0.5 inches of freezing rain.

December 9, 2005: A vigorous upper level disturbance tracked across the Great Lakes during the evening hours of December 8th with snows breaking out across the area during the early morning hours on the 9th. Snowfall amounts ranged from 6 inches in Manhattan to just over a foot in northern portions of the Lower Hudson Valley. Selected snowfall amounts included 10 inches at Newburgh 12 inches at Port Jervis, and 13 inches at Hamptonburgh.

January 3, 2006: A low pressure area south of Long Island produced a mix of snow, sleet, and freezing rain late at night before changing over to snow the following morning. Specific snowfall amounts in Orange County included 13 inches at Mount Hope and 11 inches Chester.

February 1, 2008: Light to moderate freezing rain broke out across the Lower Hudson Valley and northeast New Jersey Friday ahead of a warm front over the Mid-Atlantic states. The precipitation left about half an inch of ice on trees and power lines Orange County.

December 11, 2008: A transient high pressure area over eastern Canada provided enough cold air across northern portions of the Lower Hudson Valley for a prolonged period of freezing rain. Automated observations in tandem with pictures from trained spotters supported ice accumulations around one half inch across the northern half of Orange County. There was a major automobile accident on the Newburgh-Beacon Bridge in Orange County with eight (8) injuries. There were also scattered reports of trees and power lines down with the American Red Cross opening a shelter in Central Valley the following day. Trees were reported downed across County Roads 9, 71, and 105.

January 6, 2009: The combination of a weak high retreating over the northeast and deepening low pressure over the Great Lakes resulted in a significant accumulation of ice across northern portions of the Lower Hudson Valley. Ice amounts averaged around one-half inch, with up to almost an inch in spots. Ice accumulations in Orange County ranged from 0.3 inches in Warwick to 0.8 inches in Middletown and Monroe. Emergency management officials in both Orange and Putnam counties reported trees and power lines downed by the ice.

February 25, 2010: Orange County was hit by a winter storm which deposited record amounts of snowfall across the County. OCDES staff reported 34 inches of snow in some parts of the County, while the National Weather Service reported 32 inches of snow in Monroe, and 29 inches in both Goshen and Tuxedo. In the northeast US region as a whole, the storm was held responsible for three deaths and more than 700,000 homes and businesses were without power for significant periods, including more than 21,000 customers of Orange and Rockland Utilities. Approximately 200,000 customers of Central Hudson Gas and Electric lost power over their full operating territory, including 48,000 in Orange County. The County Executive declared a state of emergency on February 26 as per the following statement:

The County has determined that road conditions are dangerous and pose a real and substantial risk to vehicular traffic and the public safety is imperiled thereby, and the presence of non- essential vehicles on the roads will impede snow removal equipment and other essential services. Accordingly, I do hereby find that the County of Orange public safety to be imperiled by the said winter storm and, consequently, to safeguard the *health and welfare of the public, I declare a County state of emergency for the entire County of Orange, pursuant, inter alia, to New York State Executive Law Section 24, beginning at 6:00 p.m., February 25, 2010 and continuing until 7:00 a.m., February 26, 2010, unless extended by a subsequent Executive Order.*

As a result of this declaration of a County state of emergency all non-essential vehicular traffic was prohibited from all highways and roads within the County between the hours of 6:00 p.m., February 25, 2010 and 7:00 a.m. February 26, 2010. This prohibition did not apply to vehicles engaged in snow removal, sanding, salting and clearing operations.

On March 3, The Orange County Executive issued a request to the State Governor to declare the County a disaster area, giving the following justification:

The recent storms that severely impacted Orange County and the surrounding areas left in their wake a trail of devastation that is only now being calculated. Initial estimates for Orange County in material and manpower are in excess of $270,000. The Towns of New Windsor and Newburgh have initial estimates of over $200,000 in clean up and labor costs; the Town of Wallkill over $62,000.00; the City of Middletown has initial estimates of just over $100,000.00 in overtime, sand/salt costs and damage to property. These are just preliminary examples from across the County, not to mention the ongoing recovery to local infrastructure as issues become apparent once the snow is gone.

December 26, 2010: A rapidly intensifying low pressure system tracked from off the Southeast US coast on Christmas Day and then past the Mid Atlantic Coast on Sunday December 26th to just east of Long Island by early Monday morning December 27th. This intense low pressure system spread snowfall into the region Sunday morning, with bands of heavy snow plus embedded thunderstorms and very strong winds affecting the region Sunday afternoon through Sunday night. The powerful blizzard (defined when sustained winds or frequent gusts greater than or equal to 35 mph accompanied by falling and/or blowing snow, frequently reducing visibility to less than 1/4 mile for three hours or more) brought a widespread area of 20 to 30 inches of snow across the NYC metro and Lower Hudson Valley, with 10 to 20 inches across Long Island. The heavy snow was accompanied by area wide winds of 25 to 40 mph and gusts in excess of 60 mph Sunday afternoon into Sunday night, resulting in near white-out conditions with blowing and drifting snow and making all forms of travel extremely difficult to nearly impossible. In fact, all three major New York Airports were closed during and for a period after the storm. Bus service was severely hampered, and all service on the LIRR and several lines of MTA North, MTA subway, and PATH were suspended Sunday night into Monday morning due to high snow drifts. New York City struggled with snow removal due to the overwhelming blowing and drifting snow and stranded or abandoned buses and cars littering the streets, which severely hampered emergency services response times. In addition, 8000 customers lost power in New York City and Southern Westchester Counties, 8500 in Putnam and Northern Westchester, and 12,000 on Long Island during the height of the storm.

Bands of heavy snow fell at rates of one to three inches an hour and totals ranged from one to two feet. In the Village of South Blooming Grove, all roads were impassable.

The roof at Village Hall collapsed due to the accumulated snow. Several private properties also experienced damages. FEMA provided over $37 M in public assistance for those counties affected by this event.

January 11, 2011: Southeast New York received a heavy snowfall on the 11th and 12th of January from surface low pressure tracking up the Atlantic seaboard and then rapidly intensifying as it tracked just southeast of Long Island in response to an intense upper level disturbance.

An upper level disturbance worked over the region as a semi-stationary north to south band of very heavy snow developed just east of the Hudson River into the New York City metropolitan area. This band was responsible for snowfall rates of 3 to 4 inches per hour. In total, Eastern Long Island received 10 to 18 inches, with a few lower amounts across coastal Nassau County. New York City received 7 to 12 inches and the Lower Hudson Valley received 8 to 16 inches. At Central Park, 9.1 inches of snow fell. A weather emergency was declared by the New York City Mayor's Office. Regarding area airports, hundreds of international and domestic flights were cancelled and postponed.

Light snow overspread the region Tuesday evening ahead of low pressure and then became heavy with embedded thunderstorms Tuesday night as low pressure rapidly intensified. Some sleet and rain mixed in across eastern Long Island. As the upper level disturbance worked over the region late Tuesday night a semi-stationary north to south band of very heavy snow developed just east of the Hudson River into the New York City metropolitan area, gradually pivoting east Wednesday morning through early Wednesday afternoon. This band was responsible for snowfall rates of 3 to 4 inches per hour.

In total, Eastern Long Island received 10 to 18 inches, with a few lower amounts across coastal Nassau County. New York City received 7 to 12 inches and the Lower Hudson Valley received 8 to 16 inches.

January 26, 2011: A period of moderate to heavy snow overspread the region Wednesday morning into Wednesday afternoon on January 26th in response to a subtropical moisture feed ahead of a Mid Atlantic low pressure system. This bout of snow produced 2-to-5 inches across the region. The snow tapered to a light wintry mix late Wednesday afternoon into early evening, before a second heavier round of precipitation with convection worked into the region Wednesday evening. This was in response to a strong upper level disturbance working towards the region and rapidly intensifying coastal low pressure southeast of the region throwing moisture back over the area. A very heavy snow band developed over the NYC Metro, Southern and Eastern Portions of the Lower Hudson Valley and Northern and Western Long Island Wednesday evening, which gradually moved northeast late Wednesday night. This band was responsible for snowfall rates of 3-to-4 inches per hour over a 4-to-6 hour period, raising snow totals to 15-20 inches across much of the region. Lower snowfall amounts of 8-12 inches were experienced over Eastern Long Island due to sleet mixing in with the snow for a time Wednesday night.

Over 19 inches of snow accumulated in Central Park. Mayor Michael Bloomberg declared a weather emergency for New York City. A total of 36 inches had fallen in Central Park. Snow accumulations caused massive transportation delays including over a thousand airline cancellations at all of the major New York airports. Amtrak suspended its passenger rail service from New York to Boston and cut service between New York and Albany.

October 29, 2011: A historic early season winter storm impacted the area. Heavy wet snow fell across the area measuring up to a foot in the Lower Hudson Valley. Thousands of people in southeast New York lost power from snow accumulating on trees still having full foliage. This caused extensive damage to the power lines. In the Village of South Blooming Grove, the heavy winds from the storm caused massive amounts of debris and power outages. Village roads were impassable.

Late Friday night, October 28, an area of low pressure emerged from the South Carolina coastal plain into the western Atlantic Ocean. The low moved up the coast late Friday night into Saturday morning. The low began to rapidly strengthen late Saturday morning when it was east of the Delmarva coast, and continued to strengthen as it passed south of Long Island Saturday night. With water temperatures in the lower 60s, much of Long Island received mainly rainfall and up to 2 inches of rain during the event. Areas just north and west of New York City, however, were just cold enough to support a heavy wet snow. The heaviest snow fell across interior portions of the Lower Hudson Valley, with one foot or more of snowfall across highest elevations. In addition to the heavy rain and snow, strong winds were experienced along the immediate coastline.

Thousands of people across southeast New York lost power during this event as heavy snow accumulated on trees that still had partial to full foliage during mid-autumn. This caused extensive felling of trees and limbs across the region and damage to power lines.

February 8, 2013: Low pressure that formed along the northern Gulf coast by the morning of Thursday, February 7, 2013 moved northeast to near Cape Hatteras by the morning of Friday, February 8, 2013. The low then rapidly intensified while moving northeast to a position east of Cape Cod by the morning of Saturday, February 9, 2013, producing very heavy snowfall and blizzard conditions across central and eastern Long Island on February 8th and 9th, and winter storm conditions across the rest of southeast New York. Spotters reported snowfall ranging from 10 inches in Otisville, to 15.5 inches in Cornwall-on-Hudson.

February 13, 2014: A low pressure system developed along the northern Gulf Coast on February 12th, and moved to near Cape Hatteras and the Virginia capes by the morning of the 13th. The intensifying low then headed northeast, passing east of Long Island and into the Gulf of Maine early the morning of the 14th, bringing heavy snow and ice to Southeast New York. Trained spotters and the public reported widespread snowfall of 11 to 21 inches. The Montgomery Airport (MGJ) ASOS also reported freezing rain accretion of 1 tenth of an inch.

January 23, 2016: Low pressure moving across the deep South on Thursday January 21st and Friday January 22nd intensified and moved off the Mid Atlantic coast on Saturday January 23rd, bringing heavy snow and strong winds to southeast New York, and blizzard conditions to Long Island, New York City, and nearby southern Westchester County. NY Gov. Cuomo declared a state of emergency early Saturday January 23rd. Metro North and Long Island Railroad service halted at 4 PM Saturday. Orange County was on the sharp northern edge of the storm, with marked differences in snowfall from south to north. Most of the county received over 6 inches of snow, with a trained spotter reporting as much as 19 inches in Warwick, while far northern sections received much less, with little to no accumulation along the border with Ulster County.

February 9, 2017: Low pressure developed along a cold front over the Middle Atlantic early Thursday, February 9th. The low rapidly intensified as it moved off the Delmarva coast in the morning and then to the south and east of Long Island late morning into the afternoon. The low brought blizzard conditions to Long Island and portions of the Lower Hudson Valley. Heavy snow and strong winds also occurred over the New York City Metro. The blizzard brought delays and cancellations to the region's transportation systems as well as numerous accidents on roadways. The Long Island Railroad had system wide delays and at least 20 trains were cancelled. Several hundred rescues were performed by police and fire departments on Long Island. Trained spotters and the public reported 11 to 13 inches of snowfall.

March 14, 2017: Rapidly deepening low pressure tracked up the eastern seaboard on Tuesday March, 14 bringing blizzard conditions to portions of the Lower Hudson Valley. Heavy snow and sleet along with strong winds occurred across the New York City Metro. Approximately 17,000 power outages resulted from the strong winds and heavy snow. Trained spotters, amateur radio, a COOP observer, and the public reported 16 to 24 inches of snowfall. Some sleet also mixed in with the heavy snow.

5.8.6 Historical Cost and Damage Estimates

Severe winter storms result in little or no private property or public infrastructure damage. Ice storm events, or winter storms that have an ice component, can cause much more extensive damage, mostly to utility infrastructure, but moderate damage to private property has been documented. Actual damage costs can range from the thousands to millions, depending upon severity, duration, and nature of the event. Elderly and impoverished populations are typically more vulnerable during severe winter storm or ice storm events, especially if power failure results. For this reason, particular care is provided to these populations including the establishment of emergency and warming shelters during prolonged storm or power outage events.

5.8.7 Future Potential Impacts

This plan indicates the probability of future occurrences in terms of frequency based on historical events. Using the historical data presented above, and the generic descriptions of the events recorded by the NCDC as having affected Orange County, Table 5.8b summarizes the occurrence of winter storm events and their annual occurrence: Orange County and its municipal jurisdictions have experienced 70 recorded significant winter storms/ice storms between 2000 and July 2015 – an average of more than four events per year.

Table 5.8b: Occurrence of Winter Storms/Ice Storms, Orange County (2000 – 2015) *(Source: NOAA's NCDC Storm Events Database)*		
Type	Total Number of Events	Average Annual Number of Events
Heavy Snow	43	2.86
Winter Storm	15	1.0
Blizzard	1	0.07
Ice Storm	6	0.4
Winter Weather	5	0.33
Total	70	4.6

Winter storm events will remain a very frequent occurrence in Orange County, and the probability of future occurrences in the County is certain, but the impacts of snow and ice storms are more likely to be major disruptions to transportation, commerce and electrical power as well as significant overtime work for government employees, rather than large scale property damages and/or threats to human life and safety.

5.9 Wildfires

5.9.1 Description

A wildfire is defined as an uncontrollable combustion of trees, brush, or grass involving a substantial land area which may have the potential for threatening human life and property. Dry conditions at various times of the year can increase the potential for wildfire events. Often, wildfires begin abruptly and spread quickly, creating a dense smoke that can fill the surrounding area for miles. Humans start four out of every five wildfires, typically due to debris burns, arson, or carelessness. Lightning strikes are the second most leading cause of wildfires (NYS DEC, 2013).

Wildfires can occur at any time of the year, but will usually occur during warmer and dryer months. Wildfires are most commonly caused by people (i.e., arson, debris burns, and carelessness). Lightning is the next most common cause of wildfires. As reported by the Wildland Fire Assessment System (WFAS) wildfires resulting from a lightning strike largely depend on the duration of the current and the kind of fuel the lightning hits. Spread of the wildfire after ignition usually depends primarily on fuel moisture.

5.9.2 Location and Extent

Areas that are typically considered to be safe from wildfires include highly urbanized, developed areas that are not contiguous with vast areas of wild lands. Areas typically considered to be prone to wildfires include large tracts of wild lands containing heavier fuels with high continuity, at steeper slopes.

Wildfires have the potential to occur throughout Orange County, especially in the forested areas in the southeast and the extreme west of the County. Many of the areas at risk from wildfires are also popular with hikers and campers. Several major transportation routes such as the New York State Thruway (I-87) US Routes 6 and 9W, and State Routes 218 and 293 traverse forested areas, leaving them vulnerable to closure during forest fire due to smoke conditions. Areas in Orange County where the magnitude and severity of the hazard are the greatest tend to exhibit the lowest population densities in the County; as a result, exposure of people living and working in the highest hazard areas is often relatively low.

5.9.3 Historical Occurrences

While the NCDC database does not specifically report any wildfire incidents in Orange County, several wildfire events affecting Orange County have been uncovered in the course of general internet research:

> **May 31, 1998:** Severe thunderstorms in lines and clusters formed and moved over the Lower Hudson Valley of New York. Frequent lightning strikes caused numerous brush fires across Orange County.
>
> **August 10, 1999:** Wildfires in the West Point area resulted in FSA disaster declaration 2269, under which Orange County became eligible for Public Assistance funds. New York State made a request for federal assistance after the fire had already burned 1,500 acres and was posing a threat to Palisades State Park and developed land in the Town of Cornwall.

According to an Orange County press release of March 26, 2009:

> *"Every Spring NYSDEC Forest Rangers and Orange County Firefighters respond to hundreds of wildfires caused by debris burning. In fact debris burning is the most common preventable cause of wildfires in Orange County. During 2008 Orange County Fire Fighters controlled over 600 brush fires that were easily preventable."*

Figure 5.9a – New York State Wildfires per Square Mile (2001-2015) on the following page indicates that Orange County has experienced a high rate of wildfires per square mile. Per-square-mile rates across the county range from 1.4-3.4 west of the Wallkill River to 3.5-18.5 to the river's east.

Figure 5.9a: New York State Wildfires per Square Mile 2001-2015
(NYSDEC, NYSDHSES 2016)

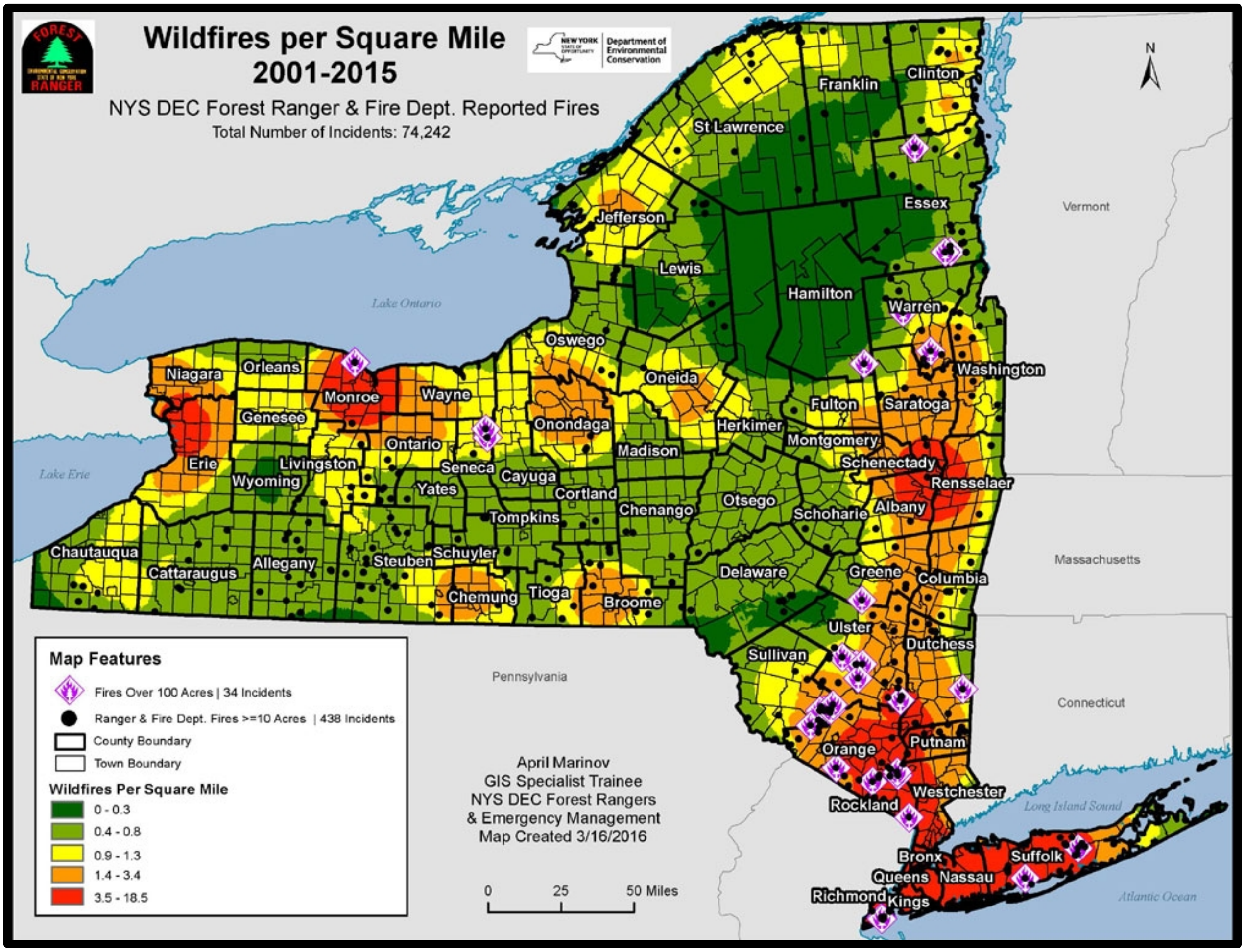
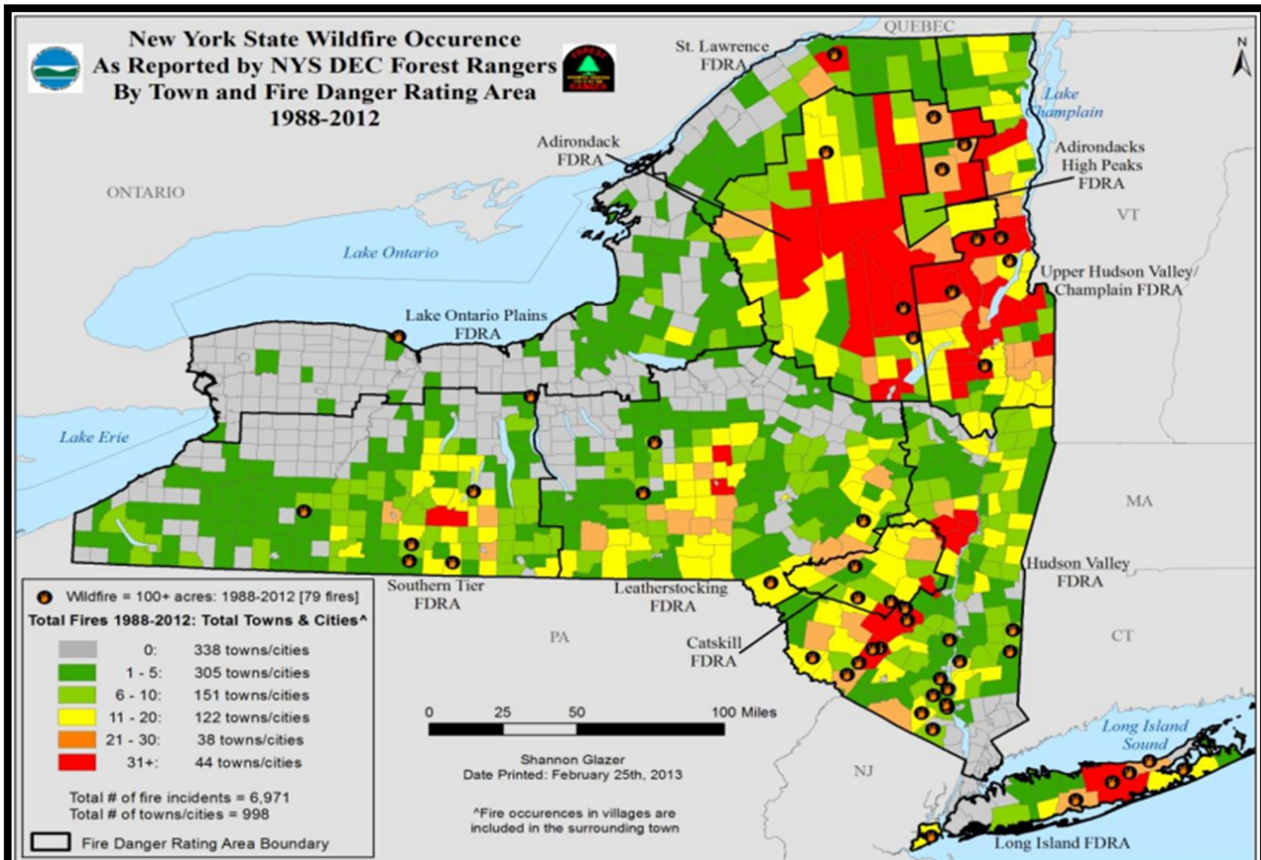


Figure 5.9b on the following page was generated by NYSDEC to map the occurrence of wildfires across New York State as reported by NYSDEC Forest Rangers. The map indicates the amount of wildfire occurrences by town from 1988-2012.

Figure 5.9b: New York State Wildfire Occurrences 1988-2012
(NYSDEC, NYSDHSES 2014)



Source: New York State Department of Environmental Conservation Forest Rangers

5.9.4 Future Potential Impacts

It is hard to predict the likelihood of wildfires, as there are many factors which contribute to the ignition of a wildfire. Debris burning is common across the County, as well as camping and backpacking and these harmless fires often are the sources of wildfires. It is likely that wildfires will continue across the County, particularly if drought conditions become more prevalent in the future. The likelihood of increased future development (particularly residential) can only result in an increase in the length of the urban-wildland interface, an increase in the improved value of property within wildfire hazard zones, and a greater risk of property damage and danger to the public in future years. The 2014 New York State Hazard Mitigation Plan lists four reasons why wildfire risks are increasing:

- The way forests were handled in the past allowed fuel in the form of fallen leaves, branches and plant growth, to accumulate. Now this fuel is lying around the forest with potential to "feed" a wildfire.
- Increasingly hot, dry weather in the U.S.
- Changing weather patterns across the country.

- More homes built in the areas called the Wildland/Urban Interface, meaning homes are built closer to wildland areas where wildfires can occur.

In 2010, NYSDEC revised its open burning policies to now ban brush burning from March 15 through May 15 – a period when 47% of all fire department-response wildfires occur. The results have been immediate, with a 74% reduction in wildfires caused by debris burning in upstate New York when compared to the previous 10-year average (2014 NYS HMP). Regulatory advancements like this will help reduce future wildfire risks.

5.10 Ice Jams

5.10.1 Description

An ice jam is described as a large accumulation of ice in rivers or streams that interrupts the normal flow of water and often leads to flooding conditions and/or damage to nearby structures. Ice jam events are often short-lived and often affect only a localized reach or area of a body of water (U.S. Army CRREL, 2004).

Ice jams form when ice floating downstream in a river stalls and begins to build into a jam, forming a dam. The "reservoir" behind the dam quickly fills with water until out of bank flooding occurs. The observed effect can be very similar to flash flooding, and sudden flooding downstream may be caused by the sudden failure or release of the ice jam. Ice jams generally form at locations where the ice transport downstream is reduced by an obstruction or a significant hydrologic change. Natural obstructions in the river can include bends, intact sheet ice cover, or a decrease in channel slope. Man-made obstructions can include bridges, existing dams, waterline crossings, and other constructions in the channel. (2011 Orange County Single Jurisdiction HMP)

Ice jams and resulting floods can occur during fall freeze-up from the formation of frazil ice (a collection of loose, randomly oriented needle-shaped ice crystals) during midwinter periods when stream channels freeze solid forming anchor ice, and during spring break-up when rising water levels from snowmelt or rainfall break existing ice cover into large floating masses that lodge at bridges or other constructions. Damage from ice jam flooding may exceed that caused by open water flooding – flood elevations are usually higher than predicted for free-flow conditions and water levels may change rapidly. During cold weather, there is a reduction in evapotranspiration, infiltration (due to frozen ground) and surface storage, (due to the filling of ground depressions with snow and ice), which result in more water being delivered to the channel. Therefore for equal amounts of total available water during cold and warm seasons, the amount of excess water available for runoff will be greater during the cold season. Additional damage may be caused by the force of floating ice colliding with buildings, other structures, and automobiles. (2011 Orange County Single Jurisdiction HMP)

Specific areas along a stream are more apt to form an ice jam than others (Montana Dept. Military Affairs, 2010):

- *Flat stream slopes* – where the slope of the river or stream flattens out; there is not enough slope for gravity to move ice further toward the stream channel;

- *Narrowed channels* – where the stream channel is naturally narrow, where the channel has been channelized or modified with rip rap, where there are bridge or other flow constrictions, or other areas where there is an absence of natural floodplain;
- *Downstream of open water* – ice can continually form where there are open water areas, contributing ice to the stream; these pieces of ice can accumulate in narrow places downstream; and
- *Floodplains* – naturally, floodplains act as places for floating ice and debris to fall out of the stream channel. If structures or stream modifications alter the natural pattern and location of the floodplains, the possibility of flooding and ice build-up increases.

5.10.2 Location and Extent

Ice jam was not originally included as a profiled hazard at the outset of the 2018 Orange County Multi-Jurisdiction Hazard Mitigation Plan project. However, after issues regarding ice jams were raised by numerous municipalities within the County, ice jams were once again chosen for further analysis in the County Plan, just as it was in the 2011 Orange County HMP.

The exact location of ice jams can be often difficult to specify. Ice jams are common in New York State which, according to the US Army Corps of Engineers Cold Region Research and Engineering Laboratory (CRREL), has experienced more ice jam events than any other state except Montana. Figure 5.10a on the following page depicts the locations of ice jams across the state from 1875 to 2007. Figure 5.10a identifies the Wallkill River was one of the top four most ice-jam-prone waterways in New York State with 52 ice jam incidents over the period along its segments in Ulster County and Orange County, NY.

Figure 5.10a: NYS Ice Jam Incidents 1875-2007
(NYSDHSES, 2007)

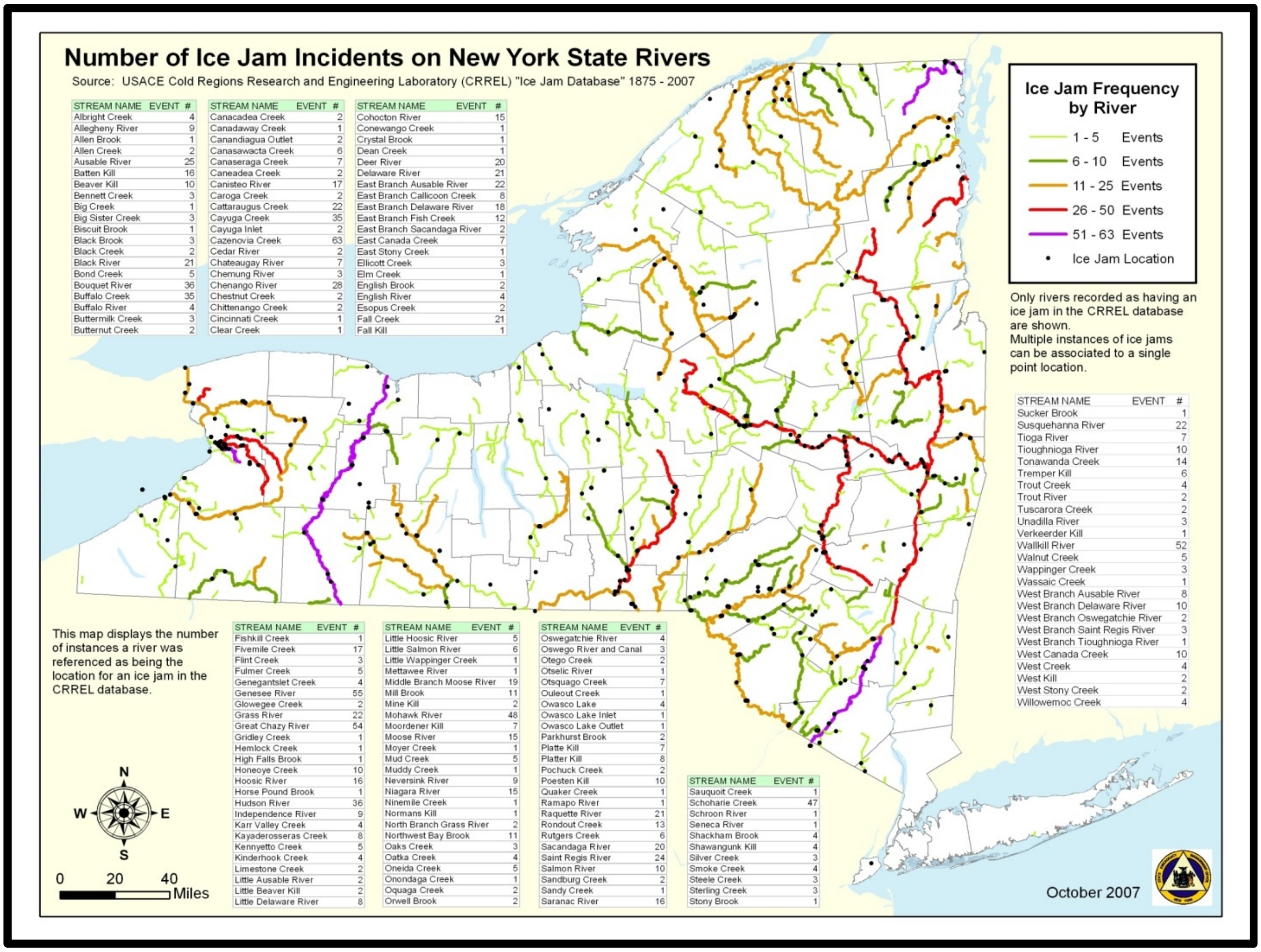
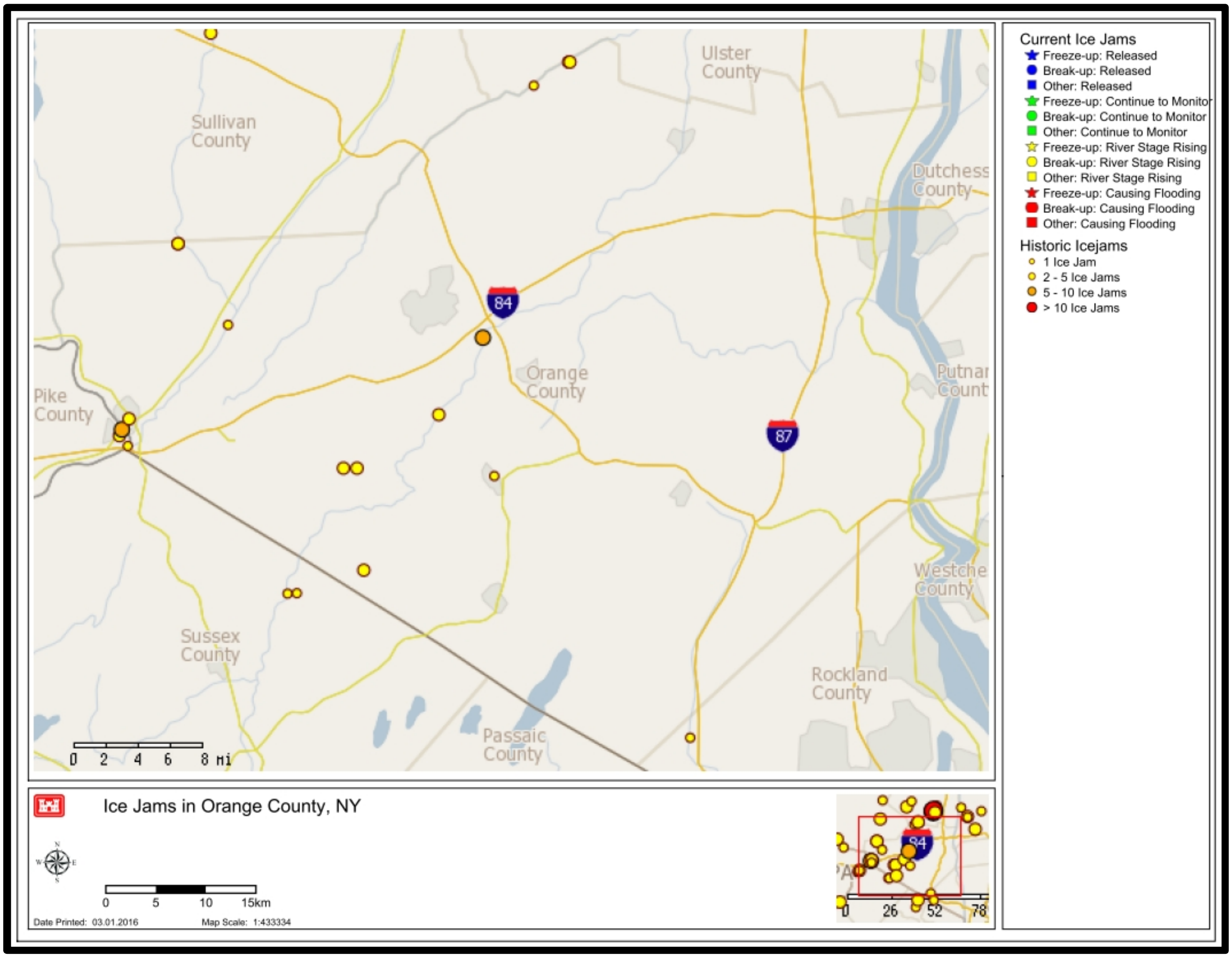


Figure 5.10b on the following page shows the locations of commonly susceptible to ice jams particular to Orange County. The map in that figure highlights ice jams in the Wallkill River watershed, as well as in the Delaware River, Neversink River, and Shawangunk Kill watersheds. The area around the City of Port Jervis is especially prone to ice jams.

Figure 5.10b: Orange County Ice Jam Incidents Recorded by USACE CRREL
(CRREL, 2016)



5.10.3 Historical Occurrence

Table 5.10a on the following page lists the 31 ice jam events that have been recorded by USACE CRREL since 1875 in Orange County.

Twelve have occurred in the City of Port Jervis on the Delaware River, dubbed an “ice gorge” by the *New York Times* in the late-1800s. Phillipsburg, in the Town of Wallkill, and Pellets Island Mountain, in the Town of Wawayanda, along the Wallkill River are the next most ice-jam-prone locations in Orange County with six and four occurrences, respectively. The hamlet of Pine Bush in the Town of Crawford has experienced four ice jams along its banks on the Shawangunk Kill and Pine Island in the Town of Warwick has had two incidents on the Pochuck Creek. Ice jam events have been more prevalent over the last 15 years in Orange County.

Table 5.10a: Ice Jam Occurrences in Orange County (1875-2015) *(Source: USACE CRREL Database, New York Times)*			
Date	Watercourse	Location	Municipality
2/27/1875	Delaware River	Port Jervis	Port Jervis, City of
2/11/1881	Delaware River	Port Jervis	Port Jervis, City of
1/1/1904	Delaware River	Port Jervis	Port Jervis, City of
3/8/1904	Delaware River	Port Jervis	Port Jervis, City of
3/19/1923	Wallkill River	Pellets Island Mountain	Waywayanda, Town of
1/26/1937	Wallkill River	Pellets Island Mountain	Waywayanda, Town of
2/8/1941	Wallkill River	Phillipsburg	Wallkill, Town of
2/8/1941	Wallkill River	Pellets Island Mountain	Waywayanda, Town of
2/22/1943	Wallkill River	Phillipsburg	Wallkill, Town of
2/28/1945	Pochuck Creek	Pine Island	Warwick, Town of
12/27/1945	Wallkill River	Phillipsburg	Wallkill, Town of
2/21/1948	Pochuck Creek	Pine Island	Warwick, Town of
2/21/1948	Wallkill River	Pellets Island Mountain	Waywayanda, Town of
2/11/1951	Wallkill River	Phillipsburg	Wallkill, Town of
2/28/1958	Wallkill River	Phillipsburg	Wallkill, Town of
1/22/1959	Wallkill River	Phillipsburg	Wallkill, Town of
1/22/1959	Shawangunk Kill	Pine Bush	Crawford, Town of
2/25/1961	Shawangunk Kill	Pine Bush	Crawford, Town of
1/7/1962	Neversink River	Godeffroy	Deerpark, Town of
3/18/1963	Shawangunk Kill	Pine Bush	Crawford, Town of
1/25/1964	Shawangunk Kill	Pine Bush	Crawford, Town of
2/16/1971	Delaware River	Port Jervis	Port Jervis, City of
1/24/1979	Quaker Creek	Florida	Florida, Village of
2/12/1981	Delaware River	Port Jervis	Port Jervis, City of
3/18/1981	Delaware River	Port Jervis	Port Jervis, City of
2/5/1982	Delaware River	Port Jervis	Port Jervis, City of
1/30/1994	Delaware River	Port Jervis	Port Jervis, City of
2/1/1994	Delaware River	Port Jervis	Port Jervis, City of
1/19/1996	Delaware River	Port Jervis	Port Jervis, City of
1/24/1999	Verkeeder Kill	Crawford	Crawford, Town of
12/18/2000	Delaware River	Port Jervis	Port Jervis, City of
2/25/2011	Wallkill River	Walden	Walden, Village of

5.10.4 Historical Cost and Damage Estimates

Descriptions of impacts and damages resulting from these events were not always recorded with these entries on the CRREL ice jam database. Some descriptions were drawn from other sources as noted. Summaries of ice jam events with recorded descriptions follows.

February 27, 1875: The City of Port Jervis was described by the *New York Times* as “panic-stricken” as the result of the severe ice jam on the Delaware River. Numerous streets (including Pike Street and King Street) and houses were flooded, and families were rescued by boat as the water level rose at the rate of one foot every minute. The Port Jervis gas works were inundated, and the *Times* later reported that this event had caused $300,000 in property damage in the City.

February 11, 1881: The *New York Times* as reported that an ice jam on the Delaware River flooded 30 to 40 houses and caused an estimated $5,000 in damage.

March 3, 1981: The Delaware River was jammed with ice causing $14.5 million in damages in the towns of Port Jervis and Matamoras. The river first jammed at Thirsty Deer, then at the Interstate 84 bridge and then at Port Jervis. King and Brain Streets were then inundated. There was 40 miles of unbroken ice. On March 18th, the Erie Railroad Delaware Bridge crossing the river to Lackawaxen was ripped off its piers and sent downstream to wipe out two other bridges. The ice jam caused flooding of agricultural and urban areas with damages to embankment, pavement, buildings, power, water, sewer and telephone utilities. The death of a resident of Matamoras was attributed to this ice jam. The cause was attributed to an extremely cold winter followed by thaw and rains coupled with a very sharp bend in the river at this location. Sandbagging and mechanical removal of ice was employed to prevent further damages.

January 24, 1999: Officials reported an ice jam on the Verkeerder Kill along the Ulster and Orange County Border. It was in the vicinity of the confluence of the Verkeerder Kill and Shawangunk Kill rivers in Crawford. Ulsterville Road from the intersection of Pirog Road South into the Town of Crawford in Orange County was closed. A bridge near the intersections of Ulsterville Road, Pirog Road, and Gillespie Street was flooded with four to five feet of water and Ulsterville Road had to be closed. Additional incidents have been reported by Orange County staff at Horan Bridge over Indigot Creek in 1996, and several times at Denton Bridge within the last five years. Although no damages are recorded, some farmland has been inundated at the latter and one home threatened at the former. Orange County staff also report that a large ice jam caused significant flooding in the City of Port Jervis in February 1857.

February 25, 2011: A Flood Advisory was issued by the National Weather Service in New York, NY at 11:00 p.m. on Friday, February 25, 2011 for urban and small streams for ice jam flooding in Orange County. The observed river stage on the Wallkill River at Gardiner downstream in Ulster County had reached 9.98 ft., and was rapidly rising due to an apparent breakup ice jam, following warm temperatures in the region. The USGS station's hydrograph located at Gardiner indicated that an initial peak of approximately 12.7 ft. occurred in the early morning hours of Saturday, February 26, but rain is forecast for Sunday. Flood stage is 13.0 ft. The NWS reported the stage at 11:00 a.m. on Tuesday, March 1, 2011 to be 15.1 ft., with minor flooding occurring and forecast to continue over the next several days along the banks of the Wallkill River from the Village of Walden to the Town of Gardiner.

5.10.5 Future Potential Impacts

It is likely that ice jams will continue to affect riverfront area of Orange County in the future, particularly in the City of Port Jervis, Town of Wallkill, Town of Wawayanda, Town of Crawford, and Town of Warwick. The frequency and damage extent of future ice jam events is more difficult to estimate, but based on historical trends ice jam events can be expected to occur two to three times per decade somewhere in the County. Recent years have produced a drop-off in the frequency of ice jam events and could lead to fewer future events if this short term trend prevails over the long term.