5.4.9 Severe Storm

This section provides profile information and the vulnerability assessment for the severe storm hazard for the Livingston County Hazard Mitigation Plan.

5.4.9.1 Hazard Profile

This section provides information regarding the description, extent, location, previous occurrences and losses, climate change projections and the probability of future occurrences for the severe storm hazard.

Hazard Description

For the purpose of this HMP and as deemed appropriated by Livingston County, the severe storm hazard includes hailstorms, windstorms, lightning, thunderstorms, tornadoes, and hurricanes, which are defined below. Northeasters (or Nor'easters) are a type of extra-tropical cyclone that most frequently occur during winter months. Because Livingston County's is located in New York's Finger Lakes, the county is not susceptible to Nor'easters; therefore, they are not profiled in this HMP.

Hail

Hail forms inside a thunderstorm where there are strong updrafts of warm air and downdrafts of cold water. If a water droplet is picked up by the updrafts, it can be carried well above the freezing level. Water droplets freeze when temperatures reach 32 °F or colder. As the frozen droplet begins to fall, it may thaw as it moves into warmer air toward the bottom of the thunderstorm. However, the droplet may be picked up again by another updraft and carried back into the cold air and re-freeze. With each trip above and below the freezing level, the frozen droplet adds another layer of ice. The frozen droplet, with many layers of ice, falls to the ground as hail. Most hail is small and typically less than 2 inches in diameter (National Weather Service [NWS] n.d.). Table 5.4.9-1 lists descriptions of hail size as outlined by National Oceanic and Atmospheric Administration (NOAA).

High Winds

High winds, other than tornadoes, are experienced in all parts of the United States. Areas that experience the highest wind speeds are coastal regions from Texas to Maine, and the Alaskan coast; however, exposed mountain areas experience winds at least as high as those along the coast. Wind begins with differences in air pressures. It is rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the earth (NWS n.d.). High winds have the potential to down trees, tree limbs, and power lines, which lead to widespread power outages and damage to residential and commercial structures throughout Livingston County. High winds are often associated by other severe storm events such as thunderstorms, tornadoes, hurricanes, and tropical storms (all discussed further in this section). Table 5.4.9-2 provides the wind descriptions used by the NWS.

Thunderstorms

A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder. A thunderstorm forms from a combination of moisture, rapidly rising warm air, and a force capable of lifting air such as a warm and cold front, a sea breeze, or a mountain. Thunderstorms form from the equator to as far north as Alaska. Although thunderstorms generally affect a small area when they occur, they have the potential to become dangerous due to their ability in generating tornadoes, hailstorms, strong winds, flash flooding, and lightning. The NWS considers a thunderstorm severe only if it produces damaging wind gusts of 58 mph or higher or large hail 1 inch in diameter (quarter size) or larger, or tornadoes.

Lighting is a bright flash of electrical energy produced by a thunderstorm. The resulting clap of thunder is the result of a shock wave created by the rapid heating and cooling of the air in the lightning channel. All thunderstorms produce lightning and are very dangerous. It ranks as one of the top weather killers in the United States and kills approximately 50 people and injures hundreds each year. Lightning can occur anywhere there is a thunderstorm.

Thunderstorms can lead to flooding, landslides, strong winds, and lightning. Roads may become impassable from flooding, downed trees or power lines, or a landslide. Downed power lines can lead to utility losses, such as water, phone and electricity. Lightning can damage homes and injure people. In the United States, an average of about 300 people are injured and 50 people are killed by lightning each year. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. An estimated 100,000 thunderstorms occur each year in the United States, with approximately 10 percent of thunderstorms classified as severe. During the warm season, thunderstorms are responsible for most of the rainfall (National Severe Storms Laboratory [NSSL] n.d.).

Tornadoes

Tornadoes are nature's most violent storms and can cause fatalities and devastate neighborhoods in seconds. A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 300 mph. Damage paths can be greater than one mile in width and 50 miles in length. Tornadoes typically develop from either a severe thunderstorm or hurricane as cool air rapidly overrides a layer of warm air. The average speed of a tornado is 30 mph but may vary from nearly stationary to 70 mph. The lifespan of a tornado rarely is longer than 30 minutes (NSSL n.d.).

Hurricanes/Tropical Storms

A hurricane is a tropical storm that attains hurricane status when its wind speed reaches 74 or more miles per hour (mph). Tropical systems may develop in the Atlantic between the Lesser Antilles and the African coast, or may develop in the warm tropical waters of the Caribbean and Gulf of Mexico. These storms may move up the Atlantic coast of the United States and impact the eastern seaboard, or move into the United States through the states along the Gulf Coast, bringing wind and rain as far north as New England before moving offshore and heading east.

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain (winds are at a lower speed than hurricane-force winds, thus gaining its status as tropical storm versus a hurricane). Tropical storms strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. They are fueled by a different heat mechanism than other cyclonic windstorms such as Nor'easters and polar lows. The characteristic that separates tropical storms from other cyclonic systems is that at any height in the atmosphere, the center of a tropical storm will be warmer than its surroundings; a phenomenon called "warm core" storm systems (NOAA 2020).

NWS issues hurricane and tropical storm watches and warnings. These watches and warnings are issued or will remain in effect after a tropical storm becomes post-tropical, when such a storm poses a significant threat to life and property. NWS allows the National Hurricane Center (NHC) to issue advisories during the post-tropical stage. The following are the definitions of the watches and warnings:

- *Hurricane/Typhoon Warning* is issued when sustained winds of 74 mph or higher are expected somewhere within the specified area in association with a tropical, subtropical, or post-tropical storm. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the warning is issued 36 hours in advance of the anticipated onset of tropical storm force winds (24 hours in the western north Pacific). The warning can remain in effect when dangerously high water or a combination of dangerously high water and waves continue, even though winds may be less than hurricane force.

- *Hurricane Watch* is issued when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the hurricane watch is issued 48 hours prior to the anticipated onset of tropical storm force winds.
- *Tropical Storm Warning* is issued when sustained winds of 39 to 73 mph are expected somewhere within the specified area within 36 hours (24 hours for the western north Pacific) in association with a tropical, subtropical, or post-tropical storm.
- *Tropical Storm Watch* is issued when sustained winds of 39 to 73 mph are possible within the specified area within 48 hours in association with a tropical, sub-tropical, or post-tropical storm (NWS 2020).

One of the most severe impacts associated with hurricanes is storm surge; however, because of Livingston County's location, storm surge is not a concern for the county and has not been detailed in this profile.

Extent

Hail

The severity of hail is measured by duration, hail size, and geographic extent. All of these factors are directly related to thunderstorms, which create hail. There is wide variation in the severity components of hail, with the most significant impact being damage to crops. Hail also has the potential to damage structures and vehicles during hailstorms.

Hail can be produced from many different types of storms; however, hail typically occurs with thunderstorm events, and the size of hail is estimated by comparing it to a known object. Most hailstorms are made up of a variety of sizes, and only the very largest hail stones pose serious risk to people, if exposed (NOAA Storm Prediction Center [SPC] n.d.). Table 5.4.9-1 lists the different sizes of hail compared to real-world objects.

Table 5.4.9-1. Hail Size

Description	Diameter (in inches)	Description	Diameter (in inches)
Pea	0.25	Golf ball	1.75
Marble or mothball	0.50	Hen's egg	2.00
Penny or dime	0.75	Tennis ball	2.75
Nickel	0.88	Baseball	2.75
Quarter	1.00	Tea cup	3.00
Half dollar	1.25	Grapefruit	4.00
Walnut or ping pong ball	1.50	Softball	4.50

Source: NOAA SPC n.d.

Windstorms and High Winds

The wind speed describes the prevailing direction from which the wind is blowing with speeds in miles per hour (mph). Table 5.4.9-2 provides the NWS descriptions of winds during wind-producing events.

Table 5.4.9-2. NWS Wind Descriptions

Descriptive Term	Sustained Wind Speed (mph)
Strong, dangerous, or damaging	≥40
Very windy	30-40
Windy	20-30
Breezy, brisk, or blustery	15-25
None	5-15 or 10-20
Light or light and variable wind	0-5

Source: NWS 2020
mph Miles per hour

NWS issues advisories and warnings for winds, which are normally site-specific. High-wind advisories, watches, and warnings are issued by the NWS when wind speeds may pose a hazard or may be life threatening. The criterion for each of these varies from state to state. Wind warnings and advisories for New York State are as follows:

- *High Wind Warnings* are issued when sustained winds of 40 mph or greater are forecast for 1 hour or longer, or wind gusts of 58 mph or greater for any duration
- *Wind Advisories* are issued when sustained winds of 30 to 39 mph are forecast for 1 hour or longer, or wind gusts of 46 to 57 mph for any duration (NWS n.d.).

Lightning

As with hail, lightning can be produced by a wide variety of situations, but it is most often associated with moderate to severe thunderstorms. As noted earlier, lightning is responsible for deaths, injuries, and property damage in all areas of the United States. Lightning-based deaths and injuries typically involve heart damage, inflated lungs, or brain damage, as well as loss of consciousness, amnesia, paralysis, and burns, depending upon the severity of the strike. Lightning can also spark wildfires or building fires, especially if structures are not protected by surge protectors on critical electronic, lighting, or information technology systems (NSSL n.d.).

Despite the potential damage associated with lightning, most strikes do not hit anything important (i.e., persons, animals, local assets). Additionally, the majority of people struck by lightning survive, although they may have severe burns and internal damage (as mentioned above). Multiple devices are available to track and monitor the frequency of lightning strikes; however, most jurisdictions only focus on cloud-to-ground lightning that occurs during periods of dry heat or when associated with severe storms.

Thunderstorms

Severe thunderstorm watches and warnings are issued by the local NWS office and NOAA's SPC. NWS and SPC will update the watches and warnings and will notify the public when they are no longer in effect. Watches and warnings for thunderstorms in New York are as follows:

- *Severe Thunderstorm Warnings* are issued when there is evidence based on radar or a reliable spotter report that a thunderstorm is producing, or is forecast to produce, wind gusts of 58 mph or greater, structural wind damage, and hail 1 inch in diameter or greater. A warning will include where the storm was located, what municipalities will be impacted, and the primary threat associated with the severe thunderstorm warning. After it has been issued, the NWS office will follow up periodically with Severe Weather Statements, which contain updated information on the severe thunderstorm and will let the public know when the warning is no longer in effect.

- *Severe Thunderstorm Watches* are issued by the SPC when conditions are favorable for the development of severe thunderstorms over a larger-scale region for a duration of at least 3 hours. Tornadoes are not expected in such situations, but isolated tornado development may also occur. Watches are normally issued well in advance of the actual occurrence of severe weather. During the watch, the NWS will keep the public informed on what is happening in the watch area and also let the public know when the watch has expired or been cancelled.
- *Special Weather State for Near Severe Thunderstorms* bulletins are issued for strong thunderstorms that are below severe levels, but still may have some adverse impacts. Usually, they are issued for the threat of wind gusts of 40 to 58 mph or small hail less than 1 inch in diameter (NSSL n.d.).

Tornado

The magnitude or severity of a tornado was originally categorized using the Fujita Scale (F-Scale) or Pearson Fujita Scale introduced in 1971. This used to be the standard measurement for rating the strength of a tornado. The F-Scale categorized tornadoes by intensity and area and was divided into six categories, F0 (gale) to F5 (incredible).

The Enhanced Fujita Scale (EF-Scale) is now the standard used to measure the strength of a tornado. It is used to assign tornadoes a "rating" based on estimated wind speeds and related damage. When tornado-related damage is surveyed, it is compared to a list of Damage Indicators (DI) and Degree of Damage (DOD), which help better estimate the range of wind speeds produced by the tornado. From that, a rating is assigned, similar to that of the F-Scale, with six categories from EF0 to EF5 representing increasing degrees of damage. The EF-Scale was revised from the original F-Scale to reflect better examinations of tornado damage surveys. This new scale considers how most structures are designed (NOAA SPC n.d.). Table 5.4.9-3 lists the EF-Scale and each of its six categories.

Table 5.4.9-3. Enhanced Fujita Damage Scale

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

Source: NOAA SPC 2014

Tornado watches and warning are issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly, that little, if any, advance warning is possible (NWS n.d.).

Hurricanes and Tropical Storms

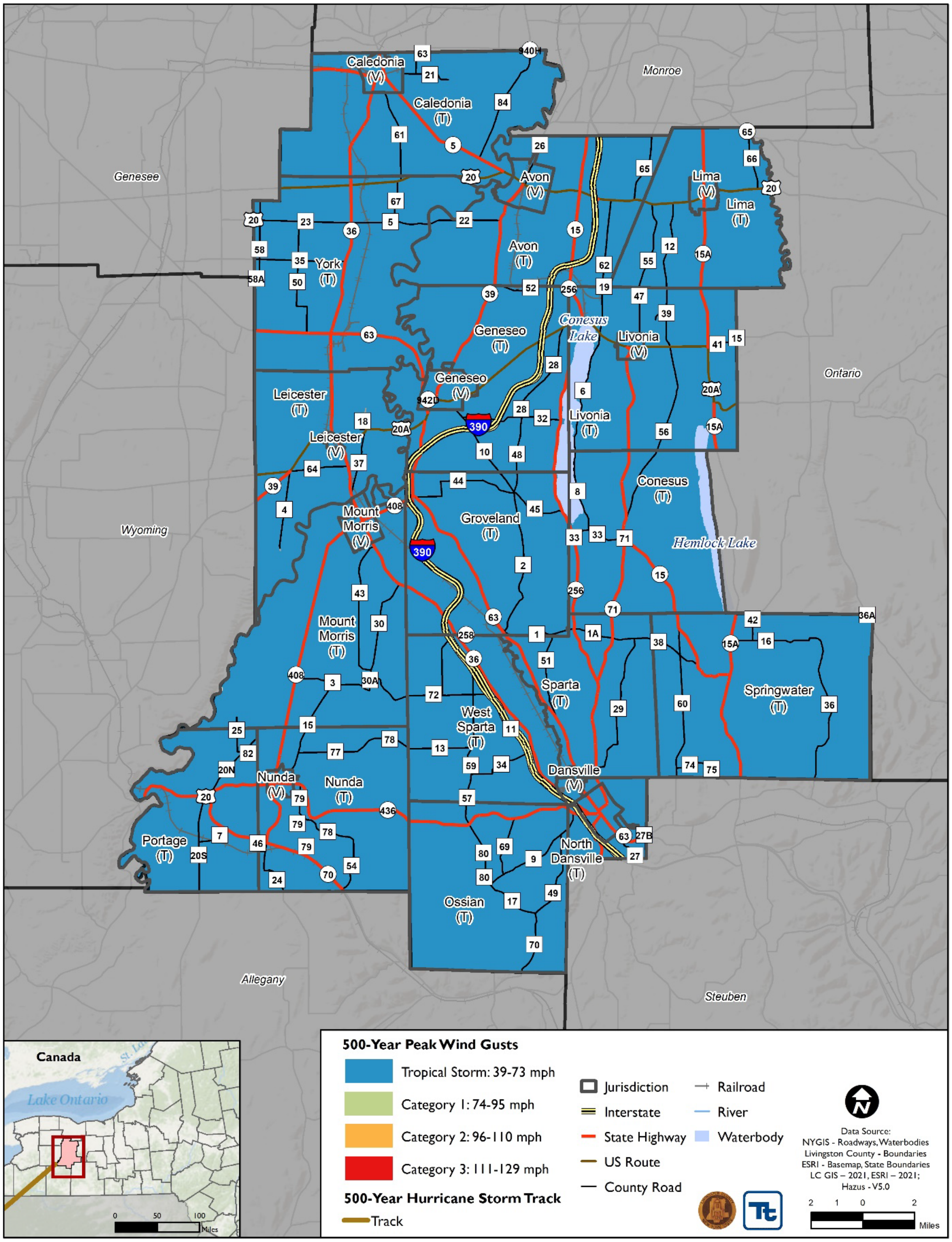
The extent of a hurricane is categorized in accordance with the Saffir-Simpson Hurricane Scale. The Saffir-Simpson Hurricane Wind Scale is a 1-to-5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous and require preventative measures (NOAA n.d.). Table 5.4.9-4 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes landfall.

Table 5.4.9-4. The Saffir-Simpson Hurricane Scale

Category	Wind Speed (mph)	Expected Damage
Tropical Storm	39-73 mph	**Dangerous winds produce some damage:** Effects include heavy rain, strong winds, wind gusts, storm surge and tornadoes.
1	74-95 mph	**Very dangerous winds will produce some damage:** Homes with well-constructed frames could have damage to roof, shingles, vinyl siding, and gutters. Large tree branches will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	**Extremely dangerous winds will cause extensive damage:** Homes with well-constructed frames could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph	**Devastating damage will occur:** Homes with well-built frames may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph	**Catastrophic damage will occur:** Homes with well-built frames can sustain severe damage with loss of most of the roof structure and some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	>157 mph	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: NWS n.d.
mph Miles per hour
> Greater than

Figure 5.4.9-1. Wind Speeds for the 500-Year Mean Return Period Hurricane Wind Event



Location

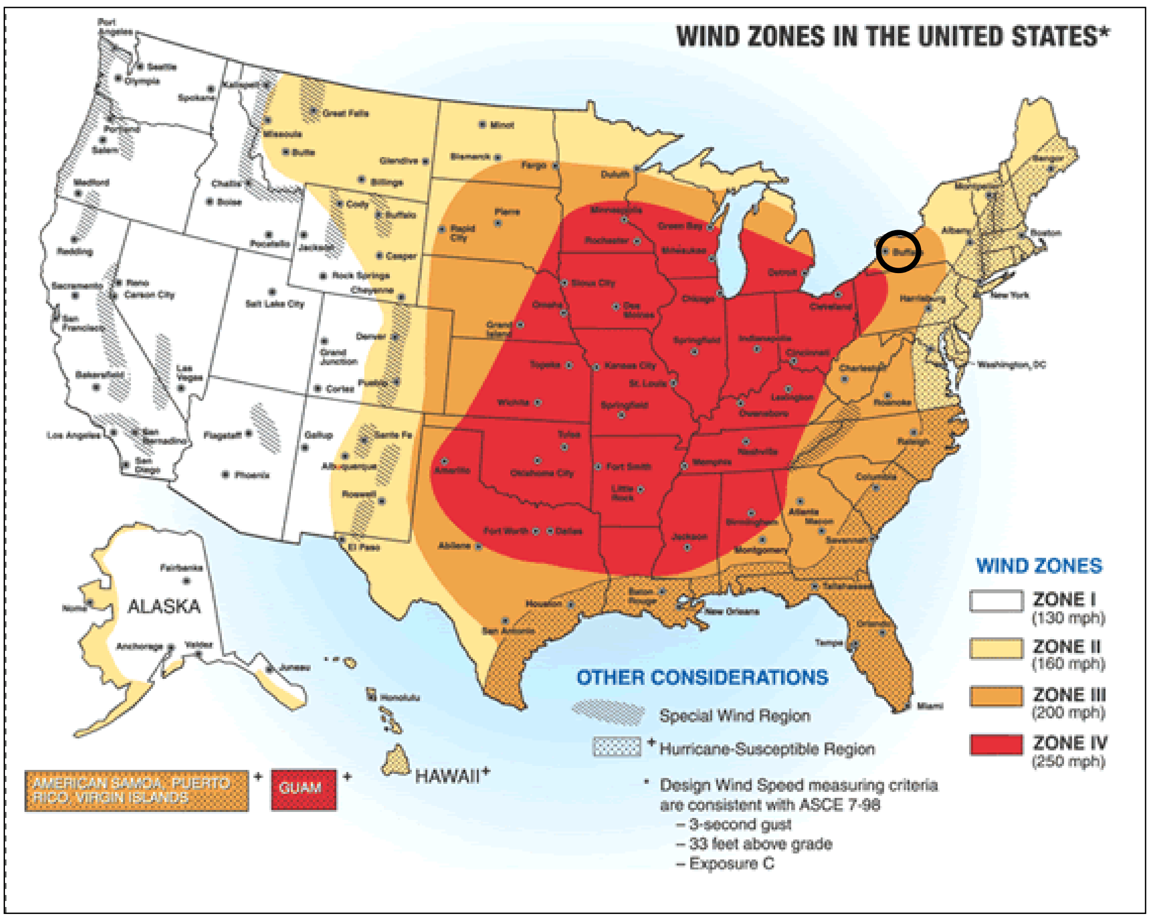
Hail

Hailstorms are most frequent in the southern and central plains states in the United States, where warm moist air off of the Gulf of Mexico and cold dry air from Canada collide, and thereby spawning violent thunderstorms. This area of the United States is known as hail alley and lies within the states of Texas, Oklahoma, Colorado, Kansas, Nebraska, and Livingston. In New York State, hailstorms can occur anywhere within the State of New York independently or during a tornado, thunderstorm, or lightning event.

Windstorms and High Winds

All of Livingston County is subject to high winds from thunderstorms, hurricanes, tropical storms, tornadoes, and other severe weather events. According to the FEMA Winds Zones of the United States map, Livingston County is located in Wind Zone III, where wind speeds can reach up to 200 mph. Figure 5.4.9-2 illustrates how the frequency and strength of windstorms impacts the United States, and the general location of the most wind activity. This is based on 40 years of tornado data and 100 years of hurricane data collected by FEMA.

Figure 5.4.9-2. Wind Zones in the United States

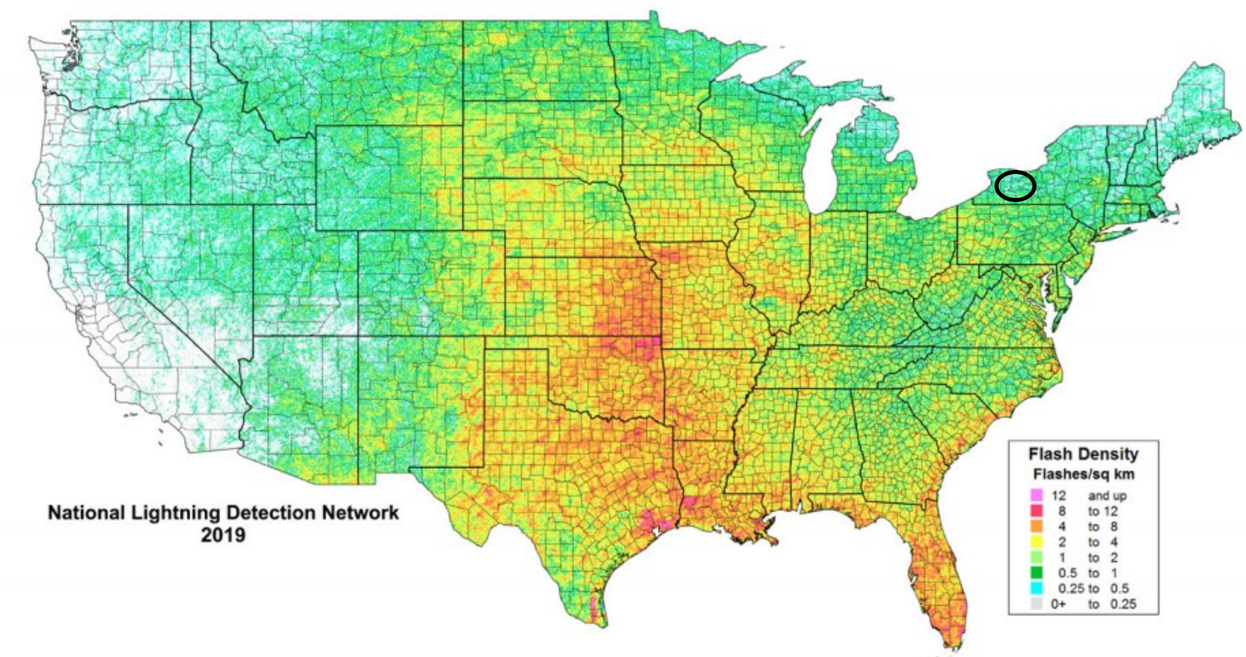


Source: *FEMA 2012*
Note: *The black circle indicates the approximate location of Livingston County. Livingston County is located within Zone III.*

Lightning

Lightning is most often associated with thunderstorms and other severe storms. Although dry lightning strikes can occur without significant precipitation anywhere in the United States, they are more frequently associated with the western portion of the country. The New York City Office of Emergency Management (NYC OEM) notes that the State of New York has a moderate frequency of lightning strikes, with 3.8 strikes occurring per square mile each year. In comparison, Florida experiences 25.3 strikes per square mile per year. Vaisala's National Lightning Detection Network (NLDN) data are the primary data source used by NWS NOAA for lighting information. Figure 5.4.9-3 provides a map of the U.S. Cloud-to-Ground Flash Density in 2019. This depicts the approximate amount of lightning strikes per square mile in 2019. According to the map, Livingston County experienced 0.25 – 1 flash per square mile.

Figure 5.4.9-3. U.S. Cloud-to-Ground Flash Density 2019



Source: Vaisala National Lightning Detection Network (NLDN) 2019
Note: The approximate location of Livingston County is within the black circle.

Thunderstorms

Thunderstorms affect relatively small, localized areas, rather than large regions such as winter storms and hurricanes. Thunderstorms can strike in all regions of the United States; however, they are common in the central and southern states. The atmospheric conditions in these regions of the country are most ideal for generating these powerful storms.

Tornado

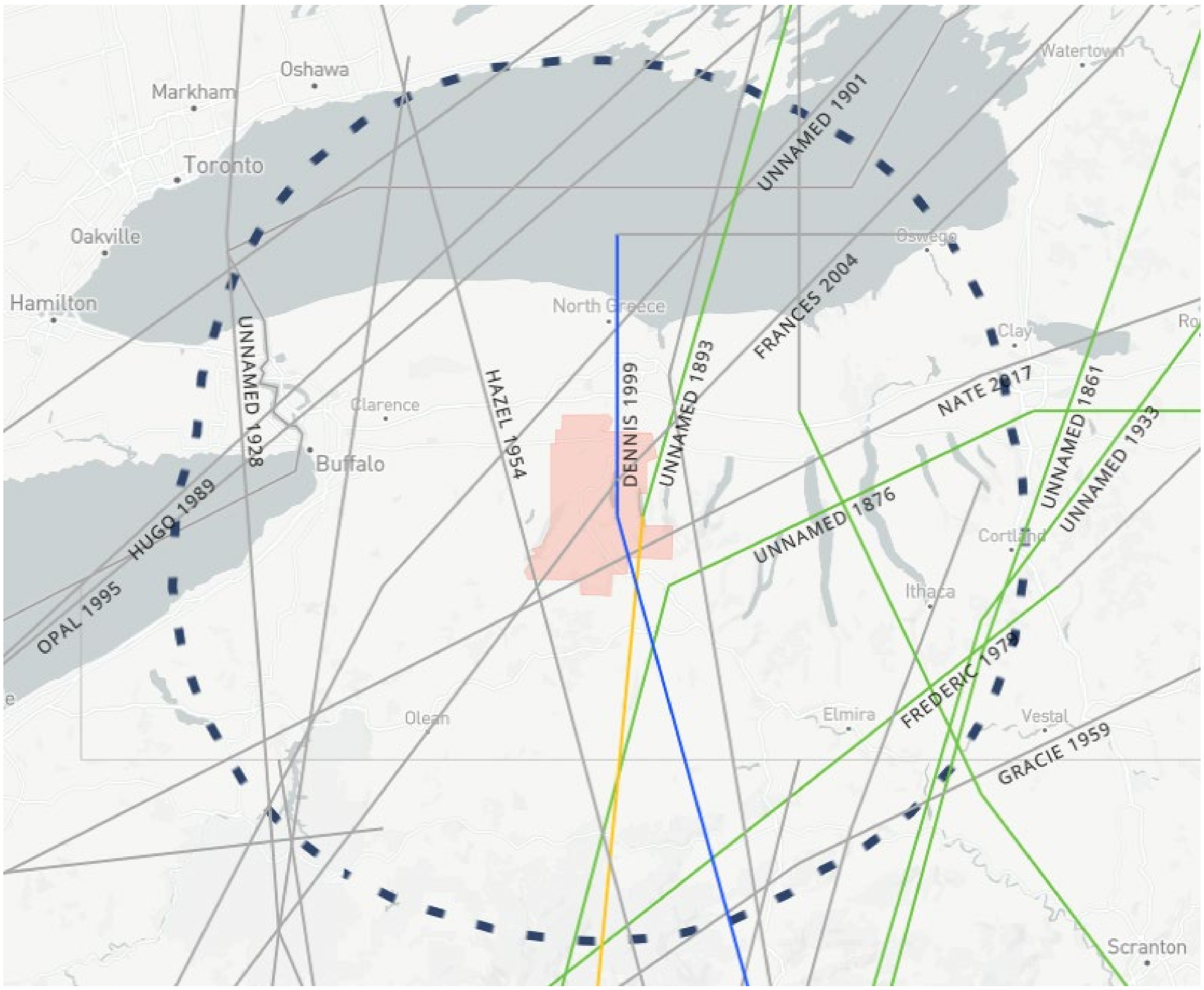
Tornadoes can occur at any time of the year, with peak seasons at different times for different states (NSSL n.d.). New York State has a definite vulnerability to tornadoes. Since 1950, over 440 tornadoes ranging from F0 to F4 have occurred throughout the state. Based on statistics from 2009 and 2019, New York State has experienced an average of 11 tornadoes annually. Livingston County experienced only two tornadoes between 1961 and 2020. (NOAA-National Centers for Environmental Information [NCEI] 2021).

Hurricanes and Tropical Storms

Hurricanes and tropical storms can impact New York State from June to November, the official eastern United States hurricane season (NOAA 2020).

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool catalogs tropical cyclones that have occurred from 1842 to 2021. Between 1950 and 2021, 22 tropical cyclones have been tracked within 65 nautical miles of Livingston County, as shown in Figure 5.4.9-4.

Figure 5.4.9-4. Hurricane Tracks within 65 Nautical Miles of Livingston County



Source: NOAA 2021.

Livingston County is not frequently impacted by hurricanes, tropical storms, or tropical depressions. It occasionally has experienced the direct and indirect landward effects associated with hurricanes and tropical storms in recent history. In 2012, Superstorm Sandy brought strong winds and heavy rains to Livingston County, which downed trees and power lines (NCEI 2017).

Previous Occurrences and Losses

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

Table 5.4.9-5 documents historical severe storm events from 1950 to August 2021 in Livingston County based on data collected from the NOAA-NCEI and FEMA databases.

Table 5.4.9-5. Severe Storm Events 1950-2021

Hazard Type	Number of Occurrences Between 1950 and 2021	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Hail	25	0	0	$147,000	$19,000
Hurricane / Tropical Storm	0	0	0	$0	$0
Lightning	3	0	1	$145,000	$0
Strong / High Winds	32	0	1	$1.980,000	$0
Thunderstorms	106	0	0	$1.940,000	$15,000
Tornado	2	0	0	$275,000	$0

Source: NOAA -NCEI 2021

Between January 1954 and August 2021, FEMA declared that New York State experienced 582 severe storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe storm, heavy rain, high wind, hurricane/tropical storm, and tornado. Generally, these disasters cover a wide region of the state; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, the FEMA database indicates that Livingston County has been included in 11 declarations for severe storm-related events (Table 5.4.9-6) (FEMA 2020).

Table 5.4.9-6. FEMA DR & EM Declarations for Severe Storm Events in Livingston County, 1954 to 2020

Disaster Number	Event Date	Declaration Date	Incident Type	Title
DR-338	June 23, 1972	1972	Flood	Tropical Storm Agnes
DR-494	March 19, 1976	1976	Severe Ice Storm	Ice Storm, Severe Storms & Flooding
DR-1095	January 24, 1996	1996	Flood	Severe Storms and Flooding
DR-1233	July 7, 1998	1998	Severe Storm(s)	Severe Storms and Flooding
DR-1335	July 21, 2000	2000	Severe Storm(s)	Severe Storms and Flooding
DR-1486	August 29, 2003	2003	Severe Storm(s)	Severe Storms, Flooding, and Tornadoes
DR-1534	August 3, 2004	2004	Severe Storm(s)	Severe Storms and Flooding
DR-1993	June 10, 2011	2011	Flood	Severe Storms, Flooding, Tornadoes, and Straight-line Winds
EM-3262	September 30, 2005	2005	Hurricane	Hurricane Katrina Evacuation

Disaster Number	Event Date	Declaration Date	Incident Type	Title
EM-3351	October 28, 2012	2013	Hurricane	Hurricane Sandy
DR-4180	July 8, 2014	2014	Severe Storm(s)	Severe Storms and Flooding

Source: FEMA 2021

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans available to producers suffering losses in those counties and in counties that are contiguous to a designated county. There have been eight USDA agricultural disasters from 2013 to August 2021 attributed to severe storms (USDA 2021):

- S3593 – 2013 Excessive Rain and Related Flooding, High Winds, and Hail
- S3777 – 2014 Excessive Snow, Flooding, Freeze, and High Winds.
- S3758 - 2014 Excessive Snow, Flooding, Freeze, and High Winds.
- S3747 – 2014 Excessive Rain, Flash Flooding, Flooding, High Winds, and Hail
- S3885 – 2015 Excessive Rain, High Winds, Hail, Lightning, and Tornado
- S4023 – 2016 High Winds
- S4031 – 2016 High Winds
- S4265 – 2017 Excessive Rain

USDA crop loss information provides another indicator of the severity of previous events. Additionally, crop losses can have a significant impact on the economy by reducing produce sales and purchases. Such impacts may have long-term consequences, particularly if crop yields are low the following years as well. USDA records indicate that Livingston County has experienced crop losses from severe storm events. Details are provided in the Table 5.4.9-7.

Table 5.4.9-7. USDA Crop Losses from Severe Storms in Livingston County, 2014-2019

Year	Crop Type	Cause of Loss	Losses
2014	Wheat, corn, beans, soybeans, potatoes	Excess Moisture/Precipitation/Rain	$2.5 million
2015	Wheat, corn, beans, soybeans, potatoes	Excess Moisture/Precipitation/Rain	$3.1 million
2016	Wheat, corn, soybeans,	Excess Moisture/Precipitation/Rain	$3 million
2017	Wheat, corn, beans, soybeans, potatoes, oats	Excess Moisture/Precipitation/Rain	$5.1 million
2018	Wheat, corn, beans, soybeans, potatoes, oats	Excess Moisture/Precipitation/Rain	$776,000
2019	Wheat, corn, beans, soybeans, potatoes, oats	Excess Moisture/Precipitation/Rain	$1.4 million
2020	Wheat	Excess Moisture/Precipitation/Rain	$12,000

Source: USDA 2020b

For this 2022 HMP update, known severe storm events that have impacted Livingston County between 2014 and 2021 are identified in Table 5.4.9-8. The jurisdictional annexes included in Section 9 of the HMP provide detailed information on damages and impacts to each municipality. Not all severe storm events that have occurred in Livingston County are included because not all sources have been identified or researched. Also, only those events that caused more than $50,000 of recorded damage are reported herein. Loss and impact information could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this plan. Shows only events where property damage exceeded $50,000.

Table 5.4.9-8. Severe Storm Events in Livingston County, 2014 to 2021

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Losses / Impacts
5/16/2014	Flood	N/A	N/A	Heavy rain along a slow moving cold front produced flooding across parts of the Genesee River valley and Finger Lakes region. Rainfall amounts of two to three inches fell on already rain-soaked soils. Honeoye Creek reached crested at 5.63 feet, a moderate flood.
8/5/2014	Flash Flood	N/A	N/A	Showers and thunderstorms developed ahead of an approaching cold front. The heavy rains from the storms fell on already saturated ground and produced localized flash flooding in Sparta. Portions of Routes 36 and 63 were washed out.
5/10/2015	Flash Flood	N/A	N/A	Thunderstorms developed during the afternoon hours across parts of the Genesee Valley and Finger Lakes. Training thunderstorms dropped upwards of four inches of rain across northern Livingston County in about an hour. The heavy rain resulted in flash flooding in the Towns of Avon and Ashantee.. Preliminary damage estimates were around $200,000.
6/14/2015	Flash Flood	N/A	N/A	A warm front lifted north across western New York during the morning ushering in an extremely moist air mass. Showers and thunderstorms began to develop during the early afternoon hours. The slow moving thunderstorms dropped two to three inches of rain across the area however rainfall amounts of one- to one-and-a-half inches of rain in less than a half hour were received.
6/14/2015	Flash Flood	N/A	N/A	A warm front lifted north across western New York during the morning ushering in an extremely moist air mass. Showers and thunderstorms began to develop during the early afternoon hours. The slow moving thunderstorms dropped two to three inches of rain across the area however rainfall amounts of one- to one-and-a-half inches of rain in less than a half hour were received.
3/8/2017	High Wind	N/A	N/A	Unusually deep low pressure moved from northwest Ontario across Hudson Bay. The low brought strong winds to the entire region with sustained winds up to 49 mph and wind gusts as high as 81 mph. A significant amount of damage resulted with hundreds of thousands left without powerï¿½ï¿½ï¿½over 100,000 in Monroe County alone. Particularly hard hit was the northern Genesee Valley region including parts of Orleans, Monroe, and Genesee counties.
10/31/2019	High Wind	N/A	N/A	A deepening area of consolidated low pressure tracked from the north shoreline of Lake Erie to Toronto, and then along the northern shoreline of Lake Ontario Thursday evening,.

Sources: *NOAA-NCEI 2021; FEMA 2021*
DR *Major Disaster Declaration*
EM *Emergency Declaration*
FEMA *Federal Emergency Management Agency*
mph *Miles per hour (wind)*
N/A *Not applicable*
NOAA *National Oceanic and Atmospheric Administration*
NCEI *National Centers for Environmental Information*
NWS *National Weather Service*

Probability of Future Events

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

Table 5.4.9-9 provides the probability of occurrences of severe storm events. Based on historic occurrences, thunderstorm events are the most common in Livingston County, followed by strong/ high wind events. However, the information used to calculate the probability of occurrences is only based on using NOAA-NCEI storm event database results.

Table 5.4.9-9. Probability of Occurrence of Severe Storm Events

Hazard Type	Number of Occurrences Between 1950 and 2021	Recurrence Interval (in years) (# Years/Number of Events)	% chance of occurrence in any given year
Hail	25	2.80	35%
Hurricane / Tropical Storm	0	0	0
Lightning	3	23.33	4%
Strong / High Winds	32	2.19	45%
Thunderstorms	106	0.66	100 %
Tornado	2	35.00	2%
TOTAL	**168**	**0.42**	**100%**

Source: *NOAA-NCEI 2021*
Note: *Probability was calculated using the available data provided in the NOAA-NCEI storm events database.*

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

In Section 5.3, the identified hazards of concern for Livingston County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for severe storms in the county is considered "frequent" (likely to occur more than once every 25 years, as presented in Table 5.3-2).

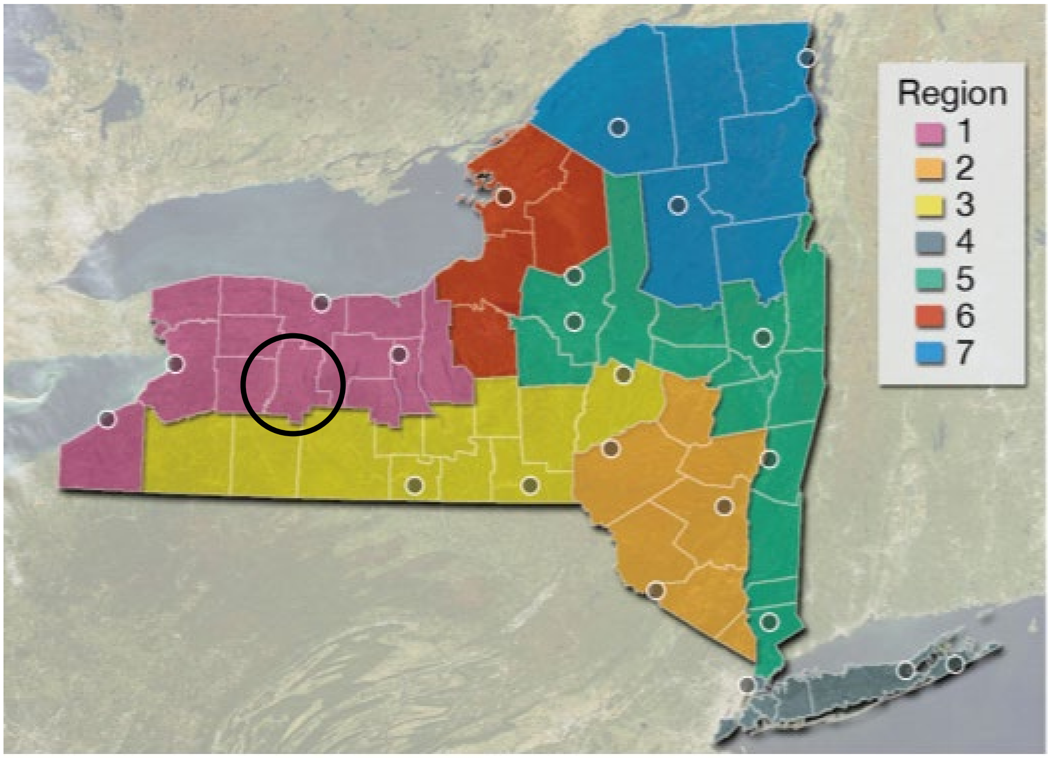
Climate Change Impacts

Climate change is beginning to affect both people and resources of Livingston County and the impacts of climate change will continue. Impacts related to increasing temperatures are already being felt in the county. ClimAID: the Integrated Assessment for Effective Climate Change in New York State (ClimAID) was undertaken to provide decision-makers with information on the state's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge (New York State Energy Research and Development Authority [NYSERDA] 2014). Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change.

Livingston County is part of Region 1, Western New York and the Great Lakes Plain (shown on Figure 5.4.9-5). In Region 1, temperatures are estimated to increase by 4.3 to 6.3 ºF by the 2050s, and 5.7 to 9.6 ºF by the 2080s (baseline of 47.7 ºF, middle range projection). Precipitation totals will increase between 4 and 10 percent by the 2050s and 6 to 13 percent by the 2080s (baseline of 34.0 inches, middle-range projection).

Some of the issues in Region 1 affected by climate change include the fact that this region has the highest agricultural revenue in the state; relatively low rainfall, and therefore, increased summer drought risk; irrigation for high-value crops; improved condition for grapes (NYSERDA 2014).

Figure 5.4.9-5. Climate Regions of New York State



Source: NYSERDA 2014
Note: Livingston County is shown within the black circle.

The projected increase in precipitation is expected to fall in heavy downpours and less in light rains. The increase in heavy downpours has the potential to affect drinking water; heighten the risk of riverine flooding; flood key rail lines, roadways, and transportation hubs; and increase delays and hazards related to extreme weather events (NYSERDA 2014).

The projected increase in precipitation is expected to occur by heavy downpours and less through light rains. The increase in heavy downpours has the potential to affect drinking water; heighten the risk of riverine flooding; flood key rail lines, roadways, and transportation hubs; and increase delays and hazards related to extreme weather events. Increasing air temperatures intensify the water cycle by increasing evaporation and precipitation, which can cause an increase in rain totals during storm events, with longer dry periods in between those events. These changes can have a variety of effects on the state's water resources.

Over the past 50 years, heavy downpours have increased, and this trend is projected to continue, contributing to localized flash flooding in urban areas and hilly regions. Flooding has the potential to increase pollutants in the water supply and inundate wastewater treatment plants and other vulnerable facilities located within floodplains. Less frequent rainfall during the summer months may impact the ability of water supply systems. Increasing water temperatures in rivers and streams will affect aquatic health and reduce the capacity of streams to assimilate effluent wastewater treatment plants.

5.4.9.2 Vulnerability Assessment

All assets in Livingston County are at risk to severe storm events. Potential losses associated with high-wind events were calculated for the 500-year Mean Return Period (MRP) probabilistic hurricane wind event. The impacts on population, existing structures, critical facilities, lifelines and the economy are presented below.

Impact on Life, Health and Safety

The impact of a hurricane wind event on life, health, and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. All Livingston County residents are at risk to the impacts caused by severe storm wind events (63,591 persons; 2015-2019 ACS 5-year Estimate).

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This is due to many factors including their physical and financial ability to react or respond during a hazard. Economically disadvantaged populations are vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate. The population over the age of 65 is also vulnerable and, physically, they may have more difficulty evacuating. Additionally, the elderly are considered vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention which may not be available due to isolation during a storm event. Please refer to Section 4 (County Profile) for the statistics of these populations.

Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Hazus estimates there will be zero displaced households and no people will require temporary shelter due to a 500-year MRP. Please note that estimates are only based on wind speed and do not account for sheltering needs associated with flooding that may accompany severe storm events.

Impact on General Building Stock

Damage to buildings is dependent upon several factors, including wind speed, storm duration, and path of the storm track. Building construction also plays a major role in the extent of damage resulting from a coastal storm. Due to differences in construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Mobile/manufactured homes, and structures constructed of wood and masonry buildings, in general, tend to experience more damage than concrete or steel buildings.

To better understand these risks, Hazus was used to estimate the expected wind-related building damages. Specific types of wind damages are also summarized in Hazus at the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.9-10 summarizes the definition of the damage categories. Table 5.4.9-11 summarizes the number and type of buildings and their estimated severity of expected damage.

Table 5.4.9-10. Description of Damage Categories

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

Source: Hazus Hurricane Technical Manual

Table 5.4.9-11. Expected Severity of Damages Caused by the 500-Year Mean Return Period Hurricane Wind Event

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	500-Year Mean Return Period Hurricane	
			Building Count	Percent of Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	28,577	None	28,484	99.7%
		Minor	0	0.0%
		Moderate	93	0.3%
		Severe	0	0.0%
		Complete Destruction	0	0.0%
Commercial Buildings	2,323	None	2,322	100.0%
		Minor	1	0.0%
		Moderate	0	0.0%
		Severe	0	0.0%
		Complete Destruction	0	0.0%
Industrial Buildings	224	None	224	100.0%
		Minor	0	0.0%
		Moderate	0	0.0%
		Severe	0	0.0%
		Complete Destruction	0	0.0%
Government, Religion, Agricultural, and Education Buildings	3,528	None	3,528	100.0%
		Minor	0	0.0%
		Moderate	0	0.0%
		Severe	0	0.0%
		Complete Destruction	0	0.0%

Source: Hazus v5.0; Livingston County 2021; RS Means 2021
Notes: % - Percent

Table 5.4.9-12 summarizes the replacement cost value damage for all occupancies estimated for the 500-year MRP wind-only event. Damage estimates are reported for the County's probabilistic Hazus model scenarios. The data shown indicates total losses associated with wind damage to the building only.

The total damage to buildings for all occupancy types across Livingston County is estimated to be approximately $10.3 million for the 500-year MRP wind-only event. All of the estimated losses are expected to occur to residential structures. Due to differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. The damage counts include buildings damaged at all severity levels from minor damage to destruction. Total dollar damage reflects the overall impact to buildings at an aggregate level. The Village of Dansville is estimated to experience the greatest damage, approximately $2.6 million in a 500-year MRP event.

Table 5.4.9-12. Estimated Building Losses from the 500-Year Mean Return Period Hurricane Wind Event

Jurisdiction	Building Replacement Cost Value	Estimated Building Losses Caused by the 500-Year Mean Return Period Hurricane Wind Event	Percent of Total
Avon (T)	$1,324,846,766	$0	0.0%
Avon (V)	$1,365,771,007	$0	0.0%
Caledonia (T)	$792,755,652	$0	0.0%
Caledonia (V)	$735,609,120	$0	0.0%
Conesus (T)	$625,005,723	$1,695,689	0.3%
Dansville (V)	$1,341,807,175	$2,631,832	0.2%
Geneseo (T)	$1,161,720,041	$0	0.0%
Geneseo (V)	$1,570,704,963	$0	0.0%
Groveland (T)	$1,203,662,583	$2,868	<0.1%
Leicester (T)	$715,987,145	$0	0.0%
Leicester (V)	$142,879,953	$0	0.0%
Lima (T)	$859,636,929	$0	0.0%
Lima (V)	$452,768,112	$0	0.0%
Livonia (T)	$1,866,897,181	$0	0.0%
Livonia (V)	$371,319,429	$0	0.0%
Mount Morris (T)	$646,574,328	$0	0.0%
Mount Morris (V)	$785,505,655	$0	0.0%
North Dansville (T)	$497,159,183	$722,101	0.1%
Nunda (T)	$544,934,442	$0	0.0%
Nunda (V)	$392,488,596	$0	0.0%
Ossian (T)	$488,703,931	$971,705	0.2%
Portage (T)	$338,465,763	$0	0.0%
Sparta (T)	$449,674,840	$1,367,760	0.3%
Springwater (T)	$702,256,303	$1,741,570	0.2%
West Sparta (T)	$423,213,015	$1,201,250	0.3%
York (T)	$1,677,949,006	$0	0.0%
Livingston County (Total)	**$21,478,296,842**	**$10,334,774**	**<0.1%**

Source: Hazus v5.0; Livingston County 2021; RS Means 2021
Notes: T – Town; V – Village; % - Percent; < - Less Than

Impact on Critical Facilities and Lifelines

Critical facilities may experience structural damage directly from high winds or falling tree limbs/flying debris, which can also result in the loss of power. Power loss can greatly impact households, business operations, public utilities, and emergency personnel. The elderly population may be more vulnerable if power loss results in interruption of heating and cooling services, stagnated hospital operations, and potable water supplies.

Emergency personnel such as police, fire, and EMS may not be able to effectively respond and maintain the safety of its residents.

Hazus estimates the probability that critical facilities (i.e., medical facilities, fire/EMS, police, EOC, schools, and user-defined facilities such as shelters and municipal buildings) could sustain damage as a result of the 500-year MRP wind event. Additionally, Hazus estimates the loss of use for each facility in number of days. Due to the sensitive nature of the critical facility dataset, individual facility estimated loss is not provided.

Table 5.4.9-13 summarizes the percent probability that each facility type may experience damage as a result of the 500-year mean return period hurricane wind event.

Table 5.4.9-13. Estimated Impacts to Critical Facilities and Lifelines from the 500-Year Mean Return Period Hurricane Wind Event

Facility Type	500-Year Mean Return Period Hurricane				
	Loss of Days	Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
EOC	0	0.0%	0.0%	0.0%	0.0%
Medical Facilities	0	0.0% - <0.1%	0.0%	0.0%	0.0%
Police Stations	0	0.0% - <0.1%	0.0%	0.0%	0.0%
Fire Stations/EMS	0	0.0% - 0.2%	0.0%	0.0%	0.0%
Schools	0	0.0% - 0.1%	0.0%	0.0%	0.0%

Source: Hazus v5.0; Livingston County Planning Partners 2021; HIFLD 2020
Notes: % - Percent; < - Less Than; EOC – Emergency Operations Center; EMS – Emergency Medical Services

At this time, Hazus does not estimate losses to transportation lifelines and utilities as part of the hurricane model. Transportation lifelines are not considered particularly vulnerable to the wind hazard; they are more vulnerable to cascading effects such as flooding, falling debris etc. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs.

Impact on Economy

Damage to structures from flooding and wind occur immediately; however, this damage can have long-lasting impacts on the economy. When a business is closed during storm recovery, there is lost economic activity in the form of day-to-day business and wages to employees. Overall, economic impacts include the loss of business function (e.g., tourism, recreation), damage to inventory, relocation costs, wage loss and rental loss due to the repair/replacement of buildings. As evidenced by Hurricane Sandy, the State of New York, including Livingston County, lost millions of dollars in wages and economic activity.

Hazus estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the "Impact on General Building Stock" subsection discussed earlier. Business interruption losses are the losses associated with the inability to operate a business because of the wind damage sustained during the storm or the temporary living expenses for those displaced from their home because of the event. Refer to Table 5.4.9-14 for a summary of Hazus estimated economic losses for Livingston County caused by the 500-year mean return period hurricane wind event.

Table 5.4.9-14. Estimated Economic Losses for the 500-Year Mean Return Period Hurricane Wind Event

Mean Return Period (MRP)	Inventory Loss	Relocation Loss	Building Loss	Wage Loss	Rental Loss	Income Loss
500-Year MRP	$0	$156,790	$10,334,770	$0	$0	$0

Source: Hazus v5.0

Debris management can be costly. Hazus estimates the amount of debris that might be produced as result of the 500-year mean return period hurricane wind event. Because the estimated debris production does not include debris generated by flooding, this is likely a conservative estimate and could be higher if multiple impacts occur. According to the Hazus Hurricane User Manual, estimates of weight and volume of eligible tree debris consist of downed trees that would likely be collected and disposed at public expense. Refer to the User Manual for additional details regarding these estimates. Overall, Hazus estimates that the 500-year mean return period hurricane wind event will not produce any debris for Livingston County.

Impact on the Environment

The impact of severe weather events on the environment varies, but researchers are finding that the long-term impacts of more severe weather can be destructive to the natural and local environment. National organizations such as USGS and NOAA have been studying and monitoring the impacts of extreme weather phenomena as it impacts long term climate change, streamflow, river levels, reservoir elevations, rainfall, floods, landslides, erosion, etc. (USGS 2017). For example, severe weather that creates longer periods of rainfall can erode natural banks along waterways and degrade soil stability for terrestrial species. Tornadoes can tear apart habitats causing fragmentation across ecosystems. Researchers also believe that a greater number of diseases will spread across ecosystems because of impacts that severe weather and climate change will have on water supplies (NOAA 2013). Overall, as the physical environment becomes more altered, species will begin to contract or migrate in response, which may cause additional stressors to the entire ecosystem within Livingston County.

Cascading Impacts to Other Hazards

Severe weather events and severe wind events can escalate the impacts of flooding and utility failure. Severe winds can be destructive to the functionality of utilities by breaching power lines and disconnecting the utility systems. Severe weather may carry extreme rainfall that could exacerbate flooding. More information about flooding and utility failure can be found in Section 5.4.3 and Section 5.4.12, respectively.

Future Changes That May Impact Vulnerability

Understanding future changes that effect vulnerability in the County can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

Understanding future changes that impact vulnerability in the Livingston County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. It is anticipated that any new development and new residents will be exposed to the severe storm events. However, due to increased standards and codes, new development might be less vulnerable to wind-related hazards compared to the aging building stock. The tables and hazard maps included in the jurisdictional annexes contain additional information regarding the specific areas of development that would increase County vulnerability to a wind event.

Projected Changes in Population

According to the 2019 American Community Survey 5-year population estimates, the population of the County has decreased by approximately 3-percent since 2010. While less people will reside in the County, those that remain are still vulnerable to severe weather and severe wind evets. Section 4, County Profile, provides additional discussion on population trends.

Climate Change

The entire State of New York is projected to experience an increase in the frequency and severity of extreme storms and rainfall. Major clusters of summertime thunderstorms in North America will grow larger, more intense, and more frequent later this century in a changing climate, unleashing far more rain and posing a greater threat of flooding across wide areas (University Corporation for Atmospheric Research [UCAR] 2017). Section 5.4.3, Risk Assessment - Flood, provides a discussion related to the impact of climate change due to increases in rainfall. An increase in storms will produce more wind events and may increase tornado activity. Additionally, increased temperatures will provide more energy to produce storms that generate tornadoes (Climate Central 2016). More strong wind and tornado events will cause all of the county's assets to experience additional risk for losses.

Change of Vulnerability since the 2015 HMP

Since the 2014 HMP, population statistics have been updated using the 5-Year 2015-2019 American Community Survey Population Estimates. The general building stock was also updated using 2021 building footprint and tax assessor data from Livingston County. Furthermore, the replacement cost values of the building inventory were updated using 2021 RS Means values. 2021 critical facility inventory data provided by the Livingston County Planning Partners and the Homeland Infrastructure Foundation-Level Data (HIFLD) were used to assess the number of critical facilities and lifelines at risk to the 500-year mean return period wind event. Additionally, the building stock and critical facility inventories created for this HMP were assessed in Hazus v5.0.

Over time, Livingston County will obtain additional data to support the analysis of this hazard. Such data may include additional details on past hazard events and impacts; specific building information, such as type of construction; and details on protective features (for example, hurricane straps). Overall, this vulnerability assessment uses a more precise and thorough approach, which provides increased accuracy for estimated exposure and potential losses for Livingston County.