5.4.6 Severe Storm

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

5.4.6.1 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 Wyoming 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 Wyoming County's is located in western New York State, 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 5.4.6-1 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 Wyoming 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 5.4.6-2 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 Wyoming 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 5.4.6-1 lists the different sizes of hail compared to real-world objects.

Table 5.4.6-1. 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 5.4.6-2 provides the NWS descriptions of winds during wind-producing events.

Table 5.4.6-2. 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 5.4.6-3 lists the EF-Scale and each of its six categories.

Table 5.4.6-3. 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 5.4.6-4 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes landfall.

Table 5.4.6-4. 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

Location

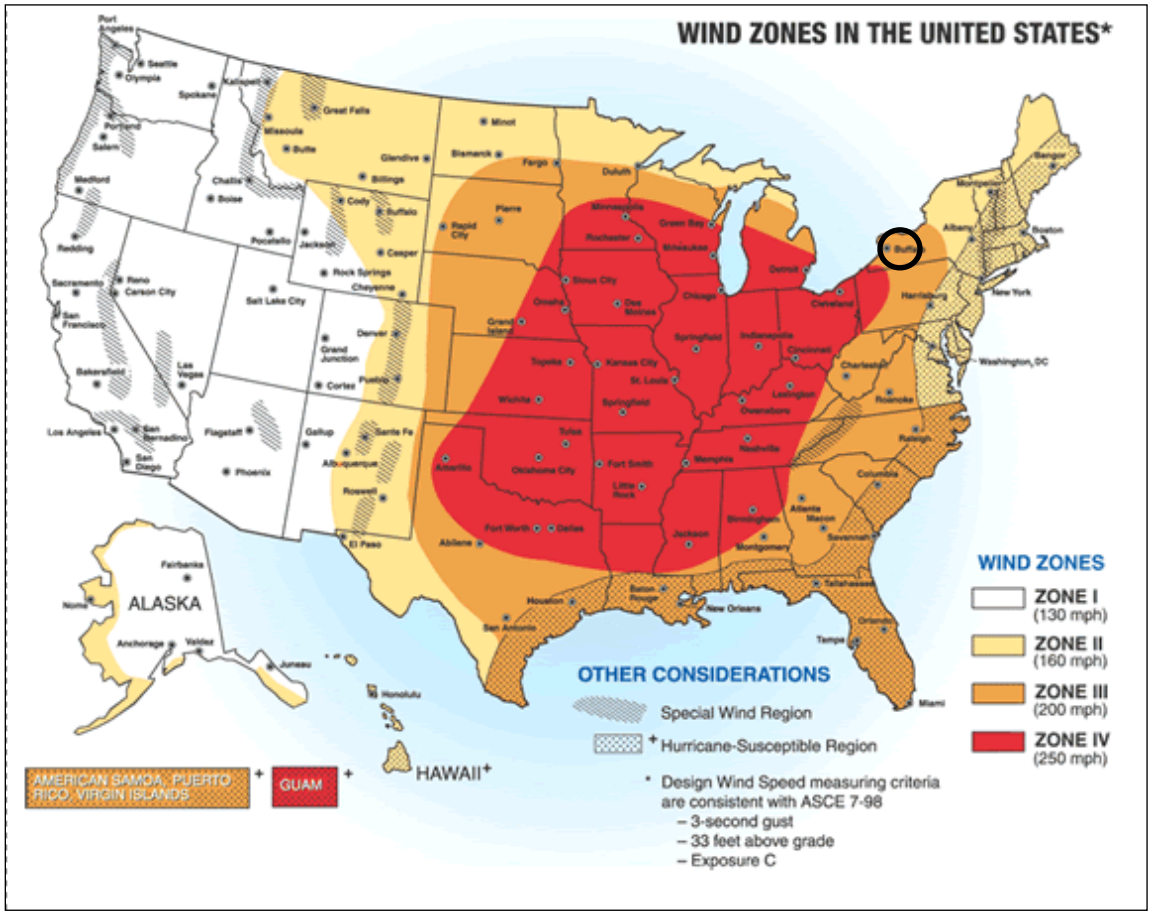
Hail

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 Wyoming. 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 Wyoming 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, Wyoming County is located in Wind Zone III, where wind speeds can reach up to 200 mph. Figure 5.4.6-1 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 5.4.6-1. Wind Zones in the United States

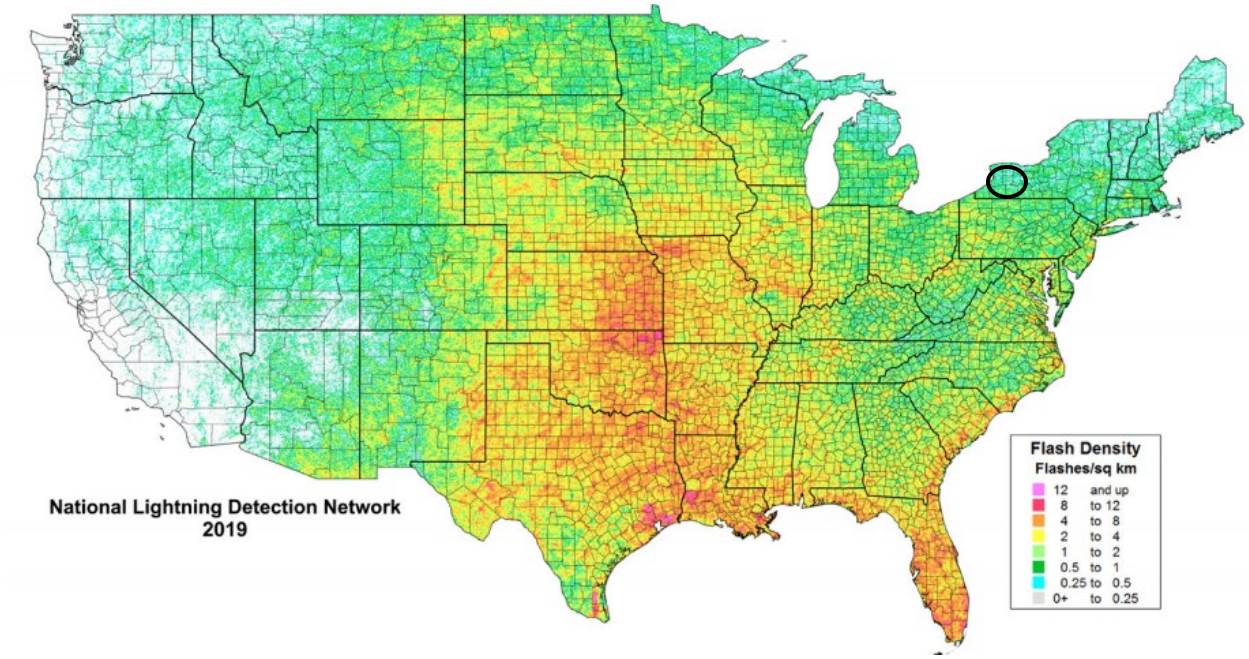


Source: *FEMA 2012*
Note: *The black circle indicates the approximate location of Wyoming County. Wyoming County is located within Zone III.*

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 5.4.6-2 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, Wyoming County experienced 1-4 flashes per square mile in 2019.

Figure 5.4.6-2. U.S. Cloud-to-Ground Flash Density 2019



Source: *Vaisala National Lightning Detection Network (NLDN) 2019*
Note: *The approximate location of Wyoming 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. It is estimated that as many as 30 thunderstorms occur each year in Wyoming County (Pennsylvania State University 2020).

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. Wyoming County has not experienced any tornadoes between 2009 and 2019 (NOAA-National Centers for Environmental Information [NCEI] 2020).

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 2019. Between 1950 and 2019, no tropical cyclones have been tracked within 65 nautical miles of Wyoming County.

Wyoming 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. These storms are based on the Historical Hurricane Tracker, which include recent effects of Hurricane Agnes and Superstorm Sandy. In 2012, Superstorm Sandy brought strong winds and heavy rains to Wyoming 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 Wyoming 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 5.4.6-5 documents historical severe storm events from 1950 to December 2019 in Wyoming County based on data collected from the NOAA-NCEI and FEMA databases.

Table 5.4.6-5. Severe Storm Events 1950-2019

Hazard Type	Number of Occurrences Between 1950 and 2019	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Hail	30	0	0	$172,000.00	$45,000.00
Hurricane / Tropical Storm	0	0	0	$0	$0
Lightning	0	0	1	$95,000.00	$0
Strong / High Winds	46	0	2	$3,315,000.00	$0
Thunderstorms	128	0	0	$1,139,500.00	$10,000.00
Tornado	3	0	0	$1,050,000.00	$0

Source: NOAA -NCEI 2020; FEMA 2020

Between January 1954 and December 2019, 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 Wyoming County has been included in five declarations for severe storm-related events (Table 5.4.6-6) (FEMA 2020).

Table 5.4.6-6. FEMA DR & EM Declarations for Severe Storm Events in Wyoming County, 1954 to 2019

Date(s) of Event	FEMA Declaration Number	Declaration Date	Event Type
May 31, 1998 – June 2, 1998	DR-1222	June 16, 1998	Severe Storms and Tornadoes
June 25, 1998 – July 10, 1998	DR-1233	July 7, 1998	Severe Storms and Flooding
July 21, 2003 – August 13, 2003	DR-1486	August 29, 2003	Severe Storms, Flooding, and Tornadoes
May 13, 2004 – June 17, 2004	DR-1534	August 3, 2004	Severe Storms and Flooding
October 27, 2012 – November 8, 2012	EM-3351	October 28, 2012	Hurricane Sandy

Source: FEMA 2020

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 six USDA agricultural disasters from 2012 to May 2020 attributed to severe storms (USDA 2020a):

- S3593 – 2013 Excessive Rain and Related Flooding, High Winds, and Hail
- S3777 – 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

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 Wyoming County has experienced crop losses from severe storm events. Details are provided in the Table 5.4.6-7.

Table 5.4.6-7. USDA Crop Losses from Severe Storms in Wyoming County, 2014-2019

Year	Crop Type	Cause of Loss	Acres Damaged	Losses
2014	Wheat	Excess Moisture/Precipitation/Rain	45.8	$8,408
2014	Corn	Excess Moisture/Precipitation/Rain	979.32	$158,943
2014	Processing Beans	Excess Moisture/Precipitation/Rain	118.3	$32,016
2014	Green Peas	Excess Moisture/Precipitation/Rain	35.3	$552
2014	Soybeans	Excess Moisture/Precipitation/Rain	537.95	$69,058
2015	Wheat	Excess Moisture/Precipitation/Rain	289.6	$23,918
2015	Corn	Excess Moisture/Precipitation/Rain	8,342.3	$563,974
2015	Processing Beans	Excess Moisture/Precipitation/Rain	315.5	$62,400
2015	Dry Beans	Excess Moisture/Precipitation/Rain	30.3	$2,891
2015	Green Peas	Excess Moisture/Precipitation/Rain	454.2	$78,614.80
2015	Soybeans	Excess Moisture/Precipitation/Rain	563.4	$77,760
2016	Wheat	Excess Moisture/Precipitation/Rain	36.7	$2,431
2017	Oats	Excess Moisture/Precipitation/Rain	119.2	$11,598
2017	Corn	Excess Moisture/Precipitation/Rain	2,688.62	$390,020
2017	Processing Beans	Excess Moisture/Precipitation/Rain	348.4	$92,690
2017	Dry Beans	Excess Moisture/Precipitation/Rain	34	$7,426
2017	Green Peas	Excess Moisture/Precipitation/Rain	233.5	$37,125
2017	Soybeans	Excess Moisture/Precipitation/Rain	278.07	$60,169
2017	Potatoes	Excess Moisture/Precipitation/Rain	699.94	$745,678
2018	Corn	Excess Moisture/Precipitation/Rain	1,263.722	$142,626.30
2018	Sweet Corn	Excess Moisture/Precipitation/Rain	28.5	$12,606
2018	Processing Beans	Excess Moisture/Precipitation/Rain	317	$101,563
2018	Dry Beans	Excess Moisture/Precipitation/Rain	71.89	$28,949
2018	Soybeans	Excess Moisture/Precipitation/Rain	742.42	$122,842
2018	Potatoes	Excess Moisture/Precipitation/Rain	400	$494,285
2019	Wheat	Excess Moisture/Precipitation/Rain	242.14	$19,329

Year	Crop Type	Cause of Loss	Acres Damaged	Losses
2019	Corn	Excess Moisture/Precipitation/Rain	3,131.59	$546,425
2019	Sweet Corn	Excess Moisture/Precipitation/Rain	21.02	$9,016
2019	Processing Beans	Excess Moisture/Precipitation/Rain	249.5	$56,088
2019	Green Peas	Excess Moisture/Precipitation/Rain	205	$56,214
2019	Soybeans	Excess Moisture/Precipitation/Rain	315.3	$49,598
2019	Potatoes	Excess Moisture/Precipitation/Rain	312.74	$417,722
2019	Oats	Excess Moisture/Precipitation/Rain	18.3	$628

Source: USDA 2020b

For this 2021 HMP Update, known severe storm events that have impacted Wyoming County between 2014 and 2019 are identified in Table 5.4.6-8. The jurisdictional annexes included in Section 9 of the HMP provide detailed information on damages and impacts to each municipality. Please note that not all events that have occurred in Wyoming County are included due to the extent of documentation and the fact that not all sources have been identified or researched. 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.

Table 5.4.6-8. Severe Storm Events in Wyoming County, 2014 to 2019

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Losses / Impacts
January 6, 2014	High Wind	N/A	N/A	A cold front produced high winds causing downed trees and powerlines in Wyoming County. Overall, the county had approximately $15,000 in property damage from this event.
May 9, 2014	Thunderstorm Wind	N/A	N/A	A cold front brought severe thunderstorms causing winds to down trees and power lines in Cowlesville. Overall, the county had approximately $25,000 in property damage from this event.
June 17, 2014	Hail	N/A	N/A	A large area of showers and thunderstorms brought strong, damaging winds and 1.25-inch sized hail in Castile.
July 8, 2014	Thunderstorm Wind	N/A	N/A	A strong cold front brought severe thunderstorms and winds, downing trees and powerlines. Overall, the county had approximately $15,000 in property damage from this event.
December 25, 2014	High Wind	N/A	N/A	A strong low pressure system pushed a cold front across the region bring strong winds that brought down power lines and trees causing an estimated $40,000 in property damage.
April 10, 2015	High Wind	N/A	N/A	Thunderstorms developed over western New York State bringing strong winds, which downed trees and power lines throughout numerous municipalities in the Genesee and Wyoming Counties. Utility companies reported power outages throughout the area with upwards of 10,000 customers without power. In Wyoming County, the Town of Albion experienced downed trees and power lines. Overall, the county had approximately $20,000 in property damage from this event.
June 12, 2015	Thunderstorm Wind	N/A	N/A	Two lines of thunderstorms produced strong winds that downed trees and power lines throughout the region. Overall, the county had approximately $15,000 in property damage from this event.
June 20, 2016	Thunderstorm Wind	N/A	N/A	Thunderstorms in the area produced damaging winds and hail that downed trees and power lines affecting Warsaw, Java, Silver Springs, Bliss, Pike, Gainesville and Eagle. Overall, the county had approximately $135,000 in property damage from this event.
July 25, 2016	Thunderstorm Wind	N/A	N/A	Strong thunderstorms produced strong winds that downed trees and power lines in Strykersville and Attica. Overall, Wyoming County had approximately $30,000 in property damage from this event.
March 1, 2017	High Wind	N/A	N/A	A powerful cold front crossed the region, bringing strong thunderstorms. The storms produced damaging winds that measured up to 62 mph in Warsaw. Trees and power lines were downed by the winds throughout the region. Overall, Wyoming County had approximately $25,000 in property damage from this event.
March 8, 2017	High Wind	N/A	N/A	A powerful front crossed the region, bringing strong thunderstorms. The storms produced damaging winds that measured up to 65 mph in Warsaw. Trees and power lines were downed by the winds throughout the region. Minor injuries were reported to drivers of

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Losses / Impacts
				tractor trailers overturned by the wind in Covington and Bennington. Overall, Wyoming County had approximately $100,000 in property damage from this event.
April 4, 2017	High Wind	N/A	N/A	Strong winds followed the passage of a cold front across the area. Wind gusts as high as 59 mph were measured. The strong winds downed trees and power lines throughout the region. A portion of Route 19 in Warsaw was closed by downed trees and wires. Overall, Wyoming County had approximately $30,000 in property damage from this event.
May 1, 2017	Thunderstorm Wind	N/A	N/A	Thunderstorms developed across the area, producing damaging winds of up to 60 mph and hail measuring up to 1 inch in diameter. Scattered power outages were reported. The storms also dropped several inches of rain in a short amount of time. Overall, Wyoming County had approximately $30,000 in property damage from this event.
June 15, 2017	Thunderstorm Wind	N/A	N/A	Severe thunderstorms moved across the area, producing strong winds and flash flooding. The winds downed trees and power lines, which led to scattered power outages in northern Erie and western Wyoming Counties. Overall, Wyoming County had approximately $25,000 in property damage from this event.
June 26, 2017	Hail	N/A	N/A	With the area under the influence of unseasonably cool air, an upper air disturbance crossed the region during the afternoon. This spawned a broken line of convection that produced hail of three-quarters to 1 inch in diameter. There was no property damage reported from this event.
July 12, 2017	Thunderstorm Wind	N/A	N/A	An isolated thunderstorm crossed Wyoming County during the evening hours. The thunderstorm winds downed trees and blew over a barn in Eagle. Overall, Wyoming County had approximately $15,000 in property damage from this event.
August 22, 2017	Thunderstorm Wind	N/A	N/A	High winds and thunderstorms impacted much of western New York State. There was no property damage reported from this event.
September 4, 2017	Thunderstorm Wind	N/A	N/A	Severe thunderstorms moved across the area, producing strong winds. The winds downed trees and power lines, and substantial damage to trees at a golf course in Attica. Overall, Wyoming County had approximately $35,000 in property damage from this event.
October 15, 2017	Thunderstorm Wind	N/A	N/A	Strong winds developed after a cold front moved across the area of Strykersville, Attica, Arcade, Warsaw, Gainesville, Perry and Castile. The winds impacted much of western New York State, with gusts measuring up to 63 mph. In Arcade, Wyoming County, a commercial sign was blown down. Several roads were closed by fallen trees and debris. Overall, the county had approximately $66,000 in property damage from this event.
April 4, 2018	High Wind	N/A	N/A	High winds and thunderstorms impacted much of western New York State. Multiple structure failures occurred, particularly in the North Country, where one man was killed by the collapse of a sugar shack. Overall, the county had approximately $20,000 in property damage from this event.
May 4, 2018	High Wind	N/A	No	A cold front brought gusts and high winds to the area. In Wyoming County, the wind gusts downed measured in excess of 58mph. There was no property damage reported from this event.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Losses / Impacts
July 5, 2018	Thunderstorm Wind	N/A	N/A	Slow-moving thunderstorms moved across the area bringing down trees on Route 78 and Strykersville Road. Overall, the county had approximately $2,000 in property damage from this event.
September 21, 2018	Thunderstorm Wind	N/A	N/A	Thunderstorms produced strong winds that downed trees and power lines in the Strykersville, Java, Warsaw, Castile and Portage areas. Overall, the county had approximately $6,500 in property damage from this event.
January 1, 2019	High Wind	N/A	N/A	Thunderstorms produced strong winds in the area. In Wyoming County, gusts were measured at 61mph. Overall, the county had approximately $5,000 in property damage from this event.
February 24, 2019	High Wind	N/A	N/A	As colder air moved in behind a front, lake effect snow developed east of the lakes with the best fetch for intense snow bands combined with wind resulting in blizzard conditions east of Lake Ontario. Overall, the county had approximately $20,000 in property damage from this event.
October 31, 2019 – November 1, 2019	High Wind	DR-4472	No	Strong winds, with gusts of up to 83 mph, developed across western New York State, downing trees and power lines. Thousands of power outages occurred across the area, and pervasive wind-related damage closed hundreds of roads. Overall, the county had approximately $500,000 in property damage from this event.

Sources: *NOAA-NCEI 2020; FEMA 2020*
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 5.4.6-9 provides the probability of occurrences of severe storm events. Based on historic occurrences, thunderstorm events are the most common in Wyoming 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 5.4.6-9. Probability of Occurrence of Severe Storm Events

Hazard Type	Number of Occurrences Between 1950 and 2019	Recurrence Interval (in years) (# Years/Number of Events)	% chance of occurrence in any given year
Hail	30	2.33	42.86%
Hurricane / Tropical Storm	0	0	0%
Lightning	0	0	0%
Strong / High Winds	46	1.52	65.71%
Thunderstorms	128	0.55	182.86%
Tornado	3	23.33	4.29%
TOTAL	**207**	**0.34**	**100%**

Source: *NOAA-NCEI 2020*
Note: *Probability was calculated using the available data provided in the NOAA-NCEI storm events database.*

It is estimated that Wyoming 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 Wyoming 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 5.3-1).

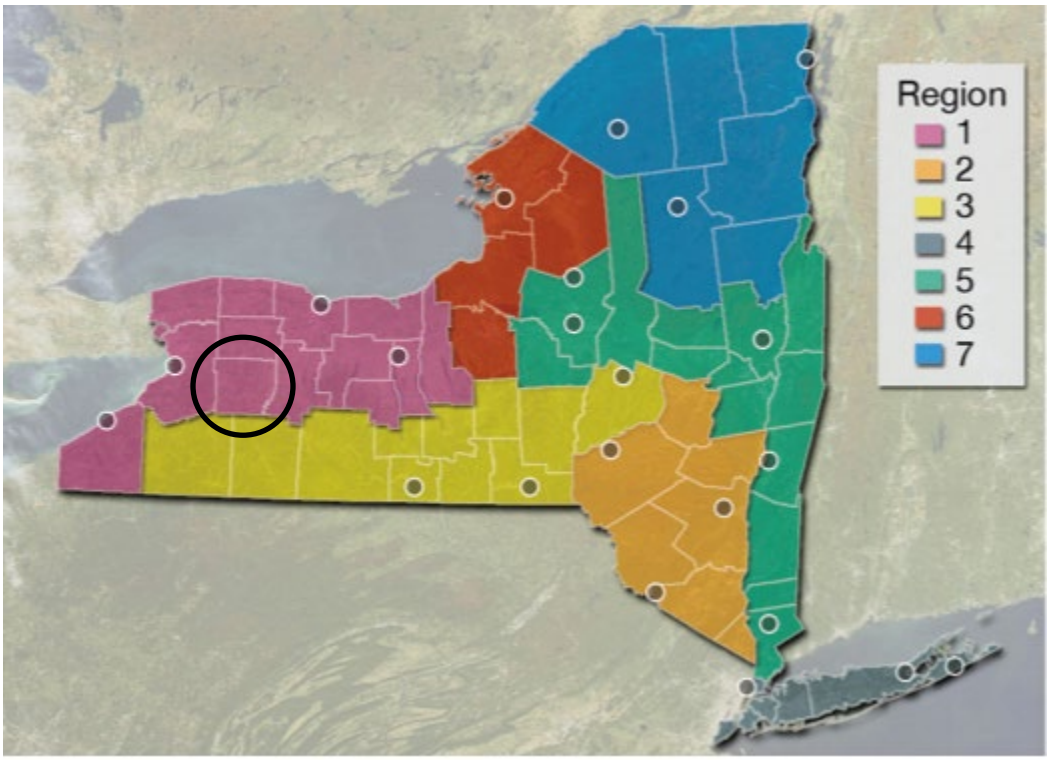
Climate Change Impacts

Climate change is beginning to affect both people and resources of Wyoming 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.

Wyoming County is part of Region 1, Western New York and the Great Lakes Plain (shown on Figure 5.4.6-3). 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 5.4.6-3. Climate Regions of New York State



Source: NYSERDA 2014
Note: Wyoming 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.

5.4.6.2 Vulnerability Assessment

To understand risk, a community must evaluate the assets exposed and vulnerable in the identified hazard area. For severe storms, the entirety of Wyoming County has been identified as the hazard area. Therefore, all assets in the county (population, structures, critical facilities and lifelines), as described in Section 4, County Profile, are vulnerable. Potential losses associated with high-wind events were calculated for the county for two probabilistic hurricane events: the 100-year and 500-year MRP hurricane events. The impacts on population, existing structures, critical facilities and the economy are presented below.

Impact on Life, Health and Safety

The impact of a severe weather event and wind on life, health and safety is dependent upon several factors including the severity of the event and whether adequate warning time was provided to residents. Hazards U.S.—Multi-Hazards (HAZUS-MH) v4.2 estimates that zero persons will be displaced from their homes or will seek shelter during a 100-year or 500-year MRP hurricane wind event. Secondary impacts caused by extreme wind events include downed trees, damaged buildings, and debris carried by high winds, which 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. Vulnerable populations include homeless persons, elderly (over 65 years old), low income or linguistically isolated populations, people with life-threatening illnesses, and residents living in areas that are isolated from major roads.

Additionally, people located outdoors (i.e., recreational activities and farming) are considered most vulnerable to hailstorms, thunderstorms and tornadoes. This is because there is little to no warning and shelter may not be available. Moving to a lower risk location will decrease a person's vulnerability. Section 4, County Profile, for population statistics for each participating jurisdiction.

Impact on General Building Stock

As discussed in Table 5.4.6-8, several thousand dollars of reported damages have occurred in Wyoming County due to severe storm events. Damage to buildings is dependent upon several factors including wind speed, wind duration, presence of hail stones or lightning, and building construction.

After considering the population exposed to the severe storm hazard, the general building stock replacement value exposed to and damaged by 100- and 500-year MRP events was examined. Wind-only impacts from a severe storm are reported based on the probabilistic model in HAZUS-MH v4.2 Potential damage is the modeled loss that could occur to the exposed inventory, including damage to structural and content value based on the wind-only impacts associated with a hurricane.

It is assumed that the entire County's general building stock is exposed to the severe storm wind hazard (greater than $8 billion). Estimated building damage was evaluated by HAZUS across the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.6-10 summarizes the definitions of the damage categories.

For both events, HAZUS-MH v4.2 estimates $0 in structure damage. However, as Table 5.4.6-8 indicates, there have been recent severe storm impacts. For instance, Wyoming County felt the effects of Hurricane Sandy in

2012 (Table 5.4.6-6). Therefore, the HAZUS-MH results are likely underestimating the potential loss to Wyoming County as a result of a wind event.

Table 5.4.6-10. 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 over, with no or very Limited water penetration.	≤2%	No	No	No	No	No
Minor Damage Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair.	>2% and ≤15%	One window, door, or garage door failure	No	<5 impacts	No	No
Moderate Damage Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.	>15% and ≤50%	> 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: FEMA 2017

Impact on Critical Facilities

HAZUS-MH v4.2 estimates the probability that critical facilities (i.e., medical facilities, fire/emergency medical services, police, emergency operations centers (EOC), schools, and user-defined facilities such as shelters and municipal buildings) may sustain damage as a result of 100-year and 500-year MRP wind-only events. Additionally, HAZUS-MH v4.2 estimates the loss of use for each facility in number of days. HAZUS-MH v4.2 estimates there is a 0-percent chance that critical facilities in Wyoming County will experience minor damage; and continuity of operations at these facilities will not be interrupted (no loss of use is estimated) as a result of the 100-year or 500-year MRP events. However, given the historical loss during previous storms, HAZUS-MH v4.2 may be underestimating the potential impacts to Wyoming County critical facilities as a result of a high wind event.

At this time, HAZUS-MH v4.2 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 transportation needs (e.g., day-to-day commuting).

Utility structures could suffer damage associated with falling tree limbs or other debris, resulting in the loss of power, which can impact business operations and can impact heating or cooling provision to citizens (including

the young and elderly, who are particularly vulnerable to temperature-related health impacts).

Impact on Economy

Severe storm events can have short- and 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.

Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting and goods transport) transportation needs. Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage and impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to the population.

For the 100-year MRP and 500-year wind events, HAZUS-MH estimates $0 in business interruption losses or inventory losses, which includes loss of income, relocation costs, rental costs and lost wages. Further HAZUS-MH estimates $0 in loss of inventory.

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 Wyoming 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 5.4.1 and Section 5.4.5, respectively.

Future Changes That May Impact Vulnerability

Understanding future changes that affect vulnerability in the county can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. Changes in the natural environment and built environment and how they interact can also provide insight about ways to plan for the future.

Projected Changes in Population

Estimated population projections provided by the 2017 Cornell Program on Applied Demographics indicates that Wyoming's population will continue to decrease into 2040, reducing total population to approximately 34,330 persons (Cornell Program on Applied Demographics, 2017). 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.

Projected Development

As discussed and illustrated in Section 4, areas targeted for future growth and development have been identified across Wyoming County. Any areas of growth could be potentially impacted by the severe storm hazard because the entire County is exposed and vulnerable to the wind hazard associated with severe storms. There are 11 sites of recent development and two sites of proposed development listed in the county.

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 5.4.1, 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

Over time, Wyoming 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). Information on particular buildings or infrastructure age or year built would also be helpful in future analysis of this hazard.