4.3.11 Severe Weather

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the severe weather hazard in Morris County.

2020 HMP Changes

- All subsections have been updated using best available data.
- Previous occurrences were updated with events that occurred between 2014 and 2019.
- The vulnerability assessment was conducted using updated population, building and critical facility/lifeline spatial data to estimate potential losses from the wind hazard using the FEMA HAZUS-MH hurricane model.

4.3.11.1 Profile

Hazard Description

For the purpose of this HMP update and as deemed appropriated by Morris County, the severe weather hazard includes hurricanes, tropical storms, thunderstorms, lightning, hailstorms, windstorms, and tornadoes which are defined in the sections below.

Hurricanes and Tropical Storm

A tropical cyclone is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain. Tropical depressions, tropical storms, and hurricanes are all considered tropical cyclones. Tropical cyclones 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. These storms rotate counterclockwise in the northern hemisphere around the center and are accompanied by heavy rain and strong winds (NWS 2013). Almost all tropical storms and hurricanes in the Atlantic basin, which includes the Gulf of Mexico and Caribbean Sea, form between June 1 and November 30 (hurricane season). August and September are peak months for hurricane development (NOAA 2013a).

Tropical cyclones are fueled by a different heat mechanism than other cyclonic windstorms such as Nor'Easters and polar lows. The characteristic that separates tropical cyclones from other cyclonic systems is that at any height in the atmosphere, the center of a tropical cyclone will be warmer than its surroundings; a phenomenon called "warm core" storm systems (NOAA 1999).

The National Weather Service (NWS) issues hurricane and tropical storm watches and warnings. These watches and warnings are issued or will remain in effect after a tropical cyclone becomes post-tropical, when such a storm poses a significant threat to life and property. The 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 cyclone. 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. The warning can remain in effect when dangerously high water or 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 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 2013a).

Thunderstorms

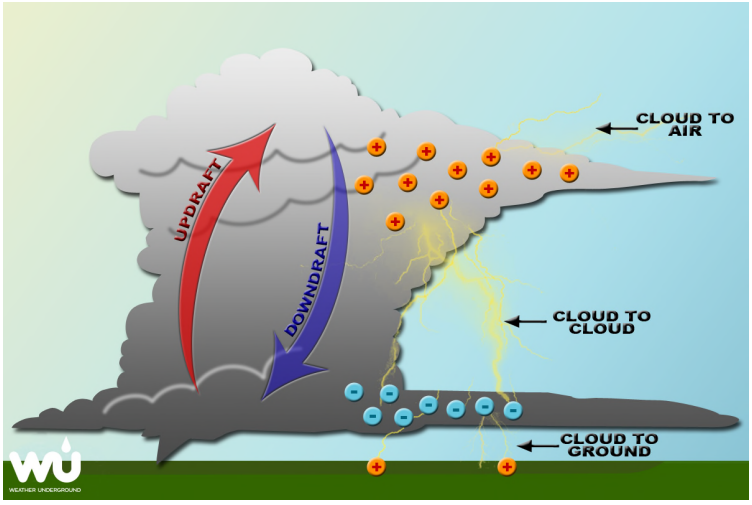
A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (National Weather Service [NWS] 2009). A thunderstorm forms from a combination of moisture; rapidly rising warm air; and a force capable of lifting air, such as a warm front, cold front, a sea breeze, 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 to generate tornadoes, hailstorms, strong winds, flash flooding, and lightning.

Thunderstorms can lead to heavy rain induced 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 loss of utility services, such as water, phone, and electricity. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. During the summer, thunderstorms are responsible for most of the rainfall.

Lightning

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. Lightning ranks as one of the top weather killers in the United States, killing approximately 50 people and injuring hundreds each year. Lightning can occur anywhere there is a thunderstorm. Lightning can be cloud to air, cloud to cloud, and cloud to ground. Figure 4.3.11-1 demonstrates the variety of lightning types.

Figure 4.3.11-1. Types of Lightning

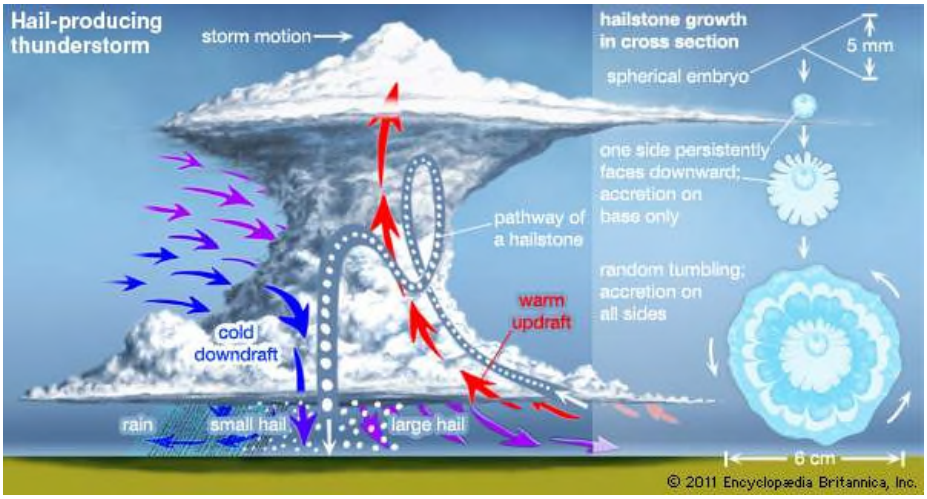


Source: Weather Underground date unknown

Hailstorms

Hail forms inside a thunderstorm or other storms with 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 degrees Fahrenheit (°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 (NWS 2010). Figure 4.3.11-2 shows how hail is formed within thunderstorms.

Figure 4.3.11-2. Hail Formation in Thunderstorms



Source: Encyclopedia Britannica 2011

Windstorms

Wind begins with differences in air pressures and occurs through 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. High winds are often associated with other severe weather events such as thunderstorms, tornadoes, nor'easters, hurricanes, and tropical storms.

Tornadoes

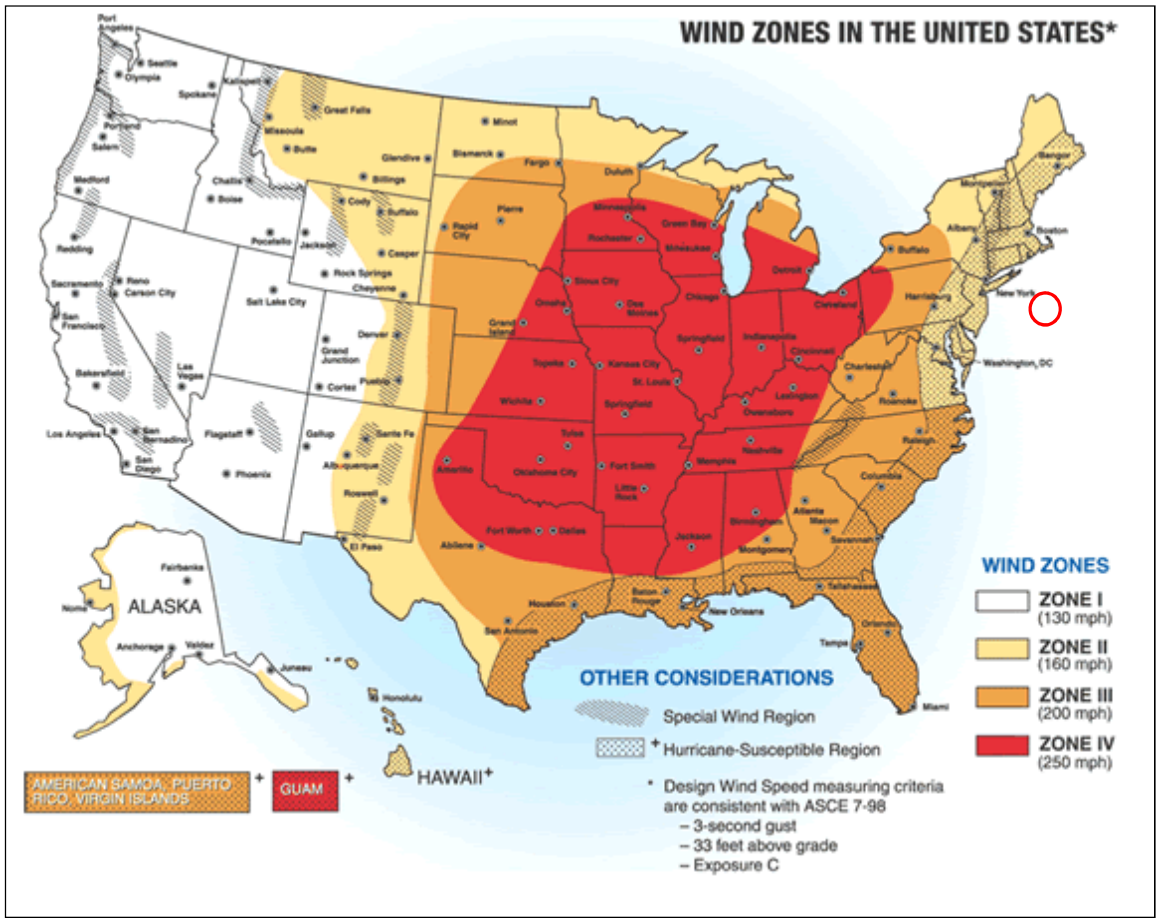
A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 250 miles per hour (mph). Damage paths can be greater than 1 mile wide and 50 miles long. Tornadoes typically develop from either a severe thunderstorm or hurricane as cool air rapidly overrides a layer of warm air. Tornadoes typically move at speeds between 30 and 125 mph and can generate combined wind speeds (forward motion and speed of the whirling winds) exceeding 300 mph. The lifespan of a tornado rarely is longer than 30 minutes (FEMA 1997). Tornadoes can occur at any time of the year, with peak seasons at different times for different states (National Severe Storms Laboratory [NSSL] 2013).

Location

All of Morris County is exposed to severe weather. According to the FEMA Winds Zones of the United States map, Morris County is located in Wind Zone II, where wind speeds can reach up to 160 mph and is part of the

hurricane susceptible region. Figure 4.3.11-3 illustrates wind zones across the United States, which indicate the impacts of the strength and frequency of wind activity per region. The information on the figure is based on 40 years of tornado data and 100 years of hurricane data collected by FEMA.

Figure 4.3.11-3. Wind Zones in the United States



Source: *FEMA 2012*
Note: *The red circle indicates the approximate location of Morris County.*

Extent

Hurricane and Tropical Storm

The extent of a hurricane is commonly 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 2013b). Table 4.3.2-1 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes landfall.

Table 4.3.11-1. The Saffir-Simpson Scale

Category	Wind Speed (mph)	Expected Damage
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 branches of trees 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 numerous 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 could 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/or 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: NOAA 2013b
Notes: mph = Miles per hour
> = Greater than

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. MRP is the average period, in years, between occurrences of a particular hazard event, equal to the inverse of the annual frequency of exceedance (Dinicola 2009).

Figure 4.3.11-4 and Figure 4.3.11-5 show the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP events. These peak wind speed projections were generated using Hazards U.S. Multi-Hazard (HAZUS-MH) model runs. The maximum 3-second gust wind speeds for Morris County range from 63.9 mph to 71.8 mph hurricane speeds for the 100-year MRP event and from 81 mph to 90 mph hurricane speeds for the 500-year MRP event. The associated impacts and losses from these 100-year and 500-year MRP hurricane event model runs are reported in the Vulnerability Assessment later in this section.

Figure 4.3.11-4. Wind Speeds for the 100-Year Mean Return Period Event Represented by the Saffir Simpson Scale

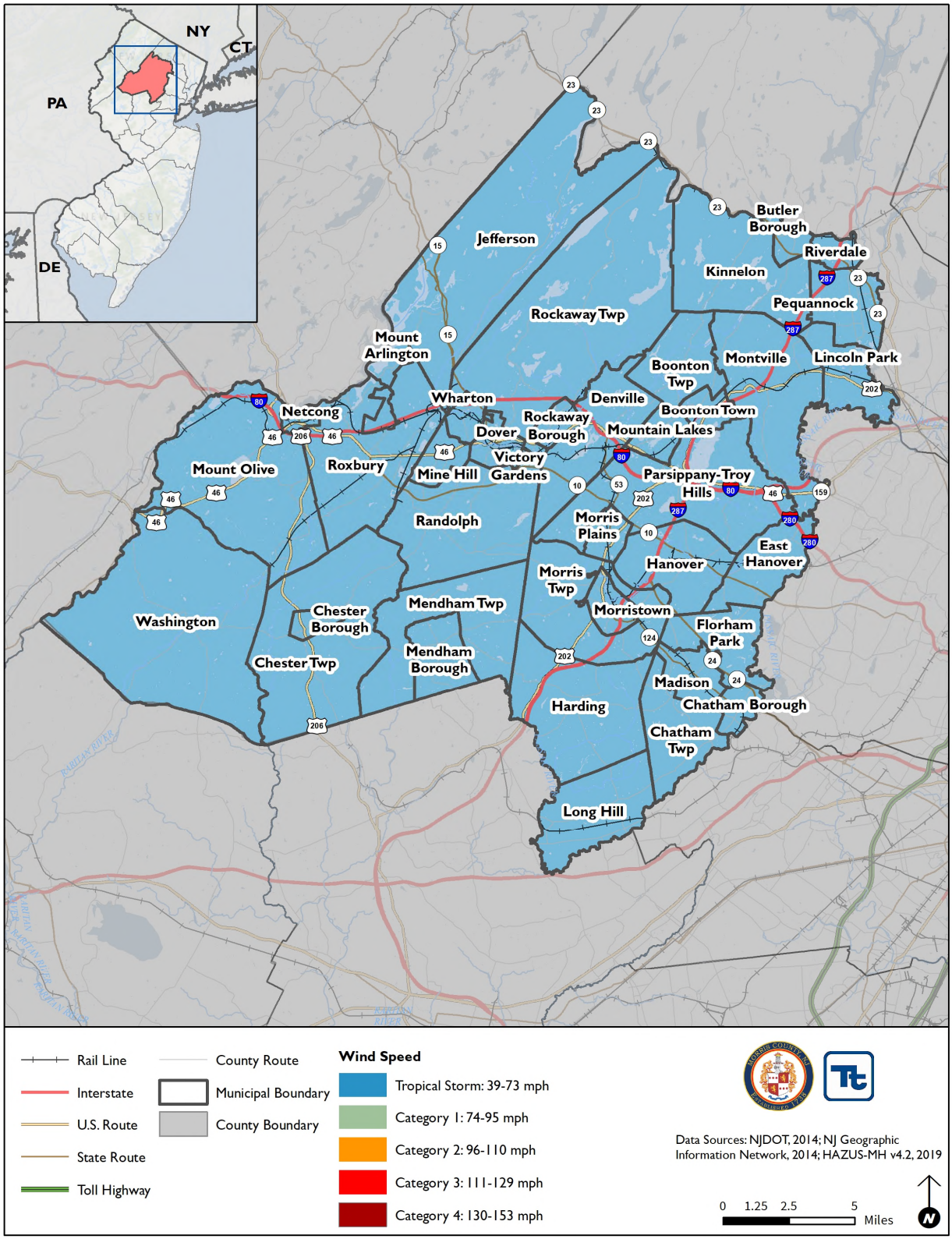
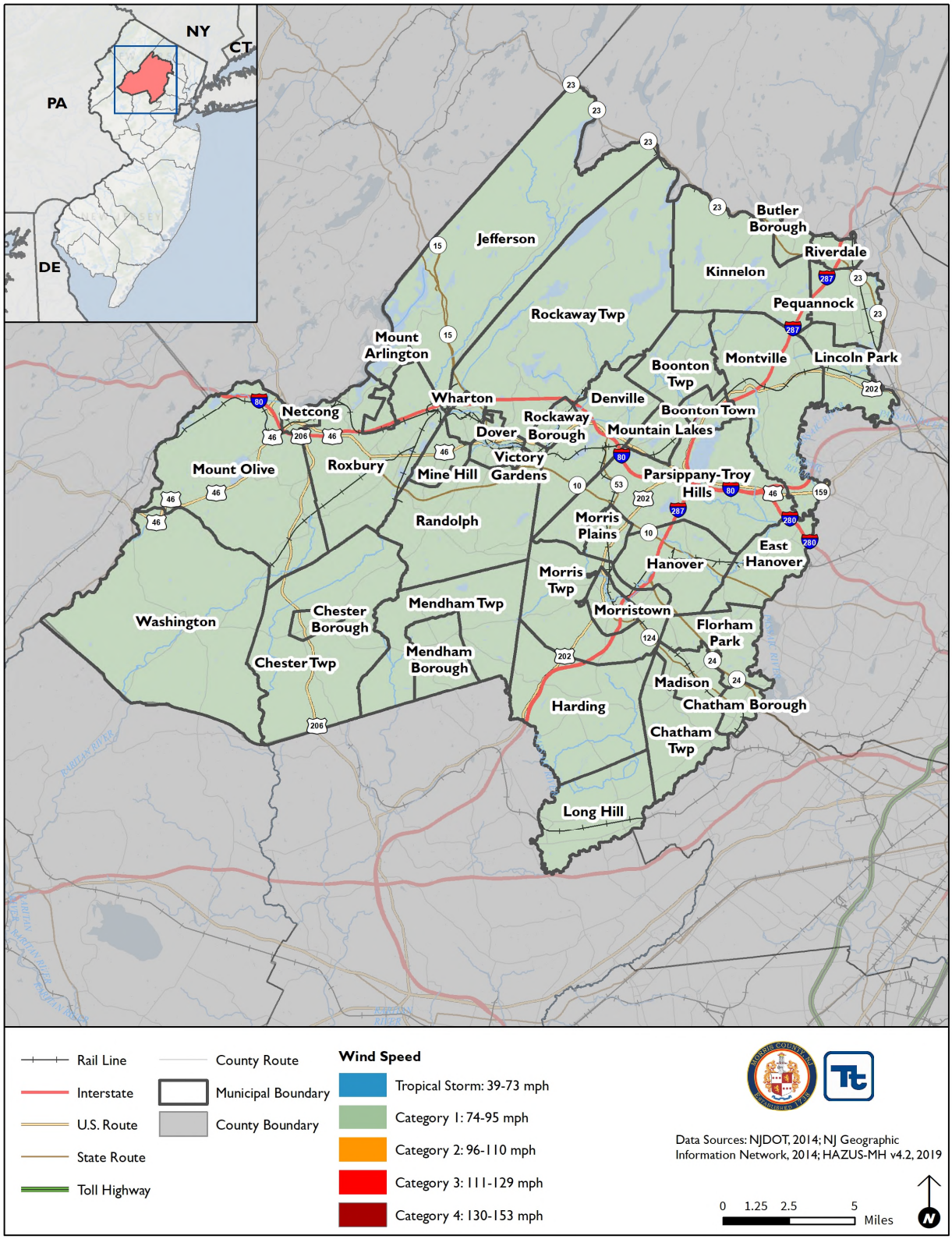


Figure 4.3.11-5. Wind Speeds for the 500-Year Mean Return Period Event by the Saffir Simpson Scale



The extent (severity or magnitude) of a severe storm is largely dependent upon the most damaging aspects of each type of severe weather. This section describes the extent of thunderstorms, lighting, hail, windstorms, and tornadoes in Morris County. Historical data presented in Table 4.3.11- shows the most powerful severe weather records in Morris County.

Table 4.3.11-2. Severe Storm Extent in Morris County (1950-2019)

Extent of Severe Storms in Morris County	
Largest Hailstone on Record	2.5 inches
Strongest Tornado on Record	F-3
Highest Wind Speed on Record	70 knots

Source: NOAA-NCEI 2019

Thunderstorms

NWS considers a thunderstorm severe if it produces damaging wind gusts of 58 mph or higher, hail 1 inch (quarter size) in diameter or larger, or tornadoes (NWS 2010). Severe thunderstorm watches and warnings are issued by the local NWS office and NOAA's Storm Prediction Center (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 Jersey are defined as follows:

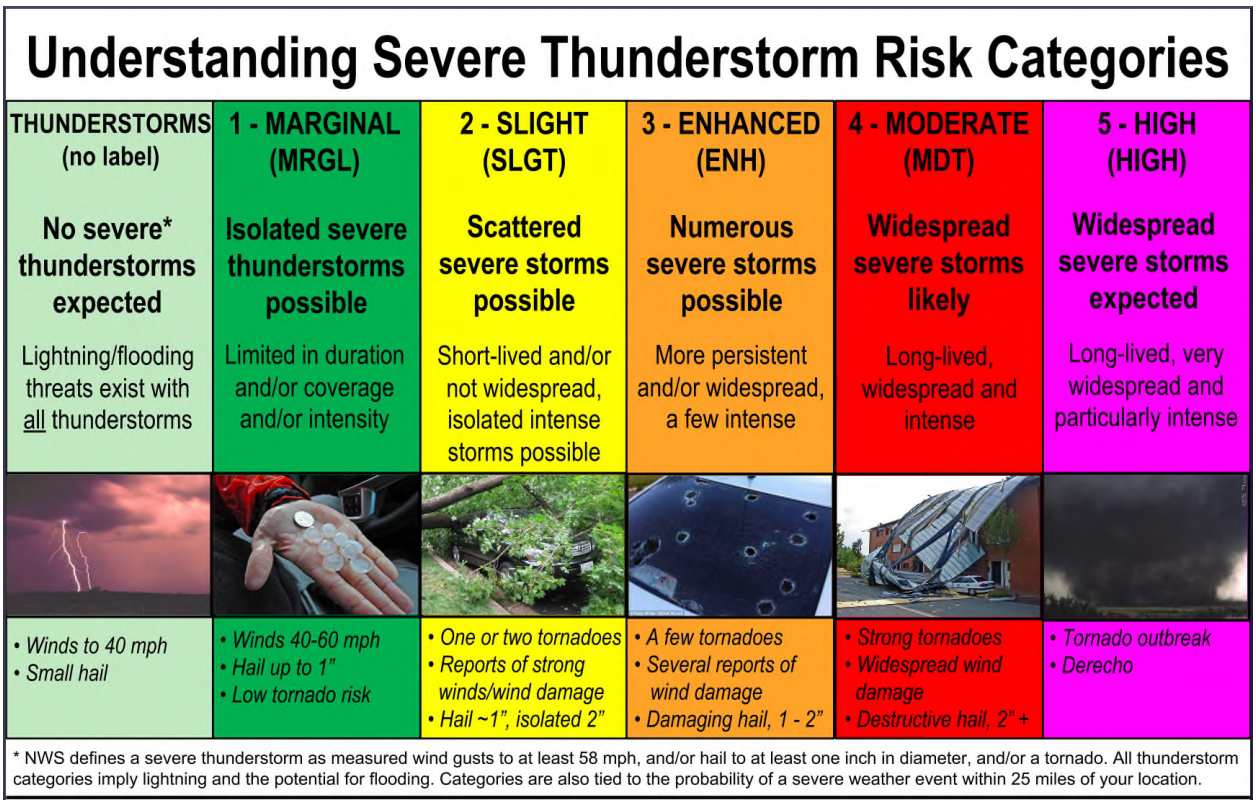
- *Severe Thunderstorm Warnings* are issued when there is evidence based on radar or a reliable spotter report that a thunderstorm is producing (or is forecast to produce) wind gusts of 58 mph or greater, structural wind damage, and hail 1 inch in diameter or greater. A warning will include the location of the storm, the municipalities that are expected to 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 (NWS 2010).

- *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, NWS will keep the public informed on developments happening in the watch area and will also notify the public when the watch has expired or been cancelled (NWS 2010).

- *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 one (1) inch in diameter (NWS 2010).

In addition, the SPC issues severe thunderstorm risk maps based on the likelihood of different severities of thunderstorms. Figure 4.3.11- shows the SPC's severe thunderstorm risk categories.

Figure 4.3.11-6. Severe Thunderstorm Risk Categories



Source: NOAA SPC 2017

Lightning

Lightning is most often associated with moderate to severe thunderstorms. The severity of lightning refers to the frequency of lightning strikes during a storm. Multiple devices are available to track and monitor the frequency of lightning.

Hail

The severity of a hail storm is measured by duration, hail size, and geographic extent. Most hail stones from hail storms are made up of variety of sizes. The size of hail is estimated by comparing it to a known object. Table 4.3.11- describes the different sizes of hail as compared to real-world objects and lists approximate measurements.

Table 4.3.11-3. 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	2.5
Nickel	0.88	Baseball	2.75

Description	Diameter (in inches)
Quarter	1.00
Half dollar	1.25
Walnut or ping pong ball	1.50

Description	Diameter (in inches)
Tea cup	3.00
Grapefruit	4.00
Softball	4.50

Source: NOAA 2012

Windstorms

Table 4.3.11- provides the NWS descriptions of winds during wind-producing events.

Table 4.3.11-4. 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 2015

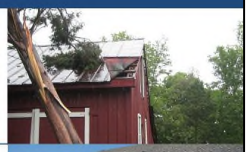
NWS issues advisories and warnings for winds, which are normally site-specific. High wind advisories, watches, and warnings are issued by the NWS when wind speeds may pose a hazard or may be life threatening. The criterion for each of these varies from state to state. Wind warnings and advisories for New Jersey 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 are forecast for any duration.
- *Wind Advisories* are issued when sustained winds of 30 to 39 mph are forecast for one 1 hour or longer, or wind gusts of 46 to 57 mph are forecast for any duration (NWS 2015).

Tornado

The magnitude or severity of a tornado is categorized using the Enhanced Fujita Tornado Intensity Scale (EF Scale). Figure 4.3.11- illustrates the relationship between EF ratings, wind speed, and expected tornado damage.

Figure 4.3.11-7. Enhanced Fujita Tornado Intensity Scale Ratings, Wind Speeds, and Expected Damage

EF Rating	Wind Speeds	Expected Damage	
EF-0	65-85 mph	'Minor' damage: shingles blown off or parts of a roof peeled off, damage to gutters/siding, branches broken off trees, shallow rooted trees toppled.	 
EF-1	86-110 mph	'Moderate' damage: more significant roof damage, windows broken, exterior doors damaged or lost, mobile homes overturned or badly damaged.	 
EF-2	111-135 mph	'Considerable' damage: roofs torn off well constructed homes, homes shifted off their foundation, mobile homes completely destroyed, large trees snapped or uprooted, cars can be tossed.	 
EF-3	136-165 mph	'Severe' damage: entire stories of well constructed homes destroyed, significant damage done to large buildings, homes with weak foundations can be blown away, trees begin to lose their bark.	 
EF-4	166-200 mph	'Extreme' damage: Well constructed homes are leveled, cars are thrown significant distances, top story exterior walls of masonry buildings would likely collapse.	 
EF-5	> 200 mph	'Massive/incredible' damage: Well constructed homes are swept away, steel-reinforced concrete structures are critically damaged, high-rise buildings sustain severe structural damage, trees are usually completely debarked, stripped of branches and snapped.	 

Source: NWS 2018

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 (NOAA 2011).

Previous Occurrences and Losses

Between 1954 and January 2019, Morris County has been included in 15 declarations for severe storm-related events classified as one or a combination of the following disaster types: severe storm, straight-line winds, tornado, or hurricane (FEMA 2019). Table 4.3.11- lists these events.

Table 4.3.11-5. Severe Storm-related FEMA Disaster Declarations

Declaration	Event Date	Declaration Date	Event Description
DR-1145	October 18-23, 1996	November 19, 1996	Severe Storms & Flooding
EM-3148	September 16-18, 1999	September 17, 1999	Hurricane: Hurricane Floyd Emergency Declarations

Declaration	Event Date	Declaration Date	Event Description
DR-1295	September 16-18, 1999	September 18, 1999	Hurricane: Hurricane Floyd Major Disaster Declarations
DR-1337	August 12-21, 2000	August 17, 2000	Severe Storms, Flooding & Mudslides
DR 1588	April 1-3, 2005	April 19, 2005	Severe Storm(s): Severe Storms and Flooding
DR-1694	April 14-20, 2007	April 26, 2007	Severe Storm(s): Severe Storms and Inland and Coastal Flooding
DR-1897	March 12-April 15, 2010	April 2, 2010	Severe Storm(s): Severe Storms and Flooding
EM-3332	August 26-September 5, 2011	August 27, 2011	Hurricane: Hurricane Irene
DR-4021	August 27-September 5, 2011	August 31, 2011	Hurricane: Hurricane Irene
DR-4048	October 29, 2011	November 30, 2011	Severe Storm
EM-3354	October 26-November 8, 2012	October 28, 2012	Hurricane: Hurricane Sandy
DR-4086	October 26-November 8, 2012	October 31, 2012	Hurricane: Hurricane Sandy
DR-4264	January 22-24, 2016	March 14, 2016	Severe Winter Storm and Snowstorm
DR4368	March 6-7, 2018	June 8, 2018	Severe Winter Storm and Snowstorm

Source: FEMA 2019

Agriculture-related drought disasters are quite common. The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. In 2018, Morris County was included in declaration S4454 for excessive rain and moisture and declaration S4455 for the combined effects of excessive rainfall, moisture, and storm-force winds from Hurricane Florence. In June 2017, indemnities for excessive moisture for all other crops totaled $1,552. In June 2018, indemnities for excessive moisture for all other crops totaled $14,892. In August 2018, indemnities for excessive moisture for all other crops totaled $13,596.

Severe weather events that have impacted Morris County between 2014 and 2019 are identified in Table 4.3.11-. With severe weather documentation for New Jersey and Morris County being so extensive, not all sources have been identified or researched. Therefore, Table 4.3.11- may not include all events that have occurred in the County. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

Table 4.3.11-6. Severe Weather Events in Morris County, 2014 to 2019

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Morris County Designated?	Location	Description
January 6, 2014	Strong Wind	N/A	N/A	Morris County	A strong cold front produced strong gusty west winds as it moved through New Jersey between 730 a.m. EST and 930 a.m. EST on the 6th. The cold frontal passage initiated the onslaught of a brutally cold arctic air mass that peaked the next day. Peak wind gusts were around 45 mph and knocked over weak tree limbs and wires. $0.1K in property damages were reported.
March 12, 2014	High Wind	N/A	N/A	Morris County	The strong pressure gradient (difference) between an intensifying strong low-pressure system and a high-pressure system in the Ohio Valley caused high to strong northwest winds to occur across New Jersey from the evening of the 12th following a cold frontal passage through the daytime hours on the 13th. Peak wind gusts averaged around 50 mph, with some gusts as high as around 60 mph. The strongest winds occurred overnight on the 12th. The high winds damaged the roof of one store in Morris County. In addition, the prolonged period of strong winds caused weak tree limbs, trees and power lines to be knocked down and caused widely scattered power outages. About 1,700 homes and businesses in NJ lost power and a number of roadways were closed because of downed trees and limbs. $25K in property damages were reported.
June 13, 2014	Thunderstorm Wind	N/A	N/A	Chester, Ironia, Greystone Park	An approaching cold front helped trigger some strong to locally severe thunderstorms across northwestern New Jersey during the late afternoon of the 13th. Hardest hit was Warren and Morris Counties. Jersey Central Power and Light reported over 1,500 of its customers lost power. Downed trees forced the suspension of travel along one commuter rail line between Warren and Morris Counties. A Skywarn spotter estimated wind gusts of 50 to 60 mph during a severe thunderstorm in Chester Township. Trees were knocked down in Randolph Township. A severe thunderstorm knocked trees down across railroad tracks in Morris Plains. This forced the suspension of New Jersey Transit commuter rail service between Morristown and Hackettstown.
July 3, 2014	Hail	N/A	N/A	Mount Arlington, Espamong, Milton, Green Pond	For the second consecutive day, a cluster of strong to severe thunderstorms affected central and northern New Jersey during the late afternoon and early evening of the 3rd. About 33,000 homes and businesses lost power throughout the state from the combination of wind damage and lightning strikes. Counties that suffered most of the outages were Cumberland, Hunterdon, Morris, Ocean and Sussex Counties. A severe thunderstorm dropped quarter size hail in Mount Arlington Borough. A severe thunderstorm knocked down a few trees and wires in the

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Morris County Designated?	Location	Description
					Lake Hopatcong area of Jefferson Township. A severe thunderstorm dropped hail as large as tennis balls in the Oak Ridge section of Jefferson Township.
July 9, 2014	Thunderstorm Wind	N/A	N/A	Succasunna	A lee side trough and an unstable air mass produced scattered strong to severe thunderstorms across portions of northeast Pennsylvania and northern New Jersey during the late afternoon to evening of the 9th. A severe thunderstorm knocked down a couple of trees along Tamarack Drive and Hawthorn Drive in Roxbury Township.
July 15, 2014	Lightning	N/A	N/A	Stirling	An approaching cold front helped trigger a series of strong to severe thunderstorms that produced large hail, damaging winds as well as lightning damage and flash flooding during the afternoon and evening of the 15th. A lightning strike caused power outages and disrupted 911 communications in Long Hill Township. $10K in property damages were reported.
October 2, 2015	Strong Wind	N/A	N/A	Morris County	Strong, gusty northwest winds occurred in the wake of a departing and intensifying low pressure system during the late afternoon into the middle of the evening on the 2nd in New Jersey. Peak wind gusts average around 50 mph and knocked down weak trees, tree limbs and wires. Scattered power outages occurred. This was further exacerbated by snow and ice on tree limbs in the northwest part of the state.
February 15, 2015	Strong Wind	N/A	N/A	Morris County	The increasing pressure difference (gradient) between a rapidly intensifying low-pressure system offshore and an arctic high-pressure system moving east from the Great Lakes caused strong to high damaging northwest winds to occur in New Jersey from the late evening of the 14th into the afternoon of the 15th. Strong wind gusts started late in the evening on the 14th, peaked during the morning of the 15th and continued into the afternoon of the 15th. In the northern half of the state, peak wind gusts averaged 45 to 50 mph. The strong to high winds caused isolated property damage (mainly stripped siding), knocked down or snapped numerous trees and tree limbs. This resulted in downed wires and power outages. The strong to high winds hampered road crews trying to keep roadways clear from the snow that fell on the 14th. It also ushered into New Jersey one of the coldest air masses of the entire winter season. The wind also caused the cancellation of several events. Speed limits on the Garden State Parkway were reduced.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Morris County Designated?	Location	Description
					Peak wind gusts included 46 mph in Lincoln Park.
April 4, 2015	Strong Wind	N/A	N/A	Morris County	Strong, gusty northwest winds circulating around an intensifying low-pressure system and approaching high pressure system had the greatest impact across northern New Jersey and coastal southern New Jersey during the second half of the morning into the afternoon on the 4th. Peak wind gusts in these areas reached between 45 mph and 50 mph and knocked down weak tree limbs and wires. The strong winds followed the passage of a cold front in New Jersey during the early morning on the 4th.
May 27, 2015	Thunderstorm Wind	N/A	N/A	Morris Plains	A lee side trough coupled with an unseasonably warm air mass triggered scattered thunderstorms in New Jersey during the late afternoon and early evening on the 27th. A couple of the thunderstorms were severe. A severe thunderstorm knocked down trees and power lines in Morris Plains.
April 3, 2016	High Wind	N/A	N/A	Morris	A strong cold front associated with a low-pressure system moving through New York State swept across the area during the late evening hours of April 2nd and early morning hours of April 3rd, accompanied by thunderstorms, very strong convectively driven winds, and small hail. As colder air behind this front drained south, precipitation changed to snow, with up to three inches falling in the higher elevations of northwest New Jersey and lesser amounts in isolated spots through most of New Jersey. Some reported peak wind gusts included: 45 MPH near Livingston at 0526EST (Morris County. Some snowfall measurements included: 0.3 inches in Jefferson Township (Morris County). 81,000 were without power across the state. Numerous trees and wires were reported down across Morris County due to high winds.
June 28, 2016	Thunderstorm Wind, Hail	N/A	N/A	Callahans, Morristown	A cold front moved eastward into the region during the late afternoon and evening hours of the 28th. Thunderstorms formed ahead of the cold front and produced hail, strong winds and flash flooding. Hail was measured at ¾ inch in diameter in Callahans and Jefferson Township during a thunderstorm. Thunderstorm winds knocked a large tree onto interstate 287 near exit 30.
July 8, 2016	Thunderstorm Wind, Hail	N/A	N/A	Succasunna, Budd Lake, Flanders, Chester, Mendham	A stationary frontal boundary was present over the region on the 8th. This allowed for the development of showers and thunderstorms. Heavy rainfall along with strong to severe thunderstorms occurred formed as instability grew in the afternoon. In Succasunna, trees were taken down by thunderstorm wind gusts. Hail from a thunderstorm was measured at ¾ inch in diameter in Budd Lake and Flanders with multiple trees taken down. Trees were also taken down in Chester and Mendham

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Morris County Designated?	Location	Description
July 14, 2016	Thunderstorm Wind	N/A	N/A	Morristown, New Vernon	A trough of low pressure ahead of a cold front led to the development of several clusters of showers and thunderstorms. Some of these thunderstorms became severe producing damaging winds. A 53-mph wind gust was measured at the Morristown Municipal Airport. Several thousand were left without power, mainly in Morris and Warren Counties. Thunderstorm winds took down numerous trees. Several trees downed and uprooted due to thunderstorm winds on Woodland Ave in New Vernon.
July 25, 2016	Thunderstorm Wind, Lightning	N/A	N/A	Green Pond, Hanover	A trough of low pressure led to the development of afternoon and evening showers and thunderstorms which became severe in spots and produced locally heavy rains. 40,000 were left without power across the state. In Green Pond, trees were downed throughout the area due to thunderstorm winds. A house on Gaspar Ave. in Hanover was struck by lightning and caught on fire.
July 30-31, 2016	Thunderstorm Wind, Heavy Rain	N/A	N/A	Morristown, Cedar Knolls, Butler, Morris Plains, Denville, Boonton, Powerville	Several clusters of thunderstorms associated with several shortwaves and a cold front became nearly stationary over Mercer County on the 29th and Hunterdon County on the morning of the 30th. Heavy rainfall over 5 inches occurred in these areas. The persistent heavy rain resulted in severe flash flooding including a state of emergency being issued in West Windsor Twp. Thousands were left without power as a result of the storms. Trees and wires down on Western Ave in Morristown due to thunderstorm winds. Trees were taken down at the intersection of 202 and route 10 in Morris Plains due to thunderstorm winds. In Butler and Morris Plains, just over two inches of rain fell in 12 hours from thunderstorms.
September 14, 2016	Thunderstorm Wind	N/A	N/A	Lake Telemark	A cluster of thunderstorms developed ahead of a cold front and moved across northern New Jersey during the late afternoon hours of the 14th. Some of the thunderstorms produced damaging winds. Large portions of trees were taken down in Lake Telemark due to thunderstorm winds.
September 19, 2016	Heavy Rain	N/A	N/A	Boonton	The remnants of tropical storm Julia and a frontal boundary interacted leading to several rounds of rainfall over the region. In Boonton, just under three and a quarter inches of rain was measured.
February 13, 2017	High Wind	N/A	N/A	Morris County	High winds blew through the area after a cold frontal passage, enough to lead to downed trees and wires during the day of the 13th and from a severe squall line early on the 13th. Temperatures were also cold enough with the main low-pressure system along the front to produce a wintry mix across northern portions of the state. Snow accumulations averaged around an inch in Morris County. A 57-mph thunderstorm wind gust was measured at the Morris NJWXNET site just before midnight on the 13th. Several thousand power outages were reported with some lasting 24 hours in Sussex and Morris counties. Tree fell onto

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Morris County Designated?	Location	Description
					power lines due to a wind gust and the Morris/Essex rail station, suspending service for a time.
March 13, 2017	High Wind	N/A	N/A	Morris County	High winds blew through the area after a cold frontal passage, enough to lead to downed trees and wires during the day of the 13th and from a severe squall line early on the 13th. Temperatures were also cold enough with the main low-pressure system along the front to produce a wintry mix across northern portions of the state. Snow accumulations averaged around an inch in Morris County. Further south, a squall line of thunderstorms moved through resulting in some wind damage around midnight on the 13th. A 57-mph thunderstorm wind gust was measured at the Morris NJWXNET site just before midnight on the 13th. Several thousand power outages were reported with some lasting 24 hours in Sussex and Morris counties. A tree fell onto a car and knocked power poles down at the intersection of Hoagland and Halsey Ave. Wind knocked down a power line along Highway 46 at the intersection of Foxhill Road. Power lines downed in Mt. Lakes area that closed Route 46.
July 7, 2017	Heavy Rain	N/A	N/A	Morris Plains	A stationary frontal boundary draped across the Delaware Valley lead to a period of heavy rainfall during the morning of July 7th. Widespread rainfall amounts over 2 inches occurred which lead to flooding.
August 2, 2017	Hail, Thunderstorm Wind	N/A	N/A	Morris Plains	A hot and humid airmass with weak boundaries led to slow moving strong to severe thunderstorms with damaging winds, hail and flooding. Over 2,000 people lost power.
August 22, 2017	Thunderstorm Wind	N/A	N/A	Long Valley, Convent Station	Severe thunderstorms formed in a hot and humid airmass ahead of a cold front. Thunderstorm winds took down trees and power poles in Long Valley. Thunderstorm winds blew a tree down onto I-287 Convent Station.
September 16, 2017	Heavy Rain	N/A	N/A	Morristown	A series of disturbances in the jet stream and a weak surface trough lead to sufficient lift within a tropical air mass to produce slow moving, heavy rain showers across portions of New Jersey. This led to localized urban and poor drainage flooding during the evening of Saturday, September 16th. In Morristown, heavy rain showers lead to localized urban and poor drainage flooding during the evening of Saturday, September 16th. A HADS Sensor near Birch Hills measured a two-hour rainfall total of 1.84 inches.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Morris County Designated?	Location	Description
March 2, 2018	High Wind	N/A	N/A	Morris County	A cold front stalled across the region on March 1st. Meanwhile, a wave of low pressure developed along this front in the Ohio Valley and move east, deepening just southeast of Long Island on March 2nd. This large and very deep area of low pressure moved slowly east over the open waters of the North Atlantic Ocean through Sunday March 4th. This led to a variety of weather hazards during this time frame. Strong Northwest winds with gusts up to around 60 mph occurred on March 2nd and 3rd. This led to widespread damage to trees and power lines, causing extensive power outages across the region. A downed tree closed three lanes of I-287 near Morristown. A downed tree closed the southbound lane of Rt. 206 at Drakesdale Road in Mount Olive Township. At one point during the event, more than 14,000 customers were without power in Morris County. A wind gust of 49 mph was recorded by the AWOS unit at Morristown Airport at 1145EST on March 2nd.
June 18, 2018	Thunderstorm Wind	N/A	N/A	Convent Station	Severe thunderstorms caused wind damage across portions of New Jersey. One person died and one other person critically injured when a tree fell onto a moving car traveling on Ford Road. Person died on June 22, 2018.
August 3, 2018	Funnel Cloud, Thunderstorm Wind	N/A	N/A	Green Pond, Morristown	Strong to severe thunderstorms moved northward across New Jersey ahead of a previously stalled long-wave trough that had begun to progress off to the east. Storms were progressive as they moved off to the north. Little to no damage occurred. A video was shared showing a waterspout over Green Pond. Time estimated from weak rotation on radar. No damage or injuries were reported. Reporter states waterspout lasted for about one minute. In Morristown, there were several reports of trees and wires being down. There was also a report of a tree falling on a car, but no injuries were reported.
October 2, 2018	Thunderstorm Wind	N/A	N/A	Convent Station	Supercellular severe thunderstorms caused wind damage across the region. In Convent Station a tree was reported down on Bradwahl Drive.
February 25, 2019	High Wind	N/A	N/A	Morris County	A departing very deep cyclone combined with strong high pressure to the west yielded a strong pressure gradient from the Plains eastward to the northern Mid-Atlantic and New England regions. High winds gusting 50-60 mph resulted in scattered power outages and trees down across the region. Some minor structural damage also occurred. In Morris Plains, West Hanover Road was closed due to a fallen utility pole and power lines.
March 15, 2019	Hail, Thunderstorm Wind	N/A	N/A	Mendham, Denville	A strong cold front associated with the remnants of the famed bomb cyclone marched across Pennsylvania on March 15, producing a narrow and brief line of severe thunderstorms with damaging winds. Hail of one inch in diameter was reported as a severe thunderstorm within a stronger line of storms moved across Morris County. In Denville, a tree was reported to be down on a home on Park Road causing significant structural damage.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Morris County Designated?	Location	Description
May 19, 2019	Thunderstorm Wind, Funnel Cloud	N/A	N/A	Mount Tabor, Ironia	A warm front moved through the mid-Atlantic on the morning of May 19. This set the stage for the warmest day of the year to that point for most of the region. The combination of daytime heating and a pre-frontal trough ahead of an approaching cold front led to thunderstorm development late in the day. Thunderstorms organized into a line which produced pockets of wind damage over eastern Pennsylvania and northern New Jersey. With the loss of daytime heating, storms weakened as they moved to the northeast. Multiple large trees were uprooted with several small pine trees snapped in Mount Tabor. A trained spotter reported a funnel cloud at the base of a rotating thunderstorm in Ironia.
May 28, 2019	Hail	N/A	N/A	Mount Freedom	Severe supercellular storms developed and moved into the region from the west during the mid to late afternoon hours. Storms produced large hail, damaging wind gusts, and 2 tornadoes. Half dollar sized hail was reported.

Source: FEMA 2019; NCEI 2019; NWS 2019; SPC 2019; NJOEM 2019; NHC 2019; NOAA 2019
DR Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph miles per hour
N/A Not Applicable

Probability of Future Occurrences

Morris County is expected to continue experiencing direct and indirect impacts of severe weather annually. These storms may induce secondary hazards such as flooding and utility failure. Since 1861, 31 tropical storms or cyclones have come within 50 miles of Morris County. Based on these statistics, Morris County can expect the impacts of a nearby hurricane or tropical storm every 16 years.

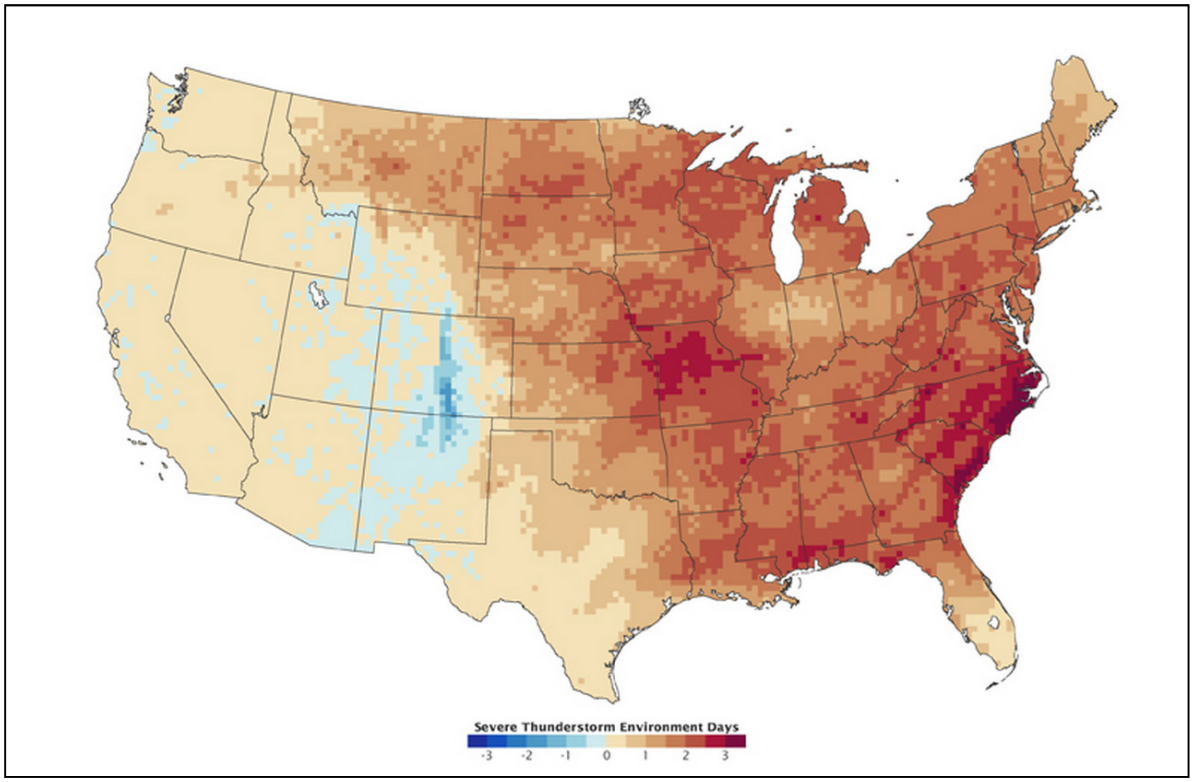
In Section 4.4, the identified hazards of concern for Morris County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for severe weather in the County is considered 'frequent'.

Climate Change Impacts

New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over five inches (12-percent) greater than the average from 1895-1970 (Sustainable Jersey Climate Change Adaptation Task Force [CATF] 2011). The heaviest 1% of daily rainfalls have increased by approximately 70% between 1958 and 2011 in the Northeast (Horton et al. 2015). Average annual precipitation is projected to increase in the region by four to 11-percent by the 2050s and five to 13-percent by the 2080s (New York City Panel on Climate Change [NPCC] 2015).

As the climate changes, temperatures and the amount of moisture in the air will both increase, thus leading to an increase in the severity of thunderstorms which can lead to derechos and tornadoes. Studies have shown that an increase in greenhouse gases in the atmosphere would significantly increase the number of days that severe thunderstorms occur in the southern and eastern United States (National Aeronautics and Space Administration [NASA] 2005).

Figure 4.3.11-4. Predicted Change in Severe Thunderstorm Environment Days from the 1962-1989 Period to the 2072-2099 Period



Source: Trapp et. al. 2007

Average annual temperatures have increased by 3°F in New Jersey over the past century (NOAA NCEI 2019). Most of this warming has occurred since 1970. The State of New Jersey, for example, has observed an increase in average annual temperatures of 1.2°F between the period of 1971-2000 and the most recent decade of 2001-2010 (CATF 2011). Winter temperatures across the Northeast have seen an increase in average temperature of 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007). By the 2020s, the average annual temperature in New Jersey is projected to increase by 1.5°F to 3°F above the statewide baseline (1971 to 2000), which was 52.7°F. By 2050, the temperature is projected to increase 3°F to 5°F (Sustainable Jersey Climate Change Adaptation Task Force 2013).

4.3.11.2 Vulnerability Assessment

A probabilistic assessment was conducted for the 100- and 500-year MRPs through a Level 2 analysis in HAZUS-MH to analyze the severe weather hazard and provide a range of loss estimates due to wind impacts. A qualitative assessment was conducted to analyze the other severe weather hazards for Morris County. Quantified residual impacts from severe weather such as flooding can also be reviewed in Section 4.3.6 (Flood). Refer to Section 4.2 (Methodology and Tools) for additional details on the methodology used to assess severe weather risk.

Impact on Life, Health and Safety

The impact of a severe weather 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. The entire population of Morris

County (498,847) is exposed to this hazard (2013-2017 American Community Survey 5-Year Population Estimate).

Lightning can be responsible for deaths, injuries, and property damage. 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 on the severity of the strike. Additionally, most people struck by lightning survive, although they may have severe burns and internal damage. People located outdoors (i.e., recreational activities and farming) are considered most vulnerable to hailstorms, thunderstorms, and tornadoes because there is little to no warning, and shelter might not be available. Moving to a lower risk location will decrease a person's vulnerability.

As a result of severe storm events, residents can be displaced or require temporary to long-term sheltering. The HAZUS-MH results for the 100-year and 500-year MRP hurricane wind events show that no households will be displaced, and no persons will need to seek shelter. However, downed trees, damaged buildings, and debris carried by high winds from hurricanes, tropical storms, or tornadoes can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on several factors, including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing.

Economically disadvantaged populations are more vulnerable because they often evaluate evacuation needs and make decisions based on the economic impact to their family. The population over the age of 65 (79,042) is also vulnerable, can physically have difficulty evacuating, and are more likely to seek or need medical attention, which may not be available due to isolation during a storm event (2013-2017 American Community Survey 5-Year Population Estimate). Section 3 (County Profile) provides for the statistics for these populations in Morris County.

Impact on General Building Stock and Critical Facilities

Wind-Only Impacts

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 storm. Due to differences in construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings, in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings.

To better understand these risks, HAZUS-MH v4.2 was used to estimate the expected wind-related building damages. The analysis shows that the annualized losses caused by hurricane wind damage for Morris County is $1.7 million. Annualized losses combine estimated losses associated with hurricane wind events for six return periods: 10-, 20-, 50-, 100-, 200-, 500-, and 1,000-year. Table 4.3.11-8 summarizes the definition of the damage categories. Specific types of wind damages are also summarized in HAZUS-MH v4.2 at the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction.

Overall, Table 4.3.11-8 shows that there is an estimated loss of $34 million and $200 million for building stock in Morris County for the 100-year event and 500-year event, respectively. Majority of these losses are for residential structures.

Table 4.3.11-7. 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: HAZUS-MH Hurricane Technical Manual

Table 4.3.11-8. Estimated Building Value Damages by the 100-Year and 500-Year MRP Hurricane-Related Winds

Municipality	Estimated Total Damages*			Estimated Residential Damage		Estimated Commercial Damage	
	Annualized Loss	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Town of Boonton	$21,320	$289,316	$1,885,891	$250,976	$1,807,181	$11,030	$23,475
Township of Boonton	$17,847	$265,215	$1,901,377	$250,402	$1,845,758	$5,532	$16,585
Borough of Butler	$23,556	$325,905	$2,145,547	$294,113	$2,078,108	$12,757	$29,369
Chatham Borough	$43,308	$531,113	$2,423,318	$501,510	$2,364,113	$14,268	$28,536
Chatham Township	$58,837	$692,144	$3,825,302	$670,804	$3,780,156	$5,553	$11,243
Chester Borough	$5,056	$170,820	$1,012,529	$150,446	$894,909	$15,641	$89,613
Chester Township	$31,682	$1,040,181	$6,021,590	$1,009,552	$5,748,764	$6,741	$33,255
Denville Township	$56,323	$1,209,275	$6,699,314	$1,112,349	$6,433,397	$27,000	$84,339
Town of Dover	$23,850	$648,924	$3,780,186	$580,748	$3,504,050	$23,747	$101,261
Township of East Hanover	$76,369	$1,000,830	$4,858,030	$863,766	$4,569,358	$71,259	$157,061
Borough of Florham Park	$61,312	$808,636	$3,981,205	$715,254	$3,790,223	$41,236	$86,426
Township of Hanover	$65,824	$992,102	$5,221,370	$813,382	$4,850,441	$48,714	$109,845

Municipality	Estimated Total Damages*			Estimated Residential Damage		Estimated Commercial Damage	
	Annualized Loss	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Township of Harding	$33,319	$553,839	$2,853,318	$542,019	$2,785,282	$5,376	$12,363
Township of Jefferson	$56,923	$1,697,501	$11,377,823	$1,640,721	$11,129,895	$22,339	$104,920
Borough of Kinnelon	$43,544	$601,242	$4,417,059	$582,151	$4,374,098	$6,371	$13,852
Borough of Lincoln Park	$41,395	$407,992	$2,586,313	$364,202	$2,490,959	$8,750	$17,575
Township of Long Hill	$46,064	$768,933	$3,534,721	$730,694	$3,456,580	$14,600	$29,256
Borough of Madison	$54,722	$650,791	$3,522,953	$593,423	$3,407,667	$22,283	$45,117
Borough of Mendham	$21,718	$546,883	$3,044,778	$526,961	$2,935,099	$7,786	$31,959
Township of Mendham	$27,893	$656,750	$3,950,545	$646,114	$3,858,213	$1,400	$4,863
Township of Mine Hill	$8,573	$244,507	$1,650,993	$231,406	$1,587,612	$3,935	$21,237
Township of Montville	$107,081	$1,136,979	$7,884,694	$1,020,331	$7,641,557	$19,449	$41,085
Township of Morris	$82,842	$1,441,351	$8,259,568	$1,324,207	$7,970,553	$40,400	$86,417
Borough of Morris Plains	$21,127	$404,347	$2,168,112	$360,735	$2,058,765	$16,740	$52,456
Town of Morristown	$35,752	$584,535	$3,130,215	$504,391	$2,912,942	$41,632	$129,031
Borough of Mount Arlington	$11,425	$376,504	$2,687,270	$358,824	$2,582,602	$4,258	$29,280
Township of Mount Olive	$58,638	$2,524,101	$15,382,022	$2,348,206	$14,242,473	$32,718	$217,329
Borough of Mountain Lakes	$18,587	$290,372	$1,823,888	$270,042	$1,779,851	$7,979	$18,252
Netcong Borough	$7,604	$324,050	$1,998,030	$310,079	$1,894,445	$5,722	$45,921
Township of Parsippany-Troy Hills	$155,051	$2,345,617	$13,187,086	$2,041,477	$12,490,565	$139,741	$338,885
Township of Pequannock	$76,141	$832,154	$5,029,598	$762,084	$4,847,481	$31,317	$62,690
Township of Randolph	$74,162	$1,964,780	$11,948,734	$1,838,588	$11,452,045	$50,078	$239,004
Borough of Riverdale	$13,343	$165,906	$970,896	$127,779	$889,826	$18,176	$41,092
Borough of Rockaway	$17,814	$410,675	$2,376,893	$369,126	$2,247,793	$21,268	$66,330
Township of Rockaway	$62,790	$1,483,600	$9,302,555	$1,290,119	$8,669,450	$49,155	$196,493
Township of Roxbury	$67,664	$2,535,761	$15,138,768	$2,408,763	$14,411,006	$60,913	$358,689
Borough of Victory Gardens	$1,371	$27,593	$203,666	$23,771	$191,453	$648	$2,591
Township of Washington	$60,154	$2,775,170	$15,462,040	$2,710,812	$14,470,817	$11,998	$89,600
Borough of Wharton	$14,311	$431,896	$2,354,198	$383,711	$2,160,799	$10,110	$46,143
Morris County (Total)	**$1,705,291**	**$34,158,287**	**$200,002,398**	**$31,524,036**	**$190,606,284**	**$938,617**	**$3,113,437**

Since 1950, approximately $10.4 million damages to property has been reported in Morris County due to severe weather events including high wind, thunderstorm wind, strong wind, tornados, lightning, heavy rain, winter storm, and hail (NOAA 2020). High wind events created the greatest value of property damage out of this total ($4.5 million). Table 4.3.11- outlines the severe weather events that have reported property damages in Morris County. It should be noted that there are more than 500 severe weather events recorded for Morris County, but only 131 have recorded property damages. Therefore, the value of losses could be much greater than what is shown in Table 4.3.11-8.

Table 4.3.11-9. Historical Severe Weather Events That Occurred in Morris County with Recorded Property Damages

Type of Event	Number of Times Event Occurred (1950 – 2019)	Total Value of Losses
Hail	1	$ 5,000
Heavy Rain	1	$ 100,000
High Wind	9	$ 4,535,000
Lightning	21	$ 1,000,010
Strong Wind	78	$ 1,522,180
Thunderstorm Wind	14	$ 2,214,000
Tornado	5	$ 1,025,000
Winter Storm	2	$ 75,000
Total	**131**	**$ 10,476,190**

Source: NOAA 2020

Impact on Critical Facilities

Critical facilities are at risk of being impacted by high winds associated with structural damage, or falling tree limbs/flying debris, which can result in the loss of power. Power loss can greatly impact households, business operations, public utilities, and emergency personnel. Emergency personnel such as police, fire, and EMS will not be able to effectively respond in a power loss event to maintain the safety of its citizens unless backup power and fuel sources are available. Loss of power can impact other public utilities, including potable water, wastewater treatment, and communications. In addition to public water services, property owners with private wells might not have access to potable water until power is restored.

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. As evidenced by Hurricane Sandy, the State of New Jersey, including Morris County, lost millions of dollars in wages and economic activity.

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.

HAZUS-MH estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the "Impact on General Building Stock" section discussed earlier. Business interruption losses are the losses associated with the inability to operate a business because of the wind damage sustained during the storm or the temporary living expenses for those displaced from their home because of the event.

For the 100-year MRP wind event, HAZUS-MH estimates approximately $155,199 business interruption losses. For the 500-year MRP wind only event, HAZUS-MH estimates approximately $13.6 million in business interruption losses for the County, which includes loss of income, relocation costs, rental costs and lost wages, in addition to $117,982 in inventory losses. Refer to Table 4.3.11-10 for a summary of these losses.

Table 4.3.11-10. Approximate Estimated Business Interruption Losses for Morris County for Mean Return Period Hurricane Wind Events

Mean Return Period (MRP)	Inventory Loss	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
100-year MRP	$0	$92,429	$0	$0	$22,770	**$115,199**
500-year MRP	$117,982	$8,643,483	$92	$2,531	$4,883,954	**$13,648,043**

Source: HAZUS-MH v4.2

Debris management can be costly and may also impact the local economy. HAZUS-MH estimates the amount of building and tree debris that may be produced as result of the 100- and 500-year MRP wind events. Because the estimated debris production does not include flooding, this is likely a conservative estimate and may be higher if multiple impacts occur. According to the HAZUS-MH 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. Table 4.3.11-11 summarizes debris production estimates for the 100- and 500-year MRP wind events.

Table 4.3.2-11. Debris Production for 100- and 500-Year Mean Return Period Hurricane-Related Winds

Municipality	Brick and Wood (tons)		Concrete and Steel (tons)		Tree (tons)		Eligible Tree Volume (cubic yards)	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Town of Boonton	0	0	120	0	13	204	199	1,595
Township of Boonton	0	0	97	0	100	1,144	272	3,026
Borough of Butler	0	0	88	0	64	306	673	2,710
Chatham Borough	1	0	91	0	71	298	627	2,231
Chatham Township	1	0	156	0	259	1,211	698	2,807
Chester Borough	5	0	78	0	43	474	151	1,919
Chester Township	22	0	405	0	537	9,570	545	10,557
Denville Township	0	0	335	0	228	2,526	1,263	11,598
Town of Dover	11	0	286	0	86	723	780	5,110
Township of East Hanover	2	0	212	0	382	1,376	1,870	6,636
Borough of Florham Park	0	0	211	0	337	1,265	1,559	5,585
Township of Hanover	2	0	276	0	525	1,999	2,125	8,099
Township of Harding	1	0	136	0	403	2,726	446	3,037
Township of Jefferson	16	0	646	0	634	15,608	2,217	29,245
Borough of Kinnelon	0	0	213	0	101	1,752	346	3,537

Municipality	Brick and Wood (tons)		Concrete and Steel (tons)		Tree (tons)		Eligible Tree Volume (cubic yards)	
	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year	100-Year	500-Year
Borough of Lincoln Park	0	0	97	0	265	919	1,139	3,556
Township of Long Hill	0	0	131	0	354	1,751	953	4,465
Borough of Madison	0	0	182	0	75	342	599	2,599
Borough of Mendham	10	0	184	0	137	1,622	479	4,820
Township of Mendham	11	0	245	0	125	4,854	311	7,163
Township of Mine Hill	4	0	108	0	59	904	290	3,557
Township of Montville	3	0	394	0	355	1,604	1,774	7,201
Township of Morris	1	0	451	0	230	2,562	1,078	11,008
Borough of Morris Plains	1	0	128	0	53	380	469	3,024
Town of Morristown	4	0	248	0	91	526	772	4,267
Borough of Mount Arlington	7	0	221	0	23	690	230	4,207
Township of Mount Olive	68	0	1,271	0	993	11,569	2,846	26,313
Borough of Mountain Lakes	0	0	78	0	42	410	251	2,124
Netcong Borough	12	0	172	0	61	332	517	2,600
Township of Parsippany-Troy Hills	10	0	785	0	671	3,890	3,764	18,853
Township of Pequannock	2	0	193	0	333	1,030	2,060	6,147
Township of Randolph	50	0	784	0	540	6,609	1,520	22,425
Borough of Riverdale	1	0	46	0	67	296	564	2,123
Borough of Rockaway	1	0	145	0	71	514	580	3,877
Township of Rockaway	0	0	599	0	431	12,302	1,244	21,391
Township of Roxbury	35	0	942	0	871	7,896	4,100	27,425
Borough of Victory Gardens	0	0	22	0	1	31	11	288
Township of Washington	60	0	1,045	0	1,367	16,148	2,305	23,325
Borough of Wharton	11	0	156	0	123	685	935	4,297
Morris County (Total)	**352**	**0**	**11,977**	**0**	**11,121**	**119,048**	**42,562**	**314,746**

Source: HAZUS-MH v4.2

According to the State of New Jersey 2019 HMP, hail alone causes $2 billion worth of crop and property damage on an annual basis in the United States (State of NJ 2019). Even though New Jersey is estimated to experience an average of two hailstorm events per year, the outcome of these events could be detrimental depending on the cost it would take for the community to recover from the damages. Likewise, these costs can add up for other severe weather events such as tornados destroying key infrastructure and level local businesses, or extreme rain events flooding out shopping centers or transportation hubs. As highlighted in Table 4.3.11-9, several severe weather events have historically caused tens of thousands to hundreds of thousands of dollars worth of damage.

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 2013c). 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 Morris County. Refer to Sections 4.3.2 (Disease Outbreak) and 4.3.10 (Infestation) for more information about these stressors.

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. Morris 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

As discussed in Section 3 (County Profile), areas targeted for future growth and development have been identified across Morris County. Any areas of growth could be potentially impacted by the severe storm hazard because the entire County is exposed and vulnerable. However, due to increased standards and codes, new development may be less vulnerable to the severe storm hazard compared with the aging building stock in the County.

Projected Changes in Population

In 2017, the Morris County Strategic Plan Steering Committee reviewed population trends for their community. The Census Bureau estimates that as of July 1, 2018, the County has 494,228 persons, which is a 0.4% increase since 2010 (Census Bureau 2019). In addition, the report indicates that employment is expected to decrease, the population is generally getting older, and household sizes are shrinking (Morris County 2017). Overall with the projected increase in population, aging demographics and infrastructure, there may be increased stress on existing infrastructure and related services.

Climate Change

As discussed earlier, studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. More frequent and severe storms will increase the County's vulnerability to each of the identified severe storm hazards. Section 4.3.6 (Flood) provides a discussion related to the impact of climate change due to increases in rainfall resulting from severe storms.

Change of Vulnerability Since the 2015 HMP

Overall, the County's vulnerability has not changed, and the entire County will continue to be exposed and vulnerable to severe weather events.