4.3.8 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 Essex County.

2020 HMP Update Changes

- All subsections have been updated using best available data.
- Previous occurrences were updated with events that occurred between 2014 and 2019.

4.3.8.1 Profile

Hazard Description

For the purpose of this HMP update and as deemed appropriated by Essex County, the severe weather hazard includes thunderstorms, lightning, hailstorms, windstorms, and tornadoes which are defined in the sections below. Nor'easters, hurricanes and tropical storms are discussed in Section 4.3.2 Coastal Storm.

Thunderstorms

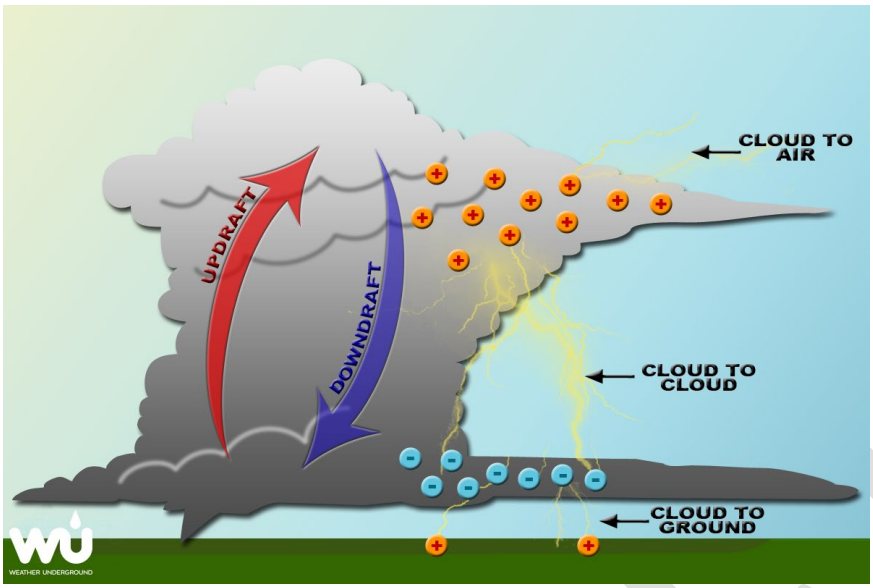
A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (National Weather Service [NWS] 2009). A thunderstorm forms from a combination of moisture; rapidly rising warm air; and a force capable of lifting air, such as a warm front, cold front, a sea breeze, 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 4.3.8-1 demonstrates the variety of lightning types.

Figure 4.3.8-1. Types of Lightning

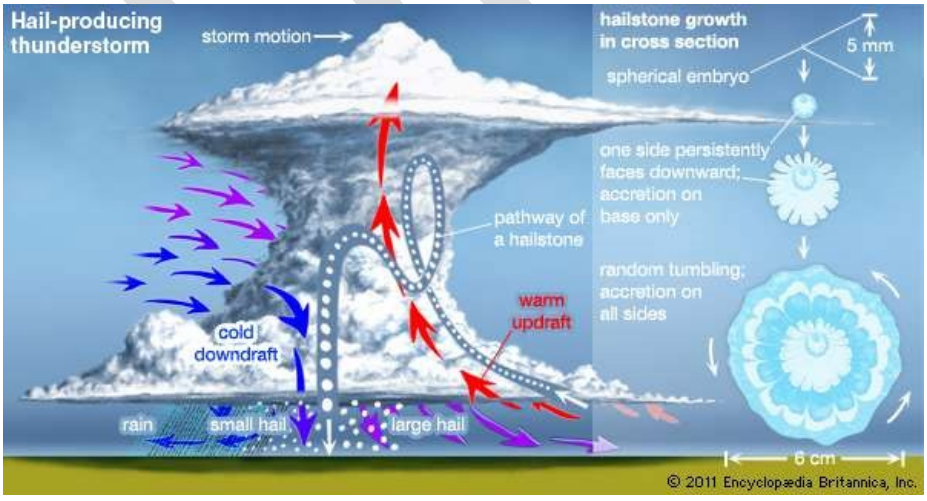


Source: Weather Underground date unknown

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 4.3.8-2 shows how hail is formed within thunderstorms.

Figure 4.3.8-2. 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 (discussed further in this section or in Section 4.3.2 Coastal Storms).

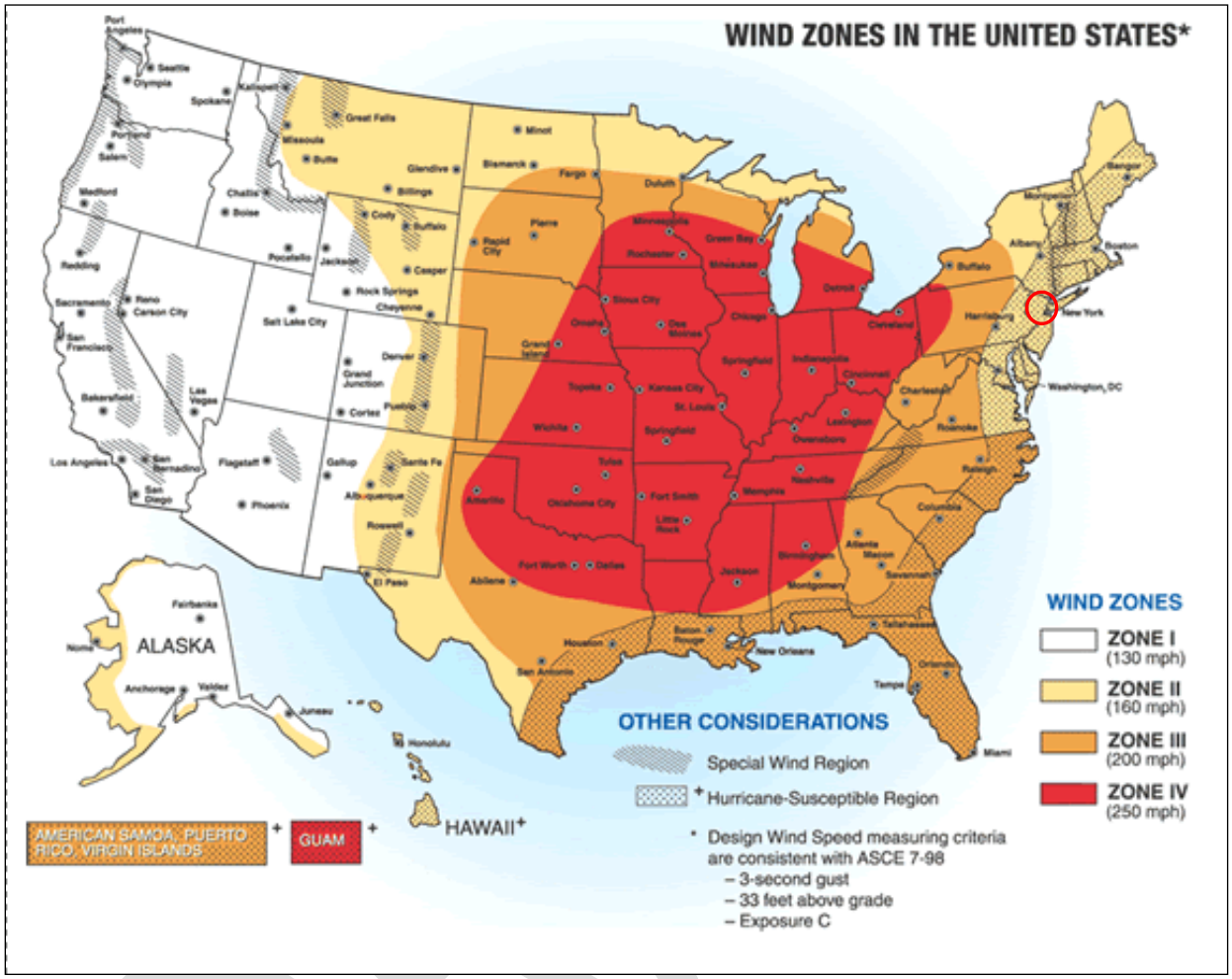
Tornadoes

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 Essex County is exposed to hail, lightning, windstorms and high wind, thunderstorms, and tornadoes and all of the County is subject to high winds from severe weather events. According to the FEMA Winds Zones of the United States map, Essex County is located in Wind Zone II, where wind speeds can reach up to 160 mph and is part of the hurricane susceptible region. Hurricanes are covered in Section 4.3.2 Coastal Storms. Figure 4.3.8-3 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 4.3.8-3. Wind Zones in the United States



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

Extent

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 Essex County. Historical data presented in Table 4.3.8-1 shows the most powerful severe weather records in Essex County.

Table 4.3.8-1. Severe Storm Extent in Essex County (1950-2019)

Extent of Severe Storms in Essex County	
Largest Hailstone on Record	1.75 inches
Strongest Tornado on Record	F-1
Highest Wind Speed on Record	90 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:

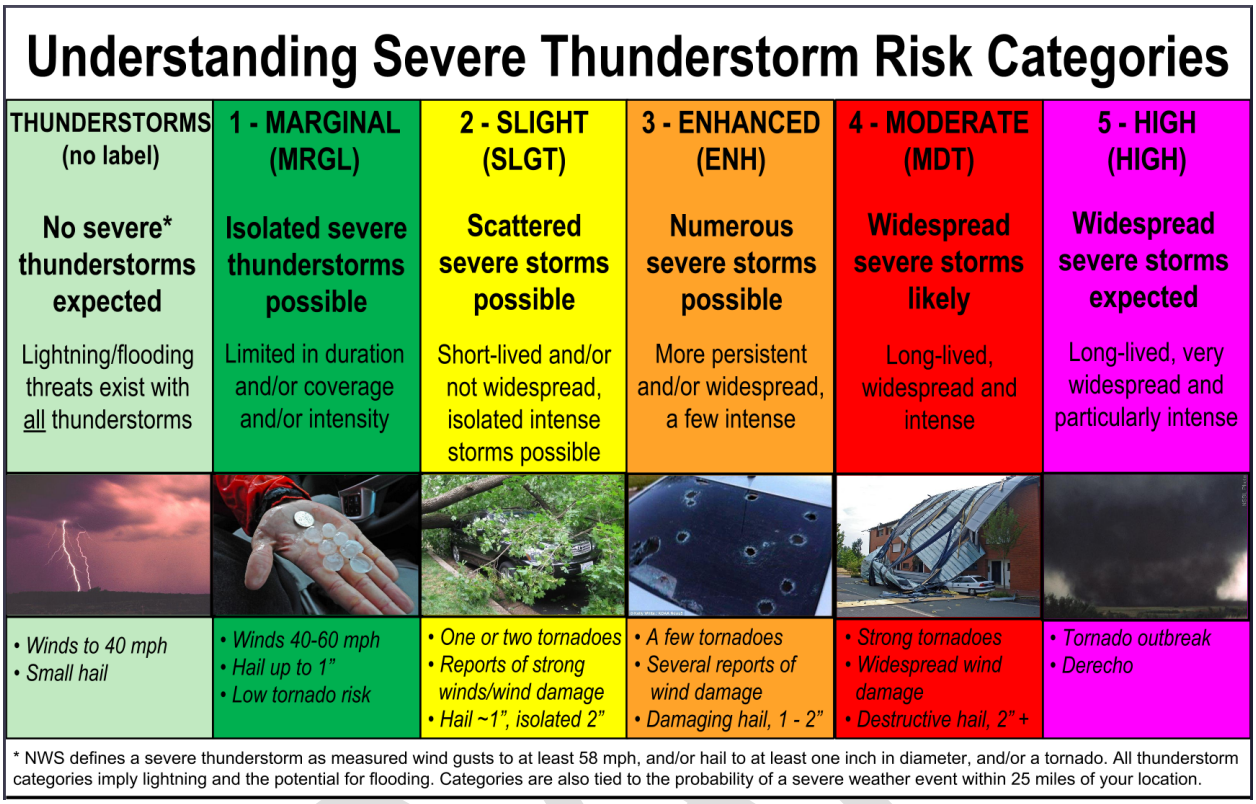
- *Severe Thunderstorm Warnings* are issued when there is evidence based on radar or a reliable spotter report that a thunderstorm is producing (or is forecast to produce) wind gusts of 58 mph or greater, structural wind damage, and hail 1 inch in diameter or greater. A warning will include the location 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 4.3.8-4 shows the SPC's severe thunderstorm risk categories.

Figure 4.3.8-4. 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 4.3.8-2 describes the different sizes of hail as compared to real-world objects and lists approximate measurements.

Table 4.3.8-2. Hail Size

Description	Diameter (in inches)
Pea	0.25
Marble or mothball	0.50
Penny or dime	0.75
Nickel	0.88
Golf ball	1.75
Hen's egg	2.00
Tennis ball	2.5
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 4.3.8-3 provides the NWS descriptions of winds during wind-producing events.

Table 4.3.8-3. 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 4.3.8-5 illustrates the relationship between EF ratings, wind speed, and expected tornado damage.

Figure 4.3.8-5. 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, Essex County has been included in 18 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 4.3.8-4 lists these events.

Table 4.3.8-4. Severe Storm-related FEMA Disaster Declarations

Declaration	Event Date	Declaration Date	Event Description
DR-245	June 18, 1968	March 25, 1974	Flood: Heavy Rains & Flooding
DR-310	September 4, 1971	September 4, 1971	Flood: Heavy Rains & Flooding
DR-402	August 7, 1973	August 7, 1973	Flood: Severe Storms & Flooding

Declaration	Event Date	Declaration Date	Event Description
DR-477	July 23, 1975	July 23, 1975	Flood: Heavy Rains, High Winds, Hail & Tornadoes
DR-701	March 28-April 8, 1984	April 12, 1984	Flood: Coastal Storms & Flooding
DR-973	December 10-17, 1992	December 18, 1992	Flood: Coastal Storm, High Tides, Heavy Rain, & Flooding
EM-3148	September 16-18, 1999	September 17, 1999	Hurricane: Hurricane Floyd Emergency Declarations
DR-1295	September 16-18, 1999	September 18, 1999	Hurricane: Hurricane Floyd Major Disaster Declarations
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(s): 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 Storm(s): Severe Winter Storm and Snowstorm
DR-4368	March 6-7, 2018	June 8, 2018	Severe Storm(s): Severe Winter Storm and Snowstorm

Source: FEMA 2019

In addition, Essex County was included in Agricultural Disaster S4455 for the combined effects of excessive rainfall, moisture, and storm-force winds from Hurricane Florence.

Severe weather events that have impacted Essex County between 2014 and 2019 are identified in Table 4.3.8-5. With severe weather documentation for New Jersey and Essex County being so extensive, not all sources have been identified or researched. Therefore, Table 4.3.8-5 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 4.3.8-5. Severe Weather Events in Essex County, 2014 to 2019

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
May 23, 2014	Hail	N/A	N/A	Bloomfield, Orange	A trough of low pressure slowly worked its way through the region, which caused isolated severe thunderstorms that produced large hail and flash flooding in portions of Northeast New Jersey. Quarter size hail was reported just west of Bloomfield. Quarter size hail was reported at the Orange Police Department.
July 2, 2014	Lightning	N/A	N/A	Newark	A strong low level shortwave swung through the Northeast with a trough at the surface. A line of strong thunderstorms formed along the trough and pushed through the area late in the afternoon into the evening. Some of these storms produced heavy rainfall, which resulted in flash flooding in portions of northeast New Jersey. A house on Lindsely Ave. was damaged by a lightning strike in Newark. $10K in property damages were reported.
July 8, 2014	Thunderstorm Wind	N/A	N/A	Fairfield, Caldwell	A line of strong with embedded severe thunderstorms formed along a slow moving cold front as it progressed through the Northeast. Multiple trees were reported down around town in Fairfield. $2K in property damages were reported. Multiple trees were reported down around town in Caldwell. $3K in property damages were reported.
August 31, 2014	Thunderstorm Wind	N/A	N/A	Watsessing	A very humid air mass combined with a passing surface trough to trigger numerous showers and thunderstorms, with embedded severe thunderstorms. Some of these storms produced very heavy rain which led to isolated flash flooding in Essex County. A tree went through the roof of a house on Roosevelt Avenue in Watsessing. $8K in property damages were reported.
November 2, 2014	Strong Wind	N/A	N/A	Eastern Essex County	A strong low pressure system passed south then east of Long Island. At Newark International Airport, a measured wind of 32 mph was reported at 12:40 pm.
December 9, 2014	Strong Wind	N/A	N/A	Eastern Essex County	A coastal storm passed just south and east of the area causing strong winds and heavy rain with isolated flooding in portions of Northeast New Jersey. At Newark International Airport, sustained winds of 35 mph were measured at 1:54 pm, and gusts of 44 mph were measured at 1:39 pm. $10K in property damages were reported.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
February 15, 2015	Strong Wind	N/A	N/A	Eastern Essex County	An area of low pressure deepened as it tracked to the northeast of the local region resulting in strong winds. At Newark International Airport, the ASOS measured sustained winds of 36 mph at 10:43 am. $10K in property damages were reported.
April 22, 2015	Strong Wind	N/A	N/A	Newark	A combination of gradient winds and convection ahead of a cold front resulted in wind gusts from 40 to 50 mph, based on observations, that caused minor damage in Northeast New Jersey. A tree fell on a car parked near the corner of Summer Avenue and Nursery Street in Newark. The wind gust is estimated based on a reported 34 mph gust measured at Newark Airport, around 2 miles away at the same time. $1.5K in property damages were reported.
July 1, 2015	Thunderstorm Wind	N/A	N/A	West Caldwell	A passing warm front triggered isolated severe thunderstorms which impacted Northeastern New Jersey. A tree fell down on Westville Avenue in West Caldwell. $1.5K in property damages were reported.
February 24-25, 2016	Strong Wind	N/A	N/A	Maplewood	Strong winds occurred behind the passage of a warm front, and ahead of a cold front. Emergency management reported downed tree limbs at Parker Avenue and Valley Street in Maplewood at 1041 pm. The roads were closed as a result. $40K in property damages were reported.
July 1, 2016	Thunderstorm Wind	N/A	N/A	South Orange, Fairfield, Caldwell, Cedar Grove	A passing cold front triggered a few severe thunderstorms over northeast New Jersey. Power lines were reported down in South Orange. $0.75K in property damages were reported. There were multiple reports of trees and power lines down throughout Fairfield. $3K in property damages were reported. There were multiple reports of trees and wires down in Caldwell. A large tree was uprooted onto 3 cars and a home in Cedar Grove. $45K in property damages were reported.
July 14, 2016	Thunderstorm Wind	N/A	N/A	Livingston, West Orange, Glen Ridge, Belleville	An approaching trough of low pressure triggered a line of strong to severe storms that moved across Northeast New Jersey. A tree fell down on a house along Mohawk Drive about 1 mile northeast of Livingston. $5K in property damages were reported. A large tree snapped and landed on a car on Maple Street just east of West Orange. $7.5K in property damages were reported. A large tree snapped and fell on a fence between West Orange and Glen Ridge. $2K in property damages were reported. A tree fell on a car along Branch Brook Drive just west of Belleville. $6K in property damages were reported.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
July 25, 2016	Thunderstorm Wind	N/A	N/A	Newark	The combination of a trough of low pressure and a trough aloft produced a line of strong to severe storms that moved over Passaic, Essex and Union Counties. Trees and wires were reported down in Newark. $3K in property damages were reported.
January 23, 2017	Strong Wind	N/A	N/A	Eastern Essex County	A deep area of low pressure passed just south and east of Long Island. A 52 mph gust was measured at Newark International Airport at 154 pm. $10K in property damages were reported.
March 2, 2017	Strong Wind	N/A	N/A	West Orange	Gusty northwest winds occurred behind a strong cold front. The broadcast media reported a downed tree in West Orange at 819 am. The tree was knocked down onto Prospect Ave. southbound between Rock Ave. and Route 280. Nearby, Newark International Airport measured a gust to 56 mph at 746 am. $50K in property damages were reported.
October 24, 2017	Strong Wind	N/A	N/A	Montclair	Strong winds occurred ahead of and behind a cold front. Per social media, a tree was knocked down at 1154 am in Montclair. $10K in property damages were reported.
April 4, 2018	Strong Wind	N/A	N/A	Eastern Essex County	Strong winds occurred ahead of and behind a cold front. The ASOS at Newark International Airport reported a wind gust of 54 mph at 537 pm. $10K in property damages were reported.
May 15, 2018	Thunderstorm Wind	N/A	N/A	Caldwell, West Orange	An approaching cold front triggered numerous severe thunderstorms over northeastern New Jersey. Large trees were reported down in Caldwell. $4K in property damages were reported. Large tree reported down on Maple Street in West Orange. $4K in property damages were reported.
July 3, 2018	Thunderstorm Wind	N/A	N/A	Belleville, Roseville	A pre-frontal trough ahead of an approaching cold front triggered strong to severe thunderstorms across the region. A tree on car with people trapped inside at the intersection of Main Street and Rutgers Street in Belleville. $5K in property damages were reported. A tree fell down on a car at the intersection of Orange Street and 4th Street in Roseville. $5K in property damages were reported.
January 30, 2019	Strong Wind	N/A	N/A	Western Essex County	Strong winds occurred behind low pressure and cold front. The ASOS at Caldwell Airport measured a 30 mph sustained wind at 504 pm. $10K in property damages were reported.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
March 15, 2019	Thunderstorm Wind, Hail	N/A	N/A	Livingston, West Orange	A cold front moved through the region triggering strong to severe thunderstorms across Northeast New Jersey. A tree down on car on Force Hill Road between East Mount Pleasant Avenue and Michele Lane. $6K in property damages were reported. Hail of 07.5 inches in diameter reported in West Orange.

Source: FEMA 2019; NCDC 2019; NWS 2019; SPC 2019; NJ HMP 2012; USGS 2011; 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

Essex 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.

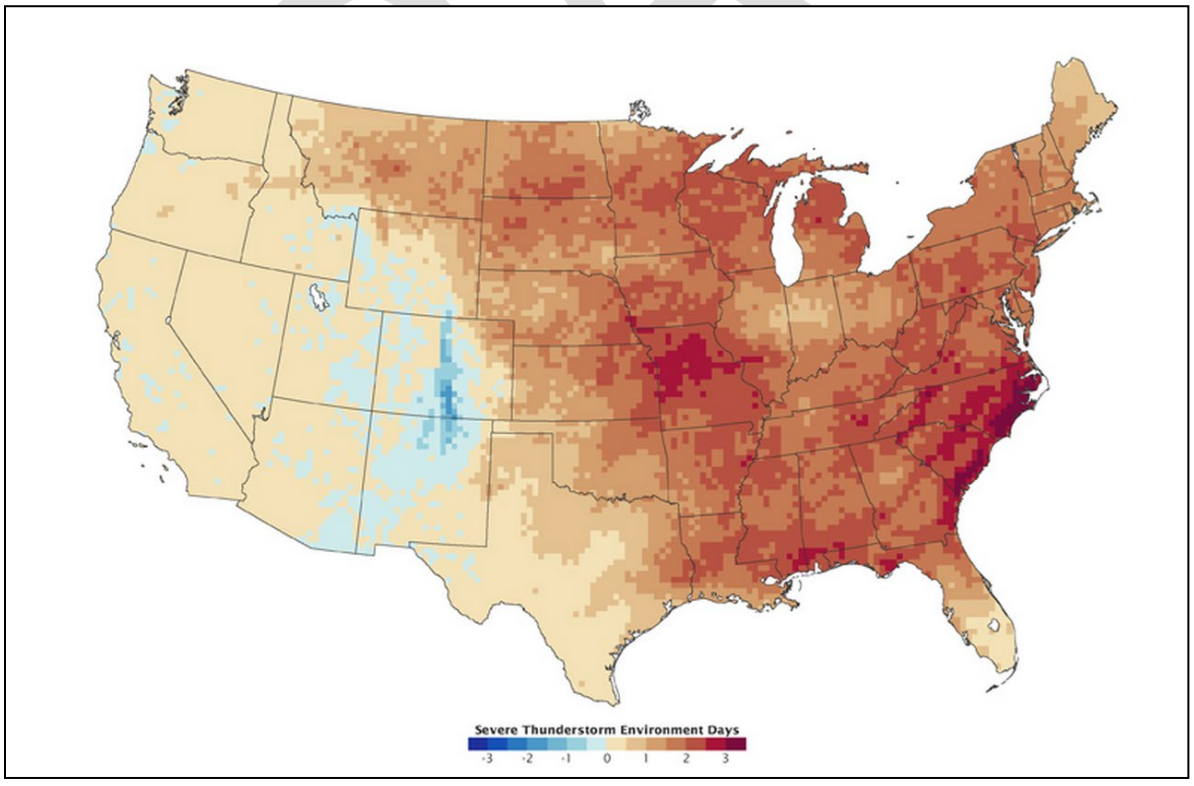
In Section 4.4, the identified hazards of concern for Essex County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for severe storms in the 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 4.3.8-6. 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).

4.3.8.2 Vulnerability Assessment

A qualitative assessment was conducted to analyze the severe weather hazard for Essex County. Wind-related vulnerability data was generated using a HAZUS-MH v4.2 analysis for the wind hazard. A probabilistic assessment was conducted for the 100- and 500-year MRPs to analyze the severe storm hazard and provide a range of loss estimates. These estimates are detailed in Section 4.3.2 (Coastal Storms).

Impact on Life, Health and Safety

The impact of a severe storms 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 Essex County (800,401) 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. In addition, 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 (102,794) 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 for Essex County. Refer to Section 4.3.2 (Coastal Storms) for details regarding wind-related impacts on Essex County's population.

Impact on General Building Stock and Critical Facilities

Damage to buildings depends on several factors, including wind speed, storm duration, path of the storm track or tornado, and distance from the tornado funnel. Depending on the size of the hail and severity of the storm, the County could see damage from hail impacting structures. Lightning can spark wildfires or building fires, especially if structures are not protected by surge protectors on critical electronic, lighting, or information technology systems. While damage to the building stock is possible as a result of lightning and hail, they are

difficult to estimate and would not have as wide of an impact as a high wind or tornado event. Refer to Section 4.3.2 (Coastal Storms) for details regarding wind-related impacts on Essex County's building stock and critical facilities.

Utility infrastructure could suffer damage from high winds associated with falling tree limbs or other debris, resulting in the loss of power or other utility service. Loss of service can impact residents, critical facilities, and business operations alike. Interruptions in heating or cooling utilities can affect populations, such the young and elderly, who are particularly vulnerable to temperature-related health impacts. 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. Lack of power to emergency facilities, including police, fire, EMS, and hospitals, will inhibit a community's ability to effective respond to an event and maintain the safety of its citizens.

Impact on Economy

As discussed, severe storm events can impact structures and the economy. 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. Refer to the Section 4.3.2 (Coastal Storm) for additional impacts on the economy as a result of severe weather events.

Future Changes that May Impact Vulnerability

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

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

Projected Development

As discussed in Section 3 (County Profile), areas targeted for future growth and development have been identified across Essex 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

According to population projections from the State of New Jersey Department of Labor and Workforce Development, Essex County will experience an increase in population through 2034 (approximately 40,000 people between 2017 and 2034). Refer to Section 3 (County Profile) which includes a discussion on population trends for the County. As the population continues to grow, residents will continue to be exposed to the severe weather hazard.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. An increase in temperatures may also lead to an increase in the frequency and

intensity of coastal storms. More frequent and severe storms will increase the County's vulnerability to each of the identified severe storm hazards. Section 5.4.6 (Flood) provides a discussion related to the impact of climate change due to increases in rainfall resulting from severe storms. In addition to the impacts of increasing temperatures and precipitation, sea level rise will increase the County's vulnerability to coastal storms. Increases in mean sea level will lead to subsequent increases in storm surge inundation depths.

Change of Vulnerability

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