SOMERSET COUNTY

HAZARD MITIGATION PLAN

SOMERSET COUNTY MULTI-JURISDICTIONAL HAZARD MITIGATION PLAN

FINAL PLAN UPDATE
JULY 2019

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Section 5.4.1: RISK ASSESSMENT- SEVERE STORM

Prepared by the Somerset County Mitigation Planning Committee

5.4.1 SEVERE STORM

This section provides a profile and vulnerability assessment for the severe storm hazards.

As part of the 2018 Plan Update, this section has been reviewed and updated to incorporate more recent hazard data.

HAZARD PROFILE

Hazard profile information is provided in this section, including information on description, extent, location, previous occurrences and losses and the probability of future occurrences within Somerset County.

Description

For the purpose of this HMP and as deemed appropriate by Somerset County, the severe storm hazard includes hailstorms, windstorms, lightning, thunderstorms, tornadoes, and tropical cyclones (e.g. hurricanes, tropical storms, and tropical depressions), which are defined below. Since most northeasters, (or Nor'easters) a type of extra-tropical cyclone, generally take place during the winter weather months, Nor'easters have been grouped as a type of severe winter weather storm, further discussed in Section 5.4.2 (Severe Winter Storm).

Hailstorm: According to the National Weather Service (NWS), hail is defined as a showery precipitation in the form of irregular pellets or balls of ice more than five millimeters in diameter, falling from a cumulonimbus cloud (NWS, 2009). Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight; they fall as precipitation, in the form of balls or irregularly shaped masses of ice. The size of hailstones is a direct function of the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the Earth's surface. Higher temperature gradients relative to elevation above the surface result in increased suspension time and hailstone size. Hailstorms are a potential damaging outgrowth of severe thunderstorms (Northern Virginia Regional Commission [NVRC], 2006). They cause over $1 billion in crop and property damages each year in the U.S., making hailstorms one of the most costly natural disasters (Federal Alliance for Safe Homes, Inc., 2006).

Windstorm: According to the Federal Emergency Management Agency (FEMA), wind is air moving from high to low pressure. It is rough horizontal movement of air (as opposed to an air current) caused by uneven heating of the earth's surface. It occurs at all scales, from local breezes generated by heating of land surfaces and lasting tens of minutes to global winds resulting from solar heating of the earth (FEMA, 1997). A type of windstorm that is experienced often during rapidly moving thunderstorms is a derecho. A derecho is a widespread and long-lived windstorm associated with thunderstorms that are often curved in shape (Johns et al., 2011). The two major influences on the atmospheric circulation are the differential heating between the equator and the poles, and the rotation of the planet. Windstorm events are associated with cyclonic storms (for example, hurricanes, thunderstorms and tornadoes (FEMA, 1997).

Lightning: According to the NWS, lightning is a visible electrical discharge produced by a thunderstorm. The discharge may occur within or between clouds or between a rain cloud and the ground (NWS, 2009). The discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm creates a "bolt" when the buildup of charges becomes strong enough. A bolt of lightning

can reach temperatures approaching 50,000 degrees Fahrenheit (°F). Lightning rapidly heats the sky as it flashes but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder. Annually, on average, 300 people are injured and 89 people are killed due to lightning strikes in the U.S. (NVRC, 2006).

Thunderstorm: According to the NWS, a thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (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 and cold front, a sea breeze, or a mountain. Thunderstorms form from the equator to as far north as Alaska. These storms occur most commonly in the tropics. Many tropical land-based locations experience over 100 thunderstorm days each year (Pidwirny, 2007). Although thunderstorms generally affect a small area when they occur, they are very dangerous due to their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. A thunderstorm produces wind gusts of less than 57 miles per hour (mph) and hail, if any, of less than 3/4-inch diameter at the surface. A severe thunderstorm has thunderstorm-related surface winds (sustained or gusts) of 57 mph or greater and/or surface hail 3/4-inch or larger (NWS, 2005). Wind or hail damage may be used to infer the occurrence/existence of a severe thunderstorm (Office of the Federal Coordinator for Meteorology, 2001).

Tornado: A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. It is spawned by a thunderstorm (or sometimes as a result of a hurricane) and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. Tornado season is generally March through August, although tornadoes can occur at any time of year. Tornadoes tend to strike in the afternoons and evening, with over 80 percent (%) of all tornadoes striking between noon and midnight (New Jersey Office of Emergency Management [NJOEM], 2011). The average forward speed of a tornado is 30 mph, but can vary from nearly stationary to 70 mph (NWS, 1995). The NOAA Storm Prediction Center (SPC) indicates that the total duration of a tornado can last between a few seconds to over one hour; however, a tornado typical lasts less than 10 minutes (Edwards, 2011). High-wind velocity and wind-blown debris, along with lightning or hail, result in the damage caused by tornadoes. Destruction caused by tornadoes depends on the size, intensity, and duration of the storm. Tornadoes cause the greatest damage to structures that are light, such as residential homes and mobile homes, and tend to remain localized during impact (NVRC, 2006).

Tropical Cyclone: Tropical cyclone is a generic term for a cyclonic, low-pressure system over tropical or sub-tropical waters (National Atlas, 2011); containing a warm core of low barometric pressure which typically produces heavy rainfall, powerful winds and storm surge (New York City Office of Emergency Management [NYCOEM], 2011). It feeds on the heat released when moist air rises and the water vapor in it condenses (Dorrego, Date Unknown). Depending on their location and strength, there are various terms by which tropical cyclones are known, such as hurricane, typhoon, tropical storm, cyclonic storm and tropical depression (Pacific Disaster Center, 2006). While tropical cyclones begin as a tropical depression, meaning the storm has sustained winds below 38 mph, it may develop into a tropical storm (with sustained winds of 39 to 73 mph) or a hurricane (with winds of 74 mph and higher).

Tropical Depression: A tropical depression is an organized system of clouds and thunderstorms with a defined surface circulation and maximum sustained winds of less than 38 mph. It has no “eye” (the calm area in the center of the storm) and does not typically have the organization or the spiral shape of more powerful storms (Emanuel, Date Unknown; Miami Museum of Science, 2000).

Tropical Storm: A tropical storm is an organized system of strong thunderstorms with a defined surface circulation and maximum sustained winds between 39 and 73 mph (FEMA, 2011). Once a storm has reached tropical storm status, it is assigned a name. During this time, the storm itself becomes more organized and begins to become more circular in shape, resembling a hurricane. The rotation of a tropical

storm is more recognizable than a tropical depression. Tropical storms can cause a lot of problems, even without becoming a hurricane; however, most of the problems stem from heavy rainfall (University of Illinois, Date Unknown).

Hurricane: A hurricane is an intense tropical cyclone with wind speeds reaching a constant speed of 74 mph or greater (FEMA, 2011). It is a category of a tropical cyclone characterized by thunderstorms and defined surface wind circulation. They are caused by the atmospheric instability created by the collision of warm air with cooler air. They form in the warm waters of tropical and sub-tropical oceans, seas, or Gulf of Mexico (NWS, 2011). Most hurricanes evolve from tropical disturbances. A tropical disturbance is a discrete system of organized convection (showers or thunderstorms), that originate in the tropics or subtropics, does not migrate along a frontal boundary, and maintains its identity for 24 hours or more (NWS, 2009). Hurricanes begin when areas of low atmospheric pressure move off the western coast of Africa and into the Atlantic, where they grow and intensify in the moisture-laden air above the warm tropical ocean. Air moves toward these atmospheric lows from all directions and circulates clock-wise under the influence of the Coriolis Effect, thereby initiating rotation in the converging wind fields. When these hot, moist air masses meet, they rise up into the atmosphere above the low pressure area, potentially establishing a self-reinforcing feedback system that produces weather systems known to meteorologists as tropical disturbances, tropical depressions, tropical storms, and hurricanes (Frankenberg, Date Unknown).

Almost all tropical storms and hurricanes in the Atlantic basin, which includes the Gulf of Mexico and Caribbean Sea, form between June 1st and November 30th. This time frame is known as hurricane season. August and September are peak months for hurricane development. The threats caused by an approaching hurricane can be divided into three main categories: storm surge, wind damage and rainfall/flooding:

- *Storm Surge* is simply water that is pushed toward the shore by the force of the winds swirling around the storm. This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase the mean water level 15 feet or more. Storm surge is responsible for nearly 90-percent of all hurricane-related deaths and injuries.
- *Wind Damage* is the force of wind that can quickly decimate the tree population, down power lines and utility poles, knock over signs, and damage/destroy homes and buildings. Flying debris can also cause damage to both structures and the general population. When hurricanes first make landfall, it is common for tornadoes to form which can cause severe localized wind damage.
- *Rainfall / Flooding* the torrential rains that normally accompany a hurricane can cause serious flooding. Whereas the storm surge and high winds are concentrated around the "eye", the rain may extend for hundreds of miles and may last for several days, affecting areas well after the hurricane has diminished (Mandia, 2011).

Extent

The extent (that is, magnitude or severity) of a severe storm is largely dependent upon sustained wind speed. Straight-line winds, winds that come out of a thunderstorm, in extreme cases, can cause wind gusts exceeding 100 mph. These winds are most responsible for hailstorm and thunderstorm wind damage. One type of straight-line wind, the downburst, can cause damage equivalent to a strong tornado (NVRC, 2006).

Hail

Hail can be produced from many different types of storms. Typically, hail occurs with thunderstorm events. The size of hail varies related to the severity and size of the thunderstorm that produced it, and is estimated by comparing it to a known object. Most hail storms are made up of a variety of sizes, and only

penny size (.75″ in diameter) or larger hail is considered severe (NJ HMP, 2011; NSSL, 2003). Table 5.4.1-1 shows the different types of hail and the comparison to real-world objects.

Table 5.4.1-1 Hail Size

Description	Diameter
Pea	1/4”
Plain M&M	1/2”
Dime/Penny	3/4”
Nickel	7/8”
Quarter	1”
Half Dollar	1.25”
Walnut or Ping Pong Ball	1.50”
Golf ball	1.75”
Hen’s Egg	2”
Tennis Ball	2.25
Baseball	2.75
Tea Cup	3”
Softball	4”
Grapefruit	4.5”
Computer CD/DVD	4.75 – 5”

Source: NWS, 2012

Tornado

The magnitude or severity of a tornado was originally categorized using the Fujita Scale (F-Scale) or Pearson Fujita Scale introduced in 1971, based on a relationship between the Beaufort Wind Scales (B-Scales) (measure of wind intensity) and the Mach number scale (measure of relative speed). It is used to rate the intensity of a tornado by examining the damage caused by the tornado after it has passed over a man-made structure (Tornado Project, Date Unknown). The F-Scale categorizes each tornado by intensity and area. The scale is divided into six categories, F0 (Gale) to F5 (Incredible) (Edwards, 2012). Table 5.4.1-2 explains each of the six F-Scale categories.

Table 5.4.1-2 Fujita Damage Scale

Scale	Wind Estimate (MPH)	Typical Damage
F0	< 73	Light damage. Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	Moderate damage. Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.

Scale	Wind Estimate (MPH)	Typical Damage
F4	207-260	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	Incredible damage. Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yards); trees debarked; incredible phenomena will occur.

Source: SPC, 2012

Although the F-Scale has been in use for over 30 years, there are limitations of the scale. The primary limitations are a lack of damage indicators, no account of construction quality and variability, and no definitive correlation between damage and wind speed. These limitations have led to the inconsistent rating of tornadoes and, in some cases, an overestimate of tornado wind speeds. The limitations listed above led to the development of the Enhanced Fujita Scale (EF Scale). The Texas Tech University Wind Science and Engineering (WISE) Center, along with a forum of nationally renowned meteorologists and wind engineers from across the country, developed the EF Scale (NOAA, 2008).

The EF Scale became operational on February 1, 2007. It is used to assign tornadoes a 'rating' based on estimated wind speeds and related damage. When tornado-related damage is surveyed, it is compared to a list of Damage Indicators (DIs) and Degree of Damage (DOD), which help better estimate the range of wind speeds produced by the tornado. From that, a rating is assigned, similar to that of the F-Scale, with six categories from EF0 to EF5, representing increasing degrees of damage. The EF Scale was revised from the original F-Scale to reflect better examinations of tornado damage surveys. This new scale has to do with how most structures are designed (NOAA, 2008). Table 5.4.1-3 displays the EF Scale and each of its six categories.

Table 5.4.1-3 Enhanced Fujita Damage Scale

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

Source: SPC, Date Unknown

In the Fujita Scale, there was a lack of clearly defined and easily identifiable damage indicators. The EF Scale takes into account more variables than the original F-Scale did when assigning a wind speed rating to a tornado. The EF Scale incorporates 28 DIs, such as building type, structures, and trees. For each damage indicator, there are eight DODs, ranging from the beginning of visible damage to complete destruction of the damage indicator. Table 5.4.1-4 lists the 28 DIs. Each one of these indicators has a description of the typical construction for that category of indicator. Each DOD in every category is given an expected estimate of wind speed, a lower bound of wind speed, and an upper bound of wind speed.

Table 5.4.1-4 EF Scale Damage Indicators

Number	Damage Indicator	Abbreviation	Number	Damage Indicator	Abbreviation
1	Small barns, farm outbuildings	SBO	15	School - 1-story elementary (interior or exterior halls)	ES
2	One- or two-family residences	FR12	16	School - jr. or sr. high school	JHSH
3	Single-wide mobile home (MHSW)	MHSW	17	Low-rise (1-4 story) bldg.	LRB
4	Double-wide mobile home	MHDW	18	Mid-rise (5-20 story) bldg.	MRB
5	Apt, condo, townhouse (3 stories or less)	ACT	19	High-rise (over 20 stories)	HRB
6	Motel	M	20	Institutional bldg. (hospital, govt. or university)	IB
7	Masonry apt. or motel	MAM	21	Metal building system	MBS
8	Small retail bldg. (fast food)	SRB	22	Service station canopy	SSC
9	Small professional (doctor office, branch bank)	SPB	23	Warehouse (tilt-up walls or heavy timber)	WHB
10	Strip mall	SM	24	Transmission line tower	TLT
11	Large shopping mall	LSM	25	Free-standing tower	FST
12	Large, isolated ("big box") retail bldg.	LIRB	26	Free standing pole (light, flag, luminary)	FSP
13	Automobile showroom	ASR	27	Tree - hardwood	TH
14	Automotive service building	ASB	28	Tree - softwood	TS

Source: SPC, Date Unknown

Since the EF Scale recently went into effect in February 2007, previous occurrences and losses associated with historic tornado events, described in the next section (Previous Occurrences and Losses) of this hazard profile, are based on the former Fujita Scale. Events after February 2007 are based on the Enhance Fujita Scale.

Hurricanes

The extent of a hurricane is categorized by the Saffir-Simpson Hurricane Scale. This scale categorizes or rates hurricanes from 1 (Minimal) to 5 (Catastrophic) based on their intensity. This is used to give an estimate of the potential property damage and flooding expected along the coast from a hurricane landfall. Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline, in the landfall region (National Hurricane Center [NHC], 2010). Table 5.4.1-5 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes land fall.

Table 5.4.1-5 The Saffir-Simpson Scale

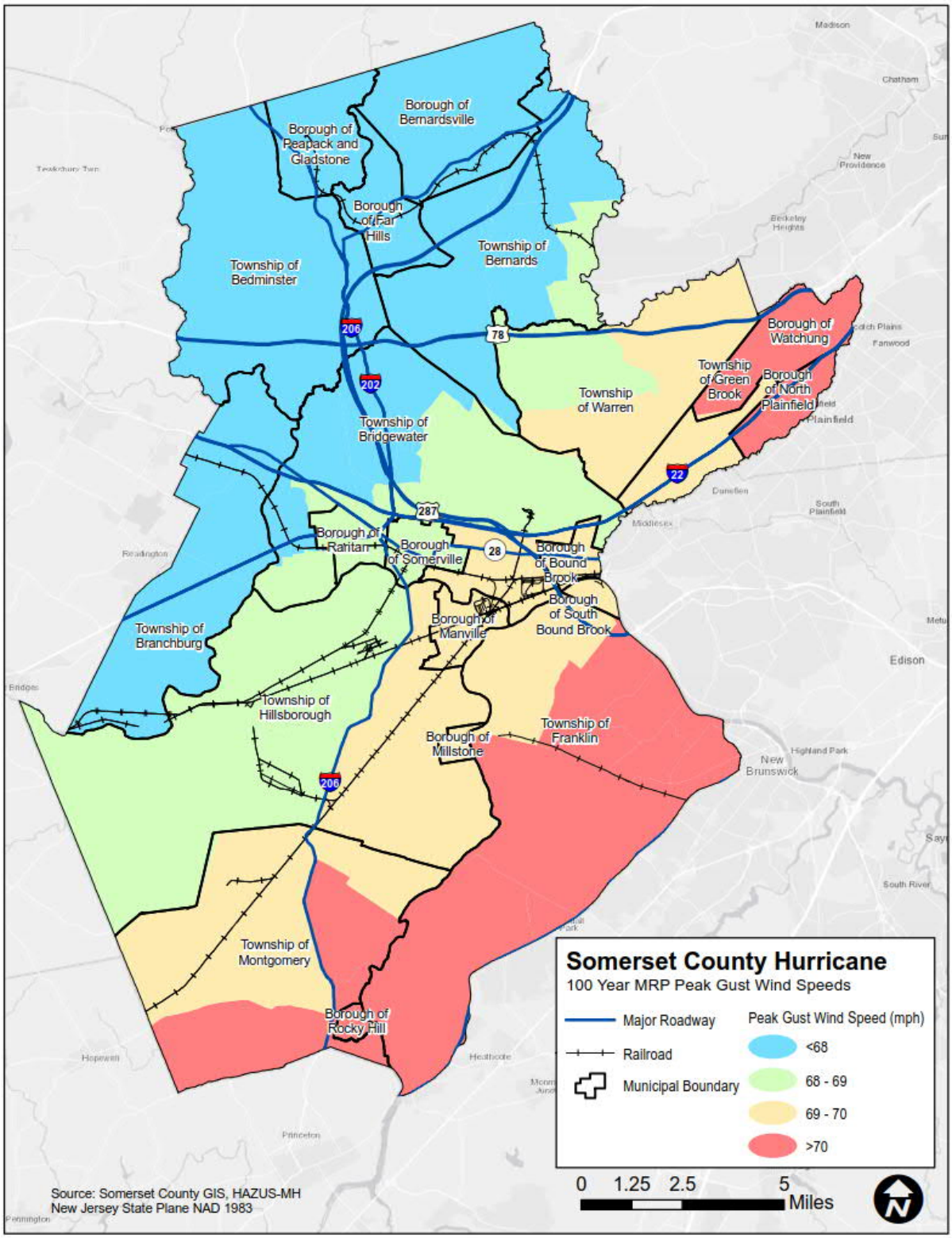
Category	Wind Speed (mph)	Storm Surge (above normal sea level)	Expected Damage
1	74-95	4 – 5 feet	Minimal: Damage is done primarily to shrubbery and trees, unanchored mobile homes are damaged, some signs are damaged, and no real damage is done to structures.
2	96-110	6 – 8 feet	Moderate: Some trees are toppled, some roof coverings are damaged, and major damage is done to mobile homes.
3	111-130	9 – 12 feet	Extensive: Large trees are toppled, some structural damage is done to roofs, mobile homes are destroyed, and structural damage is done to small homes and utility buildings.
4	131-155	13 – 18 feet	Extreme: Extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; and some curtain walls fail.
5	> 155	> 18 feet	Catastrophic: Roof damage is considerable and widespread, window and door damage is severe, there are extensive glass failures, and entire buildings could fail.
Additional Classifications			
Tropical Storm	39-73	0 - 3 feet	NA
Tropical Depression	< 38	0	NA

Source: NHC, 2010
mph = Miles per hour
> = Greater than
NA = not applicable or not available

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 of time, in years, between occurrences of a particular hazard event (equal to the inverse of the annual frequency of exceedance). For example, a flood that has a 1-percent chance of being equaled or exceeded in any given year is also referred to as the base flood and has a MRP of 100. This is known as a 100-year flood. The term "100-year flood" can be misleading; it is not the flood that will occur once every 100 years. Rather, it is the flood elevation that has a one-percent chance of being equaled or exceeded each year. Therefore, the 100-year flood could occur more than once in a relatively short period of time or less than one time in 100 years (Dinicola, 2009).

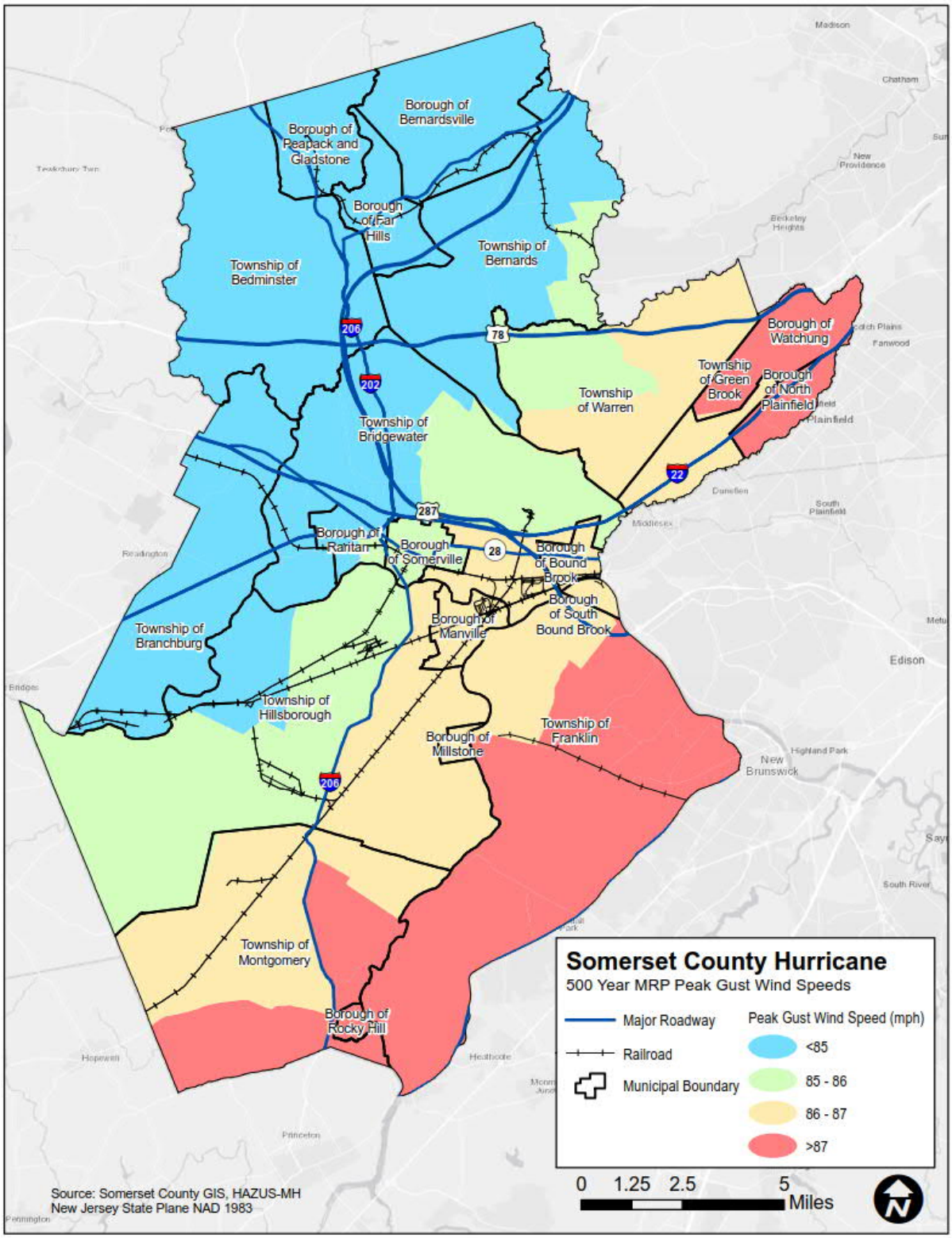
Figure 5.4.1-1 and Figure 5.4.1-2 show the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP HAZUS-MH 4.0 model runs. For the 100-year MRP event, the maximum 3-second gust wind speeds for the County range from less than 68 mph in areas to the northwest, to more than 70 mph in areas to the southeast – generally characteristic of a Category 1 hurricane or tropical storm. For the 500-year MRP event, the maximum 3-second gust wind speeds for the County range from less than 85 mph to more than 87 mph – also generally characteristic of a Category 1 hurricane. 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 5.4.1-1 Wind Speeds and Storm Track for the 100-Year Mean Return Period Event in Somerset County



Source: HAZUS-MH 4.0

Figure 5.4.1-2 Wind Speeds and Storm Track for the 500-Year Mean Return Period Event in Somerset County



Source: HAZUS-MH 4.0

Location

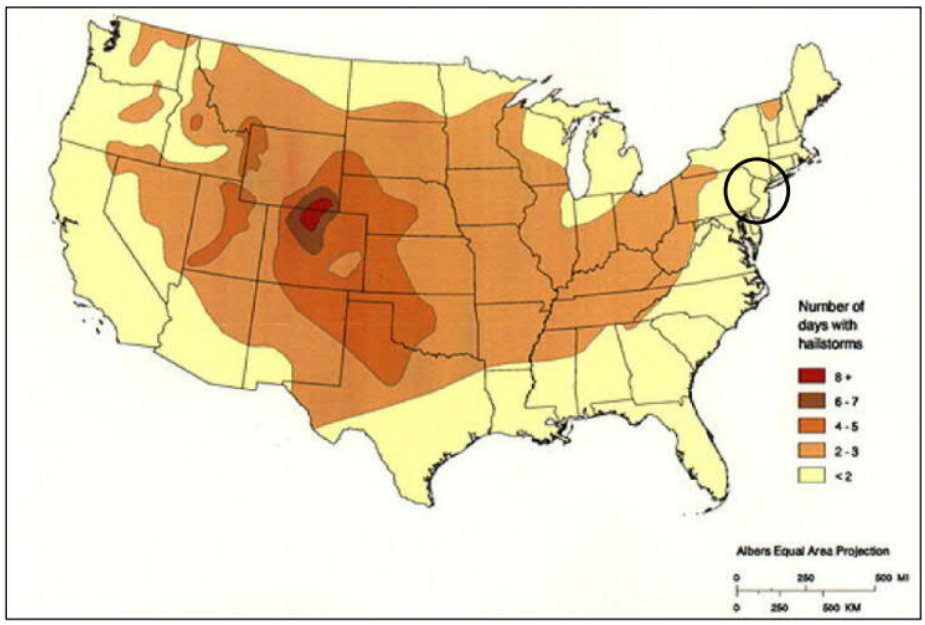
New Jersey is located in the path of precipitation-producing weather systems ("storm paths") that move across the U.S. from all directions. These systems commonly produce thunderstorms during the warm season and snow during the cold season. Occasional hurricanes, tropical storms, and nor'easters approach New Jersey from the southeast and northeast. Severe storms are a common occurrence throughout New Jersey and can affect the entire study area of Somerset County.

Severe storms are a common natural hazard in New Jersey because the State features a unique blend of meteorological factors that influence the potential for severe storms and associated flooding. Factors include temperature, which is affected by latitude, elevation, proximity to water bodies and source of air masses; and precipitation which includes snowfall and rainfall. Precipitation intensities and effects are influenced by temperature, proximity to water bodies, and general frequency of storm systems. The geographic position of New Jersey, along with other states in the Northeast U.S., makes it vulnerable to frequent storm and precipitation events. This is because nearly all storms and frontal systems moving eastward across the continent pass in close proximity to the state. Additionally, the potential for prolonged thunderstorms or coastal storms and periods of heavy precipitation is increased throughout the state because of the available moisture that originates from the Atlantic Ocean (Cornell University College of Agriculture and Life Sciences, 2011; NYS HMP, 2011).

Hailstorms

Hailstorms are more frequent in the southern and central plain states, where the climate produces violent thunderstorms. However, hailstorms have been observed in almost every location where thunderstorms occur (Federal Alliance for Safe Homes, Inc., 2006). Figure 5.4.1-3 illustrates that Somerset County and all other areas in New Jersey experience less than two hailstorms per year.

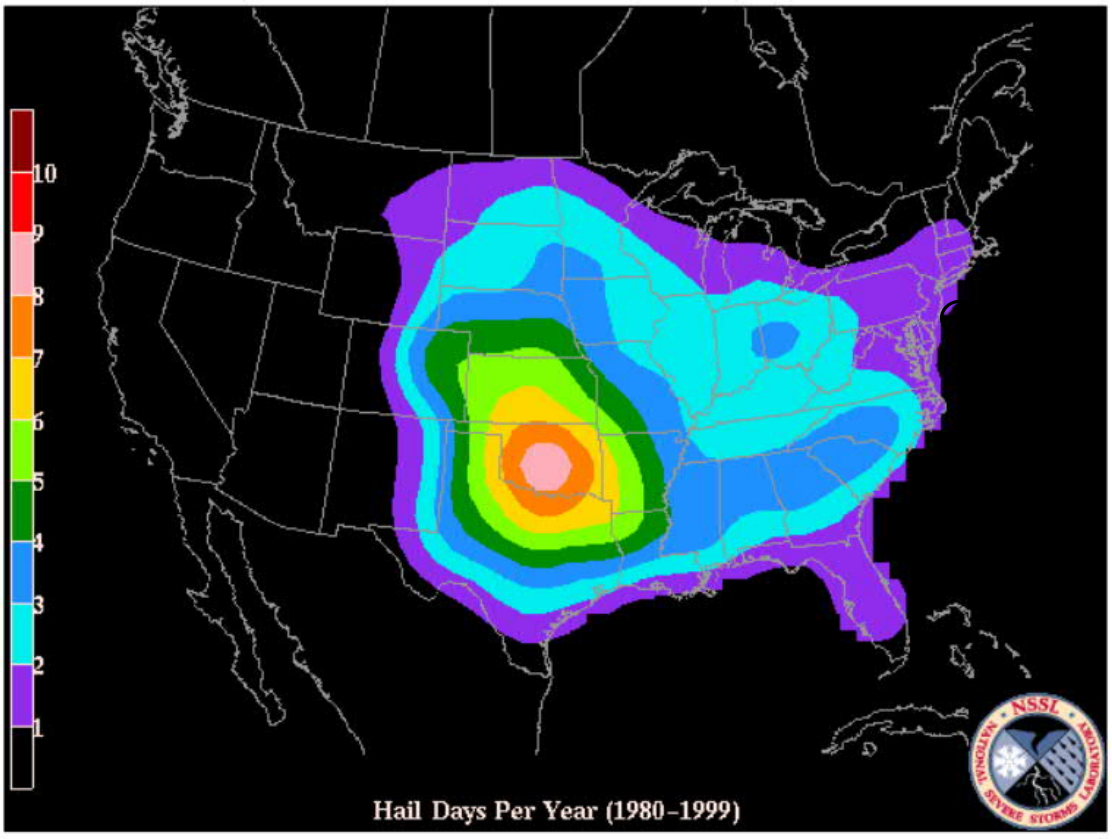
Figure 5.4.1-3 Annual Frequency of Hailstorms in the U.S.



Source: NJHMP 2014 (FEMA, 1996)
Note: The black circle highlights the State of New Jersey, which experiences less than two hailstorms annually.

Figure 5.4.1-4 illustrates the average annual number of hail days per year occurring within 25 miles of any point in the US, for hail events of at least 0.75 inches in diameter. According to this figure, all of New Jersey lies in an area mapped between one and two days of hail each year.

Figure 5.4.1-4 Total Annual Threat of Hail Events (0.75-inch diameter or greater) in the U.S., 1980-1999

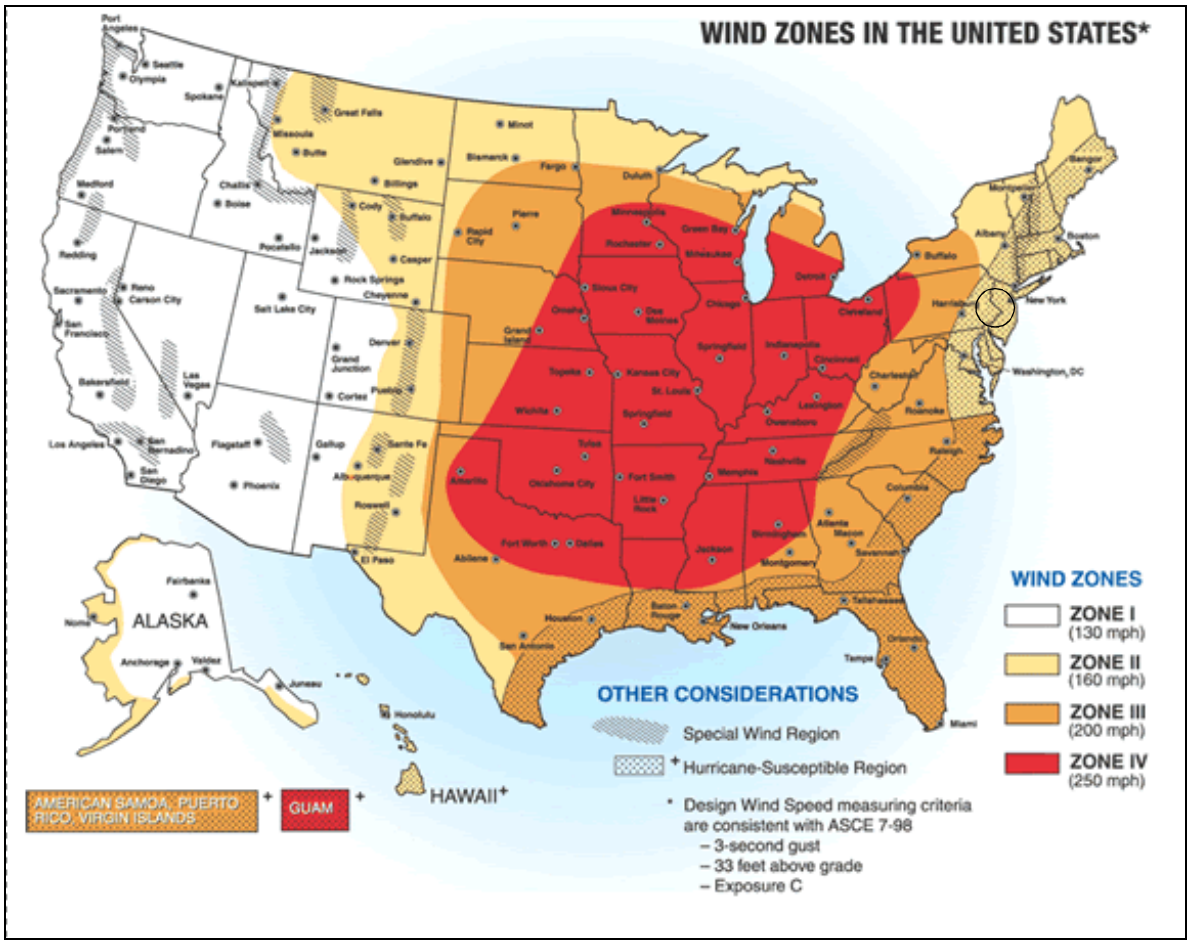


Source: NJHMP 2014 (NSSL, 2003)

Windstorms

Figure 5.4.1-5 indicates how the frequency and strength of windstorms impacts the U.S. and the general location of the most wind activity. This is based on 40 years of tornado history and 100 years of hurricane history, collected by FEMA. States located in Wind Zone IV have experienced the greatest number of tornadoes and the strongest tornadoes (NVRC, 2006). Somerset County is located in Wind Zone II with speeds up to 160 miles per hour (FEMA, 2012). The entire state of New Jersey is also categorized as the Hurricane Susceptibility Region, which extends along the northeastern coastline of the U.S.

Figure 5.4.1-5 Wind Zones in the U.S.



Source: FEMA, 2012
Note: The black circle indicates the approximate location of Somerset County; the County is located within Wind Zone II and in the hurricane susceptible region.

Table 5.4.1-6 Wind Zones in the U.S.

Wind Zones	Areas Affected
Zone I (130 mph)	All of Washington, Oregon, California, Idaho, Utah, and Arizona. Western parts of Montana, Wyoming, Colorado and New Mexico. Most of Alaska, except the east and south coastlines.
Zone II (160 mph)	Eastern parts of Montana, Wyoming, Colorado, and New Mexico. Most of North Dakota. Northern parts of Minnesota, Wisconsin and Michigan. Western parts of South Dakota, Nebraska and Texas. All New England States. Eastern parts of New York, Pennsylvania, Maryland, and Virginia. Washington, DC.
Zone III (200 mph)	Areas of Minnesota, South Dakota, Nebraska, Colorado, Kansas, Oklahoma, Texas, Louisiana, Mississippi, Alabama, Georgia, Tennessee, Kentucky, Pennsylvania, New York, Michigan, and Wisconsin. Most or all of Florida, Georgia, South Carolina, North Carolina, Virginia, West Virginia. All of American Samoa, Puerto Rico, and Virgin Islands.

Wind Zones	Areas Affected
Zone IV (250 mph)	Mid US including all of Iowa, Missouri, Arkansas, Illinois, Indiana, and Ohio and parts of adjoining states of Minnesota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Louisiana, Mississippi, Alabama, Georgia, Tennessee, Kentucky, Pennsylvania, Michigan, and Wisconsin. Guam.
Special Wind Region	Isolated areas in the following states: Washington, Oregon, California, Idaho, Utah, Arizona, Montana, Wyoming, Colorado, New Mexico. The borders between Vermont and New Hampshire; between New York, Massachusetts and Connecticut; between Tennessee and North Carolina.
Hurricane Susceptible Region	Southern US coastline from Gulf Coast of Texas eastward to include entire state of Florida. East Coastline from Maine to Florida, including all of Massachusetts, Connecticut, Rhode Island, Delaware, and Washington DC. All of Hawaii, Guam, American Samoa, Puerto Rico and Virgin Islands.

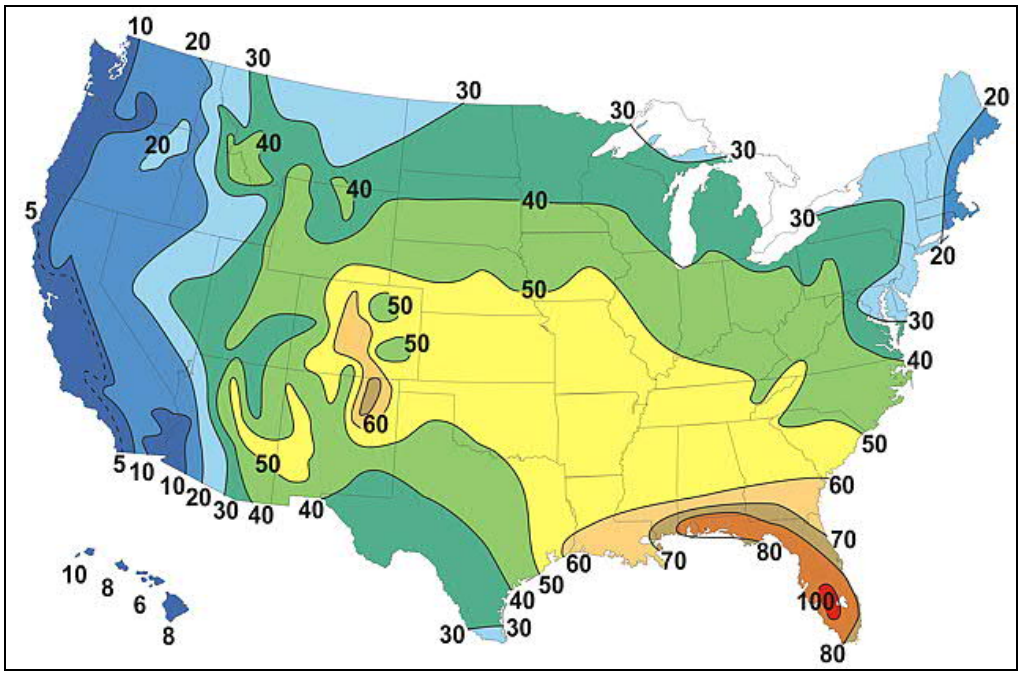
Source: FEMA, 2012

Thunderstorms

Thunderstorms affect relatively small localized areas, rather than large regions much like winter storms, and hurricane events (NWS, 2010). Thunderstorms can strike in all regions of the U.S.; however, they are most common in the central and southern states. The atmospheric conditions in these regions of the country are most ideal for generating these powerful storms (NVRC, 2006). It is estimated that there are as many as 40,000 thunderstorms each day world-wide.

Figure 5.4.1-6 shows the average number of thunderstorm days throughout the U.S. The most thunderstorms are seen in the southeast states, with Florida having the highest incidences (80 to over 100 thunderstorm days each year) (NWS, 2010). This figure indicates that most of New Jersey, including Somerset County, experiences between 20 and 30 thunderstorm days each year. A relatively small area in the northwestern corner of the state tends to experience more events, with 30 to 40 thunderstorm days per year.

Figure 5.4.1-6 Annual Average Number of Thunderstorm Days in the U.S.

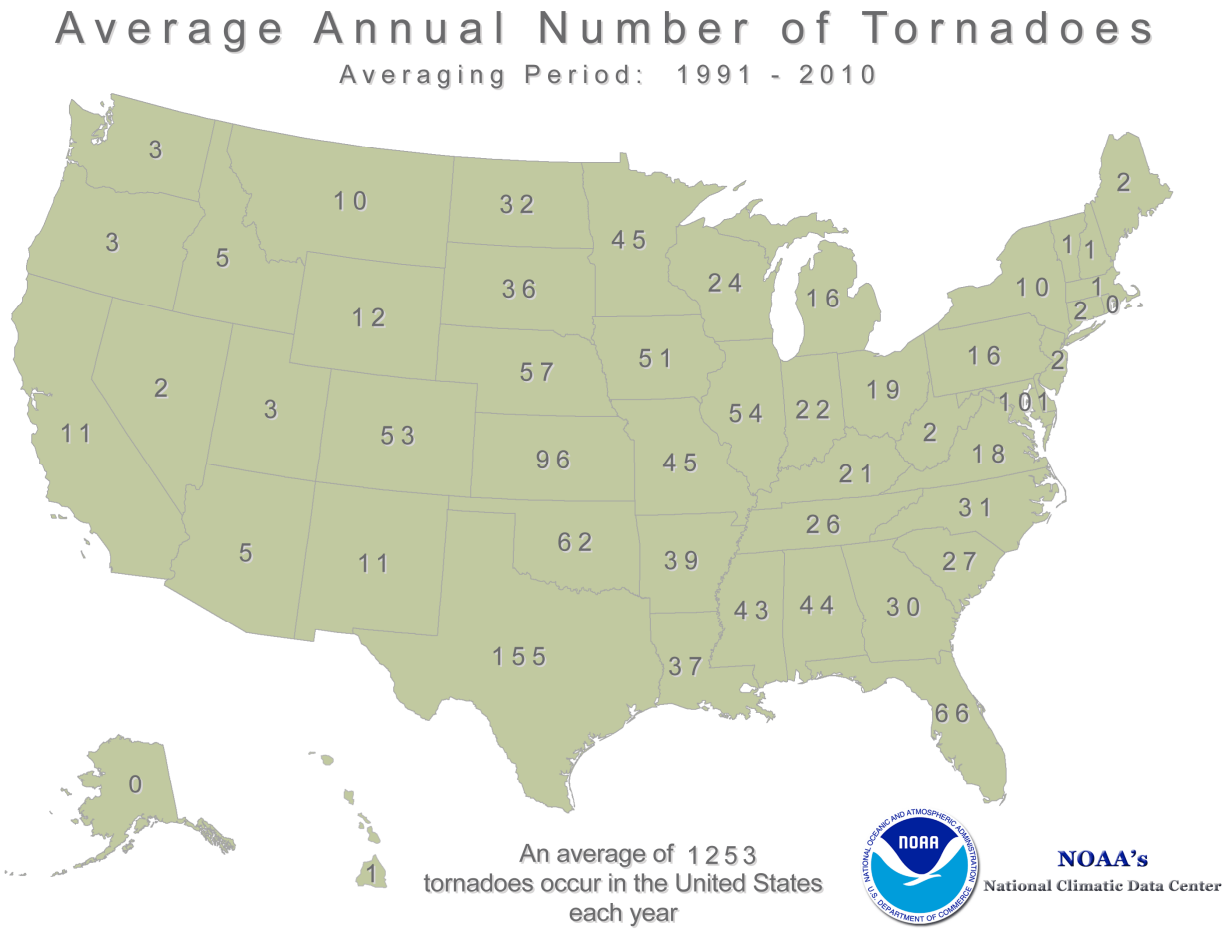


Source: NWS, 2010

Tornado

The U.S. experiences more tornadoes than any other country. In a typical year, approximately 1,253 tornadoes occur in the U.S, of which an average of 37.5 were the more damaging EF-3 to EF-5 events. The peak of the tornado season is April through June, with the highest concentration of tornadoes in the central U.S. Figure 5.4.1-9 shows the annual average number of tornadoes between 1991 and 2010 (NOAA NCDC, 2017). New Jersey experienced an average of two tornado events annually between 1991 and 2010; none of these were greater than EF-2.

Figure 5.4.1-7 Annual Average Number of Tornadoes in the U.S., 1981 to 2010

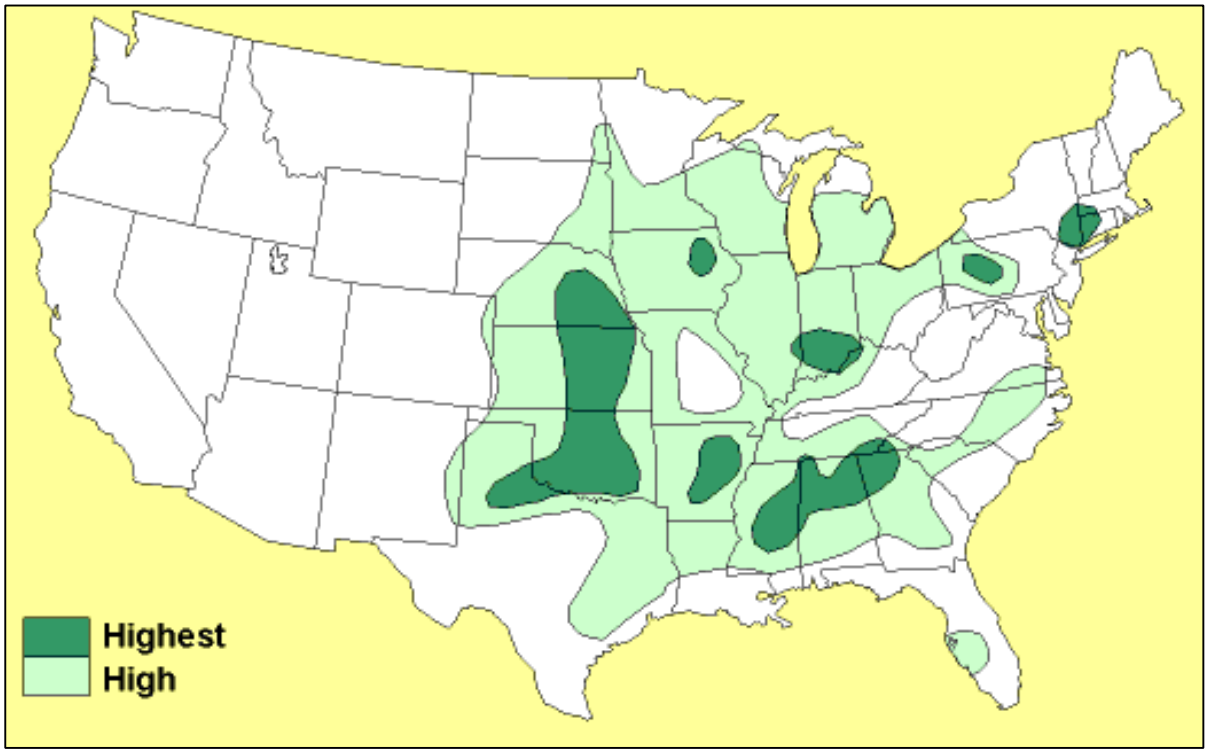


Source: NOAA NCDC, 2017 (https://www1.ncdc.noaa.gov/pub/data/cmb/images/tornado/clim/ann-avg-torn1991-2010.gif)
Note: Between 1991 and 2010, New Jersey experienced an average of two tornadoes annually.

New Jersey ranks 37th in the U.S. for frequency of tornadoes, 30th for injuries per area and 23rd for cost per area. When compared to other states on the frequency of tornadoes per square mile, New Jersey ranks 20th (NJOEM, 2011).

Figure 5.4.1-10 indicates that a majority of the State, with the exception of the northern-most border, has an overall low risk of tornado activity. Somerset County is located in north central New Jersey, which according to the figure, has a low risk of tornadoes.

Figure 5.4.1-8 Tornado Risk in the U.S.

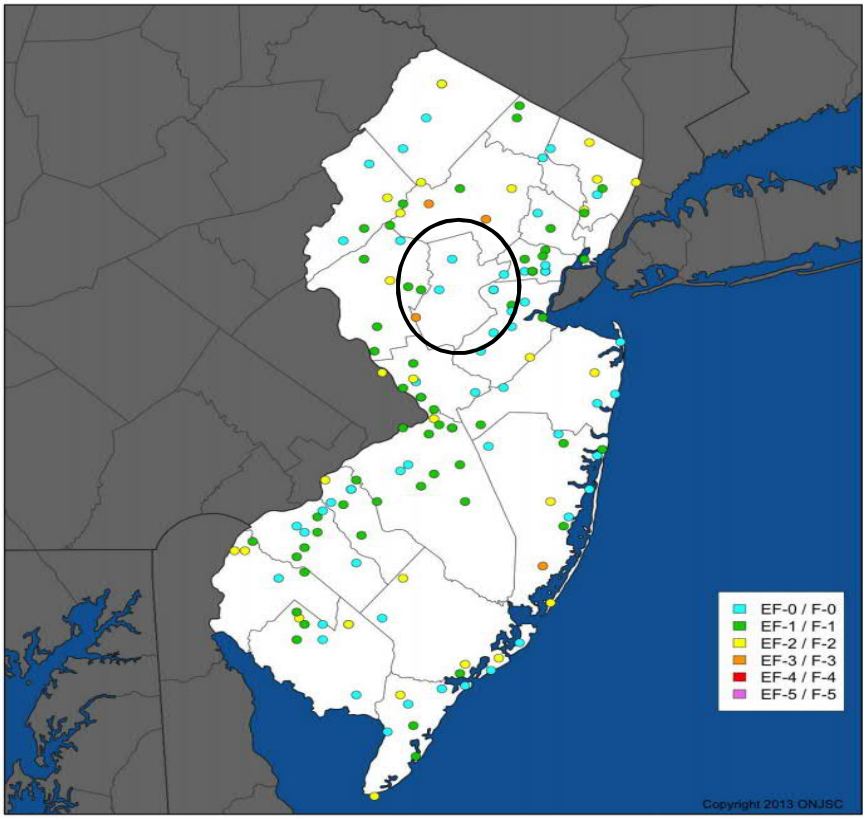


Source: The Physical Environment, 2012
Note: Somerset County is shown has having a low risk of tornado occurrences.

According to Figure 5.4.1-11, every county in New Jersey has experienced at least some tornadic activity 1951(NJOEM, 2014). According to the NOAA-NCDC, three tornadoes have occurred in Somerset County between 1951 and December 2017[1]: one in Branchburg in 1961 causing approximately $25,000 in damages (magnitude not reported) but no fatalities or injuries; one in Bedminster in October 2003 (F0) with no reported damages, fatalities, or injuries; and the largest (F3) in Hillsborough and Montgomery in October 1990 causing eight injuries and approximately $2.5 million in damages. The last reported tornado in Somerset County occurred in 2003.

[1] Note: The NCDC reports four events in Somerset County; however, the path of the fourth lies east of the Somerset County boundary, and is therefore not counted here.

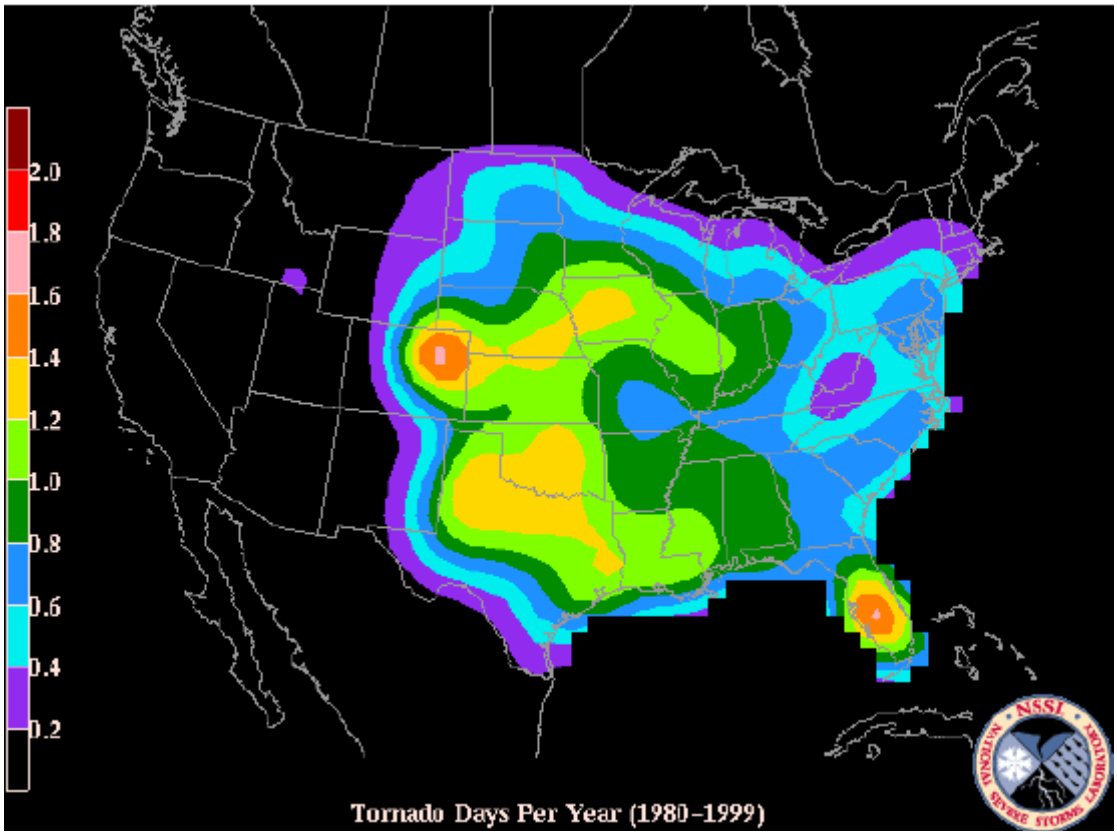
Figure 5.4.1-9 Historic Tornado Distribution and Intensity in New Jersey, 1950-2012



Source: NJOEM, 2014
Note: The black circle indicates the approximate location of Somerset County.

A study from NOAA's National Severe Storms Laboratory (NSSL) provided estimates of the long-term threat from tornadoes. The NSSL used historical data to estimate the daily probability of tornado occurrences across the U.S., no matter the magnitude of the tornado. Figure 5.4.1-12 shows the estimates prepared by the NSSL. In the State of New Jersey, it is estimated that the probability of a tornado occurring is 0.4 and 0.8 days per year. In Somerset County, it is estimated that the probability of tornado occurring is 0.6 to 0.8 days per year (NSSL, 2003; NJOEM, 2011).

Figure 5.4.1-10 Total Annual Threat of Tornado Events in the U.S., 1980-1999



Source: NJOEM, 2011; NSSL, 2003
Note: The mean number of days per year with one or more events within 25 miles of a point is shown here. The fill interval for tornadoes is 0.2, with the purple starting at 0.2 days. For the nontornadic threats, the fill interval is 1, with the purple starting at 1. For the significant (violent), it's 5 days per century (millennium)

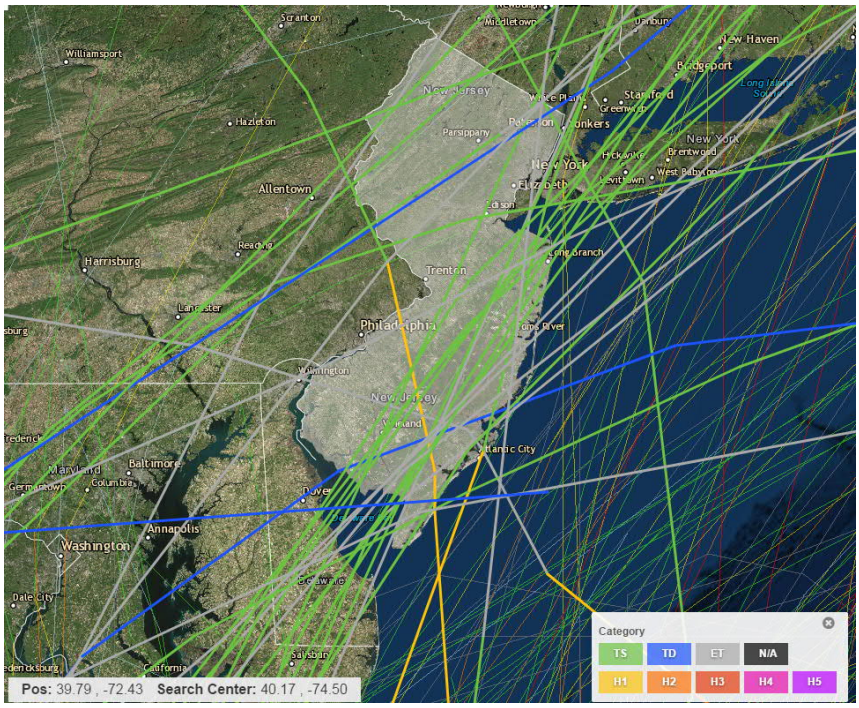
Hurricanes/Tropical Storms

Hurricanes and tropical storms can impact the state of New Jersey and Somerset County from June to November, the official eastern U.S. hurricane season. However, late July to early October is the period hurricanes and tropical storms are most likely to impact the state, due to the coolness of the North Atlantic Ocean waters (NJHMP, 2014).

Due to Somerset County's inland location, hurricanes do not appear to make direct landfall on the mitigation study area. However, multiple sources have indicated that the County has felt the direct and indirect landward effects associated with several hurricanes and tropical storms in recent history, such as Hurricane Irene in 2011 and Hurricane Sandy in 2012 (NOAA, 2012).

NOAA's Historical Hurricane Tracks tool Version 4.0 is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool tracks tropical cyclones from as far back as 1842 (depending on location) through 2016. For the State of New Jersey, 33 hurricanes, tropical storms, tropical depressions, and extratropical cyclones have crossed over the State of New Jersey. Figure 5.4.1-13 illustrates these storm tracks. The majority of these storms have passed over the eastern and southeastern parts of the State.

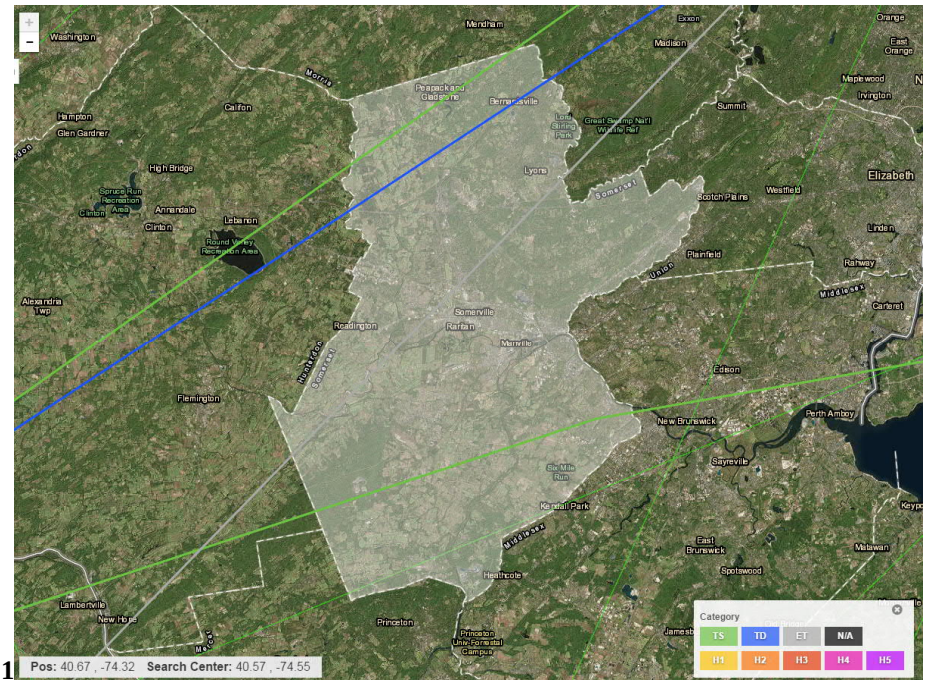
Figure 5.4.1-11 Hurricane Tracks in New Jersey, 1861 to 2016



Source: NOAA, 2018 (data current as of 2016)

Figure 5.4.1-14 displays these same occurrences for the Somerset County geography. Five hurricanes, tropical storms, tropical depressions, and extratropical cyclones are shown passing through Somerset County (NOAA, 2018). The tool's data table indicates that these were an unnamed tropical storm in August 1915; an unnamed extratropical system in September 1945; Diane, a tropical storm as it crossed the County in August 1955; and Chris, a tropical depression as it crossed Somerset County in August 1988. Data is not included in this tool for the fifth track, a tropical storm crossing along the County's southern border.

Figure 5.4.1-12 Hurricane Tracks in Somerset County, 1861 to 2016



Source: NOAA, 2018 (data current as of 2016)

Previous Occurrences and Losses

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

According to NOAA's NCDC storm events database, Somerset County experienced 31 severe storm events since the publication of Somerset County's 2014 HMP, between January 2014 and December 2017. These events were categorized as hail, heavy rain, thunderstorm wind, lightning, hurricane and tropical storms, and strong winds. Total property damages, as a result of these severe storm events, were estimated by NOAA at approximately $64,600.

As per the NJHMP 2014, between 1954 and 2012, FEMA declared that the State of New Jersey experienced 14 severe storm-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe storms, high tides, flooding, high winds, heavy rain, hail, tornadoes, and mudslides. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, the NJHMP 2014 indicates that Somerset County has been declared as a disaster area as a result of six of these severe storm events. According to information posted on FEMA's web site, New Jersey has been declared for two events since Hurricane Sandy in 2012: Severe Storms on June 23, 2015 (declared counties: Burlington, Camden, Atlantic, and Gloucester); and a Severe Winter Storm that occurred January 22-24, 2016 (declared counties: all except Sussex, Passaic, Gloucester, and Salem).

Based on all sources researched, known severe storm events that have affected Somerset County and its municipalities are identified in Table 5.4.1-7. With severe storm documentation for New Jersey being so

extensive, not all sources have been identified or researched. Therefore, Table 5.4.1-7 may not include all events that have occurred throughout the County and region.

Many severe storm events resulted in major flooding throughout the county, therefore, the flood impact of these events are further mentioned in Section 5.4.3 (Flood). According to many sources, certain severe storm events have actually been classified as Nor'easters; therefore, further discussed in Section 5.4.2 (Severe Winter Storm) and the flooding impact of the events are further discussed in Section 5.4.3 (Flood).

Table 5.4.1-7 Severe Storm Events between 1742 and 2017

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
June 6, 1742	Hail	N/A	N/A	Heavy hailstorm in Raritan, roofs damaged, 1 fatality	Somerset County HMP
May 22, 1804	Tornado	N/A	N/A	Started in Hunterdon County and moved into SC then to Middlesex County, funnel seen, roaring noise heard, one fatality	Somerset County HMP
June 19, 1835	Tornado "New Brunswick Tornado"	N/A	N/A	Began near Hillsborough, path of 17.5 miles through New Brunswick, 120 buildings destroyed, 5 fatalities, worst tornado in NJ, $61 K in damages	Somerset County HMP
September 21-24, 1882	Tropical Storm	N/A	N/A	Brought heavy rain, flooding the Passaic Valley, Bound Brook under water (Ludlum); 7.69 inches of rain fell in Somerville (AMS)	Somerset County HMP
July 31-August 5, 1915	Tropical Depression	N/A	N/A	Moved from Trenton to Bergen County, bringing 7.86 inches of rain to Somerville in 4 days, urban flooding in SC	Somerset County HMP
March 29, 1919	High Winds	N/A	N/A	Wind gusts up to 68 mph, crop and building damage	Somerset County HMP
September 21, 1938	New England Hurricane of 1938	N/A	N/A	Minor impacts to SC, including heavy rain and flooding of major rivers.	Somerset County HMP
September 12-14, 1944	1944 Great Atlantic Hurricane	N/A	N/A	$25 M in damages to NJ. NJ suffered 9 fatalities, 320 injuries, and 463 destroyed homes from this event (locations were not specified (AMS)	Somerset County HMP
September 12, 1960	Hurricane Donna	N/A	N/A	$46 K in damages throughout SC (property and crop) from heavy rain	Somerset County HMP
November 29, 1960	Tornado (F1)	N/A	N/A	$25 K in property damage (NOAA-NCDC), no reported injuries or fatalities (Tornado Project)	Somerset County HMP
November 11, 1968	Severe Storm/Wind	N/A	N/A	$238 K in property damage	Somerset County HMP
July 27, 1969	TSTM/Flooding	N/A	N/A	$23 K in property damage	Somerset County HMP
September 4, 1971			Yes		Somerset County HMP
August 26-28, 1971	Heavy Rain/Flooding "Tropical Storm Doria"	DR-310	Yes	Created the third largest flood event in SC, with Bound Brook and Manville hardest hit. Killed three people and caused approx. $138.5 M in damages in New Jersey. Created damage to public property (roads, bridges, water supply systems and sewer systems) and private and industrial holdings. The Bound Brook Water Company's Chimney Rock Reservoir experienced a devastating break. SHELDUS indicated that Somerset County experienced $2.4 M in property damage and $2 K in crop damages.	Somerset County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
June 19-24, 1972	Tropical Storm Agnes	N/A	N/A	Rainfall totals between 1 to 15 inches (NOAA-HPC); storm caused 122 deaths and $2.1 B in damages throughout the US (NWS); entered NJ as a tropical storm, record low June barometer, 5.31 inches of rain fell in Pottersville (Ludlum); $262 K in damages (property and crop) and 1 fatality to SC (SHELDUS)	Somerset County HMP
November 6, 1972	Severe Storm/Flooding	N/A	N/A	$25 K in property damage	Somerset County HMP
May 28, 1973	Tornado (F3)	N/A	N/A	12 injuries, between $50 K and $500 K in damages	Somerset County HMP
August 7, 1973	TSTM/Flooding/ Severe Storm	DR-402	Yes	USGS indicated that this event resulted in a FEMA disaster declaration due to seven inches of rain in 5 hours, 6 lives lost and approximately $67 M in total damages throughout NJ. The Green Brook and Blue Brook overflowed, flooding neighboring communities (Bound Brook), and North Plainfield were significantly impacted. $417 K in property damage (SHELDUS)	Somerset County HMP
July 13-21, 1975	TSTM/Flooding	N/A	N/A	Severe thunderstorms entered the area, causing flooding in many parts, resulted in 1 fatality and $12 M in damages in NJ (USGS); SHELDUS indicated that SC experienced $476 K in property and crop losses.	Somerset County HMP
September 26, 1977	Tornado (F1)	N/A	N/A	$25 K in property damage	Somerset County HMP
November 6, 1977	Severe Storm/Flooding	N/A	N/A	$2.4 M in property damage	Somerset County HMP
September 27, 1985	Hurricane Gloria	N/A	N/A	Heavy rains inland, downed power lines and trees. Minimal damage to NJ	Somerset County HMP
October 18, 1990	Tornado (F3)	N/A	N/A	$2.5 M in property damage, 8 injuries (NOAA-NCDC); 2 houses destroyed and 5 were uninhabitable, 200 homes were damaged (Prial, 1990)	Somerset County HMP
December 10-17, 1992	Coastal Storm/High Tides/Heavy Rain/Flooding (”Great Nor’easter of 1992”)	DR-973	Yes	Bergen, Essex, Hudson, Somerset, Union, Middlesex, Monmouth, Ocean, Salem, Atlantic, Cumberland, and Cape May Counties were declared disaster areas. Total damages for this event were estimated at $2 B. Nearly $350 M was paid on more than 25,000 flood- insured losses resulting from this storm. Total eligible amount: $51.0 M Public Assistance (25% state share $12.5 M); $10.5 M Individual Assistance (25% state share $1.32 M); $ 2.2 M Hazard Mitigation (50/50 share). NJ OEM indicated that 238 municipalities were eligible for Public Assistance in New Jersey. Although Somerset County was declared as a disaster area from this event, information regarding losses or impacts for Somerset County is scarce.	Somerset County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
August 16, 1993	TSTM/Lightning	N/A	N/A	Over 2 inches of rain fell causing street flooding, one person struck by lightning in Bridgewater	Somerset County HMP
April 16, 1994	TSTM/Strong Wind	N/A	N/A	Trees and power lines downed due to strong winds, wind gusts between 60 to 70 mph	Somerset County HMP
April 4, 1995	TSTM/Wind	N/A	N/A	Large tree fell on Klines Mill Road Bridge, weight of tree buckled the bridge	Somerset County HMP
April 30, 1996	TSTM	N/A	N/A	Tornado-like conditions in NJ, 2000 customers without power (Berkin); hardest hit areas were Branchburg, Far Hills, and Peapack, microburst caused extensive tree damage, trees fell on houses, roofs were torn off homes, trees were uprooted in many parts of SC, $100 K in property damages (NOAA-NCDC); $100 K in property damages (SHELDUS)	Somerset County HMP
July 12-13, 1996	Hurricane Bertha	N/A	N/A	Storm produced tornadoes, caused $270 M in damages and 12 fatalities in the US, 4 to 6 inches of rain fell in the area (NOAA); wind gusts reached 40 mph, tree limbs and wires down, 55,000 people lost power, rainfall totals averaged 2 to 4 inches, minor urban and poor drainage flooding, 3.04 inches of rain reported in SC (NOAA-NCDC)	Somerset County HMP
October 18-23, 1996	Severe Storms/Flooding (identified as a Nor'easter by the NJ HMP)**	DR-1145	Yes	Evacuations in Manville and North Branch, flooded basements, foundations collapsed. For New Jersey State - Individual Assistance, Hazard Mitigation, FEMA Disaster Housing Assistance $1.6 M; Individual/Family Grant Program $249 K (includes 25% state share); SBA Loans $1.2 M; Federal Hazard Mitigation Funding $256 K. According to NOAA-NCDC, Somerset County experienced approx. $31 M in property damages in SC, primarily from flooding.	Somerset County HMP
July 18, 1997	TSTM/Wind	N/A	N/A	Wind gusts reached 70 mph, fallen trees damaged cars and homes, power outages and road closures, 2 injuries were reported (NOAA-NCDC); 2 injuries (SHELDUS)	Somerset County HMP
January 9, 1998	TSTM/Wind	N/A	N/A	TSTM blew out back wall of a storage warehouse, winds knocked an employee off the loading dock, power lines knocked down, 500 people without power	Somerset County HMP
April 1, 1998	Lightning	N/A	N/A	Lightning struck a house and started a small fire, $5 K in property damages	Somerset County HMP
September 7, 1998	TSTM/Wind	N/A	N/A	18,000 homes and businesses without power, tornadoes produced in NJ, 3 deaths in NY and NJ (Malinconico); many power lines and trees knocked down, homes were damaged, many power outages, schools closed, state of emergency declared in some SC towns, road closures, 1 injury and $2.7 M in property damages (NOAA-NCDC); 1 injury (SHELDUS)	Somerset County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
September 16-18, 1999	Hurricane/Tropical Storm Floyd*	DR-1295; EM-3147; EM 3148	Yes	The July 2000 USACE Post-Flood Report indicated that damage in the 9 declared counties was estimated at $630.6 M in 2000, with Somerset County experiencing the most damage from its largest known flood event to date, particularly to residential structures. This Post-Flood Report also indicated that Bound Brook and Manville Boroughs were 2 of the top 10 most flood-impacted municipalities studied having the most economic loss from this event. Manville experienced $3.2 M and Bound Brook experienced $77 M (the highest loss out of any other municipality). According to NOAA-NCDC, it was indicated that Somerset County experienced additional losses totaling approx. $358 M in property damages, 2 deaths, over 100 injuries, 13,000 evacuations, damaged bridges, condemned and destroyed homes and contaminated roadways. Rainfall totals ranged from 10 to 12 inches, producing the highest known flood on Raritan River and Millstone River. 500,000 people were affected in the Raritan Valley as a result of flood damage to the Elizabethtown Water Company's main water treatment plant in Bridgewater, SC. The NJ OEM provided the following Federal Aid info for NJ: Total eligible Public Assistance $45 million, Total Federal Assistance $342 M; Total State Assistance/Cost Share $73.3 M.	Somerset County HMP
August 27, 2000	Lightning	N/A	N/A	Lightning struck 2 homes in Bound Brook and Warren, fires at both houses, $2 K in property damages	Somerset County HMP
December 12, 2000	Wind	N/A	N/A	$54 K in property damage	Somerset County HMP
June 11, 2001	Lightning	N/A	N/A	Lightning from a TSTM struck a house and started a fire, $85 K in property damages (NOAA-NCDC); $85 K in property damage (SHELDUS)	Somerset County HMP
July 1, 2001	TSTM/Wind	N/A	N/A	Trees and wires down, Peapack-Gladstone hardest hit areas	Somerset County HMP
August 10, 2001	Lightning	N/A	N/A	Lightning struck a barn and burned it down to the ground in Raritan, Somerville police department's phone system struck, $30 K in property damages (NOAA-NCDC); $30 K in property damage (SHELDUS)	Somerset County HMP
March 21, 2003	Hail	N/A	N/A	Quarter to golf ball sized hail damaging vehicles at a car dealership, $100 K in property damage (NOAA-NCDC); $100 K in property damage (SHELDUS); 1.75-inch hail in Green Brook and 1-inch hail in Skillman (SPC)	Somerset County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
July 22, 2003	TSTM/Wind	N/A	N/A	Large tree limbs and power lines down in Hillsborough, Franklin, and South Bound Brook, a large tent was destroyed in Hillsborough, a house was slightly damaged in South Bound Brook, 18,000 people without power (NOAA-NCDC); $1.5 M in property damage (SHELDUS); 1.5-inch hail throughout SC, power lines down (SPC).	Somerset County HMP
August 6, 2003	TSTM/Wind	N/A	N/A	Trees knocked down, Bridgewater hit hardest, one fallen tree damaged a house, downed tree crushed a car in Bound Brook.	Somerset County HMP
September 18-19, 2003	"Tropical Storm Isabel"	N/A	N/A	Category 2 storm in North Carolina with wind gusts up to 100 mph, produced heavy rain inland over the mid-Atlantic region; produced strong winds and power outages across NJ, wind gusts up to 62 mph, many trees and limbs knocked down, $1.9 M in property damage.	Somerset County HMP
November 13, 2003	High Wind	N/A	N/A	Peak wind gusts reached 58 mph throughout NJ, trees and wires down, roads blocked, houses and cars damaged, power outages reported, many injuries reported in SC, Routes 28, 202 and 206 all closed in SC, tree fell through house in Bernardsville, $2 M in property damage total in NJ (NOAA-NCDC); $125 K in property damage and 4 injuries in SC (SHELDUS); trees down, Route 206 closed (SPC).	Somerset County HMP
June 1, 2004	TSTM/Hail	N/A	N/A	TSTM knocked down trees, dropping pea to marble size hail, hail covered roadways, $1 K in crop damage (NOAA-NCDC); $1 K in crop damages (SHELDUS).	Somerset County HMP
July 1, 2004	TSTM/Wind	N/A	N/A	Trees knocked down, siding torn from homes, power lines down, about 120 homes without power, wind gusts up to 56 mph (NOAA-NCDC); large tree limbs down, some trees uprooted (SPC)	Somerset County HMP
August 11, 2004	TSTM/Wind	N/A	N/A	Entire trees and wires down, over 660 homes and businesses without power, wind gusts at 52 mph (NOAA-NCDC); TSTMs pulled down whole trees in Bedminster, power outages (Storm Data).	Somerset County HMP
September 28, 2004	Hurricane Jeanne	N/A	N/A	Caused $6.8 B in damages in the US (NOAA-HPC); storm produced tornadoes and flooding (NWS). Rainfall totals ranged from 2.6 to 4.24 inches in SC.	Somerset County HMP
January 18-19, 2006	Strong Wind	N/A	N/A	Power outages reported in northeast US, airport delays, 2 fatalities in the area (USAToday.com); peak wind gusts up to 70 mph, averaging at 45 mph throughout the area, trees and power lines were down, $200 K in property damage (NOAA-NCDC).	Somerset County HMP
February 17, 2006	TSTM/Wind	N/A	N/A	TSTMs produced damaging winds, with 52 mph wind gusts, downed trees and power lines, fallen tree closed down Route 601, $42 K in property damage.	Somerset County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
February 24, 2006	Strong Wind	N/A	N/A	Cold front brought 45 mph winds, $50 K in property damage.	Somerset County HMP
March 14-15, 2006	Strong Wind	N/A	N/A	40 mph wind gusts, $20 K in property damage.	Somerset County HMP
June 1, 2006	Lightning	N/A	N/A	Lightning struck an apartment complex, some apartments suffered slight damage (NOAA-NCDC); lightning struck a chimney of an apartment building, two apartments suffered damage (Storm Data).	Somerset County HMP
July 28, 2006	Lightning/TSTM	N/A	N/A	Trees down, lightning struck several homes throughout SC (SPC); trees knocked down in Peapack, cloud to ground lightning (Storm Data).	Somerset County HMP
August 3, 2006	TSTM/Wind	N/A	N/A	50 mph wind gusts associated with a severe TSTM, trees knocked down, telephone poles knocked down, power outages	Somerset County HMP
September 2, 2006	Tropical Storm Ernesto	N/A	N/A	Heavy rain, flooding and strong winds, power outages, 2.4 inches of rain fell in Bound Brook, 1.8 inches of rain fell in Pottersville.	Somerset County HMP
October 20, 2006	Strong Wind	N/A	N/A	40 mph winds, $30 K in property damage	Somerset County HMP
October 29, 2006	Strong Wind	N/A	N/A	45 mph winds, $378 K in property damage, 2 injuries	Somerset County HMP
November 16, 2006	Strong Wind	N/A	N/A	40 mph winds, $95 K in property damage	Somerset County HMP
December 1, 2006	Strong Wind	N/A	N/A	40 mph winds, $19 K in property damage	Somerset County HMP
January 20, 2007	Strong Wind	N/A	N/A	40 mph winds, $21 K in property damage	Somerset County HMP
February 14-15, 2007	Strong Wind	N/A	N/A	49 mph winds, $125 K in property damage	Somerset County HMP
March 5-6, 2007	Strong Wind	N/A	N/A	49 mph winds, $21 K in property damage	Somerset County HMP
April 14-20, 2007	Severe Storms and Inland and Coastal Flooding (also identified as a Nor'easter)	DR-1694	Yes	This storm created the 2nd largest flood event in SC. The 7-day rainfall total for the County ranged from 8 to 10 inches. USGS indicated that the North and South Branches of the Raritan River and the Raritan River had 20-year events. Millstone River had an 80-year event. Governor Codey declared a state of emergency for NJ. State Officials estimated that NJ experienced over $180 M in property damages. As of June 11, 2007, nearly $31 M in federal grants for flood losses has been approved for NJ residents. Bound Brook was one of the hardest hit communities and was given $5.2 M in federal aid.	Somerset County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
March 8, 2008	Heavy Rains/Strong Winds	N/A	N/A	Strong to damaging wind gusts affected the State of New Jersey on the evening of the 8th following a line of severe TSTMs passing through southwest and northern New Jersey. Transit services were delayed or suspended, and approximately 275,000 homes and businesses throughout the state lost power. The storm also brought heavy rain, and the region was primed for flooding by another heavy rain event that occurred on the 5th. In Somerset County, wind gusts of up to 55 mph were reported in Hillsborough Township. Runoff from the rainfall led to flooding along many gaged streams and rivers in Somerset County including the Raritan and Millstone Rivers. Event precipitation totals included 2.30 inches in Bound Brook Borough, 2.22 inches in Somerville Borough, and 1.94 inches in Hillsborough Township. The County had approximately $5K in damages.	Somerset County HMP
July 23, 2008	TSTM/ Lightning	N/A	N/A	An approaching cold front triggered TSTMs across the State during the afternoon and early evening of the 23rd. In Somerset County, the TSTM tore down several trees. In Somerville Borough, two very large trees were knocked down. Max wind speeds in Hillsborough Township were measured at 18 mph. In Franklin Township, lightning struck a 180 foot antenna, causing damage to the police, radio and telephone centers and filling the dispatch center at the police headquarters with smoke. Equipment was damaged and approximately $10K in damages was reported in Somerville Borough, but no other injuries were reported.	Somerset County HMP
July 27, 2008	TSTM Wind	N/A	N/A	A strong cold frontal passage triggered severe TSTMs across New Jersey on the afternoon of the 27th, bringing strong winds and heavy rain to Somerset County. Flash flooding of roadways and smaller streams was reported in and around Bound Brook Borough. Doppler Radar storm total estimates reached between 2 and 3 inches in the North Plainfield Borough area. In Green Brook Township on U.S. Route 22, a roof was partially torn off the EWA Model Car Center, allowing debris and rain to damage the interior of the building. The storm also tore down a few trees in North Plainfield Borough. Max wind speeds were recorded at15 mph in Hillsborough Township. Wind gusts of up to 64 mph were reported in North Plainfield, and approximately $100K in damages was reported in the borough.	Somerset County HMP

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
September 9, 2008	Lightning	N/A	N/A	A line of severe TSTMs moved through New Jersey during the morning and early afternoon. This rain combined with the heavy rain that fell with Tropical Storm Hanna on Sept. 6th led to flash flooding of roadways and small streams across central Somerset County from Branchburg Township east through Bound Brook Borough. Several roads were closed. Doppler Radar storm total estimates reached two inches. In addition to heavy rain, a lightning bolt struck the Grace Fellowship Church steeple in Bedminster Township. Damage was estimated at $5K, and limited to a few scorched and broken boards and the building's amplification system.	Somerset County HMP
October 28, 2008	Strong Wind	N/A	N/A	Gusty northwest winds combined with heavy wet snow and trees wet with leaves caused widespread utility outages throughout New Jersey. In central New Jersey, about 9,000 homes and businesses lost power. Peak wind gusts in Somerset County were recorded at 46 mph, with max wind speeds of 14 mph recorded in Hillsborough Township and 18 mph in Franklin Township. NOAA-NCDC reported $5K in damages for Somerset County due to strong winds, while SHELDUS reported nearly $300K in damages.	NOAA-NCDC, SHELDUS, NJWCN, Weather Underground
February 12, 2009	Strong Wind	N/A	N/A	After a cold front passed through, strong to high winds affected the State of New Jersey during the day on the 12th. Peak wind gusts averaged between 50 and 60 mph, knocking down trees, tree limbs, power lines and signs. The New Jersey Turnpike Authority banned motorcycles and car-pulled trailers. About 86,000 homes and businesses lost power in the State, with the strongest winds and most damage occurring in the central and northern parts of the state. In Somerset County, morning traffic was disrupted after a downed pole closed a westbound lane of U.S. Route 22. Further west, a downed tree caused the closure of all lanes near the Hunterdon County border. All southbound lanes of Interstate 287 were closed during the late afternoon after a large tree fell on the roadway. Vehicles were damaged by downed trees in Bridgewater Township. Peak wind gusts included 51 mph in Somerville Borough, 37 mph in Franklin Township, and 64 mph in Hillsborough Township. Damages in the County were estimated at $100K by NOAA and $39K by SHELDUS.	NOAA-NCDC, SHELDUS, NJ W&CC, Weather Underground

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
July 26, 2009	TSTM Wind/ Lightning	N/A	N/A	The combination of lightning and damaging winds from a severe TSTM left a swath of wind damage across the northern third of Somerset County during the afternoon and evening. In Bedminster Township, the shingles and half the roof of a supermarket were torn away. Numerous trees and power lines were knocked down, including those on County Routes 313 and 113, and Interstate 287. Thirteen vehicles and four condominiums were damaged by downed trees in the Bedminster Township. In Bridgewater Township, U.S. Route 202/206 was closed after a downed tree pulled down wires onto the roadway. In Bernards Township on Mountain Road, a downed tree tore a hole in the roof of a home and also damaged its deck. In Warren Township, downed trees damaged homes on Sage Drive and Church Road. A vehicle was also damaged. A lightning strike and ensuing fire damaged twelve units of a condominium on Fisher Drive in Franklin Township, and half of those were destroyed. One resident was hospitalized after she became light-headed. It took about 60 firefighters two hours to get the fire under control. A wind gust of 55 mph was recorded at the Somerville Somerset Airport, 15 mph at Cedar Brook Manor in Franklin Township, and 70 mph was recorded at Bedminster Township. Damages from the storm in Somerset County were estimated at $2M.	NOAA-NCDC, SHELDUS, Weather Underground
August 21, 2009	TSTMs/Lightning	N/A	N/A	Severe TSTMs passed through Somerset County on the 21st. In Montgomery Township, a lightning strike sparked an underground gas fire at the intersection of Skillman Road and County Route 601. About 200 homes and businesses lost gas service until the blaze was extinguished. The roadway was closed into the evening, and $10K in damages was reported in the township.	NOAA-NCDC, SHELDUS
May 8, 2010	Strong Wind	N/A	N/A	Strong west winds affected New Jersey from the afternoon into the evening. Peak wind gusts averaged around 50 mph and tore down weak trees, tree limbs and wires and caused a few road closures. About 21,500 homes and businesses lost power in northern and central New Jersey. The downed wires also started some small fires in addition to fanning a couple of larger wildfires. Somerset County reported max wind gusts of 29 mph in Franklin Township. Wind speeds of 43 mph, and $5K in damages were recorded in Hillsborough Township.	NOAA-NCDC, NJWCN, Weather Underground

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
September 22, 2010	TSTM Wind/ Lightning	N/A	N/A	During the afternoon of the 22nd, strong west winds struck the State of New Jersey, with peak gusts averaging around 50 mph. The strong winds downed trees, tree limbs and wires and caused a few road closures. About 21,500 homes and businesses lost power in northern and central New Jersey. The downed wires also started some small fires in addition to fanning a couple of larger wildfires. Somerset County reported peak wind gusts of 46 mph and numerous trees and wires were downed across the southern tier of the County in Hillsborough, Montgomery and Franklin Townships. In Montgomery Township, uprooted saplings were thrown into and damaged two moving vehicles. The drivers were not injured. Four roadways were closed because of debris. In Franklin Township, the Griggstown Causeway was closed because of a snapped utility pole. There were two dozen reports of downed trees in the Township. A lightning strike caused a transformer fire on Easton Avenue in Montgomery Township. Lightning also struck a home on Clayton Drive in Millstone Township, causing electrical damage to the home. Maximum wind gusts of 18 mph were reported in Franklin Township. Maximum wind speeds in Hillsborough Township were recorded at 45 mph, and estimated $16K in damages in Hillsborough Township.	NOAA-NCDC, SHELDUS, NJWCN,, Weather Underground

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
March 12 - April 15, 2010	Severe Storms and Flooding	DR-1897	Yes (IA and PA)	A Nor'easter moved into the area on March 12. On March 13, strong to high winds downed thousands of trees and tree limbs, hundreds of telephone poles, and caused utility outages throughout the state. The strongest winds occurred during the afternoon on the 13th. Governor Chris Christie declared a state of emergency on March 14th, and on March 26 requested a major disaster declaration. A state-wide federal disaster declaration was announced on April 2, making IA and PA available for affected areas. At the time of this report, a total $16.9M in IA had been approved and $30.7M in PA had been obligated throughout the State of New Jersey. In Somerset County, peak wind gusts reached 45 mph Bridgewater Township, and max wind speeds of 53 mph were recorded in Hillsborough Township on the 13th, where 3.11 inches of rain was recorded. In Franklin Township wind gusts peaked at 36 mph on the 13th and nearly 6 inches of rainfall was recorded over two days. Tremendous tree damage occurred in Montgomery Township. Schools were closed on the 15th as six roadways were still closed. Traffic on U.S. Route 206 was very heavy because it was the only roadway over the Millstone River that was open. Roads were also closed due to downed trees in Bernards Township, Benardsville Borough and Far Hills Borough. NOAA-NCDC reported approximately $5K in damages for Somerset County, while SHELDUS reported over $15M in damages, mostly due to storm-induced flooding in the County.	FEMA, NOAA-NCDC, SHELDUS, NJWCN, Weather Underground
February 18, 2011	Strong Wind	N/A	N/A	Strong winds affected New Jersey from the evening of the 18th into the evening of the 19th. Peak wind gusts averaged around 55 mph. The winds tore down trees, tree limbs and wires and caused power outages. Most of the highest winds and damage occurred in the central and southern part of the state. About 22,000 homes and businesses lost power. While more than two-thirds of the outages were resolved by the evening of the 19th, full power restoration did not occur until the evening of the 20th. The stronger winds reached their peak speeds during the late morning and afternoon of the 19th and then slowly decreased during the evening of the 19th. In Somerset County, peak wind gusts included 28 mph in Franklin Township, 54 mph in Hillsborough Township, and 48 mph in Somerville Borough (Somerset Airport). Wind gusts of 54 mph were reported elsewhere in the County. $5k in damages was reported in Somerset County.	NOAA-NCDC, Weather Underground

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
February 25, 2011	Strong Wind	N/A	N/A	A strong cold front moving across New Jersey produced strong to high winds during the afternoon and early evening. Peak wind gusts averaged 50 to 60 mph, with most of the highest gusts in the southern half of the state. The winds downed numerous trees, tree limbs and power lines, and also caused some structural damage. Max wind speeds of 42 mph were recorded in Hillsborough Township and gusts of 33 mph in Franklin Township. Somerset County reported $5k in damages.	NOAA-NCDC, Weather Underground
August 13-15, 2011	Severe Storms and Flooding	DR-4033	No	A series of thunderstorms preceding a cold front dropped three to seven inches of rain across a wide area of the State of New Jersey from overnight on the 13th into the day on the 14th. TSTMs, with heavy downpours, caused flash flooding of smaller streams on the 14th in southern Somerset County. TSTMs continued through the 15th and 16th, and cumulative runoff from the storms caused poor drainage and river flooding, first along Pike Run in Belle Mead (Montgomery Township) and then moderate flooding along the Millstone River. Seventy-two hour event precipitation totals ending the morning of the 16th included 6.68 inches in Montgomery Township, 6.58 inches in Hillsborough Township, 4.92 inches in Franklin Township, and 4.75 inches in Bridgewater Township. No damages were reported in the County.	FEMA, NOAA-NCDC
August 26 - September 5, 2011	Tropical Storm/Hurricane Irene	EM-3332; DR-4021	PA; IA, PA	Hurricane Irene hit the State of New Jersey on August 27th, resulting in a state disaster declaration August 29th and a presidential disaster declaration August 31st. Approximately 1.6 million customers of JCP&L and PSE&G throughout the State lost power, which for some residents was not restored until September 5th. Widespread tree wind damage (and damage to homes and vehicles when trees fell on them) occurred in every county. The highest wind gusts recorded during Hurricane Irene were 42 mph in the Township of Somerville (Somerset County) and 17 mph in Franklin Township. Thousands of homes were flooded, especially in Morris and Somerset Counties. Damage from the storm was so widespread that for the first time in state history, all 21 counties became eligible for both Individual Assistance (IA) and Public Assistance (PA). At the time of this report, a total $176.6M in IA had been approved and $111.9M in PA had been obligated throughout the state of New Jersey. Somerset County had approximately $500K in damage due to the storm.	FEMA, NOAA-NCDC, Weather Underground

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
September 28-October 6, 2011	Remnants of Tropical Storm Lee	DR-4039	No	Remnants of Tropical Storm Lee brought a series of TSTMs with torrential downpours the State of New Jersey. The TSTMs caused small stream and poor drainage flash flooding across northwest New Jersey. Rainfall totals in the heavier band that extended from northern Hunterdon County, ranged between three and five inches. Over the course of the storm, more than 1.5 inches of rain fell in Hillsborough Township, and 1.2 inches fell in Franklin Township. Runoff from the rain in Hunterdon and Morris Counties caused minor flooding around the confluence of the North and South Branches of the Raritan River. Max wind speeds of 23 mph were recorded in Hillsborough Township on the 29th, and 64 mph gusts were recorded in Franklin Township. No damages were reported in the County.	FEMA, NOAA-NCDC, NJWCN, Weather Underground
June 10, 2012	TSTM Wind	N/A	N/A	Isolated TSTMs moved across northern New Jersey during the late afternoon and early evening. Strong TSTM wind gusts downed numerous trees and power lines, leaving about 11,000 customers without electricity, mainly across Morris, Sussex, and Somerset Counties. In Somerset County, numerous trees and electric wires were knocked down near Bernardsville Borough. Other wind damage also occurred in Bernards Township. A few thousand customers lost electricity as a result of the downed power lines, but no injuries were reported. Wind gust of 64 mph were reported in Bernardsville Borough and 15 mph in Franklin Township. The County had approximately $5K in damages.	NOAA-NCDC
July 19, 2012	Severe Storms and Straight-Line Winds	DR-4070	No	A cold front from the north merged with a hot and humid air mass to trigger scattered thunderstorms throughout northern New Jersey on the afternoon and evening of the 18th. About 30,500 JCP&L and PSE&G customers lost power. In Somerset County, the severe TSTM brought wind gusts of up to 50 mph and knocked down several large tree limbs and wires in Raritan Borough. Nickel size hail fell in Hillsborough Township. No damages were reported in Somerset County.	FEMA, NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
October 26 - November 8, 2012	Hurricane Sandy	DR-4086/EM-3354	Yes (IA and PA)	Hurricane Sandy made landfall in New Jersey on October 28, causing widespread damage. However, since the storm merged with a cold-air system, it was no longer considered a tropical cyclone by the time of landfall, even though it still had hurricane-force winds. Sustained winds were well over tropical storm force in northern and central New Jersey, and gusts exceeded hurricane force (74 mph) at many coastal locations and at some exposed inland sites. In Somerset County, gusts of 24 mph were recorded in Franklin Township, and 44 mph in Hillsborough Township. Approximately 1.42 inches of rain fell in Hillsborough Township. The result of the storm was devastation to homes and infrastructure along portions of the northern and central coast, thousands of trees falling on homes, automobiles, and power lines across the state, unprecedented damage to the power grid, the loss of power to over 75% of customers, and record disruptions of transportation and communications. A federal emergency declaration was announced for New Jersey on October 29, and a major disaster declaration followed the next day, making IA and PA funds available to affected residents. Only a week after Sandy made landfall in New Jersey, a Nor'easter hit the area on November 7. Much of the State experienced wet snow which weighed down power lines and caused tree limbs to snap, significantly adding on to the existing power outages throughout the State. Additionally, some areas experienced 60 mph wind gusts. In Somerset County, max wind speeds occurred on the 8th, and were recorded at 28 mph in Hillsborough Township and at 23 mph in Franklin Township. At the time of this report, a total $274.9M in IA had been approved and $81M in PA had been obligated throughout the State of New Jersey.	FEMA, NOAA-NCDC, ONJSC, NJWCN, Weather Underground
1/6/2014	Strong Wind	N/A	N/A	Peak wind gusts were around 45 mph and knocked over weak tree limbs and wires.	NOAA-NCDC
3/12/2014	Strong Wind	N/A	N/A	Specific Somerset impacts not reported. Statewide, peak wind gusts averaged around 50 mph.	NOAA-NCDC
4/15/2014	Thunderstorm Wind	N/A	N/A	A severe thunderstorm knocked down several large trees causing isolated structural damage from wind in Somerset County and an estimated $50,000 in damages.	NOAA-NCDC
5/10/2014	Thunderstorm Wind	N/A	N/A	Scattered strong to severe thunderstorms occurred, knocking downed trees and power poles in several locations with some power outages in Basking Ridge.	NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
5/10/2014	Thunderstorm Wind	N/A	N/A	Scattered strong to severe thunderstorms occurred, knocking downed trees and power poles in several locations with some power outages. Trees and wires were downed in Liberty Corner.	NOAA-NCDC
7/2/2014	Thunderstorm Wind	N/A	N/A	A severe thunderstorm knocked down large tree limbs and wires along Zion Road in the Neshanic section of Hillsborough Township. Downed wires surrounded a truck on Castle Hill Lane. No injuries were reported.	NOAA-NCDC
7/3/2014	Thunderstorm Wind	N/A	N/A	A severe thunderstorm knocked down a couple of trees and wires in Raritan Township.	NOAA-NCDC
7/8/2014	Thunderstorm Wind	N/A	N/A	The gust front associated with a severe thunderstorm knocked down several large tree limbs in Bound Brook Borough.	NOAA-NCDC
2/2/2015	Strong Wind	N/A	N/A	Peak wind gusts average around 50 mph and knocked down weak trees, tree limbs and wires; and scattered power outages occurred across the state.	NOAA-NCDC
2/15/2015	Strong Wind	N/A	N/A	Strong wind gusts occurred across the state, ranging from about 45 to 60 mph. In Somerville, a gust of 47 mph was recorded. Downed trees and wires were common in locations across the state, as road crews were clearing snow from a storm the day before. Blowing snow reduced visibility.	NOAA-NCDC
4/4/2015	Strong Wind	N/A	N/A	Strong gusty winds occurred across the state; peak wind gusts were about 45 mph.	NOAA-NCDC
4/2/2016	Thunderstorm Wind	N/A	N/A	A microburst produced wind gusts up to 65 MPH, causing sporadic damage along a line from Raritan southeast through southern Manville, ending in Franklin Township northeast of Blackwells Mills. Saint Ann School in Raritan experienced some roof damage, and two commercial dumpsters were blown over. In Franklin Township, there was extensive tree and pole damage in the vicinity of Weston Canal Road near I-287.	NOAA-NCDC
6/8/2016	Lightning	N/A	N/A	These thunderstorms produced widespread wind damage across most of Southern and Central NJ with numerous power outages. A home in the 300 block of South Finley Avenue was struck by lightning which caused a fire.	NOAA-NCDC
6/8/2016	Thunderstorm Wind	N/A	N/A		NOAA-NCDC
6/28/2016	Lightning	N/A	N/A	Thunderstorms produced strong winds. A house in South Branch (Hillsborough Township) was struck by lightning, causing a reported $1,000 in damages.	NOAA-NCDC
6/28/2016	Thunderstorm Wind	N/A	N/A	Thunderstorms produced strong winds; trees were downed in Bernardsville and Far Hills.	NOAA-NCDC
7/8/2016	Heavy Rain	N/A	N/A	Heavy rainfall along with strong to severe thunderstorms in the area. Two and a half inches of rain fell in Peapack.	NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
7/18/2016	Thunderstorm Wind	N/A	N/A	Thunderstorms occurred; some were severe with damaging winds. Several large trees were downed in Somerset County due to thunderstorm winds leading to roadways temporarily blocked.	NOAA-NCDC
7/25/2016	Thunderstorm Wind	N/A	N/A	Showers and thunderstorms developed in the afternoon and evening, and became severe in spots producing locally heavy rains and about 40,000 without power across the state. Thunderstorm winds ripped a chimney off a house and moved two cars 100 feet in South Branch.	NOAA-NCDC
7/25/2016	Thunderstorm Wind	N/A	N/A	Showers and thunderstorms developed in the afternoon and evening, and became severe in spots producing locally heavy rains and about 40,000 without power across the state. Trees downed due to thunderstorm winds near Washington Valley Road and Tullo Road in Martinsville.	NOAA-NCDC
7/25/2016	Thunderstorm Wind	N/A	N/A	Showers and thunderstorms developed in the afternoon and evening, and became severe in spots producing locally heavy rains and about 40,000 without power across the state. A few trees were uprooted due to thunderstorm wind gusts in Bound Brook Jct.	NOAA-NCDC
7/30/2016	Heavy Rain	N/A	N/A	Stationary clusters of thunderstorms in the central part of the state caused heavy rain, severe flash flooding, and power outages. In Clyde (an unincorporated area in Franklin Township), just over two inches of rain were recorded.	NOAA-NCDC
7/31/2016	Heavy Rain	N/A	N/A	Stationary clusters of thunderstorms in the central part of the state caused heavy rain, severe flash flooding, and power outages. In East Millstone, an unincorporated area of Franklin Township, just over two inches of rain were recorded.	NOAA-NCDC
7/31/2016	Heavy Rain	N/A	N/A	Stationary clusters of thunderstorms in the central part of the state caused heavy rain, severe flash flooding, and power outages. Heavy rain was reported in Middle Bush.	NOAA-NCDC
7/31/2016	Heavy Rain	N/A	N/A	Stationary clusters of thunderstorms in the central part of the state caused heavy rain, severe flash flooding, and power outages. Heavy rain was reported in Belle Mead.	NOAA-NCDC
7/31/2016	Heavy Rain	N/A	N/A	Stationary clusters of thunderstorms in the central part of the state caused heavy rain, severe flash flooding, and power outages. Heavy rain was reported in Griggstown.	NOAA-NCDC
7/31/2016	Heavy Rain	N/A	N/A	(Note: the NCDC database includes this Griggstown event as a separate record, but it appears to duplicate the record immediately above).	NOAA-NCDC
7/31/2016	Heavy Rain	N/A	N/A	Stationary clusters of thunderstorms in the central part of the state caused heavy rain, severe flash flooding, and power outages. Heavy rain was reported in Clyde.	NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts	Source(s)
5/14/2017	Hail	N/A	N/A	0.75-inch diameter hail was estimated in Clyde after thunderstorms produced large hail across north central New Jersey.	NOAA-NCDC
5/31/2017	Hail	N/A	N/A	One thunderstorm became severe tracking northeast from Hunterdon into Somerset and Sussex counties. Numerous hail reports of 0.5 and 0.75 inches were recorded. A couple of the reports met severe criteria. One inch and nickel size hail both were measured at slightly different times in South Branch.	NOAA-NCDC
8/23/2017	Heavy Rain	N/A	N/A	Severe thunderstorms formed ahead of a cold front. Almost two and half inches of rain fell in Belle Mead.	NOAA-NCDC

Note: Monetary figures within this table were U.S. Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of inflation.

* FEMA indicates that the "Floyd" event was a Hurricane; however, the NJ OEM, NJ HMP and the USACE Post Flood Report of July 2000 indicate that this event was a Tropical Storm event for New Jersey. Therefore, for the purpose of this HMP, this event will be referred to as a Tropical Storm throughout this hazard profile, as identified by the State government agencies.

** According to many sources, these events were known as Nor'easters, therefore, they are not discussed further in this hazard profile and are further mentioned in Section 5.4.2 (Severe Winter Storm) and the flooding impact of the events are mentioned in Section 5.4.3 (Flood).

DR	Federal Disaster Declaration
EM	Federal Emergency Declaration
FEMA	Federal Emergency Management Agency
IA	Individual Assistance
K	Thousand ($)
M	Million ($)
Mph	Miles Per Hour
NCDC	National Climate Data Center
NOAA	National Oceanic Atmospheric Administration
NYS	New York State
NWS	National Weather Service
ONJSC	Office of the New Jersey State Climatologist
PA	Public Assistance
SHELDUS	Spatial Hazard Events and Losses Database for the U.S.
TSTM	Thunderstorms

Probability of Future Events

Predicting future severe storm events in a constantly changing climate has proven to be a difficult task. Predicting extremes in New Jersey is particularly difficult because of the region's geographic location. It is positioned roughly halfway between the equator and the North Pole and is exposed to both cold and dry airstreams from the south. The interaction between these opposing air masses often leads to turbulent weather across the region (Keim, 1997).

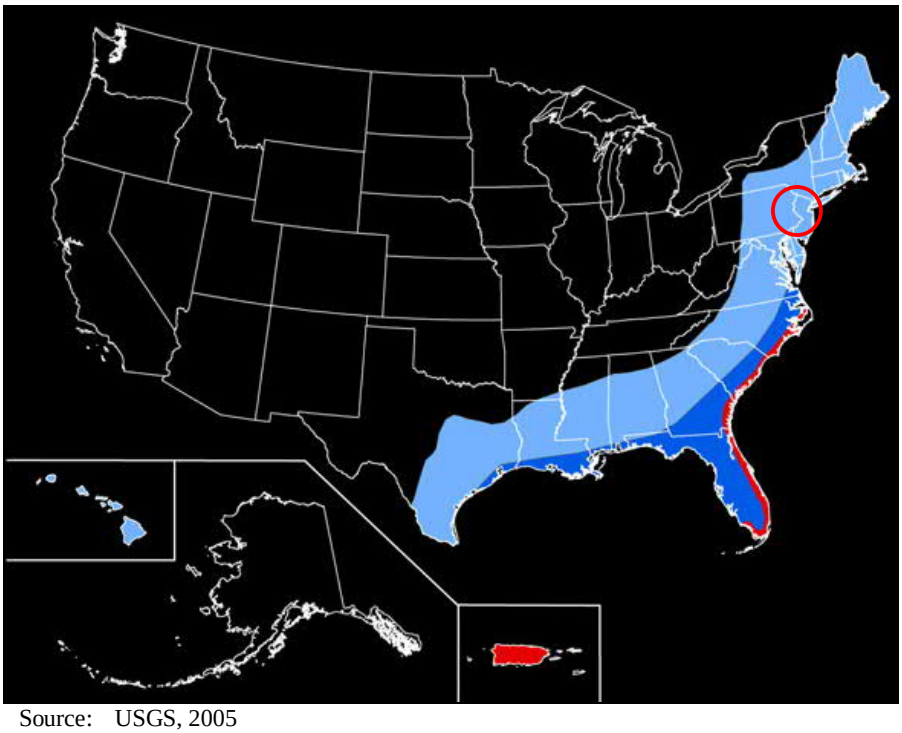
In Section 5.2, the identified hazards of concern for Somerset County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for severe storms in the County is considered 'Frequent'' (likely to occur more than once every 25 years, as presented in Table 5.3-3); however, impacts only related to severe storms, excluding those associated with hurricanes, tropical storms, Nor'easters and flooding, are expected to be minimal.

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

Hurricanes

Figure 5.4.1-15 illustrates the number of hurricanes expected to occur during a 100-year period. According to this map, portions of New Jersey, including Somerset County, can expect between 20 and 40 hurricanes during a 100-year return period.

Figure 5.4.1-13 Number of Hurricanes for a 100-year Return Period



Source: USGS, 2005
Note: The number of hurricanes expected to occur during a 100-year MRP based on historical data—light blue area, 20 to 40; dark blue area, 40 to 60; red area, more than 60. Map not to scale.

The Role of Global Climate Change on Future Probability

Climate change is beginning to affect both people and resources in the state of New Jersey, and these impacts are projected to continue growing. Impacts related to increasing temperatures are already being felt in the State.

The US Global Change Research Program's Climate Science Special Report: Fourth National Climate Assessment, Volume I (2017) projects that the frequency and intensity of severe storms will increase over time due to the effects of climate change. The frequency and intensity of extreme high temperature events are virtually certain to increase in the future as global temperature increases (high confidence). Extreme precipitation events will very likely continue to increase in frequency and intensity throughout most of the world (high confidence). Observed and projected trends for some other types of extreme events, such as floods, droughts, and severe storms, have more variable regional characteristics. Heavy rainfall is increasing in intensity and frequency across the United States and globally and is expected to continue to increase. Heatwaves have become more frequent in the United States since the 1960s, while extreme cold temperatures and cold waves are less frequent. over the next few decades (2021–2050), annual average temperatures are expected to rise by about 2.5°F for the United States, relative to the recent past (average from 1976–2005), under all plausible future climate scenarios. The last few years have also seen record-breaking, climate-related weather extremes, the three warmest years on record for the globe, and continued decline in arctic sea ice. These trends are expected to continue in the future over climate (multidecadal) timescales. Significant advances have also been made in our understanding of extreme weather events and how they relate to increasing global temperatures and associated climate changes.

VULNERABILITY ASSESSMENT

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For severe storms, the entire County has been identified as the hazard area. Therefore, all County assets (population, structures, critical facilities and lifelines), as described in the County Profile (Section 4), are vulnerable. The following text evaluates and estimates the potential impact of severe storms on the County including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, safety and health of residents, (2) general building stock, (3) critical facilities, (4) economy and (5) future growth and development
- Effect of climate change on vulnerability
- Change of vulnerability as compared to that presented in the 2008 Somerset County Hazard Mitigation Plan
- Further data collections that will assist understanding of this hazard over time

Overview of Vulnerability

The high winds and air speeds of a hurricane or any severe storm often result in power outages, disruptions to transportation corridors and equipment, loss of workplace access, significant property damage, injuries and loss of life, and the need to shelter and care for individuals impacted by the events. A large amount of damage can be inflicted by trees, branches, and other objects that fall onto power lines, buildings, roads, vehicles, and, in some cases, people. The risk assessment for severe storm evaluates available data for a range of storms included in this hazard category.

Due to the County's inland location, the loss associated with hurricanes is primarily associated with severe thunderstorm or hurricane-related rains (see flooding discussion in Section 5.4.3 Flood) and severe winds. Secondary flooding associated with the torrential downpours during hurricanes/tropical storms is also a primary concern in the County. The County has experienced flooding in association with several hurricanes and tropical storms in the past.

In the study area, winds associated with a hurricane event are similar to a severe wind storm and therefore, can support analysis of the severe storm event for this study area. The entire inventory of the County is at risk of being damaged or lost due to impacts of severe wind. Certain areas, infrastructure, and types of building are at greater risk than others due to proximity to falling hazards and/or their manner of construction.

Potential losses associated with high wind events were calculated for the County for two probabilistic hurricane events, the 100-year and 500-year MRP hurricane events. The impacts on population, existing structures, critical facilities and the economy are presented below, following a summary of the data and methodology used.

Data and Methodology

After reviewing historic data, the HAZUS-MH methodology and model were used to analyze the severe storm hazard for Somerset County. Data used to assess this hazard include data available in the HAZUS-MH 4.0 hurricane model, professional knowledge, information provided by the Steering Committee and input from the public.

A probabilistic scenario was run for Somerset County for annualized losses and the 100- and 500-year MRPs were examined for the wind/severe storm hazard. These results are shown in Figure 5.4.1-1 and Figures 5.4.1-1 and 5.4.1-2, earlier in this section, which show the HAZUS-MH maximum peak gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP hurricane events.

HAZUS-MH contains data on historic hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Hurricane and inventory data available in HAZUS-MH were used to evaluate potential losses from the 100- and 500-year MRP events (severe wind impacts). = The default data in HAZUS-MH 4.0 was the best available data for use in this evaluation. A decrease in top wind speeds in the HAZUS-MH 4.0 program resulted in a decrease of losses from the previous Hazard Mitigation Plan.

Impact on Life, Health and Safety

The impact of a severe storm on life, health and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. It is assumed that the entire County's population (U.S. Census 2010 population of 323,444 people) is exposed to this storm hazard.

Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. HAZUS-MH estimates there will be zero people displaced and zero people that may require temporary shelter due to a 100-year MRP event. For a 500-year MRP event, HAZUS-MH estimates 31 households will be displaced and 5 require short-term sheltering. Refer to Table 5.4.1-8 which summarizes the sheltering estimates for the 500-year MRP event by municipality.

Table 5.4.1-8 Sheltering Needs for the 500-year MRP Hurricane Events for Somerset County

Municipality	Displaced Households	Households Requiring Short-Term Shelter
Bedminster (T)	0	0
Bernards (T)	1	0
Bernardsville (B)	0	0
Bound Brook (B)	2	0
Branchburg (T)	0	0
Bridgewater (T)	1	0
Far Hills (B)	0	0
Franklin (T)	20	4
Green Brook (T)	0	0
Hillsborough (T)	1	0
Manville (B)	0	0
Millstone (B)	0	0
Montgomery (T)	1	0

Municipality	Displaced Households	Households Requiring Short-Term Shelter
North Plainfield (B)	4	1
Peapack Gladstone (B)	0	0
Raritan (B)	0	0
Rocky Hill (B)	0	0
Somerville (B)	0	0
South Bound Brook (B)	1	0
Warren (T)	0	0
Watchung (B)	0	0
Somerset County (Total)	**31**	**5**

Source: HAZUS-MH v 4.0 (U.S. Census 2010)

Note: Sheltering estimates are based on the default 2010 U.S. Census data in HAZUS-MH.

Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate. The population over the age of 65 is also more vulnerable and, physically, they may have more difficulty evacuating. The elderly are considered most vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention which may not be available due to isolation during a storm event. Please refer to Section 4 for the statistics of these populations in the County.

Impact on General Building Stock

After considering the population exposed to the severe storm hazard, the general building stock replacement value exposed to and damaged by 100- and 500-year MRP events was examined. Wind-only impacts from a severe storm are reported based on the probabilistic hurricane runs in HAZUS-MH 4.0. Potential damage is the modeled loss that could occur to the exposed inventory, including damage to structural and content value based on the wind-only impacts associated with a hurricane (using the methodology described in Section 5.1).

It is assumed that the entire County's general building stock is exposed to the severe storm wind hazard (greater than $44.4 billion structure only). Expected building damage was evaluated by HAZUS across the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 5.4.1-9 summarizes the definition of the damage categories.

Table 5.4.1-9 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 of 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

Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
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%	> the larger of 20% & 3 and ≤ 50%	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%	> one and ≤ the larger of 20% & 3	> 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

As noted earlier in the profile, HAZUS estimates the 100-year MRP peak gust wind speeds for Somerset County to be 66 to 72 miles per hour (mph). This equates to a Category One hurricane. For the 100-year MRP event, HAZUS-MH 4.0 estimates $33.7 Million in structure damages across the County. Residential buildings comprise the majority of the building inventory and are estimated to experience all of the damage.

HAZUS estimates the 500-year MRP peak gust wind speeds for Somerset County to range from 83 to 89 mph. This equates to a Category One hurricane and 184 Million in damages to the general building stock (structure only). This is less than one-percent of the County's building inventory. The residential buildings are estimated to experience the majority of the damage. Table 5.4.1-10 summarizes the building value (structure only) damage estimated for the annualized and 100- and 500-year MRP wind-only events by occupancy class.

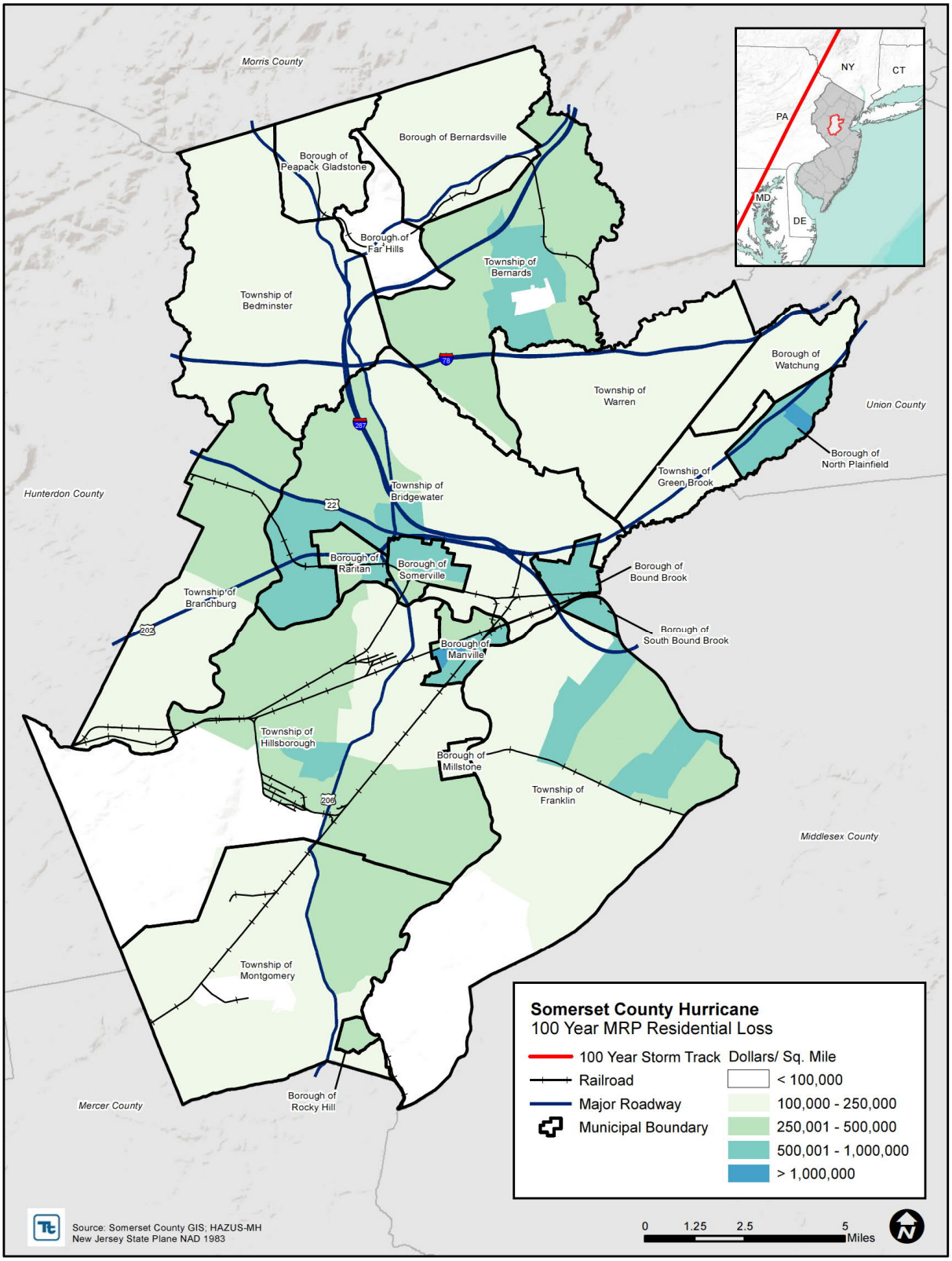
Table 5.4.1-10 Estimated Building Replacement Value (Structure Only) Damaged by the 100-Year and 500-Year Mean Return Period Hurricane-Related Winds for All Occupancy Classes

Municipality	Total Building Replacement Value (Structure Only)	Total Building Damage (All Occupancies)						Residential Buildings		Commercial Buildings	
		Annualized		100 Year		500 Year					
		Loss	% of GBS RCV Total	Loss	% of GBS RCV Total	Loss	% of GBS RCV Total	100 Year	500 Year	100 Year	500 Year
Bedminster (T)	$1,679,153,000	$34,998	0.00	$865,312	0.05	$2,994,932	0.18	$805,667	$2,838,650	$48,350	$131,708
Bernards (T)	$4,043,773,000	$144,366	0.00	$2,886,461	0.07	$15,291,184	0.38	$2,799,306	$14,996,580	$62,795	$211,744
Bernardsville (B)	$1,263,029,000	$25,043	0.00	$471,548	0.04	$2,132,279	0.17	$441,044	$2,055,470	$23,119	$54,642
Bound Brook (B)	$1,024,459,000	$36,251	0.00	$601,664	0.06	$3,782,216	0.37	$573,483	$3,623,080	$20,049	$112,783
Branchburg (T)	$2,828,305,000	$79,744	0.00	$2,748,156	0.10	$6,838,048	0.24	$2,639,133	$6,554,580	$56,567	$150,690
Bridgewater (T)	$7,132,150,000	$219,089	0.00	$5,140,558	0.07	$20,900,589	0.29	$4,948,417	$20,123,920	$116,963	$486,512
Far Hills (B)	$161,190,000	$3,902	0.00	$86,385	0.05	$375,787	0.23	$84,925	$372,302	$1,174	$2,865
Franklin (T)	$8,492,720,000	$371,563	0.00	$5,949,772	0.07	$49,997,680	0.59	$5,730,144	$47,470,840	$147,961	$1,694,062
Green Brook (T)	$1,153,646,000	$27,703	0.00	$327,713	0.03	$3,719,948	0.32	$293,589	$3,526,630	$28,065	$153,729
Hillsborough (T)	$2,207,785,000	$219,327	0.01	$5,098,432	0.23	$21,436,989	0.97	$5,022,009	$20,926,140	$52,925	$339,403
Manville (B)	$1,309,065,000	$37,206	0.00	$740,922	0.06	$4,229,884	0.32	$716,568	$4,077,140	$17,411	$111,976
Millstone (B)	$51,796,000	$2,518	0.00	$55,751	0.11	$316,766	0.61	$54,931	$309,963	$269	$2,145
Montgomery (T)	$3,309,079,000	$147,605	0.00	$4,206,986	0.13	$16,039,959	0.48	$4,123,763	$15,574,830	$66,214	$382,960
North Plainfield (B)	$2,242,474,000	$84,411	0.00	$878,721	0.04	$11,864,754	0.53	$828,281	$11,392,020	$40,535	$373,468
Peapack Gladstone (B)	$564,419,000	$8,801	0.00	$233,961	0.04	$713,912	0.13	$211,061	$667,793	$20,566	$41,133
Raritan (B)	$1,029,025,000	$21,950	0.00	$457,084	0.04	$2,098,769	0.20	$413,235	$1,918,497	$17,061	$72,347
Rocky Hill (B)	$115,133,000	$4,828	0.00	$124,796	0.11	$568,954	0.49	$120,964	$538,823	$2,535	$20,340
Somerville (B)	$1,766,099,000	$45,026	0.00	$943,051	0.05	$4,405,093	0.25	$867,724	$4,024,438	$61,304	$313,523
South Bound Brook (B)	$556,669,000	$22,819	0.00	$394,600	0.07	$2,467,885	0.44	$380,573	$2,362,850	$12,198	$93,568
Warren (T)	$2,562,281,000	$84,905	0.00	$1,314,640	0.05	$10,425,233	0.41	$1,249,052	$10,101,120	$45,443	$226,138
Watchung (B)	$925,710,000	$24,362	0.00	$220,478	0.02	$3,355,668	0.36	$200,269	$3,229,920	$14,943	$97,270
Somerset County (Total)	**$44,417,960,000**	**$1,646,417**	0.00	$33,746,989	0.08	$183,956,529	0.41	**$32,504,138**	**$176,685,586**	**$856,447**	**$5,073,006**

Industrial Buildings		Agriculture Buildings		Religious Buildings		Government		Education Buildings	
100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year	100 Year	500 Year
$7,598	$15,586	$694	$1,966	$1,679	$4,372	$287	$575	$1,038	$2,075
$8,630	$26,692	$0	$4,308	$5,328	$23,539	$2,647	$6,540	$7,754	$21,780
$2,574	$5,489	$0	$7,053	$1,814	$3,627	$1,510	$3,021	$1,488	$2,976
$4,319	$22,112	$166	$3,278	$1,888	$12,482	$314	$1,257	$1,445	$7,225
$33,193	$88,544	$883	$4,581	$2,038	$6,298	$950	$2,113	$15,392	$31,241
$33,132	$137,213	$384	$5,343	$6,837	$27,029	$1,833	$5,654	$32,992	$114,917
$207	$414	$0	$48	$0	$0	$68	$136	$11	$22
$51,522	$594,971	$996	$43,239	$8,965	$109,524	$3,776	$28,934	$6,408	$56,110
$3,488	$24,621	$0	$2,054	$473	$3,314	$706	$2,823	$1,391	$6,777
$16,088	$122,241	$1,384	$17,828	$2,788	$16,802	$1,012	$4,060	$2,226	$10,515
$3,179	$17,587	$283	$3,238	$1,279	$8,949	$549	$2,293	$1,654	$8,701
$206	$1,779	$0	$153	$326	$2,608	$0	$0	$20	$118
$7,162	$32,811	$1,107	$11,144	$4,085	$20,963	$1,061	$4,986	$3,593	$12,265
$3,081	$29,162	$0	$5,788	$3,981	$41,052	$89	$582	$2,753	$22,683
$695	$1,391	$0	$319	$884	$1,768	$248	$496	$506	$1,012
$24,247	$96,983	$127	$762	$1,033	$5,039	$380	$1,139	$1,001	$4,003
$391	$3,076	$0	$294	$503	$4,021	$214	$1,071	$190	$1,330
$5,490	$29,108	$325	$2,201	$2,284	$12,128	$3,109	$12,437	$2,815	$11,259
$450	$2,360	$30	$384	$392	$3,138	$153	$766	$803	$4,820
$12,362	$59,650	$0	$5,297	$2,877	$13,682	$306	$1,225	$4,600	$18,122
$2,467	$12,533	$0	$899	$1,049	$6,295	$223	$1,116	$1,527	$7,636
$220,480	**$1,324,321**	**$6,379**	**$120,175**	**$50,501**	**$326,633**	**$19,437**	**$81,222**	**$89,608**	**$345,586**

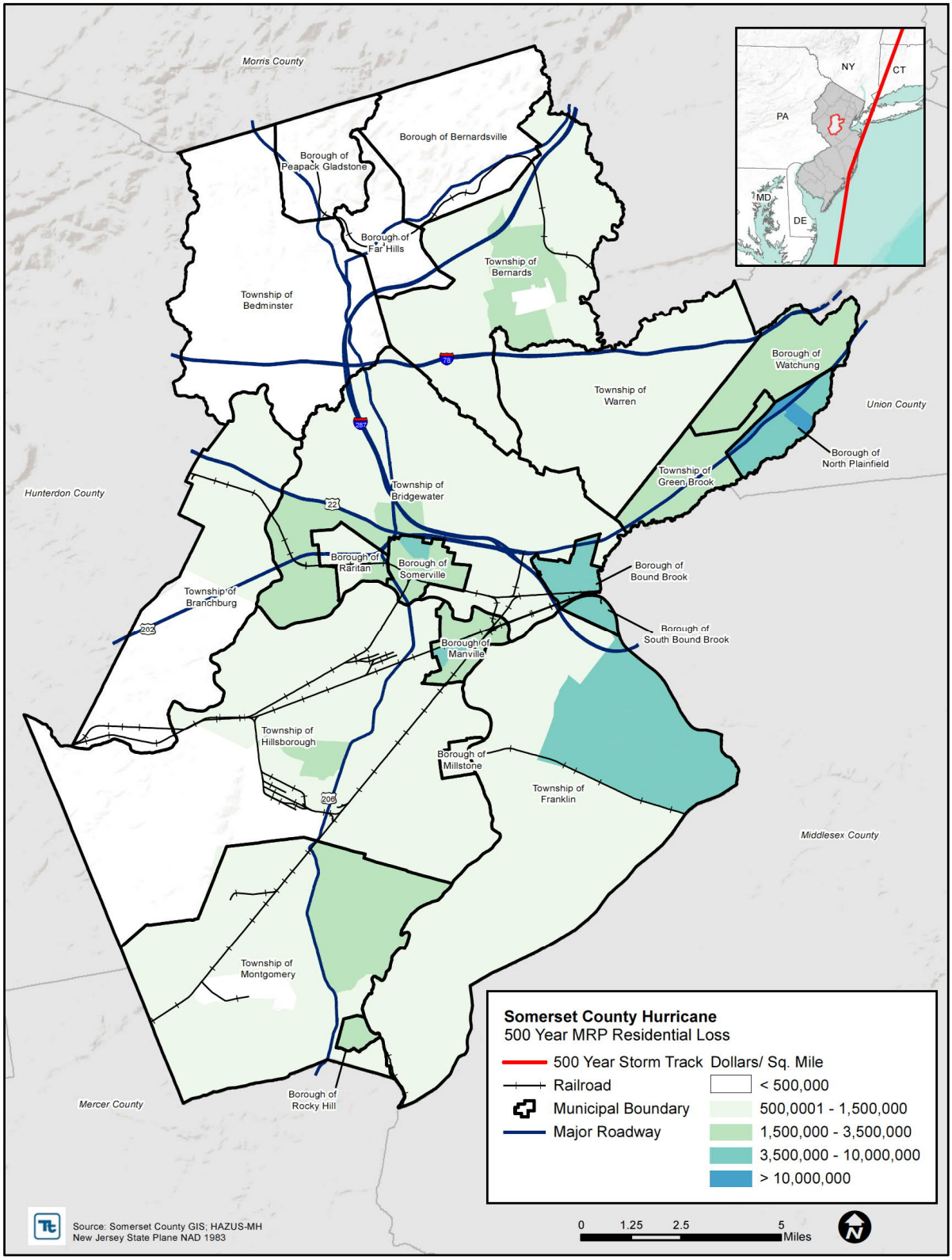
Source: HAZUS-MH 4.0
Notes: B = Borough; GBS = General Building Stock; RCV = Replacement Cost Value; T = Town

Figure 5.4.1-14 Density of Losses for Residential Structures 100-Year MRP Wind Event



Source: HAZUS 4.0 -

Figure 5.4.1-15. Density of Losses for Residential Structures 500-Year MRP Wind Event



Source: HAZUS 4.0 -

Because of differences in building 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. The damage counts include buildings damaged at all severity levels from minor damage to total destruction. Total dollar damage reflects the overall impact to buildings at an aggregate level.

Of the exceeding $35 billion in total residential replacement value (structure) for the entire County, an estimated $32.5 million in residential building damage can be anticipated for the 100-year event and $176.6 million in residential building damage can be anticipated for the 500-year event. Residential building damage accounts for 96-percent and 89-percent of total damages for the 100- and 500-year wind-only events, respectively. This illustrates residential structures are the most vulnerable to the wind hazard.

Annualized losses were also examined for Somerset County. A total of $1.6 Million is estimated as the annualized loss for the entire County; see Table 5.4.1-10 above. Please note that annualized loss does not predict what losses will occur in any particular year.

Mobile homes are particularly vulnerable to severe storms. According to Somerset County, there are 28 mobile home parks permitted by the Somerset County Health Department. Each permitted mobile home park contains five or more units.

Impact on Critical Facilities

HAZUS-MH estimates the probability that critical facilities (i.e., medical facilities, fire/EMS, police, EOC, schools, and user-defined facilities such as shelters and municipal buildings) may sustain damage as a result of 100-year and 500-year MRP wind-only events. Additionally, HAZUS-MH estimates the loss of use for each facility in number of days. HAZUS-MH estimates a 2-percent chance that critical facilities in Somerset County will experience minor damage; and continuity of operations at these facilities will not be interrupted (loss of use is estimated to be zero days) as a result of a 100-year MRP event. Tables 5.4.1-11a through 5.4.1-11b summarize the potential damages to the critical facilities in Somerset County as a result of the 100- and 500-year MRP wind events.

Table 5.4.1-11a Estimated Impacts to Critical Facilities for the 100- Year Mean Return Period Hurricane-Related Winds

Facility Type	100-Year Event				
	Loss of Days	Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
EOC	0	0 - 1	0	0	0
Medical	0	0 - 2	0 - 1	0	0
Police	0	0 - 1	0	0	0
Fire	0	0 - 1	0	0	0
Schools	0	1 - 2	0	0	0

Source: HAZUS-MH 4.0

Table 5.4.1-11b Estimated Impacts to Critical Facilities for the 500-Year Mean Return Period Hurricane-Related Winds

Facility Type	500-Year Event				
	Loss of Days	Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
EOC	0	2 10	0 - 2	0	0
Medical*	0 - 1	6 - 9	10 - 15	2 - 8	0
Police	0	2 - 12	0 - 3	0	0
Fire	0	1 - 8	1 - 3	0	0
Schools*	0	2 - 7	1 - 8	0 - 1	0

Source: HAZUS-MH 4.0

A critical facility vulnerable to severe storms not described in the tables below is the Delaware and Raritan Canal. The Delaware and Raritan Canal is an interbasin transfer that provides the raw water supply to two purveyors located in Somerset County. Since Hurricane Floyd, the Canal has been damaged in several locations, not all in Somerset County. The damage occurred from overtopping and repairs have typically cost in excess of one million dollars. In the April 2007 storm, the Canal incurred damage in Somerset County along a spillway to the Raritan River. Repairs also cost over one million dollars. FEMA did not consider all of the damage to be attributable to the storm and only reimbursed the Authority for approximately 20 percent of the repair work (Shallcross, 2007).

At this time, HAZUS-MH does not estimate losses to transportation lifelines and utilities as part of the hurricane model. Transportation lifelines are not considered particularly vulnerable to the wind hazard; they are more vulnerable to cascading effects such as flooding, falling debris, etc. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs. Critical transportation routes for evacuating areas of greatest risk to a severe storm's impact include the following:

- Major North-South Routes: Interstate Route 287, State Highway 27, State Highway 28, and U.S. Highway 206
- Major East-West Routes: Interstate Route 78, U.S. Highway 22, U.S. Highway 202
- Alternate North-South Routes: County Route 523, County Route 525, County Route 527, County Route 531, and County Route 533
- Alternate East-West Routes: County Route 512, County Route 514, County Route 518, County Route 523, County Route 525, County Route 527, County Route 531, County Route 533, County Route 567, and County Route 601 (Somerset County EOP, 1998).

Utility structures could suffer damage associated with falling tree limbs or other debris. Such impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to citizens (including the young and elderly, who are particularly vulnerable to temperature-related health impacts).

Impact on Economy

Severe storms also impact the economy, including: 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. 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 $50,000 in relocation costs. For the 500-year MRP wind only event, HAZUS-MH estimates $25 Million in business interruption losses for Somerset County which includes loss of income, relocation costs, rental costs and lost wages. Further HAZUS-MH estimates $2.8 Million in loss of inventory.

HAZUS-MH 4.0 also estimates the amount of debris that may be produced as a result of the 100- and 500-year MRP wind events.

Table 5.4.1-12 estimates the debris produced. 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: '*The Eligible Tree Debris columns provide estimates of the weight and volume of downed trees that would likely be collected and disposed at public expense. As discussed in Chapter 12 of the HAZUS-MH Hurricane Model Technical Manual, the eligible tree debris estimates produced by the Hurricane Model tend to underestimate reported volumes of debris brought to landfills for a number of events that have occurred over the past several years. This indicates that that there may be other sources of vegetative and non-vegetative debris that are not currently being modeled in HAZUS. For landfill estimation purposes, it is recommended that the HAZUS debris volume estimate be treated as an approximate lower bound. Based on actual reported debris volumes, it is recommended that the HAZUS results be multiplied by three to obtain an approximate upper bound estimate. It is also important to note that the Hurricane Model assumes a bulking factor of 10 cubic yards per ton of tree debris. If the debris is chipped prior to transport or disposal, a bulking factor of 4 is recommended. Thus, for chipped debris, the eligible tree debris volume should be multiplied by 0.4'*.

Table 5.4.1-12 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
Bedminster (T)	51	240	0	0	2,430	4,908	2,051	4,401
Bernards (T)	41	781	0	0	1,868	6,493	6,171	22,631
Bernardsville (B)	4	146	0	0	0	415	0	842
Bound Brook (B)	52	415	0	0	163	521	1,299	4,153
Branchburg (T)	99	362	0	0	1,946	4,713	5,293	12,602
Bridgewater (T)	185	1,198	0	0	2,232	6,649	10,002	29,006
Far Hills (B)	2	20	0	0	0	156	0	153
Franklin (T)	253	4,271	0	4	4,406	19,903	13,344	64,480
Green Brook (T)	1	290	0	0	0	717	0	3,700
Hillsborough (T)	197	1,390	0	0	3,956	12,568	10,030	33,470
Manville (B)	62	456	0	0	235	819	1,639	5,745
Millstone (B)	1	19	0	0	73	292	200	798
Montgomery (T)	148	879	0	0	3,909	10,230	8,572	24,415
North Plainfield (B)	30	1,253	0	0	180	11,561	1,630	10,489
Peapack Gladstone (B)	10	44	0	0	187	3,744	374	747
Raritan (B)	53	255	0	0	130	507	912	3,528
Rocky Hill (B)	4	41	0	0	60	239	286	1,143
Somerville (B)	86	473	0	0	226	669	1,790	5,267
South Bound Brook (B)	27	225	0	0	72	266	591	2,166
Warren (T)	5	494	0	0	899	5,453	2,440	15,313
Watchung (B)	2	256	0	0	0	968	0	4,010
Somerset County (Total)	**1,313**	**13,508**	**0**	**4**	**22,972**	**91,791**	**66,622**	**249,060**

Source: HAZUS-MH 4.0
Notes: B = Borough; T = Town

Future Growth and Development

As discussed and illustrated in Section 4, areas targeted for future growth and development have been identified across Somerset County. Any areas of growth could be potentially impacted by the severe storm hazard because the entire County is exposed and vulnerable to the wind hazard associated with severe storms.

Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such as storms, including those which may bring

precipitation high winds and tornado events. While predicting changes of wind and tornado events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2006).

Refer to 'The Role of Global Climate Change on Future Probability' subsection earlier in this profile for more details on climate change pertaining to New Jersey.

Change of Vulnerability

The wind model in HAZUS-MH was used to evaluate the severe storm hazard for both the 2008 original and 2013 and 2017 update HMP. Over the years, there were substantial updates to the probabilistic wind model in HAZUS-MH. These updates included changes to the estimated wind risk level (i.e., peak gust wind speeds) and additional historic hurricanes (Category 3 and higher) added to the model through 2010. According to HAZUS Technical Support, updates to the wind risk level, which decreased wind speeds for the State of New Jersey for the 100-year MRP event, were based on extensive analyses of new flight level and dropsonde data sets that have become available since the initial development of the HAZUS-MH wind model. When comparing the 2013 HMP to this update, there is a decrease in estimated potential losses: an estimated $73 Million (2013 HMP) to $34 Million (HMP update) for the 100-year MRP event. Changes to the HAZUS-MH wind model are responsible for this difference. Overall, the County's vulnerability has not changed and the entire County will continue to be exposed and vulnerable to severe storm events.

Additional Data and Next Steps

Over time, Somerset County will obtain additional data to support the analysis of this hazard. Data that will support the analysis would include additional detail on past hazard events and impacts, specific building information such as type of construction and details on protective features (for example, hurricane straps). In addition, information on particular buildings or infrastructure age or year built would be helpful in future analysis of this hazard.