SECTION 4. RISK ASSESSMENT

4.3 Hazards of Concern

This section provides a hazard profile and vulnerability assessment of the high wind hazard in Camden County. For the purpose of this HMP, the high wind hazard includes straight-line winds, and high-speed winds associated with thunderstorms, tornadoes, and coastal storms, including Nor'easters, hurricanes, and tropical storms. See Section 4.3.11 (Severe Summer Weather) for more information about hail and lightning events; and Section 4.3.12 (Severe Winter Storms) for more information about ice, blizzards and snow events, all of which may be associated with high wind episodes.

2022 HMP Changes

- All subsections have been updated using best available data.
- Previous occurrences were updated with events that occurred between 2015 and 2020.
- Coastal Storms have been included in the High Wind Hazard, while Coastal Erosion and Sea Level Rise are a separate hazard profile (Section 4.3.1).
- A vulnerability assessment was conducted using an updated asset inventory. Building footprints from the 2021 Camden County footprint dataset, footprint boundaries from the New Jersey Department of Environmental Protection's 2019 impervious surface layer, updated parcels from the 2020 MODIV tax assessor dataset, and RS Means 2020-dollar values were used to develop a structure-level building inventory and estimate replacement cost value for each building. The 2017 critical facility was reviewed and updated by the Planning Partnership.
- 5-year 2019 population estimates from ACS were used to assess population risk.
- Hazus v4.2 was used to assess the 100-year and 500-year mean return period hurricane wind events.

4.3.9 High Winds

Wind begins with differences in air pressures and occurs through rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the earth. High winds are often associated with other severe weather events such as thunderstorms, tornadoes, Nor'easters, hurricanes, and tropical storms.

Thunderstorms

A thunderstorm is a local storm produced by a cumulonimbus cloud and accompanied by lightning and thunder (National Weather Service [NWS] 2009). A thunderstorm forms from a combination of moisture; rapidly rising warm air; and a force capable of lifting air, such as a warm front, cold front, a sea breeze, or a mountain. Thunderstorms form from the equator to as far north as Alaska. Although thunderstorms generally affect a small area when they occur, they have the potential to become dangerous due to their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and lightning.

Thunderstorms can lead to heavy rain induced flooding, landslides, strong winds, and lightning. Roads may become impassable from flooding, downed trees or power lines, or a landslide. Downed power lines can lead to loss of utility services, such as water, phone, and electricity. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. During the summer, thunderstorms are responsible for most of the rainfall.

Tornadoes

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

Nor'easters

A Nor'easter is a cyclonic storm that moves along the East Coast of North America. It is called a Nor'easter because the damaging winds over coastal areas blow from a northeasterly direction. Nor'easters can occur any time of the year, but are most frequent and strongest between September and April. These storms usually develop between Georgia and New Jersey within 100 miles of the coastline and typically move from southwest to northeast along the Atlantic Coast of the United States (NOAA 2013). A Nor'easter event can cause storm surges, waves, heavy rain, heavy snow, wind, and coastal flooding. Nor'easters have diameters that can span 1,200 miles, impacting large areas of coastline. The forward speed of a Nor'easter is usually much slower than a hurricane, so with the slower speed, a Nor'easter can linger for days and cause tremendous damage to those areas impacted.

In order to be called a Nor'easter, a storm must have the following conditions, as per the Northeast Regional Climate Center (NRCC):

- Must persist for at least a 12-hour period
- Have a closed circulation
- Be located within the quadrilateral bounded at 45°N by 65°W and 70°W and at 30°N by 85°W and 75°W
- Show general movement from the south-southwest to the north-northeast
- Contain wind speeds greater than 23 miles per hour (mph)

A Nor'easter event can cause storm surges, waves, heavy rain, heavy snow, wind, and coastal flooding. Nor'easters have diameters that can span 1,200 miles, impacting large areas of coastline. The forward speed of a Nor'easter is usually much slower than a hurricane, so with the slower speed, a Nor'easter can linger for days and cause tremendous damage to those areas impacted. Approximately 20 to 40 Nor'easters occur in the northeastern United States every year, with at least two considered severe (Storm

Solution 2014). New Jersey can be impacted by 10 to 20 Nor'easters each year, with approximately five to 10 of those having significant impact on the State. The intensity of a Nor'easter can rival that of a tropical cyclone in that, on occasion, it may flow or stall off the mid-Atlantic coast resulting in prolonged episodes of precipitation, coastal flooding, and high winds.

Hurricanes and Tropical Storms

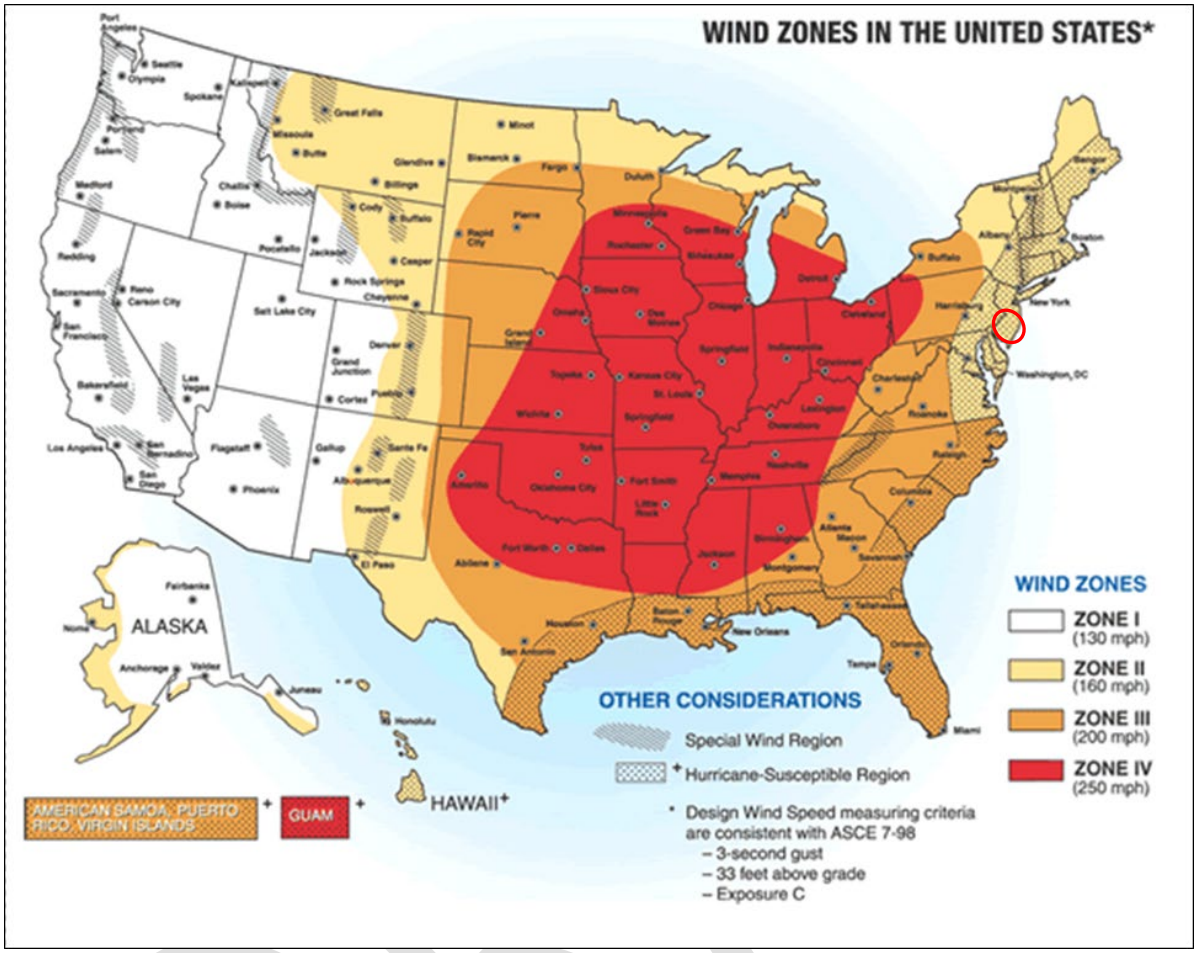
Tropical cyclones are fueled by a different heat mechanism than other cyclonic windstorms such as Nor'easters and polar lows. The characteristic that separates tropical storms from other cyclonic systems is that at any height in the atmosphere, the center of a tropical storm will be warmer than its surroundings, a phenomenon called "warm core" storm systems (National Oceanic and Atmospheric Administration [NOAA] 2013). Tropical cyclones strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. Tropical cyclones begin as disturbed areas of weather often referred to as tropical waves. As the storm organizes, it is designated as a tropical depression.

A tropical storm system is characterized by a low-pressure center and numerous thunderstorms that produce strong winds of 39 to 73 mph and heavy rain. A hurricane is a tropical storm that attains hurricane status when its wind speed reaches 74 mph or higher. Tropical systems may develop in the warm tropical waters of Atlantic Ocean, the Caribbean, and Gulf of Mexico. These storms may move up the Atlantic coast of the United States and impact the eastern seaboard, or move into the United States through the states along the Gulf Coast, bringing wind and rain as far north as New England before moving offshore and heading east.

4.3.9.1 Location and Extent

All of Camden County is exposed to severe weather and high-speed wind events. According to the FEMA Winds Zones of the United States map, Camden County is located in Wind Zone II, where wind speeds can reach up to 160 mph; and the County is part of the hurricane-susceptible region. Figure 4.3.9-1 illustrates wind zones across the United States, which indicate the impacts of the strength and frequency of wind activity per region. This is based on 40 years of tornado data and 100 years of hurricane data, collected by FEMA.

Figure 4.3.9-1. Wind Zones in the United States



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

Nor'easters

The entire State of New Jersey, including Camden County, is susceptible to the effects of Nor'easters; however, coastal communities and other low-lying areas are particularly vulnerable. Nor'easters usually form off the east coast near the Carolinas, and then follow a path northward along the coast until they blow out to sea. Although Camden County is bordered to the west by the Delaware River which is considered a coastal boundary in New Jersey, it is well upriver of areas that would experience coastal flooding via a typical Nor'easter. The county is exposed to the direct and indirect impacts of a Nor'easter including rain, snow, and wind.

Hurricanes and Tropical Storms

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool catalogs tropical cyclones that have occurred from 1842 to 2020. Between 1842 and 2020, 47 tropical cyclones tracked within 65

nautical miles of Camden County. Between 2015 and 2020, two tropical cyclones tracked within 65 miles of Camden County, and post-Tropical Storm Sandy did cross directly over Camden County in 2012.

4.3.9.2 Range of Magnitude

The extent (severity or magnitude) of a severe weather event is largely dependent upon the most damaging aspects of each type of severe weather. Table 4.3.9-1 below shows the record event for severe storm and high wind-related events in Camden County.

Table 4.3.9-1. High Wind Records in Camden County, 1950 to 2020

Extent of High Wind Events in Camden County	
Strongest Tornado on Record	F-2 (1989)
Highest Wind Speed on Record	110 mph (1989)
Strongest Hurricane on Record	Tropical Storm Bertha, 1996

Source: NOAA-NECI 2021

Table 4.3.9-2 below shows the National Weather Service (NWS) descriptions of winds during wind-producing events.

Table 4.3.9-2. NWS Wind Descriptions

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

Source: NWS 2010

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

- **High Wind Warnings** are issued when sustained winds of 40 mph or greater are forecast for one hour or longer, or wind gusts of 58 mph or greater for any duration
- **Wind Advisories** are issues when sustained winds of 30 to 39 mph are forecast for one hour or longer, or wind gusts of 46 to 57 mph for any duration (NWS, 2010).

Thunderstorms

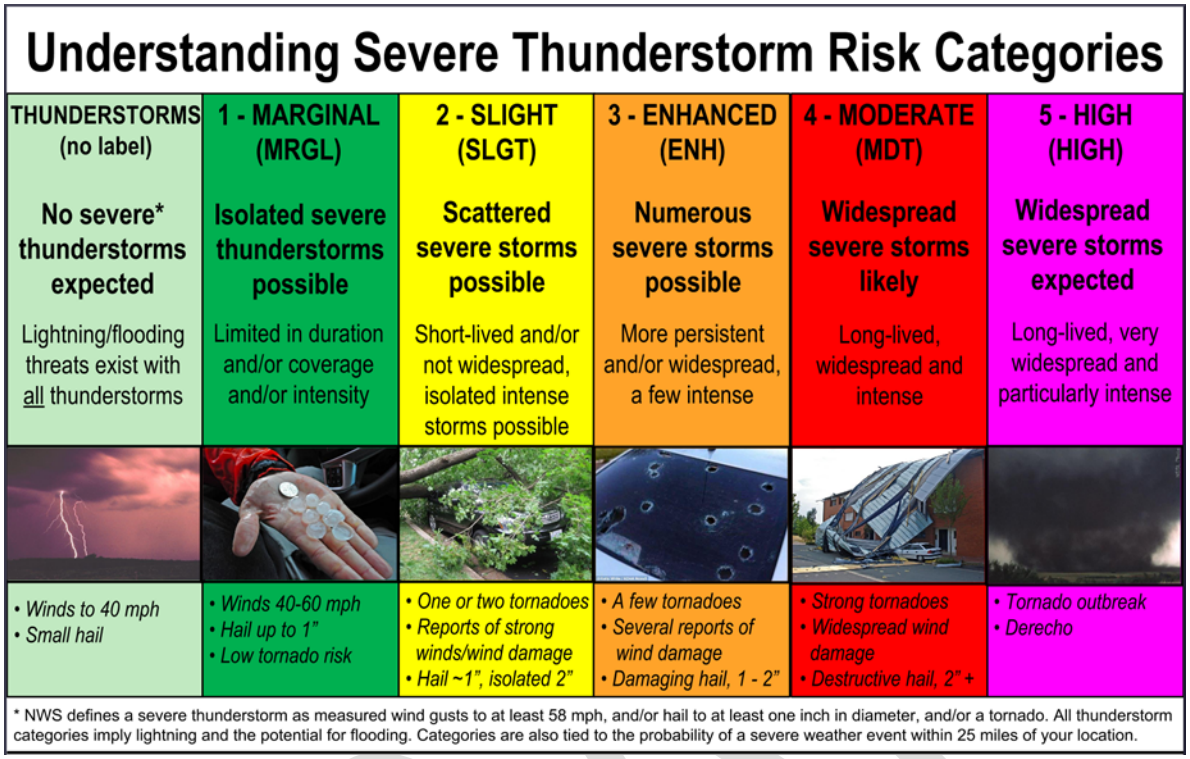
NWS considers a thunderstorm severe if it produces damaging wind gusts of 58 mph or higher, hail 1 inch (quarter size) in diameter or larger, or tornadoes (NWS 2010). Severe thunderstorm watches and

warnings are issued by the local NWS office and NOAA's Storm Prediction Center (SPC). NWS and SPC will update the watches and warnings and will notify the public when they are no longer in effect. Watches and warnings for thunderstorms in New Jersey are defined as follows:

- **Severe Thunderstorm Warnings** are issued when there is evidence based on radar or a reliable spotter report that a thunderstorm is producing (or is forecast to produce) wind gusts of 58 mph or greater, structural wind damage, and hail 1 inch in diameter or greater. A warning will include the location of the storm, the municipalities that are expected to be impacted, and the primary threat associated with the severe thunderstorm warning. After it has been issued, the NWS office will follow up periodically with Severe Weather Statements, which contain updated information on the severe thunderstorm and will let the public know when the warning is no longer in effect (NWS 2010).
- **Severe Thunderstorm Watches** are issued by the SPC when conditions are favorable for the development of severe thunderstorms over a larger-scale region for a duration of at least 3 hours. Tornadoes are not expected in such situations, but isolated tornado development may also occur. Watches are normally issued well in advance of the actual occurrence of severe weather. During the watch, NWS will keep the public informed on developments happening in the watch area and will also notify the public when the watch has expired or been cancelled (NWS 2010).
- **Special Weather State for Near Severe Thunderstorms** bulletins are issued for strong thunderstorms that are below severe levels, but still may have some adverse impacts. Usually, they are issued for the threat of wind gusts of 40 to 58 mph or small hail less than one (1) inch in diameter (NWS 2010).

In addition, the SPC issues severe thunderstorm risk maps based on the likelihood of different severities of thunderstorms. Figure 4.3.9-2 shows the SPC's severe thunderstorm risk categories.

Figure 4.3.9-2. Severe Thunderstorm Risk Categories



Understanding Severe Thunderstorm Risk Categories

THUNDERSTORMS (no label)	1 - MARGINAL (MRGL)	2 - SLIGHT (SLGT)	3 - ENHANCED (ENH)	4 - MODERATE (MDT)	5 - HIGH (HIGH)
No severe* thunderstorms expected	**Isolated severe thunderstorms possible**	**Scattered severe storms possible**	**Numerous severe storms possible**	**Widespread severe storms likely**	**Widespread severe storms expected**
Lightning/flooding threats exist with all thunderstorms	Limited in duration and/or coverage and/or intensity	Short-lived and/or not widespread, isolated intense storms possible	More persistent and/or widespread, a few intense	Long-lived, widespread and intense	Long-lived, very widespread and particularly intense
• *Winds to 40 mph* • *Small hail*	• *Winds 40-60 mph* • *Hail up to 1"* • *Low tornado risk*	• *One or two tornadoes* • *Reports of strong winds/wind damage* • *Hail ~1", isolated 2"*	• *A few tornadoes* • *Several reports of wind damage* • *Damaging hail, 1 - 2"*	• *Strong tornadoes* • *Widespread wind damage* • *Destructive hail, 2" +*	• *Tornado outbreak* • *Derecho*

* NWS defines a severe thunderstorm as measured wind gusts to at least 58 mph, and/or hail to at least one inch in diameter, and/or a tornado. All thunderstorm categories imply lightning and the potential for flooding. Categories are also tied to the probability of a severe weather event within 25 miles of your location.

Source: NOAA SPC 2017

Tornadoes

The magnitude or severity of a tornado is categorized using the Enhanced Fujita Tornado Intensity Scale (EF Scale). Figure 4.3.9-3 illustrates the relationship between EF ratings, wind speed, and expected tornado damage.

Figure 4.3.9-3. Enhanced Fujita Tornado Intensity Scale Ratings, Wind Speeds, and Expected Damage

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

Source: NWS 2018

Tornado watches and warning are issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly, that little, if any, advance warning is possible (NOAA 2011).

Nor'easters

The magnitude or severity of a severe winter storm or Nor'easter depends on several factors including a region's climatological susceptibility to snowstorms, snowfall amounts, snowfall rates, wind speeds, temperatures, visibility, storm duration, topography, and time of occurrence during the day (e.g., weekday versus weekend), and time of season.

The extent of a severe winter storm can be classified by meteorological measurements and by evaluating its societal impacts. NOAA's National Climatic Data Center (NCDC) is currently producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1 to 5. It is based on the spatial extent of the storm,

the amount of snowfall, and the interaction of the extent and snowfall totals with population (based on the 2000 Census). The NCDC has analyzed and assigned RSI values to over 500 storms since 1900 (NOAA-NCDC 2011). Table 4.3.9-3 presents the five RSI ranking categories.

Table 4.3.9-3. RSI Ranking Categories

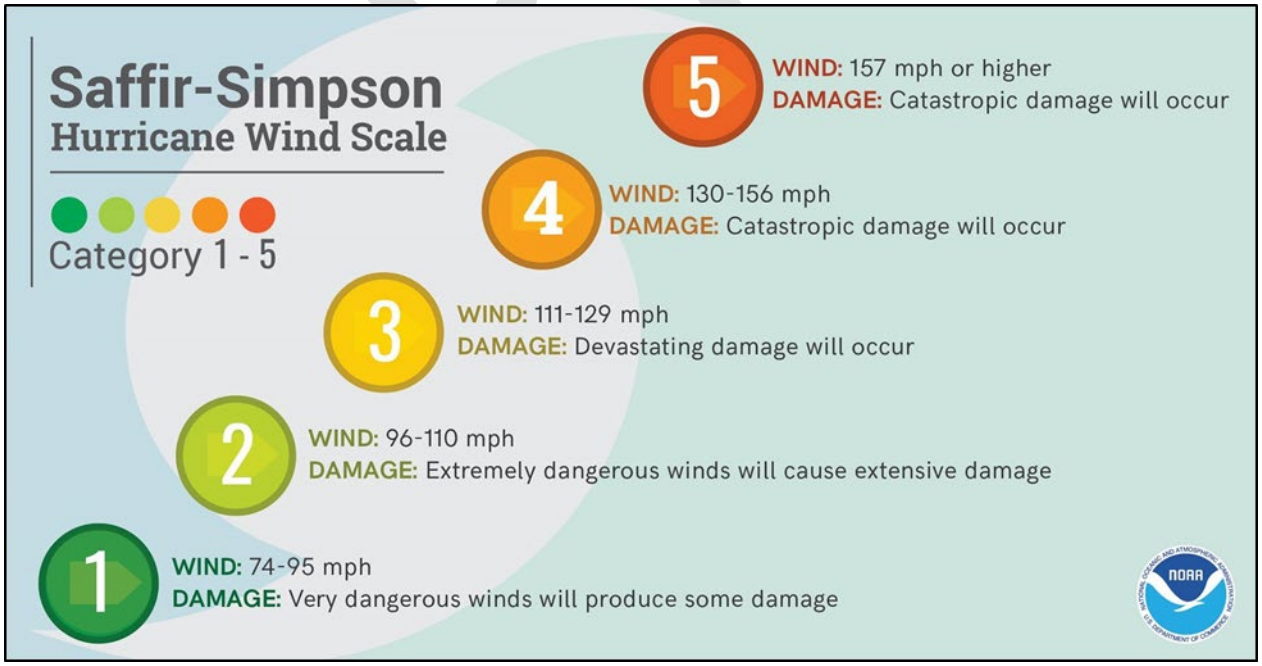
Category	Description	RSI Value
1	Notable	1-3
2	Significant	3-6
3	Major	6-10
4	Crippling	10-18
5	Extreme	18.0+

Source: NOAA-NCDC 2011
Note: RSI = Regional Snowfall Index

Hurricanes and Tropical Storms

The extent of a hurricane is categorized in accordance with the Saffir-Simpson Hurricane Scale. The Saffir-Simpson Hurricane Wind Scale is a 1-to-5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous and require preventative measures (NOAA 2013). Figure 4.3.9-4 presents this scale, which is used to estimate the potential property damage and flooding expected when a hurricane makes landfall.

Figure 4.3.9-4. The Saffir-Simpson Scale



Source: Disaster Readiness Portal 2017

Mean Return Period (MRP)

In evaluating the potential for hazard events of a given magnitude, the 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 (Dinicola 2009).

Figure 4.3.9-6 display the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP events. These peak wind speed projections were generated using Hazus model runs. The maximum 3-second gust wind speeds for Camden County are 67 to 76 mph (Tropical Storm to Category 1 hurricane), for the 100-year MRP event. The maximum 3-second gust wind speeds for Camden County are 87 to 98 mph (Category 1 to Category 2 hurricane), for the 500-year MRP event. The storm tracks for the 100- and 500-year event were not available in Hazus; a Hazus-acknowledged error in this version that will be addressed in the future. The associated impacts and losses from these 100-year and 500-year MRP hurricane events are discussed later in the Vulnerability Assessment subsection.

Figure 4.3.9-5. Wind Speeds for the 100-year Mean Return Period Event

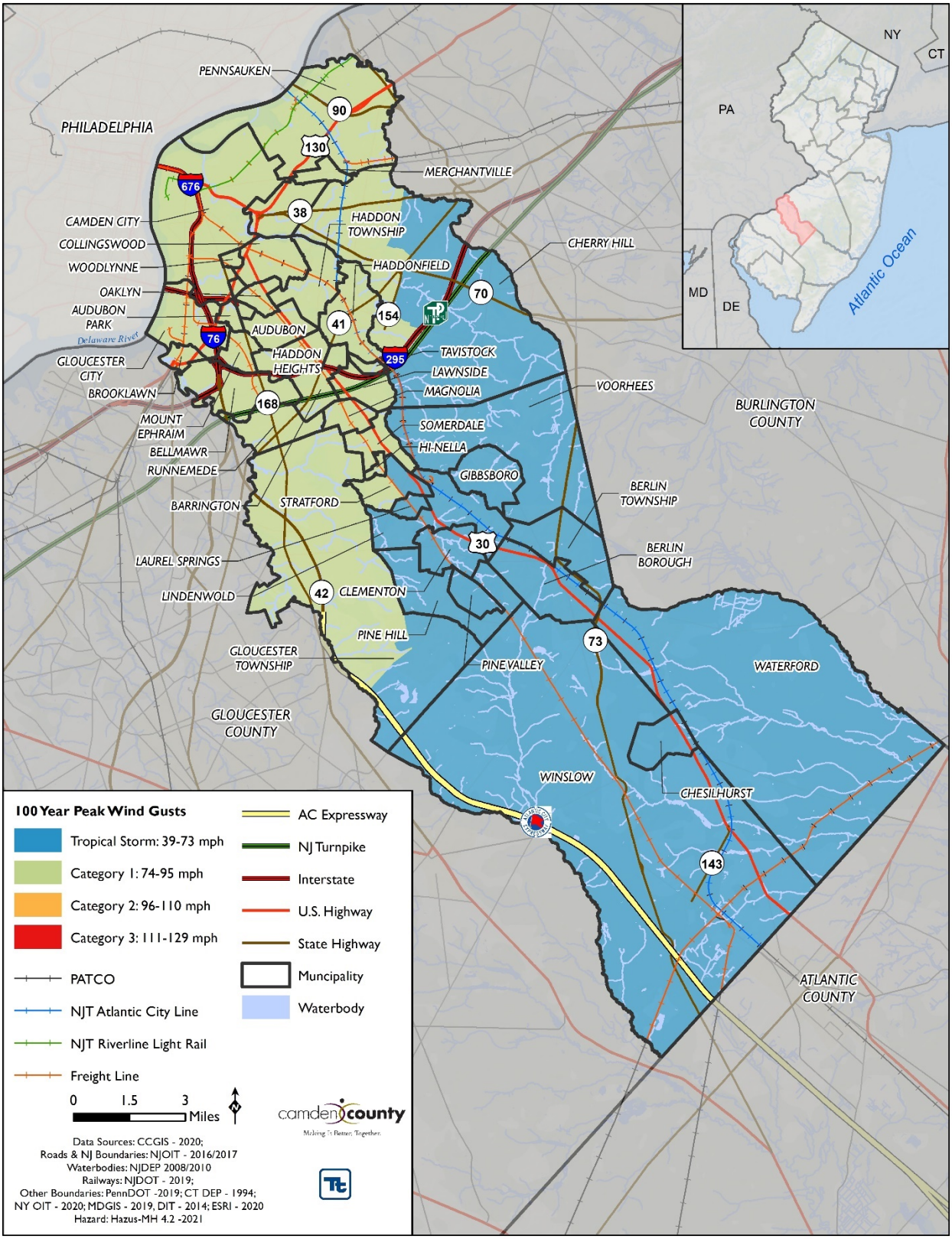
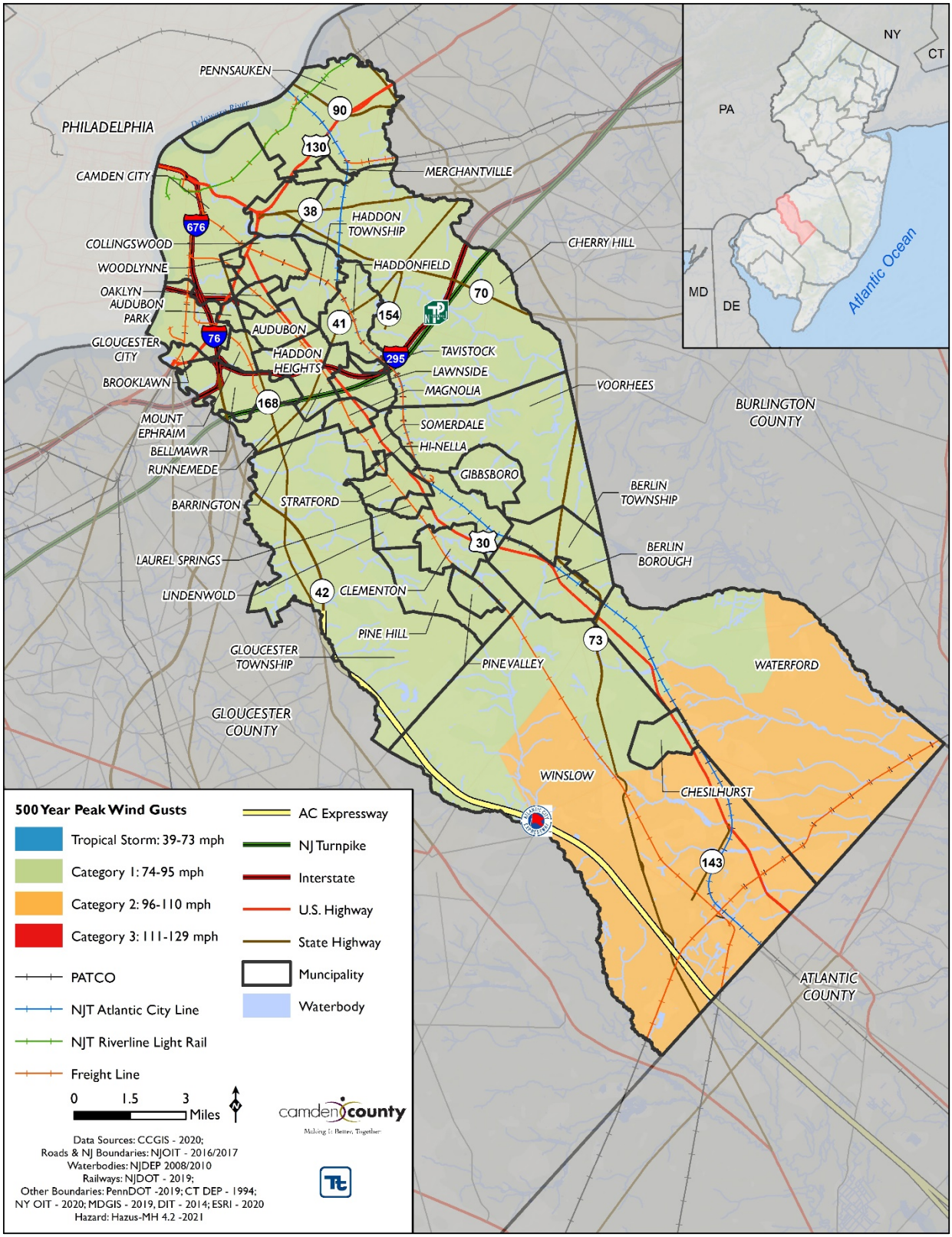


Figure 4.3.9-6. Wind Speeds for the 500-year Mean Return Period Event



4.3.9.3 Past Occurrences

Table 4.3.9-4 summarizes historical severe weather events from 1950 to 2020 in Camden County based on data collected from the NOAA-NCEI and FEMA disaster declaration databases. In the table below, "Coastal Storms" refers to Hurricanes and Tropical Storms.

Table 4.3.9-4. High Wind Events in Camden County, 1950 to 2020

Hazard Type	Number of Occurrences Between 1950 and 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
High Winds	34	0	1	$11.44 M	$0
Tornado	9	0	8	$1.25 M	$0
Thunderstorm Wind	147	2	6	$5.16 M	$0
Coastal Storms	3	0	0	$500 K	$0
Total	**193**	**2**	**15**	**$18.35 M**	**$0**

Source: NOAA-NCEI 2020; FEMA 2020
Notes: M Million; K Thousand

Between 1954 and 2020, FEMA included New Jersey in 37 severe storm-related major disaster (DR) or emergency (EM) declarations classified as one or a combination of the following disaster types: severe storms, flooding, hurricane, and coastal storms. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Camden County has been included in 11 declarations for high wind-related events classified as one or a combination of the following disaster types: severe storm, straight-line winds or tornado (FEMA 2019). Table 4.3.9-5 lists these events.

Table 4.3.9-5. High Wind-Related Disaster (DR) and Emergency (EM) Declarations for Camden County

Declaration	Event Date	Declaration Date	Event Description
EM-3148	September 16 – 18, 1999	September 17, 1999	Hurricane Floyd
DR-1530	July 12 – 23, 2004	July 16, 2004	Severe Storms and Flooding
EM-3257	August 29 – October 1, 2005	September 19, 2005	Hurricane Katrina Evacuation
DR-1694	April 14 – 20, 2007	April 26, 2007	Severe Storms and Inland and Coastal Flooding
EM-3332	August 26 – September 5, 2011	August 27, 2011	Hurricane Irene
DR-4021	August 26 – September 5, 2011	August 31, 2011	Hurricane Irene

Declaration	Event Date	Declaration Date	Event Description
EM-3354	October 26 – November 8, 2012	October 28, 2012	Superstorm Sandy
DR-4086	October 26 – November 8, 2012	October 30, 2012	Superstorm Sandy
DR-4231	June 23, 2015	July 22, 2015	Severe Storm
DR-4264	January 22 – 24, 2016	March 14, 2016	Severe Winter Storm and Snowstorm
DR-4574	August 4, 2020	December 11, 2020	Tropical Storm Isaias

Source: FEMA 2020

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans available to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2020, Camden County was included in the following USDA disaster declaration in relation to high winds as indicated in Table 4.3.9-6.

Table 4.3.9-6. High Wind-Related USDA Disaster Declarations for Camden County, 2015 to 2020

Declaration	Event Date	Approval Date	Event Description
S3931	May 28 – July 15, 2015	November 4, 2015	Excessive rain, flash flooding, high winds, and lightning

Source: USDA 2021

High wind events that have impacted Camden County between 2015 and 2020 are identified in Table 4.3.9-7. With high wind event documentation for New Jersey and Camden County being so extensive, not all sources have been identified or researched. Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality, when available.

Table 4.3.9-7. High Wind Events in Camden County, 2015 to 2020

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Camden County Designated?	Location	Description
June 23, 2015	Thunderstorm Wind, Funnel Cloud	DR-4231-NJ	Yes	Borough of Merchantville, Borough of Tavistock, Borough of Haddonfield, Borough of Lindenwold, Borough of Clementon,	Hot and humid air combined with an approaching cold mass, resulting in a squall line of severe thunderstorms to move through southern new Jersey on the afternoon of June 23. Estimated wind gusts reached 85 mph and knocked down thousands of trees and caused extensive damages and

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Camden County Designated?	Location	Description
				Sicklerville, Borough of Gibbsboro, West Berlin, Waterford Township	power losses to over 410,000 homes throughout the area. The Camden County Public Safety Office fielded over 3,500 calls for assistance during the event. One injury resulted from a driver being trapped in their car after trees and live wires fell. Damages included crop losses, and structural damages to buildings and facilities throughout the County, an estimated total over $3.35 million.
February 16, 2016	Thunderstorm Wind	N/A	No	Borough of Brooklawn, Gloucester Heights, Camden City, Pennsauken Township	A strong cold front moved through New Jersey bringing heavy downpours and severe wind gusts. Top wind speeds were estimated at 70 mph. Trees and power lines were knocked down throughout the area, and in Gloucester City, a scoreboard outside of the Junior-Senior High School was blown down. A tractor trailer was blown over on the Walt Whitman Bridge in Camden City, resulting in $5,000 in property damages. Over 30,000 customers lost power due to the event.
June 5, 2016	Thunderstorm Wind	N/A	No	Blackwood, Borough of Clementon, Waterford Township, Camden City	A cold front moved into an unstable air mass, resulting in showers and thunderstorms and straight-line winds. Thousands of people lost power as a result of the high winds. Wind gusts were recorded from 60 to 70, with the highest at 74 mph in Gloucester Township.
June 8, 2016	Thunderstorm Wind	N/A	No	Camden City, Blackwood, Delair, Borough of Barrington, Borough of Haddon Heights, Westmont, Sicklerville, Grenloch	A low-pressure system produced a quick moving line of thunderstorms that produced widespread wind damage across southern and central NJ, with numerous power outages. Wind gusts reached 70 mph. A roof was torn off a building at Camden County College due to the high

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Camden County Designated?	Location	Description
					winds, as well as numerous trees being downed.
July 23, 2016	Thunderstorm Wind	N/A	No	Borough of Magnolia, Westmont, Borough of Haddon Heights, Borough of Somerdale, Borough of Gibbsboro, Borough of Runnemede	A cold front and low-pressure system developed into showers and thunderstorms, which resulted in damaging winds and hail. Several trees and power lines were downed throughout the County.
January 23, 2017	High Wind, Strong Wind	N/A	No	Camden County	An area of low pressure strengthened off the New Jersey coastline and winds reached an excess of 50 mph. Minor tidal flooding was also reported, including considerable beach erosion due to the tide cycles. Power outages from the storm were estimated at 20,000 customers. Numerous trees were downed as a result of the high winds.
July 22, 2017	Thunderstorm Wind	N/A	No	Camden City, Borough of Oaklyn, Borough of Woodlynne, Borough of Collingswood, Borough of Mount Ephraim	Several rounds of thunderstorms produced damaging winds and flooding. Several thousand people lost power throughout the region.
April 15, 2019	Thunderstorm Wind	N/A	No	Camden City, Borough of Woodlynne, Borough of Haddonfield	Widespread straight-line wind damage and a few tornadoes were reported along the East Coast. A portion of roofing was blown off an apartment building in Camden City.
April 26, 2019	Thunderstorm Wind	N/A	No	Erlton, Cherry Hill Township, Borough of Haddonfield	A strong low-pressure system triggered widespread severe thunderstorms, resulting in wind damages and at least one funnel cloud was observed. Numerous trees and power lines were reported down throughout the area.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Camden County Designated?	Location	Description
June 13, 2019	Tornado	N/A	No	Blackwood, Gloucester Township	A line of strong to severe thunderstorms produced areas of damaging winds, resulting in multiple tornado touchdowns. A EF1 tornado took a non-continuous path from Deptford Township in Gloucester County into the Blackwood neighborhood of Gloucester Township in Camden County. There were several locations of tree and property damages, including to homes and an apartment building.
July 22, 2019	Thunderstorm Wind	N/A	No	Collingswood, Erlton, Camden City, Borough of Barrington, Westmont, Morrisville, Borough of Haddonfield, Borough of Oaklyn, Kirkwood	Widespread severe weather produced damaging winds with considerable damage to trees and power lines. Wind gusts were estimated at 80 mph.
August 19, 2019	Thunderstorm Wind	N/A	No	Pavonia, Delair, Borough of Merchantville, Westmont, Elm	A warm sector of a low-pressure system developed in the region, producing storms and damaging winds. Wind gusts reached upwards of 73 mph.
September 28, 2019	Thunderstorm Wind	N/A	No	Westmont, Cherry Hill Township	A powerful downburst caused significant damage in Cherry Hill Township including downed trees and power lines, as well as road closures.
April 9, 2020	Thunderstorm Wind	N/A	No	Gloucester City, Morrisville, Cherry Hill Township	Several post frontal squalls formed following a warm front and developed into thunderstorms with damaging winds throughout the region. A section of a roof was peeled off in Gloucester City and numerous trees were downed, with gusts reaching 60 mph.
June 3, 2020	Thunderstorm Wind	N/A	No	Borough of Haddon Heights, Gloucester Township, Pennsauken Township, Borough of Bellmawr, Haddon Hills,	A derecho developed southeast of Lake Erie, then moved rapidly across Pennsylvania and into New Jersey. Wind damage reports were numerous and widespread with gusts reaching 89 mph. Over 112,000 power outages were

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Camden County Designated?	Location	Description
				Gloucester City, Morrisville, Borough of Haddonfield, Borough of Oaklyn, Borough of Barrington, Westmont, Borough of Gibbsboro, Erlton, Borough of Magnolia, Blackwood, Borough of Somerdale, Borough of Chesilhurst, Borough of Clementon, Borough of Collingswood	reported in southern New Jersey, and several areas were without power for several days.
August 4, 2020	Tropical Storm	DR-4574	No	Camden County	Tropical Storm Isaias brought high winds, heavy rain, several tornadoes, and coastal flooding to the mid-Atlantic region, becoming the most impactful tropical cyclone to impact most of the region since Sandy in 2012.

Source: FEMA 2020; NOAA-NCEI 2020
DR Disaster Declaration (FEMA) *FEMA Federal Emergency Management Agency*
Mph miles per hour *N/A Not Applicable*

4.3.9.4 Future Occurrences

Camden County is expected to continue experiencing direct and indirect impacts of high wind events annually. These storms may induce secondary hazards such as flooding and utility failure. In Section 4.4, the identified hazards of concern for Camden County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for high winds in the County is considered 'frequent'.

The table below shows these statistics, as well as the annual average number of events and the percent chance of these individual flood hazards occurring in Camden County in future years based on the historic record (NOAA NCEI 2020).

Table 4.3.9-8. Probability of Future Occurrences of High Wind Events

Hazard Type	Number of Occurrences Between 1950 and 2020	Rate of Occurrence or Annual Number of Events (average)	Recurrence Interval (in years) (# Years/Number of Events)	Probability of Event in any given year	Percent (%) chance of occurrence in any given year
High Winds	34	0.48	2.09	0.48	48%
Tornado	9	0.13	7.89	0.13	13%
Thunderstorm Wind	147	2.1	0.48	2.08	100%
Coastal Storms	3	0.04	23.67	0.04	4%
Funnel Clouds	3	0.04	23.67	0.04	4%
Strong Wind	94	0.74	0.74	0.74	74%
Tropical Storm	3	0.04	23.67	0.04	4%
Hurricane	0	0	0	0	0%
Total	193	**2.76**	**0.37**	**2.7**	**100%**

Source: NOAA-NCEI 2020
Note: Probability was calculated using the available data provided in the NOAA-NCEI storm events database. Due to limitations in data, not all severe weather events occurring between 1950 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated. A 100 percent chance of occurring means that at least one high wind event is likely to occur annually.

4.3.9.5 Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

Climate change includes major changes in temperature, precipitation, or wind patterns, which occur over several decades or longer. Due to the increase in greenhouse gas concentrations since the end of the 1890s, New Jersey has experienced a 3.5° F (1.9° C) increase in the State's average temperature (Office of the New Jersey State Climatologist 2020), which is faster than the rest of the Northeast region (2° F [1.1° C]) (Melillo et al. 2014) and the world (1.5° F [0.8° C]) (IPCC 2014). This warming trend is expected to continue. By 2050, temperatures in New Jersey are expected to increase by 4.1 to 5.7° F (2.3° C to 3.2° C) (Horton et al. 2015). Thus, New Jersey can expect to experience an average annual temperature that is warmer than any to date (low emissions scenario) and future temperatures could be as much as 10° F (5.6° C) warmer (high emissions scenario) (Runkle et al. 2017). New Jersey can also expect that by the middle of the 21st century, 70-percent of summers will be hotter than the warmest summer experienced to date (Runkle et al. 2017). The increase in temperatures is expected to be felt more during the winter months (December, January, and February), resulting in less intense cold waves, fewer sub-freezing days, and less snow accumulation.

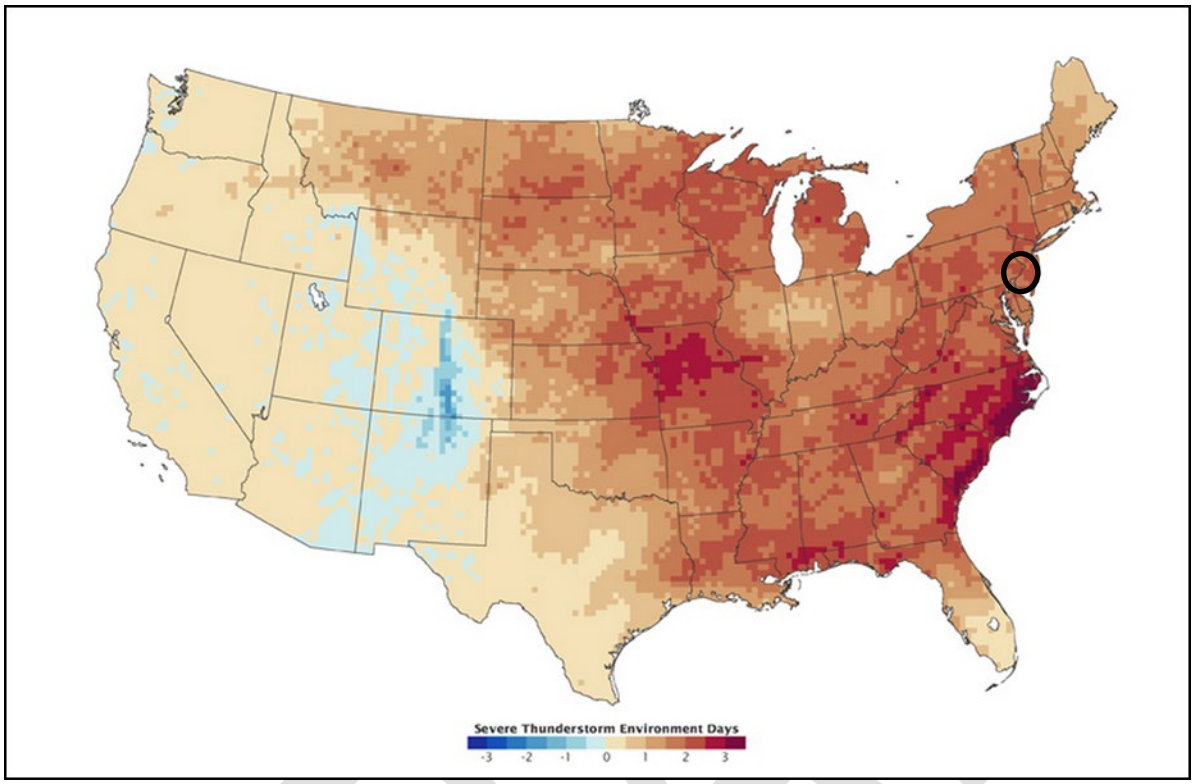
As temperatures increase, Earth's atmosphere can hold more water vapor which leads to a greater potential for precipitation. Currently, New Jersey receives an average of 46 inches of precipitation each

year (Office of the New Jersey State Climatologist 2020). Since the end of the twentieth century, New Jersey has experienced slight increases in the amount of precipitation it receives each year, and over the last 10 years there has been a 7.9 percent increase. By 2050, annual precipitation in New Jersey could increase by 4 percent to 11 percent (Horton et al. 2015). By the end of this century, heavy precipitation events are projected to occur two to five times more often (Walsh et al. 2014) and with more intensity (Huang et al. 2017) than in the last century. New Jersey will experience more intense rain events, less snow, and more rainfalls (Fan et al. 2014, Demaria et al. 2016, Runkle et al. 2017). Also, small decreases in the amount of precipitation may occur in the summer months, resulting in greater potential for more frequent and prolonged droughts (Trenberth 2011). New Jersey could also experience an increase in the number of flood events (Broccoli et al. 2020).

A warmer atmosphere means storms have the potential to be more intense (Guilbert et al. 2015) and occur more often (Coumou and Rahmstorf 2012, Marquardt Collow et al. 2016, Broccoli et al. 2020). In New Jersey, extreme storms typically include coastal nor'easters, snowstorms, spring and summer thunderstorms, tropical storms, and on rare occasions hurricanes. Most of these events occur in the warmer months between April and October, with nor'easters occurring between September and April. Over the last 50 years, in New Jersey, storms that resulted in extreme rain increased by 71-percent (Walsh et al. 2014) which is a faster rate than anywhere else in the United States (Huang et al. 2017).

As the climate changes, temperatures and the amount of moisture in the air will both increase, thus leading to an increase in the severity of thunderstorms which can lead to derechos and tornadoes. Studies have shown that an increase in greenhouse gases in the atmosphere would significantly increase the number of days that severe thunderstorms occur in the southern and eastern United States (National Aeronautics and Space Administration [NASA] 2005). Figure 4.3.9-7 below shows the predicted change in thunderstorm environment days given a doubling of greenhouse gasses in the atmosphere (Trapp et al 2007). The figure predicts that Camden County will experience between 2 and 3 times the amount of thunderstorm days in a given year during the 2072-2099 period.

Figure 4.3.9-7. Predicted Change in Severe Thunderstorm Environment Days from the 1962-1989 Period to the 2072-2099 Period



Source: Trapp et al. 2007; NASA GISS 2013
Note: The approximate location of Camden County is indicated by the black circle.

As temperatures increase so will the energy in a storm system, increasing the potential for more intense tropical storms (Huang et al. 2017), especially those of Category 4 and 5 (Melillo et al. 2014). As oceans warm, the length of hurricane season may also expand. The past six hurricane seasons have featured a tropical system occurring before the official start of the season. In 2016, a very rare winter hurricane named Alex developed in the middle of January (BBC 2019). According to NOAA's database, 39 storms formed in the Atlantic Basin before June 1 from 1851 through 2020, a long-term average of one such early storm every four to five years. The 2010s had the most such storms, and there has been a steady increase since the 1990s. However, the 1950s had six such storms, the 1930s had four and there was another four preseason storm streak from 1887 through 1890. It is possible there were other such storms in the era before satellites – before the mid-1960s – that were missed by ship observations or reports from areas impacted. It remains to be seen if expansion of the traditional hurricane season is a long-term trend or a common occurrence (Weather.com 2020). The National Hurricane Center is currently considering expanding the official hurricane season to begin in May, rather than June, as a result of the frequency of pre-season events (Highlands News-Sun 2021).

Temperatures are predicted to increase in Camden County and ocean temperatures are forecast to continue to increase, which may lead to an increase in intensity and frequency of hurricanes. It remains

to be seen if other factors such as steering currents, atmospheric sheer, and the presence of Saharan dust will be impacted in ways which increase or decrease the risk of hurricanes in Camden County.

4.3.9.6 Vulnerability Assessment

A probabilistic assessment was conducted for the 100- and 500-year Mean Return Periods (MRPs) through a Level 2 analysis in Hazus to analyze the wind hazard associated with high wind events and provide a range of loss estimates due to wind impacts. Refer to Section 4.2 (Methodology and Tools) for additional details on the methodology used to assess coastal storm risk.

Impact on Life, Health and Safety

The impact of a high wind event on life, health, and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time was provided to residents. Generally, all Camden County residents are exposed to the high wind hazard.

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This is due to many factors including their physical and financial ability to react or respond during a hazard. Economically disadvantaged populations are vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate. The population over the age of 65 is also vulnerable and, physically, they may have more difficulty evacuating. Additionally, the elderly are considered vulnerable because they require extra time or outside assistance during evacuations and are more likely to seek or need medical attention which may not be available due to isolation during a storm event. Please refer to Section 3 (County Profile) for the statistics of these populations.

Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. Hazus estimates there will be zero displaced households and no people will require temporary shelter due to a 100-year MRP event. Additionally, Hazus estimates 78 households will become displaced and 50 persons will seek short-term shelter due to a 500-year MRP wind event. Please note that estimates are only based on wind speed and do not account for sheltering needs associated with flooding and storm surge that may accompany coastal storm events.

Table 4.3.9-9. Estimated Displaced Households and Population Seeking Short-Term Shelter Caused by the 500-Year Mean Return Period Wind Event

Municipality	American Community Survey (2015-2019) Population	Hurricane Wind 500-Year Mean Return Period	
		Displaced Households*	People Requiring Short-Term Shelter*
Audubon (B)	8,661	0	0
Audubon Park (B)	854	0	0
Barrington (B)	6,716	2	1
Bellmawr (B)	11,398	1	1
Berlin (B)	7,539	3	2
Berlin (Twp)	5,553	2	1
Brooklawn (B)	2,004	0	0
Camden (C)	74,002	6	6
Cherry Hill (Twp)	70,965	12	8
Chesilhurst (B)	1,489	0	0
Clementon (B)	4,918	2	1
Collingswood (B)	13,912	4	1
Gibbsboro (B)	2,169	0	0
Gloucester (C)	11,248	1	1
Gloucester (Twp)	63,705	6	4
Haddon (Twp)	14,539	3	1
Haddon Heights (B)	7,514	0	0
Haddonfield (B)	11,345	0	0
Hi-Nella (B)	988	0	0
Laurel Springs (B)	1,959	0	0
Lawnside (B)	2,885	0	0
Lindenwold (B)	17,320	9	6
Magnolia (B)	4,272	1	1
Merchantville (B)	3,719	1	1
Mount Ephraim (B)	4,582	0	0
Oaklyn (B)	3,964	0	0
Pennsauken (Twp)	35,660	0	0
Pine Hill (B)	10,442	1	1
Pine Valley (B)	5	0	0
Runnemede (B)	8,327	1	1
Somerdale (B)	5,448	0	0
Stratford (B)	6,971	2	1
Tavistock (B)	2	0	0
Voorhees (Twp)	29,212	9	4
Waterford (Twp)	10,702	1	1
Winslow (Twp)	38,829	11	7
Woodlynne (B)	2,920	0	0
Camden County (Total)	**506,738**	**78**	**50**

Source: Hazus 4.2
Notes: B = Borough, C = City, Twp = Township
**Estimated persons requiring short-term sheltering is based on 2010 U.S. Census data.*

Impact on General Building Stock

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

To better understand these risks, Hazus was used to estimate the expected wind-related building damages. Specific types of wind damages are also summarized in Hazus at the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 4.3.9-10 summarizes the definition of the damage categories. The number of structures and their associated damage state caused by the high wind events are summarized in Table 4.3.9-11 by general occupancy class.

Table 4.3.9-10. Description of Damage Categories

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

Source: Hazus Hurricane Technical Manual

Table 4.3.9-11. Structure Damages Caused by the 100-Year and 500-Year MRP Wind Events Summarized by Occupancy Class

Occupancy Class	Total Number of Buildings in Occupancy	Severity of Expected Damage	100-year		500-year	
			Building Count	Percent Buildings in Occupancy Class	Building Count	Percent Buildings in Occupancy Class
Residential Exposure (Single and Multi-Family Dwellings)	172,571	None	171,793	99.5%	160,854	93.2%
		Minor	764	0.4%	11,065	6.4%
		Moderate	14	0.0%	628	0.4%
		Severe	0	0.0%	7	<0.1%
		Complete Destruction	0	0.0%	17	<0.1%
Commercial Buildings	12,084	None	11,990	99.2%	11,503	95.2%
		Minor	93	0.8%	541	4.5%
		Moderate	1	0.0%	39	0.3%
		Severe	0	0.0%	1	<0.1%
		Complete Destruction	0	0.0%	0	0.0%
Industrial Buildings	1,564	None	1,549	99.0%	1,483	94.8%
		Minor	15	0.9%	73	4.7%
		Moderate	0	0.0%	8	0.5%
		Severe	0	0.0%	1	0.1%
		Complete Destruction	0	0.0%	0	0.0%
Government, Religion, Agricultural, and Education Buildings	3,949	None	3,929	99.5%	3,720	94.2%
		Minor	19	0.5%	217	5.5%
		Moderate	1	0.0%	11	<0.1%
		Severe	0	0.0%	1	<0.1%
		Complete Destruction	0	0.0%	0	0.0%

Source: Camden County GIS 2021; NJDEP 2019; MODIV 2020; Hazus 4.2
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Table 4.3.9-12 summarizes the building value (structure only) damage estimated for the 100- and 500-year MRP hurricane wind-only events. Less than 1% of the entire building stock may anticipate structural damages caused by the 100-year wind event and approximately 0.2-percent of the entire building stock may anticipate structural damages caused by the 500-year wind event. Refer to Table 4.3.9-12 for a distribution of the loss by event.

The total damage to buildings (structure only) for all occupancy types across the County is estimated to be $102.1 million for the 100-year MRP wind-only event (tropical storm to Category 1 wind speeds), and approximately $476.2 million for the 500-year MRP wind-only event (Category 1 and 2 wind speeds). The majority of these losses are to residential structures. Total dollar damage reflects the overall impact to buildings at an aggregate level.

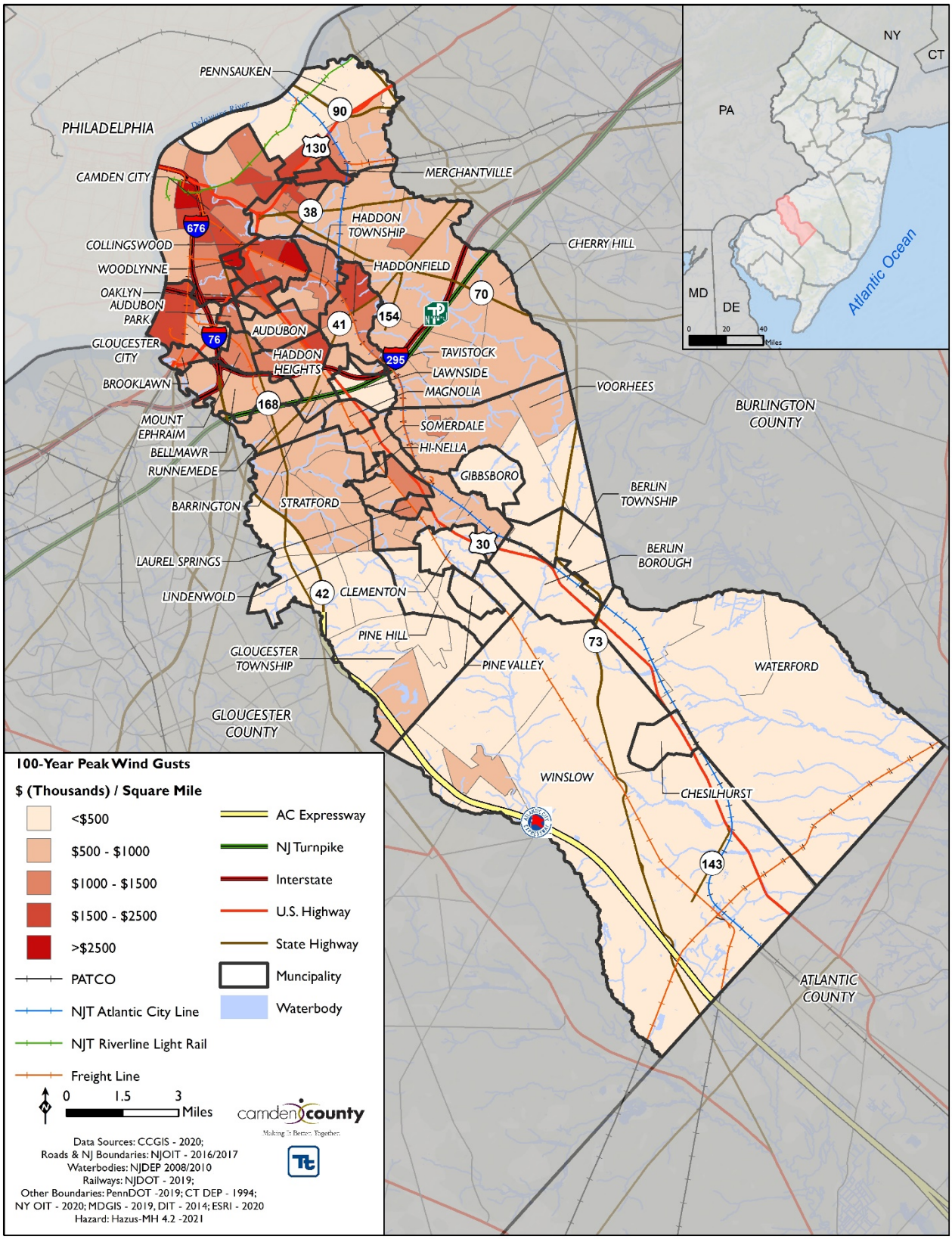
Table 4.3.9-12. Estimated Losses (Structure Only) for the 100-Year and 500-Year MRP High Wind Events

Municipality	Total Replacement Cost Value (All Occupancies)	Estimated Total Damages (Structural Only)				Estimated Residential Damages (Structural Only)		Estimated Commercial Damages (Structural Only)	
		100-Year	Percent of Total	500-Year	Percent of Total	100-Year	500-Year	100-Year	500-Year
Audubon (B)	$3,982,105,081	$1,940,867	<0.1%	$6,802,733	0.2%	$1,587,101	$5,168,322	$304,521	$1,423,348
Audubon Park (B)	$113,958,539	$119,292	0.1%	$417,971	0.4%	$99,228	$315,810	$16,667	$83,539
Barrington (B)	$3,993,943,132	$1,276,160	<0.1%	$5,659,334	0.1%	$814,618	$3,088,973	$341,275	$1,927,212
Bellmawr (B)	$4,528,930,831	$2,029,516	<0.1%	$7,574,149	0.2%	$1,649,549	$5,035,164	$216,192	$921,145
Berlin (B)	$3,513,614,243	$1,151,028	<0.1%	$8,824,077	0.3%	$951,080	$6,773,021	$160,017	$1,477,208
Berlin (Twp)	$8,790,953,567	$1,003,961	<0.1%	$10,195,825	0.1%	$608,202	$4,251,534	$352,647	$5,292,756
Brooklawn (B)	$1,349,439,712	$554,137	<0.1%	$1,631,357	0.1%	$450,691	$1,211,389	$91,563	$369,322
Camden (C)	$56,584,405,974	$13,384,502	<0.1%	$40,789,157	0.1%	$7,880,592	$23,295,334	$3,904,804	$11,586,530
Cherry Hill (Twp)	$33,592,477,509	$16,183,465	<0.1%	$76,862,267	0.2%	$13,804,120	$62,864,676	$1,865,741	$10,096,457
Chesilhurst (B)	$753,192,869	$107,434	<0.1%	$1,491,372	0.2%	$80,401	$1,088,800	$16,274	$218,869
Clementon (B)	$2,920,934,056	$861,474	<0.1%	$5,320,708	0.2%	$650,988	$3,419,862	$191,715	$1,687,927
Collingswood (B)	$9,994,688,881	$3,672,910	<0.1%	$13,307,993	0.1%	$2,543,032	$8,410,864	$1,041,937	$4,480,343
Gibbsboro (B)	$2,794,254,297	$445,227	<0.1%	$3,151,553	0.1%	$318,903	$1,780,105	$111,838	$1,229,364
Gloucester (C)	$8,699,066,833	$3,470,451	<0.1%	$10,394,974	0.1%	$2,571,888	$7,030,975	$803,892	$3,057,061
Gloucester (Twp)	$24,827,109,084	$10,953,938	<0.1%	$48,537,239	0.2%	$9,248,045	$36,519,323	$1,452,879	$10,245,614
Haddon (Twp)	$8,495,714,525	$3,351,794	<0.1%	$12,293,058	0.1%	$2,701,457	$9,088,831	$597,474	$2,896,820
Haddon Heights (B)	$4,935,884,626	$2,147,398	<0.1%	$8,267,883	0.2%	$1,568,192	$5,195,206	$537,909	$2,857,396
Haddonfield (B)	$8,852,674,248	$3,803,907	<0.1%	$15,480,597	0.2%	$2,877,100	$10,400,633	$837,229	$4,643,779
Hi-Nella (B)	$364,325,072	$91,124	<0.1%	$382,897	0.1%	$82,705	$342,823	$4,335	$21,839
Laurel Springs (B)	$1,450,376,747	$566,261	<0.1%	$2,907,369	0.2%	$465,957	$2,083,442	$89,169	$713,019
Lawnside (B)	$1,722,718,258	$462,112	<0.1%	$2,040,454	0.1%	$324,306	$1,345,360	$102,130	$514,692
Lindenwold (B)	$7,681,293,689	$2,863,451	<0.1%	$15,099,875	0.2%	$2,275,428	$10,865,108	$385,392	$2,983,846
Magnolia (B)	$2,481,735,074	$828,159	<0.1%	$3,679,470	0.1%	$637,795	$2,535,233	$132,730	$854,826
Merchantville (B)	$2,982,747,312	$980,692	<0.1%	$3,678,663	0.1%	$687,537	$2,470,651	$232,651	$931,568
Mount Ephraim (B)	$3,176,898,888	$1,150,106	<0.1%	$3,813,777	0.1%	$890,567	$2,566,026	$220,251	$1,053,414
Oaklyn (B)	$2,536,130,354	$940,317	<0.1%	$3,339,379	0.1%	$713,869	$2,233,780	$205,100	$995,100
Pennsauken (Twp)	$18,990,295,898	$7,884,465	<0.1%	$27,125,498	0.1%	$6,700,971	$21,249,926	$892,518	$3,980,043
Pine Hill (B)	$2,320,272,349	$1,320,826	0.1%	$7,237,424	0.3%	$1,269,172	$6,681,099	$29,798	$297,249

Municipality	Total Replacement Cost Value (All Occupancies)	Estimated Total Damages (Structural Only)				Estimated Residential Damages (Structural Only)		Estimated Commercial Damages (Structural Only)	
		100-Year	Percent of Total	500-Year	Percent of Total	100-Year	500-Year	100-Year	500-Year
Pine Valley (B)	$82,965,246	$12,803	<0.1%	$77,379	0.1%	$12,054	$68,924	$439	$4,874
Runnemede (B)	$4,203,633,200	$1,518,265	<0.1%	$5,622,385	0.1%	$1,071,830	$3,631,603	$400,202	$1,768,962
Somerdale (B)	$3,999,602,407	$1,159,785	<0.1%	$5,204,038	0.1%	$710,623	$2,939,874	$405,178	$2,004,932
Stratford (B)	$2,645,521,871	$1,298,170	<0.1%	$6,026,651	0.2%	$988,573	$4,240,458	$247,546	$1,418,627
Tavistock (B)	$17,692,986	$12,246	0.1%	$46,503	0.3%	$11,677	$43,356	$442	$2,421
Voorhees (Twp)	$18,757,102,175	$6,358,753	<0.1%	$39,086,355	0.2%	$5,628,301	$30,910,479	$669,176	$7,559,011
Waterford (Twp)	$4,400,620,966	$1,031,965	<0.1%	$14,097,796	0.3%	$931,231	$10,101,946	$78,432	$2,152,402
Winslow (Twp)	$17,669,828,003	$6,562,483	<0.1%	$58,061,029	0.3%	$5,940,115	$45,478,991	$499,477	$7,848,865
Woodlynne (B)	$1,039,137,958	$564,310	0.1%	$1,699,387	0.2%	$488,003	$1,398,417	$59,963	$236,616
Camden County (Total)	**$285,246,246,457**	**$102,063,755**	**<0.1%**	**$476,228,577**	**0.2%**	**$80,235,903**	**$346,126,319**	**$17,499,501**	**$99,836,995**

Source: Camden County GIS 2021; NJDEP 2019; MODIV 2020; RSMeans 2020; Hazus 4.2
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than, MRP = Mean Return Period

Figure 4.3.9-8. Density of Losses for Structures (All Occupancies) for the County 100-Year MRP Wind Event



Impact on Critical Facilities and Lifelines

Critical facilities are at risk of being impacted by high winds associated with structural damage, or falling tree limbs/flying debris, which can result in the loss of power. Power loss can greatly impact households, business operations, public utilities, and emergency personnel. For example, vulnerable populations in Camden County are at risk if power loss results in interruption of heating and cooling services, stagnated hospital operations, and potable water supplies. Emergency personnel such as police, fire, and EMS will not be able to effectively respond in a power loss event to maintain the safety of its citizens.

Hazus estimates the probability that critical facilities (i.e., medical facilities, fire/EMS, police, EOC, schools, shelters and municipal buildings) may sustain damage as a result of 100-year and 500-year MRP winds. Additionally, Hazus estimates the loss of use for each facility in number of days. Hazus estimates that the 100-year MRP wind event causes minimal damage to critical facilities and lifelines in the County (Table 4.3.9-13). Hazus estimates that there is a small probability that critical facilities and lifelines will experience moderate to severe damage (Table 4.3.9-14).

Table 4.3.9-13. Estimated Impacts to Critical Facilities and Lifelines for the 100-Year MRP Wind Event

Facility Type	100-Year Event				
	Loss of Days	Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
EOC	0	0.6-1.1%	0.0%	0.0%	0.0%
Medical	0	<0.1%	<0.1%	0.0%	0.0%
Police	0	0.5-1.1%	<0.1%	0.0%	0.0%
Fire	0	0.4%	<0.1%	0.0%	0.0%
Schools	0	0.6%	<0.1%	0.0%	0.0%

Source: Camden County Planning Partners 2021; Camden County GIS 202; Hazus 4.2
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

Table 4.3.9-14. Estimated Impacts to Critical Facilities and Lifelines for the 500-Year MRP Wind Event

Facility Type	500-Year Event				
	Loss of Days	Percent-Probability of Sustaining Damage			
		Minor	Moderate	Severe	Complete
EOC	0	3.8-7.0%	0.2-1.0%	<0.1%	0.0%
Medical	0	2.0-7.0%	0.2-2.3%	0.0%	0.0%
Police	0	3.2-7.0%	0.2-1.0%	<0.1%	0.0%
Fire	0	1.3-4.6%	0.2%	<0.1%	0.0%
Schools	0	2.8-8.3%	0.5-5.3%	<0.1	0.0%

Source: Camden County Planning Partners 2021; Camden County GIS 202; Hazus 4.2
Notes: B = Borough, C = City, Twp = Township, % = Percent, < = Less Than

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

Impact on the Economy

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

Hazus estimates the total economic loss associated with each storm scenario (direct building losses and business interruption losses). Direct building losses are the estimated costs to repair or replace the damage caused to the building. This is reported in the "Impact on General Building Stock" 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. These losses are summarized for the 100-year and 500-year MRP events in Table 4.3.9-15.

Table 4.3.9-15. Estimated Economic Losses Caused by the 100-Year and 500-Year Mean Return Period Wind Events

Mean Return Period (MRP)	Inventory Loss	Relocation Loss	Building and Content Losses	Wages Losses	Rental Losses	Income Loss
100-year MRP	$24,250	$603,830	$114,763,220	$1,096,710	$331,530	$808,830
500-year MRP	$1,044,540	$24,701,370	$550,101,660	$10,128,230	$10,618,740	$4,691,440

Source: Hazus 4.2

Debris management can be costly and may also impact the local economy. Hazus estimates the amount of building and tree debris that may be produced as result of the 100- and 500-year MRP wind events. Because the estimated debris production does not include flooding, this is likely a conservative estimate and may be higher if multiple impacts occur. According to the Hazus Hurricane User Manual, estimates of weight and volume of eligible tree debris consist of downed trees that would likely be collected and disposed at public expense. Refer to the User Manual for additional details regarding these estimates. Table 4.3.9-16 summarizes debris production estimates for the 100- and 500-year MRP wind events.

Table 4.3.9-16. Estimated Debris Generated from the 100-Year and 500-Year Mean Return Period Wind Events

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
Audubon (B)	145	845	0	0	112	460	1,007	4,222
Audubon Park (B)	9	51	0	0	12	35	96	288
Barrington (B)	141	850	0	0	0	409	2	3,391
Bellmawr (B)	164	852	0	6	299	900	1,992	6,000

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
Berlin (B)	92	1,046	0	1	231	1,389	1,568	9,409
Berlin (Twp)	153	1,376	0	0	208	1,246	1,044	6,264
Brooklawn (B)	51	192	0	0	67	150	443	998
Camden (C)	1,509	5,703	0	0	623	1,910	3,952	12,079
Cherry Hill (Twp)	1,092	8,405	0	0	2,095	7,989	15,011	57,503
Chesilhurst (B)	10	202	0	0	1	337	2	1,674
Clementon (B)	81	683	0	0	125	689	934	5,134
Collingswood (B)	339	1,789	0	0	184	564	1,576	4,856
Gibbsboro (B)	59	391	0	0	141	778	541	2,967
Gloucester (C)	333	1,291	0	0	188	559	1,367	3,835
Gloucester (Twp)	879	5,923	0	0	1,746	7,376	10,909	46,370
Haddon (Twp)	260	1,463	0	0	205	757	1,890	6,680
Haddon Heights (B)	211	1,182	0	0	101	404	910	3,614
Haddonfield (B)	331	2,032	0	0	198	995	1,638	8,164
Hi-Nella (B)	5	38	0	0	14	47	121	403
Laurel Springs (B)	46	338	0	0	45	150	427	1,423
Lawnside (B)	46	281	0	0	0	316	2	2,115
Lindenwold (B)	222	1,770	0	0	382	1,401	2,613	9,597
Magnolia (B)	72	459	0	0	94	313	793	2,656
Merchantville (B)	95	538	0	0	1	133	11	1,282
Mount Ephraim (B)	95	438	0	0	97	273	883	2,500
Oaklyn (B)	74	405	0	0	67	200	619	1,857
Pennsauken (Twp)	474	2,878	0	3	1,106	3,388	5,836	18,419
Pine Hill (B)	72	705	0	0	309	1,801	1,430	8,250
Pine Valley (B)	1	8	0	0	4	25	17	101
Runnemede (B)	131	763	0	0	165	642	1,374	5,301
Somerdale (B)	109	699	0	0	94	443	765	3,769
Stratford (B)	93	666	0	0	158	547	1,284	4,446
Tavistock (B)	1	5	0	0	1	4	6	30
Voorhees (Twp)	460	4,254	0	1	891	4,274	5,578	26,625
Waterford (Twp)	72	1,882	0	1	1,272	15,798	2,286	21,155
Winslow (Twp)	474	7,661	0	1	3,045	24,833	6,988	47,157
Woodlynne (B)	40	190	0	0	22	65	204	613
Camden County (Total)	**8,442**	**58,253**	**0**	**13**	**14,304**	**81,601**	**76,118**	**341,150**

Source: Hazus 4.2
Notes: B = Borough, C = City, Twp = Township

Impact on the Environment

According to the State of New Jersey 2019 Hazard Mitigation Plan, coastal storms can impact various natural land resources that can be easily uprooted by major wind events. Extreme winds from storms may create several tons of debris because the wind tears apart foliage and trees in Camden County. Plants along waterways may be uprooted from high wind events causing even further instability and alterations

of the shoreline. Consequentially, natural habitat that shelters the County from wind can be destroyed, impacting future mitigation (NJ OEM 2019).

Future Changes that May Impact Vulnerability

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

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

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. The New Jersey Pinelands Commission has identified Pinelands Management Area Boundaries, including regional growth areas and rural development areas that may also provide insight to where development and growth may occur in the County. In addition, each community was requested to provide recent and anticipated new development and infrastructure projects; summarized in Section 9 (Jurisdictional Annexes). Overall, there are 89 recent and anticipated new development projects in the County.

Projected Changes in Population

Camden County has experienced population decline since 2010. According to the U.S. Census Bureau, the County's population has decreased 1.3-percent between 2010 and 2019 (U.S. Census Bureau 2020). Even though the population has decreased, any changes in the density of population can impact the number of persons exposed to the high wind hazard. Higher density can have an impact on the ability for residents to evacuate during a hazard event.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. An increase in temperatures may also lead to an increase in the frequency and intensity of storms. More frequent and severe storms will increase the County's vulnerability to high wind events.

Change of Vulnerability Since the 2017 HMP

Since the 2017 analysis, population statistics have been updated using the 2015-2019 ACS population estimates. The building inventory was updated using building footprints from the 2021 Camden County footprint dataset, footprint boundaries from the New Jersey Department of Environmental Protection's 2019 impervious surface layer, and updated parcels from the 2020 MODIV tax assessor dataset. RS Means 2020-dollar values were used to develop a structure-level building inventory and estimate replacement cost value for each building. The 2017 critical facility was also reviewed and updated by the Planning

Partnership. In addition, FEMA's hurricane wind module (version 4.2) was used to estimate potential losses for the 100-year and 500-year mean return period wind events.

These changes provide an up-to-date look at the entire building stock for Camden County and gives more accurate results for the exposure and loss estimation analysis.