4.3.2 Coastal Storms

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

2020 HMP Update Changes

- All subsections have been updated using best available data.
- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2014 and 2019.

4.3.2.1 Profile

Hazard Description

For the purpose of this HMP update, the coastal storm hazard profile will include: hurricanes and tropical storms, Nor'Easters, and storm surge. Detailed information regarding these hazards in Essex County are discussed further in this section.

Hurricanes and Tropical Storm

A tropical cyclone is characterized by a low-pressure center and numerous thunderstorms that produce strong winds and heavy rain. Tropical depressions, tropical storms, and hurricanes are all considered tropical cyclones. Tropical cyclones strengthen when water evaporated from the ocean is released as the saturated air rises, resulting in condensation of water vapor contained in the moist air. These storms rotate counterclockwise in the northern hemisphere around the center and are accompanied by heavy rain and strong winds (National Weather Service [NWS] 2013). Almost all tropical storms and hurricanes in the Atlantic basin (which includes the Gulf of Mexico and Caribbean Sea) form between June 1 and November 30 (hurricane season). August and September are peak months for hurricane development (NOAA 2013a).

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

The National Weather Service (NWS) issues hurricane and tropical storm watches and warnings. These watches and warnings are issued or will remain in effect after a tropical cyclone becomes post-tropical, when such a storm poses a significant threat to life and property. The NWS allows the National Hurricane Center (NHC) to issue advisories during the post-tropical stage. The following are the definitions of the watches and warnings:

- *Hurricane/Typhoon Warning* is issued when sustained winds of 74 mph or higher are expected somewhere within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness activities become difficult once winds reach tropical storm force, the warning is issued 36 hours in advance of the anticipated onset of tropical storm force winds (24 hours in the western north Pacific). The warning can remain in effect when dangerously high water or combination of dangerously high water and waves continue, even though winds may be less than hurricane force.
- *Hurricane Watch* is issued when sustained winds of 74 mph or higher are possible within the specified area in association with a tropical, subtropical, or post-tropical cyclone. Because hurricane preparedness

activities become difficult once winds reach tropical storm force, the hurricane watch is issued 48 hours prior to the anticipated onset of tropical storm force winds.

- *Tropical Storm Warning* is issued when sustained winds of 39 to 73 mph are expected somewhere within the specified area within 36 hours (24 hours for the western north Pacific) in association with a tropical, subtropical, or post-tropical storm.
- *Tropical Storm Watch* is issued when sustained winds of 39 to 73 mph are possible within the specified area within 48 hours in association with a tropical, sub-tropical, or post-tropical storm (NWS 2013).

Nor'Easter

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 2013b). 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° 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)

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 (Storm Solutions 2013). 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.

Storm Surge

Storm surges inundate coastal floodplains through dune overwash, tidal elevation rise in inland bays and harbors, and backwater flooding through coastal river mouths. Strong winds can increase tide levels and water-surface elevations. Storm systems generate large waves that run up and flood coastal beaches. The combined effects create storm surges that affect the beach, dunes, and adjacent low-lying floodplains. Shallow, offshore depths can cause storm-driven waves and tides to pile up against the shoreline and inside bays.

Based on an area's topography, a storm surge may inundate only a small area (along sections of the northeast or southeast coasts) or storm surge may inundate coastal lands for a mile or more inland from the shoreline.

Location

All of Essex County, not just the coastal areas, is vulnerable to coastal storms, depending on the storm's track. The coastal areas are more susceptible to damage caused by the combination of both high winds and tidal surge. Inland areas, especially those in floodplains, are also at risk for flooding because of heavy rain and winds. The majority of damage following coastal storms often results from residual wind damage and inland flooding, as was demonstrated during recent tropical storms. Section 4.3.1 (Coastal Erosion and Sea Level Rise) and Section 4.3.6 (Flood) discuss Essex County's coastline and the flood hazard further. Refer to Section 9 (Jurisdictional

Annexes) for detailed maps that display the 1-percent annual chance event floodplains and Sea, Lake and Overland Surge from Hurricanes (SLOSH) inundation areas in each municipality.

New Jersey's coastal zone includes portions of eight counties and 126 municipalities. The coastal boundary of New Jersey encompasses the Coastal Area Facility Review Act (CAFRA) area and the New Jersey Meadowlands District. Figure 4.3.2-1 shows New Jersey and the highlighted coastal zone area. Essex County is not located in either the CAFRA zone or Meadowlands; however, the County does have areas influenced by coastal waters and storm surge. The coastal area includes coastal waters to the limit of tidal influence including Newark Bay and the Passaic River, and the tidal portions of their tributaries. (NJDEP 2014).

Essex County is located within the New York-New Jersey Harbor Estuary (Newark Bay). Located in the New York & New Jersey Harbor Estuary, Newark Bay is the center of the most urbanized and industrialized parts of the country. Newark Bay is approximately six miles long and one mile wide and is located at the confluence of the Passaic and Hackensack Rivers, between the shores of Newark and Elizabeth to the west, Jersey City and Bayonne to the east, and Staten Island to the south. Newark Bay is linked to Upper and Lower New York Bay by the Kill van Kull and the Arthur Kill. Port Newark is located on the western shore of Newark Bay (Our Newark Bay 2014).

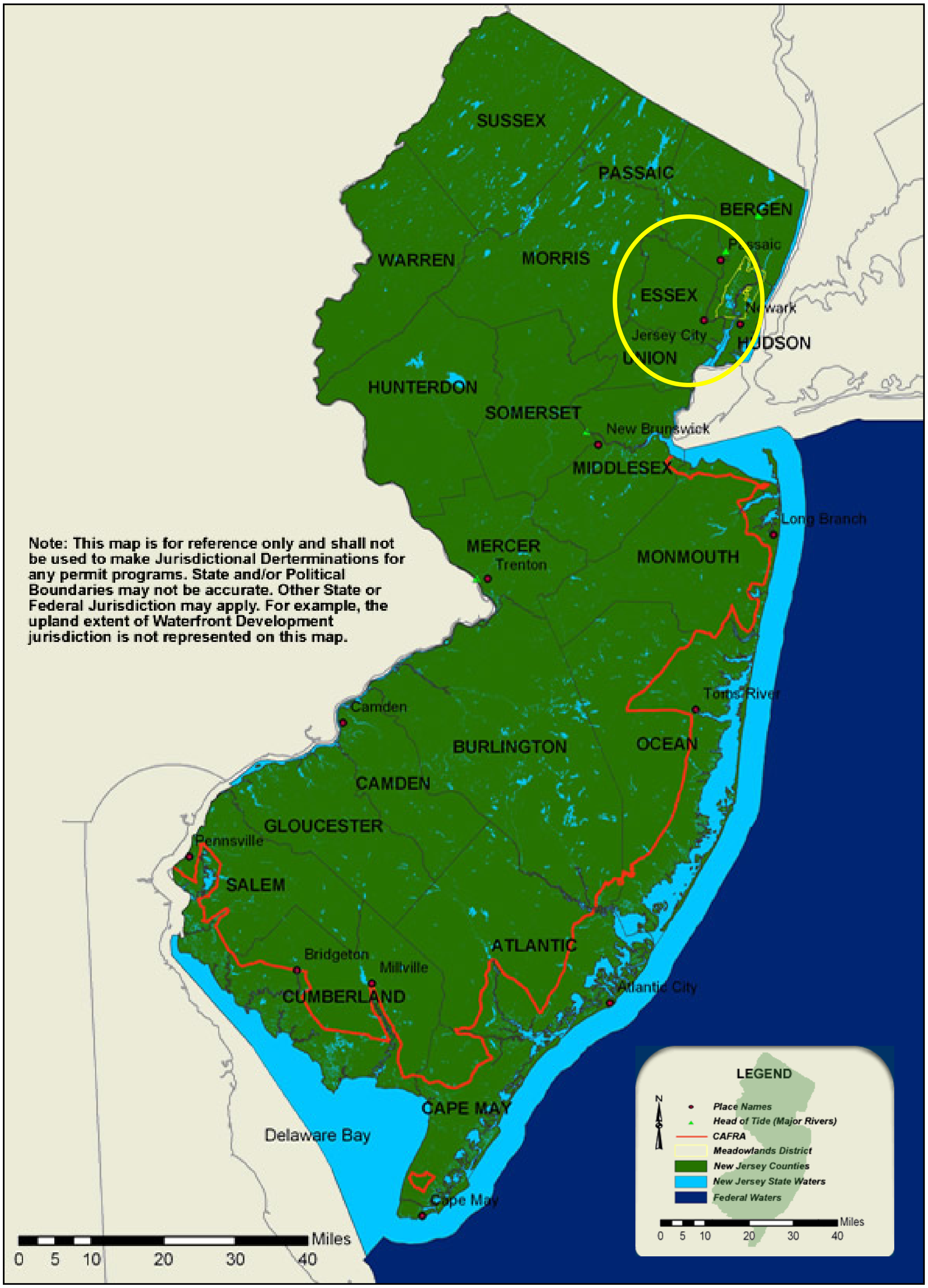
Storm Surge

Typically, storm surge is estimated by subtracting the regular/astrological tide level from the observed storm tide. Typical storm surge heights range from several feet to more than 25 feet. The exact height of the storm surge and which coastal areas will be flooded depends on many factors: strength, intensity, and speed of the hurricane or storm; the direction it is moving relative to the shoreline; how rapidly the sea floor is sloping along the shore; the shape of the shoreline; and the astronomical tide. Storm surge is the most damaging when it occurs along a shallow sloped shoreline, during high tide, in a highly populated, and developed area with little or no natural buffers (for example, barrier islands, coral reefs, and coastal vegetation).

The most common reference to a return period for storm surges has been the elevation of the coastal flood having a 1% chance of being equaled or exceeded in any given year, also known as the 100-year flood. Detailed hydraulic analyses include establishing the relationship of tide levels with wave heights and wave run-up. The storm surge inundation limits for the 1% annual chance coastal flood event are a function of the combined influence of the water surface elevation rise and accompanying wave heights and wave run-up along the coastline.

The coastal areas are more susceptible to damage caused by the combination of both high winds and tidal surge. Inland areas, especially those in floodplains, are also at risk for flooding because of heavy rain and winds. The majority of damage following hurricanes and tropical storms often results from residual wind damage and inland flooding, as was demonstrated during recent tropical storms.

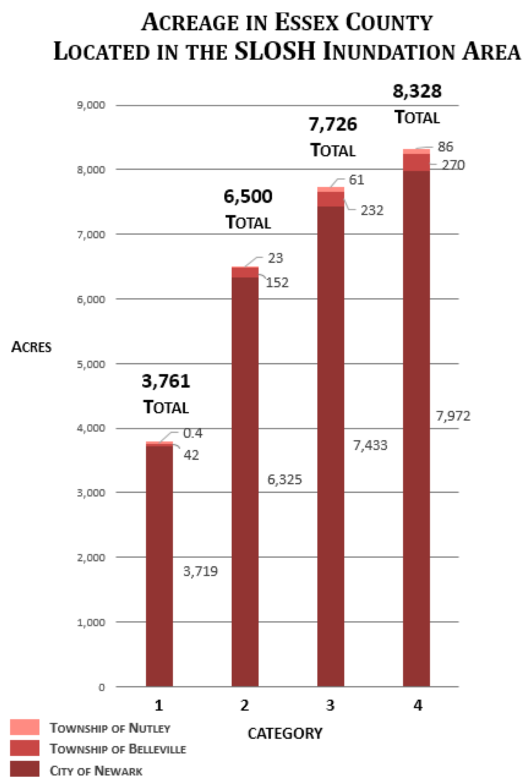
Figure 4.3.2-1. New Jersey Coastal Zone Area



Source: New Jersey Department of Environmental Protection (NJDEP) 2007
The yellow circle highlights the location of Essex County.

As noted, inundation from storm surge has devastating impacts on the State's coastal communities. The U.S. Army Corps of Engineers (USACE), in cooperation with FEMA, initially prepared SLOSH inundation maps. SLOSH maps represent potential flooding from worst-case combinations of hurricane direction, forward speed, landfall point, and high astronomical tide. It does not include riverine flooding caused by hurricane surge or inland freshwater flooding. The mapping was developed for the coastal communities in New Jersey using the computer model to forecast surges that occur from wind and pressure forces of hurricanes coastline topography. In New Jersey, hurricane category is the predominant factor in worst-case hurricane surges. The resulting inundation areas are grouped into Category 1 and 2 (dangerous), Category 3 (devastating), and Category 4 (catastrophic) classifications. The hurricane category refers to the Saffir/Simpson Hurricane Intensity Scale, summarized below.

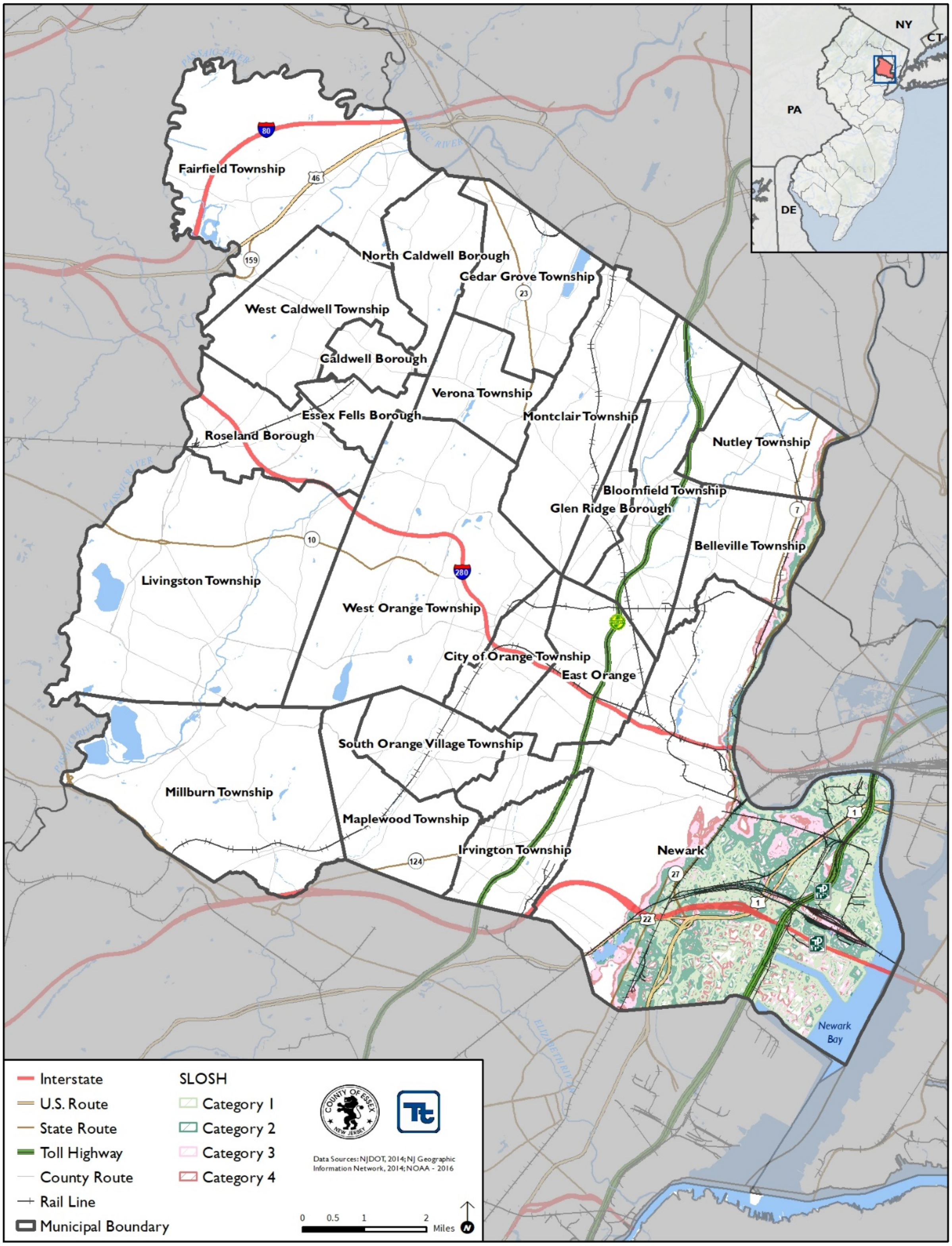
Exhibit 4.3.2-1



Source: NOAA National Hurricane Center, 2016

FEMA Region IV Risk Analysis Team developed storm surge inundation grids for the State in a spatial format from the maximum of maximums outputs from the SLOSH model. These represent the worst-case storm surge scenarios for each hurricane category (1 through 4). To assess the Planning Area's exposure to the hurricane/tropical surge, a spatial analysis was conducted using the SLOSH model. The SLOSH boundaries do not account for any inland flash flooding. Exhibit 4.3.2-1 shows the acreage of land in the SLOSH boundaries for the Township of Nutley, Township of Belleville and City of Newark. Figure 4.3.2-2 below illustrates these SLOSH zones.

Figure 4.3.2-2. FEMA Region IV SLOSH Model (Categories 1 through 4)



Extent

Hurricane and Tropical Storm

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

Table 4.3.2-1. The Saffir-Simpson Scale

Category	Wind Speed (mph)	Expected Damage
1	74-95 mph	Very dangerous winds will produce some damage: Homes with well-constructed frames could have damage to roof, shingles, vinyl siding, and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110 mph	Extremely dangerous winds will cause extensive damage: Homes with well-constructed frames could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3 (major)	111-129 mph	Devastating damage will occur: Homes with well-built frames may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4 (major)	130-156 mph	Catastrophic damage will occur: Homes with well-built frames can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5 (major)	>157 mph	Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: NOAA 2013b
Notes: mph = Miles per hour
> = Greater than

Mean Return Period

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

Figure 4.3.2-3 and Figure 4.3.2-4 show the estimated maximum 3-second gust wind speeds that can be anticipated in the study area associated with the 100- and 500-year MRP events. These peak wind speed projections were generated using Hazards U.S. Multi-Hazard (HAZUS-MH) model runs. The estimated hurricane track used for the 100- and 500-year event is also shown. The maximum 3-second gust wind speeds for Essex County range from Tropical Storm to Category 1 hurricane speeds for the 100-year MRP event. The maximum 3-second gust wind speeds for Essex County range from Category 1 to Category 2 hurricane speeds for the 500-year MRP event. The associated impacts and losses from these 100-year and 500-year MRP hurricane event model runs are reported in the Vulnerability Assessment.

Figure 4.3.2-3. Wind Speeds for the 100-Year Mean Return Period Event

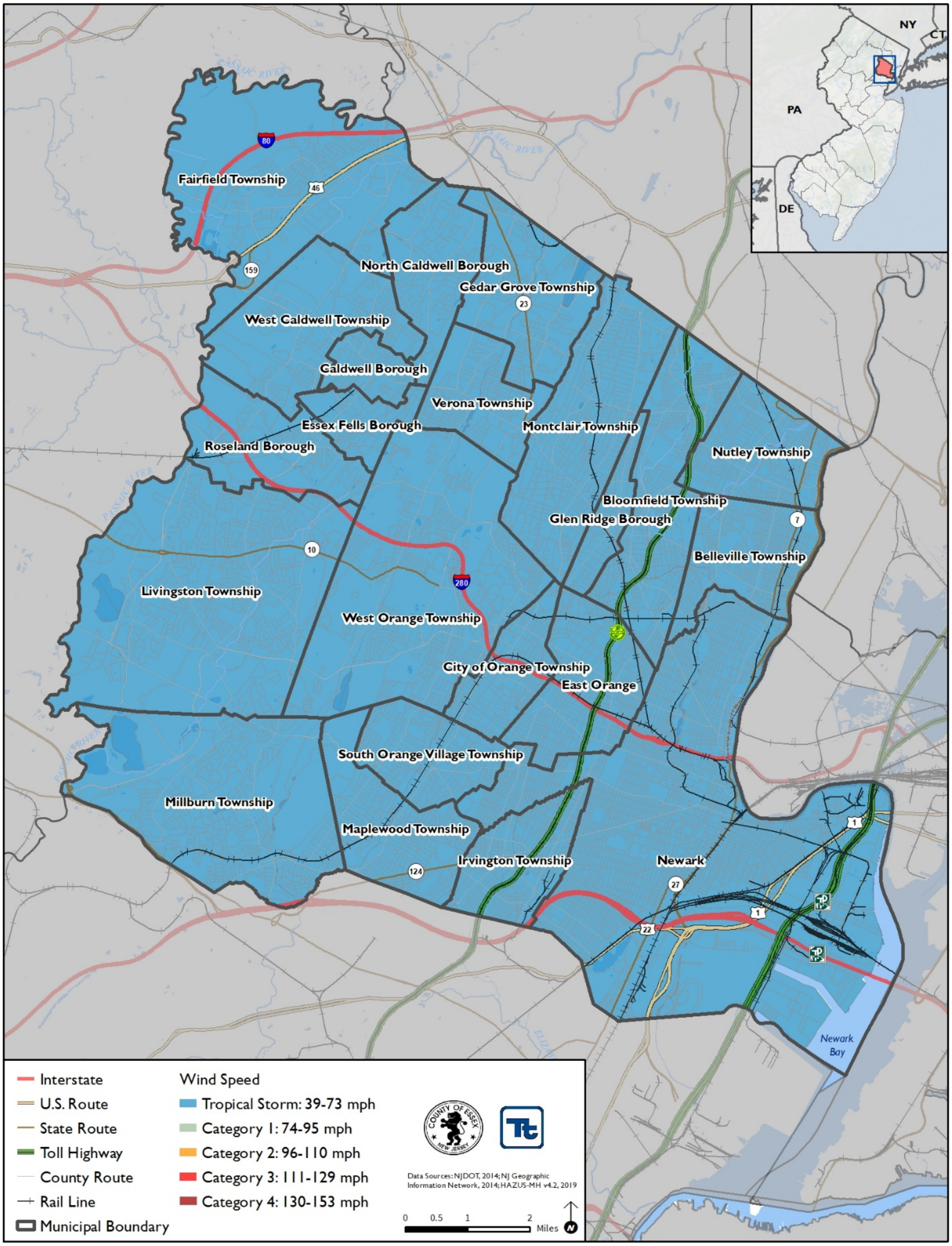
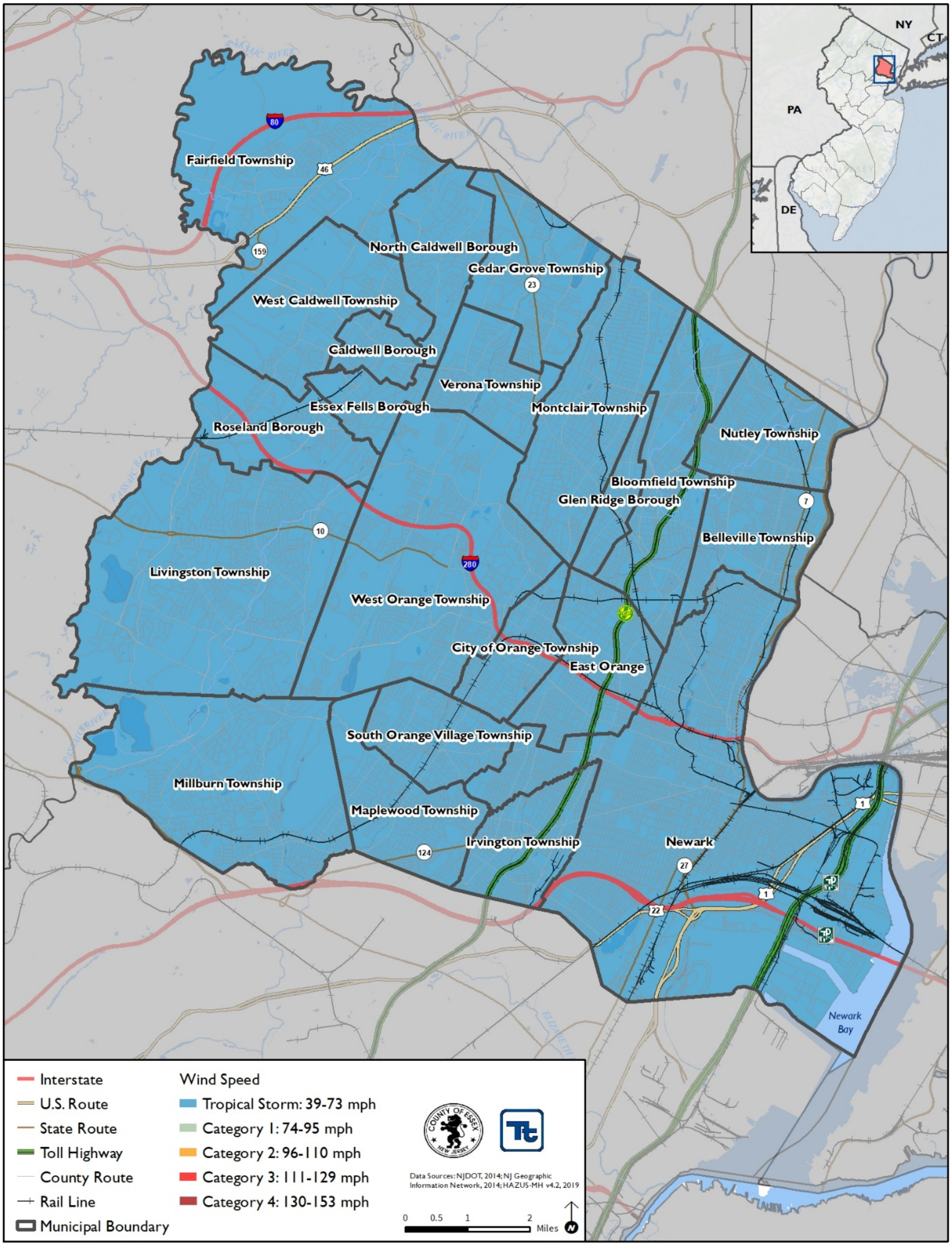


Figure 4.3.2-4. Wind Speeds for the 500-Year Mean Return Period Event



Nor'Easter

The severity of a 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, time of occurrence during the day (e.g., weekday versus weekend), and time of season. 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 U.S. 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 4.3.2-2 presents the five categories.

Table 4.3.2-2. 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
RSI Regional Snowfall Index

Nor'Easters have the potential to impact society to a greater extent than hurricanes and tornadoes. These storms often have a diameter three to four times larger than a hurricane and therefore, impact much larger areas. More homes and properties become susceptible to damage as the size and strength of a Nor'Easter intensifies (Storm Solution, 2013).

Storm Surge

Typically, storm surge is estimated by subtracting the regular/astrological tide level from the observed storm tide. Typical storm surge heights range from several feet to more than 25 feet. The exact height of the storm surge and which coastal areas will be flooded depends on many factors: strength, intensity, and speed of the hurricane or storm; the direction it is moving relative to the shoreline; how rapidly the sea floor is sloping along the shore; the shape of the shoreline; and the astronomical tide. Storm surge is the most damaging when it occurs along a shallow sloped shoreline, during high tide, in a highly populated, and developed area with little or no natural buffers (for example, barrier islands, coral reefs, and coastal vegetation).

The most common reference to a return period for storm surges has been the elevation of the coastal flood having a one-percent chance of being equaled or exceeded in any given year, also known as the 100-year flood. Detailed hydraulic analyses include establishing the relationship of tide levels with wave heights and wave run-up. The storm surge inundation limits for the one-percent annual chance coastal flood event are a function of the combined influence of the water surface elevation rise and accompanying wave heights and wave run-up along the coastline.

Previous Occurrences and Losses

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 2017 (latest date available from data source). Between 1842 and 2017, 32 tropical cyclones tracked within 65 nautical miles of Essex County. From 2012 to 2017, no tropical cyclones tracked within 65 nautical miles.

Between 1954 and 2019, FEMA issued a disaster (DR) or emergency (EM) declaration for the State of New Jersey for 37 coastal storm-related events, classified as one or a combination of the following disaster types: hurricane, tropical storm, severe storm, flooding, Nor'Easter, tropical depression, coastal storm, high tides, and heavy rain. Of those events, Essex County has been included in eight coastal storm-related declarations (EM and DR) (FEMA 2019).

Coastal storm events that have impacted Essex County between 2014 and 2019 are identified in Table 4.3.2-3. For events prior to 2015, refer to Appendix X (Risk Assessment Supplement). Please see Section 9 (Jurisdictional Annexes) for detailed information regarding impacts and losses to each municipality.

Table 4.3.2-3. Coastal Storm Events in Essex County, 2014 to 2019

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
November 2, 2014	Strong Wind	N/A	N/A	Eastern Essex County	A strong low pressure system passed south then east of Long Island. At Newark International Airport, a measured wind of 32 mph was reported at 12:40 pm.
December 9, 2014	Flood	N/A	N/A	East Newark	A coastal storm passed just south and east of the area causing strong winds and heavy rain with isolated flooding in portions of Northeast New Jersey. Passaic Ave. was closed between Central Ave. and Johnston Ave. in East Newark due to flooding.
January 24, 2015	Winter Weather	N/A	N/A	Eastern Essex County	Low pressure moved out of the northern Gulf of Mexico on the morning of the 23rd, to the Mid Atlantic coast on the morning of the 24th, then rapidly intensified on its way northeast to the Canadian Maritimes the following day. This low brought heavy snow to parts of northeast New Jersey on the 24th. Trained spotters measured an average snowfall of 5 inches. The public measured snowfall of 6 inches in Cedar Grove. A trained spotter measured snowfall of 5.6 inches in Bloomfield. Newark Airport measured 5.1 inches of snow.
January 26, 2015	Winter Storm	N/A	N/A	Eastern Essex County	A potent Alberta Clipper low moved from southwestern Canada on January 24th to the Plains states and Ohio Valley on the 25th. The low then redeveloped off the Mid Atlantic coast on the 26th and rapidly intensified into a strong nor'easter, bringing heavy snow and strong winds to parts of northeast New Jersey just west of New York City. Newark Liberty Airport reported snowfall of 6.5 inches, and north winds gusted up to 33 mph, with blowing and drifting of snow.
January 22-23, 2016	Winter Storm, Blizzard	DR-4264	Yes	Essex County	Low pressure moving across the deep South on Thursday January 21st and Friday January 22nd intensified and moved off the Mid Atlantic coast on Saturday January 23rd, bringing heavy snow and strong winds to northeast New Jersey, and blizzard conditions to the urban corridor and some nearby areas. Governor Chris Christie declared a state of emergency for New Jersey on Friday January 22nd. New Jersey Transit stopped running trains, buses and light rail at 2 AM Saturday January 23rd. Bridges and tunnels from New York City into New Jersey were shut down by mid-afternoon Saturday.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
					Travel in and out of airports lagged through Monday January 25th as airlines pre-emptively cut hundreds of flights. More than 1,000 flights out of area airports were cancelled, and Teterboro Airport were shuttered due to whiteout conditions. At Newark Airport, the storm total snowfall was 24.5 inches, where winds gusted to 39 mph. Newark Airport ASOS observations showed blizzard conditions, with visibility less than one quarter mile in heavy snow and frequent wind gusts over 35 mph through the day and into the early evening on Saturday January 23rd.
February 5, 2016	Winter Weather	N/A	N/A	Western Essex County	Low pressure developing along a cold front moving through the region on Thursday February 4th moved off the southern Mid Atlantic coast on Friday February 5th, bringing locally heavy snow to parts of interior Northeast New Jersey on the fifth. Trained spotters reported a widespread 4 to 5 inch snowfall, with locally up to 6 inches in North Caldwell.
November 15, 2016	Flood	N/A	N/A	Bloomfield, Silver Lake	Low pressure moving north along the east coast of the United States resulted in a widespread 1-3 inch rainfall event across northeast New Jersey. Isolated flooding was observed across parts of Essex County, NJ as a result of this rainfall. Newark Airport received 2.79 inches of rain. John F. Kennedy Drive was closed in both directions due to flooding between Hoover Avenue and Belleville Avenue in Bloomfield. Watessing Avenue was closed due to flooding between Grove Street and Franklin Street in Bloomfield. NJ 21 was closed northbound at East 3rd Avenue due to flooding with all lanes detoured.
February 9, 2017	Winter Storm	N/A	N/A	Essex County	Low pressure developed along a cold front over the Middle Atlantic early Thursday, February 9th. The low rapidly intensified as it moved off the Delmarva coast in the morning and then to the south and east of Long Island late morning into the afternoon. The low brought heavy snow and strong winds to portions of Northeast New Jersey. Numerous flights were cancelled or delayed at Newark Airport. Trained spotters, CoCoRaHS observers, and the public reported 6 to 8 inches of snowfall.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
March 14, 2017	Winter Storm	N/A	N/A	Essex County	Rapidly deepening low pressure tracked up the eastern seaboard on Tuesday March, 14 bringing blizzard conditions to Western Passaic county. Heavy snow and sleet along with strong winds occurred across the rest of Northeast New Jersey. The storm cancelled numerous flights at Newark airport with some mass transit services suspended. Large trees fell onto homes in Bergen county and approximately 4,500 power outages resulted from the strong winds and heavy snow. Trained spotters and the public reported 8 to 13 inches of snow and sleet.
December 9, 2017	Winter Weather	N/A	N/A	Essex County	Low pressure along a slow moving cold front off the eastern seaboard brought locally heavy snow to portions of northeast New Jersey. A strong upper jet stream enhanced the snow across the Tri-State as the low pressure passed well offshore. Trained Spotters and the public reported 4 to 5 inches of snow.
January 4, 2018	Winter Storm	N/A	N/A	Essex County	The development of the blizzard/winter storm began along the southeast coast on Wednesday January 3, 2018. An amplifying upper level trough spawned the development of low pressure off the coast of Florida. The low pressure rapidly intensified on Wednesday night through Thursday January 4, 2018 as it moved north-northeast along the coast. The low passed just east of the benchmark Thursday afternoon. The central pressure when the storm developed was around 1004 millibars at 1 pm Wednesday. 24 hours later, the central pressure fell to around 950 mb, approximately a 54 millibar drop. The rapid intensification of the storm led to heavy snow, strong winds, and near-blizzard conditions across portions of Northeast New Jersey. Thousands of flights were cancelled at Newark Airport on January 4, 2018. Homes and businesses lost power and there were numerous accidents on area roadways. The public reported 6 inches of snow in West Caldwell. Winds gusts 30 to 40 mph at the Caldwell Airport during the afternoon and evening on January 4, 2018. The FAA Contract Observer at nearby Newark-Liberty Airport reported 8.4 inches of snowfall. Winds also gusted to 44 MPH at 4:38 PM at the airport.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
February 17-18, 2018	Winter Weather	N/A	N/A	Essex County	A low pressure developed along a frontal boundary along the southeast coast on the evening of Saturday, February 17, 2018. This low gradually became better organized as it moved up the coast towards the benchmark early Sunday, February 18, 2018. This system brought heavy snow to northern portions of northeast New Jersey. CoCoRahs observers and nearby Newark Liberty Internal Airport reported 3 to 5 inches of snowfall.
November 15, 2018	Winter Storm	N/A	N/A	Essex County	A wave of low pressure developed along the Middle Atlantic coast during Thursday November 15, 2018. The low was associated with a closed upper level trough across the Midwest. As the trough translated eastward into Friday November 16, 2018, the low pressure moved up the northeast coast. The antecedent air mass ahead of the low was cold and dry for the middle of November with temperatures during the morning and afternoon of November in the upper 20s and low 30s. The moisture associated with the trough and low pressure was able to produce moderate to heavy bands of snow as the precipitation began across the entire Tri-State area due to the cold air in place. Once the low drew warmer air from the south, the precipitation gradually changed to a wintry mix and then plain rain, especially for the New York City metro and Long Island. The moderate to heavy wet snowfall significantly impacted the evening rush hour with 1-2 inch per hour snowfall rates. Hundreds of trees, tree limbs, and branches were brought down by the weight of the snow, which caused many power outages. Numerous accidents were reported and many motorists were stranded on roads until the early morning hours the next day. There were over 1,000 flights cancelled at the New York City metro airports (Kennedy, La Guardia, and Newark). The FAA contract observer at nearby Newark Airport reported 6.4 inches of snow. Trained spotters, social media, and the public reported 4 to 6 inches of snow. Impacts were widely felt across eastern Essex county with major disruption to the evening commute. Trees branches and limbs were downed due to the weight of the heavy wet snow. Nearby Newark airport reported 1-2 inch per hour snowfall rates at times during the evening commute.

Date(s) of Event	Event Type	FEMA Declaration Number (if applicable)	Essex County Designated?	Location	Description
March 3-4, 2019	Heavy Snow	N/A	N/A	Essex County	Low pressure developed across the southeast on Sunday March 3, 2019 and then tracked off the Middle Atlantic coast early on Monday March 4, 2019. The low moved just inside the 40N/70W benchmark and continued out to sea. The low brought a widespread snowfall to northeast New Jersey with the heaviest accumulations occurring across the interior. Much of the significant snow occurred overnight with improved conditions during the Monday morning commute. Trained spotters, CoCoRaHS, and the public reported 7 to 9 inches of snow.

Source: FEMA 2019; NCDC 2019; NWS 2014; SPC 2019; NHC 2019
DR Disaster Declaration (FEMA)
FEMA Federal Emergency Management Agency
Mph miles per hour
N/A Not Applicable

With coastal storm documentation for New Jersey and Essex County being so extensive, not all sources have been identified or researched; therefore, this table may not include all events that have occurred in or impacted the County.

Probability of Future Occurrences

It is estimated that Essex County will continue to experience direct and indirect impacts of coastal storms annually that may induce secondary hazards such as flooding, extreme wind, coastal erosion, storm surge in coastal areas, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences.

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

The following provides probability of each type of coastal storm discussed in this section.

Hurricane and Tropical Storm

Hurricane return periods are the frequency at which a certain intensity of hurricane can be expected within a given distance of a given location. According to the NHC, the return period for Essex County surrounding counties is 18 to 19 years for a hurricane (greater than 64 mph winds) and 74 to 76 years for a major hurricane (greater than 110 mph winds) (NHC 2014).

Nor'Easter

As with any weather phenomenon, it is nearly impossible to assign probabilities to Nor'Easters, except over the long-term. High activity seasons are when storm activity exceeds the historical 75th percentile. This means that seasons with this number of storms are expected to occur during one out of four years. Lower activity seasons are defined as when storm activity falls below the historical 75th percentile; meaning this number of storms are expected to occur during three out of four years (East Coast Winter Storms, 2013).

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. Coastal areas may be impacted by climate change in different ways. Coastal areas are sensitive to sea-level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures. According to NASA, warmer temperatures may lead to an increase in frequency of storms, thus leading to more weather events that cause coastal erosion (NASA 1997).

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

Northern and southern New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over 5″ (12%) greater than the average from 1895-1970. Southern New Jersey became

2″ (5%) wetter late in the 20th century (Office of New Jersey State Climatologist). Average annual precipitation is projected to increase in the region by 5% by the 2020s and up to 10% by the 2050s. Most of the additional precipitation is expected to come during the winter months (New York City Panel on Climate Change [NPCC2] 2009).

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Some climatologists predict that climate change may play a role in the frequency and intensity of Nor'Easters. Two ingredients are needed to produce strong Nor'Easters and intense snowfall: (1) temperatures which are just below freezing, and (2) massive moisture coming from the Gulf of Mexico. When temperatures are far below freezing, snow is less likely. As temperatures increase in the winter months they will be closer to freezing rather than frigidly cold. Future climate change has been predicted to produce more moisture, thus increasing the likelihood that these two ingredients (temperatures just below freezing and intense moisture) will cause more intense snow events.

Higher sea levels will increase the starting level for flooding from coastal storms and, therefore, smaller flooding events in the future will be able to reach the same flooding heights as present day storms. Sea-level rise in New Jersey has resulted in an increase in sea level of roughly 16 inches in the past century. The rate of sea-level rise is anticipated to increase as time goes on, with the rate of increase being tied to the rate of greenhouse gas emissions and the corresponding increase in global temperatures (Rutgers 2016). As sea levels continue to rise, an increase in the frequency and severity of coastal flooding events from coastal storms is expected. Section 4.3.1 (Coastal Erosion and Sea Level Rise) contains a discussion of the State's efforts to address sea level rise.

4.3.2.2 Vulnerability Assessment

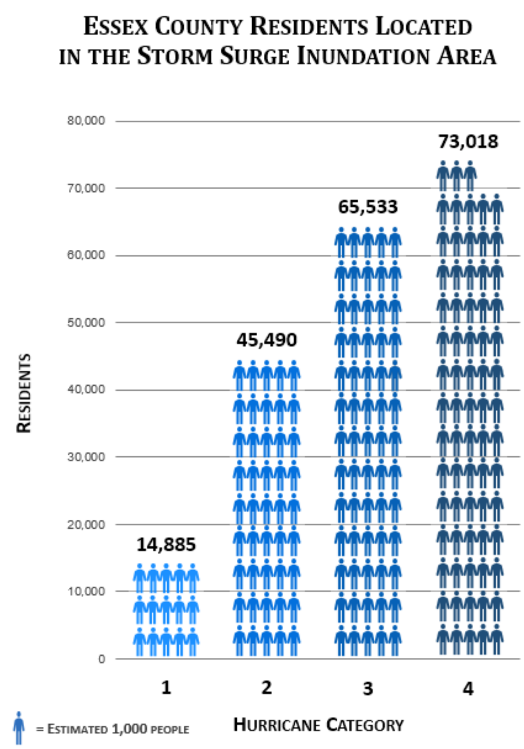
Wind-related vulnerability data was generated using a HAZUS-MH analysis for the coastal storms hazard. A probabilistic assessment was conducted for the 100- and 500-year MRPs through a Level 2 analysis in HAZUS-MH v4.2 to analyze the hazard and provide a range of loss estimates. Storm surge impacts were assessed using SLOSH data from NOAA's National Hurricane Center. 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 coastal storm on life, health and safety is dependent upon several factors including the severity of the event and whether adequate warning time was provided to residents. For the purposes of this HMP, the entire population of Essex County (800,401 people) is exposed to coastal storm events (2013-2017 American Community Survey 5-year Estimate). Residents may be displaced or require temporary to long-term sheltering due to coastal storm events. In addition, downed trees, damaged buildings, and debris carried by high winds can lead to injury or loss of life. Please refer to Section 3 (County Profile) for the total Essex County population vulnerable to this hazard.

The loss associated with coastal storms can vary across the County; secondary flooding associated with the torrential downpours during hurricanes/tropical storms is also a primary concern in the County (see flooding discussion in Section 4.3.6 Flood). The estimated population living in the Category 1 through 4 SLOSH inundation zones is summarized in Exhibit 4.3.2-2 for the County and Table 4.3.2-4 by municipality. For the Category 1 through Category 4 inundation areas, the City of Newark has the greatest total exposure with 14,793 people, 44,505 people, 63,077 people, and 69,865 people located in each area, respectively.

Exhibit 4.3.2-2



Source: NOAA National Hurricane Center, 2016; American Community Survey 2013-2017

Table 4.3.2-4. Estimated Population in the Hurricane SLOSH Inundation Zones

Municipality	Total Population	Estimated Population Exposed							
		Category 1 SLOSH	% of Total	Category 2 SLOSH	% of Total	Category 3 SLOSH	% of Total	Category 4 SLOSH	% of Total
Township of Belleville	36,383	92	0.3%	951	2.6%	2,229	6.1%	2,595	7.1%
Township of Bloomfield	48,892	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Borough of Caldwell	8,032	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Cedar Grove	12,638	0	0.0%	0	0.0%	0	0.0%	0	0.0%
City of East Orange	65,151	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Borough of Essex Fells	2,095	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Fairfield	7,671	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Borough of Glen Ridge	7,668	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Irvington	54,715	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Livingston	29,955	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Maplewood	24,706	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Millburn	20,387	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Montclair	38,572	0	0.0%	0	0.0%	0	0.0%	0	0.0%
City of Newark	282,803	14,793	5.2%	44,505	15.7%	63,077	22.3%	69,865	24.7%
Borough of North Caldwell	6,637	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Nutley	28,829	0	0.0%	35	<1%	227	<1%	558	1.9%
City of Orange Township	30,731	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Borough of Roseland	5,907	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of South Orange Village	16,503	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Verona	13,585	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of West Caldwell	10,932	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of West Orange	47,609	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Essex County (Total)	**800,401**	**14,885**	**1.9%**	**45,490**	**5.7%**	**65,533**	**8.2%**	**73,018**	**9.1%**

Sources: American Community Survey 5-year Estimate (2013 – 2017), 2017; NOAA, 2016
SLOSH = Sea, Lake and Overland Surge from Hurricanes

Socially vulnerable and economically disadvantaged populations are most susceptible to natural hazard events, based on several factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing. The population over the age of 65 is also more vulnerable and, physically, they may have more difficulty evacuating. They may 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. Table 4.3.2-5 summarizes the estimated socially vulnerable population living in each SLOSH zone.

Table 4.3.2-5. Estimated Socially Vulnerable Populations Living in the Hurricane SLOSH Inundation Zones

SLOSH Inundation Area	Population Over 65 Years	Population Below the Poverty Level
Category 1	852	2,957
Category 2	3,061	8,871
Category 3	5,105	13,530
Category 4	5,999	15,897

Sources: American Community Survey 5-year Estimate (2013 – 2017), 2017; NOAA, 2016
SLOSH = Sea, Lake and Overland Surge from Hurricanes

Residents may be displaced or require temporary to long-term sheltering. HAZUS-MH v4.2 estimates there will be 0 displaced households and 0 people that may require temporary shelter due to a 100-year MRP event. For a 500-year MRP event, HAZUS-MH v4.2 estimates 2 households will be displaced, and 0 people will require short-term sheltering. Please note these estimates are based on wind speed only and do not account for sheltering needs associated with flooding and storm surge that may accompany coastal storm events.

Impact on General Building Stock

Wind-Only Impacts

Damage to buildings is dependent upon several factors, including wind speed, storm duration, and path of the storm track. Building construction also plays a major role in the extent of damage resulting from a coastal storm. Due to differences in construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings, in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. High-rise buildings are also very vulnerable structures. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

The U.S. Census Bureau defines manufactured homes as “movable dwellings, 8 feet or wider and 40 feet or longer, designed to be towed on its own chassis, with transportation gear integral to the unit when it leaves the factory, and without need of a permanent foundation (U.S. Census, 2010).” They can include multi-wides and expandable manufactured homes but exclude travel trailers, motor homes, and modular housing. Due to their light-weight and often unanchored design, manufactured housing is extremely vulnerable to high winds and will generally sustain the most damage. According to the 2018 MODIV tax assessor data from NJOIT, there are no manufactured homes in the County.

The entire County’s general building stock is assumed to be exposed to the coastal storm hazard (greater than $73 billion in structure cost only). Expected building damage was estimated by HAZUS-MH v4.2 and includes buildings damaged at the following wind damage categories: no damage/very minor damage, minor damage, moderate damage, severe damage, and total destruction. Table 4.3.2-6 summarizes the definition of the damage categories.

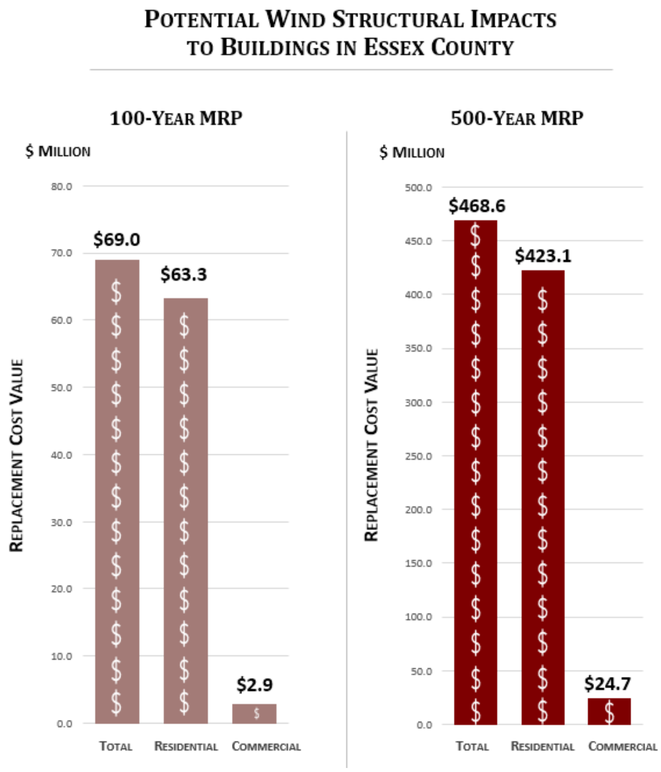
Table 4.3.2-6. Description of Damage Categories

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

Source: HAZUS-MH Hurricane Technical Manual

Exhibit 4.3.2-3 and Table 4.3.2-7 summarizes the building value (structure only) damage estimated for the 100- and 500-year MRP hurricane wind-only events. Damage estimates are reported for the County's probabilistic HAZUS-MH model scenarios. The data shown indicates total losses associated with wind damage to building structure.

Exhibit 4.3.2-3.



Source: NOAA National Hurricane Center, 2016; American Community Survey 2013-2017

Table 4.3.2-7. Estimated Building Value (Structure Only) Damaged by the 100-Year and 500-Year MRP Hurricane-Related Winds

Municipality	Total Replacement Cost Value (Structure Only)	Estimated Total Damages*		
		Annualized Loss	100-Year Event	500-Year Event
Township of Belleville	$2,698,371,020	$192,556	$3,381,110	$16,934,187
Township of Bloomfield	$3,668,749,043	$250,835	$4,637,793	$24,834,720
Borough of Caldwell	$711,283,402	$31,871	$585,788	$4,486,911
Township of Cedar Grove	$1,812,062,362	$68,407	$1,473,359	$7,912,578
City of East Orange	$3,661,597,262	$332,458	$4,641,046	$36,595,336
Borough of Essex Fells	$337,961,118	$10,987	$264,906	$1,488,965
Township of Fairfield	$3,280,911,340	$75,695	$1,746,773	$9,904,882
Borough of Glen Ridge	$694,958,216	$34,772	$691,490	$3,581,584
Township of Irvington	$3,187,766,948	$263,843	$3,446,736	$29,273,808
Township of Livingston	$4,683,896,484	$182,263	$3,683,983	$25,466,370
Township of Maplewood	$2,187,933,750	$116,936	$1,875,272	$13,531,920
Township of Millburn	$3,227,413,370	$133,899	$2,278,119	$18,249,309
Township of Montclair	$3,592,077,078	$202,280	$3,966,255	$22,012,264
City of Newark	$22,631,425,110	$1,767,308	$21,018,601	$159,024,073
Borough of North Caldwell	$1,092,780,064	$35,612	$867,292	$4,615,008

Municipality	Total Replacement Cost Value (Structure Only)	Estimated Total Damages* Annualized Loss	100-Year Event	500-Year Event
Township of Nutley	$2,394,461,023	$162,643	$3,173,692	$13,964,506
City of Orange Township	$2,049,714,805	$132,538	$1,988,910	$15,294,256
Borough of Roseland	$1,141,841,136	$39,482	$826,293	$5,555,768
Township of South Orange Village	$1,776,332,135	$98,559	$1,739,095	$11,519,412
Township of Verona	$1,371,207,640	$61,116	$1,223,554	$7,440,808
Township of West Caldwell	$2,040,415,478	$62,526	$1,450,364	$8,469,070
Township of West Orange	$5,124,878,158	$232,334	$4,063,879	$28,409,745
Essex County (Total)	**$73,368,036,940**	**$4,488,919**	**$69,024,310**	**$468,565,482**

*Source: HAZUS-MH v4.2 *Total Damages is sum of damages for all occupancy classes based on improvement value.*

The total estimated damage to buildings (structure only) for all occupancy types across Essex County is $69 million for the 100-year MRP wind-only event, and $469 million for the 500-year MRP wind-only event. The majority of these losses are to the residential building category. Refer to Figure 4.3.2-5 and Figure 4.3.2-6 which illustrate the density of estimated building loss across Essex County for these two events.

Storm Surge Hurricane Impacts

To estimate potential building exposure to storm surge, the SLOSH inundation zones were used. The estimated total number of buildings and replacement cost value are located in Categories 1 through 4 SLOSH inundation zones are summarized in Exhibit 4.3.2-4 and 4.3.2-5 for the County. Table 4.3.2-8 and Table 4.3.2-9 summarize the building exposure by municipality.

Exhibit 4.3.2-4

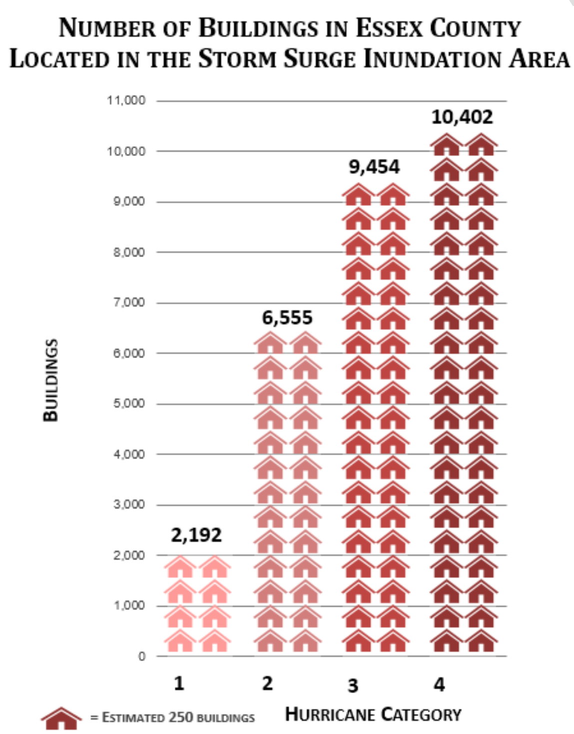
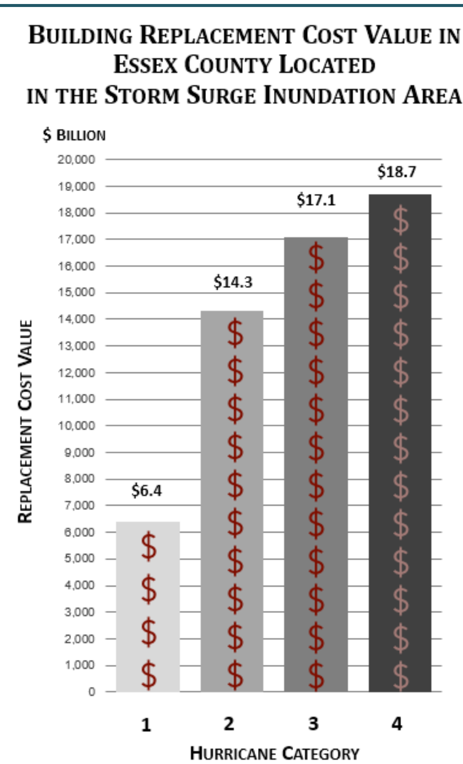


Exhibit 4.3.2-5



Source: NOAA National Hurricane Center, 2016; American Community Survey 2013-2017

Figure 4.3.2-5. Density of Losses for Structures (All Occupancies) for the County 100-Year MRP Hurricane (Wind-Only) Event

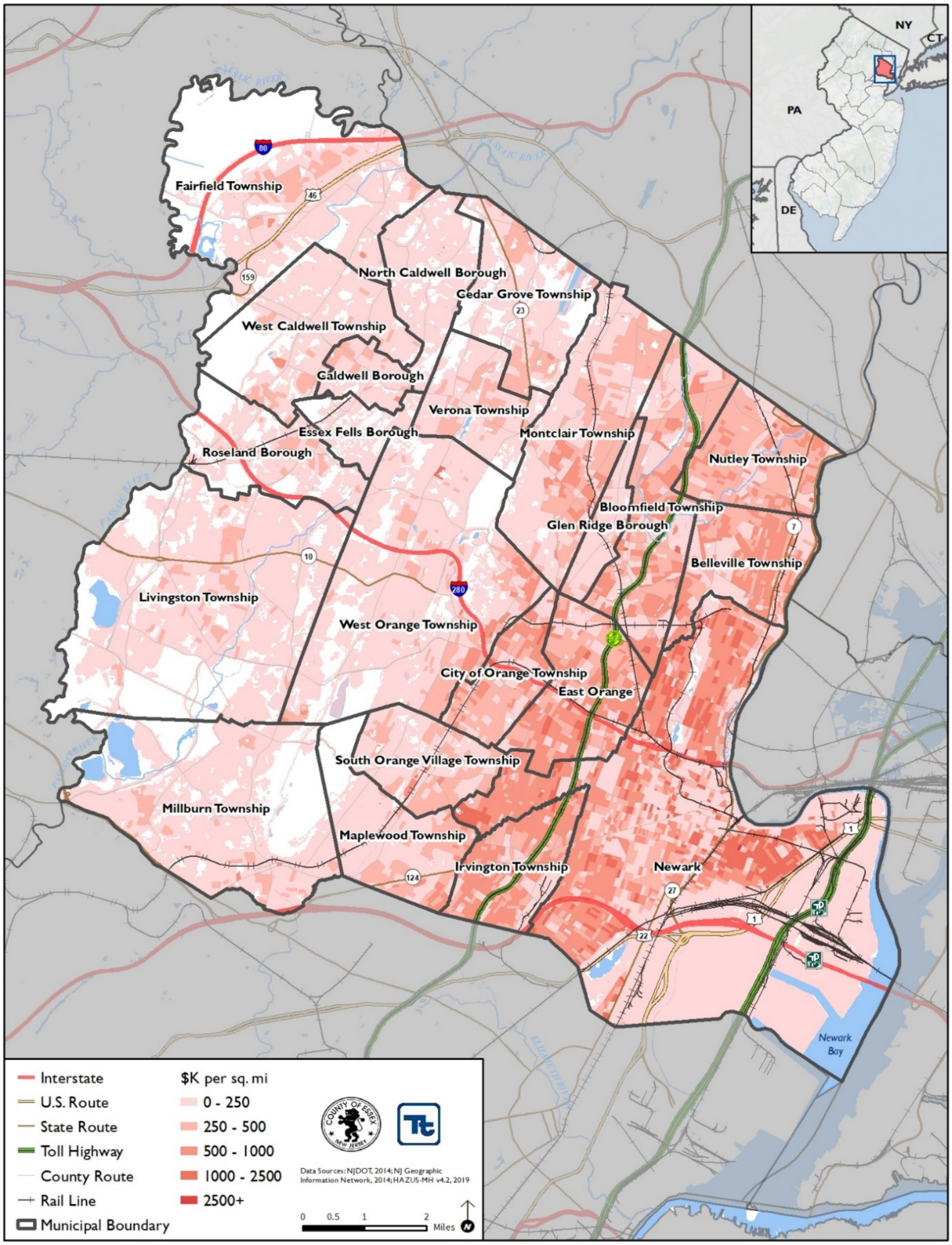


Figure 4.3.2-6. Density of Losses for Structures (All Occupancies) for the County 500-Year MRP Hurricane (Wind-Only) Event

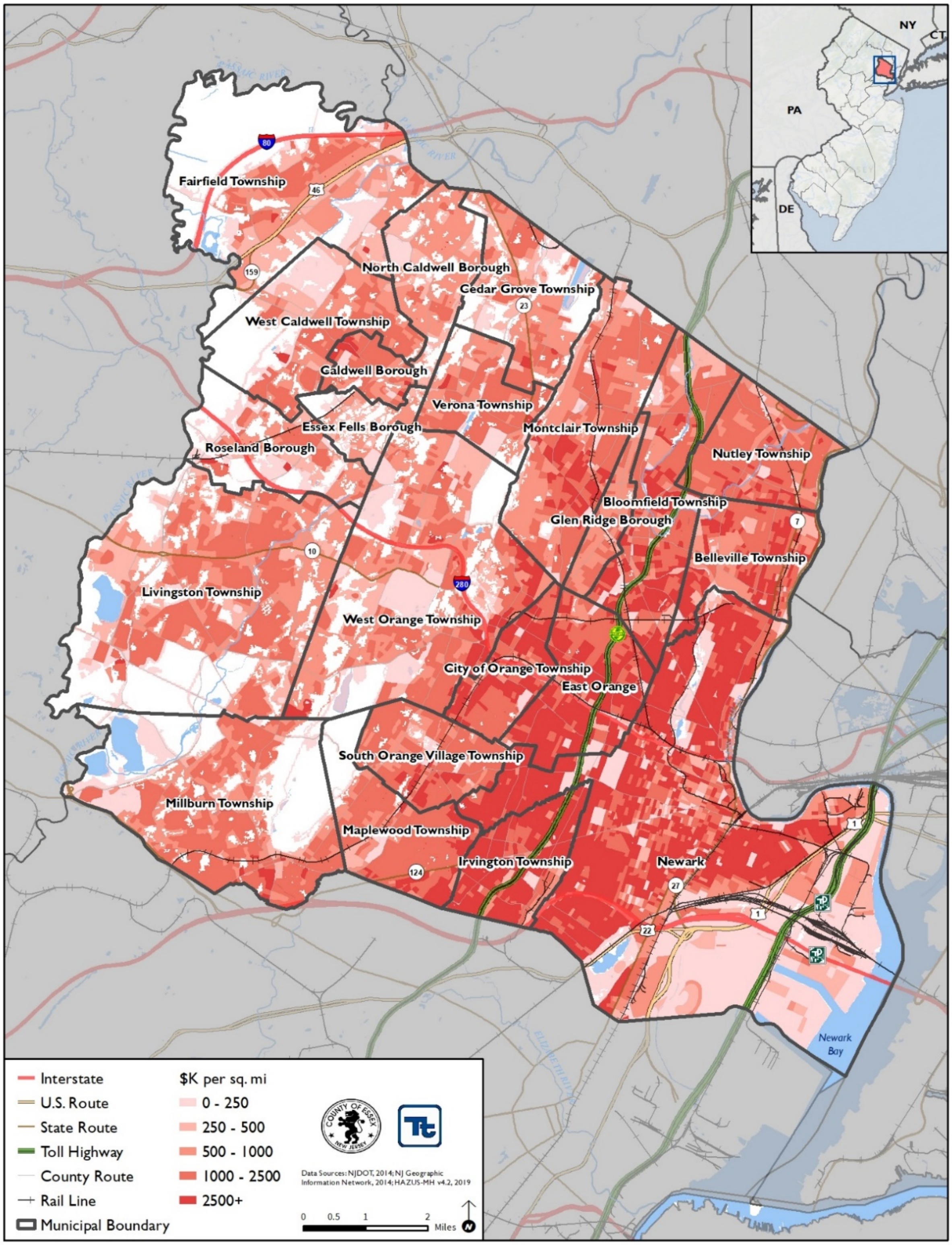


Table 4.3.2-8. Estimated Replacement Cost Value Located in the SLOSH Inundation Zones

Municipality	Total Replacement Cost Value	Replacement Cost Value in Hazard Area							
		Cat 1 Exposure	% of Total	Cat 2 Exposure	% of Total	Cat 3 Exposure	% of Total	Cat 4 Exposure	% of Total
Township of Belleville	$4,483,250,138	$75,680,812	1.7%	$346,316,511	7.7%	$554,972,044	12.4%	$740,479,251	16.5%
Township of Bloomfield	$6,021,089,887	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Borough of Caldwell	$1,183,204,981	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Cedar Grove	$3,008,045,785	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
City of East Orange	$6,090,766,912	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Borough of Essex Fells	$527,629,662	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Fairfield	$6,082,819,367	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Borough of Glen Ridge	$1,095,474,263	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Irvington	$5,384,838,816	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Livingston	$7,691,376,811	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Maplewood	$3,575,395,600	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Millburn	$5,241,567,136	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Montclair	$5,845,976,130	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
City of Newark	$40,970,549,425	$6,286,023,015	15.3%	$13,906,600,972	33.9%	$16,491,364,934	40.3%	$17,812,372,022	43.5%
Borough of North Caldwell	$1,727,767,442	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Nutley	$3,841,553,722	$0	0.0%	$6,804,317	<1%	$81,732,851	2.1%	$126,191,637	3.3%
City of Orange Township	$3,520,865,708	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Borough of Roseland	$1,955,487,279	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of South Orange Village	$2,877,374,186	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Verona	$2,213,338,613	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of West Caldwell	$3,533,044,820	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of West Orange	$8,358,783,858	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Essex County	**$125,230,200,542**	**$6,361,703,826**	**5.1%**	**$14,259,721,800**	**11.4%**	**$17,128,069,829**	**13.7%**	**$18,679,042,911**	**14.9%**

Sources: Microsoft, 2018, Open Street Map, 2019; NJOIT, 2018; NOAA, 2016

Table 4.3.2-9. Estimated Number of Buildings Located in the SLOSH Inundation Zones

Municipality	Total # Buildings	Number of Buildings in Hazard Area							
		Cat 1 Exposure	% of Total	Cat 2 Exposure	% of Total	Cat 3 Exposure	% of Total	Cat 4 Exposure	% of Total
Township of Belleville	7,910	19	0.2%	197	2.5%	462	5.8%	533	6.7%
Township of Bloomfield	11,720	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Borough of Caldwell	1,738	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Cedar Grove	3,944	0	0.0%	0	0.0%	0	0.0%	0	0.0%
City of East Orange	7,908	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Borough of Essex Fells	766	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Fairfield	3,121	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Borough of Glen Ridge	2,256	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Irvington	7,934	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Livingston	9,795	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Maplewood	6,738	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Millburn	6,437	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Montclair	9,436	0	0.0%	0	0.0%	0	0.0%	0	0.0%
City of Newark	43,085	2,173	5.0%	6,352	14.7%	8,953	20.8%	9,773	22.7%
Borough of North Caldwell	2,095	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Nutley	7,945	0	0.0%	6	<1%	39	<1%	96	1.2%
City of Orange Township	3,890	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Borough of Roseland	1,794	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of South Orange Village	4,188	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of Verona	4,113	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of West Caldwell	3,730	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Township of West Orange	11,845	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Essex County	**162,388**	**2,192**	**1.3%**	**6,555**	**4.0%**	**9,454**	**5.8%**	**10,402**	**6.4%**

Sources: Microsoft, 2018, Open Street Map, 2019; NJOIT, 2018; NOAA, 2016
Cat = Category

Impact on Land Uses

A spatial analysis was completed to assess the exposure of the residential and non-residential land uses within the County to storm surge. To estimate the land use located in the Category 1 through Category 4 storm surge inundation zones, the SLOSH boundaries were overlaid upon the general building stock and 2018 parcel layer in GIS and used to calculate the estimated the number of structures and area of parcels located in each hazard area.

Neighborhoods within the Ironbound section of the City of Newark comprise the majority of the residential land uses and structures exposed to SLOSH. Approximately 2-percent of the total residential land use acreage and 3-percent of the residential properties are located in the Category 1 storm inundation extent. However, approximately 14-percent of the total residential land use area and 19-percent of the residential properties are located in the Category 4 storm inundation extent.

The spatial analysis also shows a substantial number of the non-residential properties are exposed to storm surge as well. The City of Newark's large area of industrial and commercial land uses adjacent to the Passaic River and the Newark Bay account for the majority of the area exposed to this hazard. A substantial amount of the area is associated with Newark International Airport and the Port of Newark. Approximately 34-percent of the total non-residential land use acreage and 13-percent of the non-residential properties are located in the Category 1 storm inundation extent. However, approximately 64-percent of the total non-residential land use area and 37-percent of the non-residential properties are located in the Category 4 storm inundation extent. It is clear that the Newark's Ironbound section and the commercial and industrialized sections of the East Ward are highly exposed to storm surge.

Figure 4.3.2-7. Residential Properties Exposed to Category 1 through 4 SLOSH Areas

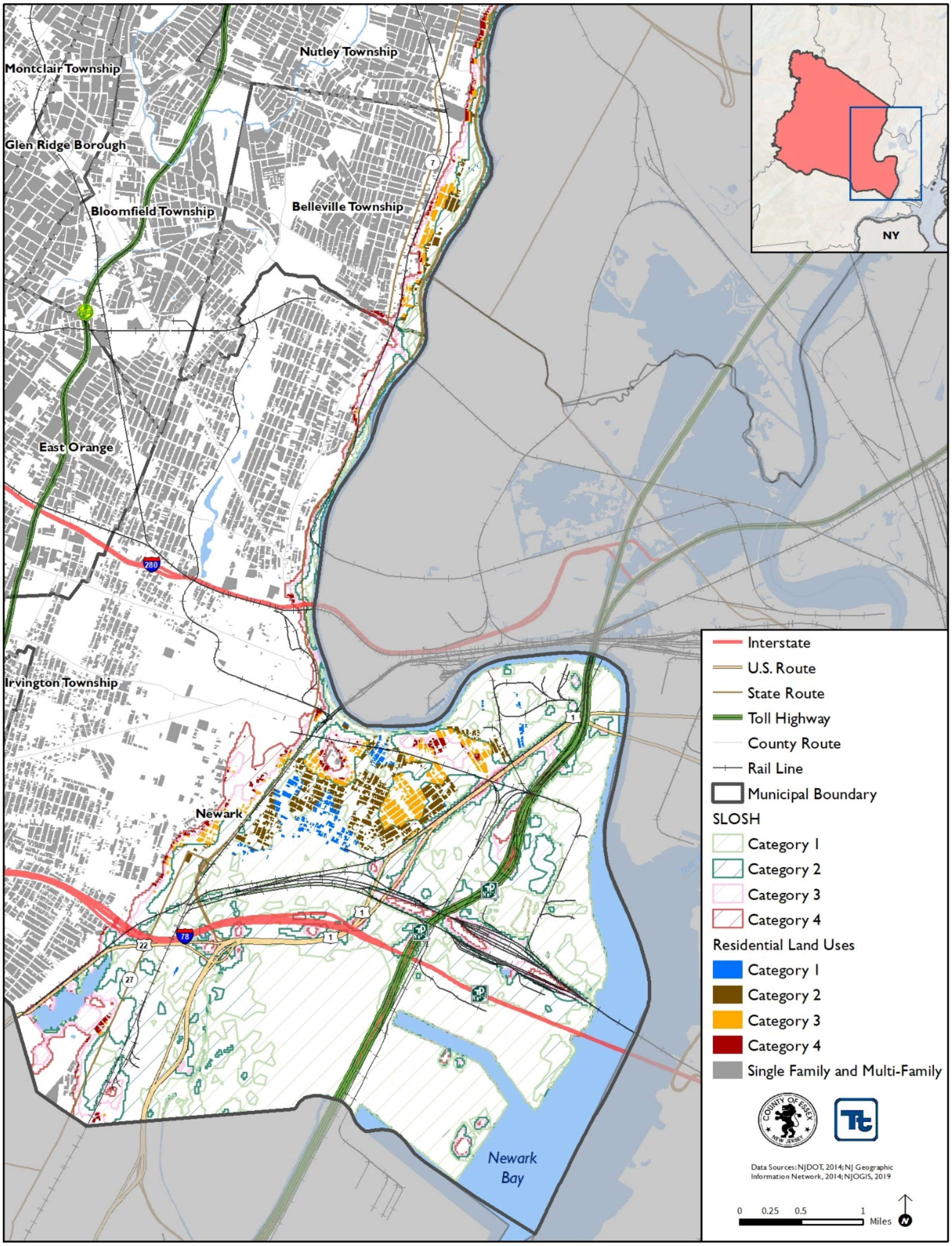


Table 4.3.2-10. Residential Land Use Exposure to SLOSH

Municipality	Total Residential Land Use Area (acres)	Total Number of Residential Properties	Number of Residential Properties in Category 1	% of Total	Residential Land Use Area Category 1 (acre s)	% of Total	Number of Residential Properties Category 2	% of Total	Residential Land Use Area in Category 2 (acres)	% of Total Residential Land Use Area	Number of Residential Properties Category 3	% of Total	Residential Land Use Area in Category 3 (acres)	% of Total Residential Land Use Area	Number of Residential Properties Category 4	% of Total	Residential Land Use Area in Category 4 (acres)	% of Total Residential Land Use Area
Township of Belleville	908	7,279	4	0.1%	0	0.1%	148	2.0%	19	2.1%	371	5.1%	46	5.1%	410	5.6%	52	5.7%
City of Newark	2,523	33,549	945	2.8%	56	2.2%	3,838	11.4%	211	8.4%	5,792	17.3%	323	12.8%	6,296	18.8%	359	14.2%
Township of Nutley	1,152	7,431	0	0.0%	0	0.0%	5	0.1%	1	0.1%	29	0.4%	7	0.6%	83	1.1%	16	1.4%
Total	**4,583**	**48,259**	**949**	**2.0%**	**56**	**1.2%**	**3,991**	**8.3%**	**232**	**5.1%**	**6,192**	**12.8%**	**376**	**8.2%**	**6,789**	**14.1%**	**427**	**9.3%**

Source: NJOIT, 2018; Microsoft, 2018; Open Street Map, 2019; NOAA 2016

Figure 4.3.2-8. Non-Residential Properties Exposed to Category 1 through 4 SLOSH Areas

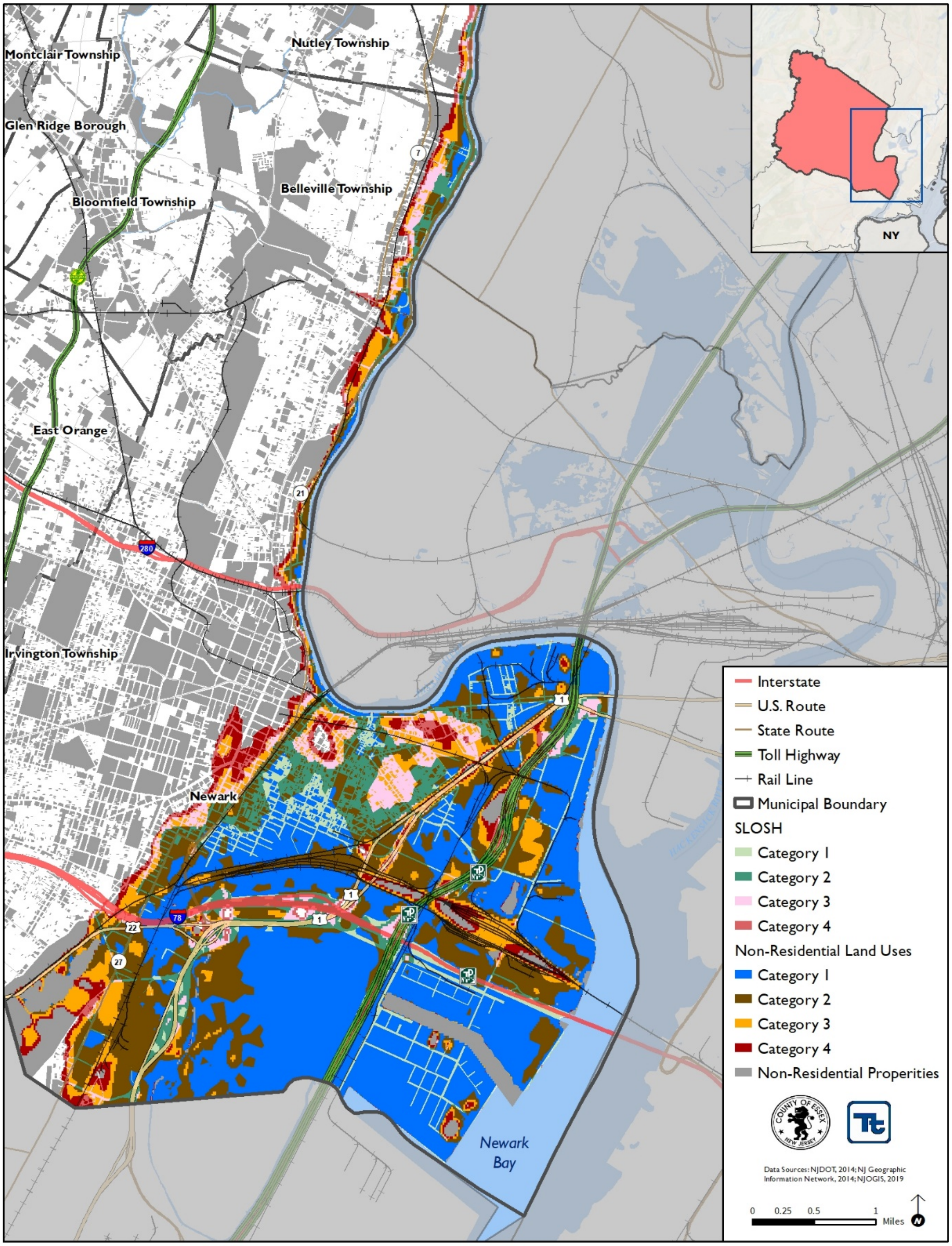


Table 4.3.2-11. Non-Residential Land Use Exposure to SLOSH

Municipality	Total Non-Residential Land Use Area (acres)	Total Number of Non-Residential Properties	Number of Non-Residential Properties in Category 1	% of Total	Non-Residential Land Use Area Category 1 (acres)	% of Total	Number of Non- Residential Properties Category 2	% of Total	Non-Residential Land Use Area in Category 2 (acres)	% of Total Non-Residential Land Use Area	Number of Non-Residential Properties Category 3	% of Total	Non-Residential Land Use Area in Category 3 (acres)	% of Total Non-Residential Land Use Area	Number of Non-Residential Properties Category 4	% of Total	Non-Residential Land Use Area in Category 4 (acres)	% of Total
Township of Belleville	766	631	15	2.4%	25	3.3%	49	7.8%	69	9.0%	91	14.4%	104	13.6%	123	19.5%	129	16.9%
City of Newark	9,594	9,536	1,228	12.9%	3,233	33.7%	2,515	26.4%	5,085	53.0%	3,162	33.2%	5,768	60.1%	3,477	36.5%	6,105	63.6%
Township of Nutley	559	514	0	0.0%	0	0.0%	1	0.2%	4	0.7%	10	1.9%	22	3.9%	13	2.5%	32	5.7%
Total	**10,919**	**10,681**	**1,243**	**11.6%**	**3,258**	**29.8%**	**2,565**	**24.0%**	**5,158**	**47.2%**	**3,263**	**30.5%**	**5,894**	**54.0%**	**3,613**	**33.8%**	**6,266**	**57.4%**

Source: NJOIT, 2018; Microsoft, 2018; Open Street Map, 2019; NOAA 2016

Impact on Critical Facilities

Utility infrastructure could suffer damage from high winds associated with falling tree limbs or other debris, resulting in the loss of power. Loss of service can impact residents and business operations alike. Interruptions in heating or cooling utilities can affect populations such the young and elderly, who are particularly vulnerable to temperature-related health impacts. Loss of power can impact other public utilities, including potable water and wastewater treatment and communications. In addition to public water services, property owners with private wells may not have access to potable water either until power is restored. Lack of power to emergency facilities, including police, fire, EMS, and hospitals, will inhibit a community's ability to effective respond to an event and maintain the safety of its citizens.

HAZUS-MH v4.2 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 v4.2 estimates the loss of use for each facility in number of days. HAZUS-MH v4.2 estimates that critical facilities in Essex 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. Table 4.3.2-13 summarizes the estimated impacts to critical facilities as a result of the 500-year MRP event.

At this time, HAZUS-MH v4.2 does not estimate losses to transportation lifelines and utilities as part of the hurricane model. Transportation lifelines are not considered particularly vulnerable to the wind hazard; they are more vulnerable to cascading effects such as flooding, falling debris etc. Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting) transportation needs.

The critical facilities and utilities located in the Category 1 through 4 inundation zones are summarized in Table 4.3.2-12 by municipality. Oil facilities have the greatest number exposed to the Category 1 inundation zone, while schools have the greatest number exposed to the Category 2 through Category 4 inundation zones.

Table 4.3.2-12. Number of Critical Facilities Located in the SLOSH Inundation Zones

Municipality	Facility Types																					
	Airport	Bus	Chemical Storage	Commercial	Correctional Institution	Electric Power	Electric Substation	EMS	Fire	Government	Hospital	Light Rail	Newark Housing Authority	Oil Facility	Police	Port	Safety	School	Shelter	Train Station	Transportation	Wastewater Treatment Plant
Category 1																						
Township of Belleville	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
City of Newark	1	1	2	0	1	3	0	0	1	1	0	0	1	4	2	2	0	0	0	0	0	2
Essex County	**1**	**1**	**2**	**0**	**1**	**3**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**4**	**2**	**2**	**0**	**0**	**0**	**0**	**1**	**2**
Category 2																						
Township of Belleville	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0
City of Newark	1	2	3	0	2	3	0	1	3	1	0	1	3	4	3	2	0	6	0	1	0	2
Essex County	**1**	**2**	**3**	**1**	**2**	**3**	**0**	**1**	**3**	**1**	**0**	**1**	**3**	**4**	**3**	**2**	**0**	**8**	**0**	**1**	**1**	**2**
Category 3																						
Township of Belleville	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	1	0
City of Newark	1	3	3	0	2	4	0	1	5	2	1	1	3	4	4	2	0	10	0	2	0	2
Township of Nutley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Essex County	**1**	**3**	**3**	**1**	**2**	**4**	**0**	**1**	**5**	**3**	**1**	**1**	**3**	**4**	**4**	**2**	**1**	**12**	**1**	**2**	**1**	**2**
Category 4																						
Township of Belleville	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	2	0	0	1	0
City of Newark	1	3	3	0	2	5	0	1	6	2	1	2	4	4	6	1	0	16	0	2	0	2
Township of Nutley	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Essex County	**1**	**3**	**3**	**1**	**2**	**5**	**1**	**1**	**6**	**3**	**1**	**2**	**4**	**4**	**6**	**1**	**1**	**18**	**1**	**2**	**1**	**2**

Source: Essex County, 2019; NOAA, 2016
*Notes: *Only municipalities within the SLOSH inundation zones are tabulated*

Table 4.3.2-13. 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	2-4	<1	0	0
Medical	0	1-3	<1	0	0
Police	0	2-4	<1	0	0
Fire	0	1-2	<1	0	0
Schools	0	1-4	0-1	0	0

Source: HAZUS-MH v4.2

Impact on Economy

Coastal 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 v4.2 estimates approximately $597,000 in business interruption costs (income loss, relocation costs, rental costs and lost wages) and no estimated inventory losses. For the 500-year MRP wind only event, HAZUS-MH v4.2 estimates approximately $31 million in business interruption losses for the County, which includes loss of income, relocation costs, rental costs and lost wages, in addition to approximately $340,000 in inventory losses.

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

Debris management can be costly and may also impact the local economy. HAZUS-MH estimates the amount of building and tree debris that may be produced a result of the 100- and 500-year MRP wind events. Because the estimated debris production does not include flooding, this is likely a conservative estimate and may be higher if multiple impacts occur. According to the HAZUS-MH Hurricane User Manual, estimates of weight and volume of eligible tree debris consist of downed trees that would likely be collected and disposed at public expense. Refer to the User Manual for additional details regarding these estimates. Table 4.3.2-14 summarizes debris production estimates for the 100- and 500-year MRP wind events.

Table 4.3.2-14. Debris Production for 100- and 500-Year Mean Return Period Hurricane-Related Winds

Mean Return Period	Brick and Wood (tons)	Concrete and Steel (tons)	Tree (tons)	Eligible Tree Volume (cubic yards)
100-year MRP	6,429	0	4,840	35,778

Mean Return Period	Brick and Wood (tons)	Concrete and Steel (tons)	Tree (tons)	Eligible Tree Volume (cubic yards)
500-year MRP	61,162	0	33,311	224,498

Source: HAZUS-MH v4.2

Future Changes that May Impact Vulnerability

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

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

Projected Development

As discussed and illustrated in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by the hurricane and tropical storm hazard because the entire Planning Area is exposed and vulnerable to the wind and storm surge hazards associated with these events. However, due to increased standards and codes, new development may be less vulnerable to the coastal storm hazard compared with the aging building stock in the county.

Each municipality identified areas of recent development and proposed development in their community. Based on the information provided from municipalities, there are no recent and proposed developments within Category 1 through 4 SLOSH boundaries. Refer to Section 3 (County Profile), and Volume II Section 9 for potential new development and storm surge inundation areas in Essex County. Refer to Figure 4.3.2-9 for a map of proposed new development and the Category 1 through Category 4 SLOSH inundation areas of Essex County.

Projected Changes in Population

According to population projections from the State of New Jersey Department of Labor and Workforce Development, Essex County will experience an increase in population through 2034 (approximately 40,000 people between 2017 and 2034). Population change is not expected to have a measurable effect on the overall vulnerability of the county's population over time. Those moving to from areas of lower vulnerability to higher will increase their vulnerability, though not in a dramatic fashion. An increase in population can lead to an increase in commuters traveling throughout and outside the County. Commuters utilizing the major transportation corridors, including the NJ Turnpike, I-78, NJ-21, or US-1&9, would be impacted during and after a coastal storm as portions of these roadways are impacted by storm surge inundation from Category 1 to Category 4 events. Refer to Section 3 (County Profile) for a discussion on population trends.

Climate Change

As discussed above, most studies project that the State of New Jersey will see an increase in average annual temperatures and precipitation. An increase in temperatures may also lead to an increase in the frequency and intensity of coastal storms. More frequent and severe storms will increase the County's vulnerability to both wind-related impacts Countywide and storm surge impacts along the Passaic River between the City of Newark and Township of Nutley. In the remainder of the County, communities will experience an increase in rainfall due to the more frequent, and severe coastal storms. Section 4.3.6 (Flood) provides a discussion related to the impact of climate change due to increases in rainfall. In addition to the impacts of increasing temperatures and precipitation, sea level rise will increase the County's vulnerability to coastal storms. Increases in mean sea level will lead to subsequent increases in storm surge inundation depths.

Change of Vulnerability Since 2015 HMP

The entire County continues to be vulnerable to the coastal storm hazard. Several differences exist between the 2015 HMP and this update. For this plan update, an updated general building stock based upon replacement cost value from MODIV tax assessment data and 2019 RS Means, and an updated critical facility inventory were used to assess the county's risk to the hazard areas. In addition, the 2017 American Community Survey population estimates were used and estimated at a structural level in place of the 2010 U.S. Census blocks. Updated hazard areas were used as well; since the 2015 HMP, NOAA has released updated storm surge inundation boundaries for the United States. This updated data was used for the exposure analysis. Due to changes in the data used, a direct comparison of the change in vulnerability is difficult. However, in comparing the hazard areas between the original storm surge data and the 2016 NOAA data, the extents are similar and an increase in vulnerability would be due to increases in population and changes in development throughout the impacted areas. The updated vulnerability assessment provides a more current exposure analysis for the County.

Figure 4.3.2-9. Potential New Development in Essex County and SLOSH