5.4.4 Flood

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 flood hazard in Sussex County.

2016 Plan Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the flood hazard is discussed. The flood hazard is now located in Section 5 of the plan update.
- New and updated figures from federal and state agencies are incorporated.
- Previous occurrences were updated with events that occurred between 2008 and 2015.
- A vulnerability assessment was conducted for the flood hazard and it now directly follows the hazard profile.

5.4.4.1 Profile

Hazard Description

Floods are one of the most common natural hazards in the U.S. They can develop slowly over a period of days or develop quickly, with disastrous effects that can be local (impacting a neighborhood or community) or regional (affecting entire river basins, coastlines and multiple counties or states). Most communities in the U.S. have experienced some kind of flooding after spring rains, heavy thunderstorms, coastal storms, or winter snow thaws (George Washington University 2001). Floods are frequent and costly natural hazards in New Jersey in terms of human hardship and economic loss, particularly to communities that lie within flood-prone areas or floodplains of a major water source.

Many floods fall into three categories: riverine, coastal, and shallow (FEMA 2005). Other types of floods may include ice-jam floods, alluvial fan floods, dam failure floods, and floods associated with local drainage or high groundwater (as indicated in the previous flood definition). Flooding in Sussex County can be the result of heavy rainfall produced by hurricanes or thunderstorms; flash flooding; ice jams and severe winter storms. Many areas of Sussex County near the Delaware River are susceptible to localized flooding due to snow melt combined with a rain event, heavy rains, or cyclonic events (including hurricanes, tropical storms, or nor'easters) (Sussex County HMP 2011). For the purpose of this HMP, and as deemed appropriate by the Sussex County Planning Committee, riverine/flash flooding and ice-jam floods are the main flood types of concern for the county. These types of flood are further discussed below.

Riverine/Flash Floods

Riverine floods occur along a channel and include overbank and flash flooding. Channels are defined, ground features that carry water through and out of a watershed. They may be called rivers, creeks, streams, or ditches. When a channel receives too much water, the excess water flows over its banks and inundates low-lying areas (FEMA 2015a; The Illinois Association for Floodplain and Stormwater Management 2006).

A flash flood is:

> "a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g., intense rainfall, dam failure, ice jam). However, the actual time threshold may vary in different parts of the country. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters" (National Weather Service [NWS] 2009).

Additionally, riverine flooding can lead to stormwater and urban drainage flooding in Sussex County. Stormwater flooding described below is due to local drainage issues and high groundwater levels. Locally, heavy precipitation may produce flooding in areas other than delineated floodplains or along recognizable channels. If local conditions cannot accommodate intense precipitation through a combination of infiltration and surface runoff, water may accumulate and cause flooding problems. During winter and spring, frozen ground and snow accumulations may contribute to inadequate drainage and localized ponding. Flooding issues of this nature generally occur in areas with flat gradients and generally increase with urbanization which speeds the accumulation of floodwaters because of impervious areas. Shallow street flooding can occur unless channels have been improved to account for increased flows (FEMA 1997).

High groundwater levels can be a concern and cause problems even where there is no surface flooding. Basements are susceptible to high groundwater levels. Seasonally high groundwater is common in many areas, while elsewhere high groundwater occurs only after a long periods of above-average precipitation (FEMA 1997).

Urban drainage flooding is caused by increased water runoff due to urban development and drainage systems. Drainage systems are designed to remove surface water from developed areas as quickly as possible to prevent localized flooding on streets and other urban areas. They make use of a closed conveyance system that channels water away from an urban area to surrounding streams. This bypasses the natural processes of water filtration through the ground, containment, and evaporation of excess water. Since drainage systems reduce the amount of time the surface water takes to reach surrounding streams, flooding in those streams can occur more quickly and reach greater depths than prior to development in that area (FEMA 2015a).

Ice Jam Flooding

As per the Northeast States Emergency Consortium and FEMA, an ice jam is an accumulation of ice that acts as a natural dam and restricts flow of a body of water. Ice jams occur when warm temperatures and heavy rains cause rapid snowmelt. The melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding (FEMA 2015a). Ice jams may also be caused by frazil ice, which forms when mist freezes and then floats down a river, stream, or creek.

There are two different types of ice jams: freeze-up and breakup. Freeze-up jams occur in the early to mid-winter when floating ice may slow or stop due to a change in water slope as it reaches an obstruction to movement. Breakup jams occur during periods of thaw, generally in late winter and early spring. The ice cover breakup is usually associated with a rapid increase in runoff and corresponding river discharge due to a heavy rainfall, snowmelt, or warmer temperatures (White 2013).

Location

Flooding in New Jersey is often the direct result of frequent weather events such as thunderstorms, heavy rains, tropical storms, and hurricanes. Floods can happen almost anywhere in New Jersey, although they do tend to occur in and around areas near existing bodies of water, such as rivers, streams, and the Atlantic Ocean. The most damaging floods (particularly riverine floods) in New Jersey appear to occur in the northern half of the state, which includes Sussex County. This is a function of several physiographic and physical features of the landscape. Greater geographic relief in the northern half results in flowing water moving down steeper gradients and being naturally or artificially channelized through valleys and gullies.

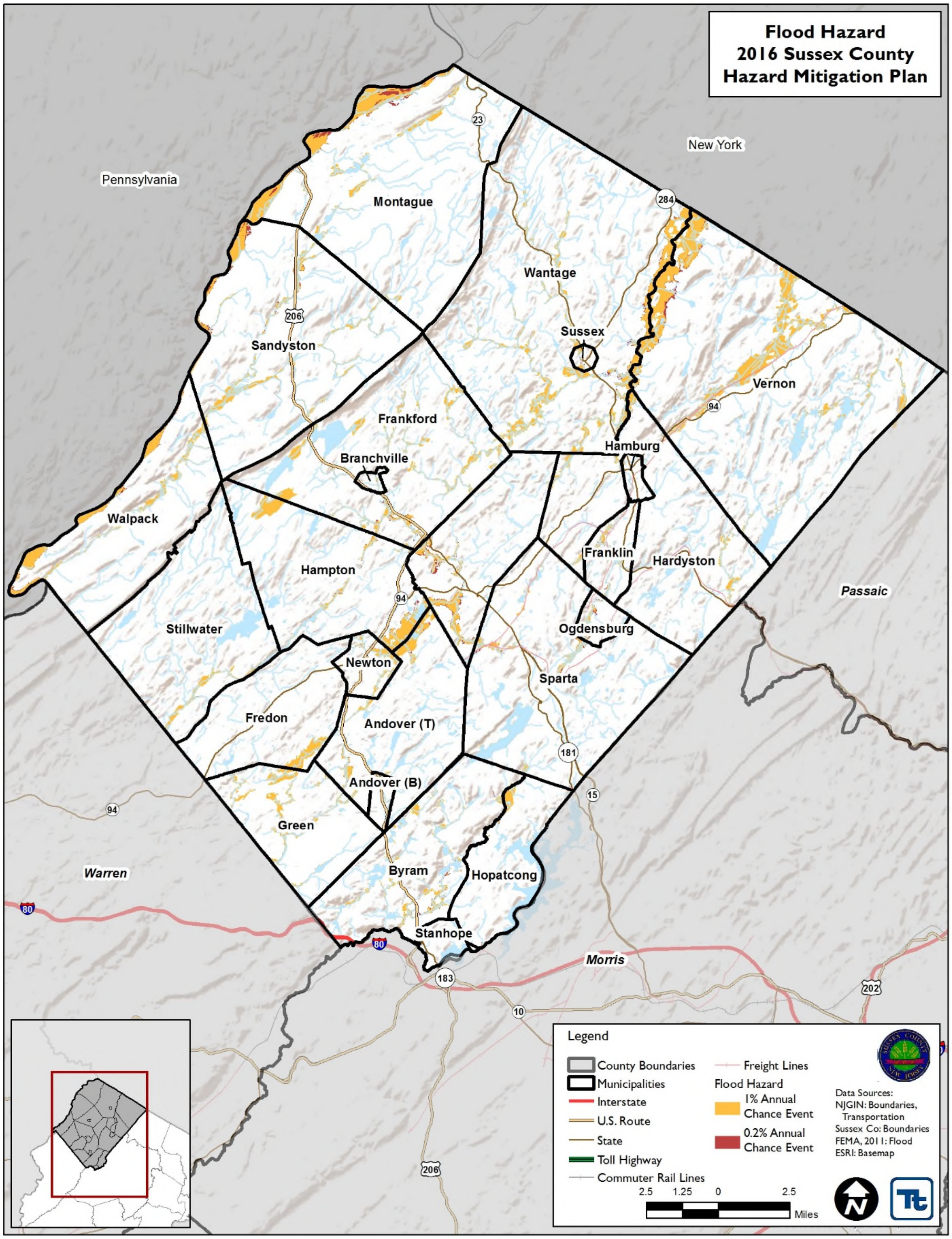
Sussex County has primarily a mountainous terrain, with significant exposure to water and vulnerability to the flood hazard. Sussex County has several large waterways, including the Musconetcong River and Paulins Kill, as well as the Delaware River, which has a total drainage area of over 14,000 square miles. Larger lakes and reservoirs include Lake Hopatcong, Lake Musconetcong and Lake Mohawk (FEMA FIS 2011). Over the years, Sussex County has been impacted by flooding, especially in the municipalities situated adjacent to these bodies of water.

Development patterns have resulted in denser development in northern New Jersey. In addition, proximity to New York City boosts property values and therefore increases damage dollar totals. Extensive development also leaves fewer natural surfaces available to absorb rainwater, forcing water directly into streams and rivers, swelling them more than when more natural surface buffered the runoff rate. Since the Delaware, Raritan, and Passaic Rivers drain more than 90% of the northern New Jersey counties, these rivers and their tributaries are common locations for flooding.

A floodplain is defined as the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that becomes inundated with water during a flood. Most often floodplains are referred to as 100-year floodplains. A 100-year floodplain is not a flood that will occur once every 100 years, rather it is a flood that has a 1% chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. Due to this misleading term, FEMA has properly defined it as the 1% annual chance flood. This 1% annual chance flood is now the standard used by most federal and state agencies and by the NFIP (FEMA 2002).

The 1% annual chance flood hazard zones are widely dispersed in Sussex County, generally following riverine corridors as shown in Figure 5.4.4-1. A significant concentration of 1% annual chance flood hazard zones is located in the northeastern portion of the County, around the Wallkill River, and the Pochuck and Wawayanda Creeks, especially as they near the New York State border in Wantage and Vernon Townships, respectively. Other 1% annual chance flood hazard zones exist along Lake Hopatcong as it forms the southeastern Sussex County boundary with Morris County, around Lake Mohawk in Sparta Township, and along Moore's Brook in Andover and Hampton Townships. Other 1% annual chance floodplains are scattered throughout the County tracing the footprints of numerous other creeks, rivers, and bodies of water, as shown in Figure 5.4.4-1 below.

Figure 5.4.4-1. FEMA Flood Hazard Areas in Sussex County



Source: FEMA 2011
FEMA Federal Emergency Management Agency

Floodprone Areas in Sussex County

Watersheds in New Jersey are referred to as the name of the water body to which the land area drains and the corresponding Hydrologic Unit Code (HUC). The HUC can range from 2 to 16 digits long- the longer the numeric code, the smaller the watershed area. NJDEP also has divided the state into 21 Watershed Management Areas (WMAs) based on large scale drainage pattern. Each WMA encompasses a particular group of major rivers. Sussex County falls within parts of 4 regions: WMA 01: Upper Delaware - Northwest Region; WMA 02: Wallkill - Northwest Region; WMA 03: Pompton, Pequannock, Wanaque, Ramapo - Northeast Region; and WMA 06: Middle Passaic, Whippany – Northeast Region. These areas delineate the principal stream systems that drain the county's land area. WMA 1, the Upper Delaware River Watershed, is the largest watershed in the county by area, with waters draining west and southwest to the Delaware River. The second largest is WMA 2, the Wallkill River Watershed. The Wallkill, which flows north into Orange County, New York, drains the north-central and northeastern section of Sussex County. WMA 3 (Pequannock River Watershed) and WMA 6 (Rockaway River Watershed) both drain to the southeast, and comprise small parts of the County.

Please refer to Section 9 for information regarding specific areas of flooding within each municipality.

Watershed Management Area 01 – Upper Delaware River

Located in the western and southern sections of Sussex County, the Upper Delaware River Watershed comprises greater than half of the county's land area, and includes the following principal waterways: the Flat Brook; the Paulins Kill; the Pequest River and a short stretch of the Musconetcong River. Waterways in WMA 01 run southwesterly, roughly parallel to one another, towards the Delaware River. Montague and Sandyston townships contain a large amount of these waterways, most of which are streams part of the Big and Little Flat Brook systems. The upper half of the Big Flat Brook flows through High Point State Park and Stokes State Forest. Clove Brook and Mill Brook also run through Montague Township. Walpack Township contains tributaries of the Flat Brook draining the west slope of the Kittatinny Ridge. Other waterways in this area include several stretches and tributaries of the Paulins Kill, Pequest River and Musconetcong River in Stillwater, Fredon, Green and Byram Townships, as well as parts of Kymer Brook and Lubbers Run (Sussex County, 2015).

Watershed Management Area 02 – Wallkill River

The Wallkill River watershed occupies the northern and northeastern parts of Sussex County, extending south through Sparta and northern Byram Townships. The Wallkill River flows northeast across the NJ state border and lets out on the Hudson River near Kingston, NY. Major tributaries of the Wallkill River that pass through Sussex County include Papakating Creek, which begins its run in Frankford Township, and Clove Brook, the upper reaches of which flow south from northern Wantage Township. Pochuck Creek drains parts of Vernon and Hardyston Townships east of Pochuck Mountain before merging with the Wallkill several miles over the NJ-NY border. Several branches of the Black Creek flow through Vernon Township (Sussex County 2015).

Watershed Management Area 03 – Pequannock River

A small area of eastern Sussex County is drained by the Pequannock River, which flows south out of Vernon Township continuing into Hardyston Township where it turns southeast, forming the border between Morris and Passaic Counties, before ultimately converging with the Passaic River in Essex County. Tributaries of the Pequannock in Sussex County include a stretch of the upper Pacack Brook and an unnamed tributary located in Hardyston Township (Sussex County 2015).

Watershed Management Area 6 – Rockaway River

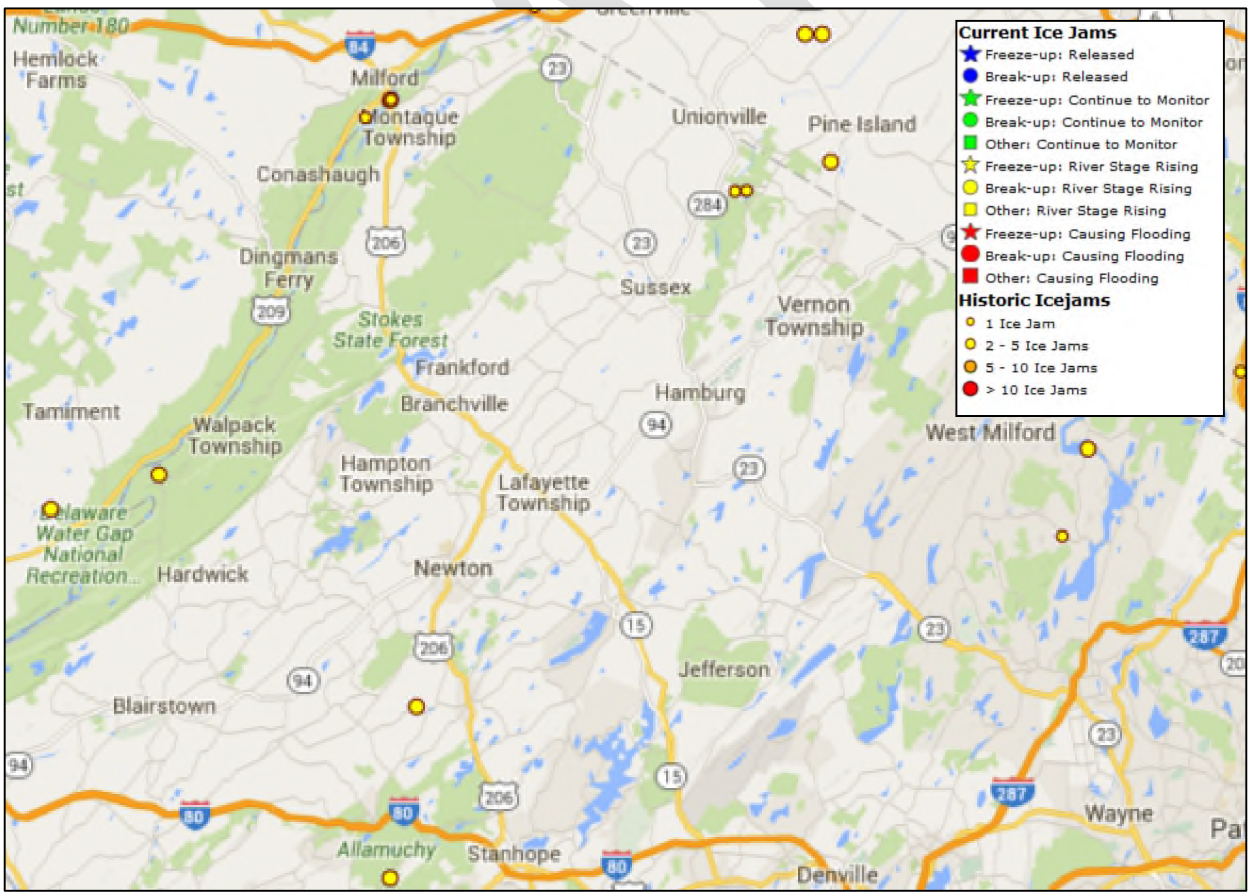
The Rockaway River itself does not pass through Sussex County, but the system's upper reaches includes many tributaries in eastern Sparta Township, where several streams merge to form Russia Brook. Russia Brook flows into Jefferson Township (Morris County) where it meets the Rockaway River (Sussex County 2015).

Ice Jam Flooding

Ice jams are common in the northeast U.S. and New Jersey is not an exception. In fact, according to the USACE, there have been 108 incidents documented between 1780 and 2015, with the most recently documented event occurring in 2014. Five New Jersey counties, including Sussex County, accounted for 87% (94) of all those events. The Delaware River experienced more ice jams during this time period than any other river in the state (32 reported ice jams).

The Ice Jam Database, maintained by the Ice Engineering Group at the USACE Cold Regions Research and Engineering Laboratory (CRREL), currently consists of over 19,000 records from across the U.S. According to the USACE-CRREL, Sussex County experienced or may have been impacted by 11 historic ice jam incidents between 1780 and 2015 (USACE 2015). Ice Jams have formed in Sussex County along Flat Brook, and the Delaware and Pequest Rivers (CRREL 2015). Figure 5.4.4-2 shows the number of ice jam incidents in Sussex County during this time period. Historical events are further mentioned in the "Previous Occurrences" section of this hazard profile.

Figure 5.4.4-2. Ice Jams in Sussex County, 1780 to 2015



Source: CRREL 2015

Natural and Beneficial Floodplain Areas

Although typically associated as a hazard area, floodplains also serve beneficial and natural functions (on ecological/environmental, social, and economic levels). Disruption of these natural systems can have long-term consequences on entire regions; however, this potential impact has only recently been noted. Some of the more well-known water-related functions for floodplains include:

- Natural flood and erosion control
  - Provide flood storage and conveyance
  - Reduce flood velocities
  - Reduce flood peaks
  - Reduce sedimentation
- Surface water quality maintenance
  - Filter nutrients and impurities from runoff
  - Process organic wastes
  - Moderate temperatures of water
- Groundwater recharge
  - Promote infiltration and aquifer recharge
  - Reduce frequency and duration of low surface flows (FEMA)

Areas in the floodplain that typically provide these natural functions are wetlands, riparian areas, sensitive areas, and habitats for rare and endangered species. According to NJ DEP 2015 Land-Use Land-Cover data and 2012 NJDEP Landscape Project Data, the County has several floodplain areas that could serve natural and beneficial functions (Landscape Project contains the endangered species data). This information is summarized in Tables 5.4.4-1 and 5.4.4-2.

Table 5.4.4-1. Acreage of Wetlands by Municipality

Municipality	Total Area (acres)	Wetland Area (acres)	% of Total
Borough of Andover	870	76	8.7%
Township of Andover	13,310	1,843	13.8%
Borough of Branchville	380	5	1.3%
Township of Byram	14,505	1,209	8.3%
Township of Frankford	22,602	3,219	14.2%
Borough of Franklin	2,843	371	13.0%
Township of Fredon	11,521	1,322	11.5%
Township of Green	10,479	1,176	11.2%
Borough of Hamburg	753	82	10.9%
Township of Hampton	16,273	2,734	16.8%
Township of Hardyston	20,811	3,403	16.4%
Borough of Hopatcong	7,953	568	7.1%
Township of Lafayette	11,453	2,157	18.8%
Township of Montague	29,749	3,701	12.4%
Town of Newton	2,172	345	15.9%
Borough of Ogdensburg	1,431	256	17.9%

Municipality	Total Area (acres)	Wetland Area (acres)	% of Total
Township of Sandyston	27,041	2,168	8.0%
Township of Sparta	24,896	2,987	12.0%
Borough of Stanhope	1,404	114	8.1%
Township of Stillwater	18,081	2,060	11.4%
Borough of Sussex	399	34	8.5%
Township of Vernon	44,789	7,841	17.5%
Township of Walpack	15,923	731	4.6%
Township of Wantage	43,174	8,246	19.1%
Sussex County Total	**342,814**	**46,646**	**13.6%**

Table 5.4.4-1. Natural and Beneficial Land in Sussex County

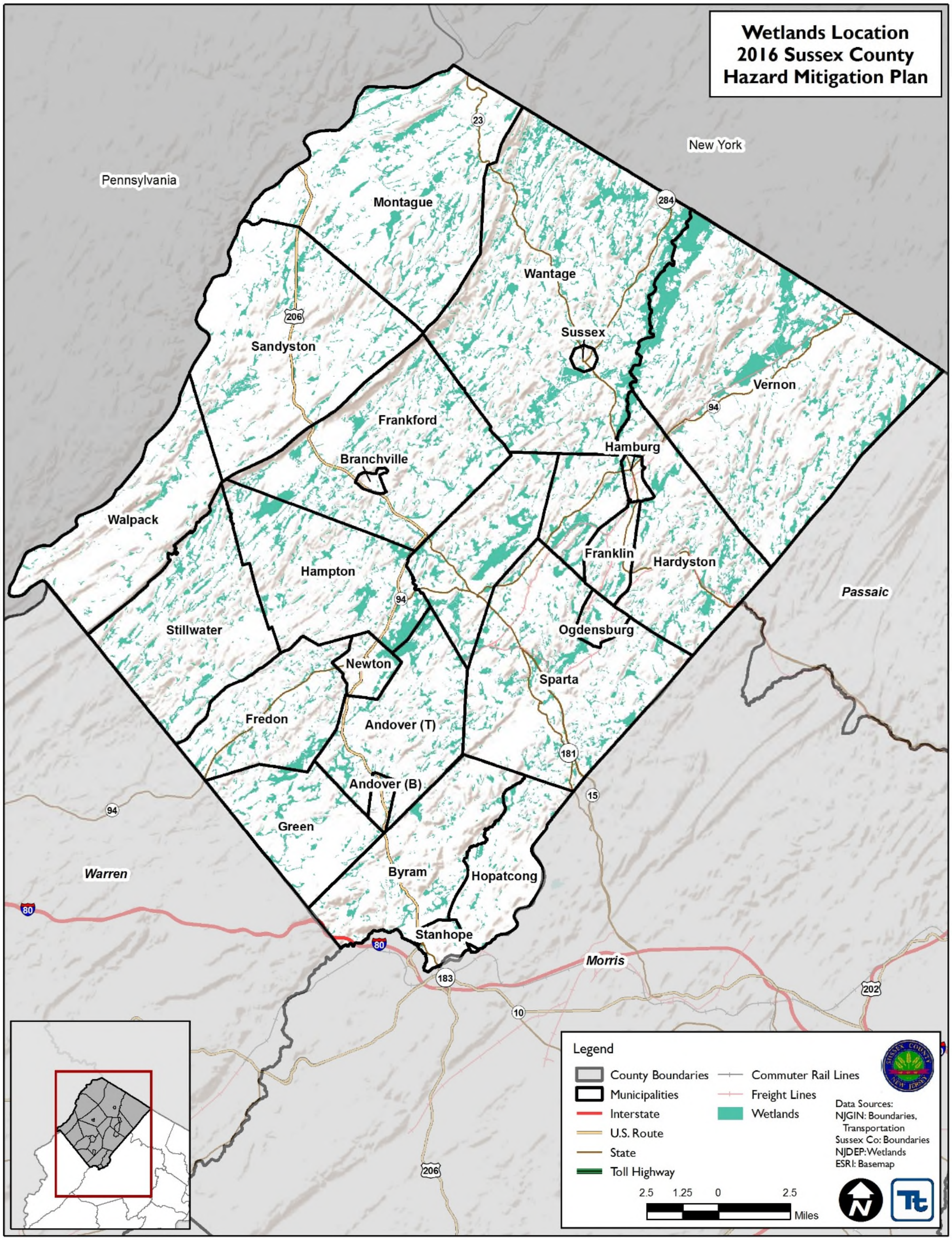
Wetlands	Area (acres)	Forest	Area (acres)	Endangered Species	Area (acres)
Agricultural Wetlands (Modified)	1,675	Coniferous Brush/Shrubland	20	Special Concern	22,775
Artificial Lakes	65	Coniferous Forest (>50% Crown Closure)	244	State Endangered	1,844
Coniferous Forest (10-50% Crown Closure)	<5	Coniferous Forest (10-50% Crown Closure)	23	State Threatened	2,341
Coniferous Scrub/Shrub Wetlands	14	Cropland And Pastureland	247		
Coniferous Wooded Wetlands	133	Deciduous Brush/Shrubland	168		
Deciduous Forest (>50% Crown Closure)	<5	Deciduous Forest (>50% Crown Closure)	1,957		
Deciduous Forest (10-50% Crown Closure)	<5	Deciduous Forest (10-50% Crown Closure)	462		
Deciduous Scrub/Shrub Wetlands	1,840	Deciduous Wooded Wetlands	<5		
Deciduous Wooded Wetlands	6,191	Exposed Flats	<5		
Disturbed Wetlands (Modified)	48	Industrial	<5		
Former Agricultural Wetland (Becoming Shrubby, Not Built-Up)	298	Mixed Deciduous/Coniferous Brush/Shrubland	96		
Herbaceous Wetlands	3,235	Mixed Forest (>50% Coniferous With >50% Crown Closure)	209		
Managed Wetland In Built-Up Maintained Rec Area	16	Mixed Forest (>50% Coniferous With 10-50% Crown Closure)	33		
Managed Wetland In Maintained Lawn Greenspace	20	Mixed Forest (>50% Deciduous With >50% Crown Closure)	226		
Mixed Deciduous/Coniferous Brush/Shrubland	<5	Mixed Forest (>50% Deciduous With 10-50% Crown Closure)	56		

Wetlands	Area (acres)	Forest	Area (acres)	Endangered Species	Area (acres)
Mixed Scrub/Shrub Wetlands (Coniferous Dom.)	33	Old Field (< 25% Brush Covered)	310		
Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	79	Orchards/Vineyards/Nurseries/Horticultural Areas	<5		
Mixed Wooded Wetlands (Coniferous Dom.)	164	Other Urban Or Built-Up Land	<5		
Mixed Wooded Wetlands (Deciduous Dom.)	146	Phragmites Dominate Old Field	<5		
Natural Lakes	15	Plantation	36		
Old Field (< 25% Brush Covered)	0	Residential, Rural, Single Unit	<5		
Phragmites Dominate Interior Wetlands	116	Streams And Canals	<5		
Streams And Canals	5	Transitional Areas	<5		
Unvegetated Flats	108				
Wetland Rights-Of-Way	36				

Source: NJDEP 2015; NJDEP 2012
Note: An additional 536 acres of land didn't have a joinable ID number for the Landscape Project data. This could be a miscellaneous potential habitat for endangered species.

According to the Landscape Project data, Sussex County contains potential habitats for over 70 endangered species from multiple taxonomic classes, including Amphibia, Aves, Bivalvia, Insecta, Mammalia, and Reptilia. Habitats for about 65 of these species are located within the 1-percent annual chance floodplain. These species include, the Indiana bat, the bald eagle, the blue-spotted salamander, and the bog turtle.

Figure 5.4.4-3. Wetlands in Sussex County



Source: NJDEP 2012

Extent

Once a river reaches flood stage, the flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category has a definition based on property damage and public threat:

- Minor Flooding - minimal or no property damage, but possibly some public threat or inconvenience.
- Moderate Flooding - some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations. (NWS 2011)

The severity of a flood depends not only on the amount of water that accumulates in a period of time, but also on the land's ability to manage this water. The size of rivers and streams in an area and infiltration rates are significant factors. When it rains, soil acts as a sponge. When the land is saturated or frozen, infiltration rates decrease and any more water that accumulates must flow as runoff (Harris 2008).

The frequency and severity of flooding are measured using a discharge probability, which is the probability that a certain river discharge (flow) level will be equaled or exceeded in a given year. Flood studies use historical records to determine the probability of occurrence for the different discharge levels. The flood frequency equals 100 divided by the discharge probability. For example, the 100-year discharge has a 1% chance of being equaled or exceeded in any given year. The "annual flood" is the greatest flood event expected to occur in a typical year. These measurements reflect statistical averages only; it is possible for two or more floods with a 100-year or higher recurrence interval to occur in a short time period. The same flood can have different recurrence intervals at different points on a river.

One hundred-year floodplains (or 1% annual chance floodplain) can be described as a bag of 100 marbles, with 99 clear marbles and one black marble. Every time a marble is pulled out from the bag, and it is the black marble, it represents a 100-year flood event. The marble is then placed back into the bag and shaken up again before another marble is drawn. It is possible that the black marble can be picked one out of two or three times in a row, demonstrating that a "100-year flood event" could occur several times in a row (Interagency Floodplain Management Review Committee 1994).

The 'base flood', previously known as the '100-year flood' is the floodplain management standard used by most federal and state agencies, including the NFIP. Inclusion within the base flood area (Special Flood Hazard Area or SFHA) determines the need for flood insurance. A structure located within a SFHA shown on an NFIP map has a 26% chance of suffering flood damage during the term of a 30-year mortgage.

The extent of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood) is used as the regulatory boundary by many agencies. Also referred to as the SFHA, this boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities. Many communities have maps that show the extent and likely depth of flooding for the base flood. Corresponding water-surface elevations describe the water elevation resulting from a given discharge level, which is one of the most important factors used in estimating flood damage.

The term "500-year flood" is the flood that has a 0.2% chance of being equaled or exceeded each year. The 500-year flood could occur more than once in a relatively short period of time. Statistically, the 0.2% (500-year) flood has a 6% chance of occurring during a 30-year period of time, the length of many mortgages.

The 500-year floodplain is referred to as Zone X500 for insurance purposes on FIRMs. Base flood elevations or depths are not shown within this zone and insurance purchase is not required in this zone.

Previous Occurrences and Losses

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

Between 1954 and 2015, FEMA declared that the State of New Jersey experienced 28 flood-related disasters (DR) or emergencies (EM) classified as flooding, or as flooding with one or a combination of the following disaster types: Severe Storms; Inland and Coastal Flooding; Mudslides; Coastal Storm; High Tides; Heavy Rain; High Winds; and Hurricane. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Sussex County was included in 11 of these flood-related declarations between 1954 and 2015, and two declarations since the original 2011 Sussex County HMP. In 2011, Sussex County experienced flooding from Hurricane Irene and Remnants of Tropical Storm Lee, and was included in the disaster declarations for both events. While Sussex County was also included in the disaster declaration for Hurricane Sandy in 2012, the damages from that storm in the County were the result of other severe weather hazards, rather than flooding. Table 5.4.4-2 lists FEMA DR and EM declarations between 2008 and 2015 for this HMP Update.

Table 5.4.4-2. FEMA DR and EM Declarations since 2008 for Flood Events in Sussex County

FEMA Declaration Number	Date(s) of Event	Event Type	Location
DR-4021	August 26 – September 5, 2011	Hurricane Irene	All 21 counties, including Sussex County
DR-4039	September 5-14, 2011	Remnants of Tropical Storm Lee/ Flash Flood/ Flood	Hunterdon, Warren, Mercer, Passaic, and Sussex

Source: FEMA 2015

United States Department of Agriculture (USDA) crop losses provide another indicator of the severity of previous events. Additionally, crop losses can have a significant impact on the economy by reducing produce sales and purchases. Such impacts may have long-term consequences, particularly if crop yields are low the following years as well. Although Sussex County has experienced annual crop losses due to natural hazard events, the USDA does not note in its records that any losses from 2008 to 2015 are a result of flood damages (USDA 2015).

For this 2016 HMP update, flood events were summarized from 2008 to 2015. Known flood events, including FEMA disaster declarations, which have impacted Sussex County between 2008 and 2015 are identified in Appendix X. For events prior to 2008, please refer to the 2011 County HMP. Please note that not all events that have occurred in Sussex County are included due to the extent of documentation and the fact that not all sources may have been identified or researched. Loss and impact information could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP Update. Please see Section 9 for detailed information regarding impacts and losses to each municipality.

Ice Jam Events

Based on review of the CRREL database, 12 ice-jam events have occurred in or near Sussex County between 1780 and 2015. Events that occurred outside of the County were included because they were close enough to the County borders to cause possible flooding impacts on Sussex County. Information regarding losses associated with these reported ice jams was limited. According to this database, there have been two ice jam events since 2008 in Sussex County, both along the Delaware River.

Probability of Future Occurrences

Based on the historic and more recent flood events in Sussex County, it is clear that the County has a high probability of flooding for the future. The fact that the elements required for flooding exist and that major flooding has occurred throughout the County in the past suggests that many people and properties are at risk from the flood hazard in the future. It is estimated that Sussex County will continue to experience direct and indirect impacts of flooding events annually that may induce secondary hazards such as 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.

According to the NOAA National Climate Data Center (NCDC) and the CRREL database, Sussex County experienced 49 flood events between 1950 and 2015, including 22 floods, 25 flash floods, and 2 ice jams. 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 Sussex County in future years (NOAA NCDC 2015).

Table 5.4.4-3. Probability of Future Occurrences of Flood Events

Hazard Type	Number of Occurrences Between 1950 and 2015	Rate of Occurrence or Annual Number of Events (average)	Recurrence Interval (in years) (# Years/Number of Events)	Probability of Event in any given year	% chance of occurrence in any given year
Flood	22	0.34	3.00	0.33	33.33
Flash Flood	25	0.38	2.64	0.38	37.88
Ice Jams	12	0.18	5.50	0.18	18.18
Total	**59**	**0.91**	**1.12**	**0.89**	**89.39**

Source: NOAA-NCDC 2015; CRREL 2015

In Section 5.3, the identified hazards of concern for Sussex 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 flood in the County is considered ‘frequent’ (likely to occur within 25 years, as presented in Table 5.3-3).

Climate Change Impacts

The climate of New Jersey is already changing and will continue to change over the course of this century. Since 1900, temperatures in the northeastern U.S. have increased an average of 1.5°F. The majority of this warming has occurred since 1970. From 1970 to 2010, average temperatures in New Jersey have increased 1.2°F (ONJSC 2013). In terms of winter temperatures, the northeastern U.S. has seen an increase in the average temperature by 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007).

In addition to the effect of increased temperatures, precipitation is expected to increase over the next several decades. Average annual precipitation is projected to increase in the region by 0-10% by the 2020s and 5-10% by the 2050s. Most of the additional precipitation is expected to come during the winter months (New York City Panel on Climate Change [NPCC] 2013). Although precipitation is expected to increase, extreme precipitation is the most likely concern for New Jersey. Extreme precipitation has the potential to cause significant flooding and in the winter produce heavy snowfall. While exact projections are not available, it is estimated that the New York City region will see an increase of 10% to 25% of the frequency of intense precipitation events (Sustainable Jersey Climate Change Adaptation Task Force 2013).

Precipitation during 2012 was slightly below normal, averaging 43.21 inches statewide. It ranked as the eighth driest calendar year of the past 30 years. The central coastal area of New Jersey was wettest in 2012, with several stations in Ocean and Burlington Counties receiving more than 53 inches. Over the long term, there has been an upward trend in annual precipitation in New Jersey. Since 1895, annual precipitation has increased at a rate of 4.1 inches per century. Heavy precipitation events have increased in the past 20 years and it is expected that this trend may continue (Rutgers Climate Institute 2013).

With this increase in frequency of precipitation, New Jersey and Sussex County may experience more flooding events. More intense, frequent flooding could lead to significant habitat loss for wildlife. Salt marshes and estuaries that serve as critical feeding grounds for birds and waterfowl, and as nursery habitats for commercial fish, could be lost (State of New Jersey 2010). Climate change may also lead to sea level rise which will lead to more frequent and extensive flooding (NJDEP 2013c).

5.4.4.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. For the flood hazard, areas identified as hazard areas include the 1-percent and 0.2-percent annual chance flood event boundaries (Figure 5.4.4-1). The following text evaluates and estimates the potential impact of flooding for Sussex County including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impacts on: (1) life, health and safety of residents, (2) general building stock, (3) critical facilities, (4) economy, (5) environment, and (6) future growth and development
- Effect of climate change on vulnerability
- Change of vulnerability as compared to that presented in the 2011 Sussex County Hazard Mitigation Plan
- Further data collections that will assist understanding this hazard over time

Overview of Vulnerability

Flood is a significant concern for Sussex County. To assess vulnerability, exposure to the 1- and 0.2-percent annual chance flood events was examined and potential losses were calculated for one- percent annual chance flood event. The flood hazard exposure and loss estimate analysis is presented below.

Data and Methodology

The 1- and 0.2-percent annual chance flood events were examined to evaluate the County's risk to the flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as the NFIP. The risk and vulnerability assessment was completed using FEMA effective DFIRM data dated September 2011.

To estimate potential losses, the Hazards U.S. Multi-Hazard (HAZUS-MH) version 3.0 flood model was used. The depth grid generated for the 2014 State HMP was incorporated into HAZUS-MH. The 1-percent annual chance depth grid was integrated into HAZUS-MH 3.0 and the riverine flood model was run to estimate potential losses at the structure level using the County's custom building and critical facility inventories. The HAZUS-MH 3.0 model uses 2010 U.S. Census demographic data, which was used to calculate displaced households and sheltering needs. Refer to Section 5.1 for additional details on the methodology.

Impact on Life, Health and Safety

The impact of the hydrologic hazards on life, health and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time is provided to residents. Exposure represents the population living in or near the hazard areas that could be impacted should an event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but everyone who may be affected by the cascading impacts of a hazard event (e.g., people are at risk while traveling in flooded areas, or their access to emergency services is compromised during an event). The degree of that impact will vary and is not strictly measurable.

Cascading impacts may also include exposure to pathogens such as mold. After flood events, excess moisture and standing water contribute to the growth of mold in buildings. Mold may present a health risk to building occupants, especially those with already compromised immune systems such as infants, children, the elderly and pregnant women. The degree of impact will vary and is not strictly measurable. Molds can grow in as short a period as 24-48 hours in wet and damaged areas of buildings that have not been properly cleaned. Very small mold spores can easily be inhaled, creating the potential for allergic reactions, asthma episodes, and other respiratory problems. Buildings should be properly cleaned and dried out to safely prevent mold growth (CDC, 2015).

Molds and mildews are not the only public health risk associated with flooding. Floodwaters can be contaminated by pollutants such as sewage, human and animal feces, pesticides, fertilizers, oil, asbestos, and rusting building materials. Common public health risks associated with flood events also include:

- Unsafe food
- Contaminated drinking and washing water and poor sanitation
- Mosquitos and animals
- Carbon monoxide poisoning
- Secondary hazards associated with re-entering/cleaning flooded structures
- Mental stress and fatigue

Current loss estimation models such as HAZUS-MH are not equipped to measure public health impacts. The best level of mitigation for these impacts is to be aware that they can occur, educate the public on prevention, and be prepared to deal with these vulnerabilities in responding to flood events.

To estimate the population exposed to the 1- and 0.2-percent flood events, the floodplain boundaries were overlaid upon the 2010 Census population data in GIS (U.S. Census 2010). The 2010 Census blocks with their centroid in the flood boundaries were used to calculate the estimated population exposed to this hazard. Within the floodplain population, senior citizens and the population in poverty are two especially vulnerable groups that must be taken under special consideration when planning for disaster preparation, response, and recovery.

Census blocks do not follow the boundaries of the floodplain and can grossly over or under estimate the population exposed when using the centroid or intersect of the Census block with these zones. The limitations of these analyses are recognized, and as such the results are only used to provide a general estimate. The total land area located in the one-percent and 0.2-percent annual chance flood zones was calculated using the regulatory FIRM for each jurisdiction, as presented in Table 5.4.4-4.

Table 5.4.4-4. Total Land Area in the 1-Percent and 0.2-Percent Annual Chance Flood Zones (Acres)

Municipality	Total Area (acres)	1% Flood Event Hazard Area		0.2% Flood Event Hazard Area	
		Area (acres)	% of Total	Area (acres)	% of Total
Borough of Andover	869.6	91.8	10.6%	91.8	10.6%
Township of Andover	13,309.8	818.9	6.2%	840.3	6.3%
Borough of Branchville	380.3	22.9	6.0%	24.7	6.5%
Township of Byram	14,367.4	1,683.6	11.7%	1,725.2	12.0%
Township of Frankford	22,602.1	2,506.5	11.1%	2,550.2	11.3%
Borough of Franklin	2,842.8	275.3	9.7%	293.8	10.3%
Township of Fredon	11,500.3	357.6	3.1%	357.6	3.1%
Township of Green	10,295.6	896.5	8.7%	896.8	8.7%
Borough of Hamburg	753.1	36.5	4.9%	39.9	5.3%
Township of Hampton	16,273.3	1,271.4	7.8%	1,313.0	8.1%

Table 5.4.4-4. Total Land Area in the 1-Percent and 0.2-Percent Annual Chance Flood Zones (Acres)

Municipality	Total Area (acres)	1% Flood Event Hazard Area		0.2% Flood Event Hazard Area	
		Area (acres)	% of Total	Area (acres)	% of Total
Township of Hardyston	20,807.4	579.6	2.8%	587.2	2.8%
Borough of Hopatcong	7,907.4	1,132.5	14.3%	1,144.3	14.5%
Township of Lafayette	11,453.2	754.1	6.6%	869.0	7.6%
Township of Montague	29,703.6	2,685.6	9.0%	2,889.0	9.7%
Town of Newton	2,171.7	364.9	16.8%	370.4	17.1%
Borough of Ogdensburg	1,431.1	174.4	12.2%	204.0	14.3%
Township of Sandyston	27,015.5	2,082.1	7.7%	2,197.0	8.1%
Township of Sparta	24,874.7	1,267.4	5.1%	1,302.4	5.2%
Borough of Stanhope	1,338.2	192.1	14.4%	193.1	14.4%
Township of Stillwater	18,077.3	391.3	2.2%	391.6	2.2%
Borough of Sussex	399.1	61.4	15.4%	68.1	17.1%
Township of Vernon	44,712.5	5,461.1	12.2%	5,576.4	12.5%
Township of Walpack	15,888.0	1,625.0	10.2%	1,676.5	10.6%
Township of Wantage	43,164.2	3,175.0	7.4%	3,263.5	7.6%
Sussex County Total	**342,138.2**	**27,907.6**	**8.2%**	**28,865.9**	**8.4%**

Source: FEMA 2011
Note: % = Percent;
The area presented includes the area of inland waterways

The calculation of the 0.2-percent annual chance flood event results is cumulative in nature, as the population exposed to the 1-percent flood event will also be exposed to the 0.2-percent annual chance flood event. Using this approach, it was estimated that 3,034 people are exposed to the one-percent annual chance event and 3,121 people are exposed to the 0.2-percent annual chance flood event. Refer to Table 5.4.4-5 for results by municipality.

Table 5.4.4-5. Estimated Population Exposed to the Flood Hazard

Municipality	Total Population	1-Percent Chance Event		0.2-Percent Chance Event	
		Total in Hazard Area	% of Total Populatio n	Total in Hazard Area	% of Total Population
Borough of Andover	606	23	3.8%	23	3.8%
Township of Andover	6,319	26	<1%	26	<1%
Borough of Branchville	841	18	2.1%	36	4.3%
Township of Byram	8,350	528	6.3%	569	6.8%
Township of Frankford	5,565	233	4.2%	233	4.2%
Borough of Franklin	5,045	73	1.4%	73	1.4%
Township of Fredon	3,437	1	<1%	1	<1%
Township of Green	3,601	358	9.9%	358	9.9%
Borough of Hamburg	3,277	0	0.0%	0	0.0%

Table 5.4.4-5. Estimated Population Exposed to the Flood Hazard

Municipality	Total Population	1-Percent Chance Event		0.2-Percent Chance Event	
		Total in Hazard Area	% of Total Populatio n	Total in Hazard Area	% of Total Population
Township of Hampton	5,196	0	0.0%	0	0.0%
Township of Hardyston	8,213	9	<1%	9	<1%
Borough of Hopatcong	15,147	10	<1%	17	<1%
Township of Lafayette	2,538	100	3.9%	104	4.1%
Township of Montague	3,847	513	13.3%	522	13.6%
Town of Newton	7,997	140	1.8%	140	1.8%
Borough of Ogdensburg	2,410	56	2.3%	56	2.3%
Township of Sandyston	1,998	21	1.1%	21	1.1%
Township of Sparta	19,722	212	1.1%	218	1.1%
Borough of Stanhope	3,610	93	2.6%	93	2.6%
Township of Stillwater	4,099	34	<1%	34	<1%
Borough of Sussex	2,130	25	1.2%	25	1.2%
Township of Vernon	23,943	469	2.0%	471	2.0%
Township of Walpack	16	1	6.3%	1	6.3%
Township of Wantage	11,358	91	<1%	91	<1%
Sussex County Total	**149,265**	**3,034**	**2.0%**	**3,121**	**2.1%**

Sources: U.S. Census 2010; FEMA, 2011

The table above shows that approximately 2.0-percent of the total population is exposed to the 1-percent annual chance flood event and that approximately 2.1-percent of the total population is exposed to the 0.2-percent annual chance flood event. Montague has the greatest proportion of its population located in the floodplain; approximately 13.3% and 13.6% for the 1-percent chance event and 0.2-percent chance event, respectively. For this project, the potential population exposed is used as a guide for planning purposes.

Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact to their family. The population over the age of 65 is also more vulnerable because they are more likely to seek or need medical attention which may not be available to due isolation during a flood event and they may have more difficulty evacuating. Special consideration should be taken when planning for disaster preparation, response, and recovery for these vulnerable groups.

Using 2010 U.S. Census data, HAZUS-MH 3.0 estimates the potential sheltering needs as a result of a 1-percent annual chance flood event. For the 1-percent flood event, HAZUS-MH 2.2 estimates 2,445 households will be displaced and 847 people will seek short-term sheltering. These statistics, by municipality, are presented in Table 5.4.4-6. The estimated displaced population and number of persons seeking short-term sheltering differs from the number of persons exposed to the 1-percent annual chance flood (Table 5.4.5-6), because the displaced population numbers take into consideration that not all residents will be significantly impacted enough to be displaced or to require short-term sheltering during a flood event.

Table 5.4.4-6. Estimated Population Displaced or Seeking Short-Term Shelter from the 1-percent Annual Chance Flood Event

Municipality	U.S. Census 2010 Population	1-percent Annual Chance Event	
		Displaced Households	Persons Seeking Short-Term Sheltering
Borough of Andover	606	32	7
Township of Andover	6,319	14	0
Borough of Branchville	841	42	3
Township of Byram	8,350	249	41
Township of Frankford	5,565	187	34
Borough of Franklin	5,045	92	18
Township of Fredon	3,437	3	0
Township of Green	3,601	108	20
Borough of Hamburg	3,277	0	0
Township of Hampton	5,196	14	0
Township of Hardyston	8,213	11	0
Borough of Hopatcong	15,147	74	40
Township of Lafayette	2,538	100	20
Township of Montague	3,847	199	101
Town of Newton	7,997	386	324
Borough of Ogdensburg	2,410	28	4
Township of Sandyston	1,998	63	5
Township of Sparta	19,722	163	44
Borough of Stanhope	3,610	10	0
Township of Stillwater	4,099	74	12
Borough of Sussex	2,130	37	7
Township of Vernon	23,943	333	143
Township of Walpack	16	5	0
Township of Wantage	11,358	221	24
Sussex County Total	**149,265**	**2,445**	**847**

Source: HAZUS-MH 3.0

The total number of injuries and casualties resulting from flooding is generally limited based on advance weather forecasting, blockades and warnings. Therefore, injuries and deaths generally are not anticipated if proper warning and precautions are in place. Warning time for flash flooding is often limited. Flash flood events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event are highly vulnerable to this hazard. Ongoing mitigation efforts should help to avoid the most likely cause of injury, which results from persons trying to cross flooded roadways or channels during a flood.

Impact on General Building Stock

After considering the population exposed and vulnerable to the flood hazard, the built environment was evaluated. Exposure to the flood hazard includes those buildings located in the flood zone. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content value.

To provide a general estimate of the structural/content replacement value exposure, the 1- and 0.2-percent DFIRM flood boundaries were overlaid upon the County's updated building stock inventory at the structure level. The buildings with their centroid in the hazard areas were totaled for each municipality. Table 5.4.4-7 and **Error! Reference source not found.** summarize these results. In summary, there are 577 buildings located in 1-percent annual chance flood boundary with approximately $401 million of building/contents exposed. In total, this represents approximately 1.3% of the County's total general building stock inventory (approximately $31.6 billion).

There are 667 buildings located in the 0.2-percent annual chance flood boundary with approximately $447 million of building/contents exposed. This represents approximately 1.4% of the County's total general building stock inventory.

Table 5.4.4-7. Estimated General Building Stock Exposure to the 1-Percent Annual Chance Flood Event – All Occupancies

Municipality	Total # Buildings	Total Improved Value (Structure and Contents)	Total (All Occupancies)			
			# Buildings	% Total	Total Improved Value (Structure and Contents	% Total
Borough of Andover	257	$182,562,894	14	5.4%	$7,833,353	4.3%
Township of Andover	2,248	$1,259,872,091	8	<1%	$4,689,338	<1%
Borough of Branchville	353	$174,318,470	7	2.0%	$3,813,930	2.2%
Township of Byram	3,401	$1,543,404,464	51	1.5%	$36,586,230	2.4%
Township of Frankford	2,716	$1,653,244,645	71	2.6%	$63,805,758	3.9%
Borough of Franklin	1,630	$881,717,214	19	1.2%	$10,492,325	1.2%
Township of Fredon	1,236	$842,171,127	1	<1%	$554,358	<1%
Township of Green	1,280	$962,383,257	28	2.2%	$25,076,647	2.6%
Borough of Hamburg	1,464	$747,007,403	2	<1%	$1,549,875	<1%
Township of Hampton	2,143	$1,398,457,332	6	<1%	$3,007,136	<1%
Township of Hardyston	3,731	$1,652,499,901	4	<1%	$1,929,690	<1%
Borough of Hopatcong	6,378	$2,224,090,408	18	<1%	$10,897,002	<1%
Township of Lafayette	1,020	$802,389,890	29	2.8%	$21,737,514	2.7%
Township of Montague	1,972	$858,431,631	39	2.0%	$12,396,929	1.4%
Town of Newton	2,320	$1,504,040,803	41	1.8%	$32,280,254	2.1%
Borough of Ogdensburg	915	$390,034,452	11	1.2%	$6,482,101	1.7%
Township of Sandyston	1,136	$588,862,570	30	2.6%	$25,738,467	4.4%
Township of Sparta	7,447	$4,731,600,744	29	<1%	$12,217,391	<1%
Borough of Stanhope	1,468	$859,784,777	3	<1%	$2,329,655	<1%
Township of Stillwater	1,871	$931,811,957	9	<1%	$9,759,944	1.0%
Borough of Sussex	579	$424,677,833	9	1.6%	$7,476,643	1.8%

Table 5.4.4-7. Estimated General Building Stock Exposure to the 1-Percent Annual Chance Flood Event – All Occupancies

Municipality	Total # Buildings	Total Improved Value (Structure and Contents)	Total (All Occupancies)			
			# Buildings	% Total	Total Improved Value (Structure and Contents	% Total
Township of Vernon	11,280	$4,759,388,701	59	<1%	$42,000,012	<1%
Township of Walpack	25	$16,093,258	9	36.0%	$6,600,302	41.0%
Township of Wantage	4,156	$2,250,158,879	80	1.9%	$51,682,498	2.3%
Sussex County Total	**61,026**	**$31,639,004,702**	**577**	**<1%**	**$400,937,352**	**1.3%**

Source: FEMA 2011, Sussex County, NJ Department of the Treasury, 2015

Table 5.4.4-8. Estimated General Building Stock Exposure to the 0.2-Percent Annual Chance Flood Event – All Occupancies

Municipality	Total # Buildings	Total Improved Value (Structure and Contents)	Total (All Occupancies)			
			# Buildings	% Total	Total Improved Value (Structure and Contents	% Total
Borough of Andover	257	$182,562,894	14	5.4%	$7,833,353	4.3%
Township of Andover	2,248	$1,259,872,091	8	<1%	$4,689,338	<1%
Borough of Branchville	353	$174,318,470	8	2.3%	$4,199,029	2.4%
Township of Byram	3,401	$1,543,404,464	74	2.2%	$46,942,082	3.0%
Township of Frankford	2,716	$1,653,244,645	74	2.7%	$68,341,330	4.1%
Borough of Franklin	1,630	$881,717,214	24	1.5%	$14,632,871	1.7%
Township of Fredon	1,236	$842,171,127	1	<1%	$554,358	<1%
Township of Green	1,280	$962,383,257	28	2.2%	$25,076,647	2.6%
Borough of Hamburg	1,464	$747,007,403	2	<1%	$1,549,875	<1%
Township of Hampton	2,143	$1,398,457,332	8	<1%	$4,432,821	<1%
Township of Hardyston	3,731	$1,652,499,901	5	<1%	$2,435,808	<1%
Borough of Hopatcong	6,378	$2,224,090,408	18	<1%	$10,897,002	<1%
Township of Lafayette	1,020	$802,389,890	36	3.5%	$25,709,371	3.2%
Township of Montague	1,972	$858,431,631	47	2.4%	$17,468,442	2.0%
Town of Newton	2,320	$1,504,040,803	45	1.9%	$34,535,528	2.3%
Borough of Ogdensburg	915	$390,034,452	36	3.9%	$13,180,254	3.4%
Township of Sandyston	1,136	$588,862,570	36	3.2%	$28,684,414	4.9%
Township of Sparta	7,447	$4,731,600,744	29	<1%	$12,217,391	<1%
Borough of Stanhope	1,468	$859,784,777	3	<1%	$2,329,655	<1%
Township of Stillwater	1,871	$931,811,957	9	<1%	$9,759,944	1.0%
Borough of Sussex	579	$424,677,833	12	2.1%	$10,026,439	2.4%
Township of Vernon	11,280	$4,759,388,701	60	<1%	$42,769,048	<1%
Township of Walpack	25	$16,093,258	9	36.0%	$6,600,302	41.0 %
Township of Wantage	4,156	$2,250,158,879	81	1.9%	$52,453,334	2.3%
Sussex County Total	**61,026**	**$31,639,004,702**	**667**	1.1%	**$447,318,638**	1.4%

Source: FEMA 2011, Sussex County, NJ Department of the Treasury, 2015

The HAZUS-MH flood model estimated potential damages to the buildings in Sussex County at the structure level using the custom County structure inventory developed for this plan. The potential damage estimated by HAZUS-MH to the residential general building stock inventory associated with the 1-percent annual chance flood is approximately $71 million or less than 1-percent of the total improved value.

Table 5.4.4-9. Estimated General Building Stock Potential Loss to the 1-percent Annual Chance Flood Event

Municipality	Total Improved Value (Structure and Contents)	1% Annual Chance Event							
		All Occupancies		Residential		Commercial		Industrial, Religious, Education and Government	
		Estimated Loss	% of Total	Estimated Loss	% of Total	Estimated Loss	% of Total	Estimated Loss	% of Total
Borough of Andover	$182,562,894	$1,396,032	<1%	$577,496	<1%	$481,273	<1%	$337,263	<1%
Township of Andover	$1,259,872,091	$381,533	<1%	$137,847	<1%	$95,922	<1%	$147,765	<1%
Borough of Branchville	$174,318,470	$547,066	<1%	$474,732	<1%	$72,334	<1%	$0	0.0%
Township of Byram	$1,543,404,464	$4,793,795	<1%	$1,781,439	<1%	$1,413,164	<1%	$1,599,192	<1%
Township of Frankford	$1,653,244,645	$10,850,315	<1%	$5,700,816	<1%	$1,451,315	<1%	$3,698,184	<1%
Borough of Franklin	$881,717,214	$1,533,181	<1%	$899,219	<1%	$115,106	<1%	$518,856	<1%
Township of Fredon	$842,171,127	$73,470	<1%	$73,470	<1%	$0	0.0%	$0	0.0%
Township of Green	$962,383,257	$3,695,734	<1%	$2,315,129	<1%	$0	0.0%	$1,380,606	<1%
Borough of Hamburg	$747,007,403	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Township of Hampton	$1,398,457,332	$866,638	<1%	$263,872	<1%	$0	0.0%	$602,766	<1%
Township of Hardyston	$1,652,499,901	$435,199	<1%	$259,680	<1%	$0	0.0%	$175,519	<1%
Borough of Hopatcong	$2,224,090,408	$1,589,809	<1%	$154,393	<1%	$0	0.0%	$1,435,416	<1%
Township of Lafayette	$802,389,890	$4,849,253	<1%	$1,576,747	<1%	$478,770	<1%	$2,793,737	<1%
Township of Montague	$858,431,631	$3,356,748	<1%	$2,999,568	<1%	$0	0.0%	$357,180	<1%
Town of Newton	$1,504,040,803	$3,855,216	<1%	$1,731,438	<1%	$809,495	<1%	$1,314,284	<1%
Borough of Ogdensburg	$390,034,452	$739,115	<1%	$283,849	<1%	$200,846	<1%	$254,420	<1%
Township of Sandyston	$588,862,570	$4,080,525	<1%	$2,468,168	<1%	$232,512	<1%	$1,379,845	<1%
Township of Sparta	$4,731,600,744	$3,134,721	<1%	$1,902,769	<1%	$876,698	<1%	$355,254	<1%
Borough of Stanhope	$859,784,777	$130,105	<1%	$130,105	<1%	$0	0.0%	$0	0.0%
Township of Stillwater	$931,811,957	$1,354,583	<1%	$202,603	<1%	$0	0.0%	$1,151,980	<1%
Borough of Sussex	$424,677,833	$402,760	<1%	$49,920	<1%	$295,283	<1%	$57,557	<1%
Township of Vernon	$4,759,388,701	$8,851,442	<1%	$2,498,547	<1%	$3,186,825	<1%	$3,166,070	<1%
Township of Walpack	$16,093,258	$3,056,909	19.0%	$166,737	1.0%	$604,668	3.8%	$2,285,503	14.2%
Township of Wantage	$2,250,158,879	$11,103,759	<1%	$5,942,944	<1%	$1,760,553	<1%	$3,400,262	<1%

Table 5.4.4-9. Estimated General Building Stock Potential Loss to the 1-percent Annual Chance Flood Event

Municipality	Total Improved Value (Structure and Contents)	1% Annual Chance Event							
		All Occupancies		Residential		Commercial		Industrial, Religious, Education and Government	
		Estimated Loss	% of Total	Estimated Loss	% of Total	Estimated Loss	% of Total	Estimated Loss	% of Total
Sussex County Total	**$31,639,004,702**	**$71,077,910**	**<1%**	**$32,591,488**	**<1%**	**$12,074,763**	**<1%**	**$26,411,659**	**<1%**

Source: HAZUS-MH 3.0, Sussex County

NFIP Statistics

In addition to total building stock modeling, individual data available on flood policies, claims, Repetitive Loss Properties (RLP) and severe RLP (SRLs) were analyzed. FEMA Region 2 provided a list of residential properties with NFIP policies, past claims and multiple claims (RLPs). According to the metadata provided: "The (*sic* National Flood Insurance Program) NFIP Repetitive Loss File contains losses reported from individuals who have flood insurance through the Federal Government. A property is considered a repetitive loss property when there are two or more losses reported which were paid more than $1,000 for each loss. The two losses must be within 10 years of each other & be as least 10 days apart. Only losses from (*sic* since) 1/1/1978 that are closed are considered."

SRLs were then examined for the County. According to section 1361A of the National Flood Insurance Act, as amended (NFIA), 42 U.S.C. 4102a, an SRL property is defined as a residential property that is covered under an NFIP flood insurance policy and:

- Has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or
- For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.
- For both of the above, at least two of the referenced claims must have occurred within any 10- year period, and must be greater than 10 days apart.

Table 5.4.4-10 through Table 5.4.4-12 summarize the NFIP policies, claims and repetitive loss statistics for Sussex County. Table 5.4.4-X summarizes the occupancy classes of the repetitive loss and severe repetitive loss properties in Sussex County. The majority of the repetitive loss occupancy class is single family residences (85.7%). There are no severe repetitive loss properties in the County (FEMA Region 2, 2014). This information is current as of November 30, 2014.

The location of the properties with policies, claims and repetitive and severe repetitive flooding were geocoded by FEMA with the understanding that there are varying tolerances between how closely the longitude and latitude coordinates correspond to the location of the property address, or that the indication of some locations are more accurate than others.

Table 5.4.4-10. Occupancy Class of Repetitive Loss Structures in Sussex County

Occupancy Class	Total Number of Repetitive Loss Properties	Total Number of Severe Repetitive Loss Properties	Total (RL + SRL)
Single Family	6	0	6
Condo	0	0	0
2-4 Family	1	0	1
Other Residential	0	0	0
Non-Residential	0	0	0
Sussex County	**7**	**0**	**7**

Source: FEMA Region 2 2014
Note (1): Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA Region 2, and are current as of 11/30/2014..
RL Repetitive Loss
SRL Severe Repetitive Loss

Table 5.4.4-**11**. Occupancy Class of Repetitive Loss Structures in Sussex County, by Municipality

Municipality	Repetitive Loss Properties				
	2-4 Family	Assumed Condo	Non Residential	Other Residential	Single Family
Borough of Andover	0	0	0	0	0
Township of Andover	0	0	0	0	0
Borough of Branchville	1	0	0	0	1
Township of Byram	0	0	0	0	1
Township of Frankford	0	0	0	0	0
Borough of Franklin	0	0	0	0	1
Township of Fredon	0	0	0	0	0
Township of Green	0	0	0	0	0
Borough of Hamburg	0	0	0	0	0
Township of Hampton	0	0	0	0	0
Township of Hardyston	0	0	0	0	0
Borough of Hopatcong	0	0	0	0	0
Township of Lafayette	0	0	0	0	1
Township of Montague	0	0	0	0	1
Town of Newton	0	0	0	0	0
Borough of Ogdensburg	0	0	0	0	1
Township of Sandyston	0	0	0	0	0
Township of Sparta	0	0	0	0	0
Borough of Stanhope	0	0	0	0	0
Township of Stillwater	0	0	0	0	0
Borough of Sussex	0	0	0	0	0
Township of Vernon	0	0	0	0	0
Township of Walpack	0	0	0	0	0
Township of Wantage	0	0	0	0	0
Sussex County	**1**	**0**	**0**	**0**	**6**

Source: FEMA, 2014
Note (1): Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA Region 2, and are current as of 11/30/2014
Note (2): The statistics were summarized using the Community Name provided by FEMA Region 2.

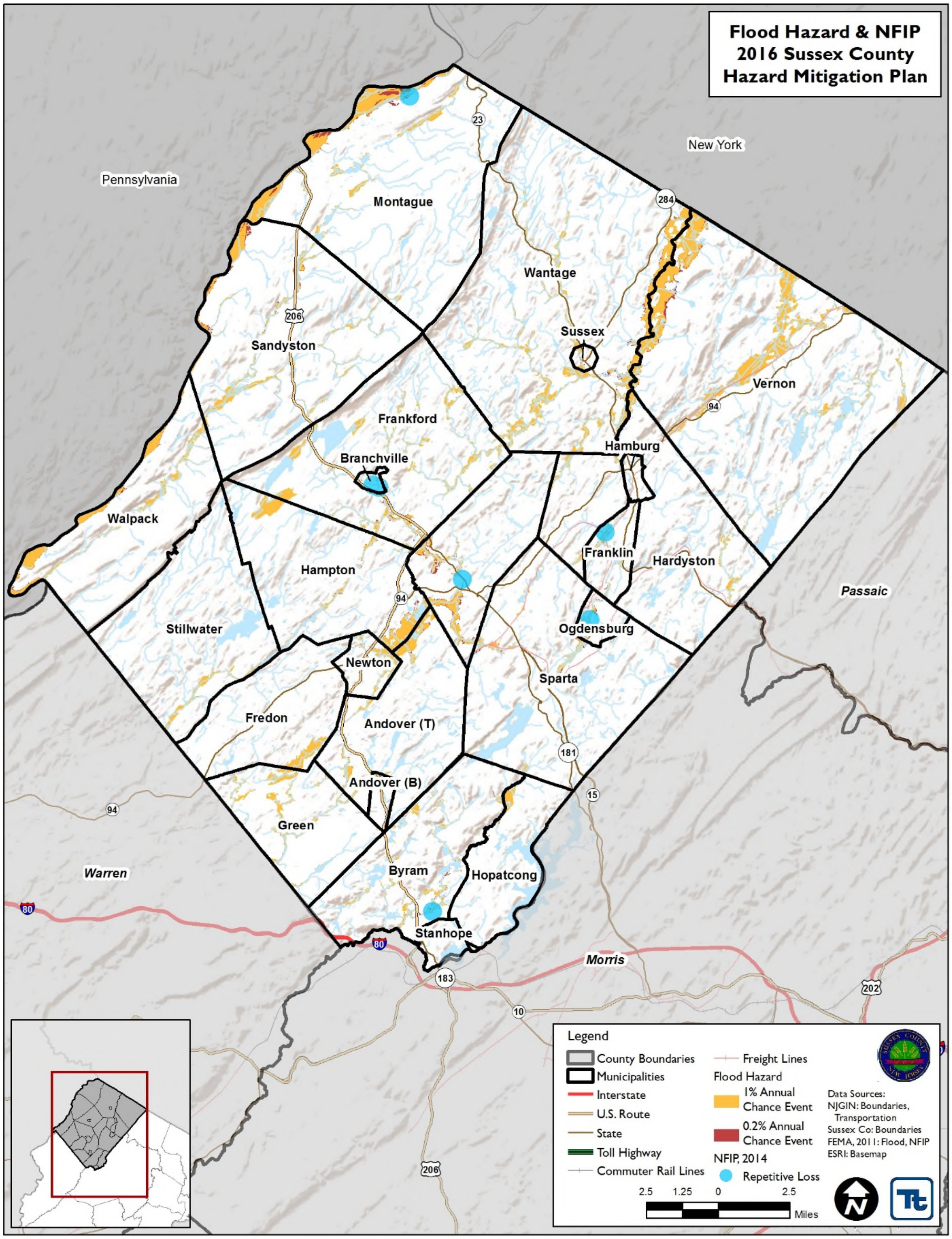
Table 5.4.4-**12.** NFIP Policies, Claims and Repetitive Loss Statistics

Municipality	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)	# Severe Rep. Loss Prop. (1)	# Policies in the 1% Flood Boundary (3)
Borough of Andover	5	1	$4,314	0	0	3
Township of Andover	7	1	$304	0	0	0
Borough of Branchville	9	6	$57,589	2	0	2
Township of Byram	34	10	$129,878	1	0	3
Township of Frankford	24	5	$61,459	0	0	7
Borough of Franklin	14	8	$67,237	1	0	2
Township of Fredon	4	1	$6,937	0	0	0
Township of Green	12	1	$11,652	0	0	2
Borough of Hamburg	4	0	$0	0	0	0
Township of Hampton	13	1	$1,023	0	0	3
Township of Hardyston	10	1	$60,787	0	0	1
Borough of Hopatcong	20	11	$128,582	0	0	0
Township of Lafayette	12	6	$125,200	1	0	5
Township of Montague	17	13	$155,437	1	0	4
Town of Newton	26	3	$58,654	0	0	13
Borough of Ogdensburg	8	8	$53,266	1	0	0
Township of Sandyston	12	3	$209,806	0	0	4
Township of Sparta	61	6	$32,999	0	0	1
Borough of Stanhope	7	2	$16,257	0	0	0
Township of Stillwater	7	3	$87,323	0	0	0
Borough of Sussex	8	5	$80,363	0	0	3
Township of Vernon	46	20	$165,380	0	0	9
Township of Walpack	0	1	$7,076	0	0	0
Township of Wantage	32	7	$182,463	0	0	13
Sussex County	**392**	**123**	**$1,703,983**	**7**	**0**	**75**

Source: FEMA Region 2, 2014
(1) *Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA Region 2, and are current as of 11/30/2014.*

Please note the total number of repetitive loss properties does not include the severe repetitive loss properties. The number of claims represents claims closed by 11/30/14.
(2) Total building and content losses from the claims file provided by FEMA Region 2.
(3) The policies inside and outside of the flood zones is based on the latitude and longitude provided by FEMA Region 2 in the policy file.
Notes: FEMA noted that where there is more than one entry for a property, there may be more than one policy in force or more than one GIS possibility.
Number of policies and claims and claims total exclude properties located outside County boundary, based on provided latitude and longitude.

Figure 5.4.4-4. NFIP Repetitive Loss Areas – Sussex County



Source: FEMA Region 2 2011, 2014

Impact on Critical Facilities

HAZUS-MH was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves, HAZUS estimates the percent of damage to critical facilities. Table 5.4.4-13 and Table 5.4.4-14 summarize the number of critical facilities located in the FEMA flood zones by type and by jurisdiction.

In cases where short-term functionality is impacted by a hazard, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce impact to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs. Actions addressing shared services agreements are included in Section 9 (Mitigation Strategies) of this plan.

Table 5.4.4-13. Number of Critical Facilities Located in the 1-percent Annual Chance Flood Zone

Municipality	Facility Types	
	Shelter	Wastewater Pump
Borough of Andover	0	0
Township of Andover	0	0
Borough of Branchville	0	0
Township of Byram	2	2
Township of Frankford	1	0
Borough of Franklin	0	0
Township of Fredon	0	0
Township of Green	0	0
Borough of Hamburg	0	0
Township of Hampton	0	0
Township of Hardyston	0	0
Borough of Hopatcong	0	0
Township of Lafayette	0	0
Township of Montague	0	0
Town of Newton	0	0
Borough of Ogdensburg	0	0
Township of Sandyston	0	0
Township of Sparta	0	0
Borough of Stanhope	0	0
Township of Stillwater	0	0
Borough of Sussex	0	0
Township of Vernon	1	0
Township of Walpack	0	0

Table 5.4.4-13. Number of Critical Facilities Located in the 1-percent Annual Chance Flood Zone

Municipality	Facility Types	
	Shelter	Wastewater Pump
Township of Wantage	0	0
Sussex County Total	**4**	**2**

Source: FEMA 2014, Sussex County

Table 5.4.4-14. Number of Critical Facilities Located in the 0.2-Percent Annual Chance Flood Zone

Municipality	Facility Types			
	DPW	Shelter	Substation	Wastewater Pump
Borough of Andover	0	0	0	0
Township of Andover	0	0	0	0
Borough of Branchville	0	0	0	0
Township of Byram	0	2	0	2
Township of Frankford	0	1	0	0
Borough of Franklin	0	0	0	0
Township of Fredon	0	0	0	0
Township of Green	0	0	0	0
Borough of Hamburg	0	0	0	0
Township of Hampton	0	0	0	0
Township of Hardyston	0	0	0	0
Borough of Hopatcong	0	0	0	0
Township of Lafayette	1	0	0	0
Township of Montague	0	0	0	0
Town of Newton	0	0	0	0
Borough of Ogdensburg	0	0	0	0
Township of Sandyston	0	0	0	0
Township of Sparta	0	0	0	0
Borough of Stanhope	0	0	0	0
Township of Stillwater	0	0	0	0
Borough of Sussex	0	0	1	0
Township of Vernon	0	1	0	0

Table 5.4.4-14. Number of Critical Facilities Located in the 0.2-Percent Annual Chance Flood Zone

Municipality	Facility Types			
	DPW	Shelter	Substation	Wastewater Pump
Township of Walpack	0	0	0	0
Township of Wantage	0	0	0	0
Sussex County Total	**1**	**4**	**1**	**2**

Source: FEMA 2014, Sussex County

Impact on the Economy

For impact on economy, estimated losses from a flood event are considered. Losses include but are not limited to general building stock damages, agricultural losses, business interruption, impacts to tourism and tax base to Sussex County. Damages to general building stock can be quantified using HAZUS-MH as discussed above. Other economic components such as loss of facility use, functional downtime and social economic factors are less measurable with a high degree of certainty.

Flooding can cause extensive damage to public utilities and disruptions to the delivery of services. Loss of power and communications may occur; and drinking water and wastewater treatment facilities may be temporarily out of operation. Flooded streets and road blocks make it difficult for emergency vehicles to respond to calls for service. Floodwaters can wash out sections of roadway and bridges (Foster, Date Unknown). In addition to travel along the roadways, public transit will be greatly impacted, causing problems for emergency responders.

Direct building losses are the estimated costs to repair or replace the damage caused to the building. Refer to the 'Impact on General Building Stock' subsection which discusses these potential losses. These dollar value losses to the County's total building inventory replacement value, in addition to damages to roadways and infrastructure, would greatly impact the local economy.

HAZUS-MH estimated the amount of debris generated from the 1-percent annual chance flood event. The model breaks down debris into three categories: 1) finishes (dry wall, insulation, etc.); 2) structural (wood, brick, etc.) and 3) foundations (concrete slab and block, rebar, etc.). The distinction is made because of the different types of equipment needed to handle the debris. Table 5.4.6-15 summarizes the debris estimated for the 1-percent flood annual chance event.

Please note this table only represents estimated debris generated by riverine flooding and does not include additional potential damage and debris which may be generated with the presence of wind.

Table 5.4.4-15. Estimated Debris Generated from the 1-percent Flood Event

Municipality	1% Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Borough of Andover	25	25	0	0
Township of Andover	6	6	0	0

Table 5.4.4-15. Estimated Debris Generated from the 1-percent Flood Event

Municipality	1% Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Borough of Branchville	33	33	0	0
Township of Byram	243	235	5	3
Township of Frankford	196	147	28	21
Borough of Franklin	96	85	7	4
Township of Fredon	0	0	0	0
Township of Green	82	59	13	9
Borough of Hamburg	0	0	0	0
Township of Hampton	12	12	0	0
Township of Hardyston	11	8	2	1
Borough of Hopatcong	28	27	1	1
Township of Lafayette	62	62	0	0
Township of Montague	439	241	115	83
Town of Newton	81	61	12	8
Borough of Ogdensburg	15	15	0	0
Township of Sandyston	123	77	27	19
Township of Sparta	797	312	288	197
Borough of Stanhope	12	7	3	2
Township of Stillwater	85	70	9	6
Borough of Sussex	67	28	23	16
Township of Vernon	904	605	179	120
Township of Walpack	119	26	53	40
Township of Wantage	271	189	48	33
Sussex County Total	**3,707**	**2,331**	**814**	**562**

Source: HAZUS-MH 3.0

Impact on the Environment

As discussed, floodplains serve beneficial and natural functions on ecological/environmental, social, and economic levels. Areas in the floodplain that typically provide these natural functions and benefits are wetlands, riparian areas, sensitive areas, and habitats for rare and endangered species. Floods however can also lead to negative impacts on the environment. Loss of riparian buffers, land use change within a watershed, and introduction of non-natural contaminants may cause environmental issues when floods occur (Montz and Tobin 1997; Rubin 2013).

To determine the exposure of the natural and beneficial land in Sussex County to the flood hazard, the acreage of wetlands, forested land, and endangered species was calculated. Refer to Table 5.4.4-XX.

Table 5.4.4-18. Acreage of Natural and Beneficial Land Located in the Floodplain

Wetlands	Area in the 1-Percent Annual Chance Floodplain (acres)	Area in the 0.2-Percent Annual Chance Floodplain (acres)
Wetlands	14,239	14,601
Forest	4,091	4,425

Wetlands	Area in the 1-Percent Annual Chance Floodplain (acres)	Area in the 0.2-Percent Annual Chance Floodplain (acres)
Endangered Species	141,182	171,555

Source: NJDEP 2015, NJDEP 2012, FEMA 2011

The basic environmental impact of major flooding is morphological; the shape of the river valley is often determined more by a catastrophic event. This process is a primary factor in forming the natural habitat for flora and fauna and may influence habitats beyond the river corridor (Hickey and Salas 1995).

Flooding can cause a wide range of environmental impacts. Impacts include but are not limited to erosion, loss of vegetation and habitats which may lead to decreased protection of the waterbody from adjacent land uses and degraded water quality. In addition, floods may generate large amounts of tree and construction debris (refer to Table 5.4.5-16), disperse household hazardous waste into the fluvial system, and contaminate water supplies and wildlife habitats with extremely toxic substances. Floods of greater depth are likely to result in greater environmental damage than floods of lesser depth. Long duration floods could exacerbate environmental problems because clean-up will likely be delayed and contaminants have the potential of remaining in the environment for a longer period of time. Cleaning up after a flood presents additional environmental concerns. The volume of debris to be collected, the extent to which public utilities (water supply systems and sewer operations) have been damaged, and the quantity of agricultural and industrial pollutants entering water bodies might present additional issues (Montz and Tobin 1997; Rubin 2013).

Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such as flood events. While predicting changes of flood events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2006).

Change of Vulnerability

Sussex County and its municipalities continue to be vulnerable to the flood hazard. However, there are several differences between the exposure and potential loss estimates between this plan update to the results in the 2011 HMP. Their differences are due to the new and updated population (U.S. Census 2010 is now available) and building inventories used, and more accurate flood depth grids used to estimate potential losses in HAZUS-MH due to the availability of their DFIRM.

For example, the 2010 HMP building inventory was the default HAZUS-MH MR4 Patch 2 general building stock with replacement values based on 2006 RS Means. For this plan update, the potential loss analysis was conducted using a custom County-wide building inventory using 2015 Sussex County and the MODIV tax assessment data. The 2010 HMP potential loss estimates were only summarized at the County level for each occupancy class; however the 2016 update estimates potential losses at the structure level using the updated building inventory and summarized for each municipality.

For this plan update, an updated depth grid, generated using 2011 FEMA effective FIRM maps for the 2014 New Jersey State HMP, was used for Sussex County. The depth grid was integrated into HAZUS-MH, and the model was run to estimate potential losses at the structure level utilizing the custom building inventory developed for this plan update.

Overall, this vulnerability assessment uses a more accurate and updated building inventory and updated flood mapping which provides more accurate estimated exposure and potential losses for Sussex County.

Future Growth and Development

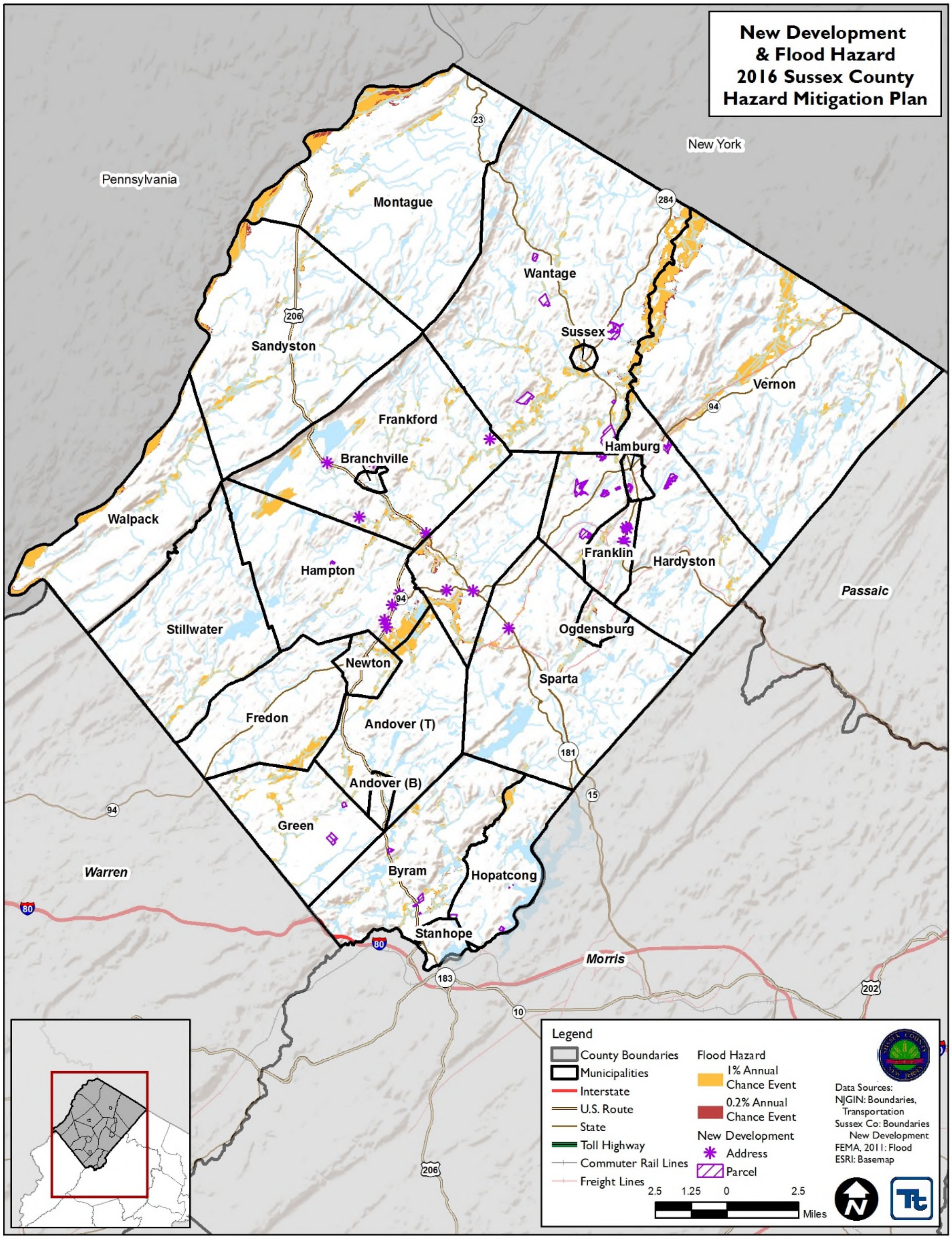
As discussed in Section 4, areas targeted for future growth and development have been identified across the County. Any areas of growth could be potentially impacted by the flood hazard if located within the identified hazard areas. Figure 5.4.4-5 illustrates the identified areas of potential new development in relation to the flood boundaries. It is the intention of the County and all participating municipalities to discourage development in vulnerable areas or to encourage higher regulatory standards on the local level.

Additional Data and Next Steps

A HAZUS-MH flood analysis was conducted for Sussex County using the most current and best available data including updated population data, building and critical facility inventories, and DFIRM. As additional FEMA Risk Mapping, Assessment, and Planning (Risk MAP) products become available, these may be used to further enhance this assessment (e.g. depth grids for additional recurrence intervals).

Specific mitigation actions addressing improved data collection and further vulnerability analysis is included in Volume II, Section 9 of this plan.

Figure 5.4.4-5. Potential New Development and Flood Boundaries



Source: FEMA 2011, Sussex County