5.4.5 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 Dutchess County.

5.4.5.1 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) (Federal Emergency Management Agency [FEMA], 2008). 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 the most frequent and costly natural hazards in New York State in terms of human hardship and economic loss, particularly to communities that lie within flood prone areas or flood plains of a major water source. As defined in the NYS HMP (NYS DHSES, 2014), flooding is a general and temporary condition of partial or complete inundation on normally dry land from the following:

- Riverine overbank flooding;
- Flash floods;
- Alluvial fan floods;
- Mudflows or debris floods;
- Dam- and levee-break floods;
- Local draining or high groundwater levels;
- Fluctuating lake levels;
- Ice-jams; and
- Coastal flooding

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). For the purpose of this HMP and as deemed appropriate by the Dutchess County Steering Committee, riverine, coastal, flash, ice jam, and dam failure flooding are the main flood types of concern for the County. These types of flood or further discussed below.

Riverine (Inland) Flooding

Riverine floods are the most common flood type. They 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 2008; The Illinois Association for Floodplain and Stormwater Management 2006).

Flash floods are "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).

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 2008).

Coastal Flooding

Coastal flooding occurs along the coasts of oceans, bays, estuaries, coastal rivers, and large lakes. Coastal floods are the submersion of land areas along the ocean coast and other inland waters caused by seawater over and above normal tide action. Coastal flooding is a result of the storm surge where local sea levels rise often resulting in weakened or destroyed coastal structures. Hurricanes and tropical storms, severe storms, and Nor'Easters cause most of the coastal flooding in Dutchess County. Coastal flooding has many of the same problems identified for riverine flooding but also has additional problems such as beach erosion; loss or submergence of wetlands and other coastal ecosystems; saltwater intrusion; high water tables; loss of coastal recreation areas, beaches, protective sand dunes, parks, and open space; and loss of coastal structures. Coastal structures can include sea walls, piers, bulkheads, bridges, or buildings (FEMA 2011).

There are several forces that occur with coastal flooding:

- *Hydrostatic forces* against a structure are created by standing or slowly moving water. Flooding can cause vertical hydrostatic forces, or flotation. These types of forces are one of the main causes of flood damage.
- *Hydrodynamic forces* on buildings are created when coastal floodwaters move at high velocities. These high-velocity flows are capable of destroying solid walls and dislodging buildings with inadequate foundations. High-velocity flows can also move large quantities of sediment and debris that can cause additional damage. In coastal areas, high-velocity flows are typically associated with one or more of the following:
    - Storm surge and wave run-up flowing landward through breaks in sand dunes or across low-lying areas
    - Tsunamis
    - Outflow of floodwaters driven into bay or upland areas

  - Strong currents parallel to the shoreline, driven by waves produced from a storm
  - High-velocity flows

  High-velocity flows can be created or exacerbated by the presence of manmade or natural obstructions along the shoreline and by weak points formed by roads and access paths that cross dunes, bridges or canals, channels, or drainage features.

- *Waves* can affect coastal buildings from breaking waves, wave run-up, wave reflection and deflection, and wave uplift. The most severe damage is caused by breaking waves. The force created by these types of waves breaking against a vertical surface is often at least 10 times higher than the force created by high winds during a coastal storm.
- *Flood-borne debris* produced by coastal flooding events and storms typically includes decks, steps, ramps, breakaway wall panels, portions of or entire houses, heating oil and propane tanks, cars, boats, decks and pilings from piers, fences, erosion control structures, and many other types of smaller objects. Debris from floods are capable of destroying unreinforced masonry walls, light wood-frame construction, and small-diameter posts and piles (FEMA 2011).

Ice Jam Flooding

An ice jam occurs when pieces of floating ice are carried with a stream's current and accumulate behind any obstruction to the stream flow. Obstructions may include river bends, mouths of tributaries, points where the river slope decreases, as well as dams and bridges. The water held back by this obstruction can cause flooding upstream, and if the obstruction suddenly breaks, flash flooding can occur as well (NOAA 2011). The formation of ice jams depends on the weather and physical condition of the river and stream channels. They are most likely to occur where the channel slope naturally decreases, in culverts, and along shallows where channels may freeze solid. Ice jams and resulting floods can occur during at different times of the year: fall freeze-up from the formation of frazil ice; mid-winter periods when stream channels freeze solid, forming anchor ice; and spring breakup when rising water levels from snowmelt or rainfall break existing ice cover into pieces that accumulate at bridges or other types of obstructions (NYS DHSES 2014).

There are two main types of ice jams: freeze-up and breakup. Freeze-up jams occur 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 (USACE 2002; NYS DHSES 2014).

Ice jams are common in the northeast U.S. and New York is not an exception. In fact, according to the USACE, New York State ranks second in the U.S. for total number of ice jam events, with over 1,500 incidents documented between 1867 and 2010. Areas of New York State that include characteristics lending to ice jam flooding include the northern counties of the Finger Lakes region and far western New York, the Mohawk Valley of central and eastern New York State, and the North Country (NYS DHSES, 2013).

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, Dutchess County experienced nine historic ice jam events between 1780 and 2015 (USACE 2015). Ice Jams typically have formed along Wappinger Creek, Fall Kill, Fishkill Creek, and Tenmile River (USAC 2015). Historical events are further mentioned in the "Previous Occurrences" section of this hazard profile.

Dam Failure Flooding

A dam is an artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material for the purpose of storage or control of water (FEMA, 2010). Dams are man-made structures built across a stream or river that impound water and reduce the flow downstream (FEMA, 2003). They are built for the purpose of power production, agriculture, water supply, recreation, and flood protection. Dam failure is any malfunction or abnormality outside of the design that adversely affect a dam's primary function of impounding water (FEMA, 2011). Dams can fail for one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam (inadequate spillway capacity);
- Prolonged periods of rainfall and flooding;
- Deliberate acts of sabotage (terrorism);
- Structural failure of materials used in dam construction;
- Movement and/or failure of the foundation supporting the dam;
- Settlement and cracking of concrete or embankment dams;
- Piping and internal erosion of soil in embankment dams;
- Inadequate or negligent operation, maintenance and upkeep;
- Failure of upstream dams on the same waterway; or
- Earthquake (liquefaction / landslides) (FEMA, 2010).

A break in a dam can produce extremely dangerous flood situations because of the high velocities and large volumes of water released by such a break. Sometimes they can occur with little to no warning. Breaching of dams often occurs within hours after the first visible sign of dam failure, leaving little or no time for evacuation (FEMA 2006).

According to the NYSDEC Division of Water Bureau of Flood Protection and Dam Safety, the hazard classification of a dam is assigned according to the potential impacts of a dam failure pursuant to 6 NYCRR Part 673.3 (NYSDEC, 2009). Dams are classified in terms of potential for downstream damage if the dam were to fail. These hazard classifications are identified and defined below:

- *Low Hazard (Class A)* is a dam located in an area where failure will damage nothing more than isolated buildings, undeveloped lands, or township or county roads and/or will cause no significant economic loss or serious environmental damage. Failure or mis-operation would result in no probable loss of human life. Losses are principally limited to the owner's property
- *Intermediate Hazard (Class B)* is a dam located in an area where failure may damage isolated homes, main highways, minor railroads, interrupt the use of relatively important public utilities, and/or will cause significant economic loss or serious environmental damage. Failure or mis-operation would result in no probable loss of human life, but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
- *High Hazard (Class C)* is a dam located in an area where failure may cause loss of human life, serious damage to homes, industrial or commercial buildings, important public utilities, main highways or railroads and/or will cause extensive economic loss. This is a downstream hazard classification for dams in which excessive economic loss (urban area including extensive community, industry, agriculture, or outstanding natural resources) would occur as a direct result of dam failure.
- *Negligible or No Hazard (Class D)* is a dam that has been breached or removed, or has failed or otherwise no longer materially impounds waters, or a dam that was planned but never constructed. Class

"D" dams are considered to be defunct dams posing negligible or no hazard. The department may retain pertinent records regarding such dams.

According to the Dam Incident Notification (DIN) system maintained by the National Performance of Dam Program (NPDP), there are 86 dams in Dutchess County. Of the 86 dams, there are 30 classified as low hazard (Class A), 39 classified as intermediate hazard (Class B), 14 classified as high hazard (Class C), and two classified as negligible or no hazard (Class D) (USACE NID 2015). However, these numbers differ from the New York State Inventory of Dams, which identifies 294 dams in Dutchess County.

Sea Level Rise

There is evidence that the global sea is rising at an increased rate and will continue rising over the next century. The two major causes of sea level rise are thermal expansion caused by the warming of the oceans and the loss of land-based ice (glaciers and polar ice caps) due to increased melting. Thermal expansion can account for 50% of sea level rise and is a result of warming atmospheric temperatures and subsequent warming of ocean waters causing the expansion. Since 1900, records and research have shown that the sea level has been steadily rising at a rate of 0.04 to 0.1 inches per year (NOAA 2013).

There are two types of sea level: global and relative. Global sea level rise refers to the increase currently observed in the average global sea level trend (primarily attributed to changes in ocean volume due to ice melt and thermal expansion). The melting of glaciers and continental ice masses can contribute significant amounts of freshwater input to the earth's oceans. In addition, a steady increase in global atmospheric temperature creates an expansion of salt water molecules, increasing ocean volume.

Local sea level refers to the height of the water as measured along the coast relative to a specific point on land. Water level measurements at tide stations are referenced to stable vertical points on the land and a known relationship is established. Measurements at any given tide station include both global sea level rise and vertical land motion (subsidence, glacial rebound, or large-scale tectonic motion). The heights of both the land and water are changing; therefore, the land-water interface can vary spatially and temporally and must be defined over time. Relative sea level trends reflect changes in local sea level over time and are typically the most critical sea level trend for many coastal applications (coastal mapping, marine boundary delineation, coastal zone management, coastal engineering, and sustainable habitat restoration) (NOAA 2013).

Short-term variations in sea level typically occur on a daily basis and include waves, tides, or specific flood events. Long-term variations in sea level occur over various time scales, from monthly to several years and may be repeatable cycles, gradual trends, or intermittent differences. Seasonal weather patterns (changes in the earth's declination), changes in coastal and ocean circulation, anthropogenic influences, vertical land motion, and other factors may influence changes in sea level over time. When estimating sea level trends, a minimum of 30 years of data are used in order to account for long-term sea level variations and reduce errors in computing sea level trends based on monthly mean sea level (NOAA 2013).

Sea level rise in Dutchess County will affect the Hudson River in the Mid-Hudson Valley. The Hudson River runs along the entire western border of Dutchess County.

Location

Water drains from the land surface through drainage features that range from rivulets in parking lots to large rivers like the Hudson River. The entire area drained by a particular body of water is called a drainage basin or watershed. In Dutchess County, there are nine major drainage basins, with most of the land in the County located within the Hudson River drainage basin. For details regarding the drainage basins in Dutchess County, refer to Section 4 (County Profile) of this plan.

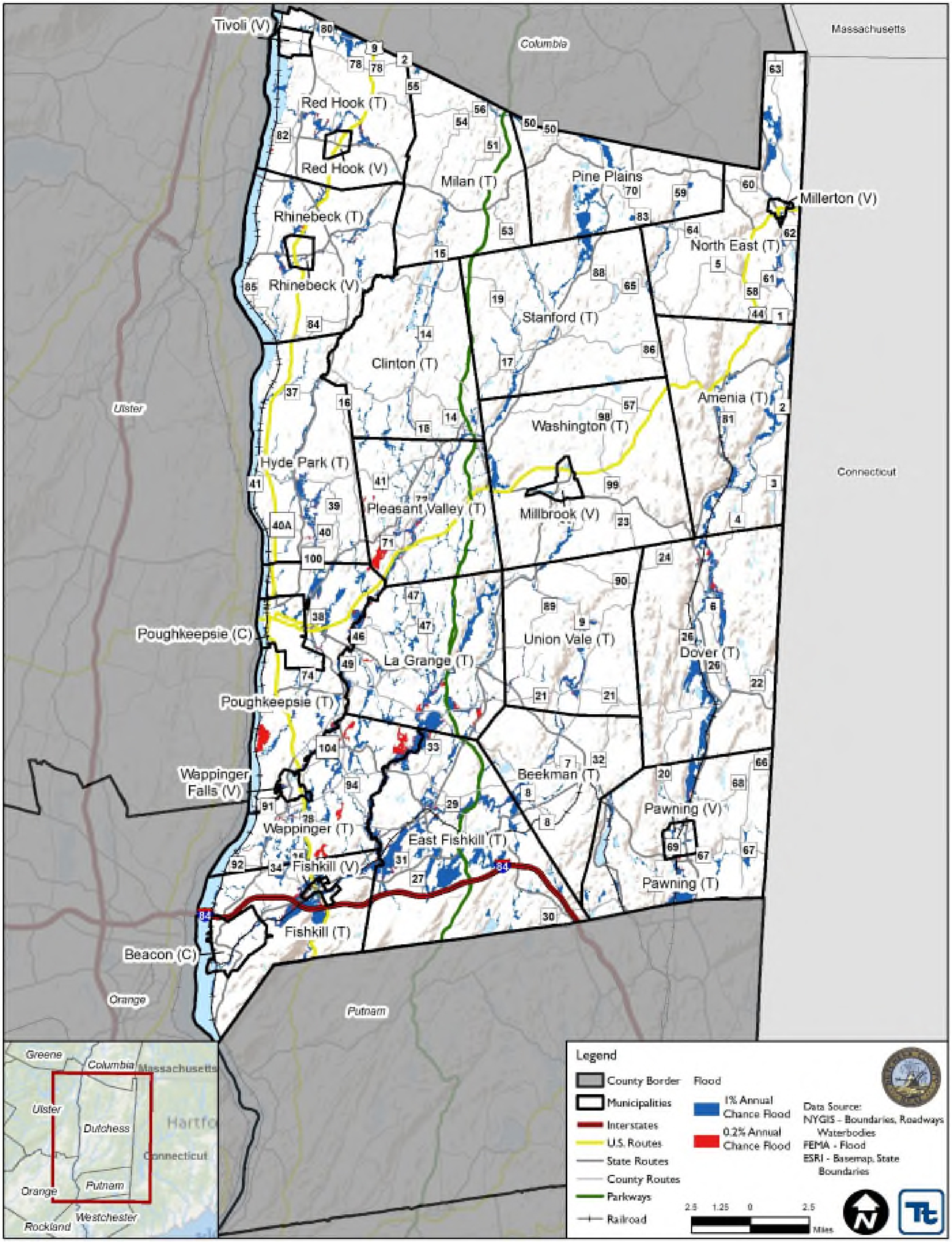
Approximately 38,444 acres (7.5%) of Dutchess County is prone to flooding. Flooding frequently occurs in the early spring when melting snow cannot be absorbed by the frozen or saturated ground. Significant floods also occur as a result of hurricanes or coastal storms that have impacted the County. Each major stream in Dutchess County has a significant number of flood prone areas and certain areas are prone to annual flooding. Major flooding in the County is triggered by coastal storms, hurricanes/tropical storms, and Nor'Easters (Dutchess County Natural Resource Inventory 2010).

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). In Dutchess County, floodplains line the rivers and streams of the County. The boundaries of the floodplains are altered as a result of changes in land use, the amount of impervious surface, placement of obstructing structures in floodways, changes in precipitation and runoff patterns, improvements in technology for measuring topographic features, and utilization of different hydrologic modeling techniques. The floodplains most susceptible to severe damaged caused by flooding are found along the lower Wappinger and Fishkill Creeks where development has occurred, and in the Harlem Valley where extensive flooding has occurred along Webatuck Creek, the Swamp River, and the Tenmile River.

Figure 5.4.5-1 illustrates the FEMA flood hazard zones in Dutchess County. According to this figure, the 1% annual chance of flood hazard zones are located along the bodies of water located throughout the County. The 0.2% annual chance of flood hazard zones are mainly found in southwestern Dutchess County.

Please refer to Section 9 (Jurisdictional Annexes) for information regarding specific areas of flooding for each participating municipality in Dutchess County.

Figure 5.4.5-1. FEMA Flood Hazard Areas in Dutchess County



Source: *FEMA*
FEMA *Federal Emergency Management Agency*

Extent

In the case of riverine flood hazard, 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 2001).

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 100-year flood, which is the standard used by most federal and state agencies, is used by the NFIP as the standard for floodplain management and to determine 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.

Sea Level Rise

According to the USGS, the coastal vulnerability index (CVI) provides a preliminary overview, at a national scale, of the relative susceptibility of the nation's coast-to-sea level rise. This initial classification is based upon variables including geomorphology, regional coastal slope, tide range, wave height, relative sea level rise, and shoreline erosion and accretion rates. The combination of these variables and the association of these variables to each other furnish a broad overview of coastal regions where physical changes are likely to occur due to sea level rise.

Previous Occurrences and Losses

Many sources provided flooding information regarding previous occurrences and losses associated with flooding events throughout Dutchess County. With so many sources reviewed for the purpose of this Hazard Mitigation Plan (HMP), 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 included New York State in 54 flood-related major disaster (DR) or emergency (EM) declarations classified as one or a combination of the following disaster types: severe storms, flooding, hurricane, tropical depression, heavy rains, landslides, ice storm, high tides, Nor'Easter, tornado, snowstorm, severe winter storm, and inland/coastal flooding. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Dutchess County was included in nine of these flood-related declarations.

For this 2015 Plan update, flood events were summarized from 1990 to 2015. Known flood events, including FEMA disaster declarations, which have impacted Dutchess County between 1990 and 2015 are identified in Table 5.4.5-1. Please note that not all events that have occurred in Dutchess 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.

Table 5.4.5-1. Flood Events in Dutchess County, 1990 to 2015

Dates of Event	Event Type	FEMA Declaration Number	Location / County Designated?	Losses / Impacts
February 3, 1994	Ice Jam	N/A	N/A	An ice jam on Fall Kill in the Town of Poughkeepsie caused a maximum annual gage height of 2.17 feet.
October 28, 1995	Flash Floods	N/A	N/A	Heavy rains produced flash floods across several streams in Dutchess County which caused mudslides and flooded roadways in the Town of Amenia and the hamlet of Stormville (Town of East Fishkill). The County had $10,000 in property damage.
January 19-21, 1996	Severe Storms and Flooding	DR-1095	Yes	Unseasonably warm temperatures resulted in the rapid melting of one to three feet of snow. In addition to the snow melt, one to three inches of rain fell, resulting in widespread flooding across Dutchess County. Small streams flooded and many roads were washed out. Extensive flooding occurred along the Hudson River and Wappingers Creek. In the higher elevations, there were numerous road washouts. In the Town of Pawling, 50% of the roads in the town were washed out. In the Towns of North East and Amenia, widespread and severe damage also occurred. In the Town of East Fishkill, an ice jam occurred on Fishkill Creek in Hopewell Junction, which caused the gaging station to reach a maximum height of 11.71 feet. On January 27th, strong winds blew across eastern New York State, downing trees, limbs and power lines across the area. Southern Dutchess County saw some of the worst damage with over 6,000 customers without power. Overall, there was $160 million in damages in New York State, of which, $7 million of damages in Dutchess County.
June 30, 1998	Severe Thunderstorms and Flash Flooding	N/A	N/A	Severe thunderstorms and flash flooding impacted Dutchess and Ulster Counties. The storms downed trees and wires and brought large hail across several locations in the counties. Torrential rains from the storms produced flash flooding across Ulster and southern Dutchess County. In Dutchess County, there were several flooded basements in the Village of Wappingers Falls and they had to be pumped out. There was also flooding of roadways in Hopewell Junction (Town of East Fishkill) and Wingdale (Town of Dover). The County had approximately $12,000 in property damages from this event.
January 18-19, 1999	Heavy Rain, Flooding and Ice Jam	N/A	N/A	Heavy rain and an ice jam in Dutchess County resulted in Wassaic Creek overflowing its banks and flooding County Route 81 in the Town of Amenia. Several homes were evacuated in this area due to the flooding. The County had approximately $10,000 in property damages.
September 16-17, 1999	Remnants of Hurricane Floyd	DR-1296	Yes	The remnants of Hurricane Floyd moved up the east coast of the United States; it brought high winds and heavy rain to eastern New York State. Rainfall totals ranged from three to six inches. Some areas received up to a foot of rain. The rain produced widespread flooding across the region, leading to severe damage and one fatality (in Dutchess County). Significant flooding was noted on many smaller tributaries including the Esopus, Catskill and Schoharie Creeks. Wind gusts from Floyd ranged from 49 mph to over 60 mph. The rain and strong winds produced

Dates of Event	Event Type	FEMA Declaration Number	Location / County Designated?	Losses / Impacts
				massive power outages. Damages to Dutchess County were approximately $1 million.
July 14-17, 2000	Severe Storms	DR-1335	Yes	Widespread and heavy rainfall impacted eastern New York State, bringing a two-day rain total of over 11 inches in some parts of the area (Ulster County). The excessive rain resulted in flooding and flash flooding. Overall, New York State had $35 million in property damage as a result of this storm series. Between July 14th and 17th, Dutchess County's rainfall totals ranged from 1.1 inches in Clinton Corners (Town of Clinton) to 1.61 inches in the Town of Red Hook.
December 16-17, 2000	Flash Flood	N/A	N/A	Between two and four inches of rain fell across eastern New York State. The combination of the heavy rain, snowmelt, and frozen ground lead to massive runoff and flooding. In Dutchess County, 3.97 inches of rain was reported in Stormville. The County had over $100,000 in property damage.
May 13 – June 17, 2004	Severe Storms and Flooding	DR-1534	Yes	May 13th – a cold front moving through New York State brought a line of strong to severe thunderstorms in the eastern part of the State. Numerous roadside culverts were washed out, and roads were closed due to heavy amounts of rain that fell in a short period of time. In Dutchess and Columbia Counties, there were several reports of hail and downed trees and power lines. June 9th – a series of strong to locally severe thunderstorms brought damage to numerous counties in eastern New York State. Most of the damage were downed trees and power lines which led to power outages.
August 10, 2003	Flash Flood	N/A	N/A	Isolated thunderstorms developed during the evening of August 10th over Dutchess and Ulster Counties. In Dutchess County, flash flooding occurred in the Towns of Hyde Park and Pleasant Valley and in the City of Poughkeepsie. In the City of Poughkeepsie, U.S. Route 44, U.S. Route 9, and State Highway 55 were all flooded. Lightning strikes in the County downed power lines between the Town of Hyde Park and the City of Poughkeepsie. At one point during the storm, the City was without power. Overall, the County had $35,000 in property damages.
August 11-12, 2003	Flash Flood	N/A	N/A	Thunderstorms produced flooding in parts of eastern New York State. In central and northern Dutchess County, flash flooding was noted in the City of Poughkeepsie on Fault Point and Van Wagner Roads. Many roads were flooded in the Village of Pleasant Valley, with rainfall totals of up to four inches falling in one hour. In the Town of Hyde Park, the Falkill Creek overflowed and caused flooding on Crum Elbow, Haviland and Roosevelt Roads. Approximately 30 residents from a mobile home park were evacuated from Haviland Road in the Town. A national historic site, Val-Kill was also flooded by the Falkill Creek. A state of emergency was declared in the County and was not lifted for a couple of days. The hamlet of Salt Point (City of Poughkeepsie) also experienced flooding of roadways and homes. The County had approximately $135,000 in property damage.
October 2005	Heavy Rain and Flooding	N/A	N/A	Two rain events in October brought a total of one to two feet of rain across eastern New York State. The first event occurred October 7th and 8th which was due to the

Dates of Event	Event Type	FEMA Declaration Number	Location / County Designated?	Losses / Impacts
				remnants of Tropical Storm Tammy. The second event occurred from October 12th through 14th. The worst flooding in New York State occurred in Dutchess County. The first event in Dutchess County caused the Wappingers Creek to crest at 8.33 feet. The second event caused the Wappingers Creek to crest at 11.16 feet at the Village of Wappingers Falls.
October 19, 2005	Heavy Rain and Flooding	N/A	N/A	Heavy rains caused flooding of the Ten Mile River which affected the Towns of Dover, Pawling, and Beekman. There was also flooding in the Town of Milan. This event resulted in $500,000 in property damage in Dutchess County.
April 16-18, 2007	Severe Storms and Inland and Coastal Flooding	DR-1692	Yes	An intense coastal storm brought heavy precipitation across the lower Hudson Valley of New York State. At first, the precipitation fell as wet snow, sleet and rain and then changed to all rain. Precipitation totals ranged from three to eight inches and led to widespread flooding across the lower and mid-Hudson Valley region. In Dutchess County, small streams and creeks flooded throughout the County. Record flooding occurred on the Wappingers Creek at Wappingers Falls which crested at 7.06 feet above its flood stage of eight feet. Moderate flooding was recorded along Tenmile River at Webatuck which crested at 11.23 feet. The flooding led to numerous road closures which included large stretches of the Taconic State Parkway in both directions. Additionally, numerous home foundations collapsed near Stormville (Town of East Fishkill). The County had approximately $5.7 million in damages.
October 2007	Heavy Rain and Flooding	N/A	N/A	Heavy wind and strong winds led to significant flooding in eastern Dutchess County. There was approximately $470,000 in property damage as a result of this event.
March 8-9, 2008	Heavy Rain and Flooding	N/A	N/A	Heavy rainfall, frozen ground and snowmelt led to flooding across portions of the eastern Catskills and mid-Hudson Valley. Rainfall totals ranged from one to three inches. In Dutchess County, heavy rainfall led to flooding across portions of the County, closing several roads. The County had approximately $10,000 in property damage.
December 12, 2008	Severe Winter Storm (Flooding)	EM-3299	Yes	This was a mixed precipitation event that brought rain and snow to the area. At times, the precipitation was heavy. Totals ranged from one to four inches. The heavy rain led to flooding of small streams and creeks in the area, in addition to widespread ponding of water in urban areas due to ice blocking storm drains. In Dutchess County, the rain led to three to four feet of standing water in the vicinity of Route 9 in the Village of Wappingers Falls. This resulted in the evacuation of approximately 36 residents from an apartment complex. Roads were also flooded in the Towns and Villages of Red Hook and Rhinebeck. The County had approximately $12,000 in property damage.
August 26 – September 5, 2011	Hurricane Irene	DR-4020	Yes	As Hurricane Irene moved north along the Atlantic coast, it weakened and made its second landfall as a Tropical Storm near Little Egg Inlet along the southeast New Jersey coast. The storm made its third landfall in New York City on August 28th. This storm brought sustained winds, heavy rain, destructive storm surge and two

Dates of Event	Event Type	FEMA Declaration Number	Location / County Designated?	Losses / Impacts
				confirmed tornadoes. Heavy rainfall resulted in widespread moderate flooding across the area. Seven deaths resulted from Irene. At least 600,000 people were ordered to evacuate their homes from storm surge and inland flooding. Widespread power outages of up to one week followed the storm. The strong winds from Irene pushed a three to five foot storm surge of water along western Long Island South, New York Harbor, the southern and eastern bays of Long Island, and southern bays of New York City. This resulted in moderate to major coastal flooding, wave damage and erosion along the coast, with heavy damage to public beaches and other public and private facilities. In Dutchess County, flash flooding was reported in several locations. Numerous roads and bridges were closed or damaged due to flooding and downed trees. There were mandatory evacuations in the County as well. Record flooding was recorded on the Hudson River at Poughkeepsie and major flooding occurred on the Hoosic River at Eagle Bridge, Hudson River at Troy and on Wappingers Creek at Wappingers Falls. Moderate flooding was reported on Tenmile River at Webatuck (Town of Amenia) and minor flooding on the Hudson River at Waterford. Flooding occurred in the Town of Rhinebeck along Route 9G. Power outages in Dutchess County impacted 25,000 customers.
July 1-2, 2013	Heavy Rain and Flash Flood	N/A	N/A	Heavy rainfall led to flash flooding which damaged and closed roadways. Evacuations took place as homes were impacted by flood waters. In Dutchess County, several roadways were closed in Hyde Park due to flash flooding. Three homes flooded on Blue Heron Lane in Staatsburg. Rainfall totals in the County reached nearly one inch.
October 27 – November 8, 2012	Hurricane Sandy	EM-3351	Yes	Hurricane Sandy moved up the east coast of the United States during the last week of October 2012. As the storm made landfall in southern New Jersey, bands of rain moved across eastern New York State. Rainfall totals in this part of the State were minimal and did not cause any flooding. The storm did bring strong and gusty winds to the area, bringing down trees and power lines across the region. Wind gusts ranged from 40 to 60 mph. In Dutchess County, Wind speeds reached 47 mph. In Lake Carmel, Route 292 was closed due to downed trees and wires between Bundy Hills Road and Sanita Road. There was numerous debris lines along the Poughkeepsie Waterfront on the Hudson River due to tidal flooding. Record flooding occurred on the Hudson River at Poughkeepsie as the River reached 9.54 feet. The surge of water moved all the way to the City of Albany. Flooding in Dutchess County occurred along the Hudson River throughout the County. Water reached the deck of the Icehouse Restaurant. Two to four feet of water reached inside the restaurant, based on water marks.
August 9, 2013	Heavy Rain and Flash Flood	N/A	N/A	Strong thunderstorms and heavy rainfall led to overflowing creeks and flooding in Dutchess County. In LaGrangeville, a creek overflowed across a roadway and

Dates of Event	Event Type	FEMA Declaration Number	Location / County Designated?	Losses / Impacts
				water was six to 12 inches deep. In Dover Plains, several roads were closed due to flooding. Rainfall totals ranged from 2.55 inches in Salt Point to 7.84 inches in Poughkeepsie.
January 8, 2014	Ice Jam	N/A	N/A	An ice jam was reported in the City of Poughkeepsie experienced an ice jam on Wappingers Creek between Jackson Road and Red Oaks near Route 346. Additionally, an ice jam was reported in the City between Walker Road and Maloney Road that is parallel to Route 376. A flood advisory was issued for the City; however, no flooding occurred as a result of this ice jam.

Sources: FEMA 2015; NOAA-NCDC 2015; NYS HMP 2014; SPC 2015
FEMA Federal Emergency Management Agency
HMP Hazard Mitigation Plan
Mph Miles Per Hour
NCDC National Climatic Data Center
NOAA National Oceanic and Atmospheric Administration
NYS New York State
N/A Not Applicable
SPC Storm Prediction Center

Probability of Future Occurrences

Based on the historic and more recent flood events in Dutchess 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 Dutchess 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 2014 New York State Hazard Mitigation Plan Update, between 1960 and 2012, Dutchess County had 56 flooding events and resulted in two fatalities, 12 injuries, over $58 million in property damage and over $1 million in crop damage. These statistics showed that the County had a 108% chance of floods occurring in the future with a recurrence interval of one (NYS DHSES 2014).

Table 5.4.5-2. Probability of Future Occurrence of Flooding Events

Hazard Type	Number of Occurrences Between 1950 and 2015	Annual Probability
Coastal Flooding	0	0%
Flash Flood	36	54.55%
Flood	31	3.23%
Ice Jams	9	13.64%
TOTAL	**76**	**---**

In Section 5.3, the identified hazards of concern for Dutchess 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 drought 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 Dutchess County is already changing, and will continue to change in the future. Climate change is beginning to affect both people and resources of the State and County and the impacts of climate change will continue. Impacts related to increasing temperatures and sea level rise are already being felt in the County. ClimAID: the Integrated Assessment for Effective Climate Change in New York State (ClimAID) was undertaken to provide decision-makers with information on the State’s vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge (New York State Energy Research and Development Authority [NYSERDA], 2011).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Dutchess County is part of Region 5, East Hudson and Mohawk River Valleys. Some of the issues in this region, affected by climate change, include: more frequent heat waves and above 90°F days, more heat-related deaths, increased frequency of heavy precipitation and flooding, decline in air quality, etc. (NYSERDA 2011).

Temperatures in New York State are warming, with an average rate of warming over the past century of 0.25° F per decade. Average annual temperatures are projected to increase across New York State by 2° F to 3.4° F by the 2020s, 4.1° F to 6.8° F by the 2050s, and 5.3° F to 10.1° F by the 2080s. By the end of the century, the greatest warming is projected to be in the northern section of the State (NYSERDA, 2014).

Regional precipitation across New York State is projected to increase by approximately one to eight-percent by the 2020s, three to 12-percent by the 2050s, and four to 15-percent by the 2080s. By the end of the century, the greatest increases in precipitation are projected to be in the northern areas of the State (NYSERDA, 2014).

Sea level rise projections that do not include significant melting of polar ice sheets suggest one to five inches of rise by the 2020s; five to 12 inches by the 2050s; and eight to 23 inches by the 2080s. Scenarios that include rapid melting of polar ice projects four to 10 inches by the 2020s; 17 to 29 inches by the 2050s; and 37 to 55 inches by the 2080s (NYSERDA 2011).

In Region 5, it is estimated that temperatures will increase by 3.5ºF to 7.1ºF by the 2050s and 4.1ºF to 11.4ºF by the 2080s (baseline of 47.6ºF). Precipitation totals will increase between 2 and 15% by the 2050s and 3 to 17% by the 2080s (baseline of 38.6 inches). Table 5.4.5-3 displays the projected seasonal precipitation change for the East Hudson and Mohawk River Valleys ClimAID Region (NYSERDA, 2014).

Table 5.4.5-3. Projected Seasonal Precipitation Change in Region 5, 2050s (% change)

Winter	Spring	Summer	Fall
5 to +15	-5 to +10	-5 to +5	-5 to +10

Source: NYSERDA 2011

The projected increase in precipitation is expected to fall in heavy downpours and less in light rains. The increase in heavy downpours has the potential to affect drinking water; heighten the risk of riverine flooding; flood key rail lines, roadways and transportation hugs; and increase delays and hazards related to extreme weather events (NYSERDA 2011).

Sea level is projected to rise along the New York State coastline and in the tidal Hudson River by three to eight inches by the 2020s, nine to 21 inches by the 2050s, and 14 to 39 inches by the 2080s (see Table 5.4.5-4). The high-end estimate for sea level rise by the 2080s is 58 inches (NYSERDA 2014). The projected increase in sea level rise has the potential to increase risk of storm surge-related flooding along the coast; expand areas at-risk of coastal flooding; increase vulnerability of energy facilities located in coastal areas; flood transportation and telecommunication facilities; and cause saltwater intrusion into some freshwater supplies near the coasts. This could impact several municipalities in western Dutchess County. Sea level rise will lead to more frequent and extensive coastal flooding (NYSERDA 2011).

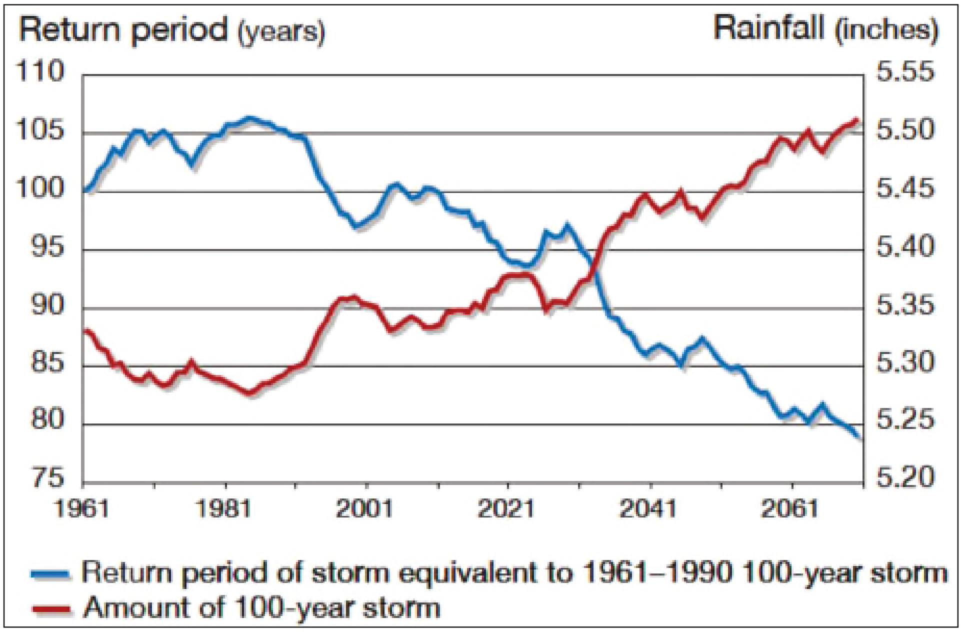
Table 5.4.5-4. Projected Sesa Level Rise in Region 5

Baseline – 0 inches (2000-2004)	Low Estimate (10th Percentile)	Middle Range (25th to 75th Percentile)	High Estimate (90th Percentile)
2020s	1 inch	3 to 7 inches	9 inches
2050s	5 inches	9 to 19 inches	27 inches
2080s	10 inches	14 to 36 inches	54 inches
2100	11 inches	18 to 46 inches	71 inches

Source: NYSERDA 2014

Increasing air temperatures intensify the water cycle by increasing evaporation and precipitation. This can cause an increase in rain totals during events with longer dry periods in between those events. These changes can have a variety of effects on the State's water resources (NYSERDA 2011). Figure 5.4.5-2 displays the project rainfall and frequency of extreme storms in New York State. The amount of rain fall in a 100-year event is projected to increase, while the number of years between such storms (return period) is projected to decrease. Rainstorms will become more severe and more frequent (NYSERDA 2011).

Figure 5.4.5-2. Projected Rainfall and Frequency of Extreme Storms



Source: NYSERDA 2011

5.4.5.2 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 5.4.5-1). The following text evaluates and estimates the potential impact of flooding for Dutchess County including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, health and safety of residents, (2) general building stock, (3) critical facilities, (4) economy, and (5) future growth and development
- Effect of climate change on vulnerability
- Change of vulnerability as compared to that presented in the 2006 Dutchess County Hazard Mitigation Plan and 2010 Eastern Dutchess All-Hazard Mitigation Plan
- Further data collections that will assist understanding this hazard over time

Overview of Vulnerability

Flood is a significant concern for Dutchess County. To assess vulnerability, exposure to the 1- and 0.2-percent annual chance flood events was examined and potential losses were calculated for 1- 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 1-percent annual chance flood event was examined to evaluate the County's risk and vulnerability to the flood hazard. The FEMA effective work map released in March 2015 for Dutchess County was used to evaluate the County's exposure to this hazard. The data used for this analysis is shown in Figure 5.4.5-1.

To estimate potential losses, the Hazards U.S. Multi-Hazard (HAZUS-MH) version 2.2 flood model was used. A depth grid was created using base-flood elevation and cross section data from FEMA and a 5-foot DEM model provided by the County; areas without elevation data from FEMA were generated using the HAZUS-MH Enhanced Quick Look tool. The depth grids were integrated into HAZUS-MH and the model was run to estimate potential losses at the structure level using the County's custom structural building inventory.

The HAZUS-MH 2.2 model uses 2010 U.S. Census demographic data. HAZUS-MH 2.2 calculated the estimated damages to the general building stock and critical facilities based on the custom inventories, provided depth grid and the default HAZUS damage functions in the flood model.

Impact on Life, Health and Safety

The impact of flooding 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 floodplain areas that could be impacted should a flood 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 effects 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.

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 scenarios and can grossly over or under estimate the population exposed when using the centroid or the 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 1-percent and 0.2-percent annual chance flood zones was calculated using the regulatory FIRM for each jurisdiction, as presented in Table 5.4.5-5.

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 20,242 people are exposed to the 1-percent annual chance event and 22,304 people are exposed to the 0.2-percent annual chance flood event. Refer to Table 5.4.5-6 for results by municipality.

Table 5.4.5-5. 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
Amenia (T)	27,951	1,429	5.1%	1,429	5.1%
Beacon (C)	3,109	251	8.1%	276	8.9%
Beekman (T)	19,653	699	3.6%	756	3.8%
Clinton (T)	24,846	1,184	4.8%	1,224	4.9%
Dover (T)	36,025	2,379	6.6%	2,551	7.1%
East Fishkill (T)	36,848	5,280	14.3%	5,533	15.0%
Fishkill (T)	19,990	4,679	23.4%	4,914	24.6%
Fishkill (V)	530	144	27.2%	189	35.7%
Hyde Park (T)	25,467	3,155	12.4%	3,321	13.0%
LaGrange (T)	25,793	3,686	14.3%	4,064	15.8%
Milan (T)	23,395	360	1.5%	360	1.5%
Millbrook (V)	1,233	96	7.8%	96	7.8%
Millerton (V)	385	25	6.5%	30	7.8%
Northeast (T)	27,544	1,207	4.4%	1,248	4.5%
Pawling (T)	27,696	2,122	7.7%	2,202	8.0%
Pawling (V)	1,259	190	15.1%	206	16.4%
Pine Plains (T)	19,921	1,615	8.1%	1,615	8.1%
Pleasant Valley (T)	21,202	2,057	9.7%	2,589	12.2%
Poughkeepsie (C)	3,649	557	15.3%	566	15.5%
Poughkeepsie (T)	19,769	3,635	18.4%	4,136	20.9%
Red Hook (T)	23,706	3,483	14.7%	3,629	15.3%
Red Hook (V)	683	10	1.5%	10	1.5%

Table 5.4.5-5. 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
Rhinebeck (T)	24,360	3,504	14.4%	3,648	15.0%
Rhinebeck (V)	977	56	5.7%	72	7.4%
Stanford (T)	32,056	1,095	3.4%	1,095	3.4%
Tivoli (V)	990	48	4.8%	61	6.2%
Union Vale (T)	23,891	745	3.1%	843	3.5%
Wappinger (T)	17,758	3,161	17.8%	3,822	21.5%
Wappinger Falls (V)	764	125	16.4%	137	17.9%
Washington (T)	36,401	661	1.8%	661	1.8%
Dutchess County (TOTAL)	**527,853**	**47,638**	**9.0%**	**51,282**	**9.7%**

Source: *FEMA*
Note: *The area presented includes the area of inland waterways and excludes bays or oceans.*
% *Percent*

Table 5.4.5-6. Estimated Population Exposed to the Flood Hazard

Municipality	Total Population	1-Percent Chance Event		0.2-Percent Chance Event	
		Total Number	% of Total	Total Number	% of Total
Amenia (T)	4,436	439	9.9%	439	9.9%
Beacon (C)	15,541	185	1.2%	185	1.2%
Beekman (T)	14,621	147	1.0%	147	1.0%
Clinton (T)	4,312	402	9.3%	402	9.3%
Dover (T)	8,699	806	9.3%	958	11.0%
East Fishkill (T)	29,029	3,569	12.3%	3,735	12.9%
Fishkill (T)	19,936	1,172	5.9%	1,458	7.3%
Fishkill (V)	2,171	943	43.4%	1,071	49.3%
Hyde Park (T)	21,571	1,125	5.2%	1,227	5.7%
LaGrange (T)	15,730	1,208	7.7%	1,217	7.7%
Milan (T)	2,370	32	1.4%	32	1.4%
Millbrook (V)	1,452	16	1.1%	16	1.1%
Millerton (V)	958	25	2.6%	25	2.6%
Northeast (T)	2,073	78	3.8%	92	4.4%
Pawling (T)	6,116	73	1.2%	181	3.0%
Pawling (V)	2,347	61	2.6%	89	3.8%
Pine Plains (T)	2,473	119	4.8%	119	4.8%
Pleasant Valley (T)	9,672	852	8.8%	1,480	15.3%
Poughkeepsie (C)	32,736	2,064	6.3%	2,064	6.3%
Poughkeepsie (T)	42,399	3,363	7.9%	3,632	8.6%
Red Hook (T)	8,240	430	5.2%	430	5.2%
Red Hook (V)	1,961	0	0.0%	0	0.0%
Rhinebeck (T)	4,891	74	1.5%	74	1.5%
Rhinebeck (V)	2,657	40	1.5%	102	3.8%
Stanford (T)	3,823	143	3.7%	143	3.7%
Tivoli (V)	1,118	0	0.0%	0	0.0%

Table 5.4.5-6. Estimated Population Exposed to the Flood Hazard

Municipality	Total Population	1-Percent Chance Event		0.2-Percent Chance Event	
		Total Number	% of Total	Total Number	% of Total
Union Vale (T)	4,877	28	<1%	90	1.8%
Wappinger (T)	22,468	2,427	10.8%	2,475	11.0%
Wappinger Falls (V)	5,522	353	6.4%	353	6.4%
Washington (T)	3,289	68	2.1%	68	2.1%
Dutchess County (TOTAL)	**297,488**	**20,242**	**6.8%**	**22,304**	**7.5%**

Sources: U.S. Census 2010; FEMA, 2015

The table above shows that approximately 6.8-percent of the total population is exposed to the 1-percent annual chance flood event and that approximately 7.5 percent of the total population is exposed to the 0.2-percent annual chance flood event. The Village of Fishkill will experience the greatest impact to population with approximately 43.4% and 49.3% for the 1-percent chance event and 0.2-percent chance event, respectively. For this project, the potential population impacted is used as a guide.

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.

Using 2010 U.S. Census data, HAZUS-MH 2.2 estimates the potential sheltering needs as a result of a 1-percent chance flood event. For the 1-percent flood event, HAZUS-MH 2.2 estimates 30,480 households will be displaced and 23,392 people will seek short-term sheltering. These statistics, by municipality, are presented in Table 5.4.5-7.

Table 5.4.5-7. 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
Amenia (T)	4,436	466	292
Beacon (C)	15,541	413	253
Beekman (T)	14,621	670	463
Clinton (T)	4,312	431	177
Dover (T)	8,699	1,185	964
East Fishkill (T)	29,029	3,615	2,913
Fishkill (T)	19,936	2,605	2,264
Fishkill (V)	2,171	539	454
Hyde Park (T)	21,571	2,234	1,696
LaGrange (T)	15,730	1,888	1,122
Milan (T)	2,370	25	1
Millbrook (V)	1,452	71	15
Millerton (V)	958	92	26
Northeast (T)	2,073	115	14
Pawling (T)	6,116	420	194
Pawling (V)	2,347	453	297
Pine Plains (T)	2,473	212	117
Pleasant Valley (T)	9,672	1,417	859

Table 5.4.5-7. 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
Poughkeepsie (C)	32,736	3,986	3,797
Poughkeepsie (T)	42,399	5,018	4,371
Red Hook (T)	8,240	590	338
Red Hook (V)	1,961	8	1
Rhinebeck (T)	4,891	301	133
Rhinebeck (V)	2,657	173	98
Stanford (T)	3,823	188	39
Tivoli (V)	1,118	61	22
Union Vale (T)	4,877	200	40
Wappinger (T)	22,468	2,411	1,840
Wappinger Falls (V)	5,522	646	585
Washington (T)	3,289	47	7
Dutchess County (TOTAL)	**297,488**	**30,480**	**23,392**

Source: HAZUS-MH 2.2

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. 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 in the flood zone 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 5.4.5-8 and Table 5.4.5-9 summarize these results. In summary, there are 3,492 buildings located in 1-percent annual chance flood boundary with an estimated $3 billion of building/contents exposed (based on improvement value). In total, this represents approximately 3.1% of the County's total general building stock inventory (approximately $97 billion).

There are 4,599 buildings located in the 0.2-percent annual chance flood boundary with an estimated $4.1 billion of building/contents exposed. This represents approximately 4.2% of the County's total general building stock inventory.

Table 5.4.5-8. Estimated General Building Stock Exposure to the 1- Percent Annual Chance Flood Event – All Occupancies

Municipality	Total # Buildings	Total Improvement Value (Structure and Contents)	Total (All Occupancies)			
			# Buildings	% Total	Total Improvement Value (Structure and Contents	% Total
Amenia (T)	2,691	$1,943,434,588	58	2.2%	$51,975,397	2.7%

Municipality	Total # Buildings	Total Improvement Value (Structure and Contents)	Total (All Occupancies)			
			# Buildings	% Total	Total Improvement Value (Structure and Contents	% Total
Beacon (C)	4,395	$3,343,631,632	37	<1%	$77,420,816	2.3%
Beekman (T)	5,075	$3,824,624,378	25	<1%	$11,035,920	<1%
Clinton (T)	3,110	$2,069,522,881	28	<1%	$13,455,938	<1%
Dover (T)	4,612	$2,781,316,617	172	3.7%	$173,295,286	6.2%
East Fishkill (T)	11,772	$10,141,818,207	316	2.7%	$185,025,408	1.8%
Fishkill (T)	5,654	$6,611,883,715	282	5.0%	$432,190,891	6.5%
Fishkill (V)	590	$684,424,401	79	13.4%	$64,031,804	9.4%
Hyde Park (T)	8,593	$6,063,728,469	456	5.3%	$141,189,372	2.3%
LaGrange (T)	6,802	$5,916,908,642	225	3.3%	$152,656,647	2.6%
Milan (T)	2,086	$1,230,195,126	6	<1%	$2,591,999	<1%
Millbrook (V)	752	$729,406,405	1	<1%	$239,535	0.0%
Millerton (V)	510	$331,725,332	18	3.5%	$11,437,918	3.4%
Northeast (T)	1,863	$1,427,398,702	18	1.0%	$11,698,811	<1%
Pawling (T)	3,403	$2,567,191,358	23	<1%	$10,710,576	<1%
Pawling (V)	882	$776,997,342	35	4.0%	$37,853,288	4.9%
Pine Plains (T)	1,935	$1,278,056,930	48	2.5%	$26,283,658	2.1%
Pleasant Valley (T)	4,718	$3,111,800,909	147	3.1%	$133,548,882	4.3%
Poughkeepsie (C)	7,829	$6,538,699,835	401	5.1%	$309,598,289	4.7%
Poughkeepsie (T)	14,092	$15,283,939,811	672	4.8%	$752,752,577	4.9%
Red Hook (T)	3,996	$3,159,628,647	67	1.7%	$45,759,271	1.4%
Red Hook (V)	930	$774,900,418	0	0.0%	$0	0.0%
Rhinebeck (T)	3,217	$2,464,483,474	72	2.2%	$47,360,472	1.9%
Rhinebeck (V)	1,303	$1,157,909,263	10	<1%	$7,822,532	<1%
Stanford (T)	3,192	$2,113,883,643	10	<1%	$2,999,559	<1%
Tivoli (V)	488	$340,051,328	0	0.0%	$0	0.0%
Union Vale (T)	2,509	$2,093,773,650	18	<1%	$5,907,819	<1%
Wappinger (T)	7,899	$5,787,089,913	231	2.9%	$157,179,263	2.7%
Wappinger Falls (V)	1,395	$1,153,456,878	33	2.4%	$144,554,726	12.5%
Washington (T)	2,812	$2,223,473,555	4	<1%	$1,835,289	<1%
Dutchess County (TOTAL)	**119,105**	**$97,925,356,049**	**3,492**	**2.9%**	**$3,012,411,942**	**3.1%**

Source: Dutchess County, FEMA, 2015

Table 5.4.5-9. Estimated General Building Stock Exposure to the 0.2-Percent Annual Chance Flood Event – All Occupancies

Municipality	Total # Buildings	Total Improvement Value (Structure and Contents)	Total (All Occupancies)			
			# Buildings	% Total	Total Improvement Value (Structure and Contents	% Total
Amenia (T)	2,691	$1,943,434,588	58	2.2%	$51,975,397	2.7%
Beacon (C)	4,395	$3,343,631,632	47	1.1%	$86,669,942	2.6%
Beekman (T)	5,075	$3,824,624,378	31	<1%	$13,863,927	<1%
Clinton (T)	3,110	$2,069,522,881	33	1.1%	$16,401,887	<1%
Dover (T)	4,612	$2,781,316,617	292	6.3%	$231,191,846	8.3%
East Fishkill (T)	11,772	$10,141,818,207	389	3.3%	$262,722,362	2.6%
Fishkill (T)	5,654	$6,611,883,715	509	9.0%	$681,994,693	10.3%
Fishkill (V)	590	$684,424,401	146	24.7%	$135,061,052	19.7%
Hyde Park (T)	8,593	$6,063,728,469	571	6.6%	$190,186,727	3.1%
LaGrange (T)	6,802	$5,916,908,642	277	4.1%	$209,528,547	3.5%

Municipality	Total # Buildings	Total Improvement Value (Structure and Contents)	Total (All Occupancies)			
			# Buildings	% Total	Total Improvement Value (Structure and Contents	% Total
Milan (T)	2,086	$1,230,195,126	6	<1%	$2,591,999	<1%
Millbrook (V)	752	$729,406,405	1	<1%	$239,535	0.0%
Millerton (V)	510	$331,725,332	27	5.3%	$16,140,158	4.9%
Northeast (T)	1,863	$1,427,398,702	27	1.4%	$15,553,064	1.1%
Pawling (T)	3,403	$2,567,191,358	27	<1%	$19,798,240	<1%
Pawling (V)	882	$776,997,342	46	5.2%	$88,981,869	11.5%
Pine Plains (T)	1,935	$1,278,056,930	48	2.5%	$26,283,658	2.1%
Pleasant Valley (T)	4,718	$3,111,800,909	301	6.4%	$227,956,917	7.3%
Poughkeepsie (C)	7,829	$6,538,699,835	402	5.1%	$310,205,001	4.7%
Poughkeepsie (T)	14,092	$15,283,939,811	770	5.5%	$1,008,776,781	6.6%
Red Hook (T)	3,996	$3,159,628,647	85	2.1%	$59,739,575	1.9%
Red Hook (V)	930	$774,900,418	0	0.0%	$0	0.0%
Rhinebeck (T)	3,217	$2,464,483,474	85	2.6%	$54,859,364	2.2%
Rhinebeck (V)	1,303	$1,157,909,263	18	1.4%	$27,222,556	2.4%
Stanford (T)	3,192	$2,113,883,643	10	<1%	$2,999,559	<1%
Tivoli (V)	488	$340,051,328	0	0.0%	$0	0.0%
Union Vale (T)	2,509	$2,093,773,650	28	1.1%	$10,564,106	<1%
Wappinger (T)	7,899	$5,787,089,913	320	4.1%	$228,735,720	4.0%
Wappinger Falls (V)	1,395	$1,153,456,878	41	2.9%	$158,206,154	13.7%
Washington (T)	2,812	$2,223,473,555	4	<1%	$1,835,289	<1%
Dutchess County (TOTAL)	**119,105**	**$97,925,356,049**	**4,599**	**3.9%**	**$4,140,285,927**	**4.2%**

Source: Dutchess County, FEMA, 2015

The HAZUS-MH model estimated potential damages to the buildings in Dutchess County at the structure level using the custom County structure inventory developed for this plan. The potential damage estimated by HAZUS-MH to the general building stock inventory associated with the 1-percent annual chance flood is approximately $513 million or less than 1-percent of the total building stock improvement value.

Table 5.4.5-10. Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event

Municipality	Total Improvement Value	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
Amenia (T)	$1,943,434,588	$4,916,023	<1%	$1,962,806	<1%	$1,756,089	<1%	$1,197,127	<1%
Beacon (C)	$3,343,631,632	$13,523,690	<1%	$1,772,256	<1%	$10,915,656	<1%	$835,778	<1%
Beekman (T)	$3,824,624,378	$853,481	<1%	$853,481	<1%	$0	0.0%	$0	0.0%
Clinton (T)	$2,069,522,881	$1,416,823	<1%	$1,234,271	<1%	$182,551	<1%	$0	0.0%
Dover (T)	$2,781,316,617	$36,242,271	1.3%	$3,752,889	<1%	$31,192,356	1.1%	$1,297,026	<1%
East Fishkill (T)	$10,141,818,207	$25,418,004	<1%	$18,295,750	<1%	$6,932,807	<1%	$189,447	<1%
Fishkill (T)	$6,611,883,715	$20,660,504	<1%	$8,285,776	<1%	$10,836,331	<1%	$1,538,397	<1%
Fishkill (V)	$684,424,401	$5,632,218	<1%	$1,212,685	<1%	$2,587,874	<1%	$1,831,659	<1%
Hyde Park (T)	$6,063,728,469	$15,825,484	<1%	$7,815,626	<1%	$5,398,896	<1%	$2,610,962	<1%
LaGrange (T)	$5,916,908,642	$28,094,956	<1%	$19,924,225	<1%	$3,577,490	<1%	$4,593,240	<1%
Milan (T)	$1,230,195,126	$1,734,239	<1%	$1,181,276	<1%	$0	0.0%	$552,962	<1%
Millbrook (V)	$729,406,405	$146,258	<1%	$0	0.0%	$0	0.0%	$146,258	<1%
Millerton (V)	$331,725,332	$762,279	<1%	$762,279	<1%	$0	0.0%	$0	0.0%
Northeast (T)	$1,427,398,702	$2,613,674	<1%	$2,372,681	<1%	$24,157	<1%	$216,836	<1%
Pawling (T)	$2,567,191,358	$2,565,943	<1%	$1,679,202	<1%	$459,316	<1%	$427,425	<1%
Pawling (V)	$776,997,342	$12,810,467	1.6%	$523,350	<1%	$766,759	<1%	$11,520,358	1.5%
Pine Plains (T)	$1,278,056,930	$8,015,511	<1%	$6,696,635	<1%	$1,318,875	<1%	$0	0.0%
Pleasant Valley (T)	$3,111,800,909	$30,188,012	1.0%	$7,432,669	<1%	$15,146,380	<1%	$7,608,963	<1%
Poughkeepsie (C)	$6,538,699,835	$81,501,515	1.2%	$26,302,877	<1%	$31,358,897	<1%	$23,839,741	<1%
Poughkeepsie (T)	$15,283,939,811	$171,287,894	1.1%	$34,745,149	<1%	$65,819,969	<1%	$70,722,775	<1%
Red Hook (T)	$3,159,628,647	$2,381,736	<1%	$2,381,736	<1%	$0	0.0%	$0	0.0%
Red Hook (V)	$774,900,418	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Rhinebeck (T)	$2,464,483,474	$6,429,683	<1%	$4,471,892	<1%	$67	<1%	$1,957,724	<1%
Rhinebeck (V)	$1,157,909,263	$137,872	<1%	$83,553	<1%	$36,404	<1%	$17,915	<1%
Stanford (T)	$2,113,883,643	$988,223	<1%	$988,223	<1%	$0	0.0%	$0	0.0%

Municipality	Total Improvement Value	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
Tivoli (V)	$340,051,328	$0	0.0%	$0	0.0%	$0	0.0%	$0	0.0%
Union Vale (T)	$2,093,773,650	$808,339	<1%	$143,315	<1%	$659,597	<1%	$5,428	<1%
Wappinger (T)	$5,787,089,913	$28,747,785	<1%	$16,121,751	<1%	$8,929,412	<1%	$3,696,621	<1%
Wappinger Falls (V)	$1,153,456,878	$8,369,358	<1%	$3,496,276	<1%	$865,799	<1%	$4,007,283	<1%
Washington (T)	$2,223,473,555	$648,029	<1%	$79,732	<1%	$568,297	<1%	$0	0.0%
Dutchess County (TOTAL)	**$97,925,356,049**	**$512,720,270**	**<1%**	**$174,572,363**	**<1%**	**$199,333,981**	**<1%**	**$138,813,926**	**<1%**

Source: HAZUS-MH 2.2

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 5.4.5-11 through Table 5.4.5-13 summarize the NFIP policies, claims and repetitive loss statistics for Dutchess County. According to FEMA, Table 5.4.5-11 summarizes the occupancy classes of the repetitive loss and severe repetitive loss properties in Dutchess County. The majority of the repetitive loss occupancy class is single family residences (79.3%). The majority of severe repetitive loss occupancy class is also single family residences (84.6%) (FEMA Region 2, 2014). This information is current as of December 31th, 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 5.4.5-11. Occupancy Class of Repetitive Loss Structures in Dutchess County

Occupancy Class	Total Number of Repetitive Loss Properties	Total Number of Severe Repetitive Loss Properties	Total (RL + SRL)
Single Family	46	11	57
Condo	5	0	5
2-4 Family	3	0	3
Other Residential	0	0	0
Non-Residential	4	2	6
Dutchess County	**58**	**13**	**71**

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 12/31/2014.
The total number of repetitive loss properties does not include severe repetitive loss properties.
RL Repetitive Loss
SRL Severe Repetitive Loss

Table 5.4.5-12. Occupancy Class of Repetitive Loss Structures in Dutchess County, by Municipality

Municipality	Repetitive Loss Properties					Severe Repetitive Loss Properties				
	2-4 Family	Assumed Condo	Non Residential	Other Residential	Single Family	2-4 Family	Assumed Condo	Non Residential	Other Residential	Single Family
Amenia (T)	0	0	0	0	0	0	0	0	0	0
Beacon (C)	0	0	0	0	0	0	0	0	0	0
Beekman (T)	0	0	0	0	0	0	0	0	0	0
Clinton (T)	0	0	0	0	2	0	0	0	0	0
Dover (T)	0	0	0	0	5	0	0	0	0	1
East Fishkill (T)	0	0	0	0	13	0	0	0	0	3
Fishkill (T)	1	0	0	0	2	0	0	0	0	1
Fishkill (V)	0	5	3	0	2	0	0	0	0	0
Hyde Park (T)	1	0	0	0	2	0	0	0	0	0
LaGrange (T)	0	0	0	0	3	0	0	0	0	0
Milan (T)	0	0	0	0	1	0	0	0	0	0
Millbrook (V)	0	0	0	0	0	0	0	0	0	0
Millerton (V)	0	0	0	0	0	0	0	0	0	0
Northeast (T)	0	0	0	0	0	0	0	0	0	0
Pawling (T)	0	0	0	0	1	0	0	0	0	0
Pawling (V)	0	0	0	0	1	0	0	2	0	0
Pine Plains (T)	0	0	0	0	0	0	0	0	0	0
Pleasant Valley (T)	0	0	0	0	4	0	0	0	0	4
Poughkeepsie (C)	1	0	0	0	4	0	0	0	0	0
Poughkeepsie (T)	0	0	0	0	1	0	0	0	0	1
Red Hook (T)	0	0	0	0	2	0	0	0	0	1
Red Hook (V)	0	0	0	0	0	0	0	0	0	0
Rhinebeck (T)	0	0	0	0	1	0	0	0	0	0
Rhinebeck (V)	0	0	0	0	0	0	0	0	0	0
Stanford (T)	0	0	0	0	1	0	0	0	0	0
Tivoli (V)	0	0	0	0	0	0	0	0	0	0
Union Vale (T)	0	0	0	0	0	0	0	0	0	0

Table 5.4.5-12. Occupancy Class of Repetitive Loss Structures in Dutchess County, by Municipality

Municipality	Repetitive Loss Properties					Severe Repetitive Loss Properties				
	2-4 Family	Assumed Condo	Non Residential	Other Residential	Single Family	2-4 Family	Assumed Condo	Non Residential	Other Residential	Single Family
Wappinger (T)	0	0	1	0	1	0	0	0	0	0
Wappinger Falls (V)	0	0	0	0	0	0	0	0	0	0
Washington (T)	0	0	0	0	0	0	0	0	0	0
Dutchess County (TOTAL)	**3**	**5**	**4**	**0**	**46**	**0**	**0**	**2**	**0**	**11**

Source: FEMA, 2014
Note (1): Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA Region 2, and are current as of 12/31/2014
Note (2): The statistics were summarized using the Community Name provided by FEMA Region 2.
Note (3): The total number of repetitive loss properties does not include severe repetitive loss properties.

Table 5.4.5-13. NFIP Policies, Claims and Repetitive Loss Statistics

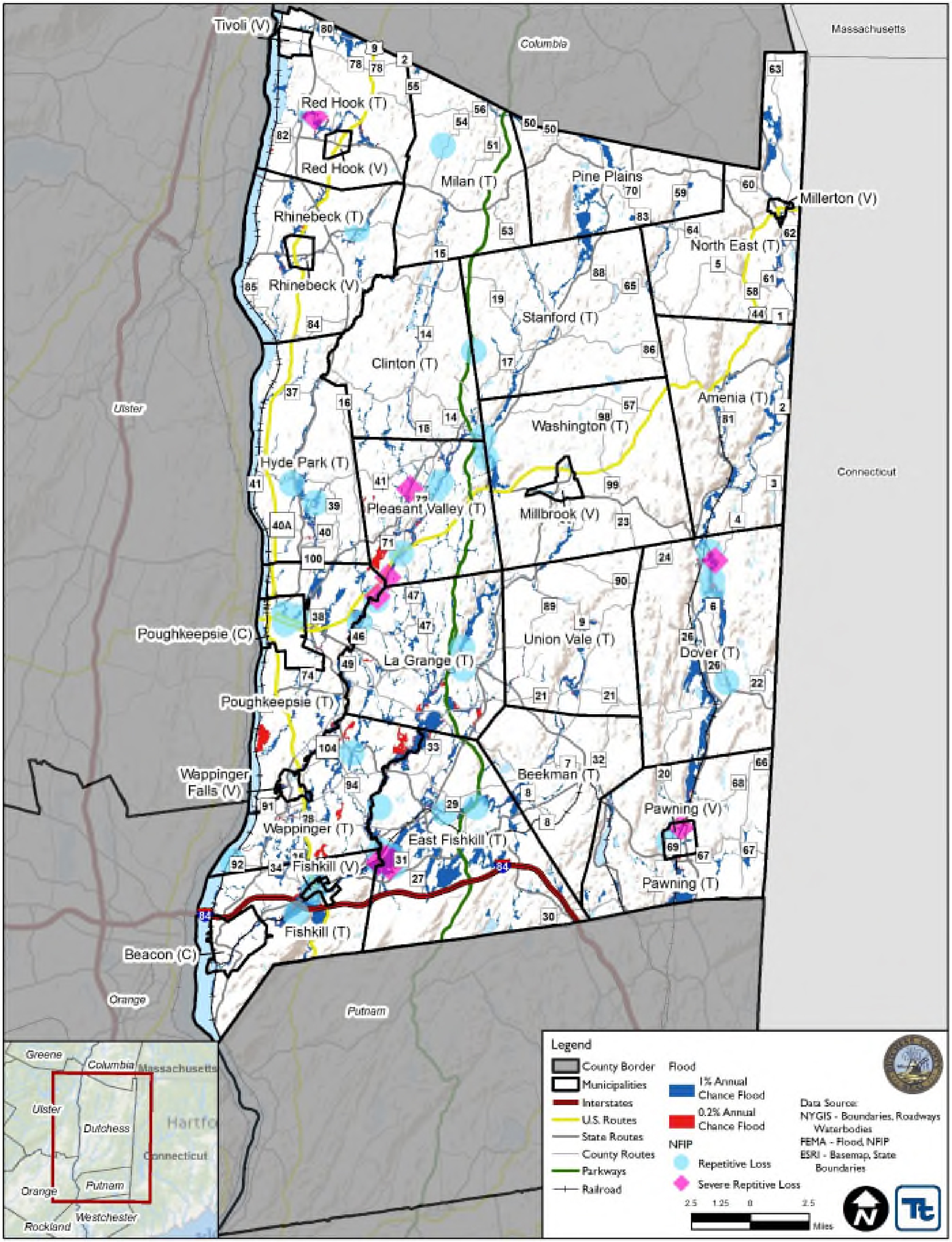
Municipality	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)	# Severe Rep. Loss Prop. (1)	# Policies in the 1% Flood Boundary (3)
Amenia (T)	27	4	$30,791.81	0	0	15
Beacon (C)	50	18	$260,776.32	0	0	11
Beekman (T)	32	3	$5,493.80	0	0	6
Clinton (T)	23	6	$107,028.82	2	0	8
Dover (T)	51	35	$403,441.95	5	1	34
East Fishkill (T)	208	96	$1,810,805.47	13	3	140
Fishkill (T)	185	28	$407,770.07	3	1	104
Fishkill (V)	50	40	$1,268,875.97	10	0	39
Hyde Park (T)	137	24	$379,548.76	3	0	84
LaGrange (T)	99	32	$406,971.71	3	0	63
Milan (T)	13	3	$15,888.73	1	0	2
Millbrook (V)	15	0	$0.00	0	0	0
Millerton (V)	7	2	$6,939.07	0	0	4
Northeast (T)	16	3	$21,266.12	0	0	2
Pawling (T)	23	9	$36,875.24	1	0	6
Pawling (V)	21	13	$1,941,505.63	1	2	16
Pine Plains (T)	14	1	$2,169.72	0	0	8
Pleasant Valley (T)	73	47	$1,309,367.89	4	4	43
Poughkeepsie (C)	152	39	$556,773.10	5	0	103
Poughkeepsie (T)	260	33	$951,155.02	1	1	174
Red Hook (T)	35	17	$384,451.19	2	1	21
Red Hook (V)	1	0	$0.00	0	0	0
Rhinebeck (T)	36	3	$28,632.56	1	0	12
Rhinebeck (V)	11	7	$49,310.95	0	0	2
Stanford (T)	22	6	$44,101.13	1	0	4
Tivoli (V)	2	2	$16,562.22	0	0	2

Table 5.4.5-13. 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)
Union Vale (T)	7	0	$0.00	0	0	1
Wappinger (T)	159	21	$313,495.17	2	0	90
Wappinger Falls (V)	37	4	$7,865.00	0	0	17
Washington (T)	15	2	$26,719.68	0	0	0
Dutchess County (TOTAL)	**1,781**	**498**	**$10,794,583.10**	**58**	**13**	**1,011**

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 12/31/2014.
The total number of repetitive loss properties does not includes the severe repetitive loss properties. The number of claims represents claims closed by 12/31/14.
(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.
A zero percentage denotes less than 1/100th percentage and not zero damages or vulnerability as may be the case.
Number of policies and claims and claims total exclude properties located outside County boundary, based on provided latitude and longitude.

Figure 5.4.5-3. NFIP Repetitive Loss Areas – Dutchess County



Source: FEMA Region 2, 2015

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 the building and contents of critical facilities. Table 5.4.5-14 and Table 5.4.5-15 summarize the number of critical facilities located in the FEMA flood zones by type and by jurisdiction. Table 5.4.5-16 details the estimated percent damage to the critical facilities affected by the 1% and 0.2% Annual Chance Flood Zones as calculated by HAZUS-MH 2.1.

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 5.4.5-14. Number of Critical Facilities Located in the 1-Percent Annual Chance Flood Zone

Municipality	Facility Types															
	Accommodation	Dam	DPW	Fire Station/EMS	Gas Station	Government	Police	Post Office	Potable Pump	Potable Storage	Rail Facility	School	Town Hall	Well	Wastewater Pump	Wastewater Treatment
Amenia (T)	2	0	0	3	1	0	0	0	1	0	1	0	0	0	0	0
Beacon (C)	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beekman (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Clinton (T)	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dover (T)	0	1	0	0	0	0	0	0	0	0	1	0	0	0	1	1
East Fishkill (T)	0	1	0	0	1	0	0	0	1	1	0	0	0	2	0	0
Fishkill (T)	2	1	0	1	1	0	0	0	1	0	0	0	0	2	0	0
Fishkill (V)	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Hyde Park (T)	1	5	0	3	3	0	0	0	1	0	0	0	0	0	0	0
LaGrange (T)	1	3	0	0	1	0	0	0	3	1	0	0	0	1	1	0
Milan (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Millbrook (V)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Millerton (V)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Northeast (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pawling (T)	0	5	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Pawling (V)	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0
Pine Plains (T)	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleasant Valley (T)	0	4	0	1	2	0	0	1	0	0	0	0	1	0	0	0
Poughkeepsie (C)	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
Poughkeepsie (T)	0	2	3	0	4	4	1	0	0	0	0	1	0	1	0	0
Red Hook (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red Hook (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.4.5-14. Number of Critical Facilities Located in the 1-Percent Annual Chance Flood Zone

Municipality	Facility Types															
	Accommodation	Dam	DPW	Fire Station/EMS	Gas Station	Government	Police	Post Office	Potable Pump	Potable Storage	Rail Facility	School	Town Hall	Well	Wastewater Pump	Wastewater Treatment
Rhinebeck (T)	0	2	1	0	0	0	0	0	1	0	0	0	0	0	0	1
Rhinebeck (V)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Stanford (T)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tivoli (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Union Vale (T)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wappinger (T)	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1
Wappinger Falls (V)	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Washington (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dutchess County (TOTAL)	**6**	**39**	**5**	**9**	**16**	**4**	**1**	**1**	**9**	**5**	**2**	**1**	**1**	**10**	**4**	**4**

Source: FEMA, Dutchess County

Table 5.4.5-15. Number of Critical Facilities Located in the 0.2-Percent Annual Chance Flood Zone

Municipality	Facility Types																	
	Accommodation	Dam	DPW	Fire Station/EMS	Gas Station	Government	Library	Police	Post Office	Potable Pump	Potable Storage	Rail Facility	School	Senior	Town Hall	Well	Wastewater Pump	Wastewater Treatment
Amenia (T)	2	0	0	3	1	0	0	0	0	1	0	1	0	0	0	0	0	0
Beacon (C)	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beekman (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Clinton (T)	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dover (T)	0	1	0	1	0	0	0	0	1	0	0	1	0	1	0	0	1	1
East Fishkill (T)	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	2	0	0
Fishkill (T)	2	1	1	1	3	0	0	0	0	1	0	0	0	0	0	3	0	0
Fishkill (V)	0	0	0	0	3	0	0	0	0	0	0	0	1	0	1	0	0	1
Hyde Park (T)	1	6	0	3	3	0	0	0	0	2	0	0	0	0	0	0	0	0
LaGrange (T)	1	3	0	0	1	0	0	0	0	3	1	0	0	0	0	1	1	0
Milan (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Millbrook (V)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Millerton (V)	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northeast (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.4.5-15. Number of Critical Facilities Located in the 0.2-Percent Annual Chance Flood Zone

Municipality	Facility Types																	
	Accommodation	Dam	DPW	Fire Station/EMS	Gas Station	Government	Library	Police	Post Office	Potable Pump	Potable Storage	Rail Facility	School	Senior	Town Hall	Well	Wastewater Pump	Wastewater Treatment
Pawling (T)	0	5	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Pawling (V)	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
Pine Plains (T)	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pleasant Valley (T)	0	4	0	1	3	0	1	0	1	0	0	0	0	0	1	0	0	0
Poughkeepsie (C)	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0
Poughkeepsie (T)	1	2	3	0	4	4	0	1	0	0	0	0	1	0	0	1	0	0
Red Hook (T)	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Red Hook (V)	0	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Rhinebeck (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rhinebeck (V)	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Stanford (T)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tivoli (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Union Vale (T)	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wappinger (T)	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	2
Wappinger Falls (V)	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Washington (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dutchess County (TOTAL)	**7**	**44**	**7**	**11**	**21**	**4**	**1**	**1**	**2**	**11**	**5**	**2**	**2**	**1**	**2**	**11**	**6**	**5**

Source: FEMA, Dutchess 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 Dutchess 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. According to Table 5.4.5-11, 117 facilities are affected by the 1-percent annual chance flood hazard. 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 estimates the amount of debris generated from the flood events as a result of 1- and 0.2-percent events. 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 5.4.5-16 summarizes the debris HAZUS-MH 2.2 estimates for these events.

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

Table 5.4.5-16. Estimated Debris Generated from the 1-Percent Flood Event

Municipality	1% Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Amenia (T)	2,996	777	1,168	1,050
Beacon (C)	1,677	782	463	431
Beekman (T)	756	340	235	181
Clinton (T)	2,481	932	893	655
Dover (T)	6,406	2,486	1,783	2,137
East Fishkill (T)	10,374	4,894	3,111	2,369
Fishkill (T)	9,873	4,055	2,813	3,004
Fishkill (V)	403	403	0	0
Hyde Park (T)	9,909	2,665	3,780	3,464
LaGrange (T)	7,761	3,022	2,726	2,014
Milan (T)	935	224	416	295
Millbrook (V)	1,527	291	683	553
Millerton (V)	78	77	1	1
Northeast (T)	925	319	338	267
Pawling (T)	5,062	1,247	2,255	1,561

Table 5.4.5-16. Estimated Debris Generated from the 1-Percent Flood Event

Municipality	1% Flood Event Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Pawling (V)	2,213	690	845	678
Pine Plains (T)	3,723	963	1,550	1,210
Pleasant Valley (T)	6,992	2,417	2,611	1,964
Poughkeepsie (C)	8,912	2,995	3,246	2,671
Poughkeepsie (T)	18,882	5,882	7,295	5,705
Red Hook (T)	1,273	672	292	308
Red Hook (V)	22	22	0	0
Rhinebeck (T)	3,070	897	1,087	1,086
Rhinebeck (V)	89	89	0	0
Stanford (T)	2,617	821	1,031	765
Tivoli (V)	586	168	179	238
Union Vale (T)	730	169	294	267
Wappinger (T)	10,546	4,208	3,569	2,769
Wappinger Falls (V)	329	177	85	67
Washington (T)	1,202	379	468	356
Dutchess County (TOTAL)	**122,348**	**43,065**	**43,216**	**36,067**

Source: HAZUS-MH 2.2

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

Dutchess 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 original 2006 HMP and 2010 Eastern Dutchess County AHMP. The original HMP looked at the damages caused by various past storms to describe the assessed risk; the 2010 Eastern Dutchess County AHMP detailed the results from New York State HMP to describe the assessed risk. For the Plan Update, new and updated population (U.S. Census 2010 is now available) and a custom building inventory were used; a more accurate flood depth grid was used to estimate potential losses in HAZUS-MH due to the availability of their DFIRM.

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

Future Growth and Development

As discussed in Sections 4 and 9, areas targeted for future growth and development have been identified across Dutchess County. Any areas of growth could be potentially impacted by the flood hazard if located within the identified hazard areas. Please refer to the specific areas of development indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Additional Data and Next Steps

A HAZUS-MH flood analysis was conducted for Dutchess County using the most current and best available data including updated building and critical facility inventories, and DFIRM. For future plan updates, more accurate loss estimates can be produced by replacing the national default demographic inventory with 2010 U.S. Census data when it becomes available in the HAZUS-MH model.

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