5.4.2 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 Warren County.

5.4.2.1 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

For the purpose of this HMP and as deemed appropriate by the Warren County Steering Committee, riverine, ice jam, flash flood, urban/stormwater, dam failure and flooding due to beaver dams are the main flood types of concern for the County. These types of flooding are 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).

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 2015. 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, Warren County experienced 27 historic ice jam events between 1780 and 2015 (USACE 2015). Ice Jams typically have formed along the English Brook, Glen Creek, Hudson River, and Northwest Bay

Brook (USACE 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 42 dams in Warren County. Of the 42 dams, there are 13 classified as low hazard (Class A), 23 classified as significant hazard (Class B), and five classified as high hazard (Class C) (NPDP 2015). However, these numbers differ from the New York State Inventory of Dams, which identifies 81 dams in Warren County (40 Class A, 13 Class B, 8 class C and 20 Class D).

Flooding Due to Beaver Dams

The beaver is the largest rodent in North America and has a long history in New York State. Beavers construct dams which result in the formation of ponds. Within and around the pond formed by dams, the beaver constructs canals for security and to transport food and building materials. Beaver dams provide wildlife habitat for differ furbearer and waterfowl species. However, the beaver's dam building activity can result in widespread flooding of woodlands and agricultural land (NYS DEC 2015). Beavers can plug culvert pipes and create dams that impound water against roadbeds which may flood or wash out roads. This can damage the roadbed when they become saturated with water and settles (Jensen and Curtis 1999).

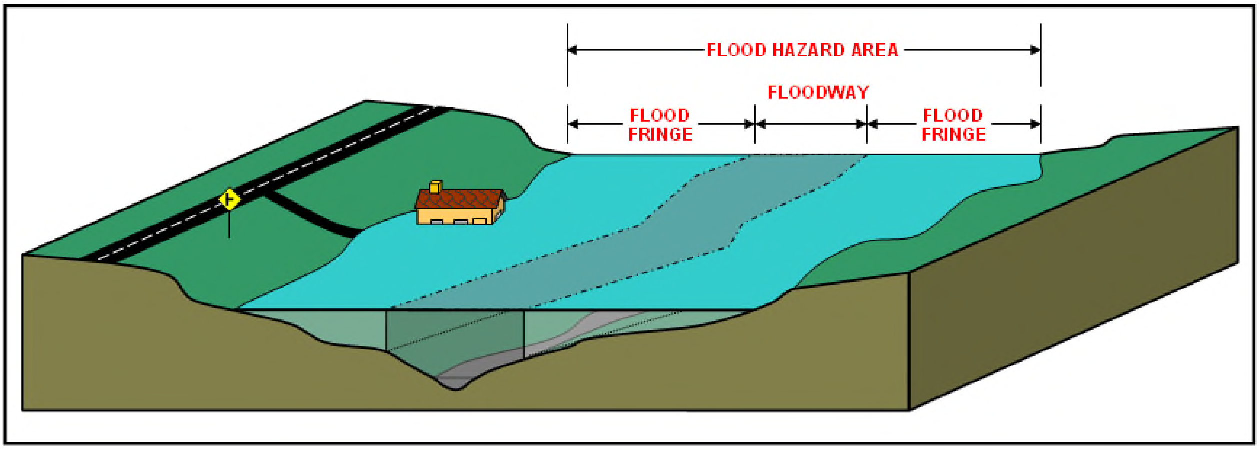
Location

Flooding in Warren County occurs in two broad regions of the County: along the Schroon River in the Riverbank section and along the Hudson River where significant rainfall and rapid snowmelt led to considerable flooding of roadways. Flooding in the County also occurs in areas of beaver dams. Heavy rainfall has the potential to force the destruction of beaver dams on lakes, rivers and streams which leads to cascading effects of downstream flooding of roadways.

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). Similarly, the 500-year flood is more properly defined as the 0.2% annual chance flood.

Figure 5.4.2-1 depicts the flood hazard area, the flood fringe, and the floodway areas of a floodplain.

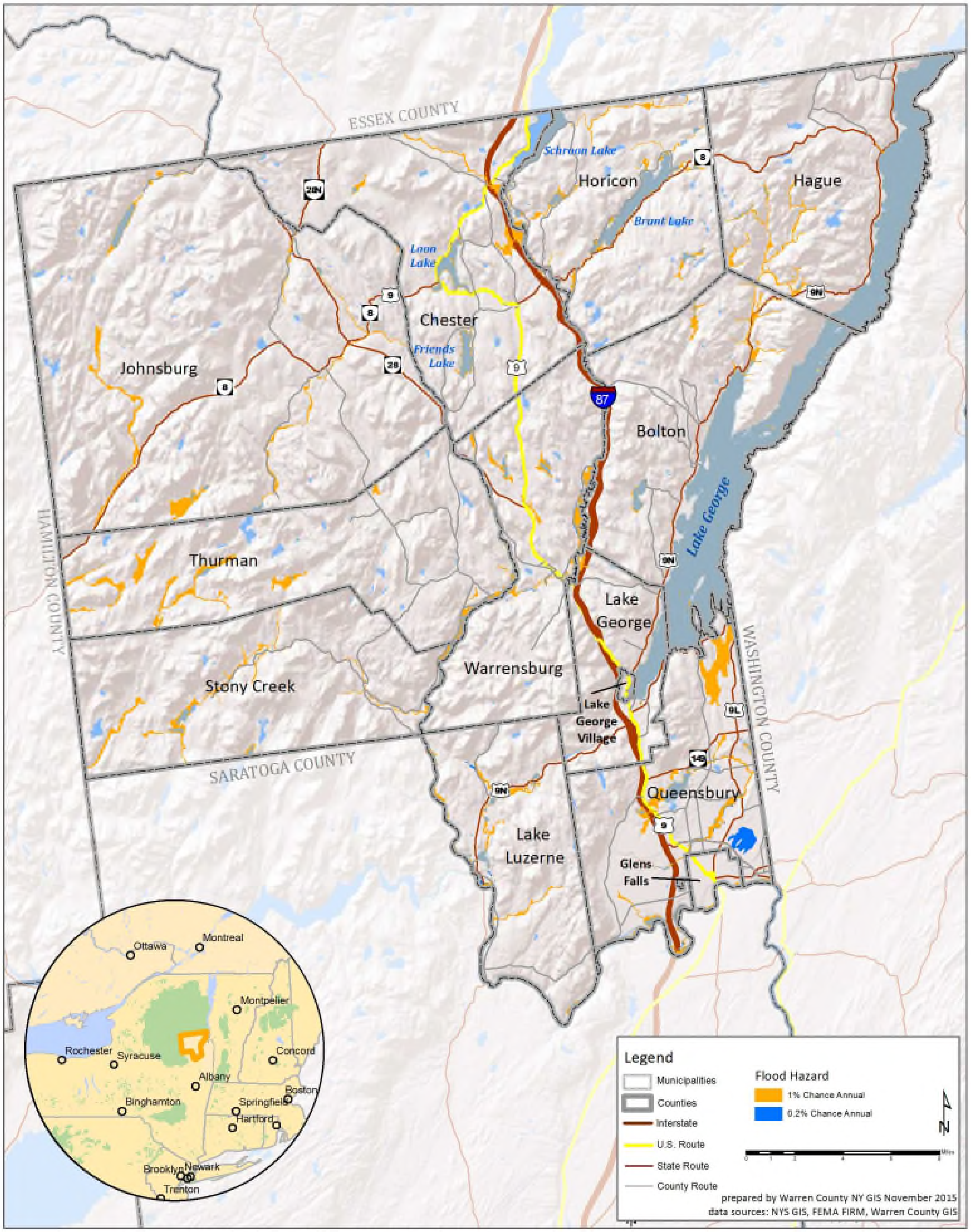
Figure 5.4.2-1. Floodplain



Source: NJDEP, Date Unknown

In Warren 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. Figure 5.4.2-2 illustrates the FEMA flood hazard zones in Warren County. According to this figure, the 1% annual chance of flood hazard zones are located along the Sacandaga River, Schroon River, Hudson River, Stony Creek and southern Lake George.

Figure 5.4.2-2. FEMA Flood Hazard Areas in Warren County



Source: *FEMA*
FEMA *Federal Emergency Management Agency*
Note: *Figure reflects total population of blocks with centroids in the flood zone*

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

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.

The extent of flooding associated with a 1% annual probability of occurrence (the base flood or 100-year flood) is used by the NFIP as the standard for floodplain management and to determine the need for flood insurance, as well as the regulatory flood boundary by many agencies. Also referred to as the Special Flood Hazard Area (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. 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 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 Warren County. With so many sources reviewed for the purpose of this Hazard Mitigation Plan (HMP) update, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP update.

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. Warren County was included in nine of these flood-related declarations.

For this 2015 Plan update, flood events were summarized from 2009 to 2015. Known flood events, including FEMA disaster declarations, which have impacted Warren County between 2009 and 2015 are identified in Table 5.4.2-1. Please see Section 9 for detailed information regarding impacts and losses to each municipality. For events prior to 2009, refer to the 2011 Warren County HMP.

Table 5.4.2-1. Flooding Events in Warren County, 2009 to 2015

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
March 13-31, 2010	Severe Storms and Flooding	DR-1899	Yes	Moderate to heavy rain fell across east-central New York State. The ground was already nearly saturated from recent snow melt, causing rivers and stream to run high. Flooding from this event caused damage to numerous roads in the northern section of Warren County. In the Town of Johnsburg, a bridge was reported washed out on Harrington Road due to a possible beaver dam break along Johnson Brook. Overall, the County had approximately $25,000 in property damage from this event.
October 1, 2010	Flooding (Remnants of Tropical Storm Nicole)	N/A	N/A	The remnants of Tropical Storm Nicole brought very heavy rains to east-central New York State. Rainfall totals from this storm ranged from three to nine inches, resulting in widespread river and small stream and urban flooding, including water in basements. In Warren County, there was standing water reported in the City of Glens Falls at the intersection of Sherman Avenue and Elm Street due to the heavy rains.
March 8-12, 2011	Ice Jam	N/A	N/A	An ice jam began to form on March 7th near the Route 28N bridge in the hamlet of North Creek (Town of Johnsburg). The water that backed up from the ice jam began flooding Old River Road on March 10th, prompting the evacuation of some residents and forced the closing of the road. The water began to recede on March 13th when the ice jam release and moved downstream. As the ice jam moved down the river, it ripped trees from the river bank and then became lodged along the Route 418 bridge in the Town of Thurman on the evening of March 13th. Overall, damage was reported at the County fish hatchery in the Town of Warrensburg and damage to a recreational property from North Creek downstream to Lake Luzerne.
April 28-30, 2011	Severe Storms, Flooding, Tornadoes, and Straight-Line Winds	DR-1993	Yes	Heavy showers and thunderstorms impacted the western and central Mohawk Valley, Adirondack region, and the Upper Hudson River Valley, including the Lake George Region (Warren County). Thunderstorms produced severe weather and very heavy rainfall. The combination of the rainfall and rapid snowmelt due to warm temperatures led to increased runoff and rapid river rises. In Warren County, flooding from this event covered nearly two-thirds of the County. Flooding occurred along the Hudson River in the County from North River southward to the Saratoga County line. Numerous municipalities reported flooding of roadways, houses, and riverside camps. Some properties had several feet of water in them. Many major roadways were closed in the County due to flooding. The North Creek Trailer Park on Route 28 in the Town of Johnsburg was evacuated because water from the Hudson River entered the park. A mudslide in excess of 200 feet occurred on 13th Lake Road in North River/North Creek. In the hamlet of North Creek (Town of Johnsburg), a couple hundred feet of railway tracks were reported under two to five feet of water with several buildings at the train station

Table 5.4.2-1. Flooding Events in Warren County, 2009 to 2015

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
				being flooded as well. In the Town of Stony Creek, the 1,000 Acres Golf Course was flooded with the 9th green under eight feet of water. Flood water receded through April 30th. The County had approximately $676,000 in property damage from this event.
May 27 – June 2, 2011	Flooding	N/A	N/A	Flooding caused severe damage along a thin line through the County and impacted the Towns of Stony Creek, Thurman, Warrensburg, Horicon, and Bolton. The County had $13.125 million in damages from this event.
August 28-30, 2011	Hurricane Irene	DR-4020	Yes	The greatest impact of Irene in eastern New York State was heavy to extreme rainfall which resulted in catastrophic flooding across portions of the region. Rainfall amounts averaged between four and eight inches with amounts of up to 12 inches falling in the eastern Catskills and Schoharie Valley. Three to six inches were common across the Lake George and Saratoga regions. The rainfall resulted in widespread flash flooding and river flooding across eastern New York State. Bridges were closed on major roadways in this area of the State. In Warren County, there was severe wind and flood damage throughout. In the Town of Lake George, Route 9N was flooded from the Route 9/9N spilt south to the ramp for Exit 21 for the Northway. Route 9L was also flooded between Route 9N and Bay Road. Two of the seven docks in the Village of Lake George floated off and were crushed.
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 Warren County, wind gusts of 65 mph pushed down the length of Lake George, creating waves that threatened to spill over the shoreline. Some of the docks along the Lake were damaged but flooding did not occur. In Glens Falls, trees and wires were knocked down from the winds.
February 1, 2013	Ice Jam	N/A	N/A	Massive ice chunks of up to 10 feet thick in spots, broke off near North Creek in Warren County. This created an ice jam on the upper Hudson River near the Town of Thurman. As the ice chunks became lodged, they caused the water behind them to jump the banks, with more than 100 yards of River Road in Thurman over 10 feet of ice chunks. The water receded by midday and the town highway department had to use loaders and backhoes to remove the ice from the roadway.
June 28, 2013	Severe Storms and Flooding	DR-4129	Yes	Heavy rain fell across the Mohawk Valley and western Adirondacks with rates of one inch per hour with three to five inches of rain falling in total. This event, with

Table 5.4.2-1. Flooding Events in Warren County, 2009 to 2015

Dates of Event	Event Type	FEMA Declaration Number	County Designated?	Losses / Impacts
				the combination of a previous rainfall event, led to significant flash flooding across both the Mohawk Valley and Adirondacks. Many roads were washed out and closed. Urbanized areas along the Mohawk River experienced flooding as well. Many communities declared state of emergencies and President Obama signed a major disaster declaration for New York State which included Herkimer, Montgomery and Warren Counties. In Warren County, the Town of Johnsburg experienced severe flooding from this event. Flash flooding occurred in the Bakers Mill section of the Town. Water rescue teams were deployed to several homes that were threatened by flooding. A state of emergency was declared for the Town as a result of flooding.
January 12, 2014	Ice Jam	N/A	N/A	Harrington Road in the Town of Thurman had ice up to scraper banks in some locations and Glen Creek Road was closed due to flooding caused by an ice jam on the Hudson River.
April 13-21, 2014	Flooding	N/A	N/A	Significant snow pack began to melt as a result of an extended period of warm weather. Up to 10 inches of liquid equivalent started melting between April 8th and April 15th. The snow melt caused many rivers and streams in and around the Adirondacks to become very high with a few reaching flood stages just from the snow melt. Heavy rain began to fall in the region on April 15th, bringing up to two inches of rain in the area. The rainfall, combined with the snow melt, caused many rivers to reach moderate flood stage. By April 21st, all rivers in the area were below flood stages. In Warren County, the Schroon River reached major flood stage and remained at this stage for several days. The flooding caused several private roads of homes and vacation properties to be impacted by water. Roads were closed due to flooding in the County.
May 13-22, 2014	Flooding	N/A	N/A	A culvert was washed out in the County.

Sources: NYSDEC 2015; FEMA 2015; NOAA-NCDC 2015; NWS 2015
FEMA Federal Emergency Management Agency
Mph Miles Per Hour
NCDC National Climatic Data Center
NOAA National Oceanic and Atmospheric Administration
N/A Not Applicable

Probability of Future Occurrences

Based on the historic and more recent flood events in Warren County, it is clear that the County will experience flooding and its impacts in the future. It is estimated that Warren County will continue to experience direct and indirect impacts of flooding events annually that may induce secondary hazards such as erosion, infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents and inconveniences.

According to the National Oceanic and Atmospheric Administration (NOAA) National Climate Data Center (NCDC) and the Cold Regions Research and Engineering Laboratory (CRREL) database, Warren County experienced 77 flood events between 1950 and 2015, including 27 floods, 26 flash floods, and 24 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 Warren County in future years (NOAA NCDC 2015; CRREL 2015).

Table 5.4.2-2. Probability of Future Occurrence of Flooding Events

Hazard Type	Number of Occurrences Between 1950 and 2015	Rate of Occurrence	Recurrence Interval (in years)	Probability of Event Occurring in Any Given Year	% Chance of Occurring in Any Given Year
Flash Flood	26	0.40	2.53	0.40	40%
Flood	27	0.41	2.44	0.41	41%
Ice Jam	24	0.37	2.75	0.36	36%

Source: NOAA-NCDC 2015; CRREL 2015

In Section 5.3, the identified hazards of concern for Warren 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 Warren 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 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. Warren County is part of Region 7 (see Figure 5.4.2-3), Adirondack Mountains. Some of the issues in this region, affected by climate change, include: loss of high elevation plants, animals and ecosystem types; decline in winter recreation; decline in milk production, etc. (NYSERDA 2011).

Figure 5.4.2-3. Climate Regions of New York State

Source: 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).

In Region 7, it is estimated that temperatures will increase by 3.7ºF to 7.4ºF by the 2050s and 4.2ºF to 11.8ºF by the 2080s (baseline of 39.9ºF). Precipitation totals will increase between 2 and 15% by the 2050s and 3 to 17% by the 2080s (baseline of 40.8 inches). Table 5.4.2-3 displays the projected seasonal precipitation change for the East Hudson and Mohawk River Valleys ClimAID Region (NYSERDA, 2014).

Table 5.4.2-3. Projected Seasonal Precipitation Change in Region 7, 2050s (% change)

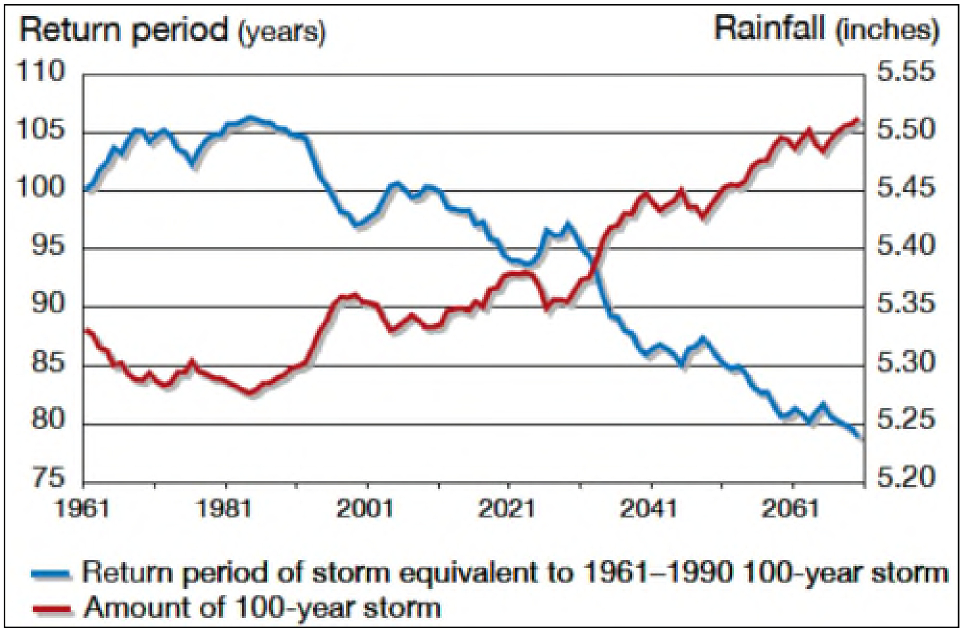
Winter	Spring	Summer	Fall
+5 to +15	-5 to +10	-5 to +5	-5 to +10

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).

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 5.4.2-4 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 5.4.2-4. Projected Rainfall and Frequency of Extreme Storms



Source: NYSERDA 2011

5.4.2.2 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 5.4.2-2). The following text evaluates and estimates the potential impact of flooding for Warren 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 2011 Warren County HMP
- Further data collections that will assist understanding this hazard over time

Overview of Vulnerability

To assess vulnerability, exposure to the one- 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. Figure 5.4.5-1 presented earlier in this section illustrates the flood boundaries used for this vulnerability assessment.

To estimate potential losses, the Hazards U.S. Multi-Hazard (HAZUS-MH) version 2.2 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 2.2 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 2.2 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).

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 one- 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 5.4.2-4.

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 3,447 people are exposed to the one-percent annual chance event and 4,136 people are exposed to the 0.2-percent annual chance flood event. Refer to Table 5.4.2-5 for results by municipality.

Table 5.4.2-4. Total Land Area in the 1-Percent and 0.2-Percent Annual Chance Flood Zones (Acres)

Municipality	Total Population	Population in the SFHA		Population in the 0.2-Percent Annual Chance Flood Zone	
		Total Exposed	% of Total	Total Exposed	% of Total
Town of Bolton	2,343	229	9.8%	229	9.8%
Town of Chester	3,354	185	5.5%	185	5.5%
City of Glens Falls	14,652	0	0.0%	0	0.0%
Town of Hague	856	67	7.8%	67	7.8%
Town of Horicon	1,578	83	5.3%	83	5.3%
Town of Johnsburg	1,956	75	3.8%	75	3.8%
Town of Lake George	3,508	9	0.3%	9	0.3%
Town of Lake Luzerne	3,342	330	9.9%	446	13.3%
Town of Queensbury	27,845	503	1.8%	564	2.0%

Municipality	Total Population	Population in the SFHA		Population in the 0.2-Percent Annual Chance Flood Zone	
		Total Exposed	% of Total	Total Exposed	% of Total
Town of Stony Creek	895	11	1.2%	11	1.2%
Town of Thurman	1,169	41	3.5%	41	3.5%
Town of Warrensburg	4,086	201	4.9%	212	5.2%
Warren County (total)	**65,584**	**1,734**	**2.6%**	**1,922**	**2.9%**

Sources: U.S. Census 2010; FEMA FIRMs; Warren County GIS

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.

The total land area located in the 1-percent and 0.2-percent annual chance flood zones was calculated for each jurisdiction, as presented in Table 5.4.2-5 below.

Table 5.4.2-5. Total Land Area Located in the 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
Town of Bolton	40,853	1,298	3.2%	1,298	3.2%
Town of Chester	53,717	1,488	2.8%	1,488	2.8%
City of Glens Falls	2,486	62	2.5%	62	2.5%
Town of Hague	41,185	1,051	2.6%	1,051	2.6%
Town of Horicon	41,932	1,554	3.7%	1,554	3.7%
Town of Johnsburg	132,322	2,247	1.7%	2,247	1.7%
Town of Lake George	18,607	267	1.4%	267	1.4%
Village of Lake George	394	12	3.0%	12	3.0%
Town of Lake Luzerne	33,991	1,153	3.4%	1,207	3.6%
Town of Queensbury	39,873	2,627	6.6%	3,168	7.9%
Town of Stony Creek	53,058	1,406	2.6%	1,406	2.6%
Town of Thurman	56,931	2,010	3.5%	2,010	3.5%
Town of Warrensburg	40,861	1,776	4.3%	1,819	4.5%
Warren County (total)	**556,210**	**16,951**	**3.0%**	**17,589**	**3.2%**

Source: FEMA FIRMs; Warren County GIS
Note: Totals do not include waterbodies

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 flood boundary were totaled for each municipality. Table 5.4.2-6 summarizes these results. In summary, there are 823 buildings located in the 1-percent annual chance flood boundary with an estimated $265 million of building/contents exposed. This represents approximately 1.7% of the County's total general building stock replacement value inventory (greater than $15 billion).

There 876 buildings located in the 0.2-percent annual chance flood boundary with an estimated $278 million of building/contents exposed. This represents approximately 1.8% of the County's total general building stock replacement value inventory.

Table 5.4.2-6. Estimated General Building Stock Exposure to the 1-Percent and 0.2-Percent Annual Chance Flood Events – All Occupancies

Municipality	Total # Buildings	Total RCV (Structure and Contents)	Total (All Occupancies)							
			1% Chance Event				0.2% Chance Event			
			# Buildings	% Total	RCV	% Total	# Buildings	% Total	RCV	% Total
Bolton	2,575	$960,513,000	39	1.5%	$7,265,557	0.8%	39	1.5%	$7,265,557	0.8%
Chester	2,668	$800,772,000	244	9.1%	$56,427,332	7.0%	244	9.1%	$56,427,332	7.0%
Glens Falls	5,483	$3,290,154,000	2	0.0%	$18,934,062	0.6%	2	0.0%	$18,934,062	0.6%
Hague	1,136	$400,664,000	14	1.2%	$6,321,928	1.6%	14	1.2%	$6,321,928	1.6%
Horicon	1,907	$589,719,000	91	4.8%	$23,768,292	4.0%	91	4.8%	$23,768,292	4.0%
Johnsburg	1,762	$563,005,000	48	2.7%	$16,254,734	2.9%	48	2.7%	$16,254,734	2.9%
Lake George	1,949	$712,923,000	4	0.2%	$1,375,354	0.2%	4	0.2%	$1,375,354	0.2%
Lake George Village	623	$397,549,000	5	0.8%	$5,837,503	1.5%	5	0.8%	$5,837,503	1.5%
Lake Luzerne	2,215	$743,990,000	137	6.2%	$29,000,180	3.9%	160	7.2%	$33,906,685	4.6%
Queensbury	11,858	$5,897,513,000	158	1.3%	$76,086,432	1.3%	175	1.5%	$81,477,089	1.4%
Stony Creek	603	$143,567,000	8	1.3%	$1,828,467	1.3%	8	1.3%	$1,828,467	1.3%
Thurman	818	$328,601,000	3	0.4%	$945,932	0.3%	3	0.4%	$945,932	0.3%
Warrensburg	1,974	$647,352,000	70	3.5%	$20,854,712	3.2%	83	4.2%	$24,216,725	3.7%
Warren County (total)	**35,571**	**$15,476,322,000**	**823**	**2.3%**	**$264,900,485**	**1.7%**	**876**	**2.5%**	**$278,559,660**	**1.8%**

Sources: Total # buildings and total RCV from HAZUS 2.2, 2010 census
Notes: GBS exposure figures generated using WCGIS digitized FEMA FIRM floodplains, current address WCGIS rooftop points. RCV calculated using HAZUS 2015 RCV spreadsheet figures, adjusted for 2015, and WC Real Property data

Table 5.4.2-7. Estimated General Building Stock Exposure to the 1-Percent and 0.2-Percent Annual Chance Flood Events – Residential Occupancy Class

Municipality	Total # Buildings (residential)	Total RCV (Structure and Contents - Residential)	Residential							
			1% Chance Event				0.2% Chance Event			
			# Buildings	% Total	RCV	% Total	# Buildings	% Total	RCV	% Total
Town of Bolton	2,448	$822,981,000	39	1.6%	$7,265,557	0.9%	39	1.6%	$7,265,557	0.9%
Town of Chester	2,526	$651,334,000	237	9.4%	$52,376,883	8.0%	237	9.4%	$52,376,883	8.0%
City of Glens Falls	4,791	$1,701,949,000	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Town of Hague	1,101	$353,406,000	11	1.0%	$3,068,854	0.9%	11	1.0%	$3,068,854	0.9%
Town of Horicon	1,857	$551,024,000	87	4.7%	$22,552,170	4.1%	87	4.7%	$22,552,170	4.1%
Town of Johnsburg	1,667	$432,270,000	44	2.6%	$10,152,586	2.3%	44	2.6%	$10,152,586	2.3%
Town of Lake George	2,369	$626,563,000	4	0.2%	$1,375,354	0.2%	4	0.2%	$1,375,354	0.2%
Lake George Village	509	$231,547,000	2	0.4%	$829,188	0.4%	2	0.4%	$829,188	0.4%
Town of Lake Luzerne	2,079	$630,992,000	137	6.6%	$29,000,180	4.6%	160	7.7%	$33,906,685	5.4%
Town of Queensbury	10,883	$4,109,512,000	141	1.3%	$36,682,951	0.9%	154	1.4%	$40,362,867	1.0%
Town of Stony Creek	578	$127,417,000	8	1.4%	$1,828,467	1.4%	8	1.4%	$1,828,467	1.4%
Town of Thurman	703	$139,453,000	3	0.4%	$945,932	0.7%	3	0.4%	$945,932	0.7%
Town of Warrensburg	1,834	$456,079,000	65	3.5%	$13,968,552	3.1%	76	4.1%	$16,484,201	3.6%
Warren County (total)	**33,345**	**$10,834,527,000**	**778**	**2.3%**	**$180,046,674**	**1.7%**	**825**	**2.5%**	**$191,148,744**	**1.8%**

Sources: Total # buildings and total RCV from HAZUS 2.2, 2010 census
Notes: GBS exposure figures generated using WCGIS digitized FEMA FIRM floodplains, current address WCGIS rooftop points. RCV calculated using HAZUS 2015 RCV spreadsheet figures, adjusted for 2015, and WC Real Property data

Table 5.4.2-8. Estimated General Building Stock Exposure to the 1-Percent and 0.2-Percent Annual Chance Flood Events – Commercial Occupancy Class

Municipality	Total # Buildings	Total RCV (Structure and Contents)	Commercial							
			1% Chance Event				0.2% Chance Event			
			# Buildings	% Total	RCV	% Total	# Buildings	% Total	RCV	% Total
Town of Bolton	94	$115,676,000	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Town of Chester	90	$86,730,000	2	2.2%	$774,139	0.9%	2	2.2%	$774,139	0.9%
City of Glens Falls	504	$1,246,369,000	1	0.2%	$6,180,680	0.5%	1	0.2%	$6,180,680	0.5%
Town of Hague	22	$21,734,000	2	9.1%	$2,588,221	11.9%	2	9.1%	$2,588,221	11.9%
Town of Horicon	32	$26,186,000	3	9.4%	$1,035,354	4.0%	3	9.4%	$1,035,354	4.0%
Town of Johnsburg	49	$73,903,000	3	6.1%	$2,134,911	2.9%	3	6.1%	$2,134,911	2.9%
Town of Lake George	60	$60,622,000	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Village of Lake George	84	$132,516,000	3	3.6%	$5,008,315	3.8%	3	3.6%	$5,008,315	3.8%
Town of Lake Luzerne	88	$74,280,000	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Town of Queensbury	693	$1,348,304,000	15	2.2%	$33,488,358	2.5%	**19**	2.7%	$35,199,099	2.6%
Town of Stony Creek	16	$10,906,000	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Town of Thurman	95	$175,935,000	0	0.0%	$0	0.0%	0	0.0%	$0	0.0%
Town of Warrensburg	89	$138,060,000	5	5.6%	$6,886,160	5.0%	7	7.9%	$7,732,524	5.6%
Warren County (total)	**1,916**	**$3,511,221,000**	**34**	**1.8%**	**$58,096,138**	**1.7%**	**40**	**2.1%**	**$60,653,243**	**1.7%**

Sources: Total # buildings and total RCV from HAZUS 2.2, 2010 census
Notes: GBS exposure figures generated using WCGIS digitized FEMA FIRM floodplains, current address WCGIS rooftop points. RCV calculated using HAZUS 2015 RCV spreadsheet figures, adjusted for 2015, and WC Real Property data

Table 5.4.2-9. Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event

Municipality	Total RCV	All Occupancies		Residential		Commercial	
		Estimated Loss (RCV)	% of Total	Estimated Loss (RCV)	% of Total	Estimated Loss (RCV)	% of Total
Bolton	$960,513,000	$6,386,000	0.7%	$5,818,000	0.6%	$0	0.0%
Chester	$800,772,000	$15,498,000	1.9%	$12,713,000	1.6%	$1,863,000	0.2%
Glens Falls	$3,290,154,000	$2,174,000	0.1%	$0	0.0%	$653,000	0.0%
Hague	$400,664,000	$225,000	0.1%	$225,000	0.1%	$0	0.0%
Horicon	$589,719,000	$16,599,000	2.8%	$14,489,000	2.5%	$1,477,000	0.3%
Johnsburg	$563,005,000	$8,912,000	1.6%	$6,946,000	1.2%	$362,000	0.1%
Lake George	$712,923,000	$1,495,000	0.2%	$1,424,000	0.2%	$0	0.0%
Lake George Village	$397,549,000	$3,277,000	0.8%	$1,206,000	0.3%	$1,866,000	0.5%
Lake Luzerne	$743,990,000	$23,399,000	3.1%	$20,378,000	2.7%	$0	0.0%
Queensbury	$5,897,513,000	$61,169,000	1.0%	$23,984,000	0.4%	$34,305,000	0.6%
Stony Creek	$143,567,000	$4,777,000	3.3%	$4,364,000	3.0%	$0	0.0%
Thurman	$328,601,000	$990,000	0.3%	$837,000	0.3%	$0	0.0%
Warrensburg	$647,352,000	$18,978,000	2.9%	$10,472,000	1.6%	$4,749,000	0.7%
Warren County (Total)	**$15,476,322,000**	**$163,879,000**	**1.1%**	**$102,856,000**	**0.7%**	**$45,275,000**	**0.3%**

Source: HAZUS MH 2.2, 2010 census data

NFIP Statistics

In addition to total building stock modeling, individual data available on flood policies, claims, Repetitive Loss properties (RL) and Severe Repetitive Loss properties (SRLs) were analyzed. FEMA Region 2 provided a list of properties with NFIP policies, past claims and multiple claims (RL/SRL) as of 11/30/2014.

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."

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 5.4.2-10 summarizes the NFIP policies, claims and repetitive loss statistics for Warren County as of 11/30/2014.

Table 5.4.2-10. 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)
Town of Bolton	13	5	$40,328	0	0	2
Town of Chester	32	28	$92,183	1	0	14
City of Glens Falls	8	0	$0	0	0	1
Town of Hague	15	1	$8,021	0	0	5
Town of Horicon	16	6	$104,432	0	0	8
Town of Johnsburg	11	3	$56,870	0	0	6
Town of Lake George	8	6	$54,723	0	0	2
Village of Lake George	6	4	$97,902	0	0	1
Town of Lake Luzerne	49	18	$786,405	0	0	35
Town of Queensbury	76	42	$1,159,853	0	0	29
Town of Stony Creek	2	1	$2,355	0	0	1
Town of Thurman	2	4	$85,530	0	0	2
Town of Warrensburg	21	3	$11,649	0	0	13
Warren County (Total)	**259**	**121**	**$2,500,251**	**1**	**0**	**119**

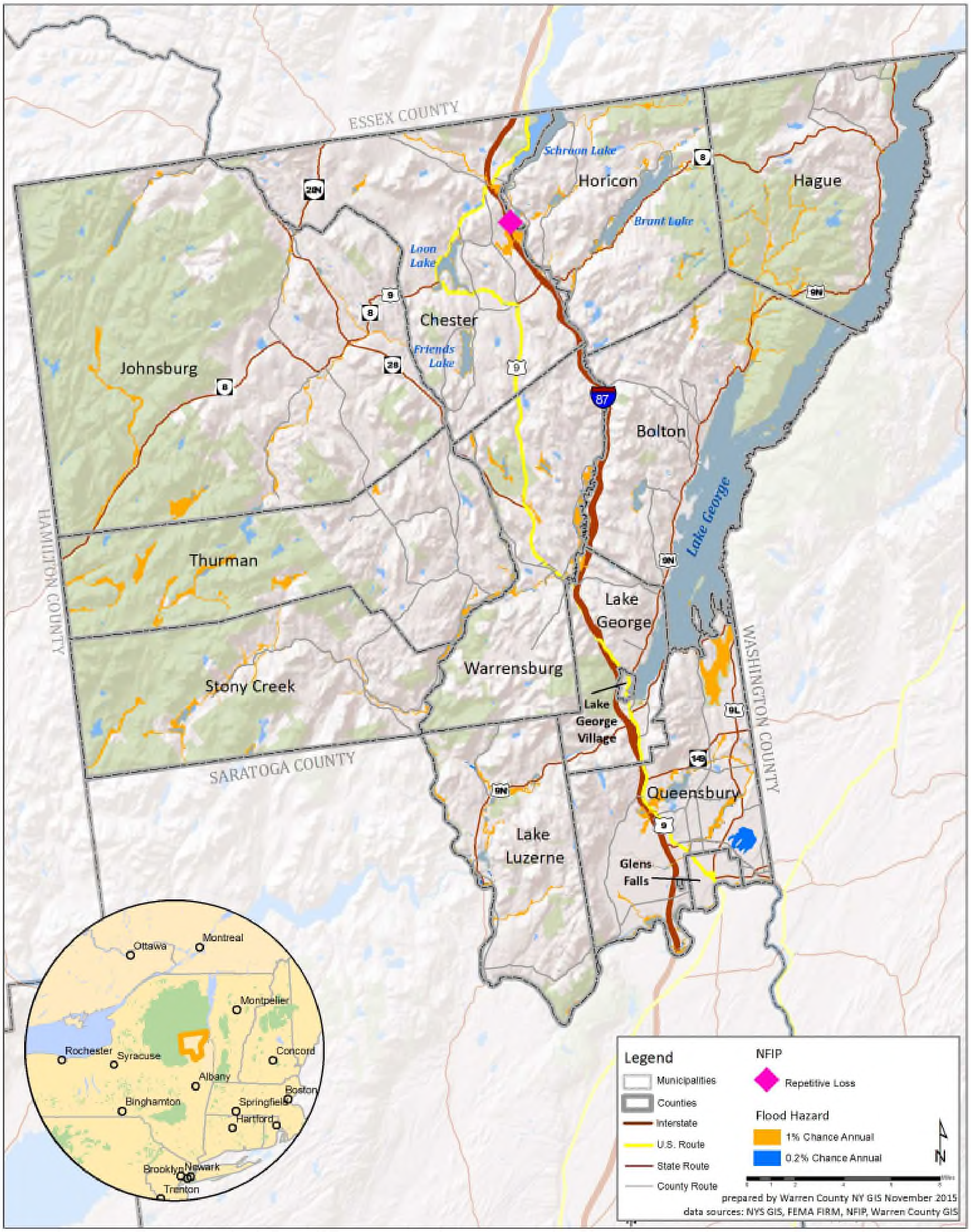
Source: FEMA, 2014
Note (1) Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA and are current as of November 30, 2015 and are summarized by Community Name. Please note the total number of repetitive loss properties excludes the severe repetitive loss properties. The number of claims represents claims closed by 11/30/2015.
Note (2) Total building and content losses from the claims file provided by FEMA Region 2.
Note (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.
Note (4) 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.

The NFIP provided data included only one RL property with the occupancy classes as follows:

- Town of Chester – Single-family residential

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.

Figure 5.4.2-5. NFIP Repetitive Loss Areas – Warren County



Sources: *NYS GIS; FEMA FIRM; NFIP; Warren County GIS*
Note: *Figure reflects total population of blocks with centroids in the flood zone*

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 5.4.2-11 and Table 5.4.2-12 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 5.4.2-11. Number of Critical Facilities Located in the 1-Percent Annual Chance Flood Boundaries

Municipality	Facility Types in 1% Chance Flood Boundary						
	Boat Facilities	Dam	Electric	Government	Highway Bridge	Rail Facility	Wastewater
Bolton	1	0	0	0	5	0	0
Chester	2	3	0	0	9	0	0
Glens Falls	0	0	0	0	0	0	1
Hague	1	0	0	0	2	0	0
Horicon	1	3	0	3	3	0	0
Johnsburg	2	2	0	1	22	0	0
Lake Luzerne	2	3	0	0	6	0	0
Lake George (T)	1	0	0	0	0	0	0
Lake George (V)	0	0	0	0	0	0	0
Queensbury	0	3	0	0	6	0	0
Stony Creek	0	1	0	0	6	0	0
Thurman	0	1	0	0	2	0	0
Warrensburg	0	1	0	2	7	0	0
Warren County	**10**	**17**	**0**	**6**	**68**	**0**	**1**

Table 5.4.2-12. Number of Critical Facilities Located in the 0.2-Percent Annual Chance Flood Boundaries

Municipality	Facility Types in 0.2% Chance Flood Boundary						
	Boat Facilities	Dam	Electric	Government	Highway Bridge	Rail Facility	Wastewater
Bolton	1	0	0	0	5	0	0

Municipality	Facility Types in 0.2% Chance Flood Boundary						
	Boat Facilities	Dam	Electric	Government	Highway Bridge	Rail Facility	Wastewater
Chester	2	3	0	0	9	0	0
Glens Falls	0	0	0	0	0	0	1
Hague	1	0	0	0	2	0	0
Horicon	1	3	0	3	3	0	0
Johnsburg	2	2	0	1	22	0	0
Lake Luzerne	2	3	0	0	6	0	0
Lake George (T)	1	0	0	0	0	0	0
Lake Gorge (V)	0	0	0	0	0	0	0
Queensbury	0	3	0	0	6	0	0
Stony Creek	0	1	0	0	6	0	0
Thurman	0	1	0	0	2	0	0
Warrensburg	0	1	0	2	7	0	0
Warren County	**10**	**17**	**0**	**6**	**68**	**0**	**1**

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 Warren 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).

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 1-percent annual chance 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 5.4.2-13 summarizes the debris HAZUS-MH 2.1 estimates for these events.

Table 5.4.2-13. Estimated Debris Generated from the 1-Percent Flood Event

Municipality	1% Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Bolton	1,511	318	704	489
Chester	2,500	509	1,112	879
Glens Falls	0	0	0	0
Hague	37	9	17	11
Horicon	2,868	585	1,254	1,029
Johnsburg	1,733	318	783	632
Lake George	198	52	79	67
Lake George Village	323	61	176	85
Lake Luzerne	3,779	761	1,678	1,340
Queensbury	3,604	768	1,584	1,252
Stony Creek	1,104	199	532	373
Thurman	183	37	79	67
Warrensburg	4,242	717	1,854	1,672
Warren County (total)	**5,753**	**1,035**	**2,558**	**2,161**

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

Warren 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. 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 Warren 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. It is the intention of the County 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 Warren County using the most current and best available data including updated building and critical facility inventories. For future plan updates, more accurate exposure and 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.