5.4.5 Flood

Hazard Profile

Hazard Description

A flood is an overflow of water from oceans, rivers, groundwater, or rainfall that submerges areas that are usually dry. This natural phenomenon can be exacerbated by features of the built environment.

Flood is a natural hazard that can occur during any season. Flooding typically occurs during prolonged rainfalls over several days, intense rainfalls over a short period of time, or when an ice or debris jam causes a river or stream to overflow onto the surrounding area. The most common cause of flooding is due to rain or snowmelt that accumulates faster than soils can absorb it, or rivers can carry it away. Flooding can also result from the failure of a water control structure.

Flooding events are a common occurrence in Warren County. A variety of flood types, such as riverine, stormwater and urban, and saturated ground failure can cause widespread damage throughout rural and urban areas, causing loss of life, injury, and severe water damage to residential and commercial buildings, bridge and road closures, transit service disruptions, and damage to electrical and communication networks and agriculture.

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, 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

For the purpose of this HMP and as deemed appropriate by the Warren County Steering Committee, riverine, flash flood, urban/stormwater, ice jam, and saturated ground failure are the main flood types of concern for the County. These types of flooding are further discussed below (New York State 2019) (Warren County 2017).

Riverine

Riverine Flooding, or fluvial flooding, is when streams and rivers exceed the capacity of their natural or constructed channels to accommodate water flow and water overflows the banks, spilling out into adjacent low-lying, dry land (FEMA 2019). This occurs when the flow of a river exceeds the bank

sides and causes damage or obstruction to a nearby floodplain. Riverine flooding can turn into a flash flood if the river is at or above its flood stage and if the soil is saturated.

Flash

A flash flood is a rapid inundation of low-lying areas caused by heavy rain associated with severe thunderstorms, tropical systems, or melting water from ice or snow. Flash flooding also occurs far away from water bodies when a large volume of water cannot be absorbed by the soil or storm water systems and travels overland unimpeded.

Figure 5.4.5-1. Warren County March 2022 Ice Jam

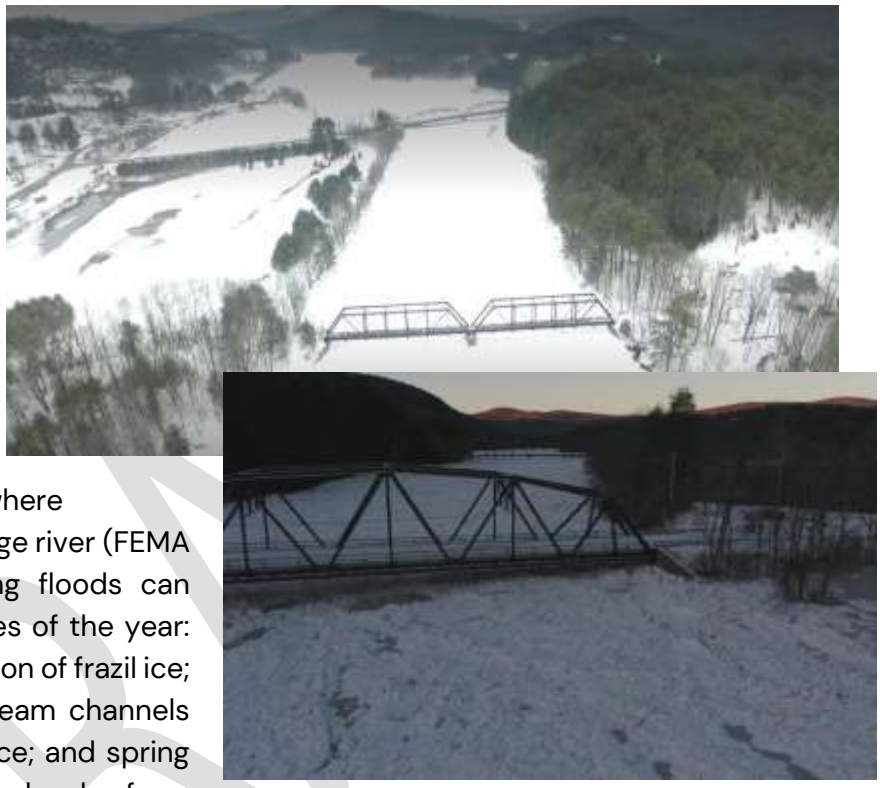
Urban/Stormwater

Local (urban) drainage systems collect groundwater from heavy rainfall in developed areas. Water that does not evaporate or become absorbed by the ground is carried by conduits to waterways such as creeks, rivers, or the ocean. These systems have two purposes: 1) to control storm water runoff during periods of heavy rainfall; and 2) to minimize disruption of activity from more frequently occurring, less significant storms. Flooding occurs when runoff exceeds system capacity, or because systems are blocked from lack of maintenance. Flooding which results from poorly designed or blocked drainage systems is categorized as flash flooding.

Ice Jam

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 (NESEC 2021).

Figure 5.4.5-2. Warren County January 2018 Ice Jam and Flood



The formation of ice jams depends on the weather and physical condition of the river and stream channels. Ice jams are common in locations where the channel slope changes from relatively steep to mild and where a tributary stream enters a large river (FEMA 2018). 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 (New York State 2019).

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 (FEMA 2018).

Saturated Ground Failure

High groundwater flooding occurs when heavy precipitation causes the water table to rise. As rainwater from high ground accumulates in low-lying areas, the water table rises to the surface, causing the ground to be completely saturated. When the water table rises through a slope, there may be a point at which the water table is above the ground level (see Figure 5.4.X-1). If this happens, the water will flow over the surface as it cannot seep into the ground – this is groundwater 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 period of above-average precipitation.

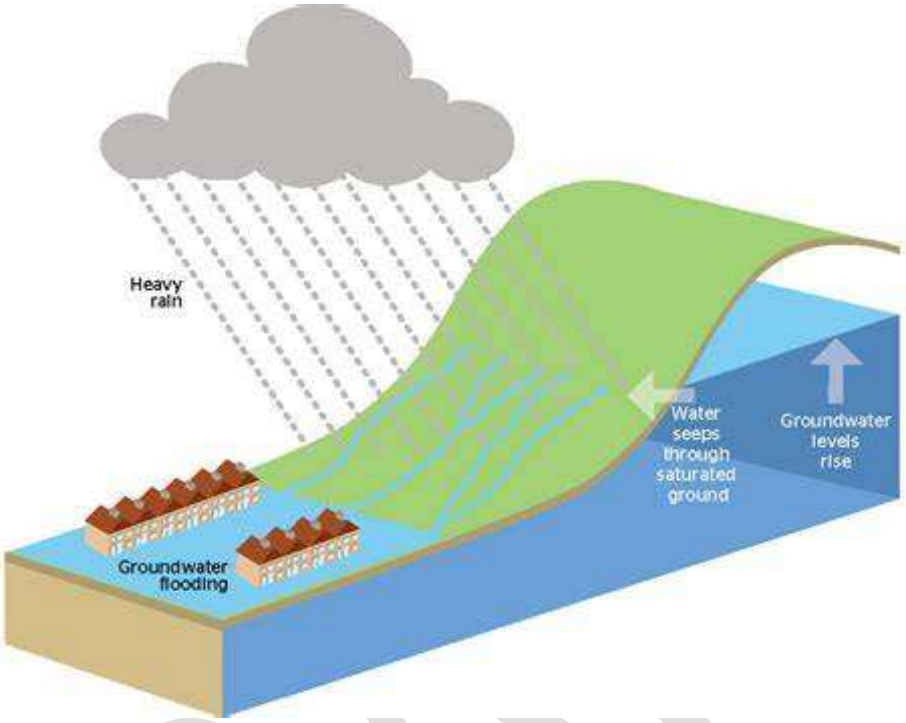


Figure 5.4.X-1: Groundwater Flooding Diagram Source: (Flood Guidance UK 2017)

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 lead 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.

Floodplain

A floodplain is flat land adjacent to a river, creek, or stream that is subject to periodic inundation. The floodplain describes the area inundated by the "100-year" flood, or a flood that has a 1% chance in any given year of being equaled or exceeded. A floodplain is designated when floodwater exceeds the capacity of the main channel, or water escapes the channel through bank erosion. During inundation, silt is deposited by retreating floodwater and trapped by vegetation, building up the floodplain. Buildup is greatest near the stream, forming natural levees in areas of stable banks. Floodplain deposits, which are coarsest near the stream, may show vertical size-graded stratification (sorting). The floodplain is an integral part of a stream system and is affected by adjustments the system makes to its sediment load and variable flow. The stream system is a network that collects fresh water from the land and carries it to the ocean. As such, floodplain deposits and floodplain development affect a larger natural structure than might first be appreciated (National Geographic 2022).

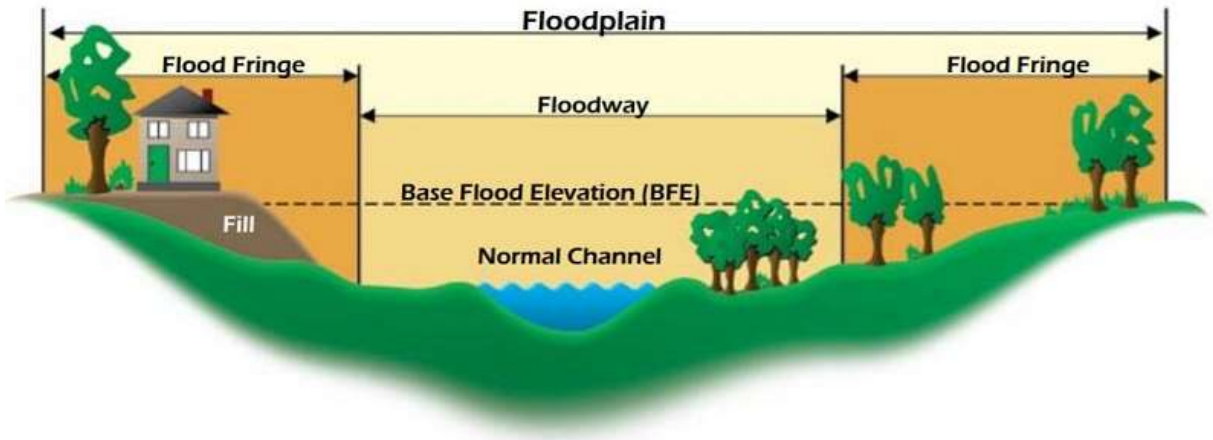


Figure 5.4.X-2: Characteristics of a Floodplain Source: (FEMA 2022)

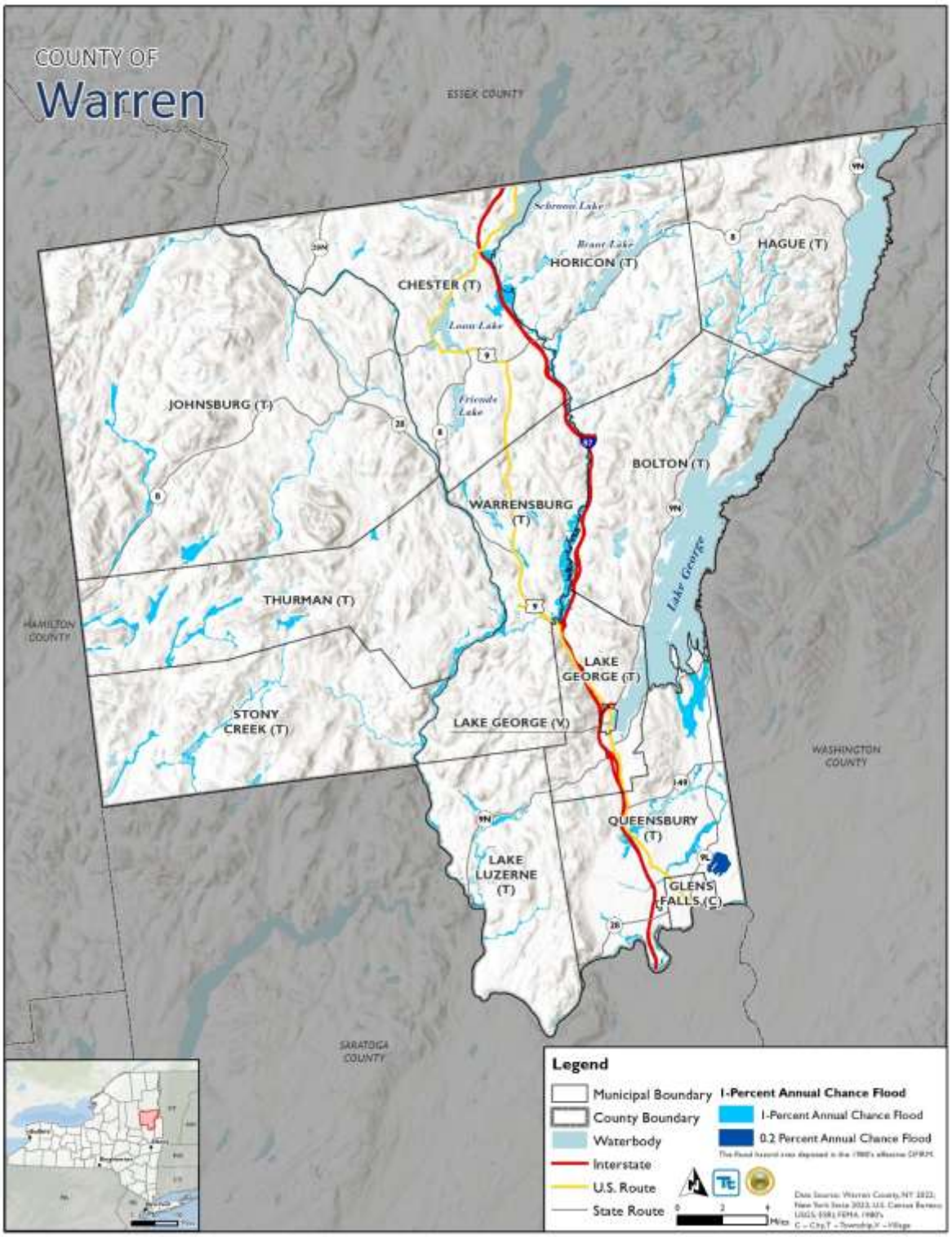
Floodplains serve multiple functions. They moderate flooding, maintain water quality, recharge groundwater, reduce erosion, redistribute sand and sediment, and support fish and wildlife habitat. Areas subject to flooding include the following:

- Locations that experience greater than the 1% annual chance flood, often referred to as the 100-year flood.
- Those subject to less extensive, more frequent, or repetitive flooding.
- Sites that experience shallow flooding, storm water flooding, or drainage problems that do not meet the National Flood Insurance Program (NFIP) mapping criteria.
- Twenty percent of flood insurance claims are from properties in these areas.
- Places affected by flood-related hazards such as riverine erosion.
- Locations that will flood in the future because of sea level rise and upstream

(National Geographic 2022) (FEMA 2022)

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 5.4.5-3. FEMA Flood Hazard Zones in Warren County 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 (Warren County 2017).

Figure 5.4.5-3. FEMA Flood Hazard Zones in Warren County



Extent

The strength or magnitude of a flood varies based on meteorological, environmental, and geological factors, including latitude, altitude, topography, and atmospheric conditions. Flood is also affected by seasonal variation, storm characteristics, warning time, speed of onset, and duration. Most floods are preceded by a warning period that allows emergency managers to communicate the need to prepare for the event. A flood may last from minutes to days (O'Connor, Grant and Costa 2002).

Warnings issued through official sources, such as the National Weather Service (NWS) and the Storm Prediction Center, provide the most reliable and timely preparedness information, but the exact flood location and depth depends on the amount, duration, and location of rainfall. Many floods, especially flash floods, occur outside of FEMA-designated flood zones.

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.

(NOAA 2021)

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 (FEMA 2022).

Previous Occurrences

The National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center's (NCDC) Storm Events Database documented 79 flood events occurring locally between 1950 and 2022. Between January 01, 2017 and June 30, 2022, there were 9 "flash flood" events and 15 "flood" events. The number and types of events are described in Table 5.4.X-2 (NOAA 2022).

FEMA Major Disaster and Emergency Declarations

Between 1954 and 2022, Warren County was included in 1 disaster (DR) or emergency (EM) declarations for flood-related events. Generally, these disasters cover a wide region of the State; therefore, they can impact many counties. However, not all counties were included in the disaster declarations as determined by FEMA (FEMA 2022). Detailed information about the declared disasters since 1954 is provided in Section 4 (County Profile).

USDA Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2012 and 2022, Warren County was included in 2 flood-related agricultural disaster declarations.

Previous Events

For this 2023 HMP update, known flood events that impacted Warren County between 2017 and 2022 are discussed below. For events prior to 2017, refer to Appendix E (Supplementary Data).

Table 5.4.5-1. Flood Events in Warren County (2017 to 2022)

Date(s) of Event	Event Type	FEMA and/or USDA Declaration Number (if applicable)	Warren County included in Declaration?	Description
07/01/2017	Flash Flood, Heavy Rain	N/A	N/A	An upper-level disturbance interacted with a very moist atmosphere on July 1, generating several rounds of thunderstorms across areas mainly along and north

Date(s) of Event	Event Type	FEMA and/or USDA Declaration Number (if applicable)	Warren County included in Declaration?	Description
				of I-90. These storms resulted in torrential rainfall and flash flooding in portions of Herkimer, Fulton, Warren, Washington, and Rensselaer Counties. It was the second straight day of heavy rainfall for some of these areas. Warren County estimated $1 million in flood damage.
01/13/2018	Flood, Ice Jam	N/A	N/A	After a frigid end of December and beginning of January, an unseasonably warm airmass was pumped into New York on January 12th on southerly winds. The temperatures reached the 50s and 60s during the day. Showers also developed in the warm airmass ahead of a cold front and were heavy at times, with some locations receiving one to three inches of rainfall. The combination of warm temperatures and heavy rainfall caused river ice to dislodge and resulted in ice jams in spots. Flooding occurred due to a combination of ice jam movement and heavy rainfall. Several roads were closed or damaged.
01/28/2018	Flood, Ice Jam	N/A	N/A	Minor flooding occurred in the vicinity of a long-lived ice jam along the Hudson River between The Glen and Warrensburg. River Road near Snake Rock in the Town of Thurman was closed due to ice jam flooding. There was four inches of water flowing across the road.
02/22/2018	Flood, Ice Jam	N/A	N/A	A large ice jam remained in place on the Mohawk River for much of the month of February. The ice jam stretched up to 17 miles from Rexford to Crane Hollow throughout the month in February. The ice jam mainly remained in place into late February. Temperatures skyrocketing into the 60s and 70s on February 20-21 coupled with around 0.50-1.00 rainfall on the 19th over the Mohawk basin allowed river levels to rise and flooding occurred by the 21st within the Stockade neighborhood of Schenectady and across the river in Scotia, as well as backwater flooding of the Alplaus Kill. A substantial

Date(s) of Event	Event Type	FEMA and/or USDA Declaration Number (if applicable)	Warren County included in Declaration?	Description
				portion of the ice jam gave way during the early morning hours of the 22nd, leading to concern for flooding in the downstream communities, but it turned out that impacts were minimal. There were some road closures in the Rotterdam Junction and Schenectady area due to the ice jam movement and breakage. The remainder of the jam gradually broke up over the next week or so with little impact.
07/23/2018	Excess Precipitation	USDA, S4479	Yes	Excessive rains and flooding during the 2018 farming season influenced the Secretary of the USDA to declare a disaster designation for 20 New York Counties, including Allegany, Broome, Chautauqua, Cortland, Dutchess, Erie, Essex, Franklin, Herkimer, Livingston, Madison, Oneida, Ontario, Oswego, Putnam, Rensselaer, St. Lawrence, Saratoga, Schuyler, Tompkins, Ulster, Warren, Warren, Wyoming, and Yates Counties.
4/1/2019	Excess Precipitation	USDA, S4622	Yes	Severe weather, heavy flooding, and excessive rains during the 2019 farming season influenced the Secretary of the USDA to declare a disaster designation for 43 Upstate New York Counties, including Albany, Allegany, Cattaraugus, Cayuga, Chautauqua, Chemung, Chenango, Clinton, Columbia, Delaware, Erie, Essex, Franklin, Fulton, Genesee, Greene, Hamilton, Herkimer, Jefferson, Lewis, Livingston, Madison, Monroe, Montgomery, Niagara, Oneida, Onondaga, Ontario, Orleans, Oswego, Otsego, Rensselaer, Saratoga, Schenectady, Schoharie, Schuler, Seneca, Steuben, Sullivan, Tioga, Washington, Wyoming, and Yates Counties.
04/20/2019	Flood, Heavy Rain / Snow Melt	N/A	N/A	Heavy rain, combined with snow melt from the Adirondacks, caused the Schroon River at Riverbank to rise above flood stage for several days. River levels reached moderate flood stage on Saturday, April 20th and remained there through Thursday, April 25th. The high-water levels resulted in water making its way into

Date(s) of Event	Event Type	FEMA and/or USDA Declaration Number (if applicable)	Warren County included in Declaration?	Description
				numerous homes and onto several roads across northern Warren County.
06/20/2019	Flash Flood, Heavy Rain	N/A	N/A	A low-pressure system tracked across the region on Thursday, June 20th, 2019, bringing periods of heavy rainfall throughout the day. This resulted in road closures in Warren County.
10/31/2019	Severe Storms and Flooding	FEMA, 4472-DR	Yes	A strengthening low-pressure system moving from Ohio to Lake Ontario drew anomalous warmth and moisture northward, with temperatures surging into the 60s and 70s over eastern New York and western New England. Showers across the southern Adirondacks and Mohawk Valley became steadier and heavier during the evening ahead of a strong cold front as the low continued to strengthen. Strong winds aloft mixed down to the surface as an intense line of showers developed along the front, resulting in sporadic wind damage and scattered power outages over eastern New York. A large swath of rainfall totaling 2-5 inches, with isolated areas as high as 7 inches, occurred over the Mohawk Valley and southern Adirondacks, resulting in reports of flash flooding. The runoff caused rapid rises on area creeks and streams, with river gauges reaching record levels along the Mohawk River at Little Falls, the West Canada Creek at Hinckley and Kast Bridge, and the Sacandaga River at Hope. Moderate flooding also occurred on the Hudson River at Fort Edward, Hadley, and North Creek; the Schroon River at Riverbank; and the Mohawk River at Delta Dam.
02/18/2022	Flood, Heavy Rain	N/A	N/A	A storm system pushed across the region during February 17-18, 2022. Warm air pushed northward into the region along with periods of rainfall before a cold front brought the return of windy and colder weather. A convective line of gusty showers also accompanied the cold frontal passage. Some locations picked up over 1 inch of rainfall which led to

Date(s) of Event	Event Type	FEMA and/or USDA Declaration Number (if applicable)	Warren County included in Declaration?	Description
				minor flooding. The warm and rainy weather ahead of the cold front resulted in some snow melt as well as some ice to break up on area rivers and streams. As the colder weather returned, localized ice jams formed, some of which led to flooding.
02/28/2022	Flood, Ice Jam	N/A	N/A	An ice jam developed along the Hudson River in the Town of Thurman causing water and ice to flow over Route 418 (River Street) between River Road and Hickory Hill Road. Water began to flow over the road during the evening hours on Saturday, February 19 causing the road to close. The water and ice eventually receded on Monday, February 28, allowing the road to reopen.
04/08/2022	Flood, Heavy Rain	N/A	N/A	A slow-moving frontal system produced widespread heavy rainfall and flooding across eastern New York from April 7-8, 2022. Rainfall amounts between 1.50 and 3.00 inches were common, though a few localized areas received upwards of 4.50 inches. Several incidents of flooding occurred within Warren County, including the areas of Thurman, Warrensburg, Chestertown, Weavertown, and Lake George. Road closures and possible washouts were reported within the towns of Warrensburg and Thurman. In Lake George, severe damage occurred to a driveway and parking lot of the Lakeview Terrace Hotel and Fairview Association.

Sources: *(NOAA 2022), (USDA FSA 2022), (FEMA 2022) (New York State 2019) (Warren County 2017)*
Notes: *Warren County has been affected by several flooding events in the past 5 years (2017 to 2022). Three of these events were declared disasters, 1 declared by FEMA and 2 declared by the USDA.*

Probability of Future Occurrences

For the 2023 HMP update, the most up-to-date data was collected to calculate the probability of future occurrence of flood events for the County. Information from NOAA-NCEI storm events database, the 2019 State of New York HMP, and the 2017 Warren County HMP were used to identify the number of flood events that occurred between 1950 and 2022. Table 5.4.5-2 presents the probability of future events for the flood event in the County.

Table 5.4.5-2. Probability of Future Flood Events in Warren County

Hazard Type	Number of Occurrences Between 1950 and 2022	Percent Chance of Occurring in Any Given Year
Flash Flood	35	48.6%
Flood	44	61%

Sources: *(NOAA 2022) (New York State 2019) (Warren County 2017)*

Note: *Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected drought events since 1968. Due to limitations in data, not all flood events occurring between 1954 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.*

A total of 79 flood events were recorded in Warren County. Based on historical occurrences, the probability of a flood event occurring is considered frequent (100% annual probability; a hazard event may occur multiple times per year). Refer to Section 5.3 for additional information on the hazard ranking methodology and probability criteria.

Climate Change Projections

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.

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.X-3), Adirondack Source: (NYSERDA 2014)

Figure 5.4.5-4. Figure 5.4.X-4: Climate Regions of New York State

Source: (NYSERDA 2014)

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 2014).

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.

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.

In Region 7, it is estimated that temperatures will increase by 3.7°F to 7.4°F by the 2050s and 4.2°F to 11.8°F by the 2080s (baseline of 39.9°F). 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).

Climate change affects flooding more than other hazards because the frequency of extreme precipitation events in the Northeast has increased in recent years. Severe storms projected in the 1950s to occur only once in 100 years are now expected to occur once every 60 years. Other climate change influences include the following:

- Spring breakup, snowmelt, and winter rains
    - Warmer spring temperatures that lead to earlier and more rapid snow melt; more late-winter precipitation likely to fall as rain, rather than as snow
- Cyclonic disturbances
    - Increasing frequency of severe cyclonic events, which may permit more northward tracking of hurricanes
- Localized summer outburst events
    - Increase formation of conditions conducive to summer outbursts and flash flooding
- Human uses and development of land
    - Development leads to increased amounts of impervious surfaces such as roads, parking lots, and buildings and can increase rainwater runoff. Development in floodplains or wetlands can potentially result in an increased floodplain level.

(New York State 2019)

Vulnerability Assessment

To assess Warren County's risk to the flood hazard, a spatial analysis was conducted using the FEMA Risk Map products dated 1984-1996. The 1-percent annual chance flood event was further examined to estimate potential loss using the FEMA Hazus model. These results are summarized below. Refer to Section 5.1 (Methodology and Tools) for additional details on the methodology used to assess flood risk.

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. The impacts from each flood hazard of concern is described below.

Riverine Flooding

To estimate population exposure to the 1-percent- and 0.2-percent annual chance flood events, the digitized flood boundaries were used. Based on the spatial analysis, there are an estimated 1,385 residents living in the 1-percent annual chance floodplain, or 2.3-percent of the County's total population. There are an estimated 1,508 residents living in the 0.2-percent annual chance floodplain, or 2.6-percent of the County's total population.

Table ***5.4.5-3*** summarizes the population exposed to the flood hazard by jurisdiction.

Table 5.4.5-3. Estimated Number of Persons in Warren County Living in the 1-percent and 0.2-percent Annual Chance Flood Event Hazard Areas

Jurisdiction	Total Population (Census Bureau 2020 Decennial)	Estimated Population Located in the Flood Hazard Areas			
		Number of Persons Located in the 1-percent Area	Percent of Total	Number of Persons Located in the 0.2-percent Area	Percent of Total
Bolton (T)	2,012	132	6.5%	132	6.5%
Chester (T)	3,086	262	8.5%	262	8.5%
Glens Falls (C)	14,830	0	0.0%	0	0.0%
Hague (T)	633	45	7.1%	45	7.1%
Horicon (T)	1,471	77	5.2%	77	5.2%
Johnsburg (T)	2,143	49	2.3%	49	2.3%
Lake George (T)	2,494	65	2.6%	65	2.6%
Lake George (V)	1,008	2	0.2%	2	0.2%
Lake Luzerne (T)	3,079	200	6.5%	245	7.9%
Queensbury (T)	29,169	376	1.3%	402	1.4%
Stony Creek (T)	758	23	3.0%	23	3.0%
Thurman (T)	1,095	8	0.7%	8	0.7%
Warrensburg (T)	3,959	147	3.7%	199	5.0%
Warren County (Total)	**65,737**	**1,385**	**2.1%**	**1,508**	**2.3%**

Sources: U.S. Census Bureau 2020; Warren County, NY 2022
Note: C = City; T = Town; V = Village; % = Percent

In addition, displaced populations were estimated for the 1-percent annual chance flood event. It is important to note that the impacts to the households in the FEMA flood hazard area are assessed using the riverine flood model in Hazus. Using 2020 U.S. Census data, Hazus estimates 8,460 people may seek short-term sheltering. These statistics, by jurisdiction, are presented in Table 5.4.5-4

Table 5.4.5-4. Estimated Population Seeking Short-Term Shelter from the 1-percent Annual Chance Flood Event

Jurisdiction	Total Population (Census Bureau 2020 Decennial)	1-Percent Annual Chance Flood Event	
		Displaced Population	Persons Seeking Short-Term Sheltering
Bolton (T)	2,012	22	7
Chester (T)	3,086	80	25
Glens Falls (C)	14,830	0	0
Hague (T)	633	11	9
Horicon (T)	1,471	72	30
Johnsburg (T)	2,143	70	11
Lake George (T)	2,494	6	2
Lake George (V)	1,008	1	0
Lake Luzerne (T)	3,079	179	42

Jurisdiction	Total Population (Census Bureau 2020 Decennial)	1-Percent Annual Chance Flood Event	
		Displaced Population	Persons Seeking Short-Term Sheltering
Queensbury (T)	29,169	298	145
Stony Creek (T)	758	36	12
Thurman (T)	1,095	8	2
Warrensburg (T)	3,959	173	34
Warren County (Total)	**65,737**	**956**	**319**

Sources: Hazus v5.1, Census 2020, Warren County NY 2022
Note: C = City; T = Town; V = Village

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. Mold spores 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 2020).

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 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.

Flash Flooding

Flash flooding events can displace populations along steep topography particularly in cases when flood waters surge into residential properties or alter the terrain into unsafe conditions requiring evacuation. According to **Error! Reference source not found.**, zero injuries have been reported from historical flash flood events that have occurred in Warren County.

Stormwater and Urban Flooding

Urban and stormwater flooding impacts are generally limited to roadways with underlying culverts. In various communities, poor drainage and rainstorms lead to localized flooding on various streets

and in residential developments. This type of flooding could cause persons to become isolated or displaced from their homes.

Ice Jam Flooding

According to the historical records in Warren County, there have been a number of ice jam flooding events. The impacts of these events includes road closure and detours ….

Dam Failure Flooding

Dam failure will have similar impacts to flood events on persons within the County. See Section 5.4.1 for further details regarding the dam failure hazard.

Impact on General Building Stock

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

Riverine Flooding

Error! Reference source not found. and **Error! Reference source not found.** summarize the number of structures located in the 1-percent and 0.2-percent annual chance flood events by jurisdiction. In summary, there are 1,252 buildings located in the 1-percent annual chance flood boundary with an estimated 721 million of replacement cost value (i.e., building and content replacement costs). In total, this represents approximately 3.1-percent of the County's total general building stock inventory. In addition, there are 1,337 buildings located in the 0.2-percent annual chance flood boundary with an estimated $783 million of building stock and contents exposed. This represents approximately 3.3-percent of the County's total general building stock inventory.

The Hazus flood model estimated potential damages to the buildings in Warren County at the structure level using the custom structure inventory developed for this HMP and the depth grid generated using the effective DFIRM data. The potential damage estimated by Hazus to the general building stock inventory associated with the 1-percent annual chance flood is approximately $92 million or 0.3-percent of the total building stock improvement value. The Town of Queensbury has the greatest amount of estimated building loss—approximately $26 million (i.e., 0.4-percent of the total replacement cost value). Refer to **Error! Reference source not found.** for the estimated losses by jurisdiction.

Table 5. Table 5.4.5-6. Estimated General Building Stock Located in the 1- and 0.2-Percent Annual Chance Flood Event

Jurisdiction	Estimated Number and Total Replacement Cost Value of Structures Located Within the Flood Hazard Area									
	Total Number of Buildings	Total Replacement Cost Value (RCV)	Number of Buildings Located in the 1-percent Area	Percent of Total	Total Replacement Cost of Buildings in the 1-percent Area	Percent of Total	Number of Buildings Located in the 0.2-percent Area	Percent of Total	Total Replacement Cost of Buildings in the 1- Area	Percent of Total
Bolton (T)	2,873	$1,509,046,268	191	6.6%	$98,407,104	6.5%	191	6.6%	$98,407,104	6.5%
Chester (T)	3,227	$1,794,523,301	265	8.2%	$136,906,097	7.6%	265	8.2%	$136,906,097	7.6%
Glens Falls (C)	5,988	$3,728,124,116	7	0.1%	$38,633,498	1.0%	7	0.1%	$38,633,498	1.0%
Hague (T)	1,313	$799,210,288	92	7.0%	$25,727,961	3.2%	92	7.0%	$25,727,961	3.2%
Horicon (T)	2,188	$1,022,605,789	113	5.2%	$73,470,929	7.2%	113	5.2%	$73,470,929	7.2%
Johnsburg (T)	2,625	$1,493,856,193	62	2.4%	$57,084,016	3.8%	62	2.4%	$57,084,016	3.8%
Lake George (T)	2,494	$2,168,962,785	62	2.5%	$20,674,796	1.0%	62	2.5%	$20,674,796	1.0%
Lake George (V)	609	$770,157,514	7	1.1%	$9,616,327	1.2%	7	1.1%	$9,616,327	1.2%
Lake Luzerne (T)	2,173	$953,667,917	137	6.3%	$33,879,914	3.6%	169	7.8%	$71,741,229	7.5%
Queensbury (T)	12,193	$7,114,031,584	173	1.4%	$147,862,914	2.1%	189	1.6%	$161,854,297	2.3%
Stony Creek (T)	807	$995,996,331	26	3.2%	$37,561,509	3.8%	26	3.2%	$37,561,509	3.8%
Thurman (T)	1,061	$497,985,792	9	0.8%	$2,463,186	0.5%	9	0.8%	$2,463,186	0.5%
Warrensburg (T)	2,758	$1,425,456,857	108	3.9%	$38,774,911	2.7%	145	5.3%	$49,091,972	3.4%
Warren County (Total)	**40,309**	**$24,273,624,737**	**1,252**	**3.1%**	**$721,063,162**	**3.0%**	**1,337**	**3.3%**	**$783,232,921**	**3.2%**

Source: Hardcopy FIRM Maps, 1980/1990; Warren County, NY 2022
Note: C = City; T = Town; V = Village; % = Percent

Table 5.4.5-7. Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event

Jurisdiction	Total Replacement Cost Value (RCV)	Estimated Loss for All Occupancies	Estimated Loss for Residential Properties	Estimated Loss for Commercial Properties	Estimated Loss for All Other Occupancies
Bolton (T)	$1,509,046,268	$3,552,740	$1,606,047	$7,470	$1,939,224
Chester (T)	$1,794,523,301	$10,392,713	$10,002,163	$378,103	$12,447
Glens Falls (C)	$3,728,124,116	$4,989,907	$0	$1,363,338	$3,626,569
Hague (T)	$799,210,288	$3,071,058	$698,467	$1,657,285	$715,306
Horicon (T)	$1,022,605,789	$9,413,994	$9,393,536	$1,210	$19,248
Johnsburg (T)	$1,493,856,193	$13,268,896	$1,531,287	$11,737,609	$0
Lake George (T)	$2,168,962,785	$1,192,120	$1,192,120	$0	$0
Lake George (V)	$770,157,514	$1,079,756	$50,369	$1,029,387	$0
Lake Luzerne (T)	$953,667,917	$10,571,303	$10,062,444	$508,860	$0
Queensbury (T)	$7,114,031,584	$26,215,898	$7,274,420	$18,941,477	$0
Stony Creek (T)	$995,996,331	$682,066	$351,593	$330,473	$0
Thurman (T)	$497,985,792	$11,374	$7,020	$0	$4,355
Warrensburg (T)	$1,425,456,857	$7,486,940	$3,912,624	$3,338,283	$236,033
Warren County (Total)	**$24,273,624,737**	**$91,928,766**	**$46,082,089**	**$39,293,495**	**$6,553,181**

Sources: Hazus v5.1, Census 2020, Warren County NY 2022, RS Means 2022
Note: C = City; T = Town; V = Village; % = Percent

NFIP Statistics

FEMA provided a list of properties with NFIP policies, past claims, and multiple claims. According to FEMA, a repetitive loss (RL) property is a NFIP-insured structure that has had at least two paid flood losses of more than $1,000 in any 10-year period since 1978. A severe repetitive loss (SRL) property is a NFIP-insured structure that has had four or more separate claim payments made under a standard flood insurance policy, with the amount of each claim exceeding $5,000 and with the cumulative amount of such claims payments exceeding $20,000; or at least two separate claims payments made under a standard flood insurance policy with the cumulative amount of such claim payments exceed the fair market value of the insured building on the day before each loss (FEMA 2018).

Table 5.4.5-8,

Table 5.4.5-9, and

Table 5.4.5-10 summarize the NFIP policies, claims, and repetitive loss statistics for Warren County. The majority of the RL and SRL properties are single-family residences. This information is current as of March, 2023.

Table 5.4.5-8. Occupancy Class of Repetitive Loss Structures in Warren County

Occupancy Class	Total Number of Repetitive Loss Properties	Total Number of Severe Repetitive Loss Properties	Total (Repetitive Loss + Severe Repetitive Loss)
Single Family	6	0	6
Business	1	1	2

Source: FEMA Region 2, 2023
Note: Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA Region 2, and are current as of March 2023
N/A Not available

Table 5.4.5-9 Occupancy Class of Repetitive Loss Structures in Warren County, by Municipality

Municipality	Repetitive Loss Properties		Severe Repetitive Loss Properties	
	Single Family	Business	Single Family	Business
Chester (T)	1	0	0	0

Municipality	Repetitive Loss Properties		Severe Repetitive Loss Properties	
	Single Family	Business	Single Family	Business
Johnsburg (T)	1	0	0	0
Lake George (T)	1	0	0	0
Lake George (V)	0	1	0	1
Lake Luzerne (T)	2	0	0	0
Queensbury (T)	1	0	0	0
Warren County (Total)	6	1	0	1

Source: FEMA Region 2, 2023

Table 5.4.5-10. NFIP Policies, Claims, and Repetitive Loss Statistics

Municipality	Number of Claims	Total Paid Claims	Number of NFIP Repetitive Loss Properties	Number of FMA Repetitive Loss Properties	Number of NFIP Severe Repetitive Loss Properties	Number of FMA Severe Repetitive Loss Properties
Bolton (T)	5	$40,328	0	0	0	0
Chester (T)	14	$90,426	1	0	0	0
Glens Falls (C)	0	0	0	0	0	0
Hague (T)	2	$8,021	0	0	0	0
Horicon (T)	5	$112,548	0	0	0	0
Johnsburg (T)	4	$56,870	1	0	0	0
Lake George (T)	7	$23,323	1	0	0	0
Lake George (V)	13	$503,746	1	1	1	1
Lake Luzerne (T)	31	$816,609	2	0	0	0
Queensbury (T)	13	$46,751	1	0	0	0
Stony Creek (T)	4	$2,355	0	0	0	0
Thurman (T)	5	$85,530	0	0	0	0
Warrensburg (T)	8	$11,649	0	0	0	0
Warren County (Total)*	**114**	**$1,801,542**	7	1	1	1

Source: RL and SRL: FEMA Region 2, 2023; Claims and policies: HUDEX,1/26 2023
**County Total includes 1 unknown claim location and 2 claims attributed to the Town of Corinth*

Flash Flooding

Flash floods occur within a few minutes or hours of excessive rainfall, a dam or levee failure, or a sudden release of water held by an ice jam. Flash floods can roll boulders, tear out trees, trigger mud slides, destroy buildings and bridges, and scour out new channels. Because flash floods typically occur along rivers, coastlines, and low-lying, all structures located in and around these are susceptible to damages from flash floods. Secondary impacts of flash floods can also damage buildings and infrastructure outside the floodplain (Wyoming 2021) (NWS 2021) (Melina and Rowan 2010).

Stormwater and Urban Flooding

The impacts to the general building stock as a result of stormwater and urban flooding is similar to the impacts of other types of flooding as described above. Stormwater flooding can damage public and private properties, destroy stormwater infrastructure, and impact roadways and utilities (NOAA 2021). Stormwater and urban flooding can occur in areas outside of the floodplain, so public and private properties not in the floodplain area also vulnerable to stormwater and urban flooding.

Ice Jam Flooding

The water ice jams hold back can lead to riverine or flash flooding upstream from the ice jam. If the ice jam breaks, flash flooding can occur downstream (NOAA, Ice Jams & Flooding 2015). Structures located near rivers and streams are most at risk of flooding from ice jams (Consortium 2021).

Dam Failure Flooding

The dams located in Warren County can have a varying impact on the general building stock. Communities that contain high hazard dams are more at risk for building stock destruction from flooding. The amount of flooding that these structures can experience depends on many factors including the reservoir size, and the time of day and season the breach occurs. Structures that are at a lower elevation from the reservoir will be most vulnerable to flooding from dam failure.

Impact on Critical Facilities and Community Lifelines

It is important to determine the critical facilities and infrastructure that may be at risk to flooding, and who may be impacted should damage occur. Critical services during and after a flood event may not be available if critical facilities are directly damaged or transportation routes to access these critical facilities are impacted. Roads that are blocked or damaged can isolate residents and can prevent access throughout the planning area to many service providers needing to reach vulnerable populations or to make repairs.

Critical facility exposure to the flood hazard was examined. Table 5.3.2-22 lists the critical facilities and number of lifelines, within the 1-percent and 0.2-percent annual chance flood boundaries. Of the 511 critical facilities located in the 1-percent annual chance flood event boundary, the greatest number are food, water, or shelter facilities. Additionally, there are 599 critical facilities located in the 0.2-percent annual chance flood event boundary, 286 of which are food, water, or shelter

facilities. A majority of the critical facilities located in the 1-percent and 0.2-percent annual chance flood event boundaries are in Larchmont and Rye, shown in Table 5.3.2-23 and Table 5.3.2-24.

In cases where short-term functionality is impacted by flooding, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce flood impacts to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

Table 5.4.5-11 Critical Facilities and Lifelines Located in the 1-Percent and 0.2-Percent Annual Chance Event Floodplain

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the 1-percent Annual Chance Flood Event Hazard Area	Number of Lifelines Located in the 0.2-percent Annual Chance Flood Event Hazard Area
Communications	16	0	0
Energy	20	0	0
Food, Water, Shelter	163	11	11
Hazardous Materials	46	1	1
Health and Medical	43	2	3
Safety and Security	211	25	25
Transportation	60	33	33
Warren County (Total)	**559**	**72**	**73**

Source: Hardcopy FIRM Maps, 1980/1990; Warren County, NY 2022

5.4.5-12. Critical Facilities and Lifeline Facilities Located in the 1-Percent Annual Chance Flood Event Hazard Area by Jurisdiction

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the 1-Percent Annual Chance Flood Event Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Bolton (T)	44	30	0	0.0%	0	0.0%
Chester (T)	57	44	6	10.5%	6	13.6%
Glens Falls (C)	93	62	2	2.2%	2	3.2%
Hague (T)	23	17	2	8.7%	1	5.9%
Horicon (T)	30	25	13	43.3%	11	44.0%
Johnsburg (T)	66	52	13	19.7%	13	25.0%
Lake George (T)	36	28	2	5.6%	2	7.1%
Lake George (V)	22	14	0	0.0%	0	0.0%
Lake Luzerne (T)	50	41	5	10.0%	5	12.2%
Queensbury (T)	202	156	10	5.0%	10	6.4%
Stony Creek (T)	20	18	6	30.0%	6	33.3%

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the 1-Percent Annual Chance Flood Event Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Thurman (T)	20	16	2	10.0%	2	12.5%
Warrensburg (T)	74	56	14	18.9%	14	25.0%
Warren County (Total)	**737**	**559**	**75**	**10.2%**	**72**	**12.9%**

Source: Warren County, NY 2022
Note: C = City; T = Town; V = Village; % = Percent

Table 5.4.5-13 Critical Facilities and Lifeline Facilities Located in the 0.2-Percent Annual Chance Flood Event Hazard Area by Jurisdiction

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the 0.2-Percent Annual Chance Flood Event Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Bolton (T)	44	30	0	0.0%	0	0.0%
Chester (T)	57	44	6	10.5%	6	13.6%
Glens Falls (C)	93	62	2	2.2%	2	3.2%
Hague (T)	23	17	2	8.7%	1	5.9%
Horicon (T)	30	25	13	43.3%	11	44.0%
Johnsburg (T)	66	52	13	19.7%	13	25.0%
Lake George (T)	36	28	2	5.6%	2	7.1%
Lake George (V)	22	14	0	0.0%	0	0.0%
Lake Luzerne (T)	50	41	6	12.0%	6	14.6%
Queensbury (T)	202	156	10	5.0%	10	6.4%
Stony Creek (T)	20	18	6	30.0%	6	33.3%
Thurman (T)	20	16	2	10.0%	2	12.5%
Warrensburg (T)	74	56	14	18.9%	14	25.0%
Warren County (Total)	**737**	**559**	**76**	**10.3%**	**73**	**13.1%**

Source: Warren County, NY 2022
Note: C = City; T = Town; V = Village; % = Percent

Flash Flooding

Information regarding the vulnerability to flash flooding is not available at this time.

Stormwater and Urban Flooding

Information regarding the vulnerability to stormwater and urban flooding is not available at this time.

Ice Jam Flooding

Similar to the impacts on general building stock, damage to critical facilities will vary for communities depending on the location of the ice jam and proximity of critical facilities to the ice jams. Major roadways can also be impacted because of inundation or debris carried by flooding, leading to road closures and disruption in services provided by or to critical facilities. Because ice jams occur in the colder months, recovery and repairs to damaged areas can take longer due to colder conditions.

Dam Failure Flooding

Similar to the impacts on the general building stock, damage to critical facilities will vary for communities depending on the distribution of their dams and proximity of critical facilities to these dams and their downstream inundation area. Major roadways within Warren County may also be impacted by dam failure because of standing floodwaters or debris carried by the flooding. Roadblocks in transportation corridors can create disruption in the services provided to or by critical facilities. This puts communities in the County at greater risk if proper warning time is not provided to the community if a dam failure were to occur.

Impact on the Economy

Flood events can significantly impact the local and regional economy. This includes but is not limited to general building stock damages and associated tax loss, impacts to utilities and infrastructure, business interruption, impacts on tourism, and impacts on the tax base to Warren County. In areas that are directly flooded, renovations of commercial and industrial buildings may be necessary, disrupting associated services. Refer to the 'Impact on General Building Stock' subsection earlier which discusses direct impacts to buildings in Warren County. Other economic components such as loss of facility use, functional downtime and socio-economic factors are less measurable with a high degree of certainty.

Riverine Flooding

Flooding can cause extensive damage to public utilities and disruptions to delivery of services. Loss of power and communications may occur, and drinking water and wastewater treatment facilities may be temporarily out of operation.

Debris management may also be a large expense after a flood event. Hazus 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 5.3.2-35 summarizes the debris Hazus estimates for these events. As a result of the 1-percent annual chance event, Hazus estimates approximately 214,778 tons of debris will be generated in total.

Table 5.4.5-14 Estimated Debris Generated from the 1-percent Annual Chance Flood Event

Jurisdiction	1-Percent Annual Chance Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Bolton (T)	381	126	150	106
Chester (T)	716	254	259	203
Glens Falls (C)	0	0	0	0
Hague (T)	77	32	25	20
Horicon (T)	418	186	125	107
Johnsburg (T)	603	156	246	201
Lake George (T)	17	6	6	5
Lake George (V)	32	30	2	1
Lake Luzerne (T)	784	295	267	222
Queensbury (T)	796	380	237	179
Stony Creek (T)	251	81	100	70
Thurman (T)	48	15	18	16
Warrensburg (T)	2,209	392	919	898
Warren County (Total)	**6,333**	**1,952**	**2,354**	**2,028**

Sources: Source: Hazus v5.1, Warren County NY 2022
Note: C = City; T = Town; V = Village

Flash Flooding

The economic impacts of flash floods are similar to the impacts of riverine floods; however, flash floods occur with little to no warning which prevents businesses and homeowners to prepare for flooding. Impacts of a flash flood can include damaged or closed roadways, utility failures, and structural damages. Overall economic impacts include loss of business function; damaged roads, bridges, buildings, and cars; utility interruptions; and expended resources to assist with recovery efforts (Wyoming 2021) (eSchoolToday 2021).

Stormwater and Urban Flooding

The economic impacts of stormwater and urban floods are similar to the impacts of riverine floods. In addition to damaging businesses and homes, this type of flooding can also lead to drinking water contamination, destroy septic system drainfields, impair tourism and recreational businesses, and disrupt critical infrastructure systems (Council 1999) (Environment 2021).

Ice Jam Flooding

Flooding from ice jams can have detrimental impacts on property and infrastructure, including damages to homes, bridges, roads, and businesses. Similar to other types of flooding, ice jam flooding can close roadways and cause power outages, limiting operations of businesses in the impacted areas. A significant ice jam flood event could cause millions of dollars in damages (Das, Reed and Lindenschmidt 2018).

Dam Failure Flooding

Dam failures have historically occurred in Warren County and can impact the local and regional economy. A failure of one of the 36 high hazard dams in the County could cause significant impacts. When Hurricane Floyd passed through Warren County in 1999, the Cortlandt Lake Dam failed due to the amount of rain and erosion (NPDP 2021). An event like Hurricane Floyd could lead to more failures, leaving the County or dam owners responsible for repairing damages and cleanup.

Impact on the Environment

Flood extents for the 1- and 0.2-percent annual flood events will continue to evolve alongside natural occurrences such as sea level rise, climate change, and/or severity of storms. Further, residents living in and around areas of wildfire may be at increased risk of flooding in the future due to changes in the natural landscape.

Riverine Flooding

Flood events will inevitably impact Warren County's natural and local environment. Severe flooding not only influences the habitat of these natural land areas, but it can also be disruptive to species that reside in these natural habitats.

Flash Flooding

Like riverine flooding, flash floods impact the natural and local environment. The surrounding environment may not be able to withstand and recover from flash flood events. Flash floods can destroy wildlife habitats, pollute rivers and streams, carry sediment and silt that can impact water quality, destroy crops and farms, uproot trees, and cause erosion of streambanks and other areas (Wyoming 2021), (eSchoolToday 2021) (New York City 2019).

Stormwater and Urban Flooding

Stormwater and urban flooding events can also impact the natural environment. Stormwater picks up and carries pollutants and other hazardous materials into waterways causing poor water quality, contaminated waters, and impacting fish and plants. Stormwater can also erode stream channels, increase sediment and debris in waterbodies, and destroy fish and wildlife habitats (Environment 2021).

Ice Jam Flooding

Like other types of flood, the environmental impacts of ice jams can include water quality issues, destroy wildlife habitats, pollution, uproot trees and vegetation, and cause erosion along streambanks and other areas.

Dam Failure Flooding

The environmental impacts of a dam failure can include significant water-quality and debris-disposal issues. Flood waters can back up sanitary sewer systems and inundate wastewater treatment plants, causing raw sewage to contaminate residential and commercial buildings and the flooded waterway. The contents of unsecured containers of oil, fertilizers, pesticides, and other chemicals get added to flood waters. Hazardous materials may be released and distributed widely across the floodplain. Water supply and wastewater treatment facilities could be offline for weeks.

After the flood waters subside, contaminated and flood-damaged building materials and contents must be properly disposed of. Contaminated sediment must be removed from buildings, yards, and properties. In addition, severe erosion is likely; such erosion can negatively impact local ecosystems.

Cascading Impacts on Other Hazards

Riverine, Flash, and Stormwater/Urban Flooding

Flood events can exacerbate the impacts of disease outbreak and landslides. After a flooding event, runoff can pick up and transport pollutants from wildlife and soils. Such organisms can then appear in water drinking facilities and transmit illnesses water-borne and vector diseases to the population (World Health Organization (WHO) 2020). Flooding can also put additional strain on dams, which may lead to dam failure. More information about these hazards of concern can be found in Section 5.4.1 (Dam Failure) and Section 5.4.2 (Disease Outbreak).

Ice Jam and Dam Failure Flooding

Dam failures and ice jams can cause severe downstream flooding, depending on the magnitude of the failure. Other potential impacts are landslides and erosion. They can also cause environmental impacts if floodwaters flow through hazardous material facilities and bring those materials to other areas.

Future Changes That May Impact Vulnerability

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

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

Projected Development

As discussed and illustrated in Section 4 (County Profile), areas targeted for future growth and development have been identified across the County. New development that has occurred in the last five years within the County, and potential future development in the next five years as identified by the County and each municipality, is included in Section 4, County Profile (Volume I) as well as the jurisdictional annexes in Section 9 (Volume II), along with an indication of proximity to known hazard zones.

Projected Changes in Population

Warren County has experienced a slight increase (less than 0.1-percent) in population since 2010 according to the U.S. Census Bureau (U.S. Census Bureau 2020). Changes in population density if flood hazard areas can affect the vulnerability of the population to flood impacts. Refer to Section 4 (County Profile), which includes a discussion on population trends for the County.

Climate Change

As discussed above, most studies project that the State of New York will see an increase in average annual temperatures and precipitation. It is anticipated that Warren County will continue to experience direct and indirect impacts of flooding events annually that may induce secondary hazards such as infrastructure deterioration or failure, utility failures, power outages, water quality and supply concerns, and transportation delays, accidents, and inconveniences.

Change of Vulnerability Since the 2017 HMP

Since the 2017 HMP was drafted, updated inventory data has become available to assess additional flood hazard areas in Warren County. This data includes the 5-Year 2017-2021 American Community Survey population estimates, updated 2021 tax assessor parcel data, 2022 general building stock data provided by the County, 2022 RS Means for building stock replacement cost valuation, and updated critical facility data provided by the County's Planning Partners. Hazus v5.1 was also used to assess the losses in the County to the overall risk from 100-year and 500-year flood risk. Overall, this vulnerability assessment uses a more accurate and updated asset inventory which provides more accurate estimated exposure to the flood hazard.