5.4.4 Flood

The following section provides the hazard profile and vulnerability assessment for the flood hazard in Tompkins County.

The hazard profile is organized as follows:	The vulnerability assessment is organized as follows:
• Description • Extent • Previous Occurrences and Losses • Probability of Future Occurrences • Climate Change Impacts	• Impact on Life and Safety • Impact on General Building Stock • Impacts on Land Use • Impact on Community Lifelines • Impact on Economy • Impact on Environment • Cascading Impacts on Other Hazards • Future Change that may Impact Vulnerability • Changes Since 2014 HMP • Identified Issues

5.4.4.1 Hazard Profile

This section provides information regarding the description, extent, location, previous occurrences and losses, climate change projections and the probability of future occurrences for the flood hazard.

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) (FEMA 2007). As defined in the NYS HMP (NYS DHSES 2019), flooding is a general and temporary condition of partial or complete inundation on normally dry land as a result of 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
- Coastal flooding

For the purpose of this HMP and as deemed appropriate by the Planning Partnership, riverine (inland), stormwater, ice jam, lakeshore, landslides associated with flooding, and dam/levee failure are the main flood types of concern for the County. These types of flood are further discussed below.

Riverine (Inland) Flooding

Riverine flooding occurs when water levels rise over the top of riverbanks due to excessive rain from tropical systems making landfall, strong thunderstorms that bring heavy rainfall, combined rainfall and snowmelt event, or an ice jam (National Severe Storms Laboratory [NSSL] 2020). Inland flooding occurs when moderate precipitation accumulates over several days, intense rainfall over a short period of time, or a river overflows due to an ice or debris jam or dam failure (NSSL 2020).

Flash Flooding

Flash floods are defined by the National Weather Service as, "A flood caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through riverbeds, urban streets, or mountain canyons sweeping everything before them. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen, for instance after a levee or dam has failed, or after a sudden release of water by a debris or ice jam." (National Weather Service [NWS], n.d.).

Stormwater Flooding

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 which is a regular occurrence in Tompkins County. Seasonally high groundwater is common in many areas, while elsewhere high groundwater occurs only after 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 2007).

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 2013). 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 channelized shallows that 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 (USACE 2002).

Types of Ice Jams

- ✓ 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.

Lakeshore Flooding

Factors such as rain, snowmelt, drought, or groundwater level changes cause water levels in surface water bodies like lakes to vary throughout the year. Lake levels can be actively managed, thereby allowing human actions to directly impact the flow of water into and out of a lake. Natural or unnatural changes in lake levels can cause several impacts, including erosion, flooding, and limited use of lakes (Minnesota Department of Natural Resources, 2020). In the context of flooding, the shoreline and outlying areas surrounding lakes can be designated as areas of special flood hazard, with inundations expected for various return periods. Flood maps can show a base flood elevation (BFE) for lakes in the Summary of Stillwater Elevations that appears in a Flood Insurance Study. Lakeshore flooding caused by high lake levels can cause flood damage by inundating structures that are typically dry. Marinas, beaches, piers, and other waterfront facilities can also be rendered unusable from lakeshore flooding. Additionally, lakeshore flooding can lead to both upstream and downstream flooding impacts.

Flood Induced Landslides

A landslide is the process that results in downward and outward movement of slope-forming materials. Landslide materials can consist of natural rock, soil, artificial fill, or any combination of these materials. The materials move by falling, toppling, sliding, spreading, or flowing (NYS DHSES 2019).

Landslides are caused by one or more of the following factors: change in slope of the terrain, change in water content, groundwater movement, frost action, increased load on the land, shocks and vibrations, weathering of rocks, and removal or change in type of vegetation covering slopes. Landslide hazard areas exist where the land has characteristics that contribute to risk of downhill movement of material, such as the following:

> Landslides can be triggered by natural changes in the environment, including heavy rain, rapid snow melt, steepening of slopes caused by construction or erosion, earthquakes, and changes in groundwater levels. Areas generally prone to landslide hazards include previous landslide areas, bases of steep slopes, bases of drainage channels, developed hillsides, and areas recently burned by forest and brush fires (NYS DHSES 2019).

- A slope greater than 33 percent
- A history of landslide activity or movement during the last 10,000 years
- Stream or wave activity that has caused erosion, undercut a bank, or cut into a bank to cause the surrounding land to be unstable
- Presence or potential for snow avalanches
- Presence of an alluvial fan, indicating vulnerability to flow of debris or sediments
- Presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.

Dam and Levee Failure Flooding

A dam or a levee 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 2007). 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 affects a dam's primary function of impounding water (FEMA 2007). Levees typically are earthen embankments constructed from a variety of materials ranging from cohesive to cohesionless soils (USBR 2012). Dams and levees 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 due to uncontrolled release or exceedance of design);
- Prolonged periods of rainfall and flooding;
- Deliberate acts of sabotage;
- 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).

Flood Control Measures

Figure 5.4.4-1. Cayuga Inlet Levee System

According to the current FEMA Flood Information Study, there is one flood control structure in the County - the levee system found along both banks of the Cayuga Inlet. This levee system was completed in 1970 and directs flow to the left bank. Nearly three miles of straightened Inlet channel and interior drainage protect a 212-acre area home to approximately 621 people and 132 structures valued at $57 million. The protected area includes the Nate's Floral Estates manufactured home community and major commercial developments on the north and western side of Route 13. The system cost $20.3 million and high water has reached more than 1.5 feet (25%) up the levee once (US Army Corps of Engineers 2020). Due to a lack of dredging this system is not currently certified to provide the level of protection it was originally designed for.

There are also unofficial levee systems, or channelized flood walls, along Fall Creek and Six Mile Creek in the City of Ithaca, that currently provide flood protection to several neighborhoods. In addition, the Dr. Donald H. Crispell Flood Control Project or the Virgil Creek Dam, funded by the US Department of Conservation was completed in 1998 to provide flood protection to downstream assets.

The numeropus stormwater detension ponds throughout the County provide localized flood control throughout but are not documnented as flood control structures.

Extent

The severity of a flood event is typically determined by a combination of several factors including stream and river basin topography along with physiography; precipitation and weather patterns; recent soil moisture conditions; and degree of vegetative clearing and impervious surface. Generally, floods are long-term events that may last for several days. Severity of a flood also depends on the land's ability to manage this water. Sizes of rivers and streams in an area and infiltration rates are significant factors. During rain events, soil acts as a sponge. When land is saturated or frozen, infiltration rates decrease and any more water that accumulates must flow as runoff (Harris 2001).

Regarding the riverine flood hazard, once a river reaches flood stage, flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category is based on property damage and level of public threat (NWS 2011).

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

Flood Induced Landslides

Extent of a landslide hazard is determined by identifying affected areas and assessing probability of a landslide occurring within a time period. Natural variables that contribute to overall extent of potential landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult, even under ideal conditions. As a result, the landslide hazard is often represented by landslide incidence and susceptibility, defined as follows:

- **Landslide incidence** is categorized by percentage of a given geographic area that has undergone landslides. High incidence means greater than 15 percent of a given area has been involved in landsliding, medium incidence means that 1.5 to 15 percent of an area has been involved, and low incidence means that less than 1.5 percent of an area has been involved. (Radbruch-Hall, Dorothy H. et al. 1982).
- **Landslide susceptibility** is defined as the probable degree of response of geologic formations to natural or artificial cutting, to loading of slopes, or to unusually high precipitation. Assumedly, unusually high precipitation or changes in existing conditions can initiate landslide movement in areas where rocks and soils have been involved with landslides in the past. Landslide susceptibility depends on slope angle and geologic material underlying the slope. Landslide susceptibility applies only to areas potentially affected, and does not imply a time frame within which a landslide might occur. High, medium, and low susceptibility are delimited by the same percentages used for classifying incidence of landsliding (Radbruch-Hall, Dorothy H. et al. 1982).

Dam Failure

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 New York Codes, Rules, and Regulations (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 (1) a dam that has been breached or removed, or has failed or otherwise no longer materially impounds waters, or (2) 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.

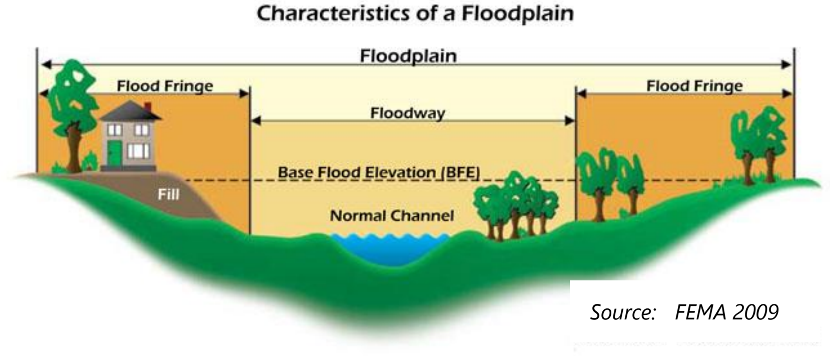
Flood Mitigation Needs Assessments

In 2005, Tompkins County undertook a Flood Mitigation Needs Assessment that examined flooding in Six Mile Creek, Salmon Creek, Fall Creek, and Cayuga Inlet as part of a Countywide Flood Hazard Mitigation Program effort that periodically funds assessments and flood mitigation projects. The assessments notes issues associated with sedimentation, debris-filled channels, erosion, and the lack of more detailed flood studies. Since 2005, the County has completed needs assessments for Taughannock Creek and Buttermilk Creek. The intent of these efforts is to gain a better understanding the complexity and interrelationships of factors that influence flooding; prioritize flood-related projects; and evaluate recommendations for the program. Several projects identified in these assessments have been implemented.

Location

Flooding potential is influenced by climatology, meteorology, and topography (elevations, latitude, and water bodies and waterways). Flooding potential for each type of flooding that affects Tompkins County is described in the subsections below.

Floodplains



Source: FEMA 2009

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. In Tompkins 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.

Flood Map Terms

- Flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA).
- SFHA = the area that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year.
- 1-percent annual chance flood = the base flood or 100-year flood.
- SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30.
- Zone B or Zone X (shaded) = Moderate flood hazard areas and are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood.
- Zone C or Zone X (unshaded) = Areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood, are labeled Zone C or Zone X (unshaded).

Flood hazard areas are identified as Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a 1 percent chance of being equaled to or exceeded in any given year. The 1 percent annual chance flood is also referred to as the base flood or 100-year flood. A 100-year floodplain is not a flood that will occur once every 100 years rather the designation indicates that a flood that has a 1-percent 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. Similarly, the moderate flood hazard area (500-year floodplain) will not occur every 500 years but is an event with a 0.2-percent chance of being equaled or exceeded each year (FEMA 2018). The 1-percent annual chance floodplain or SFHA establishes the area that has flood insurance and floodplain management requirements.

As Tompkins County does not yet have Digital Flood Insurance Rate Maps (DFIRM), locations of flood zones were provided as Q3 data generated by FEMA back in the 1970s and 1980s. The Q3 date provides information on the extent, but not the depth of flooding. During this HMP update, the County Q3 data was digitized and provided for the 1-percent and 0.2-percent annual chance flood event (refer to Figure 5.4.44). The total land area in the floodplain, inclusive of waterbodies, is summarized in Table 5.4.4-1. Refer to Section 9 for a map of each jurisdiction depicting the floodplains. Flood hazard zones occur throughout the County, predominantly along County waterways. The Q3 data provided by FEMA for Tompkins County show the following flood hazard areas:

- 1-Percent Annual Chance Flood Hazard: Areas subject to inundation by the 1-percent-annual-chance flood event. This includes Zone A and Zone AE. Mandatory flood insurance requirements and floodplain management standards apply. Base flood elevations are provided in Zone AE. Zone A has no determined flood depths.
- 0.2-Percent Annual Chance Flood Hazard: Area of minimal flood hazard, usually depicted on FIRMs as the 500-year flood level or Shaded X Zone.

Tompkins County flood map data is currently being reviewed and updated by FEMA and NYSDEC. Final Flood map updates are anticipated in 2022. In addition, flood depth grids generated by the USGS was incorporated to refine the exposure analysis.

Table 5.4.4-1. Total Area of Tompkins County Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

		Total Area Exposed to the 1-Percent Annual Chance Flood Event		Total Area Exposed to the 0.2-Percent Annual Chance Flood Event	
Jurisdiction	Total Area (acres)	Area Exposed (acres)	Percent of Total	Area Exposed (acres)	Percent of Total
Caroline (T)	35,243	464	1.3%	464	1.3%
Cayuga Heights (V)	1,121	0	0.0%	0	0.0%
Danby (T)	34,511	551	1.6%	551	1.6%
Dryden (T)	58,487	1,697	2.9%	1,698	2.9%
Dryden (V)	1,116	179	16.0%	209	18.7%
Enfield (T)	23,622	0	0.0%	0	0.0%
Freeville (V)	698	112	16.0%	112	16.0%
Groton (T)	30,580	629	2.1%	630	2.1%
Groton (V)	1,065	78	7.4%	105	9.9%
Ithaca (C)	3,891	767	19.7%	1,340	34.4%
Ithaca (T)	18,249	1,268	6.9%	1,356	7.4%
Lansing (T)	41,868	797	1.9%	797	1.9%
Lansing (V)	2,910	2	0.1%	2	0.1%
Newfield (T)	37,836	373	1.0%	373	1.0%
Trumansburg (V)	890	28	3.2%	28	3.2%
Ulysses (T)	22,697	2,974	13.1%	2,974	13.1%
Tompkins County (Total)	**314,785**	**9,921**	**3.2%**	**10,640**	**3.4%**

Source: Tompkins County GIS 2019/2020
Notes: V = Village, C = City, T = Town

Flood Gages

The USGS National Water Information System (NWIS) collects surface water data from more than 850,000 stations across the country. The time-series data describes stream levels, streamflow (discharge), reservoir and lake levels, surface water quality, and rainfall. The data is collected by automatic recorders and manual field measurements at the gage locations.

There are five USGS stream gages in the County, of which two have defined flood and action stages. Two gages are found in Ithaca (at Cayuga Lake and Fall Creek), and the remainder are found along Six Mile Creek and Salmon Creek.

The Owasco Lake Watershed Inspection Division is currently implementing a pilot project to deploy up to 4 water level monitoring gauges affixed to bridges in that watershed to provide an additional level of information regarding water levels. These gauges are not integrated into the USGS system.

Figure 5.4.4-2. USGS Stream Gages in Tompkins County

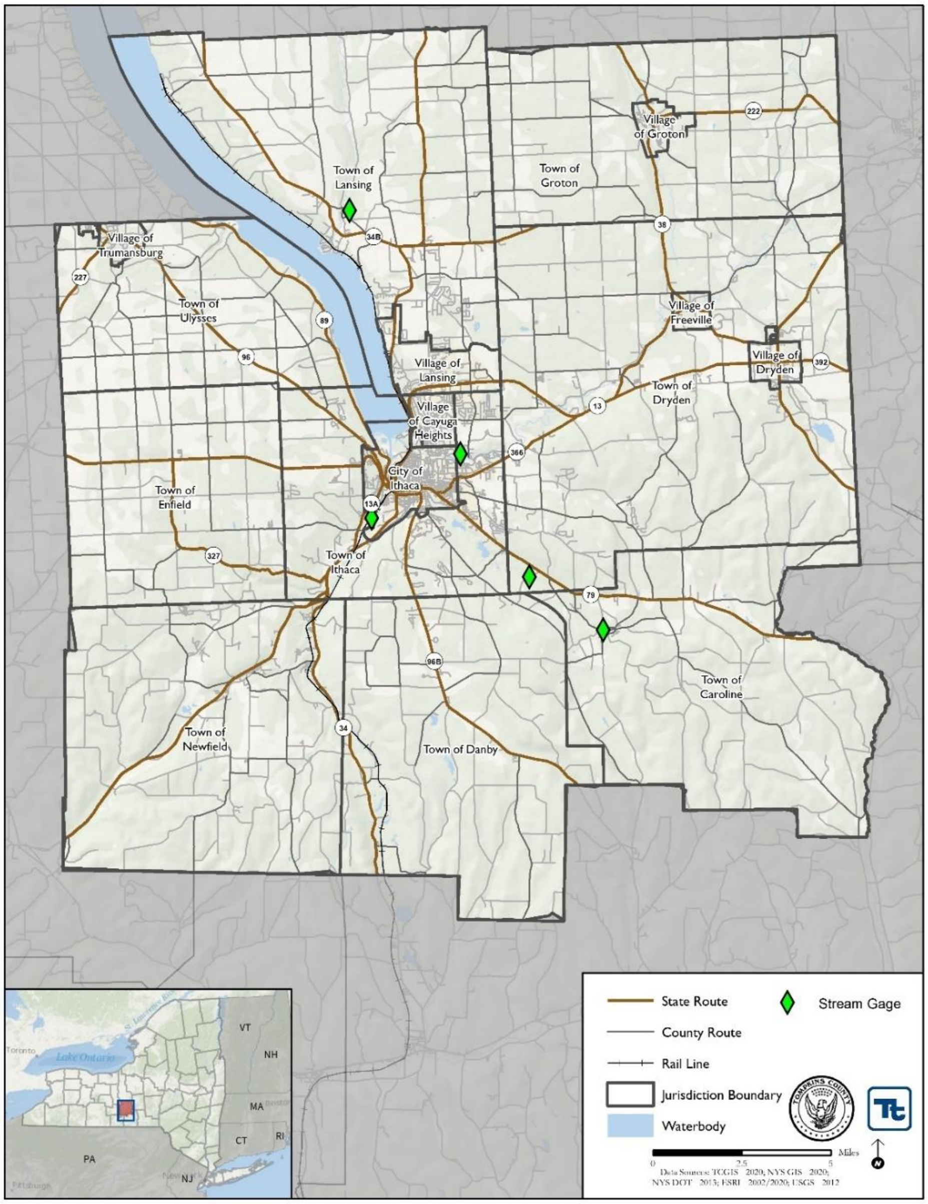


Table 5.4.4-2 shows the gages in the County with their determined flood stage and their record flood event. The USGS website provides details about each of the gages (https://waterwatch.usgs.gov/index.php) and the gage heights of flooding events. The NWS provides the different flood stages for the gages (https://water.weather.gov/ahps/).

Table 5.4.4-2. Stream Gage Statistics for Tompkins County

Gage Site Number	Site Name	Action Stage (feet)	Minor Flood Stage (feet)	Moderate Flood Stage (feet)	Major Flood Stage (feet)	Record Flood*
04233255	Cayuga Lake at Ithaca	383	383.5	384	385	386.5 in April 1993
04234000	Fall Creek at Ithaca	5.0	6.0	6.5	7.0	11.16 on February 21, 1971
04233300	Six Mile Creek at Bethel Grove	Undefined				9.78 feet, on Jan. 19, 1996
04233286	Six Mile Creek at Brooktondale	Undefined				5.38 feet, on Sept. 8, 2011
0423401815	Salmon Creek near Ludlowville, NY	Undefined				5.01 feet, on March 30, 2014

**Gage NGVD datum as noted on website*
Source: USGS 2020

Water Level Data

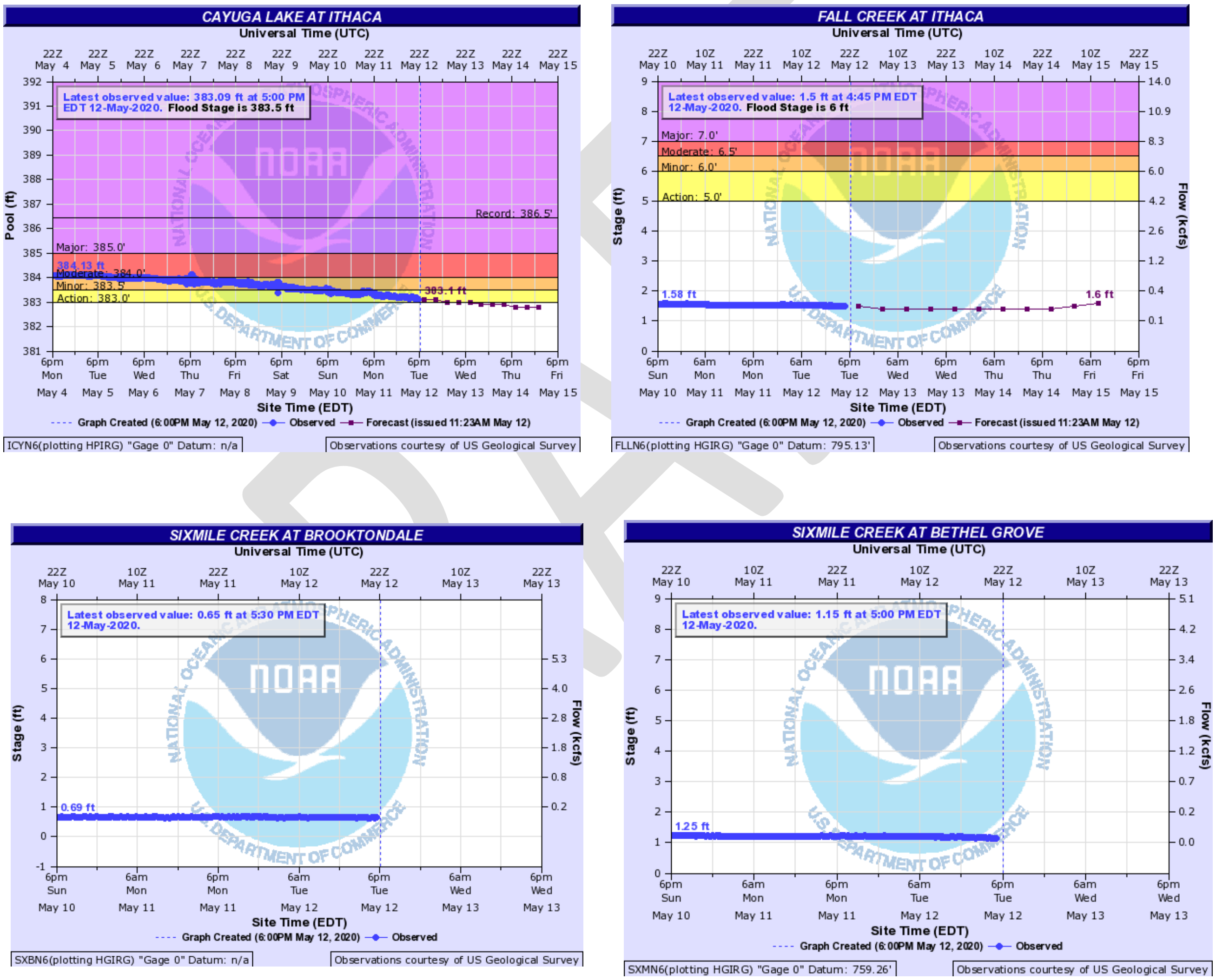
A hydrograph shows how a water level changes over time at a specific location to enable a review of historic water levels which are useful in floodplain management planning. In Tompkins County, of the five stream gages, two provide the probabilistic and deterministic forecast for specific bodies of water. These forecast hydrographs are useful to reference when flooding is expected or to determine the observed water level for the past few days. The hydrographs for Cayuga Lake at Ithaca and Fall Creek at Ithaca provide water levels for the action, minor flooding, moderate flooding, and major flooding stages. They also display the flood of record (or the highest recorded water level) for the specific gage. These stages are defined as follows:

- Action Stage - the stage which; when reached by a rising stream, lake, or reservoir represents the level where the NWS or a partner/user needs to take some type of mitigation action in preparation for possible significant hydrologic activity.
- Minor Flooding - minimal or no property damage, but possibly some public threat.
- Moderate Flooding - some inundation of structures and roads near stream. Some evacuations of people and/or transfer of property to higher elevations.
- Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.
- Record Flooding - flooding which equals or exceeds the highest stage or discharge at a given site during the period of record keeping.

(*https://water.weather.gov/ahps2/pdf/hydrograph_terminology.pdf*).

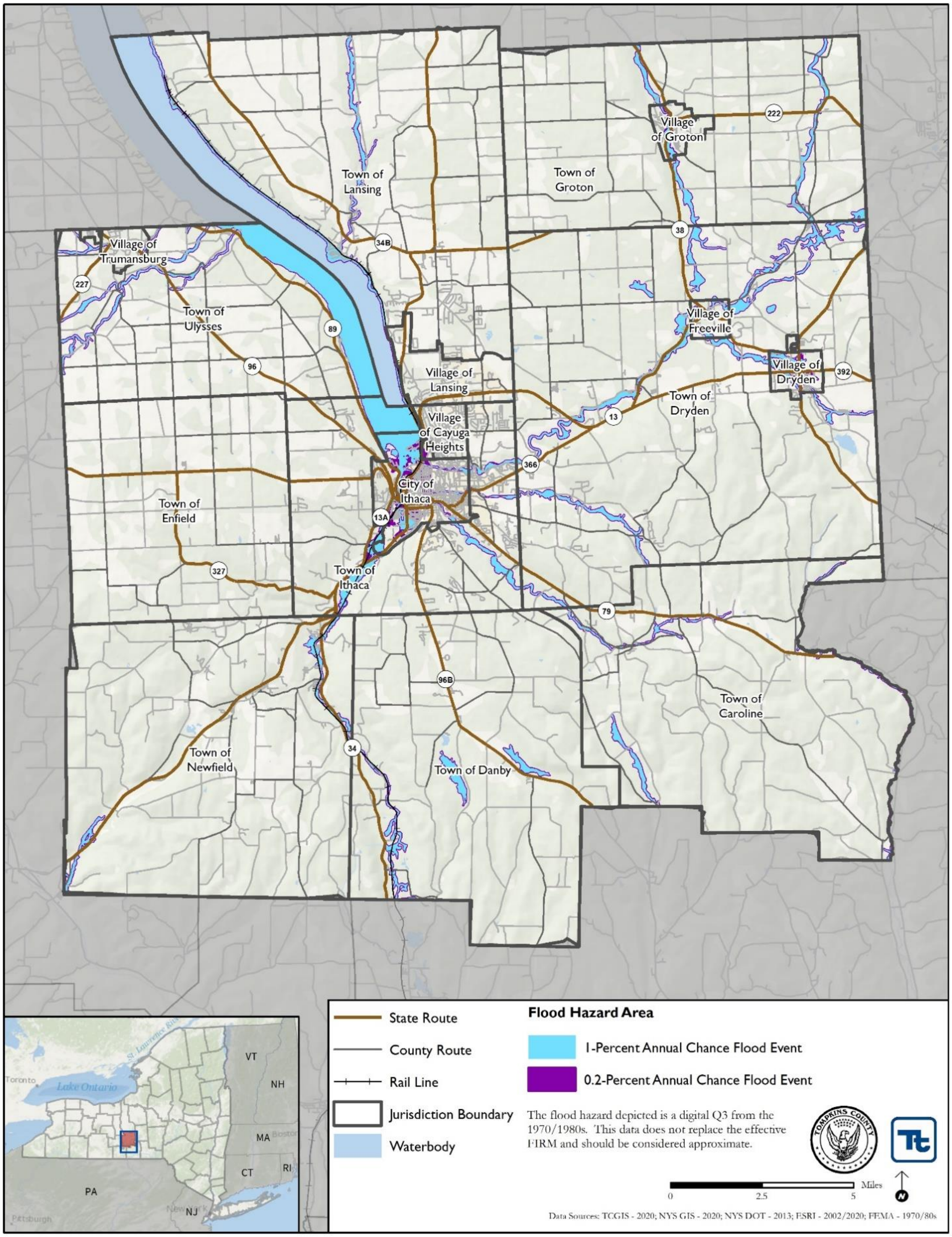
To illustrate the data available, screenshots of the gages are provided in Figure 5.4.4-3. The first hydrograph in the figure provides data collected at the *Cayuga Lake at Ithaca* gage as captured on May 20, 2020. It indicates that high water level of record is 386.5 feet, Action Stage is 383 feet, Minor Stage is 383.5 feet, Moderate Stage is 384 feet and Major Stage is 385 feet with the actual water height recorded as 383,1 feet at 6:00 pm on that day. This information is useful for local officials, emergency managers, and citizens to inform preparedness and response planning and activities to reduce potential impacts of flooding.

Figure 5.4.4-3. Flood Hydrographs for the Gages in Tompkins County



Source: NWS 2020

Figure 5.4.4-4. Tompkins County 1-Percent and 0.2-Percent Annual Flood Event Hazard Areas



Riverine/Flash Flooding/Stormwater Flooding

Tompkins County has faced frequent flood issues owing to its prolific waterways, particularly Cayuga Lake. The County is located along a major waterway drainage divide, with the southern section of the County draining to the Susquehanna River and the northern section draining to the Seneca-Oneida-Oswego River through Cayuga Lake. According to FEMA Q3 data, the County's flood zones are found in isolated areas along its major waterways, including Six Mile Creek, Taughannock Creek, Cayuga Inlet, and Fall Creek. The southern shore of Cayuga Lake and the areas immediately adjacent to the Inlet in the City and Town of Ithaca contain larger flood zones. A 500-year flood zone surrounds the core city area.

Figure 5.4.4-5. Ice jam at Cascadilla Creek near the Adams Street pedestrian bridge in Ithaca.

Source: WHCURadio.com

FEMA's Flood Insurance Studies for Tompkins County currently consist of paper Flood Insurance Rate Maps (FIRMs) that date to the mid-1980s. Separate Flood Insurance Studies are available for the Village of Dryden, Village of Groton, City of Ithaca, Town of Ithaca, Town of Lansing, Village of Lansing, and the Town of Ulysses. Currently, FEMA is developing new Flood Insurance Rate Maps which are scheduled to be finalized in 2022.

In Dryden, the FIS notes that the majority of stream reaches in the village have small main channels. This results in flooding in low, flat flood plains. The FIS notes that the lack of long-term gaging station prevents the collection of data about major floods. In the Village of Groton, floods can occur along the Owasco Inlet. The Village was hard-hit by an October 1981 flood that caused more than $3 million in damages and resulted in four feet of water in the center of the Village (Environmental Management Council, 2018). While Dryden does have the Virgil Creek Dam to help control some flooding to the Village of Dryden, the Village of Groton does not have flood control structures.

Figure 5.4.4-6. USGS Staffer tracking flow in Ithaca, NY

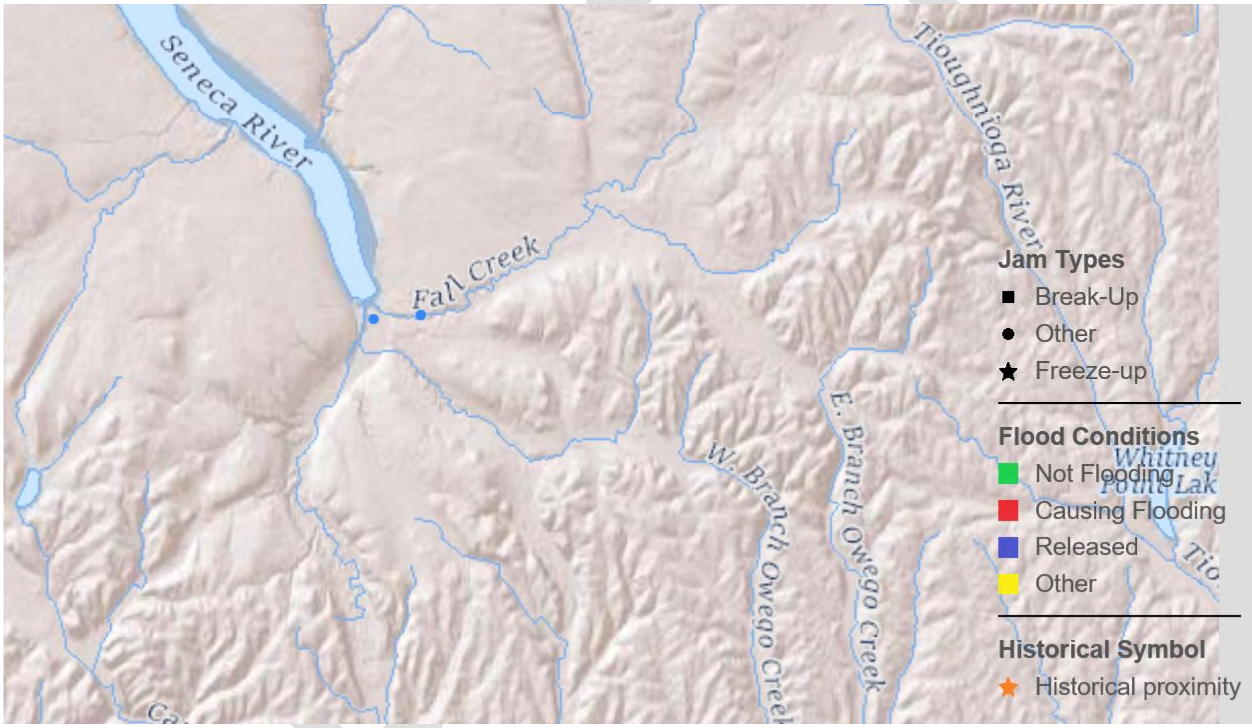
Source: USGS

The City of Ithaca faces flood vulnerability due to its location vis-à-vis Cayuga Lake and Cayuga Inlet. Low-lying areas flood during summer thunderstorms and wave action on the lake in the wintertime forces ice up the Fall Creek, blocking flow. The FIS notes that most streams in the City have some sort of channel improvement and that the Army Corps of Engineers had constructed a flood protection project along the Inlet. Lack of dredging has reduced effectiveness of this project, however dredging is currently planned to allow this project to function as designed. The Town of Ithaca also experiences flooding, predominantly due to Cayuga Inlet and from localized creek flooding during strong storms.

Both the Village and Town of Lansing experience flooding owing to high water levels in Cayuga Lake. Neither are protected by structural flood control projects, though some flood control structures, like that in Ludlowville have been recently built and provide localized stormwater protection during high precipitation events. The Town of Ulysses is similarly impacted by high lake levels.

Ice Jam Flooding

Ice jams can occur along Tompkins County's streams and rivers. Two reported incidents were reported in the Army Corps' ice jam database- one event at Fall Creek/Beebe Lake in March 2003, and one break-up event along Cascadilla Creek in January 2014. The NOAA database reported an additional ice-related flooding event in January 2005.



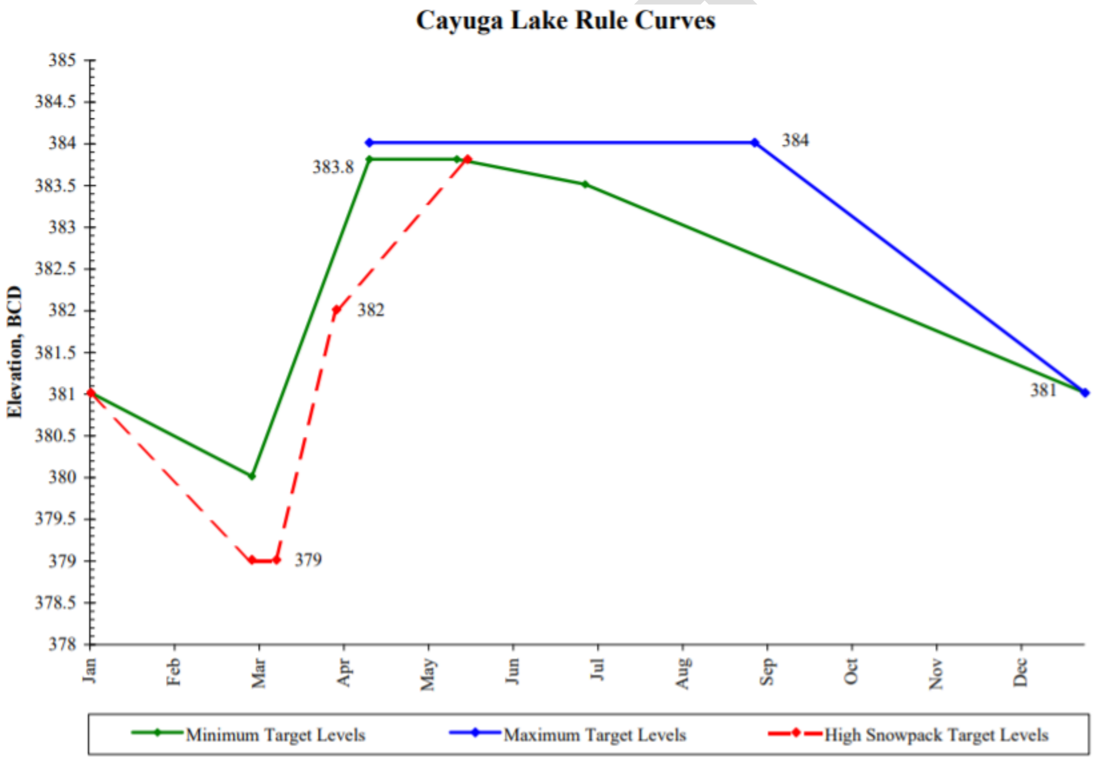
Lakeshore Flooding

Tompkins County is impacted by lakeshore flooding, particularly along Cayuga Lake. The lake has a targeted elevation range of between 382.7 and 384 feet. Target levels for a variety of conditions change slightly throughout the year, as seen in Figure 5.4.4-7. The lake's hydrology is complicated and managing water levels requires a delicate balancing of needs between upstream and downstream residents. In 2010, the four-county region surrounding Cayuga Lake signed a Call for Cooperation and Resolution to endorse a watershed study for the lake.

The New York State Canal Corporation is responsible for maintaining water levels of the Oswego River Basin canal system for navigational purposes. As a result, the Corporation operates the dam at Mud Lock. However, because Cayuga Lake drains into the Seneca River, managing water levels in the lake is difficult. During flooding conditions, lowering Cayuga Lake can damage properties along the Seneca River (Cayuga Lake Watershed Network, 2020).

A notable lakeshore flooding event occurred in June 1972, when rains from the remnants of Hurricane Agnes raised the lake level and flooded yards and basements (Environmental Management Council, 2018).

Figure 5.4.4-7: Cayuga Lake Rule Curves



**BCD = Barge Canal Datum; conversion to NGVD: subtract 1.3 feet; conversion to NAVD: subtract 1.9 feet*
Source: NYS Canal Corporation, 2020

Figure 5.4.4-8: Cayuga Lake Water Levels in 2020

**BCD = Barge Canal Datum; conversion to NGVD: subtract 1.3 feet; conversion to NAVD: subtract 1.9 feet*
Source: NYS Canal Corporation, 2020

Cayuga Lake experiences flooding somewhat regularly. In early May 2020, the National Weather Service issued a flood warning as lake levels exceeded 0.6 feet above flood stage, which causes expected flood impacts to Stewart Park, Allan H. Treman State Marine Park, and the Titus Towers area along Route 13 in Ithaca. Lakeside houses in the Towns of Ulysses and Lansing and Village of Trumansburg are also susceptible to flooding (14850.com, 2020). According to an archive of National Weather Service warnings, Flood Warnings have been issued to the City of Ithaca eleven times since 2005 (Iowa State University, 2020). The Flood Impacts based on water levels in the lake are as follows:

Figure 5.4.4-9: NWS Flood Impacts by Lake Water Level

Water Level	Description
386.5	This is the approximate level during the April 1993 record snowmelt flood.
386.3	This is approximately the lake level during the June 1972 Hurricane Agnes major flood.
385	Significant flooding occurs around the lake. This level is approximately the same as the April 1916 and March 1936 floods. Wind waves will cause unusual land erosion and damage docks.

Water Level	Description
384	Water will affect some properties along the lake shore in the towns of Ulysses, Trumansburg and Lansing. No homes are flooded at this level. Parks near the lake may flood. Wind waves may cause unusual land erosion and damage docks.
383.5	The lake level is high enough to flood normally dry areas along the shoreline and may affect some paths, or roads nearest the shore.

Source: NWS, 2020

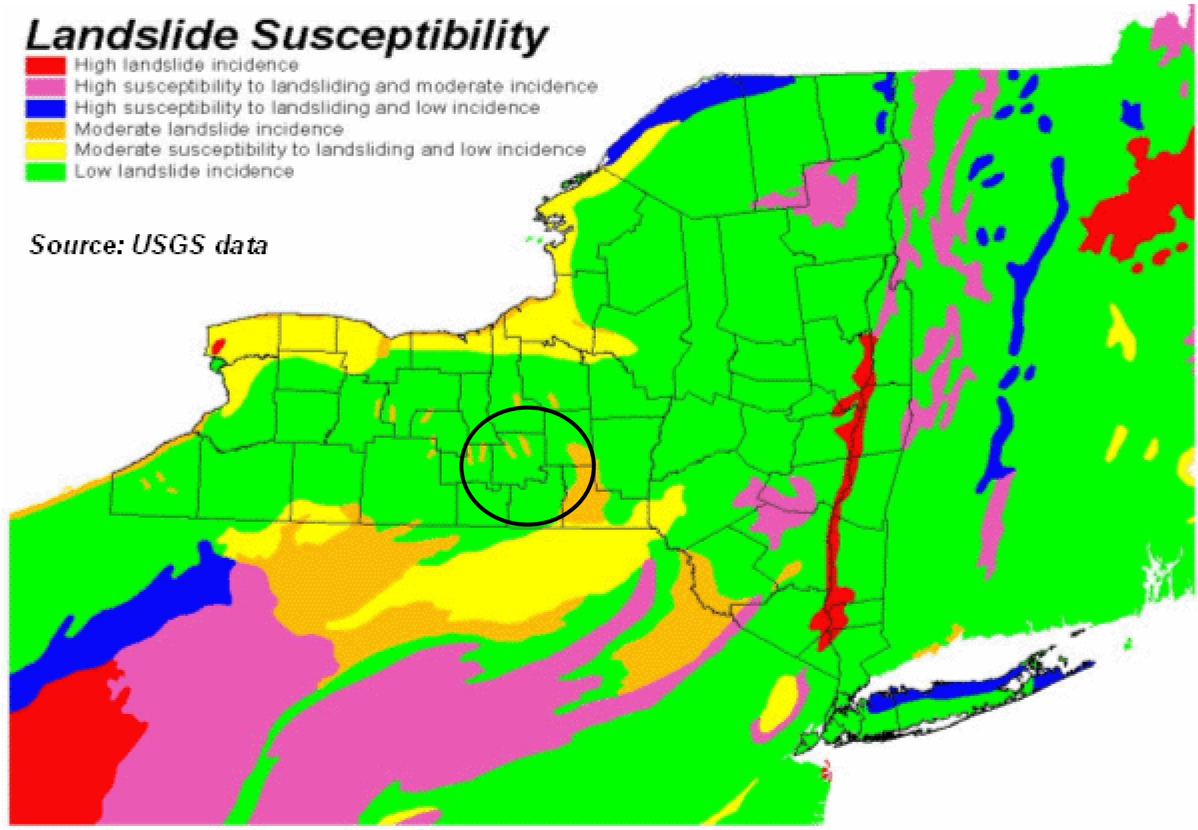
Flood Induced Landslides

Due to the topographic characteristics of Tompkins County, several municipalities are vulnerable to landslides due to flash flood events, particularly in the Towns of Dryden, Groton, Caroline, the City of Ithaca, and the Villages of Freeville and Groton. Cornell University has also reported multiple landslide events on their properties, which have resulted from flash flooding (Tompkins County HMP 2014).

Landslides have occurred in several areas of Tompkins County. The most recent landslides have occurred along creeks in the County, particularly Six Mile Creek and Fall Creek. Though there has been limited private property damage, the landslides have resulted in significant damage to roadways and public infrastructure. According to the 2020 HMP Steering Committee, there are a number of vulnerable areas within the City of Ithaca, specifically the Cascadilla and Fall Creek Gorge that are vulnerable to erosion, especially during intense precipitation events. Taughannock Falls and properties located along the gorge have also been identified as areas that are vulnerable to landslides and erosion. However, because of the slow nature of these hazards and the limited actions the County can consider for mitigation, this hazard has not been designated as a standalone hazard of concern.

Figure 5.4.4-10 shows landslide incidence and susceptibility in New York State based on known incidents and geologic data. The figure shows that there are two moderate incidence locations in the County that correspond to areas surrounding Cayuga Lake and areas located within the Pleasant Valley area.

Figure 5.4.4-10. Landslide Susceptibility in Tompkins County



Source: NYSDHSES:
Note: Circle indicates the approximate location of Tompkins County.

Dam Failure

NYSDEC maintains an inventory of dam failure data. Hazard classification, location, volume, elevation, and condition information for each dam in Tompkins County that has a federal identification number is included in the inventory. The New York State Inventory of Dams, identifies 96 dams in Tompkins County: 25 low hazard, 4 intermediate hazard, 5 high hazard, 11 negligible or no hazard classification, and 51 with an unknown classification (NYS DEC 2020).

Levee Failure

Levees protect portions of the City of Ithaca. The two levee systems, found along the left and right bank of the Cayuga Inlet, together protect 621 people, 132 structures, and $57.5 million in property. As of May 2016, the Army Corps of Engineers rates the levee at a low risk for failure, which it classifies as "Likelihood of inundation due to breach and/or system component malfunction in combination with loss of life, economic, or environmental consequences results in low risk." Unofficial levees along Fall Creek and Cascadilla Creek also protect neighborhoods from flood damage, however, these levees are not regularly inspected by State or Federal agencies.

Previous Occurrences and Losses

Tompkins County has been subject to historic flooding, some of which has been alleviated by the Cayuga Inlet project. The worst storms in Ithaca occurred in 1857, 1935 and 1937 (Ithaca Voice). More recent disruptive flood conditions occurred in 1993 and 2014. In the 1993 storm, a rapid thaw resulted in flooding in the City of Ithaca. Fish were reported to be seen swimming in the Wegmans parking lot (Environmental Management Council, 2018).

Figure 5.4.4-11. The Ithaca Journal Article on 1937 Flooding

Britain Demands 'Full Satis[f]action' for Wounding of Envoy

The Weather

U. S. Weather Bureau forecast: Fair tonight and Saturday; not much change in temperature. For detailed report, see Page 5.

THE ITHACA JOURNAL

MEMBER OF THE ASSOCIATED PRESS, THE GREATEST NEWSGATHERING ORGANIZATION IN THE WORLD

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No matter on what you're thinking of spending money — watch the changing ads in the classified section for the offer that suits you—and spend it wisely.

122nd YEAR—No. 205 EIGHTEEN PAGES ITHACA, N. Y., FRIDAY EVENING, AUGUST 27, 1937 PRICE THREE CENTS

FLOOD STRIKES ITHACA

Chinese Declare Foes Beaten Near Shanghai

London—(AP)—Authoritative quarters said the British government's demand for "full satisfaction" for the wounding of its ambassador to China was presented today to the Japanese ambassador to London.

The demand was understood to have been made by Foreign Secretary Anthony Eden to Shigeru Yoshida, the Japanese envoy, when the latter called at the foreign office to tender officially Japan's regrets.

Sir Hughe Montgomery Knatchbull-Hugessen, Britain's ambassador, was gravely wounded Thursday when shot by Japanese airmen on the road between Nanking and Shanghai.

Crowd Masses Outside

Ambassador Yoshida spent half an hour with the foreign secretary. Indicating the public interest in the tension in Anglo-Japanese relations, a crowd gathered at the Downing Street entrance to the foreign office to witness the Japanese envoy's arrival and departure.

Earlier in the day Quo Tai-Chi, the Chinese ambassador, had visit-

Shanghai—(AP)—A Chinese communique declared today that a major Japanese offensive to split the ring around Shanghai had been defeated after a furious 30-hour battle at Lotien and said the enemy was in full retreat to the Yangtze River.

Three thousand Japanese were killed and wounded in the desperate fighting 12 miles northwest of Shanghai, the army communique asserted.

While the battle raged for the vital Yangtze landing stages, the British ambasador to China, wounded by an attack from Japanese warplanes, lay dangerous close to death in the Shanghai country hospital. His recovery, and perhaps the whole future of relations between Japan and Great Britain, depended on the success of a blood transfusion from a United States sailor.

Envoy Is Improving

Doctors attending Sir Hughe Montgomery Knatchbull-Hugessen said in mid-afternoon that the envoy was continuing a gradually slow improvement. His back was broken and his right side pierced

Death Comes To Mellon, Noted Financier

Southampton—(AP)—Andrew W. Mellon, who built one of the world's greatest fortunes out of banking, oil and aluminum and who spent his late years in the nation's service as secretary of the Treasury and as ambassador to Great Britain, has passed from the American scene.

The shy, diffident, white haired financier, whose 11 years of service under three presidents was surpassed only by one of his predecessors as head of the Treasury Department, died peacefully Thursday night in his 83rd year.

He died in the home of his daughter, Mrs. David K. E. Bruce, after a month's illness from uremia and bronchial pneumonia. At his bedside as life ebbed away were his son-in-law and the financier's two pals and playmates, his son Paul and his daughter Ailsa, Mrs. Bruce.

The death of Pittsburgh's most powerful figure and one of the nation's unostentatious philanthropists was not unexpected. He had been under the physician's care for

Scenes as Flood Waters Again Visit Ithaca

REPTILE REFUGE

Fair Washed Out As Rain Causes Widespead Loss

Torrents of water rushed down on Ithaca and vicinity from all directions today to create the worst flood conditions since July, 1935. Although no lives were lost, widespread property damage was reported.

The Island and southwest sections of the city were completely inundated shortly after 7 a. m., as rising waters of the Inlet overflowed the banks to the south. A few families evacuated their homes.

Highways Under Water

The Tompkins County Fair was completely washed out during the early hours of the day, but several hundred head of cattle were rescued before the rising waters engulfed them. Smaller animals were freed from their pens to shift for themselves until captured later.

Highways were blocked in three directions out of Ithaca. The new Inlet Valley highway was under several feet of water near Meadow Street, while tons of stone and silt covered the Five Mile Drive just south of the city. The road was passable, but dangerous.

Mecklenburg Road Blocked

The Mecklenburg highway was blocked between Kennedy's and Applegate's Corners as the result of a bridge washout. Raging waters undermined Taughannock Boulevard in several places between Ithaca and Glenwood. These same

also routed over the main line from Sayre via Geneva and Trumansburg. The Ithaca Post Office sent trucks to Trumansburg for it.

Considerable damage was caused by flood waters in the vicinity of Glenside again, when Coy Glen Creek went on a rampage.

Ithaca Journal: August 27, 1937

Numerous sources provided historical information regarding previous occurrences and losses associated with flood events in Tompkins County. According to NOAA-NCEI Storm Events Database, National Performance of Dams Program (NPDP), and Cold Regions Research and Engineering Laboratory (CRREL) databases, Tompkins County has been impacted by 55 flood events, including ice jams and landslides, from 1954 to June 2020. Table 5.4.4-3 summarizes historical flood events (including ice jams) from 1954 to May 2020.

Table 5.4.4-3. Flood Events 1996-2020

Hazard Type	Number of Occurrences Between 1954 and 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Flash Flood	14	0	0	$23.09 M	$0
Flood	4	0	0	$117,000	$0
Landslides	10	-	-	-	-

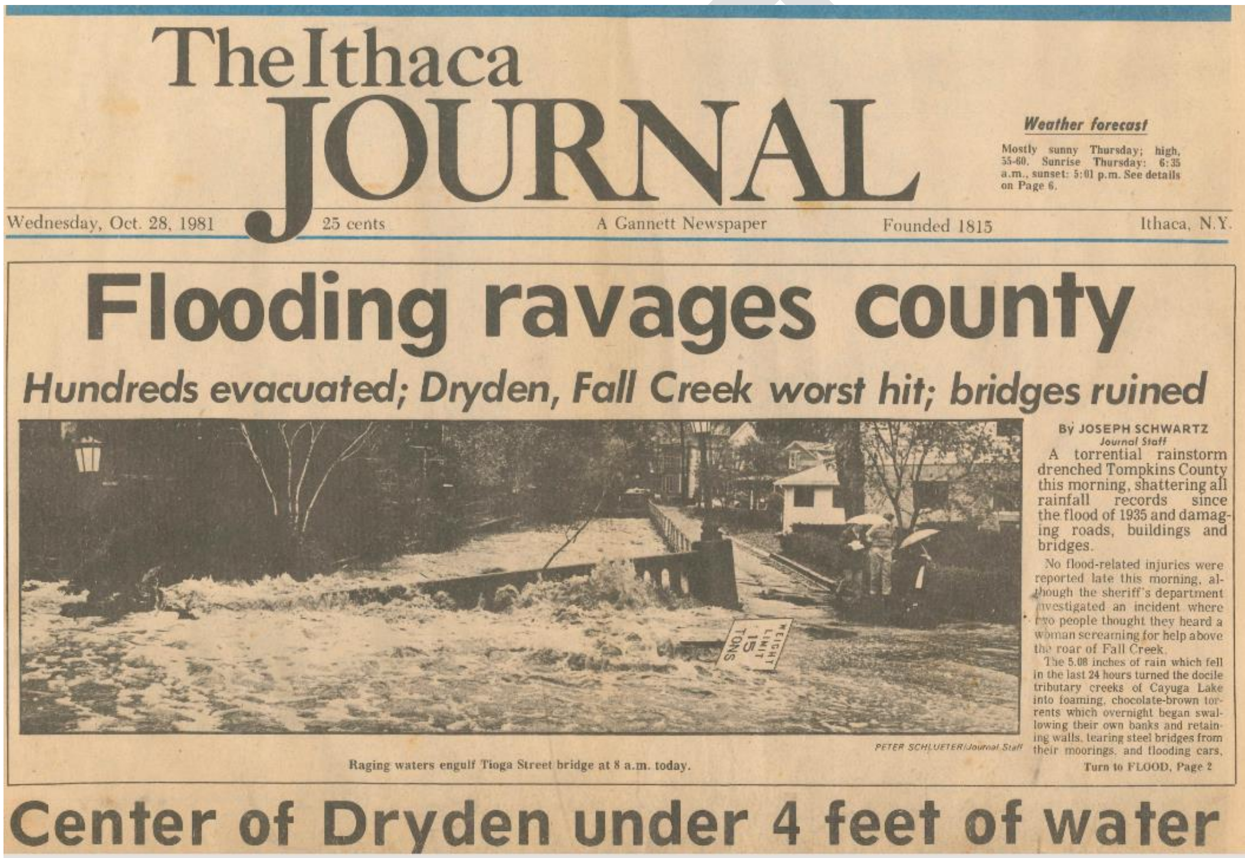
Hazard Type	Number of Occurrences Between 1954 and 2020	Total Fatalities	Total Injuries	Total Property Damage ($)	Total Crop Damage ($)
Dam Failure	0	0	0	$0	$0
Ice Jam	14	-	-	$60,000	-
Levee Failure	0	0	0	0	$0
TOTAL	**55**	**0**	**0**	**$23.2 M**	**$0**

Source: NOAA-NCEI 2020; CRREL 2020, International Levee Performance Database 2020

Notes: CRREL data does not include information on total fatalities, injuries, property damages, or crop damages; One event is counted both as a flood and as an ice jam.

M Million.

Figure 5.4.4-12. The Ithaca Journal Article on 1981 Flooding



The Ithaca JOURNAL

Wednesday, Oct. 28, 1981 25 cents A Gannett Newspaper Founded 1815 Ithaca, N.Y.

Weather forecast

Mostly sunny Thursday; high, 55-60. Sunrise Thursday: 6:35 a.m., sunset: 5:01 p.m. See details on Page 6.

Flooding ravages county

Hundreds evacuated; Dryden, Fall Creek worst hit; bridges ruined

By JOSEPH SCHWARTZ
Journal Staff

A torrential rainstorm drenched Tompkins County this morning, shattering all rainfall records since the flood of 1935 and damaging roads, buildings and bridges.

No flood-related injuries were reported late this morning, although the sheriff's department investigated an incident where two people thought they heard a woman screaming for help above the roar of Fall Creek.

The 5.08 inches of rain which fell in the last 24 hours turned the docile tributary creeks of Cayuga Lake into foaming, chocolate-brown torrents which overnight began swallowing their own banks and retaining walls, tearing steel bridges from their moorings, and flooding cars,

Turn to FLOOD, Page 2

WEIGHT LIMIT 15 TONS

PETER SCHLUETER/Journal Staff

Raging waters engulf Tioga Street bridge at 8 a.m. today.

Center of Dryden under 4 feet of water

Ithaca Journal: October 28, 1981

Between 1954 and May 2020, FEMA included New York State in 88 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. Tompkins County was included in 12 of these flood-related declarations; refer to Table 5.4.4-4.

Table 5.4.4-4. Flood-Related FEMA Declarations for Tompkins County, 1954 to 2020

Disaster Number	Incident Duration	Declaration Date	Incident Type	Title
EM-3351	October 27-- November 8, 2012	10/28/2012	Hurricane	Hurricane Sandy
DR-4031	September 7-- September 11, 2011	9/13/2011	Severe Storm(s)	Remnants of Tropical Storm Lee
DR-1650	June 26-- July 10, 2006	7/1/2006	Severe Storm(s)	Severe Storms and Flooding
DR-1534	May 13-- June 17, 2004	8/3/2004	Severe Storm(s)	Severe Storms and Flooding
DR-1335	May 3-- August 12, 2000	7/21/2000	Severe Storm(s)	Severe Storms and Flooding
DR-1233	June 25-- July 10, 1998	7/7/1998	Severe Storm(s)	Severe Storms and Flooding
DR-1148	November 8-- November 15, 1996	12/9/1996	Severe Storm(s)	Severe Storms, High Winds, Rains, and Flooding
DR-1095	January 19-- January 30, 1996	1/24/1996	Flood	Severe Storms and Flooding
DR-515	July 21, 1976	7/21/1976	Flood	Severe Storms and Flooding
DR-487	October 2, 1975	10/2/1975	Flood	Storms, Rains, Landslides, and Flooding
DR-338	June 23, 1972	6/23/1972	Flood	Tropical Storm Agnes
DR-290	July 22, 1970	7/22/1970	Flood	Heavy Rains & Flooding

Source: FEMA 2020

For this update, flood events were summarized from 1996 to 2020. Known flood events, including FEMA disaster declarations, which have impacted Tompkins County between 1996 and 2020 are identified in Table 5.4.4-5. Not all sources have been identified or researched due to the quantity of available data. Therefore, Table 5.4.4-5 might not include all events that have occurred in the County. For events prior to 2012, refer to Appendix E (Supplementary Data). For detailed information on damages and impacts to each municipality, refer to Section 9 (Jurisdictional Annexes).

Table 5.4.4-5. Flood Events in Tompkins County, 2012 to 2020

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Event Details
August 8, 2013	Heavy Rain	N/A	N/A	A stationary front generated slow-moving clusters of thunderstorms across New York. Up to one foot of water crossed Route 89 near Taughannock Falls near Trumansburg. Near Waterburg, Harvey Hill and Fish Roads were closed due to flooding. Near Enfield, the bridge at the intersection of Route 327 and Harvey Hill Road was washed out. North of Ithaca, Routes 96 and 89 were covered in flood waters. Altogether, the County saw more than $150,000 in property damage.

Dates of Event	Event Type	FEMA Declaration Number (if applicable)	County Designated?	Event Details
August 3, 2014	Flash Flood	N/A	N/A	The City of Ithaca experienced $100,000 in damage after water covered several roadways and entered a residence. The northeastern section of the City was hit hardest.
June 5, 2015	Flash Flood	N/A	N/A	A stalled warm front brought repeated clusters of thunderstorms and widespread flooding in the County. Near Newfield, homes were flooded to the first floor and the Shelter Valley mobile home park was evacuated. Altogether, $1.5 million in damage was reported.
July 9, 2015	Flash Flood	N/A	N/A	Near Ludlowville, flood waters covered Ridge Road and Route 34B following a torrential rainfall. Roads from Groton to Trumansburg were flooded, with more severe flooding seen along Pease Road. Reported damage exceeded $70,000.
July 13, 2017	Flash Flood	N/A	N/A	Central New York experienced heavy rainfall in thunderstorms resulting from a stationary cold front. Route 41 and 41A saw closures due to flooding.
July 24, 2017	Flash Flood	N/A	N/A	A stationary front caused torrential rainfall stretching from Lansing to Dryden. Approximately $75,000 in damage was recorded.
August 15, 2019	Flash Flood	N/A	N/A	Danby saw road closures due to flooding following a stationary boundary over the region that produced slow-moving thunderstorms and caused $40,000 in damage. Steam Mill Road was reported to be completely washed away at Danby Creek.
April 30, 2020	Heavy Rain and Flooding	N/A	N/A	Heavy rainfall led to rapid and enhanced flooding in Tompkins County. In Trumbulls Corners (Town of Newfield), several creeks overflowed their banks along Route 13. In Caroline Center (Town of Caroline), water was moving across several properties. Total property damage was estimated at $7,000.

Sources: FEMA 2020; NOAA-NCEI 2020; NYS HMP 2019; SPC 2018; International Levee Performance Database 2019
FEMA Federal Emergency Management Agency
HMP Hazard Mitigation Plan
Mph Miles Per Hour
NCDC National Climatic Data Center
NOAA National Oceanic and Atmospheric Administration
NYS New York State
N/A Not Applicable
SPC Storm Prediction Center
Note: Many sources were consulted to provide an update of previous occurrences and losses; event details and loss/impact information may vary and has been summarized in the above table.

Climate Change Impact

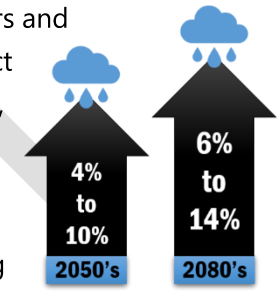
In the Southern Tier region, it is estimated that precipitation totals will increase between 4 and 10 percent by the 2050s and 6 to 14 percent by the 2080s (baseline of 35.0 inches, middle range projection). Table 5.4.46 displays the projected seasonal precipitation change for the Southern Tier ClimAID Region (NYSERDA 2014).

Table 5.4.4-6. Projected Seasonal Precipitation Change in Region 3, 2050s (% change)

Winter	Spring	Summer	Fall
+5 to +15	0 to +15	-10 to +10	-5 to +10

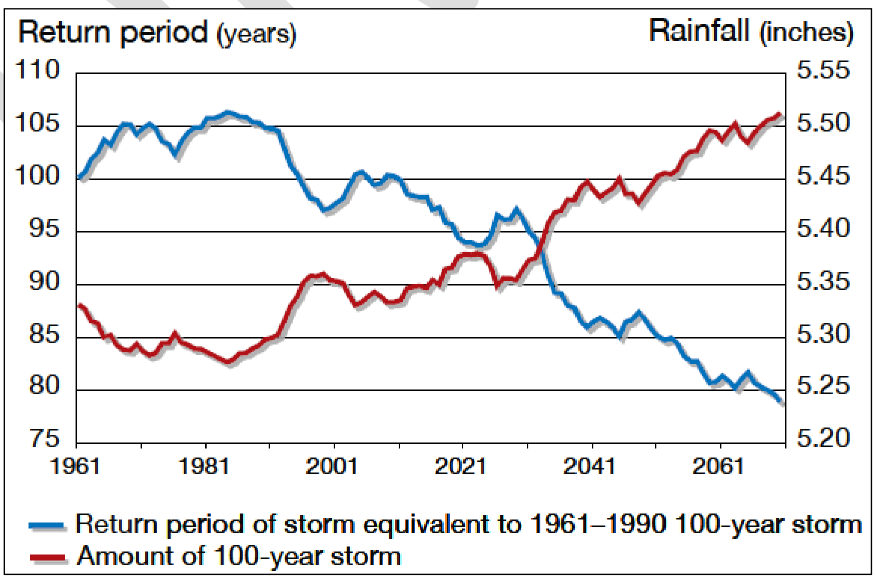
Source: NYSERDA 2011

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 hubs; and increase delays and hazards related to extreme weather events (NYSERDA 2011).



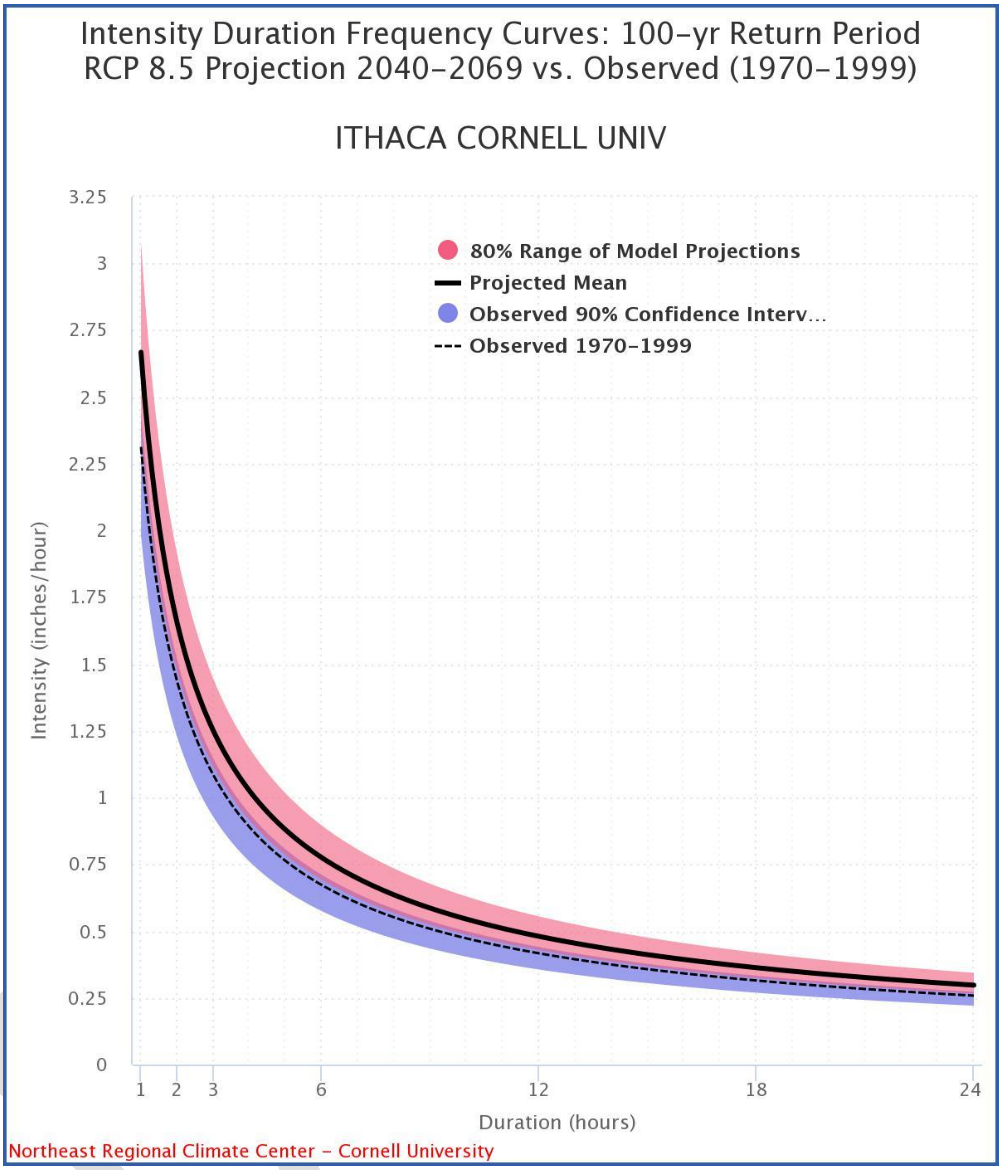
Increasing air temperatures intensify the water cycle by increasing evaporation and precipitation. This can cause an increase in rain totals during events with longer dry periods in between those events. These changes can have a variety of effects on the State's water resources (NYSERDA 2011). Figure 5.4.4-11 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 5.4.4-13. Projected Rainfall and Frequency of Extreme Storms



Source: NYSERDA 2011

Figure 5.4.4-14. Intensity Duration Frequency Curves



Source: Northeast Regional Climate Center – Cornell University

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can significantly affect the hydrograph used for the design of a dam. If the hygrograph changes, the dam conceivably could lose some or all designed margin of safety, also known as freeboard. Loss of designed margin of safety increases possibility that floodwaters would overtop the dam or create unintended loads, which could lead to a dam failure.

Probability of Future Occurrences

Based on the historic and more recent flood events in Tompkins County, and the future climate projections for this region, the County has a high probability of future flooding. Tompkins County will likely 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.

As defined by FEMA, geographic areas within the 1-percent annual chance flood area (or Special Flood Hazard Area) in Tompkins County are estimated to have a 1-percent chance of flooding in any given year. A structure located within a 1-percent annual chance flood area has a 26 percent chance of suffering flood damage during the term of a 30-year mortgage. Similarly, the 0.2-percent annual chance flood has a 6 percent chance of occurring during a 30-year time period.

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides, and excessive rainfall and snowmelt. However, the risk of such an event increases for each dam as the dam's age increases and/or frequency of maintenance decreases.

According to the NOAA National Centers for Environmental Information (NCEI) and the CRREL database, Tompkins County experienced 55 flood events between 1954 and 2020, including 4 floods, 14 flash floods, 10 landslides, 14 ice jams, and no dam or levee failures. 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 Tompkins County in future years based on the historic record (NOAA NCDC 2020).

Table 5.4.4-7. Probability of Future Occurrence of Flooding Events

Hazard Type	Number of Occurrences Between 1954 and 2020	Rate of Occurrence	Recurrence Interval (in years)	Probability of event Occurring in Any Given Year	% Chance of Occurring in Any Given Year
Flash Flood	14	0.21	4.79	0.21	20.90
Flood	4	0.06	16.75	0.06	5.97
Landslides	10	0.15	6.70	0.15	14.93
Dam Failure	0	0.00	0	0	0
Ice Jam	14	0.21	4.79	0.21	20.90
Levee Failure	0	0.00	-	0	0
TOTAL	**42**	**0.83**	**1.22**	**0.82**	**82.09**

Source: NOAA-NCEI 2020; CRREL 2020; NPDP 2020

Climate change is expected to increase the severity and frequency of heavy rain events in Tompkins County. This will likely lead to an increase in flooding events, dam failure events, and levee failure events.

In Section 5.3, the identified hazards of concern for Tompkins 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' (hazard event has 100% annual probability and may occur multiple times per year).

5.4.4.2 Vulnerability Assessment

To assess Tompkins County's risk to the flood hazard, a spatial analysis was conducted using the best available spatially-delineated flood hazard areas. The 1-percent and 0.2-percent annual chance flood events were examined to determine the assets located in the hazard areas and to estimate potential loss using the FEMA Hazus-MH v4.2 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 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. However, exposure is not limited to persons who reside in a defined hazard zone, but includes all individuals 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.

Based on the spatial analysis, there are an estimated 1,807 people in Tompkins County living in the 1-percent annual chance flood event hazard area and an estimated 10,579 people located in the 0.2-percent annual chance flood event hazard area (refer to Table 5.4.4-8). These residents may be displaced due to their homes flooding, requiring them to seek temporary shelter with friends and family or in emergency shelters. The Village of Dryden and the City of Ithaca has the greatest percentage of its population located in the 1-percent and 0.2-percent annual chance flood event hazard areas, respectively. The Village of Dryden has approximately 8.6-percent of its population exposed to the 1-percent annual chance flood event. The City of Ithaca has approximately 2.4-percent of its population exposed to the 1-percent annual chance flood event. Overall, the City of Ithaca has the greatest number of persons exposed to the 1-percent and 0.2-percent annual chance flood event hazard areas; approximately 730 persons and 9,375 persons, respectively. For this project, the potential population exposed is used as a guide for planning purposes.

Table 5.4.4-8. Number of Persons Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

Jurisdiction	Population (American Community Survey 5-Year 2014 - 2018)	Population Exposed to 1-Percent Annual Chance Flood Event		Population Exposed to 0.2-Percent Annual Chance Flood Event	
		Number of Persons	Percent of Total	Number of Persons	Percent of Total
Caroline (T)	3,362	42	1.2%	42	1.2%
Cayuga Heights (V)	489	0	0.0%	0	0.0%

Jurisdiction	Population (American Community Survey 5-Year 2014 - 2018)	Population Exposed to 1-Percent Annual Chance Flood Event		Population Exposed to 0.2-Percent Annual Chance Flood Event	
		Number of Persons	Percent of Total	Number of Persons	Percent of Total
Danby (T)	3,438	3	0.1%	3	0.1%
Dryden (T)	12,158	150	1.2%	152	1.3%
Dryden (V)	2,092	158	7.6%	215	10.3%
Enfield (T)	3,541	0	0.0%	0	0.0%
Freeville (V)	394	11	2.7%	11	2.7%
Groton (T)	3,922	106	2.7%	106	2.7%
Groton (V)	2,050	23	1.1%	48	2.4%
Ithaca (C)	30,568	730	2.4%	9,375	30.7%
Ithaca (T)	19,418	178	0.9%	221	1.1%
Lansing (T)	7,794	234	3.0%	234	3.0%
Lansing (V)	3,535	4	0.1%	4	0.1%
Newfield (T)	5,218	70	1.3%	70	1.3%
Trumansburg (V)	1,805	8	0.4%	8	0.4%
Ulysses (T)	3,178	90	2.8%	90	2.8%
Tompkins County (Total)	**102,962**	**1,807**	**1.8%**	**10,579**	**10.3%**

Source: Tompkins County GIS 2019/2020, American Community Survey 2018
Notes: V = Village, C = City, T = Town

Research has shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. This is due to many factors including their physical and financial ability to react or respond during a hazard.

Individuals most vulnerable to flood events include those: Over 65 years old, low-income, homeless, with a disability, with difficulty communicating.

The population over age 65 is also more vulnerable because they are more likely to seek or need medical attention that may not be available due to isolation during a flood event, and they may have more difficulty evacuating. Within Tompkins County, there are approximately 13,561 persons over the age of 65. Low-income persons may also be more vulnerable to economic disruptions associated with flooding or may have difficulty accessing transportation and medical care. 17,500 persons in Tompkins County live below the poverty level. Other groups particularly vulnerable to flood events are the homeless who reside in high exposure areas and those that have a difficulty in communicating, including non-native speakers and those with intermittent internet and cellular service.

The CDC 2016 Social Vulnerability Index (SVI) ranks U.S. Census tracts on socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Tompkins County's overall score is 0.3493, indicating that its communities have low to moderate vulnerability (CDC 2016). This score indicates that most, but not all, County residents will have enough resources to respond to flood events.

Estimated Potential Displaced Population and Sheltering Needs

Using 2010 U.S. Census data, Hazus-MH v4.2 estimates the potential sheltering needs as a result of a 1-percent annual chance flood event. For the 1-percent flood event, Hazus-MH v4.2 estimates 4,619 households will be displaced and 270 people will seek short-term sheltering. These statistics, by jurisdiction, are presented in Table 5.4.4-9. The estimated displaced population and number of persons seeking short-term sheltering differs from the number of persons exposed to the 1-percent annual chance flood, because the displaced population numbers take into consideration that not all residents will be significantly impacted enough to be displaced or to require short-term sheltering during a flood event.

Table 5.4.4-9. Estimated Population Displaced or Seeking Short-Term Shelter From the 1-Percent Annual Chance Flood Event Hazard Area

Jurisdiction	Population (American Community Survey 5-Year 2014 - 2018)	1-Percent Annual Chance Flood Event	
		Displaced Population*	Persons Seeking Short-Term Sheltering*
Caroline (T)	9,452	41	0
Cayuga Heights (V)	443	0	0
Danby (T)	162,968	3	0
Dryden (T)	12,089	186	2
Dryden (V)	681	171	2
Enfield (T)	2,008	0	0
Freeville (V)	3,069	42	0
Groton (T)	448,342	91	0
Groton (V)	0	168	16
Ithaca (C)	18,685	3,577	248
Ithaca (T)	1,034	88	0
Lansing (T)	1,945	112	2
Lansing (V)	1,463	0	0
Newfield (T)	189,840	78	0
Trumansburg (V)	1,366	25	0
Ulysses (T)	3,345	37	0
Tompkins County (Total)	**326,416**	**4,619**	**270**

Source: American Community Survey 2018, Hazus-MH v4.2
Notes: V = Village, C = City, T = Town
** HAZUS v4.2 uses 2010 Census data for displacement estimates. These numbers may be underestimated compared to the American Community Survey 2018 5-year estimates data.*

Potential Life Safety Impacts

Total number of injuries and casualties resulting from typical riverine and tidal flooding are generally limited based on advance weather forecasting, blockades, and warnings. Injuries and deaths generally are not anticipated if proper warning and precautions occur. In contrast, warning time for flash flooding is limited. These events are frequently associated with other natural hazard events such as earthquakes, landslides, or severe weather, which limits their predictability and compounds the hazard. Populations without adequate warning of the event, as noted above, are highly vulnerable to this hazard.

Additionally, the impact of dam failure on life, health, and safety is dependent on several factors such as the area that the dam is protecting, the location, capacity, structural integrity, and the proximity of structures, infrastructure, and critical facilities downstream of the failure inundation area. According to the US Army Corps of Engineers, the level of impact that a dam failure would have can be predicted based upon the hazard potential classification (USACE 2020). Table 5.4.4-10 outlines the recommended hazard classifications.

Table 5.4.4-10. United States Army Corps of Engineers Hazard Potential Classification for Dams

Urgency of Action	Actions for Dams in This Class	Characteristics of This Class
Very High (1)	Take immediate action to avoid failure. Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite investigations to support remediation using all resources and funding necessary. Initiate intensive management and situation reports.	Critically near failure: Dam is almost certain to fail under normal operations to within a few years without intervention. OR Extremely high incremental risk: Combination of life or economic consequences with likelihood of failure is very high. USACE considered this level of life-risk to be unacceptable except in extraordinary circumstances.
High (2)	Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim risk reduction measures, including operational restrictions as warranted. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Expedite confirmation of classification. Give very high priority for investigations to support the need for remediation.	Failure initiation foreseen: For confirmed and unconfirmed dam safety issues, failure could begin during normal operations or be initiated as the consequence of an event. The likelihood of failure from one of these occurrences, prior to remediation, is too high to assure public-safety. OR Very high incremental risk: the combination of life or economic consequences with likelihood of failure is high. USACE considered this level of life-risk to be unacceptable except in extraordinary circumstances.
Moderate (3)	Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Implement interim	Moderate to high incremental risk: For confirmed and unconfirmed dam safety issues, the combination

Urgency of Action	Actions for Dams in This Class	Characteristics of This Class
	risk reduction measures, including operational restrictions as warranted. Ensure the emergency action plan is current and functionally tested for initiating event. Conduct heightened monitoring and evaluation. Prioritize investigations to support the need for remediation informed by consequences and other factors.	of life, economic, or environmental consequences with likelihood of failure is moderate. USACE considers this level of life-risk to be unacceptable except in unusual circumstances.
Low (4)	Communicate findings to sponsor, local, state, Federal, Tribal officials, and the public. Conduct elevated monitoring and evaluation. Give normal priority to investigations to validate classification, but do not plan for risk reduction measures at this time.	Low incremental risk: For confirmed and unconfirmed dam safety issues, the combination of life, economic, or environmental consequences with likelihood of failure is low to very low and the dam may not meet all essential USACE guidelines. USACE considers this level of life-risk to be in the range of tolerability but the dam does not meet all essential USACE guidelines.
Normal (5)	Continue routine dam safety activities and normal operations, maintenance, monitoring, and evaluation.	Very low incremental risk: The combination of life, economic, or environmental consequences with likelihood of failure is low to very low and the dam meets all essential USACE guidelines. USACE considers this level of life-safety risk to be tolerable.

Source: USACE 2020

As mentioned in the earlier sections, dam failure can cause in the most extreme case, loss of life and extensive property damage, or in the least extreme case, no loss of life or significant property damage. Dam failure can cause persons to become displaced if flooding of structures occurs. Dam failure may mimic flood events, depending on the size of the dam reservoir and breach. Understanding potential outcomes of flooding for each dam in Tompkins County would require intensive hydraulic modeling.

Cascading impacts of flooding and dam failure inundation 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. Flooding in basements is a regular complaint of many Tompkins County residents. 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 2019).

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 v4.2 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.

Impact on General Building Stock

Exposure to the flood hazard includes those buildings located in the flood zone. Potential damage is the modeled loss that could occur to the exposed inventory measured by the structural and content replacement cost value. There are an estimated 1,011 buildings located in the 1-percent annual chance flood event hazard area with a replacement cost value of approximately $1.8 billion. This represents approximately 2.5-percent of the County's total general building stock inventory replacement cost value (approximately $72 billion). Additionally, there are 3,169 buildings located in the 0.2-percent annual chance flood event hazard area with a replacement cost value of approximately $5 billion, or 7-percent of the County's total replacement cost value.

The Village of Dryden and the City of Ithaca has the greatest proportion of its buildings located in the 1-percent and 0.2-percent annual chance flood event hazard areas, respectively. Approximately 9.3-percent of buildings in the Village of Dryden are exposed to the 1-percent annual chance flood event and approximately 30.8-percent of buildings in the City of Ithaca are exposed to the 0.2-percent annual chance flood event. The City of Ithaca has the greatest number of buildings and highest replacement cost value exposed to both the 1-percent and 0.2-percent annual chance flood event hazard areas. Approximately 220 buildings in the City of Ithaca, or $853 million of total replacement cost value, is located in the 1-percent annual chance flood event hazard area and approximately 2,291 buildings in the City of Ithaca, or $3.9 billion of total replacement cost value, is located in the 0.2-percent annual chance flood event hazard area. Refer to Table 5.4.4-11 for a summary of 1-percent flood inundation area exposure results for all occupancies by jurisdiction. Table 5.4.4-13 and Table 5.4.4-15 break down the 1-percent annual chance flood event hazard area exposure results for residential structures and commercial structures, respectively. Refer to Table 5.4.4-12, Table 5.4.4-14, and Table 5.4.4-16 for the building flood exposure analysis results for the 0.2-percent annual chance flood event hazard area by jurisdiction for all occupancies, residential structures only, and commercial structures only, respectively.

Furthermore, Hazus-MH v4.2 estimates approximately $317.7 million in building and content damage as a result of the 1-percent annual chance flood event (or 0.4-percent of the total building stock replacement cost value). Of the $317.7 million in potential loss, approximately $119 million is estimated to be residential structures. Refer to Table 5.4.4-17 through Table 5.4.4-19 for the potential losses from the 1-percent annual chance flood event by jurisdiction for all occupancies, residential structures only, and commercial structures only.

Table 5.4.4-11. Estimated General Building Stock Exposure to the 1-Percent Annual Chance Flood Event – All Occupancies

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value	Total Exposure (All Occupancies) 1-Percent Annual Chance Flood Event			
			Number of Buildings	Percent of Total	Replacement Cost Value	Percent of Total
Caroline (T)	3,257	$2,523,108,347	44	1.4%	$40,539,979	1.6%
Cayuga Heights (V)	1,183	$1,548,665,909	0	0.0%	$0	0.0%
Danby (T)	3,008	$2,188,454,321	4	0.1%	$63,314,094	2.9%
Dryden (T)	8,518	$8,740,906,102	108	1.3%	$202,144,314	2.3%
Dryden (V)	1,022	$1,135,109,100	95	9.3%	$134,014,552	11.8%
Enfield (T)	3,559	$2,736,468,231	0	0.0%	$0	0.0%
Freeville (V)	409	$356,699,295	12	2.9%	$10,685,304	3.0%
Groton (T)	3,610	$2,804,801,342	82	2.3%	$39,666,677	1.4%
Groton (V)	1,205	$1,203,171,190	34	2.8%	$130,781,735	10.9%
Ithaca (C)	7,450	$19,712,305,674	220	3.0%	$853,040,250	4.3%
Ithaca (T)	6,080	$10,868,181,586	68	1.1%	$108,141,225	1.0%
Lansing (T)	6,010	$6,270,191,033	177	2.9%	$114,671,345	1.8%
Lansing (V)	1,055	$3,436,043,635	2	0.2%	$1,342,126	<0.1%
Newfield (T)	4,669	$3,848,204,673	66	1.4%	$27,106,658	0.7%
Trumansburg (V)	1,061	$1,241,549,970	5	0.5%	$2,599,287	0.2%
Ulysses (T)	3,552	$3,372,144,448	94	2.6%	$103,176,446	3.1%
Tompkins County (Total)	**55,648**	**$71,986,004,856**	**1,011**	**1.8%**	**$1,831,223,994**	**2.5%**

Source: Tompkins County GIS 2019/2020; RS Means 2019
Notes: V = Village, C = City, T = Town, % = Percent, < = Less Than

Table 5.4.4-12. Estimated General Building Stock Exposure to the 0.2-Percent Annual Chance Flood Event – All Occupancies

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value	Total Exposure (All Occupancies) 0.2-Percent Annual Chance Flood Event			
			Number of Buildings	Percent Total	Replacement Cost Value	Percent Total
Caroline (T)	3,257	$2,523,108,347	44	1.4%	$40,539,979	1.6%
Cayuga Heights (V)	1,183	$1,548,665,909	0	0.0%	$0	0.0%
Danby (T)	3,008	$2,188,454,321	4	0.1%	$63,314,094	2.9%

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value	Total Exposure (All Occupancies) 0.2-Percent Annual Chance Flood Event			
			Number of Buildings	Percent Total	Replacement Cost Value	Percent Total
Dryden (T)	8,518	$8,740,906,102	109	1.3%	$202,372,708	2.3%
Dryden (V)	1,022	$1,135,109,100	122	11.9%	$151,337,473	13.3%
Enfield (T)	3,559	$2,736,468,231	0	0.0%	$0	0.0%
Freeville (V)	409	$356,699,295	12	2.9%	$10,685,304	3.0%
Groton (T)	3,610	$2,804,801,342	82	2.3%	$39,666,677	1.4%
Groton (V)	1,205	$1,203,171,190	69	5.7%	$231,795,404	19.3%
Ithaca (C)	7,450	$19,712,305,674	2,291	30.8%	$3,937,393,678	20.0%
Ithaca (T)	6,080	$10,868,181,586	92	1.5%	$135,409,269	1.2%
Lansing (T)	6,010	$6,270,191,033	177	2.9%	$114,671,345	1.8%
Lansing (V)	1,055	$3,436,043,635	2	0.2%	$1,342,126	0.0%
Newfield (T)	4,669	$3,848,204,673	66	1.4%	$27,106,658	0.7%
Trumansburg (V)	1,061	$1,241,549,970	5	0.5%	$2,599,287	0.2%
Ulysses (T)	3,552	$3,372,144,448	94	2.6%	$103,176,446	3.1%
Tompkins County (Total)	**55,648**	**$71,986,004,856**	**3,169**	**5.7%**	**$5,061,410,449**	**7.0%**

Source: Tompkins County GIS 2019/2020; RS Means 2019
Notes: V = Village, C = City, T = Town, % = Percent

Table 5.4.4-13. Estimated General Building Stock Exposure to the 1-Percent Annual Chance Flood Event – Residential Structures Only

Jurisdiction	Total Number of Buildings (Residential Structures Only)	Total Replacement Cost Value (Residential Structures Only)	Total Exposure (Residential Structures Only) 1-Percent Annual Chance Flood Event			
			Number of Buildings	Percent of Total	Replacement Cost Value	Percent of Total
Caroline (T)	2,403	$1,358,577,326	30	1.2%	$21,023,528	1.5%
Cayuga Heights (V)	1,125	$1,287,240,123	0	0.0%	$0	0.0%
Danby (T)	2,262	$1,132,751,811	2	0.1%	$2,252,094	0.2%
Dryden (T)	6,628	$3,224,220,454	82	1.2%	$42,823,334	1.3%
Dryden (V)	886	$592,216,526	67	7.6%	$32,950,788	5.6%
Enfield (T)	2,738	$1,211,029,479	0	0.0%	$0	0.0%
Freeville (V)	294	$173,619,699	8	2.7%	$3,345,889	1.9%
Groton (T)	2,557	$1,207,683,173	69	2.7%	$31,582,953	2.6%
Groton (V)	1,059	$628,462,960	12	1.1%	$73,316,114	11.7%
Ithaca (C)	6,280	$6,611,345,821	150	2.4%	$311,494,946	4.7%
Ithaca (T)	4,919	$3,912,782,485	45	0.9%	$17,034,636	0.4%
Lansing (T)	4,706	$2,768,597,390	141	3.0%	$66,779,927	2.4%
Lansing (V)	813	$1,406,653,242	1	0.1%	$252,684	<0.1%
Newfield (T)	3,638	$1,539,401,729	49	1.3%	$12,327,794	0.8%
Trumansburg (V)	950	$602,857,632	4	0.4%	$1,836,392	0.3%
Ulysses (T)	2,542	$1,394,872,075	72	2.8%	$34,609,297	2.5%
Tompkins County (Total)	**43,800**	**$29,052,311,925**	**732**	**1.7%**	**$651,630,375**	**2.2%**

Source: Tompkins County GIS 2019/2020; RS Means 2019
Notes: V = Village, C = City, T = Town, % = Percent, < = Less Than

Table 5.4.4-14. Estimated General Building Stock Exposure to the 0.2-Percent Annual Chance Flood Event – Residential Structures Only

Jurisdiction	Total Number of Buildings (Residential Structures Only)	Total Replacement Cost Value (Residential Structures Only)	Total Exposure (Residential Structures Only) 0.2-Percent Annual Chance Flood Event			
			Number of Buildings	Percent of Total	Replacement Cost Value	Percent of Total
Caroline (T)	2,403	$1,358,577,326	30	1.2%	$21,023,528	1.5%
Cayuga Heights (V)	1,125	$1,287,240,123	0	0.0%	$0	0.0%
Danby (T)	2,262	$1,132,751,811	2	0.1%	$2,252,094	0.2%
Dryden (T)	6,628	$3,224,220,454	83	1.3%	$43,051,727	1.3%
Dryden (V)	886	$592,216,526	91	10.3%	$44,980,458	7.6%
Enfield (T)	2,738	$1,211,029,479	0	0.0%	$0	0.0%
Freeville (V)	294	$173,619,699	8	2.7%	$3,345,889	1.9%
Groton (T)	2,557	$1,207,683,173	69	2.7%	$31,582,953	2.6%
Groton (V)	1,059	$628,462,960	25	2.4%	$79,890,611	12.7%
Ithaca (C)	6,280	$6,611,345,821	1,926	30.7%	$1,235,320,797	18.7%
Ithaca (T)	4,919	$3,912,782,485	56	1.1%	$21,315,108	0.5%
Lansing (T)	4,706	$2,768,597,390	141	3.0%	$66,779,927	2.4%
Lansing (V)	813	$1,406,653,242	1	0.1%	$252,684	<0.1%
Newfield (T)	3,638	$1,539,401,729	49	1.3%	$12,327,794	0.8%
Trumansburg (V)	950	$602,857,632	4	0.4%	$1,836,392	0.3%
Ulysses (T)	2,542	$1,394,872,075	72	2.8%	$34,609,297	2.5%
Tompkins County (Total)	**43,800**	**$29,052,311,925**	**2,557**	**5.8%**	**$1,598,569,260**	**5.5%**

Source: Tompkins County GIS 2019/2020; RS Means 2019
Notes: V = Village, C = City, T = Town, % = Percent, < = Less Than

Table 5.4.4-15. Estimated General Building Stock Exposure to the 1-Percent Annual Chance Flood Event – Commercial Structures Only

Jurisdiction	Total Number of Buildings (Commercial Buildings Only)	Total Replacement Cost Value (Commercial Buildings Only)	Total Exposure (Commercial Structures Only) 1-Percent Annual Chance Flood Event			
			Number of Buildings	Percent of Total	Replacement Cost Value	Percent of Total
Caroline (T)	488	$522,037,081	11	2.3%	$18,959,127	3.6%
Cayuga Heights (V)	36	$97,858,115	0	0.0%	$0	0.0%
Danby (T)	602	$658,664,565	1	0.2%	$54,176,000	8.2%
Dryden (T)	1,252	$2,249,129,019	18	1.4%	$91,650,260	4.1%
Dryden (V)	110	$424,696,715	22	20.0%	$44,041,056	10.4%
Enfield (T)	477	$665,584,455	0	0.0%	$0	0.0%
Freeville (V)	41	$48,310,505	4	9.8%	$7,339,416	15.2%
Groton (T)	532	$553,733,210	4	0.8%	$2,460,121	0.4%
Groton (V)	110	$470,116,968	22	20.0%	$57,465,621	12.2%
Ithaca (C)	795	$7,258,972,188	61	7.7%	$461,813,278	6.4%
Ithaca (T)	393	$1,044,784,625	16	4.1%	$12,865,592	1.2%
Lansing (T)	706	$1,738,318,397	33	4.7%	$25,731,418	1.5%
Lansing (V)	204	$1,566,545,224	1	0.5%	$1,089,442	<0.1%

Jurisdiction	Total Number of Buildings (Commercial Buildings Only)	Total Replacement Cost Value (Commercial Buildings Only)	Total Exposure (Commercial Structures Only) 1-Percent Annual Chance Flood Event			
			Number of Buildings	Percent of Total	Replacement Cost Value	Percent of Total
Newfield (T)	650	$1,110,380,232	16	2.5%	$13,561,250	1.2%
Trumansburg (V)	77	$416,067,237	1	1.3%	$762,896	0.2%
Ulysses (T)	620	$795,052,612	11	1.8%	$3,922,157	0.5%
Tompkins County (Total)	**7,093**	**$19,620,251,148**	**221**	**3.1%**	**$795,837,634**	**4.1%**

Source: Tompkins County GIS 2019/2020; RS Means 2019
Notes: V = Village, C = City, T = Town, % = Percent, < = Less Than

Table 5.4.4-16. Estimated General Building Stock Exposure to the 0.2-Percent Annual Chance Flood Event – Commercial Structures Only

Jurisdiction	Total Number of Buildings (Commercial Buildings Only)	Total Replacement Cost Value (Commercial Buildings Only)	Total Exposure (Commercial Structures Only) 0.2-Percent Annual Chance Flood Event			
			Number of Buildings	Percent of Total	Replacement Cost Value	Percent of Total
Caroline (T)	488	$522,037,081	11	2.3%	$18,959,127	3.6%
Cayuga Heights (V)	36	$97,858,115	0	0.0%	$0	0.0%
Danby (T)	602	$658,664,565	1	0.2%	$54,176,000	8.2%
Dryden (T)	1,252	$2,249,129,019	18	1.4%	$91,650,260	4.1%
Dryden (V)	110	$424,696,715	24	21.8%	$44,822,074	10.6%
Enfield (T)	477	$665,584,455	0	0.0%	$0	0.0%
Freeville (V)	41	$48,310,505	4	9.8%	$7,339,416	15.2%
Groton (T)	532	$553,733,210	4	0.8%	$2,460,121	0.4%
Groton (V)	110	$470,116,968	41	37.3%	$142,462,992	30.3%
Ithaca (C)	795	$7,258,972,188	323	40.6%	$2,402,707,504	33.1%
Ithaca (T)	393	$1,044,784,625	20	5.1%	$15,672,757	1.5%
Lansing (T)	706	$1,738,318,397	33	4.7%	$25,731,418	1.5%
Lansing (V)	204	$1,566,545,224	1	0.5%	$1,089,442	<0.1%
Newfield (T)	650	$1,110,380,232	16	2.5%	$13,561,250	1.2%
Trumansburg (V)	77	$416,067,237	1	1.3%	$762,896	0.2%
Ulysses (T)	620	$795,052,612	11	1.8%	$3,922,157	0.5%
Tompkins County (Total)	**7,093**	**$19,620,251,148**	**508**	**7.2%**	**$2,825,317,415**	**14.4%**

Source: Tompkins County GIS 2019/2020; RS Means 2019
Notes: V = Village, C = City, T = Town, % = Percent, < = Less Than

Table 5.4.4-17. Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – All Occupancies

Jurisdiction	Total Replacement Cost Value (RCV)	Total Losses (All Occupancies) 1-Percent Annual Chance Flood Event	
		Estimated Loss (Replacement Cost Value)	Percent of Total
Caroline (T)	$2,523,108,347	$5,052,984	0.2%
Cayuga Heights (V)	$1,548,665,909	$0	0.0%
Danby (T)	$2,188,454,321	$2,191,175	0.1%

Jurisdiction	Total Replacement Cost Value (RCV)	Total Losses (All Occupancies) 1-Percent Annual Chance Flood Event	
		Estimated Loss (Replacement Cost Value)	Percent of Total
Dryden (T)	$8,740,906,102	$5,327,817	0.1%
Dryden (V)	$1,135,109,100	$2,806,948	0.2%
Enfield (T)	$2,736,468,231	$0	0.0%
Freeville (V)	$356,699,295	$2,060,378	0.6%
Groton (T)	$2,804,801,342	$8,633,027	0.3%
Groton (V)	$1,203,171,190	$1,167,025	0.1%
Ithaca (C)	$19,712,305,674	$210,925,178	1.1%
Ithaca (T)	$10,868,181,586	$33,637,255	0.3%
Lansing (T)	$6,270,191,033	$20,189,662	0.3%
Lansing (V)	$3,436,043,635	$0	0.0%
Newfield (T)	$3,848,204,673	$2,308,491	0.1%
Trumansburg (V)	$1,241,549,970	$318,586	<0.1%
Ulysses (T)	$3,372,144,448	$23,078,672	0.7%
Tompkins County (Total)	**$71,986,004,856**	**$317,697,199**	**0.4%**

Source: Tompkins County GIS 2019/2020; RS Means 2019; Hazus-MH v4.2
Notes: V = Village, C = City, T = Town, % = Percent, < = Less Than

Table 5.4.4-18. Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – Residential Structures Only

Jurisdiction	Total Replacement Cost Value (Residential Only)	Residential Losses Only 1-Percent Annual Chance Flood Event	
		Estimated Loss (Replacement Cost Value)	Percent of Total
Caroline (T)	$1,358,577,326	$1,220,006	0.1%
Cayuga Heights (V)	$1,287,240,123	$0	0.0%
Danby (T)	$1,132,751,811	$1,023,766	0.1%
Dryden (T)	$3,224,220,454	$726,783	<0.1%
Dryden (V)	$592,216,526	$2,202,837	0.4%
Enfield (T)	$1,211,029,479	$0	0.0%
Freeville (V)	$173,619,699	$788,619	0.5%
Groton (T)	$1,207,683,173	$7,449,524	0.6%
Groton (V)	$628,462,960	$644,120	0.1%
Ithaca (C)	$6,611,345,821	$84,954,182	1.3%
Ithaca (T)	$3,912,782,485	$1,666,793	<0.1%
Lansing (T)	$2,768,597,390	$9,932,657	0.4%
Lansing (V)	$1,406,653,242	$0	0.0%
Newfield (T)	$1,539,401,729	$892,586	0.1%
Trumansburg (V)	$602,857,632	$318,586	0.1%
Ulysses (T)	$1,394,872,075	$7,277,685	0.5%
Tompkins County (Total)	**$29,052,311,925**	**$119,098,144**	**0.4%**

Source: Tompkins County GIS 2019/2020; RS Means 2019; Hazus-MH v4.2
Notes: V = Village, C = City, T = Town, % = Percent, < = Less Than

Table 5.4.4-19. Estimated General Building Stock Potential Loss to the 1-Percent Annual Chance Flood Event – Commercial Structures Only

Jurisdiction	Total Replacement Cost Value (Commercial Only)	Commercial Losses Only 1-Percent Annual Chance Flood Event	
		Estimated Loss (Replacement Cost Value)	Percent of Total
Caroline (T)	$522,037,081	$3,714,500	0.7%
Cayuga Heights (V)	$97,858,115	$0	0.0%
Danby (T)	$658,664,565	$511,339	0.1%
Dryden (T)	$2,249,129,019	$191,607	<0.1%
Dryden (V)	$424,696,715	$604,111	0.1%
Enfield (T)	$665,584,455	$0	0.0%
Freeville (V)	$48,310,505	$1,271,759	2.6%
Groton (T)	$553,733,210	$390,798	0.1%
Groton (V)	$470,116,968	$522,905	0.1%
Ithaca (C)	$7,258,972,188	$116,005,836	1.6%
Ithaca (T)	$1,044,784,625	$1,008,330	0.1%
Lansing (T)	$1,738,318,397	$5,206,785	0.3%
Lansing (V)	$1,566,545,224	$0	0.0%
Newfield (T)	$1,110,380,232	$1,232,041	0.1%
Trumansburg (V)	$416,067,237	$0	0.0%
Ulysses (T)	$795,052,612	$279,008	<0.1%
Tompkins County (Total)	**$19,620,251,148**	**$130,939,020**	**0.7%**

Source: Tompkins County GIS 2019/2020; RS Means 2019; Hazus-MH v4.2
Notes: V = Village, C = City, T = Town, % = Percent, < = Less Than

NFIP Statistics

FEMA Region 2 provided a list of NFIP policies, past claims, and repetitive loss properties (RL) in Tompkins County. According to FEMA, a 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 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 2020).

Table 5.4.4-20 summarizes the NFIP policies, claims and repetitive loss statistics for Tompkins County. Note that specific locations of repetitive loss properties were not made available for this Plan.

Table 5.4.4-20. Repetitive Loss Properties and NFIP Data for Tompkins County

Jurisdiction	Number of Repetitive Loss Properties	Number of Policies	Number of Claims	Total Losses Claimed
Caroline (T)	4	14	21	$72,531
Cayuga Heights (V)	2	2	4	$15,791
Danby (T)	0	4	0	$0

Jurisdiction	Number of Repetitive Loss Properties	Number of Policies	Number of Claims	Total Losses Claimed
Dryden (T)	2	23	9	$93,330
Dryden (V)	2	27	20	$114,915
Enfield (T)	0	0	0	$0
Freeville (V)	1	7	4	$17,760
Groton (T)	0	10	7	$23,919
Groton (V)	0	6	14	$620,881
Ithaca (C)	7	148	103	$249,490
Ithaca (T)	0	37	20	$36,215
Lansing (T)	22	35	56	$466,075
Lansing (V)	0	7	5	$6,589
Newfield (T)	2	9	6	$52,254
Trumansburg (V)	0	3	3	$902
Ulysses (T)	0	19	3	$5,798
Tompkins County (Total)	**42**	**351**	**275**	**$1,776,450**

Source: FEMA Region 2, 2020
Note: NFIP = National Flood Insurance Program, V = Village, T = Town, C = City

Impact on Land Uses

An exposure analysis was completed to determine the acres of residential and non-residential land use types located in the flood hazard areas. To estimate exposure for residential and non-residential land use types to the 1-percent and 0.2-percent annual chance flood event hazard areas, the floodplain boundaries were overlaid upon the national land use land cover data. Refer to Table 5.4.4-21 for a complete summary of this analysis.

Table 5.4.4-21. Land Use Types Exposed to the 1-Percent and 0.2-Percent Annual Chance Flood Event Hazard Areas

Land Use Type	Total Acres for County	Land Area Exposed to the 1-Percent Annual Chance Flood Event		Land Area Exposed to the 0.2-Percent Annual Chance Flood Event	
		Acres	Percent of Total	Acres	Percent of Total
Residential Land	8,100	381	4.7%	860	10.6%
Non-Residential Land	296,155	5,643	1.9%	5,877	2.0%
Natural Area Land	163,079	4,322	2.7%	4,411	2.7%
Tompkins County (Total)*	**304,255**	**6,024**	**2.0%**	**6,737**	**2.2%**

Source: Tompkins County GIS 2019/2020; NLCD 2016
Notes: V = Village, C = City, T = Town, % = Percent
Assumed Natural Land includes barren land, forests, and wetlands; This analysis does not include any areas of water
Non-Residential area = Agriculture, Barren, Developed – Open Space, Forest, Wetlands; This analysis does not incorporate areas delineated as water; Residential parcels = Developed – low intensity, Developed – medium intensity, and Developed – high intensity
**The total area is a summation of the residential land and non-residential land. Natural land area is a sub-set of non-residential land use types.*

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, and impacts on tourism. In areas that are directly flooded, renovations of commercial and industrial buildings may be necessary, disrupting associated services. Refer to the 'Impact on Buildings' subsection earlier which discusses direct impacts to buildings in Tompkins County.

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. As presented in Table 5.4.4-22, 22 critical facilities are exposed and potentially vulnerable to the 1-percent annual chance flood event.

Debris management may also be a large expense after a flood event. Hazus-MH v4.2 estimates the amount of structural debris generated during a flood event. The model breaks down debris into three categories: (1) finishes (dry wall, insulation, etc.); (2) structural (wood, brick, etc.); and (3) foundations (concrete slab and block, rebar, etc.). These distinctions are necessary because of the different types of equipment needed to handle debris. Table 5.4.4-22 summarizes the countywide debris estimates for the entire 1-percent annual chance flood event. This table only estimates structural debris generated by flooding and does not include non-structural debris or additional potential damage and debris possibly generated by wind that may be associated with a flood event or storm that causes flooding. Hazus estimates that the City of Ithaca will have the greatest amount of debris generated from a 1-percent annual chance flood event. A debris management plan will be developed as a part of the resiliency and recovery plan developed after the HMP.

Table 5.4.4-22. Estimated Debris Generated from the 1-Percent Annual Chance Flood Event

Jurisdiction	Debris Generated by the 1-Percent Annual Chance Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Caroline (T)	284	120	91	73
Cayuga Heights (V)	0	0	0	0
Danby (T)	20	9	6	5
Dryden (T)	475	184	147	144
Dryden (V)	128	128	0	0
Enfield (T)	0	0	0	0
Freeville (V)	67	49	10	8
Groton (T)	920	311	319	290
Groton (V)	248	222	15	11
Ithaca (C)	9,604	6,349	1,710	1,544
Ithaca (T)	1,188	372	452	365
Lansing (T)	698	237	255	206

Jurisdiction	Debris Generated by the 1-Percent Annual Chance Flood Event			
	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Lansing (V)	0	0	0	0
Newfield (T)	705	140	265	300
Trumansburg (V)	214	134	46	35
Ulysses (T)	176	75	55	45
Tompkins County (Total)	**14,728**	**8,331**	**3,371**	**3,026**

Impact on the Environment

As Tompkins County and its jurisdictions grow, flood events may increase in frequency and/or severity as land use changes, more structures are built, and impervious surfaces expand. Furthermore, flood extents for the 1-percent and 0.2-percent annual flood events will continue to evolve alongside natural occurrences such as sea level rise, climate change, and/or changes in the severity of extreme weather events. These flood events will inevitably impact Tompkins County's natural and local environment.

Overall, the acreage of natural, pervious areas makes up 53.6-percent of the County's total land area. Natural, pervious areas often play an import role in detaining and absorbing water that reduces flood impacts. Formalized protection of these areas is important to ensure they maintain these functions. Severe flooding can however also influence the habitat of these natural land areas, it can be disruptive to species that reside in these natural habitats. Table 5.4.4-21 summarizes the number of acres that natural area land use types are exposed to the 1-percent and 0.2-percent annual chance flood inundation areas. Approximately 2.7-percent of natural land areas are exposed to both the 1-percent and 0.2-percent annual chance flood event hazard areas.

Cascading Impacts on Other Hazards

Flood events can exacerbate the impacts of disease outbreak, harmful algal blooms, and infestations and invasive species. Flooding may further increase the transmission of water-borne diseases such as typhoid fever, cholera, and hepatitis A (World Health Organization 2020). Flooding that causes contamination of drinking water facilities, including groundwater drinking water sources, may enhance the risk of disease outbreaks based on the number of persons that come in contact with these resources, particularly those with open wounds. Standing water that occurs as a result of a flood event may become a breeding site for vector-borne diseases, like West Nile virus (World Health Organization 2020). Runoff from flood events may also exacerbate the chemical and waste discharge that contribute to harmful algal bloom outbreaks. More information about these hazards of concern can be found in Section 5.4.1 (Disease Outbreak), Section 5.4.5 (Harmful Algal Blooms), and Section 5.4.6 (Infestations and Invasive Species).

Flooding may also affect the hazard of water supply contamination through by way of damaged pipelines at stream crossings. Reduced integrity of these pipelines can sometimes result in water supply contamination. This concern was identified in the 2014 HMP, and as such, the 2016 Tompkins

County Inventory of Erosion Hazards at Pipeline Crossings, was developed with funding from the US Department of Transportation Pipeline and Hazardous Material Safety Administration (PHMSA). The report identified a total of 175 pipeline stream crossings in Tompkins County that carry either combustible gas, combustible liquids, or non-hazardous liquids. 19 of those pipelines of greatest concern have been reviewed and 5 of those crossings were selected for active tracking and mitigation solutions. Based on subsequent field visits in 2020, pipeline owners constructed the recommended mitigation solution on one those crossings. The remaining 4 crossings appear stable and will continue to be monitored for exposure. Should concerns develop regarding these crossings, pipeline owners will be contacted and provided guidance documents on the recommended mitigation measures.

Impact on Community Lifelines

It is important to determine the community lifeline 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. In addition, Hazus-MH v4.2 was used to estimate the flood loss potential to critical facilities located in the FEMA mapped floodplains. Hazus-MH v4.2 results can be found in Volume II, Jurisdiction Annexes. Table 5.4.4-23 and Table 5.4.4-24 summarize the number of critical facilities exposed to the 1-percent and 0.2-percent flood inundation areas by jurisdiction, respectively. Additionally, Table 5.4.4-25 and Table 5.4.4-26 show the distribution of critical facilities in the 1-percent and 0.2-percent annual chance flood event boundaries, respectively. Of the 22 critical facilities located in the 1-percent annual chance flood event boundary, 13 were identified as lifelines for the County. In the 0.2-percent annual chance flood event boundary, 18 critical facilities out of the 50 that are within the flood boundary are medical offices.

Table 5.4.4-23. Number of Community Lifelines Located in the 1-Percent Annual Chance Flood Event Hazard Area

Jurisdiction	Total Critical Facilities	Total Lifelines	Total Community Lifelines Exposed to the 1-Percent Annual Chance Flood Event			
			Number of Critical Facilities Exposed	Percent of Total	Number of Other Lifelines Exposed	Percent of Total
Caroline (T)	16	11	1	6.3%	0	0.0%
Cayuga Heights (V)	18	11	0	0.0%	0	0.0%
Danby (T)	12	9	0	0.0%	0	0.0%
Dryden (T)	69	40	2	2.9%	2	5.0%
Dryden (V)	19	10	3	15.8%	2	20.0%

Jurisdiction	Total Critical Facilities	Total Lifelines	Total Community Lifelines Exposed to the 1-Percent Annual Chance Flood Event			
			Number of Critical Facilities Exposed	Percent of Total	Number of Other Lifelines Exposed	Percent of Total
Enfield (T)	6	4	0	0.0%	0	0.0%
Freeville (V)	7	4	0	0.0%	0	0.0%
Groton (T)	8	6	2	25.0%	2	33.3%
Groton (V)	16	10	3	18.8%	3	30.0%
Ithaca (C)	202	73	3	1.5%	2	2.7%
Ithaca (T)	236	67	8	3.4%	2	3.0%
Lansing (T)	20	15	0	0.0%	0	0.0%
Lansing (V)	31	17	0	0.0%	0	0.0%
Newfield (T)	22	14	0	0.0%	0	0.0%
Trumansburg (V)	20	11	0	0.0%	0	0.0%
Ulysses (T)	5	4	0	0.0%	0	0.0%
Tompkins County (Total)	**707**	**306**	**22**	**3.1%**	**13**	**4.2%**

Source: Tompkins County GIS 2019/2020
Notes: V = Village, C = City, T = Town, % = Percent

Table 5.4.4-24. Number of Community Lifelines Located in the 0.2-Percent Annual Chance Flood Event Hazard Area

Jurisdiction	Total Critical Facilities	Total Lifelines	Total Community Lifelines Exposed to the 0.2-Percent Annual Chance Flood Event			
			Number of Critical Facilities Exposed	Percent of Total	Number of Other Lifelines Exposed	Percent of Total
Caroline (T)	16	11	1	6.3%	0	0.0%
Cayuga Heights (V)	18	11	0	0.0%	0	0.0%
Danby (T)	12	9	0	0.0%	0	0.0%
Dryden (T)	69	40	2	2.9%	2	5.0%
Dryden (V)	19	10	3	15.8%	2	20.0%
Enfield (T)	6	4	0	0.0%	0	0.0%
Freeville (V)	7	4	0	0.0%	0	0.0%
Groton (T)	8	6	2	25.0%	2	33.3%
Groton (V)	16	10	3	18.8%	3	30.0%
Ithaca (C)	202	73	30	14.9%	20	27.4%
Ithaca (T)	236	67	9	3.8%	3	4.5%
Lansing (T)	20	15	0	0.0%	0	0.0%
Lansing (V)	31	17	0	0.0%	0	0.0%
Newfield (T)	22	14	0	0.0%	0	0.0%
Trumansburg (V)	20	11	0	0.0%	0	0.0%

Jurisdiction	Total Critical Facilities	Total Lifelines	Total Community Lifelines Exposed to the 0.2-Percent Annual Chance Flood Event			
			Number of Critical Facilities Exposed	Percent of Total	Number of Other Lifelines Exposed	Percent of Total
Ulysses (T)	5	4	0	0.0%	0	0.0%
Tompkins County (Total)	**707**	**306**	**50**	**7.1%**	**32**	**10.5%**

Source: Tompkins County GIS 2019/2020
Notes: V = Village, C = City, T = Town, % = Percent

Table 5.4.4-25. Distribution of Community Lifeline Critical Facilities in the 1-Percent Annual Chance Flood Event Hazard Area by Type and Jurisdiction

Jurisdiction	Critical Facilities Exposed to the 1-Percent Annual Chance Flood Event							
	Dam	Education - Higher	Electrical Power Grid	Fire Station	Government	Medical Office	Post Office	Wastewater Pump Station
Caroline (T)	0	0	0	0	1	0	0	0
Cayuga Heights (V)	0	0	0	0	0	0	0	0
Danby (T)	0	0	0	0	0	0	0	0
Dryden (T)	1	0	0	1	0	0	0	0
Dryden (V)	0	0	0	1	1	1	0	0
Enfield (T)	0	0	0	0	0	0	0	0
Freeville (V)	0	0	0	0	0	0	0	0
Groton (T)	0	0	0	1	0	0	1	0
Groton (V)	0	0	0	0	0	3	0	0
Ithaca (C)	0	1	1	0	0	0	0	1
Ithaca (T)	3	3	0	0	1	0	0	1
Lansing (T)	0	0	0	0	0	0	0	0
Lansing (V)	0	0	0	0	0	0	0	0
Newfield (T)	0	0	0	0	0	0	0	0
Trumansburg (V)	0	0	0	0	0	0	0	0
Ulysses (T)	0	0	0	0	0	0	0	0
Tompkins County (Total)	**4**	**4**	**1**	**3**	**3**	**4**	**1**	**2**

Source: Tompkins County GIS 2019/2020
Notes: V = Village, C = City, T = Town

Table 5.4.4-26. Distribution of Community Lifeline Critical Facilities in the 0.2-Percent Annual Chance Flood Event Hazard Area by Type and Jurisdiction

Jurisdiction	Critical Facilities Exposed to the 0.2-Percent Annual Chance Flood Event													
	Dam	Education - Higher	Education - Primary	Electrical Power Grid	Electrical Substation	Fire Station	Fire/EMS	Government	Medical Office	Oil Facility	Post Office	Potable Water Tank	Wastewater Pump Station	Wastewater Treatment Facility
Caroline (T)	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Cayuga Heights (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Danby (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dryden (T)	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Dryden (V)	0	0	0	0	0	1	0	1	1	0	0	0	0	0
Enfield (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Freeville (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Groton (T)	0	0	0	0	0	1	0	0	0	0	1	0	0	0
Groton (V)	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Ithaca (C)	0	3	1	1	1	0	1	5	14	1	0	1	1	1
Ithaca (T)	3	3	0	0	0	0	0	1	0	0	0	1	1	0
Lansing (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lansing (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Newfield (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trumansburg (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ulysses (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tompkins County (Total)	**4**	**6**	**1**	**1**	**1**	**3**	**1**	**8**	**18**	**1**	**1**	**2**	**2**	**1**

Source: Tompkins County GIS 2019/2020
Notes: V = Village, C = City, T = Town

Table 5.4.4-27 displays the major roadways that may be impacted by the 1-percent annual chance flood event inundation area. Out of the 1,855 miles of major transportation routes in the County, 29.4 miles are exposed to the 1-percent annual chance flood event. Most of the roadways exposed to the flood hazard are local and private roadways. Bridges washed out or blocked by floods or debris also can cause isolation. This can be an issue for the commuter community that relies on these transportation routes to enter or leave the County after work.

Table 5.4.4-27. Major Roadways Exposed to the 1-Percent Annual Chance Flood Event Hazard Area

Road Type	Total Miles for County	Miles of Roadway Exposed to the 1-Percent Annual Chance Flood Event	
		Miles	Percent of Total
Local and Private Roads	1,202	20.1	1.7%
County Roads	412	4.6	1.1%
State Routes	241	4.7	2.0%
Tompkins County (Total)	**1,855**	**29.4**	**1.6%**

Source: Tompkins County GIS 2019/2020; NYS GIS 2020; NYS DOT 2013
Notes: V = Village, C = City, T = Town, % = Percent

Further, community lifeline critical facilities that are near an area where frequent urban flooding occurs are also vulnerable to the flood hazard. Urban flooding is defined by FEMA as flooding caused by rain that falls on densely populated areas that have increased amounts of impervious surfaces, which overwhelms the capacity of drainage systems (Natural Resources Defense Council 2019). This type of flooding can be exacerbated by riverine flooding within the County.

Debris from flood events may also affect culverts and sewer systems by creating bottlenecks in the wastewater system, which could not only cause or exacerbate localized urban flooding, but also cause wastewater to spill into homes and neighborhoods or contaminate local rivers and streams.

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.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the County can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. 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 in Section 4, areas targeted for future growth and development have been identified across the County. Any areas of growth located in the flood inundation areas could be potentially impacted by flooding. It is recommended that the County and municipal partners implement design strategies that mitigate against the risk of riverine flooding.

Projected Changes in Population

According to population projections from the Cornell Program on Applied Demographics, Tompkins County will experience a continual population increase from 2020 through 2040 (over 6,040 people in total by 2040). The U.S. Census Bureau also shows that the population in Tompkins County has increased 0.6-percent between 2010 and 2019 (U.S. Census Bureau 2020). Not only does the increasing population change the flood exposure risk throughout the County, persons that are already located in the County may also move into locations that are more susceptible to flooding than others. This includes areas that are directly impacted by flood events and those that are indirectly impacted (i.e., isolated neighborhoods, flood-prone roadways, etc.). Refer to Section 4 (County Profile), for additional discussion on population trends.

Climate Change Impacts

As discussed above, most studies project that the State of New York will see an increase in average annual temperatures and precipitation. Annual precipitation amounts in the region are projected to increase, primarily in the form of heavy rainfalls, which have the potential to increase the risk to flash flooding and riverine flooding, and flood critical transportation corridors and infrastructure. Increases in precipitation may alter and expand the floodplain boundaries and runoff patterns, resulting in the exposure of populations, buildings, and critical facilities and infrastructure that were previously outside the floodplain. This increase in exposure would result in an increased risk to life and health, an increase in structural losses, a diversion of additional resources to response and recovery efforts, and an increase in business closures affected by future flooding events due to loss of service or access.

Existing dams may not be able to retain and manage increases in water flow from more frequent, heavy rainfall events. Heavy rainfalls may result in more frequent overtopping of these dams and flooding of the County's assets in adjacent inundation areas. However, the probable maximum flood used to design each dam may be able to accommodate changes in climate.

Change of Vulnerability Since the 2014 HMP

The 2014 HMP assessed flood impacts based on the old FEMA's Q3 flood data and the 2011 Tompkins County tax assessor data. The 2014 analysis was performed using a parcel exposure analysis. Since the 2014 analysis, population statistics have been updated using the 5-year 2014-2018 American Community Survey Population Estimates. Additionally, this updated analysis estimated exposure and losses at the structure level with updated building stock data. The general building stock was updated using building stock data provided by the County to update the user-defined facility inventory and community lifeline: critical facility inventory dataset. The replacement cost value of these structures was updated using RS Means 2019 building valuations. Last, an updated version of FEMA's Hazus-MH flood module v4.2, incorporating updated depth grids for the City of Ithaca developed by USGS, was used to estimate potential losses for the 1-percent annual chance flood event.

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

Identified Issues

The following issues were identified for the flood hazard:

- A potable water pipeline that services the City of Ithaca is known to be located in a landslide susceptible slope area; no back-up service main is currently in operation. A slope failure in this area has the potential to result in infrastructure damage to the pipeline and cause interruptions in water service.
- Communities will not only need to continue to steer new development away from SFHAs but also will need to develop mitigation strategies for the existing commercial and residential properties in these areas.
- Significant changes to the SFHA may occur with the update of FIRM maps in 2021-22. Communities should plan for broad ranging educational campaigns for municipalities, businesses and landowners regarding what those changes may mean.
- Diverse outreach methods for notifying those living in and traveling through SFHAs should be explored.
- Investments in large scale mitigation measures in the City of Ithaca's flood control structures should be explored to ensure they continue to perform as designed or are retrofitted to address climate change impacts.