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RESILIENT NEW YORK FLOOD MITIGATION INITIATIVE

CONNOISARAULEY CREEK, CATTARAUGUS COUNTY, NEW YORK

Prepared for:

Project Team:

RESILIENT NEW YORK FLOOD MITIGATION INITIATIVE

CONNOISARAULEY CREEK, CATTARAUGUS COUNTY, NEW YORK

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IN NOVEMBER 2018, NEW YORK STATE GOVERNOR ANDREW CUOMO COMMITTED FUNDING TO UNDERTAKE ADVANCED MODELING TECHNIQUES AND FIELD ASSESSMENTS OF 48 FLOOD PRONE STREAMS TO IDENTIFY PRIORITY PROJECTS AND ACTIONS TO REDUCE COMMUNITY FLOOD AND ICE JAM RISKS, WHILE IMPROVING HABITAT. THE OVERALL GOAL OF THE PROGRAM IS TO MAKE NEW YORK STATE MORE RESILIENT TO FUTURE FLOODING.

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ACRONYMS/ABBREVIATIONS

1-, 2-, 3-D	1-, 2-, and 3-Dimensional
AC	Acres
ACE	Annual Chance Flood Event
BCA	Benefit Cost Analysis
BCR	Benefit Cost Ratio
BFE	Base Flood Elevation
BRIC	Building Resilient Infrastructure and Communities
CCDPW	Cattaraugus County Division of Public Works
CCSWCD	Cattaraugus County Soil and Water Conservation District
CDBG	Community Development Block Grants
CFA	Consolidated Funding Applications

CFR	Code of Federal Regulations
CFS	Cubic Feet per Second (ft3/s)
CRRA	Community Risk and Resiliency Act
CRREL	Cold Regions Research and Engineering Laboratory
CSC	Climate Smart Communities
DEM	Digital Elevation Model
DHS	Department of Homeland Security
DRRA	Disaster Recovery Reform Act of 2018
ECDEP	Erie County Department of Environment & Planning
EPF	Environmental Protection Fund
EWP	Emergency Watershed Protection
FCA	Flood Control Act
FEMA	Federal Emergency Management Agency
FHA	Federal Highway Administration
FIA	Federal Insurance Agency
FIRM	Flood Insurance Rate Maps
FIS	Flood Insurance Study
FMA	Flood Mitigation Assistance
FT	Feet
GIS	Geographic Information System
HMGP	Hazard Mitigation Grant Program
HSGP	Homeland Security Grant Program
H&H	Hydrologic and Hydraulic
HEC	Hydrologic Engineering Center
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center River Analysis System
HUD	United States Department of Housing and Urban Development
IPaC	Information for Planning and Consultation
LF	Linear Feet
LiDAR	Light Detection and Ranging
LOMR	Letter of Map Revision
MSC	Map Service Center
NAVD88	North American Vertical Datum of 1988
NCEI	National Centers for Environmental Information
NFHL	National Flood Hazard Layer
NFIP	National Flood Insurance Program
NHD	National Hydrography Dataset
NRCS	Natural Resources Conservation Services
NWI	National Wetlands Inventory
NYS	New York State
NYSDEC	New York State Department of Environmental Conservations
NYSDHSES	New York State Division of Homeland Security and Emergency Services
NYSDOS	New York State Department of State
NYSDOT	New York State Department of Transportation
NYSOEM	New York State Office of Emergency Management
NYSOGS	New York State Office of General Services
NYSOPRHP	New York State Office of Parks, Recreation, and Historic Places
PDM	Pre-Disaster Mitigation
RAMBOLL	Ramboll Americas Engineering Solutions, Inc.
RC	Circularity Ratio

RE	Elongation Ratio
RF	Form Factor
RL	Repetitive Loss
ROM	Rough Order of Magnitude
SFHA	Special Flood Hazard Areas
SQ MI	Square Miles (mi^2)
SRL	Severe Repetitive Loss
STORM	Safeguarding Tomorrow through Ongoing Risk Mitigation Act
USACE	United States Army Corps of Engineers
USSCS	United States Soil Conservation Service
USGS	United States Geologic Service
WQIP	Water Quality Improvement Project

1. INTRODUCTION

1.1 HISTORICAL INITIATIVES

Flood mitigation has historically been an initiative in western New York and in the Connoisarauley Creek watershed. The Connoisarauley Creek watershed has historically been a source of flooding events, including ice jams, and landslides in Cattaraugus County, New York. In response to these events, Cattaraugus County has implemented multiple streambank stabilization projects along Connoisarauley Creek. Stream stabilization projects were completed by the Cattaraugus County Department of Public Works (CCDPW) and Cattaraugus County Soil and Water Conservation District (CCSWCD) along County Road 12 (East Otto Road) in 2013 and 2015 by armoring the stream banks with rock rip rap to protect adjacent infrastructure and control erosion of the streambanks (ECDEP 2020). In addition, the Town of East Otto has worked with contractors and developers to prevent and / or minimize development with the floodplain and has passed flood damage prevention ordinances, while the Town of Ashford is currently updating and developing new flood damage prevention ordinances (Tetra Tech 2020).

1.2 FLOODPLAIN DEVELOPMENT

General recommendations for high-risk floodplain development follow three basic strategies:

1. Remove the flood-prone facilities from the floodplain
2. Adapt the facilities to be flood resilient under repetitive inundation scenarios
3. Develop nature-based mitigation measures (e.g., floodplain benches, constructed wetlands, etc.) to lower flood stages in effected areas
4. Up-size bridges and culverts to be more resilient to ice jams, high flow events, and projected future flood flows due to climate change in effected areas

In order to effectively mitigate flooding along substantial lengths of a watercourse corridor, floodplain management should restrict the encroachment on natural floodplain areas. Floodplains act to convey floodwaters downstream, mitigate damaging velocities, and provide areas for sediment to accumulate safely. The reduction in floodplain width of one reach of a stream, often leads to the increase in flooding upstream or downstream. During a flood event, a finite amount of water with an unchanging volume must be conveyed and, as certain conveyance areas are encroached upon, floodwaters will often expand into other sensitive areas.

A critical evaluation of existing floodplain law and policies should be undertaken to evaluate the effectiveness of current practices and requirements within this watershed. Local floodplain regulations should be consistent with the National Flood Insurance Program (NFIP) and Federal Emergency Management Agency (FEMA) regulations since the Towns of Ashford (Community ID #360062) and East Otto (Community ID #360067) are participating communities in the NFIP and should involve a floodplain coordinator and a site plan review process for all proposed developments. This review should be in accordance with local regulations and the NFIP requirements, which require the community to determine if any future proposed development could adversely impact the floodplain or floodway resulting in higher flood stages and sequentially greater economic losses to the community.

1.3 RESILIENT NY INITIATIVE

In November of 2018, New York State (NYS) Governor Andrew Cuomo announced the Resilient NY program in response to devastating flooding in communities across the State in the preceding years. A total of 48 high-priority flood prone watersheds across New York State are being addressed through the Resilient NY program. Flood mitigation studies were commissioned using advanced modeling techniques and field assessments to identify priority projects in these 48 flood-prone watersheds, develop state-of-the-art studies to reduce flooding and ice jams, and to improve ecological habitats in the watersheds (NYSGPO 2018). The Connoisarauley Creek watershed was chosen as a study site for this initiative.

The New York State Department of Environmental Conservation (NYSDEC) is responsible for implementing the Resilient NY program with contractual assistance from the New York State Office of General Services (NYSOGS). High-priority watersheds were selected based on several factors, such as frequency and severity of flooding and ice jams, extent of previous flood damage, and susceptibility to future flooding and ice-jam formations (NYSGPO 2018).

The Resilient NY flood studies will identify the causes of flooding within each watershed and develop effective and ecologically sustainable flood and ice-jam hazard mitigation projects. Proposed flood mitigation measures will be identified and evaluated using hydrologic and hydraulic modeling to quantitatively determine flood mitigation strategies that would result in the greatest flood reductions benefits. In addition, the flood mitigation studies incorporate the latest climate change forecasts and assess open-water and ice-jam hazards where future flood risks have been identified.

This report is not intended to address detailed design considerations for individual flood mitigation alternatives. The mitigation alternatives discussed are conceptual projects that have been initially developed and evaluated to determine their flood mitigation benefits. A more in-depth engineering design study would still be required for any mitigation alternative chosen to further define the engineering project details. However, the information contained within this study can inform such in-depth engineering design studies and be used in the application of state and federal funding and / or grant programs.

The goals of the Resilient NY Program are to:

1. Perform comprehensive flood and ice-jam studies to identify known and potential flood risks in flood-prone watersheds
2. Incorporate climate change predictions into future flood models
3. Develop and evaluate flood hazard mitigation alternatives for each flood-prone stream area, with a focus on ice-jam hazards

The overarching purpose of the initiative is to evaluate a suite of flood and ice-jam mitigation projects that local municipalities can undertake to make their community more resilient to future floods. The projects should be affordable, attainable through grant funding programs, able to be implemented either individually or in combination in phases over the course of several years, achieve measurable improvement at the completion of each phase, and fit with the community way of life. The information developed under this initiative is intended to provide the community with a basis for assessing and selecting flood mitigation strategies to pursue; no recommendations are made as to which strategies the community should pursue.

The flood mitigation and resiliency study for Connoisarauley Creek began in May of 2021 and a final flood study report was issued in August of 2021.

2. DATA COLLECTION

2.1 INITIAL DATA COLLECTION

Hydrological and meteorological data were obtained from readily available state and federal government databases, including ortho-imagery, flood zone maps, streamflow, precipitation, flooding, and ice jam reports. Historical flood reports, newspaper articles, social media posts, community engagement meeting notes, and geographic information system (GIS) mapping were used to identify stakeholder concerns, produce watershed maps, and identify current high-risk areas. New York State Community Risk and Resiliency Act (NYSDEC 2018) draft guidelines, New York State Department of Transportation (NYSDOT) bridge and culvert standards, and United States Geologic Service (USGS) *FutureFlow Explorer* v1.5 (USGS 2016) and *StreamStats* v4.3.11 (USGS 2019b) software were used to develop current and future potential discharges and bankfull widths and depths at various points along the stream channel. Hydrologic and hydraulic (H&H) modeling was performed previously, as part of the 1984 FEMA Flood Insurance Studies (FIS) for the Towns of East Otto and Ashford; however, the FIS reports were not made available by FEMA. Instead, only the Flood Insurance Rate Maps (FIRMs) were made available (FEMA 2021).

Updated H&H modeling was performed in this study using the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) v5.0.7 (USACE 2019b) software to determine water stage at current and potential future levels for high-risk areas, and to evaluate the effectiveness of proposed flood mitigation strategies. These studies and data were obtained and used, all or in part, as part of this effort. Appendix A is a summary listing of data and reports collected.

2.2 PUBLIC OUTREACH

Initial project kickoff meetings were held virtually April 20th, 2021, with representatives of the NYSDEC, NYSOGS, Ramboll Americas Engineering Solutions, Inc. (Ramboll), Highland Planning, NYSDOT, USACE, Town of East Otto, Town of Ashford, and the Cattaraugus County Department of Public Works (CCDPW) (Appendix B). During these meetings, project specifics including background, purpose, funding, roles, and timelines were discussed. Discussions included a variety of topics, including:

- Firsthand accounts of past flooding events
- Identification of specific areas that flooded in each community, and the extent and severity of flood damage
- Information on post-flood efforts, such as temporary floodwalls

This outreach effort assisted in the identification of current high-risk areas to focus on during the future flood risk assessments.

2.3 FIELD ASSESSMENT

Following the initial data gathering and agency meetings, field staff from Ramboll undertook field data collection efforts with special attention given to high-risk areas in the Towns of East Otto and Ashford as identified in the initial data collection process. Initial field assessments of Connoisarauley Creek were conducted in May of 2021. Information collected during field investigations included the following:

- Rapid "windshield" river corridor inspection
- Photo documentation of inspected areas
- Measurement and rapid hydraulic assessment of bridges, culverts, and dams
- Geomorphic classification and assessment, including measurement of bankfull channel widths and depths at key cross sections
- Field identification of potential flood storage areas
- Wolman pebble counts
- Characterization of key stream bank failures, head cuts, bed erosion, aggradation areas, and other unstable stream channel features
- Preliminary identification of potential flood hazard mitigation alternatives, including those requiring further analysis

Included in Appendix C is a copy of the Stream Channel Classification Form, Field Observation Form for the inspection of bridges and culverts, and Wolman Pebble Count Form, as well as a location map of where field work was completed. Appendix D is a photo log of select locations within the river corridor. The collected field data was categorized, summarized, indexed, and geographically located within a GIS database. This GIS database will be made available to the NYSDEC and NYSOGS upon completion of the project.

All references to “right bank” and “left bank” in this report refer to "river right" and "river left," meaning the orientation assumes that the reader is standing in the river looking downstream.

3. WATERSHED CHARACTERISTICS

3.1 STUDY AREA

The Connoisarauley Creek watershed lies entirely within Cattaraugus County, New York, encompassing areas between the Towns of East Otto, Ashford, and Ellicottville. The creek flows in a general north-northwest direction with its headwaters in the Town of Ellicottville and passes through the Towns of East Otto and Ashford before emptying into Cattaraugus Creek at the border between Erie and Cattaraugus Counties (Figure 3-1).

Within the Connoisarauley Creek watershed, the area between the confluence with Cattaraugus Creek and the US-219 (Pittsburgh-Buffalo Highway) roadway crossing in the Town of Ashford was chosen as the target area due to their historical and recent flooding issues, and the hydrologic conditions of the creek. Figures 3-2 and 3-3 depict the stream stationing along Connoisarauley Creek in Cattaraugus County, NY, in the Towns of East Otto, Ashford, and Ellicottville and in the study area of the Towns of East Otto and Ashford, respectively.

The Town of East Otto lies in the northeast part of Cattaraugus County in western New York State and has a total area of 41.6 square miles. The Town shares its northern border with the Town of Concord in Erie County, and is bordered on the east by the Town of Ashford, southeast by the Town of Ellicottville, south by the Town of Mansfield, and west by the Town of Otto. There are five hamlets located within the Town: Brooklyn, East Otto, Edies Siding, Plato, and Whiteford Hollow. Rainbow Lake and Timber Lake are the two largest bodies of water within the Town, and East Otto Creek, Goodell Creek, Utley Brook, and South Branch Cattaraugus Creek flow through the Town (Tetra Tech 2020).

The Town of Ashford lies in the north-central part of Cattaraugus County in western New York State and has a total area of 51.9 square miles. The Town is bordered to the north by the Towns of Concord and Sardinia in Erie County, east are the Towns of Yorkshire and Machias, south is the Town of Ellicottville, and west is the Town of East Otto. There are seven hamlets located within the Town: Ashford Hollow, Bellow Corners, Edies Siding, Fox, Riceville, Thomas Corners, and West Valley. Cattaraugus Creek, Connoisarauley Creek, Gooseneck Creek, Indian Creek, Buttermilk Creek, and Nigh Creek all flow through the Town (Tetra Tech 2020).

The Town of Ellicottville lies in the northcentral part of Cattaraugus County in western New York State. The Town has a total area of 45 square miles. The Town of Ellicottville is bordered by the Town of Ashford to the north, Town of Machias to the northeast, Town of Franklinville to the east, Town of Great Valley to the south, Town of Mansfield to the west, and the Town of East Otto to the northwest. There are two hamlets located within the Town: Plato and Ashford Junction. The following creeks flow through the town: Great Valley, Connoisarauley, Beaver Meadows, Elk, Bryant Hill, and McMurray (Tetra Tech 2020).

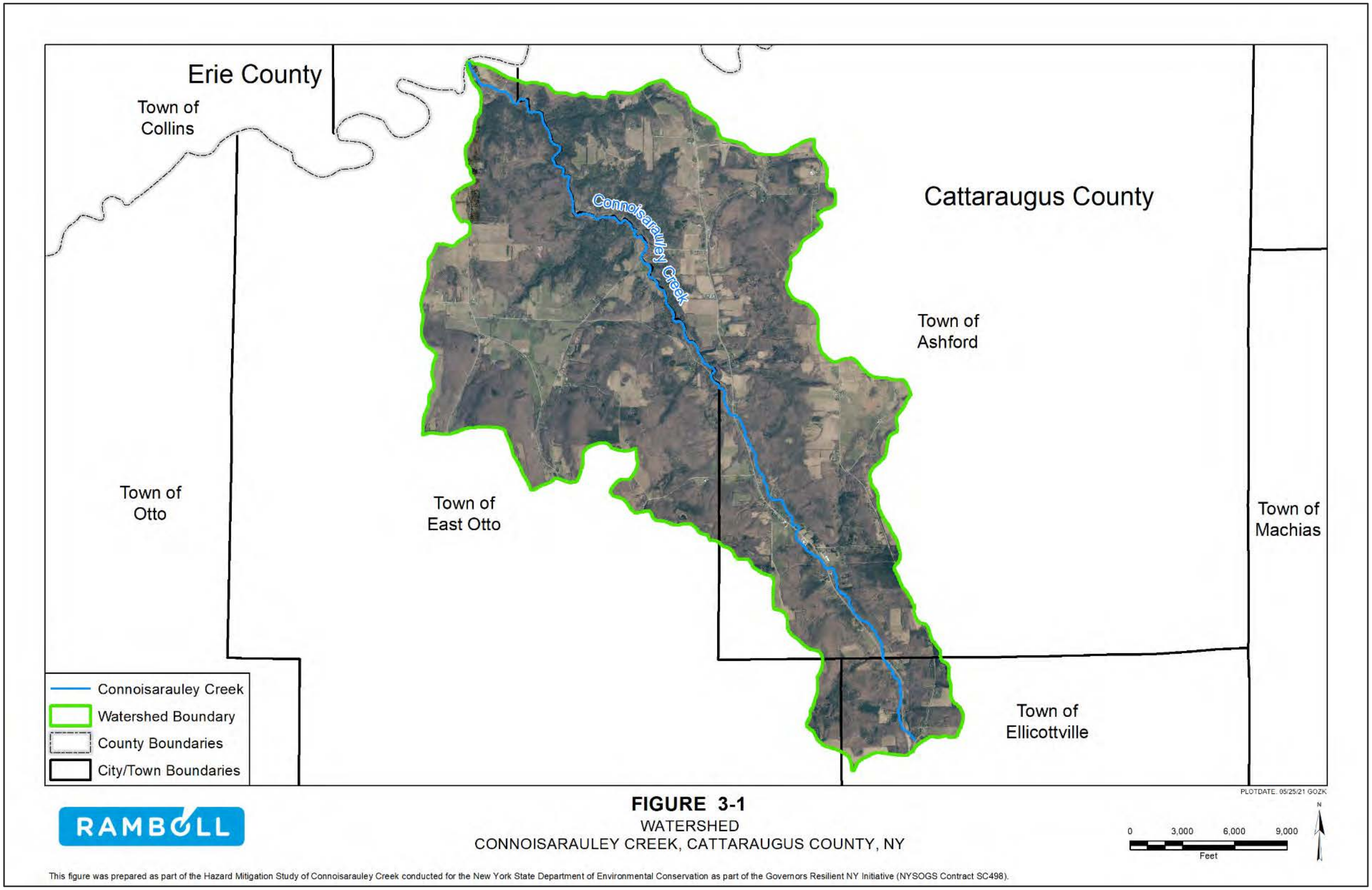

Figure 3-1. Connoisarauley Creek watershed, Cattaraugus County, NY.

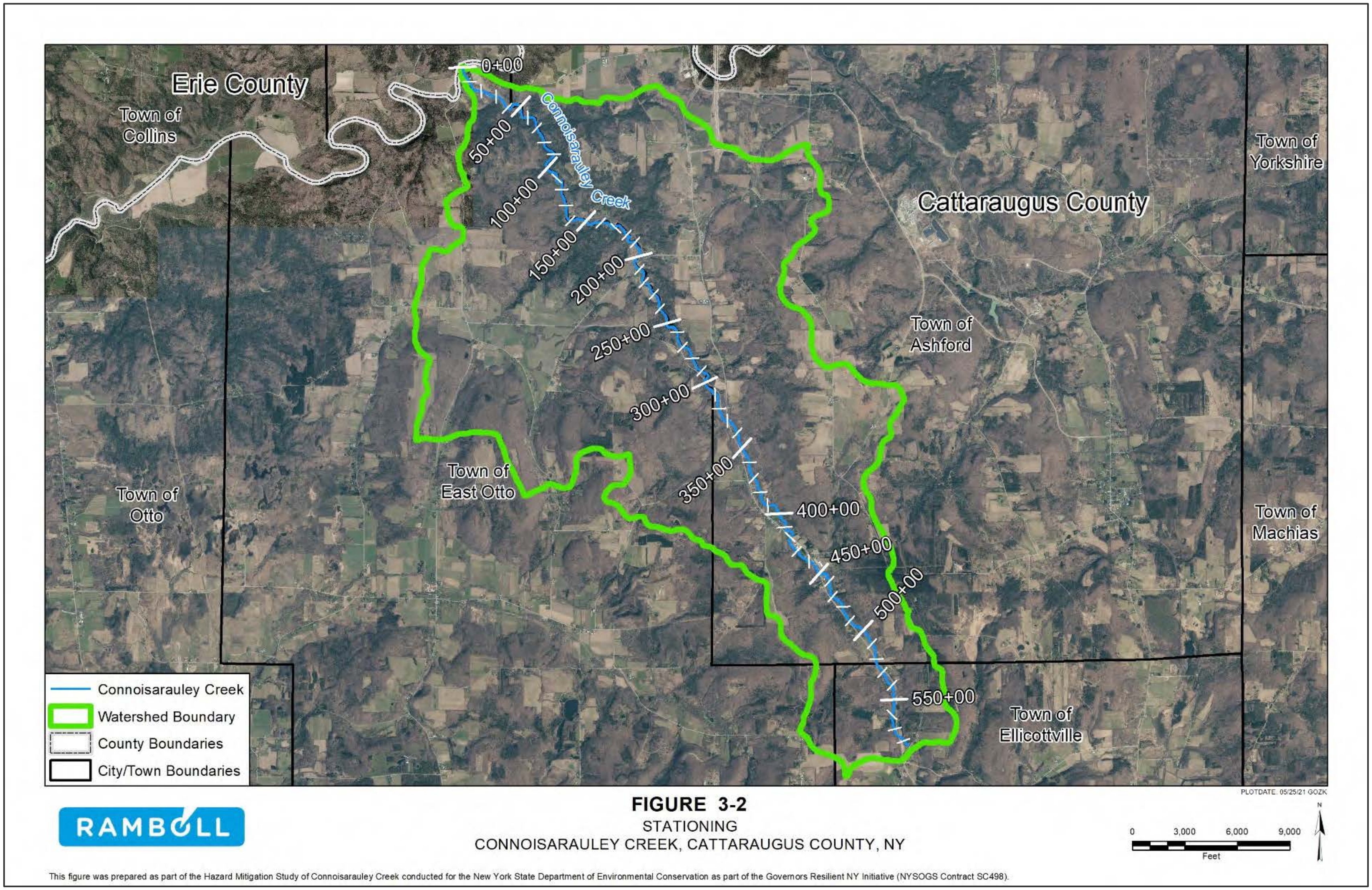

Figure 3-2. Connoisarauley Creek stationing, Cattaraugus County, NY.

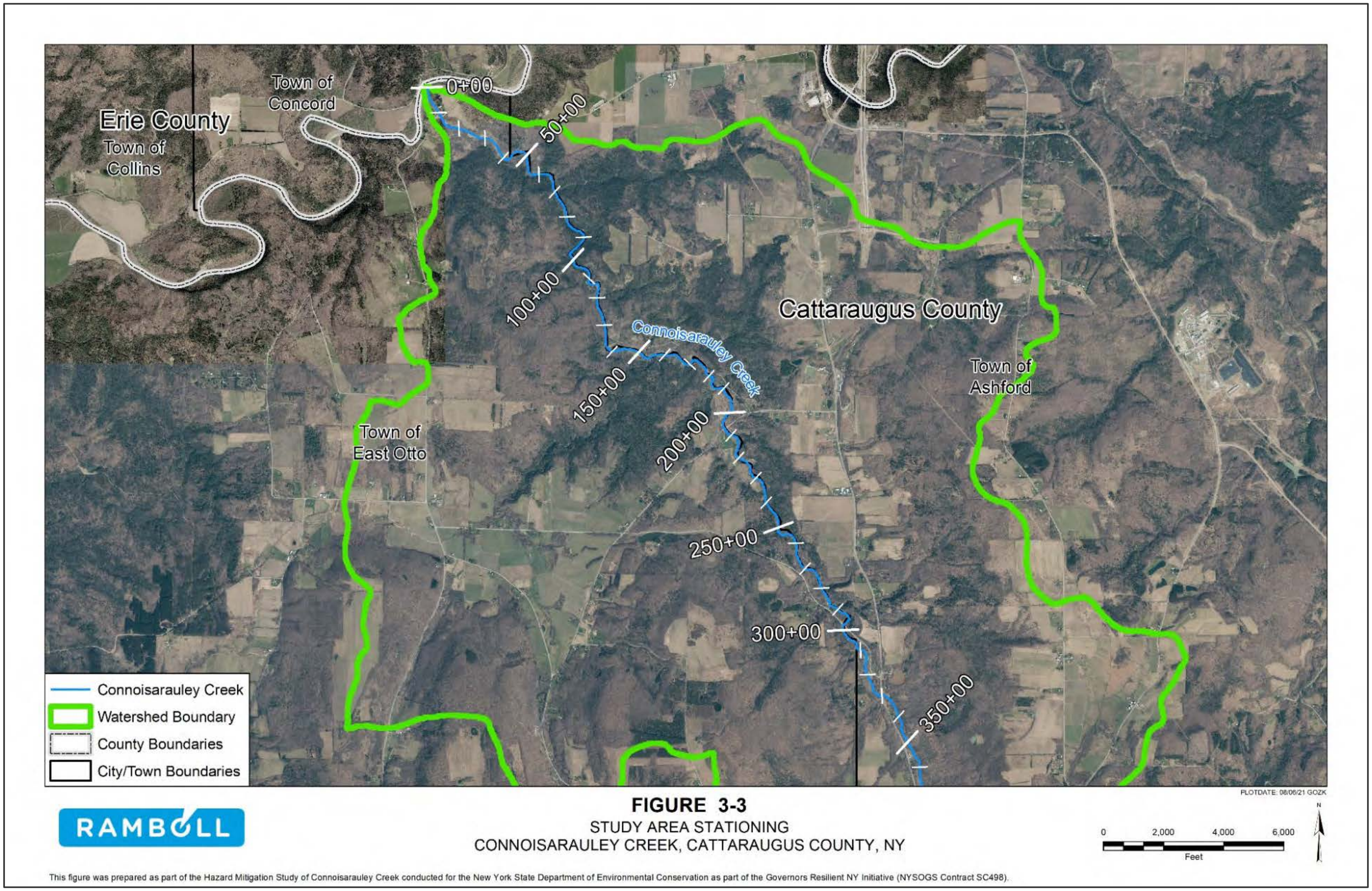

Figure 3-3. Connoisarauley Creek study area stationing, Cattaraugus County, NY.

3.2 ENVIRONMENTAL CONDITIONS

An overview of the environmental and cultural resources within the Connoisarauley Creek watershed was compiled using the following online tools:

- **Environmental Resource Mapper** – The Environmental Resource Mapper is a tool used to identify mapped federal and state wetlands, state designated significant natural communities, and plants and animals identified as endangered or threatened by the NYSDEC (NYSDEC 2021) (https://gisservices.dec.ny.gov/gis/erm/).
- **National Wetlands Inventory (NWI)** – The NWI is a digital map database available on the Environmental Resource Mapper that provides information on the "status, extent, characteristics and functions of wetlands, riparian, and deep-water habitats" (NYSDEC 2021).
- **Information for Planning and Consultation (IPaC)** – The IPaC database provides information about endangered/threatened species and migratory birds regulated by the U.S. Fish and Wildlife Service (USFWS 2021) (https://ecos.fws.gov/ipac/).
- **National Register of Historic Places** – The National Register of Historic Places lists historic places worthy of preservation, as authorized by the National Historic Preservation Act of 1966 (NPS 2014) (https://www.nps.gov/subjects/nationalregister/data-downloads.htm).

3.2.1 Wetlands

The State Regulated Freshwater Wetlands database shows the approximate location of wetlands regulated by New York State. The check zone is a 100-ft buffer zone around the wetland in which the actual wetland may occur. The National Wetlands Inventory was reviewed to identify national wetlands and surface waters (Figure 3-4). The Connoisarauley Creek watershed includes riverine habitat, freshwater forested / shrub wetlands, freshwater ponds, and freshwater emergent wetlands (NYSDEC 2021).

3.2.2 Sensitive Natural Resources

Areas designated as significant natural communities by the NYSDEC were mapped in the Connoisarauley Creek watershed. The significant natural communities identified included Hemlock-Northern Hardwood Forests in the Uplands ecological system as mapped by the Environmental Resource Mapper (NYSDEC 2021) (Figure 3-5).

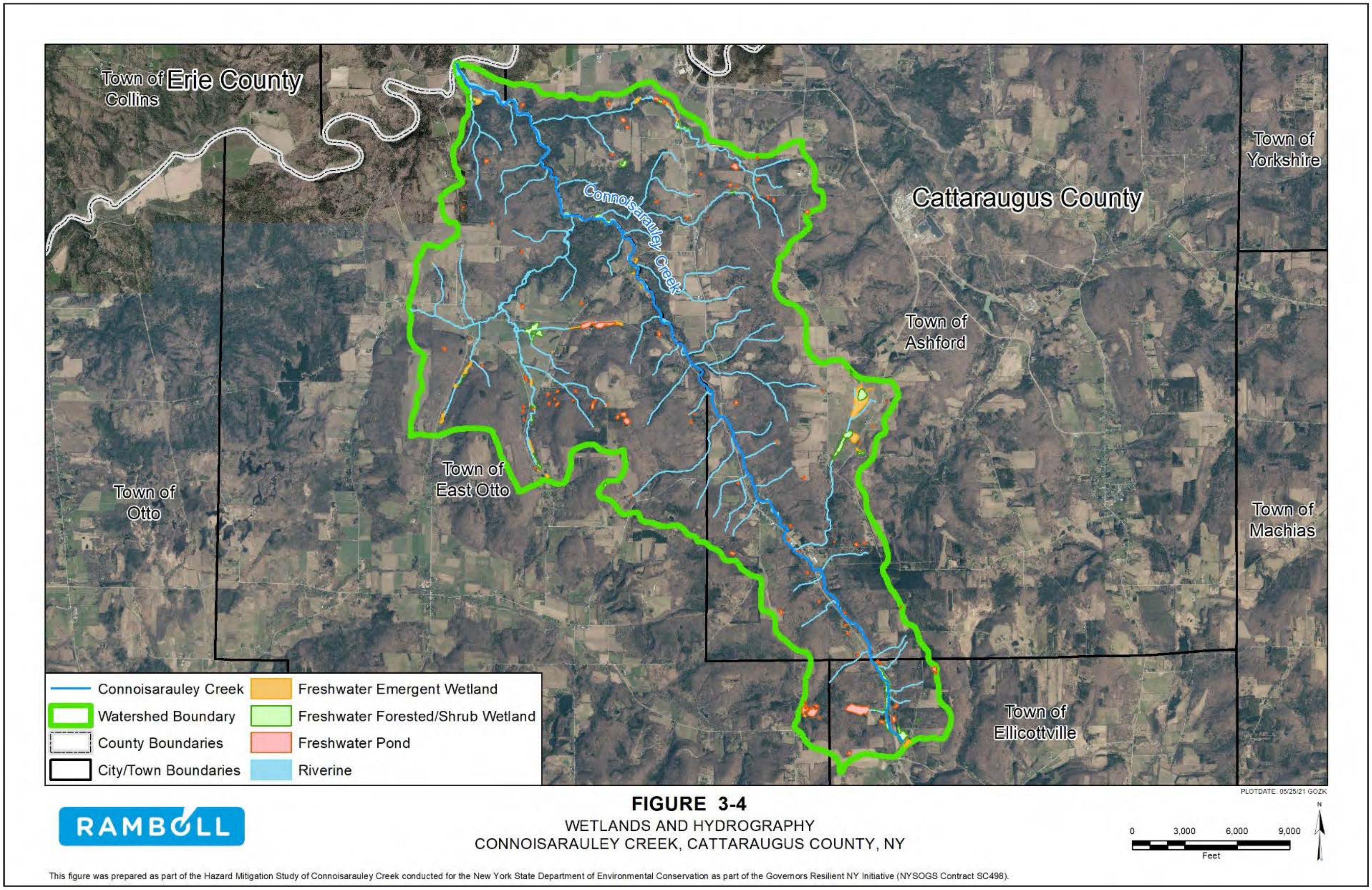

Figure 3-4. Connoisarauley Creek wetlands and hydrography, Cattaraugus County, NY.

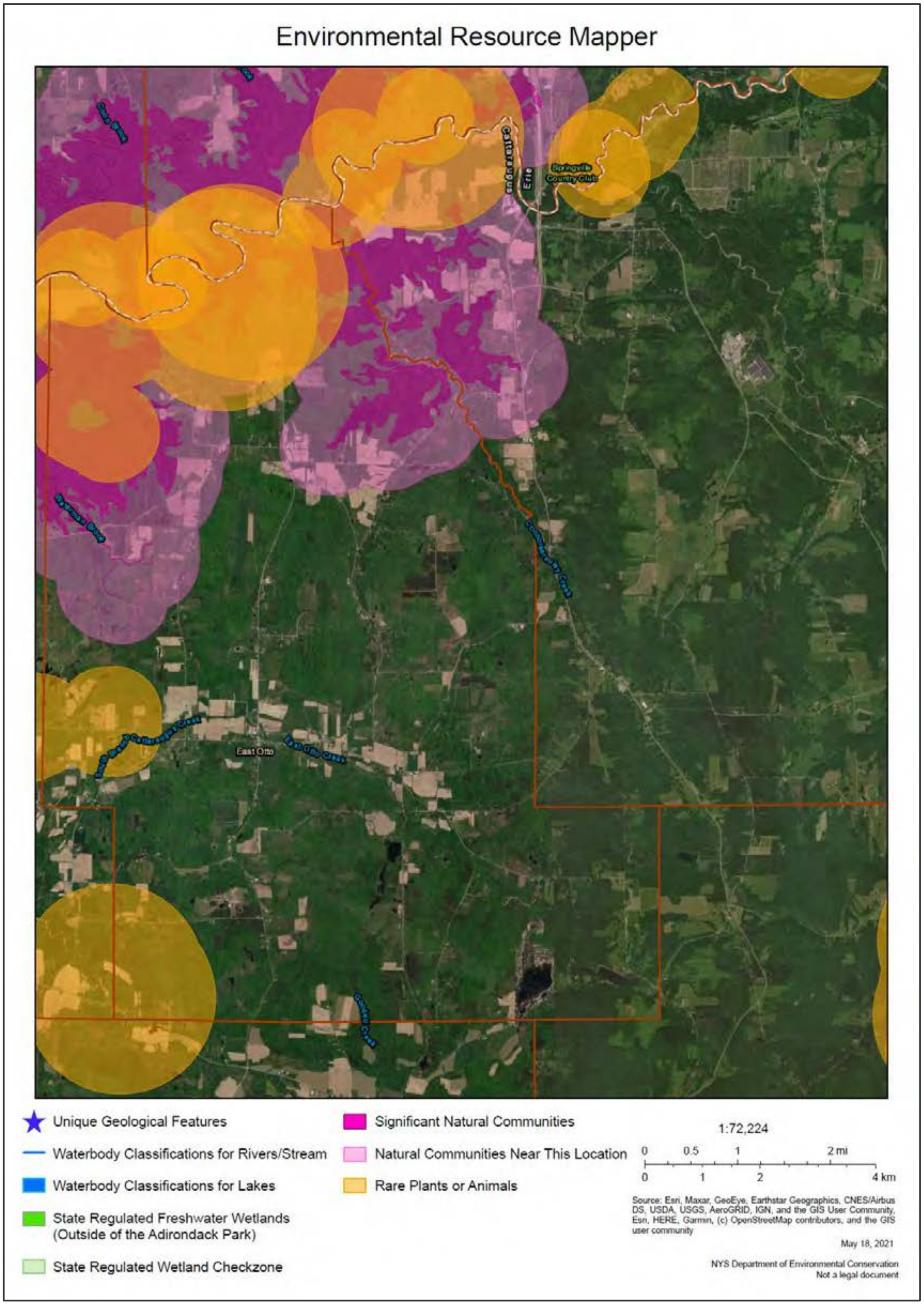

Figure 3-5. Significant natural communities and rare plants or animals, Connoisarauley Creek, Cattaraugus County, NY.

3.2.3 Endangered or Threatened Species

The Environmental Resource Mapper shows that the watershed basin contains rare plants listed as endangered, threatened, or rare by NYS and rare animals listed as endangered or threatened; however, the rare plants and animals are not listed by the NYSDEC due to their sensitive nature. The NYSDEC Regional Office should be contacted to determine the potential presence of the species identified (NYSDEC 2021).

The USFWS Information for Planning and Consultation (IPaC) results for the project area list four threatened species, the Northern Long-eared Bat (Myotis septentrionalis), Clubshell clam (Pleurobema clava), Northern Riffleshell clam (Epioblasma torulosa rangiana), and the Rayed Bean clam (Villosa fabalis). No critical habitat has been designated for the species at this location (USFWS 2021) (https://ecos.fws.gov/ipac/). The migratory bird species listed in Table 1 are transient species that may pass over, but are not known to nest within the project area.

Table 1. UFWS IPaC Listed Migratory Bird Species

(Source: USFWS 2021)

Common Name	Scientific Name	Level of Concern	Breeding Season
Bald Eagle	*Haliaeetus leucocephalus*	Non-BCC Vulnerable[1]	Breeds Sep 1 to Aug 31
Black-billed Cuckoo	*Coccyzus erythropthalmus*	BCC Rangewide (CON)[2]	Breeds May 15 to Oct 10
Black-capped Chickadee	*Poecile atricapillus practicus*	BCC-BCR[3]	Breeds April 10 to Jul 31
Bobolink	*Dolichonyx oryzivorus*	BCC Rangewide (CON)[2]	Breeds May 20 to Jul 31
Canada Warbler	*Cardellina canadensis*	BCC Rangewide (CON)[2]	Breeds May 20 to Aug 10
Prairie Warbler	*Dendroica discolor*	BCC Rangewide (CON)[2]	Breeds May 1 to Jul 31
Rusty Blackbird	*Euphagus carolinus*	BCC Rangewide (CON)[2]	Breeds elsewhere
Wood Thrush	*Hylocichla mustelina*	BCC Rangewide (CON)[2]	Breeds May 10 to Aug 31
Yellow-bellied Sapsucker	*Sphyrapicus varius*	BCC-BCR[3]	Breeds May 10 to Jul 20

1. This is not a Bird of Conservation Concern (BCC) in this area but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.
2. This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska (CON).
3. This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA.

3.2.4 Cultural Resources

No facilities listed on the National Register of Historic Places were found within the project area. Consultation with New York State Office of Parks, Recreation, and Historic Places (NYSOPRHP) should be performed to identify the potential presence of archeological resources and the subsequent need to perform a cultural resource investigation (NPS 2014).

3.2.5 FEMA Mapping and Flood Zones

The FEMA Flood Map Service Center (MSC) (https://msc.fema.gov/portal/home) is a database that contains FEMA Flood Insurance Rate Maps (FIRMs) for areas that have had FEMA flood insurance studies completed throughout the United States (FEMA 2021). The generated FIRMs for the Connoisarauley Creek watershed indicate Special Flood Hazard Areas (SFHAs), which are land areas covered by the floodwaters of the 1% annual chance flood event (ACE), along the banks of the creek, for the reaches of Connoisarauley Creek in the Towns of Ashford and East Otto. However, according to the FEMA MSC website and data library, no Flood Insurance Study (FIS) report was published for the Towns of Ashford and East Otto.

Detailed explanations of the hydrologic and hydraulic analyses performed by FEMA to develop the FIRMs is unavailable due to the lack of an FIS. All delineated flood areas for both communities are designated as Zone A. FEMA defines a Zone A as:

> *Areas subject to inundation by the 1% annual chance flood event are generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) or flood depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply (FEMA 2020).*

FEMA Zone A studies do not typically include survey of the channel or hydraulic structures. Zones A were typically delineated using simplified channel routing methodologies such as those available in the USACE Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) program. The BFE is the elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year. The non-delineated areas on the FEMA FIRMs are designated as Zone C. FEMA defines Zone C as areas outside of the 500-yr flood (0.2% annual chance flood hazard) (FIA 1980; FEMA 2020).

Connoisarauley Creek is not a Regulatory Floodway according to the FEMA FIRMs. A Regulatory Floodway is defined as the watercourse channel and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than 1-ft over the BFE. In the regulatory floodway, communities must regulate encroachments, including fill, new construction, substantial improvements, and other development within the adopted regulatory floodway and demonstrate through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed encroachment would not increase flood levels within the community during the occurrence of the base flood. This FEMA requirement does not apply to Connoisarauley Creek; however, it is recommended that each community review floodplain development on a case-by-case basis to ensure that increases in water surface elevations do not occur or identify the need to adopt a floodway if adequate information is available (FIA 1980; FEMA 2000). Figures 3-6 and 3-7 are FIRMs that include a portion of Connoisarauley Creek in the Towns of Ashford and East Otto, NY, respectively (FEMA 1984a; FEMA 1984b).

Digitized Q3 flood zone data derived from FEMA FIRMs was used to produce flood zone maps in this study. Digital Q3 flood data files contain only certain features from the FIRM hardcopy in effect at the time of scanning and do not replace the existing FIRM hardcopy maps. In addition, the process of georeferencing paper maps to digital images can distort certain features over large areas between known points. This process is not recommended to use for detailed flood zone delineation or analysis (FEMA 1996).

The hydraulic analyses performed by FEMA were based on unobstructed flow for all three communities. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail. With regards to ice-jam flooding, the effective FEMA FIRMs only reflect flooding related to open-water or free-flow conditions (FIA 1980).

For this study, ice-jam flooding extents were determined using a wide variety of sources, including stakeholder input, news reports, computer models, etc. References to ice-jam flood extents are based solely on these sources and do not reflect the flood zone areas from the effective FEMA FIRMs.

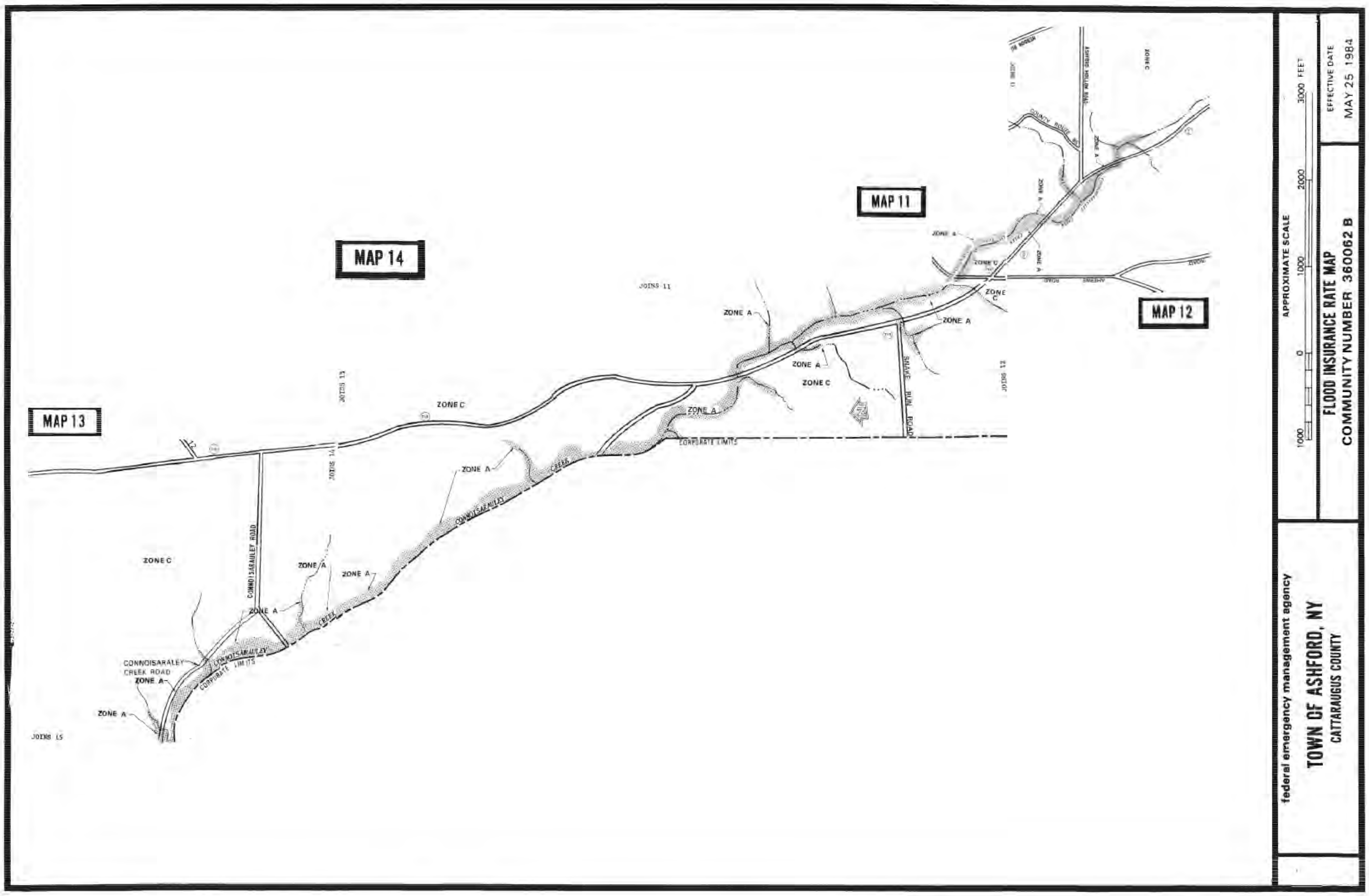

Figure 3-6. FEMA FIRM, Town of Ashford, Cattaraugus County, NY.

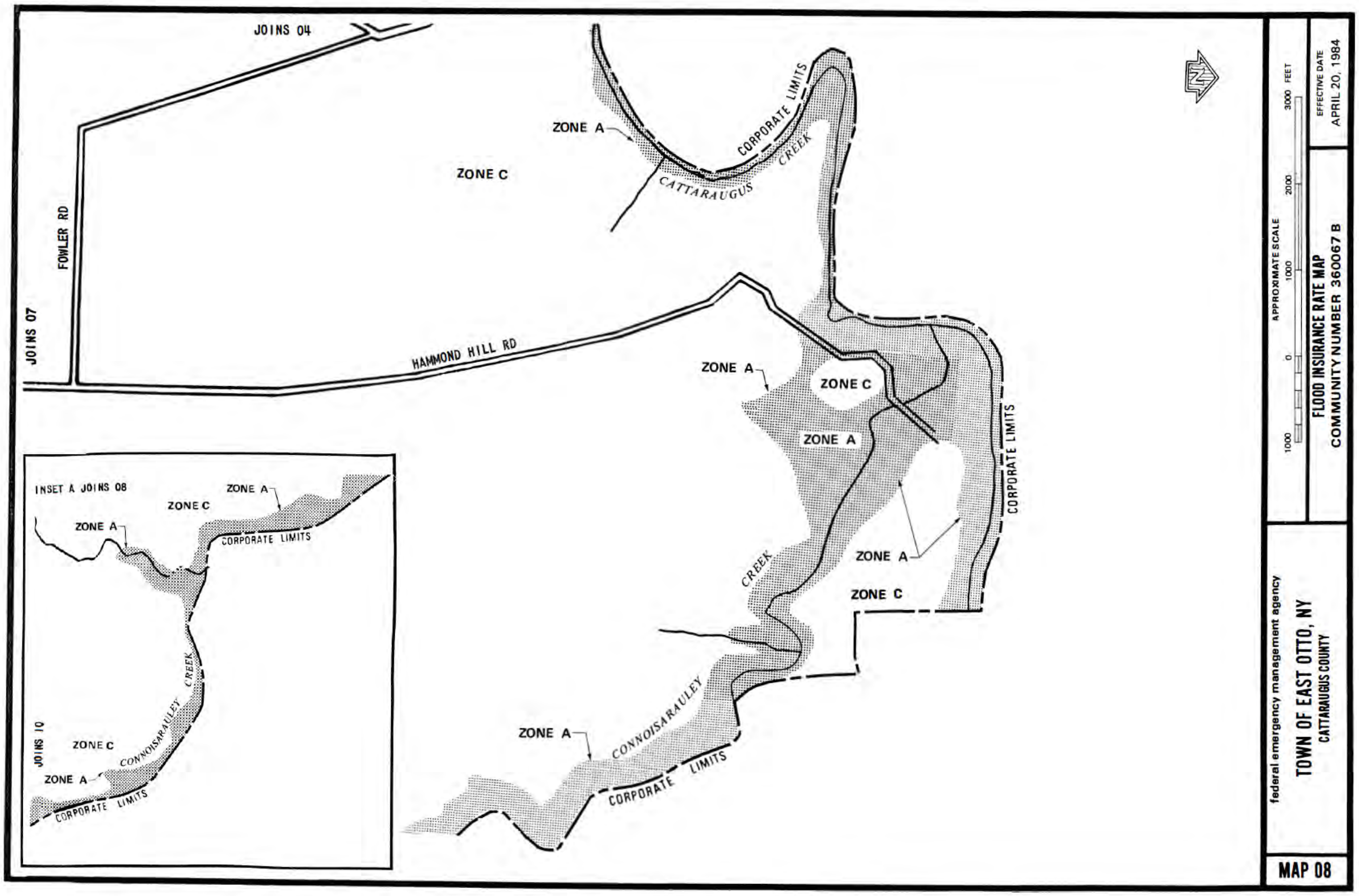

Figure 3-7. FEMA FIRM, Town of East Otto, Cattaraugus County, NY.

3.3 WATERSHED LAND USE

The Connoisarauley Creek stream corridor is largely comprised of forested (65%) and agricultural (27%) lands within the basin. Of the forested lands, deciduous (37%) and mixed (21%) forests comprise the largest proportion of these lands, while hay / pasture (20%) and cultivated crops (6%) encompass the largest percentages of agricultural lands (NLCD 2018).

The distribution of different land use and cover types varies throughout the Connoisarauley Creek basin. The upper portion of the basin, in the Towns of Ashford and East Otto, is primarily comprised of forested lands, while the middle and lower portions are primarily agricultural and forested lands. Developed areas of varying intensities along the creek are primarily in the middle portion of the basin (NLCD 2018).

3.4 GEOMORPHOLOGY

Cattaraugus County includes both glaciated and unglaciated landscapes. Within the borders of Cattaraugus County there are three physiography provinces: the Erie-Ontario Plain province, the glaciated Allegheny Plateau province, and the unglaciated Allegheny Plateau province. The Erie-Ontario Plain province is a small area of lowland in the northwest corner of the county which occupies less than 5% of the county. It is characterized with low relief, gently terraced by wave action in former pre-glacial lakes, with a series of very narrow ravines cut across by a number of streams. The lowest elevation in Cattaraugus County is just over 600 feet where Cattaraugus Creek leaves the county at the extreme northwest corner (NRCS 2002a).

The glaciated Allegheny Plateau province occupies about 75% of the county. The plateau is characterized by steep valley walls, wide ridge tops and flat-topped hills between drainageways. The Allegheny Plateau in Cattaraugus County is intersected by a number of broad, flat-bottomed valleys, presently occupied by sluggish, meandering streams. The topography is strongly influenced by the underlying bedrock, which is nearly level bedded. The Allegheny Plateau extends south from Cattaraugus Creek to just north of the Allegheny River. On the glaciated Allegheny Plateau, the elevation rises from about 1,400 feet in the major valleys to 2,200 feet. The greater part of the upland plateau lies between elevations of 1,600 to 2,000 feet (NRCS 2002a).

The unglaciated Allegheny Plateau province occupies the lower 20% of the county, following the general course of the Allegheny River. This crudely triangular area of New York, the so called Salamanca Re-entrant, escaped glaciation and is the most northerly region of unglaciated landscapes in eastern North America (Muller 1977). The contrast in relief between the glaciated and unglaciated parts of the county are striking. This area has more rugged topography, longer and steeper slopes, deeply incised and V-shaped valleys, and does not have the irregular, hilly characteristics typical of much of the glaciated areas. The elevation rises from 1,284 feet at the point where the Allegheny River enters Pennsylvania, to about 2,400 feet at the top of the plateau. The maximum recorded elevation, 2,430 feet, occurs at Claire benchmark in the Town of Allegany (NRCS 2002a).

From the unglaciated summits south of Olean to the floodplain of Cattaraugus Creek northwest of Gowanda, the total relief in Cattaraugus County is 1,825 feet, a range of elevation greater than any other western New York county (NRCS 2002a). Figure 3-8 is the Connoisarauley Creek profile of stream bed elevation and channel distance from the confluence with Cattaraugus Creek using 1-meter light detection and ranging (LiDAR) data for Connoisarauley Creek (NYSOITS 2017b).

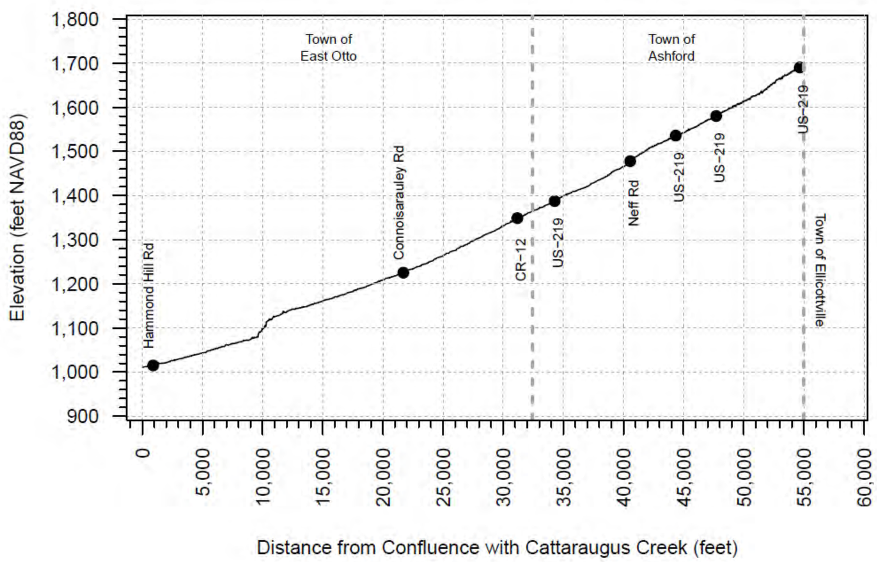

Figure 3-8. Connoisarauley Creek profile of stream bed elevation and channel distance from the confluence with Cattaraugus Creek.

Cattaraugus County contains bedrock that dates back 300 to 400 million years to the Devonian, Mississippian, and Pennsylvanian periods of the Paleozoic Era (Tesmer 1975). Many of these rocks contain the remains of typical shallow water marine invertebrates of that time. Formations of the Upper Devonian are at the lower elevations, while those of the Pennsylvanian are at the higher elevations. In general, the older rock strata occur in northern Cattaraugus County, while the younger rocks are found to the south near the Pennsylvania state line, capping the tops of the highest hills. The stratum of bedrock is generally horizontal but has a slight dip to the south or south-southwest, of approximately 40-ft per mile (Flint 1947; NRCS 2002a).

The oldest bedrock formation is of the Devonian period. In Cattaraugus County it is the Hanover Shale, which is of the Java Group. The succession of bedrock from oldest to youngest in the County is: Hanover Shale (Java Group), Dunkirk Shale (Canadaway Group), South Wales Shale (Canadaway Group), Laona Member (Canadaway Group), Westfield Member (Canadaway Group), Shumla Member (Canadaway Group), Northeast Member (Canadaway Group), Chadakoin Formation (Conneaut Group), Venango Formation (Conewango Group), Oswayo Formation (Conewango Group), Knapp Formation (Pocono Group), Olean Conglomerate (Pottsville Group), and Sharon Slate (Pottsville Group) (NRCS 2002a).

Cattaraugus County experienced several advances and retreats of glacial ice during the Pleistocene ice age. The ice age began about 300,000 years ago and ended during the late Wisconsin glaciation, about 12,000 to 17,000 years ago. In Cattaraugus County, the earlier glaciation was covered or destroyed by two later Wisconsin glacial advances, an earlier advance by the Altonian substage from the northeast, and the later Woodfordian substage from the northwest (Muller 1977).

As the glacial ice melted and receded, further exposing valley areas, large quantities of melt water discharging from the glacial front carried rock and soil debris, which was deposited as valley train terraces, kames, and eskers. Nearly level or undulating valley train terrace deposits occupy the floors of many valleys. All of these postglacial fluvial deposits generally are referred to as outwash or glaciofluvial deposits, and consist mainly of stratified sand and gravel. Erosion and sedimentation have been taking place continually since the ice retreated. Steep, fan-shaped alluvial deposits have accumulated at the mouth of the lateral streams, where the velocity of the water slowed and the sand and gravel dropped out of suspension (NRCS 2002a).

The drainage system of Cattaraugus County is separated into two systems: the Lake Erie-St. Lawrence River system and the Allegheny-Ohio-Mississippi River system. The drainage from the northern one-third of the county flows northward and then west into the Lake Erie-St. Lawrence system, and the southern two-thirds of the county flows southward into the Allegheny-Ohio-Mississippi River system. In the northern part of the county, the principal drainage system for the upland plateau is Cattaraugus Creek and its tributaries. Cattaraugus Creek forms the boundary line between the counties of Cattaraugus and Erie. Numerous tributaries, rising in the county, enter Cattaraugus Creek from the south. Of these are the Connoisarauley, which flows into Cattaraugus Creek near the center of the county, and the South Branch of Cattaraugus Creek, which enters several miles downstream. Other major streams which flow into Cattaraugus Creek include Mansfield Creek, Buttermilk Creek, Elton Creek, and Clear Creek (NRCS 2002a).

In addition, there are numerous locations where sediment depositional aggradation is occurring within the channel of Connoisarauley Creek. Aggradation is a natural fluvial process where sediment and other materials are deposited in a stream channel when the supply of sediment is greater than the amount of material that the system is able to transport. Over time, aggradation can lead to the development of sand and sediment bars within the stream channel. These sand and sediment bars may restrict flow by reducing the in-channel flow area, and may act as catchpoints for ice pieces during ice breakup events, potentially increasing open-water flood risks and ice-jam formations (Mugade and Sapkale 2015).

3.5 HYDROLOGY

Connoisarauley Creek drains an area of 21.8 square miles, is approximately 11 miles in length, and is located in the southwestern portion of New York State and in the northern portion of Cattaraugus County. Connoisarauley Creek rises in the vicinity of Hebdon Road in the Town of Ellicottville and flows north / northwest crossing US-219 multiple times in the Town of Ashford before forming the boundary between the Towns of East Otto and Ashford and emptying into Cattaraugus Creek (USGS 2020).

There are two main tributaries that flow into Connoisarauley Creek: Stony Brook and Nigh Creek. Stony Brook rises in the Town of East Otto in the vicinity of Monk Hill Road and flows west / northwest, then east / northeast approximately 3.2 miles until merging with Connoisarauley Creek near Boehm and North Connoisarauley Roads. Nigh Creek rises in the Town of Ashford south of Cross Road, and flows east / northeast approximately 3.7 miles until merging with Connoisarauley Creek approximately 1 mile upstream of the Hammond Hill Road bridge (USGS 2020).

Table 2 is a summary of the basin characteristic formulas and calculated values for the Connoisarauley Creek watershed, where A is the drainage area of the basin in square miles, B_L is the basin length in miles, and B_P is the basin perimeter in miles (USGS 1978).

Table 2. Connoisarauley Creek Basin Characteristics Factors

Factor	Formula	Value
Form Factor (R_F)	A / B_L^2	0.27
Circularity Ratio (R_C)	$4*\pi*A / B_P^2$	0.23
Elongation Ratio (R_E)	$2 * (A/\pi)^{0.5} / B_L$	0.59

Form Factor (R_F) describes the shape of the basin (e.g., circular or elongated) and the intensity of peak discharges over a given duration of time. Circularity Ratio (R_C) gives an indication of topography where the higher the circularity ratio, the lower the relief and less disturbance to drainage systems by structures within the channel. Elongation Ratio (R_E) gives an indication of ground slope where values less than 0.7 correlate to steeper ground slopes and elongated basin shapes. Based on the basin characteristics factors, the Connoisarauley Creek watershed can be characterized as an elongated basin with lower peak discharges of longer durations, high-relief topography with structural controls on drainage, and steep ground slopes (Waikar and Nilawar 2014).

There are no USGS stream gaging stations on Connoisarauley Creek, and FEMA has not published a Flood Insurance Study for Cattaraugus County or the Towns of Ashford, East Otto, or Ellicottville.

Due to the fact that there are no published FIS reports that include Connoisarauley Creek, peak discharge data was obtained using the USGS *StreamStats* software. The *StreamStats* v4.3.11 software (https://streamstats.usgs.gov/ss/) is a map-based web application that provides an assortment of analytical tools that are useful for water-resources planning and management, and engineering purposes. The primary purpose of *StreamStats* is to provide estimates of streamflow statistics for user selected ungaged sites on streams and for USGS stream gages, which are locations where streamflow data are collected (Ries et al. 2017; USGS 2019b).

Methods for computing a peak discharge estimate for a selected recurrence interval at a specific site depend on whether the site is gaged or ungaged, and whether the drainage area lies within a single hydrologic region or crosses into an adjacent hydrologic region or state. Hydrologic regions refer to areas in which streamflow-gaging stations indicate a similarity of peak-discharge response that differs from the peak-discharge response in adjacent regions. These similarities and differences are defined by the regression residuals, which are the differences between the peak discharges calculated from station records and the values computed through the regression equation. There are currently six hydrologic regions in New York State (Lumia 1991; Lumia et al. 2006).

For ungaged sites, such as Connoisarauley Creek in Hydrologic Region 5 of New York State, *StreamStats* relies on regional regression equations that were developed by statistically relating the streamflow statistics to the basin characteristics for a group of stream gages within a region. Estimates of streamflow statistics for an ungaged site can then be obtained by measuring its basin characteristics and inserting them into the regression equations (Ries et al. 2017).

For example, the equation for estimating the 100-yr flood for ungaged sites within Hydrologic Region 5 in New York is:

$$Q_{100} = 1.91 * (A)^{0.980} * (SL)^{0.636} * (P)^{0.590}$$

Where

A is the drainage area in square miles;

SL is the main channel slope in feet per mile; and

P is the mean annual precipitation, in inches (Lumia et al. 2006).

StreamStats delineates the drainage basin boundary for a selected site by use of an evenly spaced grid of land-surface elevations, known as a Digital Elevation Model (DEM), and a digital representation of the stream network. Using this data, the application calculates multiple basin characteristics, including drainage area, main channel slope, and mean annual precipitation. By using these characteristics in the calculation, the peak discharge values have increased accuracy and decreased standard errors by approximately 10% for a 1% annual chance interval (100-yr recurrence) discharge when compared to the drainage-area only regression equation (Ries et al. 2017).

However, when one or more of the basin characteristics for an ungaged site are outside the given ranges, then the estimates are extrapolated. *StreamStats* provides warnings when extrapolation occurs. Although StreamStats does provide estimates of streamflow statistics in these circumstances, no error indicators are provided with them, as the errors associated with these estimates are unknown and may be very large (Ries et al. 2017).

Estimates of streamflow statistics that are obtained from regression equations are based on the assumption of natural flow conditions at the ungaged site unless the reports that document the equations state otherwise. If human activities such as dam regulation and water withdrawals substantially affect the timing, magnitude, or duration of flows at a selected site, the regression-equation estimates provided by *StreamStats* should be adjusted by the user to account for those activities (Ries et al. 2017).

StreamStats was used to calculate the current peak discharges for Connoisarauley Creek. Table 3 is the summary output of peak discharges calculated by the USGS *StreamStats* software at select locations along Connoisarauley Creek.

Table 3. USGS *StreamStats* Peak Discharge for Connoisarauley Creek at Select Locations

(Source: USGS 2019b)						
			Peak Discharges (cfs)			
Flooding Source and Location	**Drainage Area (Sq. Mi.)**	**River Station (ft)**	**10-Percent**	**2-Percent**	**1-Percent**	**0.2-Percent**
Confluence with Cattaraugus Creek	21.8	0+00	3,060	4,880	5,740	7,980
Upstream of Confluence with Nigh Creek	18.9	70+00	2,680	4,270	5,010	6,970
Upstream of Confluence with Stony Brook	12.9	145+00	1,900	3,030	3,560	4,950
Towns of East Otto and Ashford corporate limits	7.4	307+50	1,150	1,830	2,150	2,970
Towns of Ashford and Ellicottville corporate limits	1.6	523+00	330	530	620	870

Using the standard error calculations from the regression equation analysis in *StreamStats*, an acceptable range at the 95% confidence interval for peak discharge values at the 10, 2, 1, and 0.2% annual chance flood hazards were determined. Standard error gives an indication of how accurate the calculated peak discharges are when compared to the actual peak discharges, since approximately two-thirds (68.3%) of the calculated peak discharges would be within one standard error of the actual peak discharge, 95.4% would be within two standard errors, and almost all (99.7%) would be within three standard errors (McDonald 2014). Table 4 is a summary table of the USGS *StreamStats* standard errors at each percent annual chance flood hazard for Region 5 in New York State.

Table 4. USGS *StreamStats* Standard Errors for Full Regression Equations

Source: (Lumia 2006)				
	Peak Discharges (cfs)			
	10- Percent	**2- Percent**	**1- Percent**	**0.2- Percent**
Standard Error	36.1	37.5	38.7	42.6

In addition to peak discharges, the *StreamStats* software also calculates bankfull statistics by using stream survey data and discharge records from 281 cross-sections at 82 streamflow-gaging stations in a linear regression analyses to relate drainage area to bankfull discharge and bankfull-channel width, depth, and cross-sectional area for streams across New York state. These equations are intended to serve as a guide for streams in areas of the same hydrologic region, which contain similar hydrologic, climatic, and physiographic conditions (Mulvihill et al. 2009).

Bankfull discharge is defined as the flow that reaches the transition between the channel and its flood plain. Bankfull discharge is considered to be the most effective flow for moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphological characteristics of channels (Mulvihill et al. 2009). The bankfull width and depth of Connoisarauley Creek is important in understanding the distribution of available energy within the stream channel and the ability of various discharges occurring within the channel to erode, deposit, and move sediment (Rosgen and Silvey 1996). Table 5 lists the estimated drainage area, bankfull discharge, width, and depth at select locations along Connoisarauley Creek as derived from the USGS *StreamStats* program.

Table 5. USGS *StreamStats* Estimated Drainage Area, Bankfull Discharge, Width, and Depth

(Source: USGS 2019b)					
Flooding Source and Location	**Drainage Area (Sq. Mi.)**	**River Station (ft)**	**Bankfull Depth (ft)**	**Bankfull Width (ft)**	**Bankfull Streamflow (cfs)**
Confluence with Cattaraugus Creek	21.8	0+00	2.2	61.5	640
Upstream of Confluence with Nigh Creek	18.9	70+00	2.1	57.9	570
Upstream of Confluence with Stony Brook	12.9	145+00	1.9	49.3	410
Towns of East Otto and Ashford corporate limits	7.4	307+50	1.7	39	260
Towns of Ashford and Ellicottville corporate limits	1.6	523+00	1.2	20.7	70

3.6 INFRASTRUCTURE

According to the NYSDEC Inventory of Dams dataset (2019), there is one dam within the Connoisarauley Creek watershed as identified by the NYSDEC. The dam is purposed as primary water supply and has a hazard class of D. Class D dams are also referred to as “negligible or no hazard” dams, which are defined as dams that have been breached or removed, or have failed or otherwise no longer materially impound waters, or dams that were planned but never constructed and are considered to be defunct dams posing negligible or no hazard. Table 6 lists the dams that are along Connoisarauley Creek, including hazard codes and purpose for the dam (NYSDEC 2019).

Table 6. Inventory of Dams along Connoisarauley Creek

(Source: NYSDEC 2019)				
Municipality	**Dam Name**	**River Station (ft)**	**Hazard Code**	**Purpose**
Town of Ashford	Montagues Dam	411+00	D	Water Supply - Primary

There are two large culverts identified by the NYSDOT along Connoisarauley Creek. They are both located in the Town of Ashford. Table 7 lists the culverts that are along Connoisarauley Creek, including identification numbers, owners, and structural characteristics (NYSDOT 2019b).

Table 7. Inventory of Culverts Crossing Connoisarauley Creek

(Source: NYSDOT 2019b)						
Roadway Carried	**Culvert ID (CIN)**	**River Station (ft)**	**Owner**	**Municipality**	**Span Length (ft)**	**Structure Width (ft)**
US-219	C510133	451+00	NYSDOT	Ashford	18	55
US-219	C510132	521+50	NYSDOT	Ashford	18	56

Major bridge crossings over Connoisarauley Creek include Springville Road / East Otto Road (County Route 12) and US-219. Additionally, there are numerous private driveways and roads that cross the creek in the Towns of Ashford and Ellicottville. Bridge lengths and surface widths for NYSDOT bridges and culverts were revised as of 2019. Due to safety concerns and limited access, field staff were unable to perform measurements on some of the waterway crossing structures. Table 8 summarizes the infrastructure data for bridges that cross Connoisarauley Creek. Figure 3-9 displays the locations of the infrastructure along Connoisarauley Creek.

Table 8. Inventory of Infrastructure Crossing Connoisarauley Creek

(Source: NYSDEC 2019; NYSDOT 2019b; NYSDOT 2019c; Ramboll 2021)

Roadway Carried	Structure Type	ID Number	River Station (ft)	Owner	Structure / Span Length (ft)	Structure Width [1] (ft)
Hammond Hill Road	Bridge	3321150	11+50	Cattaraugus County	50	25
Connoisarauley Road	Bridge	3321160	206+50	Cattaraugus County	32	38
Springville Road / East Otto Rd (CR-12)	Bridge	3321060	298+50	Cattaraugus County	38	32
US-219 (1)	Bridge	1041580	329+00	NYSDOT	84	26
Neff Road	Bridge	N/A	387+00	Town of Ashford	38	16
US-219 (2)	Bridge	1041570	420+00	NYSDOT	26	37
US-219 (3)	Culvert	C510133	451+00	NYSDOT	18	55
US-219 (4)	Culvert	C510132	521+50	NYSDOT	18	56
US-219 (5) [2]	Culvert	N/A	574+00	NYSDOT	N/A	N/A

[1] Structure Width is measured parallel to creek flow and refers to the curb-to-curb width, which is the minimum distance between the curbs or the bridge railings (if there are no curbs), to the nearest 30mm or tenth of a foot (NYSDOT 2006).

[2] Note: No available data from NYSDOT culverts dataset. Unable to field measure due to safety concerns.

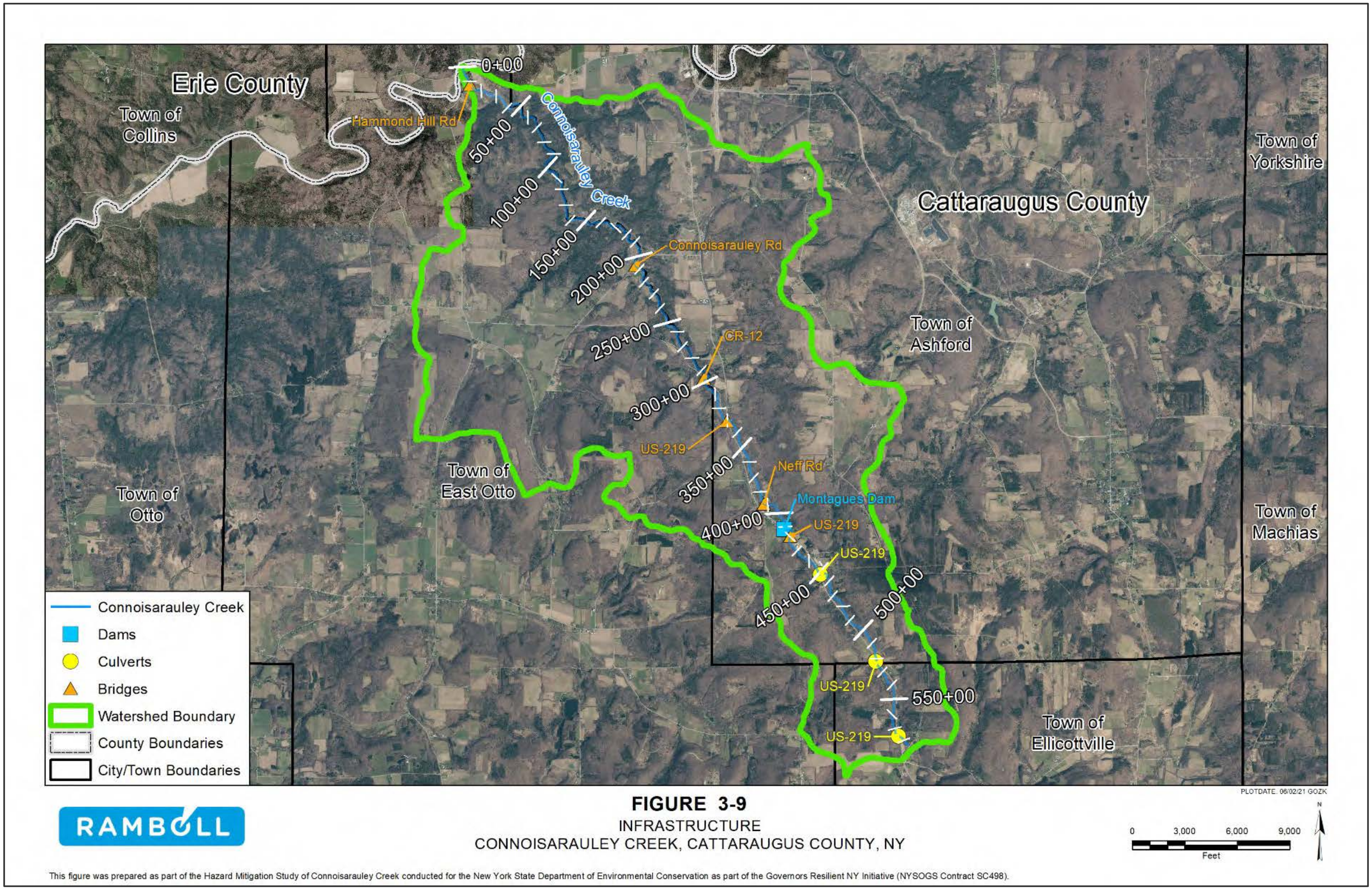

Figure 3-9. Connoisarauley Creek infrastructure, Cattaraugus County, NY.

3.7 HYDRAULIC CAPACITY

Hydraulic capacity is the measure of the amount of water that can pass through a structure or watercourse. Hydraulic design is an essential function of structures in watersheds. Exceeding the capacity can result in damages or flooding to surrounding areas and infrastructure (Zevenbergen et al. 2012). The assessment of hydraulic capacity of infrastructure, such as culverts, bridges, dams, etc., has historically been based on evaluating FEMA or other related H&H models that simulate water surface elevations as they pass through structures crossing waterways. For this study, due to the lack of a FEMA H&H study, bankfull statistics from the USGS *StreamStats* software were compared to the structures width to determine if a low-flow event could successfully pass a structure without constriction or backwater.

In New York State, hydraulic and hydrologic regulations for bridges and culverts were developed by the NYSDOT. The NYSDOT guidelines require a factor of safety for bridges that cross waterways, known as freeboard. Freeboard is the additional capacity, usually expressed as a distance in feet, in a waterway above the calculated capacity required for a specified flood level, usually the base flood elevation. Freeboard compensates for the many unknown factors that could contribute to flood heights being greater than calculated, such as wave action, minor silt and debris deposits, the hydrological effect of urbanization of the watershed, etc. However, freeboard is not intended to compensate for higher floods expected under future climatic conditions, such as those due to sea-level rise or more extreme precipitation events (NYSDEC 2020a).

The term “bridge” shall apply to any structure whether single or multiple span construction with a clear span in excess of 20 feet when measurement is made horizontally along the center line of roadway from face to face of abutments or sidewalls immediately below the copings or fillets; or, if there are no copings or fillets, at 6 inches below the bridge seats or immediately under the top slab, in the case of frame structures. In the case of arches, the span shall be measured from spring line to spring line. All measurements shall include the widths of intervening piers or division walls, as well as the width of copings or fillets (NYSDOT 2020).

According to the NYSDOT bridge manual (2019) for Region 5, which includes Niagara, Erie, Chautauqua, and Cattaraugus Counties, new and replacement bridges are required to meet certain standards, which include (NYSDOT 2019a):

The structure will not raise the water surface elevations anywhere when compared to the existing conditions for both the 2 and 1% annual chance event (50- and 100-yr flood) flows.

- The proposed low chord shall not be lower than the existing low chord.
- A minimum of 2’-0” of freeboard for the projected 2% annual chance event (50-yr flood) is required for the proposed structure. The freeboard shall be measured at the lowest point of the superstructure between the two edges of the bottom angle for all structures.
- The projected 1% annual chance event (100-yr flood) flow shall pass below the proposed low chord without touching it.
- The maximum skew of the pier to the flow shall not exceed 10 degrees.

For culverts, the NYSDOT guidelines require designs to be based upon an assessment of the likely damage to the highway and adjacent landowners from a given flow, and the costs of the drainage facility. The design flood frequency for drainage structures and channels is typically the 2% (50-yr) annual chance flood hazard for Interstates and other Freeways, Principal Arterials, and Minor Arterials, Collectors, Local Roads, and Streets. If the proposed highway is in an established regulatory floodway or floodplain then the 1% (100-yr) annual chance flood hazard requirement must be checked (NYSDOT 2018).

The term “culvert” is defined as any structure, whether of single or multiple-span construction, with an interior width of 20 ft or less when the measurement is made horizontally along the center line of the roadway from face-to-face of abutments or sidewalls (NYSDOT 2020).

In assessing the hydraulic capacity of culverts, NYSDOT highway drainage standards require the determination of a design discharge (e.g., 50-yr flood) through the use of flood frequencies. The design flood frequency is the recurrence interval that is expected to be accommodated without exceeding the design criteria for the culvert. There are four recommended methodologies: The Rational Method, the Modified Soil Cover Complex Method, historical data, and the regression equations. Each method should be assessed and the most appropriate method for the specific site should be used to calculate the design flood frequency and discharge (NYSDOT 2018).

In an effort to improve flood resiliency of infrastructure in light of future climate change, New York state passed the Community Risk and Resiliency Act (CRRA) in 2014. In accordance with the guidelines of the CRRA, the NYSDEC released the *New York State Flood Risk Management Guidance for Implementation of the Community Risk and Resiliency Act* (2020) report. In the report, the NYSDEC outlined infrastructure guidelines for bridges and culverts. In general, current peak flows shall be increased to account for future projected peak flows based on the USGS *StreamStats* tool where current 2% annual chance event peak flows shall be increased by 10% in Hydrologic Region 5 (NYSDEC 2020a).

For bridges, the minimum hydraulic design criteria is 2-ft of freeboard over the 2% annual chance flood elevation, while still allowing the 1% annual chance event flow to pass under the low chord of the bridge without going into pressure flow. For critical bridges, the minimum hydraulic design criteria is 3-ft of freeboard over the 2% annual chance flood elevation. A critical bridge is considered to be vital infrastructure that the incapacity or destruction of such would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters (NYSDEC 2020a; NYSDOT 2019a; USDHS 2010).

For culverts, the minimum hydraulic design criteria is 2-ft of freeboard over the 2% annual chance flood elevation. For critical culverts, the CRRA guidelines recommend 3-ft of freeboard over the 1% annual chance flood elevation. A critical culvert is considered to be vital infrastructure that the incapacity or destruction of such would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters (NYSDEC 2020a; NYSDOT 2018; USDHS 2010).

When compared to current guidelines, the new CRRA climate change recommendation of freeboard for bridges and culverts encourages building more flood resilient infrastructure.

To assess hydraulic capacity for this study, the USGS *StreamStats* tool was used to calculate the bankfull widths and discharge for each structure along Connoisarauley Creek. Table 9 indicates that in Cattaraugus County, NY, nearly every structure that crosses Connoisarauley Creek has a structural opening that is smaller than the bankfull width, excluding US-219 downstream Neff Road and Neff Road. However, the Neff Road bridge crossing opening is very close (within 5 ft) of bankfull width, which is an area of concern due to the close proximity of residential and commercial properties to the creek.

Table 9. Hydraulic Capacity of Potential Constriction Point Bridges Crossing Connoisarauley Creek

Source: (NYSDOT 2016b; Ramboll 2021; USGS 2019b)						
Roadway Carried	**Structure Type**	**River Station (ft)**	**Structure Length (ft)**	**Bankfull Width (ft)**	**Bankfull Discharge (cfs)**	**Annual Chance Flood Event Equivalent[1]**
Hammond Hill Road	Bridge	11+50	50	61.4	640	> 80 %
Connoisarauley Road	Bridge	206+50	32	46	360	> 80 %
Springville Road / East Otto Road (CR-12)	Bridge	298+50	38	39	260	> 80 %
US-219 (1)	Bridge	329+00	84	37	230	> 80 %
Neff Rd	Bridge	387+00	38	33	190	> 80 %
US-219 (2)	Bridge	420+00	26	32	170	> 80 %
US-219 (3)	Culvert	451+00	18	27	120	> 80 %
US-219 (4)	Culvert	521+50	18	20	70	> 80 %
US-219 (5)	Culvert	574+00	N/A	9	15	> 80 %

[1] Annual Chance Flood Event Equivalent describes the equivalent annual chance flood event for the given bankfull discharge as calculated by the USGS *StreamStats* application. The 80% annual chance flood event is equal to a 1.25-yr recurrence interval.

The structures with bankfull widths that are wider than or close to the structures width indicate that water velocities have to slow and contract in order to pass through the structures, which can cause sediment depositional aggradation and the accumulation of sediment and debris. Aggradation can lead to the development of sediment and sand bars, which can cause upstream water surfaces to rise, increasing the potential for overtopping banks or backwater flooding. Since the bankfull discharge required for water surface elevations to reach the bankfull width is low (e.g., 80% annual chance event), the likelihood of relatively low-flow events causing backwater and potential flooding upstream of these structures is fairly high.

4. CLIMATE CHANGE IMPLICATIONS

4.1 FUTURE PROJECTED STREAM FLOW IN CONNOISARAULEY CREEK

In New York state, climate change is expected to exacerbate flooding due to projected increases of 1 to 8% in total annual precipitation coupled with increases in the frequency, intensity, and duration of extreme precipitation events (events with more than 1, 2, or 4-inches of rainfall) (Rosenzweig, et al., 2011). In response to these projected changes in climate, New York State passed the CRRA in 2014 and provided guidelines for estimating projected future discharges in their 2020 report. In the report, two methods were discussed: an “end of design life multiplier”, and the USGS *FutureFlow Explorer* map-based web application (NYSDEC 2020a).

The “end of design life multiplier” is described as an adjustment to current peak flow values by multiplying relevant peak flow parameters by a factor specific to the expected service life of the structure and geographic location of the project to estimate future peak flow conditions. For Western New York, the recommended design-flow multiplier is 10% for an end of design life of 2025-2100 (NYSDEC 2020a).

The USGS *FutureFlow* software is an extension of the *StreamStats* software where regionally specific peak flow regression equations are used to estimate the magnitude of future floods for any stream or river in New York State (excluding Long Island) and the Lake Champlain basin in Vermont. The *FutureFlow* software substitutes a new climate variable (either precipitation or runoff) to the peak flow regression equations. This climate variable is obtained from five climate models that were reviewed by the World Climate Research Programme’s (WCRP) Working Group Coupled Modelling (WGCM) team during the 5th Phase of the Coupled Model Intercomparison Project (CMIP5). These five climate models were chosen because they best represent past trends in precipitation for the region (Burns et al. 2015).

With the USGS *FutureFlow* software, climate variable data is evaluated under two future scenarios, termed “Representative Concentration Pathways” (RCP) in CMIP5, that provide estimates of the extent to which greenhouse-gas concentrations in the atmosphere are likely to change through the 21st century. RCP refers to potential future emissions trajectories of greenhouse gases, such as carbon dioxide. Two scenarios, RCP 4.5 and RCP 8.5, were evaluated for each climate model in CMIP5. RCP 4.5 is considered a midrange-emissions scenario, and RCP 8.5 is a high-emissions scenario (Taylor et al. 2011).

Results of the climate models and the RCPs are averaged for three future periods, from 2025 to 2049, 2050 to 2074, and 2075 to 2099. The downscaled climate data for each model and the RCP scenario averaged over these 25-yr periods were obtained from the developers of the USGS *Climate Change Viewer* (https://www.fs.usda.gov/ccrc/tools/national-climate-change-viewer) (USGS 2013). The USGS *FutureFlow* software calculates results based on all five climate models for any of the two greenhouse-gas scenarios, and the three time periods. These available results are meant to reflect a range of variations predicted from among the five models, and two greenhouse-gas scenarios. The predictions of future mean annual runoff, obtained from the USGS *FutureFlow* software were used with the USGS regional regression equations and the computed basin characteristics, described in previous sections, to compute the expected future peak flows. The USGS *FutureFlow* software provides five estimates of the mean annual runoff for each RCP and future time period, one corresponding to each of the five climate models used. Future flows were computed for each of the five models corresponding to RCP 8.5 and the 2075 to 2099 time period, and the mean computed from the five results are displayed (Burns et al. 2015). Table 10 is a summary of the USGS *FutureFlow* projected peak discharges at select locations along Connoisarauley Creek.

Table 10. Connoisarauley Creek Projected Peak Discharges

(Source: USGS 2016)						
			Peak Discharges (cfs)			
Flooding Source and Location	**Drainage Area (mi^2)**	**River Station (ft)**	**10-Percent**	**2-Percent**	**1-Percent**	**0.2-Percent**
Confluence with Cattaraugus Creek	21.8	0+00	3,270	5,130	6,000	8,280
Upstream of Confluence with Nigh Creek	18.9	70+00	2,860	4,480	5,230	7,210
Upstream of Confluence with Stony Brook	12.9	145+00	2,050	3,210	3,750	5,160
Towns of East Otto and Ashford corporate limits	7.4	307+50	1,250	1,950	2,270	3,120
Towns of Ashford and Ellicottville corporate limits	1.6	523+00	360	570	660	910

Appendix H contains the HEC-RAS simulation summary sheets for the proposed and future condition simulations. The HEC-RAS model simulation results for the future condition model parameters using the future projected discharge values are similar to the base-condition model output, with the only difference being future projected water surface elevations are up to 0.5-ft higher at specific locations, generally upstream of bridges due to backwater, as a result of the increased discharges.

Table 11 provides a comparison of HEC-RAS base condition, using USGS *StreamStats*, and future condition, using USGS *FutureFlow*, water surface elevations at select locations along Connoisarauley Creek.

Table 11. HEC-RAS Base and Future Conditions Water Surface Elevation Comparison

(Source: USGS 2016; USGS 2019b)						
			Water Surface Elevations (ft NAVD88) [1]			
Flooding Source and Location	**Drainage Area (Sq. Mi)**	**River Station (ft)**	**10-Percent**	**2-Percent**	**1-Percent**	**0.2-Percent**
Confluence with Cattaraugus Creek	21.8	0+00	+ 0.1	+ 0.1	+ 0.1	0.0
Upstream of Confluence with Nigh Creek	18.9	70+00	+ 0.2	+ 0.2	+ 0.1	+ 0.2
Upstream of Confluence with Stony Brook	12.9	145+00	+ 0.2	+ 0.3	+ 0.2	+ 0.3
Towns of East Otto and Ashford corporate limits	7.4	307+50	+ 0.2	+ 0.4	+ 0.4	+ 0.4
Towns of Ashford and Ellicottville corporate limits	1.6	523+00	N/A [2]	N/A [2]	N/A [2]	N/A [2]

[1] Positive changes in water surface elevation indicate the future conditions water surface elevation is higher than the base condition.

[2] No water surface elevation data is available since this reach is outside of the H&H model boundary.

Table 12 provides a comparison of the current 1% annual change peak stream flows calculated using the USGS *StreamStats* software and the mean predicted future discharge calculated using the USGS *FutureFlow* at select locations along Connoisarauley Creek.

Table 12. Comparison of 1% Annual Chance Current and Future Discharges

(Source: USGS 2016; USGS 2019b)					
Location	**Drainage Area (Sq. Mi)**	**River Station (ft)**	**Current *StreamStats* Discharge (cfs)**	**Predicted Future Discharge (cfs)**	**Percent Change (%)**
Confluence with Cattaraugus Creek	21.8	0+00	5,740	6,000	4.5
Upstream Confluence with Nigh Creek	18.9	70+00	5,010	5,230	4.4
Upstream Confluence with Stony Brook	12.9	145+00	3,560	3,750	5.3
Towns of East Otto and Ashford corporate limits	7.4	307+50	2,150	2,270	5.6
Towns of Ashford and Ellicottville corporate limits	1.6	523+00	620	660	6.5

5. FLOODING CHARACTERISTICS

5.1 FLOODING HISTORY

According to the National Centers for Environmental Information (NCEI) storm events database, there have been no documented incidents of flooding or flood loses within the Connoisarauley Creek watershed. During the stakeholder engagement meeting, local officials with historical knowledge of the watershed indicated the primary driver of flood risk within the watershed was unstable channels and banks from sediment and erosion issues and landslides (NCEI 2021; Ramboll 2021).

Landslides, which are defined as the movement of a mass of rock, debris, or earth down a slope, are differentiated by the kinds of material involved and the mode of movement. Although landslides are primarily associated with mountainous regions, they also occur in areas of generally low relief and steep river valleys. Landslides are caused by a number of different events, categorized into three main causes: geological, including materials that are weak, sensitive, weathered, sheared, jointed, or fissured; morphological, including tectonic or volcanic uplift, glacial rebound, fluvial, wave, or glacial erosion, or freeze-and-thaw weathering; and anthropogenic, including deforestation, irrigation, mining, or drawdown of groundwater aquifers (USGS 2004).

Landsliding and flooding are closely allied because both are related to precipitation, runoff, and the saturation of ground by water. Slope saturation by water is a primary cause of landslides. This effect can occur in the form of intense rainfall, snowmelt, changes in ground-water levels, and water-level changes along coastlines, earth dams, and the banks of lakes, reservoirs, canals, and rivers. In addition, debris flows and mudflows usually occur in small, steep stream channels and often are mistaken for floods; as such, these two events often occur simultaneously in the same area (USGS 2004).

Landslides can cause flooding by forming landslide dams that block valleys and stream channels, allowing large amounts of water to back up. This causes backwater flooding and, if the landslide dam fails, subsequent downstream flooding. Also, solid landslide debris can “bulk” or add volume and density to otherwise normal streamflow or cause channel blockages and diversions creating flood conditions or localized erosion. Landslides can also cause overtopping of reservoirs and / or reduced capacity of reservoirs to stored water (USGS 2004).

According to local officials who participated in the stakeholder engagement meeting for Connoisarauley Creek, bank erosion and landslides have occurred along the US-219 corridor from Springville Road (CR-12) south to Ashford Hollow Road in the Town of Ashford (Ramboll 2021). In addition, the areas around Connoisarauley and Hammond Hill Roads in both the Towns of East Otto and Ashford were identified as erosion and landslide risks in the Cattaraugus County Hazard Mitigation Plan (Tetra Tech 2020).

FEMA FIRMs are available for Connoisarauley Creek in the Towns of East Otto and Ashford from FEMA. Figures 5-1 and 5-2 display the 1% annual chance flood event (Zone A) boundaries as determined by FEMA for the Towns of East Otto and Ashford, respectively (FEMA 1996).

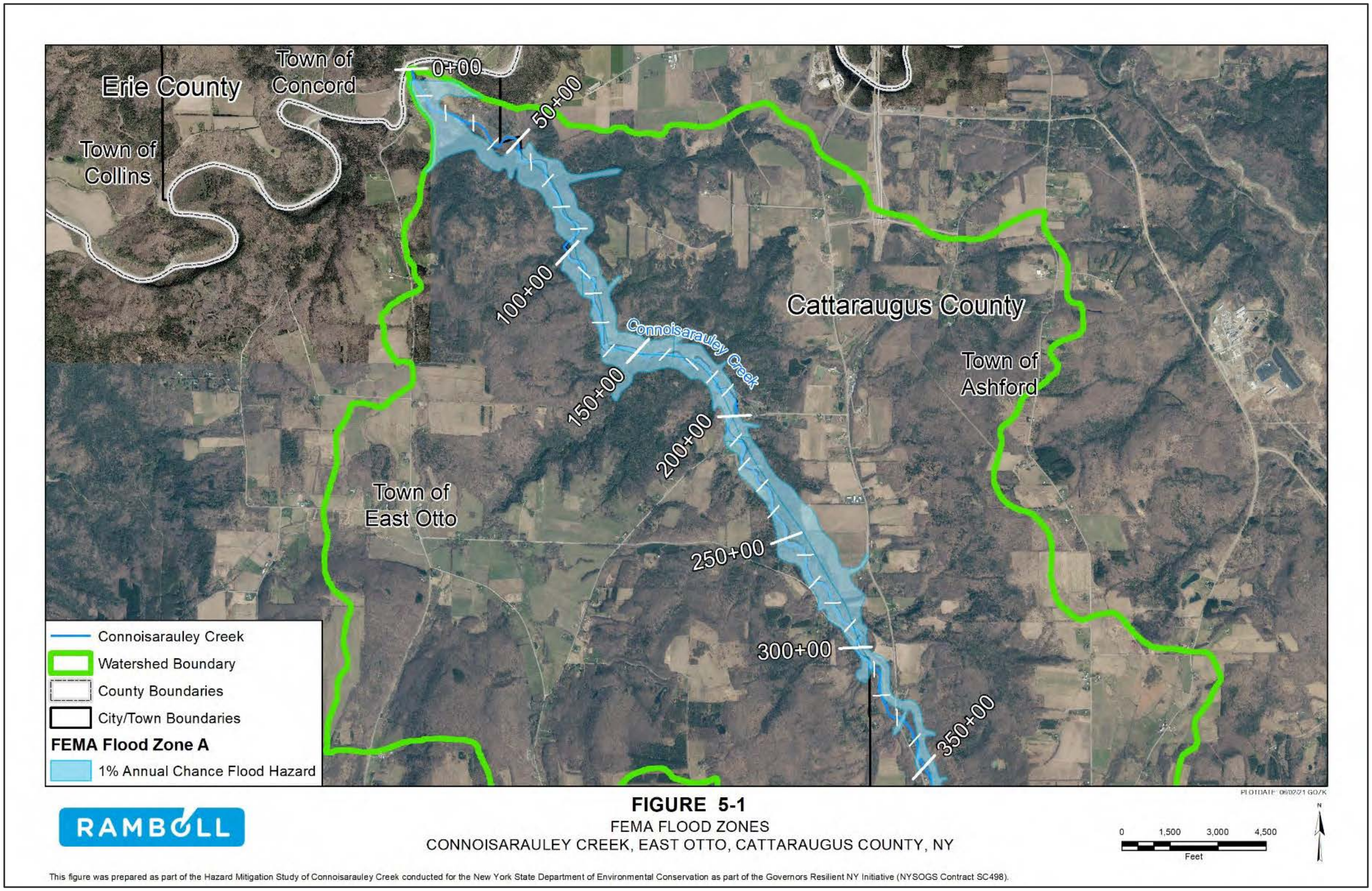

Figure 5-1. Connoisarauley Creek, FEMA flood zones, Town of East Otto, Cattaraugus County, NY.

*Note: This map was created using FIRMs georeferenced to the earth's surface. This figure is not official and may not be used for regulatory purposes.

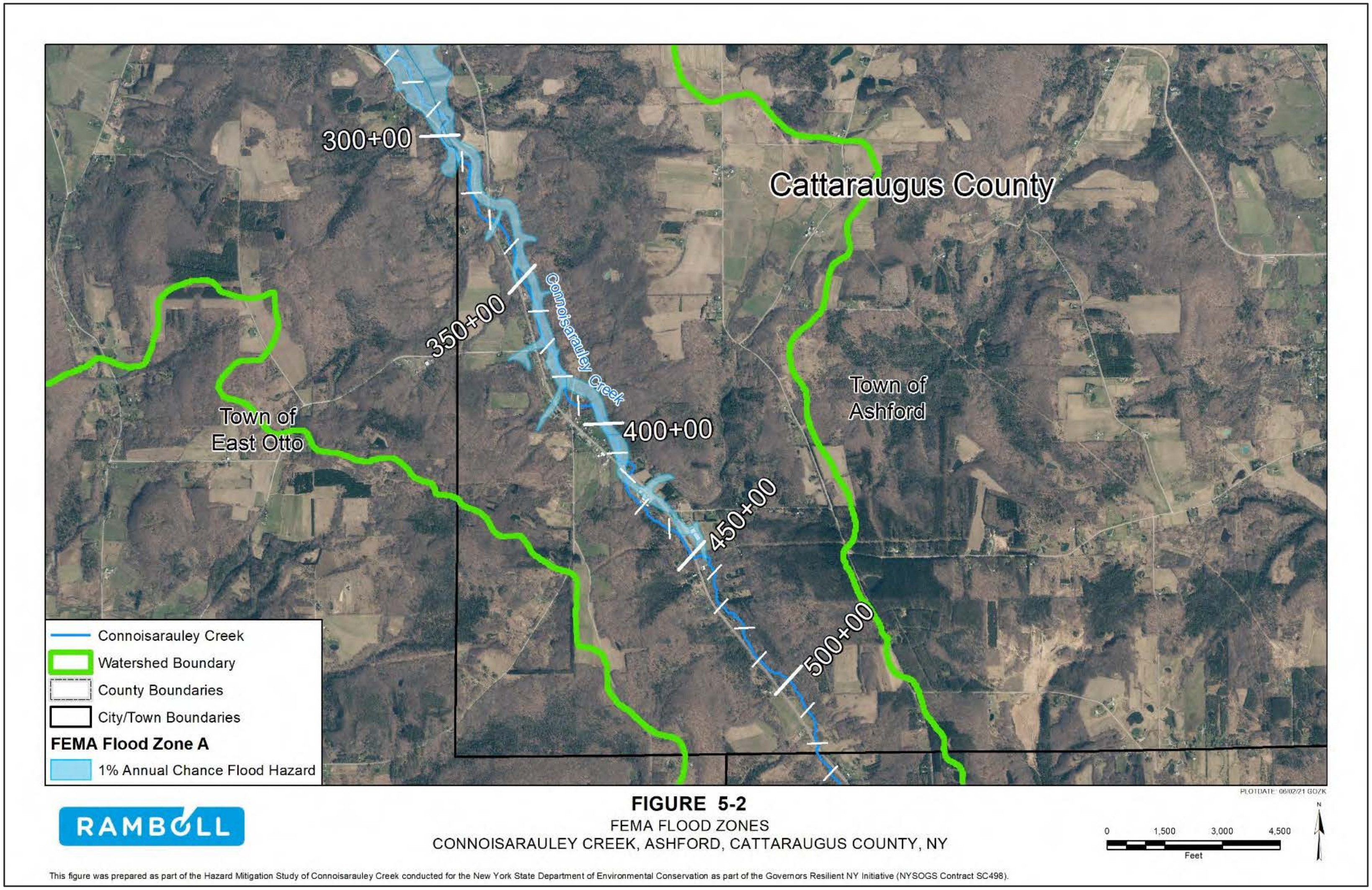

Figure 5-2. Connoisarauley Creek, FEMA flood zones, Town of Ashford, Cattaraugus County, NY.

*Note: This map was created using FIRMs georeferenced to the earth's surface. This figure is not official and may not be used for regulatory purposes.

6. FLOOD RISK ASSESSMENT

6.1 FLOOD MITIGATION ANALYSIS

For this study of Connoisarauley Creek, standard hydrologic and hydraulic study methods were used to determine and evaluate flood hazard data. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10, 50, 100, or 500-yr period (recurrence interval), have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10, 50, 100, and 500-yr floods, have a 10, 2, 1, and 0.2% chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. The analyses reported herein reflect flooding potentials based on conditions existing in the county at the time of completion of this study (FIA 1980).

Hydraulic analysis of Connoisarauley Creek was conducted using the HEC-RAS v5.0.7 program (USACE 2019b). The HEC-RAS computer program was written by the USACE Hydrologic Engineering Center (HEC) and is considered to be the industry standard for riverine flood analysis. The model is used to compute water surface profiles for 1 and 2-Dimensional (2-D), steady-state, or time-varied (unsteady) flow. In 1-Dimensional (1-D) solutions, the water surface profiles are computed from one cross section to the next by solving the one-dimensional St. Venant equation with an iterative procedure (i.e., standard step backwater method). Energy losses are evaluated by friction (Manning's Equation) and the contraction / expansion of flow through the channel. The momentum equation is used in situations where the water surface profile is rapidly varied, such as hydraulic jumps, mixed-flow regime calculations, hydraulics of dams and bridges, and evaluating profiles at a river confluence (USACE 2016a).

Hydraulic and Hydrologic modeling of Connoisarauley Creek in the Towns of East Otto and Ashford was completed to produce the effective FIRMs for both municipalities in 1984; however, no published FIS is available from FEMA so the H&H methodology used by FEMA is unknown. Due to the age and uncertainty of the H&H modeling for the effective FIRMs, an updated 1-D HEC-RAS model was developed using the following data and software:

- Cattaraugus County, NY 1-meter LiDAR DEM data with a vertical accuracy of 0.7-ft (NYSOITS 2017b)
- New York State Digital Ortho-imagery Program imagery for Cattaraugus County (NYSOITS 2017a)
- National Land Cover Database (NLCD) data (USGS 2019a)
- USGS *StreamStats* peak discharge data (USGS 2019b)
- RAS Mapper extension in HEC-RAS software
- ESRI ArcMap 10.7 with the HEC-GeoRAS extension GIS software (ESRI 2019)

The hydraulics model was developed for Connoisarauley Creek beginning at the confluence with Cattaraugus Creek (river station 0+00) and extending upstream to the Ashford Corporate Complex in the Town of Ashford (river station 485+00).

6.1.1 Methodology of HEC-RAS Model Development

Using the LiDAR DEM data, orthoimagery, land cover data, and the RAS Mapper extension in the HEC-RAS software, a base condition model was developed using the following methodology:

- Main channel, bank lines, flow paths, and cross-sections, which were drawn along the main channel at stream meanders, contraction / expansion points, and at structures, were digitized in RAS Mapper
- These features were then exported to the ESRI ArcMap 10.7 GIS software
- Using the HEC-GeoRAS extension in ArcMap, LiDAR DEM and NLCD land cover data were obtained and used to develop updated terrain profiles for overbank areas, stream centerline and cross-section downstream reach lengths for the channel and left and right overbanks, flow paths and Manning's n values for land use were assigned
- The stream centerline, cross-sections, bank lines, flow paths, and land use data were then imported back into HEC-RAS where a 1-D steady flow simulation was performed using the effective FEMA FIS peak discharges

Downstream boundary conditions for the base and future conditions models were based on the slope of the downstream reach, also referred to as Normal Depth, due to the lack of existing water surface elevation data for Connoisarauley and / or Cattaraugus Creeks.

The base condition model water surface elevation results were then compared to the FEMA FIRM water surface profiles and past flood events with known water surface elevations to validate the model.

After the base condition model was verified, it was then used to develop proposed condition models to simulate potential flood mitigation strategies. The simulation results of the proposed conditions were evaluated based on their reduction in water surface elevations.

As the potential flood mitigation strategies are, at this point, preliminary, inundation mapping was not developed from the computed water surface profiles for each potential mitigation alternative. Inundation shown on figures within this report reflects that of the effective FEMA FIRMs for the Towns of East Otto and Ashford.

The effectiveness of each potential mitigation strategy was evaluated based on reduction in water surface elevations within the H&H model simulations. The flood mitigation strategies that were modeled were:

- #1-1: Flood Bench Near Confluence with Cattaraugus Creek
- #1-2: Levee Upstream Confluence with Cattaraugus Creek
- #1-3: Increase Size of Hammond Hill Road Bridge Opening
- #2-1: Flood Benches Upstream US-219 (1)

- #3-2: Flood Bench Upstream of the Montagues Dam
- #3-3: Increase Size of US-219 (2) Bridge Opening
- #3-4: Flood Benches Upstream US-219 (2)
- #3-5: Increase Size of US-219 (3) Culvert Opening

The remaining alternatives were either qualitative in nature or required additional advanced 3-D modeling outside of the scope of this study.

Note that stationing references for Connoisarauley Creek for Sections 1 through 6 of this report are based on the USGS National Hydrography Dataset (NHD) for Connoisarauley Creek (USGS 2020); however, stationing references for the flood mitigation measures (Section 7) are based on the HEC-RAS model software. While every attempt was made to ensure consistency in the stationing values, the values may differ as a result of the differences in the data sources and methodologies.

6.2 COST ESTIMATE ANALYSIS

Rough order of magnitude (ROM) cost estimates were prepared for each mitigation alternative. In order to reflect current construction market conditions, a semi-analogous cost estimating procedure was used by considering costs of a recently completed, similar scope construction project performed in Upstate New York. Phase I of the Sauquoit Creek Channel and Floodplain Restoration Project in Whitestown, New York contained many elements similar to those found in the proposed mitigation alternatives.

Where recent construction cost data was not readily available, RSMeans CostWorks 2019 was used to determine accurate and timely information (RSMeans Data Online 2019). Costs were adjusted for inflation and verified against current market conditions and trends.

For mitigation alternatives where increases in bridge sizes were evaluated, bridge size increases were initially analyzed based on 2-ft freeboard over the base flood elevation for a 1% annual chance flood event. For mitigation alternatives where increases in culvert sizes were evaluated, culvert size increases were initially analyzed based on the NYSDOT highway drainage standards of successfully passing the 2% annual chance flood hazard.

Once the optimal bridge / culvert size was determined, further analyses were completed, including site constraints and constructability. Due to these additional constraints, for some mitigation measures the size necessary to meet existing and / or CRRA freeboard requirements were not feasible. Cost estimates were only performed for projects determined to be constructible and practical.

Infrastructure and hydrologic modifications will require permits and applications to NYS and / or FEMA, including construction and environmental permits from the State and accreditation, Letter of Map Revision (LOMR), etc. applications to FEMA. Application and permit costs were not incorporated in the ROM costs estimates.

6.3 ICE-JAM ANALYSIS

According to the USACE Cold Regions Research and Engineering Laboratory (CRREL) ice-jam database, NCEI storm events database, and the stakeholder engagement meeting, there have been no reported or observed ice-jam events on Connoisarauley Creek; however, ice jams on Cattaraugus Creek have historically caused backwater flooding at the confluence with Connoisarauley Creek flooding out properties in the area (NYSDEC 2020b; CRREL 2021; NCEI 2021).

Based on the available data, ice-jam flooding was determined not to be a driving factor of flood risk in the Towns of East Otto and Ashford. Instead, restrictive infrastructure, sediment / debris, and landslides were identified to be the primary drivers of flood risk within the watershed.

6.4 HIGH-RISK AREAS

Based on the FEMA FIRMs, NCEI storm events database, historical flood reports, and stakeholder input from engagement meetings, three areas along Connoisarauley Creek were identified as high-risk flood areas in the Towns of East Otto and Ashford.

6.4.1 High-Risk Area #1: Confluence with Cattaraugus Creek, Town of East Otto, Cattaraugus County, NY

High-risk area #1 encompasses the area in the vicinity of the confluence with Cattaraugus Creek, locally referred to as the Zoar Valley (Figure 6-1). This area has been identified as being susceptible to backwater flooding from Cattaraugus Creek during ice-jam events and landslides. In addition, the Hammond Hill Road bridge immediately upstream of the confluence is a potential constriction point due to the fact that the bridge opening width is smaller than the bankfull width.

According to the FEMA FIRM for the Town of East Otto, the area from the confluence of Connoisarauley and Cattaraugus Creeks and approximately 3,000-ft upstream is at flood risk from a 1% annual chance event (Figure 6-2). This area contains multiple residential and commercial properties and the County owned Hammond Hill Road bridge (FEMA 1984b).

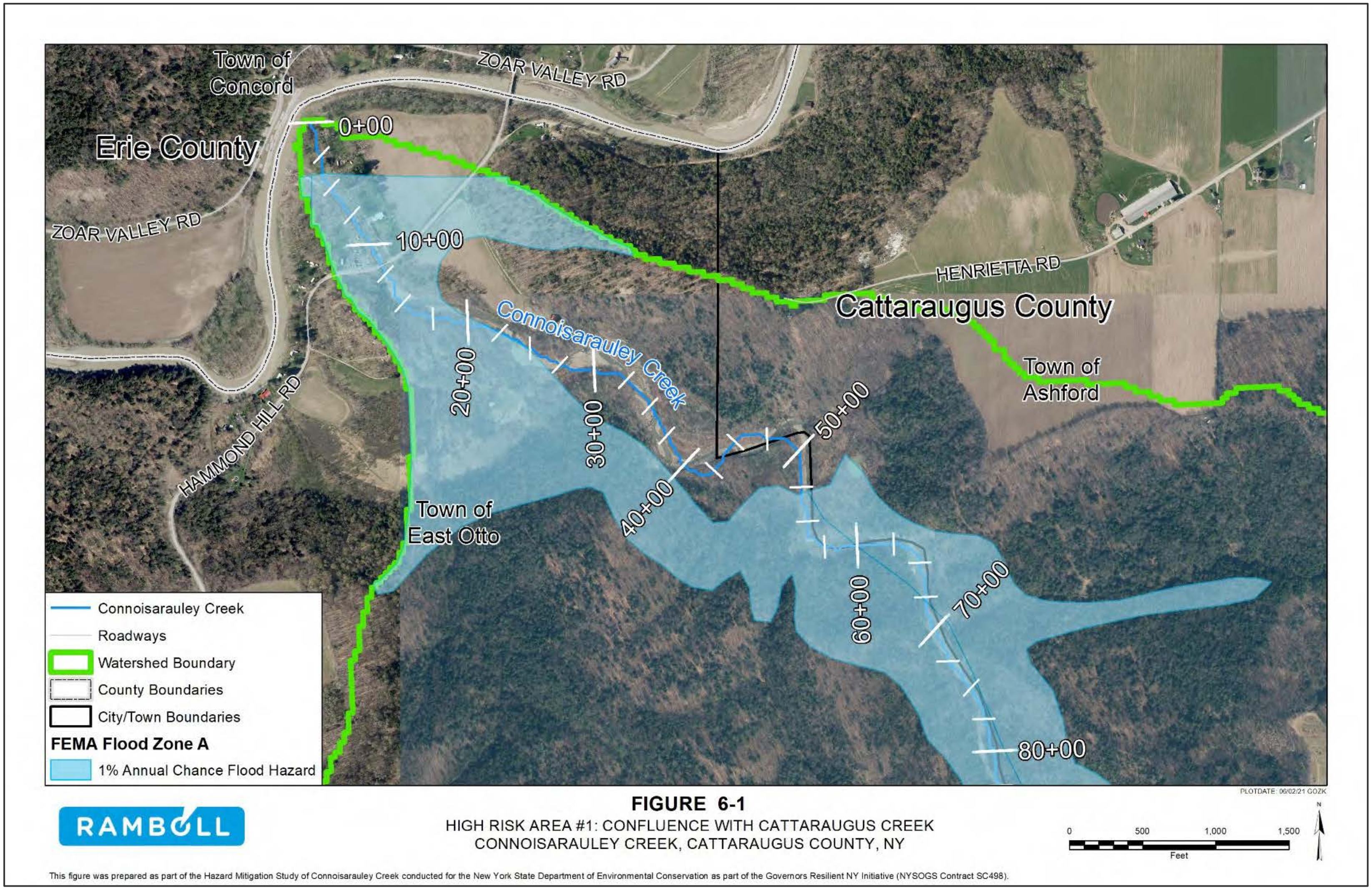

Figure 6-1. High-risk Area #1: Confluence with Cattaraugus Creek, East Otto, Cattaraugus County, NY.

*Note: This map was created using FIRMs georeferenced to the earth's surface. This figure is not official and may not be used for regulatory purposes.

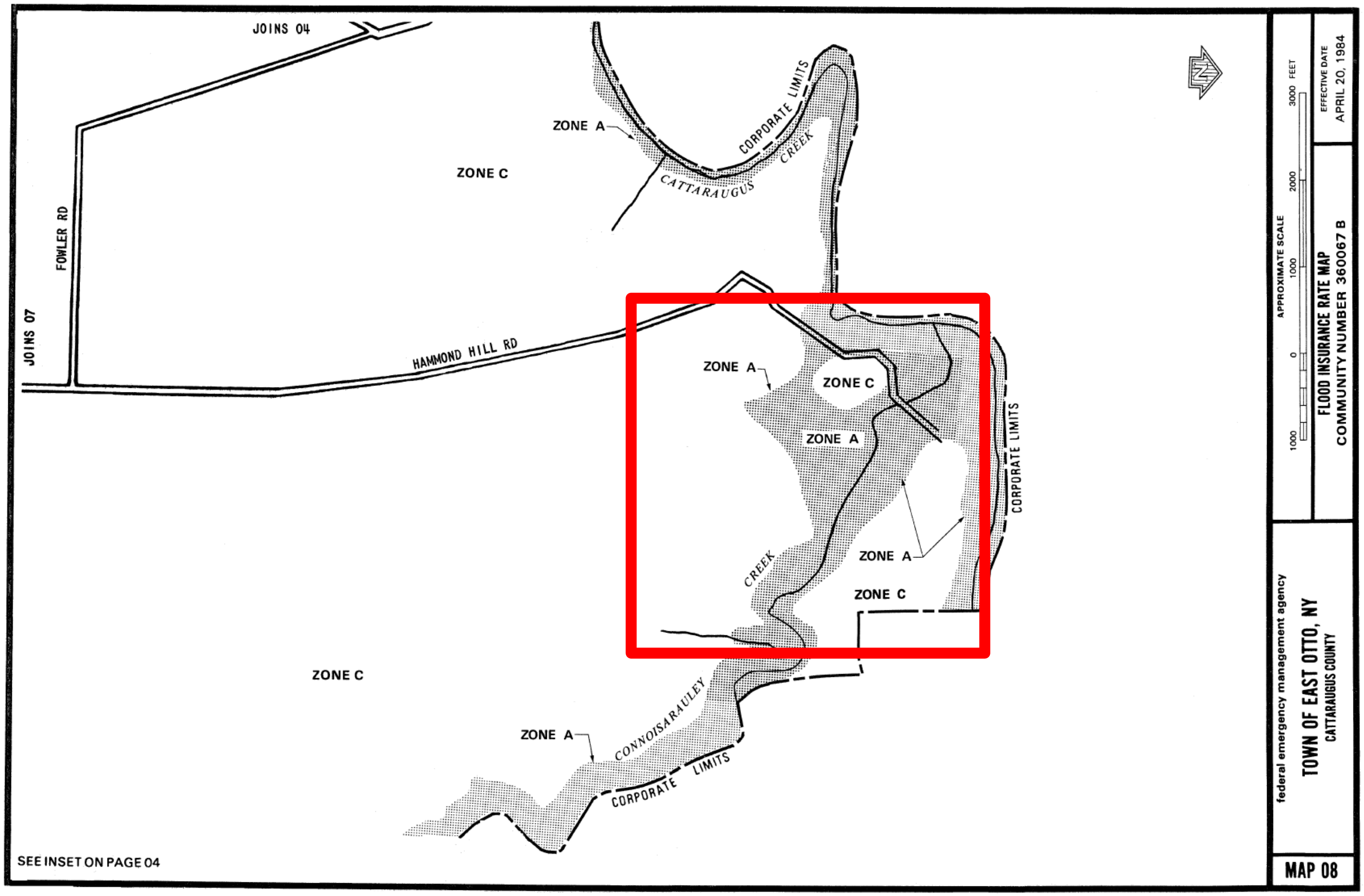

Figure 6-2. FEMA FIRM for High-risk Area #1, East Otto, Cattaraugus County, NY.

6.4.2 High-Risk Area #2: US-219 Corridor Between County Road 12 and Snake Run Road, Town of Ashford, Cattaraugus County, NY

High-risk Area #2 encompasses the US-219 corridor that runs adjacent to Connoisarauley Creek between East Otto Road (CR-12) and Snake Run Road in the Town of Ashford (Figure 6-3). This area has been identified as being susceptible to landslides, sediment aggradation, and bank erosion. In addition, the East Otto Road / CR-12 bridge is a potential constriction point due to the fact that the bridge opening width is smaller than the bankfull width.

According to the FEMA FIRM for the Town of Ashford, the areas adjacent to Connoisarauley Creek in this reach are at flood risk from a 1% annual chance event (Figure 6-4). This area contains multiple residential and commercial properties and public infrastructure, including SRB Auto Repair and Collision, the County owned East Otto Road / CR-12, and one state owned US-219 bridge (FEMA 1984a).

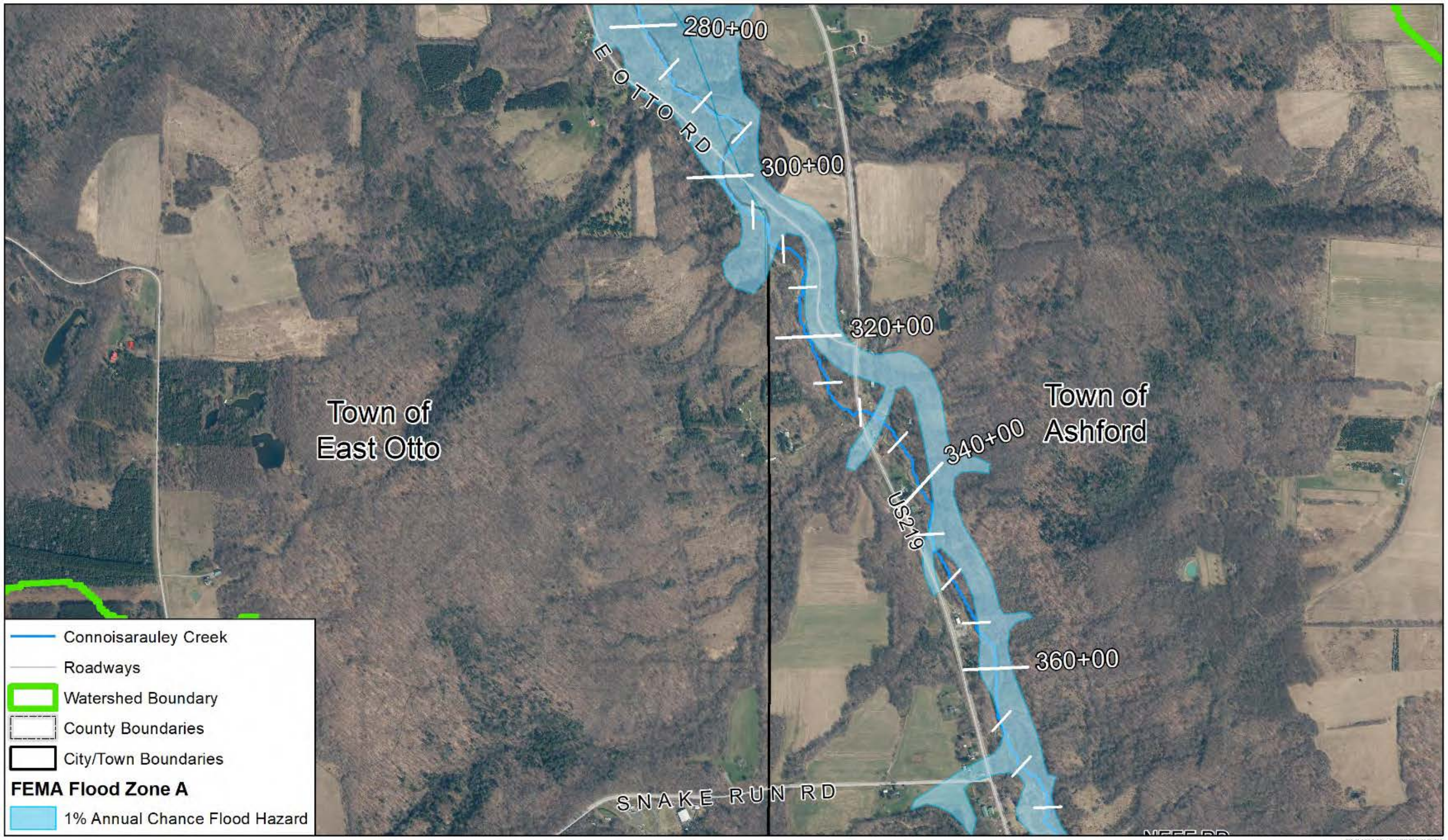

FIGURE 6-3

HIGH RISK AREA #2: US-219 CORRIDOR BETWEEN COUNTY ROAD 12 AND SNAKE RUN ROAD
CONNOISARAULEY CREEK, CATTARAUGUS COUNTY, NY

0 500 1,000 1,500 Feet

This figure was prepared as part of the Hazard Mitigation Study of Connoisarauley Creek conducted for the New York State Department of Environmental Conservation as part of the Governors Resilient NY Initiative (NYSOGS Contract SC498).

Figure 6-3. High-risk Area #2: US-219 corridor between County Road 12 and Snake Run Road, Ashford, Cattaraugus County, NY.

*Note: This map was created using FIRMs georeferenced to the earth's surface. This figure is not official and may not be used for regulatory purposes.

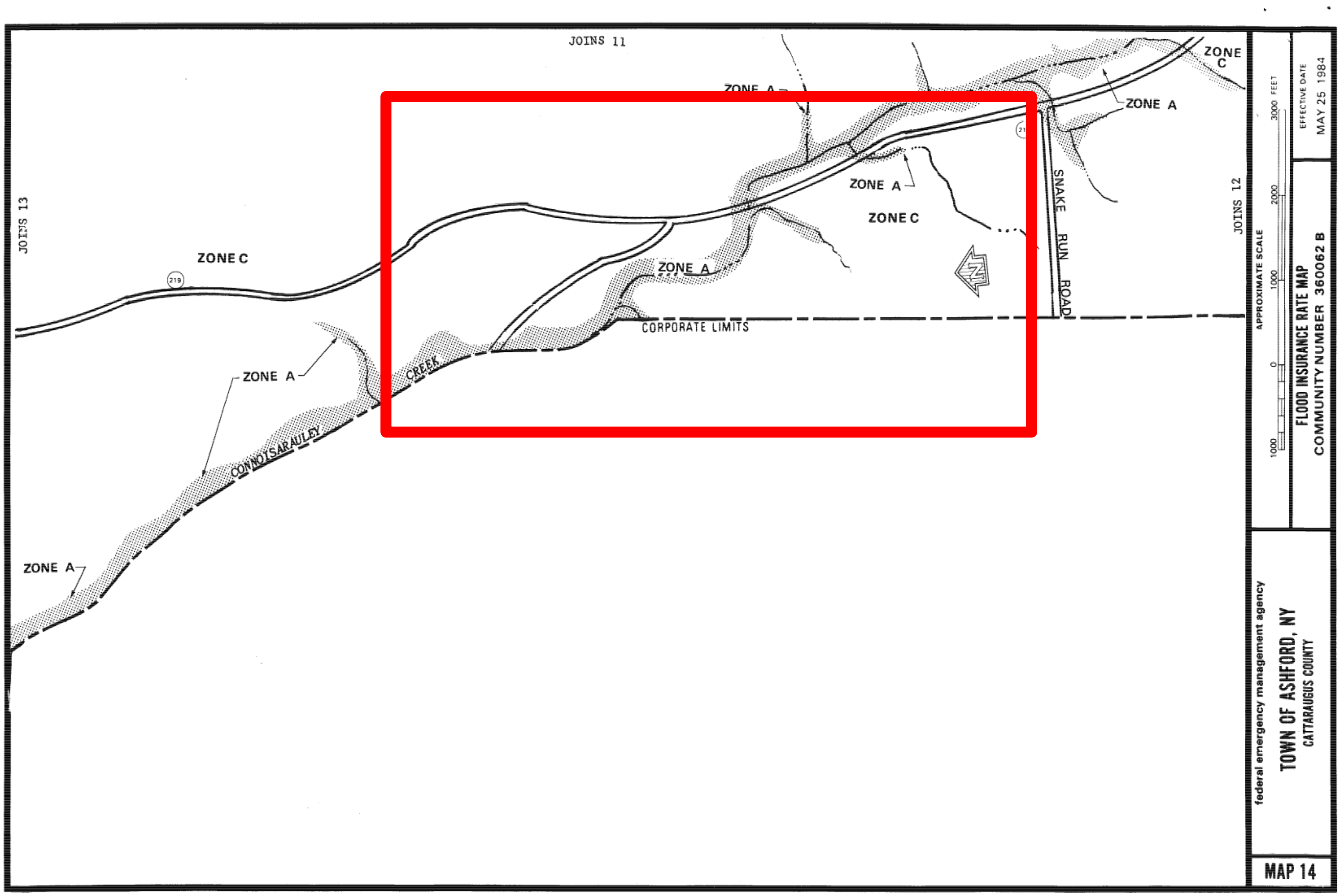

Figure 6-4. FEMA FIRM for High-risk Area #2, Ashford, Cattaraugus County, NY.

6.4.3 High-Risk Area #3: US-219 Corridor Between Neff Road and Ashford Hollow Road, Town of Ashford, Cattaraugus County, NY

High-risk Area #3 encompasses the US-219 corridor that runs adjacent to Connoisarauley Creek between Neff Road and Ashford Hollow Road in the Town of Ashford (Figure 6-5). This area has been identified as being susceptible to landslides, sediment aggradation, and bank erosion. In addition, the Neff Road and US-219 (2) bridges are potential constriction points due to the fact that the bridge opening width is very close to (Neff Rd) or smaller than (US-219) the bankfull width.

According to the FEMA FIRM for the Town of Ashford, the areas adjacent to Connoisarauley Creek in this reach are at flood risk from a 1% annual chance event (Figure 6-6). This area contains multiple residential and commercial properties and public infrastructure, including the Ashford Corporate Park, Town owned Neff Road, and two State owned US-219 bridges (FEMA 1984a).

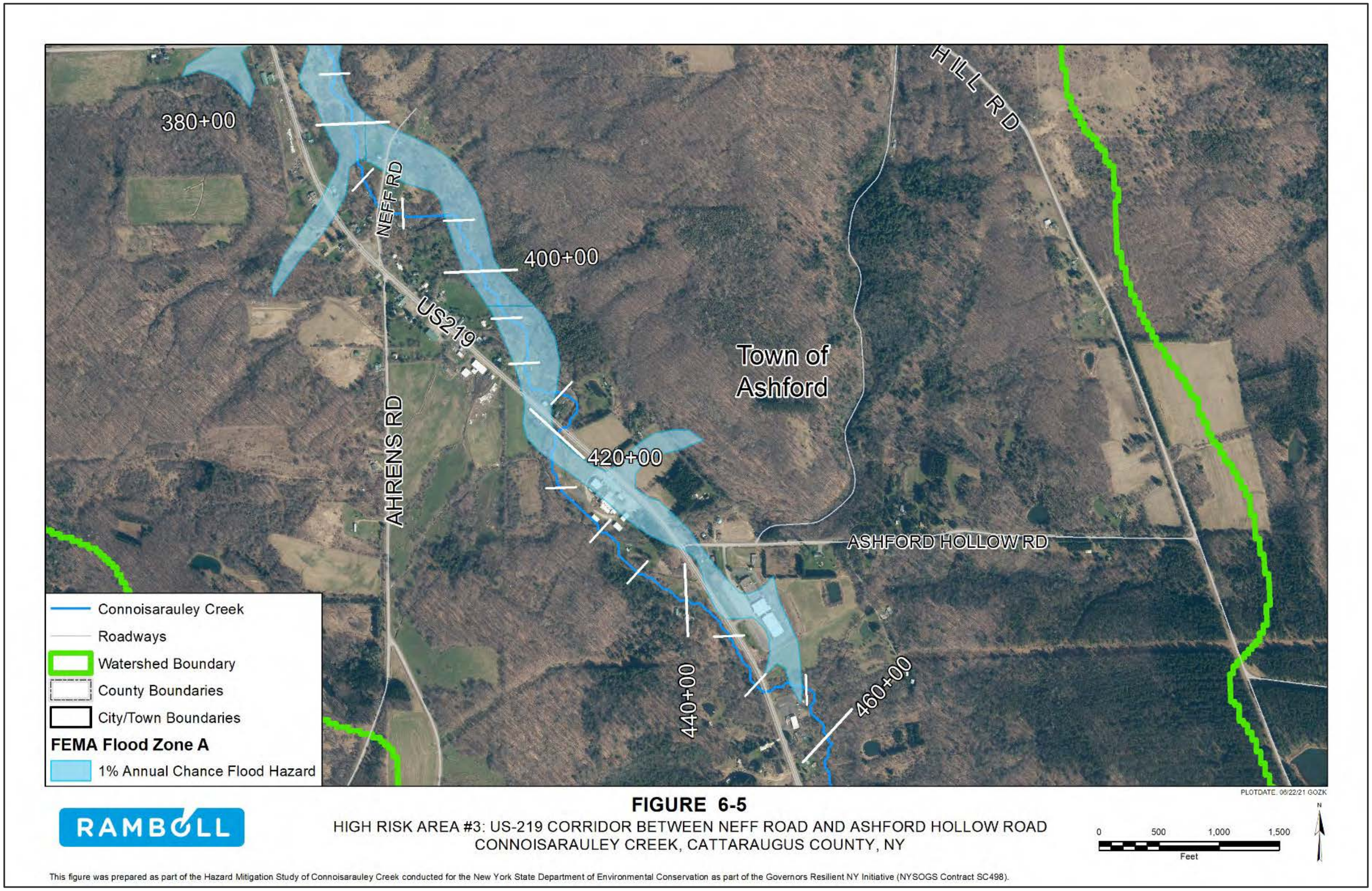

Figure 6-5. High-risk Area #3: US-219 corridor between Neff Road and Ashford Hollow Road, Ashford, Cattaraugus County, NY.

*Note: This map was created using FIRMs georeferenced to the earth's surface. This figure is not official and may not be used for regulatory purposes.

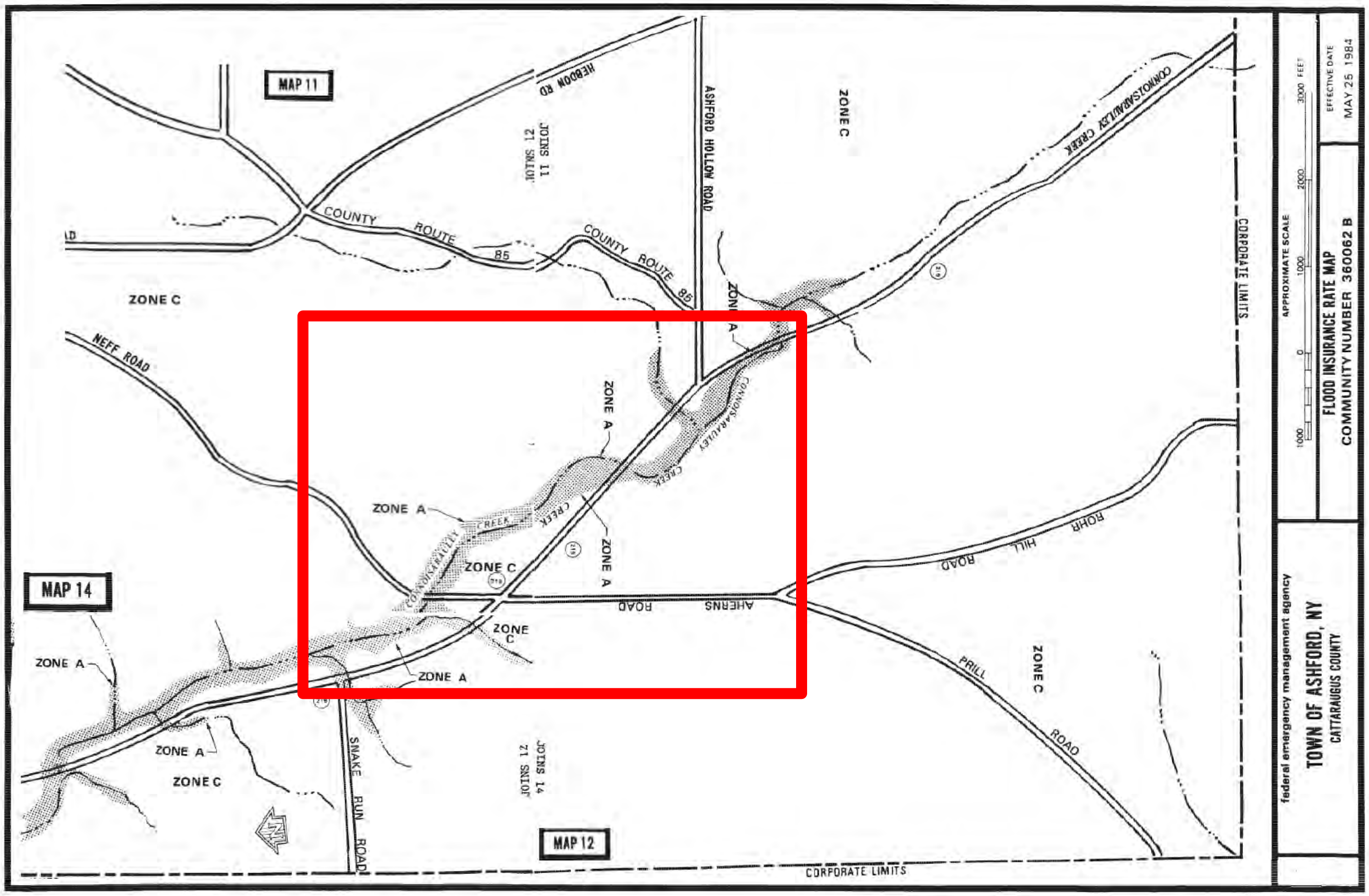

Figure 6-6. FEMA FIRM for High-risk Area #3, Ashford, Cattaraugus County, NY.

7. RISK AREA MITIGATION ALTERNATIVES

The following are flood mitigation alternatives that have the potential to reduce water surface elevations along high-risk areas of Connoisarauley Creek. These alternatives could potentially reduce flood-related damages in areas adjacent to the creek. The Towns of East Otto and Ashford, Cattaraugus County, and associated state agencies should evaluate each alternative and consider the potential effects to the community, and the level of community buy-in for each before pursuing them further.

7.1 HIGH-RISK AREA #1

7.1.1 Alternative #1-1: Flood Bench Near Confluence with Cattaraugus Creek

Installing a flood bench would provide additional storage and floodplain width over and above the current storage and width provided by the adjacent agricultural and undeveloped lands, which could potentially reduce damages in the event of flooding and address issues within High-risk Area #1. This area contains one commercial and several residential properties that are within the Zone A flood zone.

A flood bench on the left bank of Connoisarauley Creek was modeled between the confluence with Cattaraugus Creek and the Hammond Hill Road bridge crossing. The flood bench was approximately two acres and was located between river stations 2+00 and 7+00 (Figure 7-1). The flood bench designs used for the proposed condition model simulation set the minimum bench elevation approximately equal to the bankfull elevation, which was an average depth of 2.5 ft.

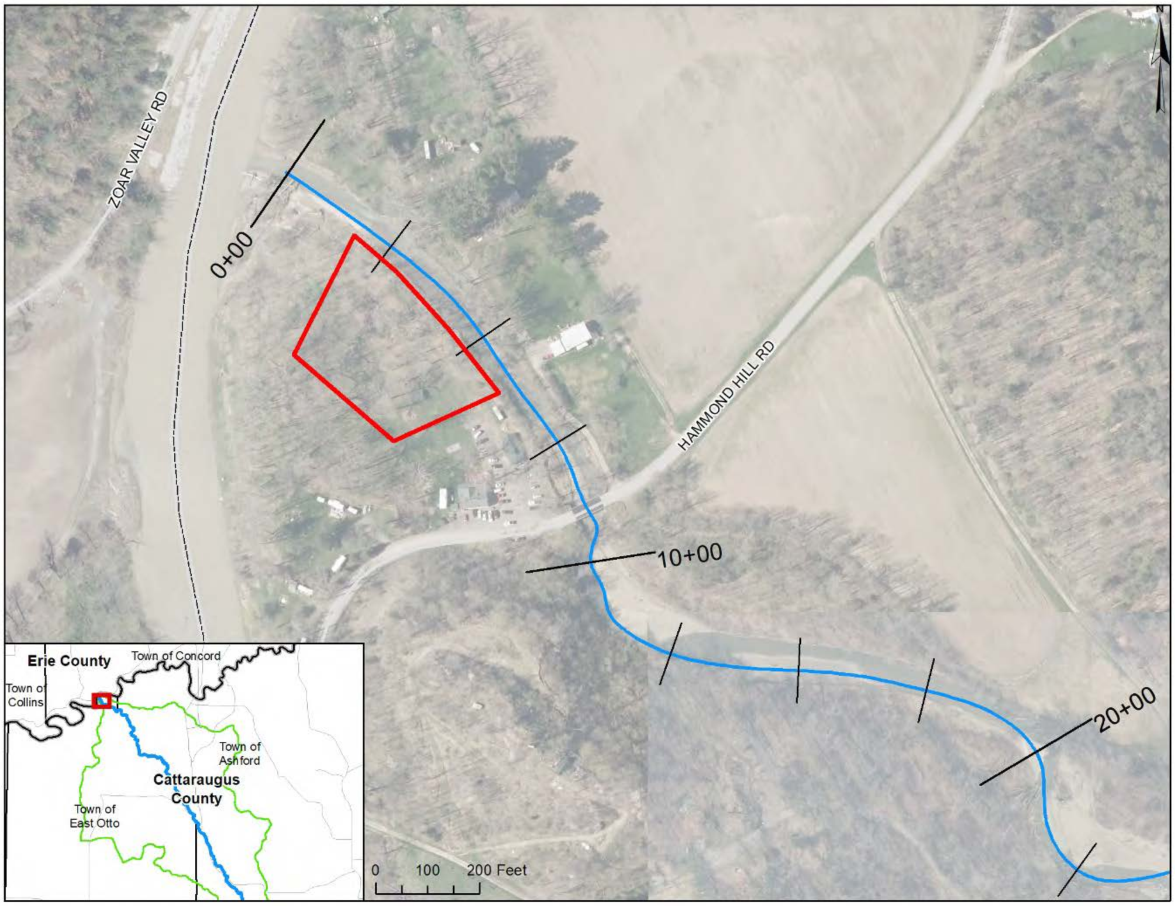

Figure 7-1. Location map for Alternative #1-1.

The flood bench is within the FEMA designated SFHA or Zone A, which is an area subject to inundation by the 1% annual chance flood event, but where base flood elevations and flood hazard factors were not determined, and where mandatory flood insurance purchase requirements and floodplain management standards apply (FIA 1980; FEMA 1982). Appendix E depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

The proposed condition model results indicated that a flood bench downstream of the Hammond Hill Road bridge reduced water surface depths by up to 1.5 ft in areas immediately in the vicinity of the flood bench and downstream of the bridge, specifically along river stations 3+00 to 9+00 (Figure 7-2). The modeling output for future conditions displayed similar results with water surface reductions of up to 1.6 ft (Appendix G).

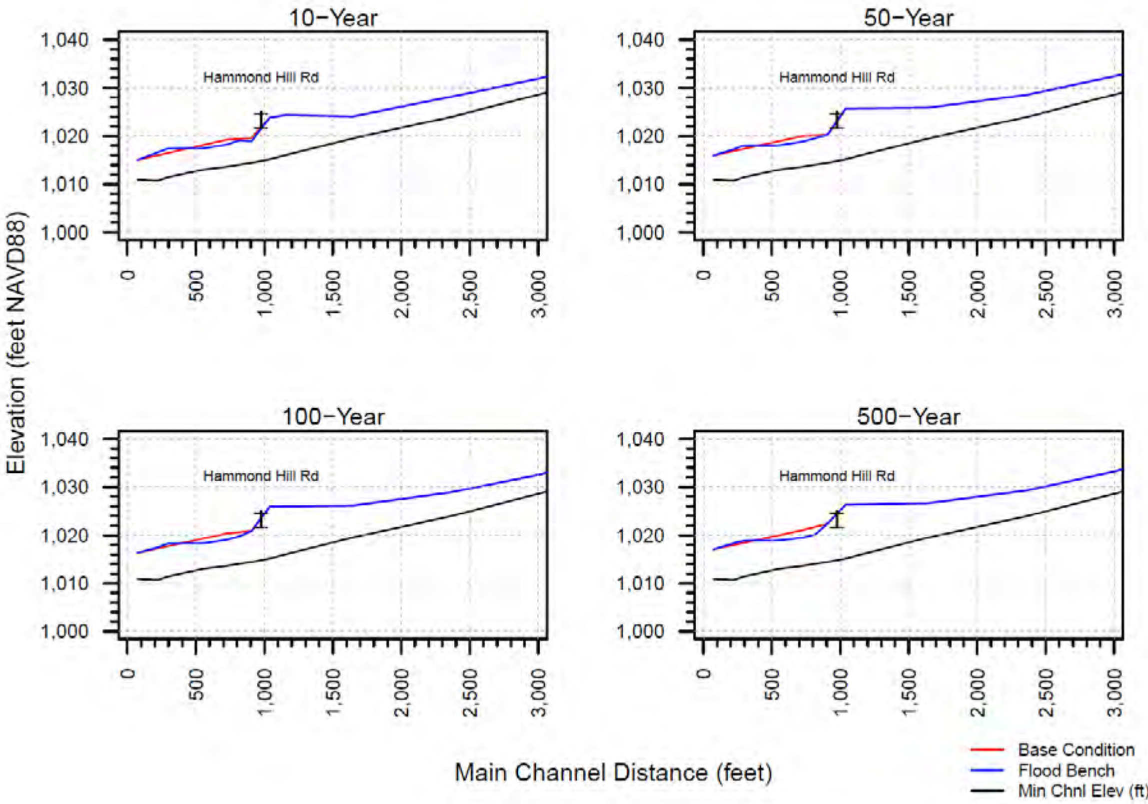

Figure 7-2. HEC-RAS model simulation output results for Alternative #1-1.

Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and / or downstream of the bench. Based on the analysis of high-risk areas, a flood bench located downstream of the Hammond Hill Road bridge crossing would provide significant flood protection in this reach from open-water flooding to adjacent areas. In addition, although not identified as a flood risk in this area, a flood bench would also provided additional storage for any ice floes that occurred on Connoisarauley Creek at the confluence with Cattaraugus Creek.

To evaluate the effectiveness of the flood mitigation impacts, the project team analyzed this alternative independently of other alternatives. However, there is the potential for added benefits (i.e., reduction in WSELs, less flooding, reduced erosion, etc.) when multiple flood mitigation projects are built in conjunction. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

The Rough Order Magnitude cost for this strategy is $680,000 which does not include land acquisition costs for survey, appraisal, and engineering coordination.

7.1.2 Alternative #1-2: Levee Upstream of Confluence with Cattaraugus Creek

This strategy is intended to restrict high-flow events from overtopping channel banks and flooding homes, properties, etc. in High-risk Area #1 by constructing a permanent levee along the left bank of Connoisarauley Creek. The levee would be approximately 1,000-ft long with a height of two feet above the future flood flow stage for the projected 1% annual chance flood elevation (1018.5 - 1028 ft NAVD 88), and located along river stations 0+50 to 11+00 (Figure 7-3). Appendix E depicts a flood mitigation rendering of a constructed levee.

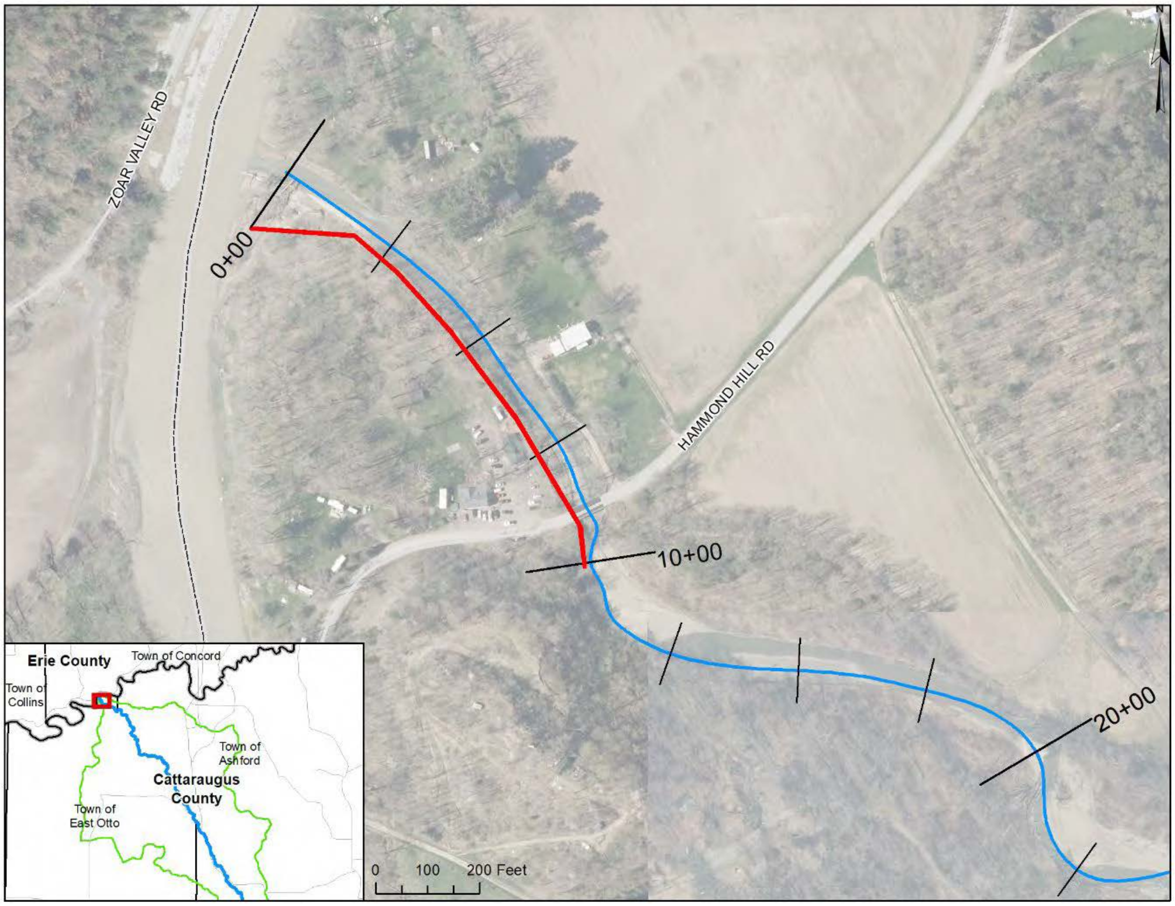

Figure 7-3. Location map for Alternative #1-2.

The proposed and future hydraulic modeling confirmed that constructing a levee along Connoisarauley Creek in the reach upstream of the confluence with Cattaraugus Creek would decrease the flood risk of adjacent areas, while leaving the flood potential of downstream and opposite bank areas unaffected (Figure 7-4).

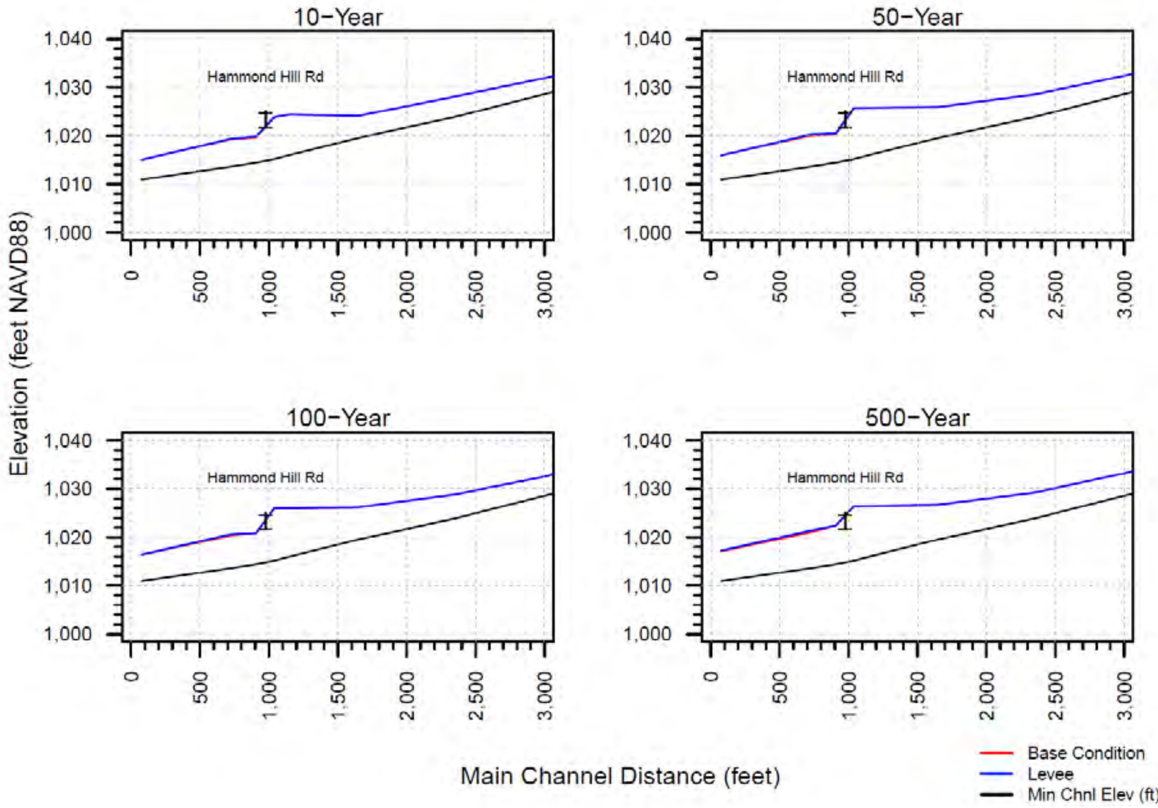

Figure 7-4. HEC-RAS model simulation output results for Alternative #1-2.

Compaction and the possibility of using cut material as fill has not been accounted for at this point. Downstream and opposite bank effects of the levee were modelled, and the levee was determined to have no measurable effects on upstream or downstream water surface elevations.

The proposed condition model simulation results indicated that water surface elevations along the levee would increase slightly due to the greater volume of water being passed through the creek channel. Without the levee, a 1% annual chance flood event would overtop the channel banks inundating numerous buildings and properties in this reach.

With the levee, model simulation results indicated this water would remain in the channel and flow downstream causing water surface elevations to increase without impairing the adjacent neighborhood. The potential benefits of this alternative are to the areas downstream of the Hammond Hill Road bridge, specifically along river stations 0+50 to 11+00.

Additional hydrologic and hydraulic modeling, coupled with an engineering review, would be necessary to determine the full scale, design criteria, and costs associated with a large-scale levee system that complies with FEMA floodplain management criteria. In addition, the levee would not remove areas from the FEMA mapped floodplain, but would only provide additional flood protection for a certain level of annual chance flood event (the 1% annual chance event for this measure).

Homeowners and businesses behind the levee would still be required to purchase flood insurance if they are within any FEMA designated flood zones (FEMA 2000).

The Rough Order Magnitude cost for this strategy is approximately $1.02 million, which does not include annual maintenance or land acquisition costs for survey, appraisal, and engineering coordination.

7.1.3 Alternative #1-3: Increase Size of Hammond Hill Road Bridge Opening

This measure is intended to address issues within High-risk Area #1 by increasing the width of the Hammond Hill Road bridge opening, which would increase the cross-sectional flow area of the channel located at river station 9+50 (Figure 7-5).

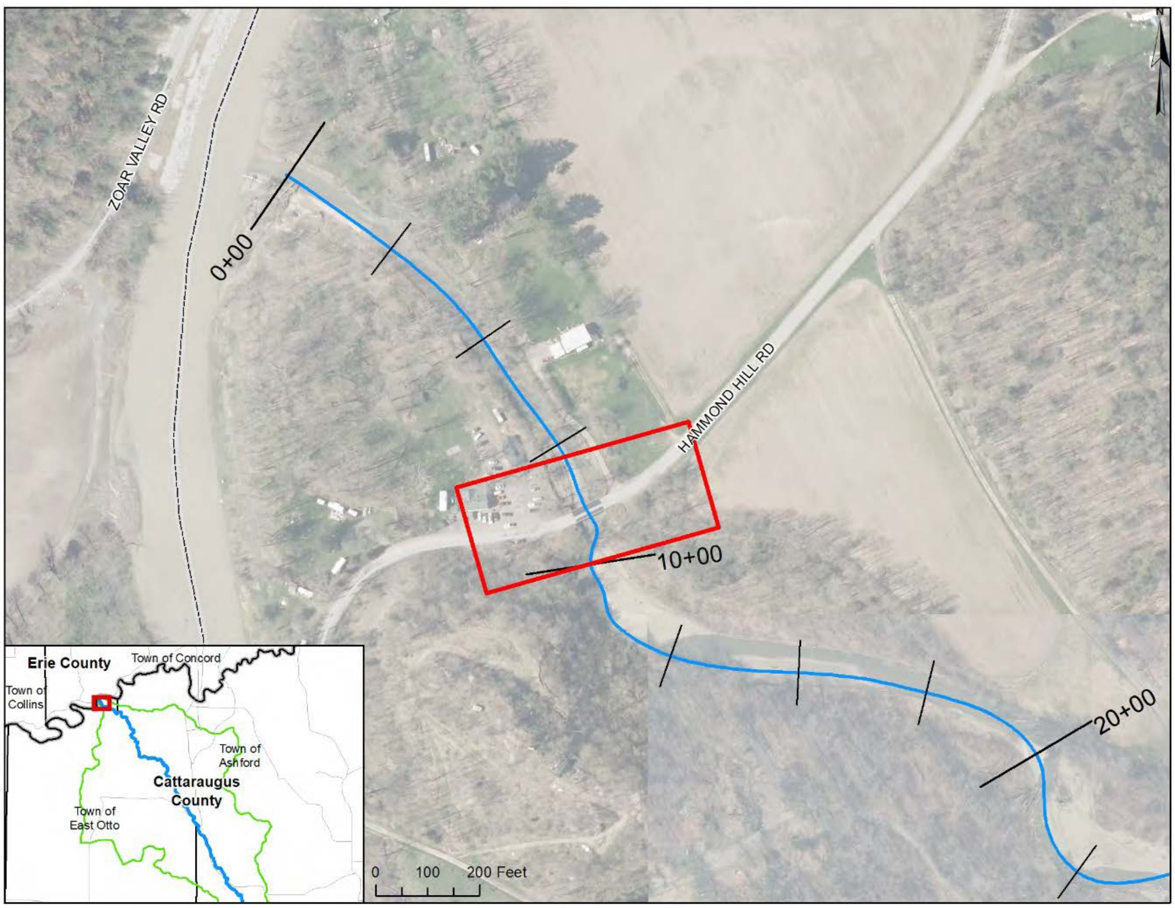

Figure 7-5. Location map for Alternative #1-3.

The bridge is owned by Cattaraugus County and has no pier in the channel. The existing bridge structure has a bridge span of 50 ft, a width of 25 ft, and a maximum height from low chord to bottom of channel of 7 ft (Figure 7-6). The flooding in the vicinity of the Hammond Hill Road bridge poses a flood risk threat to nearby residential and commercial properties and County owned infrastructure. Appendix E depicts a flood mitigation rendering of a bridge widening scenario (Ramboll 2021).

Figure 7-6. Hammond Hill Road bridge, East Otto, Cattaraugus County, NY.

According to the FEMA FIRM, there is backwater upstream of the Hammond Hill Road bridge at the 1% annual chance event WSELs (FEMA Zone A). The bridge widening design selected for this proposed condition model simulation was selected to ensure that the 1% annual chance event WSEL could successfully pass under the Hammond Hill Road bridge. To achieve the desired result, the bridge widening design increased the width of the bridge opening from 50 ft to 85 ft by widening the bridge on both banks by 17.5 ft. This measure would potentially reduce the flood risk and benefit the properties adjacent to and immediately upstream of Hammond Hill Road.

The proposed condition modeling confirmed that the Hammond Hill Road bridge is a constriction point along Connoisarauley Creek. The modeling simulation results indicated water surface reductions of up to 3.8 ft in areas immediately upstream of the bridge extending up to the Norfolk and Western Railroad crossing (Figure 7-7). The modeling output for future conditions displayed similar results with water surface reductions of up to 3.6 ft (Appendix G).

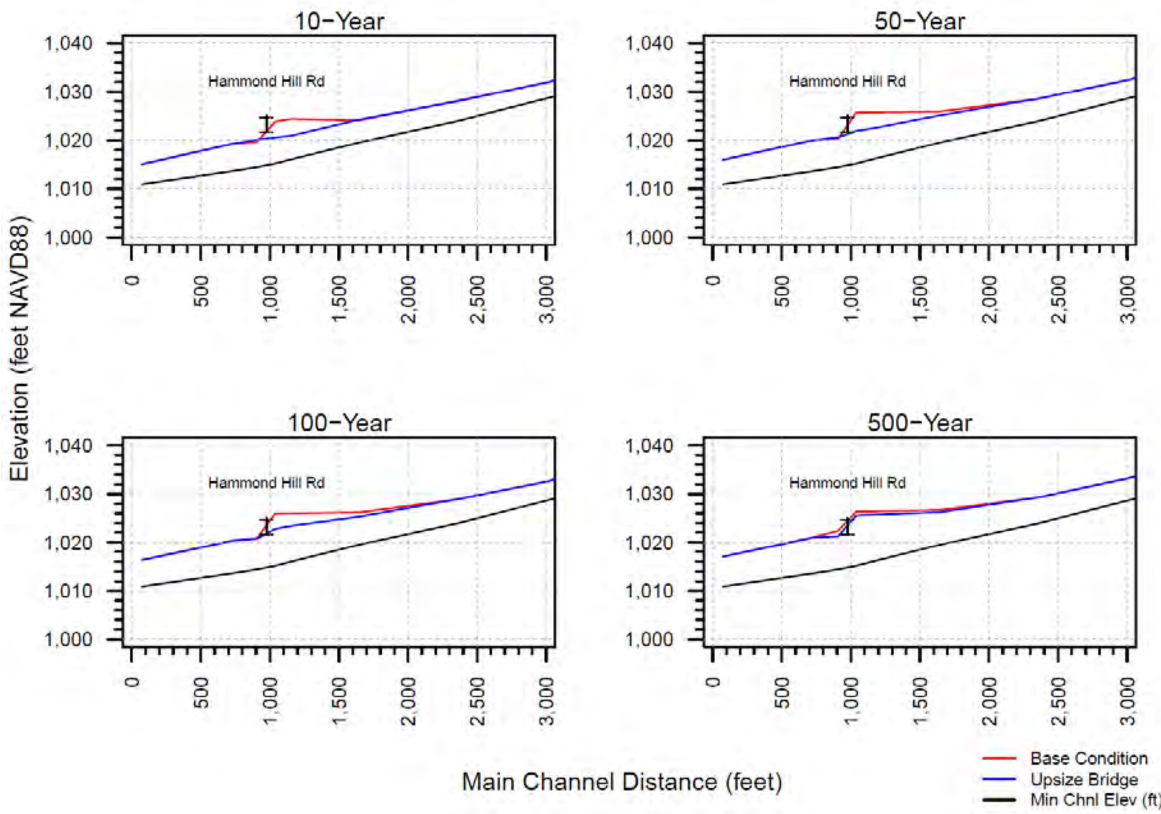

Figure 7-7. HEC-RAS model simulation output results for Alternative #1-3.

The potential water surface elevation reduction benefits of this alternative would extend approximately 1,400-ft upstream, specifically between river stations 9+50 to 23+50.

To evaluate the effectiveness of the flood mitigation impacts, the project team analyzed this alternative independently of other alternatives. However, there is the potential for added benefits (i.e., reduction in WSELs, less flooding, reduced erosion, etc.) when multiple flood mitigation projects are built in conjunction. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

The Rough Order Magnitude cost for this measure is $1.4 million, which does not include land acquisition costs for survey, appraisal, and engineering coordination.

7.1.4 Alternative #1-4: Streambank Stabilization Upstream of Confluence with Cattaraugus Creek

Streambank erosion is a natural process that occurs when the forces of flowing water exceed the ability of the soil and vegetation to hold the banks in place. The forces that cause erosion increase during flood events, and most erosion occurs at these times. Human disturbances to watersheds that increase frequency and magnitude of runoff events also increase streambank erosion. Human disturbances include logging, mining, agriculture, and urbanization. Typical urban or suburban developments which may impact a stream include houses, garages, parking lots, and walkways, including areas cleared of forest and replaced by tailored lawns (GSWCC 2000).

Loss of streambank and streamside vegetation reduces the resisting forces and makes streambanks more susceptible to erosion. This is often the single greatest contributing factor to harmful or accelerated erosion on small and medium-size streams. Streambank vegetation may be removed intentionally for various reasons, or its loss may be inadvertent due to trampling by animals or humans (GSWCC 2000).

Streambank stabilization measures work either by reducing the force of flowing water, by increasing the resistance of the bank to erosion, or by some combination of both. Generally speaking, there are four approaches to streambank protection: 1) the use of vegetation; 2) soil bioengineering; 3) the use of rock work in conjunction with plants; and 4) conventional bank armoring. Re-vegetation includes seeding and sodding of grasses, seeding in combination with erosion control fabrics, and the planting of woody vegetation (shrubs and trees). Soil bioengineering systems use woody vegetation installed in specific configurations that offer immediate erosion protection, reinforcement of the soils, and in time a woody vegetative surface cover and root network. The use of rock work in conjunction with plants is a technique which combines vegetation with rock work. Over time, the plants grow and the area appears and functions more naturally. Conventional armoring is a fourth technique which includes the use of rock, known as riprap, to protect eroding streambanks (GSWCC 2000).

Streambank stabilization can also play a vital role in flood risk management in areas located in flood-prone areas. The magnitude of that risk is a function of the flood hazard, the characteristics of a particular location (i.e., elevation, proximity to the waterway, susceptibility to fast-moving flows, etc.), measures that have been taken to mitigate the potential impact of flooding, the vulnerability of people and property, and the consequences that result from a particular flood event. A flood-risk management strategy identifies and implements measures that reduce the overall risk, and what remains is the residual risk. In developing the strategy, those responsible judge the costs and benefits of each measure taken and their overall impact in reducing the risk (NRC 2013).

Through historical flood reports, stakeholder engagement meetings, and / or field work, numerous areas along Connoisarauley Creek in the Town of East Otto have been identified as areas for potential streambank stabilization strategies. For this alternative, the reach between river stations 5+00 to 12+50 was identified as an area that has experienced streambank erosion and loss of overbank (Figure 7-8). The current conditions of the streambank in this area include: streambank instability, erosion, bank failures, and the lack and / or loss of streambank vegetation.

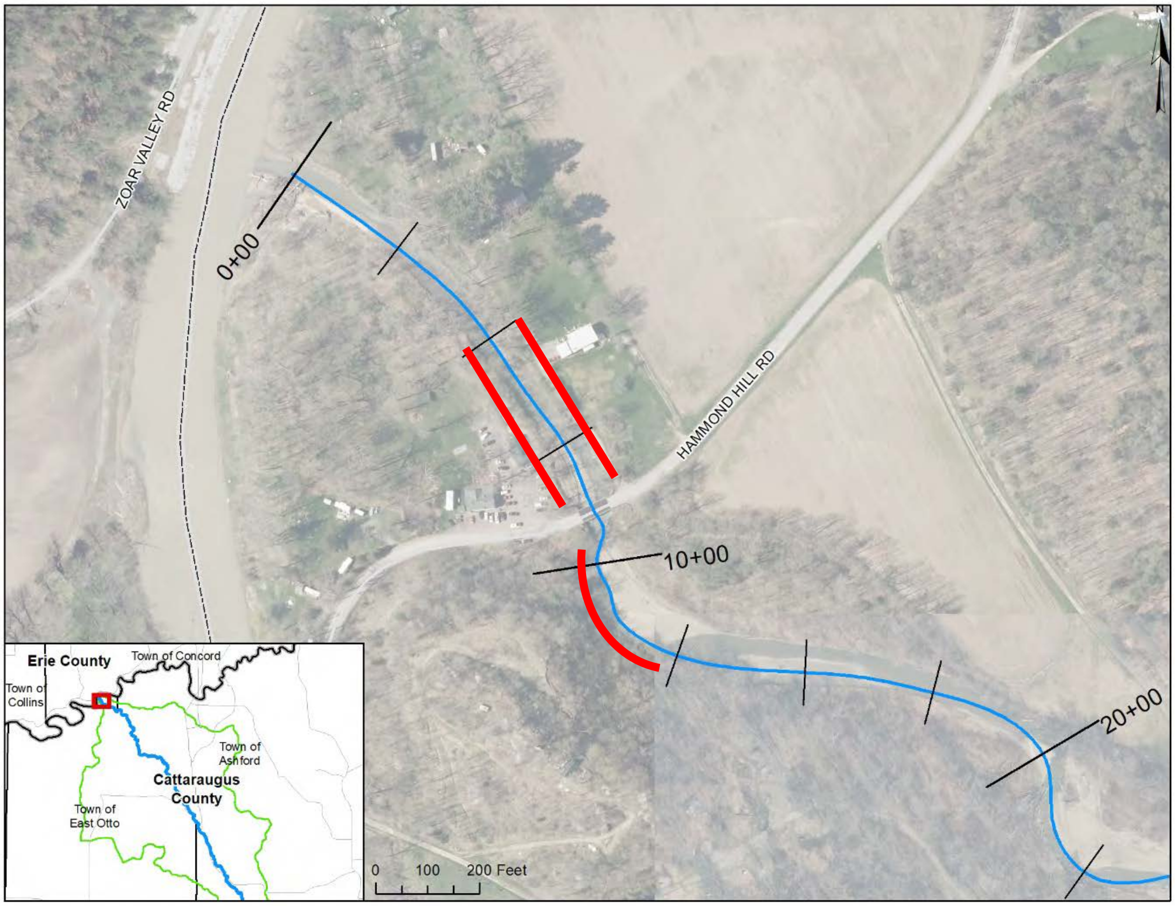

Figure 7-8. Location map for Alternative #1-4.

Appendix F contains detailed discussion of various streambank stabilization strategies, including drawings, definitions, ideal locations, design and construction considerations, maintenance, and Rough Order of Magnitude costs.

Transport of sediment and debris in streams is predominantly controlled by stream transport capacity, sediment physiochemical characteristics and supply rate. Several hydraulic and geomorphologic factors determine stream transport capacity including channel width, flow depth and cross-sectional geometry, bed slope and roughness, and discharge velocity and volume. In general, the more turbulent energy available for suspension and mobilization of sediment, the greater the sediment transport capacity per unit of stream width and the larger the size of sediment particles that can be moved (USEPA 2009a).

Larger sediments and debris generally experience more episodic movement over longer time scales through watersheds. Smaller sediments generally move more continuously and within a shorter time scale. This difference is due to the fact that larger sediments and debris rely on larger, more powerful flows for transport, which occur episodically and less frequently than flows able to move smaller particles, such as the bankfull discharge (USEPA 2009a).

To assess the applicability of different streambank stabilization strategies under higher frequency-lower flow conditions, channel velocity (feet per second) and shear stress (pounds per square foot) were calculated using the HEC-RAS software for the base conditions model at the 10% ACE.

Table 13. HECRAS Base Condition Model Output of Channel Velocity (ft/s) and Shear Stress (lb/sq ft) at the 10% ACE for Alternative #1-4

(Source: USACE 2019b)		
River Station	**Channel Velocity (ft/s)**	**Channel Shear Stress (lb/sq ft)**
74	8.86	0.94
724	9	0.88
907	9.4	0.92
975	Hammond Hill Rd	
1039	5.95	0.61
1153	2.51	0.12
1647	9.14	1.86
74	8.86	0.94

Based on the base conditions model output for channel velocity and shear stress, Table 14 summarizes the applicability of potential streambank strategies for this proposed alternative.

Table 14. Potential Streambank Stabilization Strategies for Alternative #1-4

(Source: NRCS 2009)	
Type of Treatment	**Type of Sub-Treatment**
Brush Mattresses	Staked only with rock riprap toe (initial)
Coir Geotextile Roll	Roll with Polypropylene rope mesh staked and with rock riprap toe
Gravel / Cobble	12-inch
Soil Bioengineering	Vegetated coir mat
	Live brush mattress (grown)
	Brush layering (initial / grown)
	Live willow stakes
Boulder Clusters	Boulder - Very large (>80-inch diameter)
	Boulder - Large (>40-in diameter)
	Boulder - Medium (>20-inch diameter)
	Boulder - Small (>10-inch diameter)

Due to the variable, conceptual, and site specific nature of streambank stabilization strategies, no ROM costs were determined for this measure. Additional geomorphic and engineering analyses, including additional modeling, would be necessary in order to determine the most appropriate streambank stabilization strategy and its associated costs.

7.1.5 Alternative #1-5: Sediment / Debris Retention Basin Upstream of Confluence with Cattaraugus Creek

Sediment retention basins could be established to reduce watercourse and gully erosion, trap sediment, reduce and manage runoff near and downstream of the basin, and to improve downstream water quality. A sediment control basin is an earth embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin (Figure 7-31).

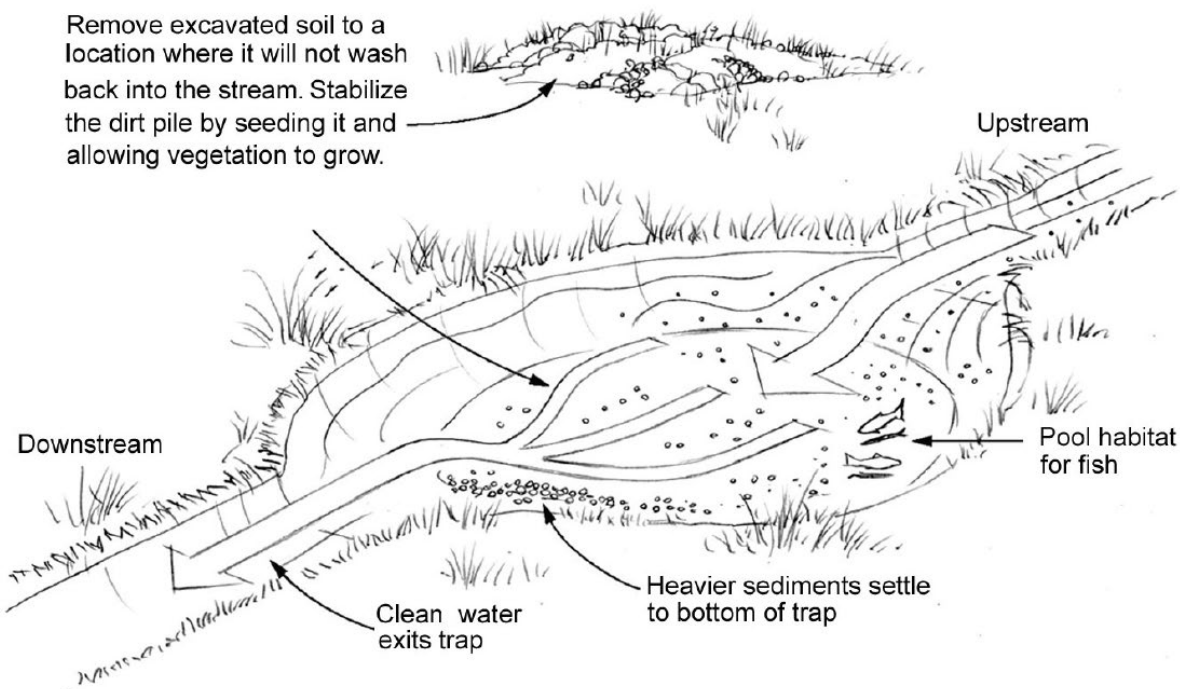

Figure 7-9. Representative diagram of an in-stream sediment retention pond (WCD 2009).

The basin should be configured to enhance sediment deposition by using flow deflectors, inlet and outlet selection, or by adjusting the length to width ratio of the creek channel. Additional hydrologic and hydraulic studies should be performed to identify the optimal locations for the sediment control basins; however, based on a preliminary analysis of the Connoisarauley Creek watershed, the areas identified in Figure 7-10 in the Town of East Otto could be potential locations for a sediment retention basin.

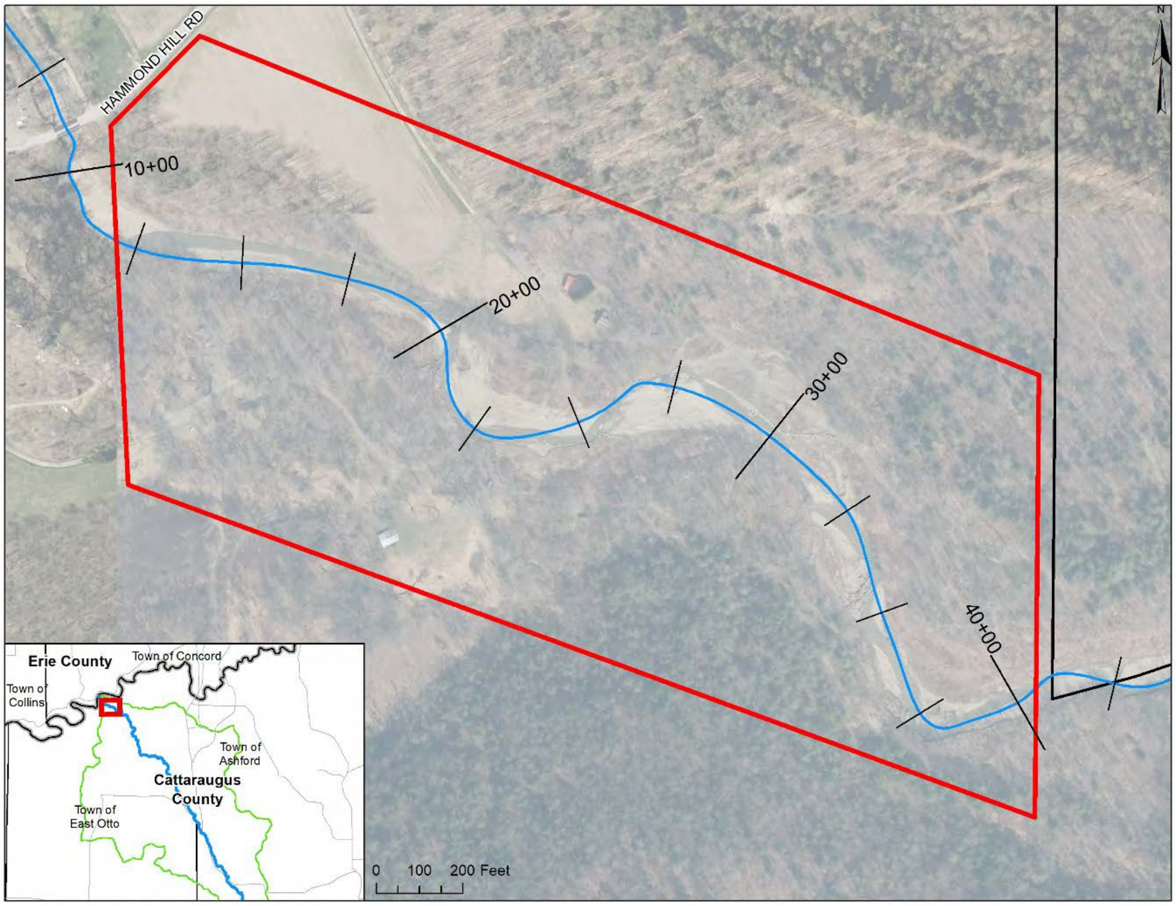

Figure 7-10. Location map for Alternative #1-5.

Sediment basin maintenance (i.e., removal of accumulated sediment) is necessary to ensure proper function. A well-functioning sediment basin allows for the trapping and removal of sediments regularly from one location rather than having to maintain an entire watercourse reach, saving money and reducing negative impacts to aquatic life and water quality. However, Sediment traps are not naturally occurring features of a watercourse. Sediment traps can have both benefits and drawbacks to fish and other aquatic life (WCD 2009).

Best maintenance practices include removing accumulated sediments periodically (i.e., every 1 to 10 years) depending upon sediment load; clearing the basin when the sediment load is at half capacity to avoid sediment build up and potential overflows, which can accumulate sediment downstream; and clearing sediments in the late summer or early fall when the water is the lowest (or when dry, if possible) (WCD 2009).

Sediment retention basins should be considered on a site-by-site basis where there are large open land areas and where downstream areas, which have historically experienced sediment issues, would benefit the most from the construction of a sediment retention basin. Advanced H&H modeling should be conducted prior to pursuing this strategy due to the complex nature of sediment transport modeling.

Due to the variable nature of identifying, designing, and constructing a sediment retention basin, no ROM costs were determined for this alternative. In addition, operation and maintenance costs to maintain the embankment, design capacity, vegetative cover, and outlet of the basin and periodic removal of any materials should be considered (NRCS 2002).

7.2 HIGH-RISK AREA #2

7.2.1 Alternative #2-1: Flood Benches Upstream of US-219 (1)

Installing a flood bench would provide additional storage and floodplain width, which could potentially reduce damages in the event of flooding and address issues within High-risk Area #2. Three potential flood benches were modeled upstream of the US-219 (1) bridge in the Town of Ashford (Figure 7-11):

- Flood Bench A located between river stations 346+50 and 351+50 on the right bank, and is approximately 0.4 acres
- Flood Bench B located between river stations 349+50 and 353+50 on the left bank and is approximately 0.5 acres
- Flood Bench C located between river stations 352+50 and 357+00 on the right bank and is approximately 0.5 acres

The flood bench designs used for the proposed condition model simulation set the minimum bench elevation approximately equal to the bankfull elevation at each cross section, which was an average depth of between 1 and 1.5 ft for the three different benches.

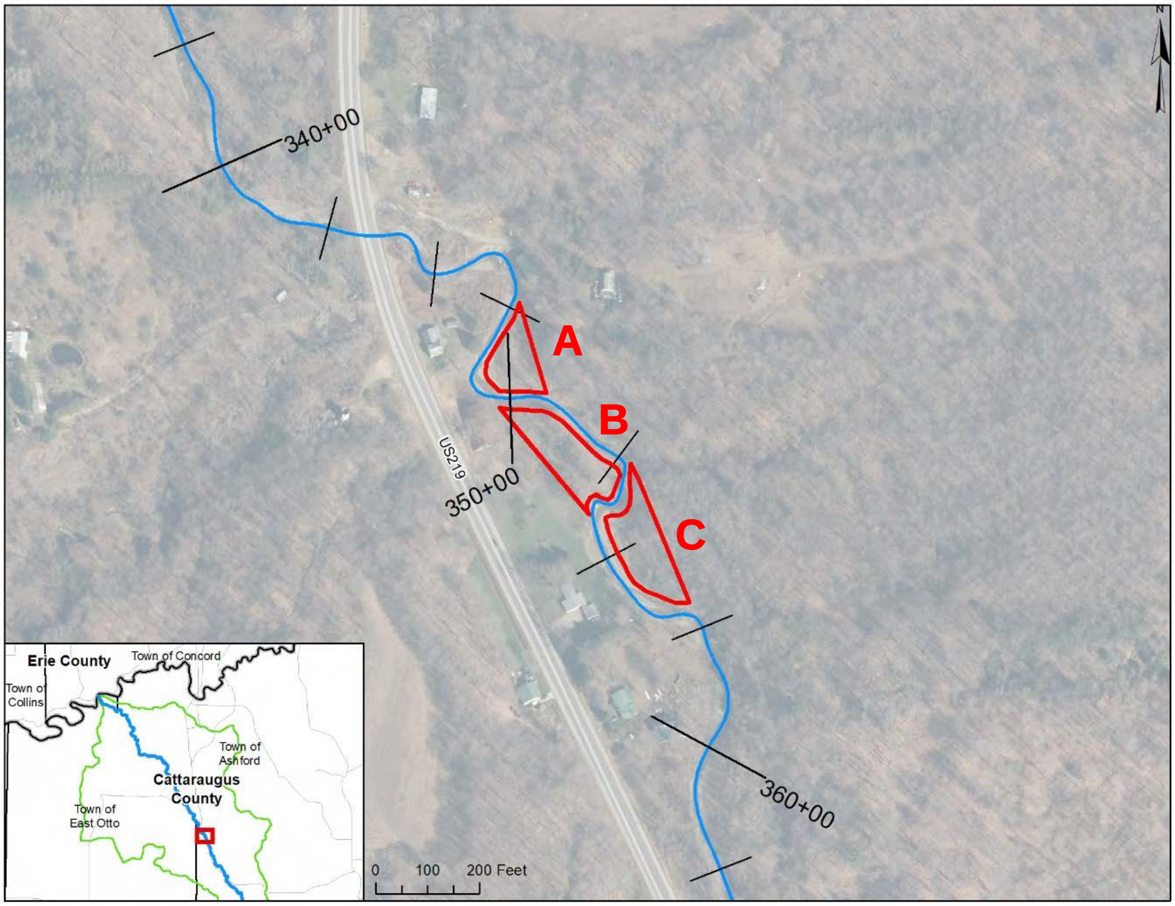

Figure 7-11. Location map for Alternative #2-1.

The flood benches are within the FEMA designated SFHA or Zone A, which are areas subject to inundation by the 1% annual chance flood event, but where base flood elevations and flood hazard factors were not determined, and where mandatory flood insurance purchase requirements and floodplain management standards apply (FIA 1980; FEMA 1984a). Appendix E depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

Table 15 outlines the results of the existing and future conditions model simulations for flood bench alternative (Appendix G). Figures 7-12 through 7-14 display the profile plots for each flood bench alternatives.

Table 15. Summary Table for Alternative #2-1 Existing and Future Conditions for Each Flood Bench Alternative

	Reductions in Water Surface Elevations (feet)		
	Flood Bench A	**Flood Bench B**	**Flood Bench C**
Existing Conditions	Up to 1.7 ft	Up to 2.2 ft	Up to 1.1 ft
Total Length of Benefited Area	1,400 ft	1,000 ft	300 ft
River Stations	347+00 to 361+00	351+00 to 361+00	356+00 to 359+00
Future Conditions	Up to 1.6 ft	Up to 2.2 ft	Up to 1.1 ft

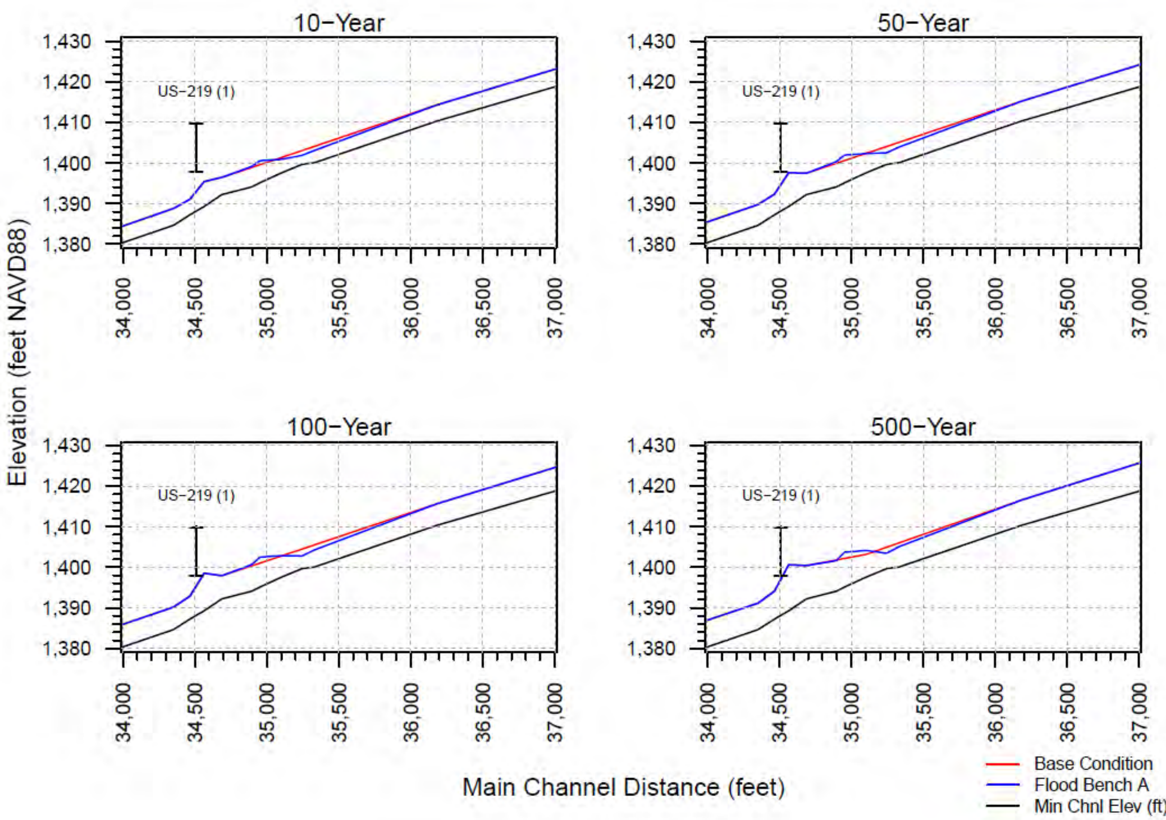

Figure 7-12. HEC-RAS model simulation output results for Alternative #2-1 Flood Bench A.

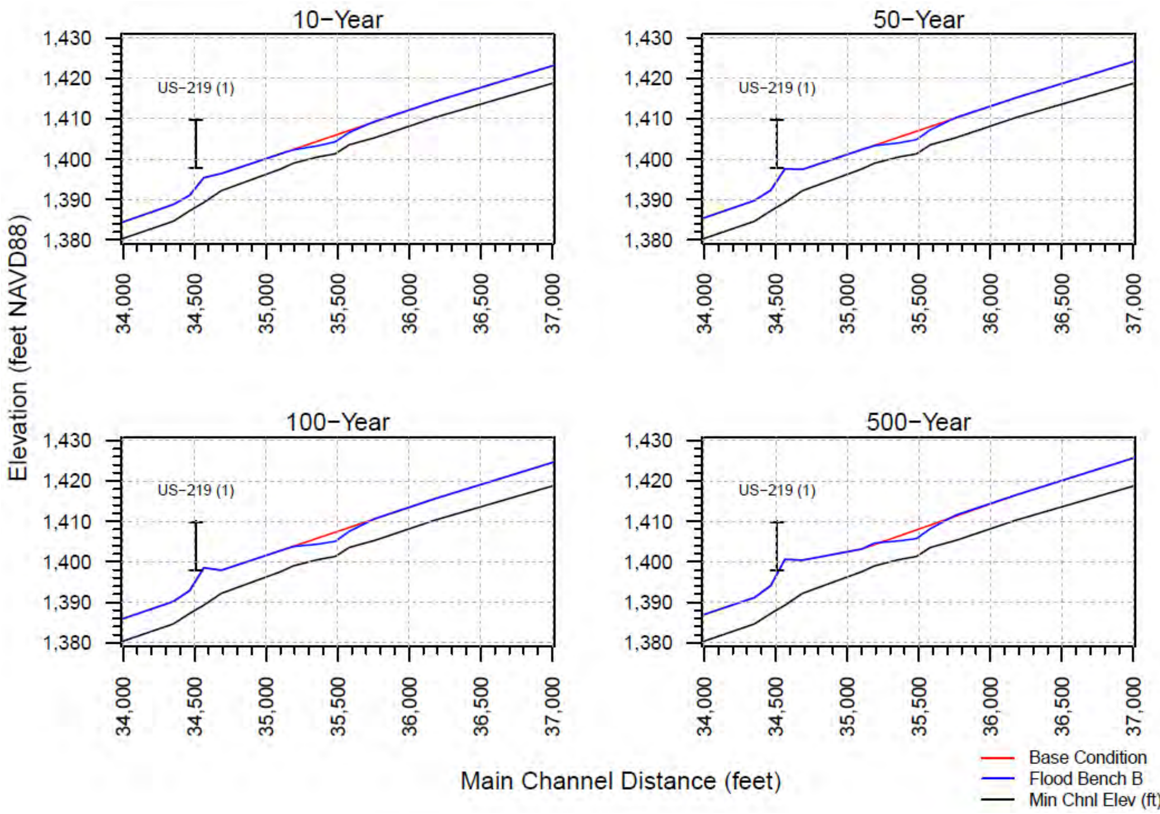

Figure 7-13. HEC-RAS model simulation output results for Alternative #2-1 Flood Bench B.

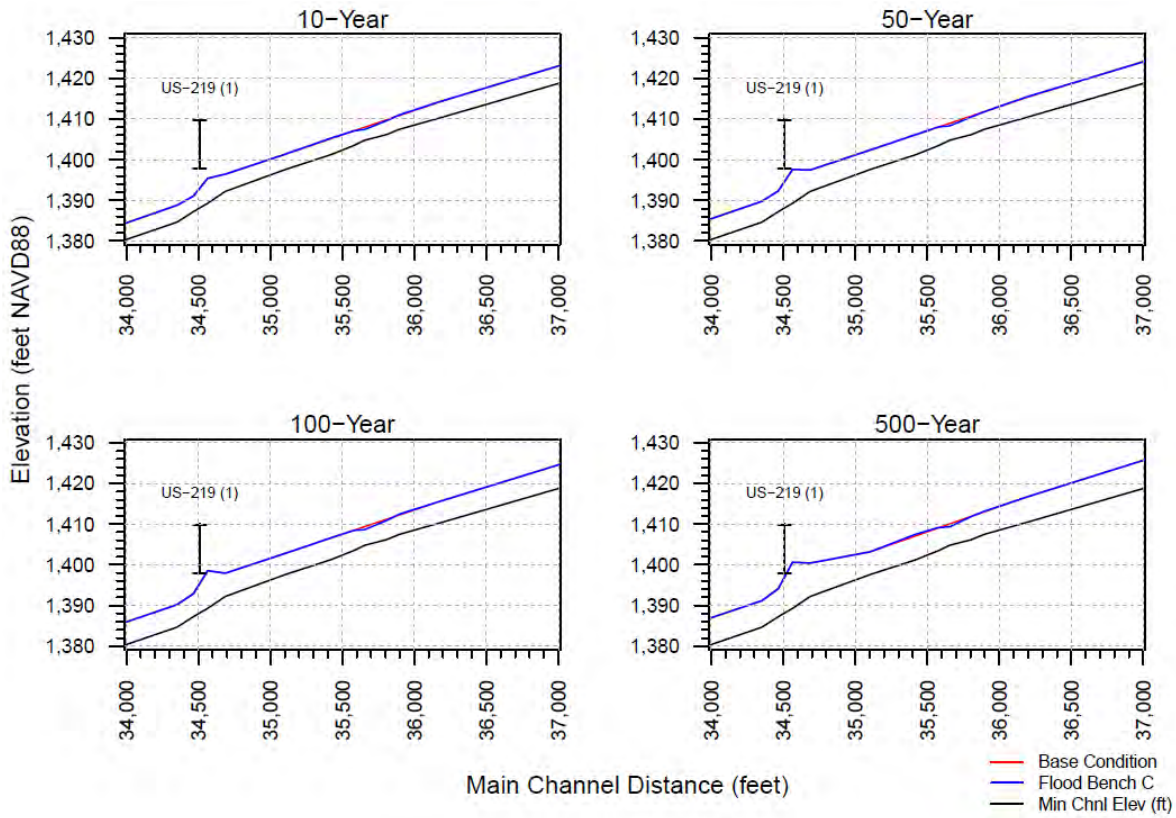

Figure 7-14. HEC-RAS model simulation output results for Alternative #2-1 Flood Bench C.

Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and / or downstream of the bench. Based on the analysis of high-risk areas, a flood bench located upstream of the US-219 (1) bridge crossing would provide significant flood protection in this reach from open-water flooding, but this benefit does not apply to all of the simulated flood benches. Flood benches A and B had the most significant benefits, while flood bench C had the least. This is most likely a result of the morphological features of the channel in this area (i.e., the significant meander in the channel flow path immediately upstream of the US-219 (1) bridge) and the distance of the flood benches upstream of the bridge crossing.

To evaluate the effectiveness of the flood mitigation impacts, the project team analyzed this alternative and each flood bench independently of other alternatives and / or benches. However, there is the potential for added benefits (i.e., reduction in WSELs, less flooding, reduced erosion, etc.) when multiple flood mitigation projects are built in conjunction. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

The Rough Order Magnitude cost for each flood bench alternative is:

- Flood Bench A: $180,000
- Flood Bench B: $230,000
- Flood Bench C: $250,000

These ROM cost estimates do not include land acquisition costs for survey, appraisal, and engineering coordination.

7.2.2 Alternative #2-2: Streambank Stabilization Upstream of US-219 (1)

Streambank erosion is a natural process that occurs when the forces of flowing water exceed the ability of the soil and vegetation to hold the banks in place. Human disturbances to watersheds that increase frequency and magnitude of runoff events also increase streambank erosion. Typical urban or suburban developments which may impact a stream include houses, garages, parking lots, and walkways, including areas cleared of forest and replaced by tailored lawns (GSWCC 2000).

Loss of streambank and streamside vegetation reduces the resisting forces and makes streambanks more susceptible to erosion. This is often the single greatest contributing factor to harmful or accelerated erosion on small and medium-size streams. Streambank vegetation may be removed intentionally for various reasons, or its loss may be inadvertent due to trampling by animals or humans (GSWCC 2000).

Streambank stabilization measures work either by reducing the force of flowing water, by increasing the resistance of the bank to erosion, or by some combination of both. Streambank stabilization can also play a vital role in flood risk management in areas located in flood prone areas (GSWCC 2000; NRC 2013).

Through historical flood reports, stakeholder engagement meetings, and / or field work, numerous areas along Connoisarauley Creek in the Town of Ashford have been identified as areas for potential streambank stabilization strategies. For this alternative, the reach between river stations 344+00 to 357+00 was identified as an area that has experienced streambank erosion and loss of overbank (Figure 7-15). The current conditions of the streambank in this area include: streambank instability, erosion, bank failures, and the lack and / or loss of streambank vegetation.

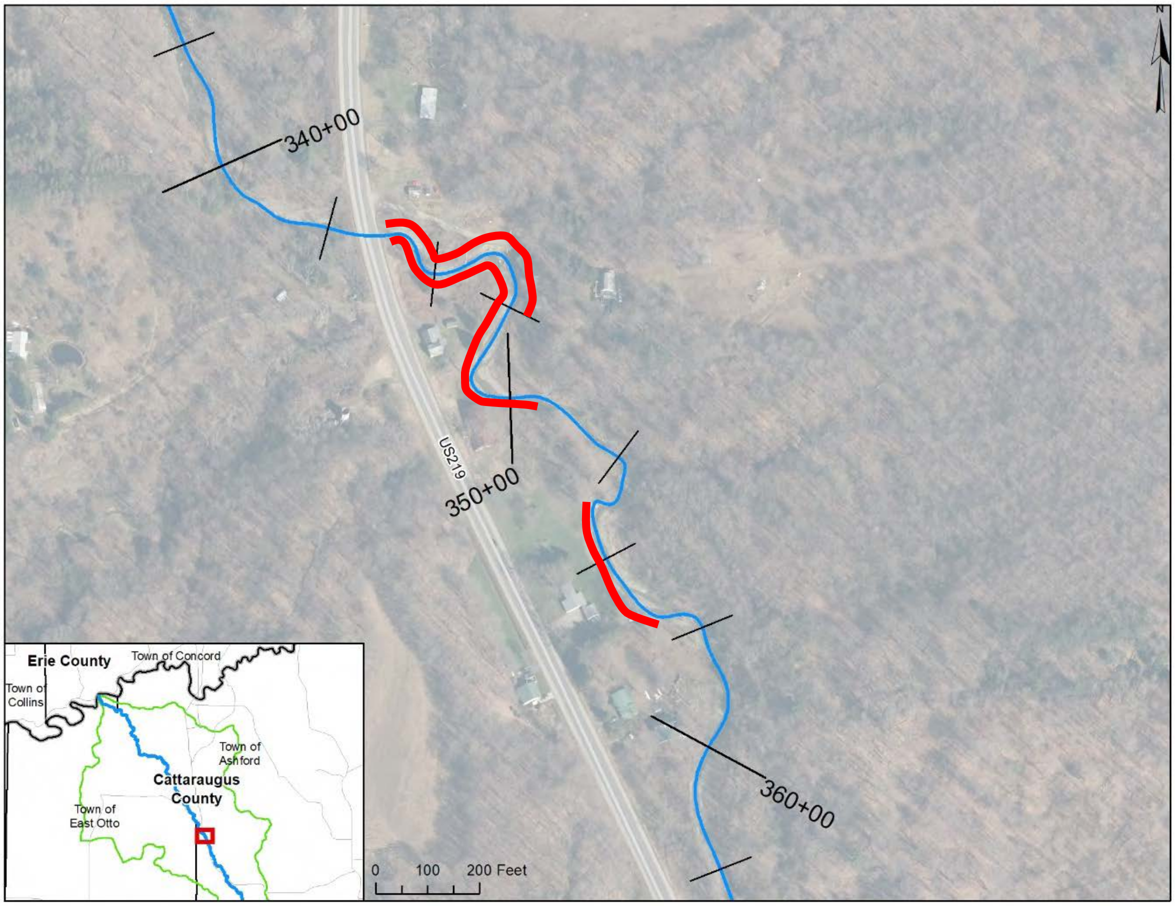

Figure 7-15. Location map for Alternative #2-2.

Appendix F contains detailed discussion of various streambank stabilization strategies, including drawings, definitions, ideal locations, design and construction considerations, maintenance, and Rough Order of Magnitude costs.

Transport of sediment and debris in streams is predominantly controlled by stream transport capacity, sediment physiochemical characteristics and supply rate. Several hydraulic and geomorphologic factors determine stream transport capacity including channel width, flow depth and cross-sectional geometry, bed slope and roughness, and discharge velocity and volume. In general, the more turbulent energy available for suspension and mobilization of sediment, the greater the sediment transport capacity per unit of stream width and the larger the size of sediment particles that can be moved (USEPA 2009a).

To assess the applicability of different streambank stabilization strategies under higher frequency-lower flow conditions, channel velocity (ft/s) and shear stress (lb/sq ft) were calculated using the HEC-RAS software for the base conditions model at the 10% ACE.

Table 16. HECRAS Base Condition Model Output of Channel Velocity (ft/s) and Shear Stress (lb/sq ft) at the 10% ACE for Alternative #2-2

(Source: USACE 2019b)		
River Station	**Channel Velocity (ft/s)**	**Channel Shear Stress (lb/sq ft)**
34352	9.42	2.13
34466	10.58	2.65
34510	US-219 #1	
34565	5.01	0.5
34688	10.05	2.35
35103	8.38	1.68
36183	10.4	2.45

Based on the base conditions model output for channel velocity and shear stress, Table 17 summarizes the applicability of potential streambank strategies for this proposed alternative.

Table 17. Potential Streambank Stabilization Strategies for Alternative #2-2

(Source: NRCS 2009)	
Type of Treatment	**Type of Sub-Treatment**
Brush Mattresses	Staked only w/ rock riprap toe (grown)
Coir Geotextile Roll	Roll with Polypropylene rope mesh staked and with rock riprap toe
Gravel/Cobble	12-inch
Soil Bioengineering	Live brush mattress (grown)
	Brush layering (initial/grown)
	Live willow stakes
Boulder Clusters	Boulder - Very large (>80-inch diameter)
	Boulder - Large (>40-in diameter)
	Boulder - Medium (>20-inch diameter)
	Boulder - Small (>10-inch diameter)

Due to the variable, conceptual, and site specific nature of streambank stabilization strategies, no ROM costs were determined for this measure. Additional geomorphic and engineering analyses, including additional modeling, would be necessary in order to determine the most appropriate streambank stabilization strategy and its associated costs.

7.3 HIGH-RISK AREA #3

7.3.1 Alternative #3-1: Streambank Stabilization Upstream of the Montagues Dam

Streambank erosion is a natural process that occurs when the forces of flowing water exceed the ability of the soil and vegetation to hold the banks in place. Human disturbances to watersheds that increase frequency and magnitude of runoff events also increase streambank erosion. Typical urban or suburban developments which may impact a stream include houses, garages, parking lots, and walkways, including areas cleared of forest and replaced by tailored lawns (GSWCC 2000).

Loss of streambank and streamside vegetation reduces the resisting forces and makes streambanks more susceptible to erosion. This is often the single greatest contributing factor to harmful or accelerated erosion on small and medium-size streams. Streambank vegetation may be removed intentionally for various reasons, or its loss may be inadvertent due to trampling by animals or humans (GSWCC 2000).

Streambank stabilization measures work either by reducing the force of flowing water, by increasing the resistance of the bank to erosion, or by some combination of both. Streambank stabilization can also play a vital role in flood risk management in areas located in flood prone areas (GSWCC 2000; NRC 2013).

Through historical flood reports, stakeholder engagement meetings, and / or field work, numerous areas along Connoisarauley Creek in the Town of Ashford have been identified as areas for potential streambank stabilization strategies. For this alternative, the reach between river stations 433+00 to 437+50 was identified as an area that has experienced streambank erosion and loss of overbank (Figure 7-16). The current conditions of the streambank in this area include: streambank instability, erosion, bank failures, and the lack and / or loss of streambank vegetation.

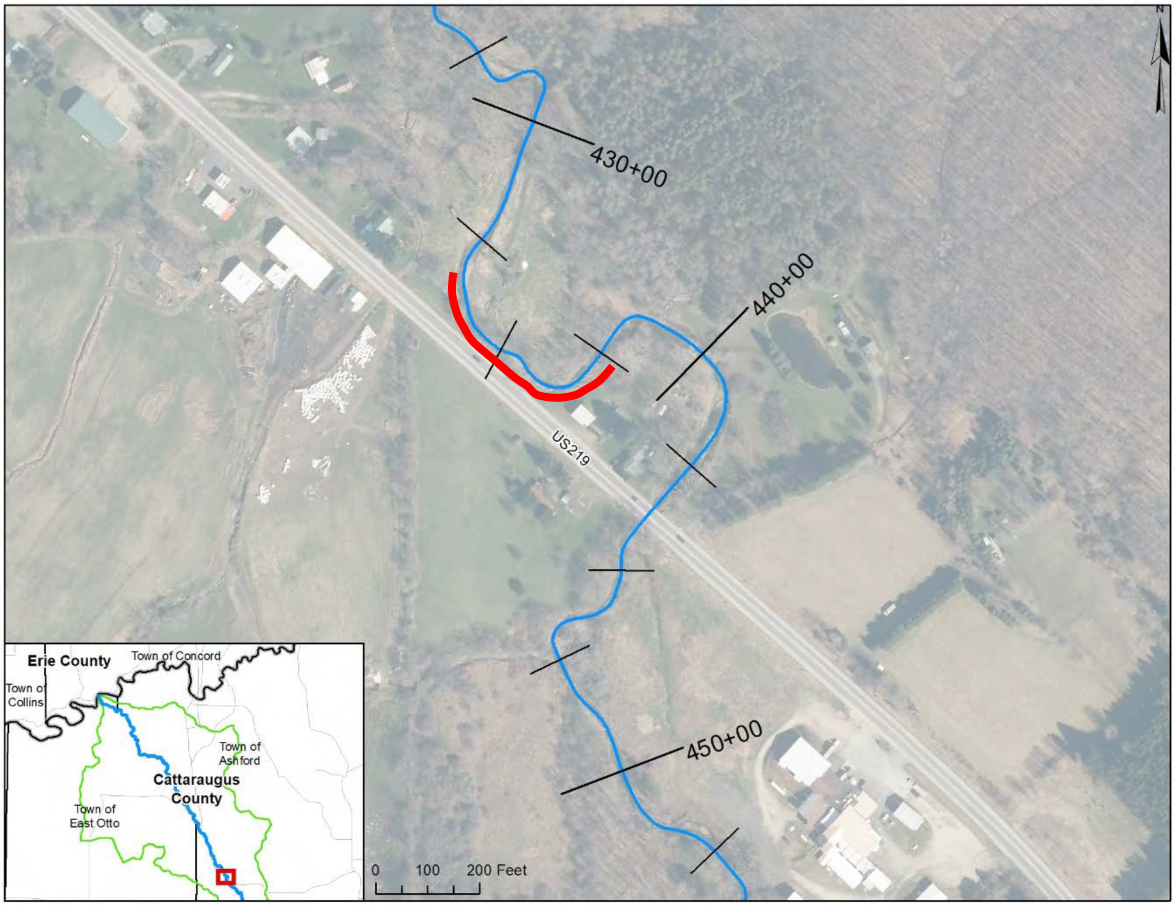

Figure 7-16. Location map for Alternative #3-1.

Appendix F contains detailed discussion of various streambank stabilization strategies, including drawings, definitions, ideal locations, design and construction considerations, maintenance, and Rough Order of Magnitude costs.

Transport of sediment and debris in streams is predominantly controlled by stream transport capacity, sediment physiochemical characteristics and supply rate. Several hydraulic and geomorphologic factors determine stream transport capacity including channel width, flow depth and cross-sectional geometry, bed slope and roughness, and discharge velocity and volume. In general, the more turbulent energy available for suspension and mobilization of sediment, the greater the sediment transport capacity per unit of stream width and the larger the size of sediment particles that can be moved (USEPA 2009a).

To assess the applicability of different streambank stabilization strategies under higher frequency-lower flow conditions, channel velocity (ft/s) and shear stress (lb/sq ft) were calculated using the HEC-RAS software for the base conditions model at the 10% ACE.

Table 18 summaries the channel velocity and shear stress values for the river stations along this proposed alternative.

Table 18. HECRAS Base Condition Model Output of Channel Velocity (ft/s) and Shear Stress (lb/sq ft) at the 10% ACE for Alternative #3-1

(Source: USACE 2019b)		
River Station	**Channel Velocity (ft/s)**	**Channel Shear Stress (lb/sq ft)**
42221	11.05	2.77
43326	8.51	1.83
44118	7.5	1.42

Based on the base conditions model output for channel velocity and shear stress, Table 19 summarizes the applicability of potential streambank strategies for this proposed alternative.

Table 19. Potential Streambank Stabilization Strategies for Alternative #3-1

(Source: NRCS 2009)	
Type of Treatment	**Type of Sub-Treatment**
Brush Mattresses	Staked only with rock riprap toe (grown)
Coir Geotextile Roll	Roll with Polypropylene rope mesh staked and with rock riprap toe
Gravel / Cobble	12-inch
Soil Bioengineering	Live brush mattress (grown)
	Brush layering (initial / grown)
Hard Surfacing	Gabions
	Concrete
Boulder Clusters	Boulder - Very large (>80-inch diameter)
	Boulder - Large (>40-in diameter)
	Boulder - Medium (>20-inch diameter)

Due to the variable, conceptual, and site specific nature of streambank stabilization strategies, no ROM costs were determined for this measure. Additional geomorphic and engineering analyses, including additional modeling, would be necessary in order to determine the most appropriate streambank stabilization strategy and its associated costs. In addition, additional H&H modeling and engineering coordination would be required to determine whether the proposed streambank stabilization strategy would affect the dam structurally and / or operationally. If modifications to the dam are necessary, then coordination with the NYSDEC regarding permitting and other dam related policies would be recommended.

7.3.2 Alternative #3-2: Flood Bench Upstream of the Montagues Dam

Installing a flood bench would provide additional storage and floodplain width, which could potentially reduce damages in the event of flooding and address issues within High-risk Area #3. The flood bench would be in the vicinity of the Montagues Dam in the Town of Ashford, approximately 1.5 acres in size and located between river stations 431+00 to 438+00 (Figure 7-17). The flood bench designs used for the proposed condition model simulation set the minimum bench elevation approximately equal to the bankfull elevation, which was an average depth of 1-ft.

The flood bench is within the FEMA designated SFHA or Zone A, which are areas subject to inundation by the 1% annual chance flood event, but where base flood elevations and flood hazard factors were not determined, and where mandatory flood insurance purchase requirements and floodplain management standards apply (FIA 1980; FEMA 1982). Appendix E depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

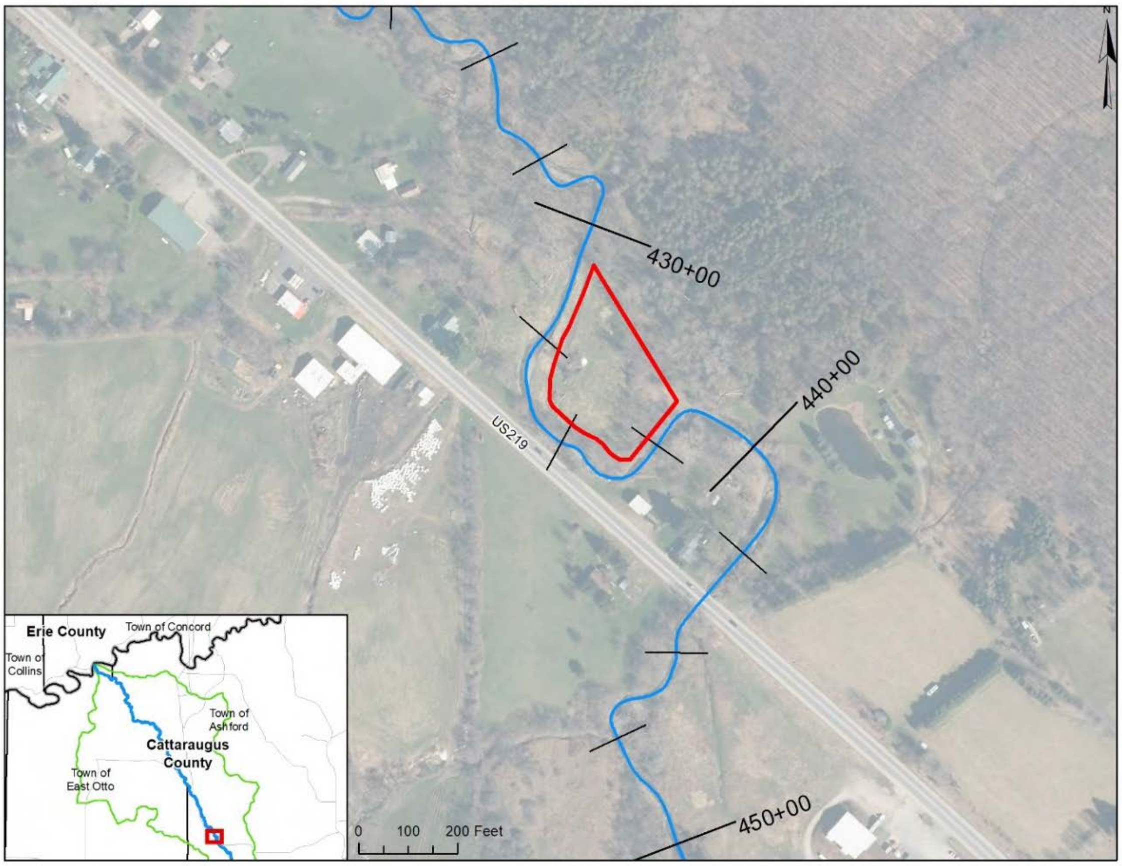

Figure 7-17. Location map for Alternative #3-2.

The flood bench design used for the proposed condition model simulation set the bench elevation approximately equal to the bankfull elevation. This measure would potentially reduce the flood risk for, and benefit the properties adjacent to and immediately upstream of, the flood bench. The proposed condition model results indicated water surface reductions of up to 1.3 ft in areas approximately 2,000-ft downstream and upstream of the flood bench, specifically along river station 422+00 to 442+50 (Figure 7-18). The modeling output for future conditions displayed similar results with water surface reductions of up to 1.2 ft for the flood bench alternative (Appendix G).

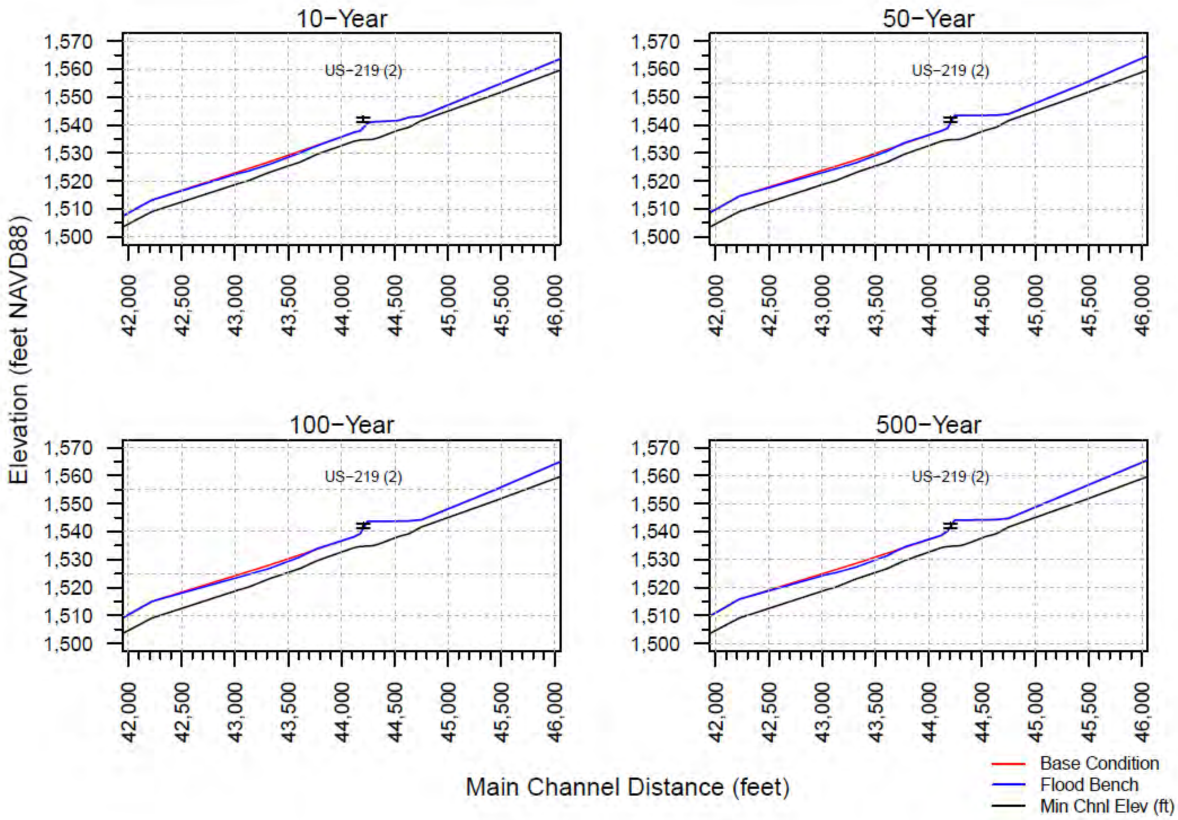

Figure 7-18. HEC-RAS model simulation output results for Alternative #3-2.

Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and / or downstream of the bench. Based on the analysis of high-risk areas, a flood bench located upstream of the Montagues Dam would provide flood protection in this reach from open-water flooding to multiple residential properties and private and state-owned infrastructure upstream of the dam.

To evaluate the effectiveness of the flood mitigation impacts, the project team analyzed this alternative independently of other alternatives. However, there is the potential for added benefits (i.e., reduction in WSELs, less flooding, reduced erosion, etc.) when multiple flood mitigation projects are built in conjunction. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

The Rough Order Magnitude cost for this measure is $390,000, which does not include land acquisition costs for survey, appraisal, and engineering coordination. Additional H&H modeling and engineering coordination would be required to determine whether the proposed flood bench would affect the dam structurally and / or operationally. If modifications to the dam are necessary then coordination with the NYSDEC regarding permitting and other dam related policies would be recommended.

7.3.3 Alternative #3-3: Increase Size of US-219 (2) Bridge Opening

This measure is intended to address issues within High-risk Area #3 by increasing the width of the US-219 (2) bridge opening, which would increase the cross-sectional flow area of the channel located at river station 443+50 (Figure 7-20).

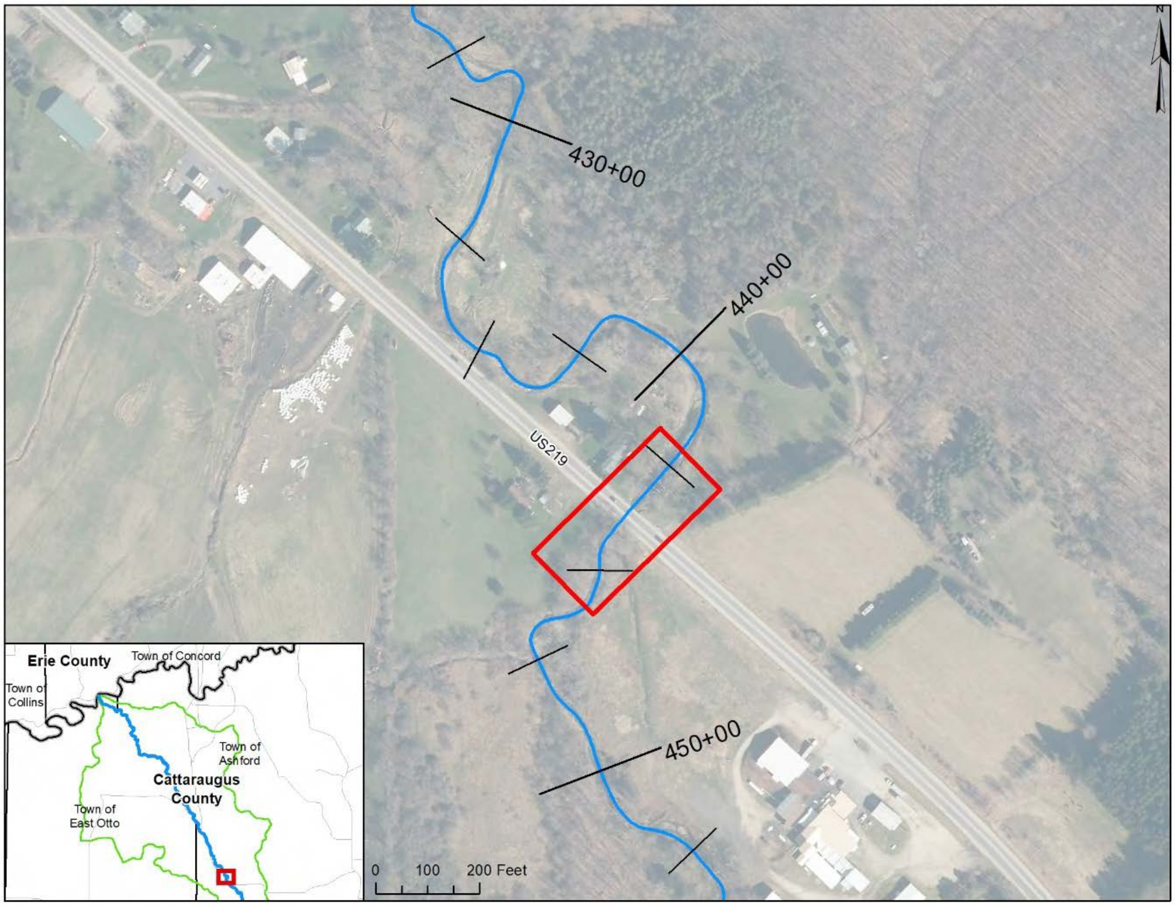

Figure 7-19. Location map for Alternative #3-3.

The bridge is owned by the NYSDOT, and the existing bridge structure has a bridge width of 37 ft, bridge span of 26 ft, and a maximum low chord to channel bottom height of 7 ft (Figure 7-20). The flooding in the vicinity of the US-219 (2) bridge poses a flood risk threat to nearby residential and commercial properties (Ramboll 2021). Appendix E depicts a flood mitigation rendering of a bridge widening scenario.

Figure 7-20. US-219 (2) bridge, Ashford, Cattaraugus County, NY.

According to the FEMA FIRM, there is backwater upstream of the US-219 (2) bridge at the 1% annual chance event WSELs (Zone A) (FEMA 1989a). The bridge widening design selected for this proposed condition model simulation was selected to ensure that the 1% annual chance event WSEL could successfully pass under the US-219 (2) bridge. To achieve the desired result, the bridge widening design used for the proposed condition model simulation increased the width of the bridge opening from 26 ft to 45 ft by widening each side of the bridge by 9.5 ft without any obstructions.

The proposed condition model results indicated water surface reductions of up to 2.7 ft in areas approximately 1,300-ft upstream of the bridge, specifically along river stations 441+50 to 454+50 (Figure 7-21). The modeling output for future conditions displayed similar results with water surface reductions of up to 2.5 ft for the bridge widening alternative (Appendix G). This measure would potentially reduce the flood risk for, and benefit the properties adjacent to and immediately upstream of, US-219 (2).

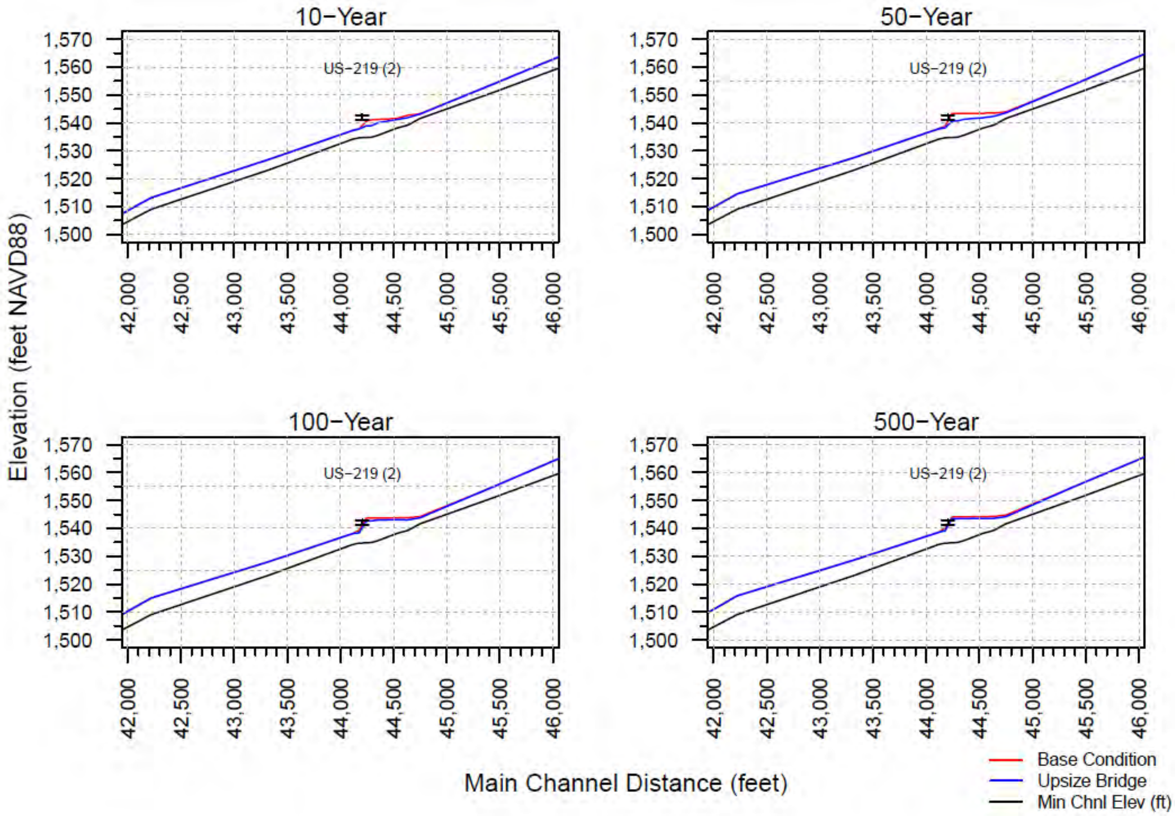

Figure 7-21. HEC-RAS model simulation output results for Alternative #3-3.

To evaluate the effectiveness of the flood mitigation impacts, the project team analyzed this alternative independently of other alternatives. However, there is the potential for added benefits (i.e., reduction in WSELs, less flooding, reduced erosion, etc.) when multiple flood mitigation projects are built in conjunction. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

The Rough Order Magnitude cost for this measure is $1.05 million, which does not include land acquisition costs for survey, appraisal, and engineering coordination.

7.3.4 Alternative #3-4: Flood Benches Upstream of US-219 (2)

Installing a flood bench would provide additional storage and floodplain width, which could potentially reduce damages in the event of flooding and address issues within High-risk Area #3. Two potential flood benches were modeled upstream of the US-219 (2) bridge in the Town of Ashford (Figure 7-11):

- Flood Bench A located between river stations 446+00 and 452+00 on the right bank, and is approximately 1.0 acres
- Flood Bench B located between river stations 451+50 and 458+00 on the left bank and is approximately 1.5 acres

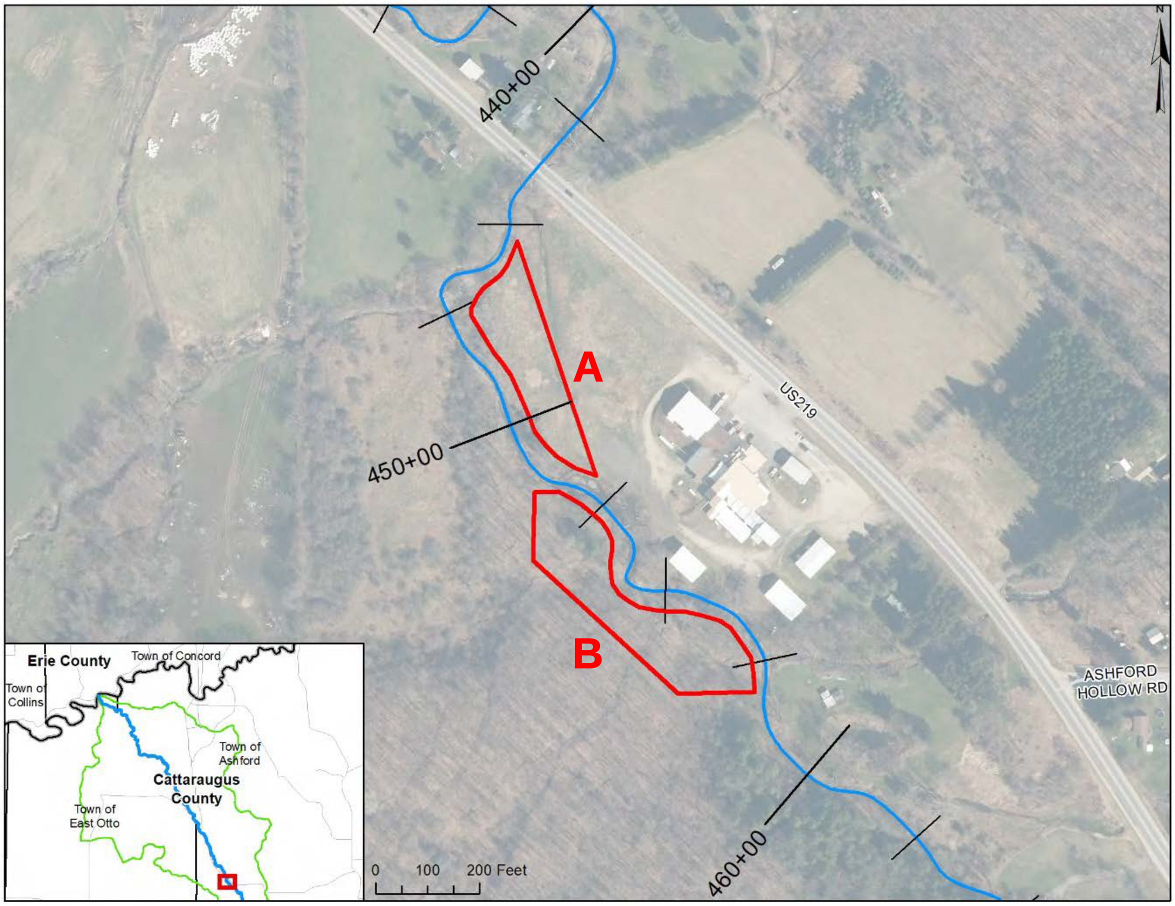

Figure 7-22. Location map for Alternative #3-4.

The flood bench designs used for the proposed condition model simulation set the minimum bench elevation approximately equal to the bankfull elevation at each cross section, which was an average depth of 1.5 ft for the two benches.

The flood benches are within the FEMA designated SFHA or Zone A, which are areas subject to inundation by the 1% annual chance flood event, but where base flood elevations and flood hazard factors were not determined, and where mandatory flood insurance purchase requirements and floodplain management standards apply (FIA 1980; FEMA 1984a). Appendix E depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

Table 20 outlines the results of the existing and future conditions model simulations for flood bench alternative (Appendix G). Figures 7-23 and 7-24 display the profile plots for each flood bench alternative.

Table 20. Summary Table for Alternative #2-1 Existing and Future Conditions for Each Flood Bench Alternative

	Reductions in Water Surface Elevations (feet)	
	Flood Bench A	**Flood Bench B**
Existing Conditions	Up to 1.4 ft	Up to 0.8 ft
Total Length of Benefited Area	2,025 ft	1,875 ft
River Stations	443+50 to 463+75	447+50 to 456+50 454+00 to 46+375
Future Conditions	Up to 0.7 ft	Up to 0.8 ft

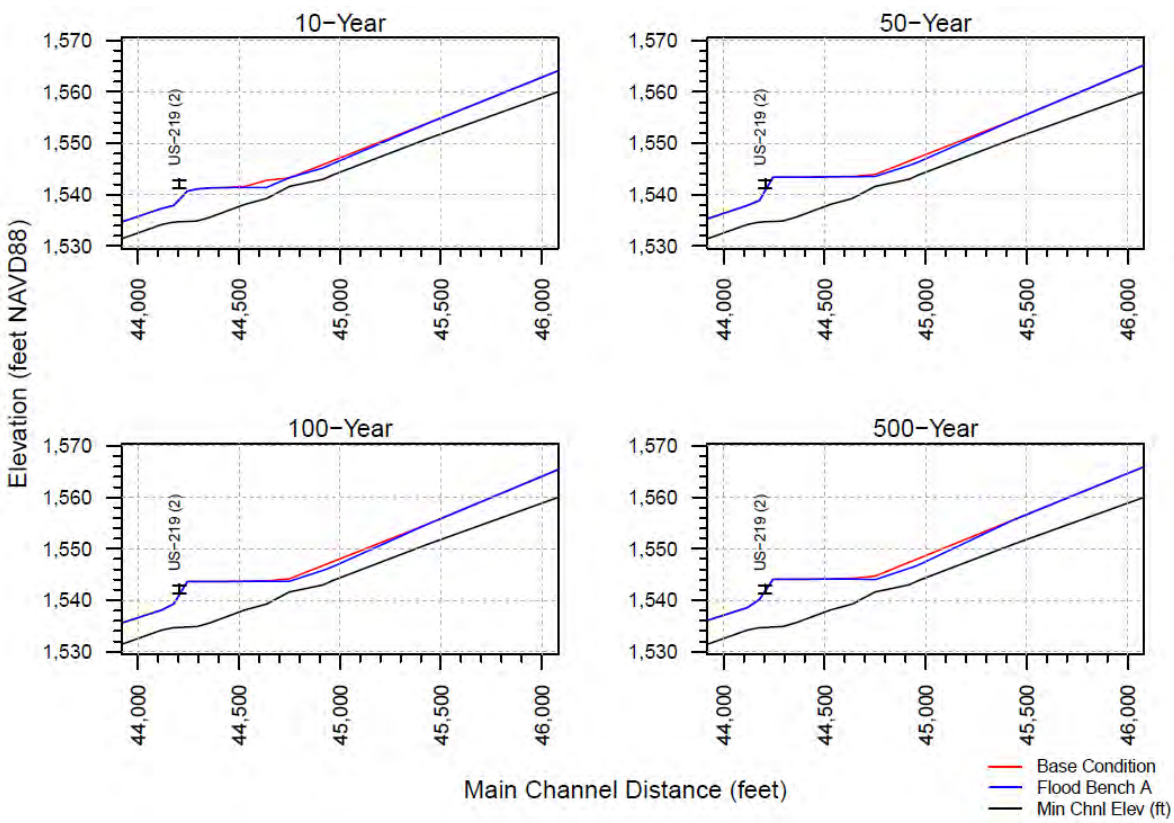

Figure 7-23. HEC-RAS model simulation output results for Alternative #3-4 Flood Bench A.

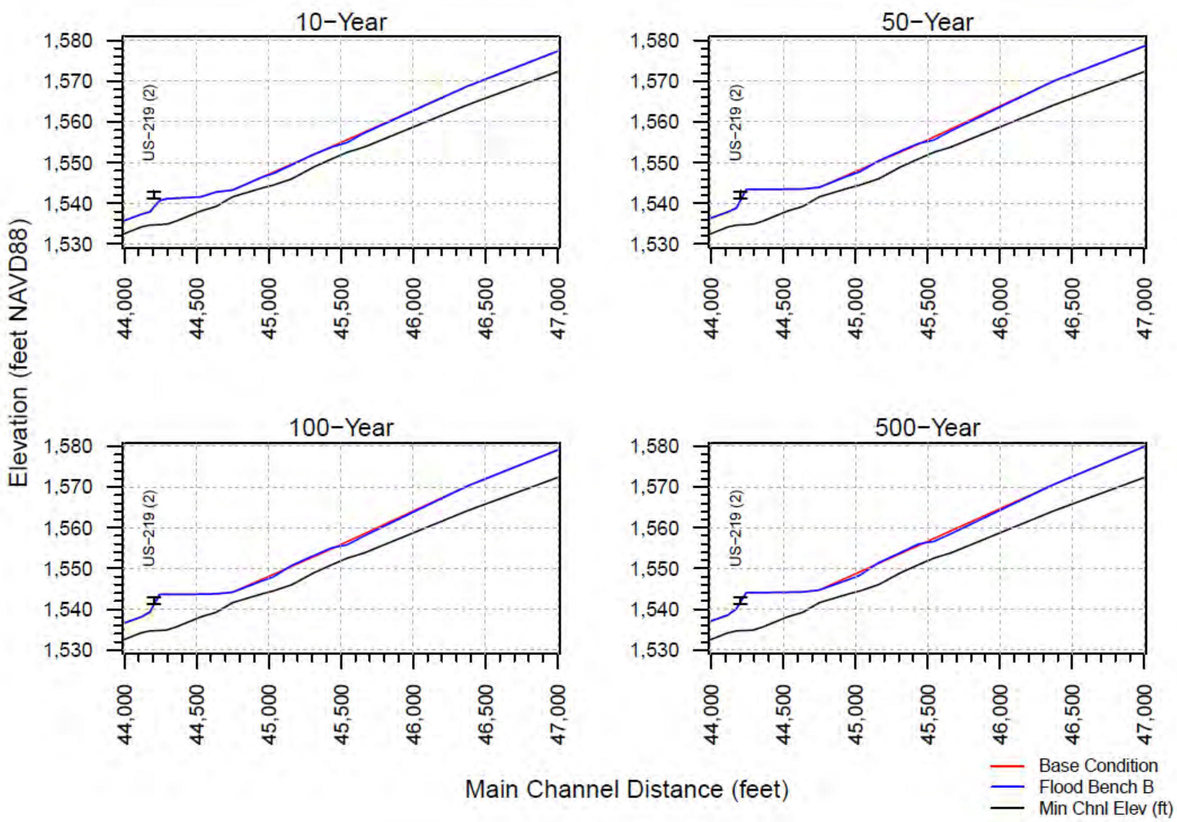

Figure 7-24. HEC-RAS model simulation output results for Alternative #3-4 Flood Bench B.

Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and / or downstream of the bench. Based on the analysis of high-risk areas, both flood benches located upstream of the US-219 (2) bridge crossing would provide significant flood protection in this reach from open-water flooding.

To evaluate the effectiveness of the flood mitigation impacts, the project team analyzed this alternative and each flood bench independently of other alternatives. However, there is the potential for added benefits (i.e., reduction in WSELs, less flooding, reduced erosion, etc.) when multiple flood mitigation projects are built in conjunction. For areas that experience significant flood damages or chronic flooding, it is recommended that multiple flood mitigation strategies in conjunction be considered and evaluated by affected communities.

The Rough Order Magnitude cost for each flood bench alternative is:

- Flood Bench A: $320,000
- Flood Bench B: $460,000

These ROM cost estimates do not include land acquisition costs for survey, appraisal, and engineering coordination.

7.3.5 Alternative #3-5: Increase Size of US-219 (3) Culvert Opening

This measure is intended to address issues within High-risk Area #3 by increasing the size of the US-219 (3) culvert opening, which would increase the cross-sectional flow area of the channel located at river station 477+50 (Figure 7-25).

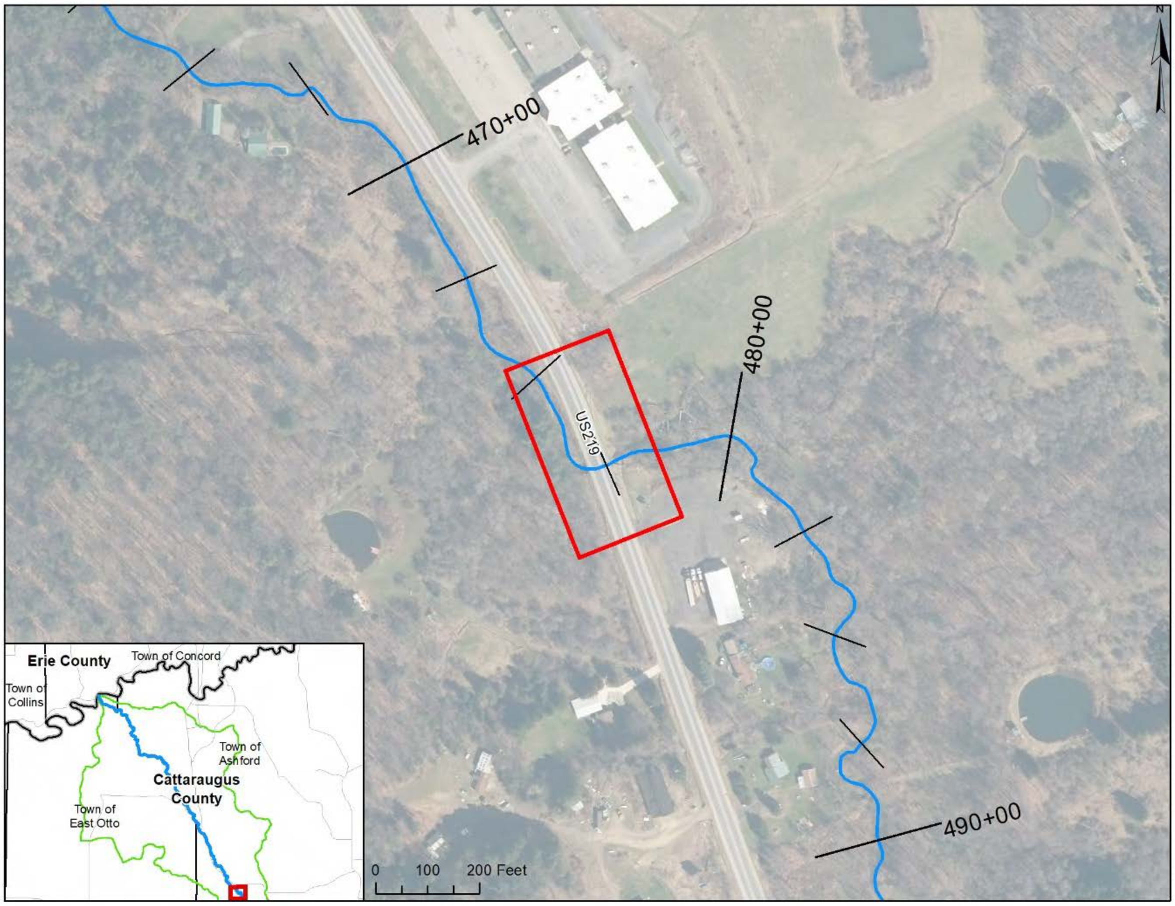

Figure 7-25. Location map for Alternative #3-5.

The culvert is owned by the NYSDOT, and the existing culvert structure has a height of 6 ft and span of 18 ft (Figure 7-26). The flooding in the vicinity of the US-219 (3) culvert poses a flood risk threat to nearby residential and commercial properties (Ramboll 2021). Appendix E depicts a flood mitigation rendering of a culvert widening scenario.

Figure 7-26. US-219 (3) culvert, Ashford, Cattaraugus County, NY.

According to the FEMA FIRM, there is backwater upstream of the US-219 (3) culvert at the 1% annual chance event WSELs (Zone A) (FEMA 1989a). The culvert widening design selected for this proposed condition model simulation was selected to ensure that the 1% annual chance event WSEL could successfully pass under the US-219 (3) culvert. To achieve the desired result, the culvert widening design used for the proposed condition model simulation increased the culvert span from 18 ft to 26 ft, and the height from 6 ft to 8 ft.

The proposed condition model results indicated water surface reductions of up to 2.4 ft in areas approximately 600 ft upstream of the culvert, specifically along river stations 474+50 to 480+50 (Figure 7-27). The modeling output for future conditions displayed similar results with water surface reductions of up to 2.7 ft for the bridge widening alternative (Appendix G). This measure would potentially reduce the flood risk and benefit the properties adjacent to, and immediately upstream of, US-219 (3) culvert .

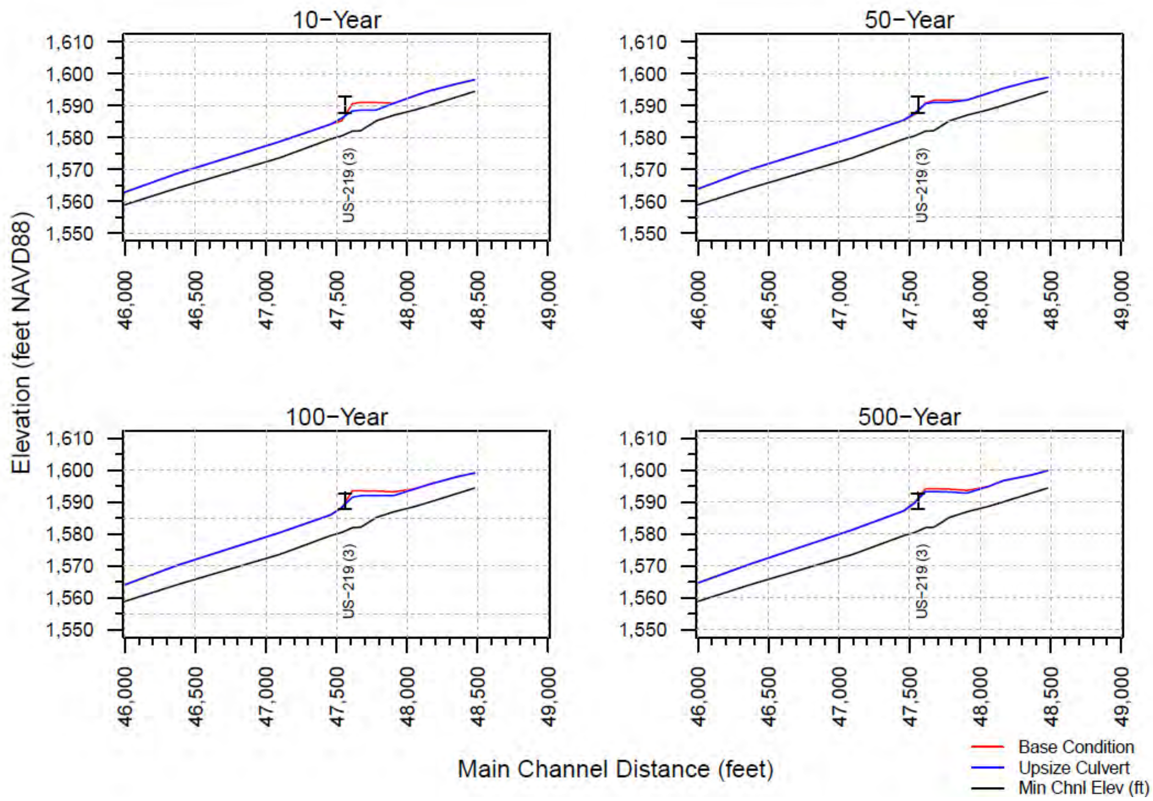

Figure 7-27. HEC-RAS model simulation output results for Alternative #3-5.

The Rough Order Magnitude cost for this measure is $1.04 million, which does not include land acquisition costs for survey, appraisal, and engineering coordination.

8. BASIN-WIDE MITIGATION ALTERNATIVES

Non-structural measures attempt to avoid flood damages by modifying or removing properties currently located within flood-prone areas. These measures do not affect the frequency or level of flooding within the floodplain; rather, they affect floodplain activities. In considering the range of non-structural measures, the community needs to assess the type of flooding which occurs (depth of water, velocity, duration) prior to determining which measure best suits its needs (USACE 2016b).

8.1 Alternative #4-1: Early-warning Flood Detection System

Early-warning flood detection systems can be implemented, which can provide communities with more advanced warning of potential flood conditions. Early forecast and warning involve the identification of imminent flooding, implementation of a plan to warn the public, and assistance in evacuating persons and some personal property. A typical low cost early-warning flood detection system consists of commercially available off-the-shelf-components. The major components of an early-warning flood detection system are a sensor connected to a data acquisition device with built-in power supply or backup, some type of notification or warning equipment, and a means of communication.

The notification process can incorporate standard telephone or cellular telephone. Transfer of data from the system can be achieved using standard or cellular telephone, radio frequency (RF) telemetry, wireless internet, or satellite transceivers. Emergency management notification techniques can be implemented through the use of radio, siren, individual notification, or a reverse 911 system. More elaborate means include remote sensors that detect water levels and automatically warn residents. These measures normally serve to reduce flood hazards to life, and damage to portable personal property (USACE 2016b).

The Rough Order Magnitude cost for this strategy is approximately $120,000, not including annual maintenance and operational costs.

8.2 Alternative #4-2: Riparian Restoration

Riparian ecosystems support many critically important ecological functions, but most riparian areas have been severely degraded by a variety of human disturbances within the Connoisarauley Creek watershed. Restoration, which is defined as the process of re-establishing historical ecosystem structures and processes, is being used more often to mitigate some of the past degradation of these ecosystems (Goodwin et al. 1997).

Riparian ecosystems generally consist of two flooding zones: Zone I occupies the active floodplain and is frequently inundated, and Zone II extends from the active floodplain to the valley wall. Successful restoration depends on understanding the physical and biological processes that influence natural riparian ecosystems and the types of disturbance that have degraded riparian areas. Adoption of a process-based approach for riparian restoration is key to a successful restoration plan. Disturbances to riparian ecosystems in the Connoisarauley Creek watershed have resulted from streamflow diversions and blockages caused by landslides; stream channelization; direct modification of the riparian ecosystem; and watershed disturbances (Goodwin et al. 1997).

With ecological processes in mind, a successful riparian restoration plan should focus on four key areas: (1) interdisciplinary approaches, (2) a unified framework, (3) a better understanding of fundamental riparian ecosystem processes, and (4) restoration potential more closely related to disturbance type (Goodwin et al. 1997).

Three issues should be considered regarding the cause of the degraded environment: (1) the location of the anthropogenic modification with respect to the degraded riparian area, (2) whether the anthropogenic modification is ongoing or can be eliminated, and (3) whether or not recovery will occur naturally if the anthropogenic modification is removed (Goodwin et al. 1997).

Riparian restoration requires a deep understanding of physical and ecological conditions that exist and that are desired at a restoration site. These conditions must be naturally sustainable given a set of water, sediment, and energy fluxes. If the conditions cannot be naturally sustained, the restoration will fail to meet the original goals (Goodwin et al. 1997).

8.3 Alternative #4-3: Debris Maintenance Around Bridges / Culverts

Debris, such as trees, branches, and stumps, are an important feature of natural and healthy stream systems. In a healthy stream network, woody debris helps to stabilize the stream and its banks, reduce sediment erosion, and slow storm-induced high streamflow events. Fallen trees and brush also form the basis for the entire aquatic ecosystem by providing food, shelter, and other benefits to fish and wildlife. In the headwaters of many streams, woody debris influences flooding events by increasing channel roughness, dissipating energy, and slowing floodwaters, which can potentially reduce flood damages in the downstream reaches. Any woody debris that does not pose a hazard to infrastructure or property should be left in place and undisturbed, thereby saving time and money for more critical work at other locations (NYSDEC 2013).

However, in some instances, significant sediment and debris can impact flows by blocking bridge and culvert openings and accumulating along the stream path at meanders, contraction / expansion points, etc., which can divert stream flow and cause backwater and bank erosion. When debris poses a risk to infrastructure, such as bridges or homes, it should be removed. Provided fallen trees, limbs, debris, and trash can be pulled, cabled, or otherwise removed from a stream or stream bank without significant disruption of the stream bed and banks, a permit from the NYSDEC is not required. Woody debris and trash can be removed from a stream without the need for a permit under the following guidelines:

- Fallen trees and debris may be pulled from the stream by vehicles and motorized equipment operating from the top of the streambanks using winches, chains and or cables.
- Hand-held tools, such as chainsaws, axes, handsaws, etc., may be used to cut up the debris into manageable sized pieces.

- Downed trees that are still attached to the banks should be cut off near the stump. Do not grub (pull out) tree stumps from the bank; stumps hold the bank from eroding.
- All trees, brush, and trash that is removed from the channel should not be left on the floodplain. Trash should be properly disposed of at a waste management facility. Trees and brush can be utilized as firewood. To prevent the spread of invasive species, such as Emerald Ash Borer, firewood cannot be moved more than 50 miles from its point of origin.
- Equipment may not be operated in the water, and any increase in stream turbidity from the removal must be avoided (NYSDEC 2013).

Any work that will disturb the bed or banks of a protected stream (gravel removal, stream restoration, bank stabilization, installation, repair, replacements of culverts or bridges, objects embedded in the stream that require digging out, etc.) will require an Article 15 permit from the NYSDEC. Projects that will require disturbance of the stream bed or banks, such as excavating sand and gravel, digging embedded debris from the streambed or the use of motorized, vehicular equipment, such as a tractor, backhoe, bulldozer, log skidder, four-wheel drive truck, etc. (any heavy equipment), in the stream channel, or anywhere below the top of banks, will require either a Protection of Waters or Excavation or Fill in Navigable Waters Permit (NYSDEC 2013).

In addition, sediment control basins along Connoisarauley Creek could be established to reduce watercourse and gully erosion, trap sediment, reduce and manage runoff near and downstream of the basin, and to improve downstream water quality. A sediment control basin is an earth embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin. The basin should be configured to enhance sediment deposition by using flow deflectors, inlet and outlet selection, or by adjusting the length to width ratio of the creek channel. Additional hydrologic and hydraulic studies should be performed to identify the optimal locations for the sediment control basins. Operation and maintenance costs to maintain the embankment, design capacity, vegetative cover, and outlet of the basin should be considered (NRCS 2002b).

Consultation with the NYSDEC can help determine if, when and how sediment and debris should be managed and whether a permit will be required.

The Rough Order Magnitude cost for this strategy is up to $20,000, not including annual maintenance and operational costs.

8.4 Alternative #4-4: Retention Basin and Wetland Management

Stormwater ponds and wetlands are designed and constructed to contain and / or filter pollutants that flush off of the landscape. Without proper maintenance, nutrients such as nitrogen and phosphorus that are typically found in stormwater runoff can accumulate in stormwater ponds and wetlands leading to degraded conditions such as low dissolved oxygen, algae blooms, unsightly conditions, and odors. Excess sediment from the watershed upstream can also accumulate in wet ponds and wetlands. This sediment can smother the vegetation and clog any filtering structures or outlets. In addition, standing water in ponds can heat up during the summer months. This warmer water is later released into neighboring waters, which can have negative impacts on aquatic life (USEPA 2009b).

Without proper maintenance, excess pollutants in ponds and wetlands may actually become sources of water quality issues such as poor water color / clarity / odor, low dissolved oxygen leading to plant die off, and prevalence of algal blooms. When these ponds and wetlands are “flushed” during a large rain event, the excess nutrients causing these problems may be transferred to the receiving waterbody (USEPA 2009b).

Maintenance is necessary for a stormwater pond or wetland to operate as designed on a long-term basis. The pollutant removal, channel protection, and flood control capabilities of ponds and wetlands will decrease if (USEPA 2009b):

- Sediment accumulates reducing the storage volume
- Debris blocks the outlet structure
- Pipes or the riser are damaged
- Invasive plants take over the planted vegetation
- Slope stabilizing vegetation is lost
- The structural integrity of the embankment, weir, or riser is compromised

Pond and wetland maintenance activities range in terms of the level of effort and expertise required to perform them. Routine pond and wetland maintenance, such as mowing and removing debris or trash, is needed multiple times each year, but can be performed by citizen volunteers. More significant maintenance such as removing accumulated sediment is needed less frequently, but requires more skilled labor and special equipment. Inspection and repair of critical structural features such as embankments and risers, needs to be performed by a qualified professional (e.g., structural engineer) who has experience in the construction, inspection, and repair of these features (USEPA 2009b). Water level management, if control structures are available, can be an effective tool to meet a range of pond and wetland habitat and process management objectives.

Program managers and responsible parties need to recognize and understand that neglecting routine maintenance and inspection can lead to more serious problems that threaten public safety, impact water quality, and require more expensive corrective actions (USEPA 2009b).

8.5 Alternative #4-5: Flood Buyout Program

Buyouts allow state and municipal agencies the ability to purchase developed properties within areas vulnerable to flooding from willing owners. Buyouts are effective management tools in response to natural disasters to reduce or eliminate future losses of vulnerable or repetitive loss properties. Buyout programs include the acquisition of private property, demolition of existing structures, and conversion of land into public space or natural buffers. The land is maintained in an undeveloped state for public use in perpetuity. Buyout programs not only assist individual homeowners, but are also intended to improve the resiliency of the entire community in the following ways (Siders 2013):

- Reduce exposure by limiting the people and infrastructure located in vulnerable areas
- Reduce future disaster response costs and flood insurance payments
- Restore natural buffers such as wetlands in order to reduce future flooding levels
- Reduce or eliminate the need to maintain and repair flood control structures
- Reduce or eliminate the need for public expenditures on emergency response, garbage collection and other municipal services in the area
- Provide open space for the community

Resilience achieved through buyouts can have real economic consequences in addition to improved social resilience. According to FEMA, voluntary buyouts cost $1 for every $2 saved in future insurance claims, an estimate which does not include money saved on flood recovery and response actions, such as local flood fighting, evacuation, and rescue, and recovery expenses that will not be incurred in the future. In order to achieve these goals, buyouts need to acquire a continuous swatch of land, rather than individual homes in isolated areas, or only some of the homes within flood-prone areas (Siders 2013).

Buyout programs can be funded through a combination of federal, state, or local funds, and are generally made available following a nationally recognized disaster. FEMA administers programs to help with buyouts under the Stafford Disaster Act, and the Department of Housing and Urban Development (HUD) administers another program through Community Development Block Grants (CDBG). These funding sources can reduce the economic burden on the local community. However, these funds also come with guidelines and regulations that may constrain policy makers' options on whether to pursue a buyout strategy, and how to shape their programs. FEMA funds may be used to cover 75% of the expenses, but the remaining 25% must come from another non-federal source. In most cases, the buyout must be a cost-effective measure that will substantially reduce the risk of future flooding damage (Siders 2013).

For homes in the SFHA, FEMA has developed precalculated benefits for property acquisition and structure elevation of buildings. Based on a national analysis that derived the average benefits for acquisition and elevation projects, FEMA has determined that acquisition projects that cost $276,000 or less, or elevation projects that costs $175,000 or less, and which are located in the 1% annual chance event (i.e., 100-yr recurrence interval) floodplain are considered cost-effective and do not require a separate benefit-cost analysis. For projects that contain multiple structures, the average cost of all structures in the project must meet the stated criteria. If the cost to acquire or elevate a structure exceeds the amount of benefits listed above, then a traditional FEMA approved benefits-cost analysis must be completed (FEMA 2015).

In the Connoisarauley Creek watershed, there are approximately 136 parcels within the FEMA Zone A (1% annual chance event / 100-yr) flood hazard area. Of the 136 parcels, 68 parcels are classified as residential, while 4 parcels are classified as commercial.

These parcels have a combined full market value of $12.2 million with residential and commercial parcels accounting for $6.1 million and $2.4 million, respectively. Table 21 summarizes the number of parcels and their full market value within the three high-risk flood areas (NYSGPO 2021).

Table 21. Summary Table for Tax Parcels within FEMA Flood Zones in High-risk Areas along Connoisarauley Creek

Source: NYSGPO 2021		
High-risk Flood Area	**Number of Parcels**	**Full Market Value**
#1: Confluence with Cattaraugus Creek	22	$1.3 million
#2: US-219 Corridor Between County Road 12 and Snake Run Road	18	$1.3 million
#3: US-219 Corridor Between Neff Road and Ashford Hollow Road	26	$5.0 million
Total	**66**	**$7.6 million**

According to FEMA severe repetitive loss and repetitive loss data, there are no properties identified as repetitive loss or severe repetitive loss properties within the Connoisarauley Creek watershed (FEMA 2019). However, there are two repetitive loss properties in close proximity to the watershed near the confluence with Cattaraugus Creek, with one of these properties in the Town of East Otto. A Repetitive Loss (RL) property is any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling ten-year period, since 1978. A Severe Repetitive Loss (SRL) property is any insurable building for which four or more claims of more than $5,000 (or cumulative amount exceeding $20,000) were paid by the NFIP, or at least two separate claims payments have been made with the cumulative amount of exceeding the fair market value of the insured building on the day before each loss within any rolling ten-year period, since 1978 (FEMA 2019; FEMA 2020). Figure 8-1 displays the tax parcels that intersect the FEMA flood zones, including generalized locations of FEMA repetitive and severe repetitive loss properties.

Due to the variable nature of buyout programs, no ROM cost estimate was produced for this study. It is recommended that any buyout program begin with a cost-benefit analysis for each property. After a substantial benefit has been established, a buyout strategy study should be developed that focuses on properties closest to Connoisarauley Creek in the highest-risk flood areas and progresses outwards from there to maximize flood damage reductions. In addition, structures located adjacent to flood prone infrastructure (i.e., bridges, culverts, etc.) should also be considered high-risk and prioritized in any buyout program strategy. A potential negative consequence of buyout programs is the permanent removal of properties from the floodplain, and resulting tax revenue, which would have long-term implications for local governments, and should be considered prior to implementing a buyout program.

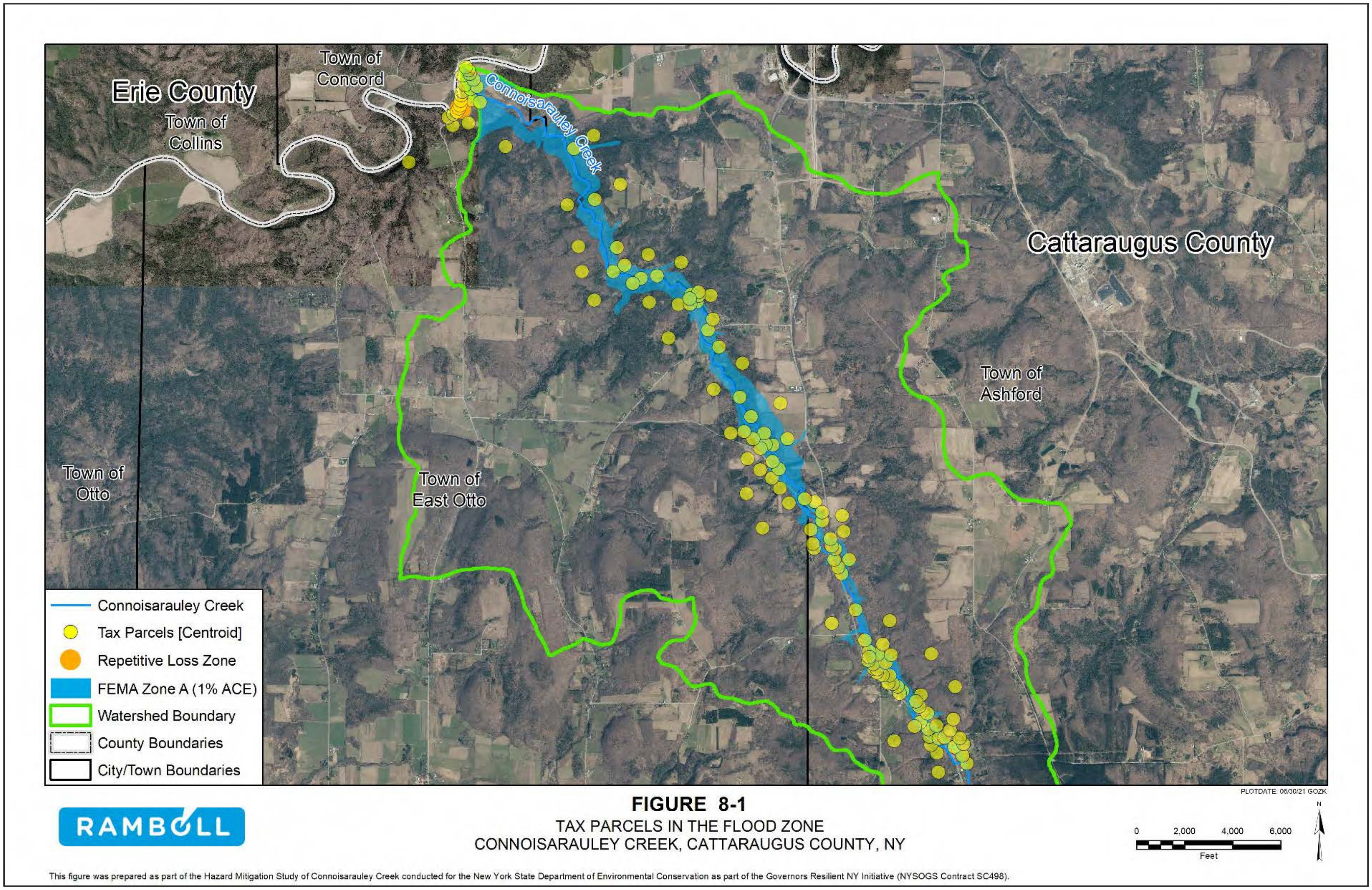

Figure 8-1. Tax parcels within FEMA flood zones, Connoisarauley Creek, East Otto and Ashford, Cattaraugus County, NY.

8.6 Alternative #4-6: Flood Proofing

Floodproofing is defined as any combination of structural or nonstructural adjustments, changes, or actions that reduce or eliminate flood damage to a building, contents, and attendant utilities and equipment (FEMA 2000). Floodproofing can prevent damage to existing buildings and can be used to meet compliance requirements for new construction of residential and non-residential buildings.

The most effective flood mitigation methods are relocation (i.e., moving a home to higher ground outside of a high-risk flood area) and elevation (i.e., raising the entire structure above BFE). The relationship between the BFE and a structure's elevation determines the flood insurance premium. Buildings that are situated at or above the level of the BFE have lower flood risk than buildings below BFE, and tend to have lower insurance premiums than buildings situated below the BFE (FEMA 2015).

In some communities, where non-structural flood mitigation alternatives are not feasible, structural alternatives such as flood proofing may be a viable alternative. The National Flood Insurance Program has specific rules related to flood proofing for residential and non-residential structures. These can be found in the Code of Federal Regulations (CFR) 44 CFR 60.3 (FEMA 2000).

For communities that have been provided an exception by FEMA, the CFR allows for the floodproofing of residential basements as outlined in 44 CFR 60.6 (c) “a permit can be obtained to floodproof a residential building basement, if it can demonstrate an adequate warning time under a flood depth less than 5 feet and a velocity less than 5 fps.” Floodproofing residential basements should be considered during the design phase of a structure prior to construction. For existing structures, floodproofing residential basements can be a difficult, complex, and expensive measure to achieve. Instead, residential structures should be raised above the BFE in accordance with local regulations. Floodproofing is allowed for non-residential structures, with design guidelines outlined in FEMA P-936 – Floodproofing Non-Residential Structures (FEMA 2000; FEMA 2013). The local floodplain administrator should carefully review local ordinances, the CFR and available design guidelines before issuing a permit for structural flood proofing. Floodproofing strategies include:

Interior Modification / Retrofit Measures

Interior modification and retrofitting involve making changes to an existing building to protect it from flood damage. When the mitigation is properly completed in accordance with NFIP floodplain management requirements, interior modification / retrofit measures could achieve the somewhat similar results as elevating a home above the BFE. Keep in mind, in areas where expected base flood depths are high, the flood protection techniques below may not provide protection on their own to the BFE or, where applicable, the locally required freeboard elevation (FEMA 2015).

Examples include:

- *Basement Infill:* This measure involves filling a basement located below the BFE to grade (ground level)

- *Abandon Lowest Floor:* This measure involves abandoning the lowest floor of a two or more story slab-on-grade residential building
- *Elevate Lowest Interior Floor:* This measure involves elevating the lowest interior floor within a residential building with high ceilings

Dry floodproofing

A combination of measures that results in a structure, including the attendant utilities and equipment, being watertight with all elements substantially impermeable to the entrance of floodwater and with structural components having the capacity to resist flood loads (FEMA 2015).

Although NFIP regulations require non-residential buildings to be watertight and protected only to the BFE for floodplain management purposes (to meet NFIP regulations), protection to a higher level is necessary for dry floodproofing measures to be considered for NFIP flood insurance rating purposes. Because of the additional risk associated with dry floodproofed buildings, to receive an insurance rating based on 1% annual chance (100-yr) flood protection, a building must be dry floodproofed to an elevation at least 1-ft above the BFE (FEMA 2013).

Examples include:

- *Passive Dry Floodproofing System*: This measure involves installing a passive (works automatically without human assistance) dry floodproofing system around a home to protect the building from flood damage.
- *Elevation*: This measure involves raising an entire residential or non-residential building structure above BFE.

Wet floodproofing

The use of flood-damage-resistant materials and construction techniques to minimize flood damage to areas below the flood protection level of a structure, which is intentionally allowed to flood (FEMA 2015).

Examples include:

- *Flood Openings*: This measure involves installing openings in foundation and enclosure walls located below the BFE that allow automatic entry and exit of floodwaters to prevent collapse from the pressures of standing water.
- *Elevate Building Utilities*: This measure involves elevating all building utility systems and associated equipment (e.g., furnaces, septic tanks, and electric and gas meters) to protect utilities from damage or loss of function from flooding.
- *Floodproof Building Utilities*: This measure involves floodproofing all building utility systems and associated equipment to protect it from damage or loss of function from flooding.
- *Flood Damage-Resistant Materials*: This measure involves the use of flood damage-resistant materials such as non-paper-faced gypsum board and terrazzo tile flooring for building materials and furnishings located below the BFE to reduce structural and nonstructural damage and post-flood event cleanup.

Barrier Measures

Barriers, such as floodwalls and levees, can be built around single or multiple residential and non-residential buildings to contain or control floodwaters (FEMA 2015). Although floodwalls or levees can be used to keep floodwaters away from buildings, implementing these measures will not affect a building's flood insurance rating unless the flood control structure is accredited in accordance with NFIP requirements (44 CFR §65.10) and provides protection from at least the 1% annual chance (100-yr) flood. Furthermore, floodwalls or levees as a retrofit measure will not bring the building into compliance with NFIP requirements for Substantial Improvement / Damage (FEMA 2013). Barrier measures require ongoing maintenance (i.e., mowing, etc.) which should be factored into any cost analysis. In addition, barrier measures tend to create a false sense of security for the property owners and residents that are protected by them. If a barrier structure is not properly constructed or maintained and fails, catastrophic damages to surrounding areas can occur.

- *Floodwall with Gates and Floodwall without Gates*: These two measures involve installing a reinforced concrete floodwall, which works automatically without human assistance, constructed to a maximum of four feet above grade (ground level). The floodwall with gates is built with passive flood gates that are designed to open or close automatically due to the hydrostatic pressure caused by the floodwater. The floodwall without gates is built using vehicle ramps or pedestrian stairs to avoid the need for passive flood gates.
- *Levee with Gates and Levee without Gates*: These two measures involve installing an earthen levee around a home, which works automatically without human assistance, with a clay or concrete core constructed to a maximum of six feet above grade (ground level). The levee with gates is built with passive flood gates that are designed to open or close automatically due to hydrostatic pressure caused by the floodwater. The levee without gates is built using vehicle access ramps to avoid the need for passive flood gates.

Modifying a residential or non-residential building to protect it from flood damage requires extreme care, will require permits, and may also require complex, engineered designs. Therefore, the following process is recommended to ensure proper and timely completion of any floodproofing project (FEMA 2015):

- Consult a registered design professional (i.e., architect or engineer) who is qualified to deal with the specifics of a flood mitigation project
- Check your community's floodplain management ordinances
- Contact your insurance agent to find out how your flood insurance premium may be affected
- Check what financial assistance might be available
- Hire a qualified contractor
- Contact the local building department to learn about development and permit requirements and to obtain a building permit

- Determine whether the mitigation project will trigger a Substantial Improvement declaration
- See the project through to completion
- Obtain an elevation certificate and an engineering certificate (if necessary)

No cost estimates were prepared for this alternative due to the variable and case-by-case nature of the flood mitigation strategy. Local municipal leaders should contact residential and non-residential building owners that are currently at a high flood risk to inform them about floodproofing measures, the recommended process to complete a floodproofing project, and the associated costs and benefits.

8.7 Alternative #4-7: Area Preservation / Floodplain Ordinances

This alternative proposes municipalities within the Connoisarauley Creek watershed consider watershed and floodplain management practices such as preservation and / or conservation of areas along with land use ordinances that could minimize future development of sensitive areas such as wetlands, forests, riparian areas, and other open spaces. It could also include areas in the floodplain that are currently free from development and providing floodplain storage.

A watershed approach to planning and management is an important part of water protection and restoration efforts. New York State’s watersheds are the basis for management, monitoring, and assessment activities. The NYS Open Space Conservation Plan, NYSDEC’s Smart Growth initiative and the Climate Smart Communities Program address land use within a watershed (NYSDEC 2014). Land use planning should be incorporated into a municipalities comprehensive plan or, if a comprehensive plan does not exist, passed as a series of ordinances that consider more restrictive floodplain development regulations besides the New York State minimum requirements.

Natural floodplains provide flood risk reduction benefits by slowing runoff and storing flood water. They also provide other benefits of considerable economic, social, and environmental value that should be considered in local land-use decisions. Floodplains frequently contain wetlands and other important ecological areas which directly affect the quality of the local environment. Floodplain management is the operation of a community program of preventive and corrective measures to reduce the risk of current and future flooding, resulting in a more resilient community. These measures take a variety of forms, are carried out by multiple stakeholders with a vested interest in responsible floodplain management and generally include requirements for zoning, subdivision, or building, building codes and special-purpose floodplain ordinances. While FEMA has minimum floodplain management standards for communities participating in the National Flood Insurance Program (NFIP), best practices demonstrate the adoption of higher standards which will lead to safer, stronger, and more resilient communities (FEMA 2006).

Further hydrology and hydraulic model scenarios could be performed to illustrate how future watershed and floodplain management techniques could benefit the communities within the Connoisarauley Creek watershed.

8.8 Alternative #4-8: Community Flood Awareness and Preparedness Programs / Education

Disaster resilience encompasses both the principles of preparedness and reaction within the dynamic systems, and focuses responses on bridging the gap between pre-disaster activities and post-disaster intervention, and among structural / non-structural mitigation. Integral to these concepts is the role of the community itself, and how the community adapts to being prepared for disasters and, ultimately, how the community takes on the effort of disaster risk reduction. By consulting the community at risk, the local stakeholder concerns can be taken into consideration, and thus be addressed accordingly in the post-disaster recovery stage (Nifa et al. 2017).

Community flood awareness programs should focus on a multi-scale, holistic strategy of preparedness and resilience, and in this way attempt to achieve a substantial reduction of disaster losses, in lives, and in the social, economic, and environmental assets of the community. This approach should incorporate four functions of flood education (Dufty 2008):

1. Preparedness conversion: learning related to commencing and maintaining preparations for flooding.
2. Mitigation behaviors: learning and putting into practice the appropriate actions for before, during and after a flood.
3. Adaptive capability: learning how to change and maintain adaptive systems (e.g., warning systems) and build community competencies to help minimize the impacts of flooding.
4. Post-flood learnings: learning how to improve preparedness levels, mitigation behaviors and adaptive capability after a flood.

In developing a program, community leaders should consider a commitment to community participation in the design, implementation, and evaluation of flood education programs. A more participatory approach to community flood and other hazards can enhance community resilience to adversity by stimulating participation and collaboration of stakeholders and decision makers in building its capability for preparedness, response, and recovery. In addition, community flood education programs should be ongoing as it is unsure when a flood event will occur (Dufty 2008).

8.9 Alternative #4-9: Development of a Comprehensive Plan

Local governments are responsible for planning in a number of areas, including housing, transportation, water, open space, waste management, energy, and disaster preparedness. In New York State, these planning efforts can be combined into a comprehensive plan that steers investments by local governments and guides future development through zoning regulations. A comprehensive plan will guide the development of government structure as well as natural and built environment.

Significant features of comprehensive planning in most communities include its foundations for land use controls for the purpose of protecting the health, safety, and general welfare of the community's citizens. The plan will focus on immediate and long-range protection, enhancement, growth, and development of a community's assets. Materials included in the comprehensive plan will include text and graphics, including but not limited to maps, charts, studies, resolutions, reports, and other descriptive materials. Once the comprehensive plan is completed, the governing board motions to adopt it, i.e., town or village board (EFC 2015).

Development of a comprehensive plan in general is optional, as is the development of a plan in accordance with state comprehensive plan statutes. However, statutes can guide plan developers through the process. Comprehensive plans provide the following benefits to municipal leaders and community members (EFC 2015):

- Provides a legal defense for regulations
- Provides a basis for other actions affecting the development of the community (i.e., land use planning and zoning)
- Helps establish policies relating to the creation and enhancement of community assets

All communities within the watershed should develop or update their respective comprehensive plans in an effort to coordinate and manage any and all land use changes and development within the Connoisarauley Creek floodplain.

In addition, any comprehensive plan developed for communities within the watershed should include future climate change and NYS Smart Growth practices. Local governments should incorporate sustainability elements throughout the comprehensive plan. “Future-proofing” management and mitigation strategies by taking climate change into consideration would ensure that any strategy pursued would have the greatest possible chance for success. NYS Smart Growth practices would maximize the social, economic, and environmental benefits from public infrastructure development, while minimizing unnecessary environmental degradation, and disinvestment in urban and suburban communities caused by the development of new or expanded infrastructure.

9. NEXT STEPS

Before selecting a flood mitigation strategy, securing funding, or commencing an engineering design phase, Ramboll recommends that additional modeling simulations and wetland investigations be performed.

9.1 ADDITIONAL DATA MODELING

Additional data collection and modeling would be necessary to more precisely model water surface elevations and the extent of potential flooding in overbank areas and the floodplain. 2-D unsteady flow modeling using the HEC-RAS program, would incorporate additional spatial information in model simulations producing more robust results with a higher degree of confidence than the currently modeled 1-D steady flow simulations. 2-D ice simulations are highly recommended to access the wintery condition with the suggested alternatives to evaluate the water level rises due to presence of ice, ice-jam, or break-up ice jam conditions.

9.2 STATE / FEDERAL WETLANDS INVESTIGATION

Any flood mitigation strategy that proposes using wetlands in any capacity, needs to be evaluated based on federal and state wetland criteria before that mitigation strategy can be pursued for consideration.

9.3 NYSDEC PROTECTION OF WATERS PROGRAM

Connoisarauley Creek is protected under Article 15 of Title 6 of the New York Codes, Rules, and Regulations (6NYCRR Part 608). Connoisarauley Creek has a designation as classification B (TS), which indicates the waterway is best used for swimming and other contact recreation, but not for drinking water, and has the potential to support trout populations and spawning. Any changes to the bed or bank of Connoisarauley Creek would need to be reviewed and approved by the NYSDEC (NYSDEC 2020c; NYSDEC 2021).

9.4 EXAMPLE FUNDING SOURCES

There are numerous potential funding programs and grants for flood mitigation projects that may be used to offset municipal financing, including:

- New York State Office of Emergency Management (NYSOEM)
- New York State Department of Transportation Bridge NY Program
- Regional Economic Development Councils / Consolidated Funding Applications (CFA)
- Natural Resources Conservation Services (NRCS) Emergency Watershed Protection (EWP) Program
- FEMA’s Unified Hazard Mitigation Assistance (HMA) Program

- FEMA's Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act
- USACE Continuing Authorities Program (CAP)

9.4.1 NYS Office of Emergency Management (NYSOEM)

The NYSOEM, through the U.S. Department of Homeland Security (DHS), offers several funding opportunities under the Homeland Security Grant Program (HSGP). The priority for these programs is to provide resources to strengthen national preparedness for catastrophic events. These include improvements to cybersecurity, economic recovery, housing, infrastructure systems, natural and cultural resources, and supply chain integrity and security. In 2018, there was no cost share or match requirement.

9.4.2 NYSDOT Bridge NY Program

The NYSDOT, in accordance with Governor Andrew Cuomo's infrastructure initiatives, announced the creation of the Bridge NY program. The Bridge NY program provides enhanced assistance for local governments to rehabilitate and replace bridges and culverts. Particular emphasis will be provided for projects that address poor structural conditions; mitigate weight restrictions or detours; facilitate economic development or increase competitiveness; improve resiliency and / or reduce the risk of flooding.

The program is currently open and accepting applications from local municipalities through the State Fiscal Years 2020-21 and 2021-22. A minimum of $200 million was made available for awards in enhanced funding under the Bridge NY program for local system projects during the two-year period. More funding may be added to either the bridge or culvert program if it becomes available after the announcement of the solicitation

Current program draft application submittals for pre-review must be received by April 14, 2021 for culvert applications, and May 5, 2021 for bridge applications.

9.4.3 Regional Economic Development Councils / Consolidated Funding Applications (CFA)

The Consolidated Funding Application is a single application for state economic development resources from numerous state agencies. The ninth round of the CFA was offered in 2019.

9.4.3.1 Water Quality Improvement Project (WQIP) Program

The Water Quality Improvement Project Program, administered through the Department of Environmental Conservation, is a statewide reimbursement grant program to address documented water quality impairments. Eligible parties include local governments and not-for-profit corporations. Funding is available for construction / implementation projects; projects exclusively for planning are not eligible. Match for WQIP is a percentage of the award amount, not the total project cost. Deadlines are in accordance with the CFA application cycle.

9.4.3.2 Climate Smart Communities (CSC) Grant Program

The Climate Smart Communities (CSC) Grant Program is a 50/50 matching grant program for municipalities under the New York State Environmental Protection Fund, offered through the CFA by the NYS Office of Climate Change. The purpose of the program is to fund climate change adaptation and mitigation projects, and includes support for projects that are part of a strategy to become a Certified Climate Smart Community. The eligible project types that may be relevant include the following:

- The construction of natural resiliency measures, conservation or restoration of riparian areas and tidal marsh migration areas
- Nature-based solutions such as wetland protections to address physical climate risk due to water level rise, and / or storm surges and / or flooding
- Relocation or retrofit of facilities to address physical climate risk due to water level rise, and / or storm surges and / or flooding
- Flood risk reduction
- Climate change adaptation planning and supporting studies

Eligible projects include implementation and certification projects. Deadlines are in accordance with the CFA cycle.

9.4.4 NRCS Emergency Watershed Protection (EWP) Program

Through the Emergency Watershed Protection (EWP) Program, the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) can assist communities in addressing watershed impairments that pose imminent threats to lives and property. Most EWP projects involve the protection of threatened infrastructure from continued stream erosion. Projects must have a project sponsor, defined as a legal subdivision of the state, such as a city, county, general improvement district, or conservation district, or an Indian Tribe or Tribal organization. Sponsors are responsible for providing land rights to do repair work, securing the necessary permits, furnishing the local cost share (25%), and performing any necessary operation and maintenance for a ten-year period. Through EWP, the NRCS may pay up to 75% of the construction costs of emergency measures, with up to 90% paid for projects in limited-resource areas. The remaining costs must come from local services. Eligible projects include, but are not limited to, debris-clogged stream channels, undermined and unstable streambanks, and jeopardized water control structures and public infrastructures.

9.4.5 FEMA Hazard Mitigation Grant Program (HMGP)

The Federal Emergency Management Agency's Hazard Mitigation Grant Program (HMGP), offered by the New York State Division of Homeland Security and Emergency Services (NYSDHSES), provides funding for creating / updating hazard mitigation plans and implementing hazard mitigation projects. The HMA program consolidates the application process for FEMA's annual mitigation grant programs not tied to a state's Presidential disaster declaration. Funds are available under the Building Resilient

Infrastructure and Communities (BRIC) and the Flood Mitigation Assistance (FMA) Programs.

For flood mitigation measures that are being considered for funding through FEMA grant programs, a benefit-to-cost analysis will be required. In order to qualify for FEMA grants and / or funding, the benefit to cost ratio must be greater than one.

9.4.5.1 Building Resilient Infrastructure and Communities (BRIC)

Beginning in 2020, the Building Resilient Infrastructure and Communities grant program, which was created as part of Disaster Recovery Reform Act of 2018 (DRRA), replaced the existing Pre-Disaster Mitigation (PDM) program and is funded by a 6% set-aside from federal post-disaster grant expenditures. BRIC will support states, local communities, tribes and territories as they undertake hazard mitigation projects, reducing the risks they face from disasters and natural hazards. BRIC aims to categorically shift the federal focus away from reactive disaster spending and toward research-supported, proactive investment in community resilience. Through BRIC, FEMA will invest in a wide variety of mitigation activities, including community-wide public infrastructure projects. Moreover, FEMA anticipates BRIC will fund projects that demonstrate innovative approaches to partnerships, such as shared funding mechanisms and / or project design.

9.4.5.2 Flood Mitigation Assistance (FMA) Program

The Flood Mitigation Assistance Program provides resources to reduce or eliminate long-term risk of flood damage to structures insured under the National Flood Insurance Program. The FMA project funding categories include Community Flood Mitigation – Advance Assistance (up to $200,000 total federal share funding) and Community Flood Mitigation Projects (up to $10 million total). Federal funding is available for up to 75% of the eligible activity costs. FEMA may contribute up to 100% federal cost share for severe repetitive loss properties, and up to 90% cost share for repetitive loss properties. Eligible project activities include the following:

- Infrastructure protective measures
- Floodwater storage and diversion
- Utility protective measures
- Stormwater management
- Wetland restoration / creation
- Aquifer storage and recovery
- Localized flood control to protect critical facility
- Floodplain and stream restoration
- Water and sanitary sewer system protective measures

9.4.6 FEMA's Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act

The STORM Act provides capitalization grants to participating states and tribes in order to loan money to local governments for hazard mitigation projects to reduce risks from disasters and natural hazards. The act states that $100 million would be authorized for fiscal years 2022 and 2023. As loans are repaid, the funds are available for other mitigation project loans.

This "resilience revolving loan fund" will be eligible for projects intended to protect against wildfires, earthquakes, flooding, storm surges, chemical spills, seepage resulting from chemical spills and floods, and any other event deemed catastrophic by FEMA. These low-interest funds will allow for cities and states to repay the loan with savings from mitigation projects. It also gives states and localities the flexibility to respond to oncoming disasters without paying high-interest rates so that they can invest in their communities.

9.4.7 USACE Continuing Authorities Program (CAP)

The Corps' Continuing Authorities Program (CAP) is a group of nine legislative authorities under which the Corps of Engineers can plan, design, and implement certain types of water resources projects without additional project specific congressional authorization. The purpose of the CAP is to plan and implement projects of limited size, cost, scope and complexity. Table 22 lists the CAP authorities and their project purposes (USACE 2019a).

Table 22. USACE Continuing Authorities Program (CAP) Authorities and Project Purposes

(Source: USACE 2019a)	
Authority	**Project Purpose**
Section 14, Flood Control Act of 1946, as amended	Streambank and shoreline erosion protection of public works and non-profit public services
Section 103, River and Harbor Act of 1962, as amended (amends Public Law 79-727)	Beach erosion and hurricane and storm damage reduction
Section 107, River and Harbor Act of 1960, as amended	Navigation improvements
Section 111, River and Harbor Act of 1968, as amended	Shore damage prevention or mitigation caused by Federal navigation projects
Section 204, Water Resources Development Act of 1992, as amended	Beneficial uses of dredged material
Section 205, Flood Control Act of 1948, as amended	Flood control
Section 206, Water Resources Development Act of 1996, as amended	Aquatic ecosystem restoration
Section 208, Flood Control Act of 1954, as amended (amends Section 2, Flood Control Act of August 28, 1937)	Removal of obstructions, clearing channels for flood control
Section 1135, Water Resources Development Act of 1986, as amended	Project modifications for improvement of the environment

All projects in this program include a feasibility phase and an implementation phase. Planning activities, such as development of alternative plans to achieve the project goals, initial design and cost estimating, environmental analyses, and real estate evaluations, are performed during the feasibility phase, to develop enough information to decide whether to implement the project. The feasibility phase is initially Federally funded up to $100,000. Any remaining feasibility phase costs are shared 50/50 with the non-Federal sponsor after executing a feasibility cost sharing agreement (FCSA). The final design, preparation of contract plans and specifications, permitting, real estate acquisition, project contracting and construction, and any other activities required to construct or implement the approved project are completed during the implementation phase. The Corps and the non-federal sponsor sign a project partnership agreement (PPA) near the beginning of the implementation phase. Costs beyond the feasibility phase are shared as specified in the authorizing legislation for that section (USACE 2019a).

10. SUMMARY

The Towns of East Otto and Ashford have had a history of flooding and landslide events along Connoisarauley Creek. Flooding and landslides in the Towns primarily occur during the summer and winters months due to heavy rains by convective systems and snow melt / rain on snow events. In response to persistent flooding, the State of New York in conjunction with the Towns of East Otto and Ashford and Cattaraugus County, are studying and evaluating potential flood mitigation projects for Connoisarauley Creek as part of the Resilient NY Initiative.

This report analyzed the historical and present day causes of flooding in the Connoisarauley Creek watershed. Hydraulic and hydrologic data was used to model potential flood mitigation measures. The model simulation results indicated that there are flood mitigation measures that have the potential to reduce water surface elevations along high-risk areas, which could potentially reduce flood related damages in areas adjacent to the creek.

Based on the flood mitigation analyses performed in this report, the mitigation measures that provided the greatest reductions in water surface elevations where the measures related to increasing the size of different infrastructure, including US-219 (2) and (3) and Hammond Hill Road.

There would be an overall greater effect in water surface elevations if multiple alternatives were built in different phases, rather than a single mitigation project. For example, building multiple flood benches along a single reach or upsizing infrastructure with a flood bench would compound the flood mitigation benefits of each measure.

Based on the analysis of the bridge and culvert widening simulations, each infrastructure crossing measure benefited from increased structural openings. However, the infrastructure upsizing measures are the costliest of the discussed flood mitigation measures. The benefits of the measures in their respective reaches should be balanced with the associated costs of each infrastructure upsizing measure to determine if it would be feasible to move the measure forward. In addition, other complications, such as traffic re-routing, should be taken into account when considering any of the infrastructure upsizing measures.

The flood bench measures discussed for Connoisarauley Creek would provide moderate flood mitigation benefits in their respective reaches. Flood benches, however, generally only benefit the areas immediately adjacent to and upstream of the constructed bench. Due to the rural and sparsely developed nature of the watershed, the location of the flood bench would be paramount to maximize its effectiveness of reducing flood risk within a reach. In addition, flood bench measures generally tend to be the costliest of flood mitigation projects when compared to other measures discussed in this report. The benefits of these measures in their respective reaches should be balanced with the associated costs of each flood bench measure to determine if it would be feasible to move a flood bench project forward.

The debris maintenance around waterway crossing infrastructure, riparian restoration, and retention basin and wetland management measures would maintain the flow channel area in Connoisarauley Creek, help to reduce and / or manage runoff into the waterway during precipitation events, trap and / or reduce sediment entering the waterway, and improve overall water quality. Sediment and debris that enters the waterway reduces the channel flow area, which over time can reduce the flow capacity of the channel and potentially lead to greater occurrences of and more damaging flooding.

Levees are effective at managing flood risk within a watershed when properly designed, constructed, and maintained. However, levees do not remove properties from flood zones so flood insurance would still be required for any property behind a levee. In addition, regulatory and permitting requirements for constructing and maintaining levees must be considered for any levee measure.

Floodproofing and flood buyout programs are effective mitigation measures but require large financial investments in individual residential and non-residential buildings. Floodproofing can reduce the future risk and flood damage potential, but leaves buildings in flood risk areas so that potential for future flood damages remains. Flood buyout programs eventually lead to the removal of buildings from the floodplain. A benefit to floodproofing versus buyouts is that properties remain in the Village and the tax base for the local municipality remains intact. Floodproofing versus flood buyouts should be considered on a case-by-case basis with all associated benefits and drawbacks.

For flood mitigation measures that are being considered for funding through FEMA grant programs, a benefit-to-cost analysis will be required. In order to qualify for FEMA grants and / or funding, the benefit to cost ratio must be greater than one. Flood buyouts / property acquisitions can qualify for FEMA grant programs with a 75% match of funds. The remaining 25% of funds is the responsibility of state, county, and local governments. The case-by-case nature of buyouts and acquisitions requires widespread property owner participation to maximize flood risk reductions. An unintended consequence of buyout programs is the permanent removal of properties from the floodplain, including tax revenue, which would have long-term implications for local governments and should be considered prior to implementing a buyout program.

Table 23 is a summary of the proposed flood mitigation measures, including benefits related to the mitigation alternative, and estimated ROM costs.

Table 23. Summary of Flood Mitigation Measures

Alternative No.	Description	Benefits Related to Alternative	ROM cost ($U.S. dollars)
1-1	Flood Bench Near Confluence with Cattaraugus Creek	Model simulated WSEL reductions of up to 1.5 ft	$680,000 [i]
1-2	Levee Upstream of Confluence with Cattaraugus Creek	No model simulated upstream or downstream effects	$1.02 million [ii]
1-3	Increase Size of Hammond Hill Road Bridge Opening	Model simulated WSEL reductions of up to 3.8 ft	$1.4 million [i]
1-4	Streambank Stabilization Upstream of Confluence with Cattaraugus Creek	Reduce force of flowing water and / or increase resistance of the bank to erosion	N/A [iii]
1-5	Sediment / Debris Retention Basin Upstream of Confluence with Cattaraugus Creek	Limits flood extents and depths downstream and helps with sediment transport	N/A [iiii]
2-1	Flood Benches Upstream of US-219 (1)	Model simulated WSEL reductions for each flood bench: Flood Bench A: up to 1.7 ft Flood Bench B: up to 2.2 ft Flood Bench C: up to 1.1 ft	Flood Bench A: $180,000 Flood Bench B: $230,000 Flood Bench C: $250,000 [i]
2-2	Streambank Stabilization Upstream of US-219 (1)	Reduce force of flowing water and / or increase resistance of the bank to erosion	N/A [iii]
3-1	Streambank Stabilization Upstream of the Montagues Dam	Reduce force of flowing water and / or increase resistance of the bank to erosion	N/A [iii]
3-2	Flood Bench Upstream of the Montagues Dam	Model simulated WSEL reductions of up to 1.3 ft	$390,000 [i]
3-3	Increase Size of US-219 (2) Bridge Opening	Model simulated WSEL reductions of up to 2.7 ft	$1.05 million [i]

Alternative No.	Description	Benefits Related to Alternative	ROM cost ($U.S. dollars)
3-4	Flood Benches Upstream of US-219 (2)	Model simulated WSEL reductions for each flood bench: Flood Bench A: up to 1.4 ft Flood Bench B: up to 0.8 ft	Flood Bench A: $320,000 Flood Bench B: $460,000 [i]
3-5	Increase Size of US-219 (3) Culvert Opening	Model simulated WSEL reductions of up to 2.4 ft	$1.04 million [i]
4-1	Early-warning Flood Detection System	Early flood warning for open-water and ice-jam events	$120,000 (not including annual operational costs)
4-2	Riparian Restoration	Restores natural habitats, reduces / manages runoff, and improves water quality	Variable (case-by-case)
4-3	Debris Maintenance Around Culverts / Bridges	Maintains channel flow area and reduces flood risk	$20,000 (not including annual operational costs)
4-4	Retention Basin and Wetland Management	Reduces erosion, traps sediments, reduces / manages runoff, and improves water quality	Variable (case-by-case)
4-5	Flood Buyouts / Property Acquisitions	Reduces and / or eliminates future losses	Variable (case-by-case)
4-6	Floodproofing	Reduces and / or eliminates future damages	Variable (case-by-case)
4-7	Area Preservation / Floodplain Ordinances	Reduces and / or eliminates future losses	Variable (case-by-case)

Alternative No.	Description	Benefits Related to Alternative	ROM cost ($U.S. dollars)
4-8	Community Flood Awareness and Preparedness Programs / Education	Engages the community to actively participate in flood mitigation and better understand flood risks	Variable (case-by-case)
4-9	Development of a Comprehensive Plan	Guides future development, provides legal defense for regulations, and helps establish policies related to community assets	Variable (case-by-case)

[i] Note: ROM cost does not include land acquisition costs for survey, appraisal, and engineering coordination.

[ii] Note: ROM cost does not include annual maintenance or land acquisition costs for survey, appraisal, and engineering coordination.

[iii] Note: Due to the variable, conceptual, and site specific nature of streambank stabilization strategies, no ROM costs were determined for this measure.

[iiii] Note: Due to the variable nature of identifying, designing, and constructing a sediment retention basin, no ROM costs were determined for this alternative.

11. CONCLUSION

Municipalities affected by flooding along Connoisarauley Creek can use this report to support flood mitigation initiatives within their communities. This report is intended to be a high-level overview of potential flood mitigation strategies, their impacts on water surface elevations, and the associated ROM cost for each mitigation strategy. The research and analysis that went into each mitigation strategy should be considered preliminary, and additional research, field observations, and modeling are recommended before final mitigation strategies are chosen.

In order to implement the flood mitigation strategies discussed in this report, communities should engage in a process that follows the following steps:

1. Obtain stakeholder and public input to assess the feasibility and public support of each mitigation strategy presented in this report.
2. Complete additional data collection and modeling efforts to assess the effectiveness of the proposed flood mitigation strategies.
3. Develop a list of final flood mitigation strategies based on the additional data collection and modeling results.
4. Select a final flood mitigation strategy or series of strategies to be completed for Connoisarauley Creek based on feasibility, permitting, effectiveness, and available funding.
5. Develop a preliminary engineering design report and cost estimate for each selected mitigation strategy.
6. Assess funding sources for the selected flood mitigation strategy.

Once funding has been secured and the engineering design has been completed for the final mitigation strategy, construction and / or implementation of the measure should begin.

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