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# SHERMAN BROOK WATERSHED FLOOD MITIGATION STUDY

# SHERMAN BROOK, ONEIDA COUNTY, NEW YORK

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Ramboll Americas Engineering Solutions, Inc.

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## ACRONYMS/ABBREVIATIONS

| | |
|---|---|
| 1-D, 2-D | 1- and 2-Dimensional |
| ACE | Annual Chance Flood Event |
| BCC | Bird of Conservation Concern |
| BCR | Bird Conservation Region |
| BFE | Base Flood Elevation |
| BRIC | Building Resilient Infrastructure and Communities |
| CAP | Continuing Authorities Program |
| 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 |
| CSC | Climate Smart Communities |
| DEM | Digital Elevation Model |
| DHS | Department of Homeland Security |
| DRRA | Disaster Recovery Reform Act of 2018 |
| EWP | Emergency Watershed Protection Program |
| FCSA | Feasibility Cost Sharing Agreement |
| FEMA | Federal Emergency Management Agency |
| FIRM | Flood Insurance Rate Maps |
| FIS | Flood Insurance Study |
| FMA | Flood Mitigation Assistance |
| GIS | Geographic Information System |
| H&H | Hydrologic and Hydraulic |
| HEC | Hydrologic Engineering Center |
| HEC-RAS | Hydrologic Engineering Center River Analysis System |
| HMA | Hazard Mitigation Assistance |
| HMGP | Hazard Mitigation Grant Program |
| HSGP | Homeland Security Grant Program |
| HUD | United States Department of Housing and Urban Development |
| IPaC | Information for Planning and Consultation |
| LiDAR | Light Detection and Ranging |
| LOMR | Letter of Map Revision |
| MSC | Map Service Center |
| NAD83 | North American Datum of 1983 |
| NAVD88 | North American Vertical Datum of 1988 |
| NCEI | National Centers for Environmental Information |
| NFIP | National Flood Insurance Program |
| NGVD29 | National Geodetic Vertical Datum of 1929 |
| NLCD | National Land Cover Database |
| 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 |
| 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 |
| PPA | Project Partnership agreement |
| RAMBOLL | Ramboll Americas Engineering Solutions, Inc. |
| RC | Circularity Ratio |
| RE | Elongation Ratio |
| REHAB | Watershed Rehabilitation Program |
| RF | Form Factor |
| RL | Repetitive Loss |
| ROM | Rough Order of Magnitude |
| SFHA | Special Flood Hazard Areas |
| SRL | Severe Repetitive Loss |
| STORM | Safeguarding Tomorrow through Ongoing Risk Mitigation Act |
| USACE | United States Army Corps of Engineers |
| USDA | United States Department of Agriculture |
| USGS | United States Geologic Survey |
| UTM | Universal Transverse Mercator |
| WFPO | Watershed Protection and Flood Prevention Operations Program |
| WQIP | Water Quality Improvement Project |
| WRI | Water Resources Investigation |
| WSEL | Water Surface Elevation |

# 1. EXECUTIVE SUMMARY

## 1.1 Challenge

Sherman Brook is located in the south-central part of Oneida County, New York (NY) and runs through the Town of Kirkland and Village of Clinton. In the most recent decade, Sherman Brook has become the source of devastating flooding which has cost over a million dollars in damages to nearby residential and commercial properties, agricultural and recreational fields, roadways and infrastructure.

Sherman Brook has historically flooded throughout the year, however most major flooding has occurred in the months of April, May, and June with the combination of heavy spring rains and snowmelt. Storms resulting in floods in the early summer months are often associated with tropical storms moving north along the Atlantic coast. The Town of Kirkland, Village of Clinton, and Oneida County have reported 12 flash flood occurrences in the past 23 years. Between the Town of Kirkland and the Village of Clinton, the flooding damages have cost the municipalities $595,000 from heavy rains and overflowing channels, including Sherman Brook (NCEI 2023).

The Town of Kirkland has commissioned a comprehensive flood study to assess the root causes of flooding along the Sherman Brook corridor including identifying and evaluating flood mitigation strategies for present day and future storm events.

## 1.2 Solution

The Town of Kirkland engaged Ramboll Americas Engineering Solutions, Inc. (Ramboll) to conduct the comprehensive flood study. The study included a review of historic and climate change hydrological and meteorological data and historical flood reports, community engagement meetings, field assessment, development of updated hydrologic and hydraulic (H&H) modeling to determine current and potential future flooding for high-risk areas, and to evaluate the effectiveness of proposed flood mitigation strategies.

Three in-person project engagement meetings were held on February 16, 2023; June 01, 2023; and October 18, 2023, with representatives of Ramboll, Highland Planning, Town of Kirkland, Village of Clinton, Herkimer-Oneida Counties Comprehensive Planning Program, NYSDEC, and NYSDOT (Appendix A). The outreach effort assisted in the identification of current high-risk areas to focus on during the future flood risk assessments.

Following the initial data gathering, Ramboll undertook field data collection efforts with special attention given to high-risk areas in the Towns of Kirkland and Village of Clinton in Oneida County. Initial field assessments of Sherman Brook were conducted in December of 2022. Additional field assessments were conducted in July 2023 on the Unnamed Tributary (Tributary #2) to Sherman Brook.

Current future climate change projection models indicate an increase in nearly all communities in New York State. In the report, the end of design life multiplier estimates for projected future discharges were the recommended methodology to account for projected climate change trends. For Sherman Brook, the recommended design-flow multiplier is 20% for an end of design life for a structure between 2025 and 2100 (Burns et al. 2015; NYSDEC 2018).

The review of existing reports, historic flooding, and stakeholder input at the public engagement meeting, six areas along Sherman Brook were identified as high-risk flood areas:

1. Craig Road
2. Upstream of New Street
3. Kiwanis Memorial Field
4. Utica Street
5. Upstream of Kirkland Avenue
6. Unnamed Tributary #2

The following are proposed flood mitigation strategies that were evaluated along Sherman Brook based on the location of the six high-risk areas. Table 1 shows the modelling approach for each proposed mitigation alternative along Sherman brook.

**Table 1. The Modelling Approach for Each Proposed Mitigation Alternative along Sherman Brook**

| Alternative No. | Proposed Mitigation Alternative Description |
|---|---|
| 1-1 | Increase Hydraulic Capacity of the Craig Road Culvert |
| 2-1 | Bank and Channel Stabilization and Grade Control Structures Upstream of New Street |
| 2-2 | Natural Stream Restoration Upstream of New Street |
| 2-3 | Increase Hydraulic Capacity of the New Street Culvert |
| 3-1 | Bank and Channel Stabilization Adjacent to Kiwanis Memorial Field |
| 3-2 | Flood Bench within Kiwanis Memorial Field Area |
| 3-3 | Increase Hydraulic Capacity of Beatty Avenue Bridge |
| 4-1 | Flood Bench Located Upstream of Utica Street |
| 4-2 | Increase Hydraulic Capacity of the Utica Street Culvert |
| 5-1 | Bank and Channel Stabilization Upstream of Kirkland Avenue |
| 5-2 | Natural Stream Restoration Upstream of Kirkland Avenue |
| 5-3 | Flood Benches Upstream of Kirkland Avenue |
| 5-4 | Increase Hydraulic Capacity of the Kirkland Avenue Bridge |
| 5-5 | Overflow Open Channel and Two New Culverts on Old Kirkland Avenue and Kirkland Avenue |
| 6-1 | Revitalization of Earthen Dam |
| 6-2 | Removal of Earthen Dam |
| 6-3 | Sediment Trap Upstream of Kellogg Street |

In addition, there are a number of basin-wide flood mitigation alternatives that could potentially benefit homeowners and stakeholders throughout the Sherman Brook watershed. These basin-wide strategies include:

- Alternative #7-1: Sherman Brook Sediment and Debris Management Study
- Alternative #7-2: Early-Warning Flood Detection
- Alternative #7-3: Riparian Restoration
- Alternative #7-4: Debris Maintenance around Infrastructure
- Alternative #7-5: Flood Buyout Programs
- Alternative #7-6: Floodproofing
- Alternative #7-7: Area Preservation/Floodplain Ordinances
- Alternative #7-8: Community Flood Awareness and Preparedness Programs/Education
- Alternative #7-9: Development/Updating of a Comprehensive Plan

## 1.3 RESULTS

The research and analysis that supported each proposed mitigation alternative in this study should be considered preliminary but provides the guidance necessary for implementation of the proposed solutions identified for each high-risk area. Additional design and hydraulic modeling and analyses would be necessary to implement many of the strategies discussed within this study. A comprehensive, organized, effective flood mitigation plan outlines a path for successful results in improving flood resiliency throughout the watershed.

Next steps to implement a flood mitigation project would involve obtaining stakeholder and public input to assess feasibility and support; completing additional technical analyses, as needed; selection of preferred flood mitigation projects; development of preliminary engineering design reports; and assessing and obtaining funding sources.

Funding sources can cover up to 100% of awarded funds, such as grants, or a percentage of the total funds awarded, like matching or cost-sharing programs, and can be awarded for both design and permitting, or construction. These types of awards are available from federal, state, and local agencies or non-governmental organizations (NGO).

Table 2 summarizes the flood mitigation benefits of each alternative proposed in this study based on the results of the technical analysis.

**Table 2. Summary of Flood Mitigation Measures**

| Alternative No. | Description | Benefits Related to Alternative | ROM Cost Estimate ($ US Dollars) |
|---|---|---|---|
| **1-1** | Increased Hydraulic Capacity of Craig Road | 1-D model simulated WSEL reductions of up to **0.2-ft**. | $260,000[1] |
| **2-1** | Bank and Channel Stabilization | Reduction in bank and channel erosion, lower flow velocities, and decreases in sediment accumulation | Variable[2] |
| **2-2** | Natural Stream Restoration | Restores natural habitats, reduces/manages runoff, and improves water quality | $760,000[1] |
| **2-3** | Increased Hydraulic Capacity of New Street | 1-D model simulated WSEL reductions of up to **4.7-ft**. | $310,000[1] |
| **3-1** | Bank and Channel Stabilization | Reduction in bank and channel erosion, lower flow velocities, and decreases in sediment accumulation | Variable[2] |
| **3-2** | Flood Bench on Kiwanis Memorial Field | 1-D model simulated WSEL reductions of up to **2.8-ft**. | $1.4 million[1] |
| | | 2-D model simulated WSEL reductions of up to **1.6-ft**. during the 2019 Halloween Storm | |
| **3-3** | Increased Hydraulic Capacity of Beatty Avenue | 1-D model simulated WSEL reductions of up to **1.0-ft**. | $2.3 million[1] |
| | | 2-D model simulated WSEL reductions of up to **1.4-ft**. | |
| **4-1** | Flood Bench located Upstream of Utica Street | 1-D model simulated WSEL reductions of up to **2.8-ft**. | $2.5 million[1] |
| | | 2-D model simulated WSEL reductions of up to **1.7-ft**. | |
| **4-2** | Increased Hydraulic Capacity of Utica Street | 1-D model simulated WSEL reductions of up to **0.6-ft**. | $410,000[1] |
| **5-1** | Bank and Channel Stabilization | Reduction in bank and channel erosion, lower flow velocities, and decreases in sediment accumulation | Variable[2] |
| **5-2** | Natural Stream Restoration | Restores natural habitats, reduces/manages runoff, and improves water quality | $670,000[1] |

| Alternative No. | Description | Benefits Related to Alternative | ROM Cost Estimate ($ US Dollars) |
|---|---|---|---|
| **5-3** | Flood Benches | 1-D model simulated WSEL reductions of:<br>• Flood Bench A: up to **2.4-ft**.<br>• Flood Bench B: up to **1.1-ft**. | A: \$5.2 million[1]<br>B: \$1.2 million[1] |
| **5-4** | Increased Hydraulic Capacity of Kirkland Avenue | 1-D model simulated WSEL reductions of up to **1.3-ft**. | \$5.1 million[1] |
| **5-5** | Overflow Open-water Channel and New Culverts on Old Kirkland Avenue and Kirkland Avenue | 1-D model simulated WSEL reductions of up to **1.2-ft**. | \$1.2 million[1] |
| | | 2-D model simulated WSEL reductions of up to **0.1-ft**. | |
| **6-1** | Revitalization of Earthen Dam | 1-D model simulated WSEL reductions of up to **0.0-ft**. | \$500,000[1] |
| **6-2** | Removal of Earthen Dam | 1-D model simulated WSEL reductions of up to **0.0-ft**. | \$510,000[1] |
| **6-3** | Sediment trap Upstream of Kellogg Street | Reduce watercourse and gully erosion, trap sediment, and improve downstream water quality in one location rather than maintaining an entire watercourse reach | Variable[2] |
| **7-1** | Sherman Brook Sediment & Debris Management Study | Identify areas where sediment and debris build-up contribute to flooding risk and develop a management plan with specific strategies to reduce those risks | \$80,000 |
| **7-2** | Early-warning Flood Detection System | Early-warning alarm for open-water and ice-jam events | \$500,000[2] |
| **7-3** | Riparian Restoration | Restores natural habitats, reduces/manages runoff, and improves water quality | Variable (case-by-case) |
| **7-4** | Debris Maintenance Around Culverts/Bridges | Maintains channel flow area and reduces flood risk | \$20,000[1] |

| **Alternative No.** | **Description** | **Benefits Related to Alternative** | **ROM Cost Estimate** ($ US Dollars) |
|---|---|---|---|
| **7-5** | Flood Buyouts/Property Acquisitions | Reduces and/or eliminates future losses | Variable (case-by-case) |
| **7-6** | Floodproofing | Reduces and/or eliminates future damages | Variable (case-by-case) |
| **7-7** | Area Preservation/Floodplain Ordinances | Reduces and/or eliminates future losses | Variable (case-by-case) |
| **7-8** | 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) |
| **7-9** | 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) |

[1] Note: Due to the conceptual nature of this measure, and significant amount of data required to produce a reasonable ROM cost, it is not feasible to quantify the costs of this measure without further engineering analysis and modeling.

[2] Note: ROM costs do not include permitting, annual maintenance or land acquisition costs for survey, appraisal, and engineering coordination.

# 2. INTRODUCTION

## 2.1 BACKGROUND

In cooperation with Oneida County Planning, the Town of Kirkland, NY obtained funding from the Oneida County Executive through their "Flood Mitigation Grant Program" for a flood mitigation study of the Sherman Brook watershed. This study will incorporate a history of reoccurring flooding, hydrologic and hydraulic analysis of existing conditions as well as methods of improving flood resiliency and developing conceptual designs for both structural and nature-based flood mitigation solutions.

Sherman Brook is a 5-mile long stream located in Oneida County, NY that flows in a general northwest direction through the Town of Kirkland and the Village of Clinton. The channel has been the source of devastating damages from floods to residential homes, local businesses, agricultural fields, parks, roads, and infrastructure. Flooding has been exacerbated in recent years due to climate change and the increased magnitude and intensity of precipitation events.

The floodplain of Sherman Brook can be characterized as narrow and flat along its lower reaches and is prone to flooding from intense weather events including a combination of heavy rains and early snowmelts. For many decades, Sherman Brook and its floodplain has experienced land use changes such as new development, straightening and channelization, and construction culverts and bridges to convey new roads through the floodplain. These changes have caused the brook to become disconnected from its floodplain - disrupting conveyance and storage of flood waters. Flooding has been exacerbated on the creek by sediment accumulation, debris jams, and restrictive infrastructure (i.e., bridges, culverts, etc.).

In the Town of Kirkland and in the Village of Clinton, there are no existing structures or non-structural flood protection measures along Sherman Brook (FEMA 2013a).

## 2.2 OBJECTIVE

The objective of this report is to address the watershed response to historic, recent, and future precipitation events and indicate flood prone areas and root cause to repetitive flooding. The investigation will provide support in proposing flood mitigation actions that will improve the community's flood resiliency.

A primary goal will be to reduce flooding by lowering surface water elevations related to infrastructure, excessive deposition and debris, uncontrolled sediment sources, head cutting or downcutting of the channel, and loss of natural floodplains. Many of these situations are a result of basin-wide conditions related to changes in land use, landcover and runoff, stormwater management, upstream sediment sources, upstream woody debris, and stream bed and bank erosion. Practical solutions and actions will be presented to meet these goals in an ecologically sustainable manner.

It is recognized that numerous watershed-wide characteristics and conditions can contribute to or cause increased flooding risk. Incompletely understood and poorly planned actions may worsen flooding risk, create negative unintended consequences, be prohibitively expensive, ineffective, and cause unnecessary ecological damage. A full understanding of these conditions is necessary.

This report will necessitate the collection and assessment of watershed-wide conditions in a holistic systems-based approach to best understand and plan mitigative measures. This report is not intended to replace or prevent flood recovery actions during actual flooding emergencies. At such times, emergency permitting, and guidance will be provided by regulatory agencies to safeguard life and property.

The watershed flood mitigation study for Sherman Brook began in December of 2022 and this final flood study report was issued in December of 2023.

## 2.3 FLOODPLAIN DEVELOPMENT

General recommendations for high-risk floodplain development follow four 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 high-risk areas.
4. Increase hydraulic capacity of bridges and culverts to be more resilient to sediment accumulation, debris jams, high-flow events, and projected future flood flows due to climate change in high-risk areas.

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 floodwater 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, finite amounts 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 FEMA regulations since all the municipalities along Sherman Brook in Oneida County are participating communities in the NFIP and should involve a floodplain coordinator and site plan review process for all proposed developments. This review should be in accordance with local regulations and 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. The communities and their NFIP community IDs along Sherman Brook are as follows:

- Town of Kirkland (Oneida County): Community ID #360531
- Town of Paris (Oneida County): Community ID #360539
- Village of Clinton (Oneida County): Community ID #360525

# 3. WATERSHED CHARACTERISTICS

## 3.1 STUDY AREA

The Sherman Brook watershed lies within the Oneida County boundaries in central New York. The watershed encompasses areas within the Towns of Kirkland and Paris, and Village of Clinton. The creek flows in a northwest direction with its headwaters in the Town of Paris and empties into St. Mary's Brook about 0.5 miles north from the Village of Clinton corporate limits (Figure 3-1).

Within the Sherman Brook watershed, the areas in the Town of Kirkland, which include the areas between Craig Road and Kirkland Avenue, were chosen as target areas due to their historical and recent flooding issues, concerns acknowledged during public engagement meetings, and the hydrologic conditions of the creek in these respective reaches.

The Town of Paris is located in the southeast portion of Oneida County, NY. The total land area contained within the corporate limits is approximately 31.5 square miles. The town is approximately three miles south from the City of Utica and is bordered by the towns of New Hartford to the north, Kirkland to the northwest, Marshall to the west, Bridgewater to the south, and Litchfield to the east (FEMA 1983).

The Town of Kirkland is located in the central portion of Oneida County, NY. The total land area contained within the corporate limits of Kirkland is approximately 33.6 square miles. The town is situated approximately 10 miles west of Utica and 11 miles south from the City of Rome. It is bordered by the towns of Paris to the southeast, Marshall to the south, Augusta to the southwest, Vernon to the west, Westmoreland to the northwest, Whitestown to the north, and New Hartford to the east (FEMA 1984a).

The Village of Clinton is located in southern portion of Oneida County, NY. The total land area contained within the corporate limits of the village is approximately 0.7 square mile. The village is situated approximately five miles southwest from the City of Utica. It is completely surrounded by the Town of Kirkland (FEMA 1984b).

It should be noted that stationing references for Sherman Brook for this report up to Section 7 are based on the USGS National Hydrography Dataset and geographic information systems (GIS) mapping software unless stated otherwise (e.g., FEMA FIS data).

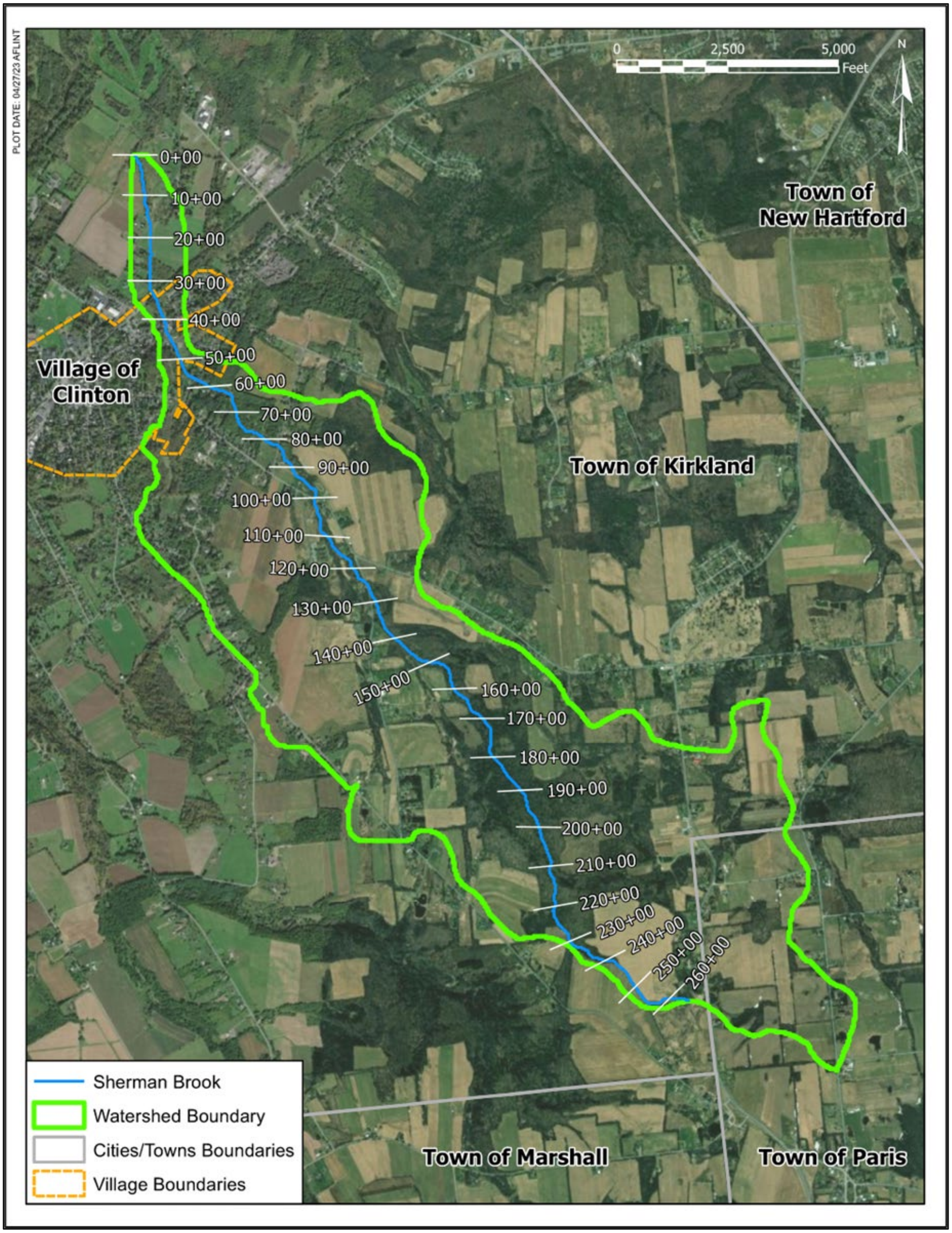


Figure 3-1. Sherman Brook location with river stationing, Oneida County, NY.

## 3.2 ENVIRONMENTAL CONDITIONS

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

- **Environmental Resource Mapper** – The Environmental Resource Mapper is an interactive 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 2022).
- **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 2022).
- **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 2022).
- **Register of Historic Places** – The New York State Historic Sites and Park Boundaries and National Register of Historic Places datasets lists historic places worthy of preservation, as authorized by the National Historic Preservation Act of 1966 (NYSOPRHP 2022).

### 3.2.1 Wetlands

The National Wetlands Inventory was reviewed to identify national wetlands and surface waters (Figure 3-2). The Sherman Brook watershed includes riverine habitat, freshwater forested/shrub wetlands, freshwater ponds, and freshwater emergent wetlands (NYSDEC 2022).

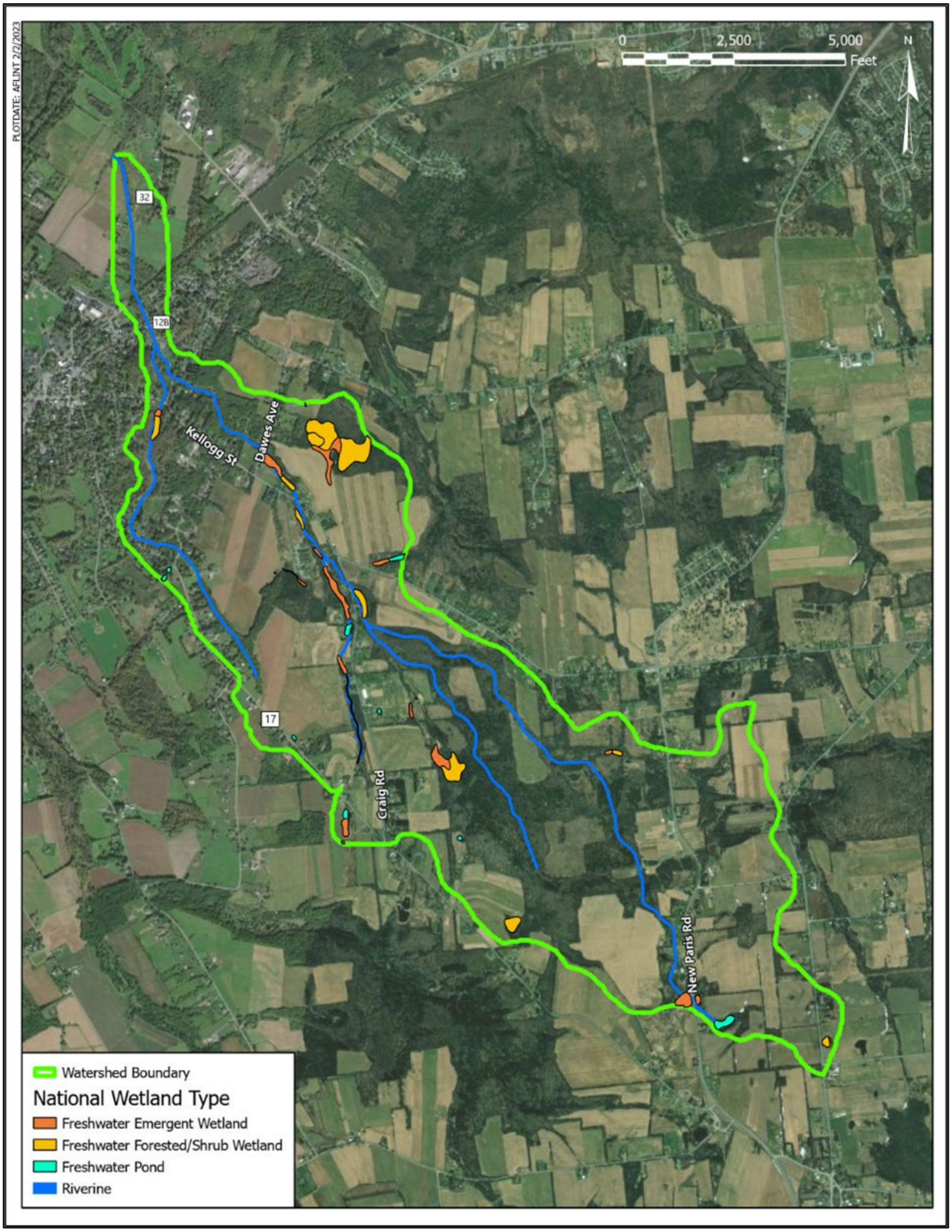


**Figure 3-2. Sherman Brook wetlands and hydrography, Oneida County, NY.**

The State Regulated Freshwater Wetlands database shows the approximate location of wetlands regulated by New York state. Maps of NYS Regulatory Freshwater Wetlands indicate the approximate boundaries of wetlands. The NYSDEC regulates freshwater wetlands that are 12.4 acres (5 hectares) or larger and the 100-ft adjacent area surrounding such wetlands. Field investigation is necessary to identify the actual regulated wetland boundaries in the field. The NYS Regulatory Freshwater Wetlands identified no wetlands in the Sherman Brook watershed (Figure 3-3).

**Figure 3-3. Significant Natural Communities and Rare Plants or Animals, Sherman Brook, Oneida County, NY.**

### 3.2.2 Sensitive Natural Resources

Sensitive natural resources are considered areas that support endangered and threatened species. These areas include rare or high-quality wetlands, forests, grasslands, ponds, streams, and other types of habitats, ecosystems, and ecological areas. Threatened and endangered species are protected by both State (6NYCRR Part 182 and ECL 11-0535 for animals; 6NYCRR Part 193 and ECL 9-1503 for plants) and federal laws.

Areas designated as significant natural communities are mapped in the Sherman Brook watershed using the *Environmental Resource Mapper* tool. According to the tool, the watershed contains no significant natural communities (NYSDEC 2022).

The United States Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) mapping tool contains data on Endangered Species Act listed species, critical habitats, migratory birds and other natural resources. Within the Sherman Brook watershed, no endangered or threatened species, National Wildlife Refuge lands, or fish were identified in the IPaC database. However, the *Danaus plexippus* (the monarch butterfly) is listed as a candidate species, which is a species under consideration for official listing under the endangered/threatened list, and is found within the Sherman Brook watershed. Furthermore, there are 14 migratory birds that are of concern either because they are on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention. Table 3 lists the migratory bird species that either migrate over, nest, and/or breed within the Sherman Brook watershed (USFWS 2022).

**Table 3. UFWS IPaC Listed Migratory Bird Species**

| Source: USFWS 2022 | | | |
|---|---|---|---|
| **Common Name** | **Scientific Name** | **Level of Concern** | **Breeding Season** |
| **Bald Eagle** | *Haliaeetus leucocephalus* | Non-BCC Vulnerable [2] | Breeds Dec 1 to Aug 31 |
| **Belted Kingfisher** | *Megaceryle alcyon* | BCC-BCR[3] | Breeds Mar 15 to Jul 25 |
| **Black-billed Cuckoo** | *Coccyzus erythropthalmus* | BCC Rangewide (CON) [1] | Breeds May 15 to Oct 10 |
| **Blue-winged Warbler** | *Vermivora pinus* | BCC – BCR [3] | Breeds May 1 to Jun 30 |
| **Bobolink** | *Dolichonyx oryzivorus* | BCC Rangewide (CON) [1] | Breeds May 20 to Jul 31 |
| **Canada Warbler** | *Cardellina canadensis* | BCC Rangewide (CON) [1] | Breeds May 20 to Aug 10 |
| **Cerulean Warbler** | *Dendroica cerulea* | BCC Rangewide (CON) [1] | Breeds Apr 20 to Jul 20 |
| **Chimney Swift** | *Chartura pelagica* | BCC Rangewide (CON) [1] | Breeds Mar 15 to Aug 25 |
| **Eastern Meadowlark** | *Sturnella magna* | BCC – BCR [3] | Breeds Apr 25 to Aug 31 |
| **Evening Grosbeak** | *Coccothraustes vespertinus* | BCC Rangewide (CON) [1] | Breeds May 15 to Aug 10 |
| **Golden-winged Warbler** | *Vermivora chrysoptera* | BCC Rangewide (CON) [1] | Breeds May 1 to Jul 20 |
| **Prairie Warbler** | *Dendroica discolor* | BCC Rangewide (CON) [1] | Breeds May 1 to Jul 31 |

| Source: USFWS 2022 | | | |
|---|---|---|---|
| **Common Name** | **Scientific Name** | **Level of Concern** | **Breeding Season** |
| **Red-headed Woodpecker** | *Melanerpes erythrocephalus* | BCC Rangewide (CON) [1] | Breeds May 10 to Sep 10 |
| **Wood Thrush** | *Hylocichla mustelina* | BCC Rangewide (CON) [1] | Breeds May 10 to Aug 31 |

[1] BCC Rangewide (CON): This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska (CON).
[2] Non-BCC Vulnerable: 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.
[3] BCC-BCR: This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA.

### 3.2.3 Cultural Resources

According to the New York State Historic Sites and Park Boundaries and National Register of Historic Places, there are no registered historic sites and parks within the Sherman Brook watershed (NYSOPRHP 2022).

### 3.2.4 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 completed FEMA flood insurance studies throughout the United States (FEMA 2023). The current Effective FEMA FIS reports for Sherman Brook in the Village of Clinton was updated with the Oneida County FIS dated September 27, 2013.

FEMA preformed a detailed study for Sherman Brook in 1984 and determined the flood zone boundaries that are used in NFIP FIRMs by applying semiautomated hydrologic, hydraulic, and mapping tools, coupled with digital elevation data. Additional data inputs for the hydraulic analysis include field-surveyed cross sections, bridge and culvert geometries and their elevations, and topographic maps compiled from aerial photographs (FEMA 1984). The detailed study produces floodway extents, new calibrations for a hydrologic and hydraulic model, and the modeling of additional frequencies. The flood profiles and base flood elevations (BFEs), also referred to as the 100-year flood elevation, are published in the detailed study (NRCS 2007).

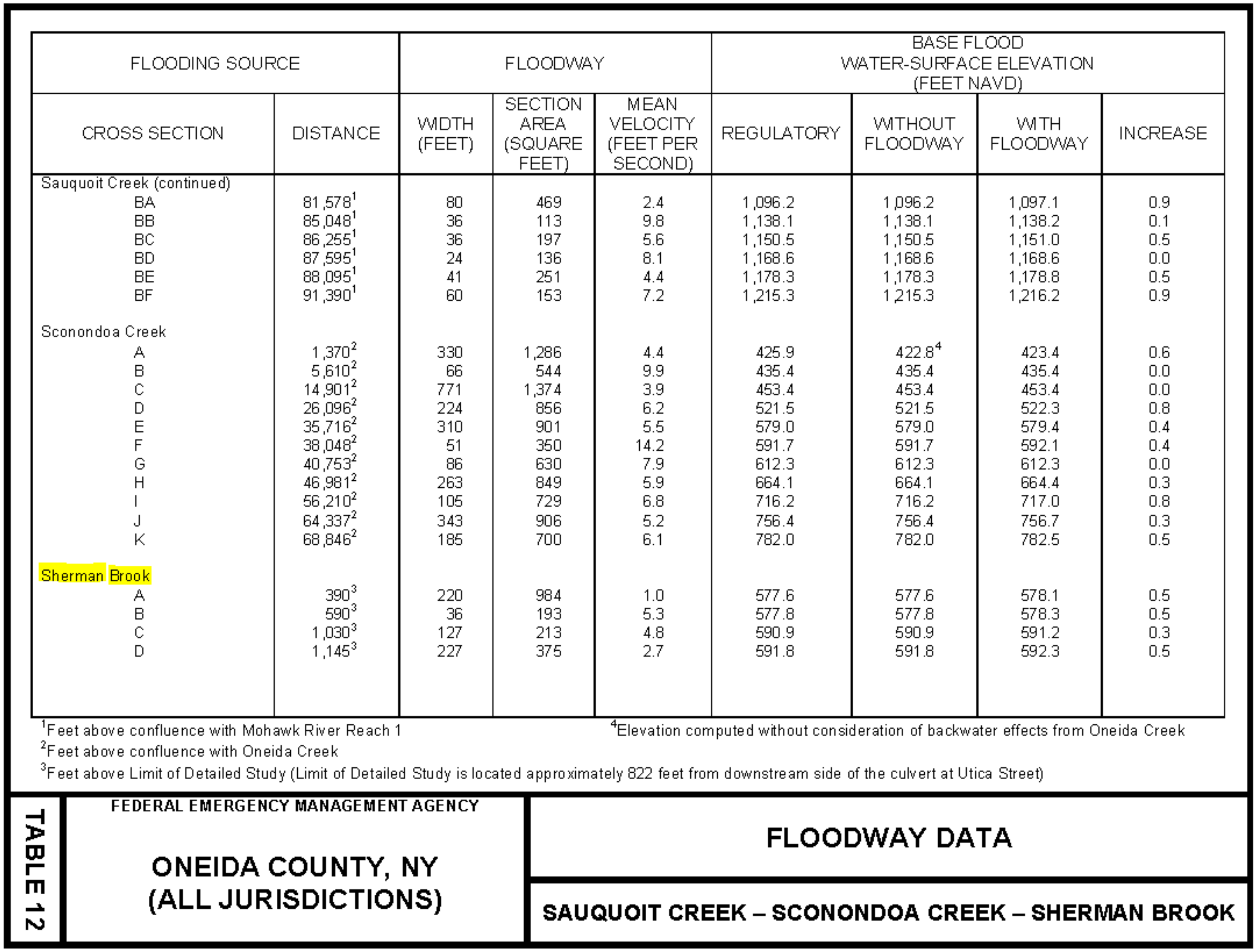
The updated 2013 hydrologic and hydraulic analyses for Sherman Brook in the effective 2013 Oneida County FIS were developed as a redelineation of the original 1984 analysis. For a redelineation study, no new engineering analyses are performed; however, for riverine studies a redelineation study can incorporate data from effective flood profiles and data tables from the effective FIS report, BFEs from FIRMs, supporting hydrologic and hydraulic analyses, and updated topographic data to formulate new floodplain boundaries (FEMA 2019a).

Portions of Sherman Brook include a Regulatory Floodway, which is defined as the watercourse channel and the adjacent land must be reserved to discharge the base flood without increasing the water surface elevation more than 1 foot over the 1% annual chance flood event (ACE) WSEL. (FEMA 2000). Figures 3-4 displays the floodway data from the FIS for Sherman Brook in the Village of Clinton, NY (FEMA 2013a).

The FIRM for the Village of Clinton that encompasses Sherman Brook indicates Special Flood Hazard Areas (SFHAs), which are land areas covered by floodwaters during the 1% ACE. The flood zones indicated in the Sherman Brook study area are Zones A and AE, where mandatory flood insurance purchase requirements apply. “A” Zones represent areas of the 1% ACE where BFEs are not provided. “AE” Zones are areas of the 1% ACE where BFEs are provided (FEMA

2013a). Figure 3-5 is a FIRM that includes a portion of Sherman Brook in the Village of Clinton and Town of Kirkland, NY (FEMA 2013a).

The hydraulic analyses performed by FEMA were based on unobstructed flow where Sherman Brook was studied from Beatty Avenue to the abandoned railroad north of the corporate limits from the Village of Clinton. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail (FEMA 2013a).



| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER-SURFACE ELEVATION (FEET NAVD) | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE | WIDTH (FEET) | SECTION AREA (SQUARE FEET) | MEAN VELOCITY (FEET PER SECOND) | REGULATORY | WITHOUT FLOODWAY | WITH FLOODWAY | INCREASE |
| Sauquoit Creek (continued) | | | | | | | | |
| BA | 81,578[1] | 80 | 469 | 2.4 | 1,096.2 | 1,096.2 | 1,097.1 | 0.9 |
| BB | 85,048[1] | 36 | 113 | 9.8 | 1,138.1 | 1,138.1 | 1,138.2 | 0.1 |
| BC | 86,255[1] | 36 | 197 | 5.6 | 1,150.5 | 1,150.5 | 1,151.0 | 0.5 |
| BD | 87,595[1] | 24 | 136 | 8.1 | 1,168.6 | 1,168.6 | 1,168.6 | 0.0 |
| BE | 88,095[1] | 41 | 251 | 4.4 | 1,178.3 | 1,178.3 | 1,178.8 | 0.5 |
| BF | 91,390[1] | 60 | 153 | 7.2 | 1,215.3 | 1,215.3 | 1,216.2 | 0.9 |
| Sconondoa Creek | | | | | | | | |
| A | 1,370[2] | 330 | 1,286 | 4.4 | 425.9 | 422.8[4] | 423.4 | 0.6 |
| B | 5,610[2] | 66 | 544 | 9.9 | 435.4 | 435.4 | 435.4 | 0.0 |
| C | 14,901[2] | 771 | 1,374 | 3.9 | 453.4 | 453.4 | 453.4 | 0.0 |
| D | 26,096[2] | 224 | 856 | 6.2 | 521.5 | 521.5 | 522.3 | 0.8 |
| E | 35,716[2] | 310 | 901 | 5.5 | 579.0 | 579.0 | 579.4 | 0.4 |
| F | 38,048[2] | 51 | 350 | 14.2 | 591.7 | 591.7 | 592.1 | 0.4 |
| G | 40,753[2] | 86 | 630 | 7.9 | 612.3 | 612.3 | 612.3 | 0.0 |
| H | 46,981[2] | 263 | 849 | 5.9 | 664.1 | 664.1 | 664.4 | 0.3 |
| I | 56,210[2] | 105 | 729 | 6.8 | 716.2 | 716.2 | 717.0 | 0.8 |
| J | 64,337[2] | 343 | 906 | 5.2 | 756.4 | 756.4 | 756.7 | 0.3 |
| K | 68,846[2] | 185 | 700 | 6.1 | 782.0 | 782.0 | 782.5 | 0.5 |
| Sherman Brook | | | | | | | | |
| A | 390[3] | 220 | 984 | 1.0 | 577.6 | 577.6 | 578.1 | 0.5 |
| B | 590[3] | 36 | 193 | 5.3 | 577.8 | 577.8 | 578.3 | 0.5 |
| C | 1,030[3] | 127 | 213 | 4.8 | 590.9 | 590.9 | 591.2 | 0.3 |
| D | 1,145[3] | 227 | 375 | 2.7 | 591.8 | 591.8 | 592.3 | 0.5 |

[1] Feet above confluence with Mohawk River Reach 1

[2] Feet above confluence with Oneida Creek

[3] Feet above Limit of Detailed Study (Limit of Detailed Study is located approximately 822 feet from downstream side of the culvert at Utica Street)

[4] Elevation computed without consideration of backwater effects from Oneida Creek

TABLE 12

**FEDERAL EMERGENCY MANAGEMENT AGENCY**

**ONEIDA COUNTY, NY**
**(ALL JURISDICTIONS)**

**FLOODWAY DATA**

**SAUQUOIT CREEK – SCONONDOA CREEK – SHERMAN BROOK**

Figure 3-4. Regulatory floodway data, Sherman Brook, Village of Clinton, Oneida County, NY (FEMA 2013a).

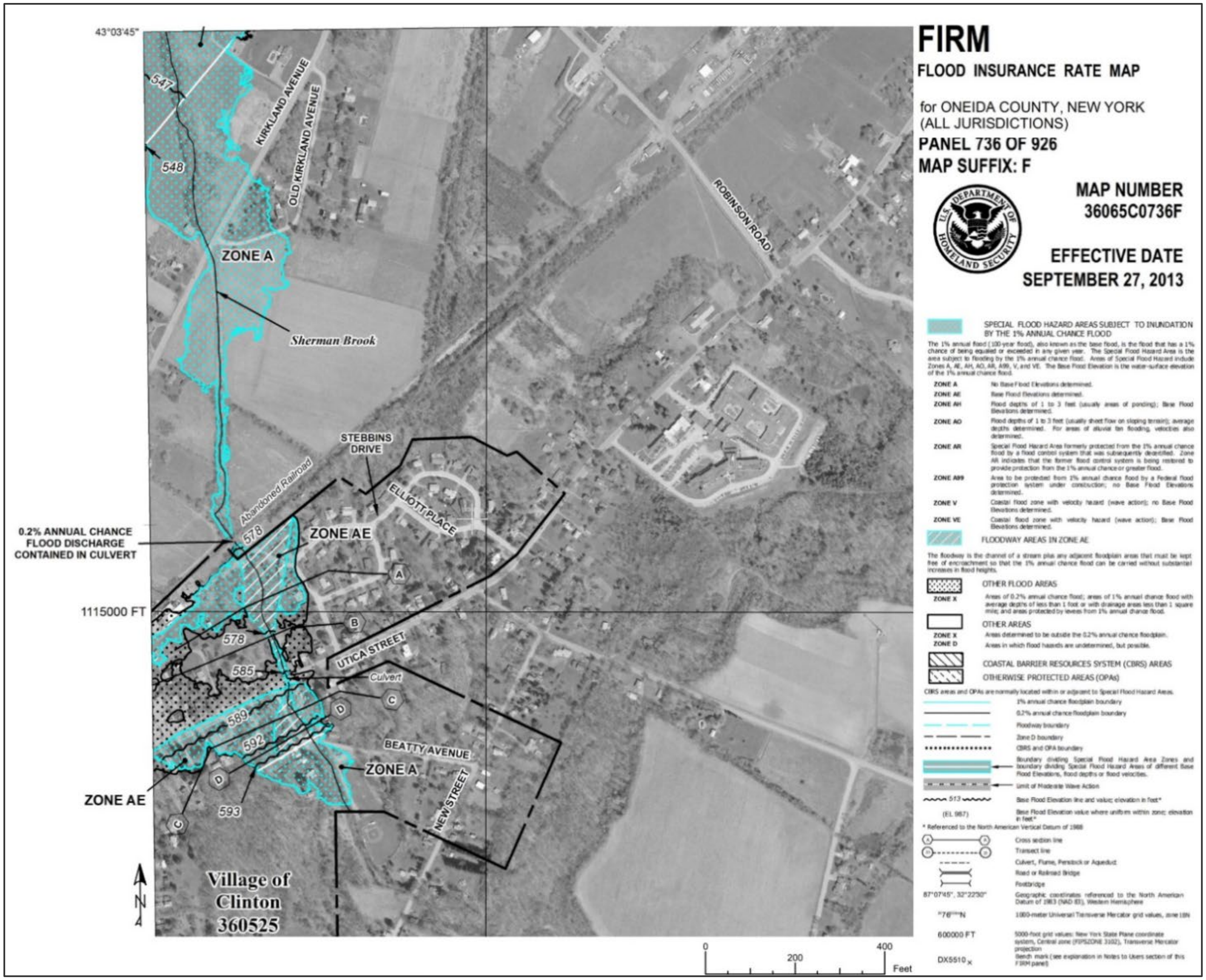


Figure 3-5. FEMA FIRM, Sherman Brook, Village of Clinton, Oneida County, NY (FEMA 2013a).

## 3.3 WATERSHED LAND USE

The Sherman Brook stream corridor is largely comprised of agricultural land (44.7%), forests (40.4%), developed lands (8.9%), and wetlands (1.2%) in the basin (USGS 2023a). Cultivated crops (31.6%) and hay/pasture (13.1%) encompass the largest percentages of agricultural lands, while deciduous forest (33%) comprises the largest proportion of forested lands (USGS 2023a).

The distribution of different land use and cover types varies throughout the Sherman Brook watershed. The upper portions of the basin in the Towns of Kirkland and Paris are primarily cultivated, forested, and wetlands with small areas of developed lands. The middle portions of the basin in the Town of Kirkland contain cultivated, forested, and small areas of wetlands and developed lands. The lower portions of the basin in the Town of Kirkland and Village of Clinton are primarily comprised of cultivated, forested, and areas of developed lands mostly along Sherman Brook (USGS 2023a).

## 3.4 GEOMORPHOLOGY

Oneida County is in the central part of New York state. It is bounded on the north by Lewis County, east by Herkimer County, south and southwest by Otsego and Madison Counties, and west by Oneida Lake and Oswego County. The total area of Oneida County is 805,900 acres, or about 1,259 square miles (including water). Utica is the county seat (NRCS 2008).
Oneida County is in seven distinct land regions or major physiographic provinces of New York state: Ontario (Oneida) Lake Plain; Erie-Ontario Lowland; Alleghany Plateau; Black River-Mohawk River Lowland; Tug Hill Plateau; Adirondack Foothills; Mohawk Valley and other valleys. These regions are different in terms of climate, relief, types of flora and fauna, bedrock, and glacial geological history. The accumulated effects of these differences result in different soils and therefore in various land uses and potentials for those uses (NRCS 2008).

The topography ranges from the nearly level terrain of river valleys to very steep hillsides in the foothills of the Adirondack Mountains in the northeastern part of the county. Low elevations, about 370 ft above sea level, are at the western edge of the county along Oneida Lake. High points include Penn Mountain (1,813 ft above sea level) southwest of Alder Creek in the town of Steuben, and several ridgetops in the southeastern part of the county (about 1,920 ft above sea level). The highest point in the county is east of Waterville on Tassel Hill (1,945 ft above sea level). About 32% of the land in the county north of the Mohawk River is above an elevation of 1,000 ft (the elevation above which soils generally have a frigid temperature regime) (NRCS 2008).

The soils in Oneida County formed mainly in glacial deposits. Under freeze-thaw conditions, which were common in areas of postglacial and periglacial conditions, water-saturated glacial drift that was deposited on valley sides flowed or slumped onto some of the lower valley slopes and bottoms. This type of mass wasting, referred to as solifluction, leaves behind poorly sorted sediment. The epoch since the glaciers left their new deposits on the landscape in Oneida County, the Pleistocene Epoch (approximately 2 million years ago) with the most recent glacier during the Wisconsin Glaciation approximately 10 to 12 thousand years ago, is a short period of time in terms of geology and soil formation. Erosion and the accumulation of sediment continue to affect the landscape. The rates of these processes can be greatly accelerated by human activities (NRCS 2008).

Except for the Proterozoic crystalline rocks of the Adirondacks, Oneida County is underlain primarily by sedimentary rocks that are of Paleozoic age and dip to the southwest at approximately 50 ft per mile. Bedrock surface exposures, generally in east-west trending zones, become younger from north to south across the county (NRCS 2008).

The principal drainage pattern in Oneida County is dendritic. This pattern is somewhat modified in places by bedrock and glacial features. The streams in the county flow west to the Great Lakes, east to the Hudson River, and south to the Susquehanna River. Five river drainage basins divide the county: the Black River basin to the northeast, Eastern Oswego basin to the west, Mohawk basin to the east, West Canada Creek subbasin to the east, and Susquehanna basin to the south (NRCS 2008).

Although the county has distinct drainage basins, waters from the major basins intermingle in the county because of the New York State Barge Canal system. Oswego basin waters enter the Mohawk River via Oneida Lake and the canal. Black River waters enter the Mohawk River via old canals and feeder canals that enter streams, such as Nine Mile Creek (NRCS 2008).

Figure 3-6 is a profile of streambed elevation and channel distance from the confluence with St. Mary’s Brook using a 2-meter light detection and ranging (LiDAR) data for Sherman Brook. The channel has a steep slope in the upstream reaches, primarily the upstream of New Street.

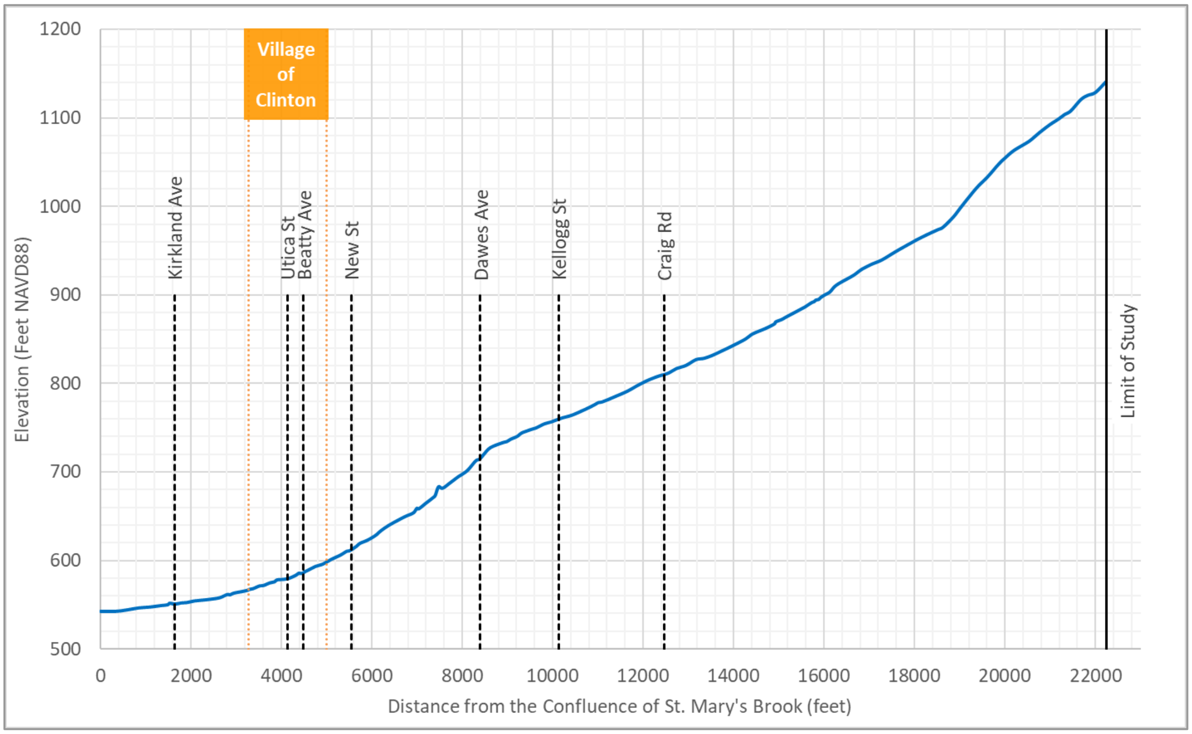


**Figure 3-6. Existing profile of stream bed elevation and channel distance from the confluence with St. Mary’s Brook.**

Along Sherman Brook, there are numerous locations where sediment depositional aggradation is occurring within the channel. 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).

Table 4 is a summary of the basin characteristic formulas and calculated values for the Sherman Brook watershed, where A is the drainage area of the basin in square miles, BL is the basin length in miles, and BP is the basin perimeter in miles (USGS 1978).

**Table 4. Sherman Brook Basin Characteristics Factors**

| Factor | Formula | Value |
|---|---|---|
| **Form Factor ($R_F$)** | $A / B_L^2$ | 0.11 |
| **Circularity Ratio ($R_C$)** | $4*\pi*A / B_P^2$ | 0.19 |
| **Elongation Ratio ($R_E$)** | $2 * (A/\pi)^{0.5} / B_L$ | 0.37 |

Form Factor (RF) 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 (RC) 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 (RE) 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 Sherman Brook 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). The high-relief topography and steep ground slopes implies that during high intensity and/or long duration precipitation events, waters within Sherman Brook will rise quickly, but also flow quickly resulting in a shorter duration flood event.

## 3.5 HYDROLOGY

Sherman Brook has a drainage area of 3.8 square miles and is approximately 5.0 miles in length. The channel is located in the south-central part of Oneida County, NY. Sherman Brook begins in the vicinity of New Paris Road/Route 12 where the corporate limits of the Town of Paris and Town of Kirkland are located. The brook continues to flow northwest within the Town of Kirkland into the Village of Clinton and empties into St. Mary's Brook (USGS 2023b).

There are two main tributaries that are unnamed which flow into Sherman Brook. "Tributary #1" is east of the main stem of Sherman Brook and begins on the east side of New Paris Road/Route 12, is approximately 3.4 miles long, and has a drainage area of approximately 1.25 square miles. Further upstream, "Tributary #2" originates just before Fountain Street and empties into Sherman Brook on the west where Kiwanis Memorial Field is located. The tributary is 2.51 miles long and has a drainage area of 0.67 square miles (USGS 2023b). Table 5 summarizes the peak discharges from the FEMA FIS report for Sherman Brook.

**Table 5. Peak Discharges from the FEMA FIS Report for Sherman Brook**

| Source: FEMA 2013a | | | | | | |
|---|---|---|---|---|---|---|
| | | | **Peak Discharges (cfs)** | | | |
| **Flooding Source and Location** | **Drainage Area (Sq. Mi)** | **River Station (ft)[1]** | **10-Percent** | **2-Percent** | **1-Percent** | **0.2-Percent** |
| At Village of Clinton/Town of Kirkland corporate limits | 3.8 | 0+00 | 515 | 850 | 1,025 | 1,700 |

[1] Note: River stationing is extracted from the Sherman Brook FEMA FIS profile plot.

General limitations of the FEMA FIS methodology are the age of the effective FIS H&H analysis, the age of the methodology, and the limited information on Sherman Brook. Regression equations developed in 1979 were used to determine peak-discharge frequency relationships, which the USGS recommends should only be used for rural streams. The portion of Sherman Brook that was surveyed by FEMA is located within the urban areas of the stream. Over time, advancements in our understanding of the complex interactions of hydrologic environments, coupled with improvements in hydrologic and hydraulic modeling and technology, has led to increased accuracy and a reduction in possible error in discharge estimations in recent years.

*StreamStats* v4.14.1 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. Developed by the USGS, 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 2023b).

*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 (Lumia et al. 2006; Ries et al. 2017).

*StreamStats* was used to calculate the current peak discharges for Sherman Brook and compared with the effective FIS peak discharges. Table 6 is the summary output of peak discharges calculated by the USGS *StreamStats* software for Sherman Brook at select locations.

**Table 6. USGS StreamStats Peak Discharge for Sherman Brook at the FEMA FIS Locations and Other Select Locations**

| Source: USGS 2023b | | | | | | |
|---|---|---|---|---|---|---|
| | | | **Peak Discharges (cfs)** | | | |
| **Flooding Source and Location** | **Drainage Area (Sq. Mi)** | **River Station (ft)** | **10-Percent** | **2-Percent** | **1-Percent** | **0.2-Percent** |
| At the confluence of St. Mary's Brook | 3.7 | 0+00 | 437 | 657 | 767 | 1,030 |
| At Village of Clinton/Town of Kirkland downstream corporate limits | 3.58 | 32+90 | 419 | 630 | 734 | 984 |
| At Village of Clinton/Town of Kirkland upstream corporate limits | 2.87 | 50+10 | 332 | 499 | 581 | 779 |
| At Dawes Avenue | 2.55 | 84+00 | 303 | 456 | 532 | 713 |
| At Craig Road | 2.03 | 124+70 | 229 | 345 | 402 | 539 |

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% ACE 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 7 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 7. USGS StreamStats Standard Errors for Full Regression Equations**

| Source: Lumia 2006 | | | | |
|---|---|---|---|---|
| | **Peak Discharges (cfs)** | | | |
| | **10-Percent** | **2-Percent** | **1-Percent** | **0.2-Percent** |
| **Average Standard Error** | 36.1 | 36.7 | 38.7 | 42.6 |

Based on the *StreamStats* standard error calculations, the FEMA FIS peak discharges were determined to be outside of the statistical range (95% confidence interval). In addition, the lack of discharge information from the FEMA model has resulted in the use of the USGS *StreamStats* peak discharges for the HEC-RAS modeling software simulations for this study.

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 analysis 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 floodplain. 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 Sherman Brook 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 8 lists the estimated bankfull discharge, width, and depth at select locations along Sherman Brook as derived from the USGS *StreamStats* program.

**Table 8. USGS StreamStats Estimated Drainage Area, Bankfull Discharge, Width, and Depth**

| Flooding Source and Location | Drainage Area (Sq. Mi.) | River Station (ft) | Bankfull Depth (ft) | Bankfull Width (ft) | Bankfull Streamflow (cfs) |
|---|---|---|---|---|---|
| At the confluence of St. Mary's Brook | 3.7 | 0+00 | 1.34 | 24.3 | 139 |
| At Village of Clinton/Town of Kirkland downstream corporate limits | 3.58 | 32+90 | 1.32 | 23.9 | 135 |
| At Village of Clinton/Town of Kirkland upstream corporate limits | 2.87 | 50+10 | 1.22 | 21.7 | 112 |
| At Dawes Avenue | 2.55 | 84+00 | 1.16 | 20.6 | 101 |
| At Craig Road | 2.03 | 124+70 | 1.07 | 20.4 | 83 |

## 3.6 INFRASTRUCTURE

According to NYSDEC Inventory of Dams dataset, there are no dams along Sherman Brook (NYSDEC 2022).

There is one large culvert as identified by the NYSDOT along Sherman Brook. The culvert is located in the Village of Clinton and carries Utica Street/Route 12. A large culvert is defined by the NYSDOT as a structure with an opening measured perpendicular to its skew that is greater than or equal to 5 ft and measured along the centerline of the roadway that is less than or equal to 20 ft (NYSDOT 2020a). In addition to the NYSDOT large culverts, there are five culverts owned by the county or town that cross Sherman Brook. Based on orthographic imagery and field observations of the Sherman Brook watershed, additional structures crossing Sherman Brook were identified. Table 9 lists the identification numbers, river station location, owners, and structural characteristics of the culverts along Sherman Brook with bankfull widths from *StreamStats* and hydraulic capacities from FEMA.

### Table 9. Culverts Along/Over Sherman Brook

Source: NYSDOT 2023; USGS 2023b; NYSOITS 2023; FEMA 2013a

| Roadway Carried | Culvert ID | River Station (ft) | Owner | Municipality | Span Length (ft)[1] | Structure Width (ft) [1,2] | Bankfull Width (ft) | Hydraulic Capacity (% ACE) |
|---|---|---|---|---|---|---|---|---|
| Craig Road | N/A | 124+70 | Town of Kirkland | Town of Kirkland | 32 | 16 | 18.6 | No FEMA FIS data |
| Kellogg Street | N/A | 101+40 | Oneida County | Town of Kirkland | 30 | 12 | 20.3 | No FEMA FIS data |
| Dawes Avenue | N/A | 84+00 | Town of Kirkland | Town of Kirkland | 80 | 12 | 20.6 | No FEMA FIS data |
| New Street | N/A | 55+50 | Town of Kirkland | Town of Kirkland | 54 | 11.5 | 21.6 | No FEMA FIS data |
| Route 12B / Utica Street | C260103 | 41+40 | NYSDOT | Village of Clinton | 52 | 18 | 23.8 | 10 |
| Private Road[3] | N/A | 33+80 | N/A | Village of Clinton | Inaccessible | | | |
| Chenango Canal Aqueduct[3] | N/A | 32+90 | N/A | Village of Clinton | Removed | | | |

[1] Measurements are based on field measurements surveyed in December of 2022.

[2] Structure Width is measured parallel to creek flow and refers to the roadway width, which is the minimum distance between the curbs or the railings (if there are no curbs), to the nearest 30mm or tenth of a foot (NYSDOT 2020b).

[3] Note: Unable to field measure due to safety concerns and no publicly available data for structural measurements.

Major bridge crossings over Sherman Brook include Beatty Avenue and County Route 12B/ Kirkland Avenue. Table 10 lists the identification numbers, river station location, owners, and structural characteristics of the bridges along Sherman Brook with bankfull widths from *StreamStats* and hydraulic capacities from FEMA. Figure 3-7 displays the locations of the infrastructure along Sherman Brook.

**Table 10. Infrastructure Crossings Over Sherman Brook**

Source: NYSDOT 2023; USGS 2023b; NYSOITS 2023; FEMA 2013a

| Structure Carried | Bridge ID (BIN) | River Station (ft) | Owner | Municipality | Bridge Length (ft) | Surface Width (ft) [1] | Bankfull Width (ft) | Hydraulic Capacity (% ACE) |
|---|---|---|---|---|---|---|---|---|
| Beatty Avenue | 2205790 | 45+00 | Town of Kirkland | Village of Clinton | 32 | 20 | 23.8 | 10 |
| County Route 32 / Kirkland Avenue | 3310710 | 16+40 | Oneida County | Town of Kirkland | 46 | 42 | 24.1 | No FEMA FIS data |

[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 2020a).

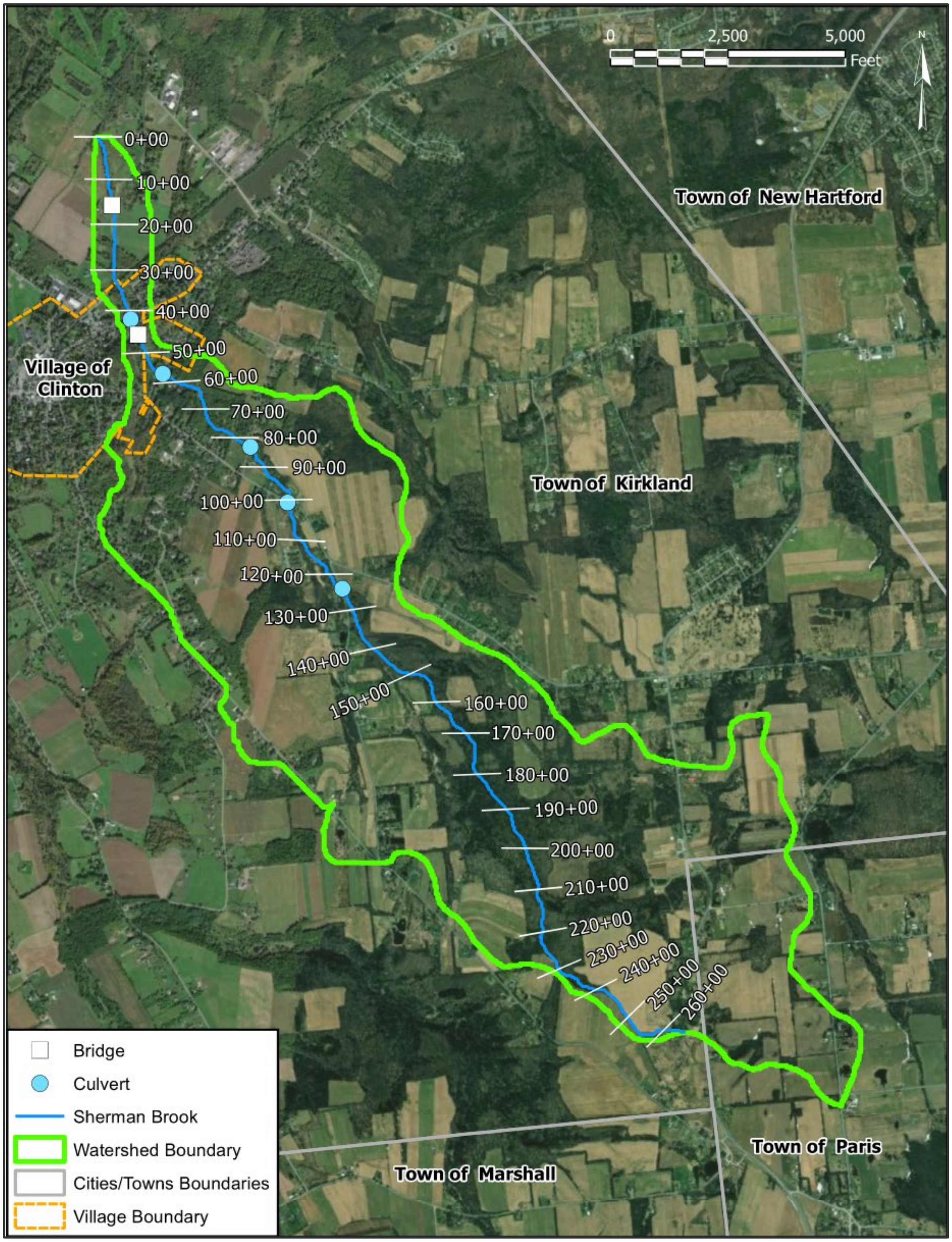


**Figure 3-7. Sherman Brook infrastructure, Town of Kirkland, Oneida County, NY.**

## 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 damage or flooding to surrounding areas and infrastructure (Zevenbergen et al. 2012). In assessing hydraulic capacity of the culverts and bridges along Sherman Brook, the FEMA FIS profile in the Village of Clinton was used to determine the lowest ACE to flow under the low chord of the ridge crossing Beatty Avenue and culvert carrying Route 12B/Utica Street, without causing an appreciable backwater condition upstream (see Tables 11 and 12).

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 2020). Table 11 displays the 1% ACE levels (feet NGVD29) and freeboard height (feet) at FEMA FIS infrastructure locations using the FIS profiles for Sherman Brook.

**Table 11. FEMA FIS 1% Annual Chance Flood Hazard Levels and Freeboard Values**

Source: FEMA 2013a

| Infrastructure Crossing/Name | River Station (ft) | 1-Percent WSEL (ft NGVD) | 2-Percent WSEL (ft NGVD) | Freeboard for 2-Percent ACE (ft) |
|---|---|---|---|---|
| Beatty Avenue | 45+00 | 593.5 | 593.4 | -2 |
| Route 12B/Utica Street | 41+40 | 589 | 586.5 | -0.6 |

* Note: Negative freeboard heights indicate overtopping and are measured from the low chord of a bridge up to the computed water surface elevation.

The term “bridge” shall apply to any structure whether single or multiple span construction with a clear span in excess of 20 ft 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 ins 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 2020b).

In an effort to improve flood resiliency of infrastructure in light of future climate change, the NYSDEC outlined infrastructure guidelines for bridges and culverts (NYSDEC 2020). For bridges, the minimum hydraulic design criteria are 2 ft of freeboard over the 2% ACE elevation while still allowing the 1% ACE flow to pass under the low chord of the bridge without going into pressure flow. For critical bridges, the minimum hydraulic design criteria are 3 ft of freeboard over the 2% ACE 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 2020; NYSDOT 2019; USDHS 2010).

For culverts, the minimum hydraulic design criteria are 2 ft of freeboard over the 2% ACE elevation. For critical culverts, the CRRA guidelines recommend 3 ft of freeboard over the 1%

ACE 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 2020; NYSDOT 2021; USDHS 2010).

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 2020b).

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, 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 2021).

To assess hydraulic capacity for this study, Table 12 represents the structure width of the infrastructure carrying roads across Sherman Brook, and the USGS *StreamStats* tool was used to calculate the bankfull widths and discharge for each structure along Sherman Brook. The results indicate that the majority of the structures crossing Sherman Brook do not have the appropriate width to successfully pass a bankfull discharge event, such as Route 12B/Utica Street, New Street, Dawes Avenue, Kellogg Street and Craig Road.

The structures with bankfull widths that are wider than or close to the structure’s width, such as Route 12B/Utica Street and New Street, 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 generally on the upstream face of a structure. Water is then forced to accelerate through the smaller structure opening and then slow down on the downstream side when expansion occurs as the channel returns to its natural size. 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% ACE), the likelihood of relatively low-flow events causing backwater and potential flooding upstream of these structures is fairly high.

### Table 12. Hydraulic Capacity of Potential Constriction Point Bridges Crossing Sherman Brook

Source: NYSDOT 2023; NYSOITS 2023; USGS 2023b

| Structure Carried | Type | River Station (ft) | Structure Width [1] (ft) | Bankfull Width (ft) [2] | Bankfull Discharge (cfs) [2] | Annual Chance Flood Event Equivalent [3] |
|---|---|---|---|---|---|---|
| County Route 32 / Kirkland Avenue | Bridge | 16+40 | 46 | 24.1 | 137 | > 80-percent |
| Route 12B / Utica Street | Culvert | 41+40 | 18 | 23.8 | 134 | > 80-percent |
| Beatty Avenue | Bridge | 45+00 | 32 | 18.6 | 134 | > 80-percent |
| New Street | Culvert | 55+50 | 11.5 | 20.3 | 111 | > 80-percent |
| Dawes Avenue | Culvert | 84+00 | 12 | 20.6 | 101 | > 80-percent |
| Kellogg Street | Culvert | 101+40 | 12 | 21.6 | 98.2 | > 80-percent |
| Craig Road | Culvert | 124+70 | 16 | 23.8 | 83 | > 66.7-percent |

[1] Structure Width is measured perpendicular to flow.

[2] Based on USGS *StreamStats* streamflow statistics.

[3] Annual Chance Flood Event Equivalent describes the equivalent ACE for the given bankfull discharge as calculated by the USGS *StreamStats* application. The 80% ACE is equal to a 1.25-yr recurrence interval and 66.7% is equivalent to 1.5-yr recurrence interval.

# 4. CLIMATE CHANGE IMPLICATIONS

## 4.1 FUTURE PROJECTED STREAM FLOW FOR SHERMAN BROOK

Based on the current future flood projection models, flood magnitudes are expected to increase in nearly all cases in New York state, but the magnitudes vary among regions. In an effort to improve flood resiliency 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 end of design life multiplier estimates for projected future discharges were the recommended methodology to account for projected climate change trends (NYSDEC 2020).

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 using the software HEC-RAS (NYSDEC 2020). For Sherman Brook, the recommended design-flow multiplier is 20% for an end of design life for a structure between 2025 and 2100 (Burns et al. 2015; NYSDEC 2018). Table 13 provides a summary of the projected future peak stream flows using the USGS *StreamStats* peak discharges and 20% CRRA design multiplier.

In general, climate models are better at forecasting temperature than precipitation and contain some level of uncertainty with their calculations and results. Based on the current future flood projection models, flood magnitudes are expected to increase in nearly all cases in New York state, but the magnitudes vary among regions. Climate model forecasts are expected to improve and as they do, the existing assessment approach can be evaluated and refined further in the future.

### Table 13. Sherman Brook Projected Peak Discharges Using 20% CRRA Design Multiplier

| Source: USGS 2023b | | | | | | |
|---|---|---|---|---|---|---|
| | | | **Peak Discharges (cfs)** | | | |
| **Flooding Source and Location** | **Drainage Area (Sq. Mi)** | **River Station (ft)** | **10-Percent** | **2-Percent** | **1-Percent** | **0.2-Percent** |
| At confluence of St. Mary's Brook | 3.7 | 0+00 | 524 | 788 | 920 | 1,236 |
| At Village of Clinton/Town of Kirkland downstream corporate limits | 3.58 | 32+90 | 503 | 756 | 881 | 1,181 |
| At Village of Clinton/Town of Kirkland upstream corporate limits | 2.87 | 50+10 | 398 | 599 | 697 | 935 |
| At Dawes Avenue | 2.55 | 84+00 | 364 | 547 | 638 | 856 |
| At Craig Road | 2.03 | 124+70 | 275 | 414 | 482 | 647 |

Appendix E 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 1 ft higher at specific locations, generally upstream of bridges or dams due to backwater, as a result of the increased discharges.

# 5. FLOODING CHARACTERISTICS

## 5.1 FLOODING HISTORY

The history of flooding along Sherman Brook indicates that flooding can occur during any season of the year. However, most major floods have occurred in April, May, and June, usually with a combination of heavy spring rains and snowmelt. Storms resulting in floods in the early summer months are often associated with tropical storms moving north along the Atlantic coast.

The Town of Kirkland, Village of Clinton, and Oneida County has reported 12 flash flood occurrences in the past 23 years (NCEI 2023). Between the Town of Kirkland and the Village of Clinton, the flooding damages have cost the municipalities $595,000 from heavy rains and overflowing channels which includes Sherman Brook. Table 14 lists the dates, locations, and a description of recorded flood occurrences from 2000-2023 in the Town of Kirkland and Village of Clinton, Oneida County, NY (NCEI 2023). Some records were documented from residents who attended the Sherman Brook public engagement meeting.

### Table 14. Summary of Flood Occurrences from 2000-2023 in Town of Kirkland and Village of Clinton, Oneida County, NY

**Source: NCEI 2023**

| Date of Flood Occurrence | Location | Summary of Description | Property Damage |
|---|---|---|---|
| 2/27/2000 | Southern Oneida | • Unseasonably warm temperatures resulted in a considerable amount of snowmelt mixed with rainfall; amounts varied between three quarters of an inch to an inch<br>• Creeks, small streams, and rivers overflowed their banks<br>• Flooding occurred on local roads, highways, driveways, backyards, basements, etc.<br>• Many people were evacuated from their homes by boat | |
| 4/4/2000 | Town of Kirkland | • Portions of Route 5 flooded | |
| 5/10/2000 | Town of Kirkland | • Road closed due to flooding | |
| 7/16/2000 | Oneida County | • Heavy thunderstorm rains and flash flooding | |
| 6/23/2001 | Town of Kirkland | • Flash flooding from heavy thunderstorm rains caused numerous road closures in the Towns of Kirkland and Westmoreland<br>• Mud and Oriskany Creeks overflowed their banks and flooded some nearby homes and roads | |
| 4/2/2005 | Town of Kirkland | • Before this storm event, the rivers and streams had high flows due to a previous rainstorm on March 28 and snowmelt<br>• This storm event brought 1 to 4 inches of rain<br>• Oriskany Creek overflowed its banks onto Kirkland Avenue near State Route 5 | $5,000 |
| 6/27/2006 | Oneida County | • Tropical moisture caused an initial round of heavy rain of 2 to 4 inches to Oneida County<br>• Another batch of heavy rain fell from a front combined with a low pressure system<br>• Total rainfall for the three day period was between 4 and 8 inches, the worst flash flooding in the county in 20 years<br>• Hardest hit areas were Western, Deerfield, Vernon and Verona, Kirkland, Oriskany Falls and Steuben<br>• A state of emergency was declared<br>• One bridge was washed out, at least 17 roads flooded, and many roads closed including NYS Thruway | $50,000,000 |
| 3/8/2008 | Town of Kirkland | • A tropical low-pressure system caused heavy rainfall amounts of 1 to 2 inches<br>• Melting snowfall exacerbated flooding in some roads, basements, and smaller creeks | |
| 10/1/2010 | Town of Kirkland | • An upper-level low pressure system interacting with abundant tropical moisture from the remnants of Tropical Storm Nicole<br>• 3 to 6 inches of rain fell across central New York<br>• Flash floods and minor to moderate flooding occurred along larger main stem rivers | |
| 4/29/2011 | Sherman Brook | • First-hand account | |

| **Source: NCEI 2023** | | | |
|---|---|---|---|
| **Date of Flood Occurrence** | **Location** | **Summary of Description** | **Property Damage** |
| 9/9/2011 | Sherman Brook | • First-hand account | |
| 6/13/2013 | Sherman Brook | • First-hand account | |
| 6/28/2013 | Village of Clinton | • Severe thunderstorms caused significant flooding of village roads, including up to 4 ft of water on College Street<br>• Oriskany Creek, Sherman Brook and other un-named streams were all out of bank in the village | $500,000 |
| 4/17/2016 | Sherman Brook | • First-hand account | |
| 6/28/2016 | Town of Kirkland | • Heavy rain and thunderstorms led to isolated flash flooding and debris flows over several roadways<br>• Urban flooding in several locations including flooded underpasses and basements<br>• A few cars were stranded in low lying areas where water was ponding up to 2-ft deep | $50,000 |
| 7/1/2017 | Sherman Brook | • First-hand account | |
| 1/12/2018 | Sherman Brook | • First-hand account | |
| 1/24/2019 | Sherman Brook | • First-hand account | |
| 8/17/2019 | Sherman Brook | • First-hand account | |
| 11/1/2019 | Village of Clinton/Town of Kirkland | • Embedded bands of thunderstorms, dropped 1 to 3 inches of rain, with localized amounts in the 3-to-5-inch range<br>• Some of this heavy rainfall fell in a short amount of time, producing several areas of flash flooding<br>• Oriskany Creek was reported to have flooded Sanford Avenue and other areas in the Town of Kirkland | $40,000 |
| 12/25/2020 | Sherman Brook | • First-hand account | |

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 10-yr 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 exceeding the fair market value of the insured building on the day before each loss within any rolling 10-yr period, since 1978 (FEMA 2019b; FEMA 2022). It is important to note that the FEMA flood loss data only represents losses for property owners who participate in the NFIP and have flood insurance. Table 15 represents the NFIP claims, damage value, and repetitive loss properties in the Town of Kirkland and the Village of Clinton, respectively.

**Table 15. NFIP Summary Statistics for the Town of Kirkland**

| Source: FEMA 2019b | | | | |
|---|---|---|---|---|
| **Community Name** | **Polices** | **Claims** | **Damage Value (in $US dollars)** | **Repetitive Loss Properties** |
| **Town of Kirkland** | 84 | 204 | $1,489,486 | 26[1] |
| **Village of Clinton** | 40 | 41 | $1,099,356 | |

[1] Reported with the Town of Kirkland and the Village of Clinton

Figure 5-1 displays the Zone A (1% ACE) boundaries for Sherman Brook, as determined by FEMA, for the reach from the upstream corporate limits of the Village of Clinton to the confluence of Sherman Brook (FEMA 2013a).

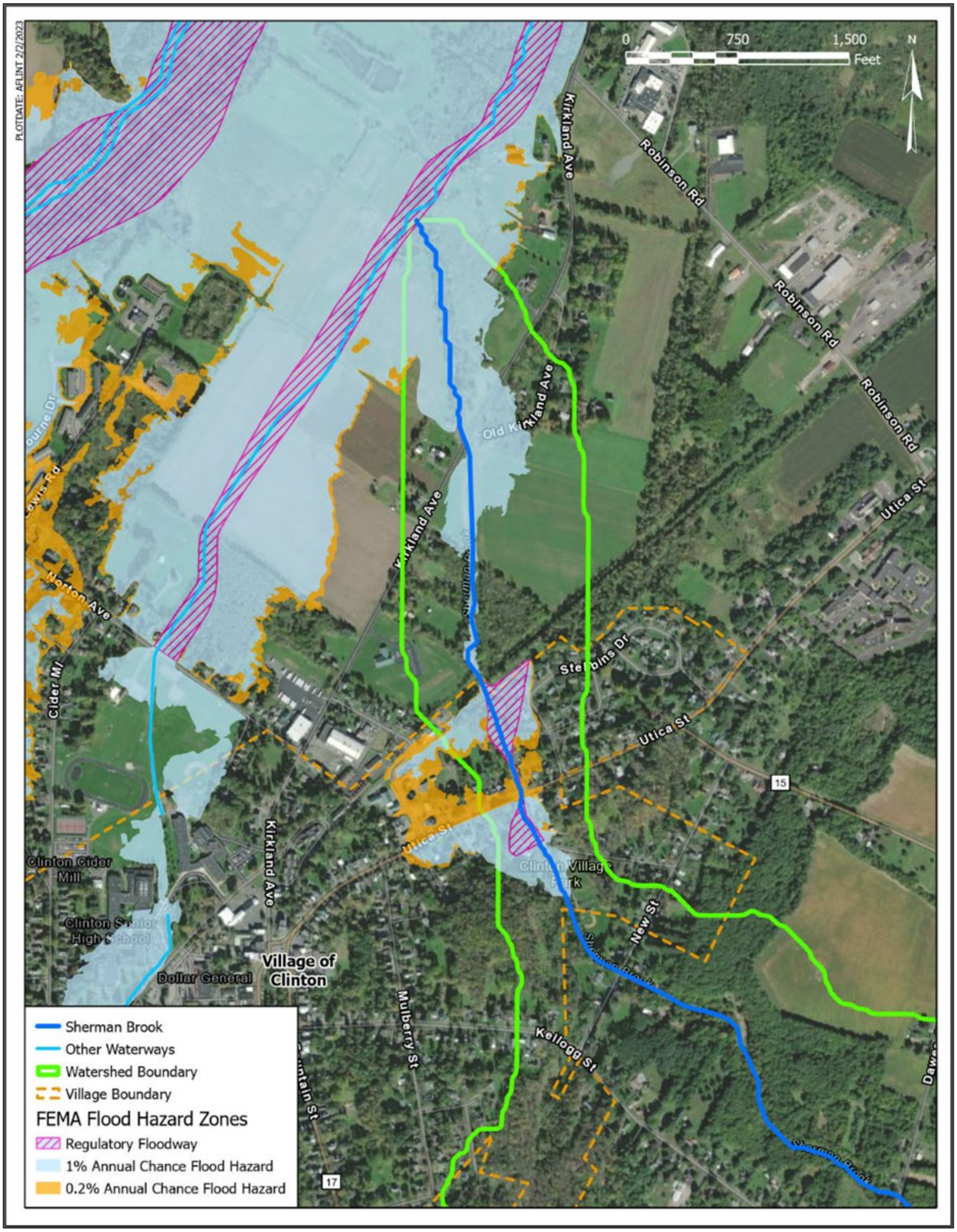


Figure 5-1. Downstream stretch of Sherman Brook, FEMA flood zones, Town of Kirkland and Village of Clinton in Oneida County, NY.

# 6. METHODOLOGY

## 6.1 INITIAL DATA COLLECTION

Hydrological and meteorological data were obtained from readily available state and federal government databases including orthoimagery, flood zone maps, streamflow statistics, precipitation records and data, and flooding events. 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. NYSDOT bridge and culvert standards, USGS *StreamStats* v4.14.1 (USGS 2023b) software, and NYSDEC Community Risk and Resiliency Act (CRRA) guidelines were used to develop current and future potential discharges, and bankfull widths and depths at various points along the stream channel.

Along Sherman Brook, hydrologic and hydraulic (H&H) modeling was performed previously, as part of the effective FEMA Flood Insurance Studies (FIS), for the Village of Clinton, in Oneida County, NY, dated November 1, 1984. FEMA released an updated effective FIS for Oneida County, dated September 27, 2013, which includes Sherman Brook and the Village of Clinton.

H&H analyses for the 2013 Effective FEMA FIS was a redelineation of the original H&H analyses performed in 1984 for Sherman Brook. The H&H analyses were completed using the USACE Hydrologic Engineering Center 2 (HEC-2) step-backwater computer program and the slope/area method. The hydrologic analyses to determine discharge-frequency relationships and peak discharges for Sherman Brook were obtained by performing calculations based on regression equations found in the USGS Water Resources Investigations 79-83 for the selected recurrence intervals (10-, 2-, 1-, and 0.2% ACE). For the Towns of Kirkland and Paris, no hydrologic analyses were performed for Sherman Brook.

Updated H&H modeling was performed in this study using the USACE HEC-RAS v6.3.1 (USACE 2023c) 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.

## 6.2 PUBLIC OUTREACH

Three in-person project engagement meetings were held on February 16, 2023; June 01, 2023; and October 18, 2023, with representatives of the Ramboll, Highland Planning, Town of Kirkland, Village of Clinton, Herkimer Oneida Counties Comprehensive Planning Program, NYSDEC and NYSDOT (Appendix A). At the project engagement meetings, project specifics including background of the Sherman Brook watershed, scope of work, and timelines were discussed. Discussions incorporated a variety of topics, including:

- Firsthand accounts of past flooding events
- Time of year flooding typically occurs
- Primary event causing flooding issues (i.e., heavy precipitation, rain on snow, debris/ice jams, etc.)
- Identification of specific areas that flooded in each community, and the extent and severity of flood damage

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

## 6.3 FIELD ASSESSMENT

Following the initial data gathering, staff from Ramboll undertook field data collection efforts with special attention given to high-risk areas in the Towns of Kirkland and Village of Clinton in Oneida County, as identified in the initial data collection process. Initial field assessments of Sherman Brook were conducted in December of 2022. Additional field assessments were conducted in July 2023 on Tributary #2. 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 B 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 C 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.

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.

## 6.4 FLOOD MITIGATION ANALYSIS

For this study of Sherman Brook, 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-, 25-, 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-, 25-, 50-, 100-, and 500-yr floods, have a 10-, 4-, 2-, 1-, and 0.2% ACE, 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 one 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 (FEMA 2001).

Hydraulic analysis of Sherman Brook was conducted using the HEC-RAS v6.3.1 program (USACE 2023c). 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 2023b).

Hydraulic and hydrologic modeling of Sherman Brook was completed by FEMA in 1984 in the Village of Clinton and updated in 2013 through a redelineation study. (FEMA 1984b; FEMA 2013a). Due to the age, format of the FIS studies, and lack of data for the entire reach, an updated 1-D HEC-RAS model was developed using the following data and software:

- Oneida County, New York 2-meter LiDAR DEM with vertical accuracy of 0.6 ft in the North American Vertical Datum of 1988 (NAVD88) (NYSOITS 2008)
- New York State Digital Ortho-Imagery Program imagery for Oneida County (NYSOITS 2022)
- National Land Cover Database (NLCD) data (USGS 2023a)
- RAS Mapper extension in HEC-RAS software (USACE 2023c)
- NYSDOT bridge and culvert data (NYSDOT 2023)
- Field survey data

### 6.4.1 HEC-RAS 1-D Model Development

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

- LiDAR DEM converted from horizontal North American Datum of 1983 (NAD83) Universal Transverse Mercator (UTM) coordinate system to the New York State Plane Central to convert DEM units from meters to feet;
- 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 using the RAS Mapper extension in the HEC-RAS software;
- LiDAR DEM data, NLCD land cover data, terrain profiles with elevations, cross-section downstream reach lengths, and Manning’s n Values were assigned to each cross-section using built-in tools within the RAS Mapper extension in the HECRAS software;
- Once all features were digitized, assigned, and updated, a 1-D steady flow simulation was performed using USGS StreamStats peak discharges in HEC-RAS.

Downstream boundary conditions for the existing and proposed conditions models were assessed using the normal depth method. Normal depth is calculated using the friction slope ($S_f$ in Manning's equation), which is the slope of the energy grade line, and can be estimated by measuring the slope of the bed at the downstream reach (USACE 2023c). For this model, the slope for the 300-ft immediately upstream of the confluence to St. Mary’s Brook was used and calculated to be 0.006.

The existing condition model water surface elevation results were compared to the FEMA FIS water surface profiles, past flood events with known water surface elevations, photo documentation of flood extents, and the effective FEMA FIS elevation profiles to validate the model. After the existing condition model was verified, it was then used to develop proposed condition models to simulate potential flood mitigation strategies.

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:

- High-Risk Area #1
  - Increase Hydraulic Capacity of the Craig Road Culvert
- High-Risk Area #2
  - Increase Hydraulic Capacity of the New Street Culvert
- High-Risk Area #3
  - Flood Bench within Kiwanis Memorial Field Area
  - Increase Hydraulic Capacity of Beatty Avenue Bridge
- High-Risk Area #4
  - Flood Bench Located Upstream of Utica Street
  - Increase Hydraulic Capacity of the Utica Street Culvert
- High-Risk Area #5
  - Flood Benches Upstream of Kirkland Avenue
  - Increase Hydraulic Capacity of the Kirkland Avenue Bridge
  - Overflow Open Channel and Two New Culverts on Old Kirkland Avenue and Kirkland Avenue
- High-Risk Area #6
  - Revitalization of Earthen Dam
  - Removal of Earthen Dam

As the flood mitigation strategies discussed in this study are at this point preliminary, inundation mapping was not developed from the computed water surface profiles for each potential mitigation alternative.

### 6.4.2 1-D Model Limitations

For this study, a 1-D HECRAS model was developed to model the existing conditions and effectiveness of the proposed mitigation alternatives. The USACE recommends choosing between 1-D and 2-D modeling on a case-by-case basis, but in general, there are certain cases where 1-D models can produce results as good as 2-D models with less effort. Those cases include the following (USACE 2023a):

- Rivers and floodplains in which the dominant flow directions and forces follow the general river flow path
- Steep streams that are highly gravity driven and have small overbank areas
- River systems that contain multiple bridges/culvert crossings, weirs, dams and other gated structures, levees, pump stations, etc. (these structures impact the computed stages and flows within the river system)

- Medium to large river systems, where there is modeling of a large portion of the system (100 or more miles), and it is necessary to run longer time period forecasts (i.e., 2-week to 6-month forecasts)
- Areas in which the basic data does not support the potential gain of using a 2-D model (USACE 2023a)

Based on the topographic and geomorphic features of the Sherman Brook watershed and the recommendations of the USACE for 1-D versus 2-D modeling, the project team concluded the best model for this study was 1-D. However, after developing the 1-D model for Sherman Brook, the project team did determine certain limitations in the 1-D model that should be noted. These limitations include the following:

- Potential overflow areas, which are areas where WSELs exceed the adjacent terrain geometry, were found in a number of locations along Sherman Brook. These areas are at the confluence of Sherman Brook. The overflow areas were primarily caused by outflow areas into other watersheds where the other streams were not modeled.
- The accuracy of a 1-D model in determining WSELs in the overbank areas outside of the main channel diminishes the further away from the main channel the user defines as an overbank area. Portions of the Sherman Brook watershed, including the downstream areas after New Street, have narrow and relatively flat floodplains which led to relatively wide and distant overbank areas in the 1-D model. A more appropriate analysis of overbank areas would require lateral 2-D storage areas in the overbank parallel to the main channel; however, this type of analysis is outside of the scope of this study.
- In general, LiDAR does not capture channel thalweg due to interference and scattering by water of the LiDAR signal. As a result, no bathymetric modifications were done to the existing model to correct for this limitation. However, for this study, some of the flood mitigation strategies that were modeled incorporated modifications to the main channel or in the immediate overbank areas.

The 1-D model results for the existing conditions along Sherman Brook were compared to the FEMA FIRM flood extents and FIS profile plot water surface elevations, and were found to be in agreement with both. Therefore, the results from the proposed flood mitigation alternatives model simulations for this study can be accepted with a high degree of confidence.

## 6.5 DEBRIS ANALYSIS

According to historical flood reports, stakeholder engagement meetings, and field work, the portions of Sherman Brook at the New Street culvert, Beatty Avenue bridge, and Kirkland Avenue bridge were identified as areas susceptible to debris and log jams on the upstream face of infrastructure crossing the channel. Within the channel upstream of the New Street culvert, at the Kiwanis Memorial Field (upstream of Beatty Avenue), and upstream of Kirkland Avenue, sediment piles, woody debris and logs block the natural flow of the channel.

The New Street culvert is a potential catchpoint for logs and debris due to the design of the structure as span length does not have the size capacity for large logs to pass through. In addition, the abandoned quarry, located upstream of the New Street structure, contributes to excess sediment and debris since the channel banks are exposed to loose sediment, which creates a higher risk for erosion in which the banks then fail to support old trees. Sherman Brook at New Street and into Kiwanis Memorial Field experiences a decrease in slope and thus, the velocity begins to slow and settle large sediment and debris in these areas which can obstruct the natural path of the channel flow.

The Beatty Avenue bridge is susceptible to log and debris jams due to the fact that the bridge has a low hydraulic capacity and cannot successfully pass the 10-, 2-, 1-, or 0.2% ACE flood events (FEMA 2013a). In addition, a large, forested area upstream of the bridge will contribute to woody debris. Figure 6-1 shows the FEMA profile plot for Sherman Brook in the Village of Clinton (FEMA 2013a).

The Kirkland Avenue bridge is known to be a location where sediment settles and accumulates as the velocity decreases in this flat region after high-flow periods. The sediment piles cause an obstruction to flow and decreases the natural flow areas. An obstruction of flow causes water surface elevation to rise where water will begin to spill over low channel banks and onto flat land.

For the debris analysis of Sherman Brook, an existing condition with debris obstruction model simulation was developed using the built-in Floating Pier Debris tool within the HEC-RAS model software (USACE 2023). The simulations involved a 15% debris obstruction for all scenarios based on stakeholder information, media, and field assessments. Manual calibration of the width and height of the debris obstruction in the model was performed to reproduce historical flood levels caused by debris jams at known locations.

Using the calibrated debris specifications, the existing condition debris simulation model was used to test the effectiveness of the flood mitigation alternatives that influence flow through Sherman Brook under both present and future conditions.

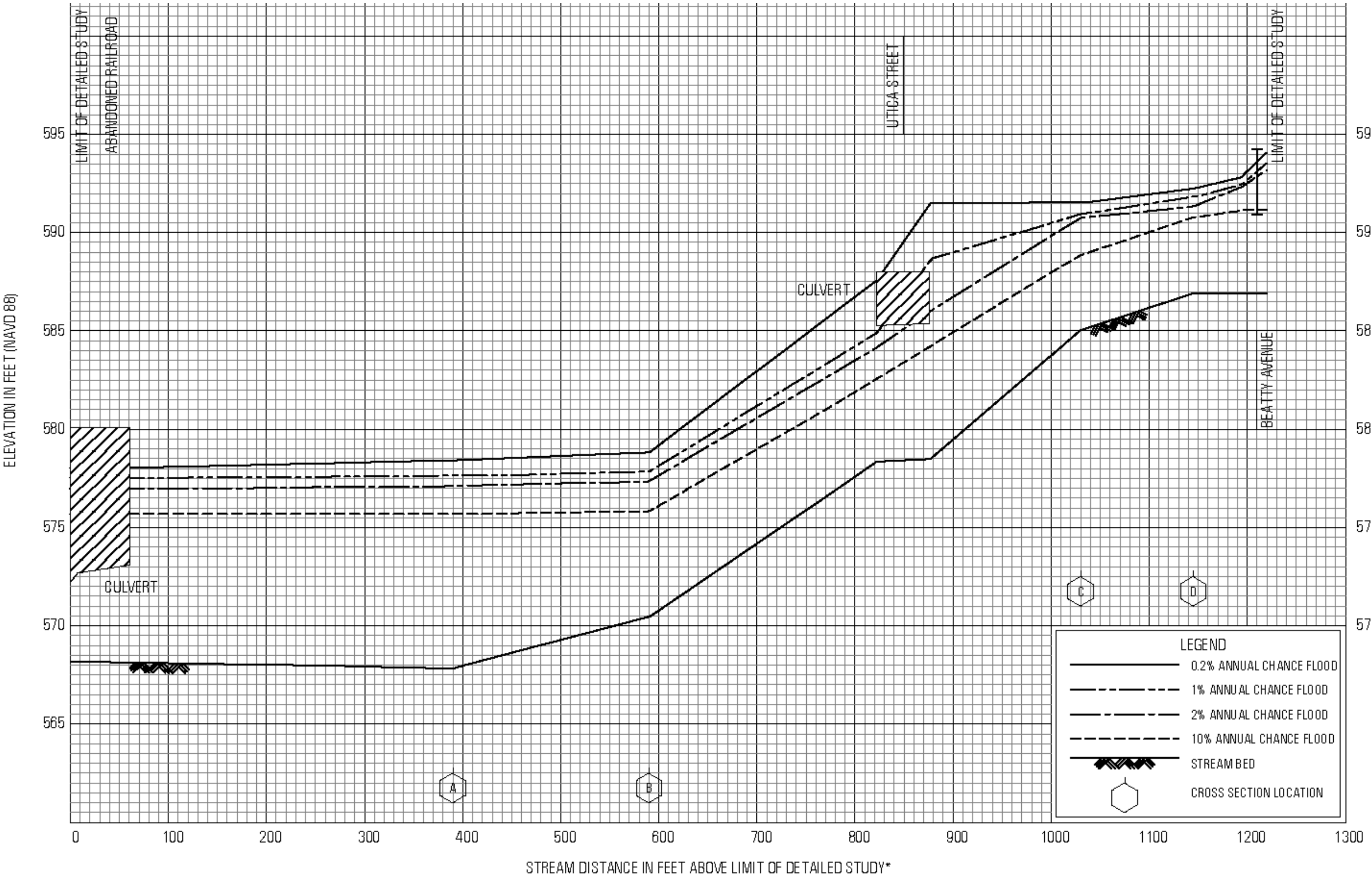


**Figure 6-1. FEMA FIS Profile plot for Sherman Brook in the Village of Clinton (Town of Kirkland), Oneida County, NY (FEMA 2013a).**

## 6.6 2-D MODELING

Due to the complex nature and steep topography of Sherman Brook, the project team determined that a 2-D H&H model was necessary to accurately and appropriately model the existing and selected proposed conditions. An updated 2-D HEC-RAS model was developed using Oneida County 2-meter LiDAR DEM (NYSOITS 2008), NYSDOT and Ramboll field-measured infrastructure data (NYSDOT 2023; Ramboll 2023), and three historical precipitation events (July 01, 2017; October 31 and November 01, 2019 (Halloween 2019); and April 05 and 06, 2023).

Precipitation data was obtained from the New York State (NYS) Mesonet, which is a network of 126 weather stations across the State established in 2014 (UAlbany 2023). The Mesonet collects, archives, and processes data in real-time every 5 minutes and was used for the 2-D model by developing distributions of rainfall intensity over the duration of a storm event (i.e., rainfall hyetograph). The July 2017, Halloween 2019, and April 2023 storm events were chosen due to their known flooding impacts and recent occurrences allowing for readily available data. For the purposes of this study, the Halloween 2019 Storm event will best represent the benefits of the flood mitigations because out of the three historic storm events, the Halloween 2019 Storm event was measured to have the most rainfall in the watershed.

The following assumptions and approximations were made during the development of the 2-D model:

- In general, LiDAR does not capture channel thalweg due to interference and scattering by water of the LiDAR signal. No bathymetric modifications were completed to the channel of Sherman Brook to correct for this limitation within the model domain, except when artifacts, such as woody debris or vegetation, block and restrict channel flow unnaturally. Modifications in the terrain were made to correct the restricted flow at the following locations:
    - Approximately 75-ft reach adjacent to Kiwanis Memorial Field along Sherman Brook
    - Approximately 150-ft reach upstream of the abandoned railroad crossing near Stebbins Drive along Sherman Brook
    - Approximately 75-ft reach through the abandoned railroad crossing near Stebbins Drive along Sherman Brook
    - Approximately 150-ft reach downstream of the earthen dam along Unnamed Tributary #2
- Bathymetric modifications were done at multiple infrastructure crossings due to the lack of LiDAR penetration through structures, including the following:
    - Kirkland Avenue
    - Utica Street
    - Beatty Avenue
    - New Street
    - Dawes Avenue
    - Kellogg Street (Unnamed Tributary #2)

Bathymetric modifications to the channel of Sherman Brook were not performed as part of this study. Channel area below daily mean water level is small as compared to the area contained within the overall floodplain. Since the channel represents a relatively small area when compared to the entire floodplain width, the area below the daily mean water level is minor in comparison to the overall error of estimate of the hydrologic estimates and the DEM.

The 2-D hydraulics model was developed for Sherman Brook beginning at the confluence with St. Mary's Brook and extending upstream to the Kellogg Street culvert for Sherman Brook, and for Unnamed Tributary #2 beginning at the confluence with Sherman Brook and extending approximately 1,000 ft upstream of the earthen dam (Figure 6-2).

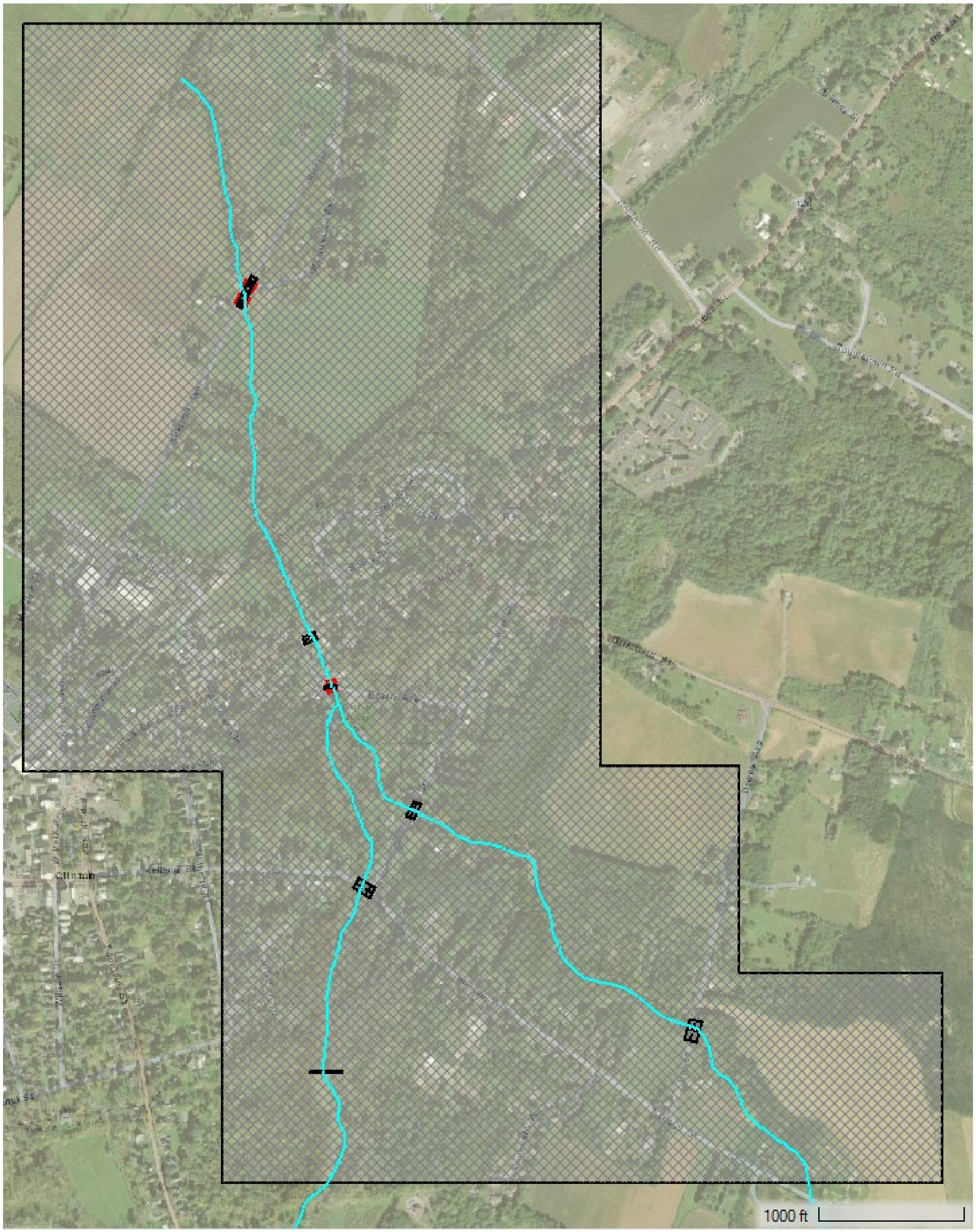


**Figure 6-2. HEC-RAS 2-D hydraulic model domain (black) and hydrography (cyan).**

An existing condition model was developed using a 2-D computational mesh, which was generated with the available tools within the HEC-RAS software. The mesh was comprised of 30-by 30-ft base elements to best represent the topography of the Sherman Brook watershed. Flow breaklines were added at infrastructure crossings and along the right and left banks of both Sherman Brook and Unnamed Tributary #2 with a refined grid spacing of 5 ft to more accurately simulate the effects of the hydraulic structures on channel flow and potential overbank flooding by assigning top of bank elevations, respectively.

The 2-D computational mesh consists of approximately 70,768 cells with an average area of 448.6 square feet. Each cell of the mesh represents an individual solution to a hydraulic equation, which when combined over the entire mesh, produces a solution for the entire model area.

The riverine mesh elements are used to calculate energy and momentum equations for the entire system. Frictional losses are typically derived through Manning's equation and the use of a Manning n value for roughness. Manning's n value is highly variable and depends on a number of factors, including size and shape of the channel, stage and discharge, seasonal changes, surface roughness, vegetation, channel irregularities, temperature, channel alignment, obstructions, scour and deposition, and suspended material and bedload (USGS 2023a). A Manning's roughness of 0.04 was used for the creek, while the remainder of the computational domain was assigned values based on the NLCD Land Cover dataset.

The upstream boundary conditions were determined using USGS *StreamStats* bankfull statistics values for both Sherman Brook and the Unnamed Tributary #2. Table 16 summarizes the bankfull statistics for both Sherman Brook and the Unnamed Tributary #2.

**Table 16. USGS *StreamStats* bankfull statistics for Sherman Brook and Unnamed Tributary #2.**

Source: USGS 2023b

| Flooding Source and Location | Drainage Area (Sq. Mi.) | River Station (ft) | Bankfull Depth (ft) | Bankfull Width (ft) | Bankfull Streamflow (cfs) |
|---|---|---|---|---|---|
| **Sherman Brook** | | | | | |
| At the confluence of St. Mary's Brook | 3.7 | 0+00 | 1.34 | 24.3 | 139 |
| **Unnamed Tributary #2** | | | | | |
| At the confluence of Sherman Brook | 0.67 | 0+00 | 0.71 | 11.3 | 32.2 |

The downstream boundary conditions for the 2-D domain used the Normal Depth method, which is the energy slope at the downstream boundary of the model. Normal Depth assumes normal flow (uniform flow) conditions. For this model, the Normal Depth for Sherman Brook was determined to be 0.008.

The precipitation boundary condition was used to input a rainfall hyetograph (average rainfall over time) for each storm event (July 2017, Halloween 2019, and April 2023). A computational interval (i.e., time-step) of 1 second was used for all the simulation scenarios and the simulation lengths were dependent on the storm event: July 2017 was simulated for 18 hours and 25 minutes, Halloween 2019 was simulated for 25 hours and 50 minutes, April 2023 was simulated for 31 hours and 20 minutes. This time step was determined through an iterative process until the model stabilized and successfully ran each simulation scenario.

The 2-D existing condition model WSELs were then compared to the effective FEMA FIS water surface and elevation profiles and the effective FEMA FIRMs to evaluate the model results. The 2-D model results for the existing conditions were found to be in line and reasonable with the effective FEMA products. The existing conditions model 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 WSELs.
The effectiveness of the modeled potential mitigation strategy was evaluated based on reduction in WSELs within the 2-D H&H model simulations. The flood mitigation strategies that were modeled in 2-D were:

- Alternative #3-2: Flood Bench within Kiwanis Memorial Field Area
- Alternative #3-3: Increase Hydraulic Capacity of the Beatty Avenue Bridge
- Alternative #4-1: Flood Bench Located Upstream of Utica Street
- Alternative #5-5: Overflow Open Channel and Two New Culverts on old Kirkland Avenue and Kirkland Avenue

## 6.7 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.

Where recent construction cost data was not readily available, RSMeans CostWorks 2023 was used to determine accurate and timely information (RSMeans Data Online 2023). 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 of freeboard over the base flood elevation for a 1% ACE 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% ACE hazard. Additionally, the cost estimates involving mitigation alternatives with culverts assume the use of prefabricated concrete culverts.

Once these optimal sizes were determined, further analysis was completed including site constraints and constructability. Due to these additional constraints, often the size necessary to meet the freeboard requirement was not feasible (e.g., private land acquisition, cost-benefit assessments, structural design challenges, etc.). Cost estimates were performed based on projects determined to be constructible and practical.

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

In addition, no benefit-cost analyses were performed for any mitigation alternative due to the conceptual nature and preliminary designs of these alternatives, which would require further analysis and engineering to determine the appropriate benefit cost ratios.

It should be noted that all ROM cost estimates are calculated at the time of the study. Cost data is based on current cost estimating data and is subject to change based on economic conditions.

## 6.8 HIGH-RISK AREAS

Based on the FEMA FIS, historical flood reports, and stakeholder input from the public engagement meeting, five areas along Sherman Brook were identified as high-risk flood areas: Craig Road, upstream of New Street, Kiwanis Memorial Field, Utica Street, and upstream of

Kirkland Avenue. All high-risk flood areas are located in the Town of Kirkland with some portions in the Village of Clinton, Oneida County, NY.

### 6.8.1 High-Risk Area #1: Craig Road

High-Risk Area #1 is where Craig Road crosses the upstream reach of Sherman Brook at river station 129+00 to river station 124+00 (Figure 6-3). Flooding in this area poses a threat to residential properties along Craig Road and infrastructure on Craig Road which is maintained by the Town of Kirkland. Currently, there is no FEMA FIS report or FIRMs for High-Risk Area #1.

The area upstream of the culvert at Craig Road is steep and the channel is surrounded by forested areas. This reach is susceptible to tree and debris buildup from the upstream forested area. Tree and debris buildup restricts the channel flow area, which can cause water surfaces to rise and potentially overtop banks or back water upstream of structures and/or meanders. At the public engagement meeting, a resident was concerned about flooding from Sherman Brook caused by a disconnect in the floodplain. During periods of high flows, the resident has observed water flowing out of the channel, across Craig Road, and into the resident’s property.

The NYSDOT uses functional classifications to group roads, streets, and highways into classes based on the character of service each road, street, and highway provides by defining the part that any particular road or street should play in serving the flow of trips through a highway network and the type of access it provides to adjacent properties. Additionally, functional classifications are used to determine if roads are eligible for project funding under the Surface Transportation Program (STP) administered by the Federal Highway Administration. Craig Road is classified as a “local rural roadway” which is not eligible for the STP funding (NYSDOT 2017). Additionally, the existing conditions model shows the Craig Road culvert does not successfully pass the NYSDOT required 2 ft of freeboard over the 2% ACE (50-yr flood) and cannot successfully pass the 1% ACE. The existing conditions model does not represent sediment or debris accumulation at the culvert location and if simulated, the results might show a higher WSE.

The channel capacity in this reach overflows the channel banks and overtops the roadway at the Craig Road culvert. In most recent flood events, the force of water has been uplifting the roadway on the upstream and downstream edges of the road. The road is showing signs of instability and has a potential risk of collapsing into the channel which would halt local traffic due to the inaccessibility of the roadway.

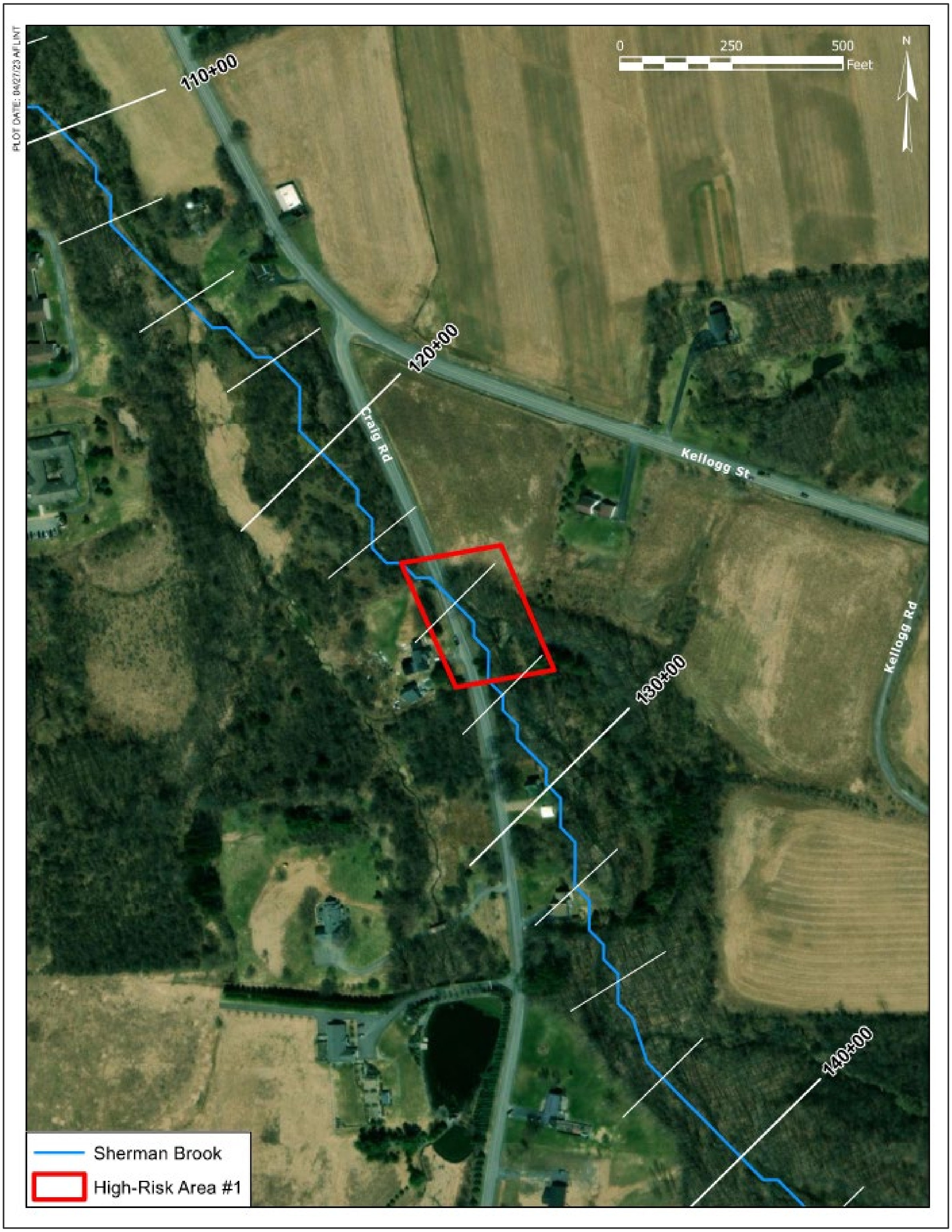


Figure 6-3. High-Risk Area #1: Craig Road, Town of Kirkland, NY.

### 6.8.2 High-Risk Area #2: Upstream of New Street

High-Risk Area #2 is an area after Dawes Avenue culvert at river station 70+00 to the New Street culvert at river station 55+00 (Figure 6-4). Flooding in this area poses a threat to residential properties along New Street, and critical infrastructure on New Street, maintained by the Town of Kirkland. Currently, there is no FEMA FIS report or FIRMs for High-Risk Area #2.

The NYSDOT functional classification for New Street is "local urban roadway," which is not eligible for the STP funding (NYSDOT 2017). Additionally, the existing conditions model shows the New Street culvert does not successfully pass the NYSDOT required 2 ft of freeboard over the 2% ACE (50-yr flood) event or cannot successfully pass the 1% ACE. The existing conditions model does not represent sediment or debris accumulation at the culvert location and if simulated, the results might show a higher WSE.

A privately owned abandoned quarry is located along the reach of High-Risk Area #2. Field access was limited as the property is privately-owned. Observations from orthoimagery suggest the quarry, about 3.8 acres, is along the channel bank. In the last ten years, the channel bank has experienced more exposure to stream bank erosion and channel bank instability than in the past.

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. 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 (GASWCC 2000).

Additionally, the area is surrounded by a steep, forested area, and with an unstable bank, trees are more susceptible to falling if loose sediment is not supporting vegetative roots. Debris and sediment accumulation restricts the channel flow area, which can cause water surfaces to rise and potentially overtop banks or back water upstream of structures and/or meanders. High-Risk Area #2 includes many source areas for sediment and debris issues.

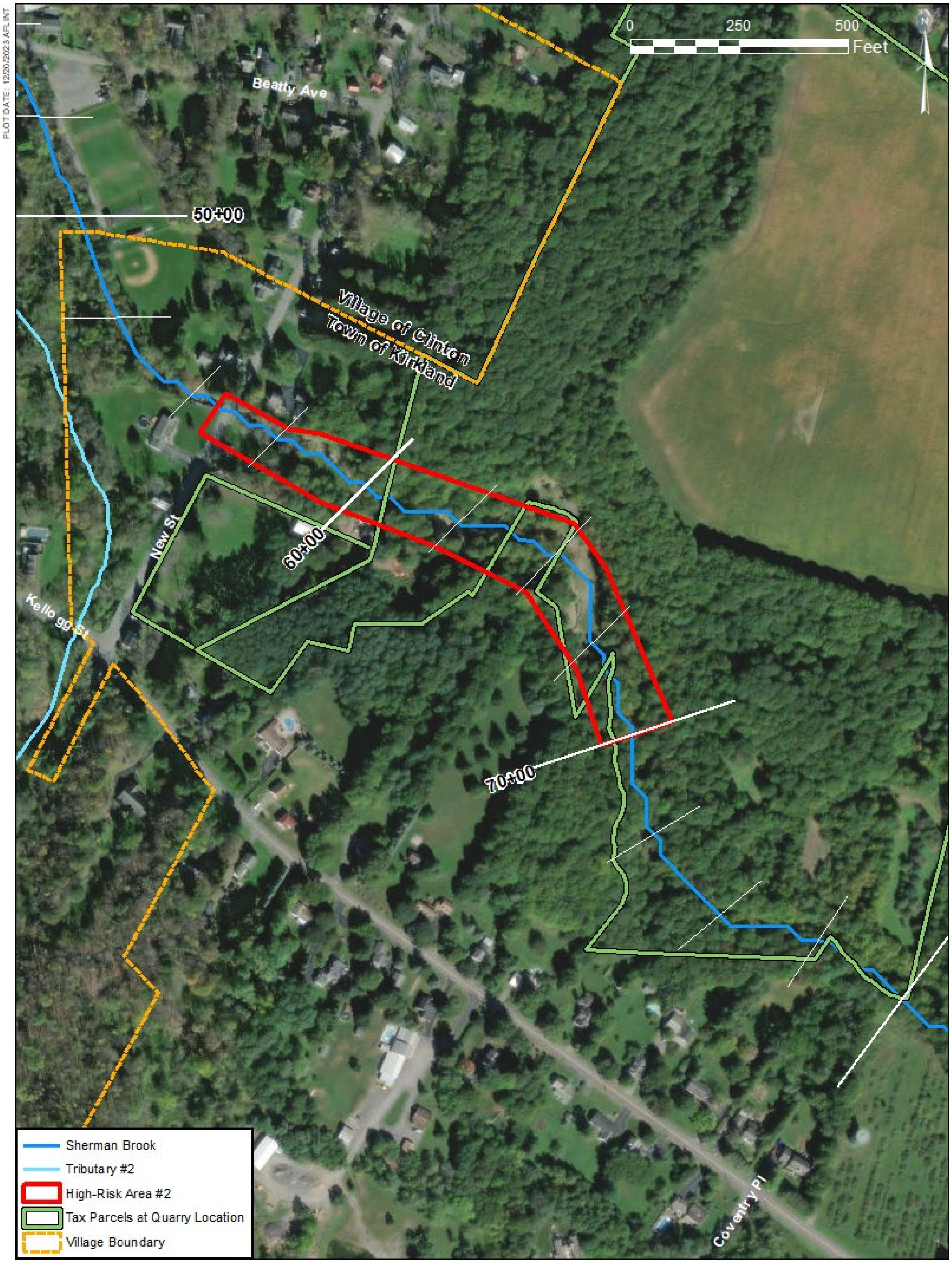


Figure 6-4. High-Risk Area #2: Upstream of New Street, Town of Kirkland, NY.

### 6.8.3 High-Risk Area #3: Kiwanis Memorial Field

High-Risk Area #3 is the downstream area of the New Street culvert at river station 55+00 to the Beatty Avenue bridge at river station 45+00 (Figure 6-5). The open space, named Kiwanis Memorial Field, consists of one baseball diamond and two soccer fields mainly for youth sporting activities. The private property is owned by the Kiwanis Club, a non-profit organization. The confluence of Tributary #2 is within High-Risk Area #3. Flooding in this area poses a threat to residential properties along New Street and Beatty Avenue, recreational fields, and critical infrastructure on Beatty Avenue maintained by the Village of Clinton. Some portions of High-Risk Area #3 are within the FEMA 1% and 0.2% ACE flood areas.

The NYSDOT functional classification for Beatty Avenue is “local urban roadway” which is not eligible for the STP funding (NYSDOT 2017). Additionally, according to the FEMA FIS and FIRM for the Village of Clinton, there is significant backwater and widespread flooding at the Beatty Avenue bridge location. In addition, the FEMA FIS profile plots show bridge crossing does not provide the NYSDOT required 2 ft of freeboard over the 2% (50-yr) ACE or cannot successfully pass the 1% ACE (FEMA 2013a).

The High-Risk Area is surrounded by a forested area on the left bank and a flat terrain on the right bank. This reach is also susceptible to sediment aggradation and tree and debris buildup from upstream sources, such as sources described in High-Risk Area #2. Aggradation and tree/debris buildup restrict the channel flow area, which can cause water surfaces to rise and potentially overtop banks or back water upstream of structures and/or meanders.

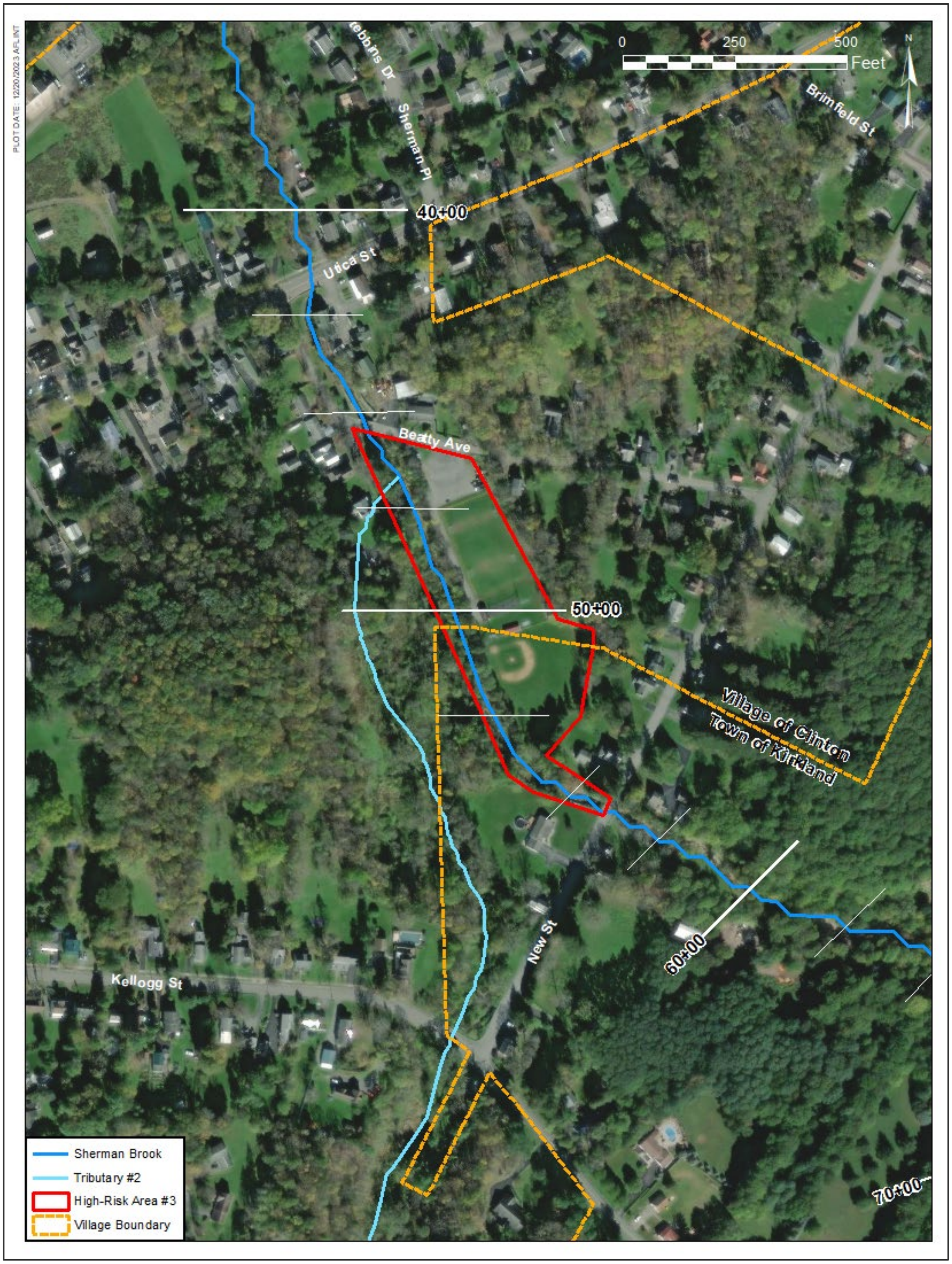


Figure 6-5. High-Risk Area #3: Kiwanis Memorial Field, Town of Kirkland and the Village of Clinton, NY.

### 6.8.4 High-Risk Area #4: Utica Street

High-Risk Area #4 is an area after the Beatty Avenue bridge at river station 45+00 to the Utica Street culvert at river station 41+00 (Figure 6-6). Flooding in this area poses a threat to residential and commercial properties along Beatty Avenue and Utica Street, and critical infrastructure on Utica Street maintained by the NYSDOT. High-Risk Area #4 is within the FEMA 1% and 0.2% ACE flood areas.

According to the FEMA FIS and FIRM for the Village of Clinton, there is significant backwater and widespread flooding at the Utica Street culvert location. In addition, the FEMA FIS profile plots show culvert crossing does not provide the NYSDOT required 2 ft of freeboard over the 2% (50-yr) ACE and cannot successfully pass the 1% ACE (FEMA 2013a).

Sherman Brook flows within the most heavily developed areas in the watershed at High-Risk Area #4 where multiple residential and commercial properties are within the 100-yr and 500-yr flood zones. In addition, there are numerous structures within the regulatory floodway of Sherman Brook and, as such, are not allowed to build fences or other structures that will obstruct the creek’s flow (FEMA 2013a).

The NYSDOT functional classification for Utica Street is “Principal Arterial Other (urban),” which is eligible for the STP funding. Additionally, Utica Street is an important route in the Village where businesses and residences that reside along or adjacent to it depend on the traffic and access (NYSDOT 2017).

The High-Risk Area #4 is surrounded by developed land and the channel bank is channelized from large boulder retaining walls which is designed to protect the channel bank from erosion. However, when the WSE is higher than the retaining walls, the channel bank begins to erode. Channel bank erosion occurs with natural channel processes such as channel migration, however, the natural process poses a constant threat to properties and structures located along the channel (USGS 2017). This disconnect between the channel and the floodplain lacks the capacity for storage of water which can be damaging to properties and structures surrounding the channel areas.

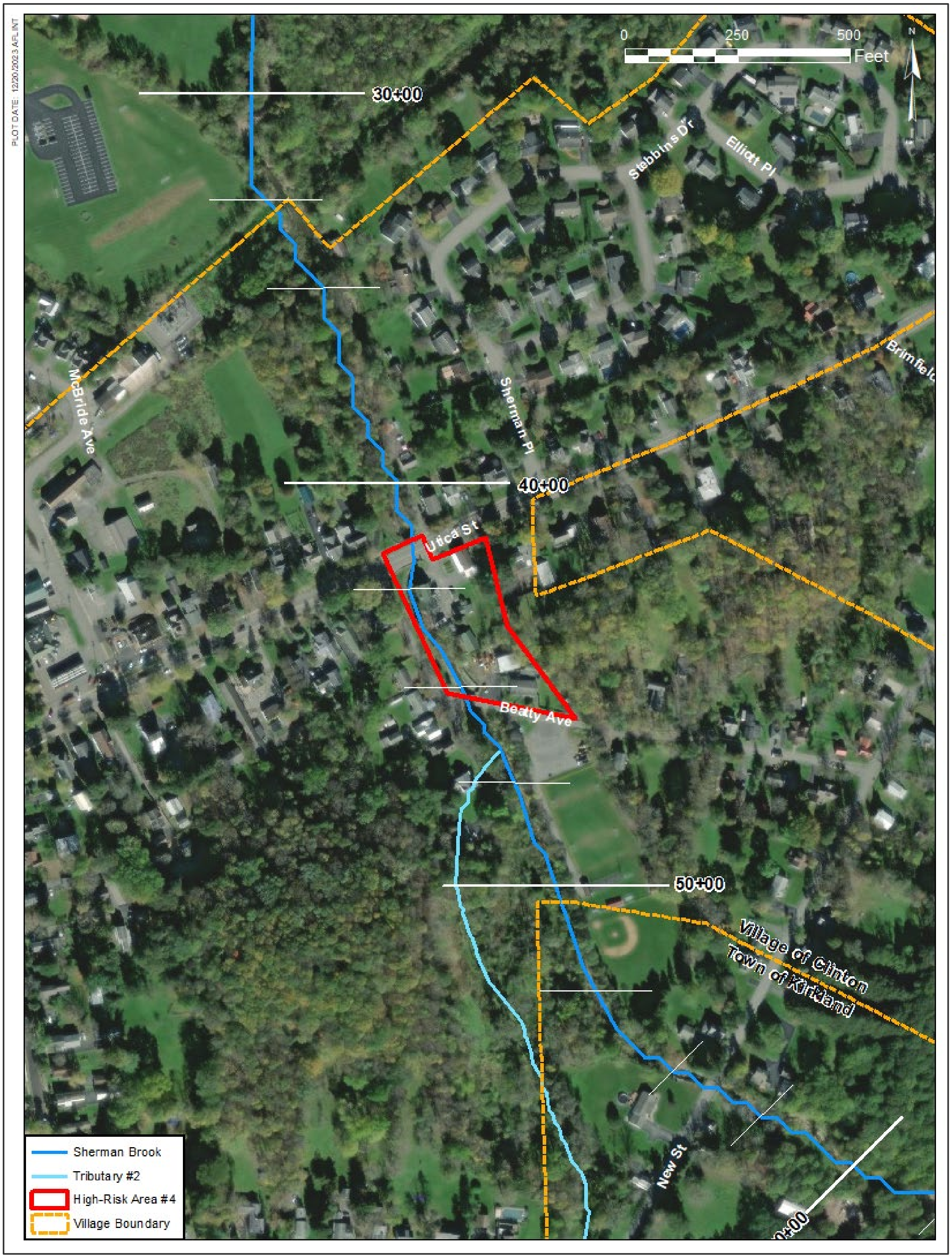


Figure 6-6. High-Risk Area #4: Utica Street, Village of Clinton, NY.

### 6.8.5 High-Risk Area #5: Upstream of Kirkland Avenue

High-Risk Area #5 is an area upstream of the Kirkland Avenue bridge at river station 32+50 to the Kirkland Avenue bridge at river station 11+00 (Figure 6-7). Flooding in this area poses a threat to residential properties and agricultural fields along Old Kirkland Avenue and critical infrastructure on Kirkland Avenue maintained by Oneida County. Currently, there is no FEMA FIS report or FIRMs for High-Risk Area #5.

The NYSDOT functional classification for Kirkland Avenue is “Major Collector (urban),” which is eligible for the STP funding (NYSDOT 2017). Additionally, the existing conditions model shows the Kirkland Avenue bridge does successfully pass the NYSDOT required 2-ft of freeboard over the 2% ACE (50-yr flood) event but will successfully pass the 1% ACE. However, the existing conditions model does not represent sediment or debris accumulation at the bridge location and if simulated, the results might show a higher WSE.

Channel systems are constantly changing and with the introduction to new development and human or natural disturbances, alluvial systems need time to adjust to reach an equilibrium. Channel bank instability causes an energy imbalance in the riverine system where high-frequency storm event causes the streams to have aggregation of sediment. (USGS 2017).

The channel upstream of High-Risk Area #5 flows through forested areas and flows adjacent to agricultural fields. This reach is also susceptible to sediment aggradation and tree and debris buildup from upstream sources as the water flow begins to slow. Aggradation and tree/debris buildup restricts the channel flow area, which can cause water surfaces to rise and potentially overtop banks or back water upstream of structures and/or meanders.

High-Risk Area #5 is a location where water tends to overtop the bank and flood the fields in the left and right banks of the channel upstream of the Kirkland Avenue bridge. Water continues to move in a northeast direction across the Old Kirkland Avenue roadway and floods residential properties. A potential reason for this regular occurrence is because in this area the channel is relatively shallow with low overbanks, so the water has a high potential to overtop the banks during high flow events. Once overtopped, the water will spill into the adjacent low-lying floodplain, which increases the potential for flood damages to nearby structures and land.

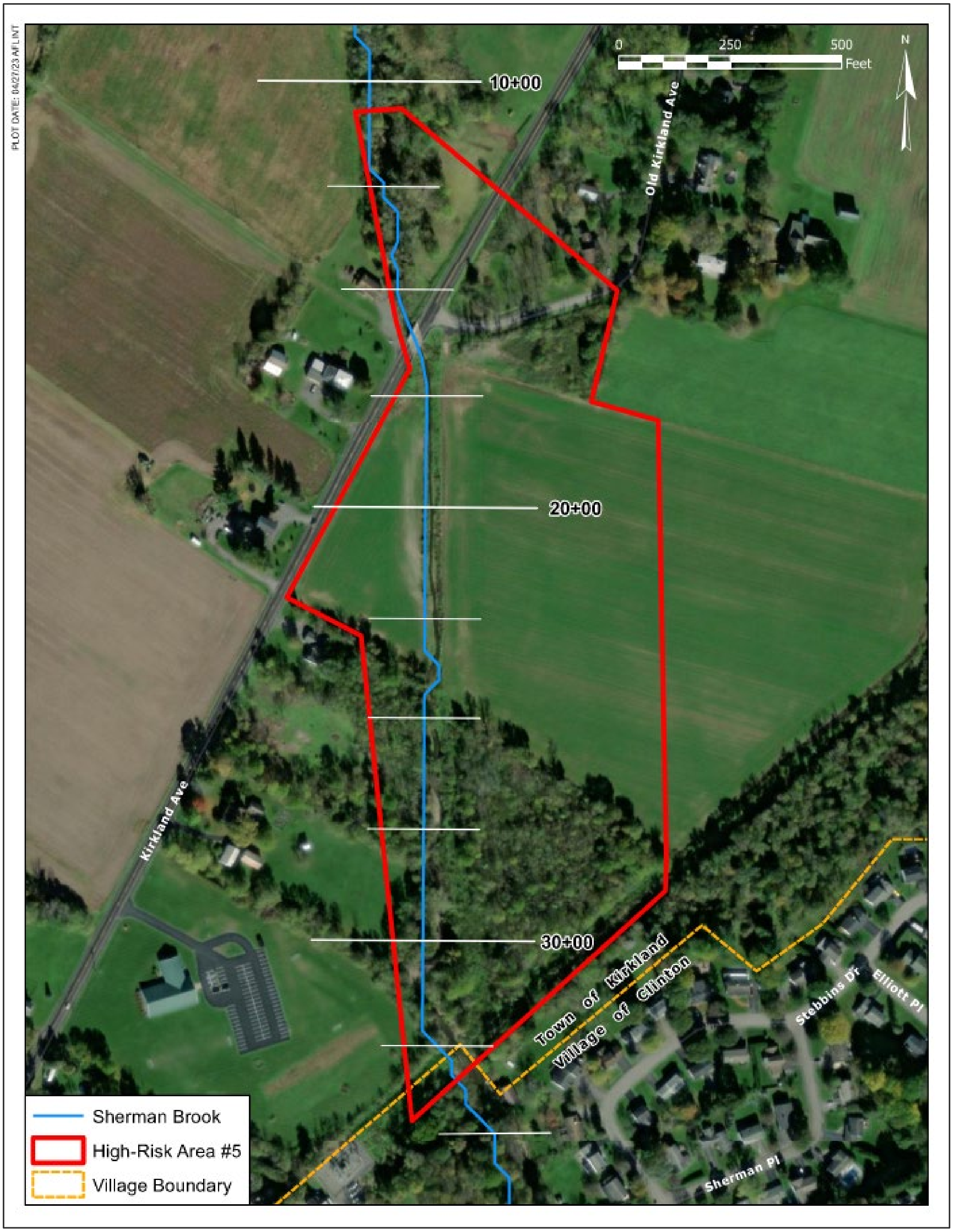


Figure 6-7. High-Risk Area #5: Upstream of Kirkland Avenue, Town of Kirkland, NY.

### 6.8.6 High-Risk Area #6: Unnamed Tributary #2

High-Risk Area #6 is located on the Unnamed Tributary #2. This tributary flows into the main branch of Sherman Brook, which is 190-feet upstream of the Beatty Avenue bridge (Figure 6-8). The focus area along this tributary is downstream of Spring Street starting at Tributary #2 (river station 42+00) to the culvert on Kellogg Street where the tributary flows through at Tributary #2 (river station 14+00).

In High-Risk Area #6, flooding was identified along the downstream areas at the confluence with Sherman Brook. Currently, there is no FEMA FIS report or FIRMs for High-Risk Area #6. Through public engagement meetings, the community requested a study of Tributary #2 for possible alternatives to decrease the flow into Sherman Brook downstream of Kiwanis Memorial Field. Community members recommended multiple potential mitigation strategies, including revitalizing or removing a dam located at Tributary #2 river station 28+50 and construction of a sediment trap upstream of Kellogg Street at Tributary #2 river station 14+00.

The NYSDOT functional classification for Kellogg Street or County Route 13 is “local urban roadway,” which is not eligible for the STP funding (NYSDOT 2017). Oneida County has developed preliminary designs to replace and increase the hydraulic capacity of the existing Kellogg Street culvert. The current culvert is a 6-ft diameter reinforced concrete pipe. A preliminary design of the replacement culvert will incorporate a 10-ft wide, 8-ft in height, 4-sided box culvert with 2-ft of embedment.

Additionally, the area is surrounded by a steep forested area, and with an unstable bank, trees are more susceptible to falling if loose sediment is not supporting vegetative roots. Debris and sediment accumulation restricts the channel flow area, which can cause water surfaces to rise and potentially overtop banks or back water upstream of structures and/or meanders. High-Risk Area #6 includes many source areas for sediment and debris issues.

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. 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 (GASWCC 2000).

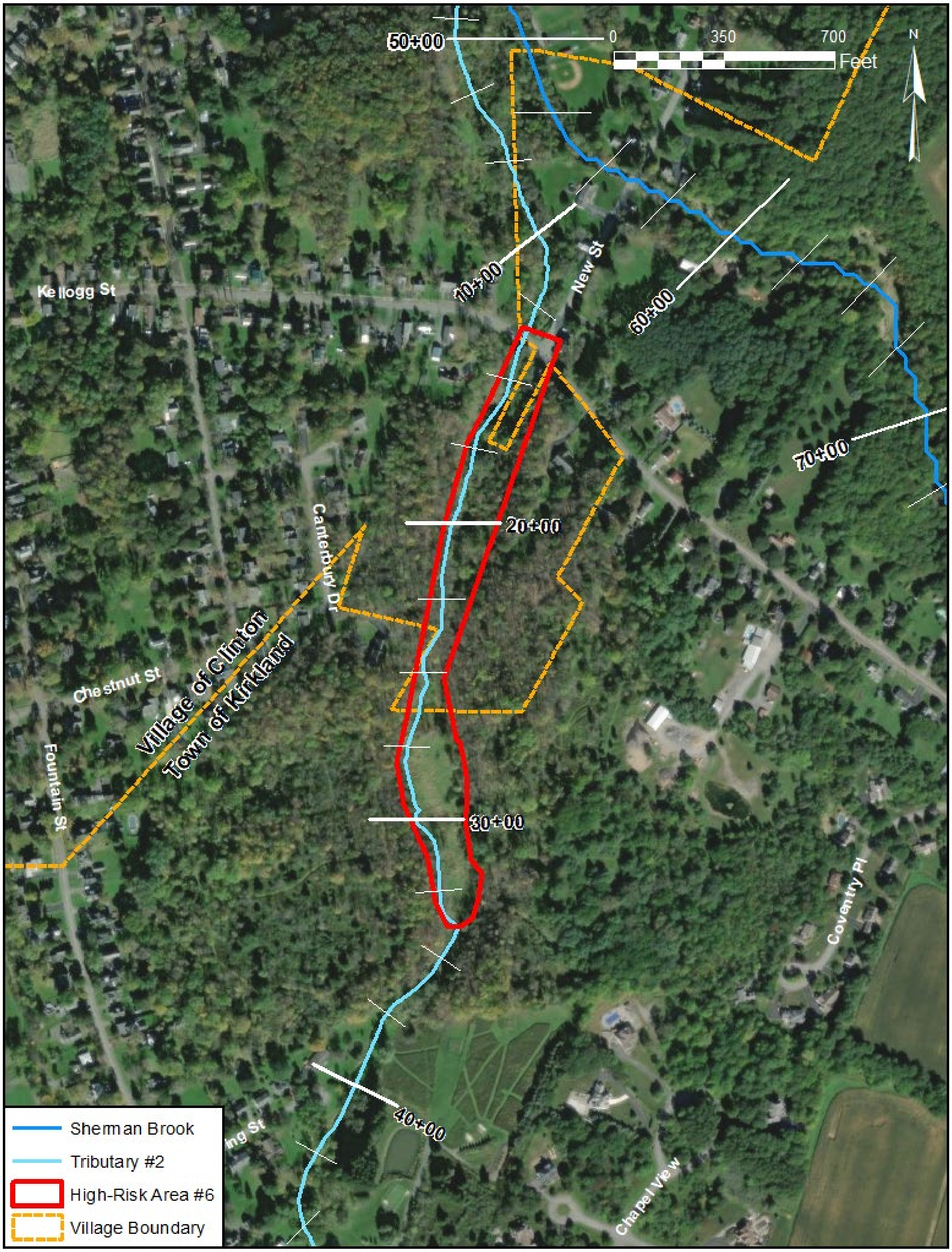


Figure 6-8. High-Risk Area #6: Tributary #2, Town of Kirkland and Village of Clinton, NY.

# 7. MITIGATION ALTERNATIVES

The following are flood mitigation alternatives that have the potential to reduce water surface elevations along high-risk areas of Sherman Brook. These alternatives could potentially reduce flood-related damages in areas adjacent to the channel.

It should be noted that stationing references for Sherman Brook for the remainder of this report are based on the HEC-RAS model software unless stated otherwise (e.g., FEMA FIS data, USGS NHD).

## 7.1 HIGH-RISK AREA #1

### 7.1.1 Alternative #1-1: Increase Hydraulic Capacity of the Craig Road Culvert

An increase in the hydraulic capacity of the Craig Road Culvert would increase the cross-sectional flow area of the channel located at river station 124+00 (Figure 7-1).

**Figure 7-1. Placement of proposed replacement culvert at High-Risk Area #1 along Sherman Brook.**

The culvert is maintained by the Town of Kirkland. The existing box culvert has a culvert span of 16-ft and a height of 3.7-ft (Figure 7-2). The flooding in the vicinity of the Craig Road culvert poses a flood-risk threat to nearby residential properties and town-owned infrastructure. Appendix D depicts a flood mitigation rendering of a culvert widening scenario.

**Figure 7-2. Upstream view of the Craig Road culvert in the Sherman Brook corridor.**

Based on the terrain, the upstream areas of this reach are steep causing high flow velocities which can be damaging to properties and infrastructure especially when the water capacity is not contained within the channel.

The existing conditions show the 4%, 2%, 1%, and 0.2% ACE WSELs successfully pass under the Craig Road culvert, but there is significant backwater upstream of the culvert. Additionally, the culvert is an obstruction in the channel that acts as a catchpoint for large sediment and debris.

By increasing the opening span of the culvert structure, the cross-sectional flow area of the channel would increase and the potential for sediment and debris to accumulate or catch on the upstream face of the bridge would be reduced, thereby reducing flood risk to areas adjacent to and immediately upstream of the culvert.

The culvert widening design chosen for this proposed condition model simulation was selected to ensure that the 2% ACE WSEL could successfully pass under the Craig Road culvert. To achieve the desired result, the bridge widening design increased the span of the culvert opening from 16 ft to 20 ft and increased the rise of the culvert from 3.7 ft to 4 ft.

For this alternative, open-water and debris-obstruction simulations were performed to test the effectiveness of the alternative at reducing water surface elevations for increasing the hydraulic capacity at Craig Road.

Table 17 outlines the results of the proposed conditions and future conditions from the model simulation. Figures 7-3 and 7-4 display the profile plots for the culvert widening alternative. Full model outputs for this alternative can be found in Appendix E.

**Table 17. Summary of Results for Alternative #1-1 with Proposed and Future Conditions Based on Open-Water Simulations for the 1% ACE**

| **Proposed Conditions** | **Increased Hydraulic Capacity** |
|---|---|
| Reductions in Water Surface Elevations | Up to 0.2-ft |
| Total Length of Benefited Area | 250-ft |
| River Stations | 127+00 to 124+50 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations | Up to 0.1-ft |
| Total Length of Benefited Area | 250-ft |
| River Stations | 127+00 to 124+50 |

The primary benefits of increasing the hydraulic capacity of the culvert would be to increase the flow capacity of the culvert structure, reduce the potential of backwater from high-flow events, and help prevent debris from catching on the structure and creating obstructions/jams upstream of the bridge. Additionally, the water surface elevation would be lowered, and the roadway would be protected from high velocity flows during frequent storm events.

The ROM cost for this strategy is approximately $260,000, which does not include land acquisition costs for survey, appraisal, and engineering coordination. Additional engineering consideration would also be required to determine if increasing the bridge opening would alter the structural integrity of the bridge in any way.

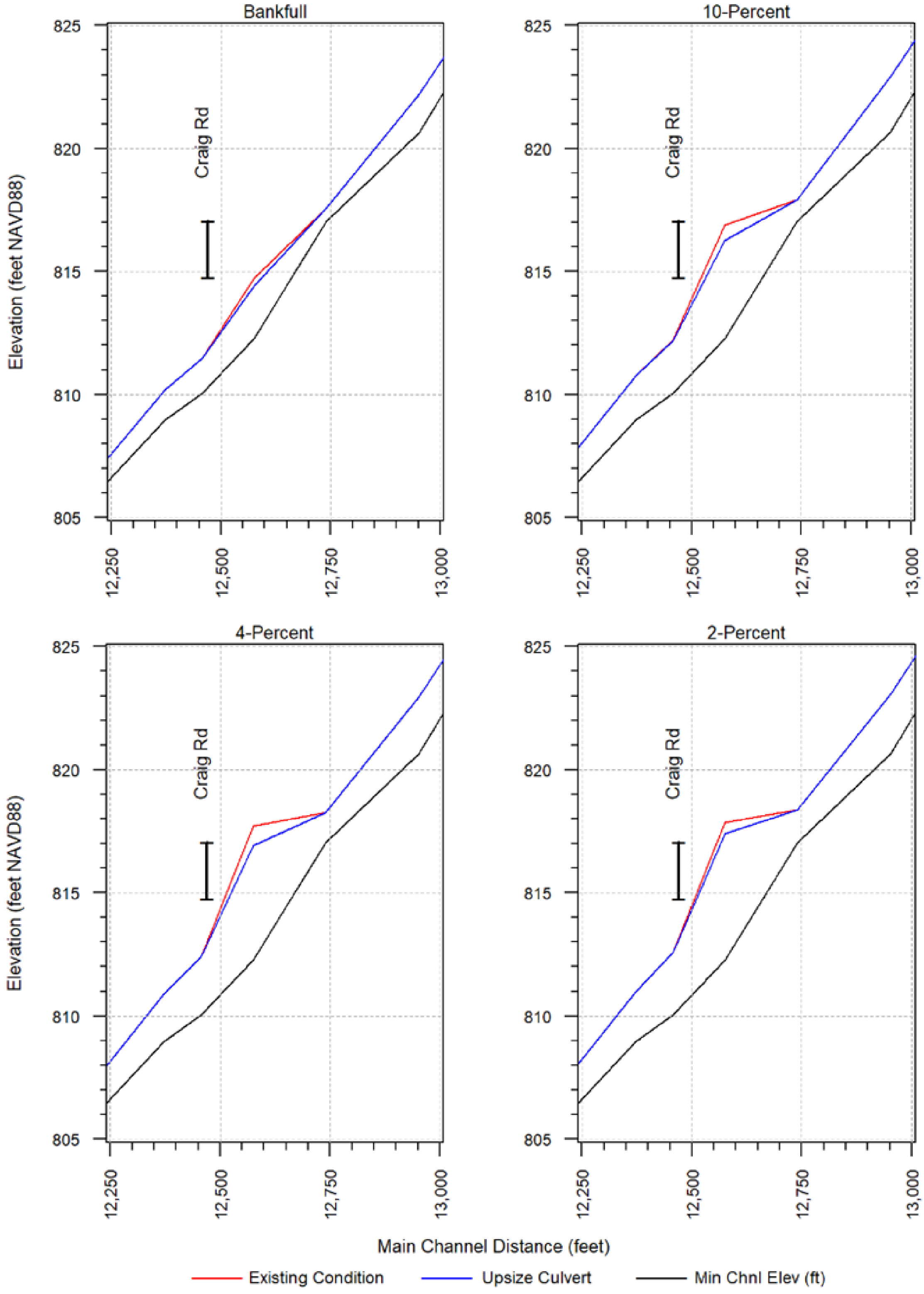


**Figure 7-3. HEC-RAS model simulation output results for Alternative #1-1 for the existing condition (red) and proposed alternative (blue) scenarios.**

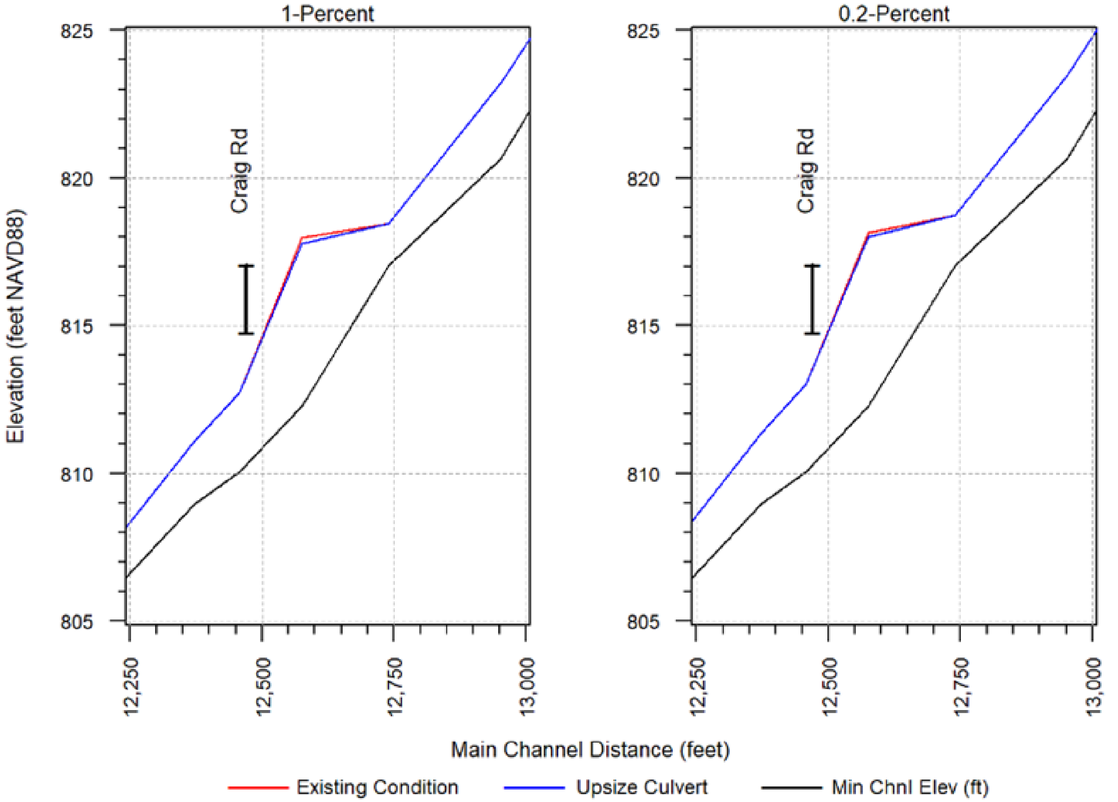


**Figure 7-3 (continued). HEC-RAS model simulation output results for Alternative #1-1 for the existing condition (red) and proposed alternative (blue) scenarios.**

## 7.2 HIGH-RISK AREA #2

### 7.2.1 Alternative #2-1: Bank and Channel Stabilization and Grade Control Structures Upstream of New Street

Within a particular reach, sediment fluxes can originate from land surface erosion, streambank erosion, upstream reach sediment input, or remobilization of sediments previously deposited within the reach. Bank and channel erosion is a significant contributor to sediment in a stream. The erosion and deposition of sediments within a stream network is highly dependent on the geomorphological features of the stream network (i.e., channel width, flow depth and cross-sectional geometry, bed slope and roughness, and discharge velocity and volume). In general, reaches with smaller cross-sectional flow area, steeper slopes, and higher flow velocities discourage the deposition of sediments, while wider channels with lower bed slopes and flow velocities act as regions of relative sediment deposition (USEPA 2009).

Streambank stabilization measures work either by reducing the force of flowing water, increasing the resistance of the bank to erosion, or by some combination of both. Generally speaking, there are four approaches to streambank protection:

- The use of vegetation
- Soil bioengineering
- The use of rock work in conjunction with plants
- Conventional bank armoring

Re-vegetation includes seeding and sodding of grasses, seeding in combination with erosion-control fabrics, and 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 established vegetation will flourish naturally, without maintenance, and will continue to protect the banks and channel from erosion. Conventional armoring is a fourth technique which includes the use of rock, known as riprap, to protect eroding streambanks.

In order to recommend the most appropriate bank and channel stabilization strategies, engineers and scientists need to have an understanding of how sediment enters, moves through, and exits a stream network. By using sediment transport models, engineers and scientists can quantify and evaluate sediment transport using four key variables: invert change, mass bed change, shear stress, and velocity.

Based on the sediment transport understandings, a streambank stabilization strategy can be recommended specifically for High-Risk Area #2. Table 18 represents the possible streambank stabilization strategies to support bank and channel stabilization for a 1% ACE in High-Risk Area #2. Appendix D also includes a cross sectional view of bank stabilization strategies and a guide to distinguish the allowable maximum shear stress and velocities for each treatment type shown in Table 18.

**Table 18. Possible Streambank Stabilization Strategies**

Source: NRCS 2009

| Type of Treatment | Type of Sub-Treatment |
|---|---|
| Brush Mattress | Staked only w/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 |
| | Brush layering (initial/grown) |
| Boulder Clusters | Small boulder (>10-inch diameter) |

The streambank strategies for High-Risk Area #2 are suggested to be designed for Sherman Brook at river station 70+00 to 56+00.

Due to the variable, conceptual, and site-specific nature of streambank stabilization strategies, no ROM cost estimates were determined for this measure. Additional geomorphic and engineering analyses, including additional modeling (i.e., coupled 1-D/2-D unsteady flow, 2-D unsteady flow and rain-on-grid), and geotechnical engineering would be necessary in order to determine the most appropriate streambank stabilization strategy and its associated costs.

### 7.2.2 Alternative #2-2: Natural Stream Restoration Upstream of New Street

During high-flow periods, bank erosion from upstream sources has deposited large amounts of sediment and debris in the channel while scouring away and destabilizing the banks. An abandoned quarry is located about 3,200 ft (0.6 miles) upstream of New Street where sediment for landscapes was extracted along the banks of Sherman Brook. In the last decade, head-cutting has become more frequent in this steep area. The channel bank has become unstable as sediment erosion increases and old-growth trees fall into the stream. As a result, the original natural channel geometry has been disrupted in this reach.

Natural stream restoration techniques can improve water quality, enhance aesthetic value, improve wildlife habitat and enhance floodplain function. A successful natural stream restoration project requires following a multi-step process to ensure thorough consideration is given to the planning and design stage before any work in the stream corridor occurs. These steps include (Fleming, et al. 2017):

- Defining the objectives such as flood control, improving recreation, improving habitat, or reducing bank erosion;
- Assessing the current condition of the stream including noting any downcutting or widening; the amount, type, and condition of bank vegetation; changes in the watershed upstream, or features downstream that are constricting flow;
- Determining the best course of action, which can include re-vegetation plans, riparian buffers, channel and bank stabilization, and other stream redesign and construction projects;
- Constructing the selected stream restoration strategy, which can involve reshaping the stream channel and floodplain, building in-stream structures, protecting the banks, and removing invasive vegetation.

This mitigation strategy proposes restoring the channel banks of Sherman Brook in High-Risk Area #2 and employing the stream restoration techniques discussed to reduce sediment aggradation, improve water quality, enhance aesthetic value, improve wildlife habitat, and enhance floodplain function along this reach. Figure 7-4 represents the location of the channel restoration area from river station 56+00 to 70+00.

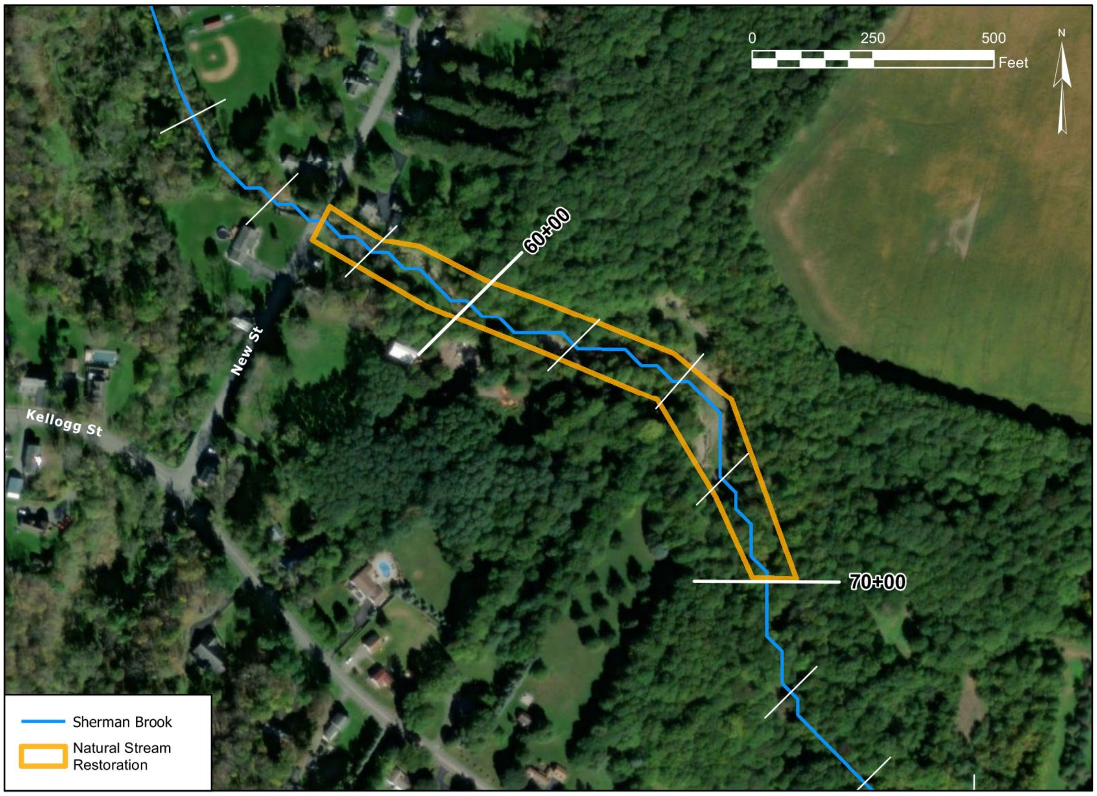


**Figure 7-4. Location map for proposed stream restoration upstream of New Street along Sherman Brook.**

By removing sediment and debris within the channel, the cross-sectional flow area would increase allowing a larger volume of water to flow through this reach unobstructed thereby reducing flood risk. Stabilizing the channel banks would make the banks more resistant to erosion and bank failure, which in turn would reduce overall sediment loads in this reach and the lower reaches of Sherman Brook.

The primary benefits of restoring the channel geometry of Sherman Brook in this reach would be to increase the flow capacity through the culvert structure and help prevent debris from catching on sediment bars and other large debris that have accumulated in this reach.

It is important to note that the removal of aggraded sediment and debris alone is not an adequate flood mitigation strategy unless the upstream sources of sediment and debris are addressed. The sources and potential strategies are best analyzed to address sediment and debris in a Sediment and Debris Management Study. The NYSDEC highly recommends identifying and addressing upstream sediment and debris sources before addressing any potential mitigation strategy that includes sediment and/or debris removal.

The ROM cost for this strategy is approximately $760,000, which does not include land acquisition costs for survey, appraisal, and engineering coordination.

### 7.2.3 Alternative #2-3: Increase Hydraulic Capacity of the New Street Culvert

This measure is intended to address issues within High-Risk Area #2 by increasing the width of the New Street culvert opening, which would increase the cross-sectional flow area of the channel located at river station 55+00 (Figure 7-5).

**Figure 7-5. Placement of proposed replacement culvert at High-Risk Area #2 along Sherman Brook.**

The culvert is maintained by the Town of Kirkland. The existing circular culvert has a diameter of 7.5-ft (Figure 7-6). The flooding in the vicinity of the New Street culvert poses a flood-risk threat to nearby residential properties and town-owned infrastructure. Appendix D depicts a flood mitigation rendering of a culvert widening scenario.

Figure 7-6. Upstream view of the New Street Culvert in the Sherman Brook corridor.

Based on the terrain, public engagement meetings, and media, the upstream areas of this reach are steep, which causes high flow velocities which can be damaging to residential properties and infrastructure especially when the water capacity is not contained within the channel.

The existing conditions show the 2%, 1%, and 0.2% ACE WSELs successfully pass under the New Street culvert, but there is significant backwater occurring upstream. Additionally, the culvert is as obstruction in the channel that acts as a catchpoint for large sediment and debris.

By increasing the opening span of the culvert structure, the cross-sectional flow area of the channel would increase and the potential for sediment and debris to accumulate or catch on the upstream face of the bridge would be reduced, thereby reducing flood risk to areas adjacent to and immediately upstream of the culvert.

The culvert widening design selected for this proposed condition model simulation was selected to ensure that the 1% ACE WSEL could successfully pass under the New Street culvert without significant backwater upstream of the bridge. To achieve the desired result, the culvert widening design would change the circle culvert to a box culvert with a span of 16 ft and a rise of 8 ft.

For this alternative, open-water and debris-obstruction simulations were performed to test the effectiveness of the alternative at reducing water surface elevations for increasing the hydraulic capacity at New Street.

Tables 19 and 20 outline the results of the proposed conditions and future conditions from the model simulation with and without a debris obstruction. Figures 7-7 through 7-8 display the profile plots for the culvert widening alternative with and without a debris obstruction. Full model outputs for this alternative can be found in Appendix E.

**Table 19. Summary of Results for Alternative #2-3 with Proposed and Future Conditions Based on Open-Water Simulations for the 1% ACE**

| Proposed Conditions | Increased Hydraulic Capacity |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 4.7-ft |
| Total Length of Benefited Area | 350-ft |
| River Stations | 58+50 to 55+00 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations (feet) | Up to 4.3-ft |
| Total Length of Benefited Area | 350-ft |
| River Stations | 58+50 to 55+00 |

**Table 20. Summary of Results for Alternative #2-3 with Proposed and Future Conditions Based on Debris-Obstruction Simulations for the 1% ACE**

| Proposed Conditions with Debris-obstruction | Increased Hydraulic Capacity |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 4.3-ft |
| Total Length of Benefited Area | 350-ft |
| River Stations | 58+50 to 55+00 |
| **Future Proposed Conditions with Debris-obstruction** | |
| Reductions in Water Surface Elevations (feet) | Up to 3.4-ft |
| Total Length of Benefited Area | 350-ft |
| River Stations | 58+50 to 55+00 |

The results show a significant reduction in the WSEL with all 1-D model simulations for alternative #2-3. Results also indicate an adverse effect immediately downstream of the New Street culvert where the proposed alterative will increase the WSEL by 0.13-ft during high-flow events only (1 and 0.2% ACE).

The potential benefits of this strategy are limited to upstream of the New Street culvert. The primary benefits of increasing the culvert opening would be to increase the flow capacity of the culvert structure, reduce the potential of backwater from high-flow events, and help prevent debris and ice from catching on the structure and creating obstructions/jams upstream of the culvert.

The ROM cost for this strategy is approximately $310,000, which does not include land acquisition costs for survey, appraisal, and engineering coordination. Additional engineering consideration would also be required to determine if increasing the culvert opening would alter the structural integrity of the culvert in any way.

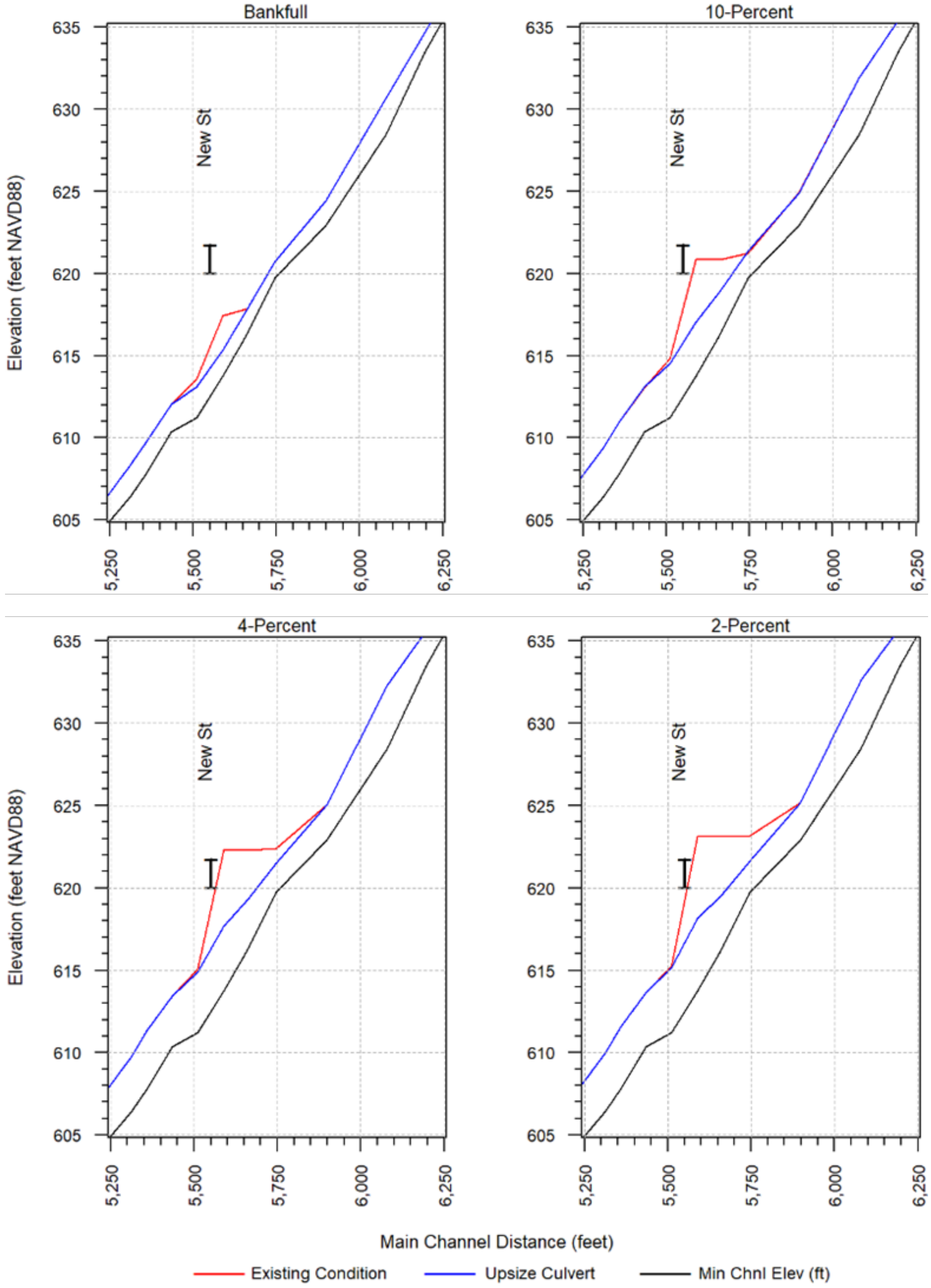


**Figure 7-7. HEC-RAS model simulation output results for Alternative #2-3 for the existing condition (red) and proposed alternative (blue) scenarios.**

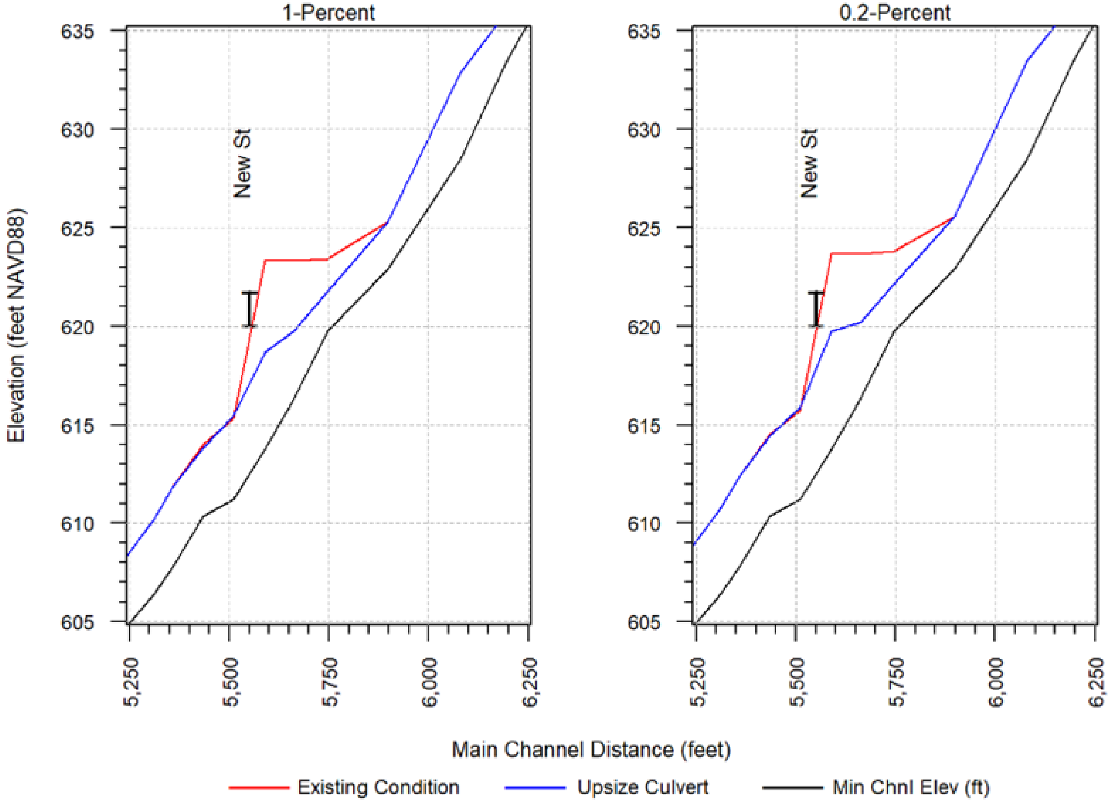


**Figure 7-7 (continued). HEC-RAS model simulation output results for Alternative #2-3 for the existing condition (red) and proposed alternative (blue) scenarios.**

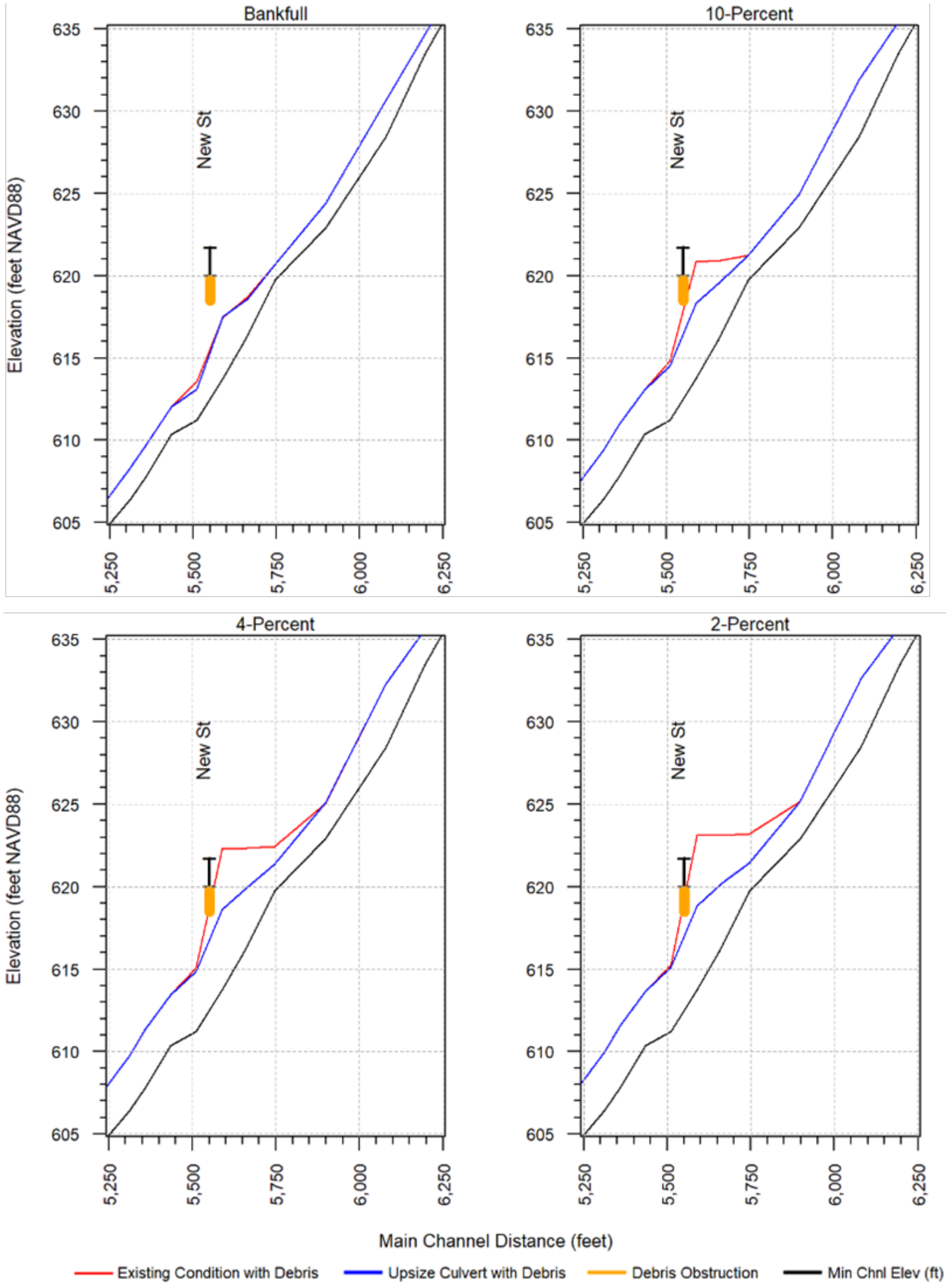


Figure 7-8. HEC-RAS model simulation output results for Alternative #2-3 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.

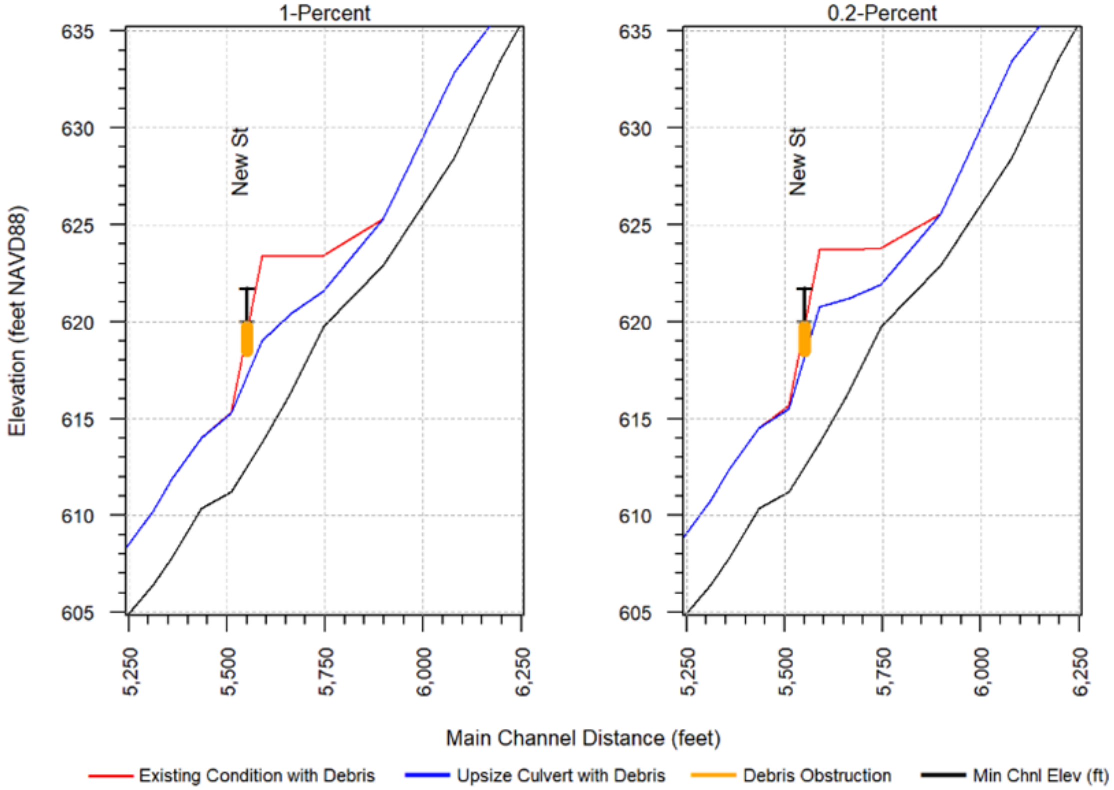


**Figure 7-8 (continued). HEC-RAS model simulation output results for Alternative #2-3 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

## 7.3 HIGH-RISK AREA #3

### 7.3.1 Alternative #3-1: Bank and Channel Stabilization Adjacent to Kiwanis Memorial Field

Within a particular reach, sediment fluxes can originate from land surface erosion, streambank erosion, upstream reach sediment input, or remobilization of sediments previously deposited within the reach. Bank and channel erosion is a significant contributor to sediment in a stream. The erosion and deposition of sediments within a stream network is highly dependent on the geomorphological features of the stream network (i.e., channel width, flow depth and cross-sectional geometry, bed slope and roughness, and discharge velocity and volume). In general, reaches with smaller cross-sectional flow area, steeper slopes, and higher flow velocities discourage the deposition of sediments, while wider channels with lower bed slopes and flow velocities act as regions of relative sediment deposition (USEPA 2009).

Streambank stabilization measures work either by reducing the force of flowing water, increasing the resistance of the bank to erosion, or by some combination of both. Generally speaking, there are four approaches to streambank protection:

- The use of vegetation (e.g., brush mattress)
- Soil bioengineering
- The use of rock work in conjunction with plants (e.g., gabions)
- 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 established vegetation will flourish naturally, without maintenance, and will continue to protect the banks and channel from erosion. Conventional armoring is a fourth technique which includes the use of rock, known as riprap, to protect eroding streambanks.

In order to recommend the most appropriate bank and channel stabilization strategies, engineers and scientists need to have an understanding of how sediment enters, moves through, and exits a stream network. By using sediment transport models, engineers and scientists can quantify and evaluate sediment transport using four key variables: invert change, mass bed change, shear stress, and velocity.

Based on the sediment transport understandings, a streambank stabilization strategy can be recommended specifically for High-Risk Area #3. Table 21 represents the possible streambank stabilization strategies to support bank and channel stabilization for a 1% ACE in High-Risk Area #3. Appendix D also includes a cross sectional view of bank stabilization strategies and a guide to distinguish the allowable maximum shear stress and velocities for each treatment type shown in Table 21.

**Table 21. Possible Streambank Stabilization Strategies**

| **Source: NRCS 2009** | |
|---|---|
| **Type of Treatment** | **Type of Sub-Treatment** |
| Brush Mattress | Staked only w/rock riprap toe (initial) |
| Coir Geotextile Roll | Roll with coir or Polypropylene rope mesh staked only without rock riprap toe |
| Live Fascine | LF Bundle w/rock riprap toe |
| Gravel/Cobble | 12-inch |
| Vegetation | Class A turf (ret class) |
| Soil Bioengineering | Vegetated Coir mat |
| | Brush layering (initial/grown) |
| | Live willow stakes |
| | Live fascine |
| Boulder Clusters | Small boulder (>10-inch diameter) |

Due to the variable, conceptual, and site-specific nature of streambank stabilization strategies, no ROM cost estimates were determined for this measure. Additional geomorphic and engineering analyses, including additional modeling (i.e., coupled 1-D/2-D unsteady flow, 2-D unsteady flow and rain-on-grid), and geotechnical engineering would be necessary in order to determine the most appropriate streambank stabilization strategy and its associated costs.

### 7.3.2 Alternative #3-2: Flood Bench within Kiwanis Memorial Field Area

This mitigation alternative will reconnect the floodplain to the channel in the Kiwanis Memorial Field Area with a flood bench that would provide additional water storage and increase the floodplain width over the current storage and width provided by the adjacent athletic fields, which could potentially reduce damages in the event of flooding and address issues within High-Risk Area #3. Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and/or downstream of the bench. The flood bench is preliminarily designed to be approximately 3.5 acres in size and located between river stations 45+50 to 53+00 (Figure 7-9).

Figure 7-9. Placement of proposed flood bench at High-Risk Area #3 along Sherman Brook.

Based on the existing conditions model, public engagement meetings, and media, the flood extents spread across the adjacent athletic field where in the past damages to property have occurred and recreational activity was prevented for an extensive time after the flood event. A flood bench will be designed to minimize the damaging impacts from these flood events.

The flood bench used for the proposed condition model simulation is designed to ensure the minimum bench elevation is approximately equal to the bankfull elevation, which was an average depth of 3 ft for the bench. Figure 1 in Appendix G represents a 15% conceptual design of the proposed flood bench.

The flood bench is within the FEMA designated Zone A or Zone AE, which are areas subject to inundation by the 1% ACE (100-yr flood event) as determined in the FIS by detailed methods and where base flood elevations are provided (FEMA 2001). Appendix D depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

For this alternative, open-water and debris-obstruction simulations were performed to test the effectiveness of the alternative at reducing water surface elevations for a flood bench at Kiwanis Memorial Field.

Tables 22 and 23 outline the results of the proposed conditions and future conditions from the 1-D model simulation with and without a debris obstruction. Figures 7-10 through 7-12 display the profile plots for the flood bench alternative with and without a debris obstruction.

**Table 22. Summary of Results for Alternative #3-2 with Proposed and Future Conditions Based on Open-Water 1-D Model Simulations for the 1% ACE**

| Proposed Conditions | Flood Bench at Kiwanis Memorial Field |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 2.8-ft |
| Total Length of Benefited Area | 700-ft |
| River Stations | 53+00 to 46+00 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations (feet) | Up to 3.0-ft |
| Total Length of Benefited Area | 700-ft |
| River Stations | 53+00 to 46+00 |

**Table 23. Summary of Results for Alternative #3-2 with Proposed and Future Conditions Based on Debris-Obstruction 1-D Model Simulations for the 1% ACE**

| Proposed Conditions with Debris-Obstruction | Flood Bench at Kiwanis Memorial Field |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 2.8-ft |
| Total Length of Benefited Area | 700-ft |
| River Stations | 53+00 to 46+00 |
| **Future Proposed Conditions with Debris-Obstruction** | |
| Reductions in Water Surface Elevations (feet) | Up to 3.0-ft |
| Total Length of Benefited Area | 700-ft |
| River Stations | 53+00 to 46+00 |

The results show a significant reduction in the WSEL with all 1-D model simulations for alternative #3-2. Results also indicate an adverse effect immediately upstream of the Beatty Avenue bridge where the proposed alterative will increase the WSEL by 0.06-ft.

Table 24 summarizes the results of the proposed conditions from the 2-D model simulation during the Halloween 2019 Storm event. Figure 7-12 displays the profile plots for the floodplain bench alternative during the July 2017, Halloween 2019, and April 2023 storm events. The full 1-D and 2-D model outputs for this alternative can be found in Appendix E and Appendix F, respectively.

**Table 24. Summary of Results for Alternative #3-2 with Proposed Conditions Based on 2-D Model during Halloween 2019 Storm Event**

| Proposed Conditions | Increased Hydraulic Capacity |
|---|---|
| Reductions in Water Surface Elevations | Up to 1.6-ft |
| Total Length of Benefited Area | 950-ft |
| River Stations | 55+50 to 46+00 |

The results of the 2-D model indicate significant reductions to WSELs within the Sherman Brook channel in the vicinity of the flood bench, which is consistent with the 1-D model results. However, the 2-D results do not indicate any significant benefits to overbank areas or flood extents when compared to the 1-D model results. This is most likely a result of the topographic and geomorphological features (i.e., steep channel slope, erodible banks, lack of flood storage) along Sherman Brook within this reach.

For this alternative to be actionable, a land acquisition is required to convert the recreational area into a natural area which will increase the water storage along the channel. Flood benches create a natural environment and during dry periods, this area could be utilized as a recreational area.

The Rough Order Magnitude (ROM) cost for this flood bench alternative is $1.4 million.
These ROM cost estimates do not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the NYSDEC will require wetland delineations, an analysis for any endangered and/or threatened species within the proposed project area, and information regarding access during construction for this mitigation alternative.

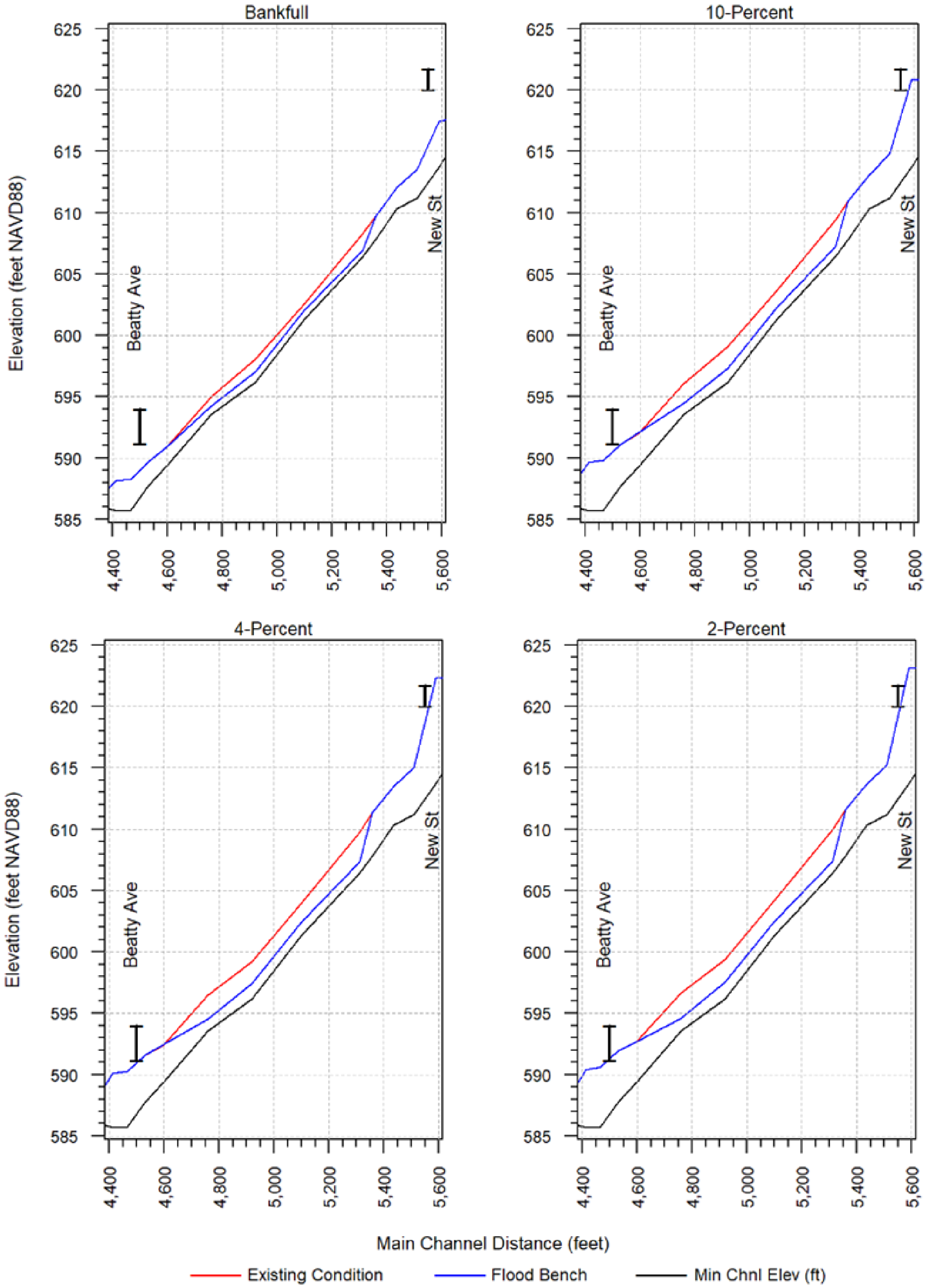


**Figure 7-10. HEC-RAS model simulation output results for Alternative #3-2 for the existing condition (red) and proposed alternative (blue) scenarios.**

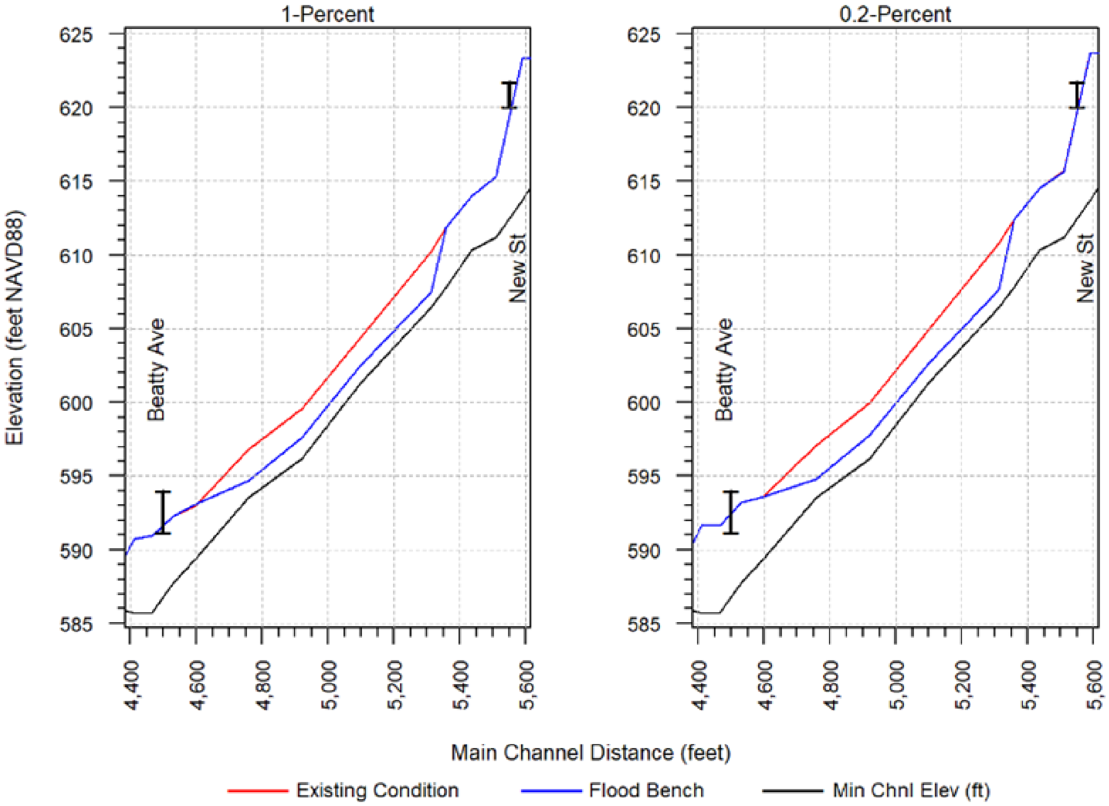


**Figure 7-10 (continued). HEC-RAS model simulation output results for Alternative #3-2 for the existing condition (red) and proposed alternative (blue) scenarios.**

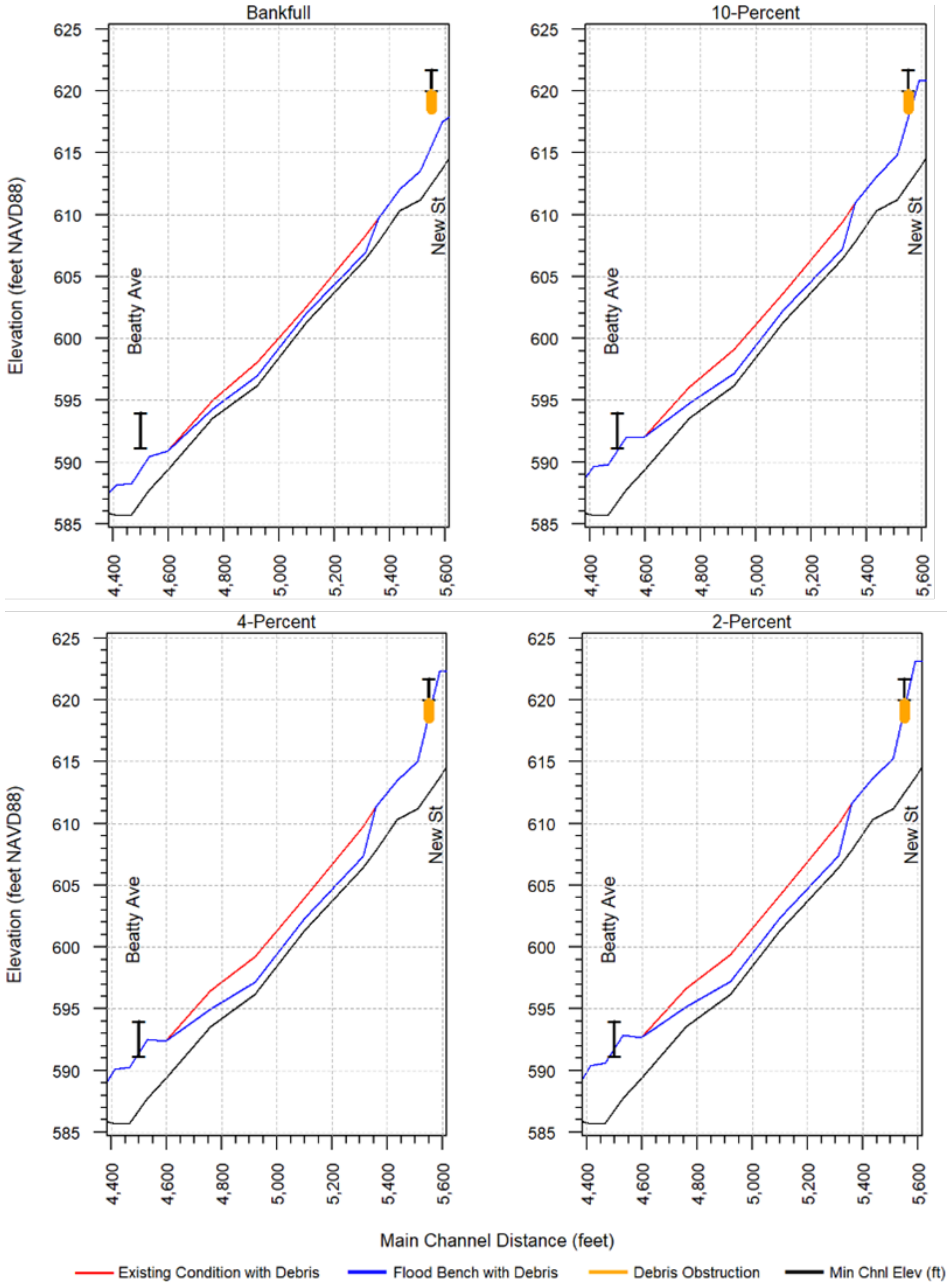


Figure 7-11. HEC-RAS model simulation output results for Alternative #3-2 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.

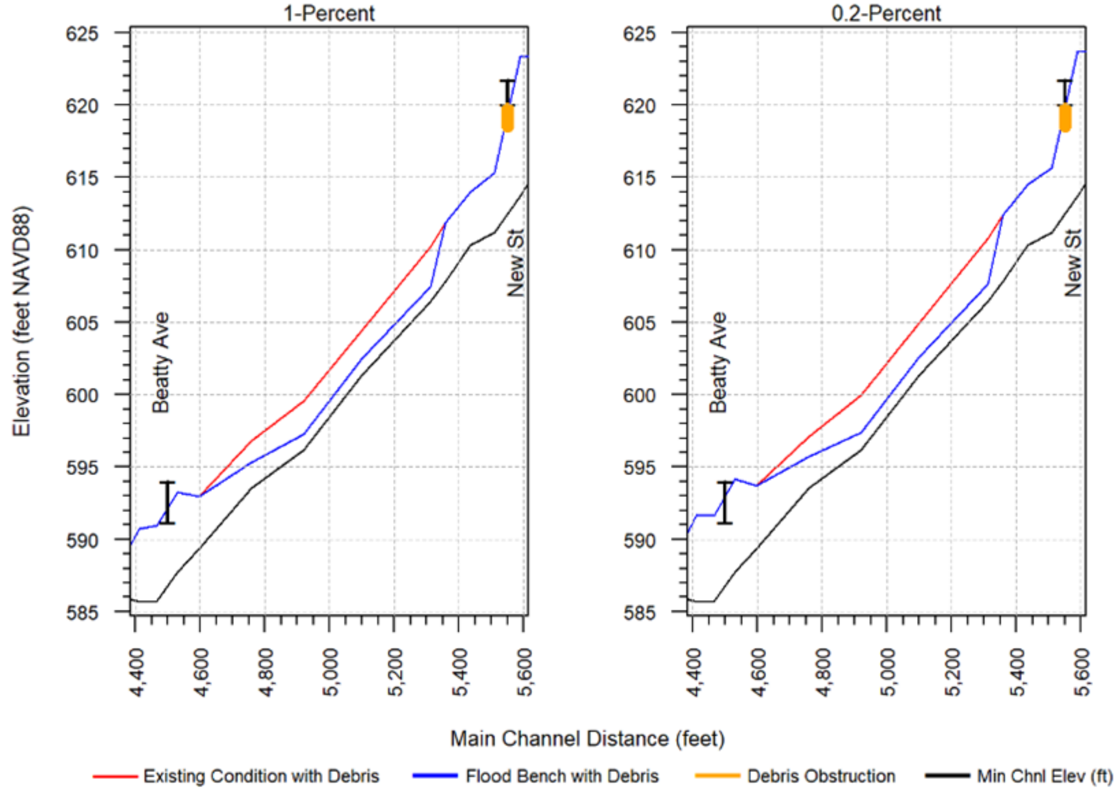


**Figure 7-11 (continued). HEC-RAS model simulation output results for Alternative #3-2 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

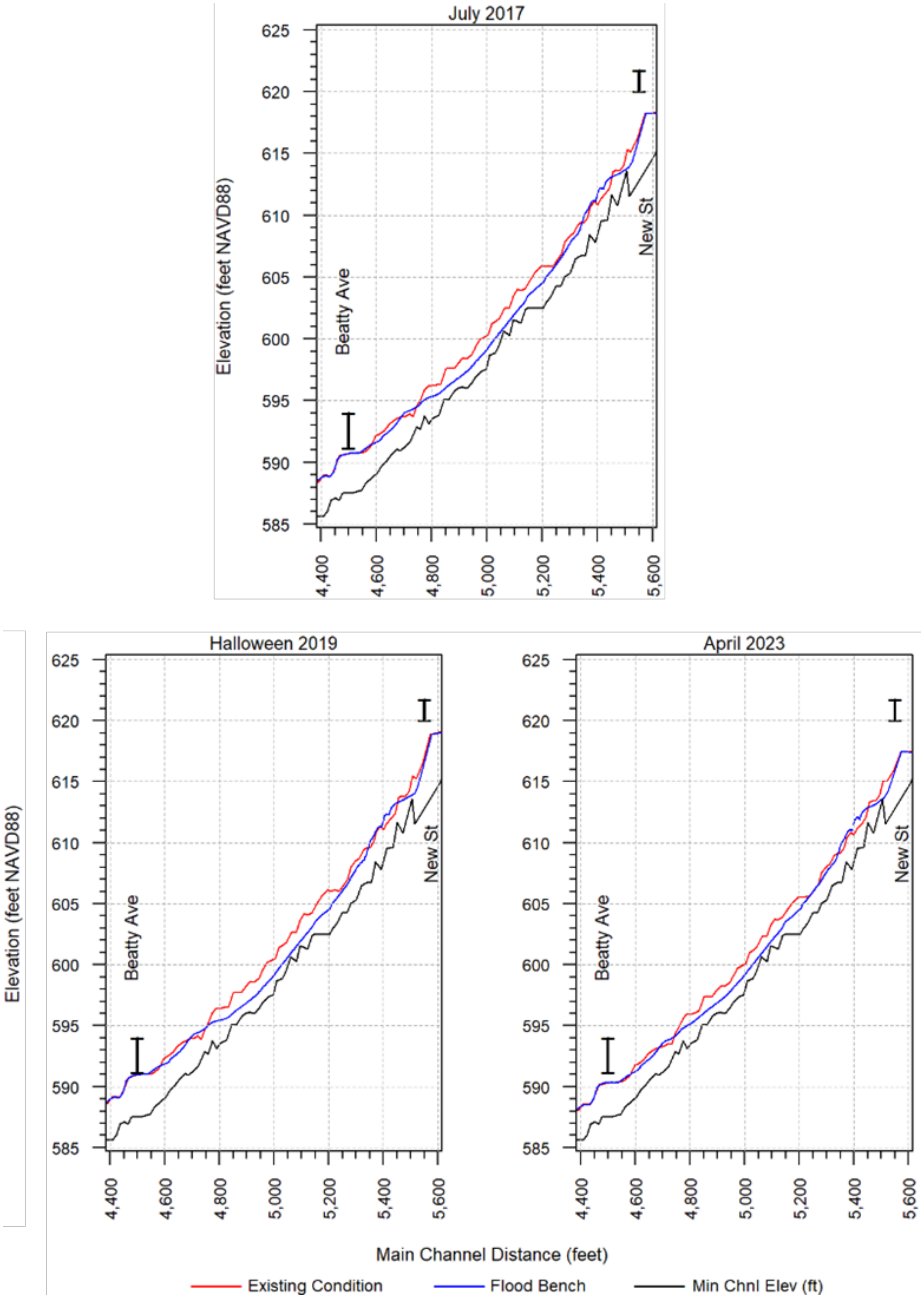


Figure 7-12. HEC-RAS 2-D model simulation output results for the existing condition (red) and proposed alternative (blue) scenarios for the three storm events.

### 7.3.3 Alternative #3-3: Increase Hydraulic Capacity of the Beatty Avenue Bridge

This measure is intended to address issues within High-Risk Area #3 by increasing the width of the Beatty Avenue bridge opening, which would increase the cross-sectional flow area of the channel located at river station 45+00 (Figure 7-13).

**Figure 7-13. Placement of proposed replacement bridge at High-Risk Area #3 along Sherman Brook.**

The bridge is maintained by the Village of Clinton. The existing bridge structure has a span of 32-ft and a low cord height of 4.5-ft (Figure 7-14). The flooding in the vicinity of the Beatty Avenue bridge poses a flood-risk threat to nearby residential, commercial, and recreational properties and village-owned infrastructure. Appendix D depicts a flood mitigation rendering of a culvert widening scenario.

Figure 7-14. Downstream view of the Beatty Avenue bridge in the Sherman Brook corridor.

Based on the orthoimagery, the bridge span is limited by the curvature of the roadway on the left bank, and downstream of the structure on the right bank is owned by private property.

The existing conditions show the 2%, 1%, and 0.2% ACE WSELs successfully pass under the Beatty Avenue bridge, but there is significant backwater upstream of the bridge. Additionally, the bridge is an obstruction in the channel that acts as a catchpoint for large sediment and debris.

By increasing the opening span of the bridge structure, the cross-sectional flow area of the channel would increase and the potential for sediment and debris to accumulate or catch on the upstream face of the bridge would be reduced, thereby reducing flood risk to areas adjacent to and immediately upstream of the bridge.

The bridge widening design selected for this proposed condition model simulation was selected to ensure that the 1% ACE WSEL could successfully pass under the Valley Mills Road bridge without significant backwater upstream of the bridge. To achieve the desired result, the bridge widening design increased the span of the bridge opening from 32-ft to 55-ft by widening the bridge on the right bank by 21-ft. Figure 2 in Appendix G represents a 15% conceptual design of the Beatty Avenue bridge widening alternative.

For this alternative, open-water and debris-obstruction simulations were performed to test the effectiveness of the alternative at reducing water surface elevations for increasing the hydraulic capacity at Beatty Avenue.

Tables 25 and 26 outline the results of the proposed conditions and future conditions from the 1-D model simulation with and without a debris obstruction. Figures 7-15 through 7-16 display the profile plots for the bridge widening alternative with and without a debris obstruction.

**Table 25. Summary of Results for Alternative #3-3 with Proposed and Future Conditions Based on Open-Water 1-D Model Simulations for the 1% ACE**

| Proposed Conditions | Increased Hydraulic Capacity |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 1.0-ft |
| Total Length of Benefited Area | 200-ft |
| River Stations | 46+00 to 44+00 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations (feet) | Up to 1.1-ft |
| Total Length of Benefited Area | 200-ft |
| River Stations | 46+00 to 44+00 |

**Table 26. Summary of Results for Alternative #3-3 with Proposed and Future Conditions Based on Debris-Obstruction 1-D Model Simulations for the 1% ACE**

| Proposed Conditions with Debris-obstruction | Increased Hydraulic Capacity |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 1.9-ft |
| Total Length of Benefited Area | 200-ft |
| River Stations | 46+00 to 44+00 |
| **Future Proposed Conditions with Debris-obstruction** | |
| Reductions in Water Surface Elevations (feet) | Up to 2.0-ft |
| Total Length of Benefited Area | 200-ft |
| River Stations | 46+00 to 44+00 |

The results show a significant reduction in the WSEL with all 1-D model simulations for alternative #3-3. Results also indicate an adverse effect immediately downstream of the Beatty Avenue bridge where the proposed alterative will increase the WSEL by up to 0.37-ft.

Table 27 summarizes the results of the proposed conditions from the 2-D model simulation during the Halloween 2019 Storm event. Figure 7-17 displays the profile plots for the bridge widening alternative during the July 2017, Halloween 2019, and April 2023 storm events. The full 1-D and 2-D model outputs for this alternative can be found in Appendix E and Appendix F, respectively.

**Table 27. Summary of Results for Alternative #3-3 with Proposed Conditions Based on the 2-D Model During the Halloween 2019 Storm Event**

| Proposed Conditions | Increased Hydraulic Capacity |
|---|---|
| Reductions in Water Surface Elevations | Up to 1.4-ft |
| Total Length of Benefited Area | 100-ft |
| River Stations | 46+00 to 45+00 |

The results of the 2-D model indicate significant reductions to WSELs within the Sherman Brook channel in the vicinity of the Beatty Avenue bridge, which is consistent with the 1-D model results. However, the 2-D results do not indicate any significant benefits to overbank areas or flood extents when compared to the 1-D model results. This is most likely a result of the topographic and geomorphological features (i.e., steep channel slope, erodible banks, lack of flood storage) along Sherman Brook within this reach.

The potential benefits of this strategy are limited to upstream of the Beatty Avenue bridge. The primary benefits of increasing the bridge opening would be to increase the flow capacity of the bridge structure, reduce the potential of backwater from high-flow events, and help prevent debris and ice from catching on the structure and creating obstructions/jams upstream of the bridge. Additionally, the alternative would minimize the damages to the infrastructure and reduce the duration the roadway is inaccessible.

The ROM cost for this strategy is approximately $2.3 million, which does not include land acquisition costs for survey, appraisal, and engineering coordination. Additional engineering consideration would also be required to determine if increasing the bridge opening would alter the structural integrity of the bridge in any way.

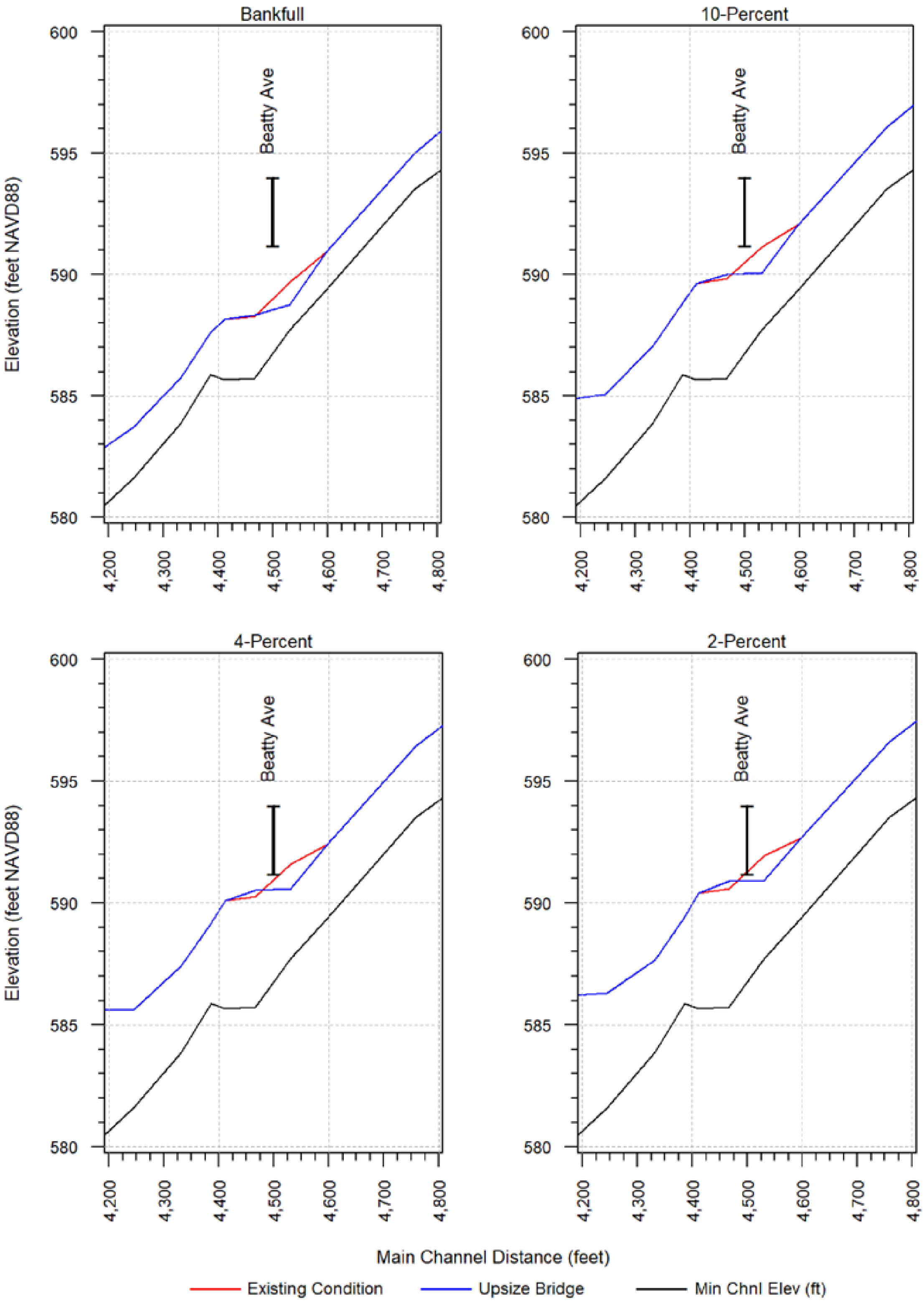


**Figure 7-15. HEC-RAS model simulation output results for Alternative #3-3 for the existing condition (red) and proposed alternative (blue) scenarios.**

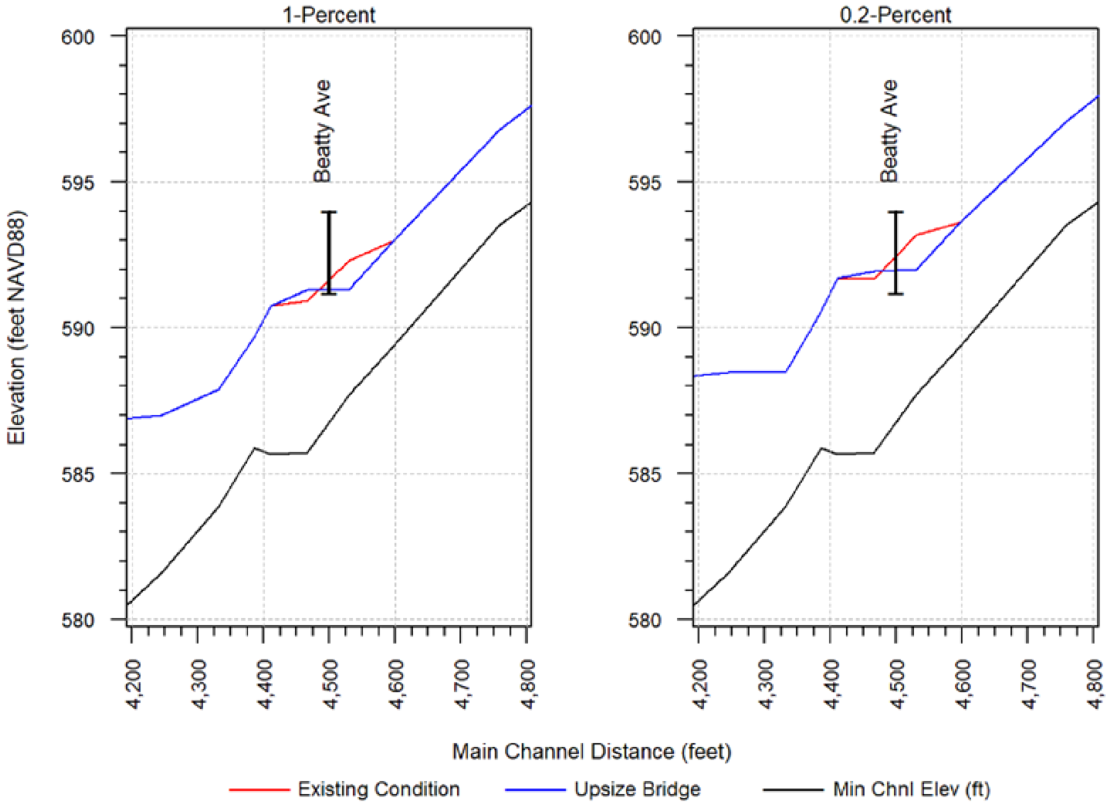


**Figure 7-15 (continued). HEC-RAS model simulation output results for Alternative #3-3 for the existing condition (red) and proposed alternative (blue) scenarios.**

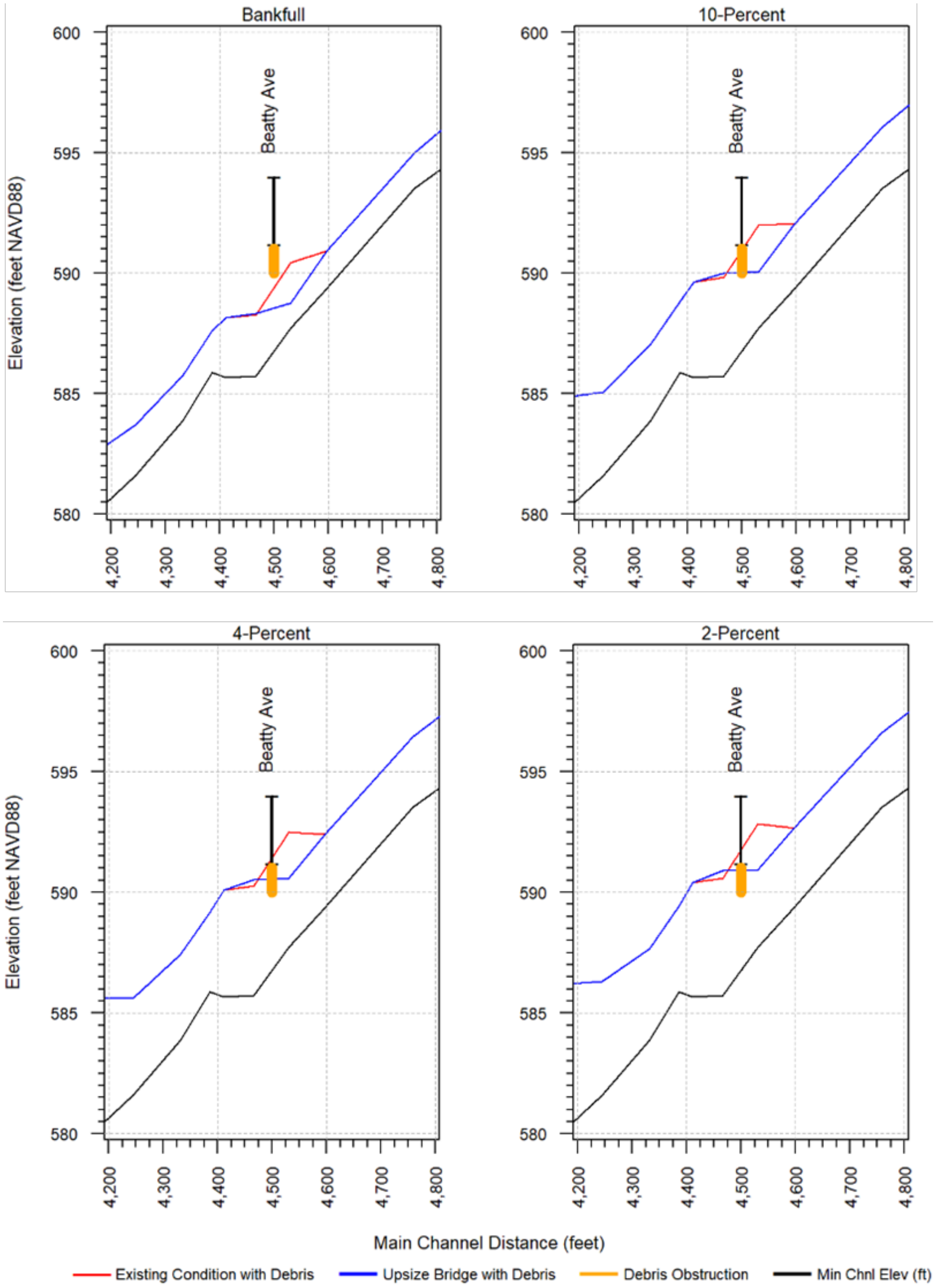


**Figure 7-16. HEC-RAS model simulation output results for Alternative #3-3 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

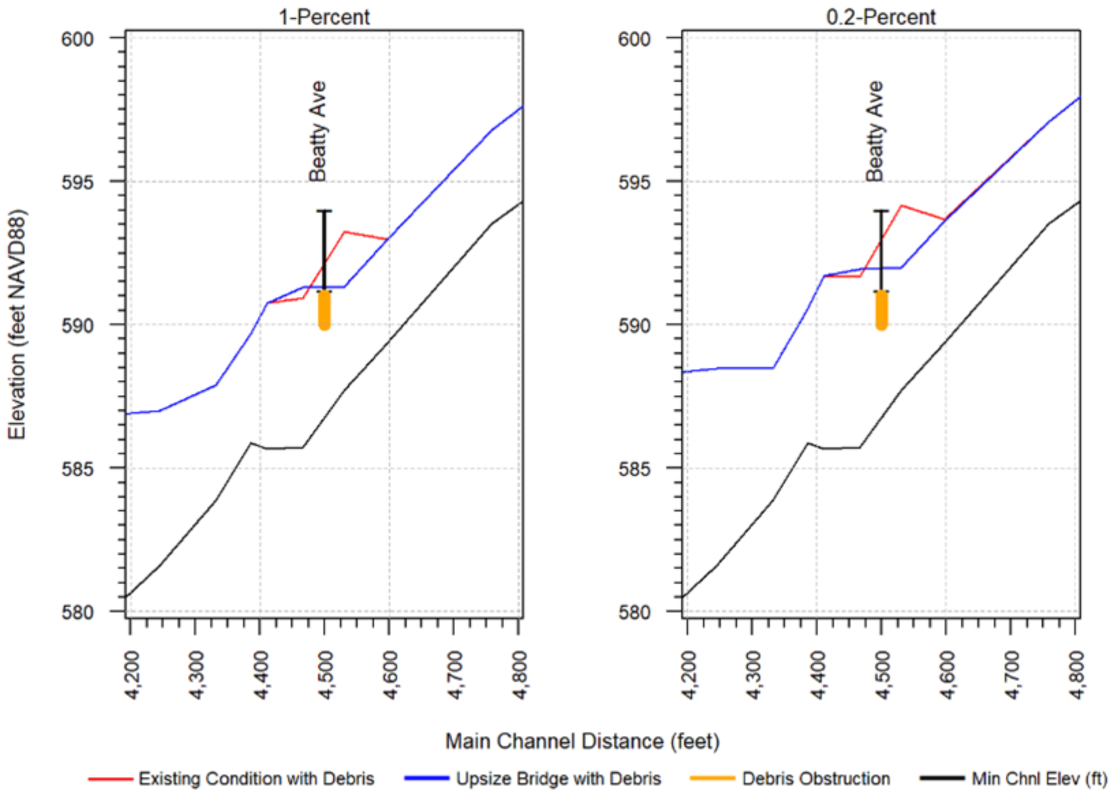


**Figure 7-16 (continued). HEC-RAS model simulation output results for Alternative #3-3 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

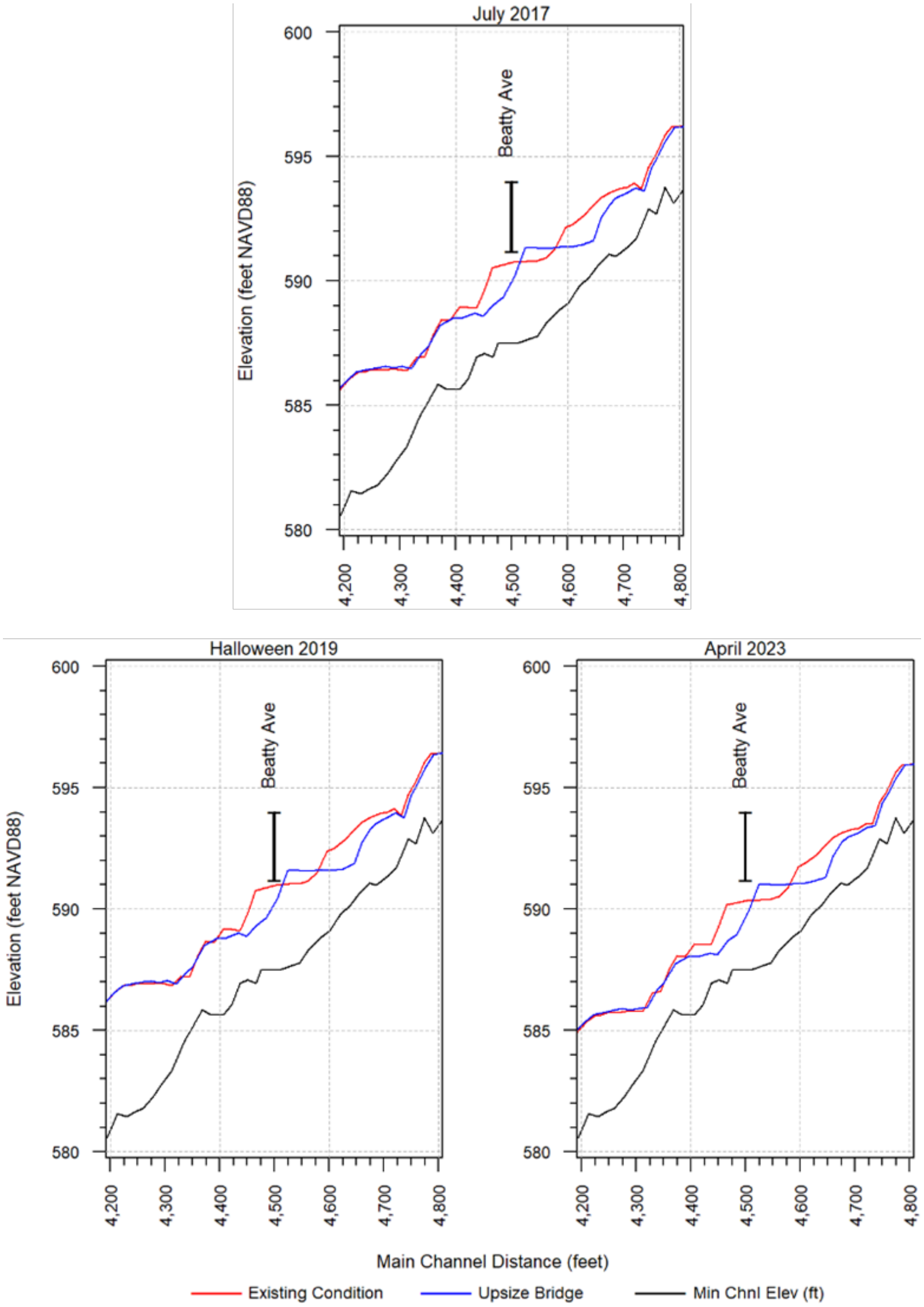


**Figure 7-17**. **HEC-RAS 2-D model simulation output results for the existing condition (red) and proposed alternative (blue) scenarios for the three storm events.**

## 7.4 HIGH-RISK AREA #4

### 7.4.1 Alternative #4-1: Flood Bench Located Upstream of Utica Street

This mitigation alternative will reconnect the floodplain to the channel in a developed area with a flood bench which would provide additional water storage and increase the floodplain width over the current storage and width, which could potentially reduce damages in the event of flooding and address issues within High-Risk Area #4. Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and/or downstream of the bench. The flood bench is preliminarily designed to be approximately 1.6 acres in size and located between river stations 41+00 to 45+00 (Figure 7-18).

Figure 7-18. Placement of proposed flood bench at High-Risk Area #4 along Sherman Brook.

Based on the existing conditions model, public engagement meetings and media, the flood extents spread across the adjacent developed area where in the past has caused damages to the properties and structural support. A flood bench will be designed to minimize these damaging impacts from flood events.

The flood bench used for the proposed condition model simulation is designed to the minimum bench elevation approximately equal to the bankfull elevation, which was an average depth of 5 ft for the bench. Figure 3 in Appendix G represents a 15% conceptual design of the proposed flood bench.

The flood bench is within the FEMA designated Zone A or Zone AE, which are areas subject to inundation by the 1% ACE (100-yr flood event) as determined in the FIS by detailed methods and where base flood elevations are provided (FEMA 2013a). Appendix D depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

For this alternative, open-water and debris-obstruction simulations were performed to test the effectiveness of the alternative at reducing water surface elevations for a flood bench at Utica Street.

Tables 28 and 29 outline the results of the proposed conditions and future conditions from the 1-D model simulation with and without a debris obstruction. Figures 7-19 through 7-20 display the profile plots for the flood bench alternative with and without a debris obstruction.

**Table 28. Summary of Results for Alternative #4-1 with Proposed and Future Conditions Based on Open-Water 1-D Model Simulations for the 1% ACE**

| **Proposed Conditions** | **Flood Bench at Utica Street** |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 2.8-ft |
| Total Length of Benefited Area | 275-ft |
| River Stations | 45+25 to 42+50 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations (feet) | Up to 3.0-ft |
| Total Length of Benefited Area | 275-ft |
| River Stations | 45+25 to 42+50 |

**Table 29. Summary of Results for Alternative #4-1 with Proposed and Future Conditions Based on Debris-Obstruction 1-D Model Simulations for the 1% ACE**

| **Proposed Conditions with Debris-Obstruction** | **Flood Bench at Utica Street** |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 2.8-ft |
| Total Length of Benefited Area | 275-ft |
| River Stations | 45+25 to 42+50 |
| **Future Proposed Conditions with Debris-Obstruction** | |
| Reductions in Water Surface Elevations (feet) | Up to 0.6-ft |
| Total Length of Benefited Area | 275-ft |
| River Stations | 45+25 to 42+50 |

The results show a significant reduction in the WSEL with all 1-D model simulations for alternative #4-1. Results also indicate an adverse effect immediately upstream of the Utica Street culvert where the proposed alterative will increase the WSEL by 0.41-ft.

Table 30 summarizes the results of the proposed conditions from the 2-D model simulation during the Halloween 2019 Storm event. Figure 7-21 displays the profile plots for the floodplain bench alternative during the July 2017, Halloween 2019, and April 2023 storm events. The full 1-D and 2-D model outputs for this alternative can be found in Appendix E and Appendix F, respectively.

**Table 30. Summary of Results for Alternative #4-1 with Proposed Conditions Based on 2-D Model During Halloween 2019 Storm Event**

| Proposed Conditions | Increased Hydraulic Capacity |
|---|---|
| Reductions in Water Surface Elevations | Up to 1.7-ft |
| Total Length of Benefited Area | 450-ft |
| River Stations | 46+00 to 41+50 |

The results of the 2-D model indicate significant reductions to WSELs within the Sherman Brook channel in the vicinity of the flood bench, which is in line with the 1-D model results. However, the 2-D results do not indicate any significant benefits to overbank areas or flood extents when compared to the 1-D model results. This is most likely a result of the topographic and geomorphological features (i.e., steep channel slope, erodible banks, lack of flood storage) along Sherman Brook within this reach.

For this alternative to be actionable, a land acquisition is required to convert a developed area into a natural area which will increase the water storage along the channel. Flood benches create a natural environment and during dry periods, this area could be utilized as a recreational area.

The ROM cost for this flood bench alternative is $2.5 million. These ROM cost estimates do not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the NYSDEC will require wetland delineations, an analysis for any endangered and/or threatened species within the proposed project area, and information regarding access during construction for this mitigation alternative.

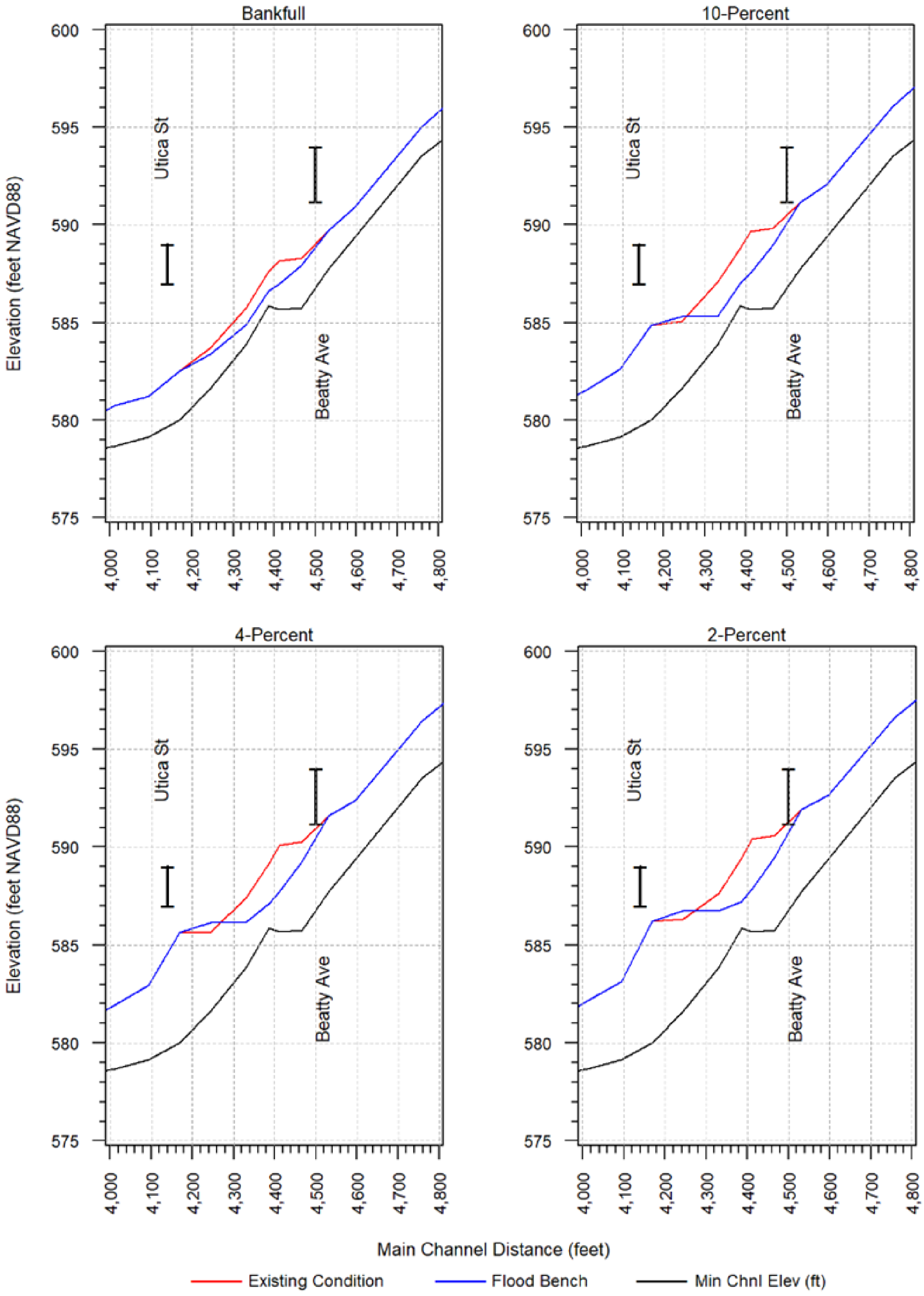


**Figure 7-19. HEC-RAS model simulation output results for Alternative #4-1 for the existing condition (red) and proposed alternative (blue) scenarios.**

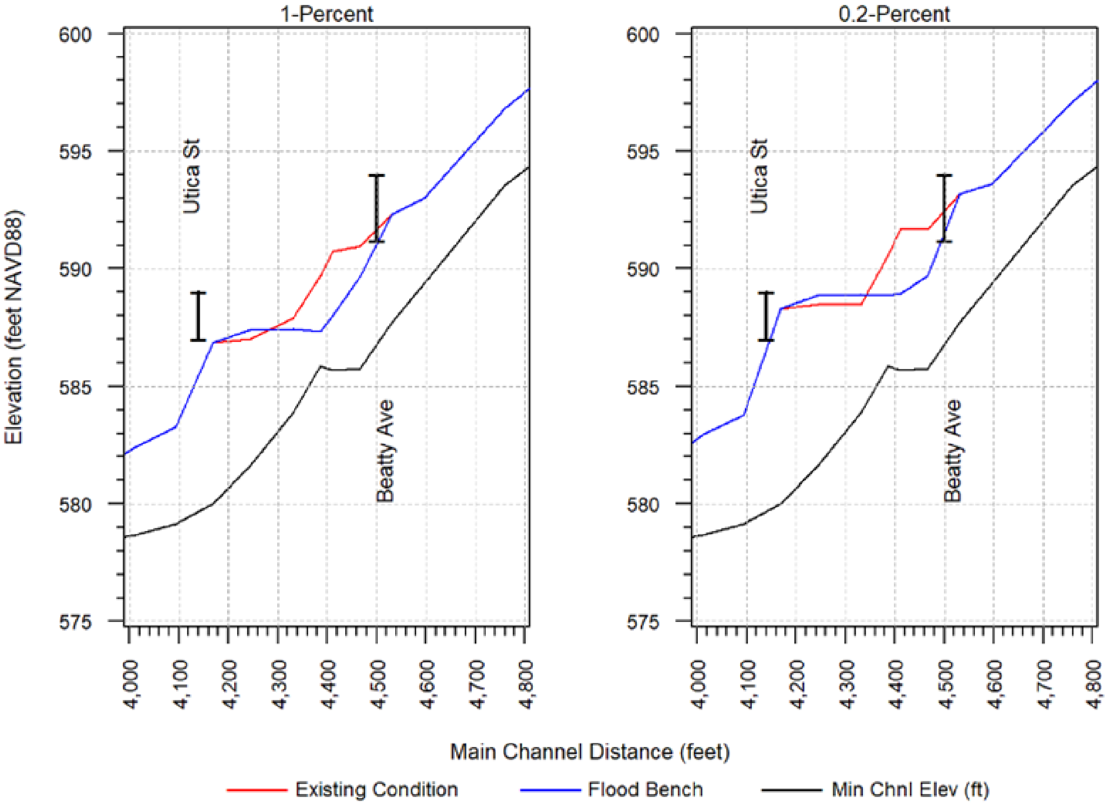


**Figure 7-19 (continued). HEC-RAS model simulation output results for Alternative #4-1 for the existing condition (red) and proposed alternative (blue) scenarios.**

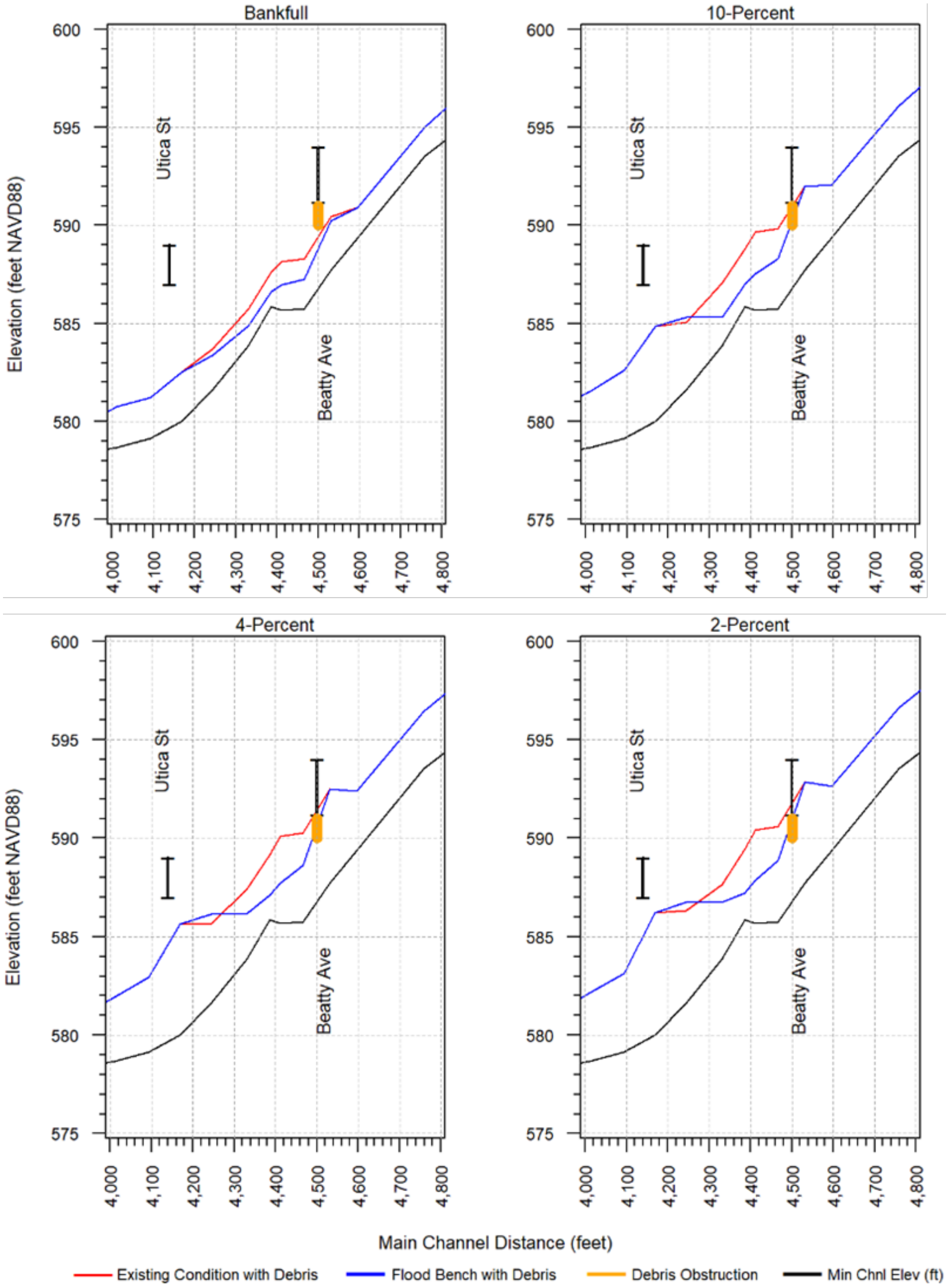


**Figure 7-20. HEC-RAS model simulation output results for Alternative #4-1 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

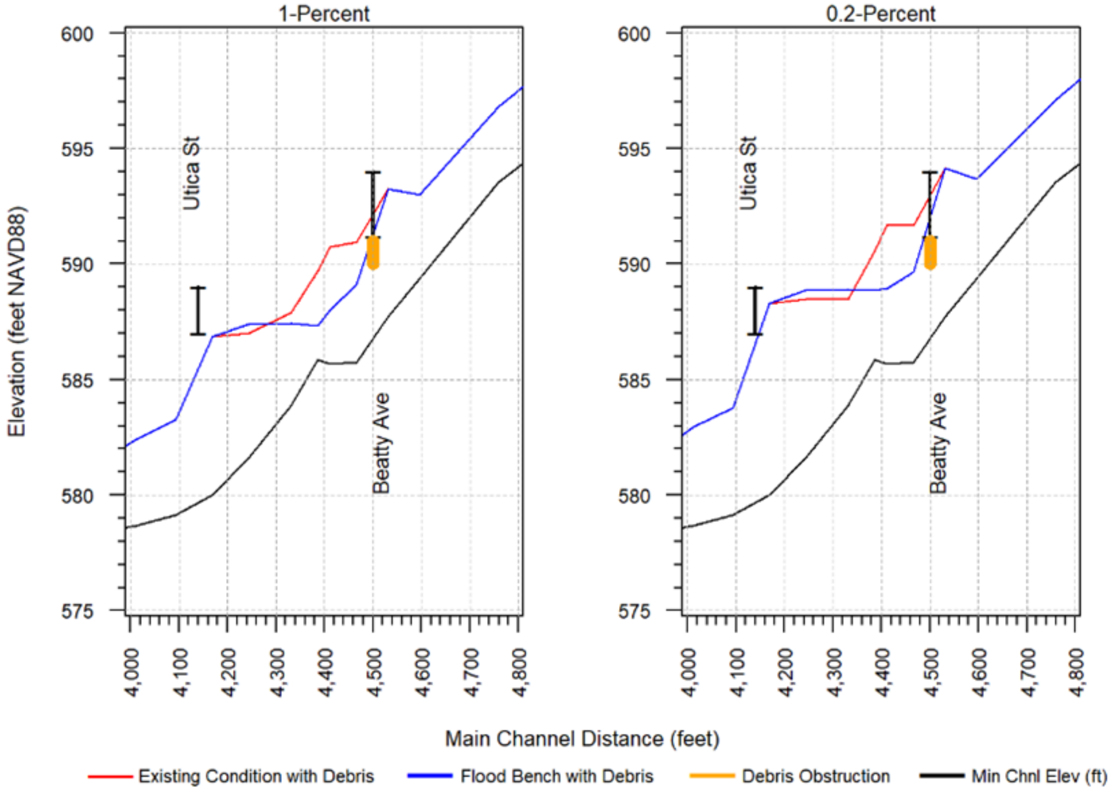


**Figure 7-20 (continued). HEC-RAS model simulation output results for Alternative #4-1 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

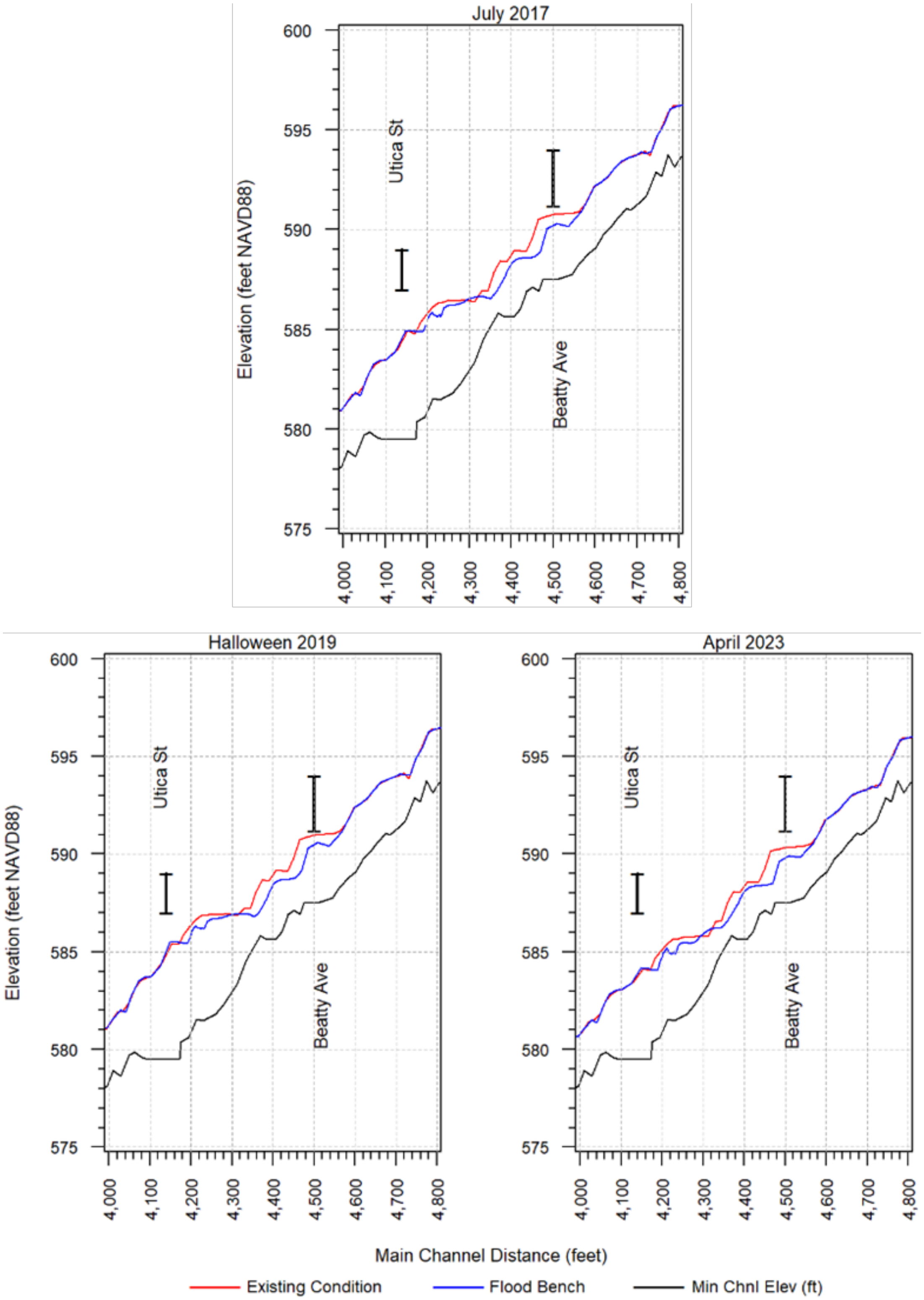


**Figure 7-21. HEC-RAS 2-D model simulation output results for the existing condition (red) and proposed alternative (blue) scenarios for the three storm events.**

### 7.4.2 Alternative #4-2: Increase Hydraulic Capacity of the Utica Street Culvert

This measure is intended to address issues within High-Risk Area #4 by increasing the width of the Utica Street culvert opening, which would increase the cross-sectional flow area of the channel located at river station 41+00 (Figure 7-22).

**Figure 7-22. Placement of proposed replacement culvert at High-Risk Area #4 along Sherman Brook.**

The culvert is maintained by the NYSDOT. The existing box culvert has a span of 18 ft with a height of 7 ft (Figure 7-23). The flooding in the vicinity of the Utica Street culvert poses a flood-risk threat to nearby residential and commercial properties and state-owned infrastructure. Appendix D depicts a flood mitigation rendering of a culvert widening scenario.

**Figure 7-23. Upstream view of the Utica Street culvert in the Sherman Brook corridor.**

Based on the orthoimagery and public engagement meetings, a structure on private property named Clinton Pottery, is adjacent to the Utica Street structure on the bank of the channel where the ground is heavily eroded. A storm event, where the flow of water is moving at high velocities, could cause damage to the structure. This risk could be minimized with the increase in hydraulic capacity to the Utica Street culvert and decrease the potential for backwater and erosion in this high-risk area.

By increasing the opening span of the culvert structure, the cross-sectional flow area of the channel would increase and the potential for sediment and debris to accumulate or catch on the upstream face of the bridge would be reduced, thereby reducing flood risk to areas adjacent to and immediately upstream of the culvert.

The culvert widening design selected for this proposed condition model simulation was selected to ensure that the 1% ACE WSEL could successfully pass under the Utica Street culvert and to decrease the WSEL at this location. To achieve the desired result, the culvert widening design increased the span of the culvert opening from 18 ft to 20 ft with an increase of height by 0.5 ft.

For this alternative, open-water and debris-obstruction simulations were performed to test the effectiveness of the alternative at reducing water surface elevations for increasing the hydraulic capacity at Utica Street.

Tables 31 and 32 outline the results of the proposed conditions and future conditions from the model simulation with and without a debris obstruction. Figures 7-24 through 7-25 display the profile plots for the culvert widening alternative with and without a debris obstruction. Full model outputs for this alternative can be found in Appendix E.

**Table 31. Summary of Results for Alternative #4-2 with Proposed and Future Conditions Based on Open-Water Simulations for the 1% ACE**

| **Proposed Conditions** | **Increased Hydraulic Capacity** |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 0.6-ft |
| Total Length of Benefited Area | 50-ft |
| River Stations | 42+50 to 41+50 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations (feet) | Up to 0.6-ft |
| Total Length of Benefited Area | 50-ft |
| River Stations | 42+50 to 41+50 |

**Table 32. Summary of Results for Alternative #4-2 with Proposed and Future Conditions Based on Debris-Obstruction Simulations for the 1% ACE**

| **Proposed Conditions with Debris-Obstruction** | **Increased Hydraulic Capacity** |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 0.6-ft |
| Total Length of Benefited Area | 50-ft |
| River Stations | 42+50 to 41+50 |
| **Future Proposed Conditions with Debris-Obstruction** | |
| Reductions in Water Surface Elevations (feet) | Up to 0.6-ft |
| Total Length of Benefited Area | 50-ft |
| River Stations | 42+50 to 41+50 |

The results show a significant reduction in the WSEL with all 1-D model simulations for alternative #4-2. Results also indicate an adverse effect immediately downstream of the Utica Street culvert where the proposed alterative will increase the WSEL by 0.55-ft.

The potential benefits of this strategy are limited to upstream of the New Street culvert. The primary benefits of increasing the culvert opening would be to increase the flow capacity of the culvert structure, reduce the potential of backwater from high-flow events, and help prevent debris and ice from catching on the structure and creating obstructions/jams upstream of the culvert.

The ROM cost for this strategy is approximately $410,000, which does not include land acquisition costs for survey, appraisal, and engineering coordination. Additional engineering consideration would also be required to determine if increasing the culvert opening would alter the structural integrity of the culvert in any way.

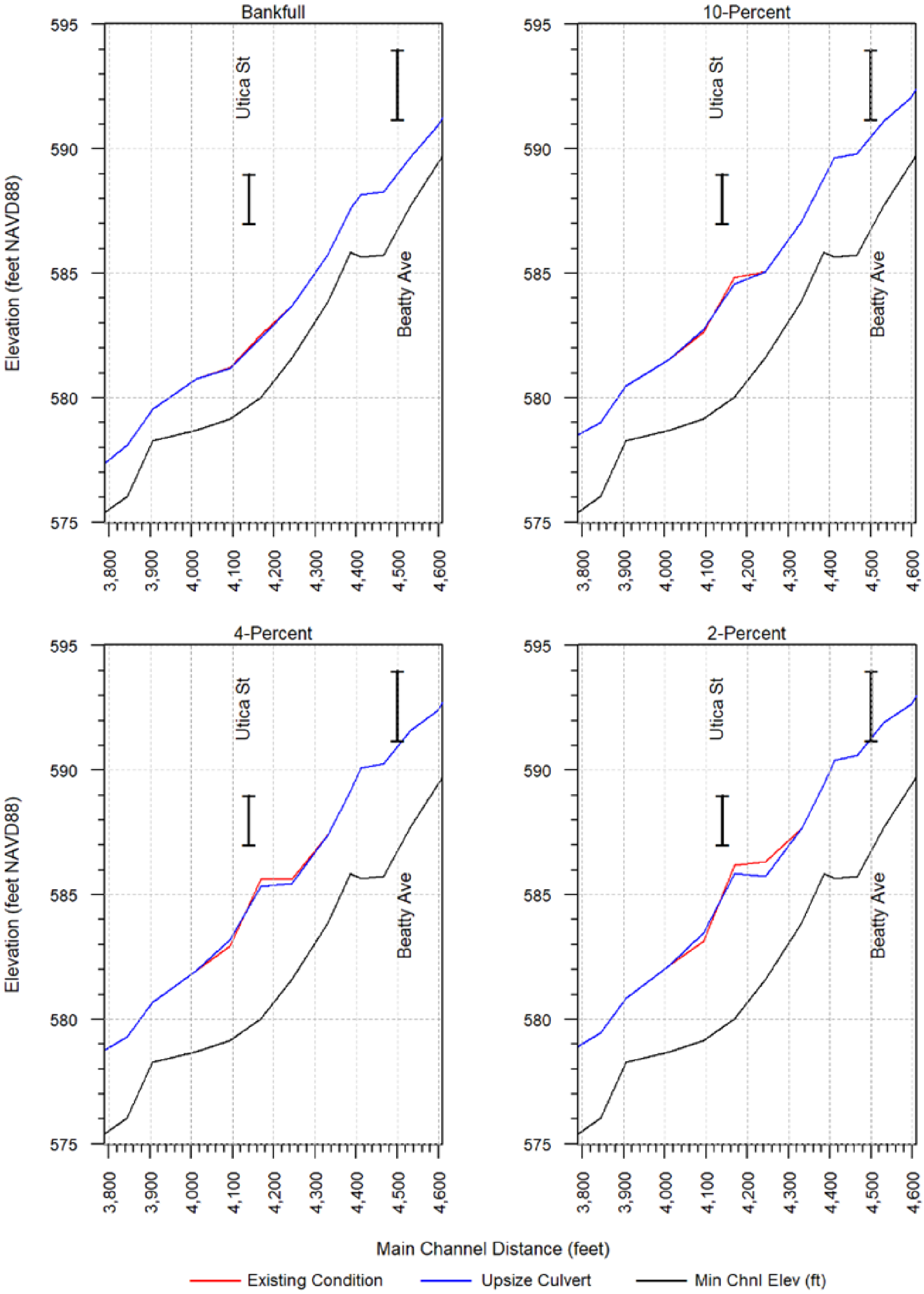


**Figure 7-24. HEC-RAS model simulation output results for Alternative #4-2 for the existing condition (red) and proposed alternative (blue) scenarios.**

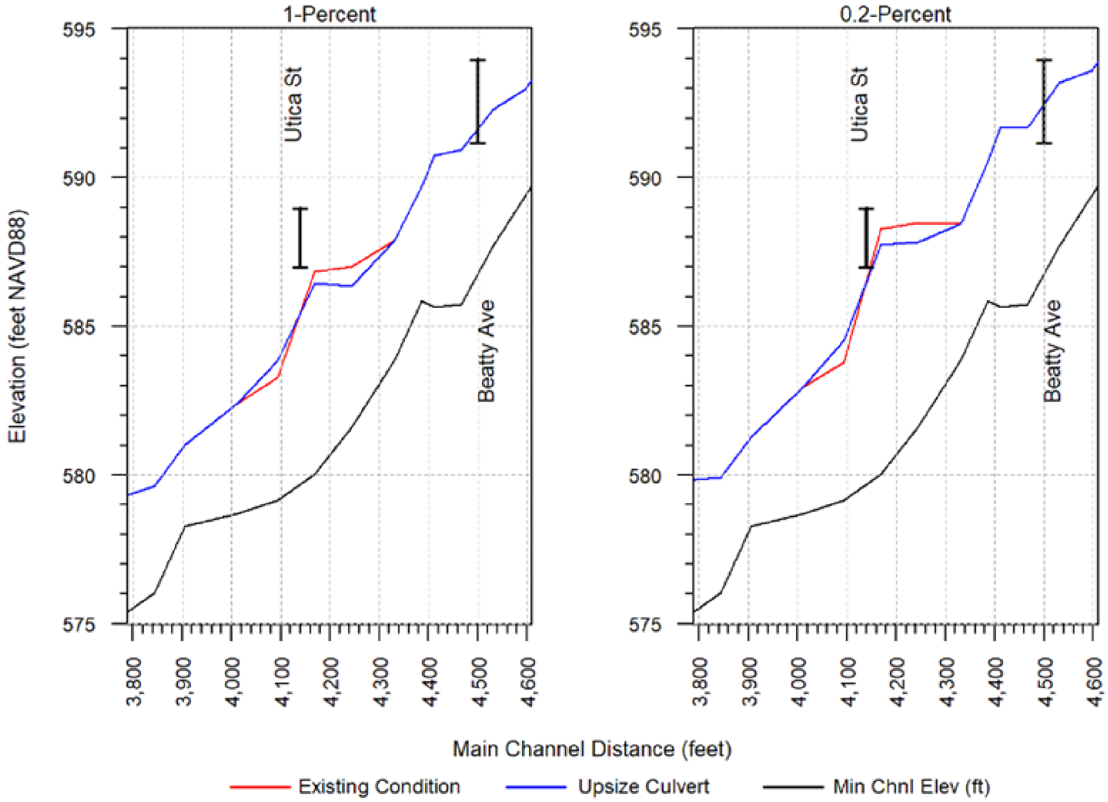


**Figure 7-24 (continued). HEC-RAS model simulation output results for Alternative #4-2 for the existing condition (red) and proposed alternative (blue) scenarios.**

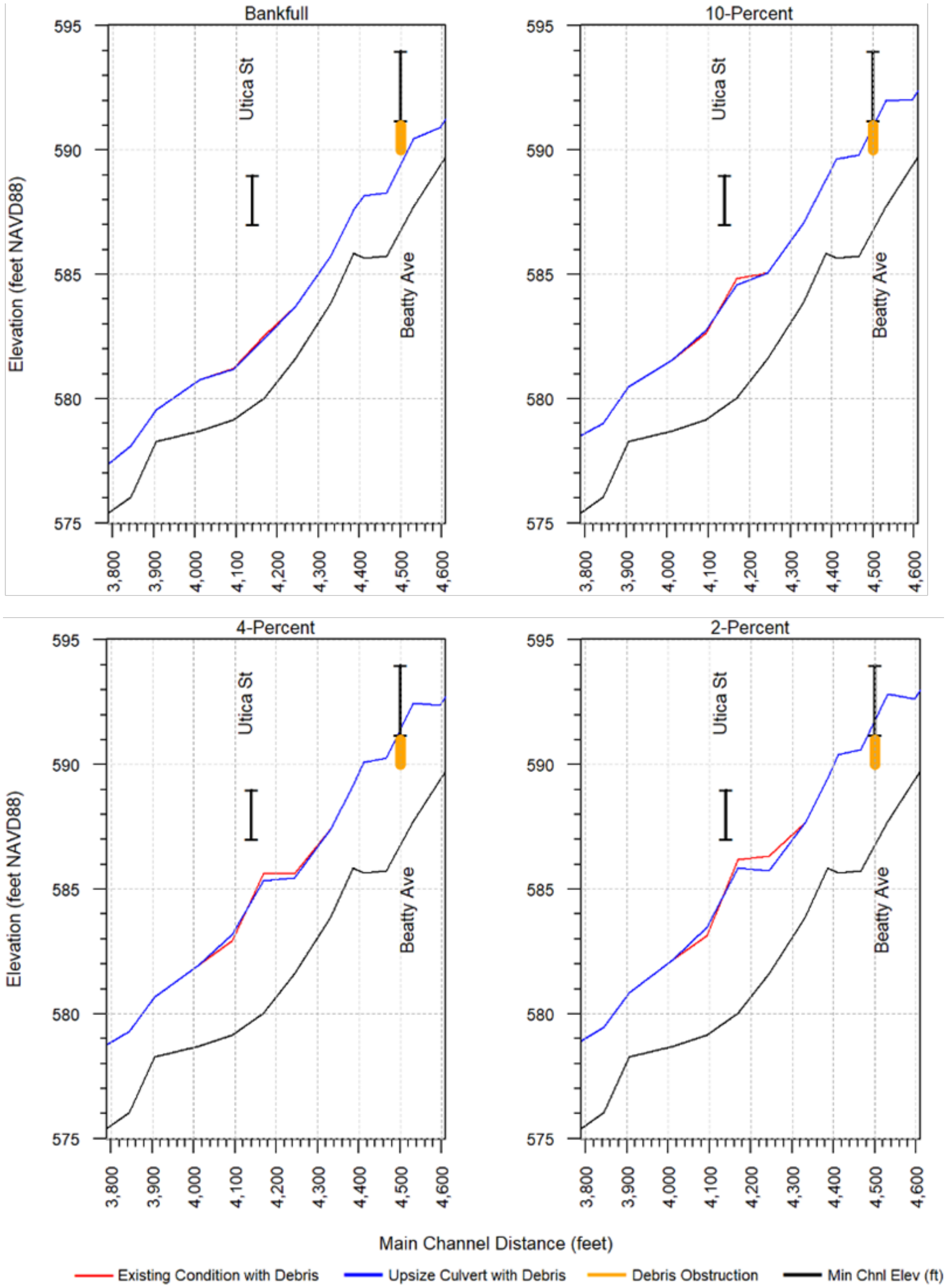


Figure 7-25. HEC-RAS model simulation output results for Alternative #4-2 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.

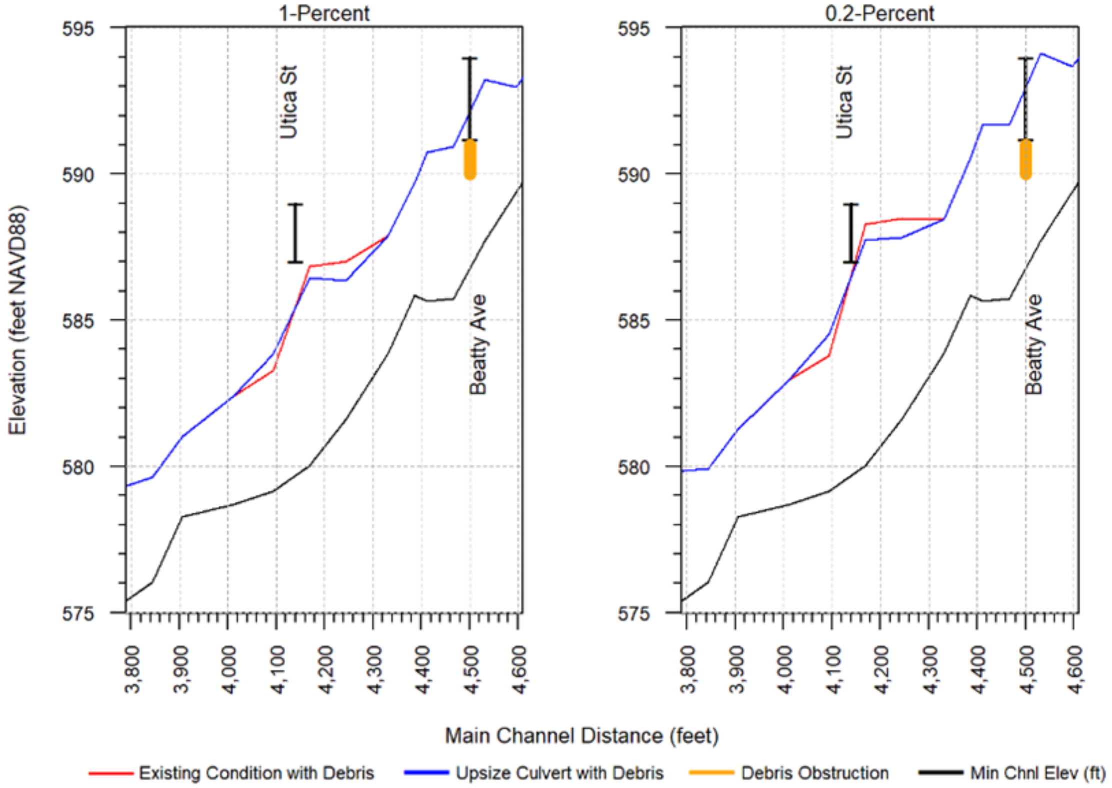


**Figure 7-25 (continued). HEC-RAS model simulation output results for Alternative #4-2 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

## 7.5 HIGH-RISK AREA #5

### 7.5.1 Alternative #5-1: Bank and Channel Stabilization Upstream of Kirkland Avenue

Within a particular reach, sediment fluxes can originate from land surface erosion, streambank erosion, upstream reach sediment input, or remobilization of sediments previously deposited within the reach. Bank and channel erosion is a significant contributor to sediment in a stream. The erosion and deposition of sediments within a stream network is highly dependent on the geomorphological features of the stream network (i.e., channel width, flow depth and cross-sectional geometry, bed slope and roughness, and discharge velocity and volume). In general, reaches with smaller cross-sectional flow area, steeper slopes, and higher flow velocities discourage the deposition of sediments, while wider channels with lower bed slopes and flow velocities act as regions of relative sediment deposition (USEPA 2009).

Streambank stabilization measures work either by reducing the force of flowing water, increasing the resistance of the bank to erosion, or by some combination of both. Generally speaking, there are four approaches to streambank protection:

- The use of vegetation (e.g., brush mattress)
- Soil bioengineering
- The use of rock work in conjunction with plants (e.g., gabions)
- 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 established vegetation will flourish naturally, without maintenance, and will continue to protect the banks and channel from erosion. Conventional armoring is a fourth technique which includes the use of rock, known as riprap, to protect eroding streambanks.

In order to recommend the most appropriate bank and channel stabilization strategies, engineers and scientists need to have an understanding of how sediment enters, moves through, and exits a stream network. By using sediment transport models, engineers and scientists can quantify and evaluate sediment transport using four key variables: invert change, mass bed change, shear stress, and velocity.

Based on the sediment transport understandings, a streambank stabilization strategy can be recommended specifically for High-Risk Area #5. Table 33 represents the possible streambank stabilization strategies to support bank and channel stabilization for a 1% ACE in High-Risk Area #5. Appendix D also includes a cross sectional view of bank stabilization strategies and a guide to distinguish the allowable maximum shear stress and velocities for each treatment type shown in Table 33.

**Table 33. Possible Streambank Stabilization Strategies**

| **Source: NRCS 2009** | |
|---|---|
| **Type of Treatment** | **Type of Sub-Treatment** |
| Brush Mattress | Staked only w/rock riprap toe (initial) |
| Coir Geotextile Roll | Roll with Polypropylene rope mesh staked only without rock riprap toe |
| Gravel/Cobble | 6-inch |
| Vegetation | Class B turf (ret class) |
| Soil Bioengineering | Brush layering (initial/grown) |
| | Live fascine |
| Boulder Clusters | Large Cobble (>5-in diameter) |

Due to the variable, conceptual, and site-specific nature of streambank stabilization strategies, no ROM cost estimates were determined for this measure. Additional geomorphic and engineering analyses, including additional modeling (i.e., coupled 1-D/2-D unsteady flow, 2-D unsteady flow and rain-on-grid), and geotechnical engineering would be necessary in order to determine the most appropriate streambank stabilization strategy and its associated costs.

### 7.5.2 Alternative #5-2: Natural Stream Restoration Upstream of Kirkland Avenue

The stream is connected to low channel banks upstream of Kirkland Avenue and has a shallow channel depth. Additionally, the stream is surrounded by fields on both sides where there is currently a low density of vegetation along the channel.

A vegetated area along the channel helps decrease the stormwater runoff flow, filter sediments and pollutants that are most likely applied to nearby agricultural fields and stabilize the stream banks from erosion. The benefits expand the interactions between hydrology, soil, and biotic communities and increase their health along the stream.

Sediment piles are increasing in size and frequency upstream of the Kirkland Avenue bridge. During high-flow periods, bank erosion from upstream sources has deposited large amounts of sediment and debris in the channel while scouring away and destabilizing the banks. As a result, the original natural channel geometry has been disrupted in this reach.

Natural stream restoration techniques can improve water quality, enhance aesthetic value, improve wildlife habitat and enhance floodplain function. A successful natural stream restoration project requires following a multi-step process to ensure thorough consideration is given to the planning and design stage before any work in the stream corridor occurs. These steps include the following (Fleming et al. 2017):

- Defining the objectives such as flood control, improving recreation, improving habitat, or reducing bank erosion;
- Assessing the current condition of the stream including noting any downcutting or widening; the amount, type, and condition of bank vegetation; changes in the watershed upstream, or features downstream that are constricting flow;
- Determining the best course of action, which can include re-vegetation plans, riparian buffers, channel and bank stabilization, and other stream redesign and construction projects;

- Constructing the selected stream restoration strategy, which can involve reshaping the stream channel and floodplain, building in-stream structures, protecting the banks, and removing invasive vegetation.

This mitigation strategy proposes restoring the channel banks of Sherman Brook in High-Risk Area #5 and employing the stream restoration techniques discussed to reduce sediment aggradation, improve water quality, enhance aesthetic value, improve wildlife habitat, and enhance floodplain function along this reach. Figure 7-26 represents the location of the channel restoration area from river station 32+50 to 16+50. Figure 7-27 is a photo taken on December 14, 2022 at the location of the proposed natural stream restoration area which is where Kirkland Avenue crosses Sherman Brook.

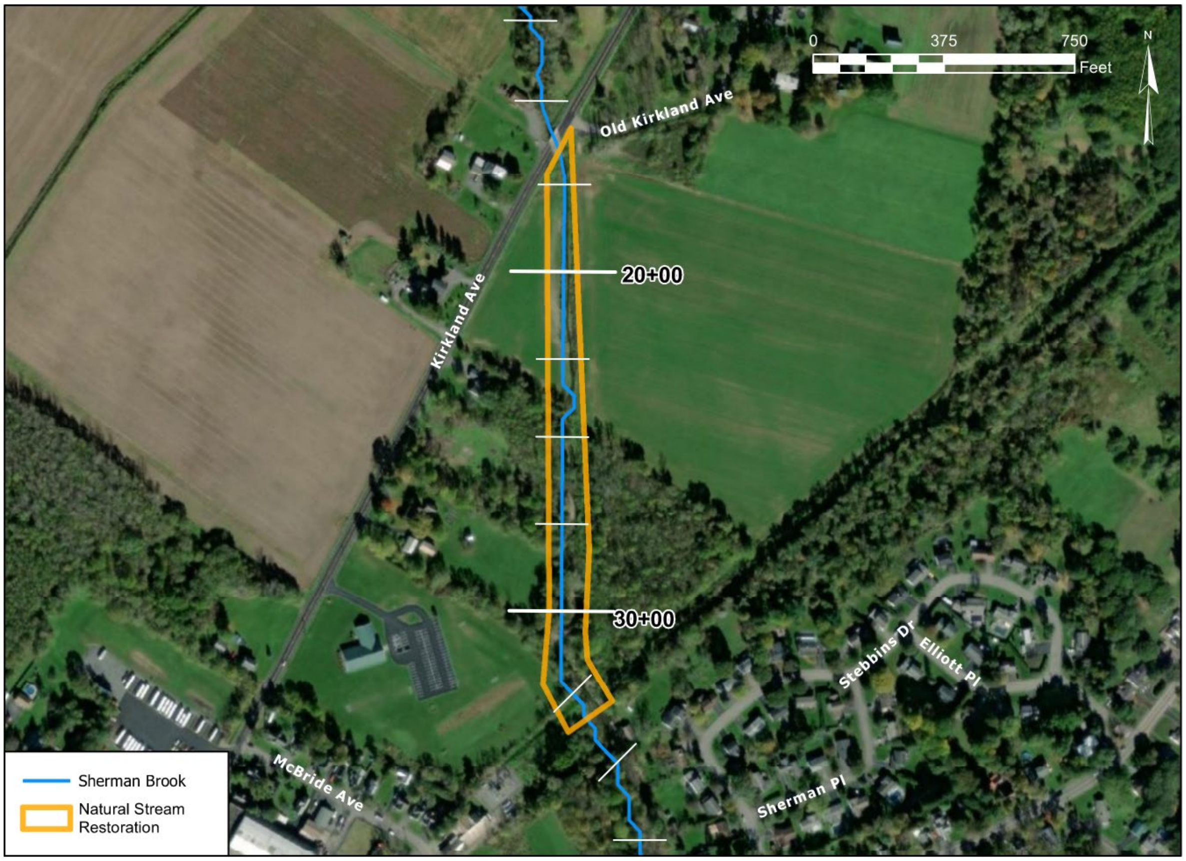


**Figure 7-26. Location map for proposed stream restoration upstream of New Street along Sherman Brook.**

**Figure 7-27. Photo of the Natural Stream Restoration Location for Sherman Brook Upstream of Kirkland Avenue.**

By removing sediment and debris within the channel, the cross-sectional flow area would increase allowing a larger volume of water to flow through this reach unobstructed, thereby reducing flood risk while stabilizing the channel banks, which would make the banks more resistant to erosion and bank failure and would reduce overall sediment loads in this reach and lower reaches of Sherman Brook.

The primary benefits of restoring the channel geometry of Sherman Brook in this reach would be to increase the flow capacity through the bridge structure and help prevent debris from catching on sediment bars and large debris that have accumulated in this reach.

It is important to note that the removal of aggraded sediment and debris alone is not an adequate flood mitigation strategy unless the upstream sources of sediment and debris are addressed. The sources and potential strategies are best analyzed to address sediment and debris in a Sediment and Debris Management Study. The NYSDEC highly recommends identifying and addressing upstream sediment and debris sources before addressing any potential mitigation strategy that includes sediment and/or debris removal.

The ROM cost for this strategy is approximately $670,000, which does not include land acquisition costs for survey, appraisal, and engineering coordination.

### 7.5.3 Alternative #5-3: Flood Benches Upstream of Kirkland Avenue

This mitigation alternative will reconnect the floodplain to the channel in High-Risk Area #5 with a flood bench which would provide additional water storage and increase the floodplain width over 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 #5. The flood benches are preliminarily designed to the following sizes and locations (Figure 7-28):

- Flood Bench A is approximately 9.8 acres in size and located between river stations 17+00 to 26+00
- Flood Bench B is approximately 2.8 acres in size and located between river stations 17+00 to 26+00

Figure 7-28. Placement of proposed flood benches at High-Risk Area #5 along Sherman Brook.

Based on the existing conditions model, public engagement meetings and media, the flood extents spread across the adjacent agricultural fields and undeveloped areas, and nearby residential properties where in the past the flood has caused damages to each property and deposited sediment and debris away from the channel. A flood bench will be designed to minimize the damaging impacts from flood events.

The flood bench used for the proposed condition model simulation is designed to the minimum bench elevation approximately equal to the bankfull elevation, which was an average depth of 4 ft for flood bench A and 2 ft for Flood Bench B.

The flood benches are within areas inundated by the 1% ACE (100-yr flood) as determined in the existing conditions model. Appendix D depicts a flood mitigation rendering of a flood bench illustrating before and after landscape features.

For this alternative, open-water and debris-obstruction simulations were performed to test the effectiveness of the alternative at reducing water surface elevations for both flood benches.

Tables 34 and 35 outline the results of the proposed conditions and future conditions from the model simulation with and without a debris obstruction. Figures 7-29 through 7-30 display the profile plots for the flood benches alternatives with and without a debris obstruction. Full model outputs for this alternative can be found in Appendix E.

**Table 34. Summary of Results for Alternative #5-3 with Proposed and Future Conditions Based on Open-Water Simulations for the 1% ACE**

| **Proposed Conditions** | **Flood Bench A** | **Flood Bench B** |
|---|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 2.4-ft | Up to 1.1-ft |
| Total Length of Benefited Area | 275-ft | 200-ft |
| River Stations | 45+25 to 42+50 | 21+00 to 19+00 |
| **Future Proposed Conditions** | | |
| Reductions in Water Surface Elevations (feet) | Up to 2.5-ft | Up to 1.0-ft |
| Total Length of Benefited Area | 275-ft | 200-ft |
| River Stations | 45+25 to 42+50 | 21+00 to 19+00 |

**Table 35. Summary of Results for Alternative #5-3 with Proposed and Future Conditions Based on Debris-Obstruction Simulations for the 1% ACE**

| **Proposed Conditions with Debris-Obstruction** | **Flood Bench A** | **Flood Bench B** |
|---|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 2.5-ft | Up to 0.8-ft |
| Total Length of Benefited Area | 275-ft | 200-ft |
| River Stations | 45+25 to 42+50 | 21+00 to 19+00 |
| **Future Proposed Conditions with Debris-Obstruction** | | |
| Reductions in Water Surface Elevations (feet) | Up to 2.6-ft | Up to 0.7-ft |
| Total Length of Benefited Area | 275-ft | 200-ft |
| River Stations | 45+25 to 42+50 | 21+00 to 19+00 |

Flood benches generally provide flood protection for localized areas in the vicinity of and immediately upstream and/or downstream of the bench. Flood benches upstream of the bridge would provide significant flood protection from debris/log flooding.

To evaluate the effectiveness of the flood mitigation impacts, the project team analyzed each flood bench independently. 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: $5.2 million
- Flood Bench B: $1.2 million

These ROM cost estimates do not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the NYSDEC will require wetland delineations, an analysis for any endangered and/or threatened species within the proposed project area, and information regarding access during construction for this mitigation alternative.

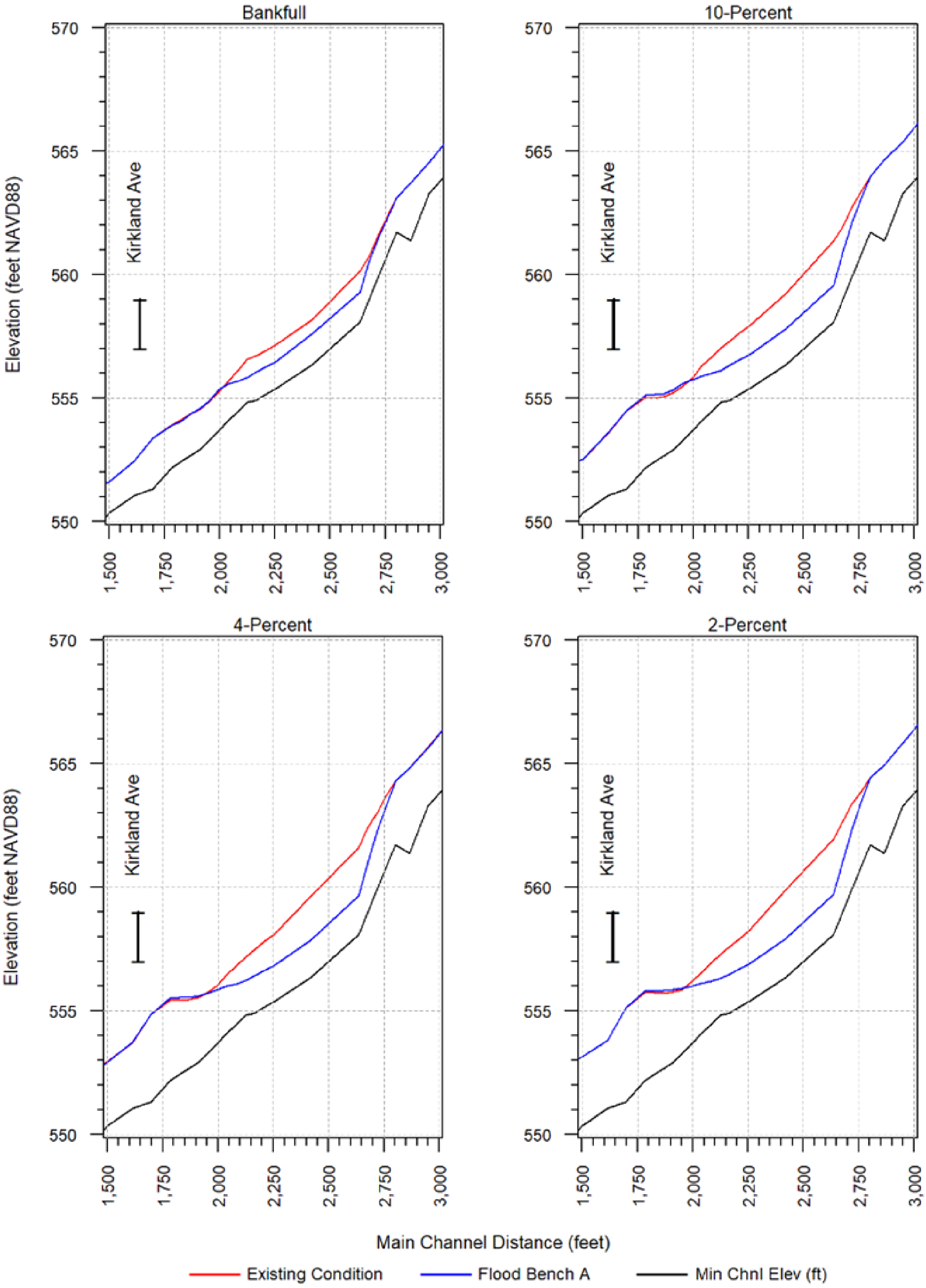


**Figure 7-29. HEC-RAS model simulation output results for Alternative #5-3 for the existing condition (red) and proposed alternative (blue) scenarios.**

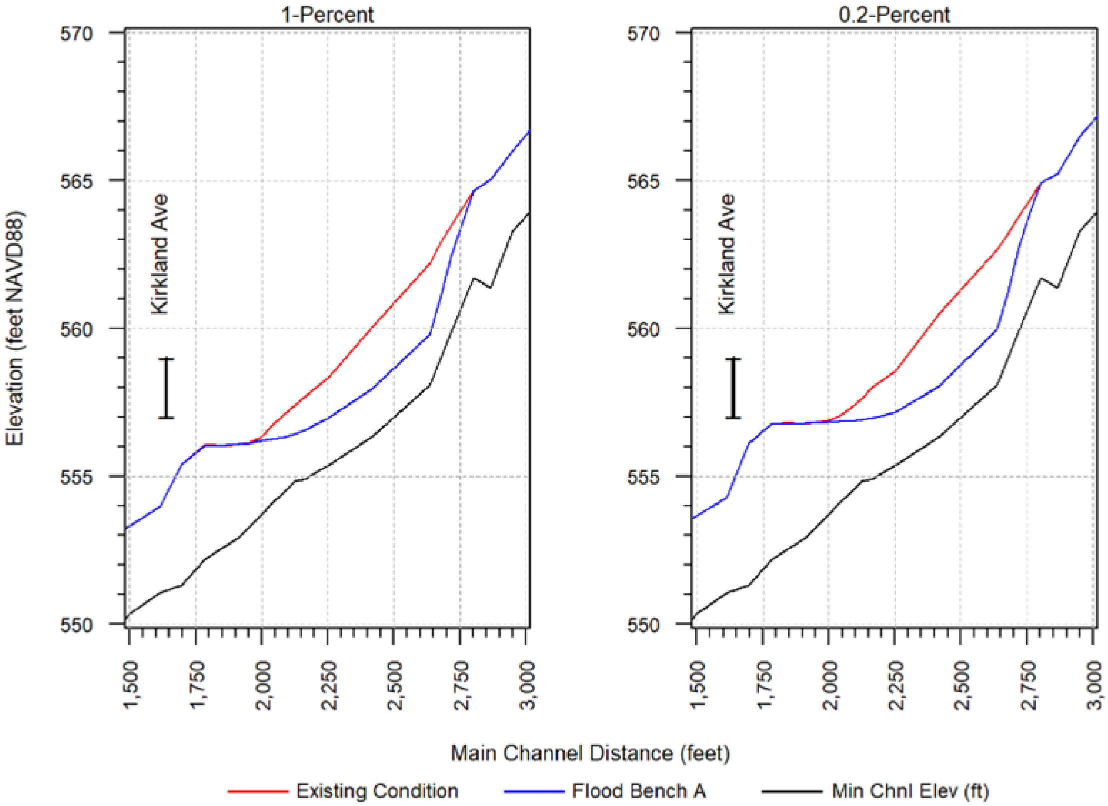


**Figure 7-29 (continued). HEC-RAS model simulation output results for Alternative #5-3 for the existing condition (red) and proposed alternative (blue) scenarios.**

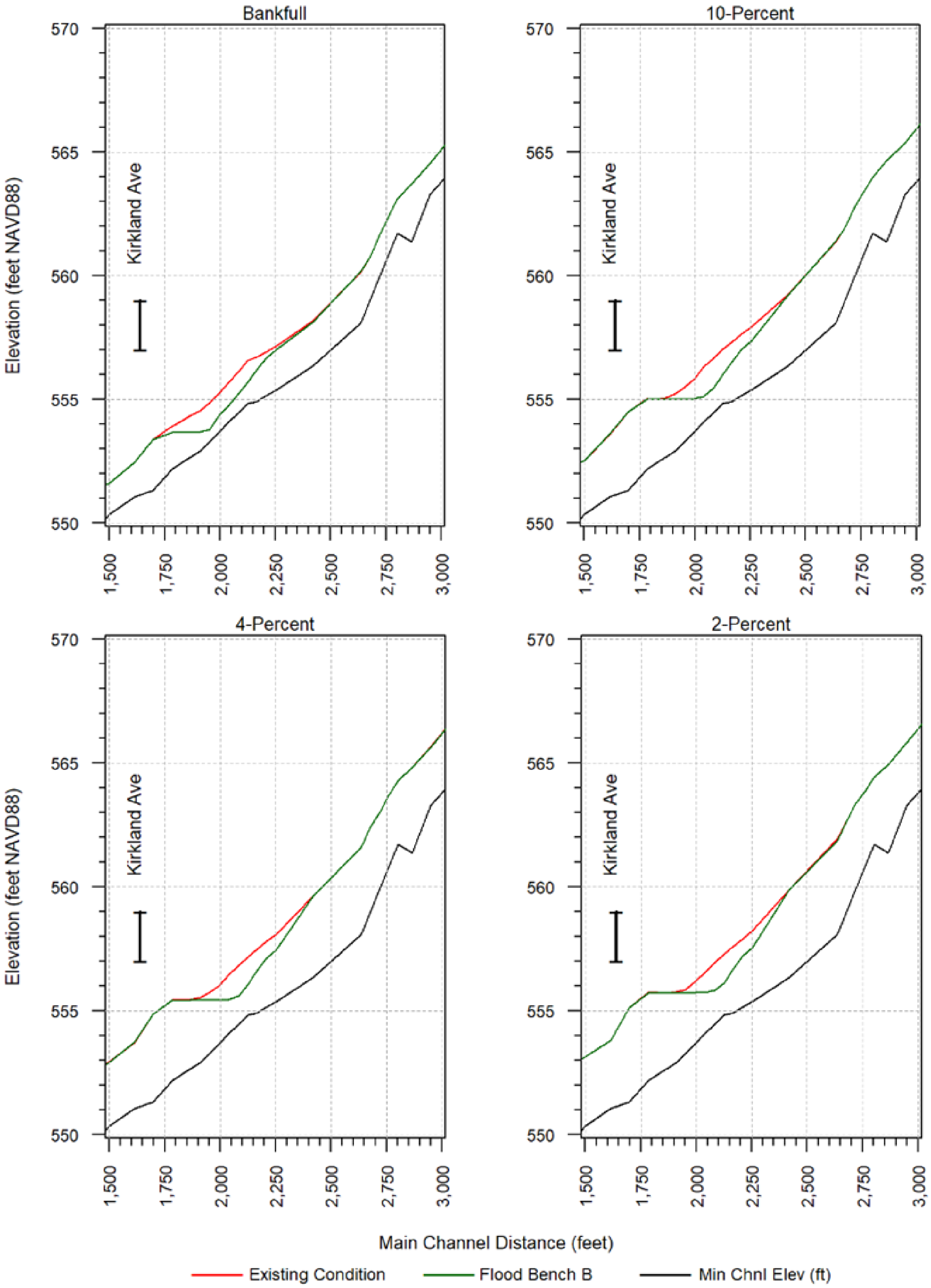


**Figure 7-29 (continued). HEC-RAS model simulation output results for Alternative #5-3 for the existing condition (red) and proposed alternative (blue) scenarios.**

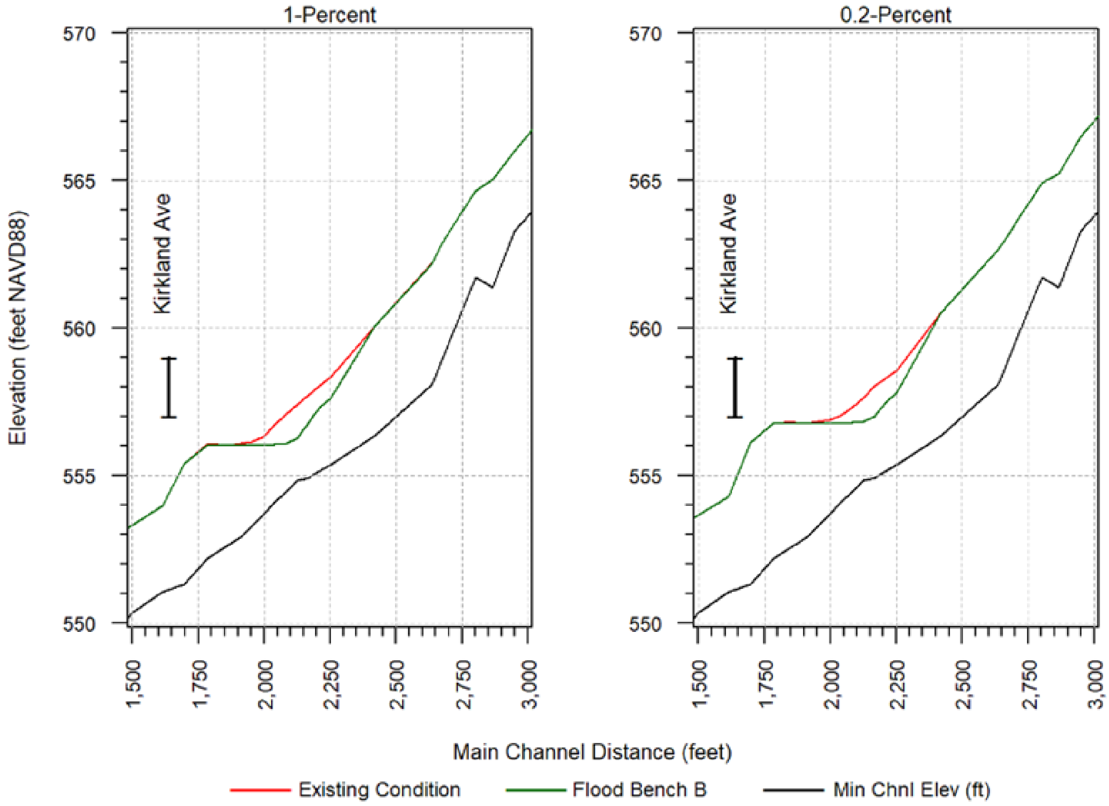


**Figure 7-29 (continued). HEC-RAS model simulation output results for Alternative #5-3 for the existing condition (red) and proposed alternative (blue) scenarios.**

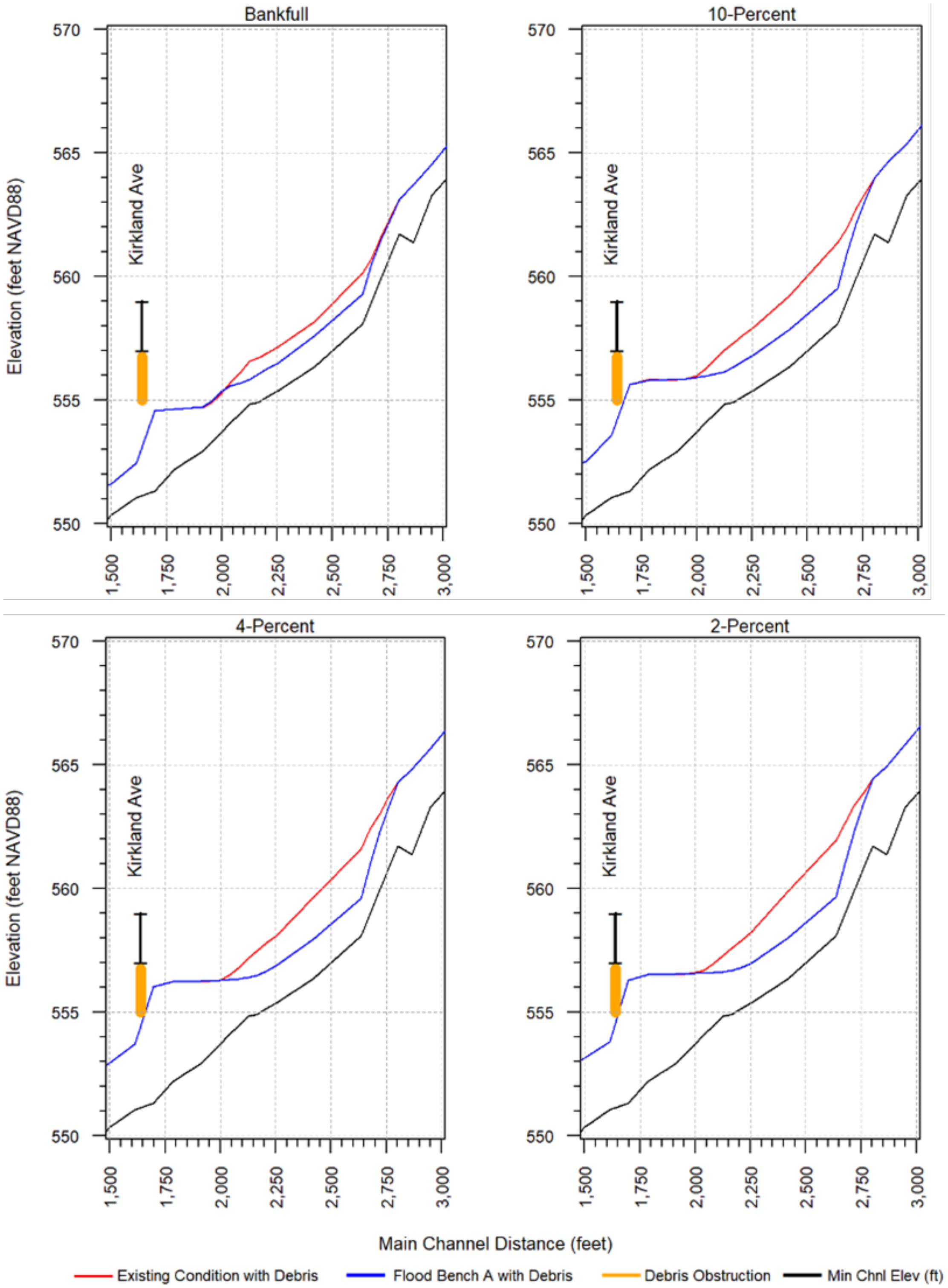


Figure 7-30. HEC-RAS model simulation output results for Alternative #5-3 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.

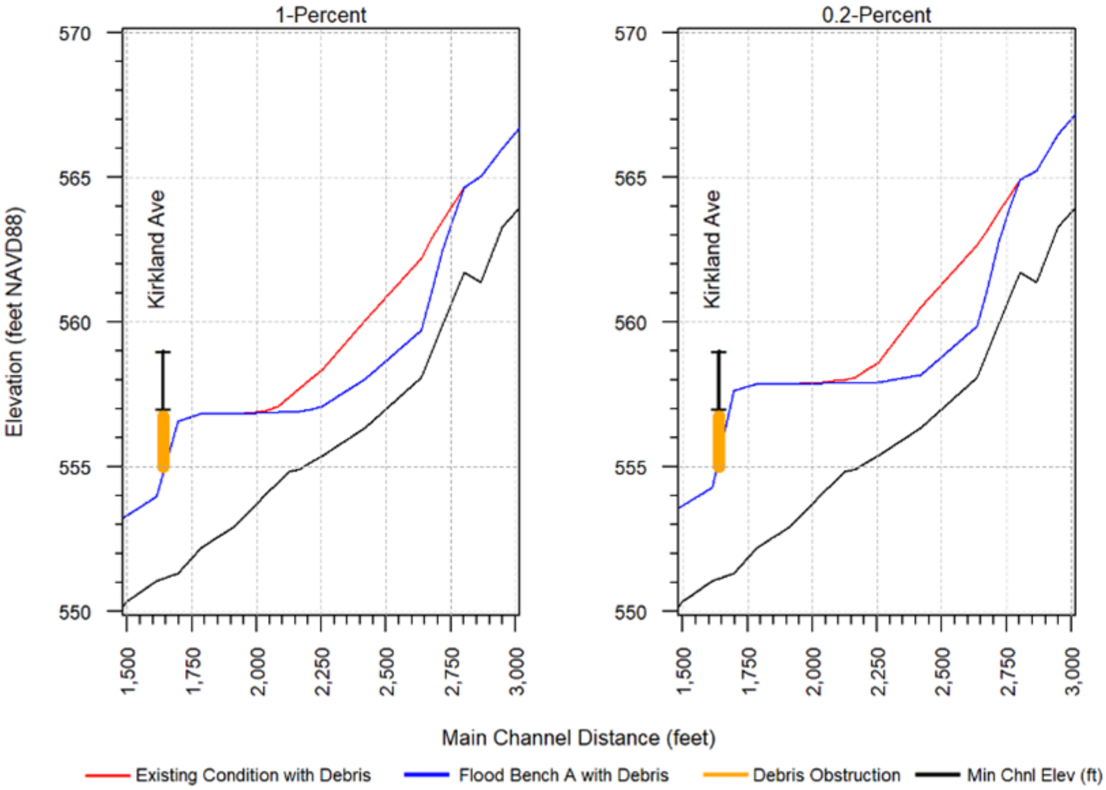


**Figure 7-30 (continued). HEC-RAS model simulation output results for Alternative #5-3 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

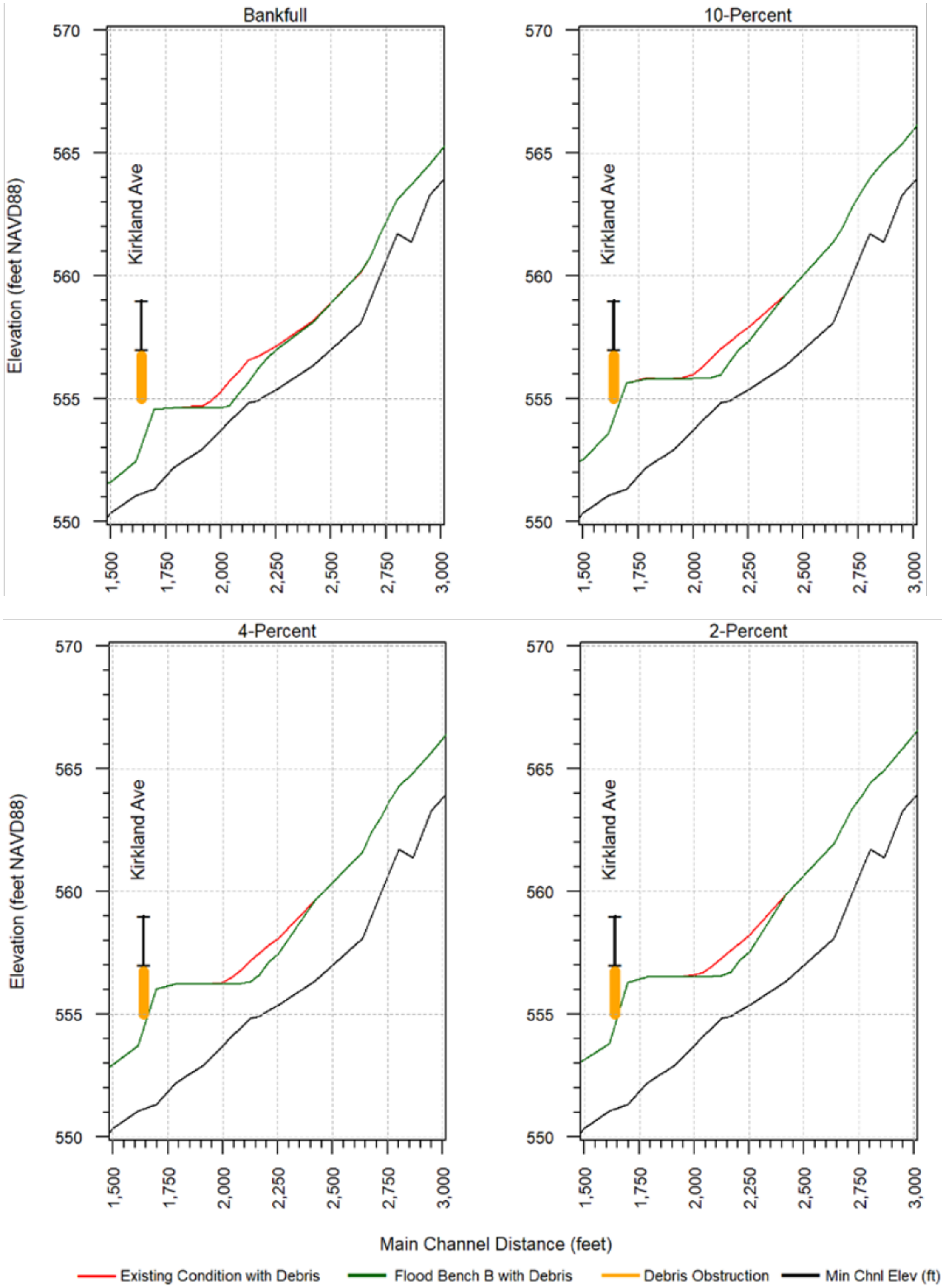


**Figure 7-30 (continued). HEC-RAS model simulation output results for Alternative #5-3 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

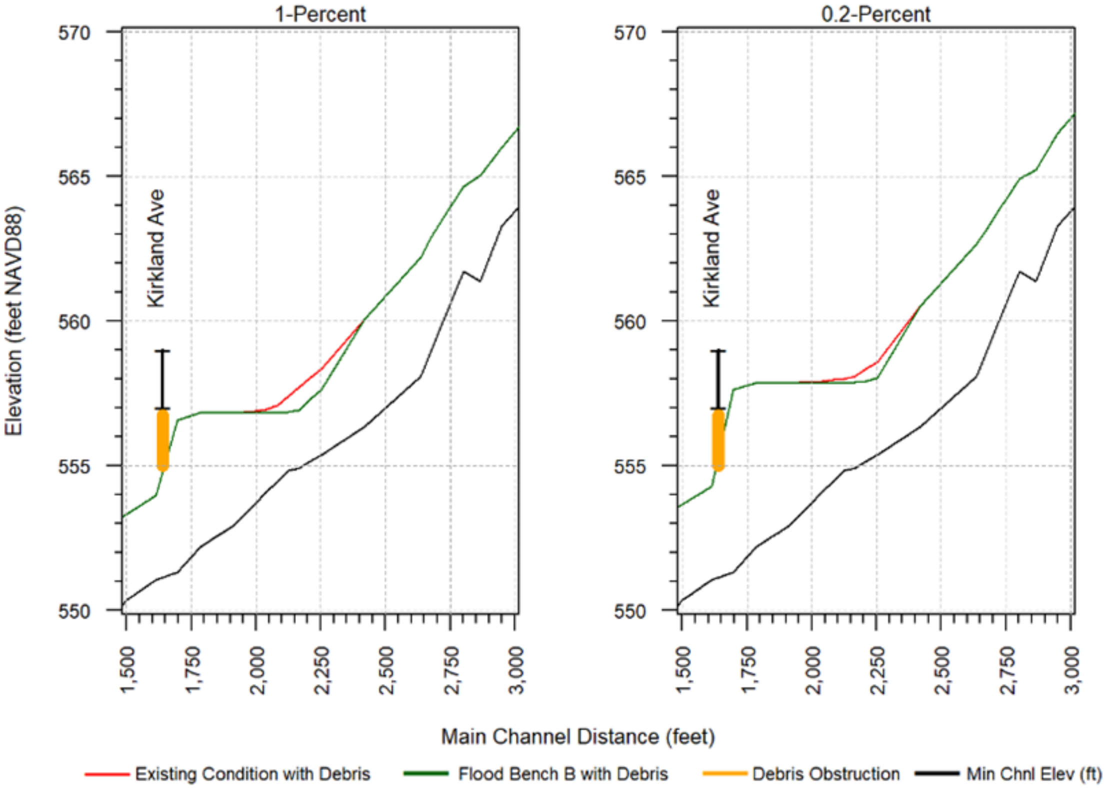


**Figure 7-30 (continued). HEC-RAS model simulation output results for Alternative #5-3 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

### 7.5.4 Alternative #5-4: Increase Hydraulic Capacity of the Kirkland Avenue Bridge

This measure is intended to address issues within High-Risk Area #5 by increasing the width of the Kirkland Avenue bridge opening, which would increase the cross-sectional flow area of the channel located at river station 16+50 (Figure 7-31).

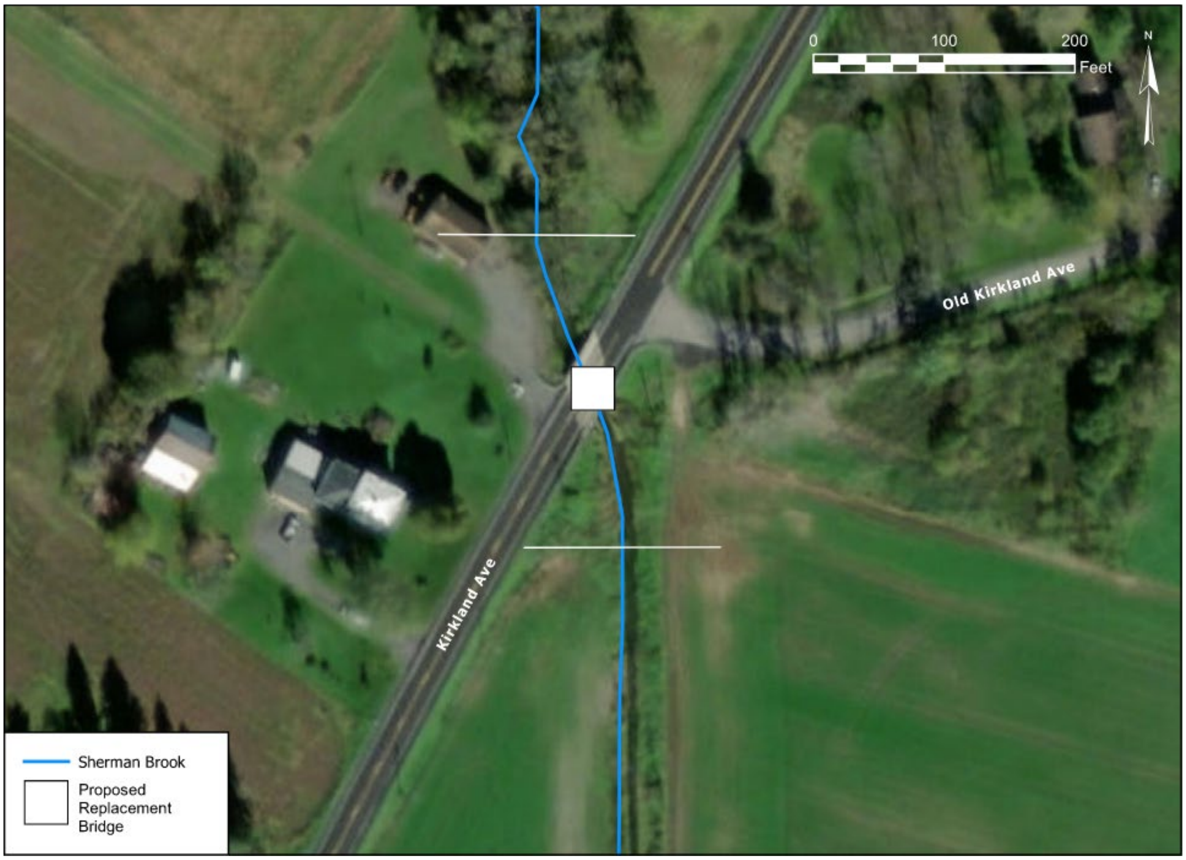


**Figure 7-31. Placement of proposed replacement bridge at High-Risk Area #5 Along Sherman Brook.**

The bridge is maintained by Oneida County. The existing bridge structure has a span of 46 ft and a height of 5.6 ft (Figure 7-32). The flooding in the vicinity of the Kirkland Avenue bridge poses a flood-risk threat to nearby residential, commercial and recreational properties and village-owned infrastructure. Appendix D depicts a flood mitigation rendering of a culvert widening scenario.

**Figure 7-32. Upstream view of the Kirkland Avenue bridge in the Sherman Brook corridor.**

By increasing the opening span of the bridge structure, the cross-sectional flow area of the channel would increase and the potential for sediment and debris to accumulate or catch on the upstream face of the bridge would be reduced, thereby reducing flood risk to areas adjacent to and immediately upstream of the bridge.

The bridge widening design selected for this proposed condition model simulation was selected to ensure that the 1% ACE WSEL could successfully pass under the Kirkland Avenue bridge without significant backwater upstream of the bridge and decrease the WSEL. To achieve the desired result, the bridge widening design increased the span of the bridge opening from 46 ft to 86 ft by widening the bridge on the right bank by 20 ft, and increased the low cord height by 0.5 ft.

For this alternative, open-water and debris-obstruction simulations were performed to test the effectiveness of the alternative at reducing water surface elevations for increasing the hydraulic capacity at Kirkland Avenue.

Tables 36 and 37 outline the results of the proposed conditions and future conditions from the model simulation with and without a debris obstruction. Figures 7-33 through 7-34 display the profile plots for the bridge widening alternative with and without a debris obstruction. Full model outputs for this alternative can be found in Appendix E.

**Table 36. Summary of Results for Alternative #5-4 with Proposed and Future Conditions Based on Open-Water Simulations for the 1% ACE**

| **Proposed Conditions** | **Increased Hydraulic Capacity** |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 1.3-ft |
| Total Length of Benefited Area | 325-ft |
| River Stations | 19+50 to 16+25 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations (feet) | Up to 1.2-ft |
| Total Length of Benefited Area | 325-ft |
| River Stations | 19+50 to 16+25 |

**Table 37. Summary of Results for Alternative #5-4 with Proposed and Future Conditions Based on Debris-Obstruction Simulations for the 1% ACE**

| **Proposed Conditions with Debris-Obstruction** | **Increased Hydraulic Capacity** |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 2.2-ft |
| Total Length of Benefited Area | 325-ft |
| River Stations | 19+50 to 16+25 |
| **Future Proposed Conditions with Debris-Obstruction** | |
| Reductions in Water Surface Elevations (feet) | Up to 2.4-ft |
| Total Length of Benefited Area | 325-ft |
| River Stations | 19+50 to 16+25 |

The results show a significant reduction in the WSEL with all 1-D model simulations for alternative #5-4. Results also indicate an adverse effect immediately downstream of the Kirkland Avenue bridge where the proposed alterative will increase the WSEL by 0.29-ft.

The potential benefits of this strategy are limited to upstream of the Kirkland Avenue bridge. The primary benefits of increasing the bridge opening would be to increase the flow capacity of the bridge structure, reduce the potential of backwater from high-flow events, and help prevent debris and ice from catching on the structure and creating obstructions/jams upstream of the bridge. Additionally, the alternative would minimize damages to the infrastructure and reduce the duration the roadway is inaccessible.

The ROM cost for this strategy is approximately $5.1 million, which does not include land acquisition costs for survey, appraisal, and engineering coordination. Additional engineering consideration would also be required to determine if increasing the bridge opening would alter the structural integrity of the bridge in any way.

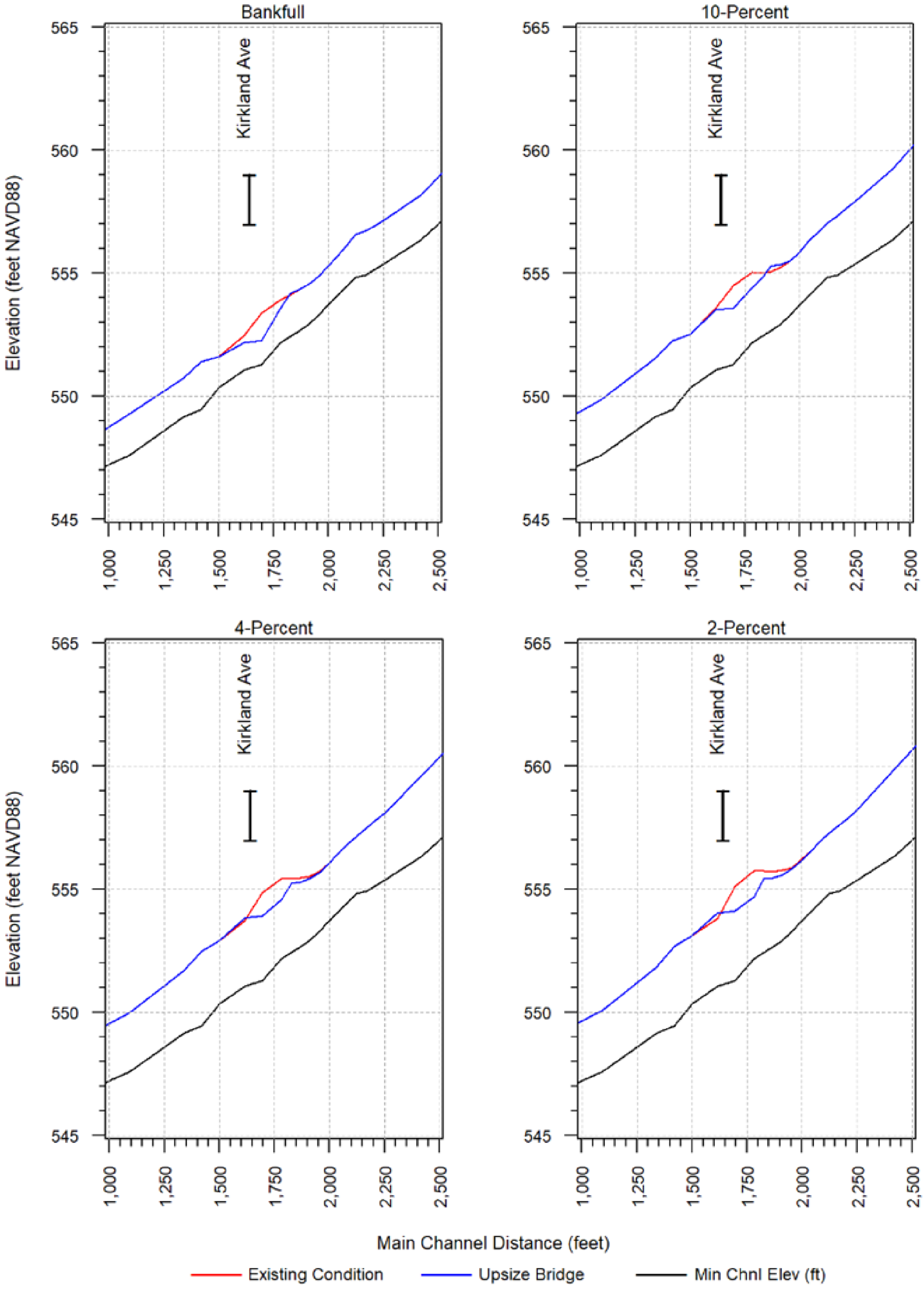


**Figure 7-33. HEC-RAS model simulation output results for Alternative #5-4 for the existing condition (red) and proposed alternative (blue) scenarios.**

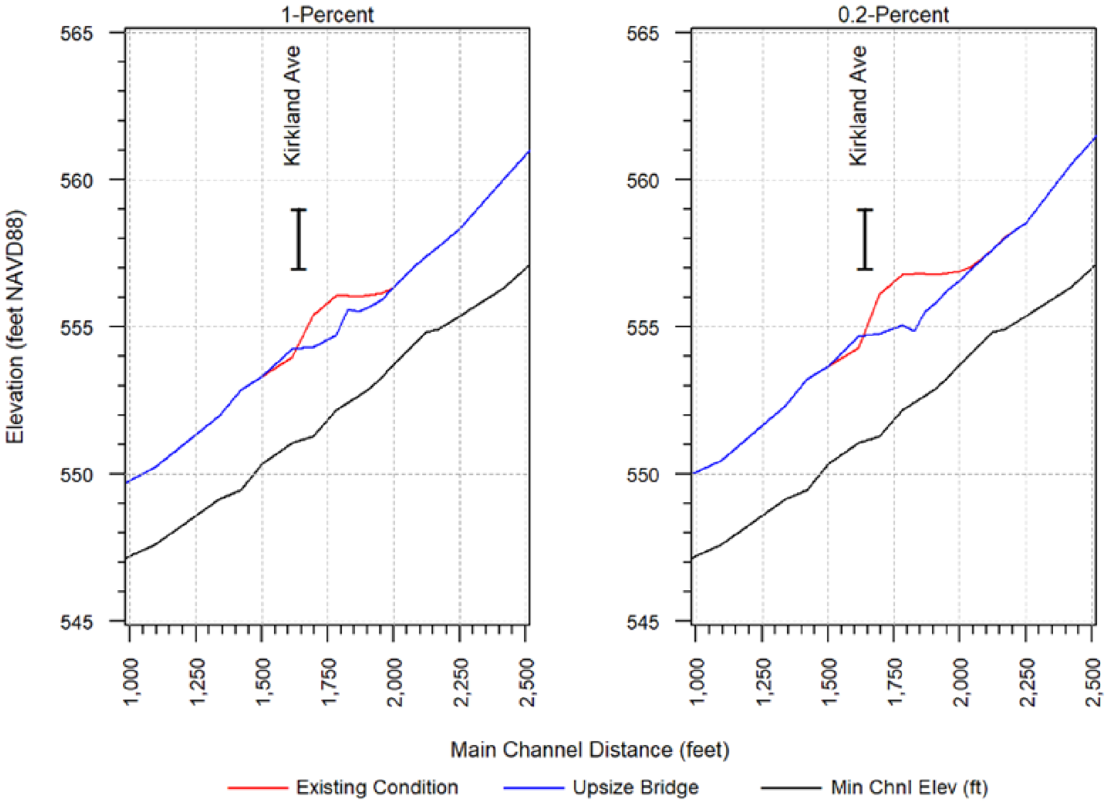


Figure 7-33 (continued). HEC-RAS model simulation output results for Alternative #5-4 for the existing condition (red) and proposed alternative (blue) scenarios.

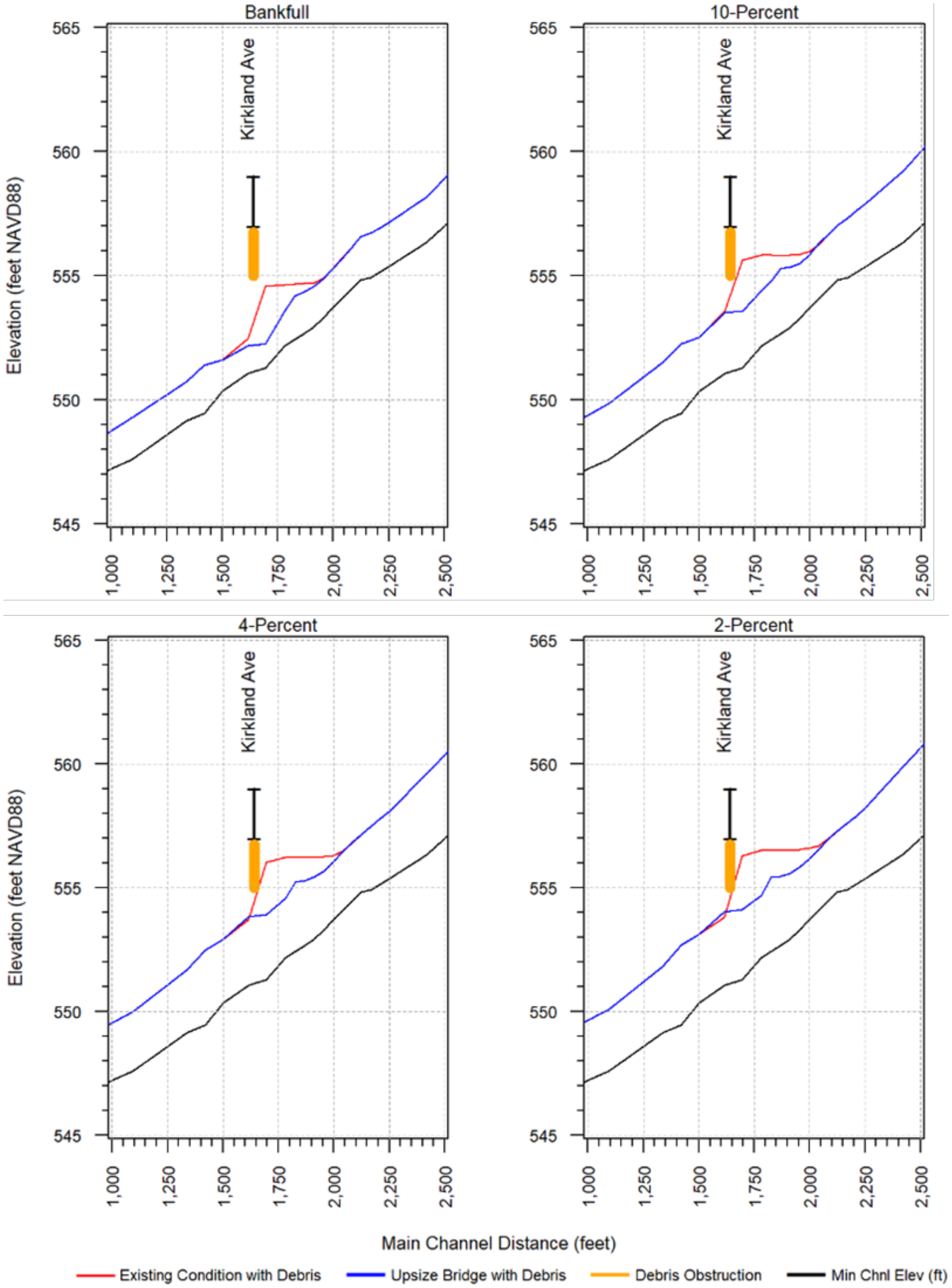


Figure 7-34. HEC-RAS model simulation output results for Alternative #5-4 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.

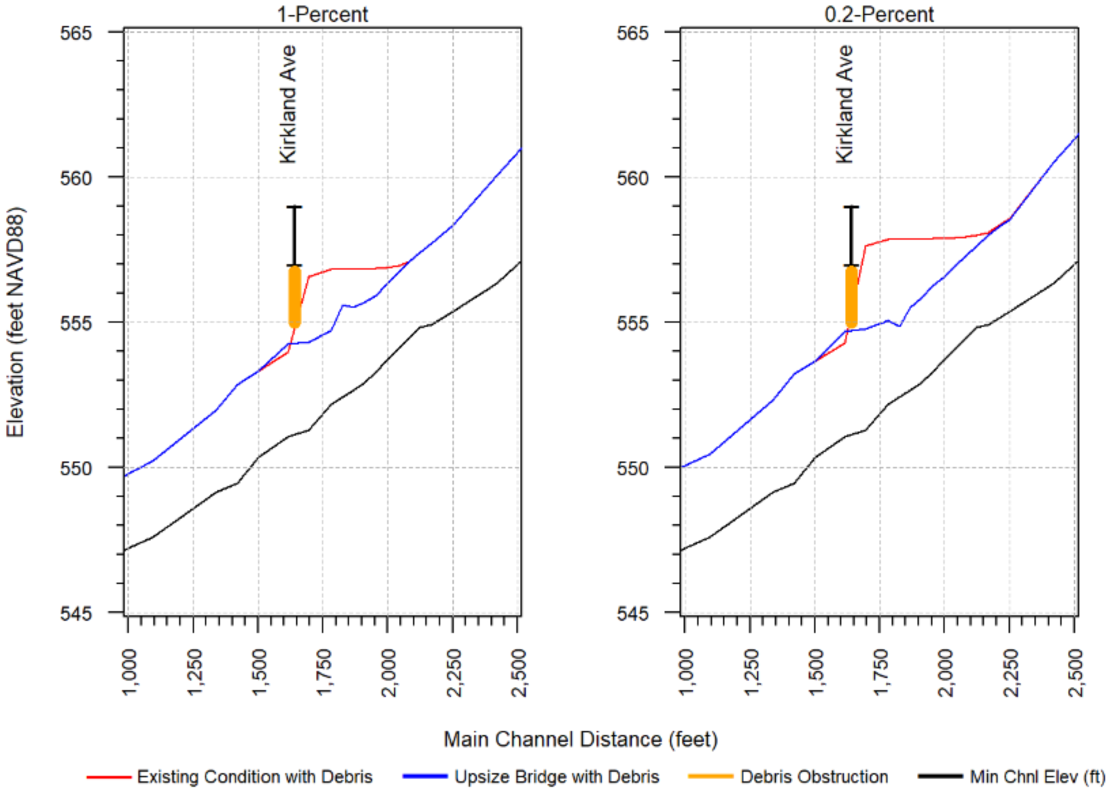


**Figure 7-34 (continued). HEC-RAS model simulation output results for Alternative #5-4 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

### 7.5.5 Alternative #5-5: Overflow Open-Water Channel and Two New Culverts on Old Kirkland Avenue and Kirkland Avenue

This measure is intended to address issues within High-Risk Area #5 by creating an overflow open-water channel on the right bank of Sherman Brook across the adjacent undeveloped area. An overflow channel will direct water that exceeds the capacity of the channel where water flows naturally during high flood events. The area will include channel banks to support high flows of water and support a 1% ACE discharge from the main channel as flow travels through the undeveloped area and private properties.

The proposed overflow channel will divide the main channel flow at river stationing 19+00, flowing northeast toward Old Kirkland Avenue, then changing the flow direction in a northwest direction towards Kirkland Avenue and returning back to the main channel at river stationing 12+00. This mitigation alternative would require two new culverts through Old Kirkland Avenue and Kirkland Avenue. The overflow channel is designed to be approximately 900 ft in length (Figure 7-35).

Figure 7-35. Placement of proposed overflow channel and new culverts at High-Risk Area #5.

The overflow channel for the proposed condition model simulation is designed with an average thalweg depth of 4-ft.

Old Kirkland Avenue is a local road maintained by the Town of Kirkland. Kirkland Avenue is a county road (County Route 32) maintained by the county. The flooding in the vicinity of the High-Risk Area #5 poses a flood-risk threat to nearby residential properties, agricultural fields, undeveloped areas and county-owned infrastructure. Appendix D depicts a flood mitigation rendering of a culvert widening scenario.

The existing conditions model, public engagement meetings, and media show flood extents that impact the adjacent fields, Old Kirkland Avenue roadway, residential properties, and the Kirkland Avenue roadway. Based on the orthoimagery, the overflow channel will flow through private property and an easement is required to continue with project approval. An overflow channel will reduce the flooding risks and contain the sediment and debris in these areas.

The culvert design selected for this proposed condition model simulation was selected to ensure that the 1% ACE WSEL could successfully pass under the two new culverts placed under Old Kirkland Avenue and Kirkland Avenue without significant backwater upstream of the bridge. To achieve the desired result, the Old Kirkland Avenue culvert is designed to have a span of the culvert opening of 12.5 ft with a rise of 4 ft. The new Kirkland Avenue bridge is designed to have a span of 15.5 ft where the low cord will be 5.5 ft away from the channel bottom. Figure 4 in Appendix G represents a 15% conceptual design of the overflow open-water channel and new culverts on Old Kirkland Avenue and Kirkland Avenue.

Tables 38 and 39 outline the results of the proposed conditions and future conditions from the 1-D model simulation with and without a debris obstruction. Figures 7-36 through 7-37 display the profile plots for the overflow channel alternative with and without a debris obstruction.

**Table 38. Summary of Results for Alternative #5-5 with Proposed and Future Conditions Based on Open-Water 1-D Model Simulations for the 1% ACE**

| **Proposed Conditions** | **Overflow Channel** |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 1.2-ft |
| Total Length of Benefited Area | 700-ft |
| River Stations | 19+00 to 12+00 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations (feet) | Up to 1.5-ft |
| Total Length of Benefited Area | 700-ft |
| River Stations | 19+00 to 12+00 |

**Table 39. Summary of Results for Alternative #5-5 with Proposed and Future Conditions Based on Debris-Obstruction 1-D Model Simulations for the 1% ACE**

| Proposed Conditions with Debris-Obstruction | Overflow Channel |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 1.5-ft |
| Total Length of Benefited Area | 700-ft |
| River Stations | 19+00 to 12+00 |
| **Future Proposed Conditions with Debris-Obstruction** | |
| Reductions in Water Surface Elevations (feet) | Up to 1.9-ft |
| Total Length of Benefited Area | 700-ft |
| River Stations | 19+00 to 12+00 |

Table 40 summarizes the results of the proposed conditions from the 2-D model simulation during the Halloween 2019 Storm event. Figure 7-38 displays the profile plots for the overflow open-water channel alternative during the July 2017, Halloween 2019 Storm, and April 2023 storm events. The full 1-D and 2-D model outputs for this alternative can be found in Appendix E and Appendix F, respectively.

**Table 40. Summary of Results for Alternative #5-5 with Proposed Conditions based on 2-D model during Halloween 2019 Storm Event.**

| Proposed Conditions | Increased Hydraulic Capacity |
|---|---|
| Reductions in Water Surface Elevations | Up to 0.1-ft |
| Total Length of Benefited Area | 500-ft |
| River Stations | 20+00 to 15+00 |

The results of the 2-D model do not indicate significant reductions to WSELs within the Sherman Brook channel in the vicinity of the Kirkland Avenue bridge, which is not in line with the 1-D model results. In addition, the 2-D results do not indicate any significant benefits to overbank areas or flood extents when compared to the 1-D model results. This is most likely a result of the different modeling equations used in 1-D versus 2-D modeling. In 1-D the model is solving an energy balance equation between cross section.  Therefore when flow enters the diversion channel it is removed from the main channel altering the energy balance. In 2-D, the model is conserving volume and mass across the boundary of each mesh cell. The 2-D solution method is more representative of flow distribution for this alternative as it incorporated more parameters than the 1-D solution.

The ROM cost for this overflow channel alternative is $1.2 million. These ROM cost estimates do not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the NYSDEC will require wetland delineations, an analysis for any endangered and/or threatened species within the proposed project area, and information regarding access during construction for this mitigation alternative.

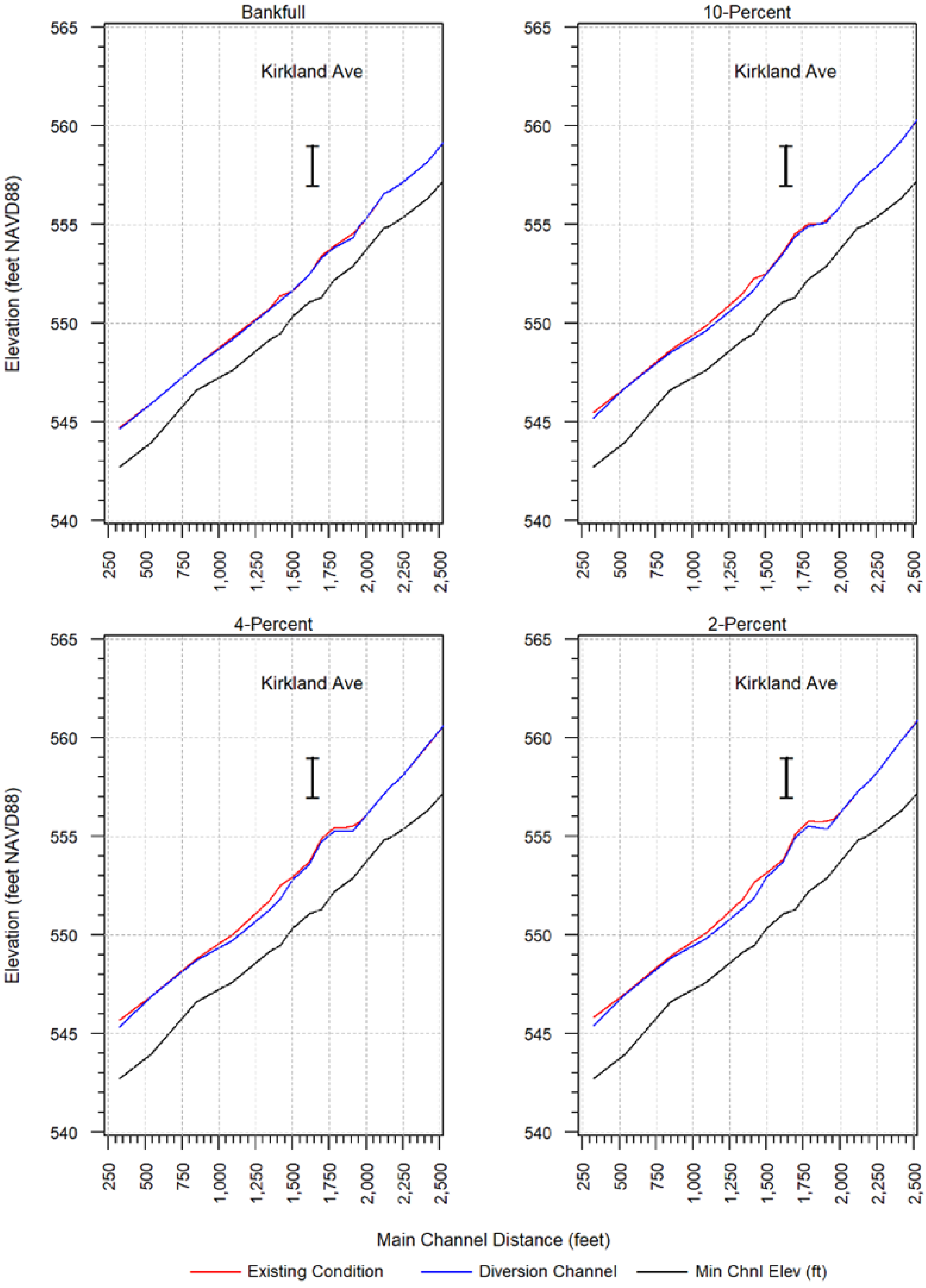


**Figure 7-36. HEC-RAS model simulation output results for Alternative #5-5 for the existing condition (red) and proposed alternative (blue) scenarios.**

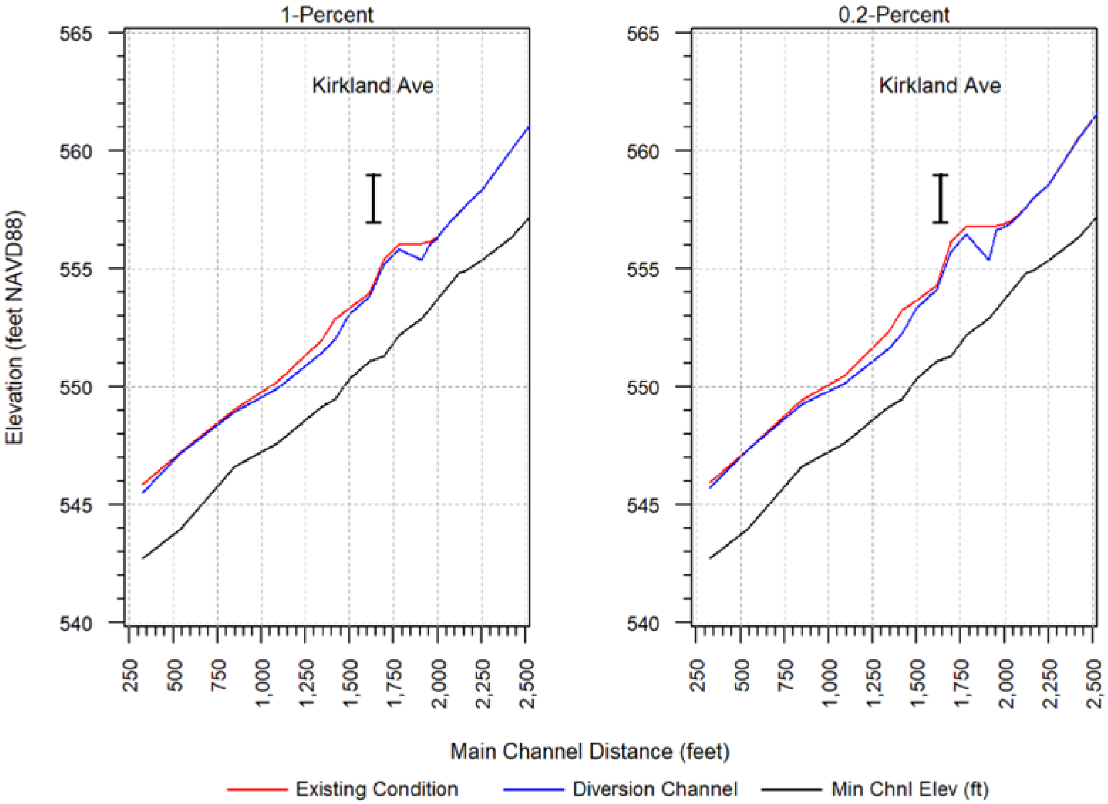


**Figure 7-36 (continued). HEC-RAS model simulation output results for Alternative #5-5 for the existing condition (red) and proposed alternative (blue) scenarios.**

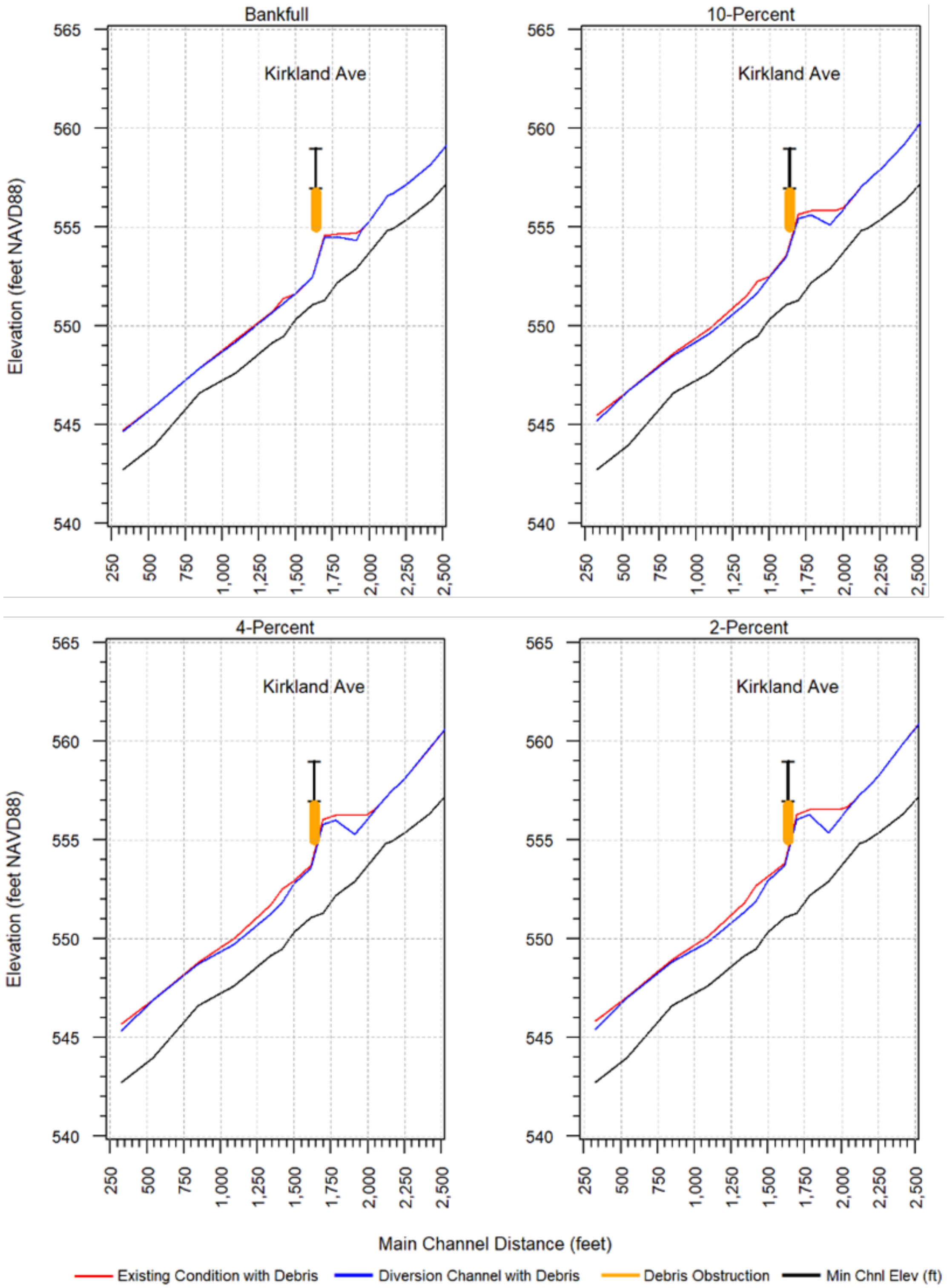


**Figure 7-37. HEC-RAS model simulation output results for Alternative #6-1 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

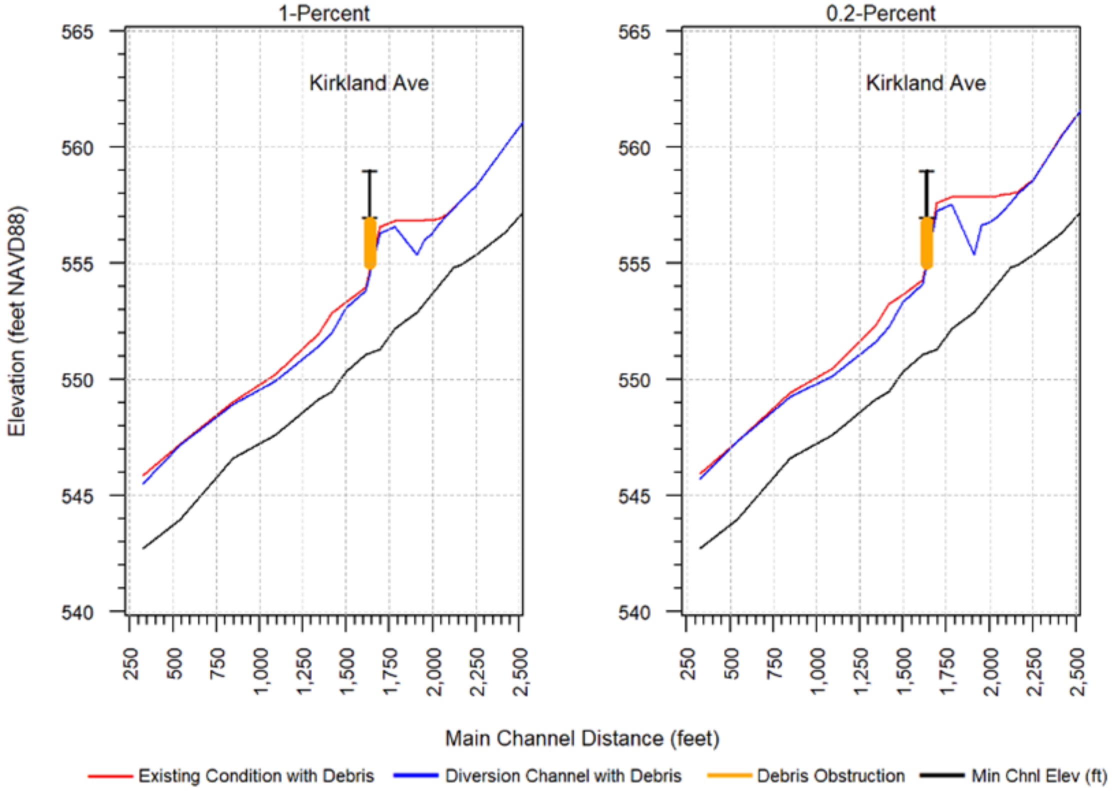


**Figure 7-37 (continued). HEC-RAS model simulation output results for Alternative #6-1 for the existing condition (red) and proposed alternative (blue) scenarios with debris obstruction.**

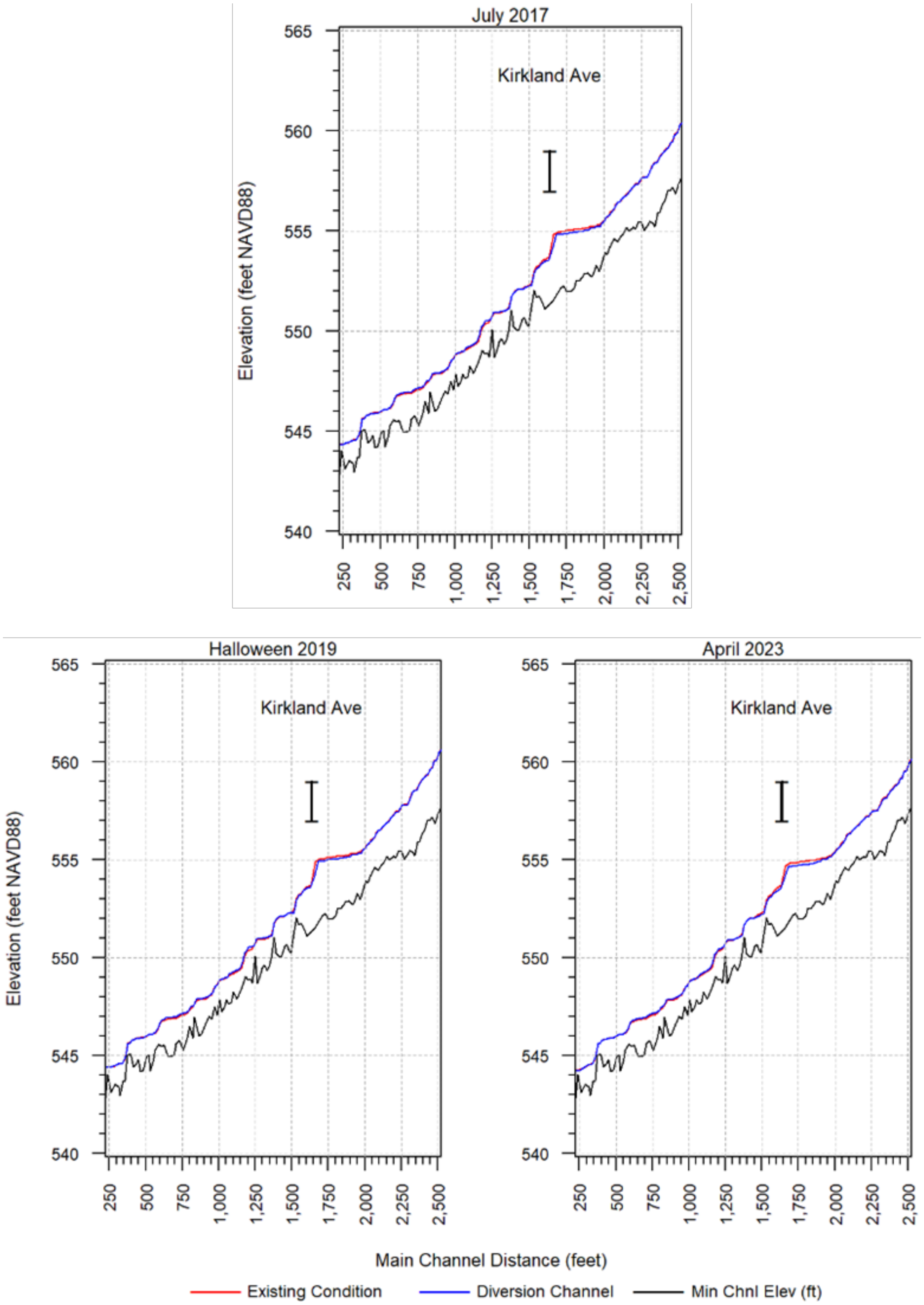


**Figure 7-38. HEC-RAS 2-D model simulation output results for the existing condition (red) and proposed alternative (blue) scenarios for the three storm events.**

## 7.6 HIGH-RISK AREA #6

### 7.6.1 Alternative #6-1: Revitalization of Earthen Dam

An earthen, man-made dam is located on an unnamed tributary to Sherman Brook, Tributary #2. The background and purpose of the dam is unknown and is currently not occupied by inhabitants. Over time, the earthen dam has eroded away by the flow of the tributary. The Sherman Brook community has recommended assessing the feasibility of a dam revitalization for the purposes of decreasing water flow into Sherman Brook. If the dam was rebuilt to its original state, before intensive erosion and lack of regular maintenance led to a partial collapse of the dam wall, water would be held back to fill an area of approximately 1.7-acres. The dam location is at Tributary #2 river station 28+50-ft (Figure 7-39).

**Figure 7-39. Placement of proposed revitalization of earthen dam along the Unnamed Tributary of Sherman Brook, Tributary #2.**

The dam is located on private property with limited road access. Based on the Oneida County, New York 2-meter LiDAR DEM, the proposed dam has a length of 160-ft, width of 10-ft, and height of 5-ft, NAVD88 (Figure 7-40). Designs of the proposed alternative would involve the eroded area to be filled with earth material in an approximate area of 2000 square feet.

**Figure 7-40. Upstream view of the eroded dam in the corridor of Sherman Brook's Unnamed Tributary, Tributary #2.**

The intent of revitalizing the dam to the original design is to decrease the water velocity and volume in the Unnamed Tributary #2 prior to its confluence with the main branch of Sherman Brook, thereby resulting in lower flows in Sherman Brook and potentially lower flood risk for areas near the confluence and downstream. In addition, heavy and intense precipitation events would collect in the reservoir upstream of the revitalized dam and would be released downstream at a slower rate than without the dam, which would reduce the potential of flash flooding.

The dam revitalization design chosen for this proposed condition model simulation was based on the original design of the dam. To achieve the desired design, the dam was designed to withhold water to fill the wetland area upstream of the dam then release flow downstream of the dam once the upstream water surface reached a specific elevation.

Table 41 outlines the results of the proposed conditions and future conditions from the model simulation. The total benefited area for revitalizing the dam mitigation was measured by the total benefited area starting at the Tributary #2's confluence to the downstream areas along Sherman Brook. Figures 7-41 displays the profile plots for the dam revitalization alternative. Full model outputs for this alternative can be found in Appendix E.

**Table 41. Summary of Results for Alternative #6-1 with Proposed and Future Conditions Based on Open-Water Simulations for the 1% ACE**

| **Proposed Conditions** | **Dam Rehabilitation** |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 0-ft |
| Total Length of Benefited Area | 0-ft |
| River Stations | 46+00 to 3+00 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations (feet) | Up to 0-ft |
| Total Length of Benefited Area | 0-ft |
| River Stations | 46+00 to 3+00 |

In New York State, a joint permit application from the NYSDEC and USACE may be required in order to construct, reconstruct or repair a dam or other impoundment. The NYSDEC is entrusted with the regulatory power to oversee dam safety. To protect people from the loss of life and property due to flooding and/or dam failure, the NYSDEC Dam Safety Section, in cooperation with the USACE, reviews proposed dam construction and/or modifications, conducts dam safety inspections, and monitors projects for compliance with dam safety criteria.

To acquire a permit for the construction, reconstruction, or repair of a dam or other impoundment, a developer must submit an application to the NYSDEC for an Article 15 Dam Construction Permit, along with the USACE Joint Application Form that, if approved, would allow activities affecting waters within the state.

Potential consequences of dam failures are an important safety measure that should be highly considered in future dam design plans. Dam safety inspections by the NYDEC are advised in any dam project plans.

The ROM cost for this strategy is approximately $500,000, which does not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the ROM cost estimate for the dam rehabilitation scenario is highly dependent on the presence or absence of contaminants in any sediment impounded behind the dam. This ROM estimate is based on no contaminants found in any sediment.

It should be noted that by rehabilitating the dam, the potential flood risk for upstream areas could be altered resulting in negative effects. Ramboll recommends additional research, data, and modeling, including advanced 2-D modeling, to more accurately determine the effects of rehabilitating the dam to upstream areas.

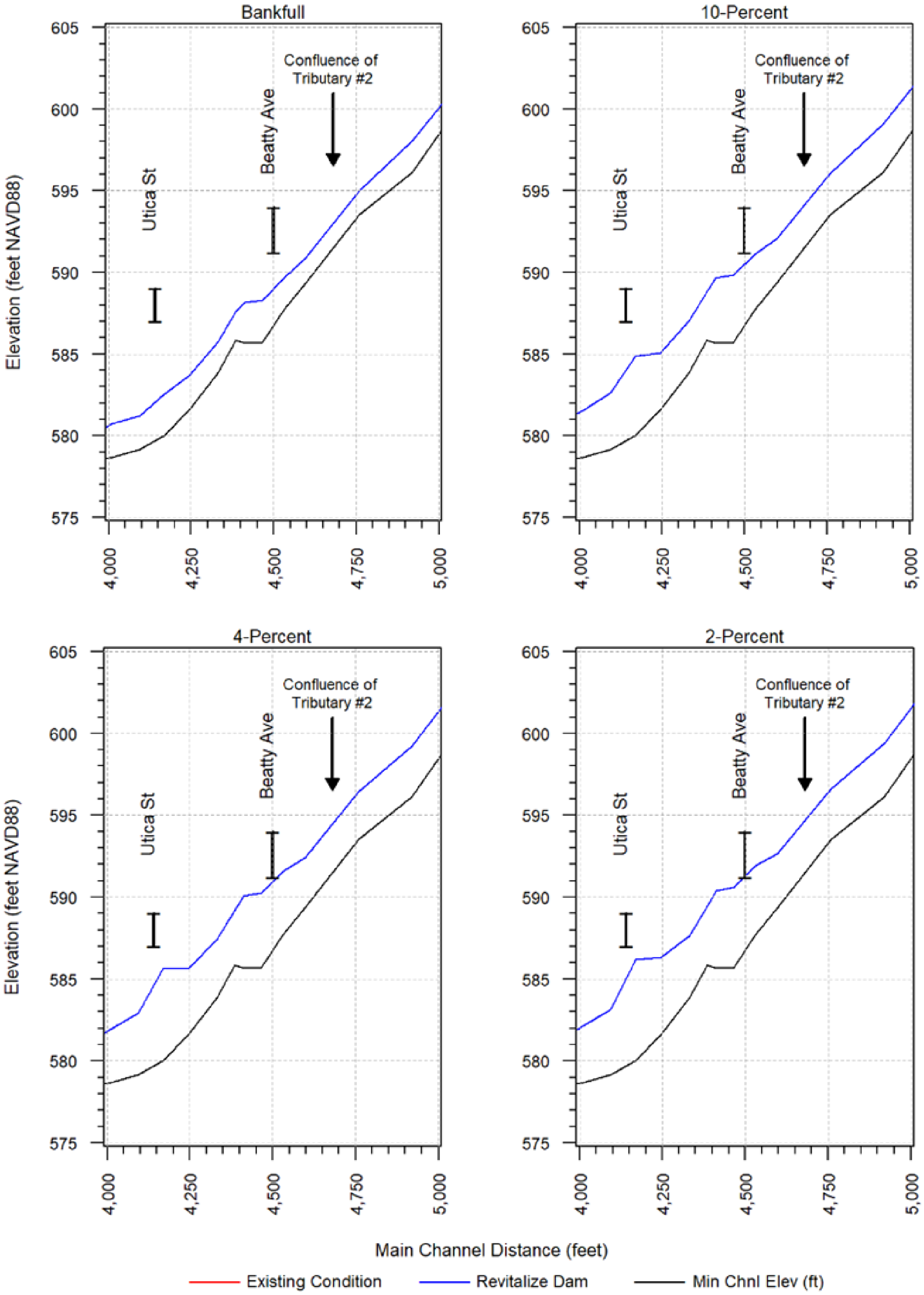


**Figure 7-41. HEC-RAS model simulation output results for Alternative #6-1 for the existing condition (red) and proposed alternative (blue) scenarios.**

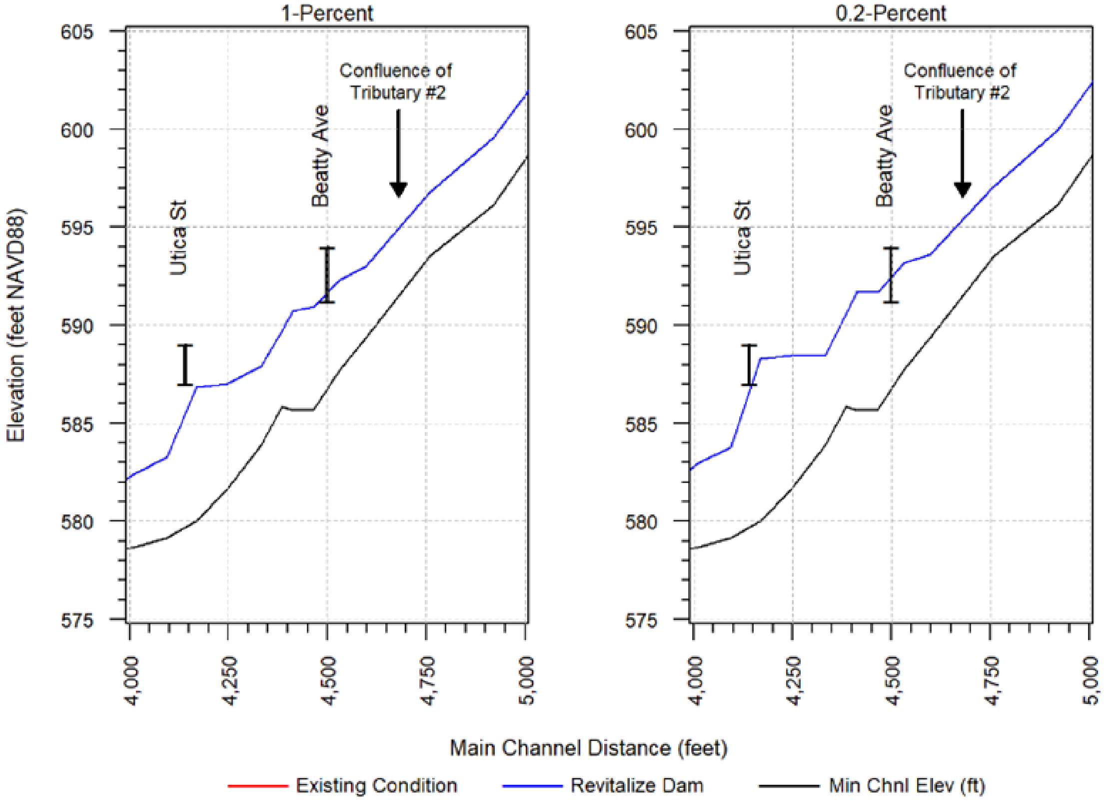


**Figure 7-41 (continued). HEC-RAS model simulation output results for Alternative #6-1 for the existing condition (red) and proposed alternative (blue) scenarios.**

### 7.6.2 Alternative #6-2: Removal of Earthen Dam

The earthen, man-made dam, located on Unnamed Tributary #2, was evaluated for the removal of earthen material. The proposed alternative would be analyzed to determine the flooding impacts downstream at the confluence of Unnamed Tributary #2 with Sherman Brook. The background and purpose of the dam is unknown and is currently not occupied by inhabitants. The removal of the dam project is located at Tributary #2 river station 28+50-ft (Figure 7-42).

**Figure 7-42. Placement of proposed removal of earthen dam along the Unnamed Tributary of Sherman Brook, Tributary #2.**

The dam is located on private property with limited road access. The design of the dam removal is to excavate the earth material to the elevation of the ground at the upstream of the existing dam. The elevation of the ground immediately upstream of the dam is 643.3-ft. An approximate area of 700 square feet is designed to be removed on the left bank and 4000 square feet on the right bank.

The intent of removing the remnants of the dam is to eliminate unnatural obstructions to the channel in high flow events. Water will flow more freely and naturally as the water travels through the area. The analysis will show if flood risk is reduced when the dam is removed to the natural state of the floodplain.

Table 42 outlines the results of the proposed conditions and future conditions from the model simulation. The total benefited area for revitalizing the dam mitigation was measured by the total benefited area starting at the confluence of Tributary #2 to the downstream areas along

Sherman Brook. Figures 7-43 displays the profile plots for the dam removal alternative. Full model outputs for this alternative can be found in Appendix E.

**Table 42. Summary of Results for Alternative #6-2 with Proposed and Future Conditions Based on Open-Water Simulations for the 1% ACE**

| **Proposed Conditions** | **Dam Removal** |
|---|---|
| Reductions in Water Surface Elevations (feet) | Up to 0-ft |
| Total Length of Benefited Area | 0 |
| River Stations | 46+00 to 3+00 |
| **Future Proposed Conditions** | |
| Reductions in Water Surface Elevations (feet) | Up to 0-ft |
| Total Length of Benefited Area | 0 |
| River Stations | 46+00 to 3+00 |

The primary benefits of removing the dam would be to increase the cross-section flow area of the channel and reduce the potential for sediment, debris, and ice to accumulate or catch on the dam, thereby reducing the flood risk to areas adjacent to and immediately upstream of the dam.

Several factors must be considered when evaluating potential dam removal projects, including the following (Duda and Bellmore 2021):

- Legal requirements, such as obtaining the necessary federal and local permits;
- Obtaining funding, identifying and getting input from stakeholders;
- Determining whether mitigation projects are necessary or required to minimize dam removal effects;
- Technical difficulty, expense, and time horizon of a proposed dam removal;
- Dam ownership (whether the dam is publicly or privately owned) and the purpose and size of the dam;
- Reservoir sedimentation, the status and ecology of the river and surrounding project lands;
- Testing requirements to categorize sediment held behind the dam for the presence or absence of hazardous materials;
- Infrastructure downstream of the dam; and
- Any necessary environmental compliance mandates.

Dam removal is an important tool for river restoration and addressing aging infrastructure. It is an ongoing activity that will continue as a large number of aging dams that are no longer serving their original purposes, have become safety liabilities, or represent potential for significant restoration action, are taken down (Duda and Bellmore 2021).

Rivers are resilient to the changes and disturbance that accompany the removal of a dam, with many of the changes occurring rapidly and representing an improvement in water quality, hydrological flows, and migratory movement of aquatic animals. Yet, some of the outcomes of dam removal may play out over longer time periods, depending on such factors as the life history of key species or implementation of other complementary river restoration actions (Duda and Bellmore 2021).

In New York State, a joint permit application from the NYSDEC and USACE may be required in order to remove a dam or other impoundment. The NYSDEC is entrusted with the regulatory power to oversee dam safety. To protect people from the loss of life and property due to flooding and/or dam failure, the NYSDEC Dam Safety Section, in cooperation with the USACE, reviews proposed dam removals, conducts dam safety inspections, and monitors projects for compliance with dam safety criteria.

The ROM cost for this strategy is approximately $510,000, which does not include land acquisition costs for survey, appraisal, and engineering coordination. In addition, the ROM cost estimate for the dam removal scenario is highly dependent on the presence or absence of contaminants in any sediment impounded behind the dam. This ROM estimate is based on no contaminants found in any sediment.

It should be noted that by removing the dam, the potential flood risk for downstream areas could be altered resulting in negative effects to downstream areas. Ramboll recommends additional research, data, and modeling, including advanced 2-D modeling, to more accurately determine the effects of removing the dam to downstream areas.

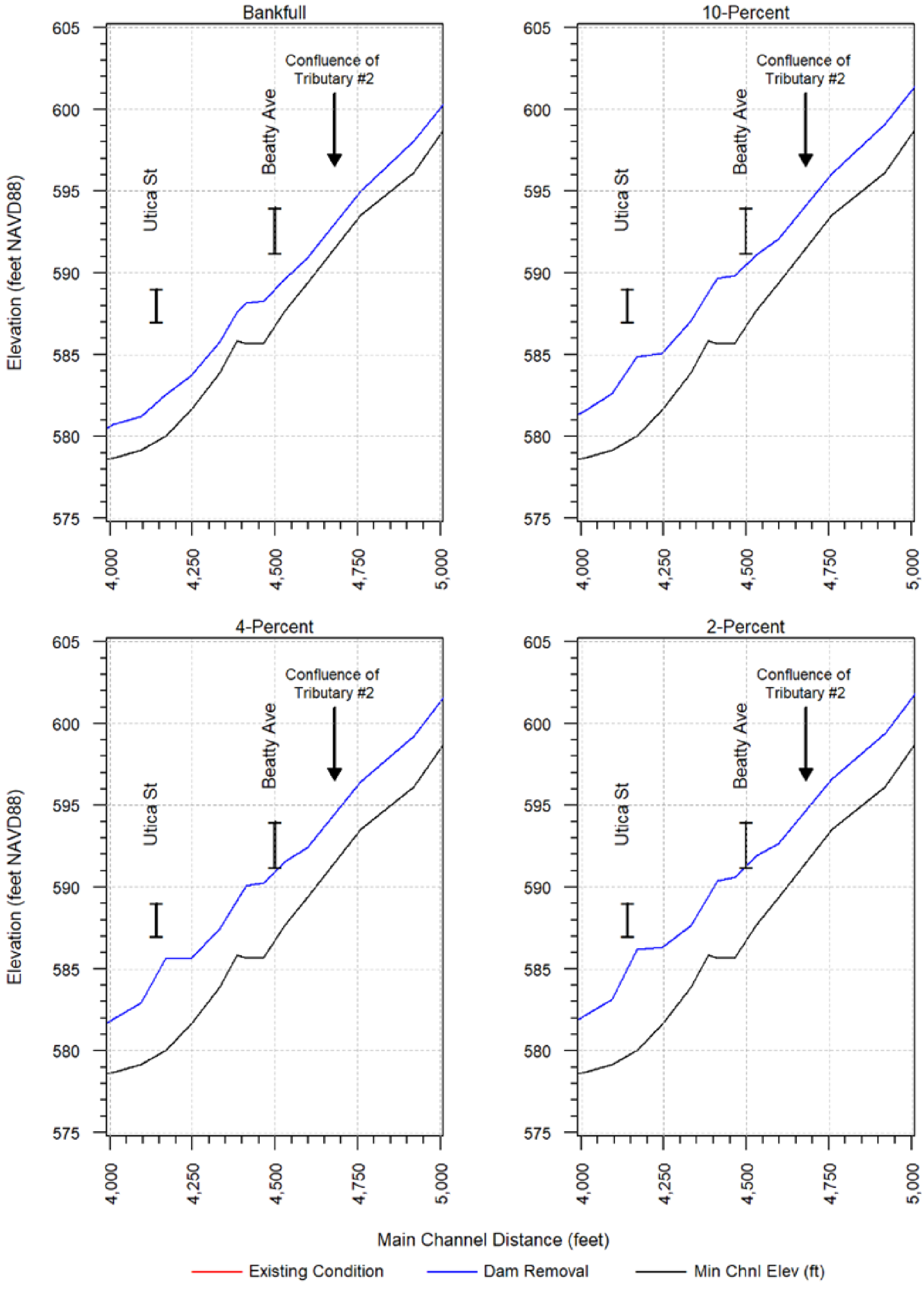


**Figure 7-43. HEC-RAS model simulation output results for Alternative #6-2 for the existing condition (red) and proposed alternative (blue) scenarios.**

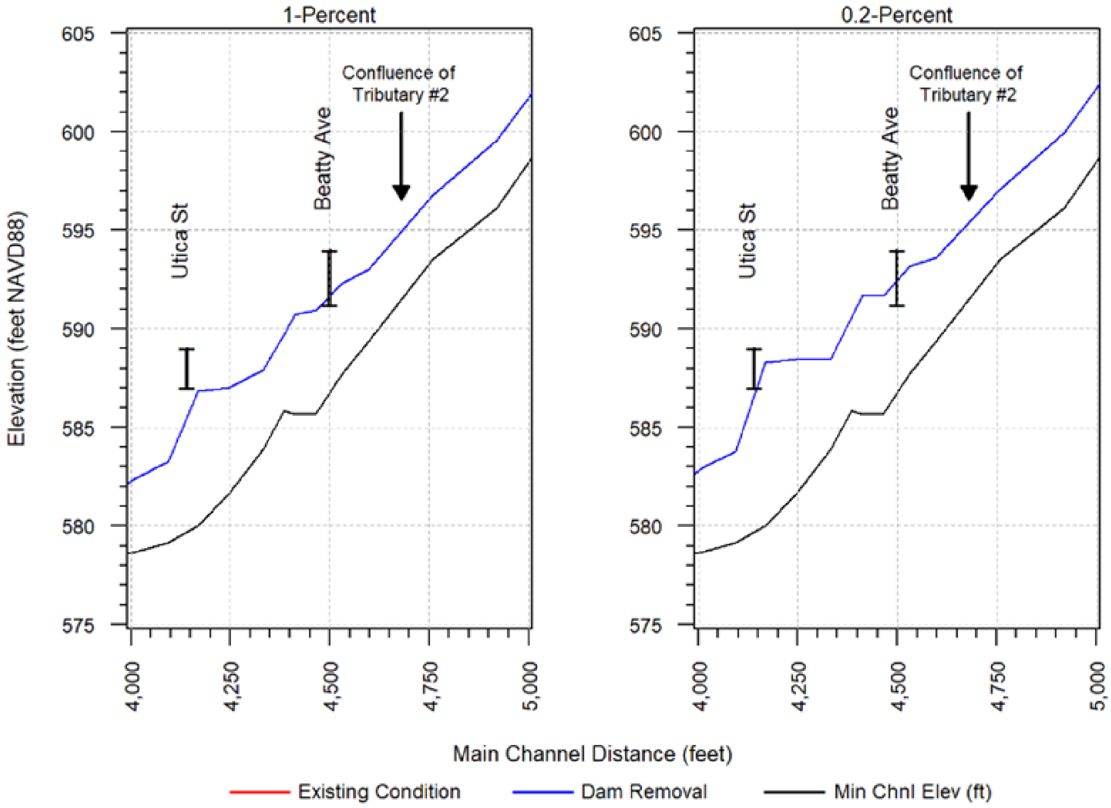


**Figure 7-43 (continued). HEC-RAS model simulation output results for Alternative #6-2 for the existing condition (red) and proposed alternative (blue) scenarios.**

### 7.6.3 Alternative #6-3: Sediment Retention Basin Upstream of Kellogg Street

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 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 7-44).

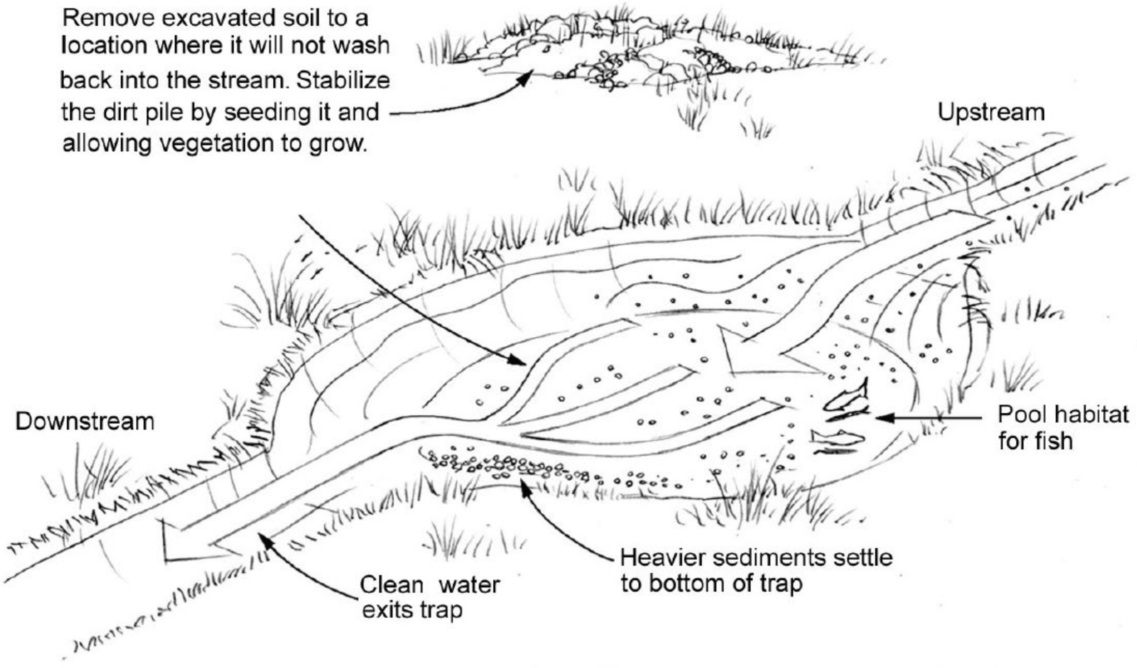


Figure 7-44. Representative diagram of an in-stream sediment retention pond (WCD 2009).

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 Sherman Brook watershed, the area identified in Figure 7-45 upstream of Kellogg Street (river station 14+00) could be a potential location for a sediment retention basin.

**Figure 7-45. Placement of proposed sediment retention basin along the Unnamed Tributary of Sherman Brook, Tributary #2.**

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).

# 8. BASIN-WIDE MITIGATION ALTERNATIVES

The purpose of non-structural flood mitigation is to change the way that people interact with the floodplain, minimize flood risk, and aims to move people away from flood-prone areas. Increasing numbers of communities have looked for alternatives to structural flood damage reduction techniques and have instead begun to pursue nonstructural techniques used to reduce flood damages that do not disturb the environment or can lead to environmental restoration. Non-structural flood damage reduction techniques have proven to be extremely viable in alternatives consisting of total non-structural, or a combination non-structural and structural measures. Examples of non-structural flood damage reduction measures are listed below (USACE 2016).

## 8.1 Alternative #7-1: Sherman Brook Sediment & Debris Management Study

This measure is intended to perform a sediment and debris management study on Sherman Brook. The objective of this study would be to provide an effective method to identify areas within the Sherman Brook watershed where sediment and debris accumulation contributes to flooding risk, and gather information necessary to develop a management plan to reduce those risks. The plan would necessitate the collection and assessment of watershed-wide conditions in a holistic systems-based approach to best understand and plan mitigative measures.

A primary goal will be to reduce flooding by lowering surface water elevations caused by undersized infrastructure, excessive deposition and debris, uncontrolled sediment sources, head cutting or downcutting of the channel, and loss of natural floodplains. Many of these situations are a result of basin-wide conditions related to changes in land use, landcover and runoff, stormwater management, upstream sediment sources, upstream woody debris, and stream bed and bank erosion. Practical solutions and actions would be presented to meet these goals in an ecologically sustainable manner.

Numerous watershed-wide characteristics and conditions can contribute to or cause increased flooding risk. Incompletely understood and poorly planned actions may worsen flooding risk, create negative unintended consequences, be prohibitively expensive, ineffective, a waste of dollars, and cause unnecessary ecological damage.

A management plan is a process that should incorporate the input of all the different people who live, work and play in the watershed when determining how the watershed should be managed. The sediment and debris management plan should be a dynamic, ever changing, process-driven document that helps define future direction for the watershed and be updated periodically, as and if improvements or changes in conditions within the creek basin occur, such as creation of floodplain areas, bridge/culvert resizing, or alterations to creek channel dimensions.

The study would provide an understanding of the intricacies, complexities, and interrelationships involved in water resource management; outline common issues faced by different municipalities within the Sherman Brook watershed; and identify specific strategies and measures to address these issues. Within the Sherman Brook watershed, diverse solutions and abatement programs of various county, state, local, and federal agencies should be integrated into a coordinated, comprehensive, interagency, watershed-based approach to management. A uniform, organized, well thought-out water resources strategy would: provide for a more effective delivery of programs; reduce duplication of efforts and agency conflicts; identify program gaps; clarify agency roles and responsibilities; provide a means of identifying and obtaining future funding opportunities; and would result in the overall enhancement of water resources within the Sherman Brook watershed.

The ROM cost estimate for a sediment and debris management study would be $80,000.

## 8.2 ALTERNATIVE #7-2: 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.

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 2016). The ROM cost for this strategy is approximately $500,000, not including annual maintenance and operational costs.

## 8.3 ALTERNATIVE #7-3: 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 Sherman Brook 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).

Adoption of a process-based approach for riparian restoration is key to a successful restoration plan, and in riparian systems, flooding disturbance is a key process to consider. Successful restoration depends on understanding the physical and biological processes that influence natural riparian ecosystems, and the types of disturbances to anthropogenic modifications that cause damage to riparian areas. In this case, alteration of historical flooding processes has caused degradation of the riparian system.

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 Sherman Brook watershed have resulted from streamflow modifications by dams, reservoirs, and diversions; 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).

The riparian restoration can be designed along any reach within the six high-risk areas of Sherman Brook. Primary locations are within high-risk area #2, upstream of New Street, high-risk area #3, Kiwanis Memorial Field, and high-risk area #5, upstream of Kirkland Avenue.

## 8.4 ALTERNATIVE #7-4: Debris Maintenance around Infrastructures

Multiple areas along Sherman Brook were identified as catchpoints for debris and sediment. Areas where debris maintenance should be employed or continued to be employed are:

- The reach between Kirkland Avenue (CR-32) and Utica Street (NY-12B)
- The reach between Beatty Avenue and New Street
- The reach between New Street and Dawes Avenue

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 Sherman Brook 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 (e.g., Alternative #6-3). 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 2002).

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 ROM cost for this strategy is up to $20,000 annually, not including additional maintenance and operational costs.

## 8.5 ALTERNATIVE #7-5: Flood Buyout Programs

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 Special Flood Hazard Area (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 cost $175,000 or less, and which are located in the 1% ACE (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 Sherman Brook watershed, there are approximately 59 tax parcels in the Village of Clinton within the FEMA 1% annual and 0.2% ACE hazard zones. Of the 59 tax parcels, 38 are classified as residential with a total full market value of $6.7 million, and 11 are classified as commercial with a total full market value of $2.8 million. Figure 8-1 displays the tax parcels that intersect the FEMA flood zones, including generalized locations of FEMA repetitive loss properties.

In addition, there are 26 FEMA repetitive loss properties within the Sherman Brook watershed.

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 Sherman Brook 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.

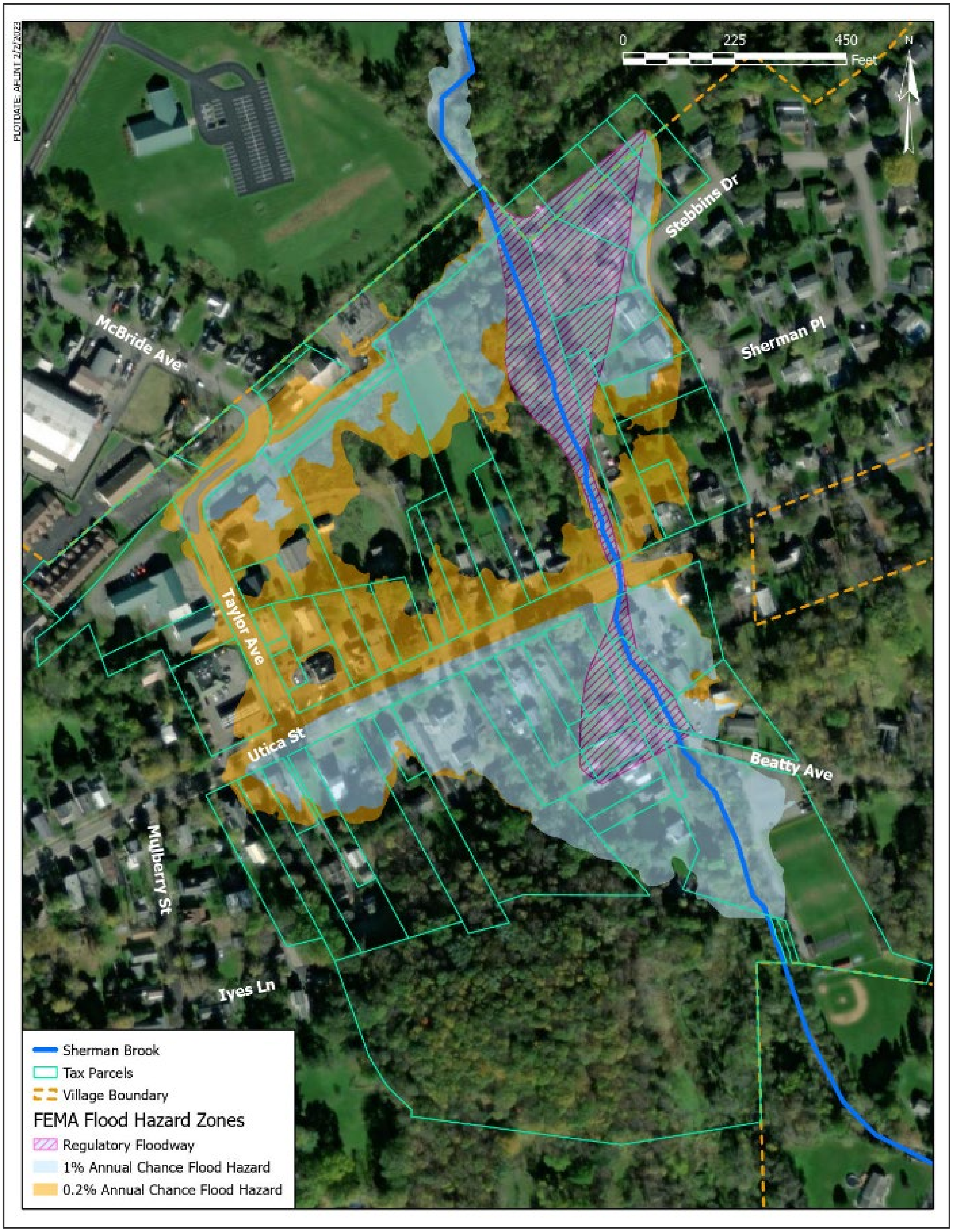


**Figure 8-1. Tax parcels within FEMA flood zones, Sherman Brook, Village of Clinton, NY.**

## 8.6 ALTERNATIVE #7-6: Floodproofing

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 is one of many factors in determining 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 ft 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 2013b). 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 the following:

### 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 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 the following:

- *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% ACE (100-yr flood event) flood protection, a building must be dry floodproofed to an elevation at least 1 ft above the BFE (FEMA 2013b). 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% ACE (100-yr flood event). Furthermore, floodwalls or levees as a retrofit measure will not bring the building into compliance with NFIP requirements for Substantial Improvement/Damage (FEMA 2013b). 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 #7-7: Area Preservation/Floodplain Ordinances

This alternative proposes municipalities within the Sherman Brook 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 Smart Growth initiative and the Climate Smart Communities Program address land use within a watershed (NYSDEC 2016). 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 Sherman Brook watershed.

## 8.8 ALTERNATIVE #7-8: 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, how it 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):

- Preparedness conversion: learning related to commencing and maintaining preparations for flooding.
- Mitigation behaviors: learning and putting into practice the appropriate actions for before, during and after a flood.

- 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.
- 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 #7-9: Development/Updating of a Comprehensive Plan

Local governments are responsible for planning in several areas, including housing, open space, transportation, water, waste management, energy, and disaster preparedness. In NYS, 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 contained in the comprehensive plan will incorporate 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):

- Provide a legal defense for regulations
- Provide a basis for other actions affecting the development of the community (i.e., land use planning and zoning)
- Help to establish policies regarding 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 Sherman Brook floodplain.

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. “Futureproofing” 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 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 AND LOCAL REGULATIONS

Prior to implementation of any mitigation alternative, pertinent local municipalities' Flood Damage Prevention laws, NYSDEC Part 502 regulations (for state-related facilities), and any other applicable state and local laws or regulations should be determined and appropriate steps taken to ensure compliance. These laws and regulations should also reflect the FEMA requirements for work within the regulated floodplain.

## 9.3 NYSDEC PROTECTION OF WATERS PROGRAM

Sherman Brook is protected under Article 15 of Title 6 of the New York Codes, Rules, and Regulations (6NYCRR Part 608). Sherman Brook has a designation as classification C(T) which indicates a best usage for fishing and that the waters shall be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes. The symbol (T) indicates that designated waters are trout waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout or trout waters applies (NYSDEC 2022).

These designations are important in regard to the standards of quality and purity established for all classifications. Any changes to the bed or bank of Sherman Brook would need to be reviewed and approved by the NYSDEC (NYSDEC 2020).

## 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)
- Regional Economic Development Councils/Consolidated Funding Applications (CFA)
- Natural Resources Conservation Services (NRCS) Watershed Funding Programs
- FEMA Unified Hazard Mitigation Assistance (HMA) Program
- FEMA Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act
- USACE Continuing Authorities Program (CAP)
- New York State Environmental Corporation (NYSEFC) Clean Water, Clean Air, and Green Jobs Environmental Bond Act of 2022

### 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 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 13th round of the CFA was offered in 2023.

#### 9.4.2.1 Water Quality Improvement Project (WQIP) Program

The Water Quality Improvement Project Program, administered through the NYSDEC, 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.

#### 9.4.2.2 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.

### 9.4.3 Natural Resources Conservation Services (NRCS) Watershed Funding Programs

The United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) administers three separate funding programs to promote landscape planning, flood prevention, and rehabilitation projects in communities throughout the country.

#### 9.4.3.1 Emergency Watershed Protection (EWP) Program

The NRCS administers the Emergency Watershed Protection (EWP) Program, which responds to emergencies created by natural disasters. It is not necessary for a national emergency to be declared for an area to be eligible for assistance. The EWP Program is a recovery effort aimed at relieving imminent hazards to life and property caused by floods, fires, windstorms, and other natural disasters.

All projects must have a project sponsor. Sponsors include legal subdivisions of the state, such as a city, county, general improvement district, conservation district, or any Native American tribe or tribal organization.

The NRCS may bear up to 75% of the eligible construction cost of emergency measures (90% within limited-resource areas as identified by the U.S. Census data). The remaining costs must come from local sources and can be in the form of cash or in-kind services. Public and private landowners are eligible for assistance but must be represented by a project sponsor.

Eligible projects include, but are not limited to, debris-clogged stream channels, undermined and unstable streambanks, and jeopardized water control structures and public infrastructures.

#### 9.4.3.2 Watershed and Flood Prevention Operations (WFPO) Program

The Watershed Protection and Flood Prevention Operations (WFPO) Program includes the Flood Prevention Operations Program (Watershed Operations) authorized by the Flood Control Act of 1944 (P.L. 78-534) and the provisions of the Watershed Protection and Flood Prevention Act of 1954 (P.L. 83- 566). It provides for cooperation between the federal government and the states and their political subdivisions to address resource concerns due to erosion, floodwater, and sediment and provide for improved utilization of the land and water resources.

The WFPO Program provides technical and financial assistance to states, local governments, and tribes to plan and implement authorized watershed project plans for the purpose of the following:

- Flood prevention
- Watershed protection
- Public recreation
- Public fish and wildlife
- Agricultural water management
- Municipal and industrial water supply
- Water quality management
- Watershed structure rehabilitation (there is a separate program that manages rehabilitation projects)

#### 9.4.3.3 Watershed Rehabilitation (REHAB) Program

The Watershed Rehabilitation (REHAB) Program helps project sponsors rehabilitate aging dams that are reaching the end of their design life and/or no longer meet federal or state standards. Watershed Rehabilitation addresses critical public health and safety concerns. Since 1948, NRCS has assisted local sponsors in constructing 11,850 project dams. Rehabilitation of watershed project dams is authorized for dams originally constructed as part of a watershed project carried out under any of the following four authorities—Public Law 83-566, Public Law 78-534, the Pilot Watershed Program authorized under the Department of Agriculture Appropriation Act of 1954, or the Resource Conservation and Development Program authorized by the Agriculture and Food Act of 1981.

Watershed project sponsors represent interests of the local community in federally assisted watershed projects. Sponsors request assistance from NRCS. When funding is allocated, the sponsor and NRCS enter into an agreement that defines the roles and responsibilities of each party to complete the rehabilitation.

Many aging dams no longer meet current state and NRCS design and safety criteria or performance standards, and may pose a potential hazard to lives and property if dam failure would occur. NRCS provides technical and financial assistance to local project sponsors to rehabilitate aging dams that protect lives and property, and infrastructure. Local sponsors who are interested in rehabilitating their aging dam may request technical and financial assistance from NRCS. NRCS prioritizes dams for rehabilitation based on the risks to life and property if a dam failure would occur.

### 9.4.4 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 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.

#### 9.4.4.1 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.

#### 9.4.4.2 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

### 9.4.5 FEMA 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 they can invest in their communities.

### 9.4.6 USACE Continuing Authorities Program (CAP)

The USACE 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 43 lists the CAP authorities and their project purposes (USACE 2019).

**Table 43. USACE Continuing Authorities Program (CAP) Authorities and Project Purposes**

(Source: USACE 2019)

| 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 USACE 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 2019).

### 9.4.7 NYSEFC Clean Water, Clean Air, and Green Jobs Environmental Bond Act of 2022

On November 8, 2022, voter participants of New York State passed the $4.2 billion NYSEFC Clean Water, Clean Air, and Green Jobs Environmental Bond Act (Bond Act). The Bond Act is structured to fund critical environmental restoration projects throughout the state in four categories:

1. Water Quality & Resilient Infrastructure
2. Open Space Conservation & Recreation
3. Restoration & Flood Risk Reduction
4. Climate Change Mitigation

The Bond Act includes, but is not limited to, funding projects to achieve the following (NYDEC 2023):

- Improve and protect the water quality of drinking water
- Reduce water and air pollution
- Create sustaining environmental jobs
- Update infrastructure which includes roads, sewers, and drinking water pipes
- Conserve and preserve wildlife habitats, agricultural lands, forests, and wetlands
- Improve public health by planting street trees
- Reduce the potential for lead exposure
- Increase renewable energy improvements in public buildings
- Protect communities and natural resources from climate change

Bond Act investments will help municipalities reimagine, redesign, and rebuild with climate resilience to strengthen communities' abilities to withstand future high-water and storm events, extreme heat risks, and other long-term environmental changes. All projects funded by the Bond Act will advance climate action priorities to reduce greenhouse gas emissions, thereby driving critical building, transportation and electrification, and advance the state's commitment to economy-wide carbon neutrality, consistent with the New York State Climate Act (NYDEC 2023).

# 10. SUMMARY

This study recognizes the flooding risk along Sherman Brook in the Town of Kirkland and the Village of Clinton. Within the Town and Village, major flooding events have been most prominent in five High-Risk Areas along Sherman Brook:

- Areas near Craig Road
- Areas upstream of New Street
- Kiwanis Memorial Field
- Areas near Utica Street
- Areas upstream of Kirkland Avenue
- Areas within Unnamed Tributary #2

Flooding typically occurs at any time within the year, but is more frequent from spring rain and snowmelt, heavy rains by connective systems, log and debris jams, and sediment piles that act as an obstruction to water flow. The primary causes of flooding in the Town are increased development in the floodplain, lack of floodplain storage, and the lack of hydraulic capacity during high flow events through infrastructure.

This report analyzed the present day causes of flooding in the Sherman Brook watershed. Hydraulic and hydrologic data was used to model potential flood mitigation measures. The 1-D model simulation results indicated that there are flood mitigation measures that have the potential to reduce water surface elevations along the three high-risk areas, which could potentially reduce flood-related damages in areas adjacent to the creek. Additional modelling, which used a 2-D model approach, analyzed the benefits more accurately with four, stakeholder-recommended strategies during three historic precipitation events [July 01, 2017; October 31 and November 1, 2019 (Halloween 2019); and April 5 and 6, 2023]. The four mitigation strategies analyzed in the 2-D model simulations are:

- Alternative #3-2: Kiwanis Memorial Field Flood Bench
- Alternative #3-3: Increase Hydraulic Capacity of Beatty Avenue Bridge
- Alternative #4-1: Flood Bench Upstream of Utica Street
- Alternative #5-5: Overflow Open-Water Channel and Two New Culverts on Old Kirkland Avenue and Kirkland Avenue

Based on the flood mitigation analyses performed in this report, the mitigation measures that provided the greatest reductions in water surface elevations were the flood bench alternatives and increasing the hydraulic capacity of the New Street culvert. However, the New Street culvert was recently replaced (less than 10 years ago), so a culvert replacement would need significant justification and benefits to surrounding areas before being considered.

Based on the analysis of the flood benches, results showed a significant decrease in the current water surface elevation along Sherman Brook at Kiwanis Memorial Field, Utica Street, Flood Bench A, and upstream of Kirkland Avenue. The current design of the Kiwanis Memorial Field flood bench would have the most beneficial effect in lowering the water surface elevation. In addition, the 2-D simulation results support the 1-D model simulation results for the flood benches located on Kiwanis Memorial Field and upstream of Utica Street.

Flood bench measures generally tend to be costly flood mitigation projects so 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. In addition, flood benches generally only benefit the areas immediately adjacent to and upstream of the constructed bench, so downstream areas generally do not observe a decrease in water surface elevations.

Flood benches can be designed for multiple uses and functions. A design plan would effectively store water during the wet seasons, and during the dry seasons, these areas could be used for recreation such as a park, or a nature trail. Plantings of biodiverse, native, and riparian plants are suggested to adequately store water, act as a buffer to decrease erosion, and increase the adaptability to wildlife habitats. Flood benches can function to reduce velocity and shear stress forces in areas that are highly susceptible to erosion and bank failures, while providing additional storage to reduce flood risk. During high-flow events, sediments and debris can flow into the flood bench and settle out due to the drop in velocity, removing them from the channel water column and downstream areas.

Increasing the hydraulic capacity of the New Street culvert, Beatty Avenue bridge, and the Kirkland Avenue bridge would decrease the water surface elevation in the High-Risk Areas #2, #3, and #5, respectively. Alternatively, the proposed alternatives to increase the hydraulic capacity for Craig Road culvert and Utica Street culvert would not significantly reduce the water surface elevation at either location.

Bridge widening measures are the most expensive of the discussed flood mitigation measures. The benefits of the measures in their respective reaches should be balanced with the associated costs of each widening measure to determine if it would be feasible to move a widening measure forward. Additionally, other complications such as traffic re-routing should be considered when considering any of the bridge widening measures.

An overflow channel would direct water flow out of the main channel when the water levels reach a specific elevation. The designs of this mitigation strategy require two new culverts to be installed along Kirkland and Old Kirkland Avenues. This proposed alternative would decrease the water surface elevations in the main channel by over a foot and would reduce the flood extents in the areas upstream of Kirkland Avenue and Old Kirkland Avenue. The 2-D simulation results do not show a significant difference in water surface elevation reduction with the overflow channel alternative during the historic precipitation events.

Revitalizing or removing the earthen dam does not benefit the areas along Sherman Brook downstream of the Tributary #2 confluence. Altering the earthen dam would require the Article 15 Dam Construction Permit from the NYSDEC and the USACE Joint Application Form that, if approved, would allow activities affecting waters within the state. Revitalizing the dam could potentially increase the flood risk of upstream areas, while removing the dam could increase the potential flood risk for downstream areas. Ramboll recommends additional research, data, and modeling, including advanced 2-D modeling, to more accurately determine the effects of altering the dam to upstream and downstream areas.

A sediment retention basin upstream of Kellogg Street would reduce watercourse and gully erosion, trap sediment, and improve downstream water quality. 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 resources and reducing negative impacts to aquatic life and water quality. Best maintenance practices include removing accumulated sediments periodically (i.e., every 1 to 10 years) depending upon sediment load.

Natural stream restoration and bank and channel stabilization strategies would maintain the flow channel area along Sherman Brook, 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. The most probable locations for these mitigation strategies are areas upstream of New Street, Kiwanis Memorial Field, and upstream of Kirkland Avenue Bridge.

A buyout program within the Sherman Brook floodplain should focus on high-risk flood properties, such as properties in between Beatty Avenue and Utica Street, Stebbins Drive, and Old Kirkland Road. Areas where buyout programs are implemented can serve as multi-functional areas, such as a flood bench designed as a park and/or recreational area. In the case of properties upstream of Utica Street and Kirkland Avenue, the H&H modeling results indicate a significant decrease in the current water surface elevations when a flood bench alternative was analyzed. Any municipality considering a buyout program should weigh the advantages and disadvantages for the acquisition and removal of properties in high-risk flood areas.

Floodproofing is an effective mitigation measure but requires a large financial investment in individual residential and non-residential buildings. Floodproofing can reduce the future flood risk and damage, but would leave buildings in flood prone areas. A benefit to floodproofing versus buyouts is that property and structures remain intact, thereby maintaining the tax base for the local municipality.

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.

In general, 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 would compound the flood mitigation benefits of each bench. Table 44 is a summary of the proposed flood mitigation measures, including modeled water surface elevation reductions and estimated ROM costs.

**Table 44. Summary of Flood Mitigation Measures**

| Alternative No. | Description | Benefits Related to Alternative | ROM Cost Estimate ($ US Dollars) |
|---|---|---|---|
| **1-1** | Increased Hydraulic Capacity of Craig Road | 1-D model simulated WSEL reductions of up to **0.2-ft**. | \$260,000[1] |
| **2-1** | Bank and Channel Stabilization | Reduction in bank and channel erosion, lower flow velocities, and decreases in sediment accumulation | Variable[2] |
| **2-2** | Natural Stream Restoration | Restores natural habitats, reduces/manages runoff, and improves water quality | \$760,000[1] |
| **2-3** | Increased Hydraulic Capacity of New Street | 1-D model simulated WSEL reductions of up to **4.7-ft**. | \$310,000[1] |
| **3-1** | Bank and Channel Stabilization | Reduction in bank and channel erosion, lower flow velocities, and decreases in sediment accumulation | Variable[2] |
| **3-2** | Flood Bench on Kiwanis Memorial Field | 1-D model simulated WSEL reductions of up to **2.8-ft**. | \$1.4 million[1] |
| | | 2-D model simulated WSEL reductions of up to **1.6-ft** during the Halloween 2019 Storm. | |
| **3-3** | Increased Hydraulic Capacity of Beatty Avenue | 1-D model simulated WSEL reductions of up to **1.0-ft**. | \$2.3 million[1] |
| | | 2-D model simulated WSEL reductions of up to **1.4-ft**. | |
| **4-1** | Flood Bench located Upstream of Utica Street | 1-D model simulated WSEL reductions of up to **2.8-ft**. | \$2.5 million[1] |
| | | 2-D model simulated WSEL reductions of up to **1.7-ft**. | |
| **4-2** | Increased Hydraulic Capacity of Utica Street | 1-D model simulated WSEL reductions of up to **0.6-ft**. | \$410,000[1] |
| **5-1** | Bank and Channel Stabilization | Reduction in bank and channel erosion, lower flow velocities, and decreases in sediment accumulation | Variable[2] |

| **Alternative No.** | **Description** | **Benefits Related to Alternative** | **ROM Cost Estimate** ($ US Dollars) |
|---|---|---|---|
| **5-2** | Natural Stream Restoration | Restores natural habitats, reduces/manages runoff, and improves water quality | \$670,000[1] |
| **5-3** | Flood Benches | 1-D model simulated WSEL reductions of:<br>• Flood Bench A: up to **2.4-ft**.<br>• Flood Bench B: up to **1.1-ft**. | A: \$5.2 million[1]<br>B: \$1.2 million[1] |
| **5-4** | Increased Hydraulic Capacity of Kirkland Avenue | 1-D model simulated WSEL reductions of up to **1.3-ft**. | \$5.1 million[1] |
| **5-5** | Overflow Open-water Channel and New Culverts on Old Kirkland Avenue and Kirkland Avenue | 1-D model simulated WSEL reductions of up to **1.2-ft**. | \$1.2 million[1] |
| | | 2-D model simulated WSEL reductions of up to **0.1-ft**. | |
| **6-1** | Revitalization of Earthen Dam | 1-D model simulated WSEL reductions of up to **0.0-ft**. | \$500,000[1] |
| **6-2** | Removal of Earthen Dam | 1-D model simulated WSEL reductions of up to **0.0-ft**. | \$510,000[1] |
| **6-3** | Sediment trap Upstream of Kellogg Street | Reduces watercourse and gully erosion, trap sediment, and improve downstream water quality in one location rather than maintaining an entire watercourse reach | Variable[2] |
| **7-1** | Sherman Brook Sediment & Debris Management Study | Identify areas where sediment and debris build-up contribute to flooding risk and develop a management plan with specific strategies to reduce those risks | \$80,000 |
| **7-2** | Early-warning Flood Detection System | Early-warning alarm for open-water and ice-jam events | \$500,000[2] |
| **7-3** | Riparian Restoration | Restores natural habitats, reduces/ manages runoff, and improves water quality | Variable<br>(case-by-case) |

| Alternative No. | Description | Benefits Related to Alternative | ROM Cost Estimate ($ US Dollars) |
|---|---|---|---|
| **7-4** | Debris Maintenance Around Culverts/Bridges | Maintains channel flow area and reduces flood risk | $20,000[1] |
| **7-5** | Flood Buyouts/Property Acquisitions | Reduces and/or eliminates future losses | Variable (case-by-case) |
| **7-6** | Floodproofing | Reduces and/or eliminates future damages | Variable (case-by-case) |
| **7-7** | Area Preservation/Floodplain Ordinances | Reduces and/or eliminates future losses | Variable (case-by-case) |
| **7-8** | 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) |
| **7-9** | 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) |

[1] Note: Due to the conceptual nature of this measure, and significant amount of data required to produce a reasonable ROM cost, it is not feasible to quantify the costs of this measure without further engineering analysis and modelling.

[2] Note: ROM costs do not include permitting, annual maintenance or land acquisition costs for survey, appraisal, and engineering coordination.

# 11. CONCLUSION

Within the Sherman Brook watershed, five High-Risk Areas were identified to have historical issues along the channel related to high water surface elevations, sediment aggradation and degradation, channel bed and streambank instability, and floodplain connectivity. Based on the technical analysis set forth in this report, a basis of potential solutions was identified and designed to address the flooding and sediment issues within the Sherman Brook watershed. This study provides an understanding of the complexity, feasibility, cost effectiveness, and benefits for the different alternatives. The proposed alternatives outlined in this report should be used to support flood mitigation and resiliency projects and is intended to be a high-level overview of proposed flood mitigation strategies and their potential impacts on water surface elevations within the Sherman Brook watershed.

The research and analysis that supported each proposed strategy should be considered preliminary but provides the guidance necessary for implementation of the proposed solutions identified for each focus area. Additional design and hydraulic modeling and analyses would be necessary to implement many of the strategies discussed within this study. A comprehensive, organized, effective flood mitigation plan outlines a path for successful results in improving flood resiliency throughout the watershed.

In order to implement the flood mitigation strategies proposed in this report, a process of engagement follows the steps below:

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 final flood mitigation plan based on the additional data collection and modeling results.
4. Select a final flood mitigation strategy or series of strategies to be completed for Sherman Brook 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.
7. 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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