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STREAM SEDIMENT AND DEBRIS MANAGEMENT PLAN

SAUQUOIT CREEK, ONEIDA COUNTY, NEW YORK

Prepared by:

STREAM SEDIMENT AND DEBRIS MANAGEMENT PLAN

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Section 1: Introduction

Background and Objectives

Our Waters, Our Communities, Our Future, a 2009 report by the New York Ocean and Great Lakes Ecosystem Council, recommended better management of natural resources and human activities through ecosystem-based management. This type of management recognizes that humans are an integral part of the ecosystem and that ecosystems, in turn, are vital in supporting life. More importantly, this report specifically recommended using ecosystem-based management in the Mohawk River watershed, recognizing the connection to the Hudson River and creating a "whole Hudson" approach to natural resource management. The development of the Mohawk River Basin Action Agenda and NYSDEC Mohawk River Basin Program initiated this move toward an ecosystem-based management system for the watershed. That management system includes major tributaries of the Mohawk River, such as Sauquoit Creek (NYOGLECC 2009; NYSDEC 2018).

The objective of this document is to provide an effective method to identify areas within the Sauquoit Creek basin where sediment and debris build-up contribute to flooding risk, and to collect the information necessary to develop a management plan to reduce those risks. 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 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, be ineffective, a waste of dollars and cause unnecessary ecological damage. A full understanding of these conditions is necessary.

This plan will necessitate the collection and assessment of watershed-wide conditions in a holistic systems-based approach to best understand and plan mitigative measures.

This plan 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.

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.

Prior Planning Reports

There have been multiple studies and planning reports developed for the Sauquoit Creek watershed basin:

- The United States Army Corps of Engineers (USACE) produced the *Detailed Project Report, Village of Whitesboro, NY* in 1981, which included detailed hydraulic analysis of multiple flood relief alternatives. The report also included delineation of wetlands, rare, threatened and endangered (RTE) species, and State Office of Historic Preservation (SHPO) reviews (USACE 1981a).

- The Herkimer-Oneida Counties Comprehensive Planning Program (HOCCPP) prepared the *Sauquoit Creek Basin Watershed Management Study* in 1997 to develop an overall scoping process and implementation strategy for the basin which will lead to a coordinated, comprehensive, intergovernmental, and interagency, approach to basin management. The Sauquoit Creek Basin Watershed Management Study provides the reader with an understanding of the many intricacies, complexities, and interrelationships involved in water resources management; outlines a number of common components of overall objectives within the basin; identifies specific tasks which need to be accomplished to meet these objectives; establishes a proposed priority for when those tasks should be completed in relation to other tasks; and suggests what agency or individual might be best suited to undertake each task (HOCCPP 1997).
- Milone and MacBroom, Inc. (MMI) completed the *Emergency Transportation Infrastructure Recovery Water Basin Assessment and Flood Hazard Mitigation Alternatives* (2014) study in response to an extensive flooding event in June of 2013. MMI conducted field surveys, hydrologic assessment; hydraulic modeling; and identification of long-term recommendations for mitigation of future flood hazards. The report recommended 11 flood mitigation strategies that ranged from infrastructure updates and / or removal to floodplain regulations and sediment management plans (MMI 2014).
- The New York Rising Community Reconstruction (NYRCR) Oneida County Planning Committee (OCPC) developed the *Oneida County NY Rising Resiliency Plan* in response to the extensive flooding events of 2013 and intense storm events in previous years, such as Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee. The NYRCR Program was a planning and implementation process established to provide rebuilding and resiliency assistance to communities heavily damaged by flooding. Drawing on lessons learned from past recovery efforts, the NYRCR Program was a unique combination of bottom-up community participation and State-provided technical expertise. The approach was two-pronged, focusing first on identification of remaining recovery needs, and then on developing countywide long-term resiliency strategies and actions. Resiliency projects ranged from infrastructure updates and / or removal to public education and emergency management coordination improvements (NYRCR 2014).
- O'Brien & Gere Engineers, Inc. (OBG), in coordination with the Town of Whitestown, completed the *Sauquoit Creek Channel and Floodplain Restoration Project, Lower Sauquoit Creek – Engineering Report* in November of 2018. The purpose of this project was to re-evaluate and assess the existing conditions of Sauquoit Creek in order to identify how and where to reconnect the floodplain and stabilize the banks. This information served as the basis for creating a detailed plan and design approach aimed at mitigating and reducing flooding along Sauquoit Creek as part of a long-term improvement strategy and program (OBG 2018).
- Ramboll, in coordination with the Sauquoit Creek Basin Intermunicipal Commission (SCBIC), produced two technical reports in response to the intense and extensive flooding event of October 31 – November 1, 2019: the *Sauquoit Creek Drainage Study: Findings of 2019 Halloween Storm – Hydraulic Modeling* (2020) and *Sauquoit Creek Drainage Study – Alternative Design* (2020) reports. The reports focused on analyzing the causes of the extensive flood

damages by reproducing the Halloween Storm flooding and then assessing the impact of different flood mitigation strategies using 2-D models. Eight flood mitigation strategies were proposed involving infrastructure updates, including bridge widening, retention pond, flood bench, and floodwall strategies (Ramboll 2020a; Ramboll 2020b).

- Appendix A is a list of completed and proposed projects for Sauquoit Creek according to the SCBIC updated as of 2020.

Schedule for Plan Updates

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. This Stream Sediment and Debris Management Plan should be a dynamic, ever changing, process-driven document that helps to define future direction for the watershed.

The following is an implementation schedule for the Stream Sediment and Debris Management Plan document:

- Complete field surveys, hydrologic assessments, and stakeholder engagement for Sauquoit Creek by November 2020
- Complete hydraulic modeling of existing, future, and proposed mitigation conditions by February 2021
- Complete draft Stream Sediment and Debris Management Plan and submit for review by March 2021
- Address comments, complete revisions, and develop Final Plan document by August 2021

This document is the first release and will 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.

Section 2: Watershed Characteristics

Study Area

Sauquoit Creek, a tributary to the Mohawk River, is located within Oneida County, New York and flows through the Towns of Paris and New Hartford, and Village of Whitesboro. It is approximately 21 miles in length and has a drainage area of 63 square miles. It is a naturally meandering stream, ranging in widths from 17 to 50 feet, and in depths of 1 foot to over 5 feet (USACE 1985; USACE 2000).

The upper two-thirds of the Sauquoit Creek watershed basin is relatively undeveloped and can be characterized as agricultural and forest land. Several small tributaries of Sauquoit Creek drain the eastern portion of the Town of Paris. The east side of the Sauquoit Creek valley is on the west slope of a local high point known as Burrstone Hill. The channel slopes in the upland area are in the range of 50 to 100 feet per mile (USACE 1985; Thompson 1966; FEMA 2013a).

Development in the form of suburban, residential, and commercial institutions encompass Sauquoit Creek near its confluence with the Mohawk River in the Villages of New Hartford, New York Mills, Yorkville, and Whitesboro and the City of Utica. These urbanized areas are affected by annual flooding of the Creek as a result of rainfall runoff and ice jams. Runoff from the creek watershed often exceeds the existing channel's capacity, resulting in flooding of the Village of Whitesboro. The runoff terrain and creek channel are less sloped in the downstream areas (USACE 1985; USACE 2000).

Gravel deposits, without periodic removal, further exacerbate the situation by reducing the already constrained channel capacity. Inundation also occurs during winter months when the stream's ice cover breaks up and becomes jammed in the meandering sections of the Creek and at bridge crossings. The streambed composition upstream of the CSX Transportation, Inc. (CSX) bridge is a gravel / cobble mixture graduating to silt / sand composition downstream of the bridge (USACE 2000).

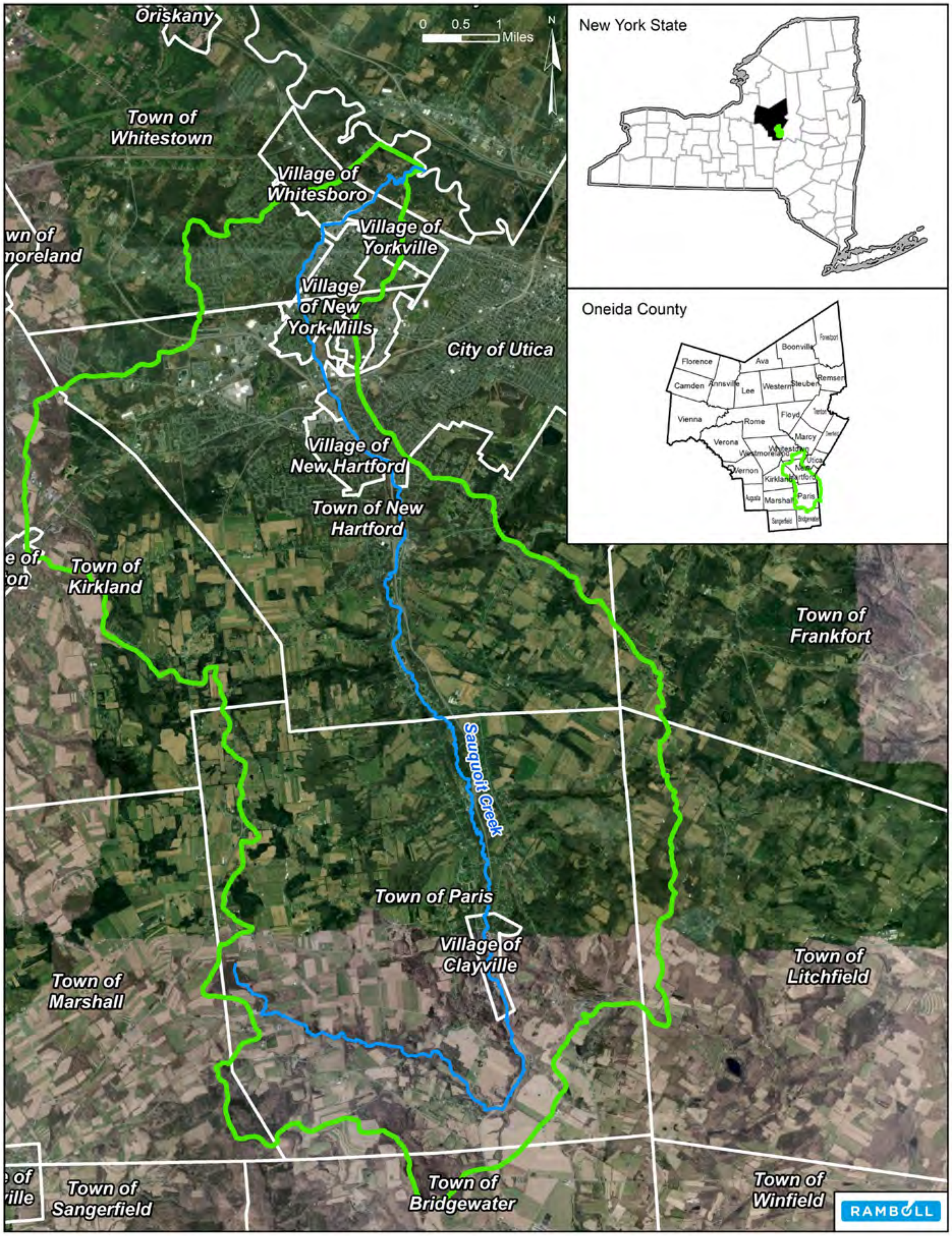

Figure 1. Sauquoit Creek Watershed Basin, Oneida County, New York.

Historical Floods

The most severe flood-related damages on Sauquoit Creek have occurred within the area of dense commercial land uses, primarily in the Villages of Whitesboro and New York Mills. According to the FEMA FIS, significant floods occurred on Sauquoit Creek in 1910, 1913, 1914, 1936, 1945, 1950, 1951, 1960, 1964, June 1972 (Tropical Storm Agnes), 1996, 1998, and 2006. Many of these floods occurred in the spring as a result of snowmelt combined with rainfall. The flood of March 1936 was caused by 4.6 inches of rainfall on a heavy snow cover, causing a snowmelt equivalent to approximately 3 inches of water. The October 1945 flood was caused by intense rainfall of 4.2 inches in a 24- hour period and is locally considered the greatest flood of record. Ice jams and bridges have also caused localized flooding on Sauquoit Creek (FEMA 2013a).

More recently, heavy rainfall in April 2011 and then Tropical Storm Irene in August 2011 caused flooding of Sauquoit Creek. In fall 2011, Whitesboro experienced severe flooding, and fire departments had to rescue people from their homes. As a result, houses and businesses were damaged, and people were without power for days. In mid to late June and early July of 2013, a severe precipitation system caused excessive flow rates and flooding in a number of communities in the greater Utica region, including in the Sauquoit Creek Basin. On July 1, 2017, a heavy precipitation event occurred where 4 inches of rain fell in 48 hours causing widespread flooding in the Village of Whitesboro and Town of New Hartford. In January of 2018, multiple ice jam events occurred along Sauquoit Creek at the Main Street and CSX Railroad bridge crossings. On October 31, 2019, a heavy precipitation event, referred to locally as the 2019 Halloween Storm, occurred where 2.92 inches of rain over a 24-hour period led to extensive flooding in the Village of Whitesboro upstream from the CSX railroad bridge (MMI 2014; Howe 2019; Ramboll 2020a)

Municipal officials provided a detailed summary of flood- and erosion-prone areas along Sauquoit Creek. In the Town of Paris, the Pinnacle Road bridge has washed out multiple times and was subsequently replaced. Sauquoit Creek near the Town of Paris Department of Public Works garage has been subject to erosion problems. The bridge at Genesee Street in the Town of New Hartford has overtopped during floods. Extensive flooding of businesses and car dealerships has occurred along Commercial Drive downstream to Main Street in the Village of Whitesboro. The NYSDOT has periodically removed sediment from the channel in the lower portion of Sauquoit Creek (MMI 2014).

Principal Flooding Problems

The Sauquoit Creek watershed basin has experienced significant flooding historically. The residents and business-owners of the Sauquoit Creek area have experienced recurring flood-related economic losses and disruption of normal activity. Members of the community and local officials have recognized the potential for flood damages and threats to human life. Protection from these actual and potential losses has been sought by local interests for many years (USACE 1985).

In particular, the floodplain of Sauquoit Creek upstream of the CSX railroad bridge in the Village of Whitesboro has been largely developed with residences and commercial establishments. This development has been subjected to repeated floods stemming from high fluvial flows, ice jams, and

Mohawk River backwater. This chronic flooding problem is the primary water resource concern in the Village.

The most frequently flooded areas along Sauquoit Creek are:

- The residential section of Whitesboro encompassing Wind Place, Dunham Place and Elmore Drive
- The residential and commercial structures on the left bank of Sauquoit Creek between the Main Street and Oriskany Boulevard Bridges
- The Parkway School in the Village of Whitesboro
- The commercial establishments along the right bank of the stream from the Route 5A entrance ramp up to the Commercial Drive Bridge (USACE 1985)
- Brookline Drive in the City of Utica
- Hand Place in the Town of New Hartford (Ramboll 2020c)

Flooding occurs on Sauquoit Creek from two principal sources: fluvial flooding, and ice jams. Fluvial floodwaters from the Sauquoit Creek watershed flowing down through the lower reaches of the creek often exceed the existing channel's capacity, resulting in overland flooding. Inundation during winter months occurs when the stream's ice cover breaks up and becomes jammed in the meandering sections of Sauquoit Creek or on the upstream facia of infrastructure crossing the waterway (i.e. bridges, culverts). Development in the basin over the years has also contributed to increased runoff from rainfall and snowmelt. In addition, the channel's capacity is often reduced by gravel deposits that have to be removed annually. Basements of some residences frequently require pumping due to seepage. Historically, floods were less frequent because mill ponds upstream provided limited storage, but over time these dam / pond systems have become silted-in and no longer contain excess floodwaters or ice (USACE 1985).

These flooding issues will be compounded by a projected increase in precipitation and extreme precipitation events. According to the *Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State* (2011) final report, regional precipitation across New York State may increase by approximately 5 to 15% by the 2080s, and by the end of the century the greatest increases in precipitation may be in the northern parts of the state. Much of this additional precipitation may occur during the winter months, while during September and October, in contrast, total precipitation is projected to be slightly reduced in many climate models (Rosenzweig, et al. 2011).

In addition, larger increases are projected in the frequency, intensity, and duration of extreme precipitation events (defined as events with more than 1, 2, or 4 inches of rainfall) at daily timescales. An increase in extreme precipitation events will increase the hazards for urban and river flooding, with associated risks for transportation in cities and in rural areas along many rivers. This will necessitate increases in street stormwater drainage and processing peak capacity and / or result in environmentally undesirable combined sewer overflow events in those communities where street runoff is channeled into the public sewage system. The scouring potential for bridge foundations in some rivers is also likely to increase (Rosenzweig, et al. 2011).

Existing Flood Mitigation Measures

In an effort to prevent flooding along Sauquoit Creek and Mud Creek, the Village of New York Mills removed silt and gravel sediment from the stream channel where eroded material from upstream has been deposited, and the lower reaches of Sauquoit Creek from the Main Street bridge crossing to the CSX railroad bridge were dredged periodically in the past. However, these reaches are no longer being dredged (MMI 2014). In addition, a 1,300-ft long and 5-ft high earthen berm was built between Sauquoit Creek and residential properties along New Hartford Street in 2013 (Ramboll 2020c).

In the Town of Whitestown, the segment of creek from Oriskany Boulevard to Route 5A along Commercial Drive has a very low-lying, broad, and heavily developed floodplain that is subject to frequent inundation that is worsened by sediment aggradation. This reach of creek was historically routinely dredged. Exposed clay has been observed in some areas where over-dredging has occurred. However, this reach is no longer being dredged (MMI 2014). In 2014, CSX Transportation, Inc. cleaned the channel and installed culvert pipes under the railroad tracks in the vicinity of the railroad crossing over Sauquoit Creek (Ramboll 2020c).

In response to recent flooding events, the Town of Whitestown, in cooperation with Oneida County and the NYSDEC, contracted Ramboll to design, plan, and coordinate a flood mitigation program along Sauquoit Creek. The Sauquoit Creek Channel & Floodplain Restoration Program began in 2016 and, in its entirety, will involve channel widening, the construction of approximately 12 floodplain benches, areas of bank stabilization and the creation of a public access trail along a 1-plus mile corridor of the lower Sauquoit Creek in Whitestown. As of the writing of this report, two flood benches have been constructed with another flood bench and five crossing pipes at the CSX railroad bridge approved for construction. The remaining benches are either in the preliminary engineering and design phase or are awaiting additional funding to begin preliminary engineering and design (Appendix B) (OBG 2018; Ramboll 2020c).

In the Village of Whitesboro, flood control measures include structural improvements of levees and floodwalls (uncertified by USACE) at various locations, and non-structural improvements consisting of condemnation of the structures or, if it was reasonable, raising and floodproofing the structures (USACE 1975).

There are no structures or non-structural flood protection measures, existing or planned, in the Villages of Clayville and New Hartford along Sauquoit Creek (FEMA 2013a).

In the Town of Paris, there are multiple small dams on Sauquoit Creek that are used to reduce some of the erosion potential of the stream by decreasing velocity. They also aid in lessening ice jams but are not regulatory and do not serve flood storage purposes (USACE 1981b). A bank stabilization and dam removal project was completed by the Oneida County Soil and Water Conservation District in 2016 - 2017 with funds that were used as mitigation from the SUNY- Nano Site wetlands loss (Ramboll 2020c).

Along Mud Creek, a detention basin and upgraded culverts were installed at the two main entrances of the Sangertown Square shopping mall. In addition, a large berm / dam is planned for construction in the Town of New Hartford adjacent to the Preswick Glenn retirement community in 2021 (Ramboll 2020c).

Geomorphology

Bedrock Geology

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 feet per mile. Bedrock surface exposures, generally in east-west trending zones, become younger from north to south across the county (NRCS 2008).

Within the Sauquoit Creek watershed, bedrock geologic ages include the Ordovician (middle to upper), Silurian (upper), and Devonian (lower to middle). These bedrock formations primarily consist of shale and limestone, but can also include siltstone, dolostone (dolomite), and chert rock types (NYSGS 1999).

Glacial Geology

Oneida County was covered by several continental ice sheets during the Pleistocene Epoch (approximately 2 million years ago). Geologic age-dating techniques suggest that the most recent glacier left this area during the Wisconsin Glaciation, only about 10 to 12 thousand years ago. At the farthest advance of the glacier, moving ice nearly one mile thick covered the county, extending hundreds of miles northward. The glacier caused tremendous amounts of erosion from both abrasion and bedrock "plucking," by pressure melting and refreezing of the ice as it moved. The present topography is a result of prior glaciations and subsequent erosion and mass wasting (NRCS 2008).

Glacial erosion crushed and fragmented rocks into a heterogeneous mixture of boulders, angular stones, gravel, sand, silt, and clay. This mixture was transported beneath, within, and on top of the glacier, sometimes for many miles, before it was deposited by the ice or by meltwater. A deposit of this mixture is called glacial till. The composition of the till is largely determined by the local bedrock from which the till was derived. The thickness of the mantle of till ranges from a few inches to tens of feet. Most of the uplands in Oneida County are covered by till. Many of the soils in the county formed in till (NRCS 2008).

Large recessional moraines formed during the last glacial advance, plugging many major valleys, such as Black River, Oriskany-Clinton, and Sauquoit-West Branch Unadilla valleys. These moraines consist of unsorted, unstratified deposits of till adjacent to the stagnant ice front (NRCS 2008).

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 (NRCS 2008).

Silty alluvial sediment deposited along the flood plains of streams and organic material accumulated in swampy areas are examples of more recent material that is not of glacial origin. These kinds of material cover a small percent of the land area in the county (NRCS 2008).

The soils in the county formed mainly in glacial deposits. The epoch since the glaciers left their new deposits on the landscape in Oneida County 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).

Surface Drainage

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. Four river drainage basins divide the county: The Black River basin to the northeast, the Eastern Oswego basin to the west, the Mohawk basin to the east, and the Susquehanna basin to the south. Sauquoit Creek drains portions of the southern half of the county northward into the Mohawk River, which then flows eastward (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).

Oneida Lake is the largest naturally occurring lake in the county. The county has several smaller natural lakes, most of which have man-made dams that have increased their size. The Forestport and Delta Lake Reservoirs supply water to maintain canal elevations and to generate hydropower. Also, part of the Hinckley Reservoir occurs in Oneida County (NRCS 2008).

Soils

The Sauquoit Creek watershed soil composition is comprised of approximately 132 different soil types. The largest soil types by proportion are the Cazenovia silt loam (9%) followed by Lima gravelly silt loam (7.7%), Amenia silt loam (5.7%), and Lansing silt loam (5.7%) (NRCS 2008).

Silt loam soils are very deep, gently sloping, moderately well-drained to well-drained soils on side slopes, foot slopes, drumlins, or hilltops and in slightly convex or concave areas on glaciated uplands in the southern and / or eastern parts of the county. They form in loamy glacial till derived mainly from limestone and shale. Areas of this soil type are mainly broad, elongated, oblong, somewhat oval, or irregular in shape (NRCS 2008).

Physiography

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, the 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 Sauquoit Creek watershed consists of the Hudson-Mohawk Lowlands in the lower reaches of the creek near the confluence with the Mohawk River, the Erie-Ontario Lowlands in the middle reaches in portions of the Towns of Whitestown and New Hartford, and the Alleghany Plateau in the middle to upper reaches in portions of New Harford and the Town of Paris (NYSGS 2016).

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 feet above sea level, are at the western edge of the county, along Oneida Lake. High points include Penn Mountain (1,813 feet 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 feet above sea level). The highest point in the county is east of Waterville, on Tassel Hill (1,945 feet above sea level). About 32% of the land in the county north of the Mohawk River is above an elevation of 1,000 feet (the elevation above which soils generally have a frigid temperature regime) (NRCS 2008).

Figure 2 is a stream bed elevation and channel distance from the confluence with the Mohawk River profile using 2-meter light detection and ranging (LiDAR) data from 2008. Sauquoit Creek has an average slope of 0.9% over the profile stream length. The creek's streambed lowers approximately 1,047 vertical feet over this reach from an elevation of 1,444-feet above sea level (NAVD 88) at the headwaters in the Town of Paris, to 397-feet above sea level at the confluence of the Mohawk River in the Town of Whitestown (NYSITS 2013).

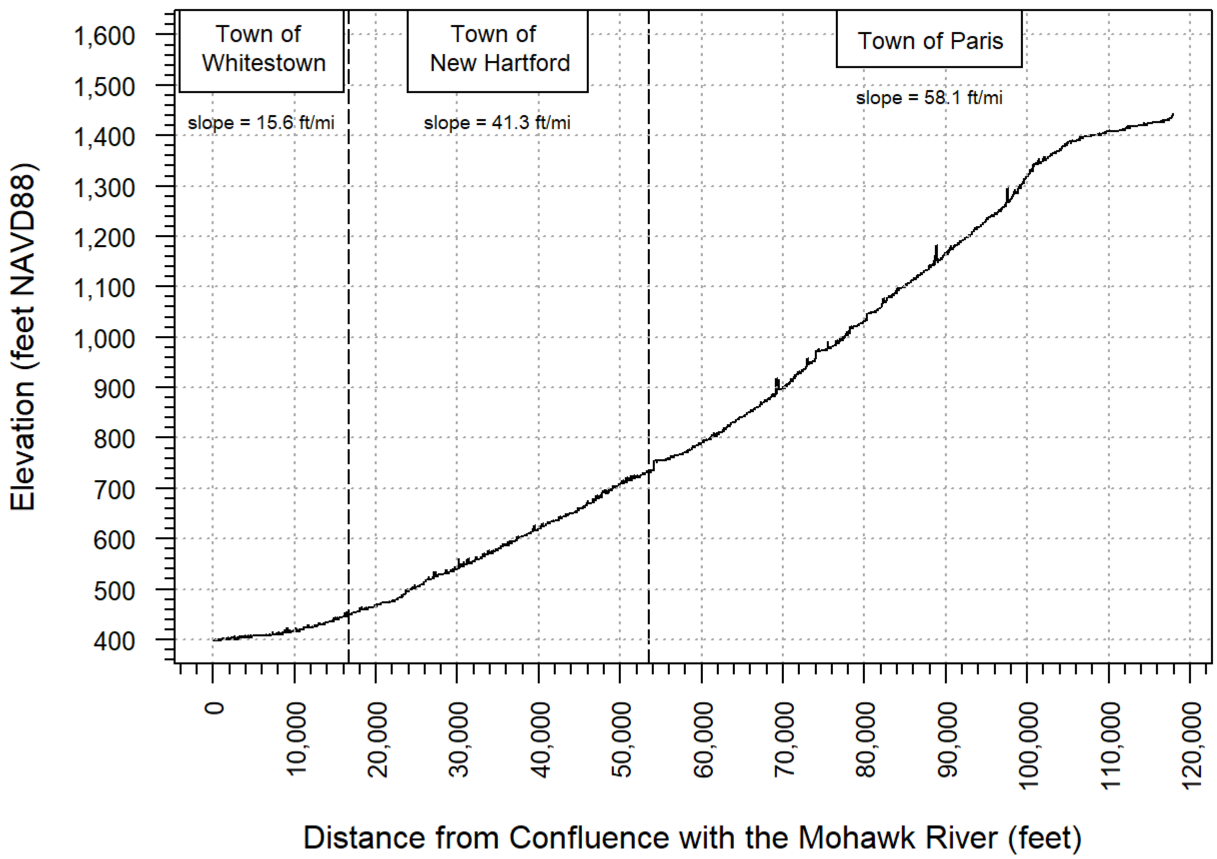

Figure 2. Sauquoit Creek profile of stream bed elevation and channel distance from the confluence with the Mohawk River.

The shape of the Sauquoit Creek watershed was evaluated by performing a morphometric analysis of the basin and calculating the form factor (R_F), circularity ratio (R_C), and elongation ratio (R_E). Form factor is the dimensionless ratio of the basin area to the square of basin length (Horton 1932). A form factor value of 0 indicates a highly elongated shape, and the value of 1.0 indicates a circular shape. Low form factor basins tend to have flatter peak flows for longer durations, while high form factor basins have high peak flows for shorter durations. The flood flows of elongated basins (e.g., low form factor) can be managed easier than that of more circular (e.g. high form factors) basins (Joji et al. 2013).

Circularity Ratio is the ratio of the area of a basin to the area of circle having the same circumference as the perimeter of the basin (Miller 1953). It is a dimensionless ratio that is influenced by length and frequency of streams, geological structures, land use / cover, climate, relief and slope of the basin. Low circularity ratios indicate that the basin is elongated in shape with low discharge of runoff and high permeability of the subsoil condition, while high circularity ratios indicate the basin is circular in shape with high discharge of runoff and low permeability of the subsoil condition (Joji et al. 2013; Aparma et al. 2015).

Elongation ratio is the ratio of the diameter of a circle having the same area as of the basin and maximum basin length (Schum 1956). It is a measure of the shape of the river basin where values generally range between 0.6 and 1. Values near 1.0 are typical of regions of low relief, whereas values in the range of 0.6 to 0.8 are generally associated with high relief, steep ground slopes and elongated basin shapes (Chow 1964). Basins with high elongation ratios tend to be more efficient in the discharge of runoff than low elongation ratio basins due to the concentration time of precipitation being lower in circular basins than in more elongated ones; thus, elongation ratios help in flood forecasting (Joji et al. 2013).

Table 1 is a summary of the basin characteristic formulas and calculated values for the Sauquoit Creek watershed, where A is the drainage area of the basin in square miles (mi^2), B_L is the basin length in miles, and B_P is the basin perimeter in miles. Based on the basin characteristics factors, the Sauquoit Creek watershed can be characterized as an elongated basin shape with high relief, steep ground slopes, and a drainage system that is structurally controlled, has flatter peak flows for longer durations with low discharge of runoff, and high permeability of the subsoil condition.

Table 1. Sauquoit Creek Basin Characteristics Factors

Source: USGS 1978		
Factor	**Formula**	**Value**
Form Factor (R_F)	A / B_L^2	0.27
Circularity Ratio (R_C)	$4*pi*A / B_P^2$	0.24
Elongation Ratio (R_E)	$2 * (A/pi)0.5 / B_L$	0.58

Wetlands

The United States Fish & Wildlife Service (USFWS) National Wetlands Inventory (NWI) database shows the approximate location of wetlands and surface waters regulated within the Sauquoit Creek watershed (Figure 3). Both freshwater forested / shrub wetlands and emergent wetlands areas are located within the watershed, including freshwater ponds and riverine habitats. According to the NWI data, freshwater wetlands (both forested / shrub and emergent) comprise 2.3 square miles (mi^2) of the total land area within the watershed (USFWS 2020).

Along Sauquoit Creek, wetlands are primarily found in the lower reaches of the creek near the confluence with the Mohawk River and downstream of the CSX railroad bridge in the Town of Whitestown, and along the middle to upper reaches in the Town of Paris.

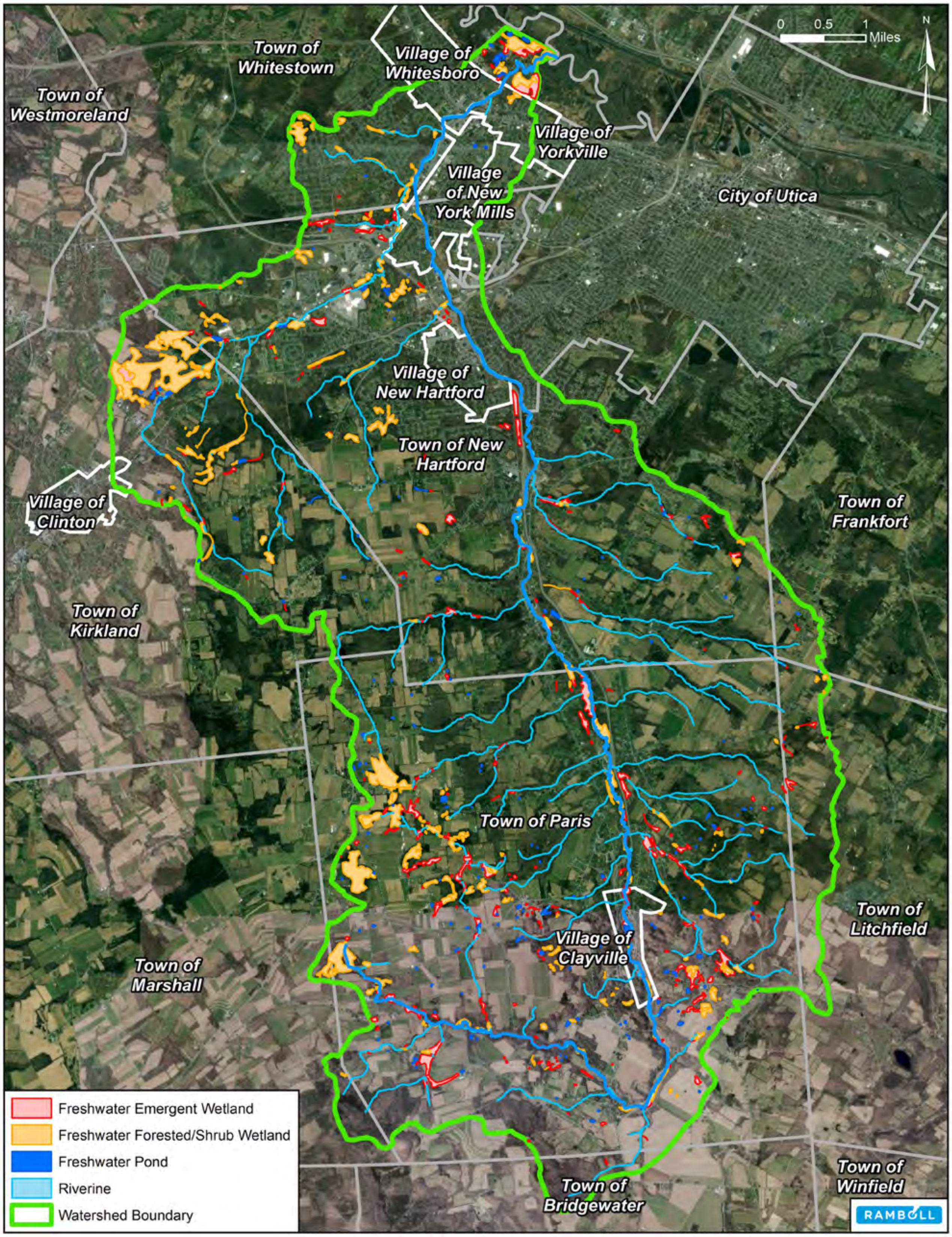

Figure 3. National Wetlands Inventory (NWI), Sauquoit Creek Watershed, Oneida County, New York.

Sensitive Natural Resources

Sensitive natural resources are considered habitats that support endangered and threatened species. These natural resources 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 by the NYSDEC using the *Environmental Resource Mapper* web-application. The *Environmental Resource Mapper* is an interactive mapping application that can be used to identify some of New York State's natural resources and environmental features that are state or federally protected, or of conservation concern. Based on the *Environmental Resource Mapper* data for Sauquoit Creek, the watershed contains no significant natural communities, and only a small area at the headwaters of the creek in the Town of Paris contains rare plants and / or animals (Figure 4) (NYSDEC 2020). The NYSDEC Regional Office should be contacted to determine the potential presence of the species identified.

In addition, the USFWS developed the *Information for Planning and Consultation* (IPaC) web-application that performs as a project planning tool and allows users to explore natural resources in specific locations, such as wetlands, wildlife refuges, GAP land cover, and other important biological resources and provides a streamlined environmental review process by following IPaC's Endangered Species Review process. Based on the IPaC database, there are no endangered species, National Wildlife Refuge lands, or fish hatcheries within the Sauquoit Creek watershed. There are 11 migratory birds that are of concern either because they are on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention. Table 2 lists the migratory bird species that either migrate over, nest, and / or breed within the Sauquoit Creek watershed (USFWS 2021).

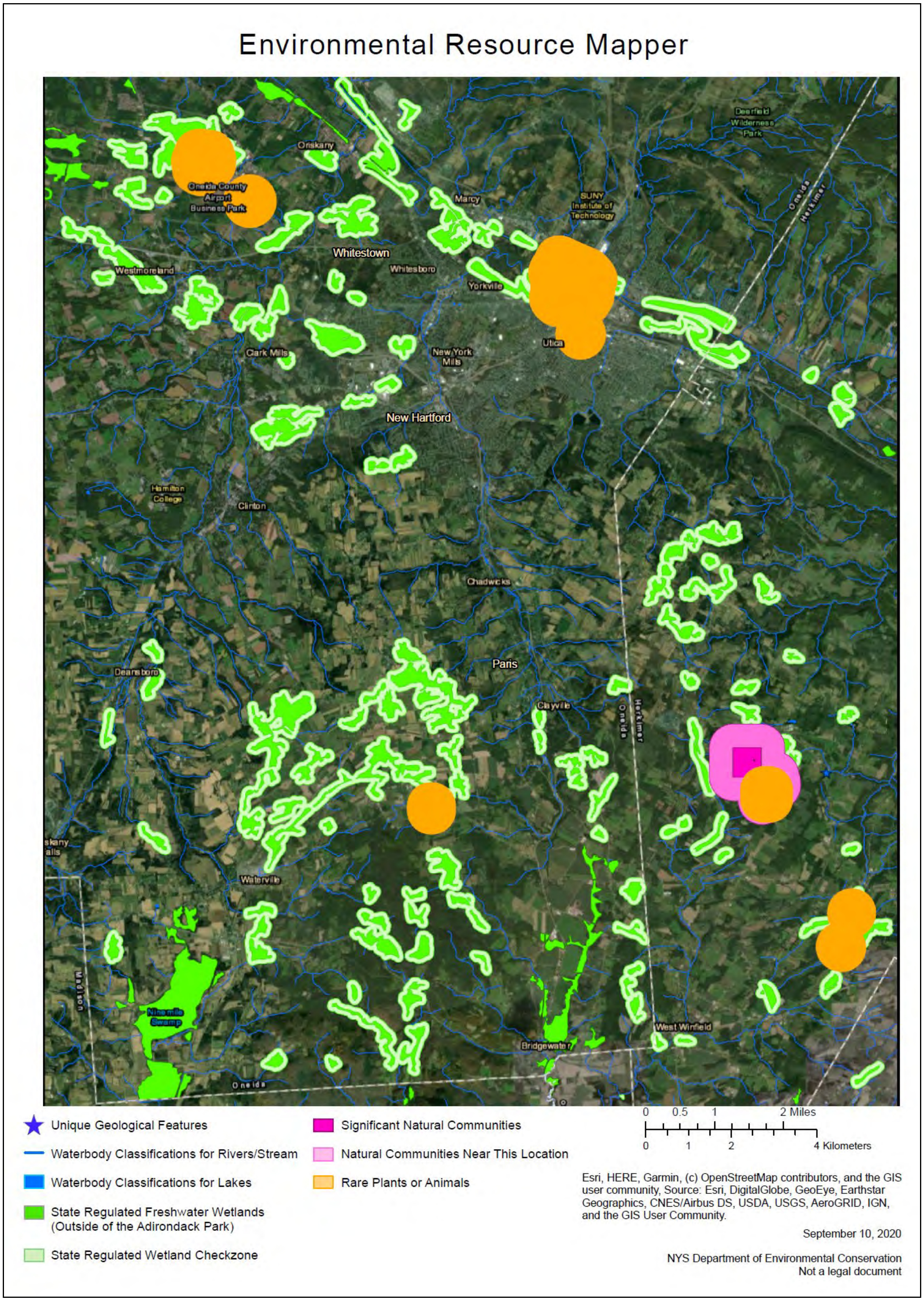

Figure 4. Significant Natural Communities and Rare Plants or Animals, Sauquoit Creek Watershed, Oneida County, New York.

Table 2. USFWS IPaC Listed Migratory Bird Species

Source: USFWS 2021			
Common Name	**Scientific Name**	**Level of Concern**	**Breeding Season**
Bald Eagle	*Haliaeetus leucocephalus*	Non-BCC Vulnerable[1]	December - August
Black-billed Cuckoo	*Coccyzus erythropthalmus*	BCC Rangewide (CON)[2]	May - October
Bobolink	*Dolichonyx oryzivorus*	BCC Rangewide (CON)	May - July
Canada Warbler	*Cardellina canadensis*	BCC Rangewide (CON)	May - August
Cerulean Warbler	*Dendroica cerulea*	BCC Rangewide (CON)	April - July
Golden Eagle	*Aquila chrysaetos*	Non-BCC Vulnerable	January - August
Lesser Yellowlegs	*Tringa flavipes*	BCC Rangewide (CON)	N/A
Prairie Warbler	*Dendroica discolor*	BCC Rangewide (CON)	May - July
Red-headed Woodpecker	*Melanerpes erythrocephalus*	BCC Rangewide (CON)	May - September
Snowy Owl	*Bubo scandiacus*	BCC Rangewide (CON)	N/A
Wood Thrush	*Hylocichla mustelina*	BCC Rangewide (CON)	May - August

[1] This is not a Bird of Conservation Concern (BCC) in this area but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.

[2] This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska (CON).

Cultural Resources

Both the New York State Office of Parks, Recreation & Historic Preservation (NYSOPRHP) and United States National Park Service (NPS) maintain databases that include information on historic buildings, structures, objects, and districts (NYSOPRHP 2018; NPS 2018). Within the Sauquoit Creek watershed, there were four historic locations found, which are listed in Table 3.

Table 3. Historic Sites Within the Sauquoit Creek Watershed

Source: NYSOPRHP 2018	
Site Name	**Municipality**
St. Paul's Episcopal Church and Cemetery	Paris Hill
Middle Mill Historic District	New York Mills
Whitestown Town Hall	Whitesboro
St. Stephen's Episcopal Church	New Hartford

Land Use

Sauquoit Creek has been substantially altered by human use. The creek's floodplain has been extensively filled and developed, especially along the lower reaches in the Towns of New Hartford and Whitestown, where the creek flattens and the floodplain becomes increasingly broad. The channel has been straightened in many areas along the creek to accommodate roads, neighborhoods, and commercial districts. Figure 5 displays channelization of Sauquoit Creek along the NY-5A / Commercial Boulevard corridor since 1950. For much of its length, especially along the mid and lower reaches, the creek banks have been armored using concrete or stacked rock walls that confine the channel, resulting in a channel that lacks the capacity to convey flows during storm events (MMI 2014). Bank armoring often has the unintended consequence of disconnecting the main channel of a waterway from its floodplain and resulting in head cutting or downcutting of the channel. Head cutting or downcutting increases sediment availability in the water column and can lead to potential aggradation and sediment issues downstream.

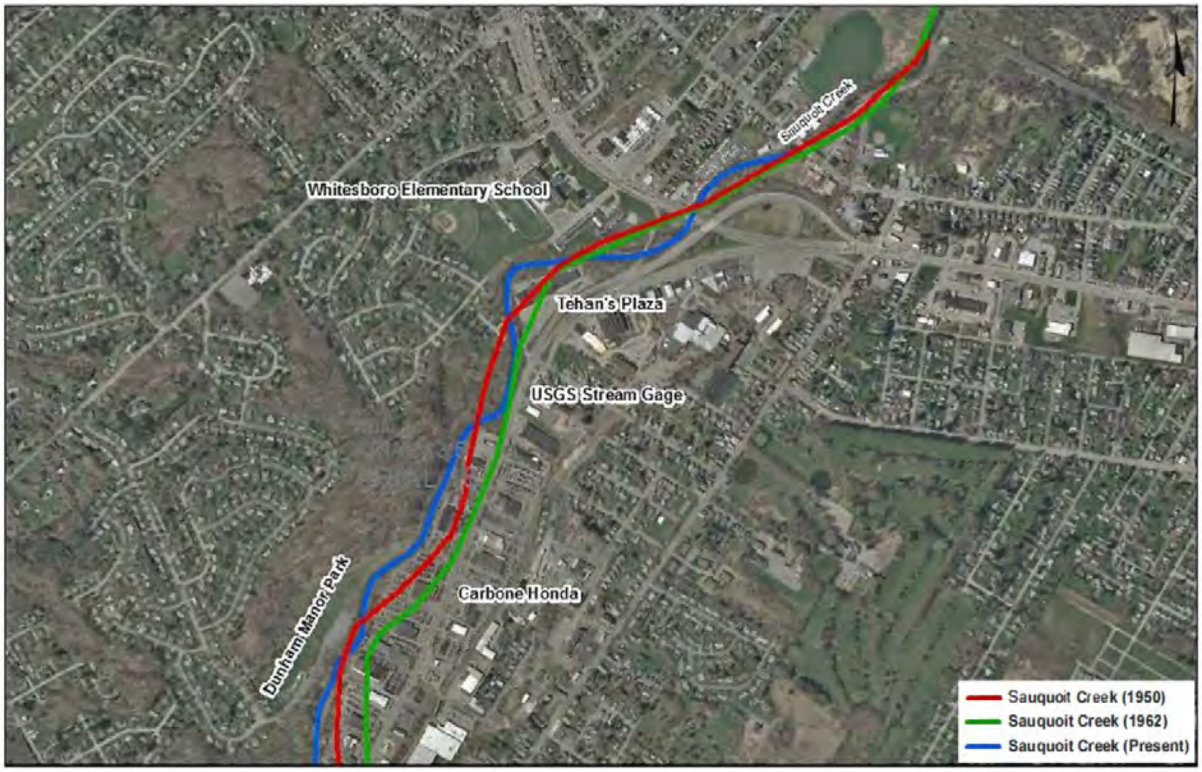

Figure 5. Historic 1950 and 1962 and present day channel alignment of Sauquoit Creek (OBG 2018).

Agricultural lands have a significant impact on water quality and sediment deposition. Agricultural production practices have led to radically altered water flow regimes within agricultural watersheds. Modification of virgin (non-cultivated) land often involved deforestation and drainage activities. In combination with cropping and grazing practices, these disruptions of the natural vegetation and soil resulted in the loss of the land's sediment filtering capacity. Compared to naturally vegetated, forested, and / or areas with stream buffers, surface runoff from rural and / or agricultural lands enter nearby waterways and contain large amounts of sediments, fertilizers, manure, etc., which negatively affects water quality and increases sediment loads in a waterway (NRC 1993).

In addition, wetlands also play a vital role in sediment transport and flooding. The loss of wetlands within the Sauquoit Creek watershed has had significant effects on local ecosystems. Wetlands are adversely affected by many human activities, including hydrologic alterations (i.e. drainage for development, dredging, channelization, damming, etc.); pollution and runoff from urban, agricultural, mining, and industrial areas; and vegetation damage by grazing domestic animals and invasive plant species (USEPA 2001).

Wetlands are significant and provide numerous benefits, not only to the environment, but to the community as well. For instance, wetlands improve drinking water quality by filtering sediments and pollutants absorbing excess nutrients from agricultural and stormwater runoff; wetlands have the potential to reduce the frequency and intensity of floods by acting as natural buffers and significant storage areas for flood waters; wetlands promote a diverse species of habitats due to the biological production that occurs within a healthy wetland and, as a result, are home to numerous threatened and endangered species; and this biological production also makes wetlands popular for outdoor recreational activities, such as hiking, fishing, hunting, etc., which can provide a significant boost to local economies through licenses, equipment sales, tourism, etc. (USEPA 2006).

Based on the 2018 land use data from the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) cropland database, a land cover analysis was performed to determine current land usage and changes in land use over time. Table 4 is a summary table of current land use by class (NASS 2019).

Table 4. 2018 Land Cover within the Sauquoit Creek Watershed

Source: NASS 2019		
Land Cover Class	Area (mi^2)	Percent Area (%)
Forest	19.24	30.88
Agriculture	18.12	29.08
Developed	11.46	18.39
Grassland / Pasture	6.25	10.03
Shrubland	6.00	9.62
Wetlands	1.15	1.85
Water	0.08	0.13
Barren	0.01	0.02
Total	**62.31**	**100**

In addition to current land usage, the NASS cropland data for New York State is available starting in 2002. Using the 2002 cropland data, a land use change over time analysis was performed. Since 2002, there has been increases in forested and developed land areas with decreases in agricultural, grassland / pasture, and water land areas. Table 5 summarizes the change in land cover data. Figure 6 displays the change in developed land cover from 2002 to 2018 within the Sauquoit Creek watershed.

Table 5. Change in Land Cover from 2002 to 2018 within the Sauquoit Creek Watershed

Source: NASS 2019				
Land Cover Class	**2002 Area (mi^2)**	**2018 Area (mi^2)**	**Difference (mi^2)**	**Percent Difference (%)**
Forest	17.40	19.24	+ 1.85	+ 10.1
Agriculture	23.95	18.12	— 5.83	— 27.7
Developed	8.58	11.46	+ 2.88	+ 28.8
Grassland / Pasture	11.09	6.25	— 4.84	— 55.8
Water	0.17	0.08	— 0.09	— 71.7

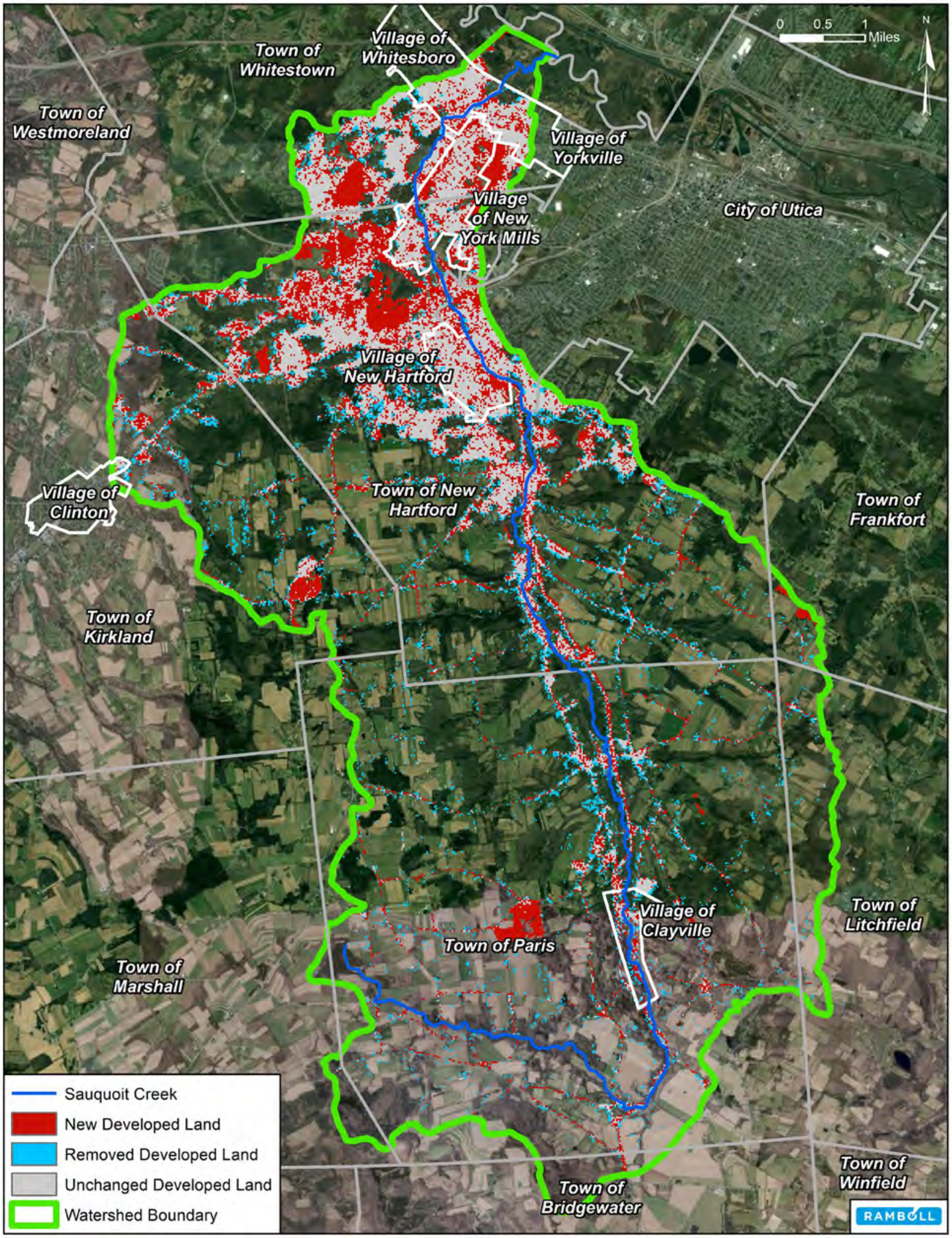

Figure 6. Change in developed land cover from 2002 to 2018, Sauquoit Creek Watershed, Oneida County, New York.

Based on the land cover change analysis, developed land areas have predominately increased in areas that are either within or directly adjacent to the floodplain of Sauquoit Creek. These developed areas produce larger areas of impervious surfaces to the watershed. Impervious surfaces effect the hydrology of nearby waterways in multiple ways, including water quality, streamflow, and flooding characteristics. Impervious surfaces increase storm water discharge to waterways without stormwater management practices that are properly designed and maintained. Existing stormwater management practices base system designs and pipe sizes on historical precipitation data (i.e. rainfall and snow melt); however, system designs and pipe sizes should be considered under future climate change contexts and stormwater management practices should take into account “future” proofing systems. Figure 7 depicts the effect land cover changes can have over time with development in a waterway’s natural floodplain.

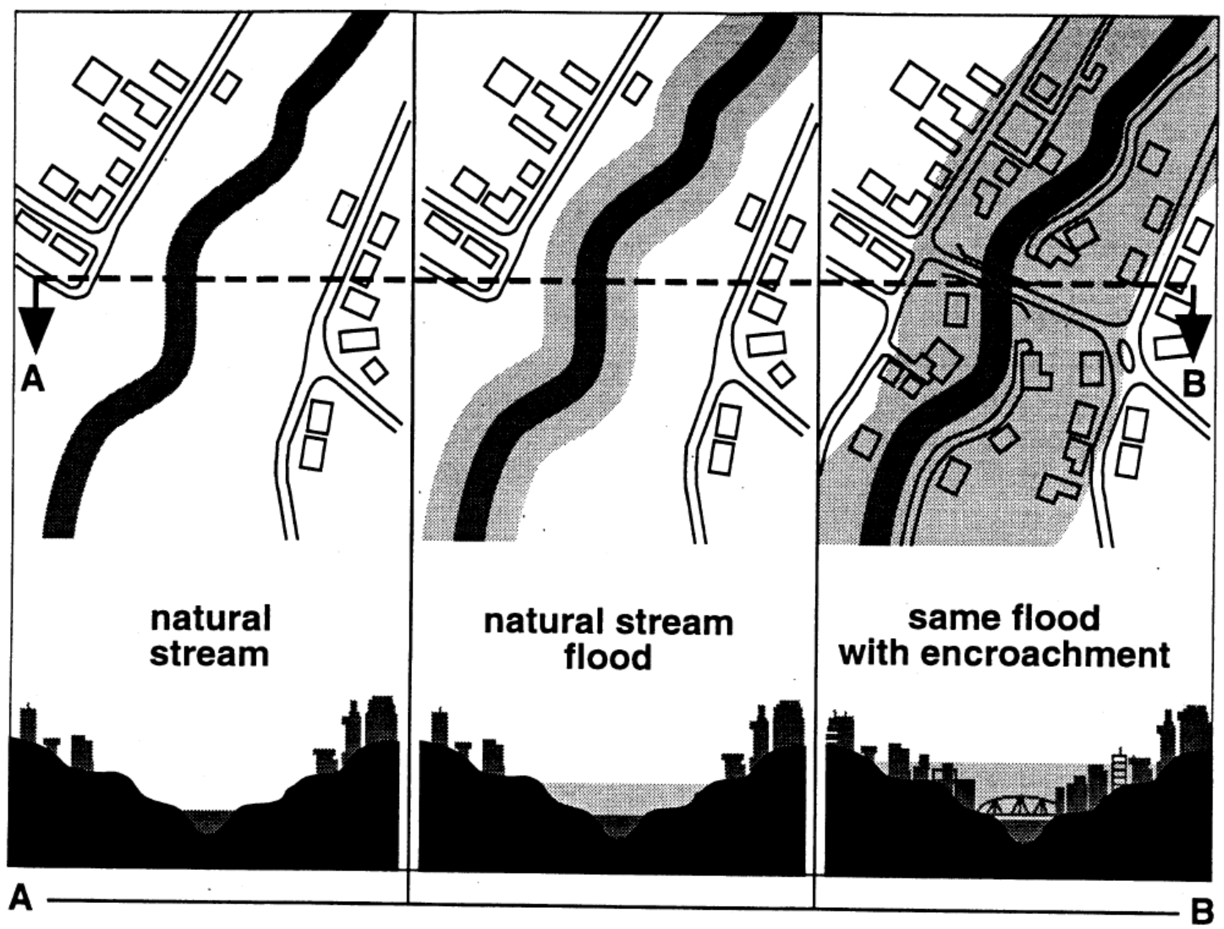

Figure 7. Effect of land cover changes due to development of a waterway’s natural floodplain (HOCCPP 1997).

In addition, water quality can be affected through runoff, where precipitation falls on impervious surfaces or construction sites and transports sediments, debris, pollutants, etc. into nearby waterways. The timing of streamflow peaks can be affected by increased impervious surfaces by increasing the occurrence and intensity of peak streamflow’s during precipitation events, as depicted in Figure 8. This, in turn, can affect the flooding characteristics of a waterbody when streamflow’s that did not cause flooding in the past do cause flooding in areas that have been developed over time.

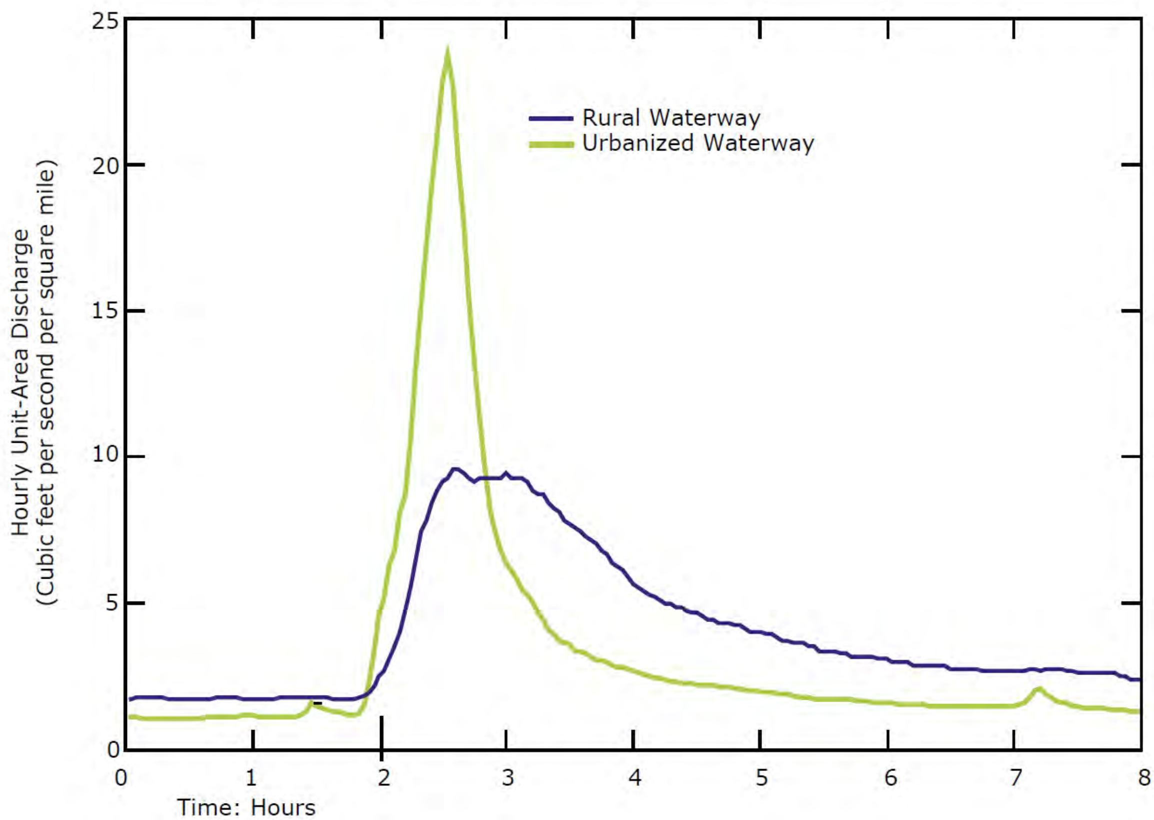

Figure 8. Idealized hydrograph comparing streamflow rates of a rural and urbanized waterway (adapted from USGS 2003).

The discharge of a waterway will vary greatly over time depending on the weather within its watershed. As a precipitation event begins, the discharge of a river will not instantaneously increase. It takes time for the rain to reach the river. The delay between when rainfall occurs and when the discharge of the river actually increases is known as lag time. Lag times will vary depending on characteristics of the watershed. Urbanized waterway basins tend to have large amounts of impermeable surfaces, such as roof tops and parking lots, which restrict infiltration into the soil. Surface runoff travels quicker to waterways, which produces higher discharges and increases the potential for flooding. Rural waterway basins, on the other hand, tend to have large vegetated areas, which allow precipitation to infiltrate into the soil and travel towards waterways at a slower rate. As a result, discharges are lower and the potential for flooding is reduced.

Hydrology

There is one United States Geologic Survey (USGS) gaging station located along Sauquoit Creek: USGS gage 01339060 at Whitesboro, New York. The gage is located along the right bank of Sauquoit Creek adjacent to Commercial Drive (NY-5A) approximately 1,000-feet upstream the Village of Whitesboro and Town of Whitestown corporate limits. The period of record for the daily discharge data collected by the gage is seven years, starting on September 26, 2014. This period of record is insufficient to perform a flood frequency analysis and assign annual chance exceedance values to observed events using the

USGS Bulletin 17C guidelines. Table 6 displays the recorded annual peak gage height, in feet, and streamflow data, in cubic feet per second (cfs), for Sauquoit Creek (USGS 2020).

Table 6. USGS Gage 01339060 Sauquoit Creek at Whitesboro, New York Annual Peak Gage Height and Streamflow Data

Source: USGS 2020			
Water Year	**Date**	**Gage Height (ft)**	**Streamflow (cfs)**
2015	Oct. 16, 2014	5.25	2,010
2016	Feb. 25, 2016	4.712	1,540
2017	Jul. 01, 2017	9.82	5,820
2018	Feb. 20, 2018	5.43	1,910
2019	Jun. 20, 2019	5.97	2,330
Halloween Storm	October 31, 2019	10.17*	6,170*

*Halloween Storm data is provisional, which is data that is subject to revision by the USGS.

An effective Federal Emergency Management Administration (FEMA) Flood Insurance Study (FIS) for Oneida County was issued on September 27, 2013 and included drainage area and discharge information for Sauquoit Creek. Table 7 lists the FEMA FIS drainage area and peak discharges for Sauquoit Creek (FEMA 2013a).

Table 7. FEMA FIS Peak Discharges for Sauquoit Creek

Source: FEMA 2013a					
Flooding Source and Location	**Drainage Area (mi^2)**	**Peak Discharges (cfs)**			
		10-percent	**2-percent**	**1-percent**	**0.2-percent**
At the confluence with Mohawk River Reach 1	61.9	6,148	8,831	10,177	13,100
At Main Street Bridge	60.1	6,014	8,702	10,120	13,205
At Stuart Court Extended	59.4	5,873	8,707	10,222	13,150
At State Route 5A	47.1	5,192	7,651	9,141	12,000
At the corporate limits of New Hartford / Whitestown	47.1	3,899	6,516	7,011	10,523
Upstream of railroad (second crossing)	43.7	3,394	5,681	6,124	9,504
At the corporate limits of New Hartford / Utica	43.4	3,899	6,516	7,011	10,523
Upstream of railroad (third crossing)	41.1	3,254	5,399	5,801	8,949
Upstream of Utica / New Hartford corporate limits	40.2	3,161	5,242	5,634	8,790
Upstream of Kellogg Road	37.0	2,920	4,838	5,226	8,227
Upstream of railroad (fourth crossing)	32.6	2,387	4,038	4,390	7,011
Upstream of Elm Street	28.5	2,074	3,486	3,786	6,025
Upstream of Pinnacle Road	17.6	1,633	2,628	2,882	4,717
Upstream of Holman City Road	13.2	1,185	1,914	2,187	3,515
Upstream of Main Street	11.9	915	1,577	1,744	2,776
Upstream of Oneida Street	8.9	872	1,394	1,512	2,300
Upstream of State Route 8	6.4	598	1,016	1,104	1,706

The FEMA FIS flood-frequency discharges for Sauquoit Creek were developed using multiple reports and methodologies for the various municipalities that intersect the creek. In the Town of Whitestown and Village of Whitesboro, peak discharge-frequency relationships were determined using United States Army Corps of Engineers (USACE) studies: *Flood Plain Information, Mohawk River. Sauquoit Creek and Oriskany Creek, New York* (1974) and *Reconnaissance Report for Sauquoit Creek and Mohawk River in the Village of Whitesboro, New York* (1975) (USACE 1974; USACE 1975). In the Towns of New Hartford and Paris, the Villages of New Hartford, Clayville, and New York Mills and the City of Utica, peak discharge-frequency relationships for Sauquoit Creek were obtained from the USACE *Sauquoit Creek Basin Study, Hydrologic and Hydraulic Planning Models, Oneida County, New York* (1981) report as determined using the USACE Hydrologic Engineering Center version 1 (HEC-1) flood hydrograph computer program (USACE 1981b).

For the Town of Whitestown and Village of Whitesboro, the hydrologic analyses were updated in 2000 by the NYSDEC, who used the HEC-1 flood hydrograph computer program due to increased development in the Sauquoit Creek drainage basin in both municipalities (FEMA 2013a).

Hydraulic analyses for Sauquoit Creek were completed for the FEMA FIS using detailed methods, the USACE HEC-2 step-backwater computer program, and the slope / area method. Detailed methods predict floodplain limits by using a wide range of tools, including semiautomated hydrologic, hydraulic, and mapping tools and digital elevation data, and field-surveyed cross-sections, including field surveys of bridges, culverts, and dams, to perform a more rigorous hydrologic and hydraulic (H&H) analysis that includes products such as floodways, new calibrations for H&H models, and the modeling of additional frequencies. Detailed studies provide Base Flood Elevations (BFEs) information, which is defined as the computed elevation to which a flood is anticipated to rise during the 1% annual chance flood or 100-year flood (NRC 2007; FEMA 2013a).

For the 2000 revisions of the FEMA FIS reports for the Town of Whitestown and Villages of Whitesboro, New York Mills and Yorkville, hydraulic analyses were performed using limited detailed methods where only select below-water portions of Sauquoit Creek and bridges and culverts were field surveyed. Water-surface elevations of floods of the selected recurrence intervals were re-computed using the USACE HEC-2 step-backwater computer program using the slope / area method (FEMA 2013a).

General limitations of the FEMA FIS methodology are the age of the H&H analysis and the age of the methodology. The original H&H analyses for Sauquoit Creek were completed in the 1970's and 1980's primarily using methodologies from USACE reports or computer programs. Advancements in our understanding of the complex interactions of hydrologic environments, coupled with improvements in H&H modeling and technology, has led to increased accuracy and a reduction in possible error in discharge estimations in recent years. In addition, there was no available streamflow data at the time of the original FEMA FIS. Streamflow data was estimated from regional flood frequency curves used to calculate discharge-frequency relationships. This process can introduce uncertainty and error into the discharge-frequency calculations due to the lack of real data to verify results.

An alternative method for determining discharge-frequency relationships is to use the USGS *StreamStats* web-application. *StreamStats* v4.4.0 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 2021).

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

Since the USGS gage on Sauquoit Creek was in service for only a short period (i.e. five years of record), for H&H analyses Sauquoit Creek is considered an ungaged site. For ungaged sites, *StreamStats* relies on regional regression equations that were developed by statistically relating the streamflow statistics to the basin characteristics for a group of stream gages within a region. Estimates of streamflow statistics for an ungaged site can then be obtained by measuring its basin characteristics and inserting them into the regression equations (Ries et al. 2017).

For example, the full regression equation for estimating the 100-year flood for ungaged sites within hydrologic Region 1 in New York is:

$$Q_{100} = 10300*(A)^{0.962} * (ST+1)^{-0.202} * (P)^{1.106} * (LAG+1)^{-0.520} * (FOR+80)^{-1.638}$$

Where

Q is the discharge recurrence interval;

A is the drainage area, in square miles;

ST is the basin storage, in percent;

P is the mean annual precipitation, in inches;

LAG is the basin lag factor; and

FOR is the basin forested area, in percent (Lumia et al. 2006).

StreamStats delineates the drainage basin boundary for a selected site by use of an evenly spaced grid of land-surface elevations, also referred to 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 discharge when compared to the drainage-area only regression equation (Ries et al. 2017).

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

In addition, estimates of streamflow statistics that are obtained from regression equations are based on the assumption of natural flow conditions at the ungaged site unless the reports that document the equations state otherwise. If human activities such as dam regulation and water withdrawals substantially affect the timing, magnitude, or duration of flows at a selected site, the regression-equation estimates provided by *StreamStats* should be adjusted by the user to account for those activities (Ries et al. 2017). Table 8 is the summary output of peak discharges calculated by the USGS *StreamStats* software for Sauquoit Creek at selected FEMA FIS profile locations.

Table 8. USGS *StreamStats* Peak Discharges for Sauquoit Creek

Source: USGS 2021					
Flooding Source and Location	Drainage Area (mi^2)	Peak Discharges (cfs)			
		10-percent	2-percent	1-percent	0.2-percent
At the confluence with Mohawk River Reach 1	62.3	5520	8040	9300	12200
At Main Street Bridge	60.9	5450	7950	9200	12100
At Stuart Court Extended	60.1	5360	7830	9050	11900
At State Route 5A	47.6	4400	6440	7450	9840
At the corporate limits of New Hartford / Whitestown	47.6	4400	6440	7450	9840
Upstream of railroad (second crossing)	46.3	4320	6330	7330	9680
At the corporate limits of New Hartford / Utica	46.3	4320	6330	7330	9680
Upstream of railroad (third crossing)	42.1	3900	5710	6610	8730
Upstream of Utica / New Hartford corporate limits	41.1	3800	5560	6440	8500
Upstream of Kellogg Road	37.4	3480	5100	5900	7790
Upstream of railroad (fourth crossing)	33.3	3040	4460	5160	6810
Upstream of Elm Street	28.8	2640	3860	4470	5900
Upstream of Pinnacle Road	22.9	2050	3010	3480	4580
Upstream of Holman City Road	18.4	1640	2390	2770	3650
Upstream of Main Street	13.3	1230	1810	2090	2760
Upstream of Oneida Street	12.4	1170	1710	1980	2620
Upstream of State Route 8	9.3	938	1380	1600	2130

Comparing the peak streamflow data from the two methods, it is evident that the FEMA FIS methodology calculated higher discharge values for the lower reaches and 0.2% annual chance events of Sauquoit Creek than did the USGS *StreamStats* methodology.

Table 9 displays the calculated percent difference between the USGS *StreamStats* and FEMA FIS peak streamflow data.

Table 9. Percent Difference Between USGS *StreamStats* and FEMA FIS Peak Streamflow Data for Sauquoit Creek

Source: FEMA 2013a; USGS 2021				
Flooding Source and Location	Percent Difference (%)			
	10-percent	2-percent	1-percent	0.2-percent
At the confluence with Mohawk River Reach 1	2.69	2.34	2.25	1.78
At Main Street Bridge	2.46	2.26	2.38	2.18
At Stuart Court Extended	2.28	2.65	3.04	2.50
At State Route 5A	4.13	4.30	5.10	4.95
At the corporate limits of New Hartford / Whitestown	— 3.02	0.29	— 1.52	1.68
Upstream of railroad (second crossing)	— 6.00	— 2.70	— 4.48	— 0.46
At the corporate limits of New Hartford / Utica	— 2.56	0.72	— 1.11	2.09
Upstream of railroad (third crossing)	— 4.51	— 1.40	— 3.26	0.62
Upstream of Utica / New Hartford corporate limits	— 4.59	— 1.47	— 3.34	0.84
Upstream of Kellogg Road	— 4.38	— 1.32	— 3.03	1.36
Upstream of railroad (fourth crossing)	— 6.02	— 2.48	— 4.03	0.73
Upstream of Elm Street	— 6.00	— 2.55	— 4.14	0.52
Upstream of Pinnacle Road	— 5.66	— 3.39	— 4.70	0.74
Upstream of Holman City Road	— 8.05	— 5.53	— 5.88	— 0.94
Upstream of Main Street	— 7.34	— 3.44	— 4.51	0.14
Upstream of Oneida Street	— 7.30	— 5.09	— 6.70	— 3.25
Upstream of State Route 8	— 11.07	— 7.60	— 9.17	— 5.53

Note: Positive percent difference values indicate the FEMA FIS peak streamflow values are higher, while negative values indicate the USGS *StreamStats* peak streamflow values are higher.

Using the standard error calculations from the regression equation analysis in *StreamStats*, an acceptable range at the 95% confidence interval for peak discharge values at the 10, 2, 1, and 0.2% annual chance flood hazards were determined. Standard error gives an indication of how accurate the calculated peak discharges are when compared to the actual peak discharges since about 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 10 is a summary table of the USGS *StreamStats* standard errors at each standard percent annual chance flood hazard.

Table 10. USGS *StreamStats* Standard Errors for Hydrologic Region 1 Full Regression Equations

Source: USGS 2006				
	Peak Discharges			
	10-percent	2-percent	1-percent	0.2-percent
Mean Standard Error (SE)	27.2%	29.4%	30.8%	35.1%

Based on the *StreamStats* standard error calculations, the FEMA FIS peak discharges were determined to be outside of the acceptable range (95% confidence interval). For this study, to maintain consistency in the modeling outputs with the FEMA models and to develop a conservative analysis of flood risk in the Sauquoit Creek watershed, the effective FIS peak discharges were used in the H&H modeling simulations.

Infrastructure

There are numerous dams along Sauquoit Creek and its tributaries that interact with the flow of the creek. Of the 11 dams within the Sauquoit Creek watershed, six are found along Sauquoit Creek while the remaining five dams are located on tributaries. All six dams located on Sauquoit Creek are purposed as other, while one is owned by the Village of Clayville, two are privately-owned, and the remaining three have no ownership data available. The dams along the creek are classified as a Class A, B, D or 0 dams according to 6 CRR-NY 673.5 Dam Safety Regulations.

> Class A or "low hazard dams" are defined as dams where failure is unlikely to result in damage to anything more than isolated or unoccupied buildings, undeveloped lands, minor roads such as town or county roads; is unlikely to result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and / or is otherwise unlikely to pose the threat of personal injury, substantial economic loss or substantial environmental damage.
>
> Class B or "intermediate hazard dams" are defined as dams where failure may result in damage to isolated homes, main highways, and minor railroads; may result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and / or is otherwise likely to pose the threat of personal injury and / or substantial economic loss or substantial environmental damage. Loss of human life is not expected.

Class D dams are also referred to as "negligible or no hazard" dams, which are defined as dams that have been breached or removed, or have failed or otherwise no longer materially impound waters, or dams that were planned but never constructed and are considered to be defunct dams posing negligible or no hazard.

Class 0 dams are defined as dams that have not had a hazard code assigned.

Table 11 lists the dams that are along Sauquoit Creek, including hazard codes and purpose for the dam (NYSDEC 2019).

Table 11. Dams Inventory Along Sauquoit Creek

Source: NYSDEC 2019					
State ID	**Dam Name**	**Waterway**	**Hazard Class**	**Owner**	**Purpose**
128-5690	**Chapman Creek Dam**	Chapman Creek	A	Private	Flood Control and Storm Water Management, Recreation
115-4346	**(115-4346)**	Mud Creek	D	N/A	Other
128-5302	**Roberts Creek Dam**	Roberts Creek	A	Town of New Hartford	Flood Control and Storm Water Management
116-0799	**Clayville Reservoir Dam**	Sauquoit Creek	B	Village of Clayville	Other
116-0801	**(116-0801)**	Sauquoit Creek	D	N/A	Other
116-0791A	**(116-0791a)**	Sauquoit Creek	D	N/A	Other
115-4446	**Sauquoit Creek Dam**	Sauquoit Creek	0	N/A	Other
129-0796	**Clayville Paper Co Dam**	Sauquoit Creek	A	Private	Other
115-0834	**Sauquoit Spinning Co Dam**	Sauquoit Creek	A	Private	Other
116-0795A	**Lattus' Dam**	Unnamed Tributary	A	Private	Other
115-5152	**Chadwicks Dam / Willowvale Bleachery Dam**	Unnamed Tributary	A	Private	Other

Major infrastructure crossings over Sauquoit Creek include Oriskany Boulevard (NY-69), Commercial Drive (NY-5A) in the Town of Whitestown and NY-5 and NY-8 in the Town of New Hartford. Bridge lengths and surface widths for NYSDOT bridges were revised as of February 2019. Structures with no or incomplete existing data were measured using a combination of field surveys and orthoimagery made available by New York State (NYSOITS 2017). Table 12 summarizes the infrastructure data for structures that cross Sauquoit Creek with their associated bankfull widths from USGS *StreamStats* and hydraulic capacity according to the FEMA FIS. Figure 9 displays the locations of the bridges and dams that cross Sauquoit Creek in Oneida County, New York (FEMA 2013a; NYSDOT 2014; NYSDEC 2019; Ramboll 2020; USGS 2021).

Table 12. Infrastructure Crossing Sauquoit Creek

Infrastructure	Type	River Station (ft)	Primary Owner	State ID	Structure Length (ft)	Structure Width[1] / Height (ft)	Bankfull Width (ft)	Hydraulic Capacity (% Annual Chance)[2]
Source: FEMA 2013a; NYDOT 2014; NYSDEC 2019; Ramboll 2020; USGS 2021								
CSX Transportation, Inc.	Railroad Bridge	58+50	CSX Transportation, Inc.	N/A	57	60	85.6	> 10 % *
Main Street (1)	Roadway Bridge	75+80	Village of Whitesboro	2255640	96	35	85.4	> 10 % *
NY-69 / Oriskany Boulevard	Roadway Bridge	88+50	NYSDOT	1009919	78	67	85.4	10 %
NY-5A Entrance Ramp	Roadway Bridge	94+00	NYSDOT	1051980	110	24	85	> 10 % *
NY-5A / Commercial Drive	Roadway Bridge	162+50	NYSDOT	1002670	113	64	76.5	> 10 % *
Clinton Street	Roadway Bridge	182+50	Town of New Hartford	2206280	78	30	76.1	1 %
Recreational Trail	Pedestrian Bridge	227+00	N/A	N/A	105	16	75.7	0.2 %
Chenango Road	Roadway Bridge	232+50	Town of New Hartford	2206680	103.4	30.2	75.5	0.2 %
NYSWR Corporation (1)	Railroad Bridge	233+24	New York, Susquehanna and Western Railway Corp.	N/A	125	16	75.5	1 %
NY-5 EB	Roadway Bridge	241+50	NYSDOT	1002221	124	49.3	73.8	0.2 %
NY-5 WB	Roadway Bridge	242+50	NYSDOT	1002222	124	50	73.8	0.2 %
Genesee Street	Roadway Bridge	271+50	NYSDOT	1052070	70	62	73.4	0.2 %

Source: FEMA 2013a; NYDOT 2014; NYSDEC 2019; Ramboll 2020; USGS 2021								
Infrastructure	**Type**	**River Station (ft)**	**Primary Owner**	**State ID**	**Structure Length (ft)**	**Structure Width[1] / Height (ft)**	**Bankfull Width (ft)**	**Hydraulic Capacity (% Annual Chance)[2]**
NYSWR Corporation (2)	Railroad Bridge	302+00	New York, Susquehanna and Western Railway Corp.	N/A	100	16	72.4	0.2 %
Kellogg Road	Roadway Bridge	376+00	Oneida County	3310860	80	52	68.6	1 %
NY-8 NB	Roadway Bridge	395+50	NYSDOT	1051502	92	30	68.5	0.2 %
NY-8 SB	Roadway Bridge	396+50	NYSDOT	1051501	92	30	68.5	0.2 %
NYSWR Corporation (3)	Railroad Bridge	397+00	New York, Susquehanna and Western Railway Corp.	N/A	106	16	68.5	0.2 %
NYSWR Corporation (4)	Railroad Bridge	431+50	New York, Susquehanna and Western Railway Corp.	N/A	76	16	67.1	10 %
Oneida Street (1)	Roadway Bridge	434+00	Town of New Hartford	2255320	104	32.5	67.1	10 %
NYSWR Corporation (5)	Railroad Bridge	453+70	New York, Susquehanna and Western Railway Corp.	N/A	75	16	65.1	1 %
Bleachery Avenue / Newell Lane	Roadway Bridge	471+00	Town of New Hartford	2205900	50	25.6	62.5	10%
Bleachery Place	Roadway Bridge	479+50	Town of New Hartford	N/A	58	15	62.4	10%
Private Road	Roadway Bridge	485+00	Removed					

Source: FEMA 2013a; NYDOT 2014; NYSDEC 2019; Ramboll 2020; USGS 2021								
Infrastructure	**Type**	**River Station (ft)**	**Primary Owner**	**State ID**	**Structure Length (ft)**	**Structure Width[1] / Height (ft)**	**Bankfull Width (ft)**	**Hydraulic Capacity (% Annual Chance)[2]**
Elm Street	Roadway Bridge	507+50	Town of New Hartford	2205890	74	33	61	10 %
NYSWR Corporation (6)	Railroad Bridge	516+24	New York, Susquehanna and Western Railway Corp.	N/A	70	16	60	10 %
Pedestrian Bridge (1)	Pedestrian Bridge	518+60	Removed					
Dam (1)	Dam	541+60	N/A	115-4446	60	10	N/A	N/A
Pinnacle Road (CR-9)	Roadway Bridge	612+50	Oneida County	3310890	49	27.6	55.1	> 10 % *
Holman City Road	Roadway Bridge	673+20	Town of Paris	2205920	32	21	49.9	2 %
NY-8 (2)	Roadway Bridge	692+00	NYSDOT	1051460	145	36	45	0.2 %
Pedestrian Bridge (2)	Pedestrian Bridge	698+50	Removed					
NYSWR Corporation (7) / Main Street (2)	Railroad and Roadway Bridge	729+50	New York, Susquehanna and Western Railway Corp. / Village of Clayville	N/A	125	28	43.1	0.2 %
Pedestrian Bridge (3)	Pedestrian Bridge	736+50	N/A	N/A	44	7	43.1	N/A
Dam (2)	Dam	740+00	Village of Clayville	116-0799	411	26	N/A	N/A
Oneida Street (2)	Roadway Bridge	755+50	Town of Paris	2263300	27	26.2	42.1	0.2 %

Source: FEMA 2013a; NYDOT 2014; NYSDEC 2019; Ramboll 2020; USGS 2021								
Infrastructure	**Type**	**River Station (ft)**	**Primary Owner**	**State ID**	**Structure Length (ft)**	**Structure Width[1] / Height (ft)**	**Bankfull Width (ft)**	**Hydraulic Capacity (% Annual Chance)[2]**
Oneida Street (3)	Roadway Bridge	773+70	Village of Clayville	2263310	38	41.5	41.8	2 %
Dam (3)	Dam	782+00	Private	129-0796	60	35	N/A	N/A
Wiremill Place	Roadway Bridge	795+00	Village of Clayville	N/A	25	10	41.2	> 10 % *
Dam (4)	Dam	803+00	N/A	116-0791A	60	16	N/A	N/A
NY-8 (3)	Roadway Bridge	822+30	NYSDOT	1004590	96	40	40.4	10 %
Dam (5)	Dam	827+80	Private	116-0795A	80	15	N/A	N/A
NY-8 (4)	Roadway Bridge	840+00	NYSDOT	1004580	51	40	39.8	10 %
NY-8 (5)	Roadway Bridge	888+30	NYSDOT	1073890	186	27	36.8	10 %
Summit Road	Roadway Bridge	901+00	Oneida County	N/A	25	25	36.3	10 %
Pedestrian Bridge (4)	Pedestrian Bridge	903+50	Removed					
Reservoir Road	Roadway Bridge	906+00	Town of Paris	N/A	36	32	36.2	1 %
NYSWR Corporation (8)	Railroad Bridge	975+80	New York, Susquehanna and Western Railway Corp.	Outside Study Area				
Greens Crossing Road	Roadway Bridge	1003+70	Town of Paris	Outside Study Area				

Source: FEMA 2013a; NYDOT 2014; NYSDEC 2019; Ramboll 2020; USGS 2021								
Infrastructure	**Type**	**River Station (ft)**	**Primary Owner**	**State ID**	**Structure Length (ft)**	**Structure Width[1] / Height (ft)**	**Bankfull Width (ft)**	**Hydraulic Capacity (% Annual Chance)[2]**
NYSWR Corporation (9)	Railroad Bridge	1021+80	New York, Susquehanna and Western Railway Corp.	Outside Study Area				
NYSWR Corporation (10)	Railroad Bridge	1053+00	New York, Susquehanna and Western Railway Corp.	Outside Study Area				
Doolittle Road (CR-18A)	Roadway Bridge	1066+20	Oneida County	Outside Study Area				
Crooked Hill Road / NYSWR Corp (11)	Railroad / Roadway Bridge	1098+00	Town of Paris / New York, Susquehanna and Western Railway Corp.	Outside Study Area				
Brennan Road (1)	Roadway Bridge	1124+20	Oneida County	Outside Study Area				
Brennan Road (2)	Roadway Bridge	1127+30	Oneida County	Outside Study Area				
Brennan Road (3)	Roadway Bridge	1143+30	Oneida County	Outside Study Area				

[1] Structure Width for bridges and culverts are measured parallel to creek flow and refers to the curb-to-curb 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 2006).

[2] Hydraulic capacity is the measure of the amount of water that can pass through a structure or watercourse. The values listed are based on the FEMA FIS flood profiles for Sauquoit Creek (FEMA 2013a).

* The FEMA FIS flood profiles only provide data for the 10, 2, 1 and 0.2% annual chance flood levels. Any value of "> 10 %" indicates that the structure cannot pass a 10, 2, 1 and 0.2% annual chance flood event (i.e. the 10, 2, 1 and 0.2% annual chance flood profile lines overtop the structure).

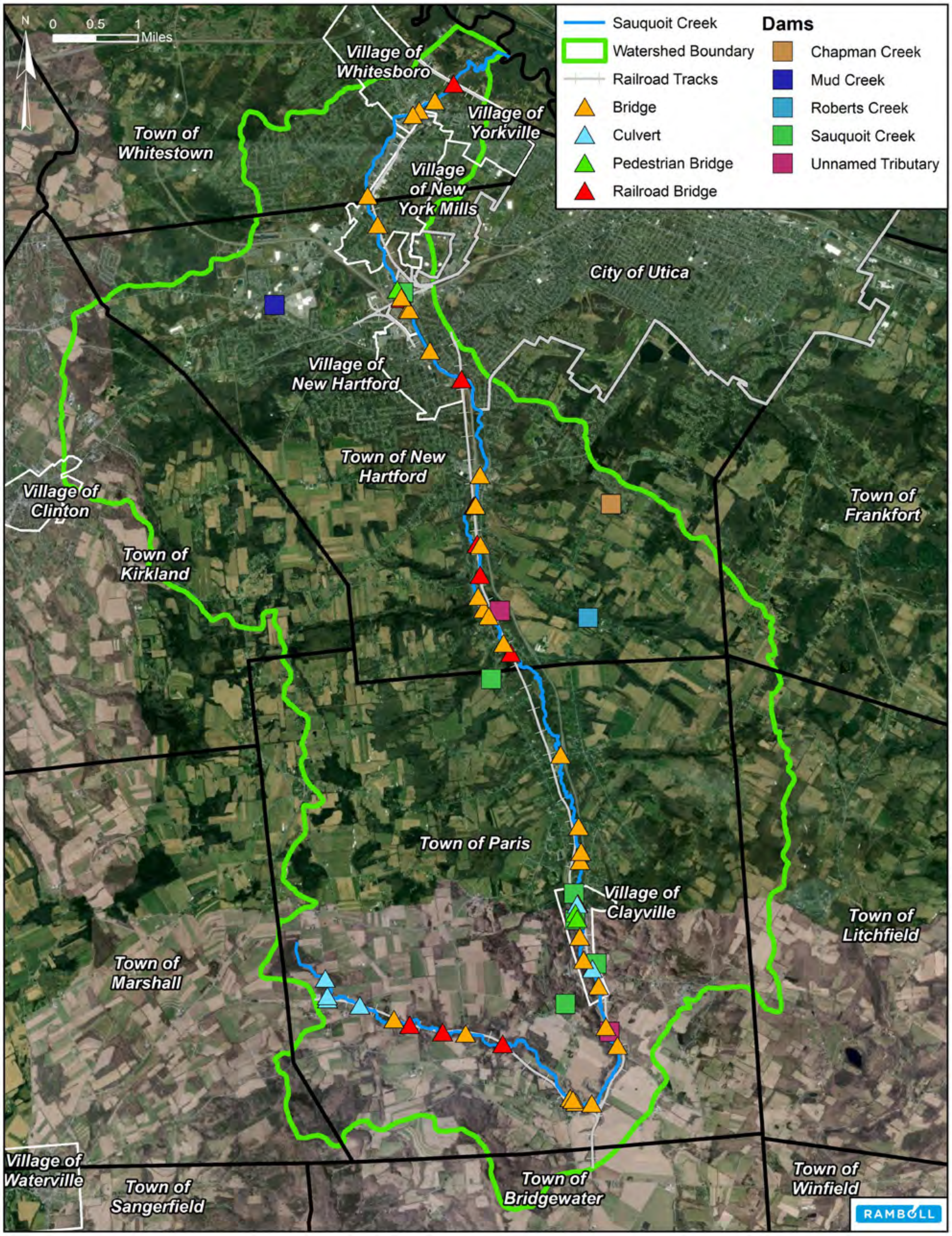

Figure 9. Infrastructure crossing Sauquoit Creek, Oneida County, New York.

Hydraulic Capacity

Hydraulic capacity is the measure of the amount of water that can pass through a structure or watercourse. Hydraulic design is an essential function of structures in watersheds. Exceeding the capacity can result in damages or flooding to surrounding areas and infrastructure (Zevenbergen et al. 2012). In assessing hydraulic capacity of the high-risk constriction point culverts and bridges along Sauquoit Creek, the FEMA FIS profile of Sauquoit Creek was used to determine the lowest annual-chance flood elevation to flow under the low chord of a bridge or culvert, without causing an appreciable backwater condition upstream (Table 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 2018).

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

According to the NYSDOT bridge manual (2019) for Region 2, which includes Oneida County, new and replacement bridges are required to meet certain standards, which include (NYSDOT 2019):

- The structure will not raise the water surface elevations anywhere when compared to the existing conditions for both the 2 and 1% Annual Chance Event (ACE) (50 and 100-year flood) flows.
- The proposed low chord shall not be lower than the existing low chord.
- A minimum of 2’-0” of freeboard for the projected 2% ACE (50-year flood) is required for the proposed structure. The freeboard shall be measured at the lowest point of the superstructure between the two edges of the bottom angle for all structures.
- The projected 1% ACE (100-year flood) flow shall pass below the proposed low chord without touching it.
- The maximum skew of the pier to the flow shall not exceed 10 degrees.

In addition, current peak flows shall be increased to account for future projected peak flows based on the USGS *StreamStats* tool where current 2% peak flows shall be increased by 20% in Region 2. For critical bridges, the minimum hydraulic design criteria is 3-feet of freeboard over the 2% annual chance flood elevation. A critical bridge is considered to be vital infrastructure that the incapacity or destruction of such would have a debilitating impact on security, national economic security, national public health or safety, or any combination of those matters (NYSDOT 2019; USDHS 2010).

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

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

In assessing the hydraulic capacity of culverts, NYSDOT highway drainage standards require the determination of a design discharge (e.g. 50-year flood) through the use of flood frequencies. The design flood frequency is the recurrence interval that is expected to be accommodated without exceeding the design criteria for the culvert. There are four recommended methodologies: The Rational Method, The Modified Soil Cover Complex Method, historical data, and the regression equations. Each method should be assessed and the most appropriate method for the specific site should be used to calculate the design flood frequency and discharge. In addition, current NYSDOT standards require peak flows to be increased to account for future projected peak flows based on the USGS *StreamStats* tool where current 2% peak flows shall be increased by 20% in Region 2 (NYSDEC 2018; NYSDOT 2018).

In assessing hydraulic capacity of infrastructure crossing Sauquoit Creek, USGS *StreamStats* bankfull width calculations and FEMA FIS profiles were used to determine the lowest annual chance flood elevation that can adequately pass under a structure. Table 13 displays the infrastructure that, according to the FEMA FIS profiles, are unable to pass the NYSDOT recommended two feet of freeboard for the projected 2% annual chance flood event.

Table 13. High Risk Hydraulic Capacity Infrastructure According to the FEMA FIS Profiles

Source: FEMA 2013a, NYSDOT 2013, NYSDOT 2014					
Infrastructure	**Type**	**River Station (ft)**	**Primary Owner**	**State ID**	**Hydraulic Capacity (% Annual Chance)**
CSX Transportation, Inc.	Railroad Bridge	58+50	CSX Transportation, Inc.	N/A	> 10 % *
Main Street (1)	Roadway Bridge	75+80	Village of Whitesboro	2255640	> 10 % *
NY-69 / Oriskany Boulevard	Roadway Bridge	88+50	NYSDOT	1009919	10%
NY-5A Entrance Ramp	Roadway Bridge	94+00	NYSDOT	1051980	> 10 % *
NY-5A / Commercial Drive	Roadway Bridge	162+50	NYSDOT	1002670	> 10 % *
NYSWR Corporation (4)	Railroad Bridge	431+50	New York, Susquehanna and Western Railway Corp.	N/A	10%
Oneida Street (1)	Roadway Bridge	434+00	Town of New Hartford	2255320	10%
Bleachery Avenue / Newell Lane	Roadway Bridge	471+00	Town of New Hartford	2205900	10%
Bleachery Place	Roadway Bridge	479+50	Town of New Hartford	N/A	10%
Elm Street	Roadway Bridge	507+50	Town of New Hartford	2205890	10%
NYSWR Corporation (6)	Railroad Bridge	516+24	New York, Susquehanna and Western Railway Corp.	N/A	10%
Pinnacle Road (CR-9)	Roadway Bridge	612+50	Oneida County	3310890	> 10 % *
Holman City Road	Roadway Bridge	673+20	Town of Paris	2205920	2%
Oneida Street (3)	Roadway Bridge	773+70	Village of Clayville	2263310	2%
Wiremill Place	Roadway Bridge	795+00	Village of Clayville	N/A	> 10 % *
NY-8 (3)	Roadway Bridge	822+30	NYSDOT	1004590	10%
NY-8 (4)	Roadway Bridge	840+00	NYSDOT	1004580	10%
NY-8 (5)	Roadway Bridge	888+30	NYSDOT	1073890	10%
Summit Road	Roadway Bridge	901+00	Oneida County	N/A	10%

* The FEMA FIS flood profiles only provide data for the 10, 2, 1 and 0.2% annual chance flood levels. Any value of "> 10 %" indicates that the structure cannot pass a 10, 2, 1 and 0.2% annual chance flood event (i.e. the 10, 2, 1 and 0.2% annual chance flood profile lines overtop the structure).

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

Bankfull discharge is defined as the flow that reaches the transition between the channel and its flood plain. Bankfull discharge is considered to be the most effective flow for moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphological characteristics of channels (Mulvihill et al. 2009). The bankfull width and depth of Sauquoit Creek is important in understanding the distribution of available energy within the stream channel and the ability of various discharges occurring within the channel to erode, deposit, and move sediment (Rosgen and Silvey 1996). Infrastructure where the bankfull width upstream of the structure exceeds the structure's length are particularly vulnerable to scour and bank de-stabilization. The high-risk hydraulic capacity infrastructure where the bankfull width exceeds the structure's length along Sauquoit Creek are listed in Table 14.

Table 14. USGS *StreamStats* Estimated Bankfull Discharge, Width, and Depth at Waterway Crossings

Source: FEMA 2013a					
Roadway Crossing	**River Station (ft)**	**Structure Length (ft)**	**Bankfull Width (ft)**	**Bankfull Depth (ft)**	**Bankfull Discharge (cfs)**
NY-69 / Oriskany Boulevard	88+50	78	85.4	3.79	1,520
Clinton Street	182+50	78	76.1	3.45	1,230
Genesee Street	271+50	70	73.4	3.35	1,140
Bleachery Avenue / Newell Lane	471+00	50	62.5	2.93	842
Pinnacle Road (CR-9)	612+50	49	55.1	2.64	661
Holman City Road	673+20	32	49.9	2.43	558
NY-8 (2)	692+00	36	45	2.23	450
Oneida Street (2)	755+50	27	42.1	2.11	396
Oneida Street (3)	773+70	38	41.8	2.1	391
NY-8 (5)	888+30	27	36.8	1.88	306

Even though these structures may have hydraulic capacity restraints, for any structures owned and maintained by the NYSDOT, a balance between physical constraints and cost versus benefit of replacing existing bridges is often necessary in order to meet NYSDOT bridge design specifications or any future guidelines.

Section 3: Sediment Characteristics in Streams

Sediment and Debris Transport in Streams

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

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

Sauquoit Creek, similar to most streams in New York, possesses a strong seasonal discharge cycle with spring discharge volumes typically many times larger than those of late summer and autumn flows. Intense or prolonged rainfall events can also generate flood pulses of hourly to daily duration, which often have significant turbulent energy. In addition, sediment transport capacity is related to discharge where high flows have significantly greater transport energy than low flows. The movement of sediments varies with time for most stream systems. As a result, the majority of sediment flux over a given year may occur over a relatively short period of time, such as during a single flood event. Between such events, sediments are typically stored within the stream or river channel (USEPA 2009a). Figure 10 is an illustration of an idealized stream profile from headwaters downslope through the channel network showing general distribution of channel types and controls on channel processes (Montgomery and Buffington 1997).

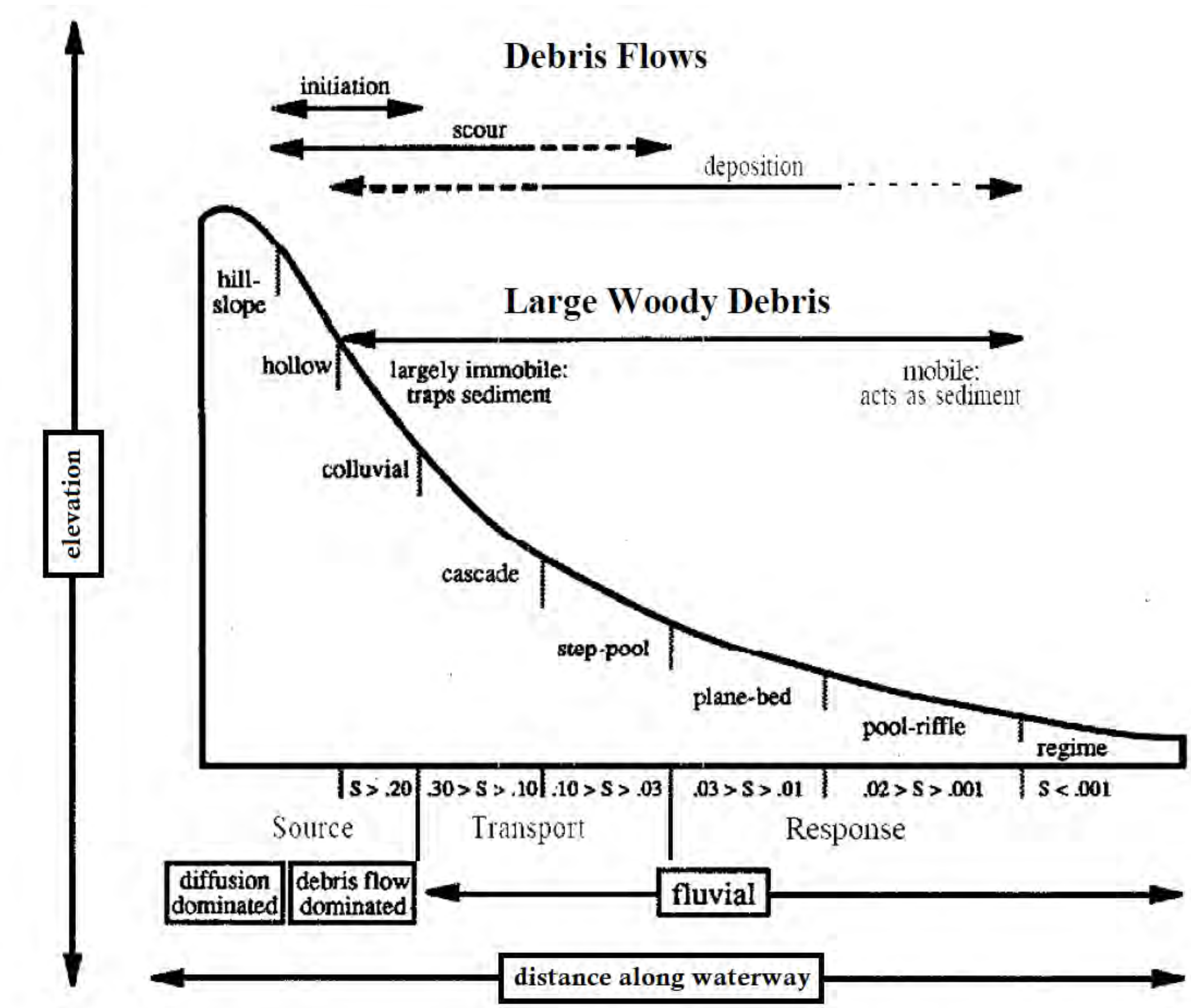

Figure 10. Idealized long profile showing the general distribution of alluvial channel types and controls on channel processes (adapted from Montgomery and Buffington 1997).

Erosion and deposition of sediments within a stream network also exhibits spatial patterns strongly related to stream morphology (i.e. erosion on the outside bend and deposition on the inside bend of a meander). Reaches with smaller cross-sectional flow area, steeper slopes, and higher flow velocities discourage the deposition of sediments. These traits tend to be characteristic of smaller streams or in the upper elevation catchments often at the headwaters of larger watersheds, such as Sauquoit Creek. By contrast, the lower reaches of Sauquoit Creek exhibit a wider channel with lower bed slopes and flow velocities, which act as regions of relative sediment deposition. Channel bottoms tend to be covered with finer sediments with some areas containing exposed rocks, boulders, and gravels in the channel beds of higher energy sections of the Sauquoit Creek. Natural sediment deposition is more characteristic of channels at lower elevations in a watershed (USEPA 2009a).

Hydraulic and geomorphologic (i.e. stream formation, floodplain characteristics, etc.) variables provide one set of controls on sediment transport capacity. Sediment transport is also regulated by the rate and quality of sediment supply (Julien 1995). Sediment supply can outpace, match, or fall below the ability of a channel to transport it. 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. Channels whose sediment supplies outpace their transport capacity will accumulate sediments. The size of a channel can decrease as sediments accumulate, increasing the likelihood of flooding and other overbank flow events. Channels with sediment supplies falling below transport capacity will work to mobilize additional material from channel beds and banks. In all streams, sediments are preferentially deposited in regions of low-energy flow, including pools and the inside of bends (Chapra 1997). If sufficient quantities of sediment are deposited, the deposition features can alter channel morphology and flow patterns, obstruct flow, and exacerbate flood events (USEPA 2009a).

Individual sediment deposits are often not permanent features since they can be scoured and moved downstream during major flow events. Streams can also flow outside their normal channels during major flow events and deposit sediments on low-lying areas adjacent to the channel such as banks, floodplains, and terraces. These sediments, in addition to lose debris, may at a later time be remobilized during an even larger flow event (USEPA 2009a).

Velocity

Flowing water is a very important mechanism for erosion, transportation and deposition of sediments. Water flow in a stream is primarily related to the stream's friction slope, but it is also controlled by the geometry of the stream channel. Water flow velocity is decreased by friction along the stream bed, so it is slowest at the bottom and edges and fastest near the surface and in the middle. In addition, the velocity just below the surface is typically a little higher than right at the surface because of weak friction between the water and the air. On a meandering section of a stream (i.e. bend), flow is fastest on the outside of the bend and slowest on the inside of the bend, which creates a secondary flow that rotates in a counter-clockwise direction. This secondary current erodes and re-suspends sediments on the creek bed and carries the suspended sediments towards the inside of the bend depositing them in the lower velocity zone near the interior bend of the meander (Figure 11).

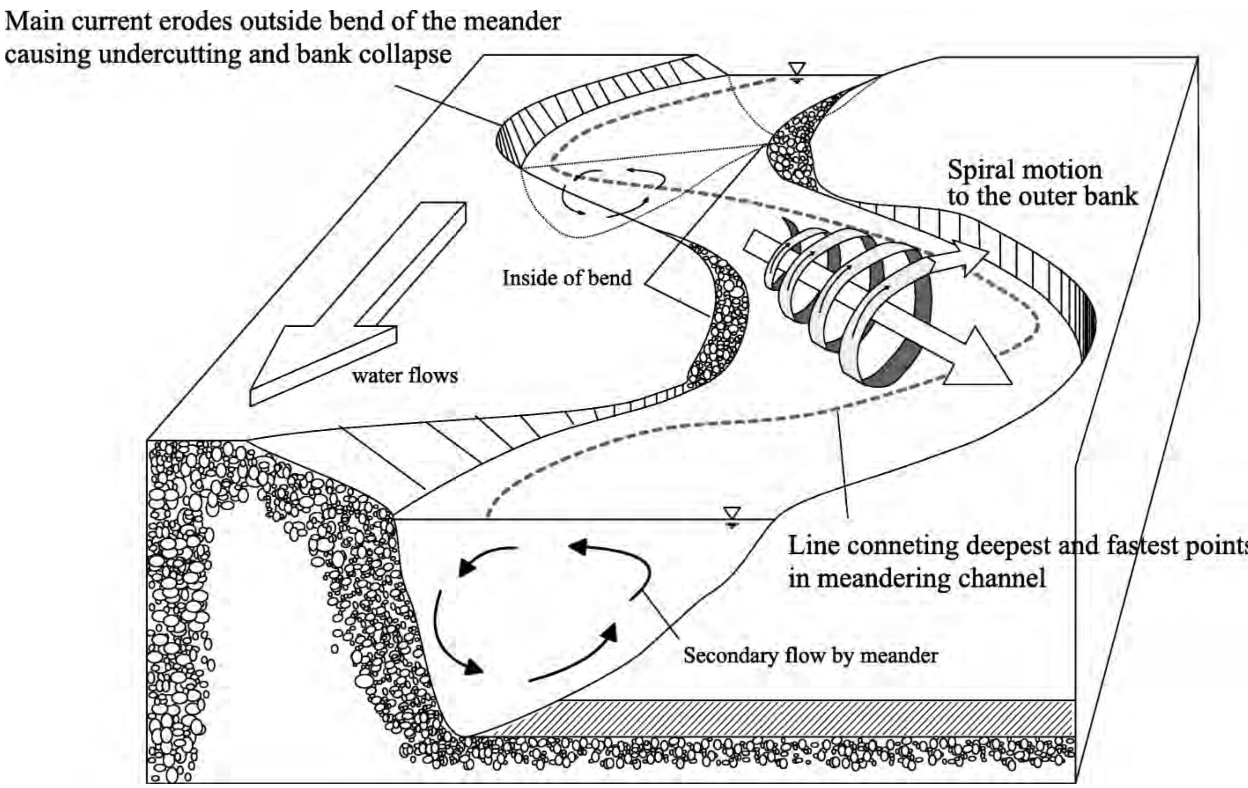

Figure 11. The variation of flow through a stream meander with secondary circulations and erosional and depositional zones (Park and Ahn 2019).

Other factors that affect stream-water velocity are the size of sediments on the stream bed and the discharge, or volume, of water passing a point in a unit of time. Smaller particles may rest on the stream bed where they can be moved by saltation and traction or they can also be held in suspension in the flowing water, especially at higher velocities. Streams that flow fast tend to be turbulent (e.g. flow paths are chaotic and the water surface appears rough) and the water may be muddy, while those that flow more slowly tend to have laminar flow (e.g. straight-line flow and a smooth water surface) and clear water. Turbulent flow is more effective than laminar flow at keeping sediments in suspension and transporting suspended sediments downstream. Figure 12 displays the Hjulström-Sundborg diagram, which shows the relationships between particle size and the tendency to be eroded, transported, or deposited at different current velocities (Earle 2019).

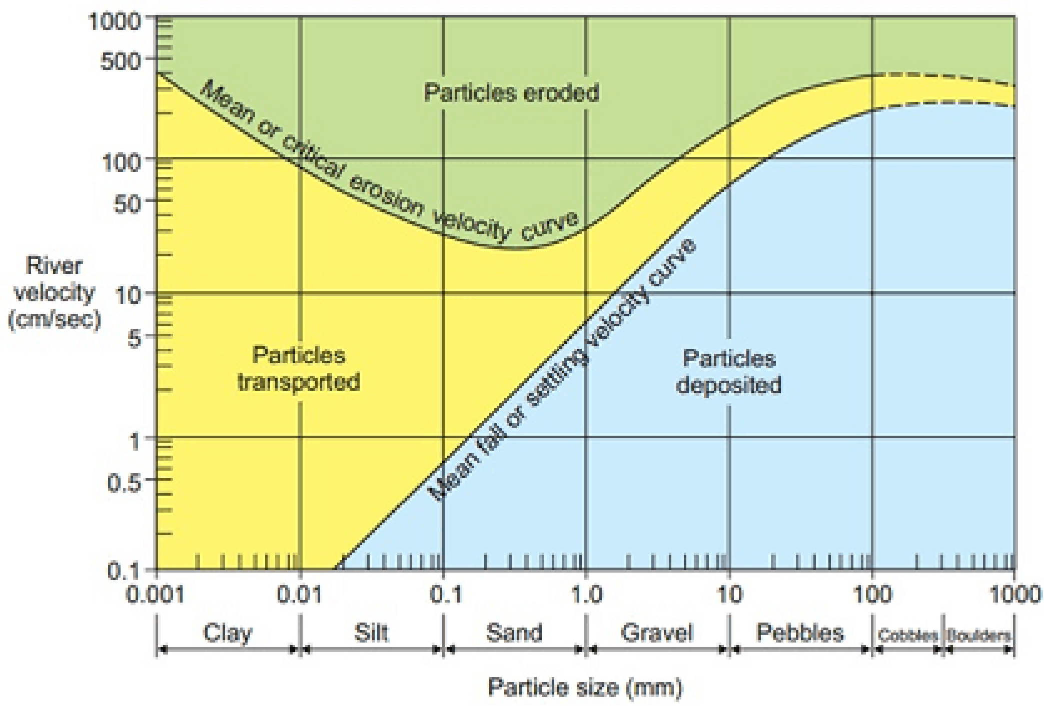

Figure 12. The Hjulström-Sundborg diagram, which illustrates the relationship between particle size (mm) and river velocity (cm/sec) to evaluate whether sediment will be eroded, transported, or deposited in a given waterway (Earle 2019).

A stream typically reaches its greatest velocity when it is close to flooding over its banks, known as the bank-full stage. As soon as the flooding stream overtops its banks and occupies the wide area of its flood plain, the water has a much larger area to flow through and the velocity drops significantly. At this point, sediment that was being carried by the high-velocity water is deposited near the edge of the channel, forming a natural bank or levee (Earle 2019).

The composition of the channel should be considered in any flood mitigation strategy that proposes to modify the channel lining of any waterway. Channelization, which is a method of river engineering that widens or deepens rivers to increase the capacity for flow volume, often includes altering the composition of the channel gradation. When determining the channel lining material, numerous channel design factors should be analyzed, including the terrain, bathymetry, channel slope, bed gradation, allowable velocity, and maximum shear stress of the lining materials. Figure 13 depicts the erosion resistance of various channel lining materials by showing the effects of flow duration and allowable velocity (NRCS 2007).

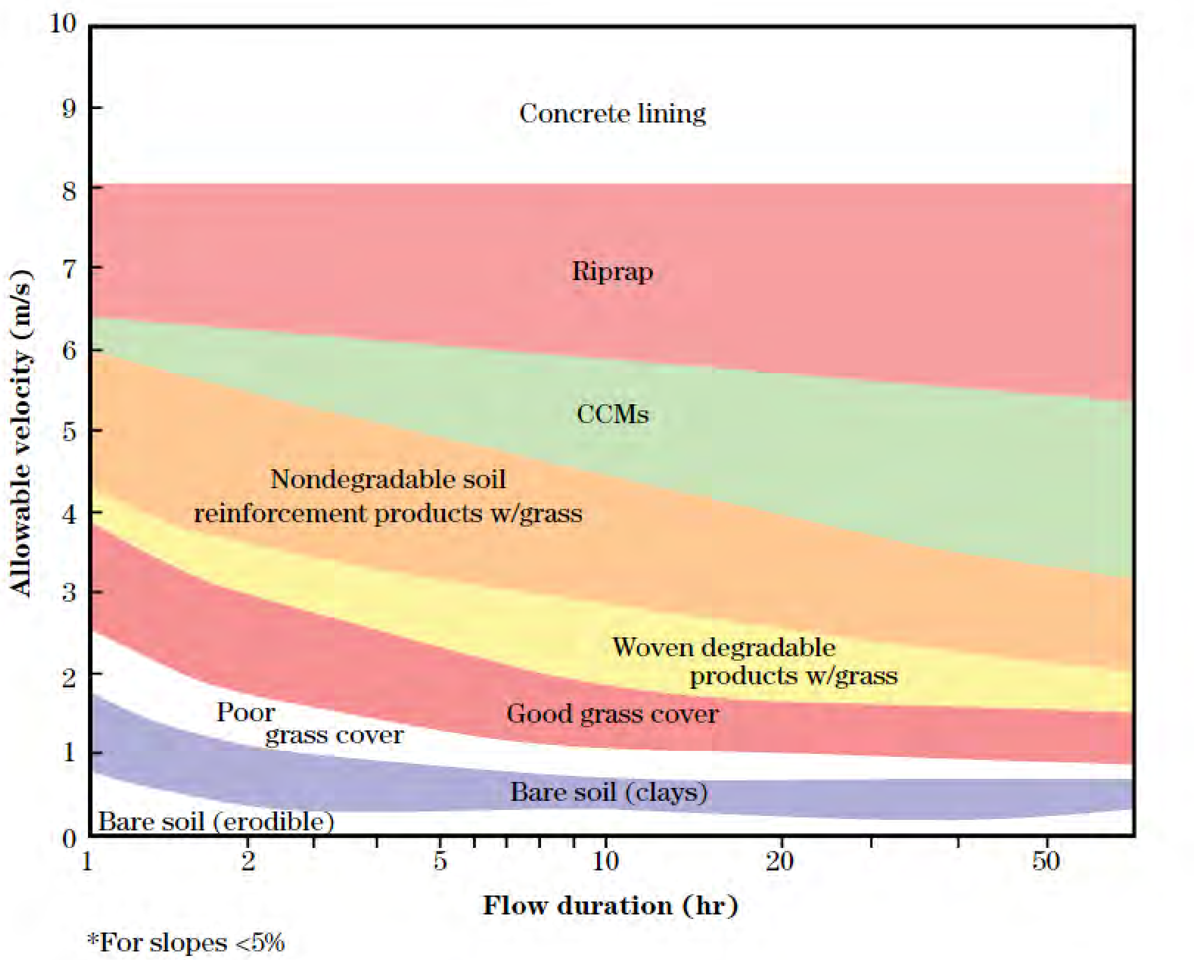

Figure 13. Effect of flow duration on allowable velocities for various channel linings (NRCS 2007).

In addition, the ecological effects of channel modifications should be considered as well. For example, concrete lining removes the typical pool-riffle sequences, and riprap placement severs the organic material input into a waterway, both of which are vital for fish habitats. It should be noted that channelization as a sediment and debris management or flood mitigation measure does not correct the root cause of the issues, but simply passes the issue downstream.

Shear Stress

Shear stress is the parameter often used as a measure of the stream's ability to entrain bed material, which is created by the friction from water acting on the bed material. Generally, shear stress acts in the direction of the flow in a uniform channel as it slides along the channel bed and banks. Within a natural stream channel, shear stress is spatially distributed and is necessary to evaluate many important hydraulic characteristics, such as bed roughness, sediment and non-mixing pollutant transport, riverbank stability, flood defense and river management. Calculating the shear stress in natural streams and rivers is difficult and expensive due to the multiple parameters and data necessary, such as the bathymetry of the channel, secondary flow areas, physical characteristics of cohesive and non-cohesive soil constituents, etc. (Ardıçlıoğlu et al. 2011; VTANR 2004).

A given particle will move only when the shear stress acting on it is greater than the resistance of the particle to movement. The magnitude of shear stress required to move a given particle is known as the critical shear stress, which is typically quantified by the Shield's critical stress value. When the shear stress equals the critical shear stress, the channel will likely be in equilibrium. Where shear stress is excessively greater than critical shear stress, channel degradation will likely result. Where the shear stress is less than critical shear stress, channel aggradation will likely result. Thus, the ability to calculate or measure both shear and critical shear stress is crucial in understanding channel adjustments (VTANR 2004).

The resistance of the particles to movement and thus its entrainment will vary depending on its size, shape, its size relative to surrounding particles, how it is oriented and the degree to which it is embedded. The size of the particle will influence the weight of the particle, while the shape will influence the flow pattern and resistance around the particle. The size of the particles relative to surrounding particles will affect the amount of shear stress the particle is exposed to via the "hiding" factor. Orientation of the particle will affect the force required to roll the particle along the bed. Packing or embeddedness will affect the amount of shear stress that the particle is exposed to (VTANR 2004).

The "hiding" affect may be the primary factor in determining critical shear stress due to turbulence within the water column. Turbulence can result in shear stress spikes that are four times greater than the average shear stress. Thus, a particle exposed to turbulence will experience greater fluid force than a particle not exposed to the turbulence (VTANR 2004).

Invert Change

The term "invert" refers to the lowest elevation of a cross-section and, in the context of this study, the cross-sections are derived from the 1-D H&H model for Sauquoit Creek. The invert change is defined as the total change in the lowest elevation of a cross-section over a model simulation run (i.e. a time-series simulation). Change in the invert elevation is determined by calculating the difference between the lowest station-elevation point between the bank stations of a given cross-section over the simulation time interval. The units of the invert change output variable is a vertical distance given in feet or meters (USACE [date unknown]).

Invert changes are used to identify areas of deposition and erosion along a cross-section. When the invert change is positive, deposition has occurred since the elevation has increased over the model simulation run. In contrast, if the invert change is negative, then erosion has occurred since the elevation has decreased over the model simulation run. Figure 14 is a representative diagram from a 1-D H&H model simulation displaying a cross section view with deposition occurring in the overbank and erosion occurring in the stream channel over a 10-hour time period.

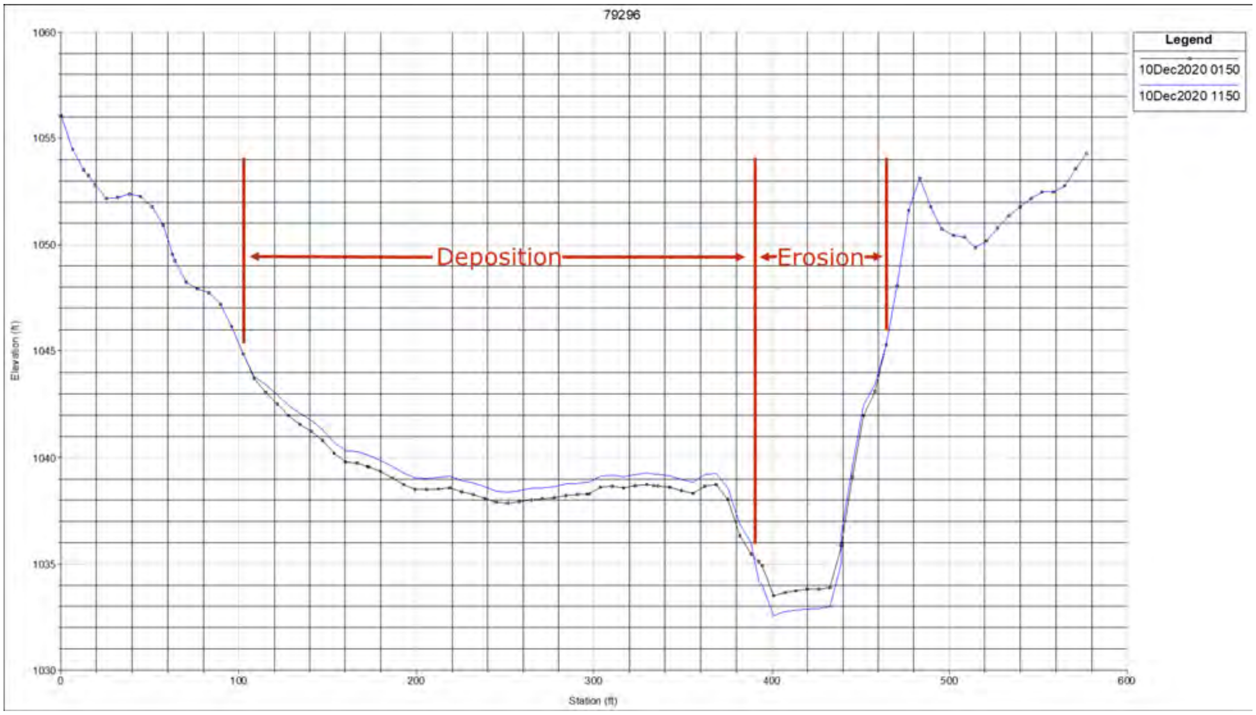

Figure 14. Representative HEC-RAS 1-D sediment transport output for invert change in cross section view.

Mass Bed Load

In most waterways, channel geometry is influenced not only by the flow of water, but by the sediment transported by the water. When the flow discharge changes, the sediment transport changes and, in turn, the channel geometry usually changes. This channel geometry change can then influence changes in the stage, which results in further changes in sediment transport (USGS 2010).

Sediment transport is divided into bed-material load (i.e. bed load) and wash load. The bed load is defined as that part of the sediment in transport whose sizes are found predominantly in the bed. Bed load is further divided into the categories of suspended bed-material load and bed load. Bed load is difficult to measure, especially by direct measurement. Bed load is highly variable in space and time across natural rivers, thus any sampling scheme must take this into account (USGS 2010).

In H&H models, mass bed load can be determined as an incremental or cumulative change for a given cross section over time. Mass bed load is determined by calculating the difference in the mass in the bed between two consecutive time steps for a given cross section. Mass bed load can be used as an indicator of sediment deposition or erosion. When the mass bed load value is positive, there is a greater influx of mass (i.e. mass in is larger than mass out) and deposition is most likely to occur. In contrast, when the mass bed load value is negative, there is a greater outflux of mass (i.e. mass out is larger than mass in) and erosion is most likely to occur. Figure 15 is a representative diagram of how mass bed changes in profile view (USACE [date unknown]).

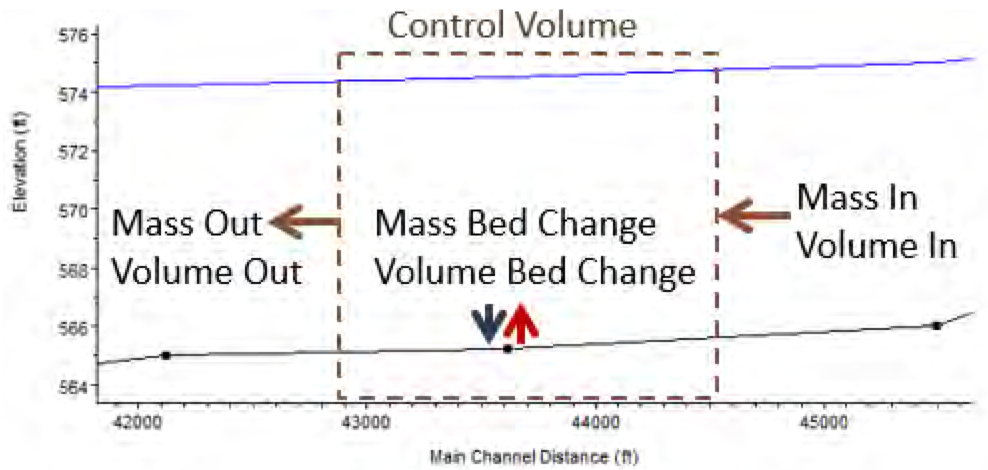

Figure 15. Representative diagram for mass and volume bed change in profile view.

Section 4: Watershed Assessment Methodology

Data Collection

A series of virtual project meetings were held in April 2020, with representatives of Ramboll Americas Engineering Solutions, Inc. (Ramboll) and the Village of New York Mills, Village of Whitesboro, City of Utica, and the Town of Paris (Appendix C). At the meetings, project specifics including background, purpose, funding, roles, and timelines were discussed. Discussions involved a variety of topics, including:

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

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

Hydrological and meteorological data were obtained from readily available state and federal government databases, including orthoimagery, flood zone maps, streamflow, precipitation, and flooding and ice jam reports. Historical flood reports, newspaper articles, social media posts, stakeholder engagement meeting notes, and geographic information system (GIS) mapping were used to identify flooding and sediment concerns, produce watershed maps, and identify current high-risk areas.

Existing hydrologic and hydraulic (H&H) models were obtained from FEMA, state, and local municipalities that have performed flood mitigation or risk studies as a part of prior construction and engineering projects. Included in the current effective county wide FEMA FIS report, H&H models were developed and / or updated as part of the FIS reports for the Town of Whitestown in 2000, New Hartford in 1982, Paris in 1983, and the Villages of Whitesboro and New York Mills in 2000. These H&H models were created using the United States Army Corps of Engineers (USACE) Hydrologic Engineering

Center's River Analysis System (HEC-RAS) software program to predict water stage at potential future high-risk areas, and to evaluate the effectiveness of flood mitigation strategies.

In addition, survey data for multiple flood mitigation and infrastructure improvement projects were obtained along Sauquoit Creek and used to inform and update H&H modeling efforts for this study. The available survey data included the Phase I and Phase II of the Whitestown Sauquoit Creek Channel and Floodplain Restoration Capital Project, and NYSDOT survey data for infrastructure improvement projects in the Town of New Hartford (Ramboll 2020c). Also included in this study is data and work done in the 2014 Milone and MacBroom, Inc. report (MMI 2014). These studies were obtained and used, all or in part, as part of this effort.

Following the data gathering and project meetings, field staff from Ramboll undertook field data collection efforts with special attention given to high-risk areas along Sauquoit Creek as identified in the data collection process. Initial field assessments of Sauquoit Creek were conducted November 5-6, 2020. 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

Appendix D is a summary listing of data and reports collected. Included in Appendix E 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 F is a Photo Log of select locations within the river corridor. The collected field data was categorized, summarized, indexed, and geographically located within a GIS database. This GIS database will be made available to the NYSDEC upon completion of the project.

Flood Mitigation Analysis (Hydraulic Modeling)

Hydraulic analysis of Sauquoit Creek was conducted using the HEC-RAS program. 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. HEC-RAS version 5.0.7 was used for this study (USACE 2019).

The model is used to compute water surface profiles for one and two-dimensional, steady-state, or time-varied (unsteady) flow. In one-dimensional solutions, the water surface profiles are computed from one cross section to the next by solving the one-dimensional St. Venant equation with an iterative procedure (i.e., standard step backwater method). Energy losses are evaluated by friction (Manning's Equation) and the contraction / expansion of flow through the channel. The momentum equation is used in situations where the water surface profile is rapidly varied, such as hydraulic jumps, mixed-flow regime calculations, hydraulics of dams and bridges, and evaluating profiles at a river confluence (USACE 2016a).

A 1-D HEC-RAS base condition model was developed for this study using the following data and software:

- Oneida County, New York 2-meter LiDAR DEM data with an exposed ground vertical accuracy of 0.6-ft (NYSDEC 2008)
- New York State Digital Orthoimagery Program imagery for Oneida County (NYSOITS 2017)
- National Land Cover Database (NLCD) data (USGS 2019)
- RAS Mapper extension in the HEC-RAS v5.0.7 software (USACE 2019)
- ESRI ArcMap 10.7 with the HEC-GeoRAS extension GIS software (ESRI 2019)

Using the LiDAR DEM data, orthoimagery, land cover data, and the RAS Mapper extension in the HEC-RAS software, the 1-D HEC-RAS base condition model was developed using the following methodology:

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

The base condition model water surface elevation results were then compared to the FEMA FIS water surface profiles, past flood events with known water surface elevations, and the effective FEMA FIS elevation profiles to validate the model. After the base condition model was verified, it was then used in the assessment of flood and sediment management strategies discussed within this report.

Sediment Transport Analysis (Hydraulic Modeling)

HEC-RAS 1-D sediment transport computations follow the capability of the USACE legacy sediment transport model, HEC-6, very closely. HEC-6 is a 1-D moveable boundary open-channel flow and sediment movement model designed to simulate changes in river profiles due to scour and deposition over fairly long time periods (typically years, but single flood event applications are possible). HEC-RAS expands capabilities beyond HEC-6 by incorporating two important developments: coupling the sediment transport engine with the unsteady flow model, and adding lateral bank failure and toe scour capabilities by coupling the vertical bed change model with the USDA-ARS Bank Scour and Toe Erosion Model (BSTEM). The sediment transport functions in HEC-RAS compute a transport capacity for each cross section based on they hydrodynamic results (e.g., shear stress, shear velocity, friction slope, velocity, fall velocity, etc.) of the channel (USACE 1995; Gibson et al. 2017).

For this study, four sediment transport simulations were performed using quasi-unsteady flow for three different annual chance flood events (50, 10 and 1%) and historical data from the 2019 Halloween Storm. Sediment data was obtained from field survey data and incorporated into the sediment transport model to assign grain sizes, bed gradation, and sediment load boundary conditions. The output results for four variables (invert change, velocity, shear stress, and cumulative mass bed change) were used to assess erosional or depositional characteristics at specific reaches along Sauquoit Creek.

Cost Estimate Analysis

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

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

For mitigation alternatives where increases in infrastructure were evaluated, site constraints and constructability were not initially taken into consideration. Cost estimates were performed based on projects determined to be constructible and practical.

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

Section 5: Planning and Mitigation Strategies

The Sauquoit Creek Sediment and Debris Management Plan should be a fluid document that incorporates the input and vision of all interested parties, including stakeholders, local and state officials, environmental groups, etc. The management plan should include a watershed planning process to help define the current goals and objectives, but also the future direction for the watershed. Figure 16 depicts general guidelines for developing, assessing, and revising watershed management strategies (HOCCPP 1997).

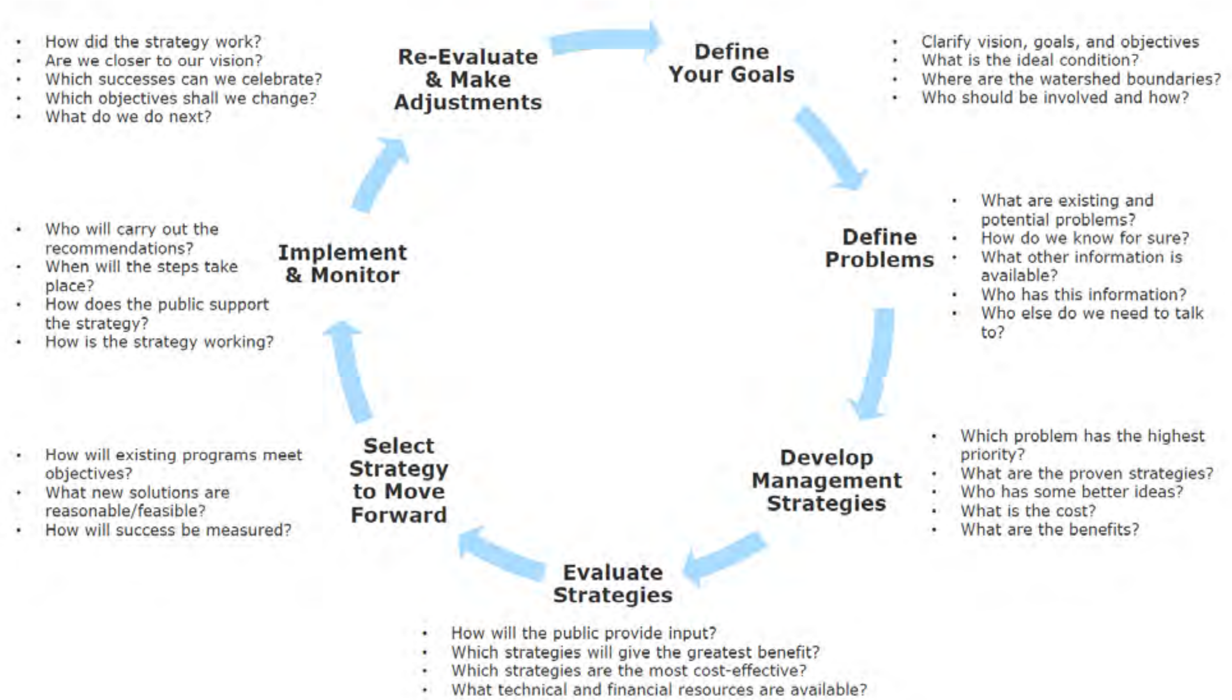

Figure 16. Sauquoit Creek Sediment and Debris Management Planning Process.

Effective, systematic, and institutionalized control of development activities is a key component of any plan to address water resource issues. In addition, each management strategy should be evaluated based on both its local and watershed-wide impacts.

The contemporary flood management strategy should address the problem of flooding by considering the best mix of flood management options available, selected among both the structural works and nonstructural measures. It should be based on an integrated and environmentally sustainable approach, which addresses fully all aspects of flood occurrence in the watershed basin.

Institutional and Regulatory Framework

Concerns about regulatory controls and institutional arrangements in the Sauquoit Creek watershed tend to fall into one of five categories relating to: master planning, regulation, financing, technical guidance for decision making, and an institutional framework or centralized managing entity that fosters a basin-wide approach to decision making (HOCCPP 1997).

(1) Master Planning: the general belief that development must be accomplished in concert with transportation, environmental, and economic planning on both a regional and local level.

(2) Regulation: institutional issues relating to regulatory concerns within the basin focus on the complexity of some regulations, the lack of certain regulations, ineffective methods of enforcement, and the lack of uniformity. A need to transition from reactive (i.e. penalties to encourage compliance) to preemptive / proactive (i.e. using education and volunteerism to encourage compliance) and to promote consistent, community-to-community regulatory controls throughout the entire basin.

(3) Financing: commonly identified as the major obstacle which prevents the implementation of many solutions and management practices. Education and further financial analysis of specific circumstances may be beneficial to illustrate a more favorable cost / benefit ratio that encourages the implementation of best management practices.

(4) Technical Guidance for Decision Making: a general need to use more accurate and appropriate sources of technical information when making land-use decisions in the watershed based on the most up-to-date scientific techniques, data, and technologies and using effective educational tools to provide the best possible technical guidance for decision making.

(5) Institutional Framework: establishment of a framework or mechanism that allows issues to be addressed based on the "good of the many" and the watershed as a whole. Basin communities will need to decide what administrative vehicle is most appropriate to address watershed issues, to determine how to best use available technical information, and how to guide land use decisions in the watershed (HOCCPP 1997).

Permitting Requirements

Stream restoration and design activities are subject to various Federal, state, and local regulatory programs. Most of these regulations are aimed at protecting natural resources and the integrity of the Nation's water resources. Designers should be aware of project permitting requirements and develop a project plan and budget identifying resources and project approaches that meet permit conditions. Depending on the type of project and its location, these can range from minimal to a full set of required Federal, state, and local permits. The applicable programs and permits can include (NRCS 2007):

- National Environmental Policy Act
- Endangered Species Act
- National Historic Preservation Act
- Wild and Scenic Rivers Act
- Fish and Wildlife Coordination Act
- Clean Water Act
- Rivers and Harbors Act of 1899
- Magnuson-Stevens Fishery Conservation and Management Act
- Local and state water quality permits
- Water rights
- National Flood Insurance Program (NFIP)
- Local and state flood permits
- Local zoning permits

Permitting agencies should be approached as soon as conceptual plans are developed. In regulatory-intensive areas, as well as in areas of high environmental risk, it may be advisable to consult with them in the early planning stages. In general, designers and planners should provide at least the following to the permitting agency (NRCS 2007):

- Site map
- Description of existing environmental conditions (written and maps, photos, drawings)
- Description of the proposed work (written and drawings)
- Property ownership
- Access and staging information
- Preferred times of implementation

Each state has individual statutes and codes that provide the legal framework for developing and managing water resource-related projects. A variety of permits are required to work within rivers, streams, and / or wetlands. State fish and wildlife agencies and land management agencies are the typical implementing agency. Local permit requirements should be fully identified when developing project plans, designs, and construction specifications. Prior to initiation of any in-stream activities, the NYSDEC should be contacted, and appropriate local, state, and federal permitting should be obtained (NRCS 2007).

Management and Mitigation Strategies

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

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

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

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

There are two types of engineering strategies to sediment and debris management and flood mitigation: structural and non-structural. Structural adjustments involve two different approaches: hard and soft structures. Hard engineering strategies act as a barrier between the river and the surrounding land where artificial structures are used to change or disrupt natural processes. Soft engineering does not involve building artificial structures, but takes a more sustainable and natural approach to managing the potential for erosion, deposition, and flooding by enhancing or protecting a river's natural features (NRC 2013).

Examples of hard engineering strategies include (NRC 2013):

- Dams (new construction or restoration)
- Pump Stations
- Engineered Drainage Systems
- Increase Bridge & Culvert Openings
- Levees
- Floodways, Spillways, and Channels

Examples of soft engineering strategies include (USACE 2002; NRCS 2002a; NRC 2013):

- Flood Benches
- Streambank Stabilization and Protection
    - Live willow staking with some biodegradable soil stabilization
    - Vegetated Coir Roles
    - Burlap tiers
    - Rootwads with boulders
    - Riprap with live stakes
    - Live Fascines
    - Slope softening and vegetation
    - Hardwood tree planting
    - Brush layers

- Sediment Detention Basin / Retention Ponds
- Removal of Debris / Loose Vegetation from Floodplain
- In-channel Obstruction / Barrier Removal (i.e. dams, large debris, etc.)
- Sediment Removal

The purpose of non-structural flood mitigation is to change the way that people interact with the floodplain, flood risk, and also aims to move people away from flood-prone areas. Non-structural flood damage reduction measures have historically not been generally desired by the public and therefore, have not been utilized to their potential extent. This attitude of the general public has been gradually changing with continued implementation of the NFIP and the increasing national interest in a more pristine environment in which to live. This change became more abrupt with the large-scale, catastrophic flooding events since the 1990s (e.g. the Great Flood of 1993 in the Mississippi River Basin, Hurricane Katrina in 2005, Superstorm Sandy in 2012, etc.). More and more communities have looked for alternatives to structural flood damage reduction techniques and instead have begun to pursue non-structural techniques used to reduce flood damages that do not disturb the environment or that 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 include (USACE 2001; NRC 2013):

- Riparian Vegetation Restoration
- Retention Basin and Wetland Management
- Soil and Watershed Promotion Legislation
- Land Use Planning / Ordinances
- Floodproofing Residential / Commercial Properties
- Flood Buyouts
- Flood Monitoring & Warning System
- Community Flood Awareness and Preparedness Programs / Education

Section 6: Sauquoit Creek Sediment and Debris Management Plan

The Sauquoit Creek watershed basin was sub-divided into eight different zones taking multiple characteristics into consideration, including streambank and in-channel hydrologic and hydraulic processes (i.e. slope, velocity, shear stress, aggregation, and degradation) and geographic and political boundaries. The zone discussions within this section are organized starting with the most upstream extent of the Sauquoit Creek study area, and moving downstream to the confluence with the Mohawk River.

Basin-wide Management Strategies

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

Large Woody Debris Removal

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 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 (NYSDEC 2013):

- 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.

Any work that will disturb the bed or banks of a protected stream (sediment 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).

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

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 Sauquoit Creek watershed. Restoration, which is defined as the process of re-establishing historical ecosystem structures and processes, is being used more often to mitigate some of the past degradation of these ecosystems (Goodwin et al. 1997).

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 both the physical and biological processes that influence natural riparian ecosystems and the types of disturbance anthropogenic modifications that have degraded 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 Sauquoit Creek 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. First, the location of the anthropogenic modification with respect to the degraded riparian area, second, whether the anthropogenic modification is ongoing or can be eliminated, and third, 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).

Sediment Retention Basin

Sediment retention basins could be established to reduce watercourse and gully erosion, trap sediment, reduce and manage runoff near and downstream of the basin, and to improve downstream water quality. A sediment control basin is an earth embankment or a combination ridge and channel generally constructed across the slope and minor watercourses to form a sediment trap and water detention basin (Figure 17). The basin should be configured to enhance sediment deposition by using flow deflectors, inlet and outlet selection, or by adjusting the length to width ratio of the creek channel. Additional hydrologic and hydraulic studies should be performed to identify the optimal locations for the sediment control basins. Operation and maintenance costs to maintain the embankment, design capacity, vegetative cover, and outlet of the basin should be considered (NRCS 2002b).

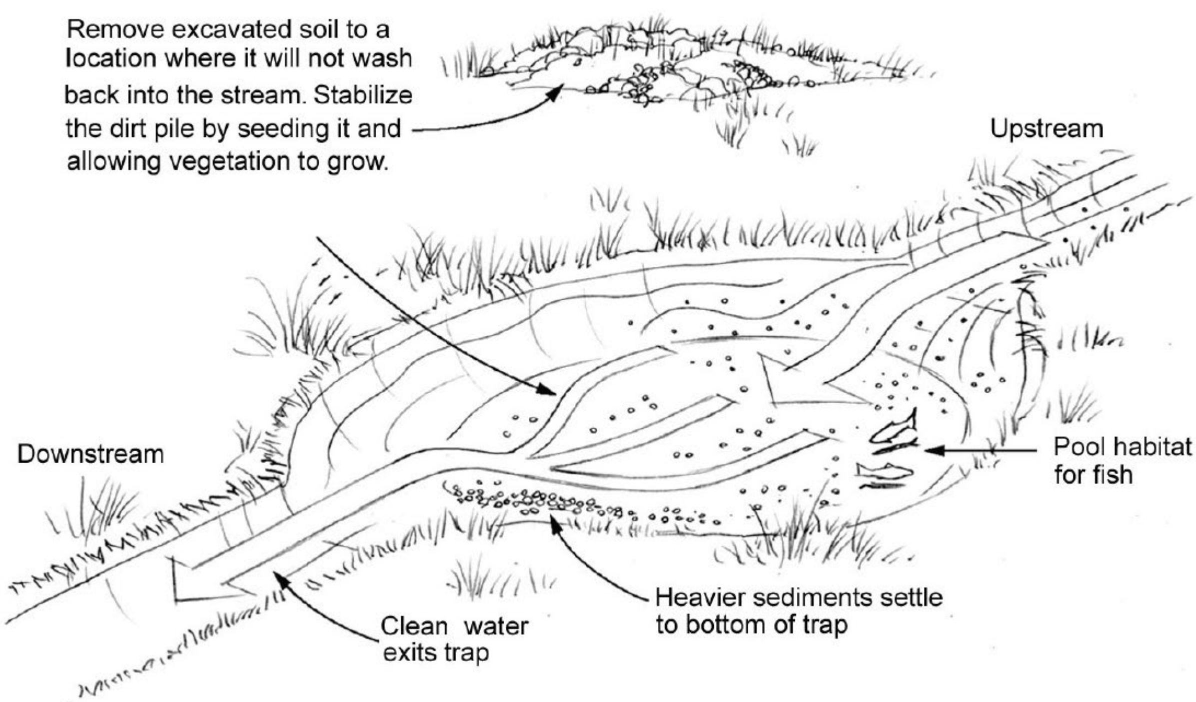

Figure 17. Representative diagram of an in-stream sediment retention pond (WCD 2009).

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.

Retention Basin and Wetland Management

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

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

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

- Sediment accumulates reducing the storage volume
- Debris blocks the outlet structure
- Pipes or the riser are damaged
- Invasive plants take over the planted vegetation
- Slope stabilizing vegetation is lost

- The structural integrity of the embankment, weir, or riser is compromised

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

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

Flood Monitoring and Warning System

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

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

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 a 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 costs $175,000 or less, and which are located in the 1% ACE (i.e., 100-year 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 2015a).

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 Sauquoit Creek in the highest-risk flood areas and progresses outwards from there to maximize flood damage reductions. According to FEMA property loss data, repetitive and severe repetitive loss properties are located within Zone H, so this zone should be prioritized when planning and implementing any flood buyout programs (FEMA 2019). 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.

In September of 2020, the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) in partnership with the Town of Whitestown, announced an offer of up to $20 million to buy out homes of residential property owners in the Village of Whitesboro through a Floodplain Easement Program. The deadline for applications to be considered for the buyout program was on November 13, 2020. In February of 2021, NRCS program officials confirmed the application review process was underway and ongoing and would take several months to complete. As of the writing of this report, the Floodplain Easement Program applications are still being reviewed (Ramboll 2020c).

<u>Floodproofing Residential / Commercial Properties</u>

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 2000c). Floodproofing can prevent damage to existing buildings and can be used to meet compliance requirements for new construction of residential and non-residential buildings.

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

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 2000c).

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

- Interior Modification / Retrofit Measures
    - Basement infill
    - Abandon lowest floor
    - Elevate lowest interior floor
- Dry Floodproofing
    - Passive dry floodproofing system
    - Elevation
- Wet Floodproofing
    - Flood openings
    - Elevate building utilities
    - Floodproof building utilities
    - Flood damage-resistant materials
- Barrier Measures
    - Floodwall with gates and floodwall without gates
    - Levee with gates and levee without 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 completing of any floodproofing project (FEMA 2015b):

- 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)

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.

Land Use Planning / Ordinances

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

The Halloween Storm of 2019 was not only a significant flooding event in the Sauquoit Creek watershed, but also demonstrated the impacts of development within the floodplain through the release of large amounts of sediment and debris from upstream to downstream areas, particularly in the Towns of New Hartford and Whitestown. For example, the recreational trail upstream of the Clinton Street bridge in New Hartford experienced significant streambank erosion where, in some areas, nearly 25 feet of the channel bank eroded and was washed away downstream releasing significant amounts of debris and sediment (Appendix F). This eroded material was deposited in multiple areas along the lower reaches of Sauquoit Creek, but most notably downstream of the NYSDOT facility in New Hartford, and at the flood benches of the Phase I - Sauquoit Creek Channel & Floodplain Restoration Program in Whitestown. Sediment and debris accumulations in the Phase I benches resulted in the under-performance of the benches in mitigating flood damages caused by the heavy precipitation event (Ramboll 2020c).

A watershed approach to land use 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 New York State Open Space Conservation Plan, NYSDEC's Smart Growth initiative and the Climate Smart Communities Program address land use within a watershed (NYSDEC [date unknown]). 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 Sauquoit Creek watershed.

Community Flood Awareness and Preparedness Programs / Education

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

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

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

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

Development of a Comprehensive Plan

Local governments are responsible for planning in a number of areas, including housing, transportation, water, open space, waste management, energy, and disaster preparedness. In New York State, these planning efforts can be combined into a comprehensive plan that steers investments by local governments and guides future development through zoning regulations. A comprehensive plan will guide the development of government structure as well as natural and built environment. Significant features of comprehensive planning in most communities include its foundations for land use controls for the purpose of protecting the health, safety, and general welfare of the community’s citizens. The plan will focus on immediate and long-range protection, enhancement, growth and development of a community’s assets. Materials included in the comprehensive plan will include text and graphics, including but not limited to maps, charts, studies, resolutions, reports, and other descriptive materials. Once the comprehensive plan is completed, the governing board motions to adopt it, i.e. town or village board (EFC 2015).

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

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

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

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

Zone A: Paris – Upstream

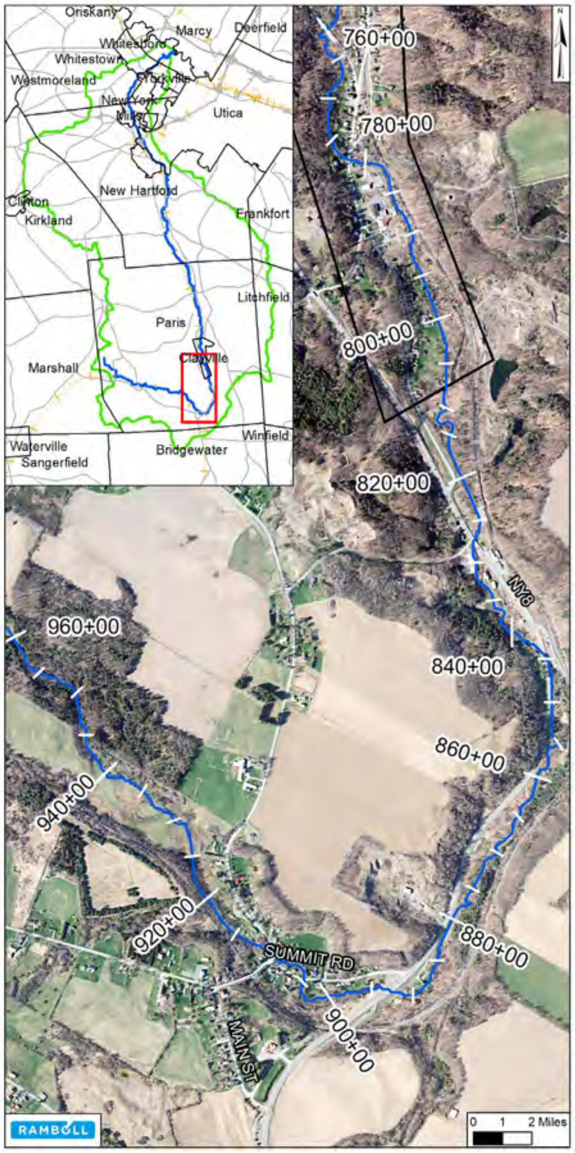

Figure 18. Location map for Zone A: Paris – Upstream.

Zone A is the most upstream reach of Sauquoit Creek assessed in this study. The zone begins around River Station (RS) 935+00 and ends near RS 805+00 at the Village of Clayville border. This reach includes five roadway crossings, including three separate crossings of NY-8, and two separate dams (Figure 18).

Flooding in this reach occurs primarily due to heavy rainfall combined with snowmelt, particularly in late winter and early spring; however, floods can be expected to occur at any time of the year. Sediment and silt build-up occurs primarily upstream of the two dams located within this reach, which are not regulatory and do not serve flood storage purposes (FEMA 1983). More specifically, the gravel bar along Sauquoit Creek in the vicinity of Summit Road has degraded over time, introducing sediment and debris into downstream areas during high flow events (Ramboll 2020c).

Based on the sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various non-structural flood damage reduction measures were analyzed for Zone B. Table 15 outlines the streambank stabilization strategies proposed for this zone. Detailed discussions of the structural engineering strategies can be found in Appendix G.

Table 15. Streambank Stabilization Strategies Proposed for Zone A

Measure Type	River Station	Description of Measure
Brush Mattresses with Riprap Toe and Hardwood Trees	806+00 to 900+00	Medium to high shear stress and low water velocity. Install Brush mattresses with riprap toe in areas experiencing heavy erosion. Install hardwood trees inland of riverbed where established shrubs or trees are not present.
Willow Stakes and Hardwood Trees	900+00 to 934+00	Low to medium shear stress and low water velocity. Place live stakes in areas with increased deposition and minimal erosion. Install hardwood trees inland of riverbed where established shrubs or trees not present.

Figure 19 displays the results of the sediment transport model simulations for Zone A for the four different annual chance flood events and the four erosional / depositional variables. Based on the sediment transport analysis, willow stakes and hardwood trees and brush mattresses with riprap toe and hardwood trees were determined to be the most appropriate streambank stabilization strategies for this reach.

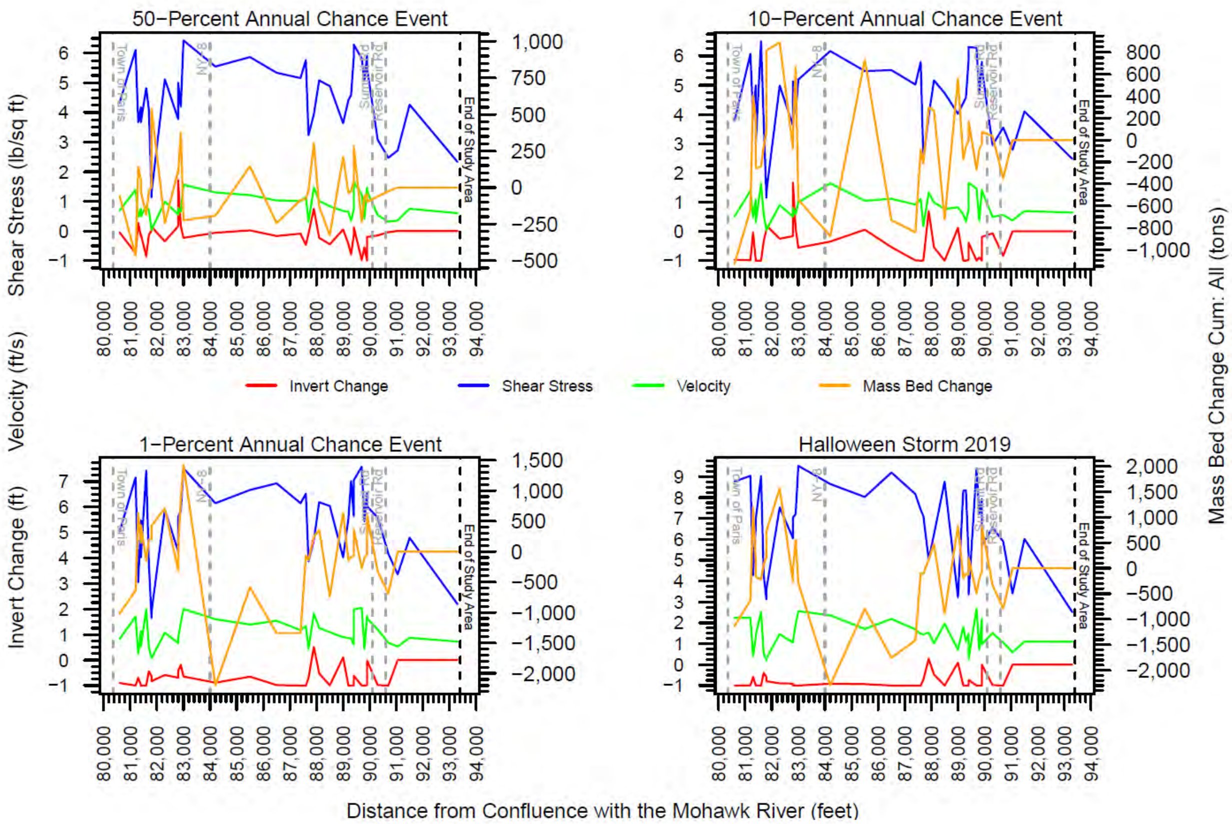

Figure 19. Analysis of invert change (ft), velocity (ft/s), shear stress (lbs./sq. ft) and cumulative mass bed change (tons) using the 1-D HEC-RAS sediment transport model for Zone A.

No structural engineering strategies were modeled and no hard structural engineering strategies are proposed for Zone A. Figure 20 displays the locations of each structural engineering strategy within Zone A.

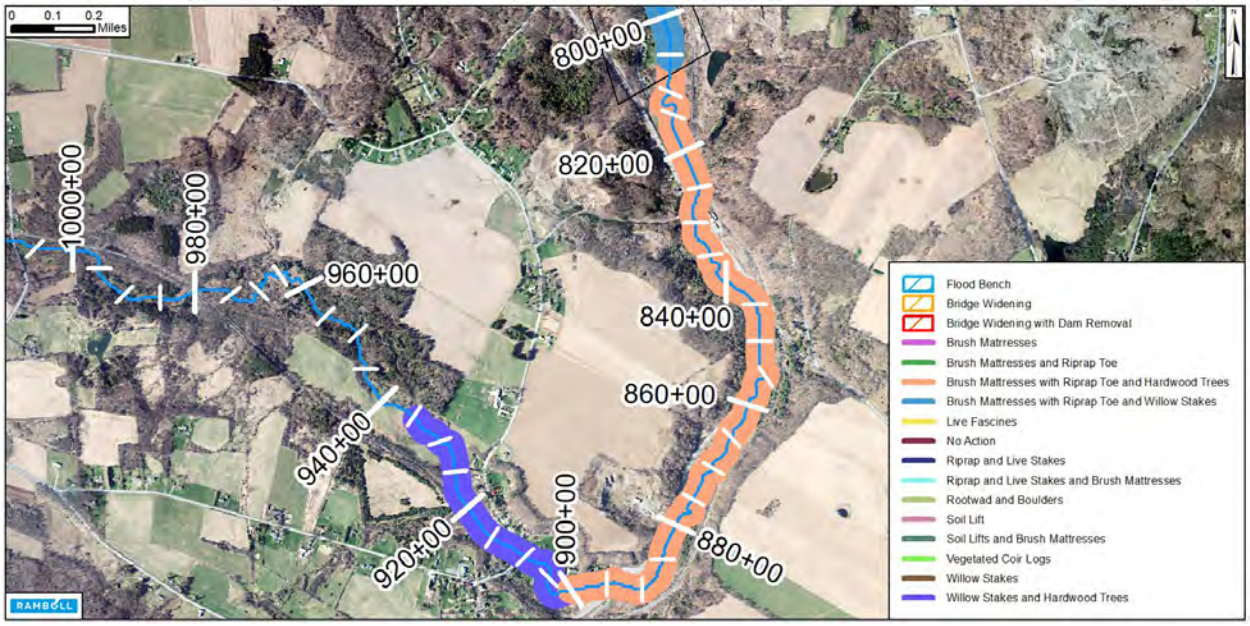

Figure 20. Locations of structural engineering strategies within Zone A.

Based on the H&H and sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various basin-wide management strategies were analyzed for Zone A.

The basin-wide management strategies proposed for this zone are:

- Large Woody Debris Removal
- Floodproofing Residential / Commercial Properties
- Land Use Planning / Ordinances
- Riparian Restoration
- Retention Basin and Wetland Management
- Community Flood Awareness and Preparedness Programs / Education
- Development of a Comprehensive Plans

In addition, due to the large proportion of agricultural lands within this zone, direct runoff from agricultural areas into ditch lines and tributaries should be evaluated and mitigation strategies developed to address each individual runoff source. For example, the removal of tile drains and / or the use of stream buffers can decrease sediment runoff into nearby waterways, thereby improving water quality and reducing sediment loads within the channel.

The Rough Order Magnitude cost for these proposed measures are outlined in Table 16 and does not include land acquisition costs for survey, appraisal, and engineering coordination.

Table 16. Rough Order Magnitude Cost for Proposed Strategies within Zone A

Measure Type	River Station	ROM Cost (U.S. dollars)
Brush Mattresses with Riprap Toe and Hardwood Trees	806+00 to 900+00	$950,000
Willow Stakes and Hardwood Trees	900+00 to 934+00	$950,000

Zone B: Paris – Clayville

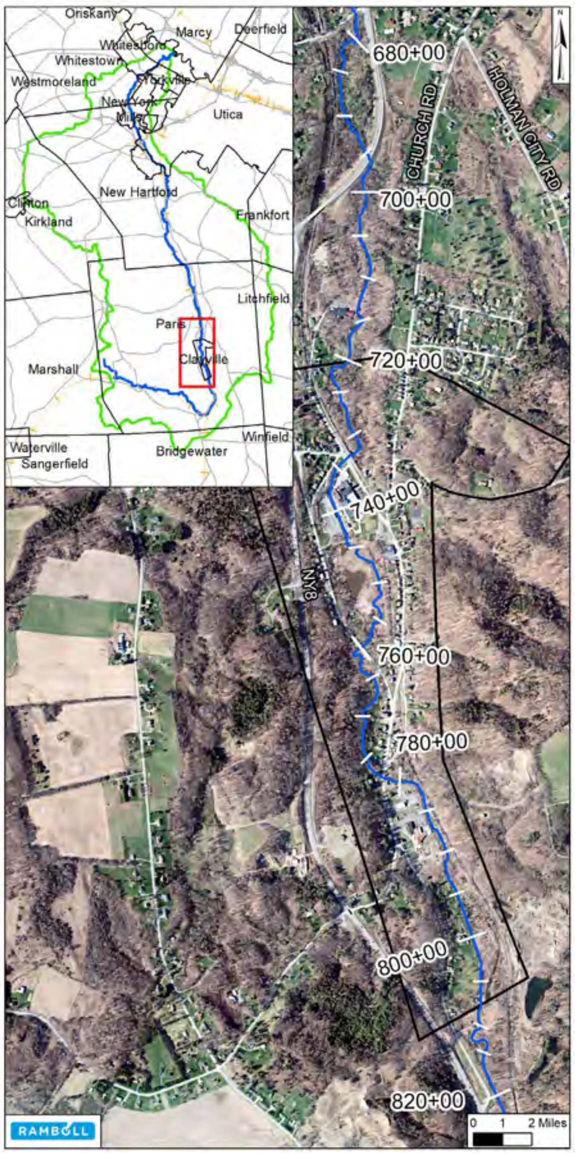

Figure 21. Location map for Zone B: Paris – Clayville.

Zone B covers the Village of Clayville starting at RS 805+00 to RS 700+00. This reach includes three roadway crossings, including Main Street and two separate crossings of Oneida Street, one railroad bridge crossing, and three separate dams (Figure 21).

Flooding in this reach occurs primarily due to heavy rainfall combined with snowmelt, particularly in late winter and early spring; however, floods can be expected to occur at any time of the year. Sediment and silt build-up occurs primarily upstream of the two dams located within this reach, which are not regulatory and do not serve flood storage purposes (FEMA 1983). In August of 2011, Hurricane Irene brought heavy rains and high winds to the region causing flash flooding along Sauquoit Creek from Village of Clayville to the Town of New Hartford (NCEI 2021).

Based on the sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various non-structural flood damage reduction measures were analyzed for Zone B. Table 17 outlines the streambank stabilization strategies proposed for this zone. Detailed discussions of the structural engineering strategy can be found in Appendix G.

Table 17. Streambank Stabilization Strategies for Zone B

Measure Type	River Station	Description of Measure
Brush Mattresses with Riprap Toe and Willow Stakes	705+00 to 728+00	Medium to high shear stress and low water velocity. Place live stakes in areas with increased deposition and minimal erosion. Install Brush mattresses with riprap toe in areas experiencing heavy erosion.
Willow Stakes	728+00 to 740+00	Low to medium shear stress and low water velocity. Place live stakes in areas with increased deposition and minimal erosion.
Brush Mattresses with Riprap Toe and Willow Stakes	740+00 to 806+00	Medium to high shear stress and low water velocity. Place live stakes in areas with increased deposition and minimal erosion. Install Brush mattresses with riprap toe in areas experiencing heavy erosion.

Figure 22 displays the results of the sediment transport model simulations for Zone B for the four different annual chance flood events and the four erosional / depositional variables. Based on the sediment transport analysis, willow stakes and brush mattresses with riprap toe and willow stakes were determined to be the most appropriate streambank stabilization strategies for this reach.

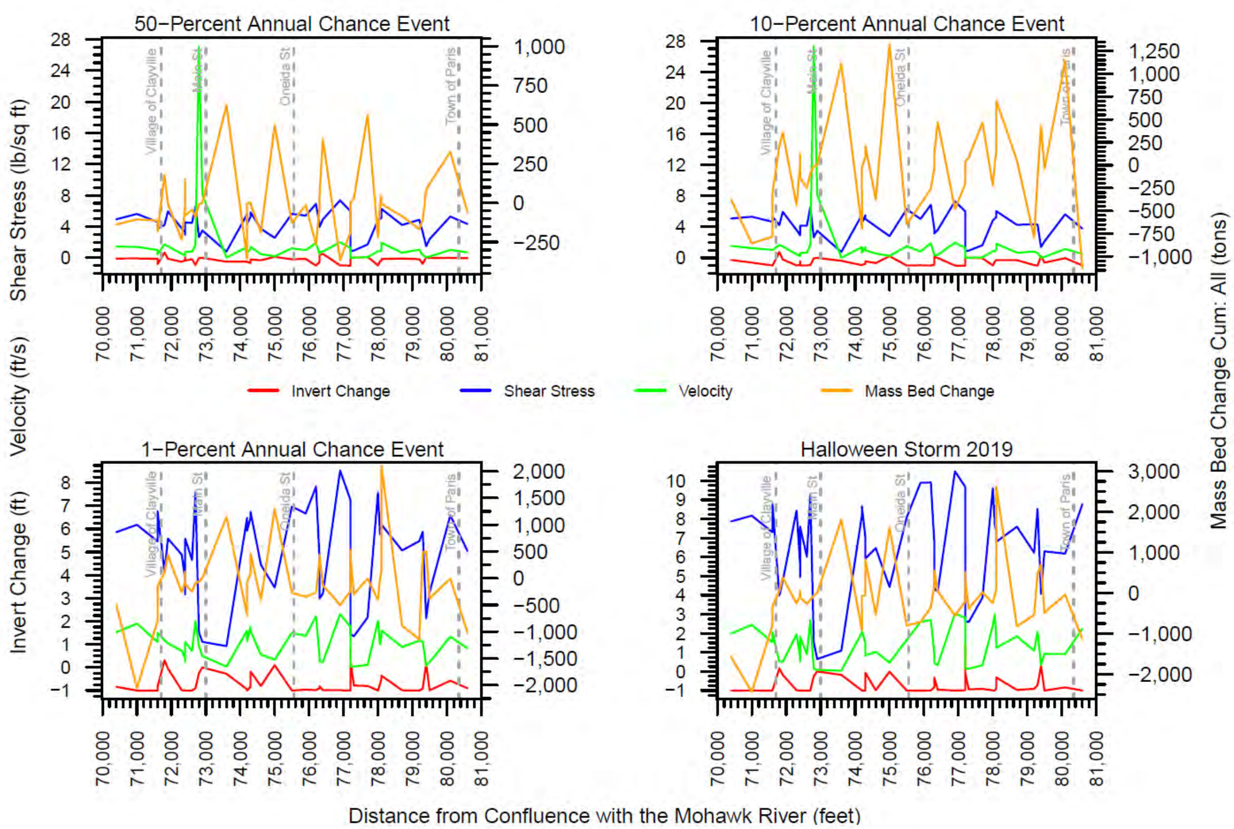

Figure 22. Analysis of invert change (ft), velocity (ft/s), shear stress (lbs./sq. ft) and cumulative mass bed change (tons) using the 1-D HEC-RAS sediment transport model for Zone B.

No structural engineering strategies were modeled and no hard structural engineering strategies are proposed for Zone B. Figure 23 displays the locations of each structural engineering strategy within Zone B.

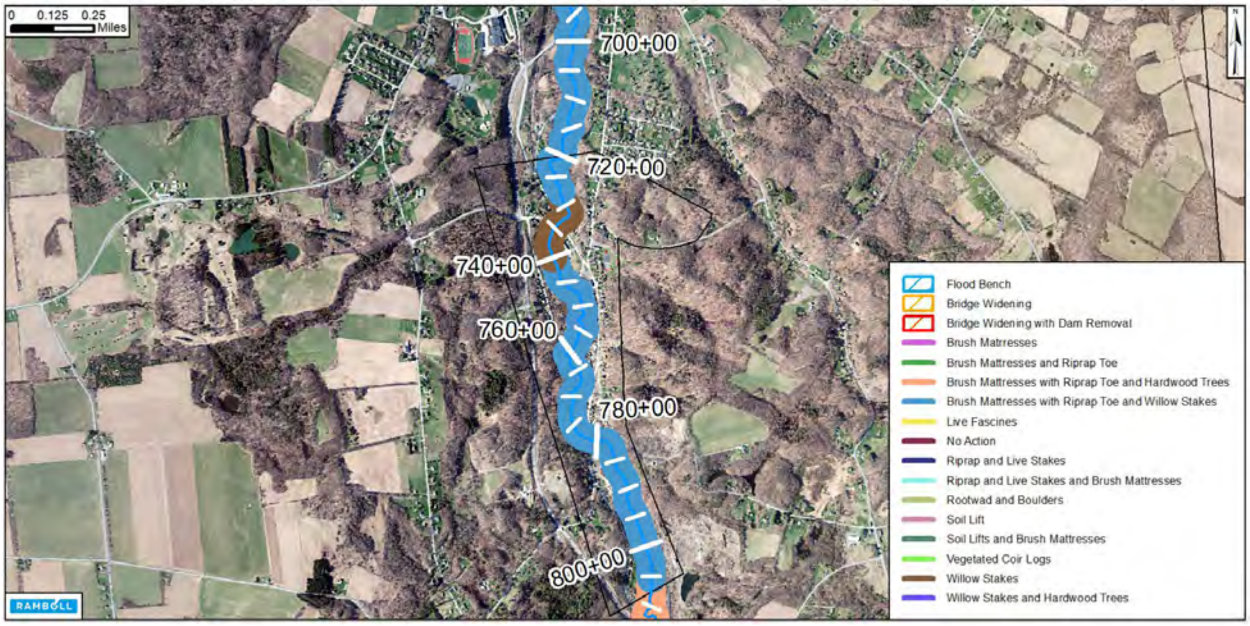

Figure 23. Locations of structural engineering strategies within Zone B.

Based on the H&H and sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various basin-wide management strategies were analyzed for Zone B.

The basin-wide management strategies proposed for this zone are:

- Large Woody Debris Removal
- Floodproofing Residential / Commercial Properties
- Land Use Planning / Ordinances
- Riparian Restoration
- Retention Basin and Wetland Management
- Community Flood Awareness and Preparedness Programs / Education
- Development of a Comprehensive Plans

In addition, due to the large proportion of agricultural lands within this zone, direct runoff from agricultural areas into ditch lines and tributaries should be evaluated and mitigation strategies developed to address each individual runoff source. For example, the removal of tile drains and / or the use of stream buffers can decrease sediment runoff into nearby waterways, thereby improving water quality and reducing sediment loads within the channel.

The Rough Order Magnitude cost for these proposed measures are outlined in Table 18 and does not include land acquisition costs for survey, appraisal, and engineering coordination.

Table 18. Rough Order Magnitude Cost for Proposed Strategies within Zone B

Measure Type	River Station	ROM Cost (U.S. dollars)
Brush Mattresses with Riprap Toe and Willow Stakes	705+00 to 728+00	$45,000
Willow Stakes	728+00 to 740+00	$10,000
Brush Mattresses with Riprap Toe and Willow Stakes	740+00 to 806+00	$120,000

Zone C: Paris – Downstream

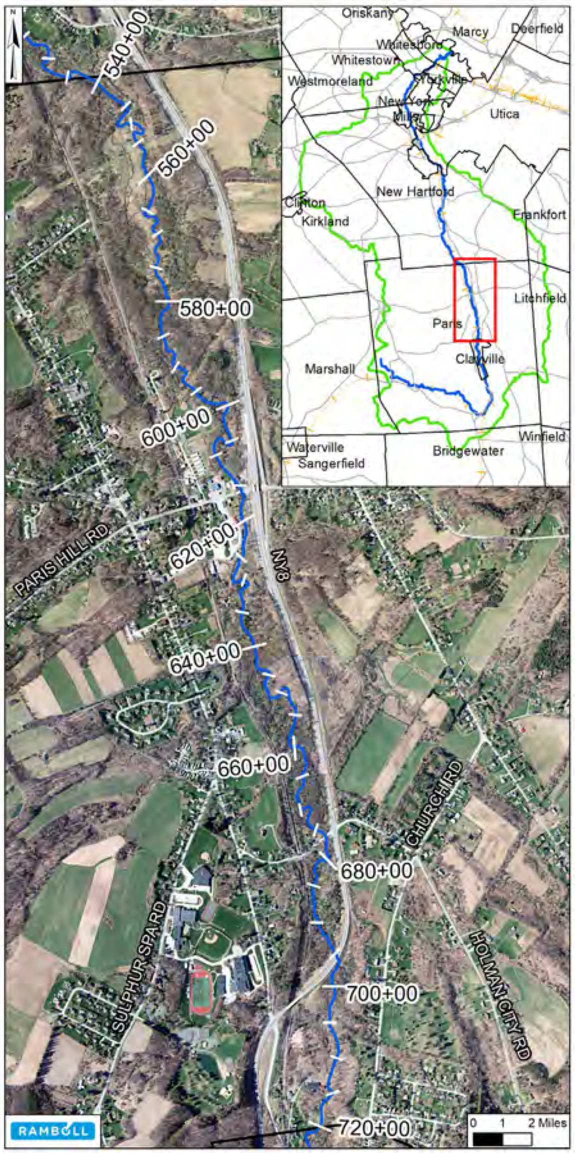

Figure 24. Location map for Zone C: Paris – Downstream.

Zone C covers the portion of the Town of Paris downstream of the Village of Clayville to the New Hartford boundary. The zone begins near RS 700+00 and ends near RS 540+00. The zone includes four roadway crossings, including Pinnacle Road, Holman City Road, and two separate crossings of NY-8, and one dam (Figure 24).

Flooding in this reach occurs primarily due to heavy rainfall combined with snowmelt, particularly in late winter and early spring; however, floods can be expected to occur at any time of the year. Sediment and silt build-up occurs primarily upstream of the two dams located within this reach, which are not regulatory and do not serve flood storage purposes (FEMA 1983).

In July of 2000, a heavy rainfall event occurred, which caused basement flooding and ponding of water on roadways in Utica and along Holman City Road. In August of 2011, Hurricane Irene brought heavy rains and high winds to the region causing flash flooding along Sauquoit Creek from the Village of Clayville to the Town of New Hartford (NCEI 2021). Historically, the confluence of Tucker Brook and Sauquoit Creek near Willow Brook Lane has overtopped its banks during flash flooding events. Large wooded debris and sediment often catch in the vicinity of the Pinnacle Road bridge crossing causing backwater and overtopping banks. In-channel debris upstream of the NY-8 crossing in the vicinity of Church Road has moved the creek out of its banks inundating nearby property (Ramboll 2020c).

Based on the sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various non-structural flood damage reduction measures were analyzed for Zone C. Table 19 outlines the streambank stabilization strategies proposed for this zone. Detailed discussions of the structural engineering strategies can be found in Appendix G.

Table 19. Streambank Stabilization Strategies for Zone C

Measure Type	River Station	Description of Measure
Riprap and Live Stakes	538+00 to 560+00	Low to medium shear stress and high water velocity.
Willow Stakes	560+00 to 580+00	Low to medium shear stress and low water velocity. Place live stakes in areas with increased deposition and minimal erosion.
Brush Mattresses with Riprap Toe and Willow Stakes	580+00 to 705+00	Medium to high shear stress and low water velocity. Place live stakes in areas with increased deposition and minimal erosion. Install Brush mattresses with riprap toe in areas experiencing heavy erosion.

Figure 25 displays the results of the sediment transport model simulations for Zone C for the four different annual chance flood events and the four erosional / depositional variables. Based on the sediment transport analysis, willow stakes, riprap and live stakes, and brush mattresses with riprap toe and willow stakes were determined to be the most appropriate streambank stabilization strategies for this reach.

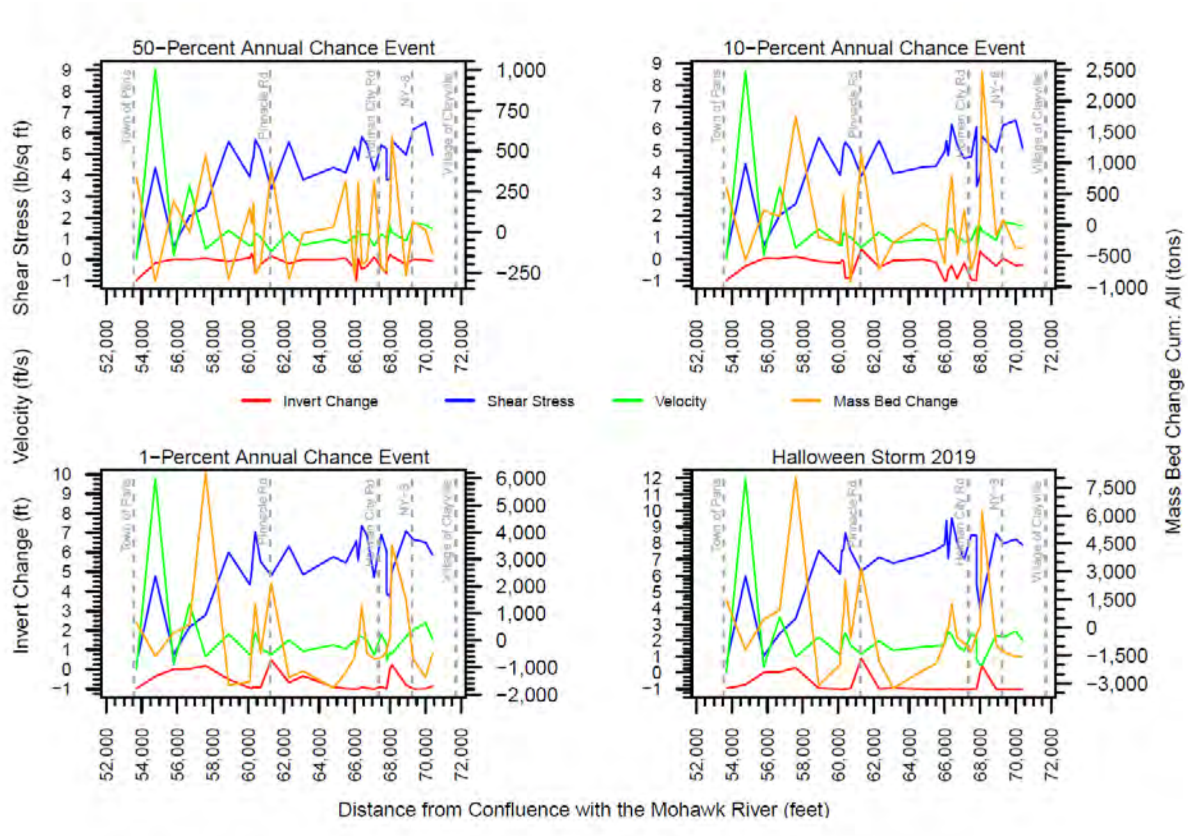

Figure 25. Analysis of invert change (ft), velocity (ft/s), shear stress (lbs./sq. ft) and cumulative mass bed change (tons) using the 1-D HEC-RAS sediment transport model for Zone C.

No structural engineering strategies were modeled and no hard structural engineering strategies are proposed for Zone B. However, based on stakeholder input, previous studies and reports, and historical accounts, the hard structural engineering strategy proposed for this zone would be the removal of the dam in the vicinity of Holman City and Church Roads. Figure 26 displays the locations of each structural engineering strategy within Zone C.

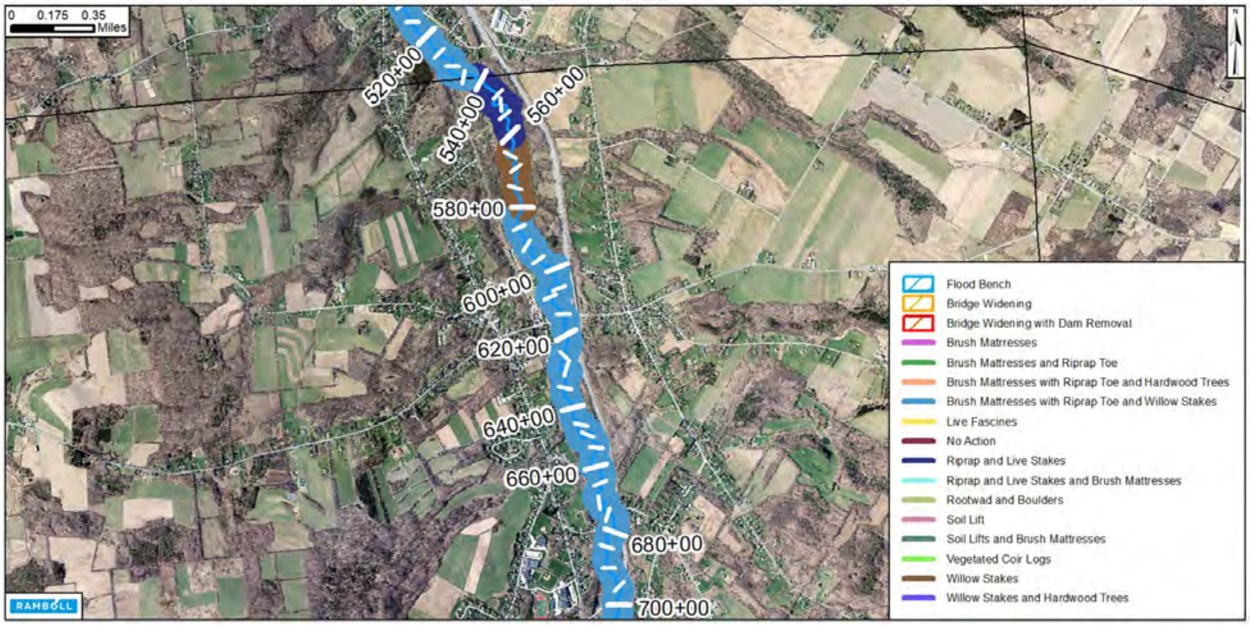

Figure 26. Locations of structural engineering strategies within Zone C.

Based on the H&H and sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various basin-wide management strategies were analyzed for Zone C.

The basin-wide management strategies proposed for this zone are:

- Large Woody Debris Removal
- Floodproofing Residential / Commercial Properties
- Land Use Planning / Ordinances
- Riparian Restoration
- Retention Basin and Wetland Management
- Community Flood Awareness and Preparedness Programs / Education
- Development of a Comprehensive Plans

In addition, due to the large proportion of agricultural lands within this zone, direct runoff from agricultural areas into ditch lines and tributaries should be evaluated and mitigation strategies developed to address each individual runoff source. For example, the removal of tile drains and / or the use of stream buffers can decrease sediment runoff into nearby waterways, thereby improving water quality and reducing sediment loads within the channel.

The Rough Order Magnitude cost for these proposed measures are outlined in Table 20 and does not include land acquisition costs for survey, appraisal, and engineering coordination.

Table 20. Rough Order Magnitude Cost for Proposed Strategies within Zone C

Measure Type	River Station	ROM Cost (U.S. dollars)
Riprap and Live Stakes	538+00 to 560+00	$50,000
Willow Stakes	560+00 to 580+00	$150,000
Brush Mattresses with Riprap Toe and Willow Stakes	580+00 to 705+00	$225,000

Zone D: New Hartford / Washington Mills

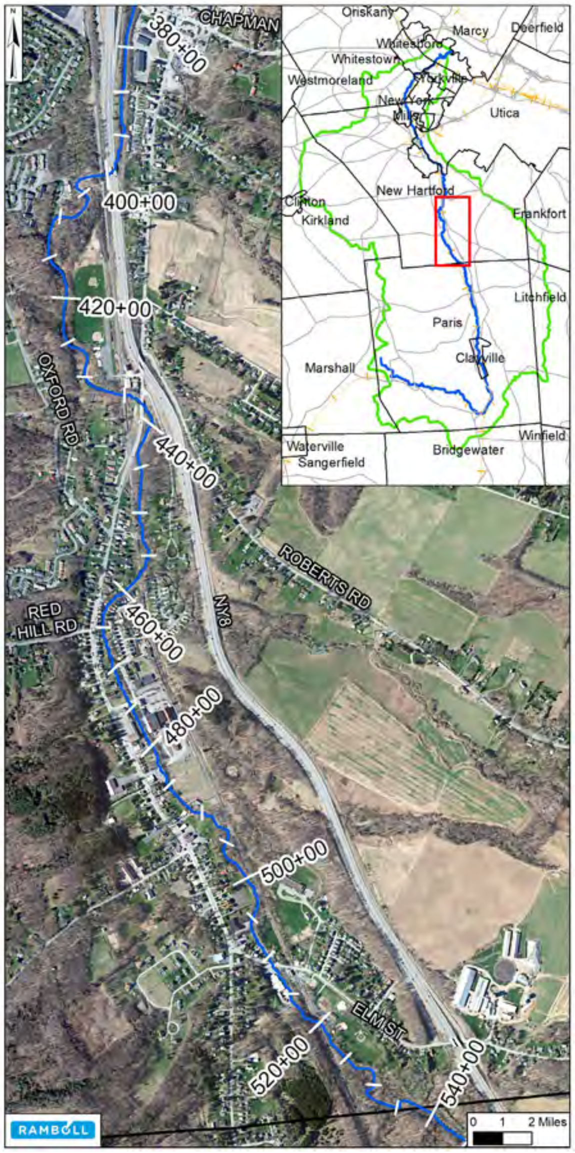

Figure 27. Location map for Zone D: New Hartford/Washington Mills.

Zone D is the upstream portion of Sauquoit Creek in the Town of New Hartford and encompasses the Washington Mills hamlet. This zone begins at RS 540+00 and ends near RS 410+00. The zone includes four roadway crossings, including, Oneida Street, Elm Street, and Bleachery Avenue, and three separate railroad bridge crossings (Figure 27).

Principal flood problems within the zone occur most frequently as a result of snowmelt in the spring or winter months combined with heavy rainfall (FEMA 1982). In April of 2011, a significant severe weather outbreak produced multiple heavy rainfall systems, which caused streams to overflow their banks, and in New Hartford and Washington Mills, many roads were rendered impassible with as much as three feet of water on some roadways. In August of 2011, Hurricane Irene brought heavy rains and high winds to the region causing flash flooding along Sauquoit Creek from Village of Clayville to the Town of New Hartford. In June of 2013, a heavy rainfall event caused major flash flooding along Sauquoit Creek, including Oneida Street from Washington Mills to Sauquoit (NCEI 2021).

Based on the sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various non-structural flood damage reduction measures were analyzed for Zone D. Tables 21 and 22 outline the streambank stabilization and structural engineering strategies proposed for this zone. Detailed discussions of each structural engineering strategy can be found in Appendix G.

Table 21. Streambank Stabilization Strategies for Zone D

Measure Type	River Station	Description of Measure
Riprap and Live Stakes	416+00 to 434+00	Medium to high shear stress and low water velocity. Place live stakes in areas with increased deposition and minimal erosion. Install riprap and live stakes in areas experiencing heavy erosion.
Brush Mattresses with Riprap Toe and Willow Stakes	434+00 to 536+00	Medium to high shear stress and low water velocity. Place live stakes in areas with increased deposition and minimal erosion. Install brush mattresses with riprap toe in areas experiencing heavy erosion.

Figure 28 displays the results of the sediment transport model simulations for Zone D for the four different annual chance flood events and the four erosional / depositional variables. Based on the sediment transport analysis, riprap and live stakes, and brush mattresses with riprap toe and willow stakes were determined to be the most appropriate streambank stabilization strategies for this reach.

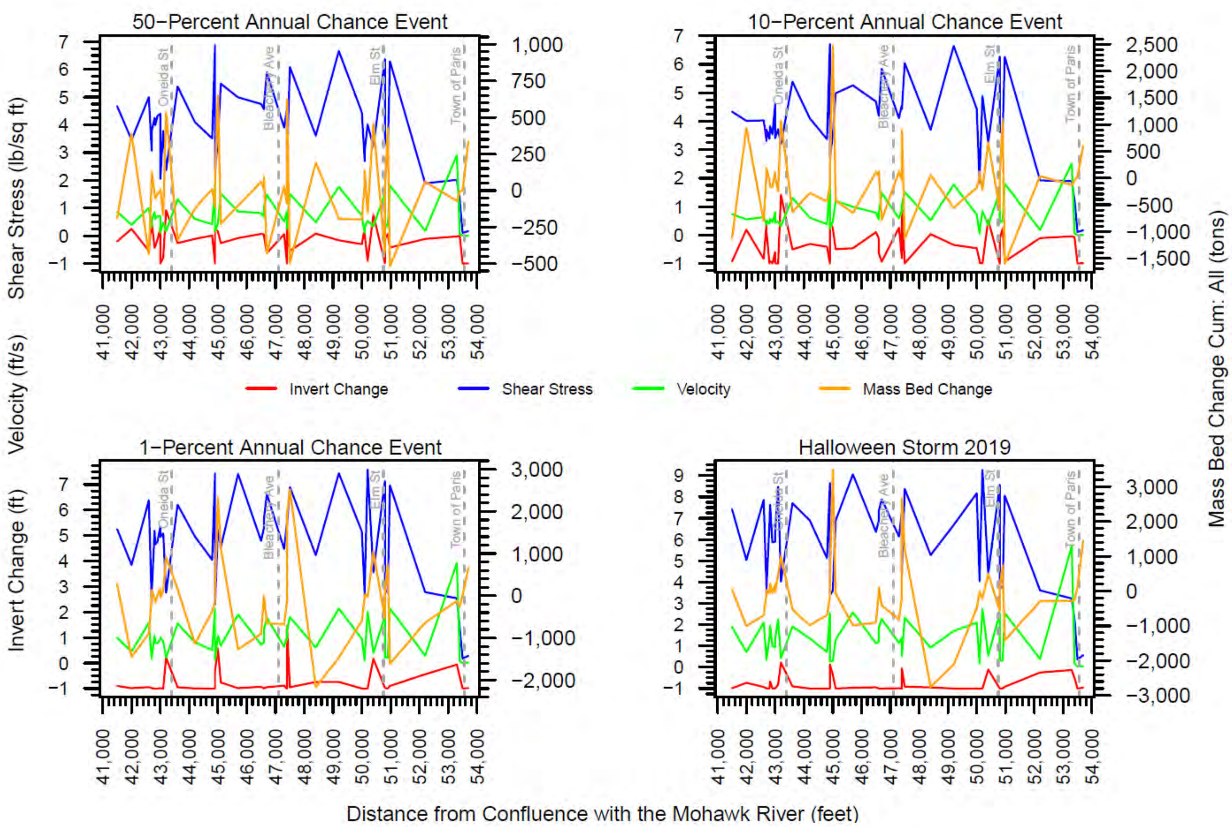

Figure 28. Analysis of invert change (ft), velocity (ft/s), shear stress (lbs./sq. ft) and cumulative mass bed change (tons) using the 1-D HEC-RAS sediment transport model for Zone D.

Based on H&H modeling, stakeholder input, previous studies and reports, and historical accounts, the soft structural engineering strategies proposed for this zone include the construction of three flood benches, the removal of an existing dam, increasing the size of the Bleachery Avenue bridge, and a sediment settling basin. Table 22 outlines the modeled structural engineering strategies with river stationing and simulation results. Figure 29 displays the model simulation results for each structural engineering strategy.

Table 22. Structural Engineering Strategies Modeled Simulation Results for Zone D

Strategy	ID	River Station	Potential Benefits
Flood Bench	Bench #1	478+50 to 474+50	WSEL reductions of up to 1 foot at low flows only
Flood Bench	Bench #2	441+00 to 432+50	WSEL reductions of up to 1 foot
Flood Bench	Bench #3	426+50 to 418+00	WSEL reductions of up to 2 feet
Bleachery Avenue - Bridge Widening by 25 feet with Dam Removal	Bridge / Dam	473+00 to 465+50	WSEL reductions of up to 4 feet

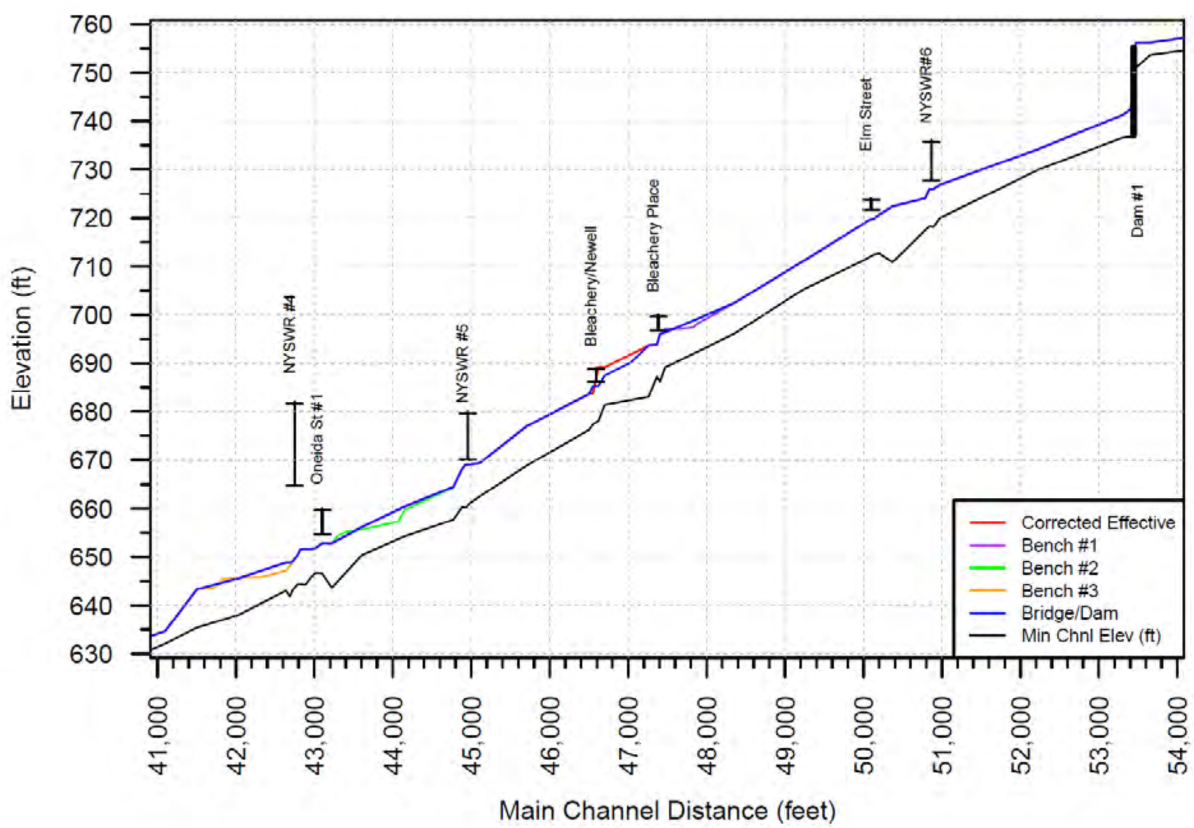

Figure 29. HEC-RAS model simulation results for each structural engineering strategy in Zone D.

Figure 30 displays the locations of each structural engineering strategy within Zone D.

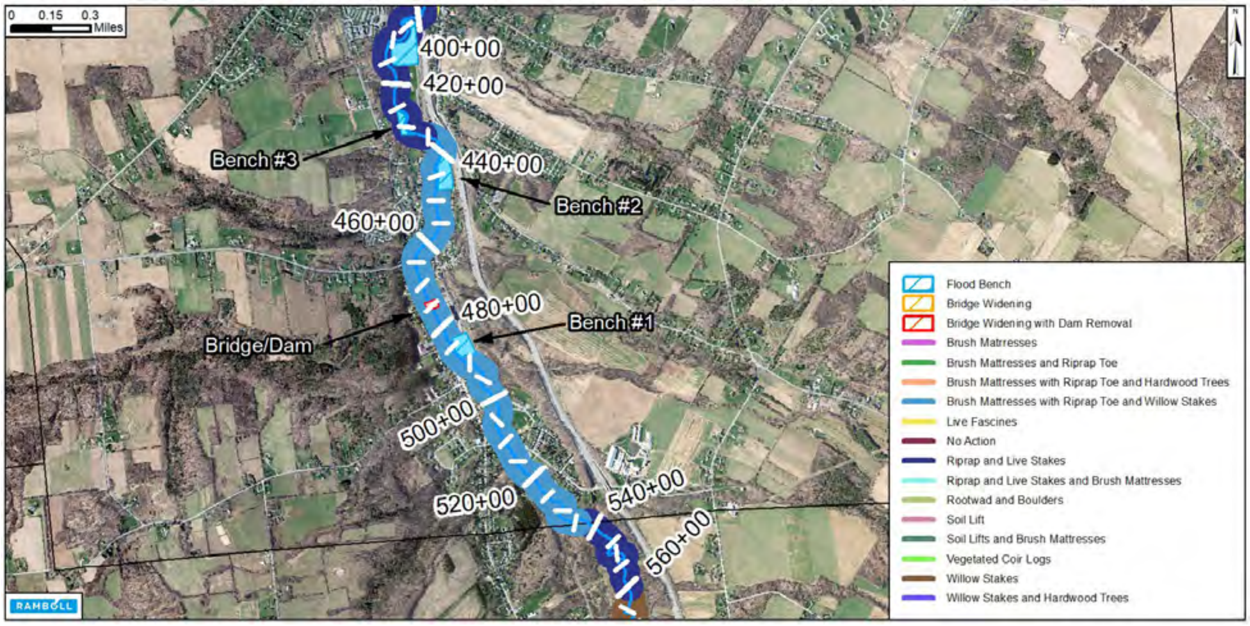

Figure 30. Locations of structural engineering strategies within Zone D.

Based on the H&H and sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various basin-wide management strategies were analyzed for Zone D. The basin-wide management strategies proposed for this zone are:

- Large Woody Debris Removal
- Floodproofing Residential / Commercial Properties
- Land Use Planning / Ordinances
- Riparian Restoration
- Retention Basin and Wetland Management
- Community Flood Awareness and Preparedness Programs / Education
- Development of a Comprehensive Plans

In addition, due to the large proportion of agricultural lands within this zone, direct runoff from agricultural areas into ditch lines and tributaries should be evaluated and mitigation strategies developed to address each individual runoff source. For example, the removal of tile drains and / or the use of stream buffers can decrease sediment runoff into nearby waterways, thereby improving water quality and reducing sediment loads within the channel.

The Rough Order Magnitude cost for these proposed measures are outlined in Table 23 and does not include land acquisition costs for survey, appraisal, and engineering coordination.

Table 23. Rough Order Magnitude Cost for Proposed Strategies within Zone D

Measure / Strategy	River Station	ROM Cost (U.S. dollars)
Riprap and Live Stakes	416+00 to 434+00	$40,000
Brush Mattresses with Riprap Toe and Willow Stakes	434+00 to 536+00	$175,000
Flood Bench #1	478+50 to 474+50	$1,500,000
Flood Bench #2	441+00 to 432+50	$1,500,000
Flood Bench #3	426+50 to 418+00	$1,500,000
Bridge Widening / Dam Removal	473+00 to 465+50	TBD – Special Case

Zone E: New Hartford / Utica – Upstream

Figure 31. Location map for Zone E: New Hartford/Utica – Upstream.

Zone E contains the reach of Sauquoit Creek that extends from the Washington Mills Park downstream to the start of Brookline Drive and the border of the Town of New Hartford and the City of Utica. This zone begins at RS 410+00 and ends at RS 315+00. This zone includes three roadway crossings, including Kellogg Road and two crossings of NY-8 (north and south bound), and one NYSWR railroad crossing (Figure 31).

Principal flood problems within the zone occur most frequently as a result of snowmelt in the spring or winter months combined with heavy rainfall (FEMA 1982). In August of 2011, Hurricane Irene brought heavy rains and high winds to the region causing flash flooding along Sauquoit Creek from the Village of Clayville to the Town of New Hartford. In July of 2017, heavy rainfall from a tropical air mass entrained over the region causing widespread flash flooding, road closures, evacuations, and water rescues along Sauquoit Creek in the City of Utica and Town of New Hartford (NECI 2021). Areas upstream of the Brookline Drive and NYSWR railroad bridge crossing (RS 305+00) experience streambank erosion and instability with debris and sediment found within the channel (Ramboll 2020c).

Based on the sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various non-structural flood damage reduction measures were analyzed for Zone E. Tables 24 and 25 outline the streambank stabilization and structural engineering strategies proposed for this zone, respectively. Detailed discussions of the structural engineering strategies can be found in Appendix G.

Table 24. Streambank Stabilization Strategies for Zone E

Measure Type	River Station	Description of Measure
Riprap and Live Stakes	318+00 to 324+00	Medium to high shear stress and low water velocity. Place live stakes in areas with a buildup of sediment and stone. Fill in eroded areas with riprap and live stakes.
Soil Lifts and Brush Mattresses	324+00 to 376+00	Medium shear stress and low water velocity. Place soil lifts on heavily eroded banks and install brush mattresses in areas with increased deposition.
Riprap and Live Stakes	376+00 to 396+00	Medium to high shear stress and low to medium water velocity. Place live stakes in areas with increased deposition and minimal erosion. Install riprap and live stakes in areas experiencing heavy erosion.
Live Fascines	396+00 to 398+00	Medium shear stress and low water velocity.
Riprap and Live Stakes	398+00 to 416+00	Medium to high shear stress and low to medium water velocity. Place live stakes in areas with increased deposition and minimal erosion. Install riprap and live stakes in areas experiencing heavy erosion.

Figure 32 displays the results of the sediment transport model simulations for Zone E for the four different annual chance flood events and the four erosional / depositional variables. Based on the sediment transport analysis, riprap and live stakes, soil lifts and brush mattresses, and live fascines were determined to be the most appropriate streambank stabilization strategies for this reach.

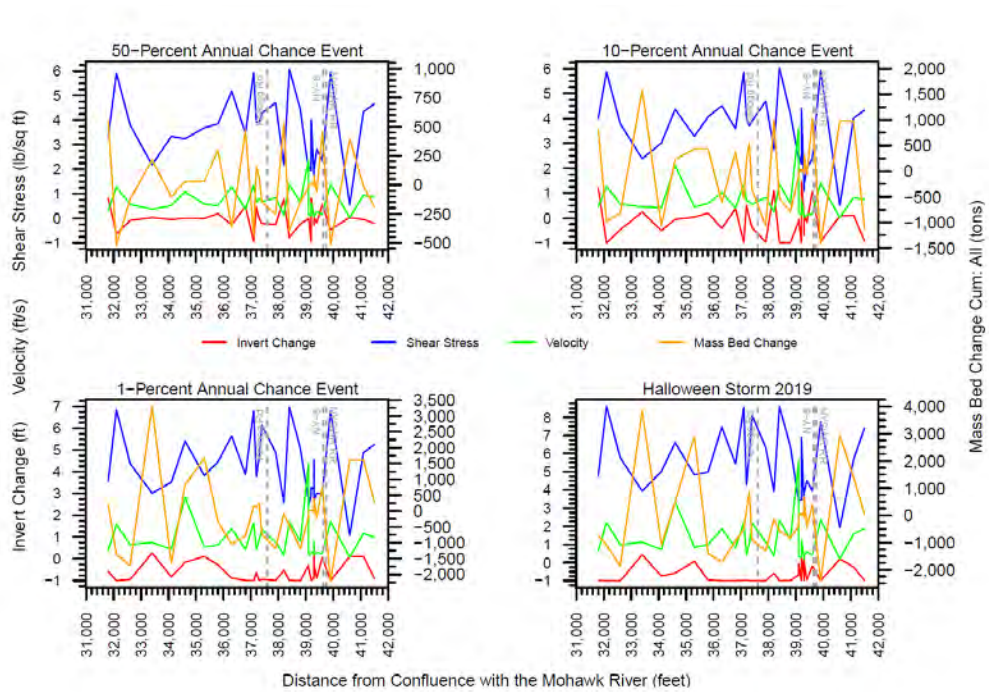

Figure 32. Analysis of invert change (ft), velocity (ft/s), shear stress (lbs./sq. ft) and cumulative mass bed change (tons) using the 1-D HEC-RAS sediment transport model for Zone E.

Based on H&H modeling, stakeholder input, previous studies and reports, and historical accounts, the soft structural engineering strategies proposed for this zone include two flood benches. Table 25 outlines the modeled soft structural engineering strategies with river stationing and simulation results. Figure 33 displays the model simulation results for each structural engineering strategy.

Table 25. Structural Engineering Strategies Modeled Simulation Results for Zone E

Strategy	ID	River Station	Potential Benefits
Flood Bench	Bench #1	409+00 to 393+50	WSEL reductions of up to 2.5 feet
Flood Bench	Bench #2	363+50 to 353+00	WSEL reductions of up to 4 feet

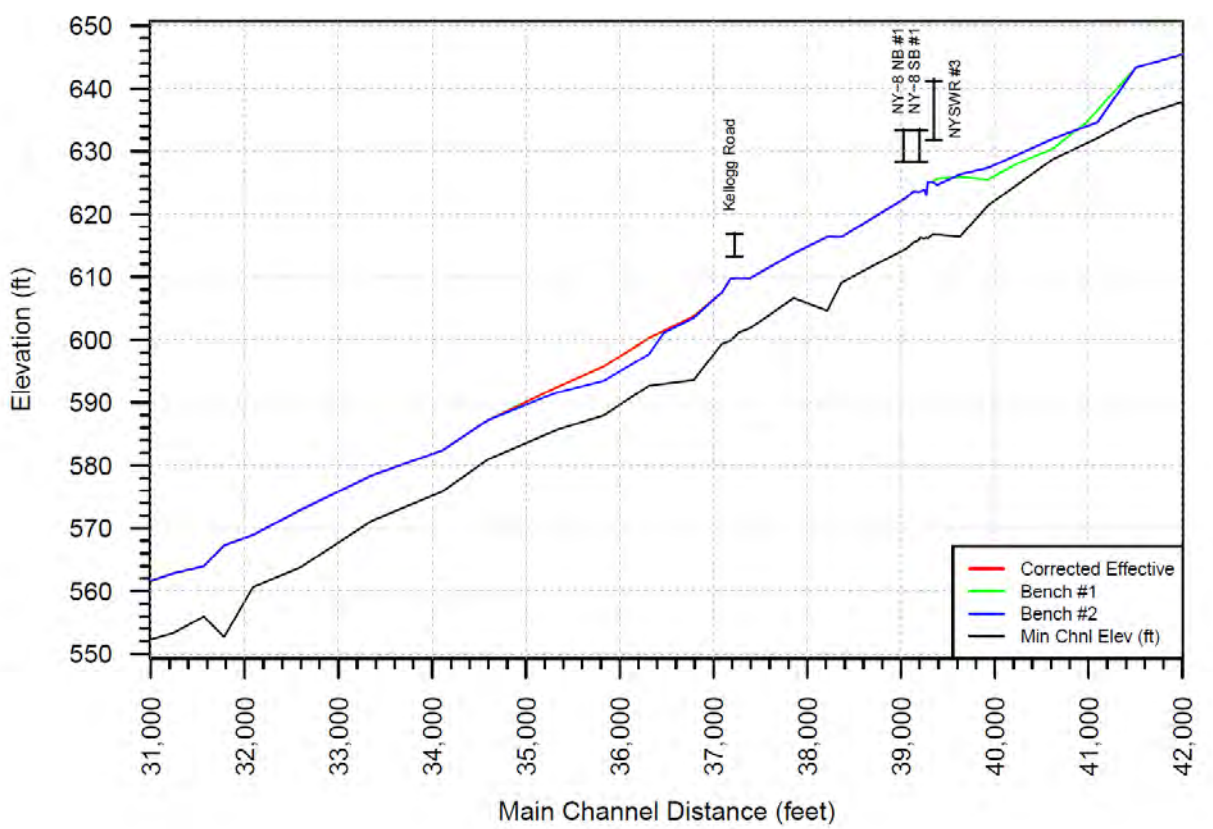

Figure 33. HEC-RAS model simulation results for each structural engineering strategy in Zone E.

Figure 34 displays the locations of each structural engineering strategy within Zone E.

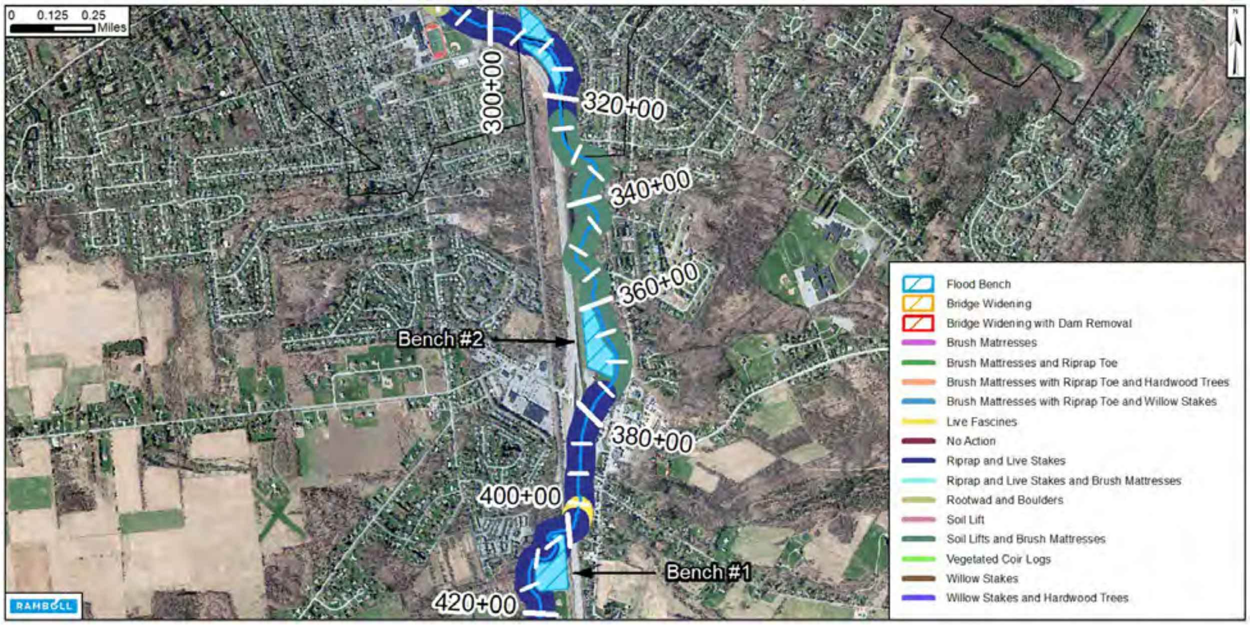

Figure 34. Locations of structural engineering strategies within Zone E.

Based on the H&H and sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various basin-wide management strategies were analyzed for Zone E.

The basin-wide management strategies proposed for this zone are:

- Large Woody Debris Removal
- Flood Monitoring and Warning System
- Sediment Retention Basin
- Flood Buyout Programs
- Floodproofing Residential / Commercial Properties
- Land Use Planning / Ordinances
- Riparian Restoration
- Retention Basin and Wetland Management
- Community Flood Awareness and Preparedness Programs / Education
- Development of a Comprehensive Plans

The Rough Order Magnitude cost for these proposed measures are outlined in Table 26 and does not include land acquisition costs for survey, appraisal, and engineering coordination.

Table 26. Rough Order Magnitude Cost for Proposed Strategies within Zone E

Measure / Strategy	River Station	ROM Cost (U.S. dollars)
Riprap and Live Stakes	318+00 to 324+00	$15,000
Soil Lifts and Brush Mattresses	324+00 to 376+00	$60,000
Riprap and Live Stakes	376+00 to 396+00	$50,000
Live Fascines	396+00 to 398+00	$25,000
Riprap and Live Stakes	398+00 to 416+00	$45,000
Flood Bench #1	409+00 to 393+50	$1,500,000
Flood Bench #2	363+50 to 353+00	$1,500,000

Zone F: New Hartford / Utica – Downstream

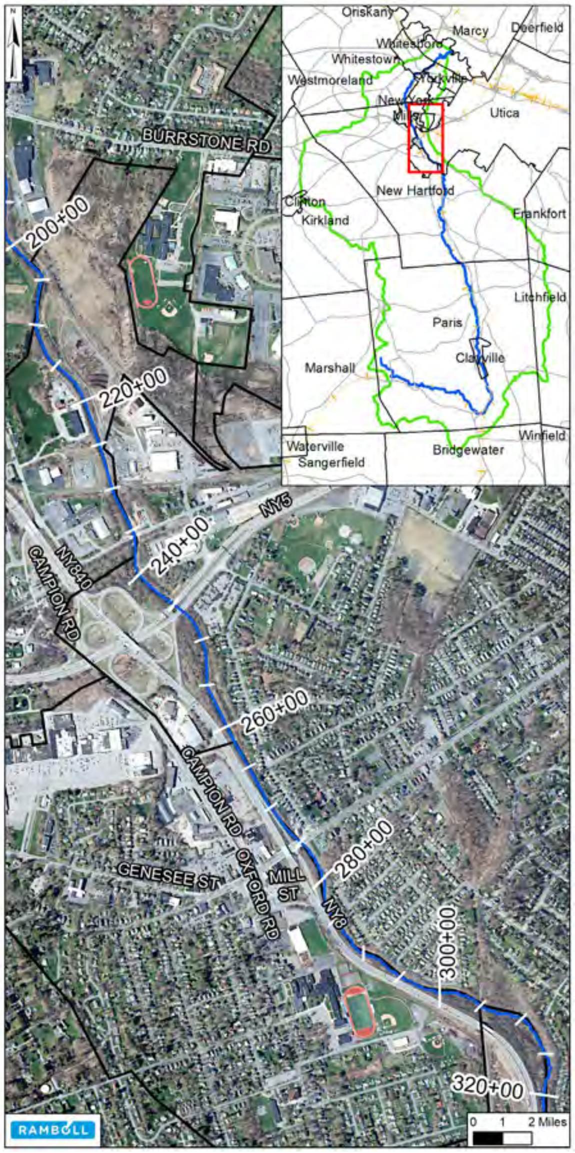

Figure 35. Location map for Zone F: New Hartford/Utica – Downstream.

Zone F contains the reach of Sauquoit Creek that borders the Town of New Hartford and City of Utica starting at the upstream end of Brookline Drive and extending downstream to NY-5. This zone starts at RS 315+00 and ends at RS 240+00. This zone includes three roadway crossings, including Genesee Street and two crossings of NY-5 (east and west bound), and one NYSWR railroad crossing (Figure 35).

Principal flood problems within the zone occur most frequently as a result of snowmelt in the spring or winter months combined with heavy rainfall (FEMA 1982). In August of 2011, Hurricane Irene brought heavy rains and high winds to the region causing flash flooding along Sauquoit Creek from the Village of Clayville to the Town of New Hartford. In July of 2017, heavy rainfall from a tropical air mass entrained over the region causing widespread flash flooding, road closures, evacuations, and water rescues along Sauquoit Creek in the City of Utica and Town of New Hartford (NECI 2021). Sediment aggradation generally occurs along Sauquoit Creek adjacent to Brookline Drive and downstream of the Genesee Street bridge crossing. Areas in the vicinity of Genesee Street, including Richardson Avenue and Brookline Drive, have also experienced flooding issues in recent years. This is most likely a result of the channelized nature of the creek in this reach, which reduces turbulent flows in the water column allowing sediment to fall out and accumulate (Ramboll 2020c).

Based on the sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various non-structural flood damage reduction measures were analyzed for Zone F. Tables 27 and 28 outline the streambank stabilization and structural engineering strategies proposed for this zone, respectively. Detailed discussions of the structural engineering strategies can be found in Appendix G.

Table 27. Streambank Stabilization Strategies for Zone F

Measure Type	River Station	Description of Measure
Rootwad and Boulders	242+00 to 252+00	Low to medium shear stress and low water velocity
Brush Mattresses and Riprap Toe	252+00 to 264+00	Medium shear stress and low water velocity. Install brush mattresses with riprap toe in areas with erosion
Rootwad and Boulders	264+00 to 290+00	Low to medium shear stress and low water velocity
Riprap and Live Stakes	290+00 to 318+00	Medium to high shear stress and low water velocity. Place live stakes in areas with a buildup of sediment and stone. Fill in eroded areas with riprap and live stakes

Figure 36 displays the results of the sediment transport model simulations for Zone F for the four different annual chance flood events and the four erosional / depositional variables. Based on the sediment transport analysis, riprap and live stakes, brush mattresses and riprap toe, and rootwad and boulders were determined to be the most appropriate streambank stabilization strategies for this reach.

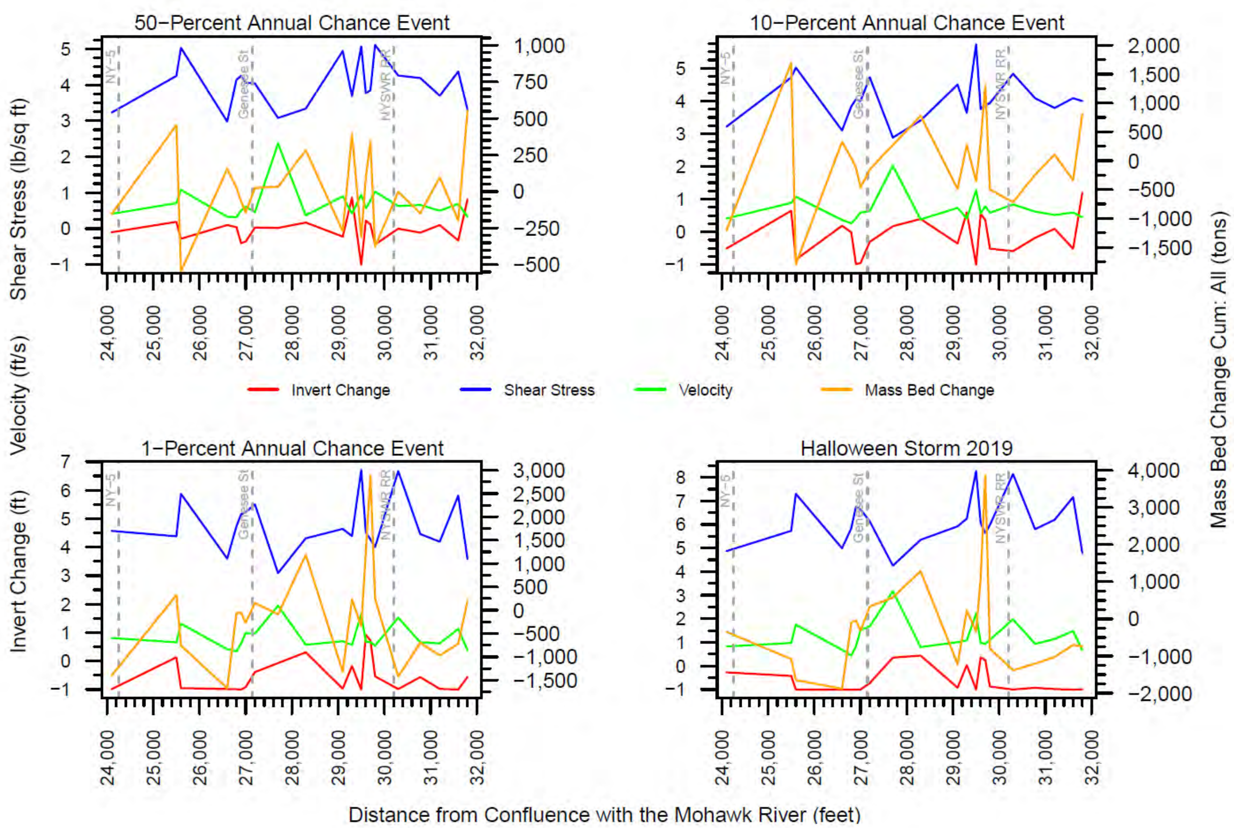

Figure 36. Analysis of invert change (ft), velocity (ft/s), shear stress (lbs./sq. ft) and cumulative mass bed change (tons) using the 1-D HEC-RAS sediment transport model for Zone F.

Based on H&H modeling, stakeholder input, previous studies and reports, and historical accounts, the soft structural engineering strategies proposed for this zone includes four flood benches and increasing the size of the Genesee Street bridge. Table 28 outlines the modeled structural engineering strategies with river stationing and simulation results. Figure 37 displays the model simulation results for each structural engineering strategy.

Table 28. Structural Engineering Strategies Model Simulation Results for Zone F

Strategy	ID	River Station	Potential Benefits
Flood Bench	Bench #1	237+00 to 230+50	WSEL reductions of up to 2.5 feet
Flood Bench	Bench #2	308+00 to 297+50	WSEL reductions of up to 4 feet
Flood Bench	Bench #3	301+50 to 297+50	WSEL reductions of up to 1 foot
Flood Bench	Bench #4	251+00 to 241+00	WSEL reductions of up to 0.5 feet
Genesee Street – Bridge Widening by 25 feet	Bridge Upsize	269+00 to 267+50	WSEL reductions of up to 3.5 feet

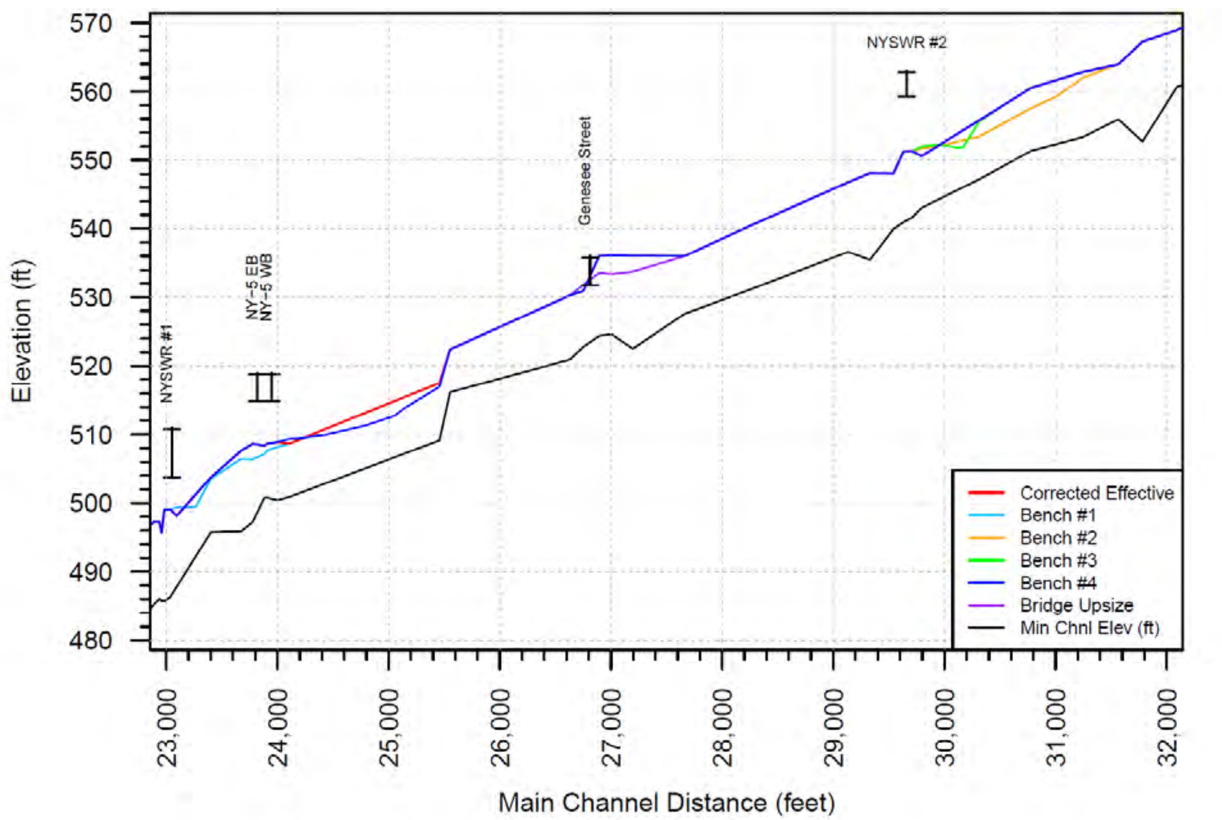

Figure 37. HEC-RAS model simulation results for each structural engineering strategy in Zone F.

Figure 38 displays the locations of each structural engineering strategy within Zone F.

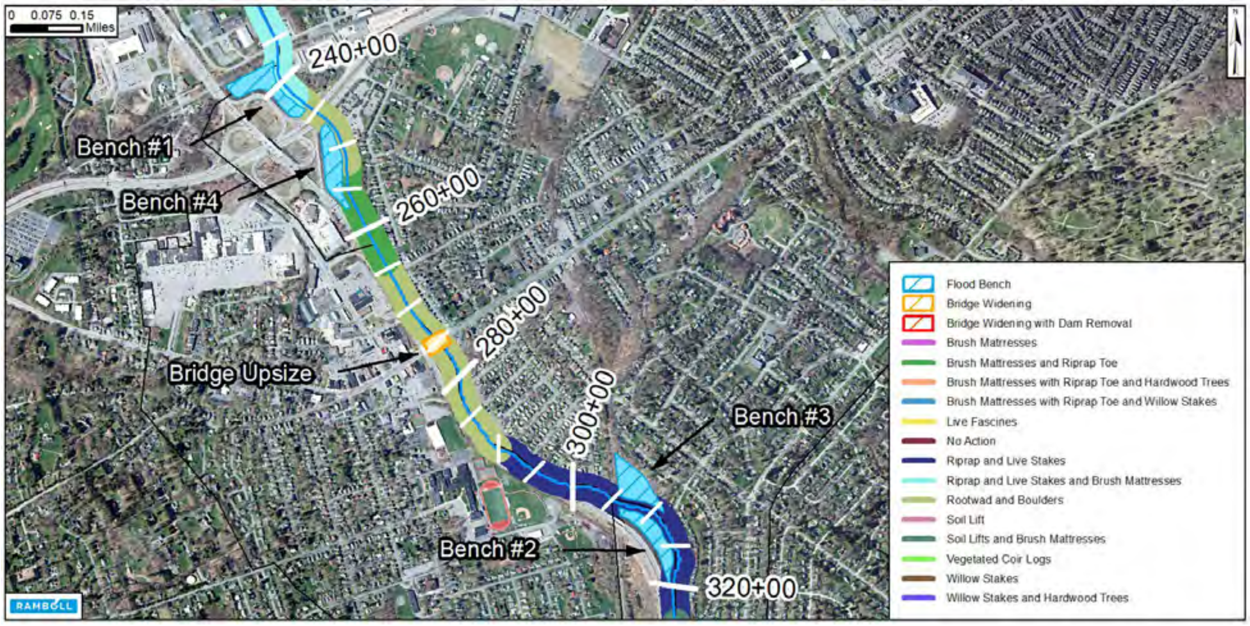

Figure 38. Locations of structural engineering strategies within Zone F.

Based on the H&H and sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various basin-wide management strategies were analyzed for Zone F.

The basin-wide management strategies proposed for this zone are:

- Large Woody Debris Removal
- Flood Monitoring and Warning System
- Sediment Retention Basin
- Flood Buyout Programs
- Floodproofing Residential / Commercial Properties
- Land Use Planning / Ordinances
- Riparian Restoration
- Retention Basin and Wetland Management
- Community Flood Awareness and Preparedness Programs / Education
- Development of a Comprehensive Plans

The Rough Order Magnitude cost for these proposed measures are outlined in Table 29 and does not include land acquisition costs for survey, appraisal, and engineering coordination.

Table 29. Rough Order Magnitude Cost for Proposed Strategies within Zone F

Measure / Strategy	River Station	ROM Cost (U.S. dollars)
Rootwad and Boulders	242+00 to 252+00	$75,000
Brush Mattresses and Riprap Toe	252+00 to 264+00	$15,000
Rootwad and Boulders	264+00 to 290+00	$225,000
Riprap and Live Stakes	290+00 to 318+00	$75,000
Flood Bench #1	237+00 to 230+50	$1,500,000
Flood Bench #2	308+00 to 297+50	$1,500,000
Flood Bench #3	301+50 to 297+50	$1,500,000
Flood Bench #4	251+00 to 241+00	$1,500,000
Bridge Upsize – Genesee Street	269+00 to 267+50	TBD – Special Case

Zone G: New York Mills / New Hartford

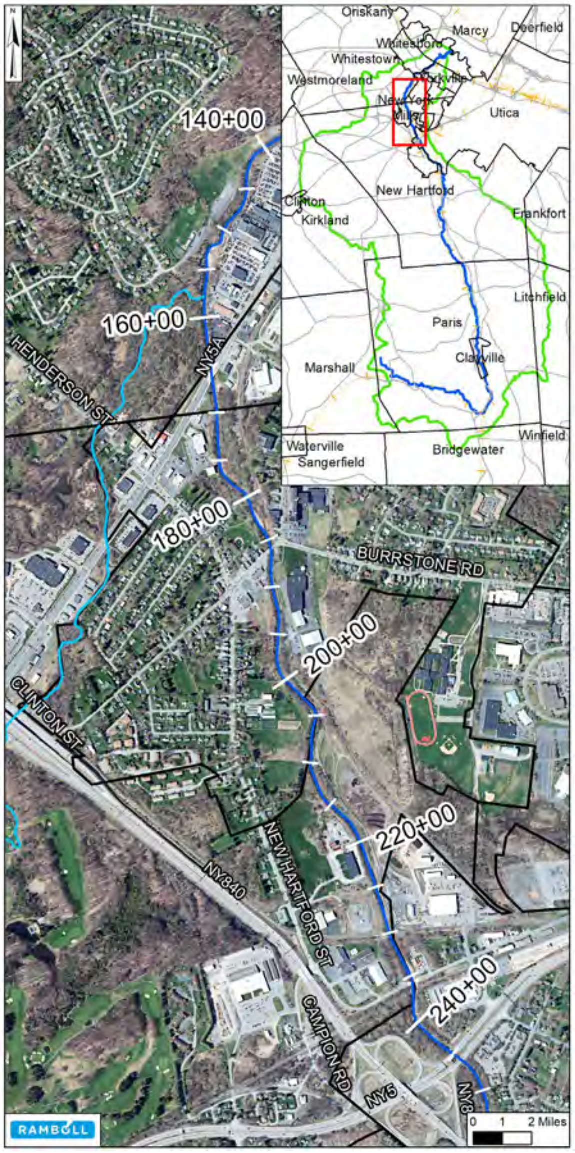

Figure 39. Location map for Zone G: New York Mills/New Hartford.

Zone G contains the reach of Sauquoit Creek that travels through Village of New York Mills. This zone begins at RS 240+00 and ends at RS 180+00. This zone includes two roadway crossings, including Clinton Street and Chenango Road, one recreational trail crossing, and one NYSWR railroad crossing (Figure 39).

Principal flood problems within the zone occur most frequently as a result of snowmelt in the spring or winter months combined with heavy rainfall (FEMA 1982). The risk of flooding within the Village of New York Mills has increased due to the deposition of eroded material from upstream portions of Sauquoit Creek, which reduces the hydraulic capacity of the channel (FEMA 2000a). In August of 2011, Hurricane Irene brought heavy rains and high winds to the region causing flash flooding along Sauquoit Creek from the Village of Clayville to the Town of New Hartford (NECI 2021). In the Village of New York Mills, there are multiple areas along Sauquoit Creek that experience flooding, including Main Street at the intersection with Elm Street and Clinton Street upstream to the State Highway Maintenance Facility near Chenango Road. In addition, Mud Creek contributes to flooding in the Village along Royal Brook Lane near Henderson Street. In October of 2019, the Halloween Storm produced a long duration, heavy rainfall event in the region. Sauquoit Creek overtopped its banks along many portions, including within the Village of New York Mills. The banks of the creek upstream of Clinton Street along the Rayhill Trail became destabilized and fell into the channel introducing a large volume of sediment and debris into downstream reaches. In addition, sediment aggradation occurs from Clinton Street upstream to the State Highway Maintenance Facility near Chenango Road. This is most likely a result of the sinuosity of the creek channel in this reach where multiple meanders cause water velocities to slow and deposit on the inside bend and erode the outside bend of a meander (Ramboll 2020c).

Based on the sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various non-structural flood damage reduction measures were analyzed for Zone G. Tables 30 and 31 outline the streambank stabilization and structural engineering strategies proposed for this zone, respectively. Detailed discussions of the structural engineering strategies can be found in Appendix G.

Table 30. Streambank Stabilization Strategies for Zone G

Measure Type	River Station	Description of Measure
Rootwad and Boulders	180+00 to 185+00	Low shear stress and water velocity
Live Fascines	185+00 to 215+00	Medium shear stress and low water velocity
Riprap and Live Stakes and Brush Mattresses	215+00 to 242+00	Medium to high shear stress and low water velocity. Install riprap and live stakes in areas with existing riprap and brush mattresses in areas with unprotected riverbeds

Figure 40 displays the results of the sediment transport model simulations for Zone G for the four different annual chance flood events and the four erosional / depositional variables. Based on the sediment transport analysis, riprap and live stakes, and brush mattresses, live fascines, and rootwad and boulders were determined to be the most appropriate streambank stabilization strategies for this reach.

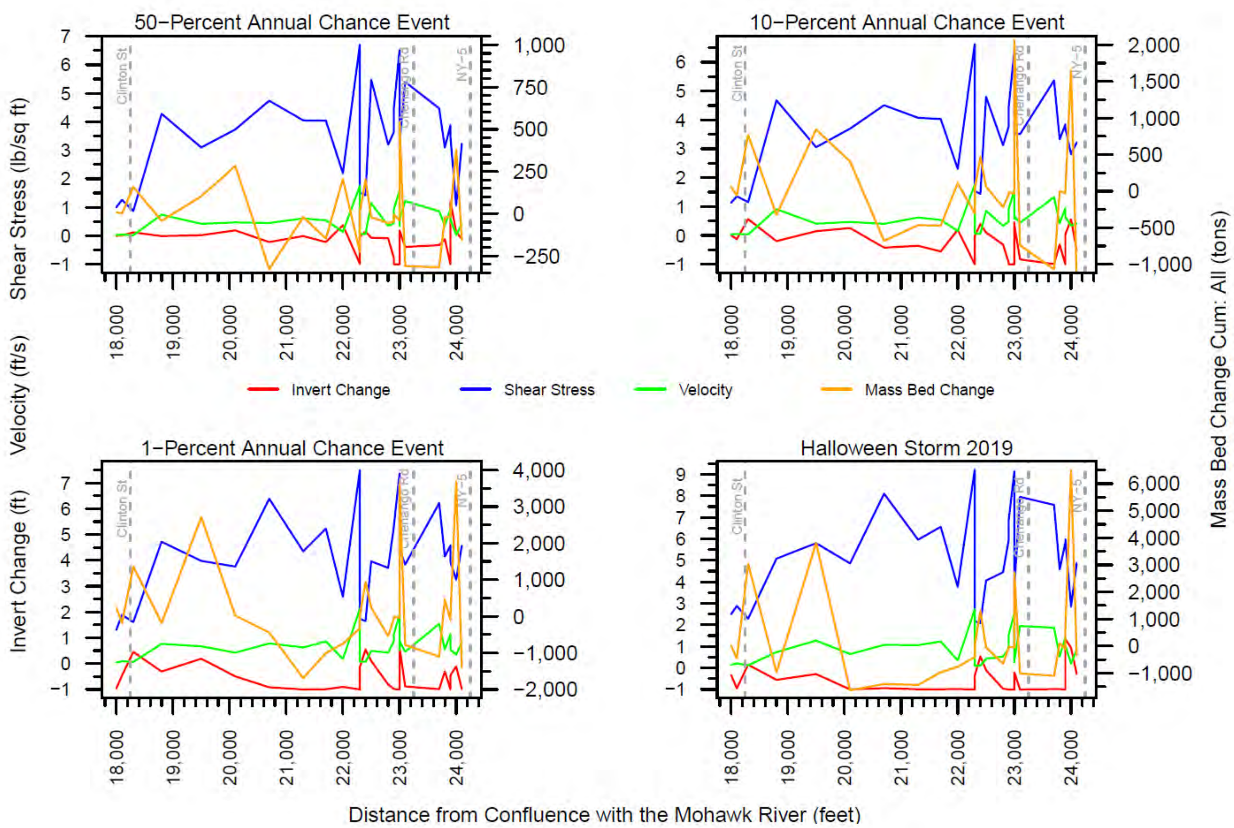

Figure 40. Analysis of invert change (ft), velocity (ft/s), shear stress (lbs./sq. ft) and cumulative mass bed change (tons) using the 1-D HEC-RAS sediment transport model for Zone G.

Based on H&H modeling, stakeholder input, previous studies and reports, and historical accounts, the soft structural engineering strategies proposed for this zone includes five flood benches and one bridge widening for Sauquoit Creek, and three flood benches for Mud Creek. Table 31 outlines the modeled structural engineering strategies with river stationing and simulation results. Figure 41 displays the model simulation results for each structural engineering strategy.

Table 31. Structural Engineering Strategies Model Simulation Results for Zone G

Strategy	ID	River Station	Potential Benefits
Flood Bench	Bench #1	**Sauquoit Creek** 172+00 to 164+00	No significant reduction in WSELs
Flood Bench	Bench #2	**Sauquoit Creek** 188+00 to 183+00	WSEL reductions of up to 0.8 feet
Flood Bench	Bench #3	**Sauquoit Creek** 198+00 to 191+00	WSEL reductions of up to 0.5 feet at low flows only
Flood Bench	Bench #4	**Sauquoit Creek** 209+00 to 199+00	WSEL reductions of up to 3 feet
Flood Bench	Bench #5	**Sauquoit Creek** 213+00 to 201+50	WSEL reductions of up to 2.5 feet
Clinton Street – Bridge Widening by 25 feet	Bridge Upsize	**Sauquoit Creek** 180+00 to 178+50	WSEL reductions of up to 3.5 feet
Flood Bench	Bench #1	**Mud Creek** 33+00 to 26+00	WSEL reductions of up to 0.5 feet
Flood Bench	Bench #2	**Mud Creek** 53+00 to 47+00	WSEL reductions of up to 1.9 feet
Flood Bench	Bench #3 *	**Mud Creek** 12+00 to 0+00	WSEL reductions of up to 0.8 feet at low flows only

* Flood Bench #3 along Mud Creek overlaps with the Sauquoit Creek Channel & Floodplain Restoration Program – Phase I Flood Bench L-7 at Site D.

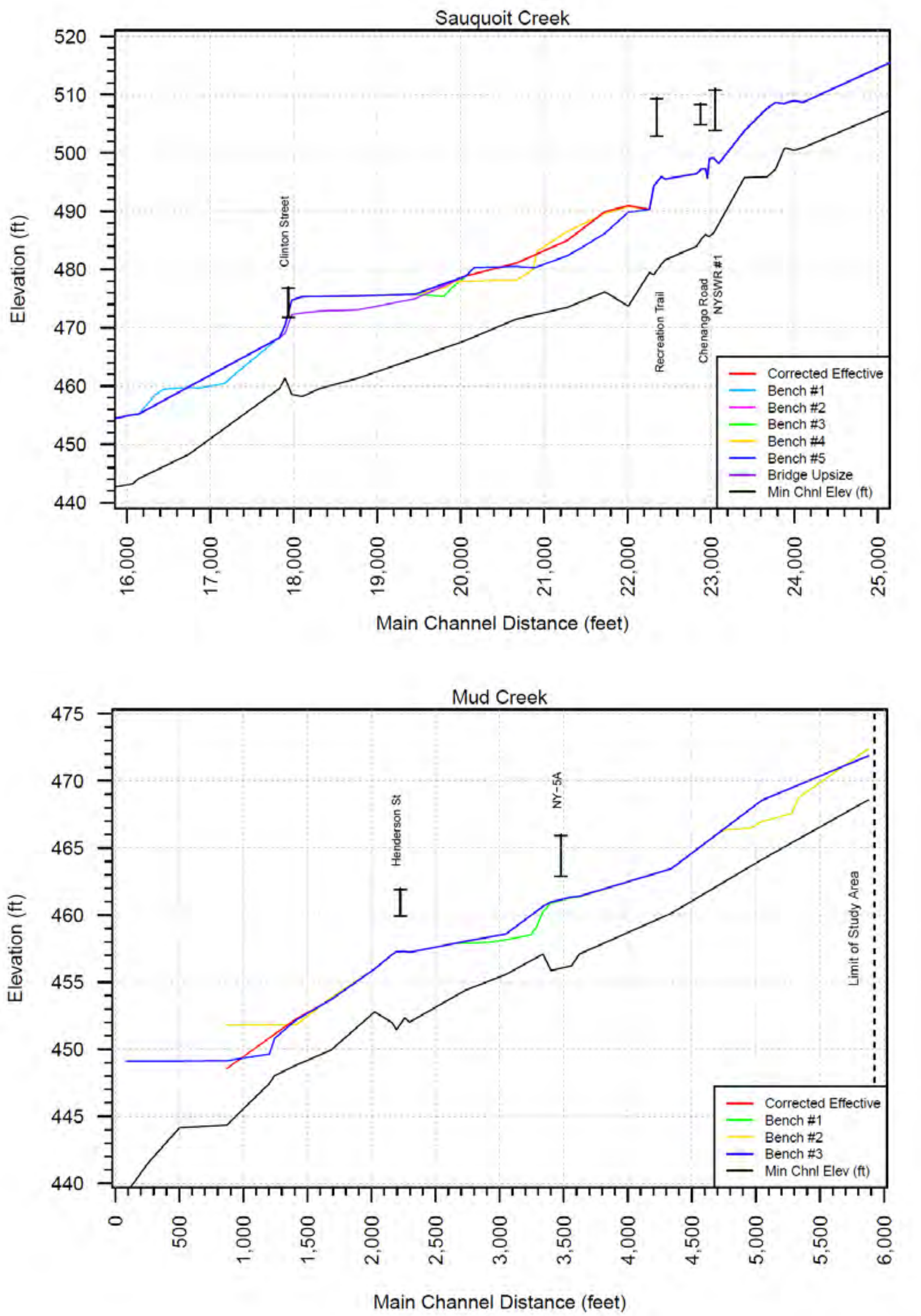

Figure 41. HEC-RAS model simulation results for each structural strategy along Sauquoit Creek (top) and Mud Creek (bottom) in Zone G.

Figure 42 displays the locations of each structural engineering strategy within Zone G.

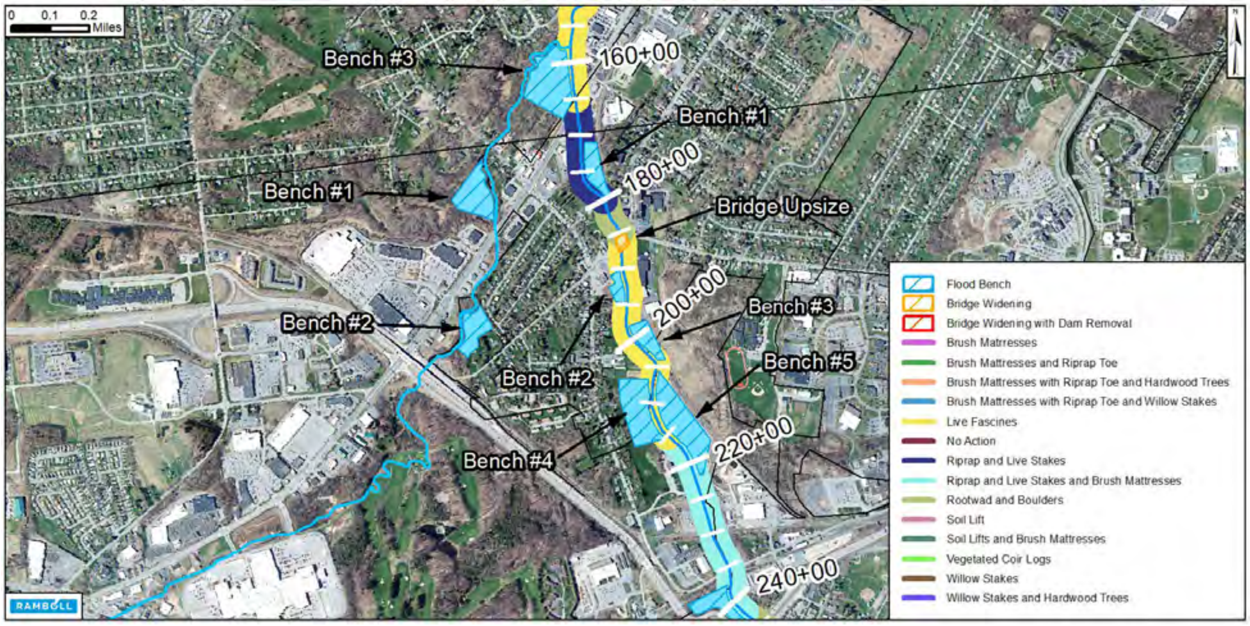

Figure 42. Locations of structural engineering strategies within Zone G.

Based on the H&H and sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various basin-wide management strategies were analyzed for Zone G. The basin-wide management strategies proposed for this zone are:

- Large Woody Debris Removal
- Flood Monitoring and Warning System
- Sediment Retention Basin
- Flood Buyout Programs
- Floodproofing Residential / Commercial Properties
- Land Use Planning / Ordinances
- Riparian Restoration
- Retention Basin and Wetland Management
- Community Flood Awareness and Preparedness Programs / Education
- Development of a Comprehensive Plan

The Rough Order Magnitude cost for these proposed measures are outlined in Table 32 and does not include land acquisition costs for survey, appraisal, and engineering coordination.

Table 32. Rough Order Magnitude Cost for Proposed Strategies within Zone G

Measure / Strategy	River Station	ROM Cost (U.S. dollars)
Rootwad and Boulders	180+00 to 185+00	$45,000
Live Fascines	185+00 to 215+00	$300,000
Riprap and Live Stakes and Brush Mattresses	215+00 to 242+00	$90,000
Flood Bench #1	172+00 to 164+00	$1,500,000
Flood Bench #2	188+00 to 183+00	$1,500,000
Flood Bench #3	198+00 to 191+00	$1,500,000
Flood Bench #4	209+00 to 199+00	$1,500,000
Flood Bench #5	213+00 to 201+50	$1,500,000
Bridge Upsize – Clinton Street	180+00 to 178+50	TBD - Special Case
Flood Bench #1	Mud Creek 33+00 to 26+00	$1,500,000
Flood Bench #2	Mud Creek 53+00 to 47+00	$1,500,000
Flood Bench #3 *	Mud Creek 12+00 to 0+00	$1,500,000

* Flood Bench #3 along Mud Creek overlaps with the Sauquoit Creek Channel & Floodplain Restoration Program – Phase I Flood Bench L-7 at Site D.

Zone H: Whitestown / Whitesboro

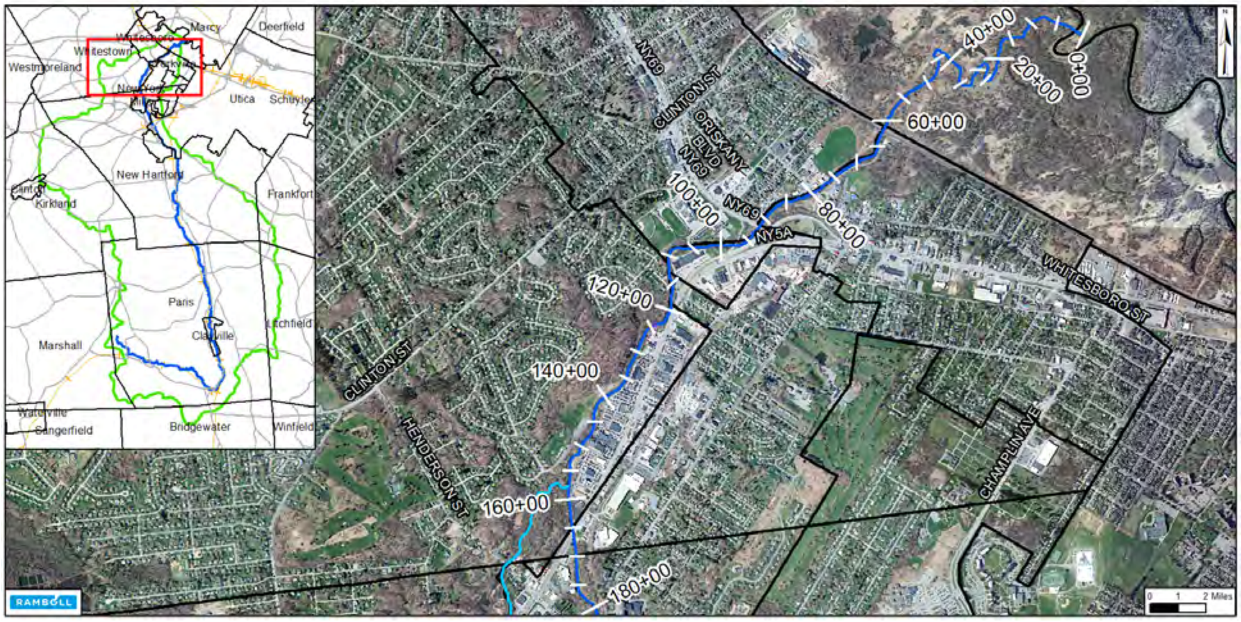

Figure 43. Location map for Zone H: Whitestown / Whitesboro.

Zone H is the most downstream reach of Sauquoit Creek and contains the Village of Whitesboro from NY-5A (Commercial Drive) to the confluence with the Mohawk River. This zone begins at 180+00 and ends at RS 0+00. This zone includes four roadway crossings, including Main Street, NY-69 (Oriskany Boulevard), NY-5A (Commercial Drive), and the ramp from NY-69 to NY-5A, and one CSX railroad crossing (Figure 43).

Flooding in the Village of Whitesboro is a twofold problem. First, areas upstream of the CSX railroad bridge crossing are subject to fluvial flooding from both Sauquoit Creek and the Mohawk River. Flooding along Sauquoit Creek can occur for high-intensity, short-duration rainfalls, whereas low-intensity, long-duration rainfall events can result in flooding of the Mohawk River with backwater creating flooding on Sauquoit Creek. Flooding from both Sauquoit Creek and the Mohawk River is the result of insufficient channel capacity and the continued development in the floodplain. Second, deposition of eroded material from upstream areas of Sauquoit Creek silt up the creek channel and reduces the hydraulic capacity of the channel and bridges (FEMA 2000b). The aggradation that occurs is most likely a result of channelization and the natural sinuosity of the creek channel in this reach where channelized areas lack strong turbulent flows to maintain sediments in the water column, and channel meanders cause water velocities to slow and deposit on the inside bend and erode the outside bend of a meander (Ramboll 2020c).

In May of 2000, a heavy rainfall event washed out numerous roads, including, NY-69 (Oriskany Boulevard). In June of 2013, a heavy rainfall event caused major flash flooding along Sauquoit Creek, which caused water to surround multiple homes within the Whitesboro area. In July of 2013, thunderstorms caused torrential rainfall across upstate New York, which caused flash flooding along Sauquoit Creek in the Village of Yorkville. In January of 2018, unseasonably warm temperatures led to melting of snow packs, which became surface runoff into local waterbodies. Combined with a moderate rainfall event, moving ice congested and jammed along bridges near Whitesboro. The ice jams caused nearly four feet of water to backup into neighborhoods along Sauquoit Creek, including Sauquoit Street, surrounding residences and leading to water rescues (NCEI 2021).

More recently, areas downstream of the confluence with Mud Creek along Sauquoit Creek experience streambank erosion and instability, which introduce sediment and debris to downstream areas. In addition, flooding occurs along multiple portions of Sauquoit Creek within this zone, including downstream of the CSX railroad crossing to Mohawk Street, and the reach extending from NY-69 (Oriskany Boulevard) downstream to the CSX railroad crossing. Sediment aggradation often occurs between the Parkway Middle School near NY-69 (Oriskany Boulevard) downstream to the CSX railroad crossing. This is most likely a result of the channelized nature of the creek in this reach, which reduces turbulent flows in the water column allowing sediment to fall out and accumulate. In addition, Main Street and Oriskany Boulevard (NY-69) are currently being reviewed for their hydraulic capacity by the NYSDOT (Ramboll 2020c).

Based on the sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various non-structural flood damage reduction measures were analyzed for Zone H. Tables 33 and 34 outline the streambank stabilization and structural engineering strategies proposed for this zone, respectively. Detailed discussions of the structural engineering strategies can be found in Appendix G.

Table 33. Streambank Stabilization Measures for Zone H

Measure Type	River Station	Description of Measure
No Action	0+00 to 30+00	Minimal-to-no shear stress or water velocity
Brush Mattresses	30+00 to 60+00	Elevated shear stress and mass bed change
Riprap and Live Stakes	60+00 to 78+50	Present riprap protection. Add live stakes within the existing riprap and add new stone in areas with erosion
Soil Lift	78+50 to 79+00	Scoured bank with moderate shear stress
Vegetated Coir Logs	79+00 to 90+00	Low water velocity and medium shear stress
Live Fascines	90+00 to 165+00	Low water velocity and medium shear stress
Riprap and Live Stakes	165+00 to 180+00	High water velocity and medium shear stress

Figure 44 displays the results of the sediment transport model simulations for Zone H for the four different annual chance flood events and the four erosional / depositional variables. Based on the sediment transport analysis, riprap and live stakes, brush mattresses, live fascines, soil lift, and vegetated coir logs were determined to be the most appropriate streambank stabilization strategies for this reach.

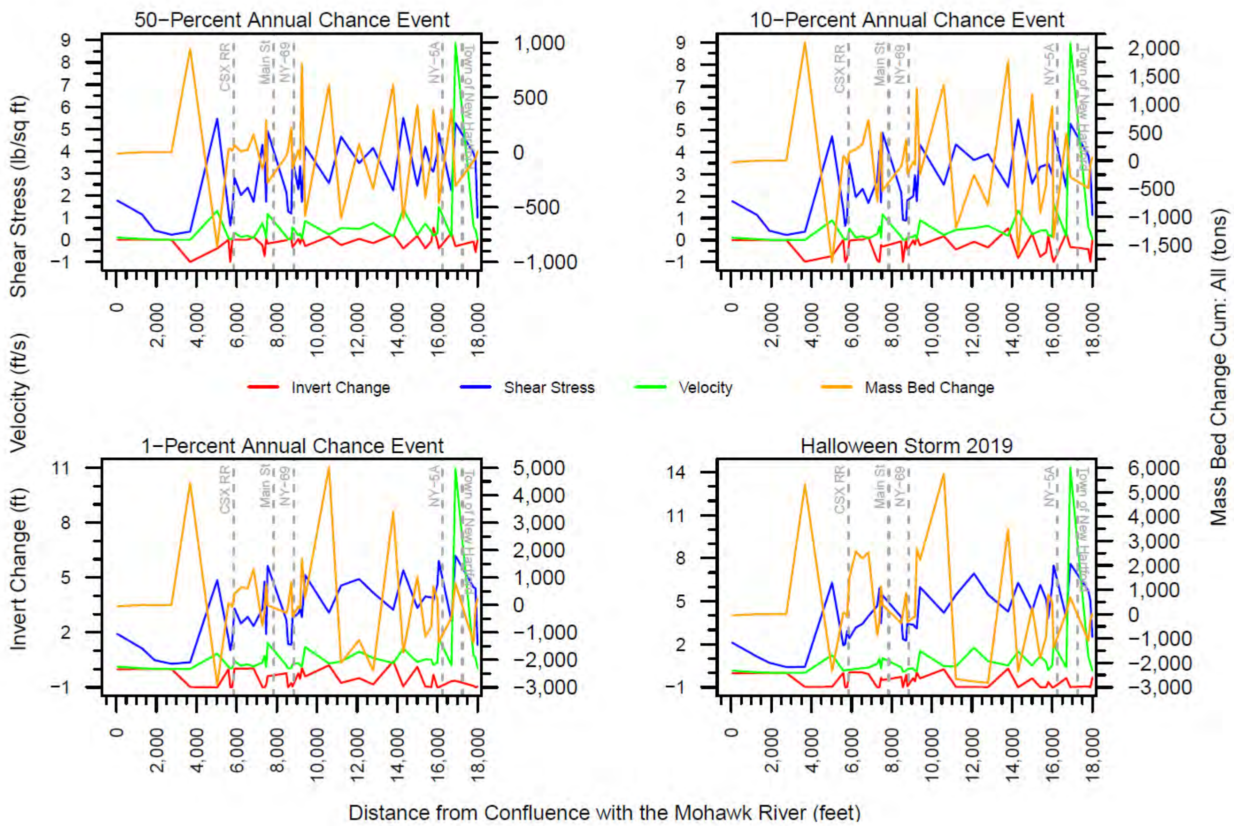

Figure 44. Analysis of invert change (ft), velocity (ft/s), shear stress (lbs./sq. ft) and cumulative mass bed change (tons) using the 1-D HEC-RAS sediment transport model for Zone H.

Based on H&H modeling, stakeholder input, previous studies and reports, and historical accounts, the soft structural engineering strategies proposed for this zone includes five flood benches and one bridge widening for Sauquoit Creek, and three flood benches for Mud Creek. Table 34 outlines the modeled structural engineering strategies with river stationing and simulation results. Figure 45 displays the model simulation results for each structural engineering strategy.

Table 34. Structural Engineering Strategies Model Simulation Results for Zone H

Strategy	ID	River Station	Potential Benefits
Flood Bench	Bench #1	65+00 to 57+50	No significant reduction in WSELs
Flood Bench	Bench #2	65+00 to 60+00	No significant reduction in WSELs
Flood Bench	Bench #3 *	123+50 to 110+00	WSEL reductions of up to 5 feet
Flood Bench	Bench #4 *	154+00 to 149+50	WSEL reductions of up to 2 feet
CSX Railroad – Crossing Pipes (Phase 2)	Crossing Pipes	69+00 to 50+00	No significant reduction in WSELs at railroad bridge – WSEL reductions of up to 5 feet downstream

* Flood Bench #3 overlaps with the Sauquoit Creek Channel & Floodplain Restoration Program – Phase I Flood Bench L-3 at Site B. Flood Bench #4 overlaps with Flood Bench L-7 at Site D.

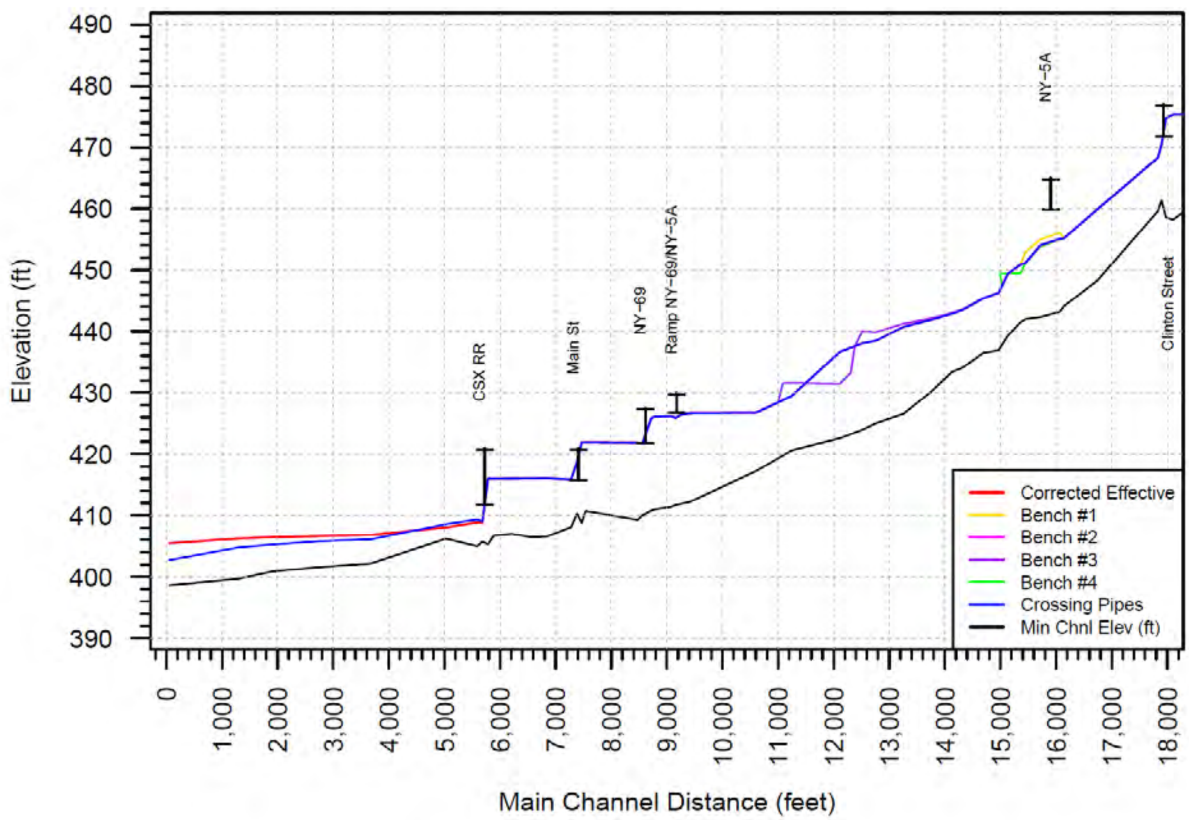

Figure 45. HEC-RAS model simulation results for each structural strategy in Zone H.

Figure 46 displays the locations of each structural engineering strategy within Zone H.

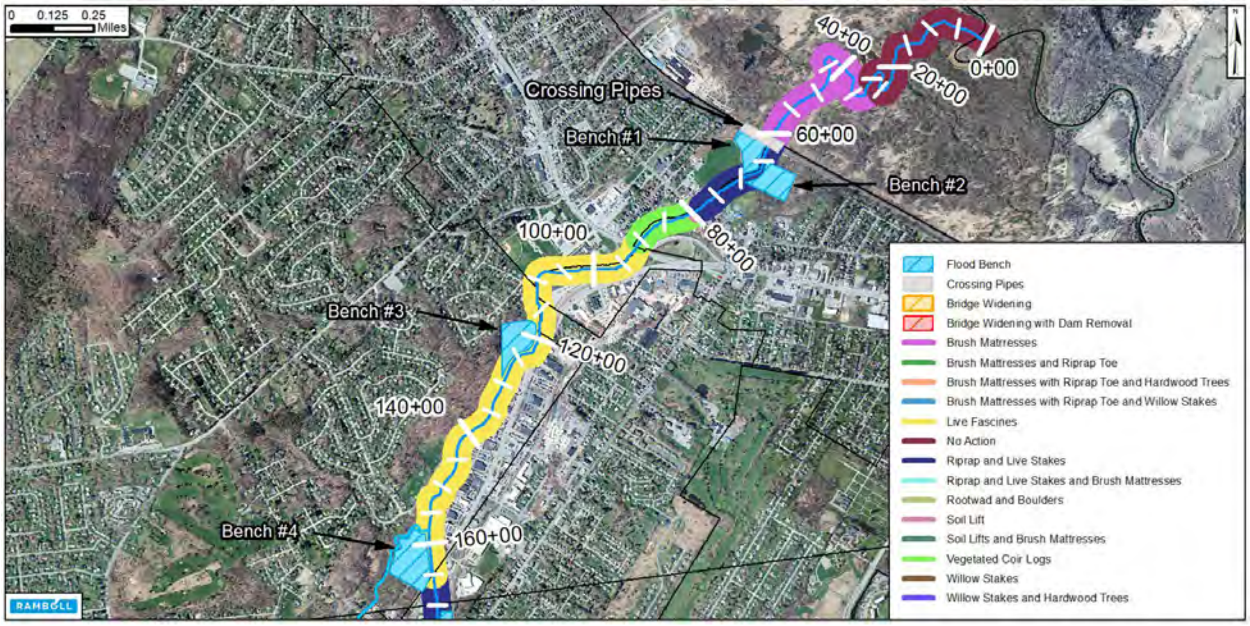

Figure 46. Locations of structural engineering strategies within Zone H.

Based on the H&H and sediment transport model simulations, stakeholder input, previous studies and reports, and historical accounts, various basin-wide management strategies were analyzed for Zone H.

The basin-wide management strategies proposed for this zone are:

- Large Woody Debris Removal
- Flood Monitoring and Warning System
- Sediment Retention Basin
- Flood Buyout Programs
- Floodproofing Residential / Commercial Properties
- Land Use Planning / Ordinances
- Riparian Restoration
- Retention Basin and Wetland Management
- Community Flood Awareness and Preparedness Programs / Education
- Development of a Comprehensive Plan

The Rough Order Magnitude cost for these proposed measures are outlined in Table 35 and does not include land acquisition costs for survey, appraisal, and engineering coordination.

Table 35. Rough Order Magnitude Cost for Proposed Strategies within Zone H

Measure / Strategy	River Station	ROM Cost (U.S. dollars)
Brush Mattresses	30+00 to 60+00	$315,000
Riprap and Live Stakes	60+00 to 78+50	$40,000
Soil Lift	78+50 to 79+00	$10,000
Vegetated Coir Logs	79+00 to 90+00	$90,000
Live fascines	90+00 to 165+00	$750,000
Riprap and Live Stakes	165+00 to 180+00	$35,000
Flood Bench #1	65+00 to 57+50	$1,500,000
Flood Bench #2	65+00 to 60+00	$1,500,000
Flood Bench #3 *	123+50 to 110+00	$1,500,000
Flood Bench #4 *	154+00 to 149+50	$1,500,000
Crossing Pipes – CSX Railroad (Phase 2)	69+00 to 50+00	$1,500,000

* Flood Bench #3 overlaps with the Sauquoit Creek Channel & Floodplain Restoration Program – Phase I Flood Bench L-3 at Site B. Flood Bench #4 overlaps with Flood Bench L-7 at Site D.

Section 7: Climate Change Implications

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* (2018) draft report. In the report, two methods for estimating projected future discharges were discussed: an end of design life multiplier, and the USGS *FutureFlow Explorer* map-based web application (NYSDEC 2018).

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 (NYSDEC 2018).

The USGS *FutureFlow Explorer* v1.5 (USGS 2015) is discussed as a potential tool to project peak flows under various climate scenarios into the future. *FutureFlow* was developed by the USGS in partnership with the New York State Department of Transportation. This application is an extension for the USGS *StreamStats* map-based web application and projects future stream flows in New York State. The USGS team examined 33 global climate models and selected five that best predicted past precipitation trends in the region. The results were then downscaled to apply to all six hydrologic regions of New York State. Three time periods can be examined: 2024-2049, 2050-2074 and 2075-2099, as well as two Intergovernmental Panel on Climate Change (IPCC) greenhouse gas emission scenarios, termed "Representative Concentration Pathways" (RCP): RCP 4.5 and RCP 8.5. RCP 4.5 is considered a midrange-emissions scenario, and RCP 8.5 is a high-emissions scenario (Taylor et al. 2011; NYSDEC 2018).

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. The USGS recommends using the *FutureFlow* application as an exploratory tool to inform selection of appropriate design flows and to judge the applications' projections as qualitative guidance to see likely trends within any watershed. Climate model forecasts are expected to improve and as they do, the existing assessment approach can be evaluated and refined further in the future. The NYSDEC recommends that future peak flow conditions should be adjusted by multiplying relevant peak flow parameters by a factor specific to the expected service life of the structure and geographic location of the project. For Sauquoit Creek, 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 36 provides a summary of the projected future peak stream flows using the FEMA FIS peak discharges and 20% CRRA design multiplier.

Table 36. FEMA FIS Peak Discharges with CRRA 20% Multiplier for Sauquoit Creek

Source: FEMA 2013a					
Flooding Source and Location	Drainage Area (mi^2)	Peak Discharges (cfs)			
		10-percent	2-percent	1-percent	0.2-percent
At the confluence with Mohawk River Reach 1	61.9	7,378	10,597	12,212	15,720
At Main Street Bridge	60.1	7,217	10,442	12,144	15,846
At Stuart Court Extended	59.4	7,048	10,448	12,266	15,780
At State Route 5A	47.1	6,230	9,181	10,969	14,400
At the corporate limits of New Hartford / Whitestown	47.1	4,679	7,819	8,413	12,628
Upstream of railroad (second crossing)	43.7	4,073	6,817	7,349	11,405
At the corporate limits of New Hartford / Utica	43.4	4,679	7,819	8,413	12,628
Upstream of railroad (third crossing)	41.1	3,905	6,479	6,961	10,739
Upstream of Utica / New Hartford corporate limits	40.2	3,793	6,290	6,761	10,548
Upstream of Kellogg Road	37.0	3,504	5,806	6,271	9,872
Upstream of railroad (fourth crossing)	32.6	2,864	4,846	5,268	8,413
Upstream of Elm Street	28.5	2,489	4,183	4,543	7,230
Upstream of Pinnacle Road	17.6	1,960	3,154	3,458	5,660
Upstream of Holman City Road	13.2	1,422	2,297	2,624	4,218
Upstream of Main Street	11.9	1,098	1,892	2,093	3,331
Upstream of Oneida Street	8.9	1,046	1,673	1,814	2,760
Upstream of State Route 8	6.4	718	1,219	1,325	2,047

Using the projected FEMA FIS peak discharges and the 20% CRRA design multiplier in the 1-D HEC RAS base condition model, future climate change conditions were simulated along Sauquoit Creek. The results of the future conditions were assessed based on the maximum change in water surface elevation for each zone. Table 37 displays the results of the future climate change conditions model simulation.

Table 37. Future Conditions Model Simulation Results for Each Zone Along Sauquoit Creek

Zone	Maximum Increase in Water Surface Elevations (ft)
A: Paris - Upstream	2.5
B: Paris - Clayville	1.8
C: Paris - Downstream	3.2
D: New Hartford / Washington Mills Park	3.6
E: New Hartford / Utica - Upstream	2.7
F: New Hartford / Utica - Downstream	2.7
G: New York Mills / New Hartford	3.5
H: Whitestown / Whitesboro	5.7

Based on the results of the future climate change conditions modeling, water surfaces are projected to increase in every zone analyzed in this study. The zones projected to be at greatest risk from future flooding are Zones G and H, which are the most downstream portions of Sauquoit Creek. These zones are also the most heavily populated and developed in the watershed.

In addition, higher water surface elevations within Sauquoit Creek can lead to higher volumes of water in the channel. Higher volumes of water can potentially have the energy to carry more and larger sediment and debris, which can lead to an increase in erosional and depositional processes along the creek. Increased sediment and debris in Sauquoit Creek can also potentially increase flood risk through minimizing channel and infrastructure hydraulic capacity. As a result, any sediment and debris or flood mitigation strategies should consider the impact of climate change and the projected increases in water surface elevations along Sauquoit Creek.

Section 8: Conclusion

Municipalities within the Sauquoit Creek watershed have historically, and continue to be affected by sediment and debris issues along the creek, which can potentially lead to flooding in areas within the Sauquoit Creek floodplain. This study set forth the technical analysis and basis for potential future actions to address sediment and debris management within the Sauquoit Creek watershed. This is considered a planning document only, but provides the guidance necessary for implementation of management strategies. Additional design and hydraulic modeling and analyses would be necessary to implement many of the strategies discussed within this study.

This study provided an understanding of the intricacies, complexities, and interrelationships involved in water resource management; outlined common issues faced by different municipalities along Sauquoit Creek; and identified specific strategies and measures to address these issues. Within the Sauquoit Creek basin, 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 Sauquoit Creek basin.

The sediment and debris management strategies proposed in this study represent a sample of the potential projects which, if undertaken, would work towards a comprehensive, basin-wide approach to water resource management within the Sauquoit Creek watershed. It should be noted that these projects do not represent an all-inclusive listing of potential projects, but are provided as a basis for intermunicipal discussions and cooperation to initiate watershed management strategies. Additional management strategies are encouraged to be formulated, debated, and promoted in the future.

Section 9: Approvals

Before work commences, final stream sediment and debris management plans must be reviewed and approved by the local Soil and Water Conservation District Office, in consultation with the NYSDEC Regional Office. In some instances, the Soil and Water Conservation District may find specific aspects of the plan require more detailed review and stamped approval by a licensed Professional Engineer.

Approval Signatures

The individuals listed below are authorized to sign and execute this management plan on the date appearing below their respective signatures.

Soil and Water Conservation District	Managing Municipality
By:	By:
Printed Name:	Printed Name:
Title:	Title:
Dated:	Dated:

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Appendix A: SCBIC Project List

SAUQUOIT CREEK BASIN INTERMUNICIPAL COMMISSION
COMPLETED PROJECT LISTING (2006 - 2020)

Year	Project	Estimated Cost	Municipality	Funding Agency
2006	Pietryka Park Sewer Project Bank Stabilization	$239,342	NY Mills	Multiple Sources
2007	Hand Place/ Oneida Street Sewer Project	$117,227	New Hartford (T)	Multiple Sources
2008	Rayhill Trail Parking and Signage	$57,139	New Hartford (T)	Multiple Sources
2011	Pietryka Park Fishing Deck	$28,282	NY Mills	NYS DEC
2011	Gravel Bar removal at CSX Tracks RR Bridge	In-Kind	Whitesboro	SCBIC
2012	NEG Grant Temporary Workers to clean creek & tributaries in entire basin	$858,506	Basin-wide	NYS DOL
2012	Mud Creek Stabilization on Royal Brook Lane	$57,000	NY Mills	SCBIC
2012	Repair of collapsed bank at Hillside Gardens, Oneida Street	$11,047	New Hartford (T)	SCBIC
2013	Earthen Berm along New Hartford Street	$110,000	NY Mills	In-Kind/SCBIC
2013	CSX Tracks channel clearing and racks	$71,554	Whitestown	ESD
2013-14	Commercial Drive, CSX Bridge and Main Street Bridge gravel removal	$379,906	Whitesboro	NYS DOT
2014	Palmers Creek Bank Stabilization, Oneida Street	$141,640	New Hartford (T)	ESD & OC
2014	CSX bridge clearing and channel installation	$2,000,000	Whitestown	CSX
2015	Washington Mills Athletic Park	$25,000	New Hartford (T)	Trout Unlimited
2016	Paris Bank Stabilization, Oneida Street Culverts	$235,000	Paris	Oneida Co & DASNY
2016	Main Street Bridge repairs	$87,000	Whitesboro	Oneida Co + in-kind
2016	Channel and Flood Plain Restoration Design	$311,500	Whitestown	ESD
2016-17	Paris Dam Removal & Stabilization	$550,000	Paris	MVEDGE
2016-17	Gingerbread House (Oneida St) Bank Stabilization	$55,000	New Hartford (T)	S&W, Mohawk River Coalition Funds
2017	Paris Highway Garage Bank Stabilization	$236,000	Paris	DASNY
2018-2020	Whitestown Flood Bench Project- Phase 1	$5,100,000	Whitestown	GIGP/ ESD/ SAM
2018	CSX Bridge H&H study	$33,500	Whitestown/Whitesboro	NYS DOT
2018	CSX Bridge and bench 30% Design	$220,000	Whitestown/Whitesboro	NYS DOT

Year	Project	Estimated Cost	Municipality	Funding Agency
2018	Preswick berms/ Sangertown detention and Grange Hill	$1,225,000	New Hartford (T)	OC
2018	Whitestown Flood Bench Engineering oversight	$225,000	Whitestown/Whitesboro	OC
2018	Trees for Tributaries	$25,000	Whitestown	NYS DEC
2019	Bank Restoration Project	$400,000	Whitestown	OC
2019	HMGP- FEMA-Engineering - Phase 2	$106,514	Whitestown/Whitesboro	FEMA
2019	Main Street Storm sewer rightsizing	$440,000	Whitesboro	OC
2020	Whitestown Flood Bench Project- Phase 2-	$2,000,000	Whitestown/Whitesboro	NYS EFC GIGP
Total		**$15,346,157**		

PROPOSED PROJECT LISTING (2006 - 2020)

Year	Project	Location	Purpose	Estimated Cost
2014	ESD Project #1- CSX Bridge	Village of Whitesboro, Whitestown near CSX tracks	Shape overflow channels to the east and west of the CSX tracks, debris removal, install a trash rack to catch debris, and reclaim disturbed areas with topsoil and seeding.	$90,823
2014	ESD Project #2- Paris bank stabilization	NYS Rte 8 & Latus Rd, Paris	Phase 1 Clean out of sediment and some repair of banks just below the dam.	$95,000
2014	Paris Dam reconstruction	NYS Rte 8 & Latus Rd, Paris	Phase 2 dam removal and bank stabilization	$250,000
2014	Hand Place Armoring	Hand Place, Town of NH	repair and redesign of bank stabilization from storms in 2011	
2014	Washington Mills Park Bank Stabilization	T. New Hartford	bank stabilization, creation of a flood plain and reconstructed fishing access point. USF&W design, Trout Unlimited materials	$10,000
2014	CSX Access Road	Whitesboro	a permanent access road to the CSX tracks bridge that would allow equipment to be brought to the creek in all types of weather	
2014	NY Mills Bank Stabilization	NY Mills	Stabilization of a section of banks just north of the New Hartford Animal Hospital/Town highway Garage	
2014	Flow model at CSX bridge	Whitesboro	design study for CSX to assist with sleeves under bridge	$30,000
2014	ESD Project #4- Palmers Creek	Oneida Street, Creekside Cafe, T. of New Hartford	bank stabilization and armoring	$58,000
2014	Palmers Creek Phase 2 to Kellogg Road	T. of New Hartford	Clearing, bank stabilization and armoring from Oneida Street to Kellogg Road	$100, 000
2014	Oneida Street Stream Bank Restoration	Oneida St, Gingerbread House, T. NH	600 feet along creek where banks are eroding or existing retaining walls are collapsing.	$425,000
2014	Detention Basin Preswick Glen	Middle Settlement Road, New Hartford	Creation of a detention basin	$1,000,000

Year	Project	Location	Purpose	Estimated Cost
2014	Elm Street Retaining Wall	Elm Street, Chadwicks, New Hartford	Retaining wall is along creek is being eroded and collapsing in spots. Residential property is falling into the creek	$233,000
2014	Detention Pond Devereux Creek	Hollywood Drive, Whitestown	Creation of a detention pond at Devereux Creek and Dunham Manor to hold back flows before hitting the Sauquoit Creek	
2014	Bank Stabilization at Dunham Park	Hollywood Drive, Whitestown	Stabilize bank and shore up fishing deck piers at the Town of Whitestown Park	$220,000
2014	Bank Stabilization at Paris Hwy Garage	Oneida Street, Paris	Stabilize bank along the creek near the town of Paris Highway garage	$236,000
2014	Washington Mills Rte 8 Diversion	Flood Plain area from Washington Mills downstream to V. of N Hartford	Model, Design and construct a diversion for flood flows from main creek onto a dentation basin adjacent to NYS Rte 8	$500,000
2014	Bioswale/Detention Area	Multiple Locations in Basin. Specifically, along Commercial Drive/ NYS 5a	An effort to reduce the rate of water inflow and to increase water quality through green practices. More underground detention and soil infiltration practices through the use of bio retention swales to control discharge of stormwater runoff and point discharge into Sauquoit Creek	$100, 000
2014	Mud Creek and Middle settlement Rd Wetland Enhancement	Mud Creek Sub-basin upstream and FP area downstream	Reduction in stormwater discharge/flooding by allowing the detention and slow release of stormwater	
2014	Whitestown Stormwater Management Plan	Sauquoit basin	Improved management of town-wide stormwater allowing for potential continued development.	$50,000
2014	Mud Creek Realignment	NY Mills	The straightening of Mud creek near Royal Brook Lane	$80,000
2014	Deflector structures	Oriskany Blvd, Town of Whitestown	construction of deflector structures on both sides of bank to stop erosion	

Year	Project	Location	Purpose	Estimated Cost
2014	Hydraulic Modeling	Basin wide	Creation of hydraulic model from the 1987 to provide water quality and flow measurements that can be used to develop storm water & sewer improvements	$100,000
2014	Stream Gauges	Various	Provides fixed surveyed elevation points for gauging real-time stream elevations	$30,000
2014	Base Mapping	Basin-wide	Provides basis for flooding projections, modeling, and what if considerations	
2014	Bleachery Ave retaining Wall	Bleachery Ave, Chadwicks, New Hartford	retaining wall along the creek is being undermined and creating sink holes. Need to re-stabilized and build the wall.	
2014	Storm sewer realignment	Main Street, Whitesboro	Storm sewer at the Main Street Bridge needs to be cleaned and realigned to prevent water back up	$85,000
2015-16	Hydraulic Modeling	Basin wide - Basin wide	Creation of hydraulic model from the 1987 to provide water quality and flow measurements that can be used to develop storm water & sewer improvements	$250,000
2015-16	Stream Gauges	Various - Basin wide	Provides fixed surveyed elevation points for gauging real-time stream elevations	$30,000
2015-16	Sediment Management	specific locations - Multiple locations	new article 15 permit to maintain channel using guidelines to remove	
2015-16	Hand Place Armoring	Hand Place - New Hartford	repair and redesign of bank stabilization from storms in 2011	
2015-16	Culvert Replacement	Rte 5 and Rte 5a/Commercial drive - New Hartford	Replace or add two parallel culverts under Seneca Turnpike	
2015-16	Mud creek rightsizing	Mud creek on Commercial Drive - New Hartford	enlarge a 1000ft section of mud creek to better convey flows	
2015-16	Palmers Creek Phase 2 to Kellogg Road	T. of New Hartford - New Hartford	Clearing, bank stabilization and armoring from Oneida Street to Kellogg Road	$100, 000

Year	Project	Location	Purpose	Estimated Cost
2015-16	Oneida Street Stream Bank Restoration	Oneida St north of Kellogg Rd - New Hartford	600 feet along creek where banks are eroding or existing retaining walls are collapsing.	$425,000
2015-16	Detention Basin Preswick Glen	Middle settlement Road - New Hartford	Creation of a detention basin	$1,000,000
2015-16	Washington Mills Rte 8 Diversion	Flood Plain area from Washington Mills downstream to V. of N Hartford - New Hartford	Model, Design and construct a diversion for flood flows from main creek onto a dentation basin adjacent to NYS Rte 8	$500,000
2015-16	Mud Creek and Middle settlement Rd Wetland Enhancement	Mud Creek Sub-basin upstream and FP area downstream - New Hartford	Reduction in stormwater discharge/flooding by allowing the detention and slow release of stormwater	
2015-16	Bleachery Ave retaining Wall/ Brookside Trailer Park	Bleachery Ave, Chadwicks - New Hartford	retaining wall along the creek is being undermined and creating sink holes. Need to re-stabilized and build the wall.	
2015-16	Bridge Replacement	Commercial Drive/Rte 5a - New Hartford	Replacing of bridge that serves as a bottleneck on commercial strip	
2015-16	Bioswale on Commercial Drive/ Rte 5a	Multiple Locations in Basin. Specifically, along Commercial Drive/ NYS 5a - New Hartford and Whitestown	An effort to reduce the rate of water inflow and to increase water quality through green practices. More underground detention and soil infiltration practices through the use of bio retention swales to control discharge of stormwater runoff and point discharge into Sauquoit Creek	$100, 000 each
2015-16	NY Mills Bank Stabilization	NY Mills - NY Mills	Stabilization of a section of banks just north of the New Hartford Animal Hospital/Town highway Garage	
2015-16	Paris bank stabilization and dam removal	NYS Rte 8 & Latus Rd - Paris	Phase 1 Clean out of sediment and some repair of banks just below the dam. Phase 2 dam removal and bank stabilization	$500,000
2015-16	Bank Stabilization at Paris Hwy Garage	Oneida Street - Paris	Stabilize bank along the creek near the town of Paris Highway garage	$236,000

Year	Project	Location	Purpose	Estimated Cost
2015-16	Removal of Failing dams	Locations along Sauquoit Creek - Paris	Removal of 8 low head dams	
2015-16	Repair of Dam above Elm Street	South of Elm Street - Paris	Repair, clean existing dam to meet current dam safety regulations	
2015-16	Box Culvert improvement	- Paris	improve and replace box culverts	$140,000
2015-16	CSX Access Road	Whitesboro - Whitesboro	a permanent access road to the CSX tracks bridge that would allow equipment to be brought to the creek in all types of weather	
2015-16	Storm sewer realignment	Main Street - Whitesboro	Storm sewer at the Main Street Bridge needs to be cleaned and realigned to prevent water back up	$75,000
2015-16	Detention Pond Devereux Creek	Hollywood Drive - Whitestown	Creation of a detention pond at Devereux Creek and Dunham Manor to hold back flows before hitting the Sauquoit Creek	
2015-16	Mohawk River Detention Basins	Mohawk Street - Whitestown	Creation of two detention basins and access road to hold water than flows north of the CSX tracks. Access from 190 Mohawk Street	
2015-16	Bank Stabilization at Dunham Park	Hollywood Drive - Whitestown	Stabilize bank and shore up fishing deck piers at the Town of Whitestown Park/ flood plain restoration	$360,000
2015-16	Whitestown Stormwater Management Plan	Sauquoit basin - Whitestown	Improved management of town-wide stormwater allowing for potential continued development.	$50,000
2015-16	Elm Street/Williams Tools	Elm Street - New Hartford	Williams Tool stabilization of banks of tributary behind the property.	$233,000
2018	Hillside Gardens- Oneida Street	New Hartford, T	Bank stabilization and sewer repair and armoring. Repeated failures at this location.	
2018	Material Removal in Flats	Whitestown	Removal of material in targeted locations for water storage	
2018	NY Mills Bank Stabilization	NY Mills	Stabilization of a section of banks just north of the New Hartford Animal Hospital/Town highway Garage	

Year	Project	Location	Purpose	Estimated Cost
2018	Sangertown Square	New Hartford, T	Mud Creek (Dunn and Sgromo Study 2012) addition of berms, outlet structures, and new box culverts on the commercial Drive Entrances.	
2018	Presbyterian Home, Middle Settlement	New Hartford, T	Addition of berms (5-10ft) and detention basin of 24 acres in size (Mud Creek) along with Wetlands enhancement (Dunn and Sgromo Study 2012)	$980,000
2018	Preswick Glenn	New Hartford, T	Addition of berms (5-10ft) and detention basin of 24 acres in size (Mud Creek) (Dunn and Sgromo Study 2012)	$980,000
2018	Mud Creek rightsizing Across from Consumer Square	Mud creek on Commercial Drive	enlarge a 1000ft section of Mud Creek to better convey flows (suggested in MMI report and (Dunn and Sgromo Study 2012)	$75,000
2018	Victoria Drive Flood Plain Restoration	Utica	acquisition of several properties and the creation of a flood bench with widening of the banks to storage flood waters could add critical detention space of flood waters upstream.	
2018	Henderson/Commercial Drive Bridge replacement	New Hartford	replace the bridge over the Sauquoit Creek on Commercial Drive when it is scheduled for replacement to eliminate the hydraulic constriction.	
2018	Grange Hill Road Project	New Hartford, T	Phase 1 construction of 2 drainage ponds. Phase 2 installation of new stormwater piping at bottom of Grange Hill under Oneida Street	Phase 1- $347,000
2018	Storm sewer separation	Whitesboro	separate storm water and sewer lines on Main Street	
2018	Greenplain	along creek NYS 5a bridge, south	A Greenplain is a comprehensive approach to flood plain management including bank stabilization, stream habitat enhancement, installation of flow control measures, and the creation of open space areas for public recreation parks.	$750,000

Year	Project	Location	Purpose	Estimated Cost
2018	Acquisition	Chadwicks and Whitesboro	Targeted acquisition of properties that are severely and repetitively flooded	$100,000-$500,000 per property
2018	Rightsizing bridges in lower reaches	Whitestown	Right sizing the bridges over the creek along Oriskany Blvd and Main Street in Whitesboro	
2018	Cusworth Property- low head dams	Oneida Street near Grange Hill Road	reclaim 3 dams located on private property and funds the on-going maintenance	
2018	Town of Paris Bank repair and Flood Plain restoration	Pinnacle Road North to Town of New Hartford almost to Chadwick's Park (near Elm Street)	Repair eroded banks and reintroduce flood plain in areas along Sauquoit Creek between Pinnacle Road and Elm Street	
2018	Bioswale on Commercial Drive/ Rte. 5a	Multiple Locations in Basin. Specifically, along Commercial Drive/ NYS 5a	An effort to reduce the rate of water inflow and to increase water quality through green practices. More underground detention and soil infiltration practices through the use of bio retention swales to control discharge of stormwater runoff and point discharge into Sauquoit Creek	$100,000-$500,000 each
2018	Removal of Failing dams	Locations along Sauquoit Creek	Removal of 8 low head dams (suggested in MMI report)	$2.1m
2018	Repair of Dam above Elm Street	South of Elm Street	Repair, clean existing dam to meet current dam safety regulations (suggested in MMI report)	
2018	CSX Access Road	Whitesboro	a permanent access road to the CSX tracks bridge that would allow equipment to be brought to the creek in all types of weather	
2018	Detention Pond Devereux Creek	Hollywood Drive	Creation of a detention pond at Devereux Creek and Dunham Manor to hold back flows before hitting the Sauquoit Creek	
2018	Mohawk River Detention Basins	Mohawk Street	Creation of two detention basins and access road to hold water than flows north of the CSX tracks. Access from 190 Mohawk Street	$250,000

Year	Project	Location	Purpose	Estimated Cost
2018	Elm Street/Williams Tools	Elm Street	Williams Tool stabilization of banks of tributary behind the property.	$233,000
2018	Seneca Turnpike Culvert Replacement	Rte. 5 and Rte. 5a/Commercial drive	Daylighting the culvert and property removal from the flood plain is the recommended option under Seneca Turnpike (suggested in MMI report)	$650,000
2018	Palmers Creek Phase 2 to Kellogg Road	T. of New Hartford	Clearing, bank stabilization and armoring from Oneida Street to Kellogg Road (CRZ plan)	
2018	Oneida Street Stream Bank Restoration	Oneida St north of Kellogg Rd	600 feet along creek where banks are eroding or existing retaining walls are collapsing.	$425,000
2018	Washington Mills Rte. 8 Diversion	Flood Plain area from Washington Mills downstream to V. of N Hartford	Model, Design and construct a diversion for flood flows from main creek onto a dentation basin adjacent to NYS Rte. 8	$500,000
2018	Bleachery Ave retaining Wall/ Brookside Trailer Park	Bleachery Ave, Chadwick's	retaining wall along the creek is being undermined and creating sink holes. Need to re-stabilized and build the wall. (suggested in MMI report)	$450,000
2018	Yearly debris removal	Basin wide	tree removal, garbage and other debris is removed from the creek after a survey by municipal public works	$200,000
2018	Bridge Replacement	Commercial Drive/Rte. 5a	Replacing of bridge that serves as a bottleneck on commercial strip (suggested in MMI report)	
2018	Stream Gauges	Various flood prone locations on creeks	Provides fixed surveyed elevation points for gauging real-time stream elevations. One located on Commercial Drive in 2014. Helpful in flood stage monitoring. (MMI report And CRZ Plan)	$100,000+ per site
2018	Hydraulic Modeling	Basin wide	Creation of hydraulic model from the 1987 study to provide water quality and flow measurements that can be used to develop storm water & sewer improvements	$250,000

Year	Project	Location	Purpose	Estimated Cost
2018	Implement Sediment Management Plans	Basin wide		$125,000
2018	Flood Plain Restoration, Wetland Protection and Enhancement	Basin wide	identify areas to restore the nature flood plain or mitigate wetlands	
2018	Updated land use controls with overlays, buffers, green innovation	All municipalities	Use land use tools to address flood resilience thru updated zoning and comprehensive plans. land use regulations that look at natural resources and flooding while balancing economic development needs	varies
2018	County Comprehensive Plan	Countywide	Plan to encourage development outside of flood risk areas and regulate building flood plain	$100,000+
2018	Riparian Buffers	Paris, Whitestown, New Hartford	Work with upstream Agricultural Community to protect riparian buffers along waterways.	
2018	Rayhill Trail extension to Parkway School	North side of Creek along Commercial Drive	Provide an extension from the Parkway Middle School along the north side of Sauquoit Creek a multi-use recreation trail that connects into Dunham Manor Park and the larger multi-jurisdiction Rayhill Trail.	
2018	Drainage way Maintenance Program	Basin wide	draft local sediment management plans. Incorporate into the annual local budgeting process.	$50,000
2018	Hand Place Armoring	New Hartford, T	repair and redesign of bank stabilization from storms in 2011(CRZ plan)	
2020	Updated land use controls with overlays, buffers, green innovation	Basin-wide	Use land use tools to address flood resilience thru updated zoning and comprehensive plans. land use regulations that look at natural resources and flooding while balancing economic development needs. Flood plain and overlay districts.	varies
2020	Basin Wide Drainage Study	Basin-wide	inventory and data collection of all drainage infrastructure, creation of a GIS database	

Year	Project	Location	Purpose	Estimated Cost
2020	Flood Plain Restoration, Wetland Protection and Enhancement	Basin-wide	identify areas to restore the nature flood plain or mitigate wetlands	
2020	Stream Debris & Maintenance Program	Basin-wide	draft local sediment management plans. Incorporate into the annual local budgeting process.	
2020	Yearly debris removal	Basin-wide	tree removal, garbage and other debris is removed from the creek after a survey by municipal public works	$200,000
2020	Rte. 20 Culvert	Rte. 20 and Patty's Pub - Bridgewater	Upsize culvert and realign Unadilla River.	
2020	Strategic Property Acquisition	Multiple locations - Chadwicks, Whitesboro, Marshall	Allow for the natural restoration of the flood plain and remove residents from harm's way.	
2020	LWRP Plan	Nail, Reall, Mud, Sauquoit, Wood, Nine Mile - Multiple Communities	request funds for the creation of a local waterfront revitalization plan. Potentially Mud Creek/ Reall and Mud Creeks commercial area	
2020	Bridge Replacement	Commercial Drive/ Rte. 5a - New Hartford	Replacing of bridge that serves as a bottleneck on commercial strip (suggested in MMI report)	
2020	Bioswale Development	Middle settlement, Commercial Drive/ Rte. 5a and Seneca Turnpike - New Hartford	An effort to reduce the rate of water inflow and to increase water quality through green practices. More underground detention and soil infiltration practices through the use of bio retention swales to control discharge of stormwater runoff and point discharge into Sauquoit Creek	$100,000-$500,000 each
2020	Flood plain restoration/ benches	New Hartford Street - New Hartford	potential location near Town Highway Garage	
2020	Mud Creek rightsizing Across from Consumer Square	NYS 5a/ Royal Brook Lane - New Hartford	enlarge a 1000ft section of Mud Creek to better convey flows (suggested in MMI report and (Dunn and Sgromo Study 2012)	$75,000

Year	Project	Location	Purpose	Estimated Cost
2020	Henderson/Commercial Drive Bridge replacement	Henderson Street - New Hartford	replace the bridge over the Sauquoit Creek on Commercial Drive when it is scheduled for replacement to eliminate the hydraulic constriction.	
2020	Green plain: South of NYS 5A Bridge along the Sauquoit Creek	NYS 5A - New Hartford	A Green plain is a comprehensive approach to flood plain management including bank stabilization, stream habitat enhancement, installation of flow control measures, and the creation of open space areas for public recreation parks.	$750,000
2020	Williams Tools	Elm and Oneida Street - New Hartford	Williams Tool stabilization of banks of tributary behind the property.	$500,000
2020	Seneca Turnpike Culvert Replacement	NYS 5a and Seneca Turnpike - New Hartford	Daylighting the culvert and property removal from the flood plain is the recommended option under Seneca Turnpike (suggested in MMI report)	$650,000
2020	Palmers Creek Bank Stabilization and Rightsizing Phase 2	Kellogg Road and Oneida Street - New Hartford	Clearing, bank stabilization and armoring from Oneida Street to Kellogg Road (CRZ plan)	$775,000
2020	Oneida Street Stream Bank Restoration	Oneida Street - New Hartford	600 feet along creek where banks are eroding or existing retaining walls are collapsing near Subway and Shampooches.	$500,000
2020	Washington Mills Rte. 8 Diversion	NYS Rte. 8 - New Hartford	Model, Design and construct a diversion for flood flows from main creek onto a dentation basin adjacent to NYS Rte. 8	
2020	Bleachery Ave retaining Wall/ Brookside Trailer Park	Oneida Street/ Bleachery Ave - New Hartford	retaining wall along the creek is being undermined and creating sink holes. Need to re-stabilized and build the wall. (suggested in MMI report)	$450,000
2020	South Utica/Washington Mills Detention	Oneida Street - New Hartford	bank stabilization, stream rightsizing & flood plain restoration on this flat, wide portion of the SC. Creation of a flood bench to store flood	$4,000,000

Year	Project	Location	Purpose	Estimated Cost
			waters could add critical detention space of flood waters upstream.	
2020	Consumer Square Flood Plain Restoration	Commercial Drive and Royal Brook Lane - New Hartford	Rightsized the Mud Creek and restore flood plain on last remaining vacant parcel before creek joins SC	
2020	Cusworth Property- low head dams	Oneida Street near Grange Hill Road - New Hartford	reclaim 3 dams located on private property and funds the on-going maintenance	
2020	Chenango Road Detention	New Hartford Highway Garage/DOT Maintenance - New Hartford	Detention area on municipal property behind the highway garage and state maintenance facility	
2020	Chadwicks Flood Plain Restoration Project	Oneida Street - New Hartford	Use damaged Washington Mills Athletic park to restore flood plain and detain water before it arrives at WM or S. Utica	
2020	Hillside Gardens	Oneida Street - New Hartford, T	Bank stabilization and sewer repair and armoring. Repeated failures at this location.	
2020	Presbyterian Home Berms	Middle settlement Road - New Hartford, T	Addition of berms (5-10ft) and detention basin of 24 acres in size (Mud Creek) along with Wetlands enhancement (Dunn and Sgromo Study 2012)	$980,000
2020	NY Mills Bank Stabilization	New Hartford Street - NY Mills	Stabilization of a section of banks near McCraith Beverage	
2020	Town of Paris Bank repair and Flood Plain restoration	Pinnacle Road north to Elm Street - Paris	Repair eroded banks and reintroduce flood plain in areas along Sauquoit Creek between Pinnacle Road and Elm Street	
2020	Removal of Failing dams	Paris	Removal of 8 low head dams at several locations along Sauquoit Creek (suggested in MMI report)	$2.1m
2020	Repair of Dam above Elm Street	Elm and Oneida Street - Paris	Repair, clean existing dam to meet current dam safety regulations (suggested in MMI report)	
2020	Riparian Buffers	Paris, Whitestown, New Hartford	Work with upstream Agricultural Community to protect riparian buffers along waterways.	

Year	Project	Location	Purpose	Estimated Cost
2020	North Utica Bank Stabilization	North Utica Park - Utica	restore and stabilize banks	$400,000
2020	Utica Flood Studies	Multiple locations - Utica	Funds for flood mitigation studies of Reall, Ballou, Nail and Sauquoit Creek	$200,000
2020	Victoria Drive Flood Plain Restoration	Victoria Drive, Oneida Street and NYS Rte. 8 - Utica	Restoration of flood plain south of Victoria Drive. Stream bank stabilization and the acquisition of land in the Town of NH.	
2020	Genesee Street Bridge	Genesee Street & Sauquoit Creek - Utica/ V of New Hartford	clean the opening of the bridge. Full of sediment. Was a 24 ft. clearance and now probably 20 or less.	
2020	Stream Gauges	Various flood prone locations on creeks	Provides fixed surveyed elevation points for gauging real-time stream elevations. One located on Commercial Drive in 2014. Helpful in flood stage monitoring. (MMI report And CRZ Plan)	$100,000+ per site
2020	Residential Acquisition	Whitesboro	Targeted acquisition of properties that are severely and repetitively flooded	$22,000,000
2020	CSX Access Road	Whitesboro	a permanent access road to the CSX tracks bridge that would allow equipment to be brought to the creek in all types of weather	
2020	Parkway Middle school Bank Repairs	Rte. 69 - Whitesboro	between Tahans and School there is erosion along the banks that needs to be stabilized	
2020	Rightsizing bridges in lower reaches	Oriskany Blvd and Main Street - Whitestown	Right sizing the bridges over the creek along Oriskany Blvd and Main Street in Whitesboro	
2020	Sauquoit Creek Flood Plain Restoration	NYS 5A/Commercial Drive - Whitestown	Bank stabilization and flood plain restoration along the Sauquoit Creek in 11 locations along 1.25 miles.	$15,000,000
2020	Material Removal in Flats	Old Mohawk Street/ Rte. 291 - Whitestown	Removal of material in targeted locations for water storage	
2020	Detention Pond Devereux Creek	Hollywood Drive - Whitestown	Creation of a detention pond at Devereux Creek and Dunham Manor to hold back flows before hitting the Sauquoit Creek	

Year	Project	Location	Purpose	Estimated Cost
2020	Oriskany Creek Dam	Valley Road - Whitestown	Removal of dam that causes water back up and bank restoration	$600,000
2020	Mohawk River Detention Basins	Old Mohawk Street/ Rte. 291 - Whitestown	Creation of two detention basins and access road to hold water than flows north of the CSX tracks. Access from 190 Mohawk Street	$100,000
2020	Hippos Drainage Area	Old Commercial Drive - Yorkville and NY Mills	Drainage study and improvements from the Collis Building to Hippos	

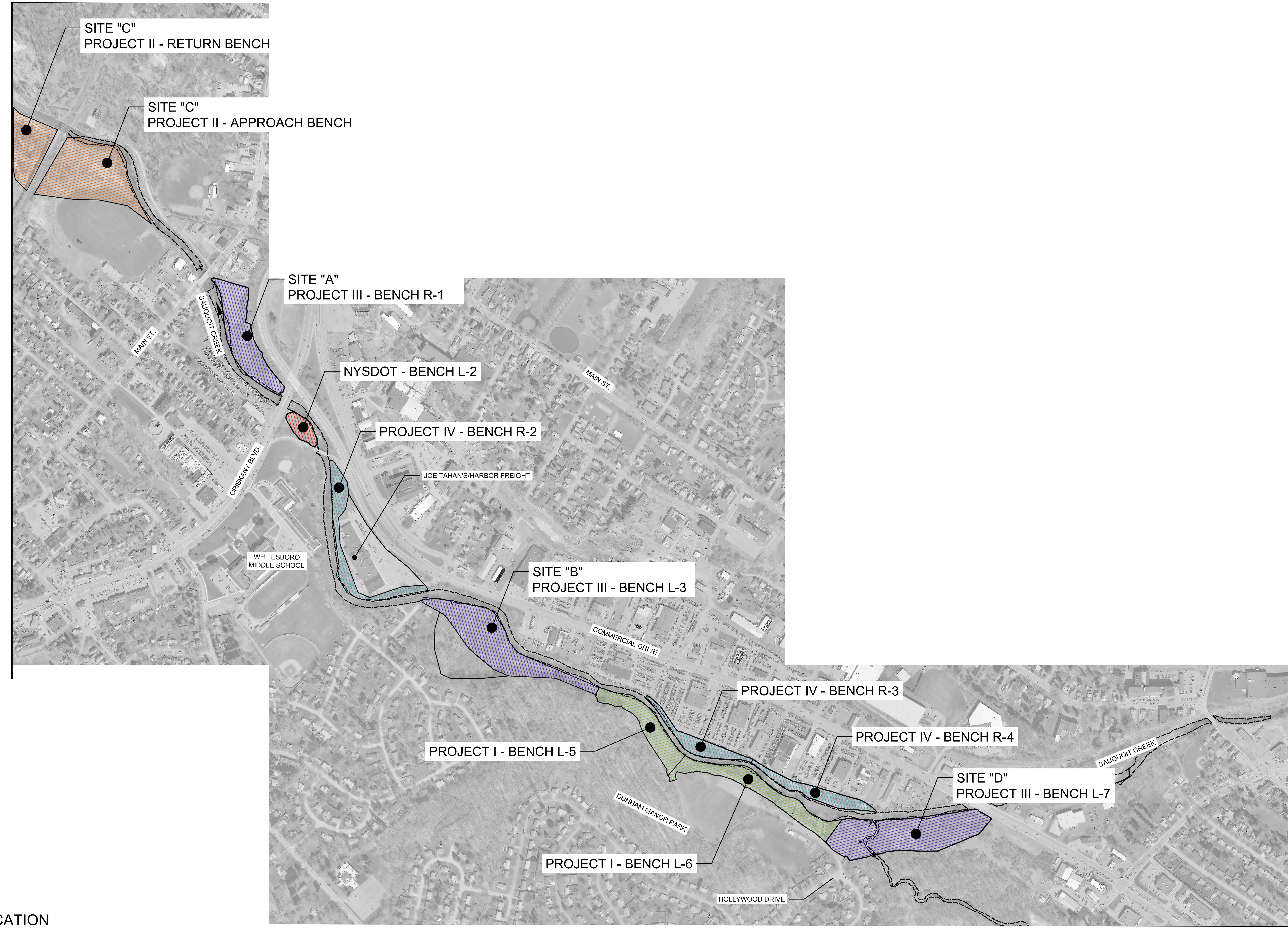
Appendix B: Sauquoit Creek Channel & Floodplain Restoration Program

The Town of Whitestown is actively engaged and working with Oneida County and New York State on the Sauquoit Creek Channel & Floodplain Restoration Program, an on-going effort started in 2016 to determine and implement the improvements needed to alleviate historical flooding along the Sauquoit Creek.

The program, in its entirety, involves channel widening, the construction of approximately 12 floodplain benches, areas of bank stabilization and the creation of a public access trail along a 1-plus mile corridor of the lower Sauquoit Creek in Whitestown on Commercial Drive / NYS Route 5A. The work will continue to stabilize the lower Sauquoit Creek while connecting it to its original floodplain. This helps create a reduction in flood stage during flooding events, minimizing damage to repetitive flood loss homes and businesses.

In September 2019, Phase 1 involving the construction of two floodplain benches at Dunham Manor Park in Whitestown, was completed. The design for Phase 2 is finished and preparations are underway to solicit bids, secure a contractor and, shortly thereafter, begin construction. Phase 2 specifically includes the construction of a floodplain bench in the Village of Whitesboro south of the CSX Railroad Crossing with five additional culverts being installed underneath the CSX Rail Line. While preparing for the construction of Phase 2, the Town is also in the process of designing Phase 3 and securing additional grant funds for Phase 4, which will include the construction of additional flood mitigation measures. At the conclusion of Phase 4, the Town will have completed everything it originally set out to accomplish in 2016.

For the last four years, the Town has been a leader on the Sauquoit Creek, setting a great example for other municipalities in the Sauquoit Creek Basin to follow. The Town is taking the recommendations from the 2014 Milone & MacBroom report - which completed an emergency water basin assessment of 13 watersheds across Upstate New York, including the Sauquoit Creek Watershed - - from concepts to reality. While the Sauquoit Creek Channel & Floodplain Restoration Program is incredibly important, it is just one component of broader efforts, or a “global approach,” which also includes the buyout of repetitive loss structures, securing funding for new bridges and smarter development. Progress on all fronts will make the biggest difference to the communities in these watersheds.



PROJECT i LOCATION

PROJECT II LOCATION

PROJECT III LOCATION

PROJECT IV LOCATION

NYSDOT PROJECT LOCATION

1"=400' 400 0 400 800

NORTH

IT IS A VIOLATION OF LAW FOR ANY PERSON, UNLESS ACTING UNDER THE DIRECTION OF A LICENSED ENGINEER, TO ALTER THIS DOCUMENT.

THIS DRAWING WAS PREPARED AT THE SCALE INDICATED. INACCURACIES IN THE STATED SCALE MAY BE INTRODUCED WHEN DRAWINGS ARE REPRODUCED BY ANY MEANS. USE THE GRAPHIC SCALE BAR TO DETERMINE THE ACTUAL SCALE. DRAWING IS NOT SCALABLE WHEN NO SCALE BAR IS PRESENT.

IN CHARGE OF	S. GANNON		
DESIGNED BY	K. BURTH		
CHECKED BY	B. WHITTAKER		
DRAWN BY	K. BURTH		

NO.	DATE	REVISION	INT.
1	10/1/2018	ISSUED FOR BID	SBG
0	08/30/2018	ISSUED FOR AGENCY REVIEW	SBG

O'BRIEN & GERE ENGINEERS, INC

SAUQUOIT CREEK CHANNEL & FLOODPLAIN RESTORATION PROGRAM

TOWN OF WHITESTOWN, NEW YORK

GENERAL

OVERALL PROJECT LOCATION PLAN

FILE NO. 20969.64756 -

DATE 1/8/2021

G-002

B-2

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Appendix C: Stakeholder Interviewee List

Village of New York Mills

RAMBOLL mmg

WATER

STAKEHOLDER ENGAGEMENT

Joseph R. Cotrupe Jr.

Project name **Sauquoit Creek Watershed Sediment and Debris Management Plan**

Subject **Stakeholder Engagement Interviews**

Meeting Date

Location

Participants

Host **Kadir Goz, Ramboll**

1. Project Summary

The Sauquoit Creek basin has experienced multiple flood events in the past five years, with the most recent occurring on October 31, 2019. The Sauquoit Creek Basin Intermunicipal Commission (SCBIC), in partnership with Oneida County, New York, is seeking to develop a "Stream Sediment and Debris Management Plan" in accordance with the New York State Department of Environmental Conservation (NYSDEC) guidelines for best practices.

2. Interview Questions

Watershed Characteristics

1. What flood mitigation projects have been proposed, completed, and/or are being planned along Sauquoit Creek in your community?

Proposed Elm St./Main St. 30" Storm Sewer all new to address Flooding on Main St.

2. Are there any development projects being proposed and/or currently constructed in the flood plain in your community?

No.

3. What are the highest risk areas for flooding, ice jams, and/or sediment and debris issues?

Clinton St. bridge up stream to New Hartford Highway garage.

All of Royal Brook Lane off Henderson St

4. What areas along Sauquoit Creek experience streambank erosion/instability (i.e. trees/banks falling into channel)?

Between Clinton St. bridge and New Hartford Highway Dept.

5. What areas within Sauquoit Creek experience headcutting (i.e. abrupt vertical drop) of the channel or where the channel is disconnected from the floodplain?

NOT in New York Mills.

6. What areas along Sauquoit Creek experience runoff with large amounts of sediments (i.e. discolored, typically brown creek water; sediment influx from fields)?

N/A

7. What areas along Sauquoit Creek does sediment aggradation occur (i.e. sediment and sand bars)?

Area behind Pietryka (little League Field) and upstream to McCraith Bev.

8. What areas along the banks of Sauquoit Creek have experienced the greatest amount of development (i.e. land cover changes from mostly forested to developed or agricultural)?

Little League Ball Field up to McCraith Beverages.

9. What tributaries of Sauquoit Creek experience the same flooding/sediment issues as discussed previously?

NOT in Village of New York Mills. All Tributaries are piped.

Except Royal Brook Lane Proximal to Mud Creek.

Flooding Issues

1. What are the flooding issues along Sauquoit Creek in your community?

   Lack of channel capacity.

2. Where are these flooding issues located (the more specific the better?

   From Clinton St. Bridge up stream to McCraith Beverages.
   Also Main St. between Elm and Porter.

3. Who owns the effected land area (i.e. public or private)?

   Private.

4. What time of year does flooding typically occur (i.e. spring during snow melt, summer storm, 100 year winter rapid snow melt and rain)?

   All the above

5. What do you believe is the cause of these flooding issues?

   Lack of capacity in channel obstructed by ice build-up and larg branches off loose banks

6. What, in your opinion, can be done to mitigate the flooding?

   Funding Assistance To upgrade storm Sewers.

7. Any other flooding related issues along Sauquoit Creek?

Mitigation Strategies

1. In your opinion, what flood mitigation/sediment management plans would be effective at reducing flooding/sediment in Sauquoit Creek?

Stream bank Stabilization

2. Where would you recommend these flood mitigation/sediment management plans be located? Why?

By McCraith Beverages east side of creek.

Because grose erosion occures.

3. What municipalities/officials/agency's would need to be involved in order to move these flood mitigation/sediment management plans forward?

D.E.C. / corps of Engineers

4. Any other comments or feedback regarding Sauquoit Creek in your community?

STAKEHOLDER ENGAGEMENT

Project name **Sauquoit Creek Watershed Sediment and Debris Management Plan**

Subject **Stakeholder Engagement Interviews**

Meeting Date **Monday, October 19, 2020**

Location

Participants **Kyle Tritten, Village of Whitesboro, DPW**

Host **Kadir Goz, Ramboll**

1. Project Summary

The Sauquoit Creek basin has experienced multiple flood events in the past five years, with the most recent occurring on October 31, 2019. The Sauquoit Creek Basin Intermunicipal Commission (SCBIC), in partnership with Oneida County, New York, is seeking to develop a "Stream Sediment and Debris Management Plan" in accordance with the New York State Department of Environmental Conservation (NYSDEC) guidelines for best practices.

2. Interview Questions

Watershed Characteristics

1. What flood mitigation projects have been proposed, completed, and/or are being planned along Sauquoit Creek in your community?
   - Enlargement of Storm Sewer Pipe along main St. to Creek
   - Proposed Flood Benches & crossing Pipes under Rail Road ~~[illegible]~~
   - Yearly Cleaning of debris & down Threes & Branches

2. Are there any development projects being proposed and/or currently constructed in the flood plain in your community?

   N/A

3. What are the highest risk areas for flooding, ice jams, and/or sediment and debris issues?
   - 1. Route 69 Bridge
   - 2. Main Street Bridge
   - 3. CSX Railroad Bridge

4. What areas along Sauquoit Creek experience streambank erosion/instability (i.e. trees/banks falling into channel)?

- From Dunham manor Park all the way to CSX Bridge

5. What areas within Sauquoit Creek experience headcutting (i.e. abrupt vertical drop) of the channel or where the channel is disconnected from the floodplain?

- disconnected only in the sense of development in Flood Plain.

6. What areas along Sauquoit Creek experience runoff with large amounts of sediments (i.e. discolored, typically brown creek water; sediment influx from fields)?

- hard to tell as we at the downstream end with all runoff from upstream.

7. What areas along Sauquoit Creek does sediment aggradation occur (i.e. sediment and sand bars)?

Between Middle school and CSX Bridge

8. What areas along the banks of Sauquoit Creek have experienced the greatest amount of development (i.e. land cover changes from mostly forested to developed or agricultural)?

N/A

9. What tributaries of Sauquoit Creek experience the same flooding/sediment issues as discussed previously?

N/A

Flooding Issues

1. What are the flooding issues along Sauquoit Creek in your community?
   - massive wide spread devastating Flooding

2. Where are these flooding issues located (the more specific the better?
   - From the creek to mohawk street
   - along main st.
   - gardner St to victory parkway
   - Rt. 69 down to railroad tracks.

3. Who owns the effected land area (i.e. public or private)?
   - Private mostly

4. What time of year does flooding typically occur (i.e. spring during snow melt, summer storm, winter rapid snow melt and rain)?
   - Spring/winter snow melt/ice jams
   - Early summer
   - Mid to late Fall

5. What do you believe is the cause of these flooding issues?
   - over development up stream
   - Increase/change in weather patterns

6. What, in your opinion, can be done to mitigate the flooding?
   - Fix development retention Ponds upstream
   - Yearly/ Tri-monthly maintainence work

7. Any other flooding related issues along Sauquoit Creek?

Mitigation Strategies

1. In your opinion, what flood mitigation/sediment management plans would be effective at reducing flooding/sediment in Sauquoit Creek?

- bank stabilization
- Channel Restoration
- Crossvanes in ~~appropriate~~ appropriate location (Deflectors)
- Possible step pools
- wider riparian Zone
- Maintainence of bank, sediment control & debris (Tri-monthly)

2. Where would you recommend these flood mitigation/sediment management plans be located? Why?

- between CSX bridge and mouth of Sauquoit Creek to Mohawk River
- main st bridge to CSX - wider riparian Buffer Zone
- Rt. 69 and main street bridge
- Rt 5 on Ramp and Dunham manor Park

3. What municipalities/officials/agency's would need to be involved in order to move these flood mitigation/sediment management plans forward?

- DEC - Army Corps of Engineers - Town of whitestown
- Village of whitesboro

4. Any other comments or feedback regarding Sauquoit Creek in your community?

STAKEHOLDER ENGAGEMENT

Project name	**Sauquoit Creek Watershed Sediment and Debris Management Plan**
Subject	**Stakeholder Engagement Interviews**
Meeting Date	Tuesday, October 20, 2020
Location	
Participants	Stephanie Wurtz and Debbie Day, City of Utica
Host	**Kadir Goz, Ramboll**

1. Project Summary

The Sauquoit Creek basin has experienced multiple flood events in the past five years, with the most recent occurring on October 31, 2019. The Sauquoit Creek Basin Intermunicipal Commission (SCBIC), in partnership with Oneida County, New York, is seeking to develop a "Stream Sediment and Debris Management Plan" in accordance with the New York State Department of Environmental Conservation (NYSDEC) guidelines for best practices.

2. Interview Questions

Watershed Characteristics

1. What flood mitigation projects have been proposed, completed, and/or are being planned along Sauquoit Creek in your community?

2. Are there any development projects being proposed and/or currently constructed in the flood plain in your community?

   The City partnered with New Hartford to get an engineering study in this surrounding area to identify mitigation options that will be practical and effective in resolving the volume of water that flows instantaneously that overwhelms the system during heavy rain events.

3. What are the highest risk areas for flooding, ice jams, and/or sediment and debris issues?

4. What areas along Sauquoit Creek experience streambank erosion/instability (i.e. trees/banks falling into channel)?

At the bend near the Brookline dead end

5. What areas within Sauquoit Creek experience headcutting (i.e. abrupt vertical drop) of the channel or where the channel is disconnected from the floodplain?

n/a

6. What areas along Sauquoit Creek experience runoff with large amounts of sediments (i.e. discolored, typically brown creek water; sediment influx from fields)?

minimal, but occasionally Brookline

7. What areas along Sauquoit Creek does sediment aggradation occur (i.e. sediment and sand bars)?

Sand bars occur along Brookline and downstream of Genesee St

8. What areas along the banks of Sauquoit Creek have experienced the greatest amount of development (i.e. land cover changes from mostly forested to developed or agricultural)?

n/a

9. What tributaries of Sauquoit Creek experience the same flooding/sediment issues as discussed previously?

n/a

Flooding Issues

1. What are the flooding issues along Sauquoit Creek in your community?
Damage to driveways, homes flooding and personal property damage, depositing of mud along the streets. Threat to public safety

2. Where are these flooding issues located (the more specific the better?
Brookline and Richardson Ave

3. Who owns the effected land area (i.e. public or private)?
Both

4. What time of year does flooding typically occur (i.e. spring during snow melt, summer storm, winter rapid snow melt and rain)?
Heavy intense rain events

5. What do you believe is the cause of these flooding issues?
Weather and development up and down stream of the City

6. What, in your opinion, can be done to mitigate the flooding?
Allow silt removal, mitigate issues caused by newer development by ensuring the retention basins are functioning properly as designed in New Hartford

7. Any other flooding related issues along Sauquoit Creek?
n/a

Mitigation Strategies

1. In your opinion, what flood mitigation/sediment management plans would be effective at reducing flooding/sediment in Sauquoit Creek?

2. Where would you recommend these flood mitigation/sediment management plans be located? Why?

New Hartford and Whitesboro- the City serves as a throughway, with minimal contribution to the system

3. What municipalities/officials/agency's would need to be involved in order to move these flood mitigation/sediment management plans forward?

New Hartford, Whitesboro., Sauquoit

4. Any other comments or feedback regarding Sauquoit Creek in your community?

Development along Commercial Dr, Kellogg Rd, and other areas has impacted the storage capacity and as a result led to frequent flooding along Brookline Dr and Richardson Ave that is concerning to our constituents.

STAKEHOLDER ENGAGEMENT

Project name	**Sauquoit Creek Watershed Sediment and Debris Management Plan**
Subject	**Stakeholder Engagement Interviews**
Meeting Date	
Location	Town of Paris
Participants	(JC) James Christian, Jr. / Town Supervisor James Canaguier / Highway Superintendent
Host	**Kadir Goz, Ramboll**

1. Project Summary

The Sauquoit Creek basin has experienced multiple flood events in the past five years, with the most recent occurring on October 31, 2019. The Sauquoit Creek Basin Intermunicipal Commission (SCBIC), in partnership with Oneida County, New York, is seeking to develop a "Stream Sediment and Debris Management Plan" in accordance with the New York State Department of Environmental Conservation (NYSDEC) guidelines for best practices.

2. Interview Questions

Watershed Characteristics

1. What flood mitigation projects have been proposed, completed, and/or are being planned along Sauquoit Creek in your community?

-Two (2) Projects have been completed. Both projects were stream bank stabilizations.
- Breached Dam removal on Route 8

-No new plans.

2. Are there any development projects being proposed and/or currently constructed in the flood plain in your community?

-no

3. What are the highest risk areas for flooding, ice jams, and/or sediment and debris issues?

- Please see attached sheet for breakdown (#1-9)

4. What areas along Sauquoit Creek experience streambank erosion/instability (i.e. trees/banks falling into channel)?

-Whole Creek

5. What areas within Sauquoit Creek experience headcutting (i.e. abrupt vertical drop) of the channel or where the channel is disconnected from the floodplain?

-None aware of.

6. What areas along Sauquoit Creek experience runoff with large amounts of sediments (i.e. discolored, typically brown creek water; sediment influx from fields)?

- Tuckers Brook (Oneida Street/Willowbrook Lane)
- Paris Hill Rd. and behind the homes on Pinnacle Rd. (Same side as Cliff's Gas Station)

7. What areas along Sauquoit Creek does sediment aggradation occur (i.e. sediment and sand bars)?

- Along the whole creek.

8. What areas along the banks of Sauquoit Creek have experienced the greatest amount of development (i.e. land cover changes from mostly forested to developed or agricultural)?

None; Controlled by proper planned development.

9. What tributaries of Sauquoit Creek experience the same flooding/sediment issues as discussed previously?

-Tuckers Brook (Oneida Street/Willowbrook Lane)

Flooding Issues

1. What are the flooding issues along Sauquoit Creek in your community?

- Please see attached sheet for breakdown (#1-9)

2. Where are these flooding issues located (the more specific the better?

- Please see attached sheet for breakdown (#1-9)

3. Who owns the effected land area (i.e. public or private)?

-Private and Public

4. What time of year does flooding typically occur (i.e. spring during snow melt, summer storm, winter rapid snow melt and rain)?

- Flash Floods and rapid snow melt and rain.

5. What do you believe is the cause of these flooding issues?

- Undersized culverts during flash floods.

6. What, in your opinion, can be done to mitigate the flooding?

- Clean up falling debri and rocks in the creek.
- Control any future development in floodplain areas.

7. Any other flooding related issues along Sauquoit Creek?

- Please see attached sheet for breakdown (#1-9)

Mitigation Strategies

1. In your opinion, what flood mitigation/sediment management plans would be effective at reducing flooding/sediment in Sauquoit Creek?

- Control any future development in floodplain areas.
- Annual Inspections and clean up along the floodplain areas.
- Trapping needed to control Beaver Dam issues.

2. Where would you recommend these flood mitigation/sediment management plans be located? Why?

- Along the entire creek.

3. What municipalities/officials/agency's would need to be involved in order to move these flood mitigation/sediment management plans forward?

- Town Planning Board
- Floodplain Administrator
- DEC, Army Corp. of Engineers, Town Highway Dept.

4. Any other comments or feedback regarding Sauquoit Creek in your community?

Town of Paris

RE: Stakeholder Engagement / Ramboll Questionnaire

Sauquoit

1. Oneida Street & Valley Place (Close to the Town line): Homes were flooded
    - Watershed Study is needed so a storm water run-off plan can be made.
    - May need to have the culverts televised. Possible they are undersized.

2. 2550 Holman City Rd. & Church Rd: Oneida County is aware of this problem.
    - Removal of Dam needed. Water level is higher than the road.

3. 2621 Church Rd: Property can be seen from Route 8 just past the old Turkey farm
    - Sauquoit Creek; Debris has moved creek out of its bank; re-routing creek.
    - Owner of farmland; Brian Stefanik

4. Route 8 South; before the Sauquoit Exit ramp.
    - Sauquoit Creek; Full of debris.

5. 9558 Pinnacle Rd: Across from Cliffs (Former Reilly's)
    - Trees down across the Sauquoit Creek.

6. Mohawk Rd. & Loughlin Rd: (3162 Mohawk St.)
    - Concerns of Culverts approach angles and not being sized correctly, which caused flooding across the streets.

7. Willow Brook Lane (Tucker Brook runs behind the houses. Tucker Brook is not on the map.
    - Earth Berm needed behind houses. We did culvert replacement with help from DASNY grant & SCBIC.

8. Paris Green: Intersection of Paris Hill Rd. / Doolittle Rd. / Old Route 12
    - No Storm water System, No Drainage. Roads will flood

Cassville:

9. Summit Rd. Bridge Area; between Route 8 & Reservoir Rd.
    - Gravel Bar needs to be replaced.

Appendix D: Data and Reports Summary

Appendix B. Summary of Data and Reports Collected			
Stream Sediment and Debris Management Plan			OBG Project # 74959
Sauquoit Creek, Oneida County, New York			18-February-2021
Year	**Type**	**Title**	**Author**
1964	Book	Handbook of Applied Hydrology	Chow VT
1966	Book	Geography of New York State	Thompson JH
1971	Book	Hydraulics of Sediment Transport	Graf WH
1978	Book	National Handbook of Recommended Methods for Water-Data Acquisition: Chapter 7 - Physical basin characteristics from hydrologic analysis	United States Geologic Survey (USGS)
1995	Book	Erosion and Sedimentation	Julien P
1996	Book	Applied River Morphology (2nd edition)	Rosgen DL, Silvey HL
1997	Book	Surface water-quality modeling	Chapra SC
1998	Book	Fluvial Forms and Processes: A New Perspective	Knighton D
2004	Book	Stream Geomorphic Assessment Handbooks: Appendix O - Vermont Stream Geomorphic Assessment	Vermont Agency of Natural Resources (VTANR)
2014	Book	Handbook of Biological Statistics (3rd Edition)	McDonald JH
2019	Computer Software	ArcGIS for Desktop 10	Environmental Systems Research Institute (ESRI)
2019	Computer Software	HEC-RAS Version 5.0.7	United States Army Corps of Engineers (USACE)
2019	Computer Software	RSMeans Cost Works 2019 v16.03	Gordian, Inc.
2019	Computer Software	StreamStats v4.3.11	United States Geologic Service (USGS)
2019	Computer Software	Web Soil Survey 3.3	United States Department of Agriculture (USDA)
2020	Computer Software	Environmental Resource Mapper	New York State Department of Environmental Conservation (NYSDEC)
1999	Data	Statewide Bedrock Geology	New York State Geological Survey (NYSGS)
2008	Data	Oneida County, NY - LiDAR Terrain Elevation	New York State Department of Environmental Conservation (NYSDEC)
2013	Data	New York State 2 Meter DEM – Oneida 2008 Collection	New York State Office of Information Technology Services (NYSITS)
2013	Data	Railroads	New York State Department of Transportation (NYSDOT)
2014	Data	Culvert Point Locations & Select Attributes - New York State Department of Transportation	New York State Department of Transportation (NYSDOT)
2016	Data	Physiographic Provinces of New York	New York State Geological Survey (NYSGS)
2017	Data	2017 12-inch Resolution 4-Band Orthoimagery Central Zone	New York State Office of Information Technology Services (NYSITS)
2018	Data	National Register of Historic Places – New York State	National Park Service (NPS)

Appendix B. Summary of Data and Reports Collected			
Stream Sediment and Debris Management Plan			**OBG Project # 74959**
Sauquoit Creek, Oneida County, New York			**18-February-2021**
Year	**Type**	**Title**	**Author**
2018	Data	New York State Historic Sites and Park Boundary	New York State Office of Parks, Recreation & Historic Preservation (NYSOPRHP)
2019	Data	2018 New York Cropland Data Layer	National Agricultural Statistics Service (NASS)
2019	Data	Bridge Point Locations & Select Attributes - New York State Department Of Transportation	New York State Department of Transportation (NYSDOT)
2019	Data	Inventory of Dams - New York State (NYSDEC)	New York State Department of Environmental Conservation (NYSDEC)
2019	Data	Multi-Resolution Land Characteristics Consortium (MRLC) - National Land Cover Database (NLCD) 2016 Land Cover Conterminous United States	United States Geologic Survey (USGS)
2019	Data	National Flood Hazard Layer, Erie County, NY	Federal Emergency Management Agency (FEMA)
2019	Data	NYS Roadway Inventory	New York State Department of Transportation (NYSDOT)
2020	Data	Ice Jam Database	Cold Regions Research and Engineering Laboratory (CRREL)
2020	Data	National Wetlands Inventory - Version 2 - Surface Waters and Wetlands Inventory	United States Fish & Wildlife Service (USFWS)
2020	Data	New York State Civil Boundaries	New York State Office of Information Technology Services (NYSITS)
2020	Data	Storm Events Database	National Centers for Environmental Information (NCEI)
2020	Data	USGS 01339060 Sauquoit Creek at Whitesboro NY	United States Geologic Survey (USGS)
2020	Data	USGS National Hydrography Dataset (NHD) for Hydrologic Unit (HU) 4	United States Geologic Survey (USGS)
2019	News Report	Local floods reflect rise in extreme rainfall, experts say	Howe S
2019	Online Book	Physical Geology (2nd Edition)	Earle S
N/A	Report	HEC-RAS 1D Sediment Transport	United States Army Corps of Engineers (USACE)
1932	Report	Drainage-basin characteristics	Horton RE
1953	Report	Issue 3 of Technical Report: A Quantitative Geomorphologic Study of Drainage Basin characteristics in the Clinch Mountain Area, Virginia and Tennessee	Miller VC
1956	Report	Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey	Schumm SA
1974	Report	Flood Plain Information, Mohawk River, Sauquoit Creek and Oriskany Creek, New York	United States Army Corps of Engineers (USACE)
1975	Report	Reconnaissance Report for Sauquoit Creek and Mohawk River in the Village of Whitesboro, New York	United States Army Corps of Engineers (USACE)

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Stream Sediment and Debris Management Plan			**OBG Project # 74959**
Sauquoit Creek, Oneida County, New York			**18-February-2021**
Year	**Type**	**Title**	**Author**
1981	Report	Detailed Project Report, Village of Whitesboro, NY	United States Army Corps of Engineers (USACE)
1981	Report	Sauquoit Creek Basin Study, Hydrologic and Hydraulic Planning Models, Oneida County, New York	United States Army Corps of Engineers (USACE)
1982	Report	Flood Insurance Study, Town of New Hartford, Oneida County, New York	Federal Emergency Management Agency (FEMA)
1983	Report	Flood Insurance Study, Town of Paris, Oneida County, New York	Federal Emergency Management Agency (FEMA)
1985	Report	Sauquoit Creek at Whitesboro, New York – Flood Control Study	United States Army Corps of Engineers (USACE)
1991	Report	Regionalization of flood discharges for rural, unregulated streams in New York, excluding Long Island	United States Geologic Survey (USGS)
1995	Report	HEC-6: Reservoir Sediment Control Applications	United States Army Corps of Engineers (USACE)
1997	Report	Channel classification, prediction of channel response, and assessment of channel condition	Washington State Department of Natural Resources (WADNR)
1997	Report	Sauquoit Creek Basin Watershed Management Study	Herkimer-Oneida Counties Comprehensive Planning Program (HOCCPP)
2000	Report	Flood Insurance Study, Village of New York Mills, Oneida County, New York	Federal Emergency Management Agency (FEMA)
2000	Report	Flood Insurance Study, Village of Whitesboro, Oneida County, New York	Federal Emergency Management Agency (FEMA)
2000	Report	Proposed Plan for Flood Control in Sauquoit Creek at Whitesboro, New York	United States Army Corps of Engineers (USACE)
2001	Report	Non-Structural Flood Damage Reduction Within The Corps of Engineers: What Districts Are Doing	United States Army Corps of Engineers (USACE)
2001	Report	Stability Thresholds for Stream Restoration Materials. In: Ecosystem Management and Restoration Research Program (EMRRP) Technical Notes Collection	United States Army Engineer (USAE)
2002	Report	Streambank and Shoreline Protection Manual	Natural Resources Conservation Service (NRCS)
2005	Report	Sediment Transport Modeling in HEC-RAS	Bruner G and Gibson S
2006	Report	Magnitude and Frequency of Floods in New York	United States Geologic Survey (USGS)
2006	Report	Sediment Transport Computations in HEC-RAS	Gibson S, Brunner G, Piper S, Jensen M
2007	Report	Elevation Data for Floodplain Mapping	National Research Council (NRC)
2007	Report	National Engineering Handbook - Part 654	Natural Resources Conservation Service (NRCS)
2008	Report	Soil Survey of Oneida County, New York	Natural Resources Conservation Service (NRCS)

Appendix B. Summary of Data and Reports Collected			
Stream Sediment and Debris Management Plan			**OBG Project # 74959**
Sauquoit Creek, Oneida County, New York			**18-February-2021**
Year	**Type**	**Title**	**Author**
2009	Report	Bankfull discharge and channel characteristics of streams in New York State	United States Geologic Survey (USGS)
2009	Report	Environmental Impact and Benefits Assessment for Final Effluent Guidelines and Standards for the Construction and Development Category	United States Environmental Protection Agency (USEPA)
2009	Report	Our Waters, Our Communities, Our Future: Taking Bold Action Now to Achieve Long-term Sustainability of New York's Ocean and Great Lakes	New York Ocean and Great Lakes Ecosystem Conservation Council (NYOGLECC)
2010	Report	DHS Risk Lexicon – 2010 Edition	United States Department of Homeland Security (USDHS)
2011	Report	An Overview of CMIP5 and the Experiment Design	Taylor KE, Stouffer RJ, and Meehl GA
2011	Report	Investigation of Average Shear Stress in Natural Stream. Tirana (ALB): International Balkans Conference on Challenges of Civil Engineering	Ardıçlıoğlu M, Selenica A, Özdin S, Kuriqi A, Genç O
2011	Report	Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation	New York State Energy Research and Development Authority (NYSERDA)
2012	Report	Hydraulic Design of Safe Bridges	United States Department of Transportation, Federal Highway Administration
2013	Report	Drainage Basin Delineation and Quantitative Analysis of Panamaram Watershed of Kabani River Basin, Kerala Using Remote Sensing and GIS	Joji VS, Nair ASKN, Baiju KV
2013	Report	Flood Insurance Study, Oneida County, New York	Federal Emergency Management Agency (FEMA)
2013	Report	Levees and the National Flood Insurance Program: Improving Policies and Practices	National Research Council (NRC)
2014	Report	Emergency Transportation Infrastructure Recovery Water Basin Assessment and Flood Hazard Mitigation Alternatives, Sauquoit Creek, Oneida County, New York	Milone & MacBroom, Inc. (MMI)
2014	Report	Oneida County NY Rising Resiliency Plan	New York Rising Community Reconstruction (NYRCR)
2015	Report	Development of flood regressions and climate change scenarios to explore estimates of future peak flows	United States Geologic Survey (USGS)
2015	Report	Quantitative Analysis of Geomorphology and Flow Pattern Analysis of Muvattupuzha River Basin Using Geographic Information System	Aparna P, Nigee K, Shimna P, Drissia TK
2016	Report	HEC-RAS River Analysis System User's Manual Version 5.0	United States Army Corps of Engineers (USACE)

Appendix B. Summary of Data and Reports Collected			
Stream Sediment and Debris Management Plan			**OBG Project # 74959**
Sauquoit Creek, Oneida County, New York			**18-February-2021**
Year	**Type**	**Title**	**Author**
2017	Report	New One-Dimensional Sediment Features in HEC-RAS 5.0 and 5.1	Gibson S, Sanchez A, Piper S, Brunner G
2017	Report	StreamStats, version 4.3.8: U.S. Geological Survey Fact Sheet 2017–3046	United States Geologic Survey (USGS)
2018	Report	DRAFT New York State Flood Risk Management Guidance for Implementation of the Community Risk and Resiliency Act	New York State Department of Environmental Conservation (NYSDEC)
2018	Report	Highway Design Manual: Chapter 8 – Highway Drainage	New York State Department of Transportation (NYSDOT)
2018	Report	Sauquoit Creek Channel and Floodplain Restoration Project, Lower Sauquoit Creek – Engineering Report	O'Brien & Gere Engineers, Inc. (OBG)
2019	Report	Bridge Manual	New York State Department of Transportation (NYSDOT)
2020	Report	Sauquoit Creek Drainage Study – Alternative Design	Ramboll Americas Engineering Solutions, Inc. (Ramboll)
2020	Report	Sauquoit Creek Drainage Study – Findings of 2019 Halloween Storm – Hydraulic Modeling	Ramboll Americas Engineering Solutions, Inc. (Ramboll)
2020	Report	Sauquoit Creek Stream Sediment & Debris Management Plan Stakeholder Interviews	Ramboll Americas Engineering Solutions, Inc. (Ramboll)
2020	Report	Standard Specifications (US Customary Units), Volume 1	New York State Department of Transportation (NYSDOT)

Appendix E: Permit Application and Field Work Forms

- *Most work conducted as part of a stream sediment and debris management plan will fall under the NYS Joint Application process. The Joint Application Form is used to apply for permits from several agencies. The following links provide details on completing the Joint Application Form:*
    - o http://www.dec.ny.gov/permits/6222.html
    - o http://www.dec.ny.gov/docs/permits_ej_operations_pdf/jntappinstruc.pdf
    - o http://www.dec.ny.gov/docs/permits_ej_operations_pdf/jointapp.pdf
- *Once the plan has been completed, this section can be incorporated into the previous section.*
- *An Agricultural Environmental Management (AEM) stream corridor assessment may be needed for 404 Army Corps of Engineers (ACOE) permits.*
- Minor projects may fall under ACOE Nationwide Permits, some of which may require a pre-construction notification. Any significant alteration within stream channels below ordinary high water would likely require an individual ACOE 404 permit.
- Projects that fall under ACOE Nationwide Permits may be required to apply for and obtain a Water Quality Certification from DEC indicating that the proposed activity will not violate water quality standards.

Project/Sample Information

Project	5231-01 - Flood Hazard Mit. and Watershed Assessment
Stream	Sauquoit
Location	
Sample ID	78+00-79+00
Sample Date	11/20/13
Sampled By	CPM
Sample Method	Wolman Pebble Count

Particle Distribution (%)

silt/clay	
sand	
gravel	
cobble	
boulder	
bedrock	

Sample Site Descriptions by Observations

Channel type	
D100 (mm)	
Colluvium	
Debris	
Other	

Particle Sizes (mm)

D16	
D35	
D50	
D84	
D95	

(Bunte and Abt, 2001)

Particle Name	Size Limits (mm) lower	upper	Tally	Count	Percent Passing	Cumulative % Finer
silt/clay	0	**0.063**			0.0	0.0
very fine sand	0.063	**0.125**			0.0	0.0
fine sand	0.125	**0.250**			0.0	0.0
medium sand	0.250	**0.500**			0.0	0.0
coarse sand	0.500	**1**			0.0	0.0
very coarse sand	1	**2**			0.0	0.0
very fine gravel	2	**4**			0.0	0.0
fine gravel	4	**5.7**		4	0.0	0.0
fine gravel	5.7	**8**		3	0.0	0.0
medium gravel	8	**11.3**		9	0.0	0.0
medium gravel	11.3	**16**		9	0.0	0.0
coarse gravel	16	**22.6**		12	0.0	0.0
coarse gravel	22.6	**32**		18	0.0	0.0
very coarse gravel	32	**45**		10	0.0	0.0
very coarse gravel	45	**64**		12	0.0	0.0
small cobble	64	**90**		3	0.0	0.0
medium cobble	90	**128**			0.0	0.0
large cobble	128	**180**			0.0	0.0
very large cobble	180	**256**			0.0	0.0
small boulder	256	**362**			0.0	0.0
small boulder	362	**512**			0.0	0.0
medium boulder	512	**1024**			0.0	0.0
large boulder	1024	**2048**			0.0	0.0
very large boulder	2048	**4096**			0.0	0.0
bedrock	4096	**-**			0.0	0.0
			Total	0	0.0	-

(Wenthworth, 1922)

F-T Particle Sizes (mm)

F-T n-value	0.5
D16	
D5	

(Fuller and Thompson, 1907)

D (mm) of the largest mobile particles on bar

Mean	

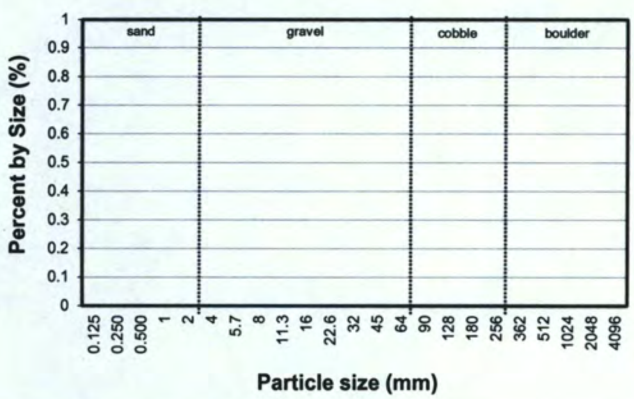
Riffle Stability Index (%)

(Kappesser, 2002)

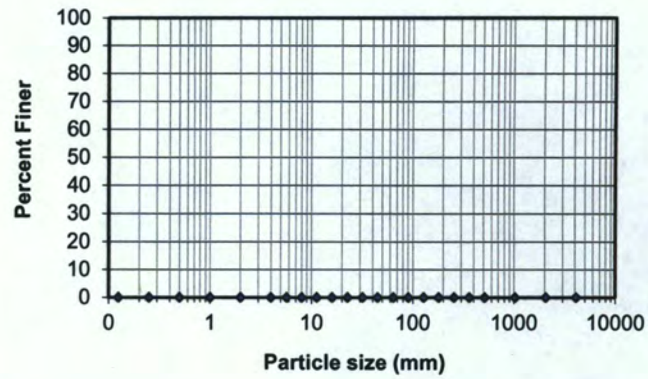
Notes

Some larger material upstream of debris block

Particle Size Histogram



Gradation Curve



Project/Sample Information

Project	5231-01 - Flood Hazard Mit. and Watershed Assessment
Stream	Sanquit
Location	near BBQ
Sample ID	363+00
Sample Date	11/21/13
Sampled By	JCM
Sample Method	Wolman Pebble Count

Particle Distribution (%)

silt/clay	
sand	
gravel	
cobble	
boulder	
bedrock	

Sample Site Descriptions by Observations

Channel type	
D100 (mm)	
Colluvium	
Debris	
Other	

Particle Sizes (mm)

D16	
D35	
D50	
D84	
D95	

(Bunte and Abt, 2001)

Particle Name	Size Limits (mm) lower	upper	Tally	Count	Percent Passing	Cumulative % Finer
silt/clay	0	**0.063**			0.0	0.0
very fine sand	0.063	**0.125**			0.0	0.0
fine sand	0.125	**0.250**			0.0	0.0
medium sand	0.250	**0.500**			0.0	0.0
coarse sand	0.500	**1**			0.0	0.0
very coarse sand	1	**2**			0.0	0.0
very fine gravel	2	**4**			0.0	0.0
fine gravel	4	**5.7**			0.0	0.0
fine gravel	5.7	**8**			0.0	0.0
medium gravel	8	**11.3**			0.0	0.0
medium gravel	11.3	**16**		1	0.0	0.0
coarse gravel	16	**22.6**		1	0.0	0.0
coarse gravel	22.6	**32**		4	0.0	0.0
very coarse gravel	32	**45**		4	0.0	0.0
very coarse gravel	45	**64**		4	0.0	0.0
small cobble	64	**90**		7	0.0	0.0
medium cobble	90	**128**		7	0.0	0.0
large cobble	128	**180**		16	0.0	0.0
very large cobble	180	**256**		7	0.0	0.0
small boulder	256	**362**		5	0.0	0.0
small boulder	362	**512**		0	0.0	0.0
medium boulder	512	**1024**		1	0.0	0.0
large boulder	1024	**2048**			0.0	0.0
very large boulder	2048	**4096**			0.0	0.0
bedrock	4096	**-**			0.0	0.0
			Total	0	0.0	-

(Wenthworth, 1922)

F-T Particle Sizes (mm)

F-T n-value	0.5
D16	
D5	

(Fuller and Thompson, 1907)

D (mm) of the largest mobile particles on bar

Mean	

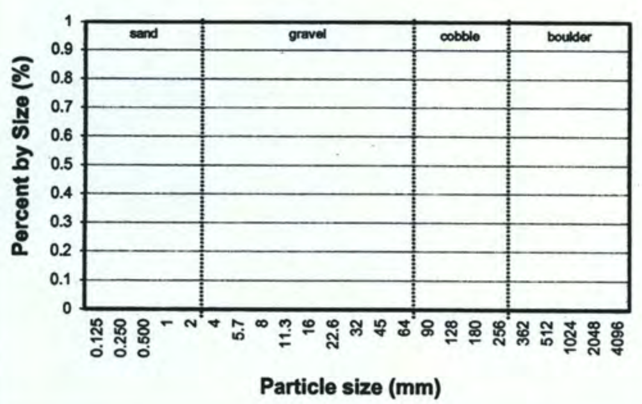
Riffle Stability Index (%)

(Kappesser, 2002)

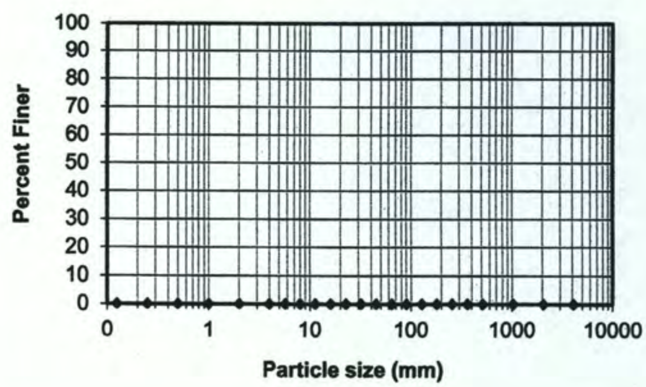
Notes

Potential storage site

Particle Size Histogram



Gradation Curve



Project/Sample Information

Project	5231-01 - Flood Hazard Mit. and Watershed Assessment
Stream	Sauquoit Creek
Location	Just u/s trib Mud and dam
Sample ID	158+00
Sample Date	11/21/13
Sampled By	JCM
Sample Method	Wolman Pebble Count

Particle Distribution (%)

silt/clay	
sand	
gravel	
cobble	
boulder	
bedrock	

Sample Site Descriptions by Observations

Channel type	
D100 (mm)	
Colluvium	
Debris	
Other	

Particle Sizes (mm)

D16	
D35	
D50	
D84	
D95	

(Bunte and Abt, 2001)

Particle Name	Size Limits (mm) lower	upper	Tally	Count	Percent Passing	Cumulative % Finer
silt/clay	0	**0.063**			0.0	0.0
very fine sand	0.063	**0.125**			0.0	0.0
fine sand	0.125	**0.250**			0.0	0.0
medium sand	0.250	**0.500**			0.0	0.0
coarse sand	0.500	**1**			0.0	0.0
very coarse sand	1	**2**			0.0	0.0
very fine gravel	2	**4**			0.0	0.0
fine gravel	4	**5.7**			0.0	0.0
fine gravel	5.7	**8**			0.0	0.0
medium gravel	8	**11.3**			0.0	0.0
medium gravel	11.3	**16**		2	0.0	0.0
coarse gravel	16	**22.6**		3	0.0	0.0
coarse gravel	22.6	**32**		3	0.0	0.0
very coarse gravel	32	**45**		5	0.0	0.0
very coarse gravel	45	**64**		10	0.0	0.0
small cobble	64	**90**		11	0.0	0.0
medium cobble	90	**128**		7	0.0	0.0
large cobble	128	**180**		7	0.0	0.0
very large cobble	180	**256**		3	0.0	0.0
small boulder	256	**362**			0.0	0.0
small boulder	362	**512**			0.0	0.0
medium boulder	512	**1024**			0.0	0.0
large boulder	1024	**2048**			0.0	0.0
very large boulder	2048	**4096**			0.0	0.0
bedrock	4096	**-**			0.0	0.0
			Total	0	0.0	-

(Wenthworth, 1922)

F-T Particle Sizes (mm)

F-T n-value	0.5
D16	
D5	

(Fuller and Thompson, 1907)

D (mm) of the largest mobile particles on bar

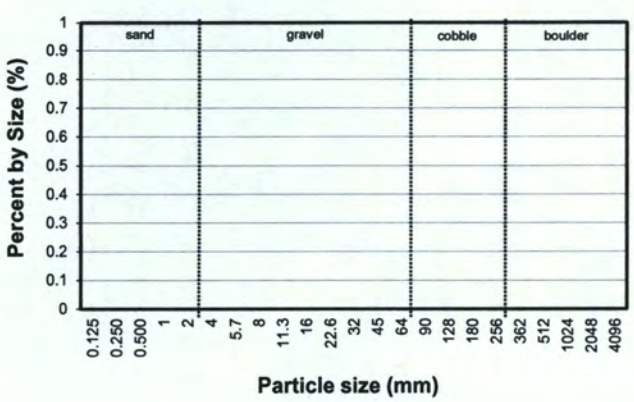
Mean	

Riffle Stability Index (%)

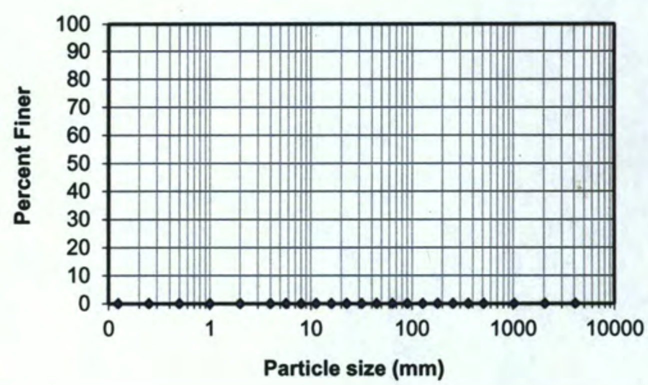
(Kappesser, 2002)

Notes

Particle Size Histogram



Gradation Curve



Project/Sample Information

Project	5231-01 - Flood Hazard Mit. and Watershed Assessment
Stream	SAUQUOIT
Location	79+50
Sample ID	
Sample Date	11/21/13
Sampled By	JCM
Sample Method	Wolman Pebble Count

Particle Distribution (%)

silt/clay	
sand	
gravel	
cobble	
boulder	
bedrock	

Sample Site Descriptions by Observations

Channel type	
D100 (mm)	
Colluvium	
Debris	
Other	

Particle Sizes (mm)

D16	
D35	
D50	
D84	
D95	

(Bunte and Abt, 2001)

Particle Name	Size Limits (mm) lower	upper	Tally	Count	Percent Passing	Cumulative % Finer
silt/clay	0	**0.063**			0.0	0.0
very fine sand	0.063	**0.125**			0.0	0.0
fine sand	0.125	**0.250**			0.0	0.0
medium sand	0.250	**0.500**			0.0	0.0
coarse sand	0.500	**1**			0.0	0.0
very coarse sand	1	**2**			0.0	0.0
very fine gravel	2	**4**			0.0	0.0
fine gravel	4	**5.7**			0.0	0.0
fine gravel	5.7	**8**			0.0	0.0
medium gravel	8	**11.3**			0.0	0.0
medium gravel	11.3	**16**		1	0.0	0.0
coarse gravel	16	**22.6**		7	0.0	0.0
coarse gravel	22.6	**32**		5	0.0	0.0
very coarse gravel	32	**45**		12	0.0	0.0
very coarse gravel	45	**64**		10	0.0	0.0
small cobble	64	**90**		5	0.0	0.0
medium cobble	90	**128**		1	0.0	0.0
large cobble	128	**180**		1	0.0	0.0
very large cobble	180	**256**			0.0	0.0
small boulder	256	**362**			0.0	0.0
small boulder	362	**512**			0.0	0.0
medium boulder	512	**1024**			0.0	0.0
large boulder	1024	**2048**			0.0	0.0
very large boulder	2048	**4096**			0.0	0.0
bedrock	4096	**-**			0.0	0.0
			Total	0	0.0	-

(Wenthworth, 1922)

F-T Particle Sizes (mm)

F-T n-value	0.5
D16	
D5	

(Fuller and Thompson, 1907)

D (mm) of the largest mobile particles on bar

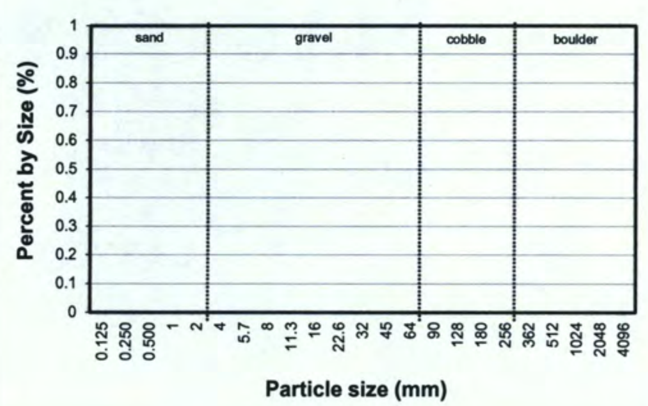
Mean	

Riffle Stability Index (%)

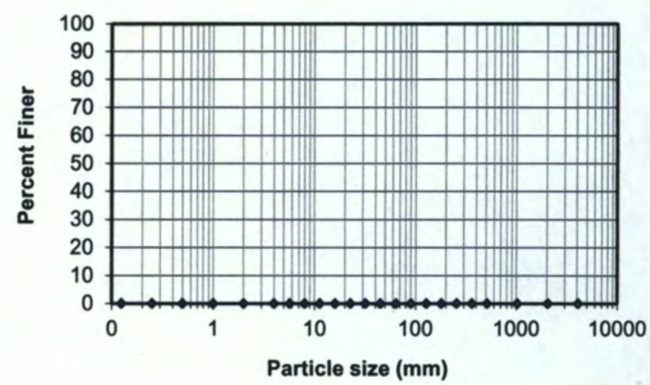
(Kappesser, 2002)

Notes

Particle Size Histogram



Gradation Curve



Project/Sample Information

Project	5231-01 - Flood Hazard Mit. and Watershed Assessment
Stream	SAUQUOIT
Location	110+00
Sample ID	
Sample Date	11/21/13
Sampled By	JCM
Sample Method	Wolman Pebble Count

Particle Distribution (%)

silt/clay	
sand	
gravel	
cobble	
boulder	
bedrock	

Sample Site Descriptions by Observations

Channel type	
D100 (mm)	
Colluvium	
Debris	
Other	

Particle Sizes (mm)

D16	
D35	
D50	
D84	
D95	

(Bunte and Abt, 2001)

Particle Name	Size Limits (mm) lower	upper	Tally	Count	Percent Passing	Cumulative % Finer
silt/clay	0	**0.063**			0.0	0.0
very fine sand	0.063	**0.125**			0.0	0.0
fine sand	0.125	**0.250**			0.0	0.0
medium sand	0.250	**0.500**			0.0	0.0
coarse sand	0.500	**1**			0.0	0.0
very coarse sand	1	**2**			0.0	0.0
very fine gravel	2	**4**			0.0	0.0
fine gravel	4	**5.7**			0.0	0.0
fine gravel	5.7	**8**			0.0	0.0
medium gravel	8	**11.3**			0.0	0.0
medium gravel	11.3	**16**			0.0	0.0
coarse gravel	16	**22.6**			0.0	0.0
coarse gravel	22.6	**32**		1	0.0	0.0
very coarse gravel	32	**45**		4	0.0	0.0
very coarse gravel	45	**64**		6	0.0	0.0
small cobble	64	**90**		8	0.0	0.0
medium cobble	90	**128**		9	0.0	0.0
large cobble	128	**180**		6	0.0	0.0
very large cobble	180	**256**		6	0.0	0.0
small boulder	256	**362**		1	0.0	0.0
small boulder	362	**512**			0.0	0.0
medium boulder	512	**1024**			0.0	0.0
large boulder	1024	**2048**			0.0	0.0
very large boulder	2048	**4096**			0.0	0.0
bedrock	4096	**-**			0.0	0.0
			Total	0	0.0	-

(Wenthworth, 1922)

F-T Particle Sizes (mm)

F-T n-value	0.5
D16	
D5	

(Fuller and Thompson, 1907)

D (mm) of the largest mobile particles on bar

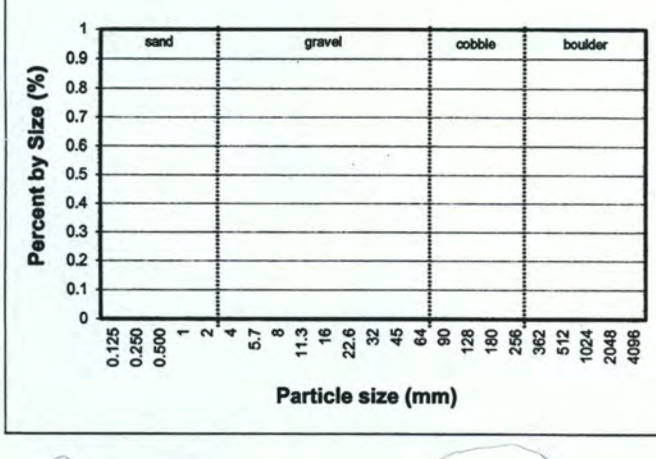
Mean	

Riffle Stability Index (%)

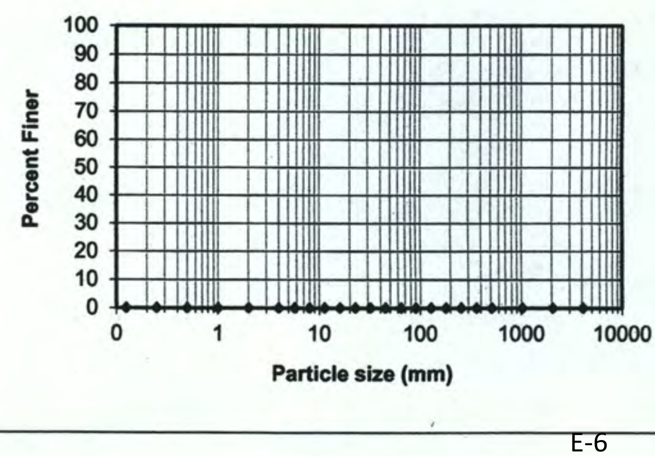
(Kappesser, 2002)

Notes

Particle Size Histogram



Gradation Curve



Field Observation Form

By:______________________ Date: ____________________ Project Name: _________________________________
Project Number: _______________________________

Location/Description
____
____
____
____
____

Sketches (Include flow depth, channel bed material, Manning values, flow direction, etc.)

Plan View:

Section View:

OBG
Part of Ramboll

Structure Data

☐ Bridge ☐ Culvert

Height: ____________ Width: ___________ ☐ Box # Sides: _____ ☐ Pipe ☐ Arch ☐ Other

Length in direction of flow: ______________ Manning Value Top: ___________ Bottom: ____________

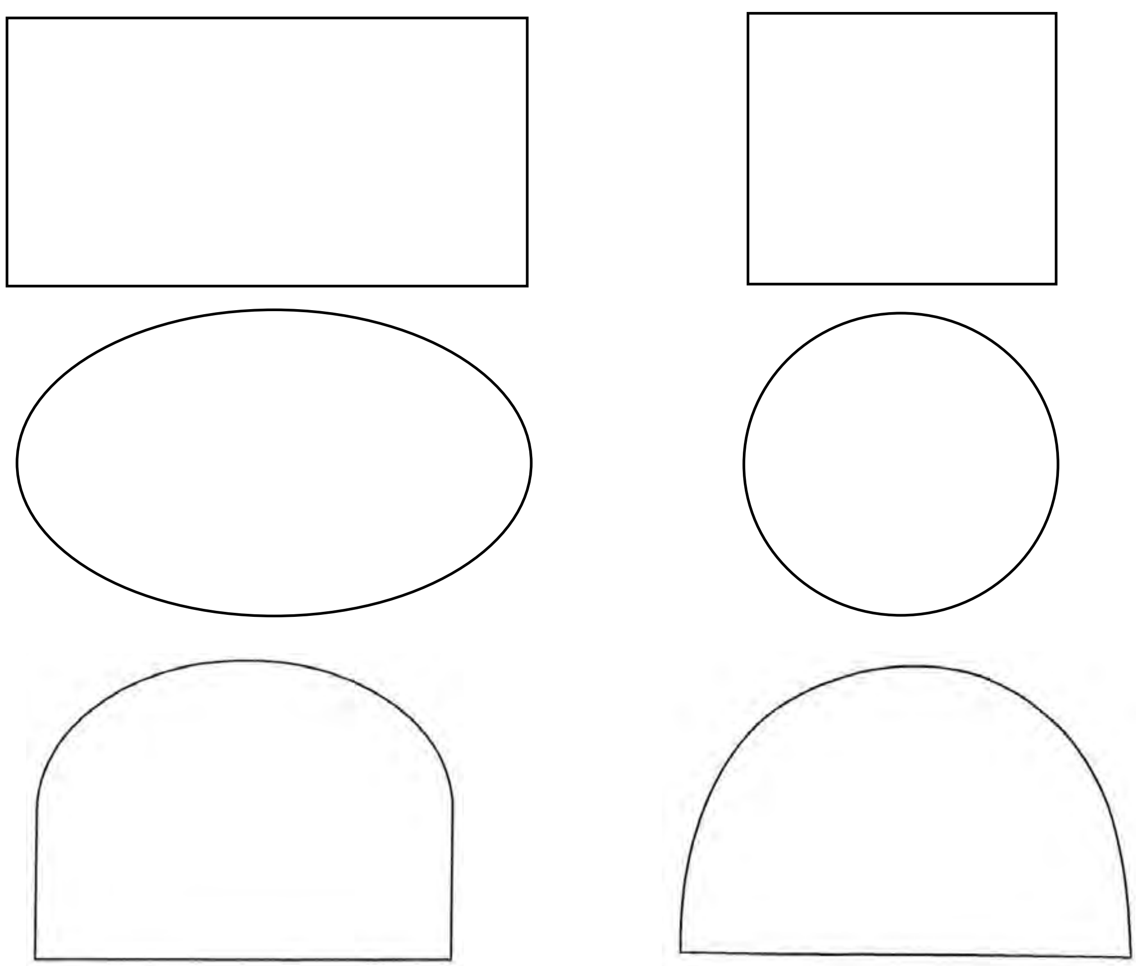
Description:

____

____

____

Typical Culvert Shapes (fill in dimensions)



ATLANTIC TESTING LABORATORIES

WBE certified company

May 19, 2017

O'Brien & Gere Engineers, Inc.
101 First Street
Utica, NY 13501

Attn: Mr. Shaun Gannon

Re: Soil Laboratory Testing
Sauquoit Creek – Whitestown, NY
ATL Report No.: UT4374SL-01-05-17

Ladies/Gentlemen:

On May 12, 2017 our representative obtained one sample of sandy gravel material (UT4374S01) from Tehan's Plaza and delivered it to our Utica, New York facility for testing. A Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregates in accordance with ASTM C 127/AASHTO T 85, a Relative Density (Specific Gravity), and Absorption of Fine Aggregates in accordance with ASTM C 128/AASHTO T 84 and a Particle Size Analysis (with Hydrometer) in accordance with ASTM D 422 were performed on this sample. See the attached Particle Size Distribution Report. The results follow:

DENSITY, RELATIVE DENSITY, AND ABSORPTION OF COARSE AGGREGATES
ASTM C 127/AASHTO T 85

ATL Sample No.	Relative Density (OD)	Relative Density (SSD)	Apparent Relative Density	Absorption (%)
UT4374S01	2.59	2.64	2.71	1.7

DENSITY, RELATIVE DENSITY, AND ABSORPTION OF FINE AGGREGATES
ASTM C 128/AASHTO T 84

ATL Sample No.	Relative Density (OD)	Relative Density (SSD)	Apparent Relative Density	Absorption (%)
UT4374S01	2.49	2.54	2.63	2.1

Please contact our office should you have any questions or if we may be of further service.

Sincerely,
ATLANTIC TESTING LABORATORIES, Limited
For

Andrew J. Ward
Operations Manager
award@atlantictesting.com

AJW/gg

cc: Mr. Shaun Gannon - Shaun.gannon@obg.com

Enclosure

ATLANTIC TESTING LABORATORIES

WBE certified company

Particle Size Distribution Report

Project: Sauquoit Creek

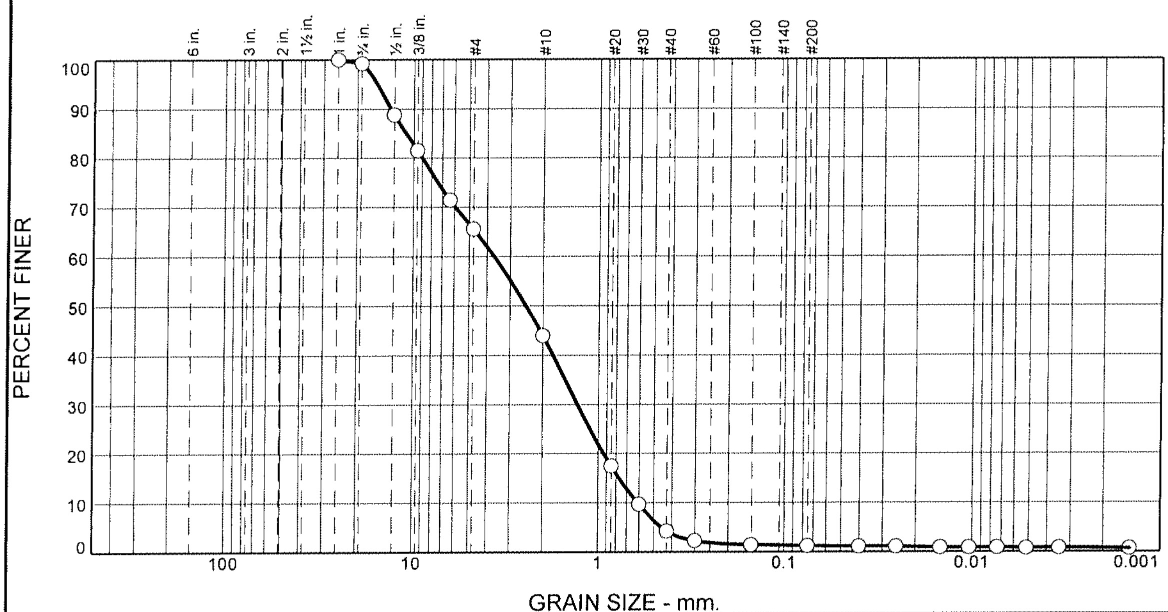
Report No.: UT4374SL-01-05-17

Client: O'Brien & Gere Engineers, Inc.

Date: 05/19/17

Sample No: UT4374S-01 **Source of Sample:** Tehan's Plaza

Location: In-situ **Elev./Depth:** N/A



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	1	33	22	40	3	0	1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	OUT OF SPEC. (X)
1	100		
.75	99		
.5	89		
.375	81		
.25	71		
#4	66		
#10	44		
#20	17		
#30	10		
#40	4		
#50	2		
#100	1		
#200	1.2		

* (no specification provided)

Soil Description

Brown sandy gravel

Atterberg Limits

PL= --- LL= --- PI= ---

Coefficients

D_{85}= 10.9974 D_{60}= 3.6579 D_{50}= 2.4601
D_{30}= 1.2964 D_{15}= 0.7704 D_{10}= 0.6101
C_u= 6.00 C_c= 0.75

Classification

USCS= SP AASHTO= ---

Remarks

Delivered by C. Tabor on May 12, 2017
ASTM D 422 (with Hydrometer)

Figure

ATLANTIC TESTING LABORATORIES, LIMITED

Reviewed by: [signature]

Date: 5/19/17

ATLANTIC TESTING LABORATORIES

WBE certified company

May 19, 2017

O'Brien & Gere Engineers, Inc.
101 First Street
Utica, NY 13501

Attn: Mr. Shaun Gannon

Re: Soil Laboratory Testing
Sauquoit Creek – Whitestown, NY
ATL Report No.: UT4374SL-02-05-17

Ladies/Gentlemen:

On May 12, 2017 our representative obtained one sample of sandy gravel material (UT4374S02) from Pietryka Park and delivered it to our Utica, New York facility for testing. A Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregates in accordance with ASTM C 127/AASHTO T 85, a Relative Density (Specific Gravity), and Absorption of Fine Aggregates in accordance with ASTM C 128/AASHTO T 84 and a Particle Size Analysis (with Hydrometer) in accordance with ASTM D 422 were performed on this sample. See the attached Particle Size Distribution Report. The results follow:

DENSITY, RELATIVE DENSITY, AND ABSORPTION OF COARSE AGGREGATES
ASTM C 127/AASHTO T 85

ATL Sample No.	Relative Density (OD)	Relative Density (SSD)	Apparent Relative Density	Absorption (%)
UT4374S02	2.62	2.66	2.73	1.6

DENSITY, RELATIVE DENSITY, AND ABSORPTION OF FINE AGGREGATES
ASTM C 128/AASHTO T 84

ATL Sample No.	Relative Density (OD)	Relative Density (SSD)	Apparent Relative Density	Absorption (%)
UT4374S02	2.50	2.56	2.65	2.2

Please contact our office should you have any questions or if we may be of further service.

Sincerely,
ATLANTIC TESTING LABORATORIES, Limited

For
Andrew J. Ward
Operations Manager
award@atlantictesting.com

AJW/gg

cc: Mr. Shaun Gannon - Shaun.gannon@obg.com

Enclosure

ATLANTIC TESTING LABORATORIES

WBE certified company

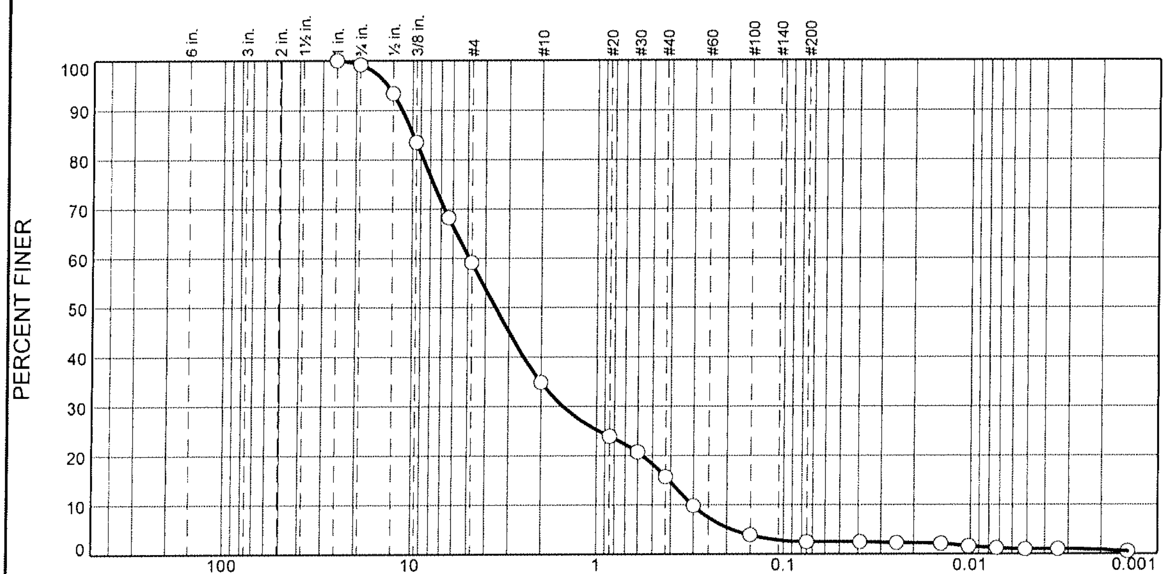
Particle Size Distribution Report

Project: Sauquoit Creek **Report No.:** UT4374SL-02-05-17

Client: O'Brien & Gere Engineers, Inc. **Date:** 05/18/17

Sample No: UT4374S-02 **Source of Sample:** Pietryka Park

Location: In-situ **Elev./Depth:** N/A



% Cobbles	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	1	40	24	19	14	1	1

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	OUT OF SPEC. (X)
1	100		
.75	99		
.5	93		
.375	84		
.25	68		
#4	59		
#10	35		
#20	24		
#30	21		
#40	16		
#50	10		
#100	4		
#200	2.5		

Soil Description

Brown sandy gravel

Atterberg Limits

PL= --- LL= --- PI= ---

Coefficients

D_{85}= 9.8983 D_{60}= 4.8881 D_{50}= 3.5297
D_{30}= 1.5202 D_{15}= 0.4086 D_{10}= 0.3043
C_u= 16.06 C_c= 1.55

Classification

USCS= SW AASHTO= ---

Remarks

Delivered by C. Tabor on May 12, 2017
ASTM D 422 (with Hydrometer)

* (no specification provided)

Figure

ATLANTIC TESTING LABORATORIES, LIMITED

Reviewed by: [signature] Date: 5/19/17

Appendix F: Photo Log







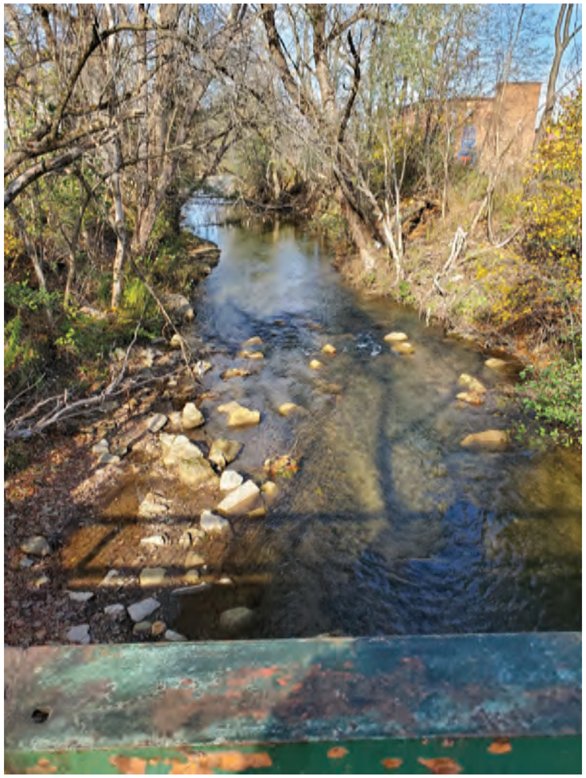






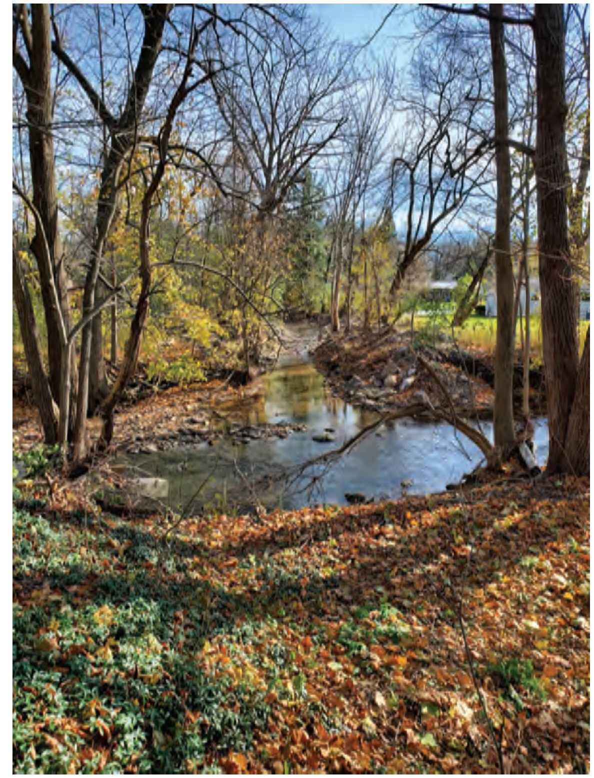












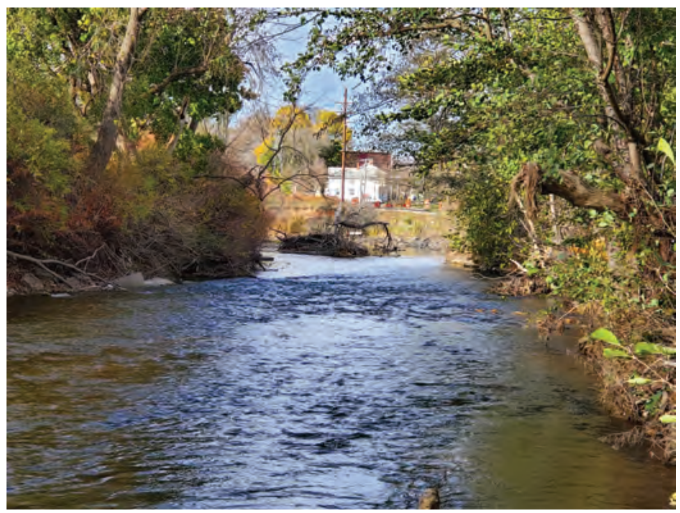













































Appendix G: Sediment Management Strategies Project Sheets

Vegetated Coir Logs

Vegetative plugs placed in densely-packed coconut fiber rolls (Figure 1)

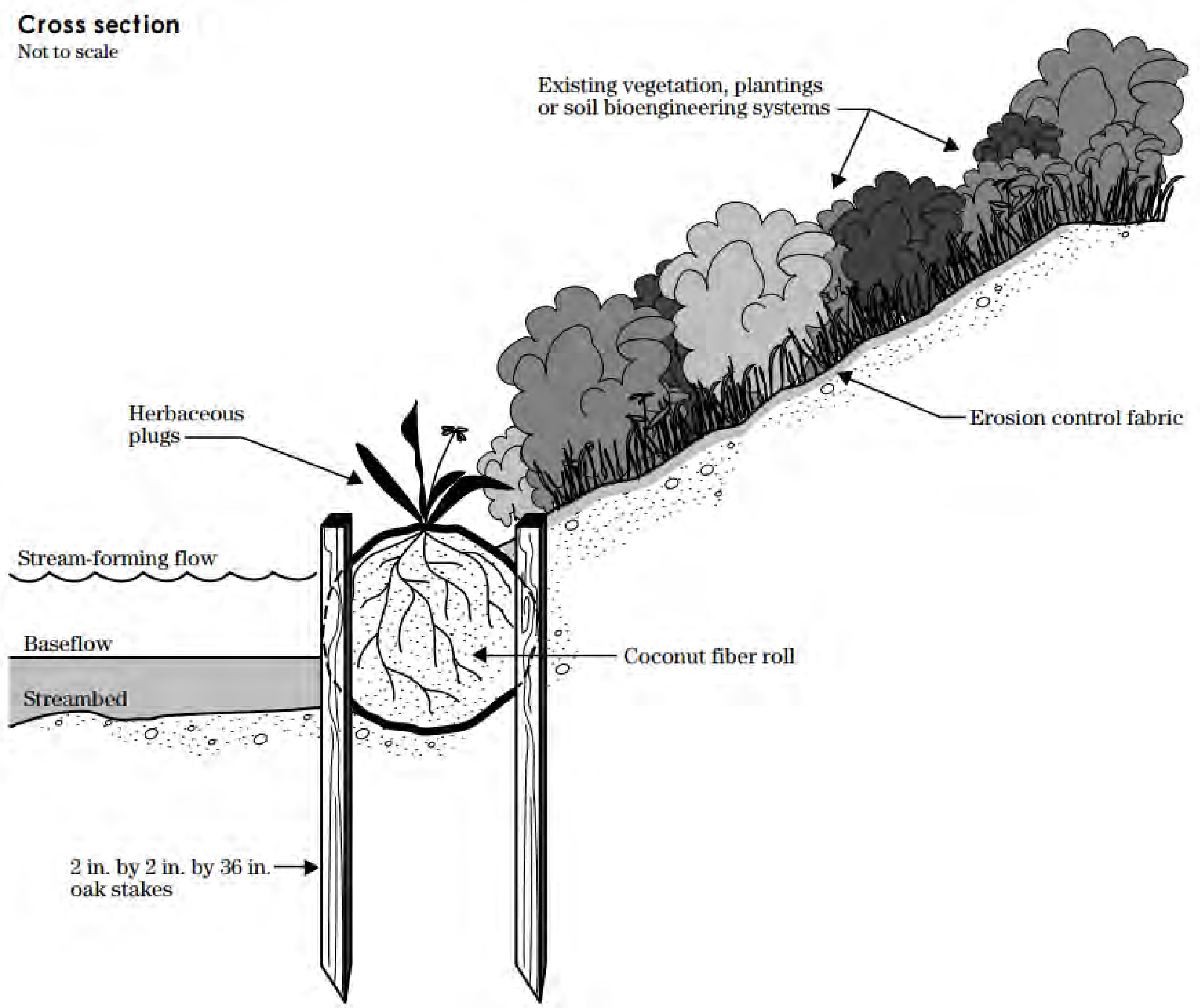


Figure 1. **Vegetated coir logs (NRCS 1996).**

Issue Solution Addresses

Vegetated coir logs prevent erosion by reinforcing the streambank and acting as a natural retaining wall against water velocity. The vegetated rolls are flexible and can mold to the existing curvature of the streambank. They are also highly effective in developing stream channel banks by trapping sediment behind the fiber rolls and improving conditions for vegetation establishment on the water's edge.

Ideal Location

Coir logs are suitable in low energy environments and work best in areas with minimal ice build-up. High energy environmental can dislodge the logs or cause the logs to break down before rooting the vegetative plugs. Gradual slopes less than 1V:2H (vertical:horizontal) are preferred.

Design and Construction Considerations

- **Site-Specific Conditions:** Vegetated coir logs are suitable in water velocities of 8 ft/s or less.
- **Materials:** Pre-constructed coir logs, coir netting (optional), vegetated plugs (pre-rooted is preferred), rot-resistant wooden stakes, and erosion control blanket (optional). Erosion control blankets and coir netting are recommended and can reduce the need for maintenance long-term.
- **Construction:** The density of vegetated plugs depends on the fiber roll diameter (Table 1). The root system shall be placed below the water level. The stakes shall be placed on both sides of the roll every 2-4 ft, depending on anticipated water velocity.

Table 1. Vegetated Plug Density

Log Diameter (inch)	Vegetated Plug Density (plug/linear foot)
8	1
12	2
16	3
20	5

- **Spacing:** If the shoreline is greater than 10 ft, the coir logs shall be laced together in a continuous line with no gapping between rolls.
- **Placement:** Install the first row of the coir logs parallel to the streambank such that the top two inches of the log are visible at mean water elevation. Additional vertical tiers can be added on the bank slope for further stabilization (Table 2).

Table 2. Interval Spacing

Slope (V:H)	Interval Spacing (ft)
1:1	5-10
1:2 > Slope > 1:1	10-20
1:4 > Slope > 1:2	20-40

- **Maintenance:** Replacement of the rolls may be required if the log begins to break apart due to elevated water velocity or ice damage. For the first year, it is encouraged to inspect the structure after the first few floods (~ 3 visits). Monitoring can reduce to once a year after that. Over time, sediment will cover the coir logs, and vegetation will establish.

Other design considerations include installation schedule (i.e., time of year), bank preparation, trench excavation methods, backfilling, compaction and drainage.

Permitting and Regulatory Considerations

The extent of permit requirements will depend on the location and final design of the project. Consult with your local municipality, NYSDEC, and USACE before beginning any stabilization activities.

Rough Order of Magnitude Cost

The total cost is approximately $1,000/20 linear ft. This price includes materials, transportation, and installation. Costs vary with design, site access, installation timeframe, supplier, and labor rates.

Applications and Effectiveness

- Protect slopes and encourage deposition of sediment

- Coir logs expedite vegetative cover by providing stabilized medium
- Molds to existing curvature of streambank
- Minimal disturbance of streambank

Brush Mattresses

Living ground cover of layered branch cuttings (Figure 2)

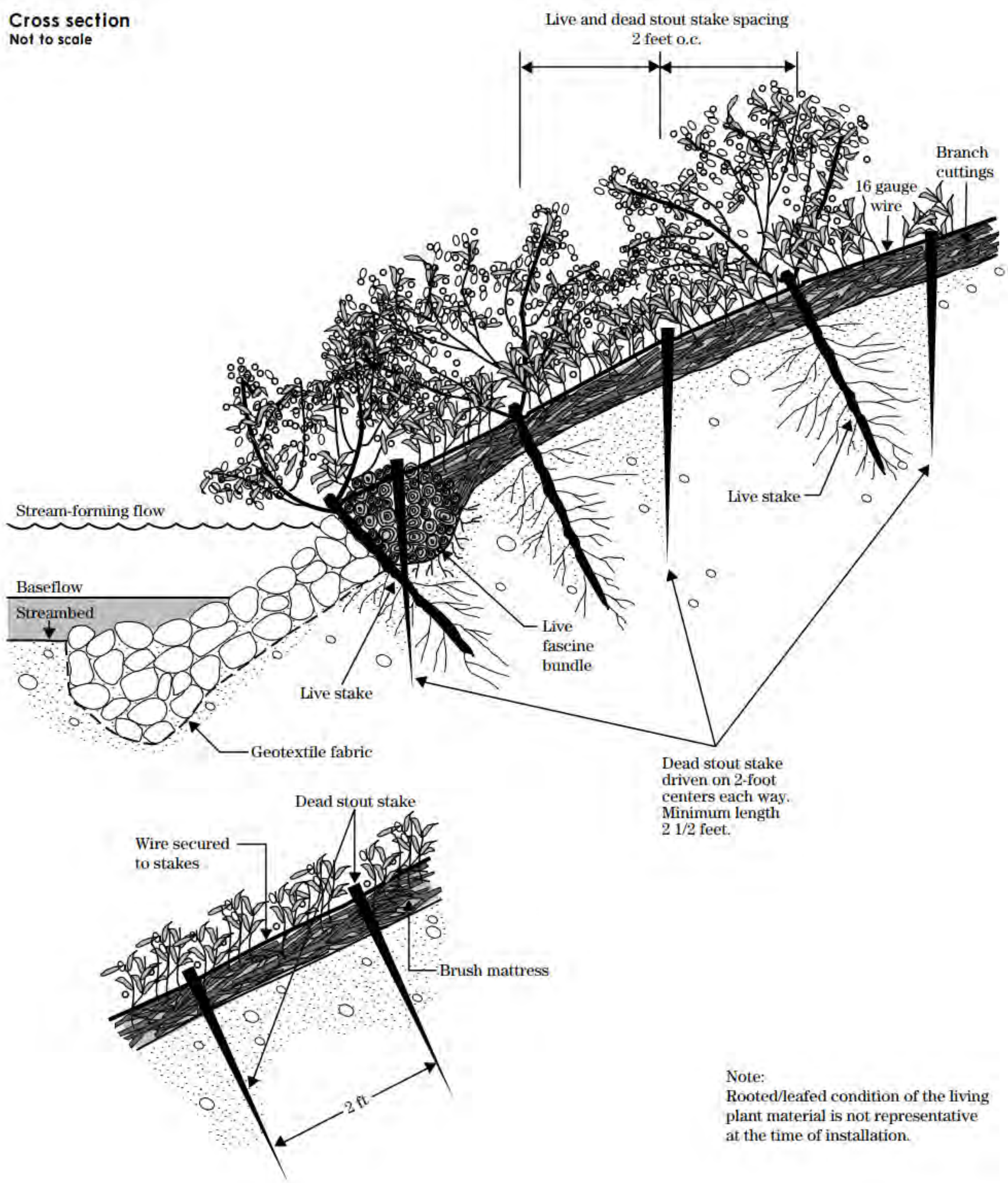


Figure 2. Brush mattresses (NRCS 1996).

Issue Solution Addresses

Brush mattresses slow water velocities along the streambank and reduce erosion. The open space between the woody material allows for sediment deposition and water drainage. The build-up of sediment enhances the colonization of native plants.

Ideal Location

Brush mattresses are best suited for perennial streams with low to medium water velocities. Constant water flow and sunny conditions will encourage the growth of the wood cuttings. Brush mattresses can be installed on slopes 1V:2H or flatter.

Design and Construction Considerations

- **Site-Specific Conditions:** Brush mattresses are suitable in water velocities of 5 ft/s. Brush mattresses are commonly implemented with other shoreline stabilization methods to ensure proper protection. Rock bolsters provide toe stabilization against high water velocities and shear stress, Table 3. Note, shoreline protection is dependent on vegetation establishment.

Table 2. **Brush Mattresses Configuration**

Brush Mattress Type	Water Velocity (ft/sec)	Shear (lb/ft^2)
Staked only without rock bolster at toe	Initial Planting: < 4.0	0.4 – 3
	Established Vegetation: < 5.0	4.0 – 7.0
Staked with rock bolster at toe	Initial Planting: < 5	0.8 – 4.1
	Established Vegetation: < 12	4.0 – 8.0

- **Materials:** Live branch cuttings of a native growing species (e.g., willow) approximately 6 to 9 ft in length, biodegradable untreated twine, dead stout stakes (minimum length of 2.5 ft), 12 gauge galvanized wire, and live fascines. Additional materials may include rock bolster and geotextile fabric for toe stabilization.
- **Placement:** First, install the live fascines in a trench (8 to 10 inches deep and wide) at the streambank base. Place the live branches into the fascines so that the basal end (where the roots grow) faces the riverbed. Drive dead stout stakes into the brush mattress approximately 12 to 18 inches apart. Lastly, wrap metal wire around each stake and pull tightly across the live branches.
- **Maintenance:** Repair of the nature-based structure may be required dependent on stream velocity, flood frequency, sediment load, and timing. For the first year, inspect the structure for loose branches or live fascines after the first few floods (~ 3 visits). Add additional stakes as needed. For the first two dry seasons, water the branches every two weeks if a soaking rain does not occur during a three-week timeframe.

Other design considerations include installation schedule (i.e., time of year), bank preparation, stock type, trench excavation methods, backfilling, compaction and drainage.

Permitting and Regulatory Considerations

The extent of permit requirements will depend on the location and final design of the project. Consult with your local municipality, NYSDEC, and USACE before beginning any stabilization activities.

Rough Order of Magnitude Cost

Total cost ranges from \$38 to \$84/10 ft^2. This price includes materials, transportation, and installation. Costs vary with design, site access, installation timeframe, supplier and labor rates.

Applications and Effectiveness

- Applicable for steep fast-flowing streams
- Captures sediment and encourages vegetation establishment
- Requires good soil to stem contact and moist conditions for branches to grow
- Encourages conditions for colonization of native vegetation
- Immediate protection of streambank after installation

Willow Stakes (Live)

Live willow cuttings with the branches trimmed off (Figure 3)

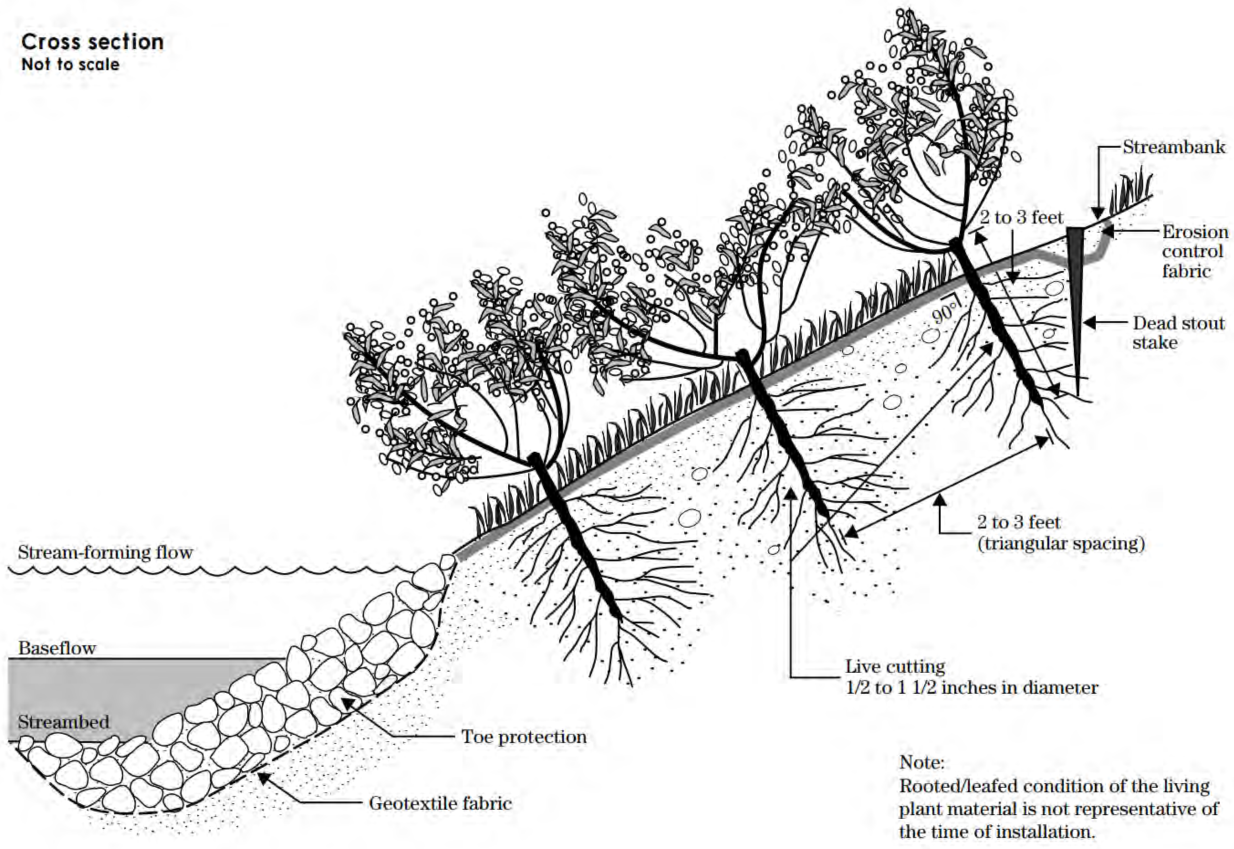


Figure 3. Willow stakes (live) (NRCS 1996).

Issue Solution Addresses

Live willow stakes are a cost-effective streambank stabilization method for slopes with soil exposure or minor erosion. The willow roots and branches will stabilize the soil, uptake soil moisture, and reduce over-bank runoff. Live stakes can be used alone or with other nature-based stabilization methods.

Ideal Location

Willow stakes are most successful on low to medium slopes with sunlight exposure and minimal invasive species presence. Best planted on soils with high water tables or soils with moderate draining conditions (high organic matter and clay content).

Design and Construction Considerations

- **Site-Specific Conditions**: Willow stakes are best suitable for water velocities below 9.8 ft/s and shear stress below 2 lb/ft^2. The willow stakes will not protect the slope until the willow has developed roots.

- **Materials:** Willow Cuttings (approximately 0.5 to 1.5 inches in diameter and 2 to 3 feet long). Optional materials include erosion control fabric, grass seeds, and dead stout stakes. Fertilizer or other soil amendments may be required based on soil conditions.
- **Branch Preparation:** Soak the branches before installation. Do not install dried stakes. The branch's basal end should be cut on an angle for easier planting, while the top should have a squared cut. Remove all side branches with minimal damage to the bark.
- **Spacing:** Place the live cuttings approximately 2 to 3 feet apart using a triangular spacing, at a density of 2 to 4 stakes per yd^2. Install the first row of cuttings about 4 ft from the edge of the water at low tide.
- **Installation:** The stakes shall be tapped four-fifths of length into the ground at a 90-degree angle. Remove the stake if it splits during installation and try again. After installation, firmly press the soil surrounding the cutting and cover all exposed ground will grass seed.
- **Maintenance:** The live stakes should be watered once per week during the 1^{st} growing season if placed in dry soil conditions. Pruning may be required if the willow grows too large.

Other design considerations include installation schedule (i.e., time of year), bank preparation, stock type and size, exposed soils and invasive species presence.

Permitting and Regulatory Considerations

The extent of permit requirements will depend on the location and final design of the project. Consult with your local municipality, NYSDEC, and USACE before beginning any stabilization activities.

Rough Order of Magnitude Cost

The cost of live willow stakes ranges from $ 0.7 to $ 5 per stake. This price does not include installation. Costs vary with design, site access, supplier and labor rates.

Applications and Effectiveness

- A cost-effective method for slopes that require minimal effort
- Repair small earth slips and slumps
- Some species of willow can grow in unfavorable soil conditions
- Can be combined with other hard and/or soft stabilization methods

Vegetated Geogrid (Soil Lifts)

Biodegradable matting wrapped around the soil to form tiers

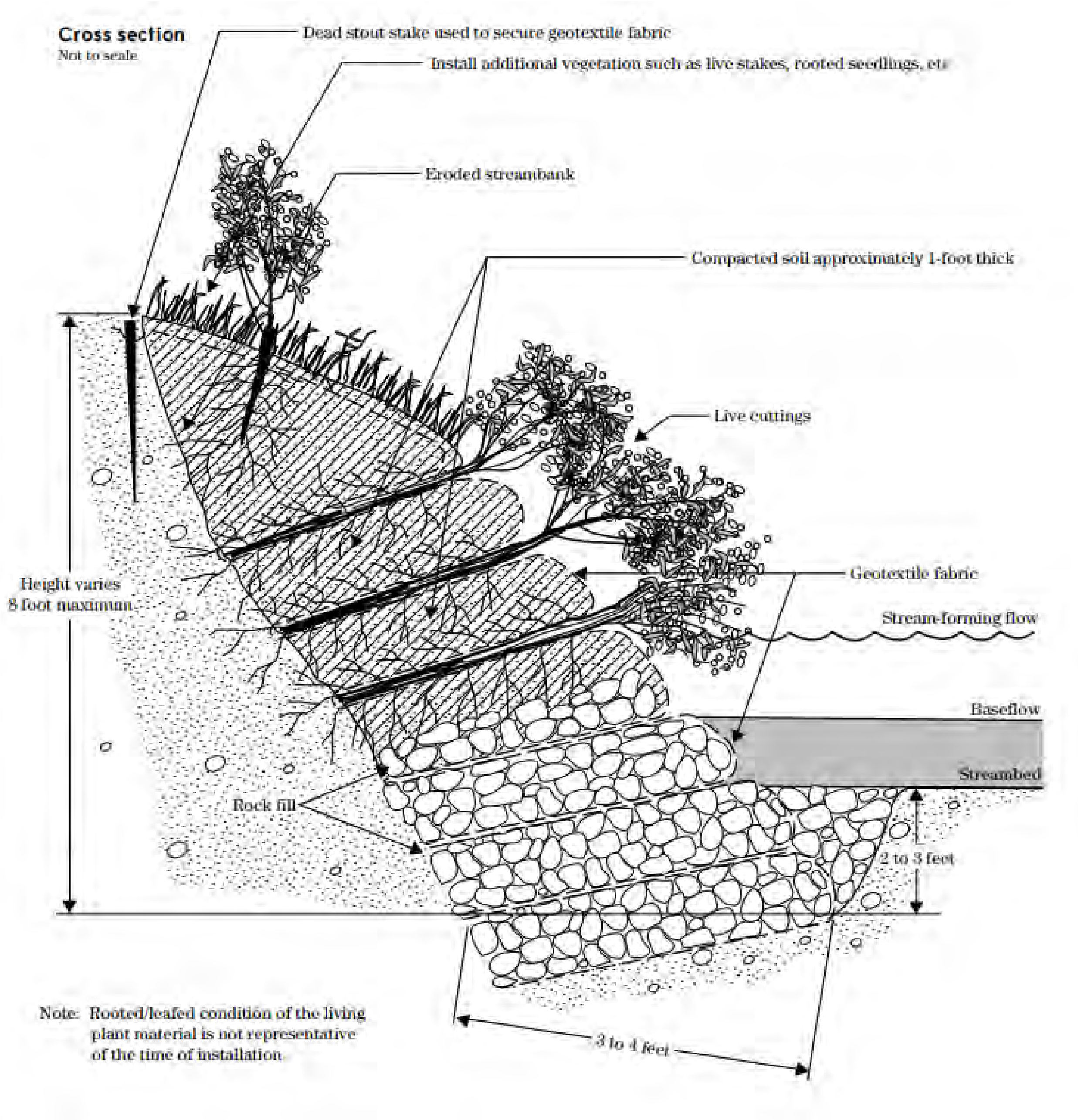


Figure 1. Soil lift (NRCS 1996).

Issue Solution Addresses

Soil lifts are used on moderate to high energy riverbanks to help protect against erosion and sliding soil. They are also used to rebuild a bank that is already compromised by moderate erosion. The tiers enhance the slope's condition for colonization of native vegetation.

Ideal Location

Soil lifts are best implemented on outside bends that are experiencing moderate erosion. The tie-in slow should not be steeper than 2V:1H.

Design and Construction Considerations

- **Site-Specific Conditions**: Soil lifts are best suitable for water velocities below 12 ft/sec and shear stress below 6.25 lb/ft^2 for fully grown vegetation.
- **Materials:** Biodegradable erosion control fabric, soil suitable for plant growth, dead stout stakes (2.5-4 ft long), branch cuttings (0.5-2 in diameter and 4-6 ft long), rock fill, and batter board (optional). The batter board helps define the front edge of the lift during construction.
- **Rock Toe:** Rockfill is required for toe establishment. The toe should start 2-3 ft below the streambed elevation and 3-4 ft wide. Wrap the fabric over the rock in 12 in. increments.
- **Spacing:** Each tier should be approximately 1-ft thick.
- **Installation:** The first layer of live cuttings (6-8 in. thick) shall be placed at the stream-forming flow, with the basal end touching the back of the excavated slope. Cover the branches with a layer of soil until the stems are mostly covered. Place the geotextile layer over the cuttings and leave an overhang of geotextile material. Cover the geotextile with 12 in. of soil and compact the soil to ensure good soil contact with the branches. Pull overhang of geotextile material over the soil and adjust the cloth until the desired contour. Continue this process, alternating layers of branch clippings and wrapped soil until the bank is restored—the maximum total height of 8 ft.
- **Maintenance:** Minimal maintenance is required due to the geotextile fabric. However, the system is susceptible to erosion prior to vegetation establishment. The vegetation is essential to ensure the tiers do not fail after the fabric begins to deteriorate.

Other design considerations include installation schedule (i.e., time of year), bank preparation, stock type, and geotextile selection. Engineering analysis is recommended for soil lift designs with a total height greater than 7 ft and 20 ft in length.

Permitting and Regulatory Considerations

The extent of permit requirements will depend on the location and final design of the project. Consult with your local municipality, NYSDEC, and USACE before beginning any stabilization activities.

Rough Order of Magnitude Cost

Total cost is approximately $104/linear ft. This price includes materials, transportation, and installation. Costs vary with design, site access, installation timeframe, supplier and labor rates.

Applications and Effectiveness

- Provides a newly constructed streambank that functions immediately
- Encompasses the soil to prevent soil slides
- The system can be complicated and expensive
- Produces rapid vegetative growth and ideal conditions for colonization of native vegetation

Rootwad with Boulders

The placement of a trunk of a dead tree (Rootwad) and large stone (Figure 5)

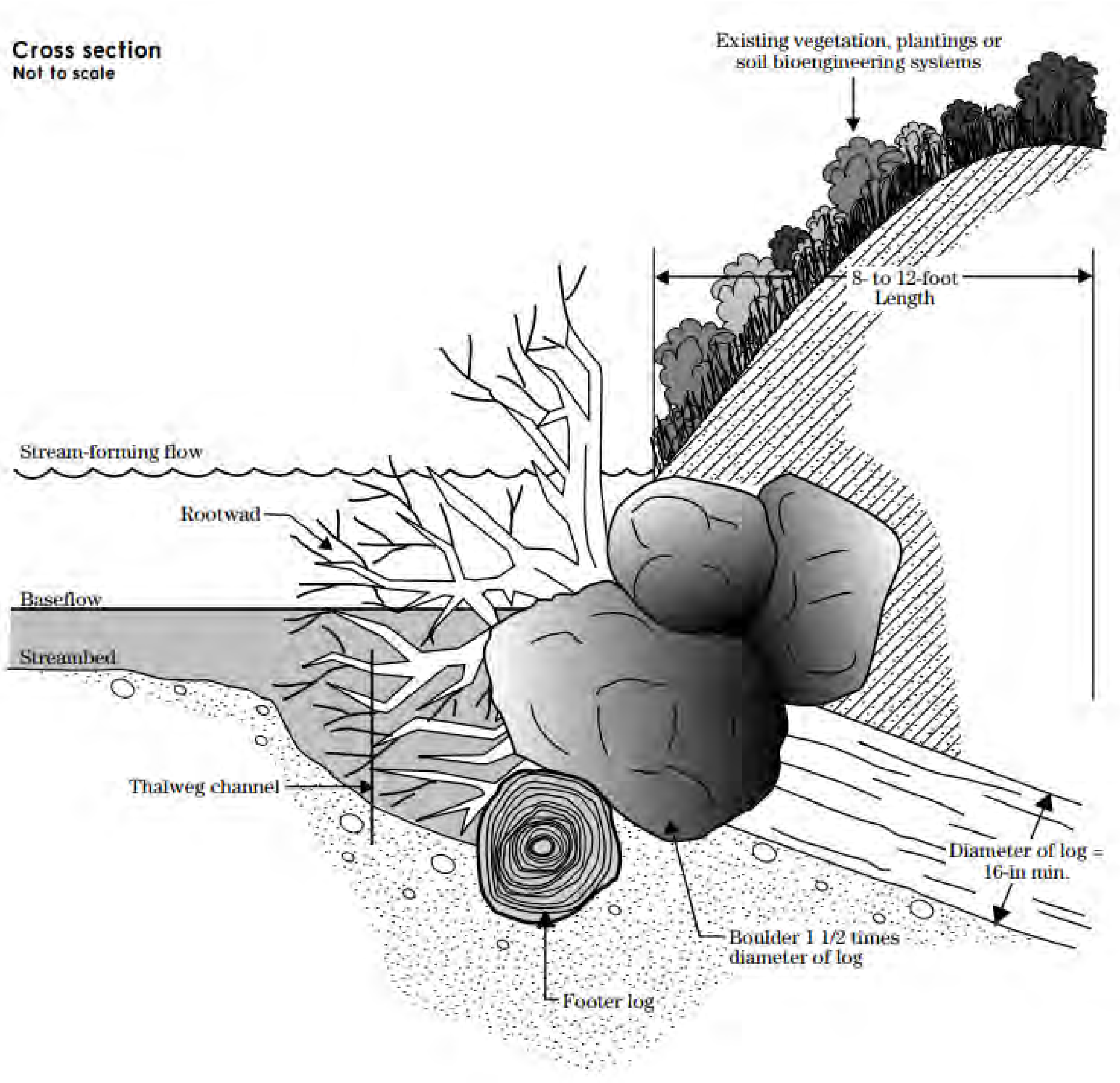


Figure 1. Rootwad with boulders (NRCS 1996).

Issue Solution Addresses

The combination of rootwad and boulders are best utilized for streambed stabilization and enhanced in-stream habitat. This combined technique is also effective on meandering streams with out-of-bank flow conditions.

Ideal Location

Rootwads and boulders are ideal in newly constructed channels to mimic natural conditions or where woody habitat is limited. They can be placed in riffles (shallow depths with fast/turbulent water) or pools (deep depths and slow current), depending on the stream type. Banks need to have at least 15% silt or clay; otherwise, bank erosion will occur around rootwads.

Design and Construction Considerations

- **Site-Specific Conditions**: Rootwads and boulders are best used on sites with water velocities below 8 ft/sec. The rootwads can tolerate high boundary shear stress if the rootwads are correctly anchored.
- **Materials:** Trees (hemlock or hardwood) with root ball intact (~12 ft long boles), footer log, and boulders (minimum of 1.5 times the log diameter).
- **Spacing:** Space the rootwads 3-4 times the root bulb diameter continuously along the channel bank.
- **Installation:** Install the footer log, at the expected scour depth, on a slight angle against streamflow along the eroding bank. Install the rootwad so the brace roots are flush with the streambank and are slightly angled towards the direction of the streamflow. Lastly, place boulders around the rootwad and footer log to prevent the trees from dislodging.
- **Maintenance:** For the first year, inspect the rootwads after significant flow events for channel bank erosion. Inspect the site for signs of undercutting, vegetation survival, and animal damage.

Other design considerations include installation schedule (i.e., time of year), soil composition, bank preparation, and exposed soils (upper bank). Professional installation and design is required.

Permitting and Regulatory Considerations

The extent of permit requirements will depend on the location and final design of the project. Consult with your local municipality, NYSDEC, and USACE before beginning any stabilization activities.

Rough Order of Magnitude Cost

Total cost ranges from $18 to $91/linear ft, with an average cost of $37/ linear ft. This price includes materials, transportation, and installation. Costs vary with design, site access, installation timeframe, supplier and labor rates.

Applications and Effectiveness

- Immediate stabilization of the streambed
- Creates in-stream habitat for fish rearing and spawning
- Requires vegetation planting or other shoreline stabilization methods for the upper portion of the bank
- May be used in high-velocity streams
- Requires professional installation and engineering design

Riprap with live stakes

The combination of large, loose, angular stone with live, vegetative cuttings (Figure 6)

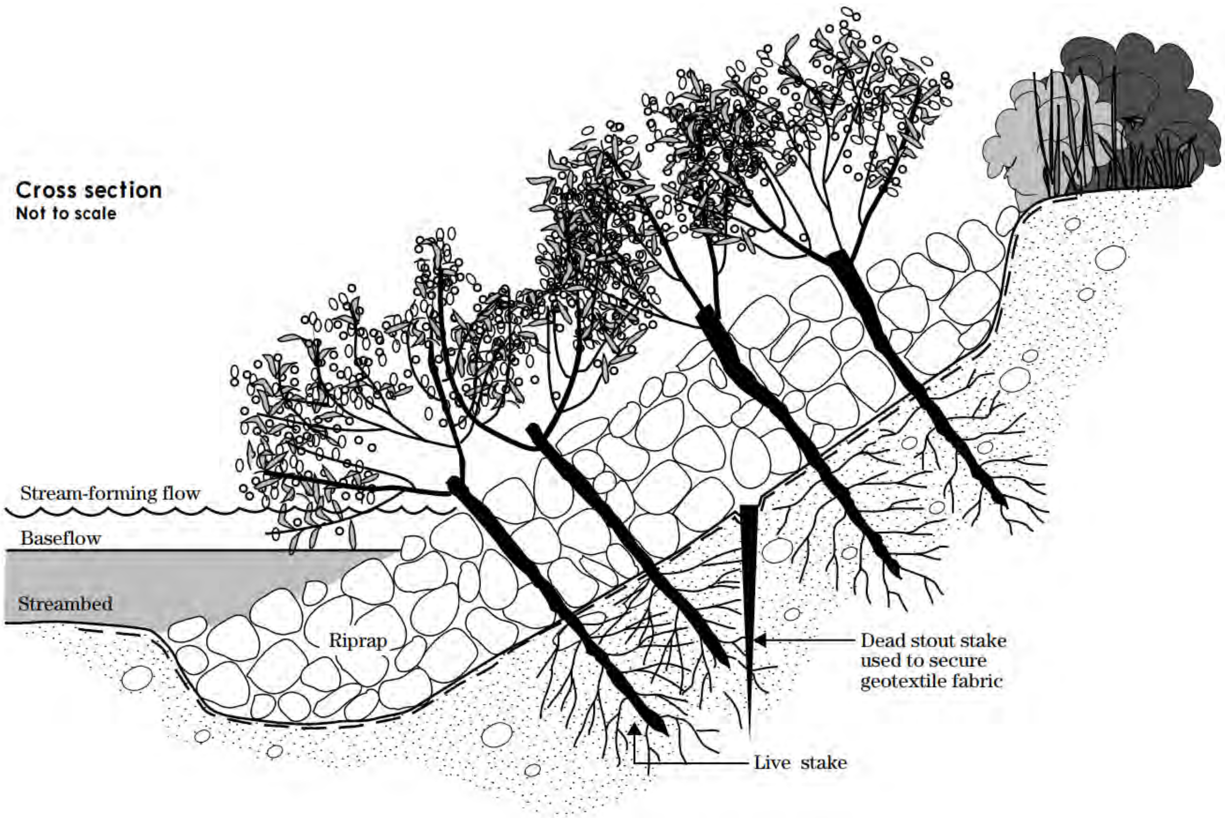


Figure 1. Riprap with live stakes (NRCS 1996).

Issue Solution Addresses

Riprap and live stakes are an effective method for shoreline stabilization and toe establishment. This technique can also repair small earth slips and slumps and prevent scouring. The live stakes are planted in the rock joints to establish riparian vegetative cover and provide further erosion control after root establishment.

Ideal Location

Riprap and live stakes are best in locations where erosion forces are severe and softer methods are not effective. The individual stone allows for shoreline protection along meandering riverbeds that require a flexible structure. The maximum recommended slope of the riverbank is 1V:2H; however, 1V:3H is preferred.

Design and Construction Considerations

- **Site Specific Conditions**: Live stakes and riprap are best used for water velocities between 5 and 15 ft/sec.
- **Materials:** Stem Cuttings (long woody branches) of a native naturally growing species (minimum diameter of 0.25 inches and a minimum length of 4 ft), geotextile fabric, wooden stakes (minimum length of 2.5 ft), and dense, hard angular riprap that meets NYSDOT Specifications.

- **Riprap Sizing:** The size of the riprap will increase with water velocity. See Table 3 for maximum sizing requirements.

Table 4. **Riprap Sizing**

Velocity (fps)	D_{max} (in)
5	6
8.5	12
10	18
12	24
15	36

- **Placement and Spacing:** Stake the geotextile fabric in place along the streambed and bank. The placement of the vegetative stakes is dependent on soil cohesion and slope (Table 4). The cuttings should be placed at random intervals above the stream-forming flow. Carefully place the riprap around the vegetative stakes and use smaller stones in any void space that does not have cuttings. If rip-rap is already present, insert the live stakes perpendicular to the slope using a dead blow hammer.

Table 4. **Spacing for Vegetative Stakes**

	Spacing (ft on Center)	
Slope Steepness (V:H)	Cohesive Soils (high clay content)	Non-Cohesive Soils (high sand content)
1:5:1	N/A	N/A
1:2	1.5 – 3	1.5 – 2
1:3 or flatter	3 – 5	2 – 4

- **Maintenance:** Vegetative cuttings may require watering for 6 weeks after installation, dependent on installation timeframe. For the first year, it is encouraged to inspect the system after each of the first few floods (~ 3 visits). Monitoring can reduce to once a year thereafter. Repair of the nature-based structure may be required until the vegetation is fully established.

Other design considerations include installation schedule (i.e., time of year), stone quality (graded vs uniform), bank preparation, trench excavation, backfilling, and stone placement.

Permitting and Regulatory Considerations

The extent of permit requirements will depend on the location and final design of the project. Consult with your local municipality, NYSDEC, and USACE before beginning any stabilization activities.

Rough Order of Magnitude Cost

Total cost ranges from $6 to $23/linear foot. This price includes materials, transportation, and installation. Costs vary with design, site access, installation timeframe, supplier and labor rates.

Applications and Effectiveness

- Useful for slopes subject to seepage or weathering
- Vegetative roots can improve drainage by removing soil moisture and prevent washout between the rip-rap.
- Provides immediate protection and is effective in reducing erosion on actively eroding banks.
- Dissipates some of the energy along the streambank and induces sedimentation.
- Rip-rap sizing and vegetative density will depend on the water velocities.

Live Fascines

Live fascines (Figure 7) are long bundles of live woody cuttings tied together and buried in a streambank parallel to the stream's flow.

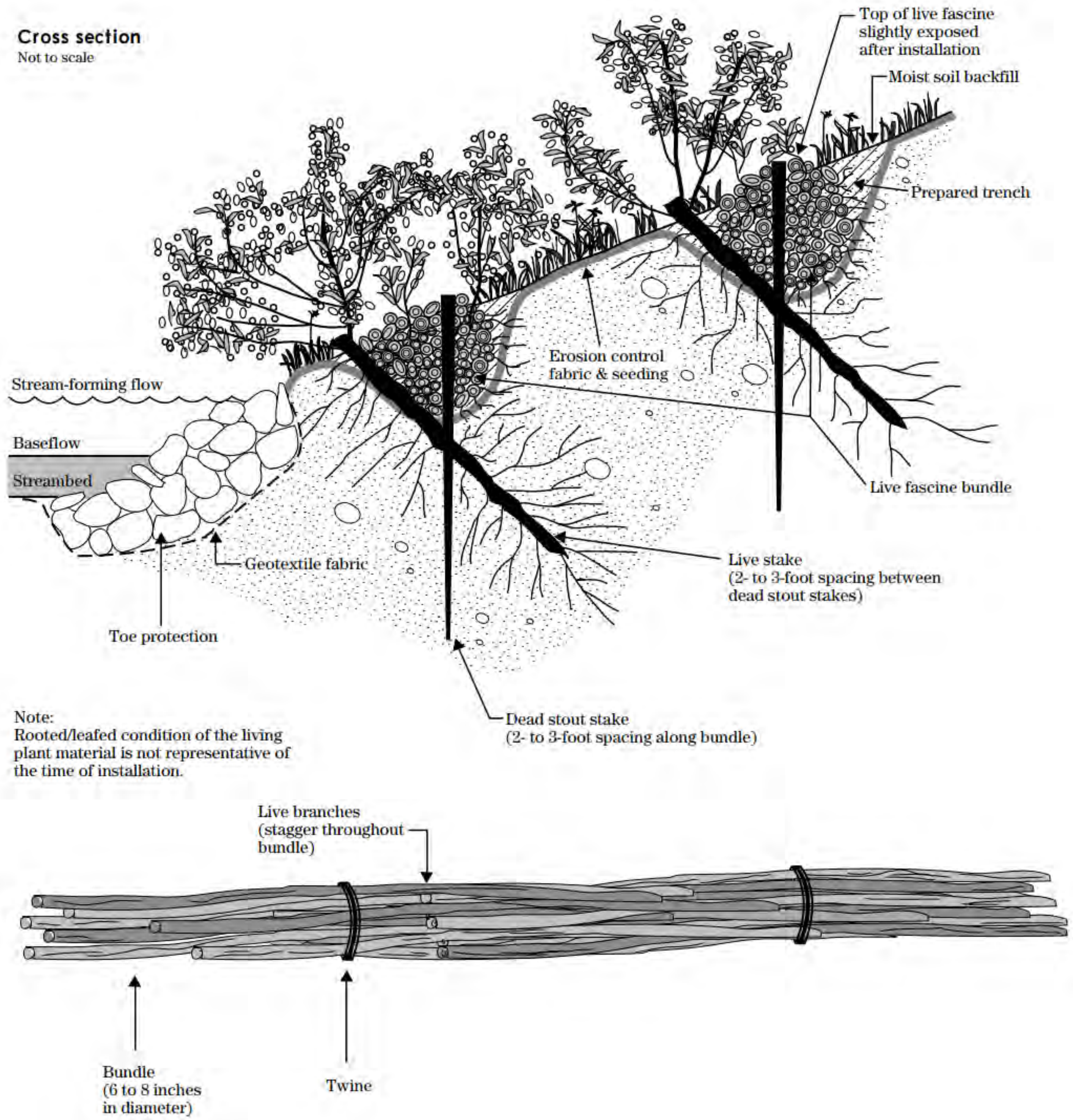


Figure 1. **Live Fascines (NRCS 1996).**

Issue Solution Addresses

Live fascines are useful in controlling erosion related to wave action and over-bank runoff on long slopes. A series of plant-filled trenches will reduce slope segments and dissipate water energy available for erosion. Angled or horizontally plant-filled trenches act as a water retention system, allowing for improved infiltration rates and reducing over-bank runoff. In time, the live fascines will produce roots and top growth, providing soil reinforcement, surface protection, and groundwater uptake. Other benefits include improved fishery habitat, water quality, and natural-looking aesthetics.

Ideal Location

Best applied on gentle slopes experiencing light to moderate erosion. The bank face must be a maximum of 15 feet long and should not have slopes steeper than 1V:2H; a slope of 1V:3H is preferred. Live fascines require soil conditions with high organic matter and clay content to ensure that the fascines stay anchored to the shoreline and have enough moisture for vegetation growth.

Design and Construction Considerations

- **Configuration:** Live fascines are commonly implemented with other shoreline stabilization methods to ensure full protection. The rip-rap provides toe stabilization and prevents wave reflection (Table 5).

***Table 5.* Stress Type and Levels**

Bundle Configuration	Velocity	Shear
Angle only without rock bolster protection	< 8 ft/sec	1.2 to 2.1 lb/ft^2
Angle with rock bolster protection	< 12 ft/sec	>3.1 lb/ft^2
On-contour only without rock bolster protection	< 6 ft/sec	0.1 to 0.6 lb/ft^2
On-contour w/rock bolster protection	< 8 ft/sec	>2.0 lb/ft^2

- **Materials:** Stem Cuttings (long woody branches) of a native naturally growing species (minimum diameter of 0.25 inches and a minimum length of 4 ft), biodegradable untreated twine, wooden stakes (minimum length of 2.5 ft). The bundles should consist of branches of different ages, sizes and species.
- **Bundle Construction:** The live end of each branch must be pointed in the same direction, and the cut ends shall be staggered throughout the bundle, with a total bundle length of approximately 4 ft.
- **Spacing:** The vegetated bundles must be anchored to non-eroding portions of the bank. The spacing between the live fascines bundles is dependent on soil type and slope. For a slope of 2:1, the live fascines shall be placed 3-5 ft apart for loose erosive soil and 5-7 ft for cohesive soil.
- **Placement:** Install the live fascine bundles above the stream-forming flow, except on small drainage area sites (generally less than 2,000 acres).
- **Maintenance:** Repair of the nature-based structure may be required until the vegetation is fully established. For the first year, it is encouraged to inspect the system after each of the first few floods (~ 3 visits). Monitoring can reduce to once a year thereafter.

Other design considerations include installation schedule (i.e., time of year), bank preparation, trench excavation, backfilling, compaction and drainage.

Permitting and Regulatory Considerations

The extent of permit requirements will depend on the location and final design of the project. Consult with your local municipality, NYSDEC, and USACE before beginning any stabilization activities.

Rough Order of Magnitude Cost

Total cost ranges from $10 to $30/ft for 6 to 8 in. bundles. This price includes materials, transportation, and installation. Costs vary with design, site access, installation timeframe, supplier and labor rates.

Applications and Effectiveness

- Effective for streambank stabilization with minimum disturbance
- Provides immediate protection again surface erosion and shallow slides (1 to 2 ft depth)
- An angular installation will facilitate drainage while the roots uptake water seepage
- Bundles are capable of trapping soil and reduce slope length by creating a series of shorter slopes
- Encourages growth of native vegetation by providing surface stabilization

Hardwood Tree Planting

A native hardwood tree planted upland of other shoreline stabilization techniques

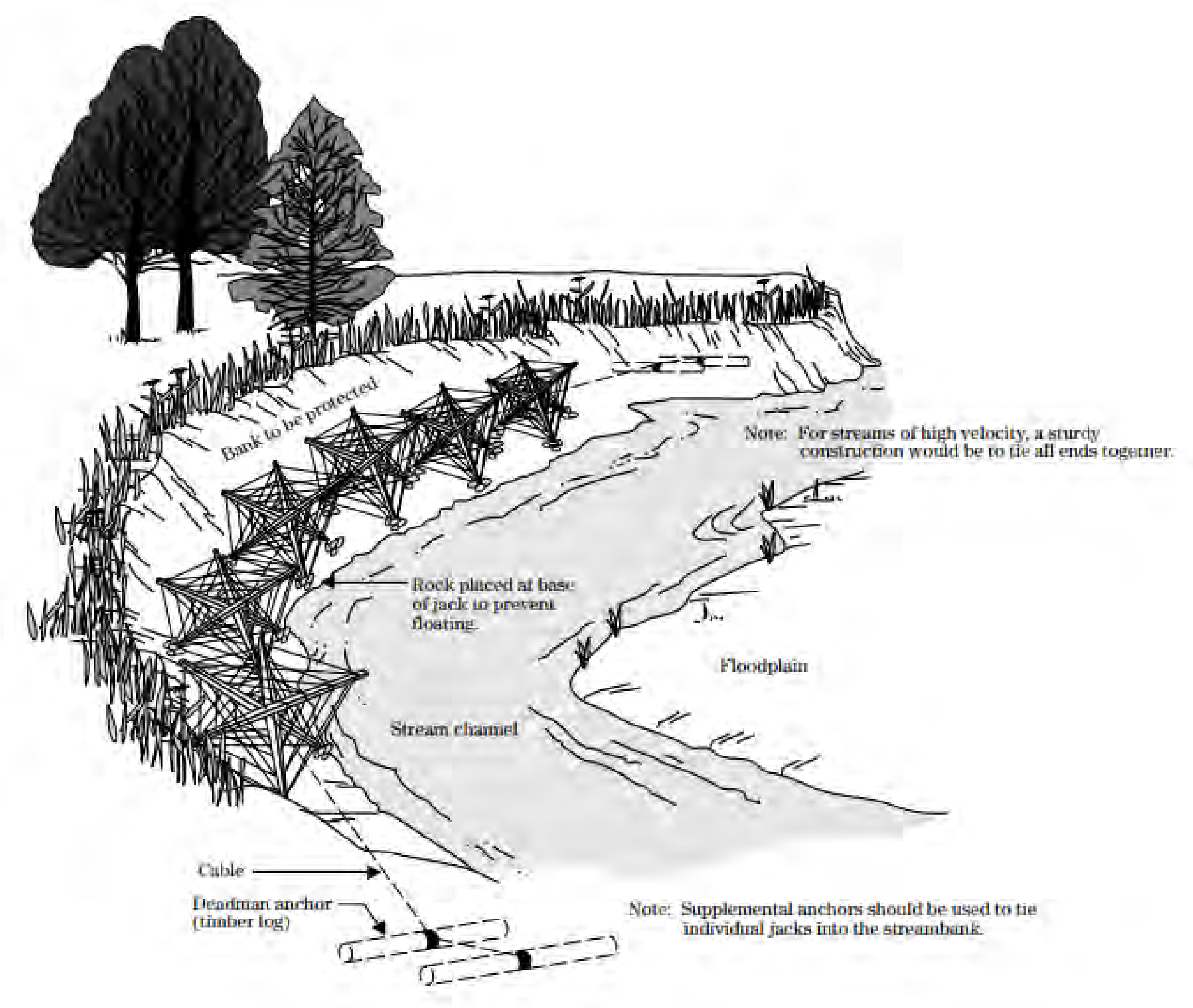


Figure 8. Tree planting upland of shoreline stabilization method (NRCS 1996).

Issue Solution Addresses

Upland tree planting is a useful technique to protect against erosion caused by over-bank runoff. Trees intercept the falling rain in their canopies and absorb the water through their roots. Woody species have a deep root structure which prevents against earth slips by holding the soil in place, trapping upland sediment carried by stormwater and absorbing excess soil moisture. Also, trees provide other ecological benefits, including natural habitat, reduction in stream water temperatures, and improved water quality.

Ideal Location

Tree plantings are most successful against over-bank runoff when placed upland of other streambank stabilization methods. The tree plantings will require sunlight, ideal soil conditions (dependent on species) and room to grow to maturity.

Design and Construction Considerations

- **Materials:** Native trees, fertilizer, and mulch. Conduct a site evaluation to determine the appropriate tree species, e.g., light exposure, wind, aboveground and belowground utilities, soil characteristics, surrounding vegetation, and distance to the water table.
- **Placement and Spacing:** Tree spacing (Table 6) will allow room for the tree to expand as it grows to maturity. The placement of the tree is dependent on soil moisture conditions, sunlight availability, and site size.

***Table 6.* Tree Spacing**

Tree Description	Spacing (ft)
Columnar Species	6-8
Small Trees	20-30
Large Trees	50-60

- **Installation Schedule:** For deciduous species, planting shall occur during April to June 1 and October 15 to December 15. For Evergreen trees, planting should be completed during April 1 to Jun 1 and September 1 to November 15.
- **Planting:** Dig a hole twice the size of the root ball. Mix the soil with slow-releasing fertilizer. Remove the tree from the container, gently loosen roots and place the tree within the hole. Once the tree looks level, put additional soil within the hole and compress down. Apply 2-3" layer of wood chips around the base. Pull the mulch 1" away from the base of the tree to avoid fungus or insect damage.
- **Maintenance:** The tree plants will require watering two weeks after planting. For the first two dry seasons, water trees every two weeks if a soaking rain does not occur during a three week timeframe. Monitor the tree(s) for dead, diseased, or dying limbs and prune and thin as necessary.

Other design considerations include site preparation (weed control, scalping of sod), soil health, sunlight availability, insect treatment, and stock.

Permitting and Regulatory Considerations

The extent of permit requirements will depend on the location and final design of the project. Consult with your local municipality, NYSDEC, and USACE before beginning any stabilization activities.

Rough Order of Magnitude Cost

Total cost ranges from $106 for smaller trees to 2,423 for larger trees. This price includes materials, transportation, and installation. Costs vary with design, site access, installation timeframe, supplier and labor rates.

Applications and Effectiveness

- Reduces over-bank runoff and captures stormwater sediment
- The root structure prevent against earth slips through soil moisture uptake and soil stabilization
- Increases diversity and available habitat
- Increase water quality through pollutant uptake from groundwater and stormwater runoff

Vegetated Riparian Buffer

Vegetated corridors that parallel streams, rivers, lakes, and wetlands.

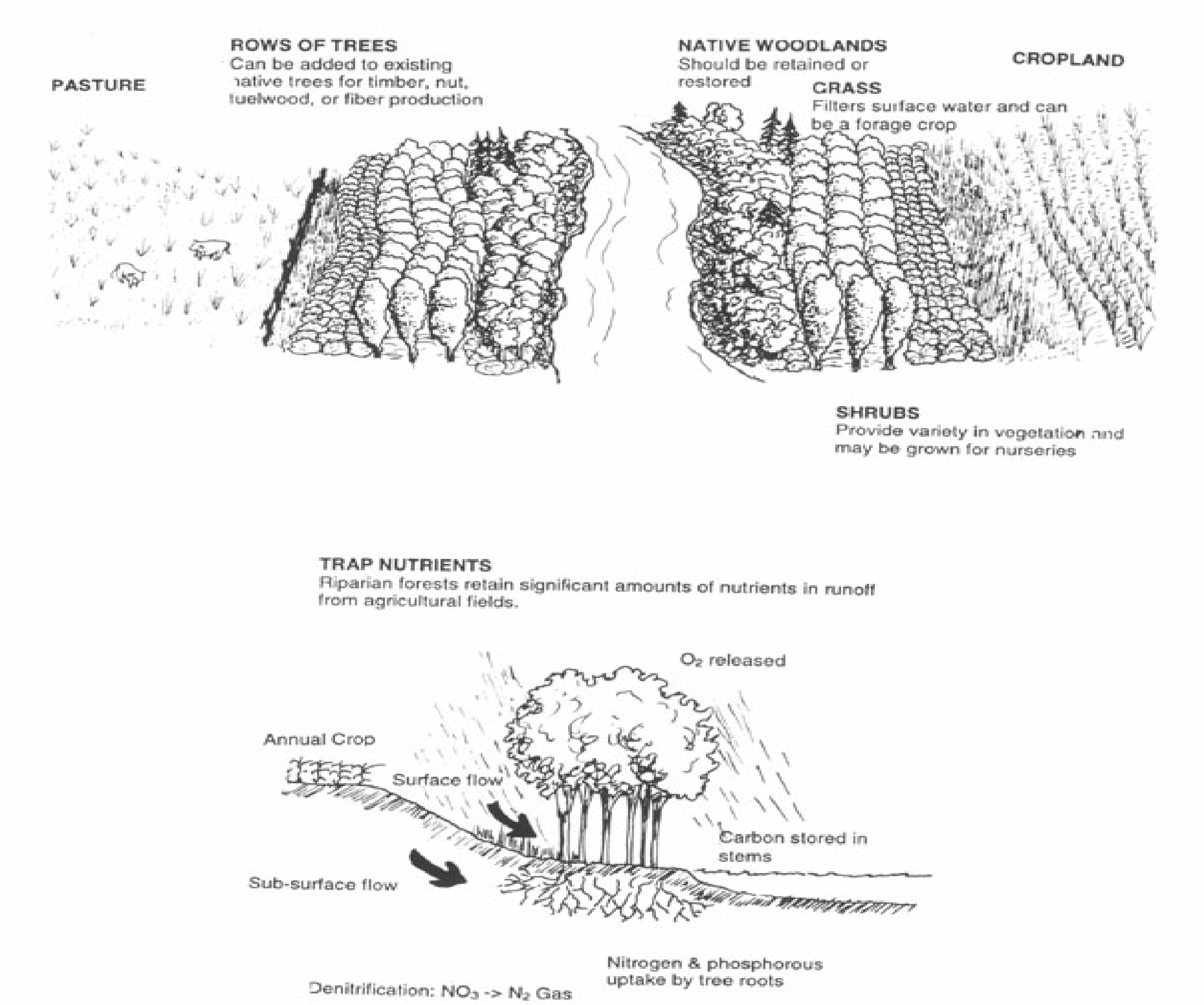


Figure 9. **Vegetated riparian buffers adjacent to pasture and cropland (NRCS [date unknown]).**

Issue Solution Addresses

Vegetated riparian buffers are designed to intercept stormwater runoff before it enters adjacent water bodies. In the process, they trap sediment, nutrients, and contaminants that are carried within stormwater before it reaches the waterbodies. The mechanisms through which they accomplish this include:

- Stoppage of transport of sediment by buffer vegetation.
- Slowing runoff to allow for stormwater infiltration, settling of sediment, and uptake of water, nutrients, and contaminants by vegetation.

It is estimated that vegetated riparian buffers can reduce sediment concentrations of up to 90 percent. Their ability to reduce concentrations of nitrogen, phosphorus, and other constituents also significantly improve the quality of the adjacent water bodies.

Ideal Location

Vegetated riparian buffers generally parallel the shoreline of the adjacent water bodies and should be placed so that they are located within the flow path of contributing sources of stormwater runoff that contains significant concentrations of sediment and other constituents (e.g., pasture and cropland). Designers need to work with the landowners to maximize the efficacy of the buffer while minimizing the amount of land that is taken out of revenue generation (e.g., agricultural production, commercial real estate).

Design and Construction Considerations

Essentially, any vegetated buffer that can be established between the contributing drainage area and the adjacent water body will improve water quality within the aquatic resource. That said, the following should be considered during design:

- The ideal total width of the buffer is at least 150-feet, but should be no less than 30 feet.
- As illustrated in Figure 9, the buffer will ideally contain various elements. Inclusion of woody species improves soil stabilization and evapotranspiration and should be implemented where practicable. Specific elements should include:
    - A band of grasses and forbs closest to the adjacent land use. In an agricultural setting, these bands can be planted with harvestable crops such as hay or straw provided that the stubble is left to stabilize the soil.
    - A band of shrubs and small trees. This band can be made up of fruit and nut trees from which crops can be harvested or can be harvested for biofuels (e.g., willow).
    - A band of woodlands that are allowed to mature with minimal harvest or ongoing maintenance.
- All native species should be included in design.
- It is recommended that several different species be used on one site to maximize diversity.
- Livestock should be excluded from all buffers to the extent practicable.

Materials: Native trees, shrubs, and seed; fertilizer; and mulch. Conduct a site evaluation to determine the appropriate species, e.g., light exposure, wind, aboveground and belowground utilities, soil characteristics, surrounding vegetation, and distance to the water table. Fast growing hardwoods such as cottonwood and poplars, silver maple, and willows can be used so they can be harvested for biofuels within 4-6 years or can be left longer to produce small dimension lumber and biofuels.

Placement and Spacing: spacing between rows and trees within a row varies with species and objectives. Common plantings will be 8 to 10 feet between rows and 4 to 6 feet between trees within the row; shrubs will be planted at closer spacings.

Installation Schedule: For deciduous species, planting shall occur during April to June 1 and October 15 to December 15. For Evergreen trees, planting should be completed during April 1 to June 1 and September 1 to November 15. Seeding shall be performed during two seasonal windows: April 1 to June 15, October 15 through December 1.

Maintenance:

- The grass and forb zone should be mowed a minimum of once annually to control woody vegetation.
- The tree and shrub species can be selectively cut to produce biofuels and/or lumber or can be left to mature. Monitor the woody species for dead, diseased, or dying limbs and prune and thin as necessary.

Other design considerations include site preparation (weed control, scalping of sod), soil health, sunlight availability, insect treatment, and stock.

Permitting and Regulatory Considerations

The extent of permit requirements will depend on the location and final design of the project. Consult with your local municipality, NYSDEC, and USACE before beginning any stabilization activities.

Rough Order of Magnitude Cost

Costs are site-specific and will depend on the length/width of the buffer and the vegetation species used. If the riparian zone is vegetated and hydrologically connected between the upland and stream, there may be no cost at all, other than the cost and effort of negotiating an easement with the landowner to promote long-term buffer health.

If riparian buffers do not exist and must be newly established (e.g., by way of stream bank reengineering), costs for a forest buffer costs between $250–$700 per acre to plant and maintain. Costs include site preparation, plants, planting, maintenance, and replanting by the landowner.

Riparian forest buffers qualify for the conservation programs (e.g., Trees for Tribs), which can help with the cost of establishment and provides an annual payment. Forest buffers might also result in a bonus for trees planted and a per-acre incentive.

Applications and Effectiveness

- Reduces poullutant and nutrient loading to adjacent water bodies
- Shade provided by trees can reduce thermal impacts
- The vegetative root structure helps stabilize site soils
- Increases diversity and available wildlife habitat

References

Natural Resources Conservation Service (NRCS). [date unknown]. Guidance on Agroforestry System Design – Riparian Forest Buffer. In: Sustaining Agroforestry Systems for Farms and Ranches. Washington DC (US): United States Department of Agriculture (USDA). Available from: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/forestry/sustain/guidance/?cid=nrcsdev11_009302.

Natural Resources Conservation Service (NRCS). 1996. Engineering Field Handbook - Chapter 16: Streambank and Shoreline Protection. Washington DC (US): United States Department of Agriculture (USDA). Available from: https://efotg.sc.egov.usda.gov/references/public/IA/Chapter-16_Streambank_and_Shoreline_Protection.pdf.

Allowable Velocity and Maximum Shear Stress

Type of Treatment	Allowable Shear lb/sq ft	Velocity ft/sec
Brush Mattresses[1]		
Staked only w/ rock riprap toe (initial)	0.8 - 4.1	5
Staked only w/ rock riprap toe (grown)	4.0 - 8.0	12
Coir Geotextile Roll[2]		
Roll with coir rope mesh staked only without rock riprap toe	0.2 - 0.8	< 5
Roll with Polypropylene rope mesh staked only without rock riprap toe	0.8 - 3.0	< 8
Roll with Polypropylene rope mesh staked and with rock riprap toe	3.0 - 4.0	< 12
Live Fascine[3]		
LF Bundle w/ rock riprap toe	2.0 - 3.1	8
Soils[4]		
Fine colloidal sand	0.02-0.03	1.5
Sandy loam (noncolloidal)	0.03-0.04	1.75
Alluvial silt (noncolloidal)	0.045-0.05	2
Silty loam (noncolloidal)	0.045-0.05	1.75-2.25
Firm loam	0.075	2.5
Fine gravels	0.075	2.5
Stiff clay	0.26	3-4.5
Alluvial silt (colloidal)	0.26	3.75
Graded loam to cobbles	0.38	3.75
Graded silts to cobbles	0.43	4
Shales and hardpan	0.67	6
Gravel/Cobble[4]		
1-inch	0.33	2.5-5
2-inch	0.67	3-6
6-inch	2	4-7.5
12-inch	4	5.5-12
Vegetation[4]		
Class A turf (ret class)	3.7	6-8
Class B turf (ret class)	2.1	4-7
Class C turf (ret class)	1	3.5
Retardance Class D	0.6	Design of roadside channels HEC-15
Retardance Class E	0.35	
Long native grasses	1.2-1.7	4-6
Short native and bunch grass	0.7-0.95	3-4

Type of Treatment	Allowable Shear lb/sq ft	Velocity ft/sec
Soil Bioengineering[4]		
Wattles	0.2-1.0	3
Reed fascine	0.6-1.25	5
Coir roll	3-5	8
Vegetated coir mat	4-8	9.5
Live brush mattress (initial)	0.4-4.1	4
Live brush mattress (grown)	3.90-8.2	12
Brush layering (initial/grown)	0.4-6.25	12
Live fascine	1.25-3.10	6-8
Live willow stakes	2.10-3.10	3-10
Hard Surfacing[4]		
Gabions	10	14-19
Concrete	12.5	>18
Boulder Clusters[5]		
Boulder		
Very large (>80-inch diameter)	37.4	25
Large (>40-in diameter)	18.7	19
Medium (>20-inch diameter)	9.3	14
Small (>10-inch diameter)	4.7	10
Cobble		
Large (>5-inch diameter)	2.3	7
Small (>2.5-inch diameter)	1.1	5
Gravel		
Very Course (>1.25-inch diameter)	0.54	3
Course (>.63-inch diameter)	0.25	2.5

[1] Brush mattresses (ERDC TN EMRRP-SR-23): http://el.erdc.usace.army.mil/emrrp/pdf/sr23.pdf.
[2] Coir Geotextile roll (ERDC TN EMRRP-SR-04): http://el.erdc.usace.army.mil/emrrp/pdf/sr04.pdf.
[3] Live Fascine (ERDC TN EMRRP-SR-31): http://el.erdc.usace.army.mil/emrrp/pdf/sr31.pdf.
[4] Stream Restoration Materials (ERDC TN EMRRP-SR-29): http://el.erdc.usace.army.mil/emrrp/pdf/sr29.pdf.
[5] Boulder Clusters (ERDC TN EMRRP-SR-11): http://el.erdc.usace.army.mil/emrrp/pdf/sr11.pdf.

Additional Sources:

Wisconsin Department of Transportation, Erosion Control - Product Acceptability List (PAL):
http://www.dot.wisconsin.gov/library/research/docs/finalreports/tau-finalreports/erosion.pdf

Texas Department of Transportation, Approved Products List:
http://www.dot.state.tx.us/mnt/erosion/contents.htm

Reference:

Natural Resources Conservation Service (NRCS). 2009. Engineering Field Handbook - Chapter 16: Streambank and Shoreline Protection - Wisconsin Supplement. Washington DC (US): United States Department of Agriculture (USDA). Report No.: EFH Notice 210-WI-119. Available from: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_024948.pdf.

Appendix H: Labor and Equipment Inventory (Optional Section)

- This section should include pertinent contact information (Staffing, contractors, emergency numbers, etc.) and equipment inventory along with location.
- This section should identify how much manpower and type(s) of equipment needed for each of the problematic areas.
- To be completed by municipalities.