Sawkill Creek

Stream Corridor Assessment Report

Ulster County, NY

Prepared for:

The Sawkill Watershed Alliance,
Town of Woodstock,
Town of Kingston,
Town of Ulster

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Executive Summary

The Sawkill Creek runs 19.5 miles linking the communities of Woodstock, Kingston and Ulster in Ulster County, NY. The Sawkill confluences with the Esopus Creek in the Town of Ulster, which in turn confluences with the Hudson River in the community of Saugerties. In total, the Sawkill drains a watershed area of 42 square miles.

The Town of Woodstock, on behalf of the Sawkill Watershed Alliance and the neighboring Sawkill watershed towns of Ulster and Kingston, successfully applied for a grant from the NYS DEC Hudson River Estuary Program to fund this Sawkill Stream Corridor Assessment. An inter-municipal steering committee supervised the project.

Integrated River Solutions was retained to conduct this overall inventory of the current stream corridor condition and to provide a more focused review of one selected problematic area within each of the watershed towns.

Assessment Methodology

The assessment sought to provide an understanding of current condition based on a review of aerial photography flown in 1995, 2001, and 2004 followed by a field inventory from Keefe Hollow Road in Woodstock to the confluence with the Esopus in Ulster. This inventory enabled digital mapping of the location and extent of conditions that are important in understanding stream corridor condition and highlighting concerns. The inventory conducted by Integrated River Solutions complements a similar assessment completed in 2002 by the Ulster County Soil and Water Conservation District (UCSWCD) which conducted a similar walkover from Echo Lake to the Yerry Hill Bridge in Woodstock. The combined assessments provide a complete inventory of the Sawkill Creek.

The physical condition and response of the Sawkill Creek to natural and/or human-induced events were inventoried and described in the report. Events, or actions, include flooding, berming, stream bank hardening (revetment), and construction of bridges and culverts. The natural responses to those events or actions include streambank erosion (lateral stream migration), headcutting (vertical stream degradation), channel avulsions and channel obstructions.

All streams and rivers both erode sediment and deposit sediment as a natural process, but the rates of erosion and deposition can lead to an understanding of stream condition. For example, streambank erosion under naturally stable conditions may progress at a rate of inches per decade while in areas that are destabilized, migration rates may accelerate to a few hundred feet in a given storm event.

Integrated River Solutions digitally mapped the following stream features: streambed scour and streambank erosion, hardening of streambanks with rock rip rap or other means, grade controls – both natural (bedrock ledges) and man made, bridge and culvert crossings of the Creek, debris blockages, stable healthy reaches, and other channel and floodplain conditions including clay exposures, bank failures and their apparent causes, sites of mass hillslope wasting and past management practices to alleviate erosion or other problems.

The Sawkill was divided into “River Miles” for the purposes of the assessment and one of the most helpful aspects of this report is its presentation of aerial photography showing the digitally mapped features for the entire main stem of the Sawkill. A user of this report can find their point of interest on the aerial image, identify the digitally mapped features, and then refer to the section of the report that defines and describes that feature to gain an introductory level of understanding. A full collection of the digital mapping and associated database files have been submitted as part of this inventory and assessment on compact disk. The digital information allows for further detailed assessment and future incorporation into a comprehensive watershed management plan.

Three chronically problematic sites were identified by each of the watershed Towns for further evaluation and recommendations. The sites include the "John Joy Road Area" in the Town of Woodstock, the "Sweet Meadows Area" in the Town of Kingston, and the "Sawkill Creek Confluence with Esopus Creek Area" in the Town of Ulster. In each of these sites, erosion and flooding is a major ongoing concern. Integrated River Solutions conducted a site visits in each area to met with the Towns and other stakeholders to fully understand their concerns. The report provides detailed observations and recommendations for each site based on the site meetings and information collected as part of the inventory.

Summary of Findings

The Sawkill exhibits the characteristics of a mountain stream that is experiencing a common set of pressures that are experienced when a river shares its valley floor and floodplain with roads and bridges, residential homes, commercial areas, water supply reservoirs, and an intricate drainage system of ditches and culverts.

Erosion over the length of the Sawkill is comparable with other inventoried streams in this region, which were selected for assessment based on perceived elevated levels of erosion and suspended sediment. Over the total 19.5 mile length of the Sawkill assessed as part of this study, 10.5% of streambanks are experiencing erosion. These streambank erosion rates are similar to those measured in the Batavia Kill (Windham, Ashland, and Prattsville) prior to extensive restoration efforts, on the Stony Clove Creek (Hunter and Shandaken) and on the Upper Esopus Creek (Shandaken and Olive).

The most frequent erosion is located in the upper watershed in the Town of Woodstock. The largest total length of eroded bank on the Sawkill occurs between River Miles 3 - 5 which are located in the area downstream of Bearsville and surrounding the bridge on Yerry Hill Road. The largest exposed bank surface area is located in River Mile 0-1, which is the area near Keefe Hollow Road. It is the mountainous headwater areas that experience the greatest surface area of bank erosion because the stream is confined within a narrow valley that is steeply sloped and comprised of highly erodible glacial till soils.

The Sawkill headwaters contribute a tremendous volume of sediment (gravel, cobble and boulders) to the downstream corridor. In an undeveloped and natural floodplain setting, this sediment would deposit extensively where the valley's slope transitions from steep to gentle. Effective streambank stabilization and/or stream restoration within River Miles 3-5 could reduce the eroded length of streambank over the entire Sawkill corridor by nearly one third. Stabilization and/or restoration in River Mile 4-5 alone could reduce the eroded length by 22%.

Extensive floodplain berming was inventoried in the same reaches where streambank erosion is most frequent. Twenty-four instances of berming were observed, totaling more than 1.5 miles in length. The most extensive floodplain berming was measured in the heavily populated areas of Woodstock in River Miles 3-6. This area also coincides with the greatest streambank erosion. The berms are largely constructed of excavated stream gravels, which make them prone to erosion and failure.

Extensive lengths of bedrock, providing natural grade control, were inventoried along the channel bottom in the Sawkill Creek. The Sawkill drops nearly 2000 feet over its 19.5 mile length, averaging nearly 100 feet per mile. Over this length, 2.2 miles contain bedrock stream bottom. This extensive "bedrock control" of the stream's grade (slope) imparts stability to long stretches of the Sawkill by arresting any channel headcutting and incision.

Two headcuts were identified in the upper reaches. There were two significant headcuts identified, in River Miles 1-2 and 2-3. While the uppermost headwaters of the Sawkill were not assessed as part of this study, observations made by the UCSWCD in 2001-2002 identified some 30 log jams and 64 failing banks in this area. It is reasonable to expect that some headcuts moving upstream in these headwater reaches will continue to undermine these steep streambanks, entraining more trees and creating more log jams leading to ongoing bank erosion. These reaches are considered largely inaccessible and therefore may be untreatable. As a result, excess sediment including fine clay and silt that create turbid conditions during and after periods of elevated flow is expected to continue.

Only one bridge crossing was identified as a potential problem. Bridges, if poorly sited or inadequately spanning a floodplain, can restrict floodwaters and create scouring backwaters upstream of the bridge and/or increased velocities downstream of the bridge. Of the 18 bridges inventoried along the Sawkill, only one, located at John Joy road was found to possibly contribute to stream instability as a result of the bridges modification of flows during flood conditions.

The frequency of stream channel obstructions is highest in the headwaters. The largest single obstruction found along the Sawkill was in Woodstock at the site known as the "Woodstock Log and Debris Jam". The single greatest channel obstruction found during the assessment was the "Woodstock Log Jam site," near the Mallory Grove Park below the Yerry Hill Road Bridge in River Mile 4-5. The source of trees contributing to this massive jam was in large part, the two vegetated meander bends above the Yerry Hill Bridge which erode on average, 14.5 and 8 feet per year. After this assessment was completed and in the late fall 2006, the Town of Woodstock Highway Department cleared much of the log and debris jam below the bridge and opened a flood overflow channel, temporarily alleviating excessive stream erosion below the bridge.

Some 30 debris jams were inventoried by UCSWCD in 2001-2002 in the upper headwaters of the Sawkill. Integrated River Solutions inventoried an additional 35 debris jams over the remaining 19.5 mile length. It is expected that several may have been recorded by both teams. The obstructions should be assessed individually for their detriment or benefit to the Sawkill, and threat to adjacent properties and infrastructure.

The Sawkill is predominated by Rosgen C and B stream types. Classifying stream types provides an understanding about what a given reach of stream looks like, how it behaves and how it might respond to management activities. Fifty one percent of the Sawkill was identified as C-stream type and 39% was identified as B stream type. Reaches that are C stream types are typically formed in broad valleys, have well developed floodplains, and develop sinuous channels. Stability of "C" channels relies heavily on the density and vigor of riparian vegetation and the stability adjacent stream reaches. These reaches are considered "sensitive" from a stream management perspective and can experience high rates of erosion if destabilized. B stream types are considered more resilient than C's – with steeper channels in narrower valleys. Erosion rates are typically lower. This information will provide and excellent foundation for the development of a comprehensive watershed management plan.

1.0 Project Description

The community and local municipalities have raised concerns regarding the potential impacts of channel stability, erosion, and flooding on water quality, ecological health, and public safety and were interested in determining the scale and scope of several of these processes in their watershed. The Town of Woodstock, in cooperation with the Sawkill Watershed Alliance, Town of Kingston, and Town of Ulster, requested professional assistance to conduct a stream corridor inventory and assessment along the length of the Sawkill Creek. In 2006, the Town of Woodstock retained Integrated River Solutions, Inc. to perform the inventory and assessment from Keefe Hollow Road, in the Town of Woodstock, to the confluence of the Sawkill and Esopus Creeks, in the Town of Ulster.

The evaluation of the Sawkill Creek began with the review of existing reports and data, which were used to refine the inventory and items for assessment. Recent aerial imagery (2004) was used to prepare a digital alignment and stationing along the stream channel. The imagery and alignment were compared with earlier imagery to evaluate trends in channel alignment and instability. In addition, the imagery was used to facilitate an understanding of the current conditions of the Sawkill Creek and to refine the scope of the stream corridor inventory.

The inventory focused on field reconnaissance, and included mapping and defining the existing stream conditions and noting instances of apparent environmental degradation. This assessment provides a common, reproducible set of data, mapping and photography in order to document the magnitude and extent of channel instabilities, perform spatial trend analyses, and provide site-specific recommendations as applicable. It can be used to provide the foundation for a phased watershed management strategy and to initiate further comprehensive planning.

One site from each of the three towns was selected for further evaluation and recommendations. The site selection process was performed by the project advisory group, which includes representatives from each town.

At each location, a site visit was conducted to review the issues with each respective group and to identify potential causes of instability and flooding. A set of recommendations was compiled for each site based on field observations, data collected during the inventory, and professional judgment. The recommendations outlined are specific to each site and include potential alternatives for remediation, mitigation, impact minimization, and further assessment.

1.1 Watershed Characterization

Sawkill Creek is located in Greene and Ulster Counties, in the glaciated Allegheny Plateau physiographic province of New York State. Sawkill Creek is a tributary to Esopus Creek, a subwatershed to the Hudson River. The watershed covers approximately 42 square miles (26,810 acres) and is located in the Towns of Hunter, Woodstock, Saugerties, Ulster and Kingston.

The main stem of Sawkill Creek is approximately 19.5 miles long, and falls approximately 1950 feet through its course. The headwaters originate at Echo Lake on the border of the Towns of Hunter and Woodstock at an elevation of 2,075 feet above mean sea level. The creek joins with two first-order tributaries before reaching an unnamed second-order tributary, combining to form a third-order stream. The stream meanders through the Village of Woodstock before flowing into the Town of Kingston near River Mile 12. Sawkill Creek terminates at Esopus Creek, at a base elevation of 135 feet above mean sea level.

The valley landform ranges from a moderately sloping to gradually sloping convex ridges with dendritic patterned drainages of varied densities and spacing. The valley bottom ranges in width from as little as a few feet in the headwaters to hundreds of feet in the middle and lower portions of the watershed. The morphology of Sawkill Creek and its tributaries varies depending on the watershed area, valley confinement, valley slope, bedrock structural controls, and anthropogenic features such as road encroachments and bridge structures. The predominant stream types along the mainstem include Rosgen Types C and B.

The stream substrate varies throughout the mainstem, changing from larger cobble and boulder in the headwaters to predominantly gravel through the majority of its length. Significant exposures of bedrock are present both in the headwaters and in the lower valley. Glacial till is the most extensive source of parent material in the watershed. Significant amounts of glacial till, outwash, and clay materials are present in varying depths throughout the basin.

2.0 Review of Background Information

The evaluation of the Sawkill Creek began with the review of existing reports and data that were used to refine the inventory and items for assessment. Information cited during the original project scoping was examined as a portion of the evaluation. The data and reporting included:

- 2001 Sawkill Watershed map, produced by the Catskill Center for Conservation and Development.
- 2002 report on the condition of the stream corridor from Echo Lake to Bearsville Flats, Ulster County Soil and Water Conservation District (UCSWCD).
- 2004 survey data of the Woodstock logjam site, UCSWCD.
- 2002 "Report on the Historical Distribution of Fishes in the Sawkill, Ulster County, New York" by Thomas Coote, in conjunction with Robert Schmidt of Simon's Rock College.
- 2000 publication entitled The Catskill Forest: A History, by Michael Kudish, Purple Mountain Press, Ltd.

Most relevant was the report and data compiled by the Ulster County Soil & Water Conservation District (UCSWCD), which inventoried many of the same physical attributes and features included as a part of this evaluation. The UCSWCD conducted their assessment from July 2001 to February 2002 and covered a portion of the Sawkill Creek, between Echo Lake and Yerry Hill Road, in the Town of Woodstock. A total of thirty (30) debris and logjams and sixty-four (64) failing banks were identified, located and described within the report. The majority of the sites identified were located within their two most upstream study areas, Echo Lake and Keefe Hollow.

Ensuing sections in this report describe the upper reaches of the Sawkill Creek as containing extensive streambank erosion, which corresponds to the earlier findings by the UCSWCD. It is recommended that data from the UCSWCD assessment be merged with the GIS developed in this study to provide a complete coverage of the Sawkill Creek. In addition, if further assessment of the headwater area is warranted, areas that overlap between the two inventories should be evaluated for trends in streambank erosion and overall stability.

3.0 Aerial Photography Evaluation

Lateral migration is a natural process where streams continuously adjust their planform, and move across their flood plains. Typically this migration of the stream channel is characterized by erosion at the outer bend of a stream meander, with deposition of sediment on the inside area of the meander (point bar). Bank erosion recruits sediment and wood to the stream, creates and maintains in-stream and floodplain habitats, maintains overall habitat diversity within the stream corridor, and enables the stream to respond to changing conditions within its watershed. If a stream cannot expend its energy by down cutting (degradation), then the energy will be expended through lateral erosion. This process is strongly influenced by geologic controls, loss of riparian vegetation, and anthropogenic (man-made) impacts that can cause accelerated rates of erosion and introduce excess sediment into the system. The introduction of additional sediment from migrating streambanks further contributes to lateral migration

Lateral migration typically becomes a problem when the erosion threatens infrastructure or property. While all natural stream systems experience some degree of lateral migration, under stable conditions the movement of the channel may not even be measurable on an engineering or management time scale.

Problems result when streams which demonstrate stable conditions and migration rates of inches per decade are suddenly destabilized and migration rates accelerate to as much as a few hundred feet in a given storm event. Rapid lateral migration can cause an increase in excess sediment entering the stream system, damaging aquatic health and water quality, as well as an over-widening of the stream channel, loss of riparian vegetation, channel straightening, and change in flow or sediment regime.

Aerial photographs provide an excellent resource to help document and understand watershed, stream, and landscape interaction. Comparisons of historical and recent imagery can be used to investigate the changes (and impacts) relating to land use, vegetation, and general development, as well as to correlate changes in stream channel morphology to disturbances documented in the imagery. They are especially well suited for studying change in stream channel planform, migration, and erosion, because the streambanks are usually reasonably clear. This is true even on single aerial photos or orthophotos.

3.1 Method

In order to understand the current stream conditions while facilitating the interpretation (and appropriate prioritization) of problems identified during the stream corridor inventory, the evaluation of historical trends of change was conducted. An assessment of aerial imagery was initiated for the Sawkill Creek to compare stream channel planform alignment over a series of historical images, to assess changes in alignment and document lateral rates of erosion.

Digital orthographic imagery combines the image characteristics of a photograph with the geometric quality of a map. Unlike a standard aerial photograph, relief displacement in the orthophoto has been removed so that ground features are displayed in their true ground position. Correlating refers to the process of positioning an image to a known coordinate system so that the scale, rotation, and coordinates match a defined set of units with position.

Digital orthographic imagery, acquired in 2004, was used to prepare a recent stream alignment for use in the collection and production of the stream corridor inventory data. In addition to the contemporary aerial photography, two historical aerial photograph series (2001 and 1995) were digitally correlated. The visible channel alignments, evident on each of the imagery series, were digitized and compared to determine the location, frequency and magnitude of historical channel avulsions and migration. This information was correlated to the stream corridor inventory data, collected during subsequent portions of this study.

3.2 Findings

Significant channel migration and avulsion took place in 11 reaches, all of which were measured in the Town of Woodstock. The stream bank erosion inventory data, described later in this report, confirmed that the majority of these areas still contained erosion and exposed banks in 2006, indicating these reaches remain unstable and continue to erode.

River Mile 3-6 in the Town of Woodstock contains the reach commonly known as the “Woodstock Log Jam Site”, which has the highest frequency and greatest magnitude of channel adjustment. This area displays nearly 2,000 feet of abandoned channel and the highest rates of stream bank migration, avulsions, and frequency of debris and obstructions in the entire corridor. The aerial imagery confirmed that the largest channel adjustments in the “log jam” area occurred from channel avulsions, most likely due to the large accumulations of debris and sediment. Although lateral migration and streambank erosion were observable, large stands of mature trees existed between the former and current channel location discounting the possibility of channel migration and streambank erosion solely.

The highest rate of lateral migration and erosion was measured in two locations just upstream from Yerry Hill Road along two concurrent meander bends. The upstream meander bend (Station 203+00) eroded approximately 120ft between 1995 and 2001, and an additional 10ft between 2001 and 2004. The average rate of erosion for this streambank over the period was approximately 14.5ft/year. The adjacent downstream meander bend (Station 212+00) eroded approximately 60ft between 1995 and 2001, and an additional 15ft between 2001 and 2004. The average rate of erosion for this streambank over the period was approximately 8 ft/year. Table 1 displays the location and migration rates at several reaches along the Sawkill Creek.

These areas should be further evaluated for a better understanding of the current stability of these reaches and the potential causes of migration and/or avulsion. An evaluation, pairing stream flow data during the time intervals would assist in determining if large flood events have been responsible for the processes or if the changes occurred as the result of smaller more common events.

Table 1. Rates of streambank erosion measured at several areas along Sawkill Creek.

Town	River Station	River Station	Average Channel Migration in Feet (1995 - 2001)	Average Channel Migration in Feet (2001 - 2004)	Rate of Erosion (ft/year)
Woodstock	124+00	2.35	30	Minimal	3
Woodstock	139+00	2.63	35	Minimal	4
Woodstock	203+00	3.85	120	Minimal	13
Woodstock	212+50	4.03	60	15	8
Woodstock	231+00	4.38	300	10	Avulsion + 3
Woodstock	245+00	4.64	275	30	Avulsion + 10
Woodstock	251+50	4.76	25	5	3
Woodstock	268+00	5.08	50	10	7
Woodstock	292+50	5.54	20	Minimal	2
Woodstock	494+50	9.37	15	Minimal	2
Woodstock	518+00	9.81	50	Minimal	6

4.0 Stream Corridor Inventory

In the initial stages of a watershed assessment and planning effort, it is necessary to gain a basic familiarity with the stream corridor and the surrounding watershed. The stream corridor inventory involves a complete and detailed reconnaissance along the entire stream corridor by the project team. The inventory includes the spatial location and extent of existing stream conditions and sites of environmental degradation that can be used to document the magnitude and extent of channel instabilities, to perform spatial trend analysis, and to formulate general recommendations. Additionally, this assessment sets the foundation for a phased watershed management strategy and provides opportunities for public education and outreach.

The Sawkill Creek was inventoried from Keefe Hollow Road, in the Town of Woodstock, to the confluence of the Sawkill and Esopus Creeks, in the Town of Ulster, using Global Positioning System (GPS) equipment to locate various stream features. The data was integrated into a Geographic Information System (GIS) containing several base mapping layers, including topography, plannimetric, Sawkill Creek watershed boundary, and aerial imagery, and tax parcel information. The GIS serves as the main repository for the collected data and inventory mapping and provides the ability to graphically summarize and interpret findings. A copy of the complete inventory has been submitted with this report in digital format. Extents of the stream corridor inventory by Town, along the Sawkill Creek, is represented in Table 2.

Table 2. Sawkill Creek inventory delineation by Town, River Stationing, and River Mile.

Town	River Stationing	River Miles	Total Miles Inventoried
Woodstock	0+00 – 651+50	0.00 – 12.34	12.34
Kingston	651+50 – 792+62	12.34 – 15.01	2.67
Ulster	792+62 – 834+20	15.01 – 15.80	0.79

4.1 Method

Preparation for the assessment included the development of a “data dictionary” to streamline and direct the GPS data collection procedure. The data dictionary was designed to provide a common list of stream and stream related features. Data included the location of and related information regarding the following stream corridor features:

- Bed Scour and Bank Erosion
- Rip Rap and Revetment
- Bedrock
- Grade Controls
- Bridge and Culvert Crossings
- Debris Blockages
- Level I Stream Classification
- Tributary Confluences
- Potential Reference Reaches
- Clay Exposures
- Notable Channel/Floodplain Conditions

Attribute data was collected relevant to these features and individual observations, and they were further processed and stratified for interpretation. Examples include the length and height of individual features such as: bank failures, bank failure mechanisms, mass wasting, clay exposures, and past stabilization practices. The data dictionary used in this study is included as Appendix A.

Trimble GEOEXPLORER 3c handheld GPS receivers were employed for the inventory. A two-person field team utilized the GPS equipment to locate the positions of each observed feature. The units provided one-meter horizontal accuracy for individual positions. In addition, digital photographs and written field notes were recorded at each feature. The images were collected and indexed in a numbered serial file system and were correlated to the GPS positions. The field notes were taken to provide supplemental information that was not included in the data dictionary, and were also correlated to the GPS features.

The data was processed using the industry standard differential correction procedure to correct the raw GPS field data. The feature positions and attributes were exported to the GIS and edited to reduce any significant error. The data was projected into the New York State Plane coordinate system (NY State Plane, NAD 83, East Zone, Feet) and combined with various base maps and data for further assessment and presentation.

The GIS was used to summarize and evaluate the initial findings of the inventory for this report and can facilitate appropriate management of watershed resources in the future.

4.2 Findings

The spatial location and frequency of sites of environmental degradation have been included in the GIS database. Significant findings are presented and discussed below. The delineation of data by River Stationing and River Mile were used to report findings, perform trend analysis and draw comparisons. For the purposes of this report, this is the length in feet and miles downstream from the assessment starting point. The coverage begins in the Town Woodstock just upstream of the termination of Keefe Hollow Road, enters the Town of Kingston at River Mile 12.3, and then flows into the Town of Ulster at River Mile 15.1 before reaching its confluence with the Esopus Creek at River Mile 15.8.

4.2.1 Streambank Erosion

Streambank instability is characterized by excessively eroding cut banks, which may slough into the active stream channel, exacerbated by sparse riparian vegetation. Stream bank erosion impairs instream habitat through excessive generation and accumulation of sediment in the channel, reduction in habitat complexity, and reduction in cover provided by stream banks and vegetation.

The inventory identified seventy-nine (79) individual sections of streambank erosion. General streambank physical characteristics are summarized in Figures 1 though 3.

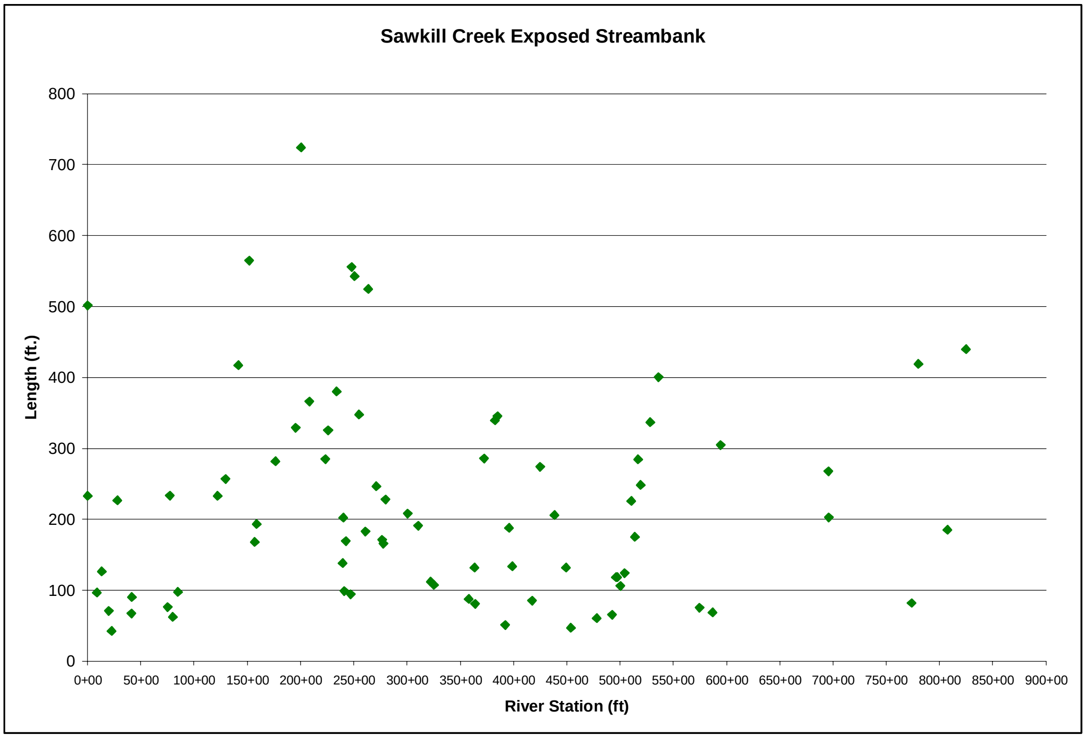


Figure 1. Length of exposed streambank measured along Sawkill Creek.

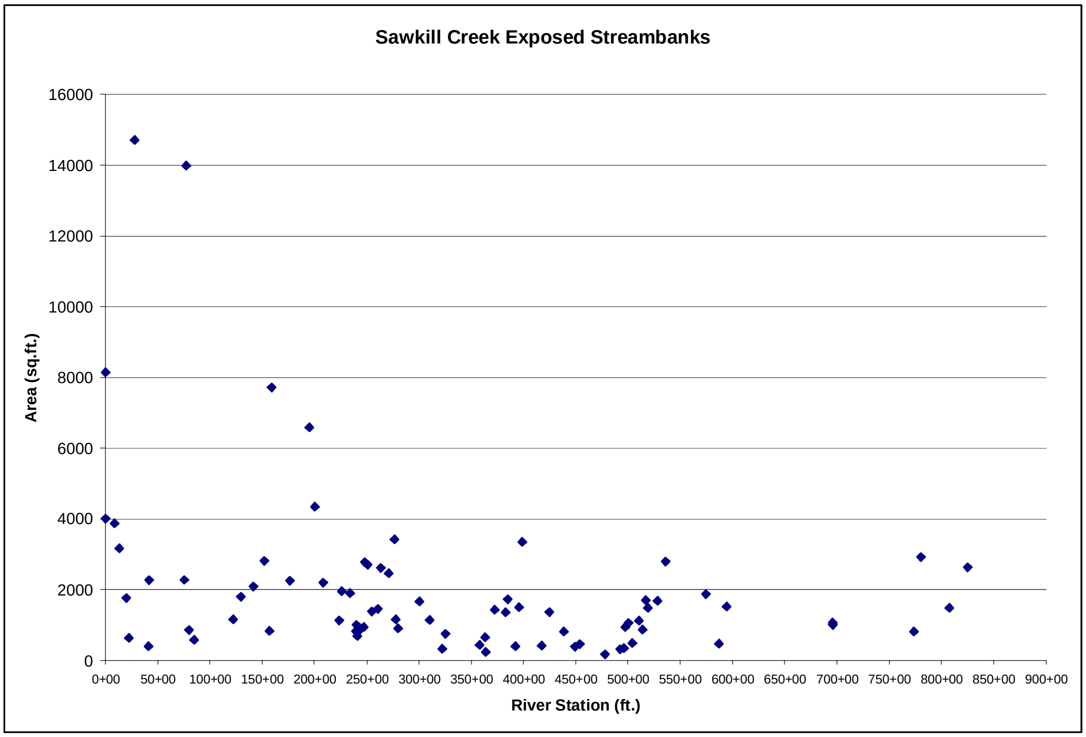


Figure 2. Areas of exposed streambank measured along Sawkill Creek.

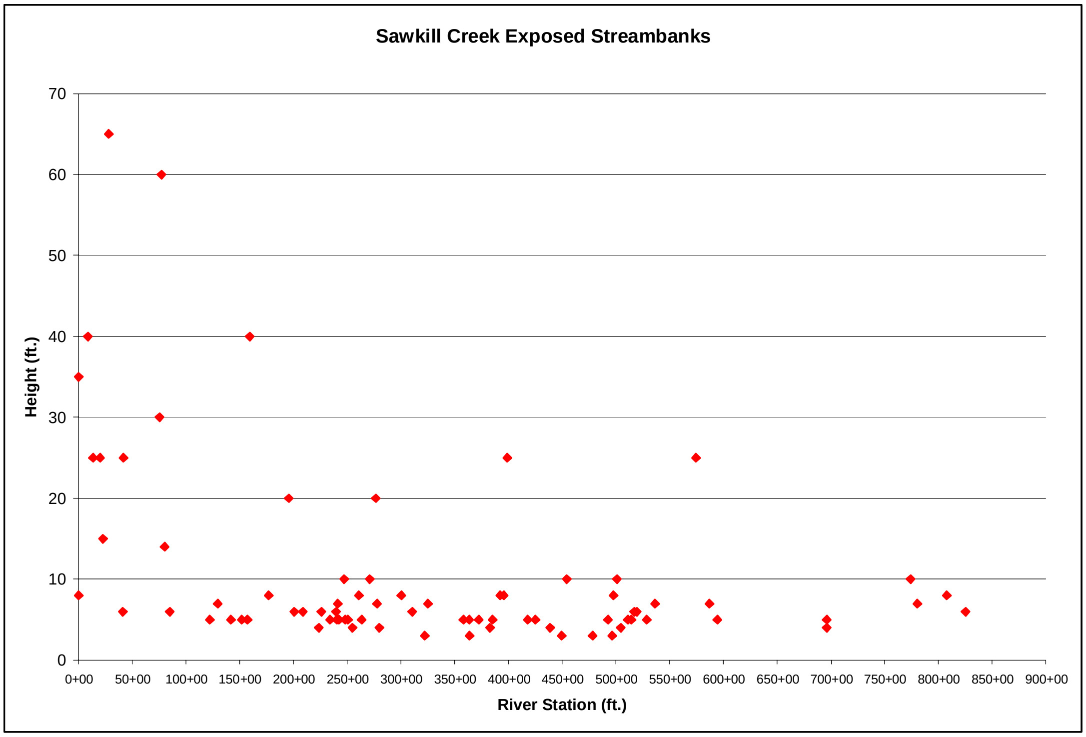


Figure 3. Height of exposed streambanks measured along Sawkill Creek.

The total length of eroded bank was 17,430 feet (3.3 miles) over the 83,420-foot (15.6 mile) long assessment of the Sawkill Creek, representing approximately 20.9% of the total stream channel length or 10.5% of the total streambank length. The average length of eroded stream banks was 220 feet, with an average height of 10.6 feet.

The total exposed area subject to erosion was approximately 162,200 square feet, equal to 3.72 acres of surface area. Table 3 presents a summary of the collected streambank erosion data and includes the location, type of failure, dimensions of streambank, bank soil composition, vegetation type, adjoining land use, and the name of the Town in which the streambank is located.

Bank failure can occur in various modes depending on the bank soil properties and the morphology of the stream. Some bank failure modes include shallow, planar, rotational, and cantilever-type failures. Most commonly, bank failures in local streams result from erosion of soil from the channel toe (undermining) and subsequent slope failure. Data from this inventory reveals the most common modes of failure were cantilever and planar-type (Table 3).

Table 3. Streambank erosion data along the Sawkill Creek.

Station	Failure Type	Height	Length	Area	Slope	Bank Material	Vegetation	Town
0+00	Planar	8	501	4010	Vertical	Cobbles	Coniferous	Woodstock
0+00	Planar	35	233	8144	1:1	Gravel	Barren Soil	Woodstock
8+59	Planar	40	97	3878	1:2	Gravel	Barren Soil	Woodstock
13+31	Planar	25	127	3168	1:1	Gravel	Barren Soil	Woodstock
19+97	Planar	25	71	1768	1:1	Gravel	Barren Soil	Woodstock
22+53	Planar	15	42	637	Vertical	Gravel	Coniferous	Woodstock
28+00	Planar	65	226	14713	Vertical	Sand	Barren Soil	Woodstock
41+15	Planar	6	67	403	Vertical	Gravel	Barren Soil	Woodstock
41+63	Planar	25	91	2269	1:2	Gravel	Coniferous	Woodstock
75+29	*******	30	76	2281	1:2	Clay & Silt	Shrubs	Woodstock
77+29	Cantilever	60	233	13991	1:1	Gravel	Barren Soil	Woodstock
80+08	Cantilever	14	62	867	1:2	Clay & Silt	Barren Soil	Woodstock
84+93	Cantilever	6	98	588	1:1	Gravel	**********	Woodstock
122+16	Planar	5	233	1164	2:1	Cobbles	Barren Soil	Woodstock
129+62	Cantilever	7	257	1799	1:1	Cobbles	Barren Soil	Woodstock
141+72	Cantilever	5	417	2086	1:1	Gravel	Barren Soil	Woodstock
151+91	Cantilever	5	565	2823	1:2	Gravel	Deciduous	Woodstock
157+09	Cantilever	5	168	841	1:1	Gravel	Deciduous	Woodstock
158+94	Planar	40	193	7724	1:2	Clay & Silt	Barren Soil	Woodstock
176+68	Planar	8	282	2253	Vertical	**********	**********	Woodstock
195+41	******	20	329	6584	2:1	Cobbles	Barren Soil	Woodstock
200+61	Cantilever	6	724	4346	1:1	Clay & Silt	Deciduous	Woodstock
208+41	******	6	366	2198	1:2	Cobbles	Barren Soil	Woodstock
223+35	******	4	285	1139	1:1	Gravel	Barren Soil	Woodstock
225+86	Cantilever	6	326	1955	1:1	Clay & Silt	Barren Soil	Woodstock
233+83	******	5	380	1901	Vertical	Sand	Barren Soil	Woodstock
239+51	******	6	139	831	Vertical	Sand	Barren Soil	Woodstock
240+13	Cantilever	5	202	1011	1:1	Gravel	Deciduous	Woodstock
241+01	******	7	99	692	Vertical	Gravel	Barren Soil	Woodstock
242+33	Cantilever	5	169	846	1:1	Sand	Sedge, Grass	Woodstock
247+01	Cantilever	10	95	946	1:1	Clay & Silt	Barren Soil	Woodstock
247+88	*******	5	556	2779	Vertical	Gravel	Deciduous	Woodstock
250+61	Cantilever	5	543	2713	1:1	Gravel	Barren Soil	Woodstock
254+79	******	4	348	1391	Vertical	Sand	Deciduous	Woodstock
260+71	Cantilever	8	183	1462	1:2	Clay & Silt	Sedge, Grass	Woodstock
263+43	Cantilever	5	525	2624	1:2	Gravel	Deciduous	Woodstock
270+94	Planar	10	246	2465	1:1	Clay & Silt	Barren Soil	Woodstock
276+44	Planar	20	171	3421	1:1	Clay & Silt	Deciduous	Woodstock
277+79	*******	7	166	1159	Vertical	Clay & Silt	Barren Soil	Woodstock
279+72	*******	4	228	912	1:1	Gravel	Barren Soil	Woodstock
300+44	Cantilever	8	208	1664	1:1	Gravel	Deciduous	Woodstock
310+32	Cantilever	6	191	1146	1:1	Gravel	Deciduous	Woodstock
322+11	*******	3	112	336	***	**********	**********	Woodstock
325+13	Cantilever	7	108	753	1:1	Gravel	Sedge, Grass	Woodstock
358+06	Other	5	88	439	1:1	Gravel	Deciduous	Woodstock
363+37	Other	5	132	660	Vertical	Gravel	Deciduous	Woodstock

363+87	Other	3	80	241	1:1	Gravel	Deciduous	Woodstock
372+50	Other	5	286	1428	Vertical	Sand	Coniferous	Woodstock
382+73	Other	4	339	1358	1:1	Clay & Silt	Coniferous	Woodstock
385+13	Planar	5	346	1728	1:1	Sand	Coniferous	Woodstock
392+38	Planar	8	51	409	1:1	Sand	Coniferous	Woodstock
395+75	Planar	8	188	1503	1:1	Gravel	Coniferous	Woodstock
398+81	Planar	25	134	3349	1:2	Clay & Silt	Coniferous	Woodstock
417+54	Other	5	85	426	Vertical	Gravel	Coniferous	Woodstock
424+89	Other	5	274	1368	1:1	Gravel	Deciduous	Woodstock
438+65	Other	4	206	823	1:2	Gravel	Deciduous	Woodstock
449+37	Cantilever	3	132	397	1:1	Gravel	Deciduous	Woodstock
453+91	Cantilever	10	47	469	1:1	Gravel	Deciduous	Woodstock
478+26	Other	3	61	182	1:1	Gravel	Deciduous	Woodstock
492+59	Other	5	65	326	1:1	Gravel	Deciduous	Woodstock
496+21	Other	3	119	356	1:1	Gravel	Deciduous	Woodstock
497+38	Other	8	119	948	1:1	Gravel	Deciduous	Woodstock
500+67	Other	10	106	1062	1:1	Clay & Silt	Deciduous	Woodstock
504+32	Other	4	124	497	1:2	Gravel	Deciduous	Woodstock
510+81	Other	5	226	1129	1:2	Clay & Silt	Deciduous	Woodstock
514+20	Cantilever	5	175	877	1:2	Gravel	Barren Soil	Woodstock
517+02	Planar	6	284	1705	1:1	Clay & Silt	Deciduous	Woodstock
519+37	Other	6	248	1490	1:2	Sand	Deciduous	Woodstock
528+60	Cantilever	5	337	1684	1:1	Sand	Shrubs	Woodstock
536+20	Cantilever	7	400	2803	1:1	Clay & Silt	Deciduous	Woodstock
574+39	Planar	25	75	1878	1:1	Sand	Barren Soil	Woodstock
586+89	Other	7	68	478	1:1	*********	Barren Soil	Woodstock
594+43	Other	5	305	1524	1:1	Clay & Silt	Deciduous	Woodstock
695+87	Planar	4	268	1071	1:1	Cobbles	Deciduous	Kingston
696+03	Cantilever	5	203	1013	1:1	Cobbles	Coniferous	Kingston
773+84	Other	10	82	819	1:2	Clay & Silt	Deciduous	Kingston
780+39	Other	7	419	2932	1:2	**********	Coniferous	Kingston
807+72	Other	8	185	1482	1:1	Clay & Silt	Deciduous	Ulster
825+12	Other	6	440	2638	1:1	Clay & Silt	Deciduous	Ulster

Frequency analysis of the erosion data shows a high density of erosion in the area between Stations 200+00 and 280+00 in River Mile 3-6. Eroded stream banks in the upper portion of the watershed were generally greater in height and with overall greater areas of soil exposure, potentially due to the confinement of the valley in the headwaters. Typically, this valley morphology generates the potential for large streambank failures through relatively small adjustments in stream channel alignment.

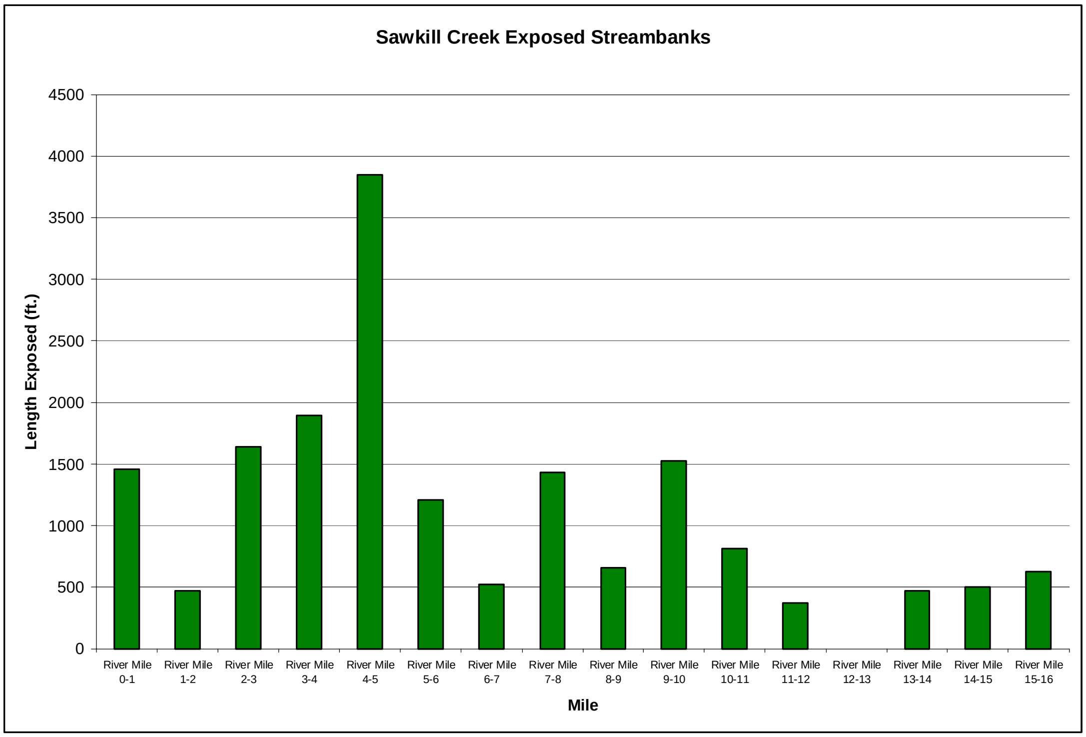


Figure 4. Length of exposed streambank on the Sawkill Creek expressed by River Mile.

Streambank erosion data was further delineated by river mile, as displayed in Figures 4 and 5. The largest total length of eroded bank occurs in River Mile 4-5, while the largest exposed bank area is located in River Mile 0-1.

In order to initially prioritize reaches for future management and planning, stream reaches were sorted by total exposed area and total length, Table 2. River Mile 4-5 is ranked highest of the reaches with the longest length of eroded streambank, and third in eroded bank area. In theory, effective streambank stabilization and/or restoration within River Mile 4-5 could reduce the eroded length of streambank over the entire corridor by nearly 22% and reduce the exposed area of streambank by 13%.

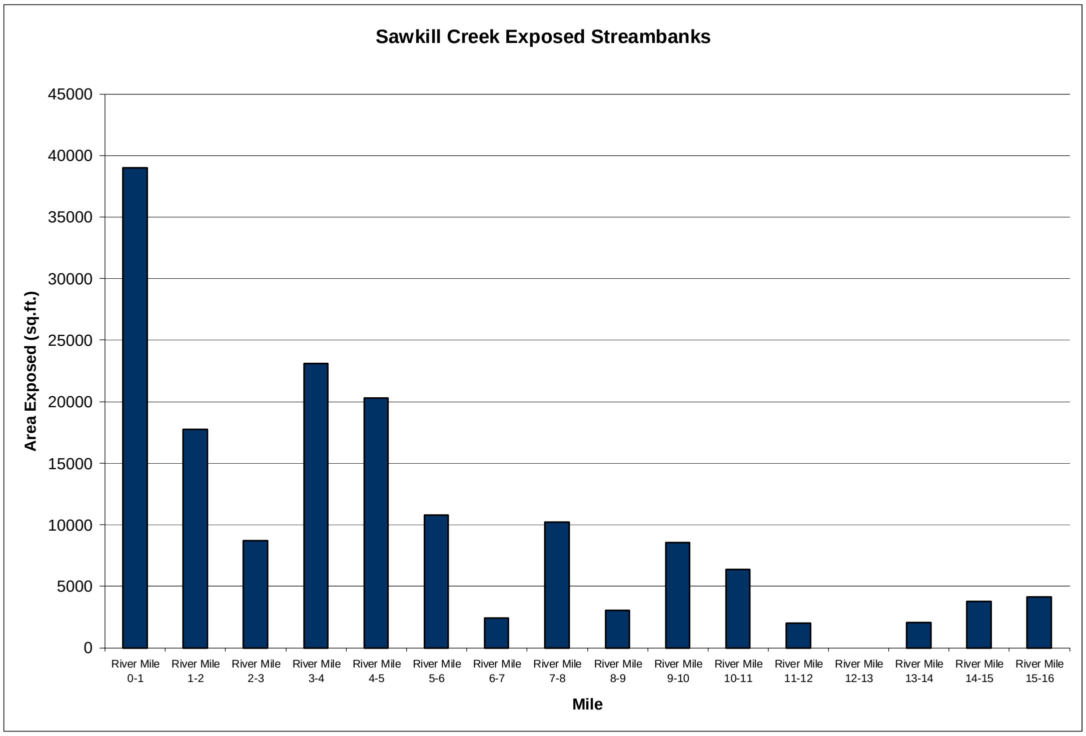


Figure 5. Area of exposed streambank on the Sawkill Creek expressed by River Mile.

Similarly, adjoining River Mile 3-4 ranked second in both eroded area and length. Nearly 1/3 of the inventoried eroded streambanks by length are located within this two-mile stretch.

Table 4. percentages of streambank erosion per river mile along the Sawkill Creek.

Sort By Area			
Rank	**Mile ID**	**Area (sq.ft.)**	**Percentage**
1	River Mile 0-1	38,989	24%
2	River Mile 3-4	23,105	14%
3	River Mile 4-5	20,291	13%
4	River Mile 1-2	17,727	11%
5	River Mile 5-6	10,767	7%
6	River Mile 7-8	10,201	6%
7	River Mile 2-3	8,712	5%
8	River Mile 9-10	8,572	5%
9	River Mile 10-11	6,365	4%
10	River Mile 15-16	4,120	3%
11	River Mile 14-15	3,751	2%
12	River Mile 8-9	3,057	2%
13	River Mile 6-7	2,429	1%
14	River Mile 13-14	2,084	1%
15	River Mile 11-12	2,003	1%
16	River Mile 12-13	0	0%

Sort By Length			
Rank	**Mile ID**	**Length (ft.)**	**Percentage**
1	River Mile 4-5	3,848	22%
2	River Mile 3-4	1,895	11%
3	River Mile 2-3	1,640	9%
4	River Mile 9-10	1,527	9%
5	River Mile 0-1	1,455	8%
6	River Mile 7-8	1,429	8%
7	River Mile 5-6	1,210	7%
8	River Mile 10-11	812	5%
9	River Mile 8-9	659	4%
10	River Mile 15-16	625	4%
11	River Mile 6-7	520	3%
12	River Mile 14-15	501	3%
13	River Mile 13-14	470	3%
14	River Mile 1-2	469	3%
15	River Mile 11-12	373	2%
16	River Mile 12-13	0	0%

Similar regional inventories performed in the Batavia Kill, a sub basin of the Schoharie Creek watershed, and the Stony Clove, a sub basin of the Esopus Creek watershed, produced comparative percentages. NYCDEP considers these watersheds to be priority basins for developing stream management plans, not only for their demonstration of the negative impacts associated with channel instability and excessive streambank erosion, and streambed incision in a setting that is mountainous, but also because they have densely settled stream corridors (GCSWCD, 2003). According to Amy DeGaetano, Stream Project Coordinator for Greene County Soil and Water Conservation District (GCSWCD), the percentage of streambank erosion in the Stony Clove measured 6% by total streambank length in 2001 (personal communication, October 26, 2006). The Batavia Kill measured 11.8% in 1997, and 7.6% in 2003 (GCSWCD, 2003). The reduction in the Batavia Kill was due in part to substantial stream restoration efforts since 1999.

4.2.2 Sedimentation

Bank instability and erosion frequently result in excessive sediment inputs into stream channels. These sediments can consist of finer clay, silt, and sands, to larger size gravel, cobble, and boulders. Fine sediment increases the turbidity of a stream and may adversely affect aquatic life and fisheries through sediment deposition in pools, spawning gravels, and stream-bottom habitat for aquatic invertebrates, and by restriction of light penetration necessary for photosynthesis by aquatic plants (Skinner, 1983). Excessive larger-sized sediment inputs may also alter the stream channel morphology and change the composition of aquatic habitats and associated fish and macro invertebrate communities. Stream channel aggradation is the progressive buildup or rising of the channel bed and floodplain due to sediment deposition. Aggradation indicates that stream discharge and/or bed-load characteristics are changing within a reach. Furthermore, sedimentation may encourage change in the plan and profile of the stream channel, potentially causing damage to property through lateral migration of meander bends and excessive cutting of the stream bottom.

Potential sources of sediment include erosion of poorly vegetated and/or disturbed areas such as stream banks or beds, or impacted tributaries. Other sources may be runoff from poorly vegetated upslope areas affected by natural disturbance, such as landslide, or by human disturbance such as an increase in impervious surface poorly located or constructed roads, poorly managed timber harvests, construction or poorly implemented agricultural practices.

Signs of sedimentation were observed in nineteen (19) reaches of the Sawkill, typically in the form of sediment deposition or an aggrading channel bed. Figure 6 shows the instances of aggradation stratified by River Mile. The greatest number of observations was recorded in River Mile 9-10. River Mile 9-10 also contains excessive streambank erosion in the lower portion of the reach near John Joy Road Bridge. This area is discussed in detail in the Site Recommendations section of this report.

In stream systems with excessive erosion and sedimentation, reduction of sediment can only be effectively accomplished by addressing the sources of sediment. This is typically accomplished by promoting the reestablishment of vegetation on the eroding surfaces, changing land use practices, bank stabilization, seeding, planting, or a combination of these. Public acceptance and application of a set of agreed-upon best management practices may greatly encourage natural stream recovery over the long term on moderately disturbed sites, while more intensive stabilization/restoration may be necessary for more severely disturbed areas.

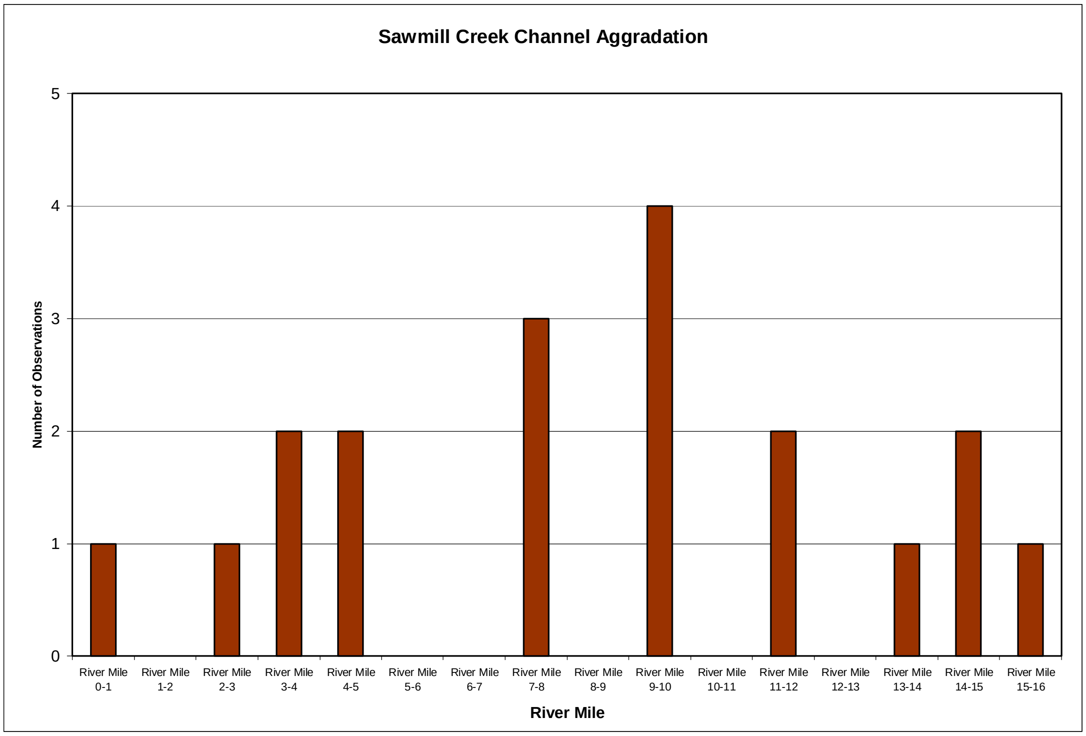


Figure 6. Instances of channel aggradation displayed by River Mile.

4.2.3 Channel Avulsions

Channel avulsion is a sudden shift in channel location. Avulsions are formed during large storm events when high discharge erodes a new channel in the floodplain. Avulsions are more common in braided or aggrading stream channels, but can also occur in areas with a steeper floodplain. Five instances of recent channel avulsions were observed, two in the upper watershed in River Mile 1-2, two in River Mile 4-5, and the other in River Mile 11-12.

4.2.4 Channel Headcutting

Incised stream systems are characterized by a lowering of the streambed elevation and the stream's abandonment of its floodplain. These stream systems typically exhibit high streambanks and streambank height ratios greater than 1, commonly bounded by terraces that are no longer active at the bankfull stage.

Channel incisement is caused by many factors. These include: channelization, straightening, encroachment, confinement (lateral containment), urban development, change in flow or sediment regime, and riparian vegetation and buffer conversion. Problems associated with incision include: accelerated bank erosion, land loss, lowering of water tables, land productivity reduction, and accelerated downstream sedimentation. Incised conditions can cause a loss of stream access to the flood plain, losing the benefits from overbank flows.

Headcutting involves the initiation of channel incision at a "nick point" as the stream channel bed elevation adjusts to a natural or human-induced disturbance. This can be as subtle as an over-steepened riffle zone or as obvious as a cascade or "waterfall" . As the streambed erodes and lowers at the nick point, the active headcut will migrate upstream. Headcutting may eventually cause channel incision.

Controlling a headcut is one of the most difficult challenges in stream restoration. Common headcut treatments typically include applying less erodible material to the channel bottom, to temporarily slow the progression, or installing structural grade control. Other methods for headcut control include elevating the stream channel by filling what was previously incised, or realigning the stream channel to increase meander and reduce the local channel slope.

Along the length of the Sawkill two headcuts were observed. They are located within adjacent River Miles 1-2 and 2-3 in the upper sections of the assessment. Large sections of the Sawkill Creek contain bedrock along the channel bottom that provides natural grade control, effectively preventing large-scale channel incision. More than 50 observations of bedrock channel bottom were recorded, totaling more than 2.2 miles along the Sawkill Creek. Additionally, 4 manmade dams were located within the corridor, adding to the stability of the channel bottom.

4.2.5 Berms, Levees and Dikes

Periodic flooding of rivers and streams and the associated inundation of the floodplain is a natural process. This process is important in sustaining the riparian community, and moderating surface and groundwater flow regimes by storing water in soils, stream banks and subsurface aquifers. This storage has the potential to extend late-season flow and benefit fish population survival.

Construction of berms, levees or dikes has been a common practice for flood control. This practice leads to confinement of the channel, increased stream velocities during high-flow events, a cessation of the natural flooding process, and possibly increased flooding in upstream and downstream areas. Without flooding, riparian communities can convert from water-loving species to more drought-tolerant species, and stream bank and aquifer storage of water necessary to sustain late-season flow may be lost.

Although specific locations prone to flooding and flood damage were not identified as part of this inventory, the location and length of berms was recorded. There were 24 observations of floodplain berming, totaling 8,320 feet in length (Figure 7). Extensive floodplain berming was inventoried in the heavily populated areas of Woodstock, identified as River Mile 3-6. Again, this segment contains the highest percentages of eroded streambank.

The majority of the berms appeared to be constructed from gravel and cobble sediment, presumably side cast material resulting from past channel excavation. The berming observed most likely provides some limited protection from flooding during low to moderate flood events, but since the general construction was formed of stream channel sediment it is likely that it can be easily eroded during large flow events.

Most of the berms inventoried were discontinuous in length and varied in overall height. Variations in the elevations along the majority of the berms inventoried may allow floodwater to easily breech certain areas. Discontinuity may create abnormal divergence and convergence of floodwater and result in unpredictable floodplain deposition and scour. Additionally, the discontinuity may allow floodwater to flow behind the berms and prevent floodwater and ancillary drainage from flowing back into the stream channel.

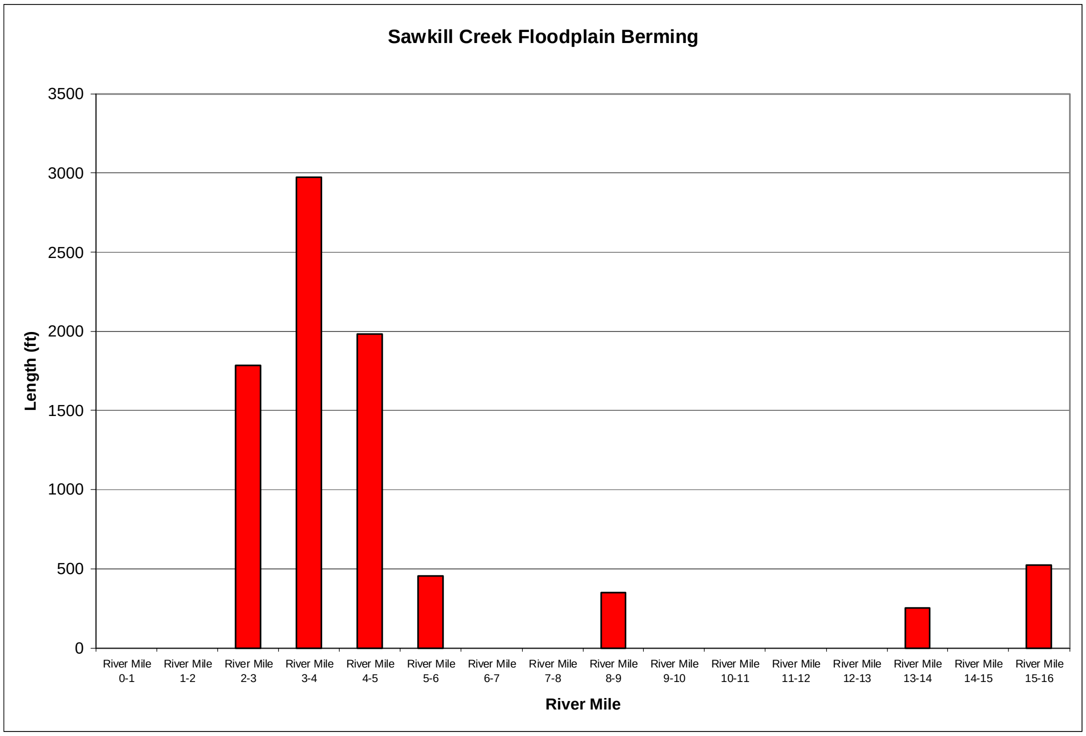


Figure 7. Length of berms measured along the Sawkill Creek per River Mile.

Berms also have the potential to increase channel velocity and result in erosion, both through the bermed area and in downstream reaches. Furthermore, confinement of floodwater can create increased water surface elevations in upstream areas resulting in increased flooding.

4.2.6 Bridge & Culvert Crossings

Materials that were used in many older bridge structures were incapable of spanning long distances and bridges were generally constructed wherever convenient or physically possible. Although contemporary bridges are constructed from much stronger materials and able to span much longer distances, local economics often limits the ability to span entire stream and floodplain areas. In many cases this leads to a restriction of floodwater (due to the hydraulics of the bridge) and can create a backwater effect on the upstream side, with symptoms such as increased sediment deposits, and increased stream velocity on the downstream side, with symptoms such as increased erosion.

There were 18 bridge and culvert crossings located along the Sawkill, ranging from small footbridges to the large New York State Thruway Bridge at the confluence of the Sawkill and Esopus Creeks. Attributes within bridge and culvert locations include the designation of state, county and private authority, bridge identification number, and the transitioning highway name. A single bridge located at John Jay Road exhibited evidence of channel instability, streambank erosion and sedimentation potentially caused by the modification of flow by the bridge. This area is discussed in detail in the Site Recommendations section of this report.

4.2.7 Channel Obstructions

Historically, substantial effort has been made to remove woody obstructions from stream channels and floodplains; however it has been found that woody debris can assist in channel stability, varying in quantity and general reliance by stream type. In certain stream types debris jams and blockages can be beneficial (incised streams), and in others can lead to increased food water surface elevations, channel erosion, and excessive sediment deposition.

The inventory documented the number, type, and extents of the debris and obstructions. The data revealed information on current channel stability and the potential impacts from the obstructions for future channel stability and risk to infrastructure.

The inventories of the Sawkill identified thirty-five (35) debris jams, consisting of downed trees and plant materials, some including items such as tires and stone. Figure 8 displays the number of occurrences of debris within the delineated River Miles.

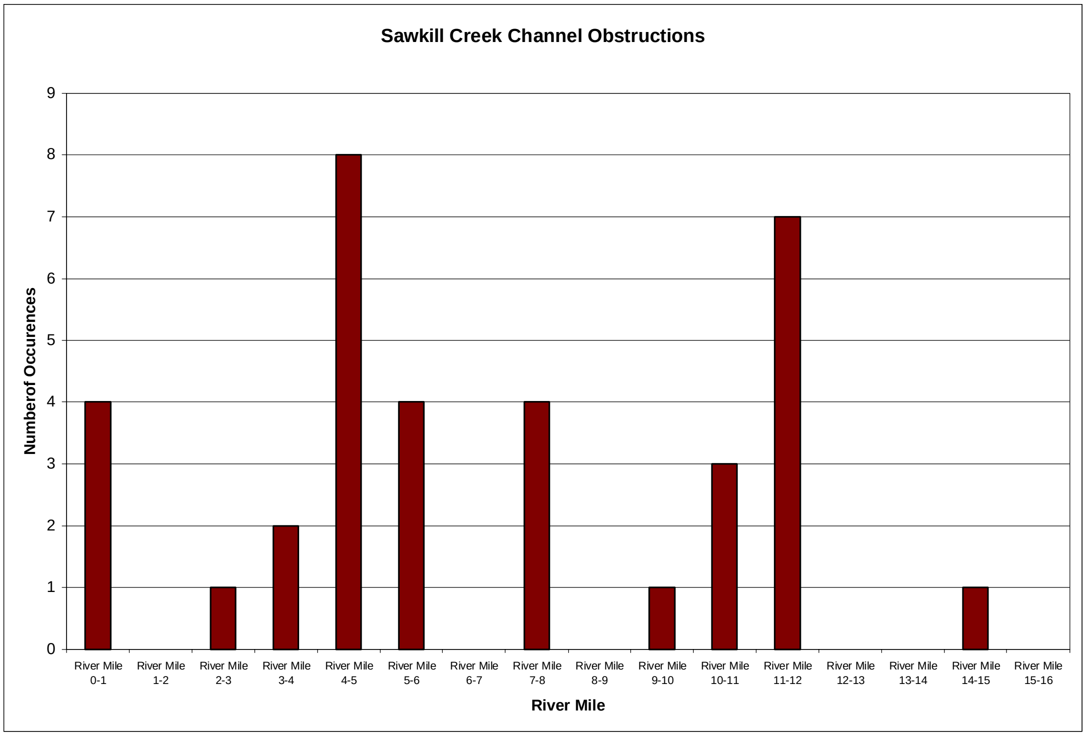


Figure 8. Instances of debris accumulation and channel obstructions inventoried along Sawkill Creek.

The largest and most extensive quantity of material was located in River Mile 4-5. This reach also had the greatest length in streambank erosion. The position of the reach within the valley and the existing channel morphology naturally promotes deposition of materials. A dramatic decrease in stream and valley slope was observed through the area in relation to upstream adjoining reaches. These result in a reduction in velocity and stream power and a subsequent reduction in the ability to transport both sediment and debris.

4.2.8 Tributary Confluences

Multiple stream confluences with the Sawkill were observed. These tributaries provide increased connectivity of the Sawkill to the upper reaches of the watershed and may also provide valuable habitat for numerous fish and invertebrate species. Tributaries inventoried included perennial watercourses that were actively flowing at the time of the assessment and in general originated from perceivable natural sources. Over the total length of the Sawkill Sixty-two (62) confluences were observed, ranging from small drainageways to moderately sized streams. The reach containing the highest number of tributaries was River Mile 13-14, with 10 confluences.

4.2.9 Dumped Waste

Trash, garbage and solid waste introduced by humans may adversely affect water quality and wildlife habitat, and negatively impact the aesthetic character of the stream corridor.

Dumped waste of appreciable quantity was observed and recorded at three locations, including yard debris, general trash, and rubbish. Materials were located at River Station 65+90, 731+70 and 736+50.

4.2.10 Grade Control Features

A common practice for controlling erosion of stream bottoms is the installation of grade control check dams constructed of concrete, steel sheet piling, gabion baskets or other materials. Check dams are frequently used to address stream channel incision, to raise base stream flow elevation for easier water withdrawal, or to reduce stream slope by creating a barrier across the stream channel. Typically, grade control structures result in aggradation above the structure that flattens the stream slope. The aggraded section of stream pushes erosive forces against the streambanks, and often the stream will migrate around the structure, requiring bank armoring to prevent loss of the check dam. These structures also impede migration by fish and biotic life to upstream reaches during varying flow events. Naturally, bedrock and large boulders provide this control, as well as constructed dams, migration barriers, and specific grade control structures.

Large sections of the Sawkill Creek contain bedrock along the channel bottom that provides natural grade control effectively preventing large-scale channel incision. More than 50 observations of bedrock channel bottom were recorded, totaling more than 2.2 miles along the Sawkill Creek. Additionally, 4 manmade dams were located within the corridor, adding to the stability of the channel bottom.

4.2.11 Existing Streambank Revetment

Streambank management activities which provide structural protection or revetment of stream banks using riprap, gabion baskets, concrete or steel walls, can have significant destabilizing affect on stream form. Traditional approaches to streambank protection typically do not address the source or cause of the instability eroding the streambanks, and often redirect these problems either upstream or down stream from the original problem. While riprap may provide immediate benefit to an actively eroding streambank, if the erosion was occurring as a result of an evolution in the streams morphological form, the bank hardening will simply relocate the impact of the erosive forces further downstream. Additionally, traditional streambank protection methods can also increase stream velocity by reducing stream channel roughness and these projects are typically neither conducive to fisheries habitat nor aesthetically pleasing.

Several types of streambank protection measures have been employed throughout the Sawkill. These include riprap, retaining walls and log cribbing. Figure 9 displays the length of streambank revetment by River Mile.

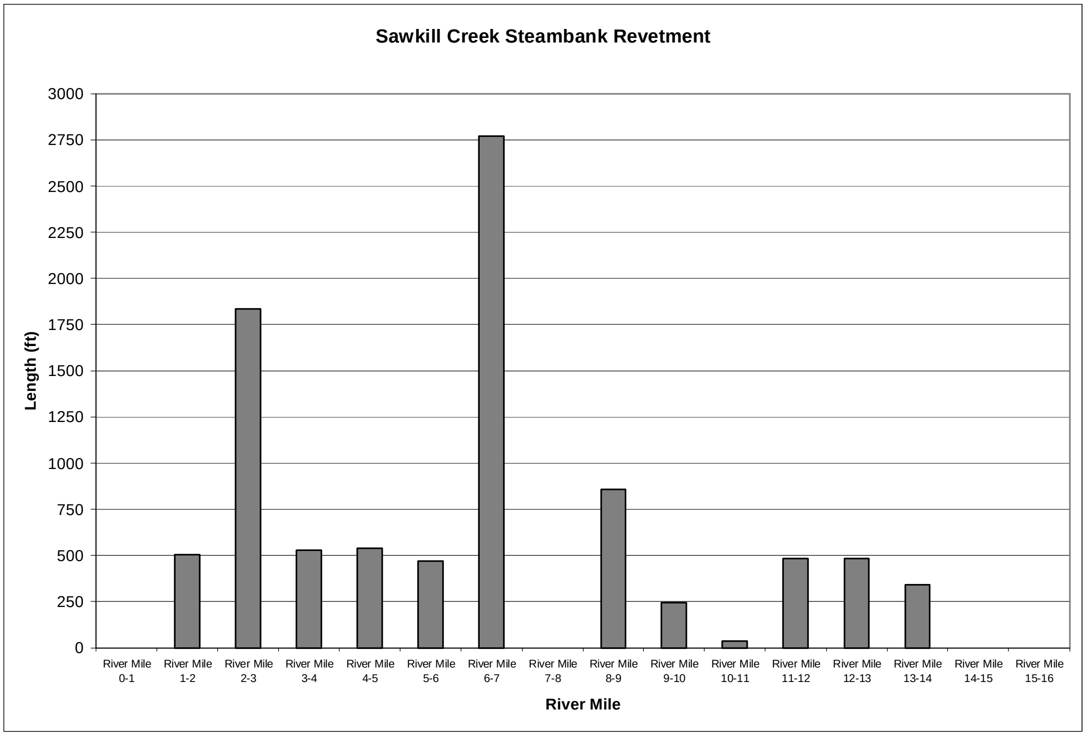


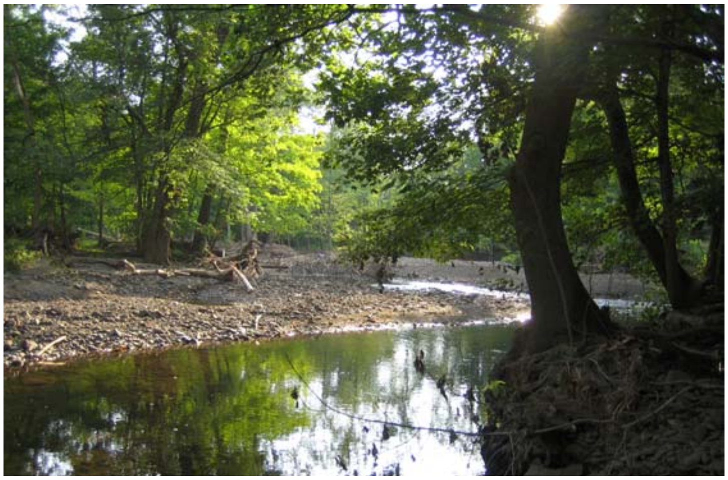
Figure 9. Streambank revetment inventoried along the Sawkill Creek by River Mile.

4.2.12 Stormwater Outfalls

During the inventory, stormwater outfalls from culverts were located within the immediate stream corridor. Additional attribute data collected at each outfall included the size and type of pipe as well as photo documentation.

A total of 39 outfalls were located, consisting primarily of direct outlets from roadway drainage.

5.0 Rosgen Level I Stream Type Classification



The Rosgen classification system uses several delineative criteria to sort streams into distinct classes. The system has four levels of classification, each requiring different data and building on preceding classification and assessment. Progressing through these classes provides stream managers enhanced interpretation of the character of the area of interest.

The Rosgen classification scheme is a hierarchical assessment of the basin and stream channel morphology, which can be used to:

- Predict a river's behavior from its appearance;
- Develop specific hydraulic and sediment relationships for a given stream type and its state;
- Provide a mechanism to extrapolate site-specific data to stream reaches having similar characteristics; and
- Provide a consistent frame of reference for communicating stream morphology and condition among a variety of disciplines and interested parties (Rosgen, 1996).

The classification performed in this study was conducted at the broadest scale, primarily using maps and aerial photographs (Level I classification). At this scale, stream classification involves an examination of the stream channel form to determine whether it is a single or multiple-thread channel. Further classification is made based on four primary delineative criteria that include the stream reach's entrenchment ratio, width/depth ratio, sinuosity and slope. There are eight stream types identified in the Level I classification scheme: Aa, A, B, C, D, E, F, and G. (Rosgen, 1996)

Within the Level II classification, refinement is performed based on field measurements of the morphological form and bed particle. Two additional levels of assessment supplement Rosgen's classification system. Rosgen's Level III protocols are used to determine a stream reach's condition, or level of departure from the stable form, while Level IV methods aim to verify a stream's current state and assess potential for change in stability of form.

Level I classification provides an initial sorting of stream types within a study area and is based primarily upon remotely sensed data. In this assessment, the results of a Level I classification were subsequently verified by on-site reconnaissance during the stream corridor walkover. The Level I classification may be thought of as a preliminary application which, in addition to providing the foundation for subsequent levels of evaluation, also prepares and familiarizes the investigator with the landforms and stream types to be encountered.

5.1 Method

Aerial photography and topographic data were utilized to perform a Level I stream typing of the basin. USGS topographic mapping was used to sample slope and valley morphology. Aerial imagery aided in determining channel sinuosity for use within Rosgen Level I classification keys. The Level I classification was refined in the field during the GPS field reconnaissance.

5.2 Findings

Sinuosity of the Sawkill Creek reflects the general slope of the valley, valley constraints and anthropogenic impact. The current stream alignment contains three generic plan-form morphologies; relatively straight, and meandering with moderate sinuosity and low sinuosity.

Remote sensing and field reconnaissance revealed 52 changes in stream type within the inventoried stream reach, which spanned 5 major categories. The spatial extents of the stream types have been provided within the GIS database.

Rosgen Level I stream types along the Sawkill were consistent with the landform and slope ranges inventoried. Five stream types were inventoried, including B, C, D, F and G. Figure 10 displays the distribution of stream types.

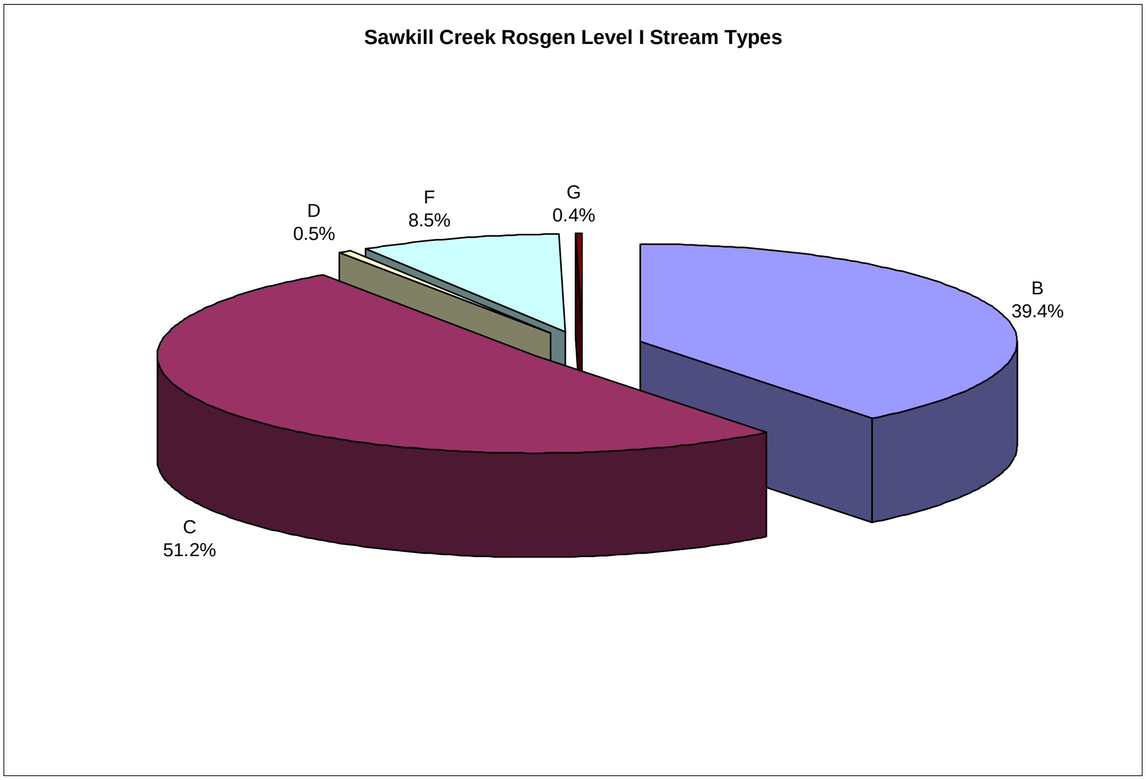


Figure 10. Rosgen Level I Stream Type Distribution for the Sawkill Creek.

5.2.1 The "B" Stream Type:

The "B" stream type exists predominantly in moderate relief landforms with narrow, gently sloping valleys. "B" stream types are moderately entrenched, display a low channel sinuosity and exhibit bed morphology dominated by rapids with infrequently spaced pools. Typically the dominant channel slope range is 2 - 4% (Rosgen, 1996). The "B" stream types are typically located in narrow valleys that limit the development of a wide floodplain. Streambank erosion rates are typically low in the “B” stream type as are rates of aggradation and degradation.

Approximately 7.1 miles of Sawkill Creek contain “B” type channels, this equates to 39.4% of the total length. This stream type was identified in 21 distinct reaches.

5.2.2 The “C” Stream Type

The “C” stream types are generally located in broad valleys with floodplain terraces constructed from alluvial deposition. Their channels have a well-developed floodplain, are slightly entrenched, are relatively sinuous with a channel slope of 2% or less, and possess bed morphology indicative of a riffle/pool configuration (Rosgen, 1996). The “C” stream type is a sinuous low relief channel containing characteristic point bars within the active channel. The overall stability of “C” type channels relies heavily on the density and vigor of riparian vegetation and the stability of neighboring reaches. General riparian management and storm water controls are necessary for stability of sediment and stream flow regimes.

“C” type channels occur in 21 different reaches making up the majority of Sawkill Creek. Nearly 51% of the stream, measuring approximately 9.9 miles, can be characterized as a “C” type stream channel.

5.2.3 The “D” Stream Type

“D” stream type is uniquely configured as a multiple channel system exhibiting a braided, or bar-braided pattern with high with/depth ratio, and a channel slope generally the same as the attendant valley sloped stream types are found in landforms and related valley types consisting of steep depositional fans, steep glacial trough valleys, glacial outwash valleys, broad alluvial mountain valleys, and deltas. Bank erosion rates are characteristically high, sediment supply is high, and aggradation and lateral extension are dominant channel adjustment processes. (Rosgen, 1996)

A single “D” reach locate at Station 39+46 in Woodstock, characterized by three distinct channels, was inventoried measuring 465 feet.

5.2.4 The “F” Stream Type:

The “F” stream types are the classic entrenched and meandering channels that are evolving toward reestablishment of a functional floodplain inside the confines of the existing channel. These stream types are incised in gentle gradient valleys containing highly weathered rock and/or erodible materials and are generally laterally unstable. “F” channels typically contain riffle/pool sequence channels with a high width to depth ratio (Rosgen 1996).

The Sawkill Creek contains approximately 8,060 feet of “F” type channel that comprises 8.5% of the streams total length and consisted of relatively short isolated reaches throughout the stream length.

5.2.5 The “G” Stream Type:

The “G” stream type, or gully, is an entrenched, narrow, and deep, step/pool channel with a low to moderate sinuosity. Channel slopes are generally steep, although “G” channels may be associated with gentler slopes where they occur as down-cut gullies in meadows. Although these stream types can occur in a variety of land types to include alluvial fans, debris cones, meadows, or channels within older relic channels, typical landforms include narrow valleys or deeply incised alluvial or colluvial materials. “G” stream types are generally unstable, with grade control problems and high bank erosion rates (Rosgen 1996).

A single “G” type stream reach was inventoried measuring 330 feet, located at Station 716+30 in the Town of Kingston. This reach was fairly narrow, deep, and was bounded on both sides by steep bedrock banks. The bedrock channel makes this reach extremely stable and resistant to streambank and bed erosion.

6.0 Summary and Conclusions

The review of background information assisted in developing several recommendations for future data analysis for refined assessment. The UCSWCD study identified extensive erosion in the headwaters of the Sawkill. It is recommended that data from the assessment be merged with the GIS developed in this study, providing a complete coverage of Sawkill Creek, and an ability to evaluate trends in streambank erosion in overlapping reaches. These trends can assist in refined stream corridor reach prioritization and enhanced management of the corridor.

Several evaluations of this study identified notable instabilities in the headwaters, primarily in the form of extensive streambank erosion. This excessive erosion negatively impacts these reaches and provides surplus sediment to the system, impacting lower reaches of the watershed. The reaches near the Village of Woodstock were determined to be historically unstable, currently impacted by excessive streambank erosion and channel migration, and prone to avulsion. The excessive sediment inputs in the headwaters are suspected of hindering natural recovery of these reaches. Reduction of sediment inputs in the headwaters will potentially accelerate recovery and improve the performance of stream restoration project proposed for the area.

The aerial photograph evaluations developed a reproducible data set that can be used in future management efforts. Eleven reaches were identified where significant channel migration and avulsion took place. The stream bank erosion inventory data confirmed that the majority of these areas still exhibit active erosion and contain exposed banks, indicating that these reaches remain unstable.

An example of this is River Mile 3-6, located in the Town of Woodstock, which contains the reach commonly known as the “Woodstock Log Jam Site” and has the highest frequency and greatest magnitude of channel adjustment. Nearly 2,000 feet of abandoned channel, the highest rates stream bank migration and highest frequency of debris and obstructions in the entire watershed were inventoried in this area. A streambank in this portion of the inventoried stream reach (located at Station 203+00) had the greatest migration rate in the watershed, measuring approximately 70 feet over the course of 10 years.

The stream corridor inventory included the collection of several hundred data points, photographic documentation of these features, and a GIS. The GIS facilitated graphic analysis and summarization of the findings and was used to produce inventory mapping.

The most significant finding of the inventory was the extent of streambank erosion in the watershed. This was confirmed by the comparison of the Sawkill Creek data with that of the Stony Clove and Batavia Kill watersheds, considered to be heavily impacted by streambank erosion. Analysis, stratified by River Mile, of the length and area of erosion further assisted in prioritization of the reaches and evaluation of the relationships and trends with other collected stream features. It was found that the upper extent, through the Village of Woodstock, contained higher than average levels of erosion. The headwater reaches contained higher failing banks with greater soil exposure, while reaches through the Village of Woodstock contained the greatest overall frequency of erosion. Other relevant data in this area included a high frequency of debris-occurrences and high debris-jam potential. Historic floodplain disconnection resulting from extensive berming was also significant in this area.

Fifty-two (52) changes in Rosgen Level I stream type were revealed along the inventoried stream reach, through remote sensing and field reconnaissance. These included B, C, D, F, and G types. The stream types along the Sawkill were consistent with the landform and slope ranges and were predominately Rosgen “C” and “B” type. Rosgen “C” type reaches dominated over half of the length of the corridor. These reaches are inherently dependent on the density and vigor of riparian vegetation for stability, as well as stable and consistent sediment and flow regimes. The majority of the reaches containing substantial streambank erosion were C type reaches. Rosgen “B” stream types were the second-most frequent and are located in areas that contained natural and artificially limited floodplains. Rosgen “D”, “F” and “G” reaches comprised less than 10% of the corridor, are typically less stable, and are considered a transitional channel phase.

7.0 Identification and Prioritization of High Risk Stream Reaches

Upon completion of the stream corridor assessment, “high-risk” stream reaches were identified in each of the three towns. The project advisory group (including representatives from each town) selected a priority site for further evaluation and recommendations. The community and project partners prioritized the reaches based on the findings of the stream corridor inventory and feedback from the community. The prioritization was particularly sensitive to recognized problem areas.

Site visits were conducted to review the issues with each respective group and to identify potential causes of instability at each location. A set of recommendations was compiled for each site based upon field observations, data collected during the inventory, and professional judgment. The recommendations outlined are specific to each site and include alternatives for remediation, mitigation, impact minimization, and further assessment.

7.1 Town of Woodstock - “John Joy Road Area”
(River Station 525+00, River Mile 9.94)

The project advisory group and the Town of Woodstock selected a reach surrounding John Joy Road (in the Town of Woodstock) for further evaluation. Attendees at the July 19, 2006 site visit included an adjacent landowner, the Town of Woodstock Highway Superintendent, and representatives of both the Sawkill Watershed Alliance and Integrated River Solutions.

On numerous occasions, the county-owned and maintained bridge on John Joy Road has been inundated by storm flow and debris. This has required emergency response by the Town of Woodstock Highway Department to relieve debris blockages. Floodwater has damaged John Joy Road on several occasions, which has resulted in costly repairs. Streambank erosion and large accumulations of sediment and debris have been inventoried in the reach upstream of the bridge, which also suggests a backwater condition at the bridge.

In addition to the damage and maintenance, the flooding forces the closure of John Joy Road. This requires emergency vehicles and residents to take an approximate 6-mile detour around the flooded site. Department staff confirmed that the road is typically closed once a year due to flooding of this nature, which creates an elevated risk to public safety.

Recently the Town of Woodstock Highway Department was in the process of obtaining regulatory approval to remove a large debris blockage in the stream channel, located approximately 200 feet upstream of the bridge. This plan was being initiated to reduce expected flooding of the roadway and mitigate the potential for the debris to become lodged in the bridge opening. As part of the plan, the department planned to excavate portions of a large depositional feature that was created in the area by the debris accumulation. Before the highway department was able to take action, a flood event occurred, causing water to flow around the bridge structure (to the north) and over John Joy Road. During the flood event, several large trees and their roots blocked the upstream bridge opening and required emergency removal by the Department. Significant repair was necessary along the road as a result of the damage.

7

7.1.1 Observations

As part of the study, a site visit was made in order to gain insight on the scale and overall complexity of the problems in the area. The following observations were made from the visit and initial evaluation of the assessment data.

The reaches surrounding the bridge are Rosgen "C4" type stream channels dominated by center and side bar gravel formations. These formations display little vegetation and evidence of recent enlargement. Channel sediments consisted of gravel substrate with several instances of recent deposition. The area upstream of the bridge on John Joy Road contained several debris jams and numerous downed trees, which most likely instigate sedimentation and aggravate flooding. Several recent deposits of sand, gravel, and debris were observed throughout the wooded portions of the floodplain.

Extensive streambank erosion along several meander bends located upstream of the bridge were noted. Review of aerial imagery from 1995, 2001 and 2004 revealed moderate lateral migration upstream of the bridge. Lateral migration measured 30 and 40 feet demonstrating rates of erosion of 4.5 to 5 feet per year. Further streambank erosion threatens the stability of the confluence with the "Van Dale Road" tributary.

Several past attempts to stabilize sections of the streambank using riprap and large rock were noted upstream of the bridge. Currently, numerous pieces of riprap have become dislodged and are scattered along the channel bottom. The stream has flanked a section of the failed riprap that now extends into a portion of the active channel, creating a minor flow diversion.

A review of the FEMA Flood Insurance Rate Map for the Sawkill Creek displays the 100-year flood boundary extending more than 800ft. northwest of Sawkill Road along both sides of John Joy Road. The stream channel and an area of the northwest floodplain, approximately 400ft. wide is also included within the Floodway Area. The FEMA Flood Insurance Rate Maps for the Sawkill Creek are currently being updated and are under development for FEMA by the NYSDEC.

7.1.2 Comments, Recommendations, & General Discussion

The recurring problems with debris and sediment accumulation, bank scour, and erosion upstream of the John Joy Road Bridge should be further investigated to determine their causes. From this initial evaluation it is suspected that the following factors compound these problems:

- The inadequate cumulative hydraulic capacity of the bridge structure and floodplain may result in backwater (and a subsequent accumulation of gravel and debris) during high flow events.

- The sediment accumulation causes a reduction in mean stream-channel depth, upstream from the bridge area, which results in both lower flow velocity and reduced sediment transport capacity.

- Erosion both in the reach and from upstream areas contributes to an excessive, supply of sediment and large woody debris.

- The natural tendency of the stream channel to migrate both laterally and down valley will intensify both sediment and debris supply to the site.

Development of a hydraulic model of the bridge and surrounding reach is recommended. Standard models (e.g. HEC RAS) can provide the ability to analyze hydraulic requirements necessary to reduce floodwater surface elevations and improve water and sediment conveyance through bridge and floodplain. The developed model could be used to efficiently evaluate multiple scenarios and would be required to analytically justify any alternatives.

The potential alternative exists to raise the elevation of John Joy Road on the northern portion of the bridge approach in attempt to alleviate flooding of the roadway and to lessen damage during moderate flood events. Drainage under the road could be designed to allow passage of floodwater under the roadway onto the downstream floodplain area. Initial observations of the current profile of John Joy Road, the elevation of the bridge approach, and the elevations of the upstream and downstream floodplain appear to make this a feasible option. An adequately engineered design, one which takes into account the hydrology of the Sawkill Creek at this point and the hydraulics of both the bridge and surrounding floodplain area, would be required to determine the targeted flood flow and elevations used for the design in order to assure adequate protection of the roadway and upstream and downstream floodplain areas.

It is recommended that any direct attempt to alleviate flooding at the bridge should include stream restoration upstream of the bridge. This reach is an ideal candidate for “natural channel design” techniques to improve sediment transport, reduce local streambank erosion and sediment yield, and strengthen the confluence with “Van Dale Road” tributary, maintaining and possibly improving the habitat and natural characteristics of the stream channel.

If the problems causing the debris and sediment accumulation can not be addressed due to funding or time constraints, this area should receive limited routine maintenance to prevent future blockage of the bridge opening. If this is required, a management strategy should be developed for the area allowing controlled access by equipment to maintain proper stream channel alignment, dimensions, and slope that would not create additional impacts to the area nor neighboring stream reaches.

2004 AERIAL IMAGE
SCALE: 1in. = 300ft.

Figure 11: Sawkill Creek near John Joy Road.

7.2 Town of Kingston - "Sweet Meadows Area"

(River Station 666+00, River Mile 12.61)

The project advisory group and the Town of Kingston selected a reach commonly known as the Sweet Meadows Area (in the Town of Kingston) for further evaluation. This reach is named after the private development located in the adjacent floodplain. A site visit was conducted on August 9, 2006. Several homeowners from the surrounding area were present at the site visit, along with the Town of Kingston Highway Superintendent and representatives of both the Sawkill Watershed Alliance and Integrated River Solutions.

The Highway Superintendent and residents informed the group that the Sweet Meadows development and Sawkill Road (CR 31) have been flooded on numerous occasions. This has raised concern amongst numerous adjacent landowners not only within the Sweet Meadows development, but also in the Town. It was stated that on several occasions Sawkill Road has been closed due to the flooding, which creates a safety issue where emergency vehicles and residents must take an extensive detour around the flooded site.

Several homeowners have endured property damage and flooding of their residences in the past and report that the frequency and magnitude of the flooding has increased and will result in more severe damage. Floodwater in the Sawkill Creek has been observed by the residents to recede quickly after a flood event and has been known to leave fish lying along the roadway.

Residents remembered the community removing rocks from the Sawkill by hand sometime in the early 1980's after a large flood event. It is believed that approximately 70 tons of material was removed and hauled off by dump trucks. It was discussed that the Town of Kingston excavated sediment from this area of the Sawkill between 10 and 20 years ago and stabilized sections of the road with riprap. The residents also believe that up to eight feet of soil was removed from the south floodplain to facilitate the construction of the Sweet Meadows development.

More recently, floodwater has been observed backing up in the storm drains, presumably during periods of elevated flood stage in the Sawkill Creek. This leads to increased flooding within the development caused by backflow from the Sawkill Creek combined with the inability of the development's stormwater to drain from the site.

An unnamed tributary enters the Sawkill Creek immediately downstream of the Sweet Meadows area. The tributary flows from the western slopes of Jockey Hill along Moray Hill Road and then behind (south of) Sweet Meadows before flowing under Sawkill Road and entering the Sawkill Creek. On several occasions the tributary has also flooded portions of the Sweet Meadows site.

In response to past flooding, the US Army Corps of Engineers and NYS Department of Environmental Conservation jointly inspected the area in 1974. Both agencies concluded that channel improvement alone would not solve the flooding problem. After serious flooding in March of 1980, a study was initiated by the US Army Corps of Engineers. A conceptual flood protection project was developed proposing the cutting of the rock at the waterfall to deepen the lower reach of the stream, channel excavations to remove gravel, and clearing and snagging upstream. The DEC agreed to participate in the project and in 1984 plans and specifications were developed.

Two property owners along the downstream end of the area were opposed to the proposed project. NYSDEC Bureau of Flood Protection recommended additional streambank stabilization to prevent bank erosion.

In August of 1985, the US Army Corps of Engineers responded and concurred that bank protection would be needed, which would decrease the benefit/cost ratio from 1.1 to 0.8. This resulted in a withdrawal by the US Army Corps of Engineers. After flooding in January of 1996, a second attempt was initiated by the Town of Kingston to reopen the project with the US Army Corps of Engineers and NYSDEC. This effort was also halted due to an increase in the local cost-sharing required by the Town that exceeded $833,000.

7.2.1 Observations

The stream channel through this section of Sawkill Creek is trapezoidal in shape and classifies as an F stream type. The reach is exceptionally straight, having extremely low sinuosity. It is apparent that some form of channel dredging and straightening has occurred in the past. Although this type of stream channel is not typically the natural stable form found in this setting, it does appear to be relatively stable. The north floodplain, which does not contain any residential or commercial structures, appeared to be higher in elevation than the south floodplain where Sawkill Road and the Sweet Meadows development exist.

Both right and left streambanks appeared generally stable. Moderate vegetative growth was present along both streambanks, and although the width of the vegetated buffer was relatively narrow, it did appear that it added to the overall stability of the streambanks. Review of aerial imagery from 1995, 2001, and 2004 did not reveal any noticeable lateral migration or erosion of the Sawkill Creek.

A large bedrock shelf acts as a waterfall at the lower extents of the reach providing both lateral stability and grade control for the area. A small unnamed tributary flows behind the residences of Sweet Meadows. Erosion was present within this channel and evidence of channel incision of between one and three feet was observed.

7.2.2 Comments, Recommendations, & General Discussion

It is likely that several factors combine to aggravate the flooding problem through Sweet Meadows. These factors include: the general location of the residences and roadway relative to the stream channel and floodplain, the magnitude and rapid flooding associated with the Sawkill Creek in this area, and the amplified flooding resulting from the tributary and the stormwater collection system in the area.

The timing of the flood peaks between the Sawkill Creek and the unnamed tributary may have a direct impact on magnitude of the flooding observed. Landowners confirmed that the extents of the flooding can regularly be attributed to one stream or the other, and is obviously worsened when both streams flood simultaneously.

An assessment of the tributary and its floodplain should be initiated to determine the location of flooding and the direct impact it has on the Sweet Meadows area.

Due to the relatively small size of the tributary, options may exist to create increased floodplain capacity and resolve some of the flooding issues stemming from the tributary. It may also be possible to correct and stabilize several observed channel instabilities such as erosion and incision.

The stormwater drainage network in the Sweet Meadows development and along Sawkill Road may exacerbate flooding in instances where runoff within the area cannot drain properly. Although not assessed as part of this study, it is possible that the discharge pipes of the drainage network are submerged during periods of elevated flow in both the Sawkill Creek and the tributary. This situation could lead to the reduction in the volume of stormwater exiting the site during periods of elevated water surface elevations in the Sawkill Creek and tributary.

A review of the existing stormwater drainage network within the Sweet Meadows development should be conducted. The review and/or assessment should determine: the locations and sizes of catch basins and subsurface piping, the locations of the stormwater outfalls to both the Sawkill Creek and the tributary and their respective elevations relative to each stream channel, and estimated water surface elevation during flood stage. In addition, the capacity of the system should be determined in relation to outfall of the system during various flood stages.

Once the review of the system is complete, recommendations should be compiled for possible upgrades to the stormwater system to alleviate flooding, prevent backflow from the Sawkill Creek and the tributary, and improve overall stormwater drainage and/or storage.

A review of the FEMA Flood Insurance Rate Map for the Sawkill Creek confirms that the entire Sweet Meadows site is located within the 100-year floodplain. The area is defined as Zone AE, a special flood hazard area inundated by the 100-year flood. In addition, approximately ¾ of the development is contained within the floodway area. It is unknown whether the area was located in the 100-year floodplain prior to the development or introduced by the lowering of the floodplain during construction, as suspected by several residents. Floodplain maps for portions of the Sawkill Creek are currently under development for FEMA by NYSDEC.

There are several potential options that could reduce and/or alleviate the impacts of flooding at the Sweet Meadows area. All would require an analysis of the area to include detailed survey information, a hydrologic assessment, and a hydraulic analysis. A significant portion of this work may have been completed by the US Army Corps of Engineers during previous assessments, and may be included or amended by the FEMA update of the local flood mapping.

It was discussed on site that floodwater has entered portions of Sawkill Road on several occasions resulting in its closure, but has not directly flooded the residences. There is the possibility of raising several low spots along Sawkill Road, which may aid in reducing the impacts of the smaller "out of bank" flood events. This will also prevent the closure of Sawkill Road during low to moderate flooding events, allowing access by residents and emergency vehicles, and may prove to reduce maintenance costs.

In order to mitigate the direct flood impacts from Sawkill Creek several options exist but will require a combination of assessments and evaluations including: watershed hydrology, local channel and floodplain hydraulics, project costs, ratio of project cost to overall benefit, habitat modifications, regulatory approvals, and community support. Options for mitigation include: Community or government buyout of flooded residential areas; Lowering of the base elevation of the stream channel, as outlined by the ACOE, to provide increased channel capacity and floodwater conveyance; Lowering the elevation of the north floodplain to provide increased floodplain capacity.

An important factor to consider with any flood related problem is the frequency of the storm event that requires mitigation. The general cost associated with alleviating the effects of smaller floods is far less than that associated with large events, and grows exponentially as the requirements for abatement increase. It is important to relate the statistics associated with the storm events' frequency of occurrence with the capital costs of flood mitigation projects to make educated decisions prior to action.

Flood control is often accomplished through the development of impoundment areas, designed to attenuate storm flow and release flows at lower rates, ultimately reducing flood elevations in downstream reaches. Generally, the tendency to create inline impoundment structures is discouraged due to the proven environmental impact associated with them. Two large inline impoundments exist along the Sawkill Creek. These are reservoirs owned and operated as part of the City of Kingston water supply. Although improbable, these structures present a potential option for attenuating flood peaks and providing some floodwater storage.

The inventory identified at least one of these structures as moderately impacted by sediment accumulation, which would require extensive excavation of the impoundment area as part of any retrofit. The outlet structures of one or both dams may require enhancements in order to effectively manage flow releases.

This alternative would require thorough hydrologic modeling of the Sawkill watershed and hydraulic routing of upstream and downstream reaches, as well as consideration for the response and timing of flooding of the downstream Esopus Creek. Although this study did not examine this alternative, it is recommended that the feasibility of this option be initially investigated.

Reduction of stormflow and associated water surface elevations in Sawkill Creek may also be accomplished by modifying runoff characteristics of the smaller sub-basin drainages in the watershed. This watershed approach requires thorough hydrologic and hydraulic assessment of the watershed, the appropriate location of new stormwater-management practices and the identification of possible stormwater retrofit opportunities.

The development of local ordinances or regulations that exceed the current New York State requirements for stormwater management placed on new or proposed development would promote this approach. Currently New York State requires the pre-developed 10 and 100-

year frequency runoff to remain unchanged after the site is developed. A new local law could require design and implementation of practices that reduce developed discharge rates below these pre-developed rates. This requirement could reduce flood flow rates over time by having any new or proposed development essentially over-mitigate stormwater without adding significant cost to local government. In addition, a program could be initiated to evaluate, enhance, and possibly retrofit existing stormwater management areas to detain and treat additional runoff.

The watershed approach to reduce peak flows would be a long-term, extensive effort, but could address multiple objectives and provide multiple ancillary benefits for Sawkill Creek. The implementation of effective stormwater controls could also lead to improvements in water quality, ecology and stream channel stability.

2004 AERIAL IMAGE
SCALE: 1in. = 300ft.

Figure 12: Sawkill Creek near Sweet Meadows.

7.3 Town of Ulster - "Sawkill Creek Confluence Area"

(River Station 818+00, River Mile 15.50)

The project advisory group and representatives from the Town of Ulster selected a reach located at the confluence of the Sawkill and Esopus Creeks (in the Town of Ulster) for further evaluation. A private landowner, the Floodplain Coordinator for the Towns of Kingston and Ulster, and representatives of both the Sawkill Watershed Alliance and Integrated River Solutions attended a site visit on September 27, 2006 held at Heritage Energy, a local heating oil business. A second site visit was conducted on December 19, 2006 with the Floodplain Coordinator, the Town of Ulster Water Treatment Plan Supervisor, and representatives of both the Sawkill Watershed Alliance and Integrated River Solutions at the Costanzi Crane & Rigging Company.

The site was chosen due to historic flooding of several local businesses along the Sawkill, and the recent flooding that caused significant damage to numerous homes and businesses downstream of the site on the Esopus Creek.

The Floodplain Coordinator informed the group that on several occasions the parking lot of Heritage Energy, a local heating oil business, has been flooded. Although this typically occurs only during large storm events, it was not believed that the actual building or ancillary structures were affected. It was added that several berms located along the floodplain had been recently removed by Heritage Energy. There is a possibility the berms were originally installed to protect the area from flooding, but actually prevented stormwater and flow from exiting the area and increased the amount of water around the building.

Similar flooding has occurred at Costanzi Crane & Rigging Company, another local business located within the adjacent Esopus Creek floodplain. The group described the flooding as isolated to the parking areas during large storm events.

7.3.1 Observations

The Sawkill Creek at the confluence is a Rosgen C4 stream type, which extends upstream approximately 2,400 feet. This reach of the Sawkill is dominated by gravel substrate and contains several small, side channel gravel bars and one small, central gravel bar. The assessment conducted through this reach inventoried a gravel berm located along the southern streambank between Station 810+00 and 815+00, adjacent to Heritage Energy. The berm is approximately 500ft. long, 6ft. high, and is vegetated with a mixture of deciduous trees and shrubs. The berm is discontinuous along its length and varies in elevation.

Two bridges are located in the reach. The Sawkill Road Bridge, located at Station 818+00, is operated and maintained by the Ulster County Department of Highways and Bridges. The NYS Thruway Bridge, located at Station 830+25, is operated by the NYS Thruway Authority.

One unnamed tributary enters the reach downstream of the Sawkill Road Bridge. The tributary flows east along the property owned by Eagle Diesel Power, before crossing under Sawkill Road. It then flows north along the shoulder of Sawkill Road for approximately 850 feet before entering the Sawkill Creek.

Erosion was inventoried along northern streambank upstream of the Thruway Bridge. The exposed bank measured 440ft. long and 6ft. high, and was slightly undercut. The floodplain along the top of the bank contained moderately dense mature deciduous trees and shrubs. The exposed bank was comprised primarily of gravel and contained several small trees along the bank slope. A review of the aerial imagery from 1995, 2001 and 2004 did not reveal any significant lateral migration, erosion, or shift in the channel alignment. This suggests that the erosion along the streambank has not significantly progressed or is relatively recent.

A large wetland area and pond are present on the southern floodplain, downstream of the Sawkill Road Bridge and extends to the Esopus Creek. The wetland area is bisected by the NYS Thruway. It was discussed on site that the wetland areas may have been artificially created during the construction of the Thruway in order to obtain fill material. Although the wetland area is not regulated by NYSDEC, a portion of the area is included on the National Wetlands Inventory Map and is regulated by the U.S. Army Corp of Engineers.

A review of the FEMA Flood Insurance Rate Map for the Sawkill Creek, displays the entire area located within the 500-year flood boundary, and only the portion of the southern floodplain between Sawkill Road and the NYS Thruway being included within the 100-year floodplain boundary. There do no appear to be any residential or commercial structures or roadways included within the 100-year floodplain boundary. The FEMA Flood Insurance Rate Maps for the Sawkill Creek are currently being updated and are under development for FEMA by the NYSDEC.

7.3.2 Comments, Recommendations, & General Discussion

The general concern for the site is flooding and associated risk to adjacent residential and commercial properties. There has not been a flood mitigation plan developed for the Town of Kingston or Ulster. The Town of Ulster is currently working on a grant that would be used to develop that plan.

The frequency and extent of flooding in this particular area generally depends on amount of precipitation, the timing of flood peaks between the Sawkill and Esopus Creeks, and local obstructions in the channel and floodplain in the area of the bridge structures. The most significant flooding in this area of the Sawkill Creek would generally occur when large floods in both systems peak simultaneously at the confluence area as was the case in April 2005. Although a solution to mitigate flooding in this area would entail detailed analysis of the area, which is beyond the scope of this study, several general recommendations based on the need for future assessment and evaluations were developed.

Determining the magnitude and frequency of the April 2005 storm event that caused flooding in the area and extensive damage in the Esopus Creek corridor would assist in clarifying flood mitigation expectations, quantifying risk and aid in future planning. It was discussed at the site visit that during the April 2005 flood event the Sawkill Creek flooded the parking lots of both Heritage Energy and Costanzi Crane Company, but did not flood the structures or nearby residential structures. The importance of determining the frequency of this storm will assist in relating the statistical probability of the flooding to the expected flood risk and damage to the area. As an example, if the April 2005 flood event in the Sawkill Creek was deemed a 25-year recurrence flood event, than it could be expected that severe flooding and damage would occur during larger magnitude events, such as the 100-year recurrence event and may warrant mitigation. Alternatively, if the April 2005 flood event was deemed a 100-year recurrence flood or greater, than the flooding of the Sawkill in this area may be regarded as insignificant and require minimal to no mitigation.

Due to the scale and complexity of the Sawkill and Esopus watersheds, a thorough understating of the hydrology and hydraulics would be required to effectively alleviate existing and future flood risk. It is recommended that the Towns of these watersheds assess the need for the development of a hydrologic model to understand the existing conditions of the watersheds. Hydrologic modeling that can simulate precipitation runoff and routing would act as a decision support tool for future mitigation planning. Data used in the creation of hydrologic model, and model output can be used to identify and prioritize sub basins based on their response to precipitation. The model can be used to facilitate effective selection of alternatives for structural and nonstructural controls to provide floodwater elevation reduction, reduce existing damage, and prevent future damages.

Hydraulic models are used for simulating water surface elevations of various flow events, determining hydraulic characteristics of channels such as water velocity, and channel stress. Modeling can be used to evaluate the existing conditions that are affecting flood elevations, such as bridges, floodplain fill, berming, as well as the effect of obstructions and the efficiency of sections of channel. Multiple scenarios can be modeled to evaluate opportunities for channel modification to improve hydraulic conditions, flood elevation reduction, and measures to reduce damage to existing structures.

Updated hydrologic and hydraulic models for both watersheds are in development by New York State DEC to update the existing FEMA Flood Insurance Rate Maps. It is recommended that the Town acquire digital copies of these models and associated GIS information of the boundaries upon their finalization. These models can be used as a planning tool to evaluate the existing conditions that are affecting flooding and be used to develop actions for mitigation.

As discussed earlier, a berm was inventoried along the streambank behind Heritage Energy. The berm appeared discontinuous, allowing for floodwater to access the adjacent floodplain during extreme events. This berm may be a remnant of the gravel berm that was reportedly removed by Heritage Energy to allow floodwater to drain from their site, back toward the Sawkill. As the area behind this berm is only flooding during extreme events (>50-year recurrence) and the floodwater is able to access the area, there is no further action suggested.

Flooding of the Heritage Energy and Eagle Diesel Power parking lots were observed on April 16, 2007 following a heavy rain event. During this event the Sawkill Creek did not crest the top of the bank, or result in flooding of the area. Flood water from the small unnamed tributary which flows east along the property owned by Eagle Diesel Power, was observed overtopping its banks and inundating the area west of Sawkill Road. This condition may aggravate and increase flooding of the area during periods where inundation occurs as the result of the Sawkill Creek flooding.

It is recommended that the existing stormwater drainage network within this area be investigated, and opportunities for modifying the tributary and/or stormwater network be evaluated to more effectively transport flow to the Sawkill Creek and away from the parking areas.

The southern floodplain, downstream of the Sawkill Road Bridge, remains mostly vegetated and includes a large wetland area and 1.8 acre pond. This area is included within the 100-year flood boundary and provides a significant amount of flood storage for both the Sawkill Creek, as well as the Esopus Creek during large flood events. The Constanzi Crane Company utilizes a portion of the area (lower lot) for equipment storage and parking.

Modification that would result in a decrease in flood storage capability of this area should be avoided. In addition, opportunities may exist to enhance this area for increased levels of floodwater storage, as well as improve habitat benefits.

2004 AERIAL IMAGE
SCALE: 1in. = 300ft.

Figure 13: Sawkill Creek near confluence with Esopus Creek.

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