Getting to Know Your Streams and Stream Program

Delaware County, NY

Prepared by:
Delaware County Soil and Water Conservation District
in partnership with New York City Department of Environmental Protection

Contact Information:

Delaware County Soil and Water Conservation District
Stream Management Program
44 West Street, Suite 1
Walton, NY 13856
607-865-5223 Phone
607-865-5335 Fax

Staff:

Larry Underwood, Executive Director
Graydon Dutcher, Stream Program Coordinator
Ben Dates, Stream Program Engineer
Gale Neale, Stream Program Engineer
Jeff Russell, Stream Program Technician
Jessica Patterson, Stream Program Technician
Mike Coryat, Stream Program Technician
Catherine Skalda, Catskill Streams Buffer Initiative Coordinator
Jay Dinga, Data Budget Specialist

Table of Content

Introduction to Streams

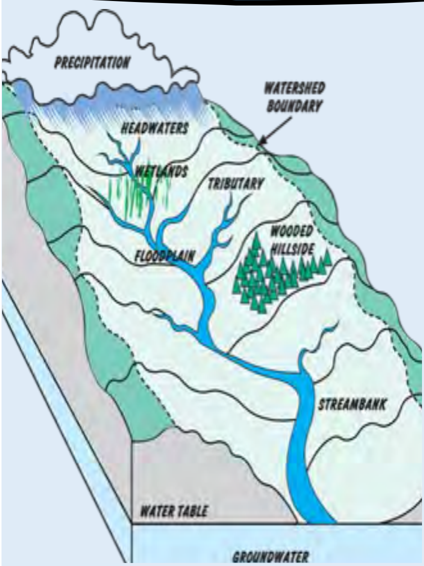
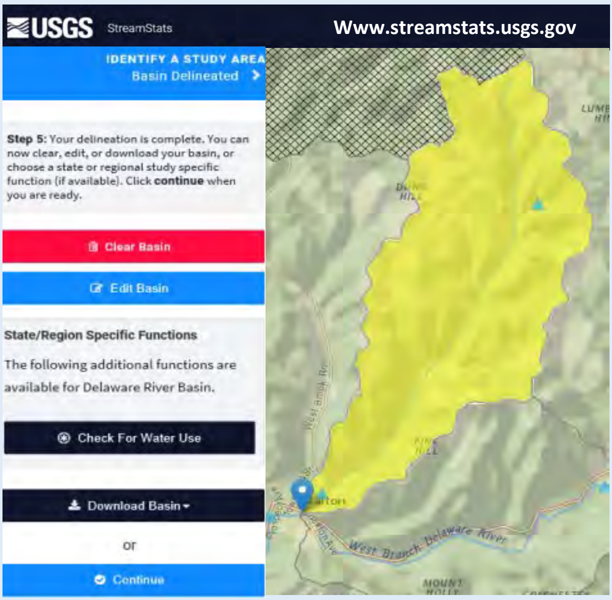


Illustration of a watershed (unknown source)

The streams and rivers in Delaware County have, historically, been central features of the local culture and industry. From the industrial uses of hydro-powered mills and waterborne highways to recreation in fishing and swimming, our waterways have shaped the character of our community. While our streams no longer drive our local industries in the same way, they still affect our everyday lives and the functions of our local governments. Streams and rivers are never constant, so it is important to understand how and why streams change. This understanding is essential when approaching any level of stream management from general stream gravel maintenance to post-flood recovery.

Streams reflect the regional climate, biology, geology, and topography. The water flowing through the drainage system reflects the watershed characteristics that are influenced by the water (hydrologic) cycle. Drainage area or watershed size is defined as the amount of land area that drain stormwater runoff into the stream network. The travel time for the water through the stream network varies with the shape of the watershed and the topography. A steep watershed typically exhibits a higher (and faster) peak discharge than a flatter watershed.



Stream Stats is a web-based application that provides access to an assortment of analytical tools that are useful for engineering and design purposes. The user can delineate a stream (like the map on the right) to obtain drainage area, basin characteristics and estimate the flow statistics for the selected project site. Knowing the drainage area is just one piece of a puzzle for designing a stream restoration project.

Streams flow at many different levels over the course of a year, ranging from a small trickle of a dry summer to the raging torrent associated with the rapid thaw of a thick snowpack or severe rain storm. There are three basic types of stream flow: base flow, storm flow and flood flow. Base flow sustains stream channel between storms, during subfreezing, or during drought periods and is largely the water flowing in the stream from groundwater springs and seeps. Storm flow, also known as bank full flow, appears in the channel in direct response to precipitation (rain) and/or snowmelt. Flood flow is water that gets outside of the streambanks though it results from the same rain/snowmelt circumstances just a greater magnitude.

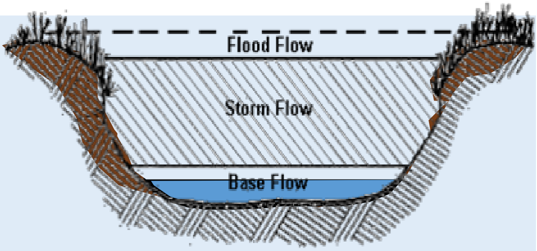
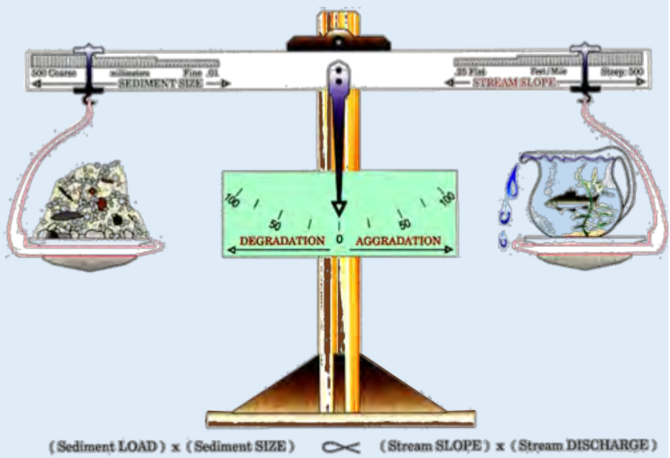


Illustration of a typical stream cross section showing stream flow (unknown source)

Streams obey certain physical laws to maintain their shape such as dimension, pattern, and profile. As water moves over the land it picks up sediment while it forms its channel to create and maintain their shape and size. A properly sized stream channel is able to transport water and sediment in a balance. Streams that are in balance with their landscape adapt a form that can move sediment through both small and large floods, retaining their previous form after the flood passes. A number of factors can change the stability of a stream such as natural changes in flow input, sediment and land use. Channelization of the stream and placement of berms, culverts and bridges can also have a negative impact on stream stability.

Sediment that is considered to be in equilibrium in a stream system when the volume of water is enough to transport the available sediment without building up (aggradation) in the channel or cutting down the streambed (degradation). Streams will adjust their shape, size and slope in order to transport the sediment. The figure to the right shows the relationship between a set of four physical variables: sediment size, sediment load, stream discharge and stream slope. It also shows the stream channel response: degradation and aggradation. The figure suggests that one change in the equilibrium from the four physical variable will trigger a response by either eroding the stream channel bed or filling the stream channel full of gravel.



Source: (Rosgen, 1996)

Stream features are described in terms of their dimensions with regard to planform, profile, and cross-section. The planform is the path that the stream follows within its valley. A stream will have sinuosity (bending) as it meanders across the valley floor. Sinuosity is related to slope and energy. A stream that has high sinuosity will have a longer distance with a lower average slope than a stream that is straighter with a higher average slope. Profile dimensions of elevation and length are used to describe the slope and bedform of a stream channel from top of the watershed to the mouth of the stream. Slope is a critical contributor to the energy of the stream. The energy of water flowing down a slope is needed to move sediment. A stream's slope can vary from high gradient (slope greater than 4%) to medium gradient (2-4%) to low gradient (less than 2%). The Figures A & B below show that the gradient is typically greatest at the top of the watershed and will gradually decline as the stream flows down the valley and makes its way to the bottom of the watershed where it has the lowest gradient.

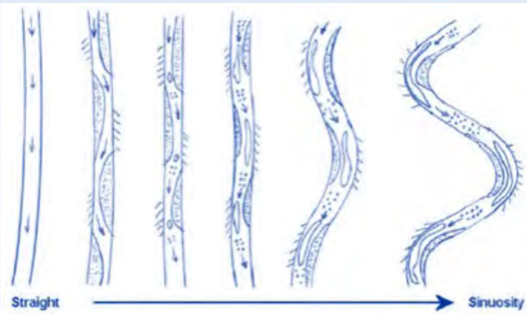


Figure A: Planform of a Stream with Increasing Sinuosity (After Keller, 1972)

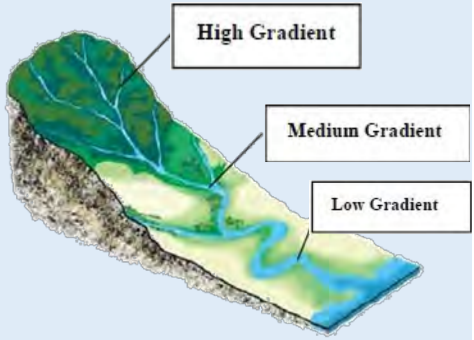
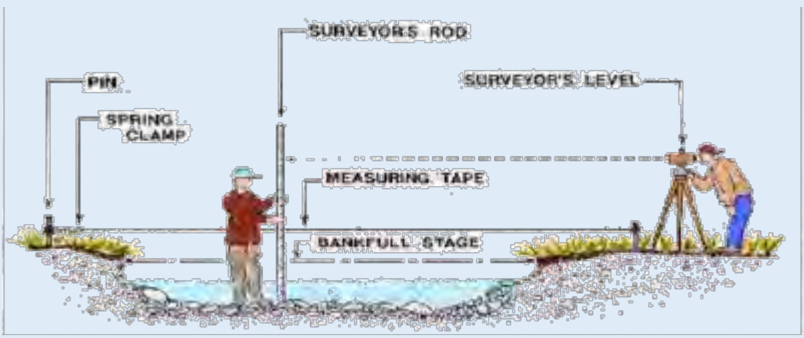


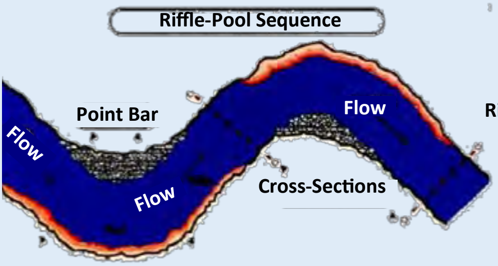
Figure B: Stream's slope from high gradient to low (unknown source)

Cross-section dimensions of the stream channel, together with current velocity, allow for the calculation of discharge. These measurements are the basis for developing hydraulic geometry and stream flow. The image below shows where the cross-section of a stream channel is surveyed. A cross-section survey is typically performed in a representative riffle.



A field guide for bankfull stage determination and conducting a stream channel survey was recently published by the USDA Forest Service, (Harrelson et al, 1994).

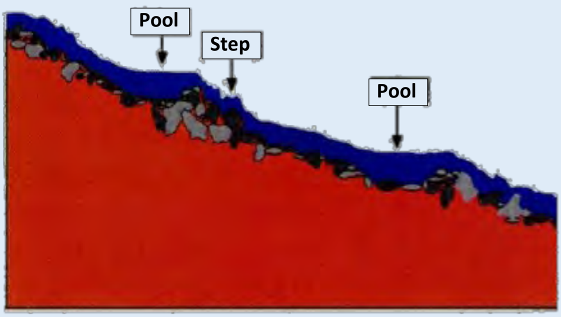
A wide variety of **stream channel types** can exist within the watershed, but there are two basic stream systems that can be easily identified in the field. A stream in a stable reach will maintain a balance in length to its riffle to pool ratio. **Riffle-pool sequence** are best recognized by their flatter valley bottoms, floodplains, meandering streams, and alternating riffles and pools. Pools are found on the bends in the stream and are features with lower slope and greater depth that act to slow the velocity of the water. The water enters the bend and creates a vortex-like helical flow that dissipates energy it spirals into the deeper water. Gravel can be found in the inside of the bend (as known as a point bar) which is a characteristic of a stable stream.



Typical riffle-pool sequence (Rosgen, 1996)

Riffle-pool sequence on Tremper Kill
Town of Andes

The second stream system is called a **step-pool sequence** and are typically found on steep narrow valleys or in the headwaters. The energy is dissipated through the step pools much like a series of speed bumps would slow down a car. Step-pools do not have floodplains.



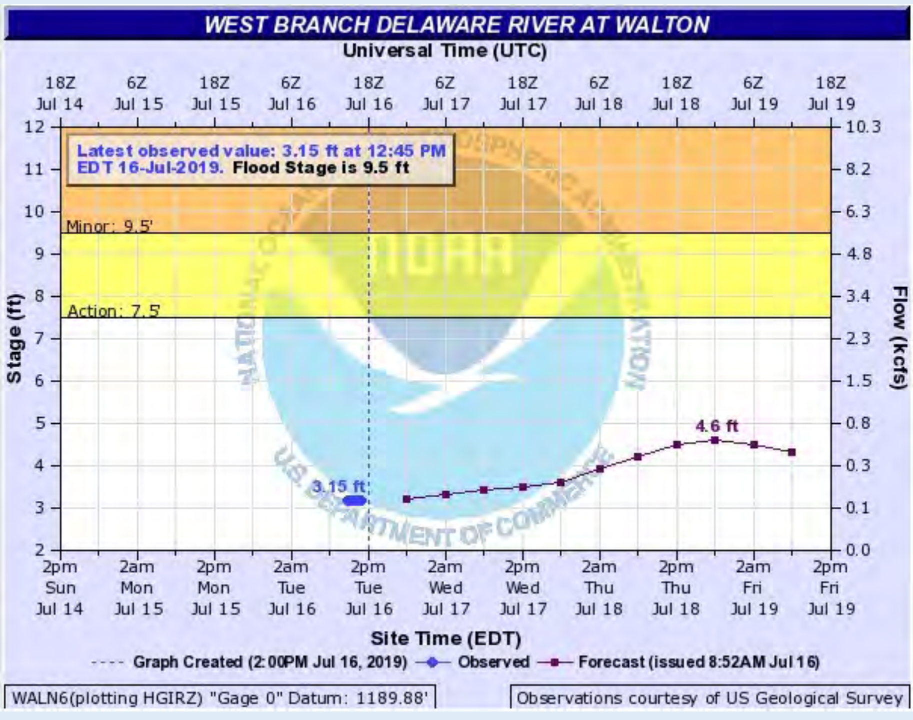
Typical step-pool sequence (Rosgen, 1996)

Step-pool sequence on Unnamed Tributary
Town of Walton

United States Geological Survey Stream Gage

The United States Geological Survey (USGS) has real-time stream gages located throughout Delaware County. The stream gages record at 15-60 minute intervals the stream flow (discharge) and Water level surface elevation (stage). Some stream gage information are used by the National Weather Service's model for Advanced Hydrologic Prediction Services to predict flood events. The advanced prediction and the USGS stream gage information can be found on the National Weather Service's website:
https://water.weather.gov/ahps/forecasts.php.

The usefulness of this flood prediction tool can be seen in Walton, NY where several stream gages help the village predict rising flood waters. The Town and Village of Walton recently received an additional stream gage along West Brook at Austin Lincoln park in December 2017, as well as reactivated the stream gage along East Brook downstream of East Street. These two gages along with the West Branch Delaware River gage at the Delaware County Fairgrounds are used by Delaware County Soil and Water Conservation's Stream Program and Delaware County Emergency Service to predict water level during a storm event. Having local knowledge of where the stream first breaks out onto the floodplain or roadway in relation to the level indicated on the stream gage is an important tool for checking the accuracy of the National Weather Service's models as well as aiding in the safety of the citizens in Delaware County.



Introduction to Floodplains

A **floodplain** is an area of land next to the stream or river which stretches from the streambanks to the valley walls. This area experiences flooding during periods of high water discharges. The floodplain is a very important component of the stream system during flood events:

* Stream energy is dissipated on the flat ground decreasing the velocity and energy within the stream channel.
* Flood peaks are lowered due to storage and infiltration. Water that spills out of the banks is temporarily stored on the floodplain, reducing flooding downstream.
* Floodplains provide a place for debris and sediment to be deposited to form topsoil.

Ouleout Creek near Franklin, NY – 2006

A highwater event is not considered a bankfull flood event until the flow spills out of the streambank. Bankfull flow event is not considered a flood event until it overtops the banks. Bankfull happens on average, every 1.2 to 2 years and is largely responsible for the shape of the stream channel within the floodplain. These events determine the size of the channel that is needed to convey the water. The frequency of inundation within the bankfull channel is enough that the perennial vegetation, often, can't grow in the channel either because roots won't tolerate saturation and because seedlings are regularly swept away. The floodplain may be on one side or both sides of the stream, depending on the site. In areas that a the stream cannot access a floodplain on either side (but is doing so elsewhere along the stream), the channel is considered entrenched, or contained within its banks.

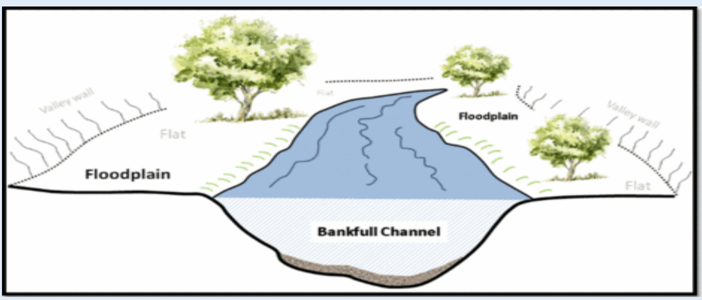


Illustration shows floodplains on both sides of the stream (unknown source)

Highway/Public Utility Infrastructure Influence

Changes to floodplain connectivity are commonly caused by human activity when structures, fill or undersized culverts are placed in a river's path. Streams and rivers can also be disconnected from their floodplains by berming, dredging, relocation or natural incision. This interruption to their natural balance causes the water to concentrate during the swift-moving floods, resulting in excessive erosion of the channel bed and banks. Erosion along such unstable channels will continue until a balance is once again achieved. This process will require decades, even centuries, to re-achieve equilibrium. In this time, tons of sediment will be introduced into the river system, requiring time and resources for successful management.

Flood damage on unknown stream (unknown source)

Berms are described as an earthen embankment or wall, usually built with the intent of flood prevention or as a result of side cast sediment piling during stream channel dredging. When a stream is disconnected from its floodplain through these practices, water and energy becomes trapped within the stream channel. If the berm structure fails, it could cause devastation in its path as all the energy is released at once. The photo on the right shows the river and the high energy that was trapped within the bermed channel. Notice how the river created bends to dissipate its energy and regains it's floodplain.

Some of the most highly visible impacts to stream and floodplains result from the construction and maintenance of highway infrastructure. Roads are commonly located close to streams, especially in mountainous regions that typically have narrow and winding valleys. Road encroachment has narrowed and deepened many streams, resulting in increased stream velocity. The increased velocity may cause the stream to react by increasing streambank and bed erosion adding excess sediment to the system that will deposit downstream when the velocity decreases. Roadside ditches can also impact the streams by collecting and concentrating stormwater runoff which increases flood peaks. Without stormwater retention and/or filtration, runoff also transports contaminants, excess sediment and nutrients that degrade water quality.

Proper culvert and bridge installation, orientation and sizing is particularly important for maintaining stream stability and flow. Structures that are built wider than the stream's natural dimensions will lead to the deposition of sediment under and near the structure during periods of low flow. Sediment that is deposited under the bridge may then reduce the designed flow of the channel at high flow, requiring frequent excavation and maintenance to maintain the design capacity. Structures that are built too narrow will exhibit a depositional wedge upstream of the structure and scour downstream. The narrow structure will cause water to back-up resulting in localized flooding.

If a bridge or culvert is undersized, the water and debris will be forced through the narrow opening concentrating the energy. If debris plugs the opening it will cause problems downstream and upstream of the structure similar to the picture to the right. Water becomes backed up behind the structure until water flows over the road and, sometimes, causes catastrophic failure of the structure and road.

Undersize culvert damaged during 2011 flood event

Undersize culvert on Mallory Brook, Town of Hamden

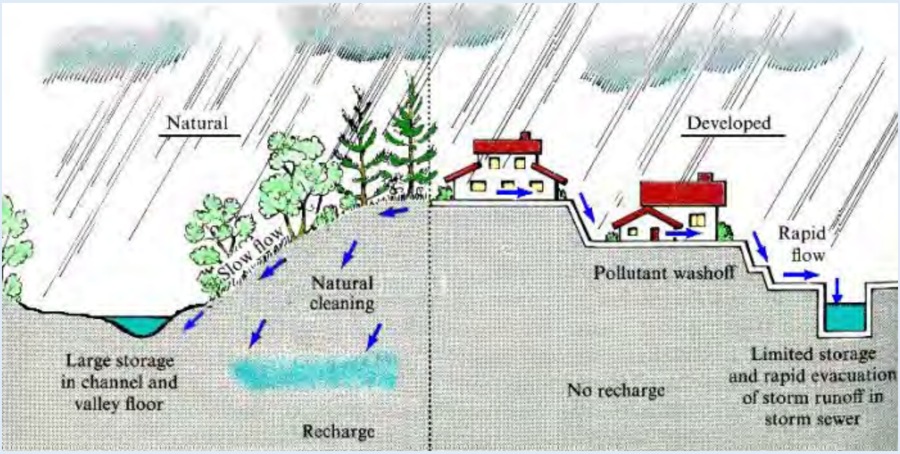
The culvert to the left is an example of an undersized culvert that is backing up water, causing the sediment to deposit upstream. The berm along the streambank is the result of past stream maintenance where gravel was dredged from the stream channel to prevent the road from flooding.

The photo to the right is at the same location as the above picture. The Town of Hamden received a grant in 2010 to replace the deteriorated culvert with a three-sided bridge and remove the gravel berms. Since its installation there has been no flooding on the town road. Delaware County Soil and Water Conservation District can provide technical assistance with proper culvert sizing and regulatory permit.

3-sided bridge on Mallory Brook, Town of Hamden

Residential and Commercial Development Influence

Development of residential and commercial areas can have a significant impact on the watershed and on the ecology of the riparian (streamside) area. Buildings, roads and parking lots are most often made of hard materials that are commonly referred to as "impervious," or incapable of absorbing water. These impervious surfaces do not allow for the rain water to soak into the ground. Rain water that is soaked into the ground can recharge the water table and slowly make its way back into the streams. In developed areas, the rain water is blocked from soaking into the ground. The mix of water and the pollutants known as "stormwater runoff" is concentrated and often runs directly into streams. Stormwater runoff in a natural landscape is compared to runoff in a developed landscape in the figure below. The rain water enters the stream system quicker in the developed areas which will result in the water rising faster with potential to increase flooding.



Natural vs. Developed Runoff (Dunne & Leopold, 1978)

Homeowners who enjoy their stream and desire to be close to it tend to clear all the trees and shrubs along the streambanks to provide views and access. They sometimes replace natural conditions with an un-natural mowed lawn that provides little benefit to stream health or local wildlife. Mowed lawn will increase stormwater runoff that would normally be a slow flow that would be absorbed by the trees, shrubs and ground. This leads to water getting to the stream system faster that may produce increase streambank erosion or cause flooding issues. The landowner can prevent any impacts to the stream by minimizing the disturbance in the flood prone area and promoting a low dense natural buffer between the yard and the stream which will provide property protection, aesthetic value and wildlife habitat.

Agricultural Influence

The abundance of water and cold-hardy grasses have supported agricultural industries for centuries. The clearing of riparian forest to grow hay or corn up to the edge of the stream causes unstable streams and massive erosion problems. Streams were also moved to maximize property as fields were created to obtain the most profitable land for growing crops or grazing cattle. Streams were pushed to the sides of valleys resulting in the stream that is no longer located in the lowest point of valley. These streams were traditionally maintained and reinforced to stay in place by berms, hardening the streambanks (i.e rocks, wood boards, metal plates, etc.), removing the gravel or other stabilization methods. The figure below illustrates the stream's reaction to being moved across the valley.

Stream that has been moved to higher elevation in a valley (unknown source)

The stream channel bed will fill with gravel because it doesn't have the stream slope and velocity to move the sediment causing erosion on the streambank to occur. The water will eventually push out of the streambank which typically happens during a storm event and flow to the lowest elevation of the valley. This type of erosion is known as an avulsion (or embayment).

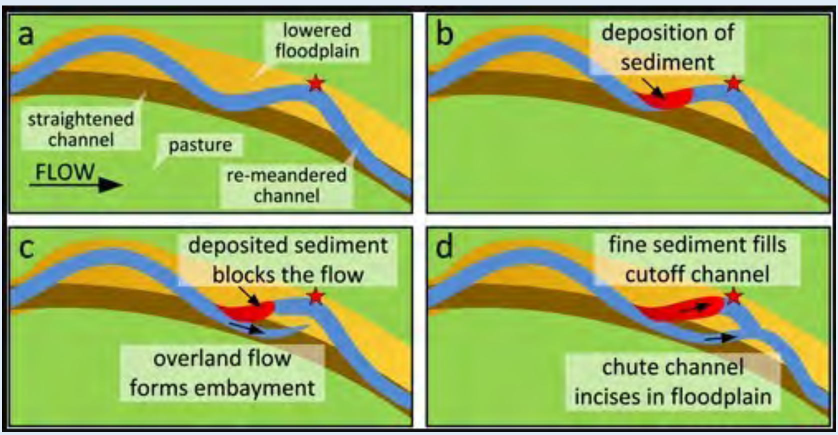


Illustration showing the evolution of improper stream maintenance (unknown source)

Introduction to Riparian Buffer

The word ***riparian*** can be defined as "of or pertaining to the bank of a river or watercourse." Riparian areas are comprised of streams, rivers, lakes, wetlands, and floodplains that form a complex and interrelated hydrologic system. They are the transitional area between the aquatic and terrestrial systems and are thus well adapted to a wide variety of environmental conditions. Riparian areas are not only important plant and animal habitat, but also contribute to, and reflect, the health and quality of the surrounding landscape.

Healthy Riparian Systems

Streams with healthy, vegetated, riparian buffers are more stable and resilient than those without vegetation and can help protect and maintain the character and function of the stream and streamside habitat (Figure 1). Healthy riparian buffers offer a number of important ecosystem services which include:

- Filtering pollutants and sediment from overland runoff
- Protecting water quality
- Stabilizing and protecting streambanks
- Protecting infrastructure and properties from flood and ice flow damage
- Providing for recreation, education, and sense of place
- Shading aquatic habitat and reducing water temperatures, and
- Providing habitat and food supply for aquatic and terrestrial wildlife

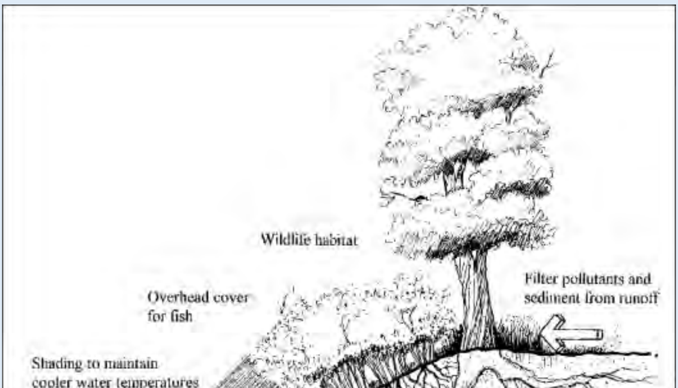


Figure 1: Schematic of a generic riparian buffer and its functions (Source: USDA A Practical Streambank Engineering Guide, 1998)

Riparian Buffers and Stream Protection

Riparian buffers help preserve and protect many critical interactions between the aquatic ecosystem of the stream or wetland and the floodplain and upland ecosystems. Employing appropriate riparian stewardship practices will not only help ensure the preservation of riparian buffer health, aesthetics, recreational opportunities, water quality, and aquatic habitat, but may significantly reduce or even prevent costly restoration and repairs stemming from damages caused by unstable stream systems.

Riparian Restoration

Successful riparian restoration begins with an understanding of the current condition of the stream and riparian area and its ability to maintain the varying flows of the stream while also protecting and supporting the native flora and fauna. Understanding of the natural stream processes and benefits of riparian buffers helps us in our efforts to restore both stability and functions of degraded streams and associated riparian habitat.

Invasive Species (IS) Management

Invasive species are non-native species that can, if introduced and left unchecked, cause either economic harm, environmental harm, or harm human health. Invasive plant species are aggressive plants that have the ability to grow and reproduce rapidly, and often outcompete more beneficial native vegetation in the areas in which they are present. Invasive plants often form dense monocultures that can crowd out native plants, reducing the quality of the local environment and wildlife habitat. New York State regulates the sale, introduction and transport of many identified invasive species. Invasive plant species can grow quickly, form monocultures, and outcompete native plant species, reducing the overall habitat quality for many of the native wildlife species that rely on these quality habitats for food and shelter.

Invasive Species Site Assessment:

Changing conditions due to any kind of disturbance such as a flood event, or even a change in management practices at the site may introduce invasive plants. Some common invasive plant species often found in riparian habitats are listed below. The IS Ranking identified in the table below identifies the relative risk of spread of the plant within NY State. Presence of these species within or around any stream or buffer project site should be identified, and a management, monitoring, or control plan developed.

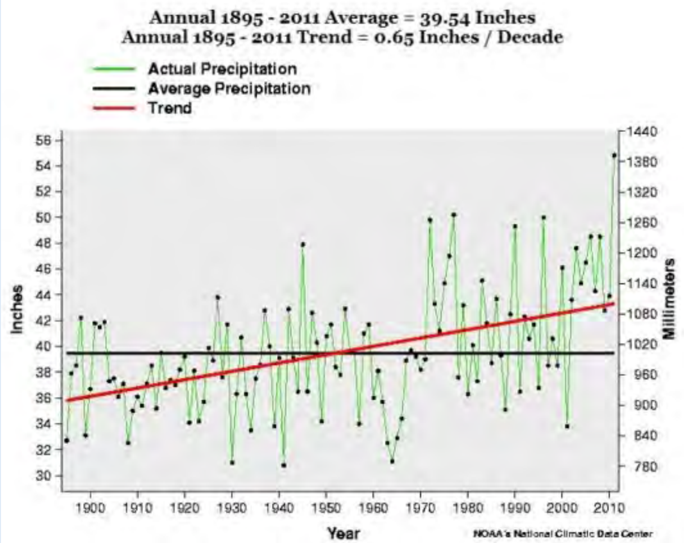
Common Invasive Plants found in Riparian Areas in Delaware County NY

Common Name	Scientific Name	NY State Ranking
Japanese Knotweed	*Fallopia japonica*	Very High
Multi-flora Rose	*Rosa multiflora*	Very High
Non-native Honeysuckle	*Lonicera (sp.)*	Very High
Wild Parsnip	*Pastinaca sativa*	Not Ranked
Purple loosestrife	*Lythrum salicaria*	Very High
Reed Canary Grass	*Phalaris arundinacea*	High
Oriental Bittersweet	*Celastrus orbiculatus*	Very High
Autumn Olive	*Elaeagnus umbellata*	Very High

Stream Management Practices

People have been manipulating local streams for hundreds of years, from the construction of mills dams in the 1800s to the more recent practice of gravel harvest to maintain the road in the 1960s. The comment “There were little to no flooding issues back in the 1960’s when the streams were maintained” is an all too familiar saying that is heard from the public at stream presentations. A look at **historical rainfall** in the graph below shows that the 1960’s were some of the driest years in our recent past. Thus, extensive manipulation of our streams during this era produced few observable problems that would have, otherwise, been highlighted during floods. In the time following, rainfall has increased and the poor stream management that has occurred in the past has manifested itself in the form of instability issues in the present. The current local climatic trend towards an increasing frequency of high intensity storms will likely exacerbate the existing stream instabilities caused by past mismanagement.

Historic Rainfall



The more intense and frequent storms create a challenge for all who live and work near water. The traditional stream channel maintenance of creating a parabolic (u-shape) channel with the removal of gravel to make the channel deeper and wider does not work with the current powerful water flows we see today. These old methods of maintenance end up creating excessive streambank erosion and gravel deposition, costing additional money to repair. The following section will discuss stream channel disturbance and new methods of stream management.

Channel Disturbance and Evolutionary Sequence

Dredging is often proposed as a means of increasing channel capacity especially after a flood event. The typical parabolic (u-shape) stream channel is shown in the photo to the right. The gravel is often left along the streambanks due to the lack of access at the site, or the gravel berms may be left in an attempt to contain the water and stop flooding.

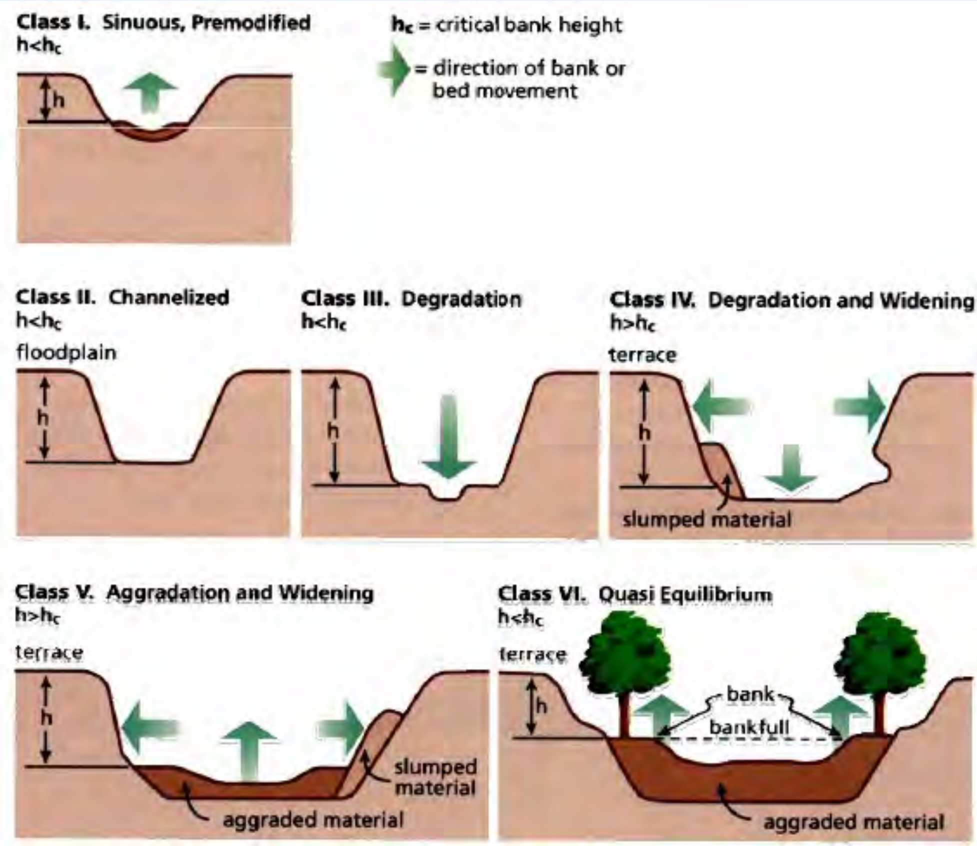
Three things that occurs when stream channels are dredged:

Historic photo of a parabolic stream channel (unknown source)

- An abrupt change in elevation in the stream bottom is created at the project site which creates erosion of the stream bottom, this instability is called a headcut. The headcut will continue to move upstream, destabilizing the stream bed as it moves, releasing a huge amount of sediment supply from the bed and banks. This instability may also undermine existing bank protection and structures as it travels upstream.
- This newly released sediment will often deposit in the center of the stream channel much like the location shown in the picture below. This happens because the stream's velocity and energy is overwhelmed by the introduction of an excessive amount of sediment. The stream can't move the sediment any longer, and it comes to a halt.
- Additional erosion will occur in the vicinity of the new gravel deposit as the stream is trying to achieve equilibrium with a new bottom elevation and slope. In short, it is trying to match downstream with what is happening upstream. Once the gravel is deposited, the water will attempt to bypass this new obstacle through the path of least resistance which might result in streambank erosion or further downcutting.

Photo on the left shows stream channel dredging on Bull Run during 2011 flood response.

Streams that have been disturbed by dredging, incision, straightening, or channelization follow a **systematic path to recovery**. This process has been documented in six classes described by Simon and Hupp (1992) shown in the illustration below. It is important to note that this process can also happen naturally, but accelerated with incorrect maintenance.



- Class I, stream channel in its natural pre-disturbed state.
- Class II, stream channel after being disturbed naturally or by dredging, presumably straightened and deepened
- Class III, the channel erodes deeper because the channel is no longer connect to its floodplain.
- Class IV, the channel starts to erode its streambanks because energy can no longer be dissipated on the floodplain.
- Class V, sediment deposits in the over-wide channel, and creates a new floodplain.
- Class VI, a new relatively stable channel is established with a floodplain within the original channel, and the former floodplain becomes a terrace.

Improper Sizing of Stream Channel

Improper stream sizing, either by over-sizing or under-sizing the channel, may create future problems and should be avoided. Streams that are over-sized may allow too much water to remain in the channel, in effect disconnecting the channel from the floodplain. This technique is highly discouraged due to the fact that the parabolic shape concentrates the water flow with no energy dissipation and the smooth surface increases the water velocity. The series of photos below show the sequence of stream evolution after improper post-flood response on the Third Brook stream located in Walton, NY was excavated after the 2006 flood event using the parabolic design.

Photo 1 shows an area of stream **directly after a flood event**. This area appears to be in bad condition, but it is in relatively stable form. The gravel after a flood flow settles out into an overlapping or shingle-like effect wedging sediment material together. This interlocked material is less likely to move in a smaller storm event.

Photo 2 is in the same location **after post-flood work**, notice the straight and parabolic u-shape channel. Re-arranging the stream bed and banks loosened the sediment material allowing this material to be more easily transportable.

Photo 3 shows the stream channel **two months later**. Notice that the stream has begun to erode along its streambanks and become wider. The loose sediment is easily transported downstream. The stream will continue to adjust in order to establish an equilibrium and to create a new floodplain.

Proper Sizing of Stream Channel

There are many cases where stream work is necessary to protect public infrastructure, homes, or to open up plugged channels after a flood event. To avoid situations such as those described on the previous pages, it is necessary to work with the stream and to have an understanding of how streams work. There is no one answer that fits all streams and circumstances, and in some cases technical assistance from Delaware County Soil and Water Conservation District (DCSWCD) or NYS Department Environmental of Conservation (NYSDEC) may be needed. DCSWCD offers Post-Flood Emergency Stream Intervention (ESI) training for municipality and highway department staff for more information about properly sizing stream channels.

There are two ways to properly size stream channels:

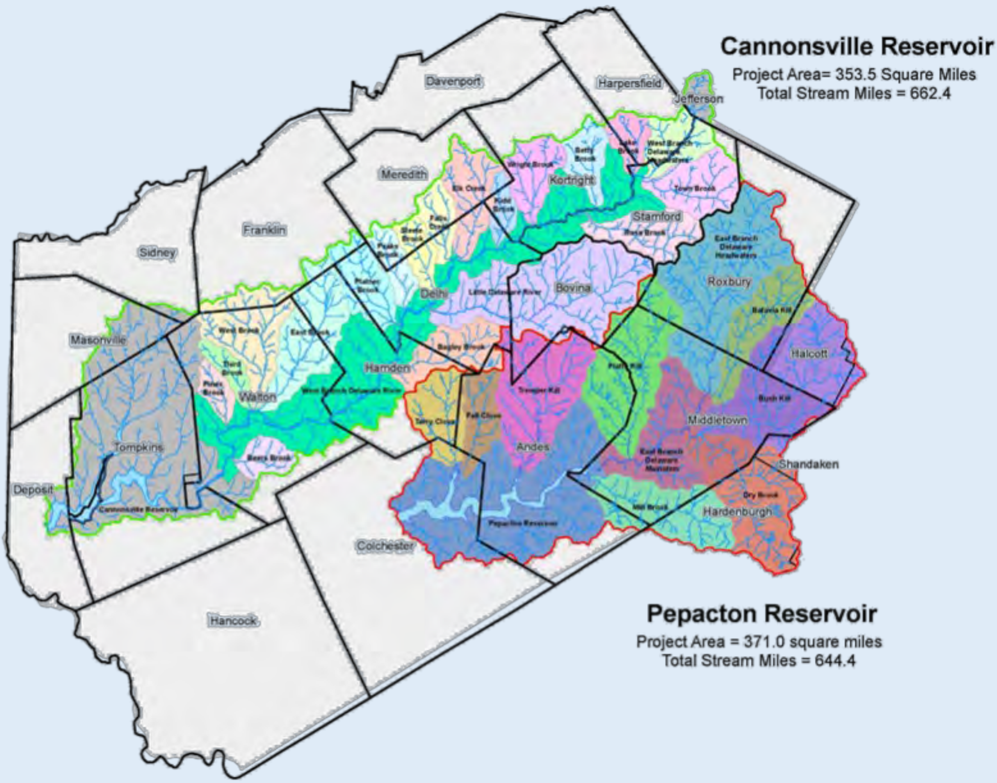
- *The Stable Riffle Reach Concept:* This is the preferred method that uses measurements (width & depth) of a stream reach that was not damaged or appears stable upstream or downstream of the impacted area. This "duplication" method will allow for natural processes to adjust the stream and have minimal adverse impact to the stream health. Similar stream slope must be taken into consideration when using this method.
- *Regional Bankfull Hydraulic Geometry Tables:* Regional Bankfull Hydraulic Geometry Tables for use throughout New York State were developed by DEC using information gathered from USGS stream gaging stations. USGS uses regression equations to relate bankfull discharge and bankfull channel dimensions (width, depth, and cross-sectional area) to watershed size at a specific stream location. With this information, DCSWCD staff can design a typical cross section to be used for the emergency reconstruction of a severely damaged stream.

Environmental Permitting

Compliance with New York State and Federal environmental permitting Laws will need to be established before any stream work can begin especially after a flood event. This compliance will need to be documented prior to receiving any Federal Emergency Management Agency (FEMA) or State Office of Emergency Management (SOEM) disaster relief funds. Work without the necessary permits can lead to significant fines, the need to redo the project, and reimbursement refusal from funding agencies. Examples requiring permits: structures across a stream (bridges or culverts), bank stabilization (rock rip rap), excavation of gravel in a stream channel, or heavy equipment in a stream to remove debris.

Get to Know Your Stream Management Program

Delaware County Soil and Water Conservation District (SWCD) contracted with the New York City Department of Environmental Protection (DEP) on December 6, 2000 for the purpose of establishing the Stream Management Program and developing stream management plans for the West and East Branches of the Delaware River and their tributaries. This partnership was established as part of the requirement of the Filtration Avoidance Determination (FAD) in order to protect the water quality of New York City's Cannonsville and Pepacton reservoirs.



Stream Corridor Management Plans

Comprehensive Stream Corridor Management Plans for the West Branch Delaware River (2006) and East Branch Delaware River (2007) were completed by the Delaware County Soil & Water Conservation District (DCSWCD), NYC Department of Environmental Protection (NYCDEP), and Delaware County Planning Department (DCPD). The plans document the overall condition of the Stream Feature Inventory (SFI) and provide recommendations that address water quality, stream stability, the protection of life and property, and wildlife habitat. The plans can be viewed on the catskillstreams.org website. Seven additional SFIs will be completed within the current 5-year contract with NYCDEP along the tributaries of the West and East Branches of the Delaware River.

A Delaware Basin Project Advisory Committee (PAC) was formed in 2008 to represent the collective interests of local government, property owners, watershed agencies, and not-for-profit organizations to identify and drive the local needs for the implementation of the stream management plan recommendations, ranking the Delaware Watershed Stream Management Implementation Program grants.

<u>Benefits for the local communities</u>:

- Enact a system-wide approach for stream restoration projects
- Apply a flood hazard mitigation program to identify flooding issues and reduce flood impacts
- Protect public infrastructure
- Protect water quality and wildlife habitat
- Provide funding, education programs, and technical assistance
- Provide highway department assistance with culvert assessment, sizing, and permitting
- Provide streamside landowners assistance with improving streamside stability and habitat by planting trees and shrubs through the Catskill Streams Buffer Initiative program
- Provide technical assistance for the National Program Insurance's Community Rating System

<u>Training available for Municipal and Local Government Officials:</u>

- Post-Flood Emergency Stream Intervention and Flood Response
- 4-Hour Erosion and Sediment Control course endorsed by NYS DEC
- Sponsorship to the New York State Floodplain Conference and sponsorship to obtain Certified Floodplain Manager certificate
- Stream Mechanics and Floodplain Management
- Stream walks, youth education and volunteer tree plantings

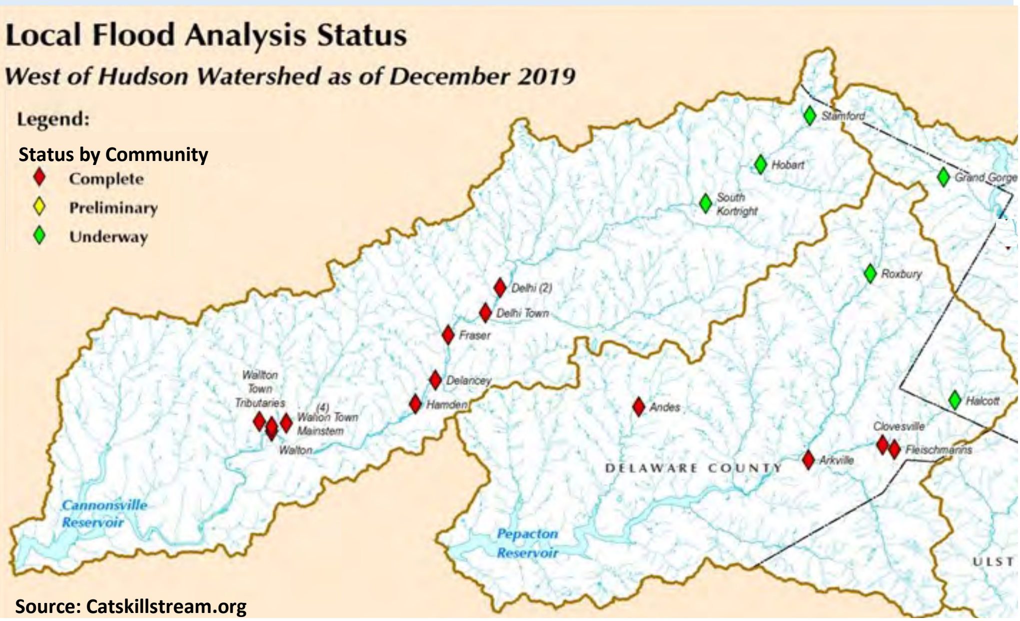
Local Flood Analysis Program

New York City watershed communities have experienced severe floods with considerable frequency in the past several years. The flood events of 1996, 2006, and 2011 delivered record levels of pollutants to the West-of-Hudson New York City reservoirs. Pollutants included a wide variety of substances and materials such as nutrients, sediment, microorganisms, raw sewage, organic and inorganic chemicals, as well as debris such as fuel tanks, lumber, houses, buildings, automobiles and personal belongings. The local communities, DCSWCD and NYCDEP were driven to find a solution that provided long-term water quality benefits as well as public safety and economic sustainability for the communities.

The Local Flood Analysis (LFA) is a volunteer program for the municipalities guided by a flood commission composed of members from local communities. The LFA is designed to analyze flood conditions and identify hazard mitigation projects following multiple high-water events in the New York City watersheds. The mission of the LFA program: to reduce the impacts of flooding to local communities and to protect the New York City water supply. Those communities participating in the LFA program as of 2019 are shown in the graphic below.

The LFA Program was written to function in two stages:

- Provide funding for an engineering analysis of flood conditions and identification of potential flood mitigation projects
- Provide grant funding for project design and implementation that are prioritized by the flood commissions with approval from the municipalities



Source: Catskillstream.org

Delaware Watershed Stream Management Implementation Program

Delaware Watershed Stream Management Implementation Program (SMIP) grant funding is available through the Delaware County SWCD Stream Management Program for municipalities that have adopted the West Branch and/or East Branch Management plans and have signed a Memorandum of Understanding (MOU). These grant funds support the stream management initiatives that benefit water quality within the New York City portions of the Delaware Watershed. Projects with water quality often have overlapping benefits that improve local infrastructure, mitigate flooding, and improve stream habitat. The following are *examples* of activities within each identified grant category. SMIP grant proposals may encompass activities not listed here; the examples are meant only as guide. Applications can be found on **Catskillstreams.org** or contact DCSWCD office 607-865-7161.

- *Flood Damage Prevention/Floodplain Management:* development of flood management planning and response plans; flood recovery assistance; flood management training.
- *Highway Infrastructure Improvement:* upgrade undersized culverts; potential cost-share to properly size bridges; potential cost-share to re-align streams upstream/downstream of bridges/culverts; utility crossing management; floodplain management on public lands.
- *Stormwater Quality Improvement:* hydro-seeding of open ditches; implementation of stormwater techniques to retain and/or infiltrate stormwater; wetland enhancement; filter strips; rain gardens and/or bioswales.
- *Stream-Based Recreation or Habitat Enhancements:* stream access improvements; increasing navigability; development of watershed recreation plans; opening streamside amenities open to public; public fishing related construction projects; fisheries improvements and habitat enhancements.
- *Restoration Projects:* any construction project not covered in the above categories. Such projects may include a gamut of projects from passive restoration to full-scale restoration projects that would provide multi-faceted benefits to local community.
- *Education/Outreach/Training:* workshops; public meetings; school projects; stream clean-ups; volunteer plantings; educational kiosks; outreach materials; training projects/opportunities; stream celebration.
- *Planning and Assessment:* floodplain management; coordinated flood response; technical assistance; land use/open space planning and/or incorporating stream management into economic development initiatives.
- *Local Flood Hazard Mitigation:* design and alterations of existing infrastructure to reduce flood water velocities, flow paths and/or elevations; positively address hydraulic constrictions; floodplain restoration and reconnection projects; restoration of naturally stable stream channel dimensions and sediment transport processes.

Note: Projects that cannot be funded by SMIP are those involving construction of berms, improper use of riprap, construction of flood control walls, use of non-native plant materials or dredging.

A Decade's Look at Stream Projects

The representatives from the Town and Village boards have been active members of the Project Advisory Committee (PAC) and Flood Commissions. Members continue to be supportive partners with the Delaware County Stream Management Program and not only help to identify projects, but provide local support for funding sources through staff time as part of their cost-share. Below is a table that summarizes the that have been completed since 2004 when project implementation began.

Total Construction Projects 2004-2020			
# Projects	Length (ft)	Total	Match Fund
80	39,848	$14,390,236	$6,526,474

Complete summary tables can be found on page 36 in **Appendix A** of all projects within Delaware County.

DCSWCD would like to thank all the agencies, municipalities, NYCDEP and stream program staff for their support with receiving grants. These grants help to supplement the NYCDEP contract funds to provide for additional projects within Delaware County.

- NYS DEC Water Quality Improvement Program (WQIP)
- NYS DEC Environmental Protection Fund (EPF)
- Army Corps of Engineers Water Resources Development Act (WRDA)
- Open Space Institute (OSI)
- Natural Resource Conservation Service Emergency Watershed Protection (EWP)
- Federal Emergency Management Agency (FEMA)

Members of the Walton Flood Commission met with representatives from the Army Corps of Engineer during a WRDA project site tour on November 5, 2018.

Stream Management Project Before and After Photos

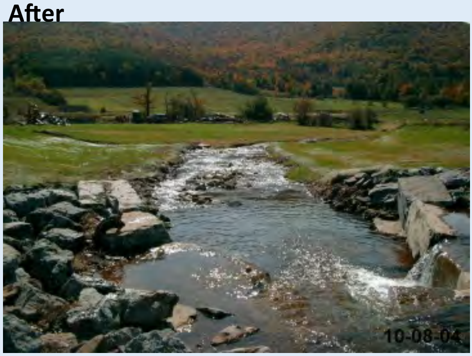
As can be seen from the tables on the previous pages, there have been a number of projects completed within the East and West Branch Delaware River Watersheds. The following section is intended to show a sample of the projects with before and after photos.

Delaware WB, Town Brook, Post Farm Repair (2004)

The first restoration project in the West Branch Delaware River watershed was completed in the Town of Stamford on Town Brook. The project length was 1200 feet and included thirteen rock cross vanes and eleven straight vanes that were incorporated along four constructed meander bends to assist in reducing shear stress and bank erosion.

Before

After



Delaware East Branch at Margaretville Fair Grounds (2008)

The first restoration project in the East Branch Delaware River watershed was completed in the Village of Margaretville. The project length was 900 feet to stabilize the channel alignment and dimensions using three rock vanes at a site where existing sheet piling was no longer functional as streambank protection.

Before

After

West Branch Delaware at Terrace Avenue (2008)

The reduction of erosion to the West Branch of the Delaware River was achieved by the installation of approximately 700 feet of rock riprap and a rock vane to direct stream flow energy toward the center of the river. In addition terraces were constructed on the bank above the stream surface for the purpose of installing plant materials for stabilization.

Before

After

Floodplain Restoration at West Brook Restoration (2011)

To prevent further flooding of the Big M and Walton Central School, a floodplain reclamation project was constructed near the Sunoco gas station. Property was purchased by Open Space Institute and donated to the Village of Walton. Soil was removed to the proper elevation and tree/shrubs were planted along the streambank.

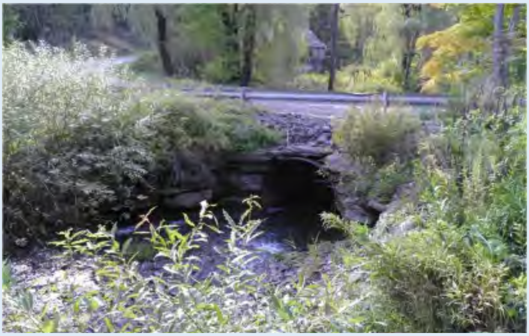
Before

After

Roses Brook, Roxbury Mountain Rd. Culvert (2012)

This project is located in the Town of Stamford and was funded by a Delaware Watershed Stream Management Implementation Program (SMIP) grant that sought to replace an undersized round culvert with a three sided culvert to increase capacity and allow the structure to pass large storm flows. Delaware County Department of Public Works partnered with DCSWCD to design and construct the culvert.

Before



After

Post-Flood Training at Dry Brook, George Rd (2013)

The DCSWCD regularly trains contractors, municipal highway personnel, and regulatory personnel to approach post-flood intervention in preparation for future floods. Part of this 2013 training was hands-on construction at a site located in the Town of Middletown. The project was implemented on Dry Brook to stabilize approximately 1,000 feet of an impaired channel by relocating the channel to its original location. The channel was re-sized using the Regional Bankfull Hydraulic Geometry Tables to establish the proper geomorphic size and shape, and restored access to the floodplain.

Before

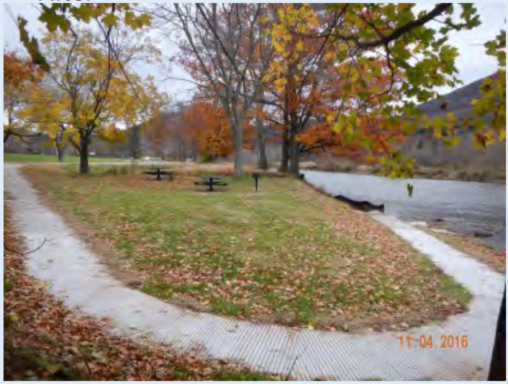
After

Ice House Boat Launch (2016)

This project is located in the Town of Walton funded under the Delaware Watershed Stream Management Implementation Program (SMIP) grant to provide river access with an "American Disabilities Act (ADA)" compliant concrete ramp. The project included a walkway to the boat launch as well as an informational kiosk.

Before

After



Floodplain Restoration at West Brook Restoration (2019)

This project consisted of the removal of approximately 52,000 cubic yards of fill material that was placed on the floodplain over the course of decades. Fill was moved to off-site locations in order to reclaim the floodplain and reduce flood water on Delaware Avenue. The work involved lowering the floodplain elevation by a maximum of 10 feet, with an average lowering of approximately, 4 feet.

Before

After

South Street Streambank Restoration (2019)

This project consisted of sheet pile driven deep below the streambed to address the mass wasting and rotational geotechnical failures causing the erosion of the existing streambank. A vegetated riprap toe was placed at approximately the bankfull elevation to resist erosive hydraulic forces, protect the stabilization material in front of the sheet pile, provide a more natural streambank, and limit the depth of the sheet pile and need for soil anchors. Joint plantings were used to vegetate portions of the rock toe above the ordinary high water mark to improve the aesthetics and provide some shade.

Before

After

Marvin Hollow Streambed and Bank Stabilization (2019)

A localized storm event in 2019 led the Marvin Hollow streambed to headcut and scour approximately 2.5 feet down over 175 linear feet, exposing a layer of glacial till. This glacial till was comprised, almost entirely, of clay and silt and caused the stream to run turbid even at low flows. This water quality concern was remedied by elevating the streambed and installing step-pools to hold grade and dissipate energy.

Before

After

Catskill Streams Buffer Initiative

Catskill Streams Buffer Initiative (CSBI) assists landowners to become better stewards of their riparian (streamside) area through protection, enhancement, management, or restoration by:

- Providing Riparian Corridor Management Plans to create awareness about riparian management issues specific to individual properties
- Implementing best management practice design and/or prescriptive measures and installation to encourage positive riparian stewardship and
- Disseminating educational materials and activities as needed for landowners so that they may understand the critical role of their buffer and how to maintain it in optimal functioning condition

Efforts by individual streamside landowners to improve and maintain proper stream processes and streamside buffers can be substantial, especially with the control of invasive species and the management of desirable native vegetation. Site visits to streamside landowners and personalized riparian corridor management plan may be provided at the request of the landowner. A riparian corridor management plan would address floodplain function, stream processes (including streambank and stream channel maintenance), invasive species control (with Japanese knotweed management as a primary focus), and the importance of desirable native streamside vegetation and its function. Funding may be available for enhancing the riparian buffer with native shrubs and trees through the Catskill Streams Buffer Initiative program. Complete summary tables can be found on page 41 in **Appendix B** of all projects within Delaware County. Visit catskillstream.org for more information or call Catherine Skalda, CSBI Coordinator at 607-865-7161.

DCMO BOCES Third Brook Plantings (2015)

The CSBI program organizes many volunteer planting events with schools, 4-H groups and local organizations. The photo to the below are students from the DCMO BOCES planting live willow stakes along the Third Brook Stream Restoration and Stabilization project that was constructed in 2014.

CREP/CSBI Historic Agricultural Lands Pilot Program

Riparian buffers are one of the most important aspects of preserving healthy streams and protecting water quality. Forested buffers, consisting of trees, shrubs and herbaceous plants, help to reduce pollution entering waterways by slowing and filtering storm-water runoff. Vegetated buffers also help to reduce flooding and erosion by stabilizing stream banks and absorbing high-velocity flows. Wildlife use buffers as travel corridors and shoreline transition zones, which increases overall biodiversity and improves in-stream health. Well-established and connected riparian areas perform critical functions for maintaining healthy, resilient stream ecosystems. The capacity for riparian areas to sustain these functions depends in part on the quality, density, and diversity of the riparian vegetation and how it interacts with the stream ecosystem.

Both the Conservation Reserve Enhancement Program (CREP) and Catskill Streams Buffer Initiative (CSBI) programs were developed to address all of these issues for the streamside farmer and homeowner. CREP is an FSA/NRCS federal-based program, which has been available for active farmlands for many years and has many benefits for the farmer, including incentive and rental payments for establishment of buffers. The federal government has recently expanded this program to include historic agricultural lands which are no longer actively farmed but still are relatively open and non-forested. CSBI has been available to non-farm homeowners within the New York City West of Hudson Watersheds for nearly 10 years, and assists non-farm landowners in the design and implementation of riparian buffers to enhance the resiliency and stability of their properties. Combining these two programs offers landowners with historic farmland or marginal pastureland the added benefits of both the CREP and CSBI programs.

Research has shown that there are great environmental benefits to planting forested riparian buffers along streams even if there are no cattle or cropping inputs that need to be filtered by the buffers. There are great benefits to in-stream habitats both from the shade as well as other woody material input into the stream. These in-stream habitats in turn help to clean the water in the stream by processing nutrients.

Additional benefits offered by forested riparian buffers include:

- increased shade to reduce water temperature and increase dissolved oxygen concentrations in stream,
- added organic matter and woody material to the stream, providing food and structure for aquatic organisms,
- stabilizing stream banks with deeper roots than herbaceous buffers, reducing sediment to stream,
- creating travel corridors and habitat for song birds and other wildlife,
- increased removal of nitrogen and other nutrients and pollution

Enrollment in the CREP/CSBI program will allow the landowner to improve their property by establishing a forested riparian buffer and all of its associated ecological benefits, while receiving compensation for the installed practices, as well as installation of additional practices not included in the federal program, such as native seed establishment, addressing streambank stability issues, expansion of planting areas and plant densities, and invasive species control. Additionally, landowners will have access to expert technical assistance through their County Soil and Water Conservation Districts (SWCD), as well as development of Best Management Practices (BMPs) and a Riparian Corridor Management Plan (RCMP).

Below is a table that summarizes the pilot projects that were completed in 2019.

Project / Planting	Stream	Total 2019 Planting Acres	Total Number of Plants	Stream Feet
Parrinello	East Brook	**12.06**	2839	**2500**
D'Orazio	East Brook	**4.94**	956	**1350**
Siegel	East Brook	**1.34**	473	**1600**
Hobbs	East Brook	**1.32**	669	**1000**

Photo: Siegel CREP/CSBI riparian buffer planting on East Brook in the Town of Walton.

Post-Flood Emergency Stream Intervention

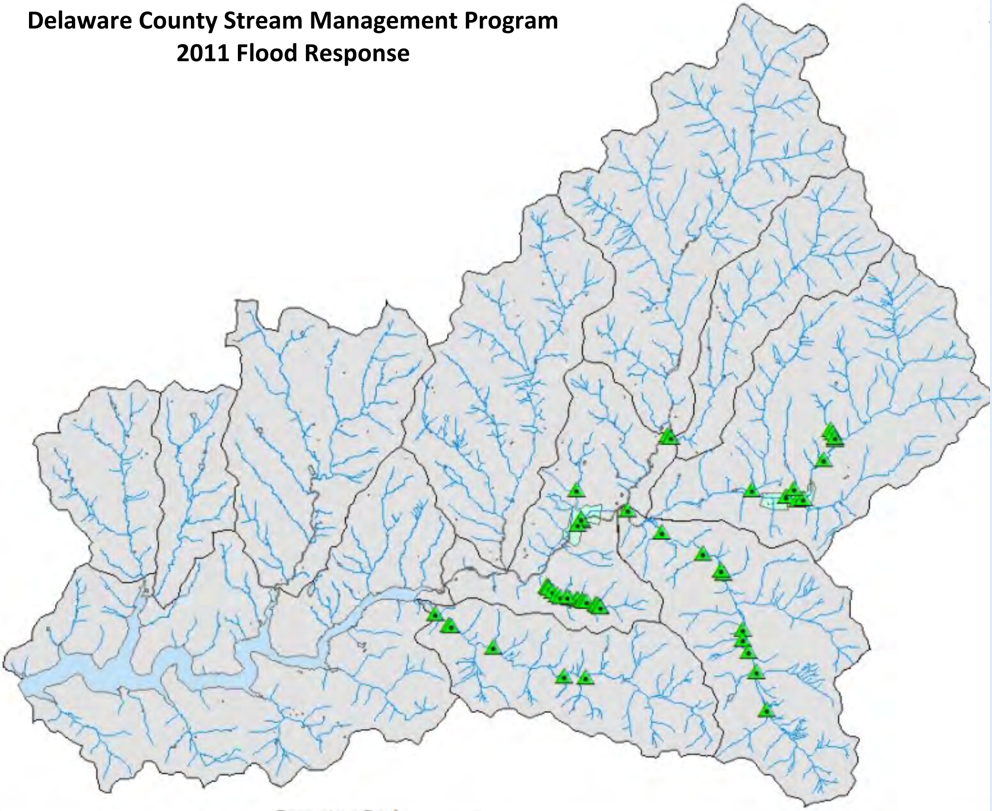
Emergency stream work or "stream intervention" must occur within hours and days of a damage flood event, leaving little time for assessment and design. Deciding where to work and how much to address are critical to effective response. Over-excavating stream channels or extending operations into less impacted stream reaches can have negative implications for stream function, stream stability, aquatic habitat, and water quality, not to mention fiscal consequences to the community. DCSWCD, working from their experience following floods in 2006-2008, provided local highway departments and private construction contractors with a series of hands on training sessions to enable them to make decisions on where and how to work in streams following flood events. DCSWCD stream program staff developed a protocol for the proper sizing of streams in the Catskills and strategies for restoring the stream's access to its floodplain, preserving sinuosity, and minimizing disturbance. This training also demonstrated these concepts at 5 construction sites within the Catskill that had features of a flood damaged streams. The training was sponsored by NYSDEC Environmental Protection Fund and DCSWCD contract funds from NYCDEP. Over 1,000 contractors, highway department, NYSDOT, NYSDEC and other agency staff have been trained in post-flood response. This program was so successful that NYSDEC expanded the training to be a state-wide program.

In 2011, Delaware County experienced more historic flooding from Hurricane Irene and Tropical Storm Lee, devastating the East Branch Delaware River communities. A coordinated effort was created in the post-flood efforts with the Delaware County Emergency Operation Center, Delaware County Department of Public Works, Town Highway Departments, municipal leaders and the Delaware County Soil and Water Conservation District. Using the post-flood emergency stream intervention protocol at 41 damaged sites, DCSWCD staff assisted the highway departments and local contractors with permitting, technical assistance on sizing streams, and construction site inspections.

Benefits for the local communities:

- Quick response time, and long lasting stream project that will require little maintenance in the future
- Technical assistance immediately following flood for emergency stream channel repair
- Assistance in acquiring regulatory permits needed for FEMA funding reimbursement

Delaware County Stream Management Program
2011 Flood Response



Pepacton Basin

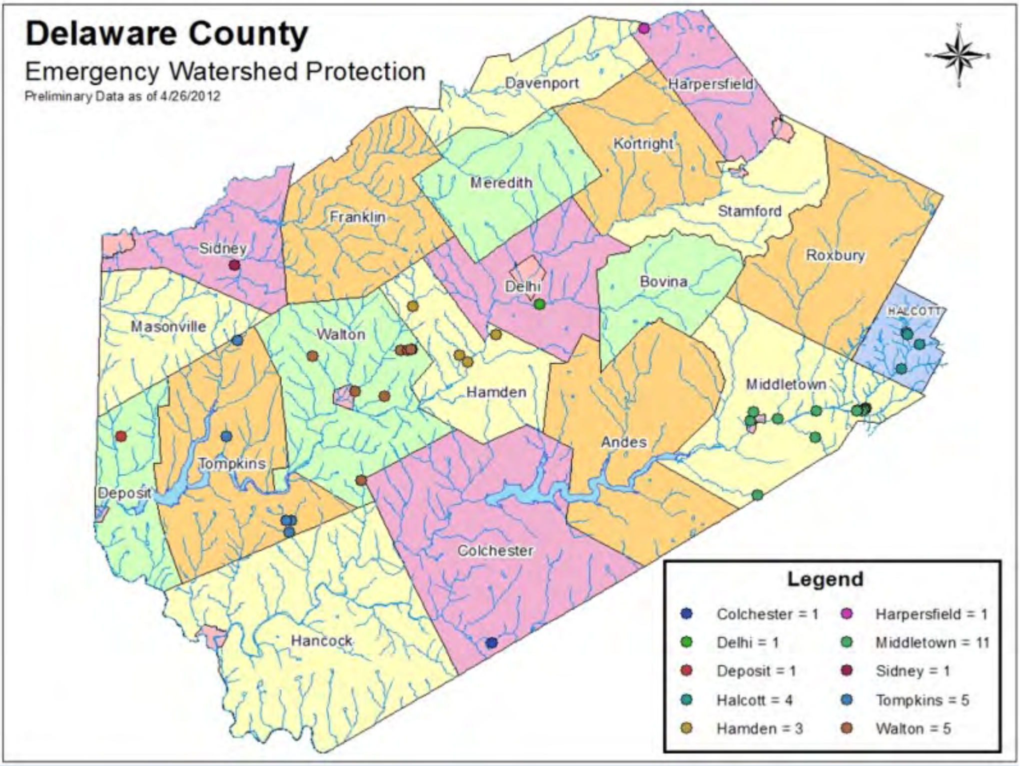
Streams	Remediation (miles)	Inspection (miles)
Mill Brook	0.2	0.7
Huckleberry Brook	1	1.2
Bull Run	0.1	0.5
Dry Brook	2.1	4
Big Red Kill	0.4	0.1
Bush Kill	0.2	1.1
Emory Brook	0.1	0.1
Vly Creek	0.5	1.4
Bruce Scudder	0.2	0
Batavia Kill	0.1	0
East Branch Del.	0	0.2
Johnson Hollow	0	0.1
Mead Hollow	0	0.2
Turk Hollow	0	0.4
Elk Creek	0	0.3
West Settlement	0	0.5
Little Red Kill	0	0.1
Total	4.9	10.9

Photo above shows post-flood response after 2011 on Mill Brook after DCSWCD staff technical assistance with stream channel dimensions.

Emergency Watershed Protection Projects

In 2012, Delaware County municipalities received funding through the Natural Resource Conservation Service's Emergency Watershed Protection (EWP) program to complete 32 projects on streams that were impacted by Hurricane Irene and Tropical Storm Lee. The Emergency Watershed Protection (EWP) program funds 75% of the cost to implement the project; a 25% match was funded by Delaware County Soil and Water Conservation District's contract with New York City Department of Environmental Protection (in NYC Watershed) as well as the New York State Empire State grant (outside NYC Watershed). Delaware County Soil and Water Conservation District's Stream Corridor Management Program and Delaware County Department of Public Works designed the projects and conducted the construction oversight.

Below is a map showing the project locations throughout Delaware County and also four projects within Greene County.



Emergency Watershed Protection Projects Before and After Photos

Delaware County Soil and Water Conservation District staff have assisted municipalities inside and outside the NYC watersheds with design, regulatory permits, bidding and construction inspection through funding from the Natural Resources Conservation Service's Emergency Watershed Protection funds and the Empire State Development Funds (provided the 25% cost-share for outside NYC watershed projects). This section is intended to show a sample of the projects with before and after photos.

Town of Harpersfield: Johnson Road (2013)

This project consisted of repairing an eroding streambank and removing excessive gravel deposition on Charlotte Creek. 500 linear feet of riprap was installed along the toe of the bank to protect the road and utility poles.

Before

After

Town of Delhi: Thomson Cross Road (2013)

This project consisted of streambank repair along Thomson Cross Road on the Little Delaware River. To protect the eroding streambank, rip rap was buried along approximately 500 feet of the bank to create a bench. Live willow stakes were planted in between the rip rap. The steep hill slope was seeded and mulched.

Before

After

Future Stream Management Projects

Delaware County Soil and Water Conservation District recently signed another 5-year contract with New York City Department of Environmental Protection to continue to fund the existing Stream Management Program; this most recent contract will end in 2025 and is expected to continue further in the future. Staff will continue to provide technical assistance to all municipalities and landowners whenever requested. In addition, DCSWCD will complete the contract deliverables listed below:

- Delaware Watershed Stream Management Implementation Program Grant funding
- Local Flood Analysis Project implementation
- Stream Feature Inventory
- Education and Outreach workshops and trainings
- Large Bioengineered Catskill Stream Buffer Initiative Project implementation
- Catskill Streams Buffer Initiative Program (CSBI) Riparian Buffer Project implementation
- Riparian Buffer Management Plans creation for CSBI Program

To find out more information about the Delaware Watershed projects, programs, training opportunities or grants, please visit the Catskillstreams.org website or contact Delaware County Soil and Water Conservation District at:

Delaware County Soil and Water Conservation District
Stream Management Program
44 West Street, Suite 1
Walton, NY 13856
607-865-5223 Phone
607-865-5335 Fax

Appendix A

The tables on the following pages summarizes all projects within Delaware County that have been completed since 2004 when project implementation began.

Year Completed	Municipality	Project Name	Length (ft)	Total	Match Fund	Match Fund
2004	Town of Stamford	Delaware WB, Town Brook, Post Farm	1,200	$226,260	$169,422.64	EPF-NPS
2006	Town of Stamford	Delaware WB, Town Brook, Post Farm Repair	1,125	$68,718	$49,000	SDWA
2007	Town of Andes	Delaware EB, Tremper Kill, Tuttle Farm	1,000	$71,718	$35,859	EPF-NPS
2007	Town of Kortright	Delaware WB, Wright Brook, Rama Farm	1,100	$91,254	$59,327	EPF-PPG
2007	Town of Stamford	Delaware WB, Town Brook, Palmatier Farm	150	$51,170	$26,560	SDWA
2008	Town of Walton	West Branch Delaware at Terrace Avenue	850	$871,216	$721,855	WRDA
2008	Village of Mar-garetville	Delaware EB, Margaretville Fair Grounds	700	$390,076	$195,038	EPF-PPG
2009	Town of Hamden	Launt Hollow, Post Flood Response Training Site	1,200	$28,900	$14,450	EPF-WQIP
2009	Town of Middletown	Platte Kill, Post Flood Re-sponse Training Site	400	$18,200	$9,100	EPF-WQIP
2009	Town of Tompkins	Delaware WB, Trout Creek, Loewentheil Farm	1,275	$115,305	$67,904	EPF-NPS
2009	Town of Walton	West Brook, Post Flood Re-sponse Training Site	1,100	$28,000	$14,000	EPF-WQIP
2010	Town of Walton	East Brook, County Rt 22	650	$336,631	$330,981	FEMA

Year Completed	Municipality	Project Name	Length (ft)	Total	Match Fund	Match Fund
2011	Town of Hamden	Mallory Brook Culvert	200	$170,202	$0	None
2011	Town of Harpersfield	ODell Lake Rd Ditch Stabilization	300	$29,008	$0	None
2011	Town of Walton	Pines Brook Culvert Outfall	50	$8,500	$0	None
2011	Village of Walton	Floodplain Restoration at West Brook Restoration	500	$313,326	$197,490	OSI Land Purchase
2012	Town of Roxbury	Johnson Hollow Brook, Van-Valkenburg Farm	1,050	$35,984	$0	None
2012	Town of Stamford	Roses Brook, Roxbury Mountain Rd. Culvert	27	$246,720	$0	DEP
2012	Town of Walton	Marvin Hollow, DSR-D-TW-03	75	$5,300	$3,975	EWP
2013	Town of Delhi	Little Delaware, Thompson Cross Rd.	500	$89,832	$62,874	EWP
2013	Town of Delhi	Frisbee Farm Streambank Stabilization	180	$29,500	$0	None
2013	Town of Halcott	Elk Creek	125	$68,550	$68,550	EWP
2013	Town of Halcott	Turk Hollow	150	$24,263	$24,263	EWP
2013	Town of Halcott	Vly Creek 1	250	$30,653	$30,653	EWP
2013	Town of Halcott	Vly Creek2	300	$58,740	$58,740	EWP
2013	Town of Hamden	East Brook, Phoenix Farm	125	$74,500	$55,875	EWP
2013	Town of Hamden	Holmes Hollow	80	$28,951	$21,713	EWP
2013	Town of Hamden	Launt Hollow	140	$19,924	$14,943	EWP
2013	Town of Kortright	Swantak Streambank Stabilization Project	126	$34,821	$0	None
2013	Town of Middletown	Bull Run	165	$46,500	$34,875	EWP
2013	Town of Middletown	Bush Kill, Bauer Property	200	$59,710	$44,782	EWP
2013	Town of Middletown	Bush Kill, Fleischmanns Site 07	400	$220,867	$75,851	EWP
2013	Town of	Dry Brook, Arkville	1,145	$398,427	$298,820	EWP

Year Completed	Municipality	Project Name	Length (ft)	Total	Match Fund	Match Fund
2013	Town of Middletown	Dry Brook, George Rd	600	$68,709	$51,532	EWP
2013	Town of Middletown	Mill Brook Stream Stabilization	150	$29,977	$22,483	EWP
2013	Town of Middletown	George Rd, Post Flood Response Training Site	1,039	$63,500	$45,500	EPF-WQIP
2013	Town of Tompkins	Chamberlain Brook	55	$27,222	$20,417	EWP
2013	Town of Tompkins	Trout Creek, Pine Swamp Rd	200	$48,952	$36,714	EWP
2013	Town of Walton	East Brook, CT RT 22 Phase II	1,050	$143,500	$93,000	EWP
2013	Town of Walton	McGibbon Hollow, Sites 1,2,3,4	296	$62,300	$46,724	EWP
2013	Village of Fleischmanns	Vly Creek Fleischmanns Site 04	470	$631,546	$473,660	EWP
2013	Village of Fleischmanns	Vly Creek Fleischmanns Site 05	423	$210,337	$133,508	EWP
2013	Village of Fleischmanns	Vly Creek Fleischmanns Site 2-3	500	$269,601	$202,201	EWP
2013	Village of Margaretville	Scotts Run, Margaretville Bus Garage	440	$39,300	$29,475	EWP
2014	Town of Hamden	Chambers Hollow Bank Stabilization	230	$60,000	$45,000	EWP
2014	Town of Hamden	Lower Dingle Hill Streambank Stabilization	165	$25,850	$0	None
2014	Town of Middletown	Johnson Farm Streambank Stabilization	400	$53,483	$0	None
2014	Town of Middletown	Gray Farm Streambank Stabilization	203	$18,727	$0	None
2014	Town of Walton	Beers Brook Bank Stabilization #1	310	$50,793	$0	None
2014	Town of Walton	Beers Brook Bank Stabilization #2	320	$47,962	$0	None
2014	Town of Walton	Third Brook Stream Restoration and Stablilization	1,110	$457,034	$342,775	WRDA
2015	Town of Andes	Gulf Brook	135	$71,102	$0	None
2015	Town of Colchester	Holiday Brook	220	$39,110	$0	None

Year Completed	Municipality	Project Name	Length (ft)	Total	Match Fund	Match Fund
2015	Town of Wal-	Walton Green	0	$20,000	$0	None
2015	Town of Wal-	Third Brook Emer-	700	$157,803	$29,216	WRDA
2016	Town of	Hamden Boat	100	$55,718	$0	None
2016	Town of	West branch Resto-	1,500	$1,293,169	$0	None
2016	Town of Stamford	Palmatier	241	$25,590	$0	None
2016	Town of Wal-	Boyd	847	$140,980	$0	None
2016	Town of Wal-	Walton Boat launch	100	$82,900	$0	None
2017	Town of Bo-	Little Delaware	760	$298,427	$0	None
2017	Town of Tompkins	Magee ESI	290	$28,700	$0	None
2017	Town of Wal-	East Brook ESI	600	$184,000	$0	None
2018	Town of	Phoenix	1,900	$344,000	$0	None
2018	Town of Hamden	East Brook SL 5.68 Road Shoulder Stabilization	191	$69,500	$0	None
2018	Town of Harpersfield	Odell Lake Road Culvert Replace-ment	50	$321,000	$144,465	WRDA
2018	Town of Stamford	Town Brook SL 4.78 Streambank Stabili-zation	175	$35,900	$0	None
2018	Town of Wal-	Beers Brook SL 3.3	180	$35,000	$0	None
2018	Village of Fleischmanns	Fleischmanns Floodplain Restora-tion Project	525	$140,000	$0	None
2018	Village of	Grant Brook Wall	60	$22,538	$0	None
2018	Village of Walton	West Branch Dela-ware River Flood-plain Reclamation	640	$1,184,950	$484,320	WRDA

Year Completed	Municipality	Project Name	Length (ft)	Total	Match Fund	Match Fund
2019	Town of Andes	Close Hollow Road Slope Stabilization	160	$210,147	$40,000	WRDA
2019	Town of Bovina	Miller Ave Culvert Re-placement Project	110	$344,896	$182,856	WQIP
2019	Town of Harden-burgh	Mill Brook Slope Stabili-zation	950	$565,000	$0	None
2019	Town of Roxbury	Hardscrabble Stream-bank Stabilization	950	$147,792	$109,000	WRDA
2019	Town of Walton	Marvin Hollow Streambed and Bank Stabilization	175	$59,950	$0	None
2019	Village of Delhi	Delhi River Walk Phase II	200	$60,534	$0	None
2019	Village of Walton	South Street Stream-bank Restoration	600	$1,746,760	$1,306,728	WRDA/ WQIP
2020	Town of Middletown	Catskill Recreation Foot Path	2,640	$40,383	$0	None
2020	Village of Walton	Water Street Boat Launch	50	$63,870	$0	None

Appendix B

The tables on the following pages summarizes all projects for **Catskill Streams Buffer Initiative** within Delaware County that have been completed since 2009 when project implementation began.

Project Year	Project Name	Stream	Town/Village
2009	Bare Root Planting-In house	Plattekill Creek	Middletown/New Kingston
2009	Frog Alley	Headwaters EB Delaware	Middletown
2009	Riparian Sedge Planting	Launt Hollow	Hamden
2009	Riparian Planting Stakes- in house	West Brook	Walton
2009	Trout Creek (Loewentheil) Contract Planting	Trout Creek	Trout Creek
2010	Mary Smith Hill	Mary Smith Brook	Roxbury
2010	Coulter Brook B	Little Delaware River	Bovina
2010	Plattekill Supplemental in house planting	Plattekill Creek	Middletown
2010	Plattekill Trib	Plattekill Creek	Middletown/New Kingston
2010	Coulter Brook A	Little Delaware River	Bovina
2010	Brush Brook Trib-Tires B	Brush Brook Trib	Bovina
2010	Elm Street-Delhi	Steele Brook	Delhi
2010	Glen Burnie	Glen Burnie Brook	Delhi
2010	EB Headwaters-Macmore Rd	Headwaters EB Delaware	Roxbury
2010	Brush Brook Trib Tires A	Brush Brook Trib	Bovina
2010	Marvin Hollow	Marvin Hollow Brook	Walton
2010	East Brook - CR22	East Brook	Walton
2010	Pines Brook Planting-In house	Pines Brook	Walton

Project Year	Project Name	Stream	Town/Village
2010	Andes - Ballentine Park Planting	Tremperskill Creek	Andes
2010	Roxbury - Kirkside Park Planting	East Branch Delaware	Roxbury
2010	Margaretville - Village Park Planting	East Branch Delaware	Margaretville
2010	Beers Brook B	Beers Brook	Walton
2010	Beers Brook A	Beers Brook	Walton
2011	Plattekill Creek-New Kingston	Plattekill Creek	Middletown/New Kingston
2011	Halcott Comm Garden-Vly Creek Trib Plantings	Vly Creek	Halcott Center
2011	Meadows Golf Center Planting	East Branch Delaware	Margaretville
2011	East Platner Brook Planting & Knotweed yr 1	Trib to East Platner Brook	Delhi
2011	Thomson Hollow IS & Planting-yr 1 (contract)	Thomson Hollow Brook	Roxbury
2011	West Brook Restoration A	West Brook	Walton
2011	West Brook Restoration B	West Brook	Walton
2011	Mallory Brook	Mallory Brook	Hamden
2011	SUNY Delhi OEC Planting-Spring	Little Delaware	Delhi
2011	Weaver Hollow Restoration	Weaver Hollow Brook	Andes
2011	Davis Floodplain	West Brook	Walton
2012	Delaware Avenue Riparian Planting	West Branch Dela-ware	Delhi
2012	Trib to Little Delaware, MF Rose/ planting - Yr 1 part 2	Little Delaware Trib	Delhi
2012	Montgomery Hollow Riparian Restora-tion	South Montgomery Hollow Brook	Roxbury
2012	Peakes Brook Riparian Restoration	Peakes Brook	Delhi
2012	Mill Brook Riparian Restoration #1 (Contract)	Mill Brook	Middletown