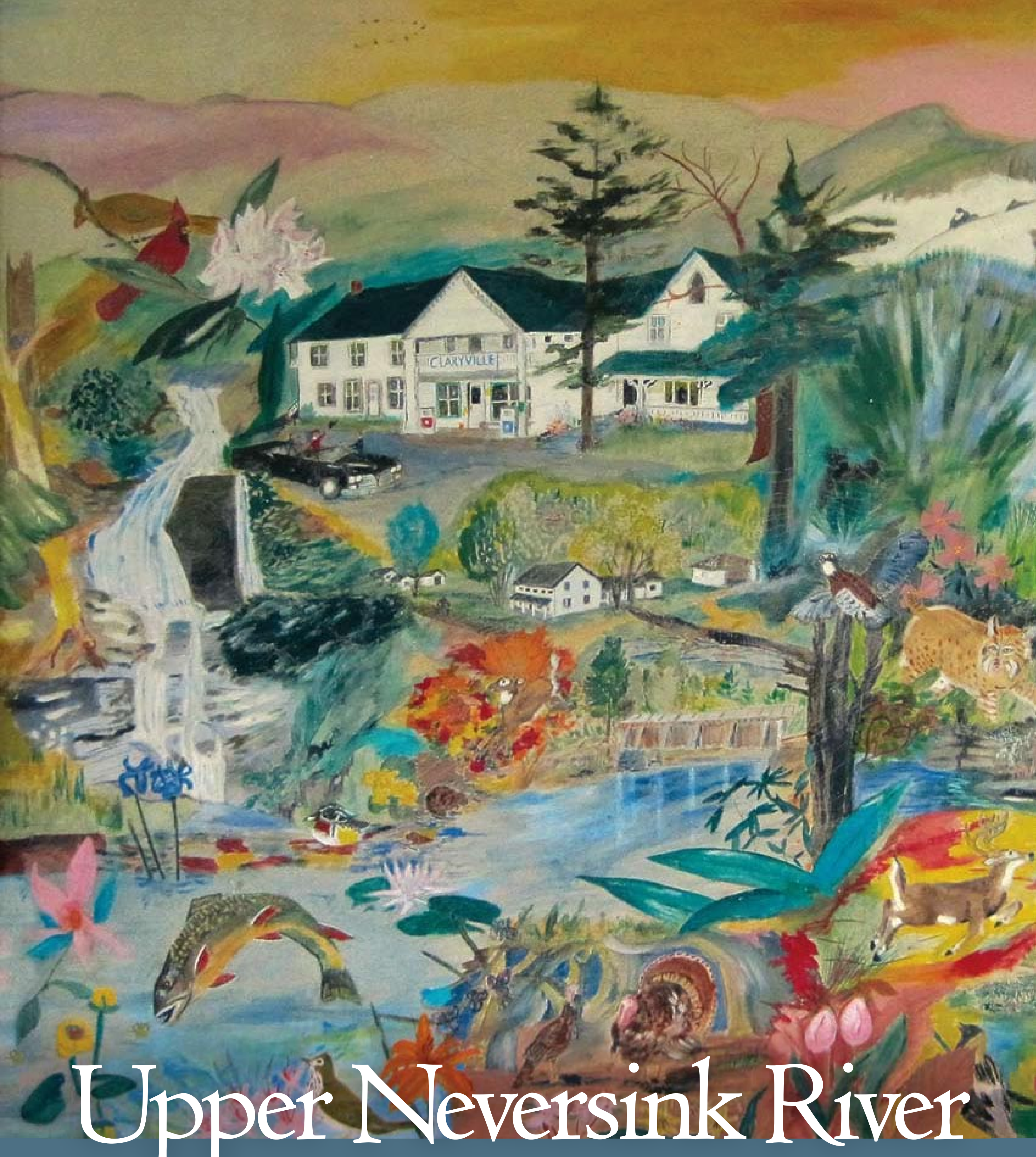
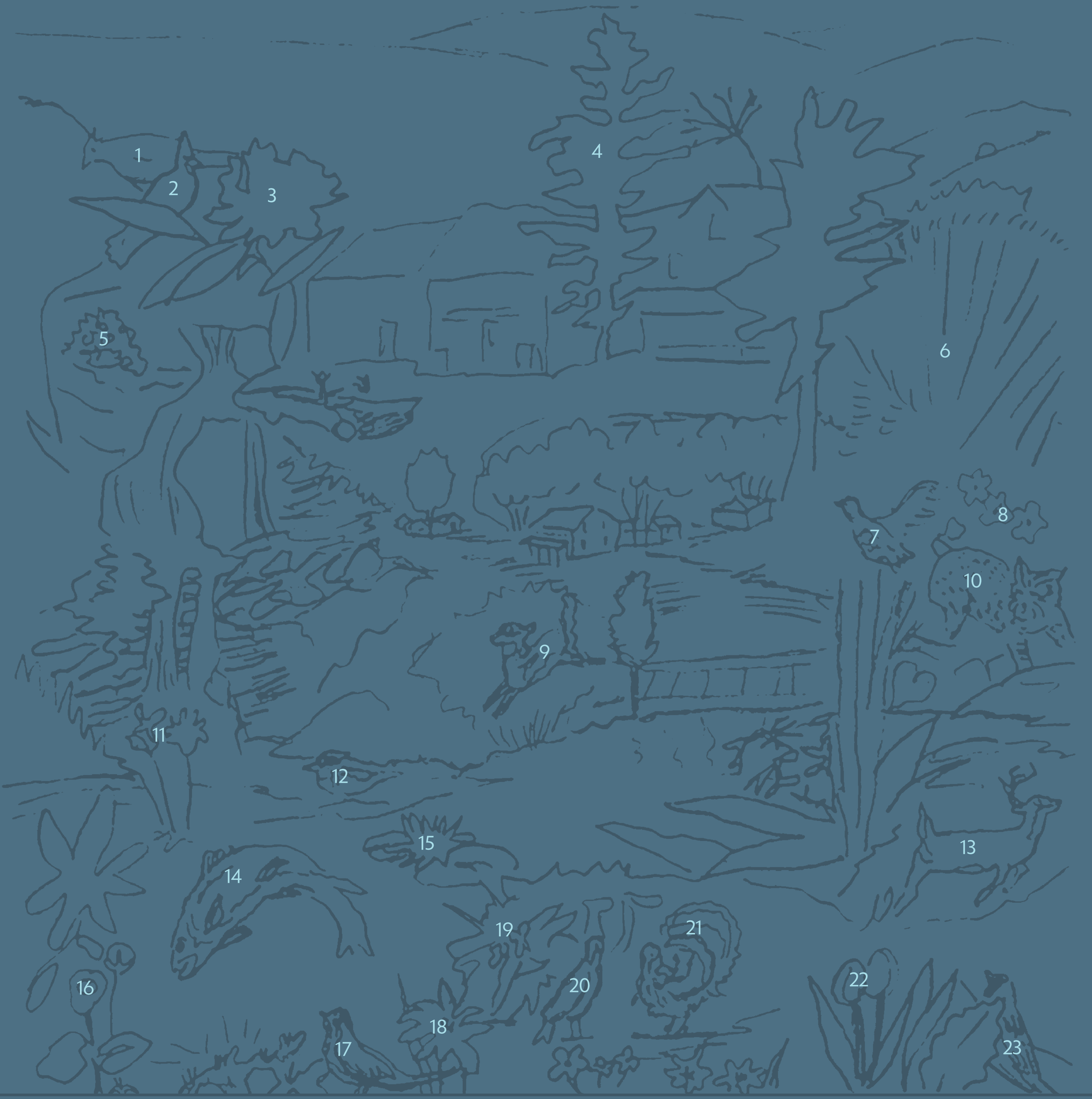


Upper Neversink River

Stream Management Plan

RONDOUT NEVERSINK
STREAM PROGRAM
SULLIVAN COUNTY SOIL & WATER CONSERVATION DISTRICT



Bob Dice painted *The Claryville Mural* during the years 1973–1979, an illustration of both the natural and built worlds of the Neversink River. The mural includes many different images of the Claryville area including the fire tower, tannery chimneys, the old General Store and post office and some of the oldest homes in the area. Bob served as Town of Neversink Historian for a number of years and is remembered for the local history hikes he lead. The painting, presently owned by the Dice family, shows his love and knowledge of the neighborhood.

1. Female Cardinal
2. Male Cardinal
3. Great Rhododendron
4. Eastern Hemlock
5. Mountain Laurel
6. Silky Willow
7. Ruffed Grouse
8. Soapwort
9. Whitetail faun
10. Bobcat
11. Blue Flag Iris
12. Wood Duck
13. Whitetail buck
14. Brook Trout
15. Fragrant Water Lily
16. Variegated Pond-Lily
17. Bicknell's Thrush
18. Daylily
19. Blue Marsh Violet
20. Wild Turkey Hen
21. Wild Turkey Tom
22. Pink Lady Slippers
23. American Goldfinch

Upper Neversink River

Stream Management Plan

RONDOUT NEVERSINK
STREAM PROGRAM
SULLIVAN COUNTY SOIL & WATER CONSERVATION DISTRICT

Acknowledgments

THE RONDOUT NEVERSINK STREAM PROGRAM is pleased to release the Upper Neversink River Stream Management Plan, a guide outlining management options for local residents, municipalities, interested organizations and agencies to conserve the Neversink watershed.

The Project Team gives special thanks to the streamside residents who assisted the planning effort by providing valuable information in our public surveys, sharing history, maps and photographs of the stream, and giving permission for our field crews to access the stream for data collection. We met many landowners who shared their experiences of living streamside for generations. Through our stream feature inventory, we developed a better understanding of stream conditions and trends, and look forward to implementing management recommendations that will help efforts to coordinate projects that can meet the communities goals and lead to a healthier Neversink River.

Thanks to the primary authors of this plan: Mark Vian and Chris Tran of NYC DEP, Jenn Hoyle of Milone and Macbroom, Inc., and Carol Smythe (Neversink Historian). Additional thanks to the data collection and management team: Shawn Goulet and Dan Melnick of Milone and Macbroom, Inc., and Tiffany Runge, Anthony Lombardo, Anthony Micucci, Bob Walner, Beth Dickinson, and Lisa Jennings, student interns from SUNY Ulster. Thanks to Paul Brown of NYC DEP who knows the river from decades of water testing; and the entire staff of Sullivan County Soil & Water Conservation District including Stacie Howell and Brenden Wagner. Due to watershed regional similarities, significant portions of this Neversink Plan were adapted from plans created for the Rondout, Schoharie and Ashokan basins.

The planning process would not be possible without the helpful, active involvement and public support of Stream Management Planning by the Town Supervisors of Denning and Neversink, Bill Bruning and Mark McCarthy, respectively. Highway Superintendents Dan Van Saders (Denning) and Preston Kelly (Neversink) contributed invaluable information from the field in their area of expertise. And thank you to those who attended our neighborhood meetings, and shared stream history: Mike Dean, Bud Cox; Karl Connell, the late Mike Schiffer, Mitchell and Gioia Brock, and members of the Winnisook Club. Our outreach in the community related to the plan would not have been successful without the enthusiastic assistance of Barbara Redfield, Pat Wellington and the members of Neversink Association, our Watershed Advisory Group participants, and the many additional volunteers listed in this document. Your input, support and guidance in development of this plan helped produce what we believe will be an important tool for managing the Neversink River in challenging times.

This plan will be put forth for adoption by the Towns of Neversink and Denning during the winter of 2013.

KAREN RAUTER, *Stream Program Coordinator*
Rondout Neversink Stream Program
Grahamsville, NY
February 2013

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Introduction

Why do we need a Stream Management Plan?

The community process for local stream management planning is an emerging practice in the Catskills region that recognizes the stream's importance to our overall quality of life. The purpose is to coordinate decision-making around common goals we collectively identify for the stream. This stream management plan was created cooperatively by bringing together the Neversink watershed community, local leaders and area agency representatives, and identifies many common goals for the Neversink River and its adjacent floodplains, forests and wetlands.

The residents of the Upper Neversink River valley—from the High Peaks of Denning to the Neversink Reservoir—know the awesome power of the River. Over the past several centuries, they learned how to harness that power for industry, but also to keep out of its way when floodwaters roared. High water on this river is often described as the fearful sound of tumbling boulders as they are pushed down the streambed, shaking the foundations of homes and the people inside.

Over generations, working mills, tanneries, berms, revetment and "digger dams" for fish habitat were installed, and in some reaches, the River was intentionally redirected. Abutments and numerous bridges were built to allow human settlement on both sides of the stream. Stunning waterfalls frequently flow across narrow points in the roads constructed through the valley, causing road failures in notorious spots that are faithfully repaired again and again.

Floodplains and streamside wetlands were filled in some places while diversions to sluice water into floodplain ponds were created in others, and pastures and lawns have frequently been cleared along creek banks and terraces. Fishing clubs have historically supplemented the native fisheries by introducing sport fish for recreation.

Each of these activities contributes to the overall picture of stream management in practice today along the Neversink. Even with these human impacts, the stream remains relatively wild, and generally quite healthy. It shifts around within its floodplain during big floods, as those who remember the floods of 1928 or 1996 and many others will attest. The fishing is good, but local anglers will tell you it was better twenty years ago. The water quality is high for the most part, but recent floods have created new conditions that contribute to turbidity. The forests that have returned to the hillsides throughout the Catskills over the past century keep the water cooler and the banks more stable overall on the Neversink. So why does this stream need a management plan?

In past years, most activities affecting the stream have been relatively uncoordinated. Landowners managed their own stream banks and floodplains; highway superintendents managed road embankments and bridges; power companies clear their rights-of-way.

When there were major problems, federal agencies such as Natural Resources Conservation Service or the Federal Emergency Management Agency brought resources to address immediate needs. NYS Department of Environmental Conservation requires a permit for certain activities in or near streams. The U.S. Army Corps of Engineers also has a similar permitting program.

Each of these players in stream management has had their own objectives, specific knowledge or area of expertise, and individual ideas about what needs to be done to keep their section of the stream healthy. No single force, however, holds responsibility for coordinating all of these isolated efforts. More importantly, as a group we can pay more attention to how one action on the stream may directly compromise the interests and efforts of others.

Streams are systems: what someone does on their own stream bank can create significant effects—good or bad—upstream or downstream. In this way, streams are in many ways a community resource, and might be better managed with

a coordinated effort. We recognize the many benefits streams contribute to our community's quality of life, and also the many risks they pose. Coordinating our decision-making around stream management goals we identify and hold together will contribute to the common good.

This coordination requires an ongoing commitment, and this Plan provides a framework and process to significantly improve those efforts. With a wealth of local knowledge about the Neversink, many questions still remain:

- *What are the safest management options for the community which includes major roads and development in the floodplain?*
- *How can we know whether the erosion we see along stream banks is just a natural part of the way streams evolve, or whether we are seeing excessive erosion and a stream system destabilized by the way we've managed it in the past?*
- *Where there are problems, will the stream "fix" itself, and how long will that take? What further problems will likely result in the meantime?*
- *Do we need to change our management strategies, and undertake proactive projects to restore or protect stream channel stability?*
- *Large trees falling into the stream as a result of erosion can cause the stream to change course and act unpredictably, but will removing the wood destabilize the stream in a different way?*
- *How can we know more reliably the condition of the fish community and the quality of the stream habitat?*
- *Where should we invest our limited resources for restoration or protection?*
- *What is the trend in the overall ecological health of the Neversink River?*

In recent decades, advances have been made in the science of stream form and function. As part of the process of developing this plan, assessments and inventory of the condition of the stream were undertaken using state of the art methods, and the results of those assessments are described in this Plan. These baseline conditions in the upper Neversink River will help those faced with these challenging questions measure future conditions against the baseline to determine trends.

In late 2009, New York City Department of Environmental Protection (DEP) contracted Sullivan County Soil and Water Conservation District (SCSWCD) to develop and implement a stream management plan for the Upper Neversink River Watershed. This stream management plan represents the joint efforts of the Neversink streamside community, local leaders and representatives of agencies involved in different aspects of stream management.

In addition to identifying our common goals, it identifies competing goals as well, and provides a road map for coordination among the many stakeholders—or those who rely on, work with, recreate in, and/or live by the waters of the Neversink, including: local landowners concerned about erosion, flooding, the fishery and the beauty of the stream; the highway departments of the Towns of Denning and Neversink, Sullivan and Ulster Counties, who are responsible for managing the roads, bridges and

culverts that residents and area emergency personnel use regularly; angling clubs whose members return year after year to the birthplace of flyfishing; and the downstream communities of the lower Neversink and the City of New York, whose nine million residents ultimately receive some of the Neversink's water for drinking.

The Neversink River Stream Management Plan summarizes the benefits, problems and needs of the entire creek and watershed sub-basin. The plan provides recommendations for long-term stream stewardship and protection of water quality. This Plan also includes summaries of earlier investigations and historical data on the Upper Neversink, as well as the results of inventories, assessments and analyses completed specifically for inclusion in the Plan. Based on this information, the Plan presents recommendations we can follow to individually and collectively reduce the risks of living in the Neversink valley, improve the ecology of the stream and floodplain, and protect its many ways it is a valuable resource to everyone in the community.

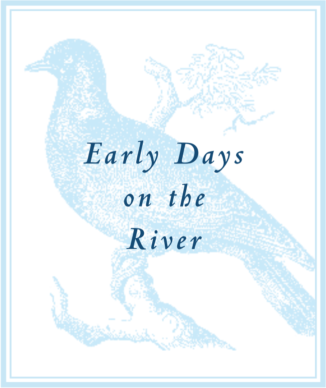
CLOCKWISE FROM TOP:

Isaac Hamilton's mill at Ladleton, circa 1891, on the East branch of the Neversink. (Time and the Valleys Museum Archives)

Locally-produced leather shoe from Weise home, Claryville. (Time and the Valleys Museum)

Pigeon Brook is a tributary of the West Branch of the Neversink. This was one of the streams described in 1899 in Picturesque Ulster *as "seem(ing) to have an inexhaustible supply of fish". (NYS Archives)*

Some Local History



The story of "Upper Neversink" is long and winding, as the water finds its way in two branches downward to the river itself. The land and the water drew early settlers to the area.

Tanneries played a huge part in the development of "Upper Neversink." There were four tanneries in the area. Men were needed to work in the tanneries themselves; they were needed to draw in the raw hides and to draw out the tanned ones. They were needed to fell the trees; to peel the bark; and to transport the bark to the tanneries.

The streams were pure and sparkling when the early settlers arrived. The ill effects of tannery acids would damage the streams for many years to come. Interestingly all the tanneries were located on the East Branch with the exception of one that was located below the joining of the waters. The West Branch had many sawmills that sat on stream banks so they could use waterpower. This meant that sawdust leached down into the stream and did damage, too.

West Branch

We are fortunate to have different chroniclers of life in the West Branch. By 1713 the Hanford family had arrived in America from England. By 1872, one of the Hanford descendants was settling in the West branch at what they called the "Upper Neighborhood." More towards Frost Valley was known as the "Lower Neighborhood." Marcia Hanford Joslin writes in her letters that there were seven families in the Upper Neighborhood when her family arrived. That area became known as “Branch.” The first post office in the area was opened on January 14, 1884 with William P. Alverson as postmaster. The last Branch post office closed in 1957.

We know that the Hanfords and other men of the area hauled bark to the tanneries and later they made hemlock shingles and later yet they made hoops for barrels and pails. Some worked for Clarence Roof at the well-known property Wintoon. Others may have worked at the Forstmann estate at Frost Valley. The Forstmann estate later formed the nucleus for the YMCA holdings.

Detail of Bob Dice’s map of Uper Neversing (1780s–1840s)

The number of trout that were caught in the West Branch seems unbelievable. John Burroughs wrote of one expedition where they caught trout in excess and ate them for breakfast, lunch and supper. He also told of seeing the empty pigeons nests along the stream as they fished. (This is after the passenger pigeon was essentially killed off to extinction.)

Streams coming down off the mountainsides powered the East Branch and West Branch on their way to the Neversink River. On the West Branch, some of the major streams were: the Biscuit, High Fall Brook (same name, different brook than the one feeding into the Rondout), and the Round Pond outlet.

East Branch

Three tanneries on the East Branch were enough to furnish a lot of employment and to do a lot of damage to the stream. The community of Denning hosted a tannery, as did Ladleton. The one near the original Sullivan—Ulster line was in Dewittville. These were truly important industries for the valley.

George Walter Erts, the unofficial historian of Denning, reported that there were eight sawmills up the East Branch. Ladleton was first known as Pardeesville. The turning mill there produced so many ladles that the name changed to Ladleton.

DeWittville was first known as Potterville. Robert Dice wrote about the road up to the Sullivan-Ulster line. It seems that the road went directly over a subterranean vat of old tanbark from the tannery. Each spring the tanbark worked its way to the surface defying all the rock and gravel that were dumped into the road to keep the tanbark down.

Two Branches Join Together

Whence the two branches meet and join and the river takes on substance. The slowly winding river is deceptive as it makes it way down to stoke the thirst of the Neversink Reservoir. The "normal" river winds slowly and offers opportunities for swimming, fishing. On the rare day when the stormy skies unload more than the river can handle—bridges wash out; riverbanks relocate and the inexorable power of a river gone wild sometimes takes a life.

The fourth tannery was located in Claryville down from the Reformed Church on the left. Presently a tannery chimney remains to show us the location.

One should not forget tales of the supernatural that were in favor at that time. *The Tannery Witch* tells a gruesome story. Bob Dice in his detailed map of *Uper Neversing (1780s–1840s)* shows locations for the "ghostly lady in black" and the "headless Claryville ghost."

Historians tell us that the Divine Cemetery served as the final resting place for many of the earliest settlers. The cemetery was located on the far side of the river and was part of the Camp 4H Pines property. It is reported that the stones were all fieldstones and that there was no record of the burials except in the memories of the early settlers. As the Neversink raged through the area, as it tended to do, all visible trace of the cemetery disappeared. Historians mourn the loss and still look for some record of who was buried there.

Halls Mills is the last community before the Neversink courses towards the reservoirs. There the covered bridge remains standing and unused as a final testament to an earlier time. This was the second covered bridge at Halls Mills; the first having been located upstream until it lost a battle with fiercely rising waters.

Many books have been written about the joys of fishing on the Neversink River. Those fishermen mourned the river as it was. They joined the residents of the area in their sadness for the past.

We're told two gristmills were located on the streams and two covered bridges briefly held reign, one on the West Branch and one on the East Branch. A cranberry bog was described as being near Halls Mills. Tanning brought prosperity to the area and tanning decimated the area in return. The past is an exciting story in local history.

—*Contributed by* Carol Smythe,
Town Historian, Neversink

Community Stakeholders

Public Support and Input

Spring 2010 marked the official start to stakeholder involvement in the Neversink River Stream Management Planning Project. Sullivan County Soil and Water Conservation District (SCSWCD) and New York City Department of Environmental Protection (DEP) representatives presented information on their water resource programs and the various components of the stream management plans to participants.

Two presentations were hosted by the District at the Claryville Reformed Church Hall, at the confluence of the legendary East and West Branches of the River. The first was a two-day training presentation on the latest stream bank soil bioengineering techniques held in April, attended by over fifty regional stream managers. A keynote message was delivered by Deputy Commissioner of NYC DEP, Paul Rush, a native of the Rondout Neversink watershed.

In May, the first of four neighborhood meetings with local landowners convened, also at the Church Hall, which incorporated an informational presentation, followed by a lively question and answer session that included passionate discussions that assured active participation in the planning process.

Results from the initial sessions reinforced the fact that a critical component of the stream management planning process is public support and input for the project.

Developing a stream management plan for the Neversink brings landowners, professional staff and elected officials together—in formal and informal meetings, and educational site visits.

To that end, presentations were made throughout the summer at landowner gatherings at the West Branch headwaters including to members of the Winnisook Club; Wintoon Waters, LLC; at various Frost Valley YMCA fishing members and Neversink Association's Annual Meeting.

Prior to 2010, Gilmour Planning drafted and distributed a public opinion survey of streamside landowners along the Rondout Creek, Sundown (or East Branch Rondout) Creek, Sugarloaf Brook and the East, West and mainstem Neversink River. A roundtable committee of 20 local and regional stakeholders met three times (June, October and December, 2009) during the planning period to review the survey instrument and its findings and to offer insight about key concerns regarding the watershed region.

Feedback from the public opinion survey helped guide key areas of interest for this management plan. Out of the 175 surveys sent out, SCSWCD received 76 (return rate of 43%); nearly two-thirds of the responses were from second homeowners. For detailed information about the results of the survey, please view Appendix A to read the full report by Gilmour Planning. General themes include 1) A desire for more road, drainage and infrastructure improvements (54% of Neversink responses) and 2) A desire for more flood planning and emergency preparation (43% of Rondout responses). These interests persisted as respondents were asked what type of technical assistance they need.

For the Neversink, habitat improvement and tree planting received the highest number of responses (22% and 20% respectively), whereas easements and sustainable timber harvest received the lowest number (13% and 8% respectively). Additionally, when asked if they would like to be contacted 84% of those responding gave a positive response, with 55 providing specific name and contact information—a testament to value the streamside landowners place on their relationship to the Neversink River. A selection of written comments received on the survey is highlighted below:

- *I am concerned about road maintenance adjacent to the Neversink and about stream bank erosion.*
- *Because of my limited time spent in residence, I don't feel that I am qualified to make decisions for the full-time residents.*
- *I am interested in help with bank erosion to protect a pasture/hayfield that has been significantly diminished due to erosion.*
- *The most severe land erosion is below my property and the new bridge over the west banks of the Neversink.*
- *Let the towns and county take the material from channel cleaning and gravel bar removal. It can be crushed for road resurfacing or used as fill. Vegetate the banks. Then most important is a maintenance program: it's much easier to cut up a tree that's fallen in the river before a bunch more get washed downstream and become an entangled mess that the river now has to find a new way around.*
- *Keep the Neversink River in a natural state.*
- *Frost Valley does wonderful research. I think they should be approached to do more.*

The Neversink region has numerous fishing, hunting and landowner clubs which have been in place for decades, some stretching back a century. Outreach was conducted at over a half dozen private landowner association meetings. Public interest in this planning project rose as word circulated from resident to resident. Association members take their roles seriously and have aided in communication.

All of the stakeholders listed in the table below have an interest in maintaining the Neversink River as a well-functioning natural resource, and many of them have direct management influence over it.

* * *

With the completion of the plan, the next phase included review of the plan's recommendations by the community, stakeholders and a Watershed Advisory Group (WAG)—a formal extension from the initial roundtable gatherings, which has met twice to review the general recommendations within this Plan. The Watershed Advisory Group is currently evolving as the program establishes itself in the community. The group comprises twenty five local volunteer residents and involved agency representatives. Meetings were held in December 2011, and May and October 2012 with subcommittee meetings formed for Education and Highways & Infrastructure, meeting bi-monthly.

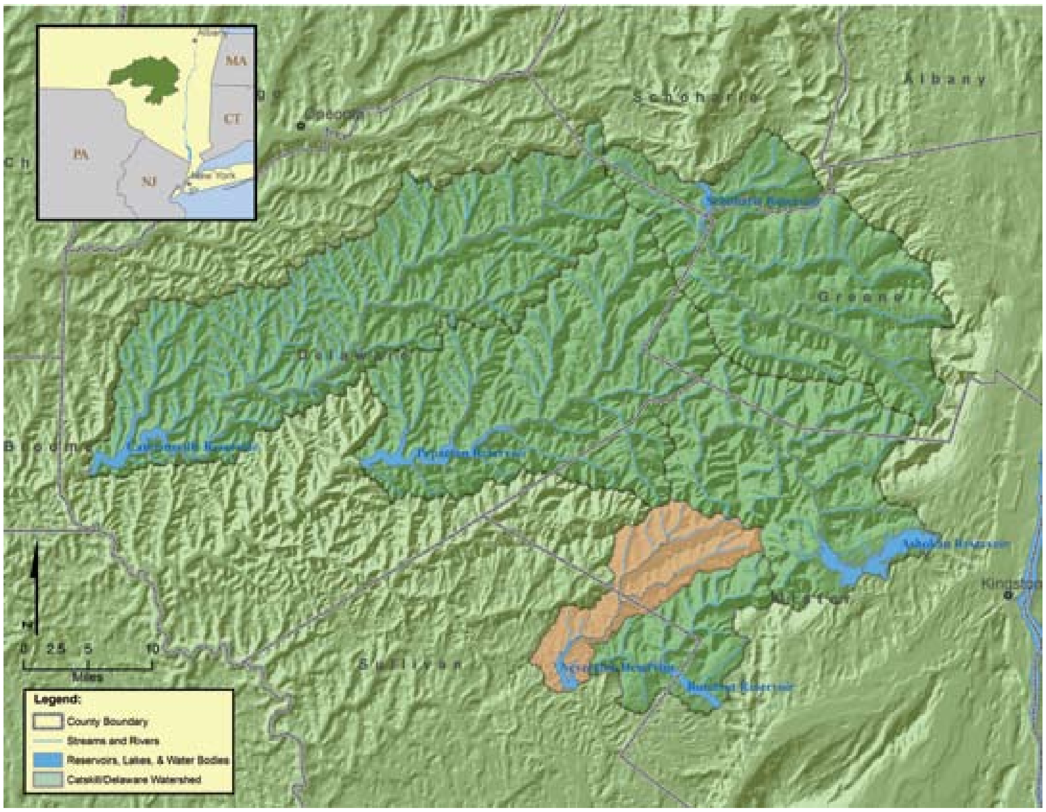
Four historic floods struck the communities between October 2010 and September 2012, increasing interest in stream management planning in the community. A discussion forum was held by Claryville Fire District to promote community involvement in June 2012, while two District-hosted informational meetings continued into December to gather detailed information that informed site-specific plan recommendations and to initiate the creation of a real flood damage database.

The program team has revised the Plan to ensure that it adequately reflects stakeholders' concerns in relation to the scientific criteria needed to guide the future implementation of recommendations. A revised draft was presented to the Towns of Denning and Neversink for formal adoption in winter 2013.

Stakeholder groups within the Neversink basin

Landowners and Landowner Associations	Federal Emergency Management Agency
Towns of Neversink & Denning	Frost Valley YMCA
Sullivan & Ulster County Soil & Water Conservation District	NYS Department of Environmental Conservation Region 3 staff
Town and County Highway Departments	US Environmental Protection Agency
NYC Department of Environmental Protection	NYS Department of Transportation, including Region 1 staff and county-level maintenance staff
NY State Emergency Management Office	Tri-Valley Central School

The Upper Neversink River



Regional Setting

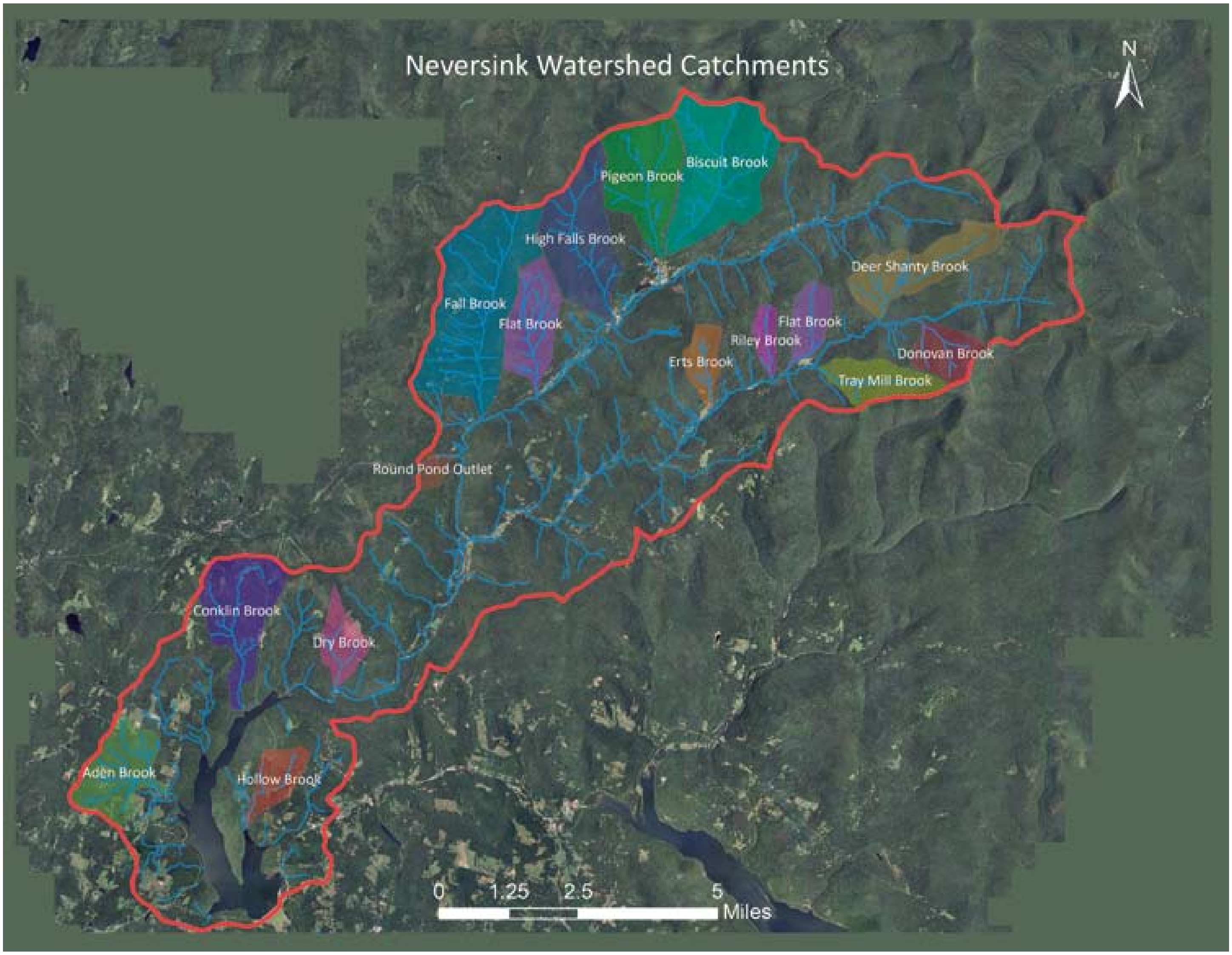
The upper Neversink Watershed is located in the southern portion of the Catskill Mountain region of southeast New York State. The East and West Branches of the Neversink River begin in the town of Denning in Ulster County, flowing southwest for approximately 12 miles of stream length before coming to a confluence in the town of Neversink in Sullivan County. The mainstem of the Neversink that is formed by the confluence of the East and West branches continues to flow for just under

6 miles before entering the Neversink Reservoir. The total watershed drainage area of the Neversink River above the reservoir is approximately 71 square miles. Despite historic streamside development, a large portion of the Neversink watershed remains relatively densely forested.

The Catskill Forest Preserve was established in 1885 by the New York State Assembly, and is designated as forever wild forest lands by an 1894 amendment to the New York State Constitution (now Article 14). This amendment states that the land within the preserve "shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall the timber thereon be sold, removed or destroyed."

In 1904, a boundary or "blue line" was established around the Forest Preserve and private land as well, designating the Catskill Park. As a result of expansion over the years, the park now encompasses nearly 700,000 acres, approximately half of which is public Forest Preserve. The Catskill Park is unique due to its makeup of both public and private land, illustrating how wilderness and the practices of modern civilization can coexist.

Sub-basins of the Upper Neversink River.



The Upper Neversink is also located within the New York City Water Supply Watershed. At 2,000 mi^2, the NYC Watershed is the largest unfiltered water supply in the United States, providing 1.4 billion gallons of clean drinking water daily to over nine million residents in New York City and some nearby municipalities (nearly half the population of New York State). The upper Neversink makes a significant contribution to this water supply, highlighting the importance of conservation measures in this region.

The Neversink Reservoir is one of the most important components of New York City's water supply system. Water from the Neversink Reservoir is tunneled into the Rondout Reservoir, which is the terminal reservoir in the Delaware system and, as such, also accepts waters from the Cannonsville and Pepacton Reservoirs. These "upstream" reservoirs are connected to the Rondout Reservoir by tunnels to three Tunnel Outlet facilities, each of which houses hydroelectric plants.

Neversink Reservoir receives drainage from approximately 92 square miles and holds a maximum of 34.9 billion gallons of water. After being transported to the Rondout Reservoir, the water is diverted to the Delaware Aqueduct through the Rondout Effluent Chamber where water enters the building through one of four intake levels (to maximize water quality) and is regulated by a combination of 6 large valves. The waters that make up the Rondout Reservoir supply more than 50% of the City's daily supply of water on average.

The NYC Department of Environmental Protection (DEP) operates this drinking water supply under a Filtration Avoidance Determination (FAD) issued by the Environmental Protection Agency (EPA) and the New York State Department of Health (DOH). Central to the maintenance of the FAD are a series of partnership programs between NYC and the upstate communities, as well as a set of rules and regulations administered by the DEP. Due to its location within the NYC Watershed, land use in the Upper Neversink watershed is subject to the DEP rules and regulations written to protect water quality. Go to: http://www.nyc.gov/html/dep/html/watershed_protection/watershed_regulations.shtml for the regulations.

Physical Geography

The Catskill Mountain chain is an example of a *physiographic region*—the Appalachian Plateau—in which most parts are similar in geologic structure and have had a relatively unified geomorphic history. The pattern of relief features and landforms differ significantly from that of adjacent regions. This region provides a geomorphic history shaped nearly 12,000 years ago by the movement of the Wisconsin Glaciers which once covered most of Canada and the northern United States (Titus 1996).

The Upper Neversink is nestled between the Rondout and Esopus basins in the southern portion of the Catskill Park. It is located primarily in the towns of Neversink in Sullivan County, and Denning in Ulster County. Through its course the stream drops approximately 2,105 ft. in elevation

from its highest point on the West Branch at nearly 3,544 ft., until it flows into the Neversink Reservoir at 1,439 ft. in elevation. The total water-shed area is approximately 71 mi^2, draining several high peaks of the Catskill Mountain chain, including Wildcat and Slide Mountain. Other peaks drained by the system include the southern exposure of the Beaver Kill Range, Doubletop, Fir, Spruce, Balsam Cap, Rocky, Lone, Table, Van Wyck, Wood Hull, Red Hill, Denman, and Blue Hill.

Large tributaries which deliver flows to the Upper Neversink River include: Biscuit Brook, High Falls Brook, Flat Brook, Fall Brook, Donovan Brook, Deer Shanty Brook, Riley Brook, and Erts Brook. The Neversink watershed also has numerous smaller unnamed tributaries which drain the smaller sub-basins. Most of the watershed is oriented northeast to southwest.

Climate

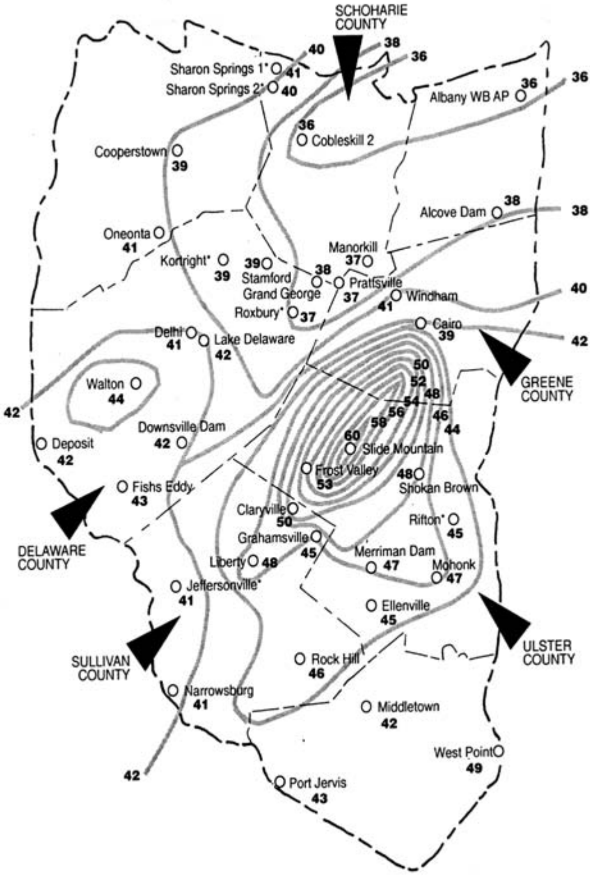
The climate of the Neversink basin is primarily driven by the *humid continental* type, which dominates the northeastern United States. The average annual temperature for the area is 44–48° F and the area typically receives approximately 47–50" of rain/year (Northeast Regional Climate

Center-Northeast Maps). Due to up-sloping and down-sloping, the character of the mountaintop topography can affect the climate of the basin. Up-sloping occurs when air is lifted up over the mountains, the air expands, cooling and condensing into moisture, which takes the form of clouds and precipitation. Down-sloping occurs when air sinking within a dome of high pressure or air that is forced downslope of a mountain range, warms up and loses moisture, as is shown by a drop in relative humidity (Thaler, 1996). These weather phenomena can cause differences in cloud cover and precipitation within the Catskills, and explains the drastic variations in rainfall between Catskill basins.

Changing Weather Effects on the Watershed

Global climate change will significantly impact the Neverink basin in coming years. Greenhouse gases are trapping energy in our atmosphere that would normally be lost to space and cause global temperatures to rise. This warming is a natural phenomenon that provides enough heat to allow humans to thrive on earth, but the burning of fossil fuels, and the atmospheric concentration of other gases such as methane, has dramatically increased the rate of warming. Based on local data collected between 1952 and 2005, researchers have concluded that a broad general pattern of warming air temperatures, increased precipitation, increased stream runoff and increased potential evapotranspiration has occurred in the Catskills region (Burns et al., 2007). Temperature increases will have effects on food production, plants, wildlife, invasive species, flooding, drought, snowfall and the economy.

Current climatic trends point to the potential for our climate to migrate to the extent that by the end of the century, summers in upstate New York may feel like Virginia (Frumhoff et al., 2006). This climatic migration will have significant effects on plant and animal life, allowing new warmer climate species to thrive at the expense of our traditional plants and animals. The number of snow-covered days across the Northeast has already decreased,

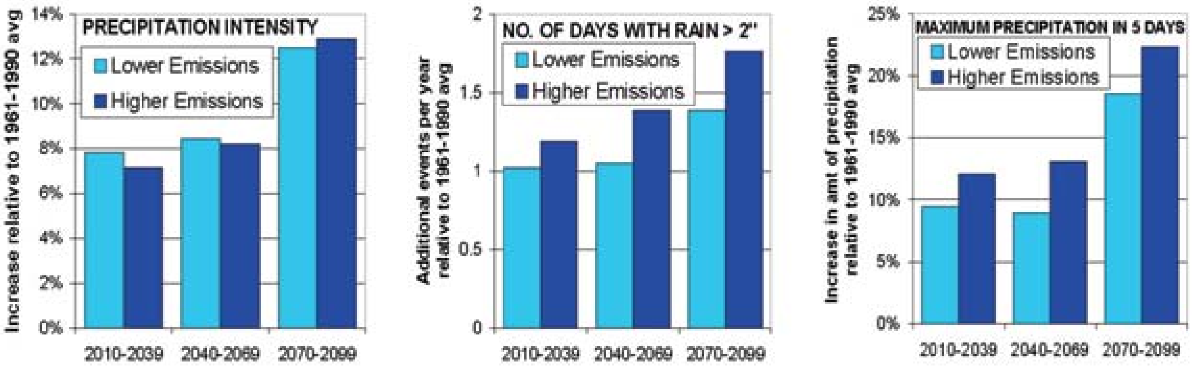


Average annual precipitation in the Catskills.

as less precipitation falls as snow and more as rain, and as warmer temperatures melt the snow more quickly. By the end of the century, the southern and western parts of the Northeast could experience as few as 5 to 10 snow-covered days in winter, compared with 10 to 45 days historically (Frumhoff et al., 2006). Decreased snowfall and increased rainfall would have negative effects on stream flows and the economy of the Catskills; and will create conditions more hospitable to invasive species.

With the lack of snow fall, streams and groundwater will not receive a slow sustaining release of water through the winter and spring. Replacing the slow release will be more intense storms, which will sporadically dump large quantities of water into the system potentially causing damaging flooding. However, streams will return to base flow relatively quickly once the rain stops. Modeling predictions indicate that in the next century we will see more extreme stream flows that will cause streams to flow higher in winter, likely increasing flood risk, and lower in summer, exacerbating drought (Frumhoff et al., 2006).

Because we do not have a clear understanding of all of the coming impacts of climate change, stream managers need to employ the "no-regrets policy" with regard to their current management actions and policies. The no-regrets policy is the recognition that lack of certainty regarding a threat or risk should not be used as an excuse for not taking action to avert that threat, that delaying action until there is compelling evidence of harm will often mean that it is then too costly or impossible to avert the threat. Stream managers—including streamside landowners—will need a basic understanding of how streams are formed and evolve to effectively adapt to coming changes. They will need to anticipate and compare the consequences of different management options, and will need to act conservatively: oversizing culverts and bridge spans, leaving larger buffers of undisturbed streamside vegetation. For public health and safety, it will be necessary to inform residents of the risks to infrastructure and personal property in areas where conditions indicate a high risk of stream channel shifting across the floodplain.



Projected increases in three indices of extreme precipitation: (1) precipitation intensity, (2) number of days per year with more than two inches of rain, and (3) maximum amount of precipitation to fall during a five day period each year (Frumhoff et al., 2006)

Geology of the Neversink Watershed

Water
Shapes the
Landscape

Wise stream management requires a good foundation in understanding the regional and local geologic controls on stream geomorphic, ecologic, and water quality condition. Water quality is directly and indirectly influenced by geology. This section of the plan highlights the key geologic features with implications for stream management (lithology or composition, valley and stream morphology, and water quality). The Catskills are a gentle sort of mountains crafted from eons of

Bedrock reach along the West Branch Neversink River scouring stream water and carving glacial ice as the terrain slowly uplifted as a plateau over millions of years. This stream-dissected plateau in the southern and eastern Catskills is characterized by steep mountain valleys carved in sedimentary bedrock from the mid to late-Devonian period (390–360 million years ago). These valleys are also filled with the deposits left behind from the last Ice Age that ended 10 thousand years ago. Following the retreat of the continental ice sheet out of the Catskills, streams got back to work in shaping the valley bottoms. The sedimentary bedrock framework and Ice Age glacial legacy deposits are largely what control valley bottom characteristics such as slope, valley and stream confinement.

General Geologic History

The Catskill Mountains that comprise the NYC Catskill and Delaware water supply watersheds are a noted example of this cyclic patterns in geology. In the mid to late Devonian period of earth's history the towering Acadian mountains to the east eroded into vast deltaic plains of meandering and braided rivers sloping into an inland sea (about where Binghamton is now). Robert Titus compares it to the modern Bangladesh river complex draining the Himalayan Mountains in geologic setting (Titus, 1998). Those vast ancient river deltas laid down layer upon layer of sediment: stream gravels and sand, and floodplain silt and clay, creating the Catskill Delta (Isachsen et al, 2000). These were not barren deltas; there were fern tree forests and fish in the waters. Over time, these deposits were buried and turned to rock only to be upthrust again to the surface encountering the force of eroding water and inexorable return to stream sediment: a cycle of mountains to rivers to mountains to rivers.

The high peaks of the Catskill Mountains all have a similar range in elevation from 3,000–4,000 ft in elevation above sea level. The common interpretation of this relatively unique condition is that the Catskills are an example of an eroded peneplain. That means the mountain tops were once part of a flat plain that probably had additional rock layers above the Devonian rocks. The plain was then uplifted as part of the Alleghany plateau (Isachsen, et al, 2000). The streams that meandered across that ancient plain were steepened and eroded away the rock above the Devonian strata and carved valleys out of the uplifting terrain. The more erosion-resistant sandstone and conglomerate caps of the current mountain tops yielded a mountain range with very similar heights.

The Ice Ages of the last 1.6 million years (Pleistocene Epoch) have left the latest mark on the Catskill landscape. Vast continental ice sheets, and in some of the high peaks, smaller local mountain glaciers scoured the mountains and left thick deposits of scoured sediment in the valleys. Once the ice sheet started melting back into the Hudson River valley and to the north, smaller alpine glaciers possibly formed in the mountains and further sculpted the landscape. The glaciers left a legacy that still profoundly influences hill slope, stream channel stability, and water quality throughout the Catskills.

Bedrock Geology Composition

The bedrock composition of the upper Neversink watershed is entirely sedimentary rocks: shales, siltstones, sandstones, and at higher elevations conglomerate. The mapped geologic formations that make up most of the watershed are the Upper Walton formation comprising sandstone, shale, and siltstone and at higher elevations the Slide Mountain and Honesdale formations comprising mostly sandstone and conglomerate with some shale. The coarse grain rocks are stream channel deposits, and you can often observe old channel features, such as cross-bedded troughs, gravel bars, and in some rare places fossilized log jams in outcrops. The fine grain rocks are typically the floodplain deposits. Often the red shales show old soil horizons with fossilized root holes and in places Devonian tree parts. Each package of coarse and fine grain rocks equals one story of a prehistoric stream channel's meander across the Devonian delta plain.

Valley Morphology

The sedimentary bedrock composed of the nearly flat-lying, alternating thick layers of sandstone, shale, and at higher elevations conglomerate are responsible for the characteristic stair-step pattern observed in the mountain valley walls, and to some degree in the changes of valley scale slope in the valley bottom. In the headwaters, the more resistant sandstone and conglomerate layers form the steeper valley walls and valley grade control, while the more erodible shales tend to form the gentler slopes of the valley walls.

Most of the stream valleys draining the Southern Escarpment are oriented NE-SW, bisecting the two predominant bedrock fracture orientations. This orientation is principally based on pre-glacial erosion of the landscape, which was controlled by the fractured, very gently southwest dipping bedrock. The orientation of stream valleys is important, influencing the microclimate, average depth of snowpack and local hydrological regime in many ways.

Bedrock planform control along the West Branch Neversink River

Surficial Geology Composition

Surficial geology is concerned with the material covering bedrock. In the Catskills this surface material is principally soils and glacial deposits. The focus here is on the glacial geology of the watershed and stream corridor. The Ulster County and Sullivan County Soil Surveys are excellent sources for examining the soils of the Upper Neversink watershed (Tornes, 1979; Seifried, 1989).

The Pleistocene was a period of accelerated erosion in the Catskills as the flowing ice sheet bulldozed sediment and "quarried" bedrock. Glacial erosion broke the rock down into an entrained mixture of fragments ranging in size from boulders to clay. This mixture of saturated sediment was carried along by ice and deposited as till (unsorted assemblage of glacial sediment; pictured on page 17) or as stratified "drift" if the sediment was subsequently sorted by melt-water streams. These glacial deposits filled in deep river ravines that once drained the landscape prior to the last glacier's advance over the mountains. The figure on page 19 presents the surficial geology of the Upper Neversink watershed as mapped by Cadwell (1987). Note that this map is at 1:250,000 scale and significantly oversimplifies the distribution of varied glacial deposits.

As the climate warmed and ice thinned, the landscape was deglaciated—lobes of the continental ice sheet melted back from the Catskills in periodic stages. Meltwater from the decaying ice left a complex array of stream (outwash plain)

Glacial till exposure along the stream and ice-contact (kame) sand and gravel deposits. Pro-glacial lakes would have formed where mountains, recessional moraines (deposits at former glacial margins) and ice impounded water and left deposits of layered silt and clay.

The ice age deposits typically found in the upper Neversink watershed are generally directly from ice contact—glacial till; or from melt water deposits along the ice margin and the valley walls—kame terraces, or in meltwater streams discharging from the melting ice—outwash. There is not much evidence at the surface for large pro-glacial lakes that would have received the meltwater. Previous surficial geologic mapping efforts have not noted much presence of the layered silt and clay glacial lake deposits that make the adjacent Esopus Creek watershed very prone to muddy water. Observations from a streamside landowner of "chunks" of layered lake deposits in post-flood bar deposits show that they are present but not all that exposed.

Following deglaciation, streams became the acting geomorphic agent in the valley bottoms, re-working much of the glacial sediment into Holocene alluvium. Much of the active stream corridor is floored with this alluvial material typically ranging in sediment size from sand to boulders (*pictured below*).

Alluvial (stream-deposited) material exposed in an eroding bank

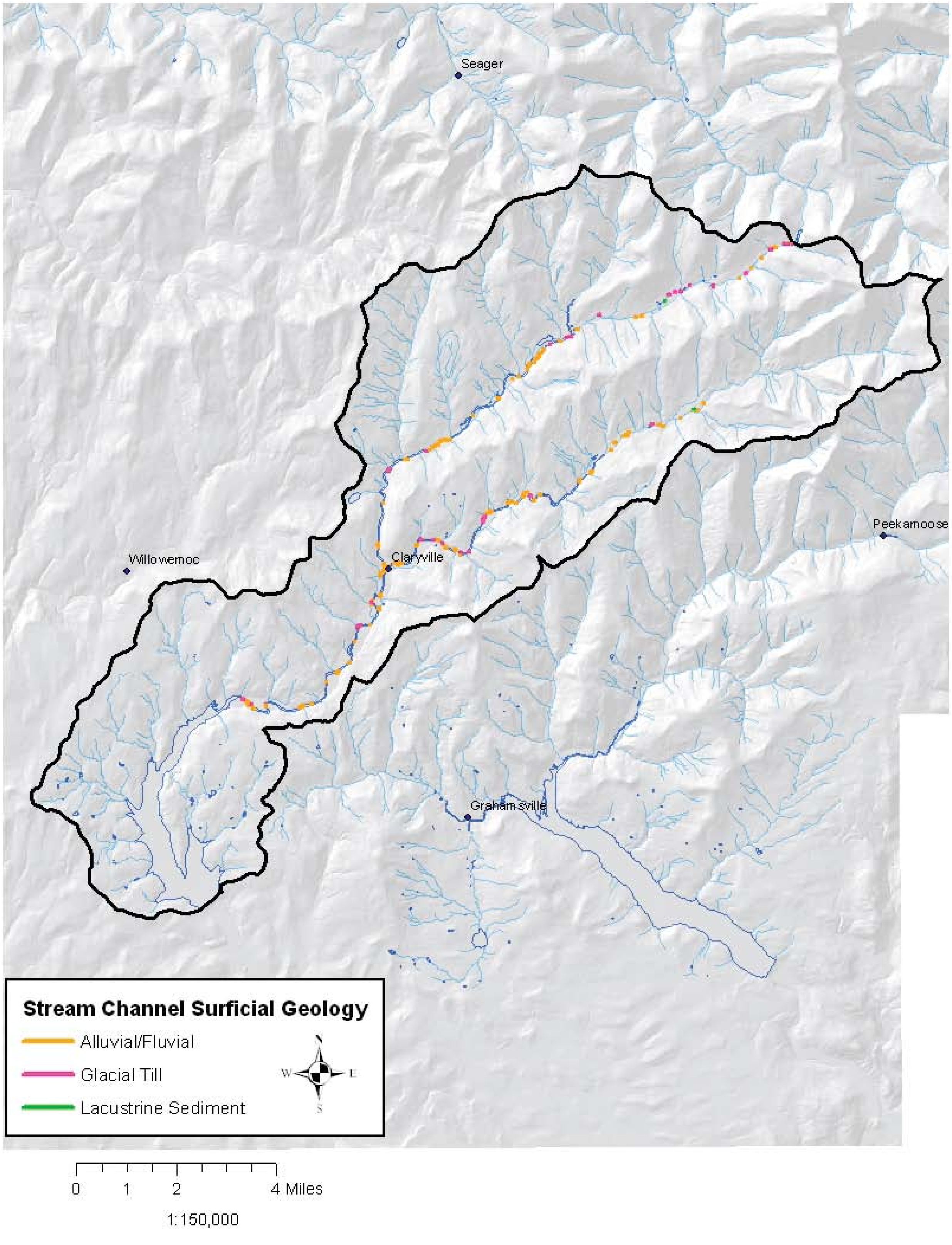
The stream feature inventory completed for the Stream Management Plan includes mapping active streambank and adjacent hill slope erosion. The geologic material exposed in the banks and hill slopes is recorded and can be used to show the distribution of stream channel geology as presented in the map on page 19.

Stream Morphology

Glacial geology sets the geologic framework for most of the Upper Neversink stream system. Since glacial till is more resistant to erosion than former stream deposits, it can locally influence planform and grade control. Rich (1934) notes several locations in both branches where glacial moraines force the current stream channel to one side of the valley and often in contact with bedrock. Also, these morainal valley obstructions tend to create the wide valley alluvial plains upstream of the obstruction (e.g. valley floor between Fall Brook and Biscuit Brook). These features can further confine the active channel corridor and be a source of bedload material supply.

Alluvial channels are stream channels with stream-deposited sediment on all boundaries. Non-alluvial channels are stream channels are with a direct contact with material not supplied by the stream, such as bedrock, glacial till or glacial lake silty clay. There are many places in the upper Neversink stream network that have non-alluvial or mixed-boundary conditions. Eroding "bank run" banks (sand, gravel, cobble from glacial meltwater streams or alluvial sediment from more historic streams) tend to experience higher lateral adjustments because the material, if not protected by roots, is easily entrained and mobilized. These

Example of imbricated Catskill stream sediment



Stream channel surficial geology map derived from the SFI

banks, if not exposed to lots of recurrent shear stress can recover to a stable slope and vegetate quickly. Dense glacial till banks will tend to form steep high banks from mass failures and take a long time to recover. Stream banks with glacial lake deposits tend to be the result of slumping and consequently can be active for a long period of time. The stream feature inventory did not reveal the presence of this condition that is so common in the central Catskill stream corridors.

While there are many grade and planform controls on stream morphology at a range of scales, from large woody debris to bridges, bedrock is the fundamental valley scale control for grade and channel planform. Where the stream flows against a bedrock valley wall or across a bedrock valley bottom the stream's erosional process is effectively arrested in a timescale that matters for stream management. There are numerous bedrock grade and planform controls throughout the upper Neversink stream network, more so in the West Branch.

Modern stream deposits in the Catskill Mountains are principally derived from erosion of the layered sedimentary Catskill bedrock. As a result, stream clasts (sediment particles and classes) have a low spherocity ("roundness"), typically forming platy or disk-like particle shapes. This platy shape affects the stability of the streambed in a number of ways. First, it allows the particles to imbricate, or stack up at an angle, forming an overlapping pattern like fish scales or roof shingles (*pictured below*).

Imbricated streambeds are thus generally more stable or "locked up", and all other things being equal, generally require a larger flow to mobilize the bed material than nonimbricated beds. However this same platy shape can also, under the right conditions, act like an airplane wing and be lifted by the streamflow more readily than would a spherical particle of similar weight. Once this occurs for even a few particles, the imbrication is compromised and significant portions of the streambed become mobile.

Land Use & Land Cover

94%
of Land in
the Neversink
Watershed
is Forested

Land use and land cover of a watershed have a great influence on water quality and stream stability. The watershed's land cover directly impacts stream hydrology by influencing the amount of stormwater runoff. Forests, natural meadows and wetlands naturally absorb rainwater, allowing a portion of it to percolate back into the ground. However, impervious surfaces such as pavement, parking lots, driveways, hard-packed dirt roads and rooftops increase the amount of rainfall that flows over land and reduces the amount of rainfall that percolates into the soil to recharge groundwater wells and streams.

Impervious cover is a major influence on streams and stream life due to the way it changes the amount and duration of stormwater that gets to the stream. Generally, the more impervious surface there is in a watershed,

the less groundwater recharge. This, in turn, leads to a lower water supply to the summer flows, and greater storm flows, together with increased erosion in streambed). In addition to degrading streams, watersheds with a high percentage of impervious surfaces are prone to larger and more frequent floods, which cause property damage through inundation, as well as ecological harm resulting from lower base stream flows.

The literature documents deleterious effects of impervious surfaces on biota (Limburg and Schmidt, 1990; May et al., 2000; Wang et al., 2001; Roy et al., 2005), stream stability (Booth, 1990; CWP, 1998; White and Greer, 2005; Wohl, 2005) and instream water quality (Groffman et al., 2004 and Deacon et al., 2005). For example, impervious surfaces can raise the temperature of stormwater runoff, which in turn reduces the waters ability to hold dissolved oxygen and harms some game fish populations, while promoting excess algal growth. Field observation, research and hydrologic modeling suggest a threshold of 10% impervious surface in a watershed, after which there is marked transition to degraded stream conditions (CWP, 1998 and Booth, 2000).

Table 1. Land Use Classification

Land Use	Percent	Acres
Parks/Forest/Open Space	93.75	55,208.80
Non-Woody Vegetation/Recreation	5.11	3,009.38
Rural Housing	0.31	184.008
Roads	0.25	149.898
Single Family Units	0.19	114.718
Urban (impervious/built up land)	0.16	93.11
Agriculture (Livestock)	0.11	63.28
Agriculture (Crops)	0.041	23.848
Low Density Housing	0.041	24.64
General Residential Housing	0.026	15.26
Mobile home	0.001	0.77
Industrial	0.005	2.82
Commercial Offices	0.0003	0.20
Total Acres	100.0000	58,890.70

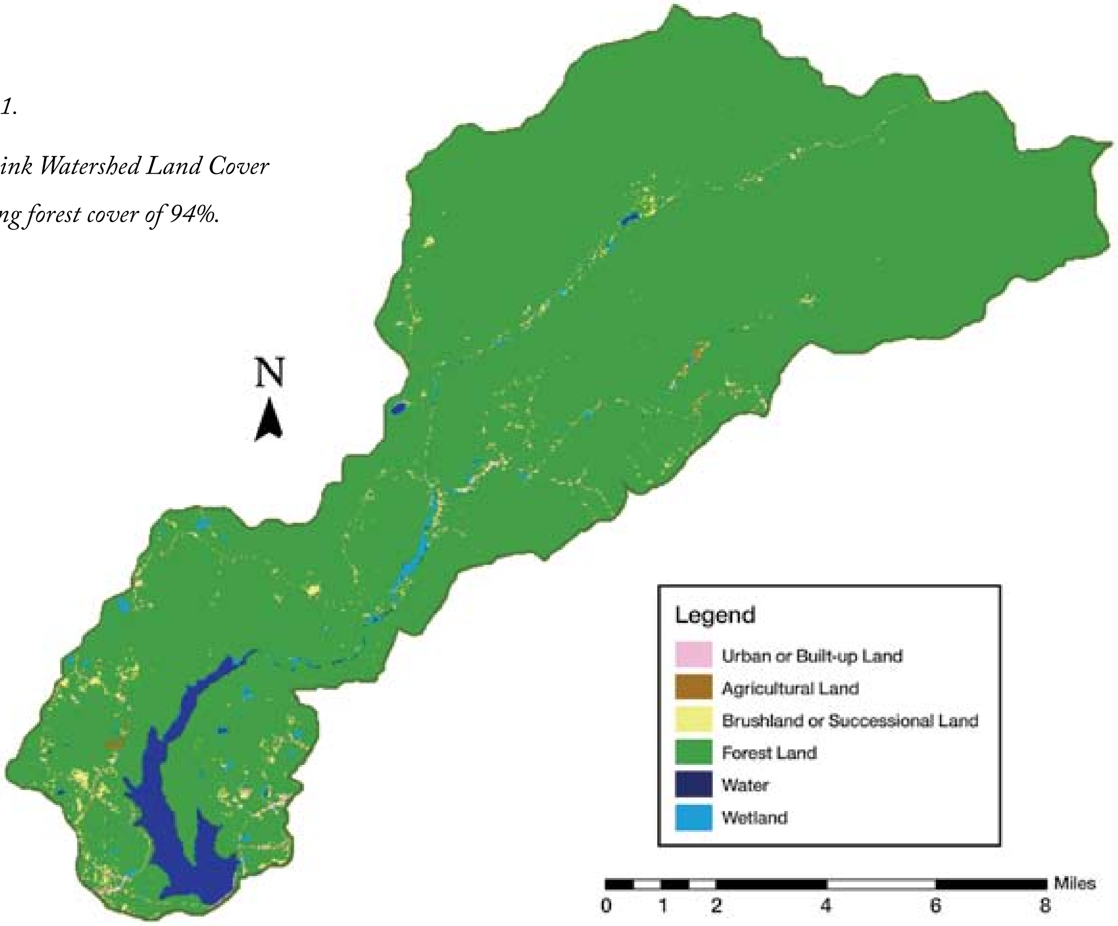
Certain types of pollution are often associated with particular land uses, such as sedimentation from construction activities. There has been a vast array of research demonstrating that as land uses become more urbanized (built), biotic communities decline in health (Limburg and Schmidt, 1990; Schueler and Holland, 2000; May et al., 2000; Wang et al., 2001 and Potter et al. 2005). Concentrations of selected chemical constituents, including nitrate, in stream base-flow were strongly affected by the predominant land use in a large Hudson Valley study (Heisig, 2000). The decline of watershed forest cover below 65% percent marked a transition to degraded water quality (Booth, 2000). Based upon these results, land use/cover appear to be good indicators for long-term trend tracking. These results can be correlated with in-stream water quality data and then used to focus best management practices towards the land uses with the greatest impact on water quality.

Land use of the Upper Neversink River watershed was analyzed by a team of scientists at Frost Valley YMCA Roehm Technology Center using the LANDSAT ETM geographic information system (GIS) coverage (provided by the National Land Use Cover Data). To simplify the data, the 47 classifications assigned to the different types of land cover have been re-classified and grouped together under more general land use categories. Table 1 (*opposite*) and Figure 1 illustrate the categories and percentages of the different land use types present in the Upper Neversink River watershed.

The overwhelming majority (94%) of land use in the Neversink watershed is forested area. A large portion of this forest land is owned by the State of New York and under current state laws will remain undeveloped. Non-woody vegetation, including recreational fields, follows in a distant second at 3,009 acres (5%). Residential property is less than 1% of the region, covering approximately 338 acres of the watershed. There is very little commercial and industrial activity in the Neversink watershed; combined they make up less than 3% of the land cover. The majority of the impervious surface in this area is made up of the network of roads which fragment the landscape.

Figure 1.

Neversink Watershed Land Cover depicting forest cover of 94%.



Approximately 38,173 acres of the forest in the Neversink watershed is deciduous, totaling over 64% of the total land cover in the watershed. Over 21% of the landscape is covered by coniferous forest and over 7% by mixed forest. Livestock and crop agriculture occupy approximately 0.15% of the watershed combined. Impervious surfaces, consisting of roads, residential, urban and industrial areas total around 0.44% of the watershed. Although the total impervious surface area is low in the Neversink watershed, negative impacts on the stream are still possible. Instances where roads and homes occur directly adjacent to the stream can result in significant runoff during storm events. Proper land use planning to direct development and preserve sensitive areas can be utilized to maintain a manageable low level of impervious cover.

Land Cover Classification

Land Use	Percent	Acres
Deciduous Forest	64.82	38,173.49
Coniferous Forest	21.68	12,768.90
Mixed Forest	7.24	4,264.62
Grass/Herbaceous	1.25	735.42
Impervious Surface	0.40	235.04
Water	3.74	2201.97

Photo courtesy of Ed Ostapscuk

Brown trout in the Neversink River.

Fisheries & Wildlife

Biodiversity and Recreation on the Upper Neversink River

With its largely intact forest stands and small closely-knit residential communities, the Neversink watershed provides an example of an interactive balance between humans and nature. The features of this watershed support a diversity of life, including plants, insects, fish, animals, and people. The number and variety of organisms found in this geographic region, often referred to as biodiversity, are all connected in a complex web of life.

The functioning of this web is a system of interactions between living organisms, and is highly dependent on interactions with countless

Photo courtesy of Ed Ostapscuk

non-living factors in the surrounding environment. This ecosystem includes factors such as energy from the sun, availability of water, balanced chemistry, and regular climate cycles. These factors are in a delicate balance that is required for the survival of each individual organism; it is difficult to predict what would happen if any one factor was significantly altered or removed.

For example, the list of web interactions required for the life cycle of a single tree may be in the hundreds or thousands. Likewise, the list of animals that will utilize a single fallen tree is in the thousands—well-known creatures include squirrels, woodpeckers, grouse, bears, foxes, skunks, beavers, otters, mice, and shrews as well as worms, salamanders, beetles, ants, centipedes, sowbugs, and other insect larvae. There are twice as many species of beetles alive on dead and dying wood as there are species of mammals, birds, reptiles, and amphibians in the entire world (Kyker-Snowman, 2003). The fallen tree provides critical habitat, steady moisture, and food for a multitude of mosses, fungi, trees, and vascular plants. For each fallen tree removed either during land use changes or during cleanup efforts after falling, effects reverberate throughout the ecosystem. If enough fallen trees are removed, the structure of the overall community would likely change.

Recognizing these relationships, many people work toward the protection and preservation of the ecosystem functions we receive from nature, including cleaner air through vegetation respiration, cleaner water through soil and wetland filtration, soil formation from forests, pollination of food crops from our native insects, natural flood water retention/groundwater recharge, and pest control from our native bats, birds, and insects (e.g. dragonflies/damselflies).

Due to its status as a nationally renowned fly fishing stream, many efforts in the Neversink watershed are focused on the preservation of critical trout habitat. The Neversink River provides the clean, cold, and well oxygenated water that is critical to trout habitat. In turn, local residents and tourists alike flock to accessible fishing sites in hopes of enjoying the angling and natural beauty that is provided by this stream. Tourism related to fishing has played an important role in the economy of the Catskill region that continues to this day.

The New York State Department of Environmental Conservation (DEC) classifies the surface waters in New York according to their ability to sustain trout populations (T) or trout spawning (TS). These classifications indicate the presence of trout (T) throughout the Neversink River, with trout spawning (TS) documented in the headwaters of the West Branch. Trout spawning likely occurs in several other locations throughout the river, but has not yet been documented in the DEC classification. Proposals for updating these classifications have been prepared and are currently under review.

Northern Monk's-hood is a state and federally threatened species that occurs along streambanks in the Catskills.

The fishing opportunities along the Neversink River have attracted several of the famous trout anglers of the 20th century. Theodore Gordon, renowned for his fly tying, fishing, and writing, moved to the Neversink in the early 1890's and became a familiar site along the river. Gordon's local fly fishing legacy was succeeded in 1918 upon the arrival of Ed Hewitt, who acquired much of the land along the main branch of the Neversink. Hewitt used the River as a laboratory for the invention of various fly fishing equipment and tying techniques. In his later years, he began to rent out his property to an exclusive few along a stretch of the river that contained some of the more pristine and productive trout pools (Francis, 2000). This location for fishing and outdoor recreation became known as the Big Bend Club, and is currently still in existence.

The quality of fish habitat in the Neversink watershed can be attributed in part to the presence of dense and largely undisturbed forest. Forests adjacent to the stream promote good water quality by offering temperature control, woody debris sources, and a buffer against upland contaminants—all favorable habitat for many terrestrial creatures. This includes a wide range of small mammals like moles, voles, shrews, fox, weasel, otter, mink, beaver, and muskrat. Abundant streams with cobble beds, undercut banks, and streamside wetlands and forests are habitat for damselflies, dragonflies, stream salamanders, turtles, frogs and the threatened Northern Monk's-hood. Riparian forests are particularly important breeding habitat for birds such as the Louisiana waterthrush, yellow warbler and warbling vireo. Stream corridors are the preferred foraging habitat for the many bat species likely to occur in the watershed.

The change in elevation from stream valley floor to Catskill peaks, and the presence of both evergreen and deciduous forests contribute to the watershed's biodiversity. Forests with features such as talus slopes, cliffs, and mature forests are habitat for plants and animals adapted to these conditions. High altitude coniferous forests are habitat for unique bird species such as the Blackburnian warbler and the rare Bicknell's Thrush. The large, unfragmented nature of the forests creates favorable habitat for wide-ranging animals (such as black bear and bobcat) and wildlife that prefer forest interiors (such as hermit thrush and red-eyed vireo).

Grassy fields, open woods, and shrubby patches make important contributions to biodiversity of the watershed. These open and scrubby areas can provide nesting habitat for shrub land bird species, like the Veery, that are declining in New York State as old farms revert to forests. Young forests are habitat for Canada warbler, while open shrub lands and dense thickets are preferred by Northern cardinals. Many species, like Black-and-white warbler, require a complex of different habitats to complete breeding, foraging, over wintering, and migration portions of their life cycles. As a result, maintaining connectivity between the stream and the adjacent uplands is very important for biodiversity conservation.

Otter sightings are reported by landowners along the East and Main Branches of the Upper Neversink.

Photo courtesy of Jason Hamm

Threats to Ecosystem Health

Although the Neversink watershed supports a wide diversity of fish and wildlife, it has its share of threats to ecosystem health. Whether it's through the removal of key elements from the ecosystem, or the introduction of non-native factors, it's clear that humans can have a profound impact on the ever changing natural landscape.

Despite its popular standing as a trout fishery, aquatic ecosystem health in the Neverink River has experienced pressures, both past and present. Early settlers to the Neversink valley quickly realized the angling opportunities provided by the river and its native brook trout, and thought to enhance the fishing experience by introducing brown trout from Europe. Brown trout were known to grow larger in size and could withstand higher levels of habitat disturbance and fishing pressure than brook trout. With this adaptability these, it wasn't long before brown trout established themselves in the Neversink and out-competed brook trout for habitat and resources. Many now view the brown trout as an important part of the ecosystem and support its increased presence. Currently, the NYS DEC annually stocks the Neversink Reservoir with approximately 3,000 brown trout (NYSDEC Spring Trout Stocking for Sullivan County).

Many alterations of the Neversink ecosystem can be sourced back to famous fly fishing residents of the watershed. One such resident by the name of Ed Hewitt was well known for importing salmon eggs and fry from Norway and Scotland in an attempt to establish a population in the Neversink River. Hewitt also tried to improve trout habitat by introducing invertebrate nymphs and larvae from England as an additional source of food, and by building large "log and plunk dams" in order to increase the frequency and depth of pools (Francis, 2000). These habitat alterations may improve fishing conditions, but can interfere with natural ecosystems.

Fish and other aquatic organisms also face ongoing threats associated with climate change. Recent studies suggest that precipitation has increased in the Catskill region over the past 50 years, with the sharpest increase occurring between the late 1990s and 2005. Air temperature has also increased significantly over this time period, averaging an increase of approximately 0.6° C per 50 years. Total subsequent runoff of all of this extra precipitation has not only increased in volume over this time period, but the high volume of runoff associated with the seasonal transition from winter to spring appears to be occurring earlier in the year (Burns et al., 2006). This increase in water volume contributes to larger and more frequent flood events, which can have deleterious effects on aquatic organisms that are not adapted to consistent high flows, increased water temperature, and changes in water quality. Early season increases in temperature allow aquatic insects that trout rely on for food to emerge earlier and at smaller sizes. As a result, fewer insect offspring are produced and the food web is significantly altered (Williams et al., 2007).

As precipitation increases across the Catskill region, the exposure of the delicate ecosystems to acid rain also becomes higher. The mortality of brook trout in the Catskill Mountains has been linked to the acidification of streams, most notably in locations where the soils are poorly buffered such as in the Neversink watershed (Baldigo & Murdoch, 1997). Acid rain also negatively impacts bird populations, such as the Wood Thrush, in that the decrease in pH results in the loss of tree canopy, as well as the depletion of calcium in the soils which is relied on for the production of eggs (Hames et al., 2002). The atmospheric deposition of mercury, sourced from the coal industry and various forms of energy production, can also contribute to the lower levels of calcium in the soils and its inevitable impact on breeding birds.

Species imported from other areas that thrive in our region, often called invasive species, can also have dramatic effects on the landscape. If the concentration of greenhouse gases continues to increase in our atmosphere, climate change is likely to continue well into the 21st century. Not only will this have a negative impact on native species, but it also makes habitat in the Catskill region more suitable for invasive species. For example, Japanese barberry *(Berberis thunbergii)* is native to Asia, but has thrived in the Neversink basin choking out native species and diminishing recreational opportunities. The woolly adelgid *(Adelges tsugae)*, a small aphid-like insect pest native to China and Japan, is threatening to decimate our eastern hemlock *(Tsuga canadensis)* populations. Once infested, hemlock mortality rates range between 50%–99% (Orwig, 2002). The plant species most likely to replace hemlocks are hardwood tree species and possibly non-native or invasive species. Ultimately, this will have a dramatic effect on the structure of these communities. For example, the distribution and abundance of brook trout and diversity of aquatic insects will likely decline with the hemlock forests (Evans, 2002). Hemlock forests maintain stable, lower water temperatures and more stable hydrologic regimes (i.e. they don't dry up as much) than the hardwood forests that will likely replace them (Snyder et al., 2002). These are just a few examples of how human actions can import and release invasive species.

On the East Branch Neversink River.

Rare species located in the Neversink watershed, such as the Northern Monk's hood and the Bicknell's Thrush, are particularly susceptible to the previously described threats to ecosystem health because their populations are small in numbers and are very habitat specific. As critical habitat diminishes, rare species decline in numbers and become endangered, or disappear altogether.

Management Recommendations

Stream managers can consider the following general recommendations to maintain and protect important stream corridor habitats:

- *Limit disturbance and protect both small and large stream corridor wetlands that provide significant habitat for amphibians, reptiles, and breeding birds in the watershed;*
- *Most shrubland breeding birds are relatively tolerant of human development if appropriate habitats exist, and unlike some grassland birds, do not require large habitat patches for breeding. Landowners who maintain shrubby thickets in uplands adjacent to stream corridors can support shrub land birds;*
- *Where possible, plant native species appropriate to the pre-existing or predicted ecological community for a site;*
- *Stream managers are encouraged to learn to recognize the Appalachian tiger beetle and other declining and threatened species and report observations to the NY Natural Heritage Program.*
- *Riparian buffer widths can be established to conserve habitat function, in addition to water quality, hydrologic, and geomorphic functions. It is particularly important to maintain habitat connectivity needed by wildlife to complete their life cycles. To evaluate connectivity, consider the needs of indicator species or species of conservation concern in the watershed.*
- *The area within 300 ft of the forest edge is considered "edge" habitat. Edge habitats support increased densities of deer and invasive plants, and are avenues for nest predators to enter forests. A minimum 300 ft forested stream buffer will protect forest health and provide better breeding habitat for forest wildlife;*
- *Riparian forests at least 50 acres in size with an average total width of at least 300 ft can provide forest interior habitat that supports sensitive species, such as the Scarlet Tanager.*
- *Most of the amphibian and reptile observations in this watershed are within or near stream corridors. Seeking to create a minimum 500 ft forested buffer around stream corridor wetlands will provide terrestrial habitat required by stream- and vernal pool breeding amphibians to complete their life cycles, and to protect wetlands from adjacent land uses;*
- *If buffer widths of 30–100 ft are maintained, riparian forest canopies will provide enough shading and cooling of streams to maintain water temperatures within the tolerances required for healthy trout physiology*
- *Minimum buffers of 50–100 ft are often recommended to protect aquatic communities. Large woody debris deposited into streams provides important shelter for fish, and in particular for trout. At a minimum, a 50 ft buffer appears necessary to maintain sufficient woody debris inputs to streams. Riparian vegetation provides leaves and other forms of litter that feed macroinvertebrates. In turn, aquatic macroinvertebrates are the major food source for most freshwater fish.*

- *A minimum 100 ft buffer is recommended to protect aquatic macroinvertebrate and fish abundance.*
  A number of stream corridor species depend on the natural channel processes of a healthy stream to provide habitat during parts of their life cycles: Stream salamanders are generally sensitive to siltation, scouring, nutrient enrichment, channelization, and diversion of water.
  Maintaining natural stream processes and riparian buffers protects salamander habitats.

- *There are only 10 rivers in NYS with populations of Appalachian tiger beetle. This beetle is typically found on riverside sand and cobble bars at the edges of forested streams where stream management practices maintain natural stream processes, including the natural flooding regimes that prevent dense plant growth on cobble bars. Gravel mining and off-road vehicle use of sand and gravel bars can destroy beetle larvae.*

OBSERVED BREEDING BIRDS

Known or suspected breeding birds in the Neversink River Watershed (Source: *2000–2005 Breeding Bird Atlas*)

Common Name	Common Name	Common Name
Acadian Flycatcher	Common Raven	Pine Warbler
Alder Flycatcher	Common Yellowthroat	Purple Finch
American Black Duck	Cooper’s Hawk	Red-bellied Woodpecker
American Crow	Dark-eyed Junco	Red-breasted Nuthatch
American Goldfinch	Downy Woodpecker	Red-eyed Vireo
American Kestrel	Eastern Bluebird	Red-shouldered Hawk
American Redstart	Eastern Kingbird	Red-tailed Hawk
American Robin	Eastern Phoebe	Red-winged Blackbird
American Woodcock	Eastern Towhee	Rock Pigeon
Bald Eagle	Eastern Wood-Pewee	Rose-breasted Grosbeak
Baltimore Oriole	European Starling	Ruby-throated Hummingbird
Barn Swallow	Field Sparrow	Ruffed Grouse
Barred Owl	Golden-crowned Kinglet	Savannah Sparrow
Belted Kingfisher	Gray Catbird	Scarlet Tanager
Bicknell’s Thrush	Great Blue Heron	Sharp-shinned Hawk
Black-and-white Warbler	Great Crested Flycatcher	Song Sparrow
Black-billed Cuckoo	Great Horned Owl	Spotted Sandpiper
Blackburnian Warbler	Hairy Woodpecker	Swainson’s Thrush
Black-capped Chickadee	Hermit Thrush	Swamp Sparrow
Blackpoll Warbler	House Finch	Tree Swallow
Black-throated Blue Warbler	House Sparrow	Tufted Titmouse
Black-throated Green Warbler	House Wren	Turkey Vulture
Blue Jay	Indigo Bunting	Veery

Common Name	Common Name	Common Name
Blue-gray Gnatcatcher	Killdeer	Vesper Sparrow
Blue-headed Vireo	Least Flycatcher	Warbling Vireo
Bobolink	Louisiana Waterthrush	White-breasted Nuthatch
Broad-winged Hawk	Magnolia Warbler	White-throated Sparrow
Brown Creeper	Mallard	Wild Turkey
Brown-headed Cowbird	Mourning Dove	Willow Flycatcher
Canada Goose	Nashville Warbler	Winter Wren
Canada Warbler	Northern Cardinal	Wood Duck
Cedar Waxwing	Northern Flicker	Wood Thrush
Cerulean Warbler	Northern Rough-winged Swallow	Worm-eating Warbler
Chestnut-sided Warbler	Northern Saw-whet Owl	Yellow Warbler
Chimney Swift	Northern Waterthrush	Yellow-bellied Flycatcher
Chipping Sparrow	Olive-sided Flycatcher	Yellow-bellied Sapsucker
Cliff Swallow	Osprey	Yellow-billed Cuckoo
Common Grackle	Ovenbird	Yellow-rumped Warbler
Common Merganser	Pileated Woodpecker	Yellow-throated Vireo

Breeding bird species known or suspected to be breeding within the watershed. The species list is derived from reports of observed breeding bird activity within the *Breeding Bird Atlas* Blocks 5263B, 5264A, 5364A, 5364C, 5363A, 5364B, 5364D, 5465C, and 5464A that overlap the watershed. Parties using these data for environmental review purposes do so at their own risk.

RARE WILDLIFE

Rare plant and animal species with known populations within the watershed and documented examples of rare and high quality ecosystems within the watershed

Common Name	Scientific Name	State Protection	State Rarity Rank	Global Rarity Rank
Appalachian Tiger Beetle	*Cicindela ancocisconensis*	Unprotected	S2	G3
Bigleaf Yellow Avens	*Geum macrophyllum var. macrophyllum*	Not Listed	S1	G5
Jacob's-ladder	*Polemonium vanbruntiae*	Rare	S3	G3
Bicknell's Thrush	*Catharus bicknelli*	Special Concern	S2	G4
Bald Eagle	*Haliaeetus leucocephalus*	Threatened	S2	G5
Northern Monkshood	*Aconitum noveboracense*	Threatened	S1	G3

SIGNIFICANT NATURAL FOREST COMMUNITIES

Documented examples of rare and/or high quality ecosystems within the watershedquality ecosystems within the watershed

Common Name	State Protection	State Rarity Rank	Global Rarity Rank
Beech-Maple Mesic Forest	Not Listed	S4	G4
Hemlock-Northern Hardwood Forest	Not Listed	S4	G4
Mountain Fir Forest	Not Listed	S2	G3
Mountain Spruce-Fir Forest	Not Listed	S2	G3
Spruce-Northern Hardwood Forest	Not Listed	S3	G3

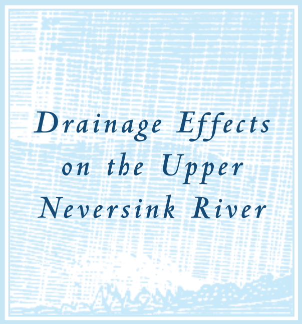
Hydrology & Flood History

Understanding the hydrology of a drainage basin is important to the stream manager because stream flow patterns affect aquatic habitat, flood behavior, recreational use, and water supply and quality. Water flowing through the Neversink River reflects the integrated effects of all watershed characteristics that influence its hydrologic cycle. The dynamics of the Neversink watershed and stream system change as rain and snow vary over time creating the runoff and stream flow (discharge). Data about hydrology can help us in our efforts to assess flood frequency and magnitude, as well as inform the ways we seek to manage the stream and watershed.

The hydrology of the Neversink is characterized by the climate of the drainage basin, its geology and land use/cover (permeable or impermeable surfaces that affect infiltration and runoff, and human-built drainage

Floods cause repeated damage to County Road 47; this photo August 2011.

systems), and its vegetation (uptake of water by plants, protection against erosion, and influence on infiltration rates). The factors that affect timing and amount of stream flow are referred to as the stream's *hydrologic regime*. For example, a stream with an urbanized watershed where water will run off the hardened surfaces directly into the stream will have higher peak discharges following storms than a watershed, such as the Neversink River, which is mostly forested and allows a higher percentage of rain water to infiltrate before it reaches the stream.



Drainage Effects on the Upper Neversink River

The Neversink River watershed encompasses over 70 square miles of watershed drainage area. Streams in this watershed are primarily perennial, meaning that they flow year-round except in smaller headwater streams or in extreme drought conditions. The Neversink runs predominantly southwest before entering the Neversink Reservoir in the town of Neversink. The drainage pattern is controlled by the topography which was formed in large part during the last period of glacial activity. Within the Neversink watershed, drainage pattern of small side tributaries is primarily dendritic (branching, tree-like form), typical of Catskill Mountain sub-basins.

Estimated mean annual precipitation in the Neversink basin is approximately 47–50 inches per year, and often comes as late winter rain-on-snow events, summer storms, or remnants of autumn hurricanes[1]. Due to the steep side slopes of this watershed, stream levels can rise and fall relatively quickly during intense storm events. The watershed can also retain snowpack into the spring, often resulting in flash floods when rain melts existing snow. This flashiness is mitigated by the heavy forest cover throughout much of the watershed, but is intensified in developed areas which lack vegetated riparian zones and consist of impervious surfaces.

There are two general categories of streamflow: storm flow (also called flood flow) and base flow, between which streams fluctuate over time. Storm flow fills the stream channel in direct response to precipitation (rain or snow) or snowmelt, whereas base flow is primarily groundwater-fed and sustains streamflow between storms and during subfreezing or drought periods. A large portion of storm flow is made up of *overland flow*, runoff that occurs over and just below the soil surface during a rain or snowmelt event. This surface runoff appears in the stream relatively quickly and recedes soon after the event. The role of overland flow in the Neversink watershed is variable, depending upon time of year and severity of storms or snowmelt events. Higher stream flows are common during spring due to rain, snowmelt and combination events, and during hurricane season in the fall. During summer months, actively growing vegetation on the landscape draws vast amounts of water from the soil through *evapotranspiration*. This demand for groundwater by vegetation can significantly delay and reduce the amount of runoff reaching streams during a rain storm. During winter months, precipitation is held in the landscape as snow and ice. However, frozen ground may increase the amount of overland flow resulting from a rain storm if the air temperature is above freezing, particularly in spring on north facing slopes.

Subsurface storm flow, or *interflow*, comes from rain or snow melt that infiltrates the soil and runs down slope through the ground. Infiltrated water can flow rapidly through highly permeable portions of the soil or displace existing water into a channel by "pushing" it from behind. In the Neversink valley, subsurface flow can occur fairly rapidly along layers of essentially impermeable glacial lake silt/clay deposits. Subsurface storm flow shows up in the stream following overland flow, as stream flow declines back toward base flow conditions.

Base flow consists of water that infiltrates into the ground during and after a rain storm, sustaining streamflow during dry periods and between storm flows. The source of base flow is groundwater that flows through unsaturated and saturated soils and cracks or layers in bedrock adjacent to the stream. In this way streams can sustain flow for weeks or months between precipitation events and through the winter when the ground surface and all precipitation is otherwise frozen. Stable-temperature groundwater inputs keep stream water warmer than the air in winter and cooler than the air in summer—this process is what enables fish and other aquatic life to survive in streams year-round.

Streams transition between subsurface flow and base flow based on weather conditions, and there is no specific time period or flow magnitude that defines which flow the stream is at. One method which is commonly used to trace the rate of rise and fall in stage, or water level, is the analysis of *hydrographs*. A hydrograph is a graphical representation of the magnitude of stream flow over some period of time, and often displays "peaks" and "valleys", which are high and low rates of discharge serving as a reflection of weather patterns. A distinction can be made between base flow and storm flow by drawing a line connecting the valleys of the hydrograph. Storm flows will be above this line, while base flows will fall below it.

Hydrologists also use a hydrograph of a stream to characterize the relationship between flow and timing. A *stream gage* is necessary to monitor stream discharge and develop a hydrograph. The United States Geological Survey (USGS) maintains five continuously recording stream gages on the Neversink River upstream of the reservoir, which includes two on the east branch (USGS ID# 0143400680, drainage area 8.93 mi^2 & USGS ID# 01434017, drainage area 22.9 mi^2), two on the west branch (USGS ID# 01434021, drainage area 0.77 mi^2 & USGS ID# 01434498, drainage area 33.8 mi^2), and one on the main branch (USGS ID# 01435000, drainage area 66.6 mi^2). All gage information is available online at the USGS website at **http://waterdata.usgs.gov/ny/nwis/rt**.

Stream gages normally provide an update of the measurement of water stage, or height, every 15 minutes. From a given stage, it is possible to calculate the rate of *discharge*, or volume of water flowing by that point by using a relationship developed by the USGS called a *rating curve*. Using this rating curve, the magnitude of flow in the Neversink at the gage location can be determined at any time just by knowing the current stage, or

Photo courtesy of Charles Breiner.

Tropical Storm Irene, August 2011.

flow can be predicted for any other stage of interest. Additionally, we can use the historic record of constantly changing stage values to construct a picture of stream response to rain storms, snow melt or extended periods of drought, to analyze seasonal patterns or flood characteristics.

All of the Neversink gages have a long enough period of record to prepare a hydrograph for the stream. Each spike on the graph represents a peak in stream flow (and stage) in response to rain storms or snow melt. Stream level rises (called the "rising limb" of the hydrograph) and falls as the flood recedes (called the "falling (or receding) limb" of the hydrograph). In the examples below, overland flow accounts for most of the sharp peaks. These graphs represent the daily average flow calculated for each entire day, rather than the continuous 15-minute data.

Long time periods can be used to observe seasonal trends or long-term averages for the entire period of gage record. As is typical of the weather patterns in upstate NY, flows tend to be higher in the autumn (hurricane season) compared to winter (water held in ice and snow), and higher flows in spring (snow and ice melt, with rain-on-snow events) compared to summer (drought conditions with vegetation using a lot of water). However, changing climate patterns often make flows difficult to predict, and large events can happen during any season.

Storm flows can exceed stream channel capacity and cover previously dry areas, which is referred to as flooding. Flooding can occur in response to runoff associated with spring snowmelt, summer thunderstorms, fall hurricanes, and winter rain-on-snow events, and can range from minor events to significant discharges that extend far beyond channel boundaries, damage infrastructure and carve new channels.

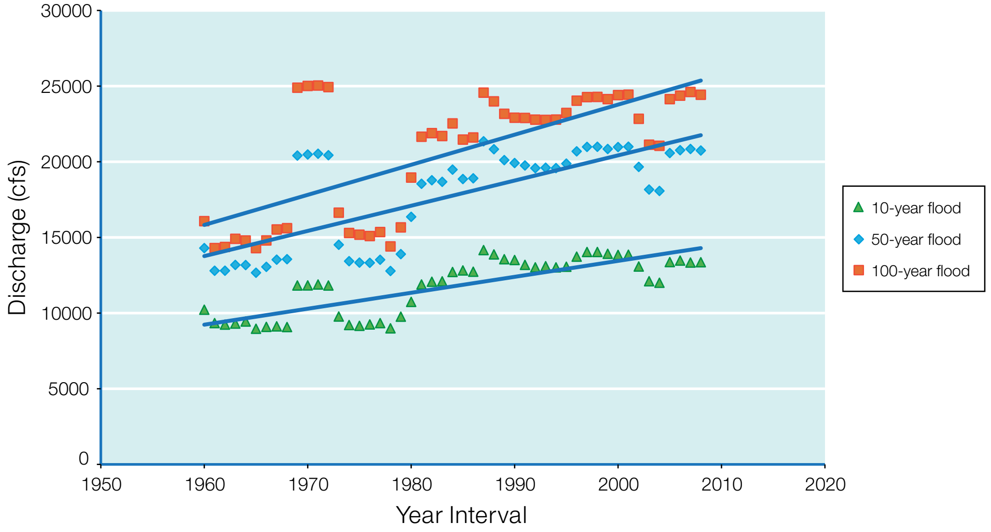
The prediction and evaluation of the likelihood of flooding is a useful tool to resource and land managers, one that allows for the appropriate planning of development and infrastructure, as well as anticipate potential property damage and safety issues. The USGS has developed a standard method for calculating flood frequency from peak flow data at stream gages, which is provided for public use upon request. This is accomplished by taking the long-term peak flow record and assigning a probability to each magnitude of flood event. Generally, the longer the period of record the more accurate the statistical probability assigned to each flow magnitude.

Flood frequency distributions show flood magnitude for various degrees of probability (or percent likelihood). This value is most often converted to a number of years, called “recurrence interval” (RI) or “return period”. For example, the flood with 20% chance of occurring or being exceeded in any single year corresponds to what is commonly referred to as a “5–year flood” (each of these values is the inverse of the other—just divide 1 by % probability to get RI in years, or divide 1 by RI in years to get % probability). This simply means that on average, for the period of record (the very long term), this magnitude flood will occur about once every 5 years. This probability is purely statistical; in a stable climate, the probability for a particular size flood to occur remains the same year to year over time, though the actual distribution of flood events in time is not regular. Many years may go by without a certain magnitude flood, or it may occur several times in a single year.

Since some of the stream gages along the Neversink have been established for several decades, we can study historic records, interview knowledgeable individuals from the area, and look at photographic records from the watershed to help describe some major historical flood events

50-YEAR TRENDS IN THE FREQUENCY OF LARGE FLOODS

Neversink River at Claryville Gage Station



Climate trends show increases in the intensity and frequency of heavy rainfall events that produce out-of bank flows and inundate the floodplain. This graph plots stream gage data for 10–, 50– and 100–year flood events on the Neversink. Note that the 50-year flood in 1960, around 13,000 cfs, now occurs every 10 years, on average.

and draw conclusions about the nature of flooding in the valley.

Flooding occurs in response to excessive runoff associated with spring snowmelt, summer thunderstorms, remnants of fall hurricanes, and winter rain-on-snow events. Ten of the thirty-one major floods recorded at the Neverink River gages above the reservoir occurred in spring and are presumably associated with major snowmelt events from either spring thaw or rain-on-snow events. Some dates of flood occurrences are consistent between multiple Neversink gages, showing some comparison can be made between the separate branches.

Conversely, weather in the Catskills can produce localized historically significant flood events such that a peak may not be recorded at each gage for the same time period or storm event. An event in January of 1996 resulted in a greater than five year RI floods at the Neversink near Claryville and West Branch Neversink at Claryville gages; yet did not cause a significant event at any of the other Neversink gages. This shows that comparisons between various sections of the same stream are not always perfect. This is especially so with summer thunderstorms, where highly localized storm cells can produce ten or more inches of rain in one portion of the watershed, and only a few inches in an adjacent portion of the watershed watershed for the same storm.

The risk of flood damage to public and private properties increases as development encroaches further into floodplains. Observed trends in stream gaging records suggest that damaging floods may be occurring at a higher frequency than they have in the past. As large floods occur more frequently, morphological changes to the stream channel happen at a more rapid pace, resulting in increased erosion rates and instances of channel migration into developed floodplains. An increasing trend in flood frequency makes it difficult to predict the probability of recurrence for large flows. As a result, bridges and other forms of infrastructure that are designed based on flood recurrence intervals are at risk of being inadequately constructed.

Unique hydrology should be taken into consideration for the management of any stream, as flood history and dynamics play a large role in determining the shape, or morphology, of stream channels and the hazards associated with land uses on the banks and in the floodplain. If we want to minimize their impact on property, infrastructure and other damages or inconvenience, it is critical that we understand and plan for flooding behavior. For example, applications for stream disturbance permits (from NYS DEC) typically increase following floods, as landowners and municipalities attempt to repair damage caused by floods. Historically, this has been activity that constrains and controls stream channels, rather than working with processes we can measure and, to some extent, predict. The results are often costly, and sometimes catastrophic, such as when berms or levees fail, or bridges wash out. These "control" approaches typically result in ongoing maintenance costs that can draw valuable community resources away from other projects. With a better understanding of stream and floodplain processes, we can work to make our efforts more effective and in many cases, reduce these repeated repair costs.

The Riparian Community

Although people value trees and other plants along a stream for their contribution to the beauty of the landscape, the vegetation in a watershed—especially in the streamside or riparian area—plays a critical role in providing for a healthy stream system. This streamside plant community maintains the riverine landscape and moderates conditions within the aquatic ecosystem.

As rainfall runs off the landscape, riparian vegetation slows the rate of runoff; captures excess nutrients carried from the land; protects stream banks and floodplains from the erosive force of water; and regulates water temperature changes. It also provides food and cover to animals and fish and other aquatic life; and conserves soil moisture, ground water, and atmospheric humidity.

Riparian vegetation serves as a buffer for the stream against activities on upland areas. Most human activities like agriculture, development, or recreation, can result in disturbances that can negatively impact the unprotected stream. Riparian vegetation captures and stores pollutants in overland flow from upland sources, such as salt from roadways and excess fertilizers from lawns and cropland. The width, density, and structure of the riparian community are important characteristics of the buffer also affect how well it works in the watershed.

On bare soils, high stream flows can result in bank erosion and overbank flow can cause soil erosion and scour on the floodplain. The roots of vegetation along the bank hold the soil and shield against these erosive flows. On the floodplain, vegetation slows flood flows, reducing the energy of water and its potential to cause erosion and scour. As vegetation slows the water, the fine sediment and soil suspended in the water has more chance to settle on the floodplain (rather than be carried away by the stream).

Vegetation intercepts rainfall and slows runoff, increasing the amount of precipitation that infiltrates the soil and reduces overland runoff. This helps to decrease the occurrence of destructive flash floods, lowers the height of flood waters, and extends the duration of the runoff event. These benefits are evident in forested watersheds such as the Upper Neversink when compared to watersheds of similar size which have high levels of urban development. The reduction in flood stage and duration also results in fewer disturbances to the stream banks and floodplains.

Streamside vegetation also functions to provide climate, habitat, and nutrients necessary for aquatic and terrestrial wildlife. Trees shading a stream help maintain cool water temperatures needed by native fish. Low-hanging branches and roots on undercut banks create cover for fish from predators such as birds and raccoons. Natural additions of organic leaf and woody material provide a food resource needed by terrestrial insects and aquatic macroinvertebrates (stoneflies, mayflies, etc.)—the primary source of food for fish.

A healthy riparian community is diverse, with a wide variety of plants, including trees, shrubs, grasses, and herbs. The age of plant species are varied with a healthy regeneration rate so that new plants ensure the future of the community. Riparian communities are unique in that they must adapt to frequent disturbance from flooding. Consequently, many riparian plants including willow, alder, and sycamore, can re-grow from stump sprouts or reestablish their root system if up-ended. Also, seeds from these species are adapted to thrive in gravel bars and lower flood benches, where they can sprout in sediment deposited there during high flows.

DIVERSE PLANT TYPES
(trees, shrubs, grasses, herbs)
+
DIVERSE PLANT AGES
(young and old)
+
DISTURBANCE-ADAPTED, MOISTURE-LOVING PLANTS
(accustomed to flooding and ice flows)
=
HEALTHY RIPARIAN BUFFERS
A healthy riparian community is densely vegetated, has a diverse age structure and is composed of plants that can resist disturbance.

Catskill mountain forests have evolved continuously over time reflecting the changes in climate, competition and human land use. The first of these changes was the result of the climatic warming that occurred after the most recent glaciation which enabled warm climate adapted plant communities to replace the cooler climate communities. Following the retreat of the glaciers, the forest of the Upper Neversink watershed gradually re-established and evolved from the boreal spruce/fir dominated forests, (examples of which can presently be found in Canada) to the maple-beech-birch northern hardwood forests (typical of the Adirondacks and northern New England) with the final transition of the lower elevations of the watershed to a southern hardwood forest dominated by oaks, hickory and ash (typical of the northern Appalachians). Dr. Michael Kudish provides an excellent documentation of evolution and site requirements of the region's forests in his book, *The Catskill Forest: A History* (Kudish, 2000).

More recently, human activities have affected the forest through both development and harvesting of desirable species (high-grade wood) for wood products. Native Americans used prescribed burning as a means of allowing nut bearing oaks and hickories to establish dominance in the forests. European settlers in the 18th and 19th centuries contributed to a rising industrial economy by clearing vast areas of land for agriculture, harvesting construction materials and hemlock bark for the extraction of tannin. The land cover in the Upper Neversink began to revert to forest with the local collapse of these economies in the 20th century and the acquisition of much of the land by the State for the Catskill Forest Preserve (Kudish, 2000).

Prior land uses play a big role in what types of vegetation we find along the stream. Due to the steepness of the sides of the valley, the most intensive development activities were confined to the valley floor along the stream. Pastures and fields were created from cleared, forested floodplains. Old abandoned fields have consistently recovered, with primary-colonizer species dominating the initial regrowth including sumac, aspens, and white pine. These species are succeeded by other light loving hardwood tree species such as ash, basswood, elm, and birch or in lower parts of the watershed, hickories, butternut, and oak. Hemlocks are largely confined to steeper stream banks and slopes where cultivation or harvesting of hemlocks for bark was impossible. More recent housing construction has re-intensified activity along the stream and been accompanied by the introduction of non-native vegetation typical of household lawns and gardens. Today the Upper Neversink watershed is largely forested. Agriculture and development activities are concentrated along the valley floor, leaving the riparian area predominantly herbaceous.

The Riparian Forest

Typically, riparian forest communities consist of species that thrive in wet locations and have the ability to resist or recover from flood disturbances. Extensive riparian communities typically exist in floodplain or wetland areas where a gentle slope exists. Many of the species present in these plant communities are exclusive to riparian areas. In areas where a steep valley slope exists, the riparian community may occupy only a narrow corridor along the stream and then quickly transition to an upland forest community. Soils, ground water, and available sunlight may create conditions that allow the riparian forest species to occupy steeper slopes along the stream, as in the case where hemlock inhabits the northfacing slopes along the watercourse.

Proximity to water means that these forests are subject to extreme forces of nature and human development. Natural disturbances include floods, ice flows, and to a lesser extent, high winds, pest and disease epidemics, drought, and fire. Large deer herds can also significantly alter the composition and structure of vegetation through browsing, leaving stands of mature trees with no understory.

In recent years, several flooding events on the Upper Neversink have created and reopened numerous high flow channels, reworked point bars, scoured floodplains and eroded formerly vegetated stream banks. Immediately following these floods, the channel and floodplains were scattered with woody debris and downed live trees. In many locations vegetation has not yet recovered from these floods. Over time, without additional large flooding events, trees and shrubs, flattened by the force of floodwaters, will re-established their form. Gravel bars and sites disturbed in previous flood events will become the seedbed for herbs and grasses. This type of natural regeneration is possible where the stream is stable and enough time passes between major flood events. Frequent floods and ice prevent large trees from establishing in the area disturbed by runoff events that reach bankfull flow (expected to occur on average every 1.5 years). Ice flows can also cause channel blockages, resulting in erosion and scour associated with high flow channels and overbank flows. Typically this type of disturbance has a short recovery period.


Only very cold winter temps, well below freezing, will slow the spread of Hemlock Wooly Adelgid, an invasive insect that attacks trees by feeding on sap at the base of the needles.

Local geology and stream geomorphology may complicate the recovery process. A number of sites were found along the Neversink River where vegetation has not been able to re-establish itself on bank failures created during recent flood events. On these sites, it will be necessary to understand the cause of the failure before deciding whether or not to attempt planting vegetation to aid in site recovery. In these instances, the hydraulics of flowing water, the channel morphology, the geology of the stream bank, and the requirements and capabilities of vegetation of specific types of plants must be considered before attempting restoration.

Pests and diseases that attack vegetation can also affect changes in the ecology of the riparian area and could be considered a disturbance.

The hemlock woolly adelgid (*Adelges tsugae*) is an insect, which feeds on the sap of hemlocks (*Tsuga spp.*) at the base of the needles causing them to desiccate and the tree to take on a grayish color. Stress caused by this feeding can kill the tree in as little as 4 years or take up to 10 years where conditions enable the tree to tolerate the attack (McClure, 2001). This native insect of Japan was first found in the U.S. in Virginia in 1951 and has spread northward into the Catskills (Adams, 2002).

In the eastern United States, the adelgid attacks eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*Tsuga carolinianna Engelman*) and can affect entire stands of hemlock. Once a tree is infested, the population fluctuates, allowing for some hemlock regrowth in periods when their density is low. But this regrowth is stunted and later attacked as the adelgid population increases. With each successive attack, tree reserves become depleted and eventually regrowth does not occur. The native predators of hemlock woolly adelgid have not offered a sufficient biological control, but recent efforts to combat the insect include experimentation with an Asian lady beetle (*Pseudoscymnus tsugae Sasaji*) which is known to feed on the adelgid. Initial experimental results have been positive, but large-scale control has yet to be attempted. The US Forest Service provides extensive information about this pest at its Northeastern Area forest health protection webpage: **www.na.fs.fed.us**.

A loss of hemlocks along the banks of the Neversink River poses a threat to stream bank stability and the aquatic habitat of the stream. Wildlife, such as deer and birds, find the dense hemlock cover to be an excellent shelter from weather extremes. Finally, dark green hemlock groves along the stream are quiet, peaceful places that are greatly valued by the people who live along the stream.

The Olive Natural Heritage Society, Inc. is monitoring the advance of the hemlock woolly adelgid in the Catskills and is working in cooperation with NYS DEC on testing releases of *Pseudosymnus tsugae*. Due to the widespread nature of the infestation, the use of chemical pest control options such as dormant oil would most likely provide little more than temporary, localized, control. The use of pesticides to control adelgid is not recommended in the riparian area due to potential impacts on water quality and aquatic life.

Without a major intervention (as yet unplanned), it is likely that the process of gradual infestation and demise of local hemlock stands by woolly adelgid will follow the patterns observed in areas already affected to the south. Reports from Southern Connecticut describe the recolonization of hemlock sites by black birch, red maple and oak (Orwig, 2001). This transition from a dark, cool, sheltered coniferous stand to open hardwood cover is likely to raise soil temperatures and reduce soil moisture for sites where hemlocks currently dominate vegetative cover. Likewise, in the streams, water temperatures are likely to increase and the presence of thermal refuge for cool water loving fish such as trout are likely to diminish. Alternatives for maintaining coniferous cover on hemlock sites include the planting of adelgid resistant conifers such as white pine as the hemlock dies out in the stand (Ward, 2001).

Other forest pests are on the brink of infesting the Catskills that pose even greater risks than the woolly adelgid. Emerald Ash Borer (*Agrilus planipennis; EAB*) and Asian Long-horned Beetle (*Anonplophora glabripennis; ALB*) are two particular insects that have ravaged forests elsewhere in the United States. EAB threatens the Catskills from the west as its makes its way from Michigan through Ohio, Pennsylvania and the southern tier of NY. Likewise ALB threatens to invade from the south (New York City) or east (Worchester, MA). The high level of tourism and second home ownership in the Catskills makes this area particularly vulnerable to the transport of these species. Together, these two pests could seriously impact the forests that comprise the livelihood of so many creatures and humans. Statewide concerns about EAB and ALB have led to a recent ban on the movement of firewood within a 50 mile radius of where it was cut; quarantines are being updated regularly by New York State Department of Environmental Conservation.

Although natural events disrupt growth and succession of riparian vegetation growth, human activities frequently transform the environmental and, as a result, can have long lasting impact on the capability of vegetation to survive and function.

Presently, the most significant sources of human disturbance on riparian vegetation in the Upper Neversink include the construction and maintenance of roadway infrastructure, the maintenance of utility lines, and the development of homes and gardens near the stream and its floodplain.

Due to narrow and steep valley walls, the alignment of Ulster County Route 47/Frost Valley Road and Denning Road closely follows the stream alignment of the Upper Neversink River. Use and maintenance of these roads has a significant impact on the riparian vegetation. The narrow buffer of land between the stream and the road receives runoff containing salt, gravel, and chemicals from the road that stunt vegetation growth or increase mortality. This disturbance fosters the establishment of undesirable, invasive plants which establish more quickly than native vegetation in these areas. The linear gap in the canopy created by the roadway separates the riparian vegetation from the upland plant communities. This opening also allows light into the vegetative understory which may preclude the establishment of native, shade-loving plants such as black cherry and hemlock.

Utility lines parallel the roadway and cross the stream at various points requiring the utility company to cut swaths through the riparian vegetation at each crossing, further fragmenting essential beltways for animal movement from streamside to upland areas. Although the road right-of-way and utility line sometimes overlap, at several locations along the stream the right-of-way crosses through the riparian area separate from the road. This further reduces the vigor of riparian vegetation and prevents the vegetation from achieving the later stages of natural succession, typified by climax species such as sugar maple, beech and hemlock.

Residential land use and development of new homes can have a great impact on the watershed and the ecology of the riparian area. Houses require access roads and utility lines that frequently have to cross the stream. Homeowners who love the stream and want to be close to it may clear trees and shrubs to provide access and views of the stream. Following this clearing, the stream bank begins to erode, the channel over-widens and shallows. The wide, shallow condition results in greater bedload deposition and increases stress on the unprotected bank. Eventually stream alignment may change and begin to cause erosion on the property of downstream landowners. Catskill stream banks require a mix of vegetation such as grasses and herbs that have a shallower rooting depth, shrubs with a medium root depth, and trees with deep roots. Grasses alone are insufficient to maintain bank stability in steeply sloping streams such as the Neversink.

Many people live close to the stream and maintain access to the water without destabilizing the bank. By carefully selecting a route from the house to the water's edge and locating access points where the force of the water on the bank under high flow is lower, landowners can minimize disturbance to riparian vegetation and stream banks. Restricting access to foot traffic, minimizing disturbance in the flood prone area, and promoting a dense natural buffer provide property protection and a serene place that people and wildlife can enjoy.

Invasive Plants and Riparian Vegetation

Sometimes the attempt to beautify a home with new and different plants introduces a plant that spreads out of control and "invades" the native plant community. Invasive plants present a threat when they alter the ecology of the native plant community. This impact may extend to an alteration of the landscape should the invasive plant destabilize the geomorphology of the watershed (Melanson, 2002).

The spread of Japanese knotweed (*Fallopia japonica*), an exotic, invasive plant gaining a foothold in many streams in the Catskills, is an example of a plant causing such a disruption. It shades out existing vegetation and forms dense stands along the bank. Although the impact of a Japanese knotweed invasion on the ecology of the riparian area is not fully understood, the traits of Japanese knotweed pose several concerns. Some of these concerns include:

- Knotweed appears to be less effective at stabilizing streambanks than shrubs and trees with deeper roots, possibly resulting in more rapid bank erosion.
- The shade of its broad leaves and the cover by its dead litter limit the growth of native plants that provide food and shelter for associated native animals.
- Knotweed branches do not lean out over stream channels, providing little cooling from shade.
- Dead knotweed leaves (*detritus*) may alter food webs and impact the food supply for terrestrial and aquatic life.
- Large stands of knotweed impede access to waterways for fishing and streamside hiking.
- Knotweed may alter the chemical make-up of the soil, altering soil microfauna and soil properties.

Japanese knotweed: first shoots emerge (spring); full bloom (summer) and dried stalks (after killing frost).

Japanese knotweed is very difficult to control. One small fragment of stem or underground root can start a whole new stand, and is often spread by floods or inadvertent transport through fill or cutting. The broad use of herbicides, while partially effective, is not a viable option due to the threat chemicals pose to the fragile aquatic ecosystem. Mechanical control, by cutting or pulling, is labor intensive and requires regular attention. While Japanese knotweed colonizes nearly five continuous miles of stream banks in some areas of the Catskills, there was no Japanese knotweed found along the banks of the entire Upper Neversink River.

Since Japanese knotweed has not taken root along the Upper Neversink River and its tributaries, it is particularly important to prevent additional spread of the aggressive plant by ensuring that fill material introduced to the riparian area is clean from knotweed fragments.

Mapping of Physiognomic Classes

As part of the stream management planning process, physiognomic vegetation classes (e.g., open-canopy forest, shrub-brush, herbaceous) were mapped and the riparian vegetation assessed for the Upper Neversink watershed. The purpose of this analysis was to provide the planning team with baseline information about plant communities present in the watershed, a description of the condition of vegetation in the riparian area, and recommendations related to the management of riparian vegetation along the stream.

Mapping of physiognomic classes was loosely based on the Vegetation Classification Standard produced by The Federal Geographic Data Committee. The mapping was based upon 2006

Vegetation Classes for the riparian corridor of the Neversink River

Vegetation Classification	Area (acres)	Percent of Total Area
Deciduous Closed Tree Canopy	1071.76	34.84
Mixed Closed Tree Canopy	639.60	20.79
Deciduous Open Tree Canopy	45.46	1.48
Evergreen Closed Tree Canopy	631.40	20.53
Herbaceous Vegetation	357.07	11.61
Shrubland	76.56	2.49
Bare Soil	57.07	1.86
Evergreen Open Tree Canopy	26.81	0.87
Impervious Surface	76.21	2.48
Unpaved Road	23.72	0.77
Mixed Open Tree Canopy	26.03	0.85
Water	42.36	1.38
Revetment	1.85	0.06
Total Area	2779.92 acres	100.00 %
Inadequate Vegetation	515.91 acres	18.55 %

digital-ortho pictometry and was confined to the riparian and near adjoining upland areas within 300 feet of the Neversink River. This classification was selected because it allows identification of locations, such as herbaceous or cobble deposits, where the combination of channel morphology and riparian vegetation would indicate the greatest cost-benefit from riparian buffer plantings and bio-engineered bank stabilizations.

The mapping analysis included the approximate delineation of the classes through the photo interpretation of 2006 digital orthophotography acquired from the Pictometry International Corporation. A physiognomic class GIS data layer was created using heads-up digitizing techniques with ESRI's Arcview software. The photo interpretation was field checked with class boundaries, and classifications were amended based upon field observations.

Summary of Findings

According to this riparian vegetation assessment, deciduous closed tree canopy (approximately 1072 acres), mixed closed tree canopy (approximately 640 acres), and evergreen closed canopy (631 acres) were the largest physiognomic classes within the 100 foot buffer, while deciduous open tree canopy and evergreen open tree canopy occupied approximately 45 acres and 27 acres respectively. The Neversink River benefits greatly from this predominance of forest vegetation of the riparian area. Forested land cover helps to provide a high degree of stability to the watershed by slowing storm runoff and helping to protect against stream bank erosion. Protection of forest communities as well as planting riparian vegetation near the stream will help ensure long-term stream stability, but the effectiveness of stream protection provided by vegetative communities differs based on their width, plant density, vegetation type and the stream's geomorphic characteristics. 515 acres, or 19% of land area was considered to lack healthy vegetative cover; this included areas of herbaceous vegetation, bare soil and revetment.

Riparian ecosystems are an important component of watershed protection and resource conservation. Therefore, it is important to maintain and improve the riparian vegetation along the Neversink River and its tributaries. The Catskill Streams Buffer Initiative (CSBI) helps residential landowners add vegetation to protect property and preserve natural habitat along stream banks in the Catskill/Delaware watershed areas. The CSBI is a funded initiative of the Stream Management Program. In partnership with coordinators at county Soil and Water Conservation Districts, CSBI's technical staff diagnose streamside-related problems and recommend solutions to effectively manage streamside property. By cultivating strong streamside buffers that use vegetation native to the Catskill region, CSBI helps landowners create streamside habitat, reduce stream bank erosion, and improve water quality. Applications for this program as well as broader watershed management and stream basics can be found at **www.CatskillStreams.org**.

Wetlands in the Upper Neversink Watershed

Wetlands are areas that are saturated or inundated at a frequency and duration that influences the development of soil characteristics and plant communities. Prolonged, regular inundation or saturation causes low-oxygen conditions to develop in wetland substrates, which results in the formation of 'hydric soils' and favors the growth of specially adapted plant species called 'hydrophytes'. While there are many types of wetlands, such as marshes, swamps, fens, and bogs, all can be generally characterized by the presence of periodic flooding or saturation, hydric soils, and hydrophytic vegetation.

Wetlands occur throughout the landscape and perform a variety of important functions. Floodplain wetlands intercept overland flow and detain overbank flooding to reduce flood flows. Wetlands located in depressions throughout the landscape detain overland flow, which also decreases flooding. Many wetlands intercept groundwater and serve as sources of headwater streams. Wetland vegetation takes up nutrients and pollutants and traps sediment to improve water quality. Chemical transformations unique to the low-oxygen conditions in wetland sediments also remove or retain nutrients and pollutants and sequester carbon. In addition to storing floodwaters, improving water quality, and providing stream flow, wetlands also provide critical fish and wildlife habitat. Eighty percent of breeding birds and over 50% of migratory birds are dependent upon wetlands. Almost all sport fish species are known to utilize wetlands for spawning and nursery grounds. Nearly half of the Nation's threatened and endangered species rely on wetlands for their survival.

It has been estimated that the nation has lost over half of its wetland area since the time of European settlement. It is now recognized that wetlands perform functions that benefit ecosystems well beyond their boundaries. Wetlands are currently protected, created, and restored through a variety of regulatory and non-regulatory programs. Much effort has also been placed on wetland mapping and research to assess the distribution, characteristics, and functions of wetlands.

The National Wetlands Inventory maps for the West of Hudson portion of the New York City Watershed, including the Neversink Reservoir Basin, were updated in 2005 through a DEP contract with the US Fish and Wildlife Service. The NWI update was based on 2003 aerial photography and identified approximately 422 acres of vegetated wetlands and ponds in the Neversink Basin. This amounts to 0.7% of the basin's area. Forested wetlands were most abundant, accounting for nearly 40% of the wetland acreage, followed by ponds (25%), scrub-shrub (18%), and emergent wetlands (17%). This basin-wide acreage is an estimate based on interpretation of color-infrared aerial photography. Site-specific, smaller-scale information requires field verification.

The vast majority (94%) of the wetlands mapped in the Neversink basin are associated with surface waters, whey they perform important water quality, floodwater storage, habitat, and baseflow support functions. Forty seven percent are located in the headwaters of the basin, either as the source of streams (16%), or along headwater streams (31%). Forty six percent are along third or higher order streams, largely the Neversink River and its branches. One percent of the NWI-mapped wetlands are adjacent to deepwater habitats, such as the reservoir. Surface water outflows could not be ascertained through remote sensing for 6% of the wetlands in the basin. These wetlands may lack a surface water outflow, or may have an intermittent or ephemeral connection that could not be detected on the aerial photography. Isolated and intermittently connected wetlands provide important habitat for amphibians and other wildlife.

Wetland Protection

Wetlands are protected through State and federal regulations. Many municipalities implement local wetland regulations as well, though no municipal wetland ordinances have been implemented within the Neversink Basin. Nationally, the rate of wetland loss has declined since the implementation of wetland regulations. However, wetlands continue to be threatened through activities such as excavation or filling for the construction of residential, industrial, and commercial facilities, draining and clearing for agricultural production, and direct or indirect discharge of pollutants.

An emergent wetland in the headwaters of the West Branch of the Neversink River.

Water Quality

A Closer Look at the High Peaks Source

The purpose of this section is to provide a general understanding of water quality in the Upper Neversink River. For the purposes of the NYC water supply, the Neversink River is famously known to supply the highest quality water, with the exception of the time periods following large storms when in-stream turbidity and suspended solids are high. NYCDEP has a long-term water quality sampling program of streams in the NYC water supply watersheds. Water quality samples are

collected at a fixed frequency from a network of sampling sites throughout the watershed. Grab samples are generally collected once a month. Storm event sampling is also performed at selected sites. While the analyses performed on samples from a specific site vary somewhat based on the objectives for the site, in general, samples are tested for temperature, pH, alkalinity, specific conductivity, dissolved oxygen, turbidity, nutrients, dissolved organic carbon, total organic carbon, chloride, suspended solids (selected sites), major cations (Ca, Mg, Na, K) (analyzed monthly), and total and fecal coliform (most sites). The current monitoring system was re-designed in 2008 and was based on multiple objectives (NYCDEP, 2009), and included a sampling site on the Neversink River at Claryville. Results are presented in annual water quality monitoring reports (e.g. NYCDEP, 2010).

Turbidity

Turbidity is an index of water clarity. Although there are no numerical standards for turbidity or suspended sediment, these constituents are of concern in streams because the presence of fine-grain sediments such as clay particles suspended in the water column can affect stream biota. These fine sediments can settle on substrates used by colonizing algae and invertebrates and can fill the small spaces between gravel where fish lay their eggs. Transmission of light through the water can be reduced, which can affect stream productivity through decreased photosynthesis. Turbid waters also become warmer as suspended particles absorb heat from sunlight, which can also cause oxygen levels to fall. For purposes of drinking water, turbidity is of concern because the associated particles have the potential to both carry and mask pathogens and interfere with disinfection.

Turbidity is an optical measurement of the light-scattering at 90° caused by particles suspended in water. Turbidity is measured in arbitrary "nephelometric turbidity units" (NTUs) by a "nephelometer". The higher the NTU value, the lower the water clarity. Turbidity can be influenced not only by the amount of particles in suspension, but also by the shape, size, and color of the particles. There is no single, fixed relationship between turbidity and total suspended solids. Total suspended solids are a measure of suspended solids concentration, expressed as a mass per volume (mg/L) obtained by physically separating the liquid and solid phases by filtration.

The median turbidity value for the Neversink River near Claryville based on data from 1987–2009 is 0.7 NTU. While the Neversink River usually has fairly low turbidity values, storms can cause these numbers to increase by three orders of magnitude. For example, samples collected during storm events have had turbidities as high as 750 NTU. Likewise the median value for total suspended solids is 0.6 mg/l, but during storm events has reached almost 2,900 mg/l.

Recently, there has been a noticeable increase in how long the Neversink Reservoir remains turbid after a large storm like the one that occurred September 18, 2012. The annual median turbidity from monthly sampling in the river has a 25-year average of about 0.4 NTUs; that annual median

increased to 0.5 NTUs (+25%) in 2011, and to 0.6 NTUs (+50%) in 2012. In years past, these annual median values have increased following large flood events, an effect that usually lasts for one or two years, but then returns to the long-term average, and it is too soon to evaluate the longer term effects of the large floods the Neversink experienced in the last three years. The Rondout Neversink Stream Program expects to continue its assessment of possible sources of fine sediment entrainment and associated turbidity in the next several years, and will continue to focus its management activities and resources on stream projects that have the potential to address elevated suspended sediment loading.

Temperature

Water temperature is one of the most important variables in aquatic ecology. Temperature affects movement of molecules, fluid dynamics, and metabolic rates of organisms as well as a host of other processes. In addition to having its own potential "toxic" effect (i.e. when temperature is too high), temperature affects the solubility and, in turn, the toxicity of many other parameters. Generally the solubility of solids increases with increasing temperature, while gases tend to be more soluble in cold water (i.e. available O_2 to fish).

In densely wooded areas where the majority of the streambed is shaded, heat transferred from the air and groundwater inputs drive in-stream temperature dynamics. However, in areas that aren't shaded the water temperatures can rise much more quickly due to the direct exposure to the sun's radiation. Rock and blacktop also hold heat and can transfer the heat to the water (like hot coals in a grill). Annual fluctuation of temperature in a stream may drive many biological processes, for example, the emergence of aquatic insects and spawning of fish. Even at a given air temperature, stream temperature may be variable over short distances depending on plant cover, stream flow dynamics, stream depth and groundwater inflow. Water temperatures exceeding 77° Fahrenheit cannot be tolerated by brook trout, and they prefer water temperatures less than 68° Fahrenheit (TU, 2006).

The annual median water temperature of Neversink River from 1987 to 2009 was 7.0°C (44.6°F). The annual median temperature ranged from 4.0°C (39.2°F, 1987) to 9.0°C (48.2°F, 1998).

pH

For optimal growth, most species of aquatic organisms require a pH in the range of 6.5 to 8.0, and variance outside of this range can stress or kill organisms. Due to the acidity of rainfall in the northeast, maintaining this range is of concern. According to the NYSDEC (2004a), average pH of rainfall in New York ranges from 4.0 to 4.5. Annual (1987–2009) median pH values for the period of record for the Neversink River near Claryville ranged from 6.1 to 6.9. The annual medians were generally slightly acidic.

Chloride

Chlorides are salts resulting from the combination of chlorine gas with a metal. Common chlorides include sodium chloride (NaCl), calcium chloride (CaC12) and magnesium chloride (MgC12). Chlorides can get into surface water from several sources including geologic formations containing chlorides, agricultural runoff, industrial wastewater, effluent from wastewater treatment plants, and the salting of roads. Excess chloride can contaminate fresh water streams and lakes, negatively affecting aquatic communities.

Concentrations of chloride of approximately 140 mg/L should be protective of freshwater organisms for short-term exposure; concentrations less than 35 mg/L are likely protective during long-term exposures (Environment Canada, 2001). Overall, approximately 5 percent of species would experience effects from chronic exposure to concentrations of chloride of 210 mg/L, while 10 percent of species would be affected at concentrations of 240 mg/L (Environment Canada, 2001). According to the United States Environmental Protection Agency, biota on average should not be affected if the four-day average concentration of chloride does not exceed 230 mg/L more than once every three years (USEPA, 2005a). Biotic impacts would be minimal if the one-hour average chloride concentration did not exceed 860 mg/L more than once every three years (USEPA, 2005a). The major sources of chloride in the Neversink watershed are most likely geology and road salting. The annual median chloride concentrations are low across the board, ranging from 1.6 mg/l to 3.3 mg/l; and though they have shown increases, the degree is relatively small.

Biomonitoring

Benthic macroinvertebrates (BMI) are animals without backbones that are larger than 1 millimeter and live at least a portion of their life cycles in or on the bottom of a body of water. In freshwater systems these animals may live on rocks, logs, sediments, debris and aquatic plants during their various life stages. A few common examples of BMIs include crustaceans such as crayfish, mollusks such as clams and snails, aquatic worms, and the immature forms of aquatic insects such as stonefly, caddisfly and mayfly nymphs.

BMIs function at the lower levels of the aquatic food chain, with many feeding on algae, detritus, and bacteria. Some shred and eat leaves and other organic matter that enters the water, and others are predators. Because of their abundance and position in the aquatic food chain, BMIs play a critical role in the natural flow of energy and nutrients through the aquatic system (Covich et al., 1997). For example, Sweeney (1993) demonstrated in a second order stream, that leaf litter and woody debris were primarily consumed in the forested woodlot where the debris originated. Also, as benthos die, they decay, leaving behind nutrients that are reused by aquatic plants and animals in the food chain. Insects fill the roles of predators, parasites, herbivores, saprophages, and pollinators, among others, which indicate the pervasive ecological and economic importance of this group of animals in both aquatic and terrestrial ecosystems (Rosenberg et al., 1986).

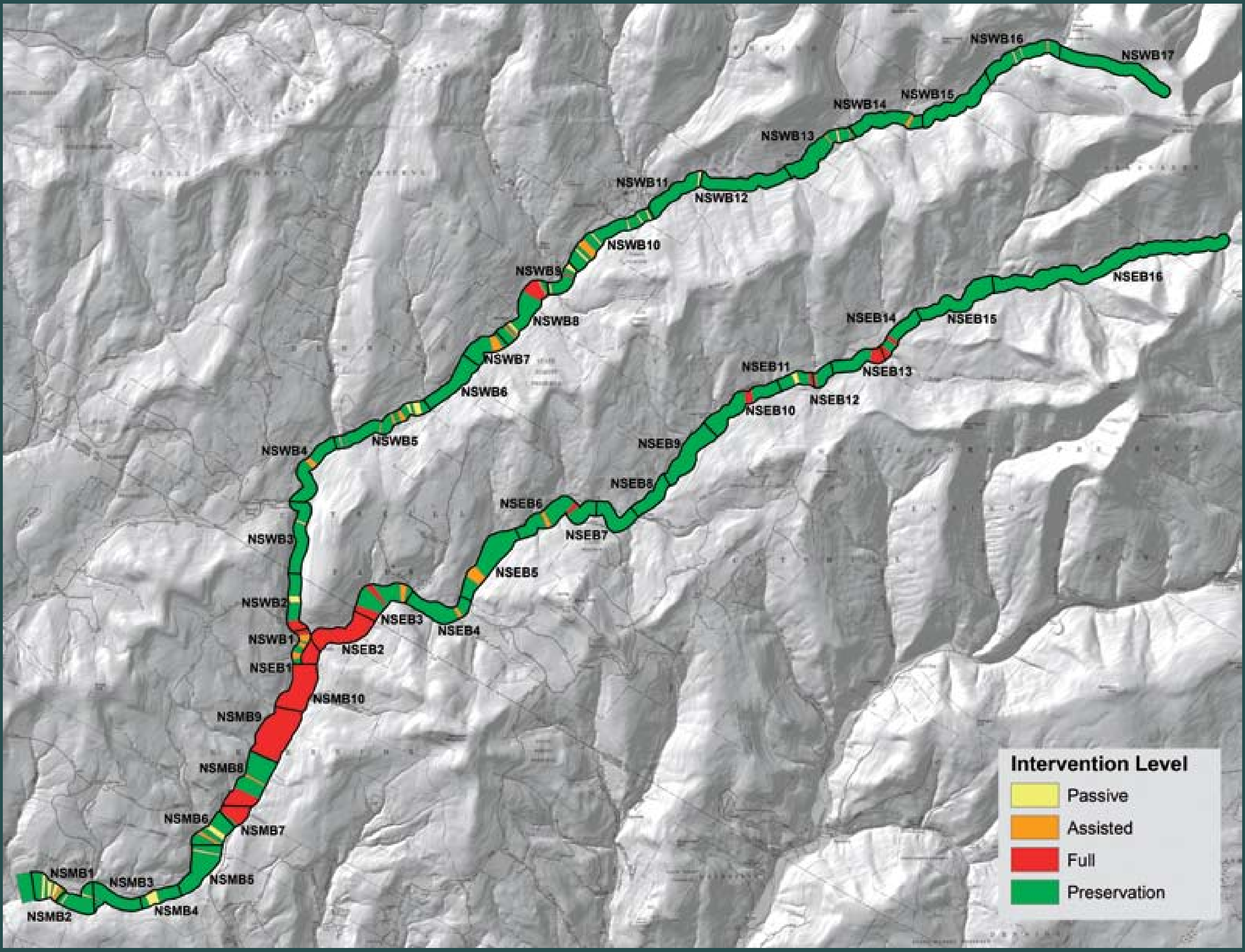
Biological assessments have been used by many states to evaluate the effectiveness of water quality programs, particularly for nonpoint source impact determinations (USEPA, 2002). In New York State, the first recorded biological monitoring effort dates from 1926–1939, but the regulatory role of stream biomonitoring did not begin in New York until after the passage of the Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act). The primary objective of New York State's program was to evaluate the relative biological health of the state's streams and rivers through the collection and analysis of macroinvertebrate communities (Bode et al, 2002).

Biological monitoring is an attractive methodology for documenting water quality for several reasons. First, the community collected at a given site reflects the water quality at that site over several weeks, months, or years. The alternative methodology of grabbing a water sample reflects the water quality at the instant the sample is collected (i.e. a snap shot image). Second, the community-based approach focuses on the biological integrity of the water body, and not a limited number of chemical parameters. Third, samples can be preserved in reference collections for future application; this provides a convenient routine of summer collection and winter analysis. Finally, biological assessments tend to be much more cost effective than chemical analysis.

Standardized protocols for benthic macroinvertebrate monitoring were developed in the mid-1980s due to the need for cost-effective habitat and biological survey techniques (Plafkin et al., 1989). The primary driver of the development was limited economic resources available to states with miles of unassessed streams. It was also recognized that it was crucial to collect, compile, analyze, and interpret environmental data rapidly to facilitate management decisions and resulting actions for control and/or mitigation of impairment. Therefore, the conceptual principles of rapid bioassessment protocols (RBPs) were as follows: cost-effective, yet scientifically valid procedures; provisions for multiple site investigations in a field season; quick turn-around of results for management decisions, easily translated to management and the public; and environmentally benign procedures (Barbour et al. 1999).

In the 2004 NYS DEC issued a report entitled *30 Year Trends in Water Quality of Rivers and Streams in New York State Based on Macroinvertebrate Data 1972–2002* (Bode et al, 2004). Based on the biomonitoring data the East Branch of the upper Neversink River was assesses as slightly impacted by acidity. The West Branch of the Ipper Neversink River was assessed as non-impacted. The reach had previously been assessed as slightly impacted. The Upper Neversink River at Claryville, downstream of the confluence of the East and West branches was also assessed as non-impacted.

INTERVENTION LEVELS MAP



Summary of Management Unit Recommendations

This section contains observations of the condition of the Upper Neversink River made during a walkover assessment conducted in 2010 and updated after Tropical Storm Irene in 2011 for East Branch and Main Stem. Detailed descriptions and specific recommendations are presented for the stream length existing from the top of the watersheds near Lake Winnisook on the West Branch and Deer Shanty Brook on the East Branch, downstream to the Neversink Reservoir. The exception to this is those areas on New York State lands, which are in "forever wild" status and thus are left unmanaged.

The Neversink River was organized into 40 Management Units (MUs) defined using physical stream characteristics, historical channel alignments, location of bridges and road infrastructure, and valley characteristics. These MU descriptions provide summary statistics, outline some of the historical conditions relating to current stream function, and describe current morphological conditions (bed and bank form), sediment transport dynamics, general streamside (riparian) vegetation condition, and proximity and arrangement of roads, bridges and culverts. They also briefly address issues related to flood risks, in-stream habitat and water quality. These descriptions were meant to provide landowners and other stream managers information that might be useful in the management of their property for optimum stream health and to guide future policy and program development by regional decision-makers and agency personnel.

The stream feature inventory was conducted during the summer of 2010. The following is a list of some of the features that were mapped using a handheld Global Positioning System (GPS) unit with 3–5 meter accuracy:

- Eroding banks
- Eroding beds (or head-cuts)
- Depositional bars—point, side, transverse (or diagonal), center bars
- Debris or log jams
- Culvert outfalls
- Revetment types—berms, walls, riprap, dumped stone, log cribbing
- Cross sectional locations
- Grade control features—including bedrock outcrops and dams
- Japanese knotweed colony locations
- Bridges and their abutments
- Clay exposures in the banks
- Spring seeps
- Tributaries

Photographs were taken of each feature significant to overall stream functioning. The information from this assessment was compiled within a series of Arcview Geographic Information Systems (GIS) software shapefiles maintained by the New York City Department of Environmental Protection (NYCDEP). Sample maps displaying important stream features are provided for each management unit.

In the summary table at the beginning of each management unit, the first entry is "Intervention Level". This refers to level of effort suggested for the management activities recommended for each unit. There are four categories: 🟩 ***Preservation*** indicates that conditions are stable and healthy and should be protected as a reference model to guide management of other units; 🟨 ***Passive Restoration*** indicates that there may be some instability of the channel bed, but it appears that the stream will recover from disturbance through self-correction and re-establish its stability without intervention, and that the appropriate management is to monitor the reach to track its evolution; 🟧 ***Assisted Restoration*** indicates that there is sufficient channel instability to warrant active management (e.g., installation of soil bioengineering stabilization practices) but that major channel work is not necessary and management can be effective at the site scale; 🟥 ***Full Restoration*** indicates that significant instability problems are present which will require intervention such as channel work to reestablish its effectiveness in transporting sediment.

While bank erosion occurs even in pristine settings, much of the bank erosion we see in the Neversink and elsewhere in the Catskills is the result of some of the ways we have managed the stream, its floodplain and roads and bridges in the stream corridor. Since streams are integrated systems, management decision in one reach has the potential to create disturbance up or downstream, and effective management requires that watershed communities coordinate these decisions in collaboration with each other. For that reason, the recommendations in this section of the management plan consider conditions both at the site of the erosion and upstream and downstream as well. In addition, the relative significance of each erosion site, its causes and the options for treatment all are best understood and addressed in the context of the entire watershed.

Published here are three management units of significance to the community. The full set of documents is online at:
www.catskillstreams.org/nr.html

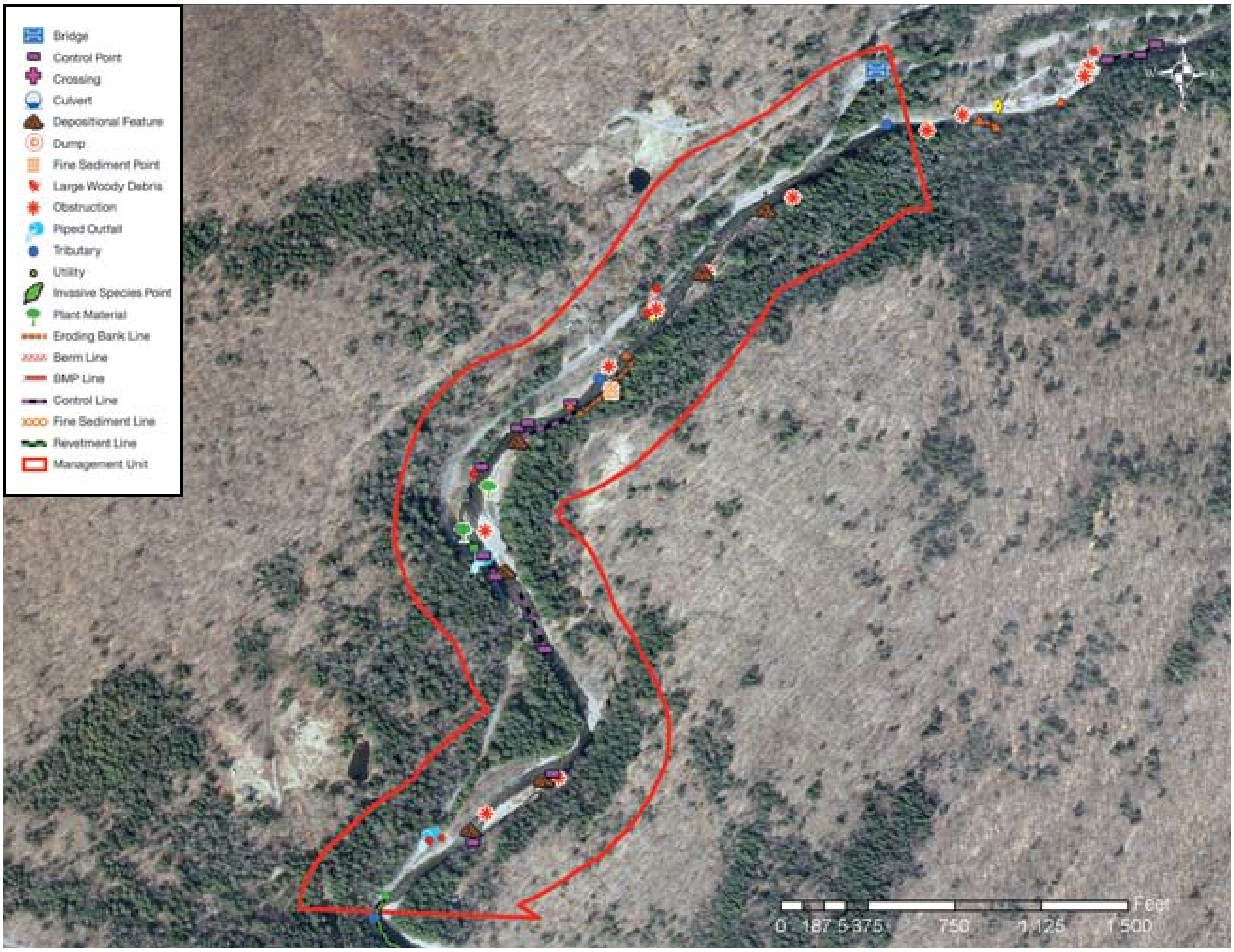
MUWB4.1

Neversink River West Branch

MANAGEMENT UNIT 4

STREAM FEATURE STATISTICS

- 3.00% of stream length is experiencing erosion
- 2.49% of stream length has been stabilized
- 9.02 acres of inadequate vegetation within the 100 ft. buffer
- 300 feet of stream is within 50 ft. of the road
- There are two building structures located within the 100-year floodplain boundary of the Neversink River



Stream Feature Inventory 2010 (Figure 1)

WEST BRANCH MANAGEMENT UNIT 4

BETWEEN STATION 10300 AND STATION 15200

Management Unit Description

This management unit begins near the confluence of Fall Brook at Station 15200, continuing approximately 4,800 ft. to the confluence with Round Pond Brook near Station 10300. The drainage area ranges from 31.30 mi^2 at the top of the management unit to 32.50 mi^2 at the bottom of the unit. The valley slope is close to 1.28%. The average valley width is 532.92 ft.

Summary of Recommendations
West Branch Management Unit 4

Intervention Level	Assisted restoration of the bank erosion site from Station 13540 to Station 13200 (BEMS NWB4_13200).
Stream Morphology	Protect and maintain sediment storage capacity and floodplain connectivity. Conduct baseline survey of channel morphology.
Riparian Vegetation	Investigate and evaluate 5.59 acres of potential riparian buffer improvement areas for future buffer restoration. Potential riparian buffer improvement areas were observed at various locations throughout this management unit (Figure 7).
Infrastructure	Inspect revetment beginning at Station 10380 on the right bank for scour that could lead to structural instability.
Aquatic Habitat	Fish population and habitat survey.
Flood Related Threats	Floodproofing as appropriate. http://www.fema.gov/library/viewRecord.do?id=1420
Water Quality	Investigation of water quality impacts of piped outfalls at Station 12360 and Station 10650. Maintain household septic systems.
Further Assessment	Detailed survey of BEMS NWB4_13200 erosion site to determine appropriate treatment options.

Historic Conditions

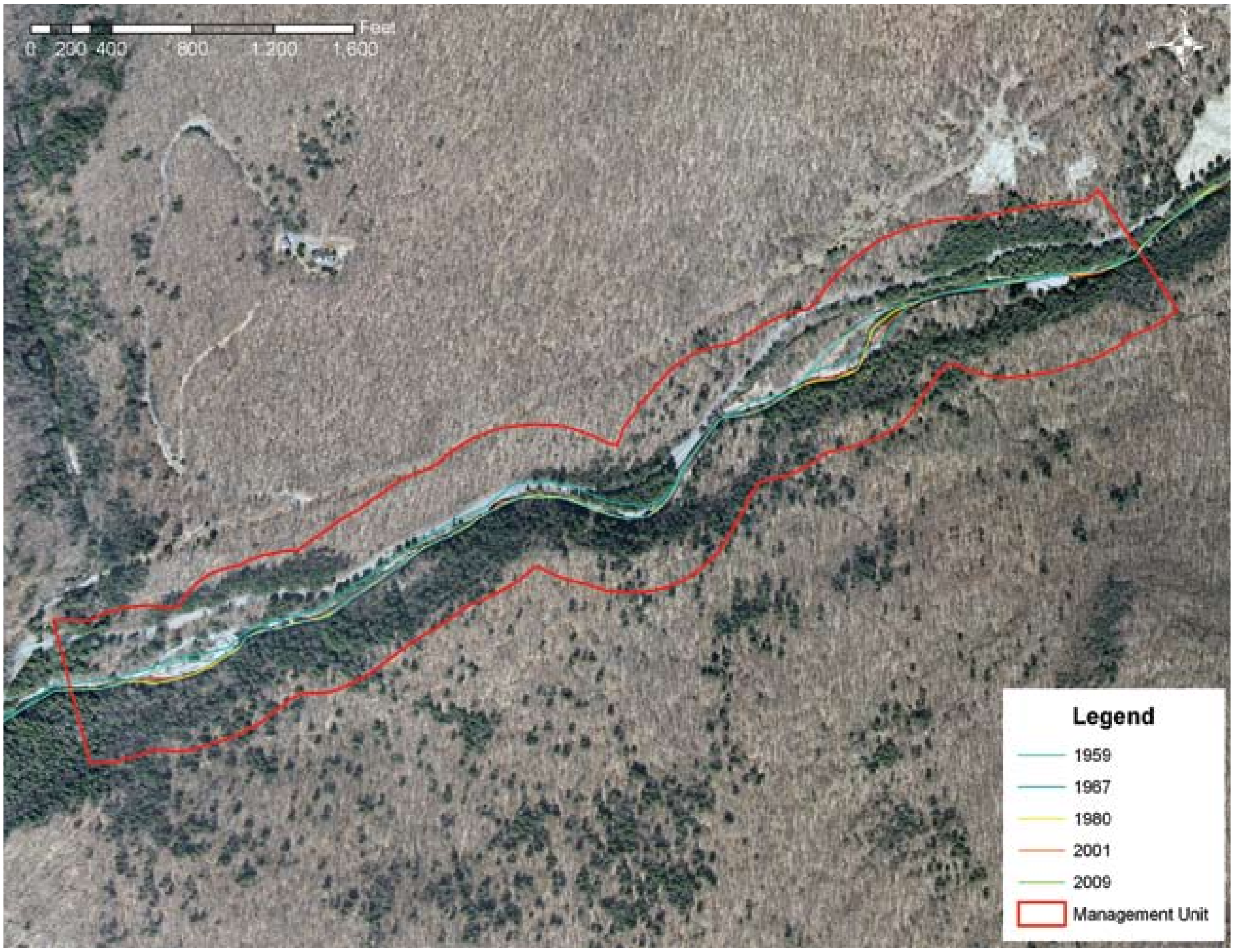
Excerpt from 1875 Beers Map (Figure 2)

As the glaciers retreated about 12,000 years ago, they left their "tracks" in the Catskills. See Section 2.4 *Geology of Upper Neversink River,* for a description of these deposits. These deposits make up the soils in the high banks along the valley walls on the Neversink mainstem and its tributaries. These soils are eroded by moving water, and are then transported downstream by the River. During the periods when the forests of the Neversink watershed were heavily logged for bark, timber, firewood and to make pasture for livestock, the change in cover and the erosion created by timber skidding profoundly affected the Neversink hydrology and drainage patterns.

According to the map of Forest Industries in the Catskills and the associated descriptions included in *The Catskill Forest: A History* by Michael Kudish (Purple Mountain Press, 2000), Joseph H. Prothero owned a sawmill that was formerly located downstream of the convergence with Fall Brook. While no historic raceways or other evidence of the sawmill was observed in this management unit, according to Beers' 1875 Atlas, it was located on the right bank near the convergence of the unnamed tributary near Station 13400.

The 1875 Beers Atlas of this area indicates that by that time, the stream had been harnessed for manufacturing, primarily saw mills, woodworking shops and tanneries *(Figure 2)*. Raceways were built in the floodplains to divert water to ponds for use as needed. Floodplains were profoundly altered in the process, as these watercourses also became areas of preferential channelized flow when floodwaters inundated the floodplains. When woody debris jams blocked the primary channels, these raceways sometimes eroded out to become major secondary channels, or even took over the full flow to become a new primary watercourse.

During large runoff events, floodplains adjacent to the confluence of major tributaries receive large slugs of material eroded out of the steep streams draining the valley walls, overwhelming the Neversink's ability to transport it, creating an alluvial fan. Like changes in the floodplains made by humans, these episodes can result in catastrophic shifts in channel alignment. In the roughly one hundred and twenty centuries since the retreat of the glaciers, the position of Neversink River has moved back and forth across its



Historical channel alignments from five selected years (Figure 3)

floodplain numerous times in many locations. A comparison of historical channel alignments *(Figure 3)* and in-stream observations made during a stream feature inventory in 2010 *(Figure 1, page 1)* indicate some lateral channel instability. According to records available from the NYSDEC DART database twenty-seven NYS Article 15 stream disturbance permits have been issued in this management unit. These permits pertain to activities which have the potential to significantly impact stream function, such as bank stabilization, stream crossings, habitat enhancement, and logging practices. database (**http://www.dec.ny.gov/cfmx/extapps/envapps/**).

Stream Channel and Floodplain Current Conditions

The following description of stream morphology references stationing in the foldout Figure 4. “Left” and “right” references are oriented looking downstream, photos are also oriented looking downstream unless otherwise noted. Stationing references, however, proceed upstream, in feet, from an origin (Station 0) at the confluence with the Neversink East Branch. Italicized terms are defined in the glossary. This characterization is the result of surveys conducted in 2010.

WBMU4 is features a distinct S-curve meander in the river between the confluences of Fall Brook and Round Pond Brook. The upstream reaches begin with a meander across the valley floor to the right valley wall from Station 15200 to Station 12700. WBMU4 begins with the confluence of Fall Brook at Station 15100. At the confluence the Fall Brook watershed includes approximately 5 square miles draining a valley between High Falls Ridge and the Beaver Kill Range to the north. A cobble delta bar was observed in the main channel at the confluence. *(A224)* Potential riparian buffer improvement areas were identified between Station 14700 and Station 14250 *(Figure 7)*. A large downed tree was observed on a left bank floodplain terrace at Station 14600, followed by a cobble bankfull bench with grass and sedge vegetation beginning at Station 14450 and extending 400 feet to Station 14050. *(A228)* Another downed tree was observed on the floodplain terrace near the end of the cobble bar.

Cobble delta bar in main channel at confluence (A224)

Cobble bankfull bench (A228)

At Station 13900 a 115-foot stone berm was observed in the thick forested riparian buffer between a flood chute in the right floodplain and Frost Valley Road. The berm appeared to be actively maintained as evidenced by recently placed stones. Some scour was observed on the right bank at the downstream end of the berm indicating that the flood chute conveys flow during high flow events. *(A237 and A235)* A headcut was observed in the main channel near at large boulder at Station 13800 that has caused a minor drop in stream grade at this location.

Actively maintained berm on right floodplain (A237)

The riparian buffer has the potential to be improved along the right bank between Station 13550 and Station 12910. An eroding bank segment was observed on the left bank extending 340 feet from Station 13540 to Station 13200 (BEMS NWB4_13200). This bank failure site was documented as active; while there is hardening at the toe, hydraulic erosion and fluvial entrainment are causing scour at the crown of the bank exposing glacial till. The 50-foot length of the eroding segment from 13450 to 13400 was documented as a fine sediment source although it is not a significant source of turbidity. In addition, an unnamed tributary conveying flow from the right valley wall (and former location of Prothero sawmill) was observed joining the main channel across from the bank failure site near Station 13400. It is possible that the additional sediment and flow conveyed by this tributary is contributing to this bank erosion. *(A242)* Due to the active erosion at the tip of the bank failure and the ongoing contribution from the tributary, recommendations for this site include *assisted restoration* to improve bank stability.

Scour on right bank downstream of berm (A235)

Erosion on left bank (A242)

Two building structures are located within the FEMA-mapped 10-year floodplain on the right bank north of Frost Valley Road near Station 13400. Exposed shale bedrock was observed directly downstream of the bank erosion site, extending 260 feet from Station 13200 to Station 12940. The bedrock is constraining the river laterally on the left bank and forming a grade control for the left bed for this segment of the river. *(A253)* A partially vegetated cobble point bar begins at Station 12940 and continues through Station 12300. The willow growing on this bar near Station 12500 was documented as a potential plant source for restoration projects throughout this section of the river. *(A258)* Across from the point bar, at the apex of the meander toward the right valley wall near Station 12800, placed quarry rock forms a stream bed grade control on the right bed. *(P7290125)* Downstream of the quarry rock a 40-foot long stone berm was observed on the right bank.

As the main channel begins to flow east across the valley floor toward the left valley wall more revetment and exposed bedrock were observed stabilizing the right bank, which is within 50 feet of Frost Valley Road in this location. A stone gabion revetment was observed extending 100 feet from Station 12520 to Station 12420 on the right bank. This revetment was documented as in good structural and functional condition, although the riparian buffer was documented as thin with mangled fencing on top of the gabions. *(P72901130)* A sloped stone revetment was observed in good structural and functional condition extending 60 feet from Station 12420 to Station 12360. Both of these revetments were most likely designed to stabilize the bank near Frost Valley Road.

Bedrock grade and planform control (A253)

Potential willow harvest source (A258)

Placed quarry rock forming grade control (P7290125)

A piped outfall was observed at the end of this revetment near Station 12360 conveying flow from Frost Valley Road to the main channel. The outfall is constructed of a 2-foot diameter smooth steel pipe with 3 feet of outfall and good outfall protection. *(A263)* It is recommended that the water quality impacts of this outfall be investigated to better understand and possibly mitigate the water quality implications of this conveyance.

Exposed bedrock was observed providing stream bed grade control for the width of the main channel from Station 12400 to Station 12280, and again from Station 12200 to Station 11900. *(A260, A266)* The river reaches the apex of the meander toward the left valley wall near Station 11500 before meandering toward the right valley wall again to converge with Round Pond Brook. A large fallen tree was observed above bankfull height on the left bank near Station 11300. *(A272)* Exposed bedrock controls stream bed grade for the width of the channel from Station 11300 to Station 11230, followed by a thickly vegetated cobble center bar observed on the left bed. *(A276)* This cobble center bar ends near Station 10800, where exposed bedrock again forms a grade control for the width of the main channel for 85 feet to Station 10715.


Stone gabion revetment on right bank (P7190130)


Piped outfall conveying flow from Frost Valley Road (A263)


Exposed bedrock providing grade control (A260)


Bedrock grade control (A266)


Fallen tree above bankfull height (A272)


Vegetated cobble center bar (A276)

The main channel flows within 50 feet of the main channel for the remaining 400 feet of WBMU4. A stone berm was observed between the main channel and Frost Valley road extending 50 feet from Station 10700 to Station 10650. A piped outfall conveying flow from Frost Valley road, through the right bank floodplain to the main channel was observed at the end of this berm. The outfall is constructed of a 18-inch diameter plastic pipe, and appeared to convey fine sediments from the road based on outwash observed on the right bank. *(P7290144)* It is recommended that the water quality impacts of this outfall be investigated to better understand and possibly mitigate the water quality implications of this conveyance.

A stacked rock revetment was observed protecting Frost Valley Road for the last 80 feet of the management unit beginning near Station 10380 and continuing into WBMU3. The potential exists for adding a riparian buffer to this revetment. The revetment was documented in good structural and functional condition although deposition on the left bank appeared to be directing flow toward the revetment, which could be causing scour below the water level. It is recommended that this revetment be inspected for structural stability. *(A280)*


Fine sediment outwash on right bank (P7290144)


Stacked rock revetment protecting Frost Valley Road (A280)

WBMU4 ends at Station 10300, at the apex of a meander toward the right valley wall approximately 50 feet upstream of the convergence with Round Pond Brook.

Sediment Transport

Streams move sediment as well as water. Channel and floodplain conditions determine whether the reach aggrades, degrades, or remains in balance over time. If more sediment enters than leaves, the reach aggrades. If more leaves than enters, the stream degrades. (See Section 3.1 for more details on Stream Processes).

This management unit contains both sediment storage reaches and sediment transport reaches. The storage reaches act as a "shock absorber", holding *bedload* delivered during large flow events in depositional bars and releasing it slowly over time in more moderate flood events. These depositional areas are very dynamic, with frequent lateral channel migration through bank erosion, *avulsions* and woody debris accumulations. The densely forested portion of the watershed upstream of this management unit serves as a continuous source of large woody material that is transported downstream and deposited during flood events. This large woody debris often serves as an obstruction to sediment transport, resulting in the aggradation of bed material. Sediment storage reaches can result from natural conditions, like the widening valley floor and decreased channel slope as is the case in this management unit or as the unintended consequence of poor bridge design, check dams or channel overwidening. This is one process by which floodplains are created and maintained. Healthy undeveloped floodplains throughout the Neversink watershed like the floodplains on both banks throughout WBMU4 reduce the velocity of higher flows thereby mitigating the threat of stream bank erosion and property damage during flood events.

In some locations in WBMU4 the river is confined by the bedrock or high banks leaving no accessible floodplain for sediment deposition and storage. This section of the river acts as a transport reach. Transport reaches are in a state of *dynamic equilibrium,* effectively conveying sediment supplied from upstream during each flow event.

To better understand sediment transport dynamics of this section of the Neversink, a baseline survey of channel form and function is recommended for this management unit.

Riparian Vegetation

One of the most cost-effective methods for landowners to protect streamside property is to maintain or replant a healthy buffer of trees and shrubs along the bank, especially within the first 30 to 50 ft. of the stream. A dense mat of roots under trees and shrubs bind the soil together, and makes it much less susceptible to erosion under flood flows. Mowed lawn does not provide adequate erosion protection on stream banks because it typically has a very shallow rooting system. Interplanting with native trees and shrubs can significantly increase the working life of existing rock rip-rap placed on stream banks for erosion protection. Riparian, or streamside, forest can buffer and filter contaminants coming from upland sources or overbank flows. Riparian plantings can include a great variety of flowering trees and shrubs, native to the Catskills, which are adapted to our regional climate and soil conditions and typically require less maintenance following planting and establishment.

Some plant species that are not native can create difficulties for stream management, particularly if they are invasive. Japanese knotweed (*Fallopia japonica*), for example, has become a widespread problem in recent years. Knotweed shades out other species with its dense canopy structure (many large, overlapping leaves), but stands are sparse at ground level, with much bare space between narrow stems, and without adequate root structure to hold the soil of stream banks. The result can include rapid stream bank erosion and increase surface runoff impacts. There were no occurrences of Japanese knotweed documented in this management unit during the 2010 inventory.

An analysis of vegetation was conducted using aerial photography from 2009 and field inventories *(Figure 5).* In this management unit the predominant vegetation type within the riparian buffer is evergreen closed tree canopy (44.00 %) followed by deciduous closed tree canopy (31.14%). *Impervious* area makes up 4.50% of this unit's buffer. No occurrences of Japanese knotweed were documented in this management unit during the 2010 inventory.

There are 8.60 acres of wetland (10.87% of WBMU4 land area) within this management unit mapped in the National Wetland Inventory as three distinct classifications (see Section 2.5, *Wetlands and Floodplains* for more information on the National Wetland Inventory and wetlands in the Neversink watershed). Wetlands are important features in the landscape that provide numerous beneficial functions including protecting and improving water quality, providing fish and wildlife habitats, storing floodwaters, and maintaining surface water flow during dry periods (See Section 2.5 for wetland A type descriptions and regulations). The wetland classified as Riverine is 1.79 acres in size, the wetland classified as Freshwater Forested Shrub is 4.42 acres in size, and the wetland classified as Freshwater Pond is 2.39 acres in size.

Flood Threats

INUNDATION As part of its National Flood Insurance Program (NFIP), the Federal Emergency Management Agency (FEMA) performs hydrologic and hydraulic studies to produce Flood Insurance Rate Maps (FIRM), which identify areas prone to flooding. The upper Neversink River is scheduled to have its FIRMs updated with current surveys and hydrology and hydraulics analysis in the next few years, and the mapped boundaries of the 100-year floodplain are likely to change. There are two structures WBMU4 within the 100-year floodplain as identified on the FIRM maps; they are located on the right bank north of Frost Valley Road near Station 13400. FEMA provides guidance to homeowners on floodproofing at: http://www.fema.gov/library/viewRecord.do?id=1420

BANK EROSION Due to a number of conditions in WBMU4, the stream banks within the management unit are at some risk of erosion, primarily associated with ineffective sediment conveyance. The channel gradient is relatively low in WBMU4, leading to bed aggradation in some areas. Aggrading conditions lead to channel widening via bank erosion. One area of erosion was documented in the management unit during the stream feature inventory.

An eroding bank segment was observed on the left bank extending 340 feet from Station 13540 to Station 13200 (BEMS NWB4_13200). This bank failure site was documented as active; while there is hardening at the toe, hydraulic erosion and fluvial entrainment are causing scour at the crown of the bank exposing glacial till. The 50-foot length of the eroding segment from 13450 to 13400 was documented as a fine sediment source although it is not a significant source of turbidity. Due to the active erosion at the tip of the bank failure, recommendations for this site include *assisted restoration* to improve bank stability.

INFRASTRUCTURE A stone gabion revetment was observed extending 100 feet from Station 12520 to Station 12420 on the right bank. This revetment was documented as in good structural and functional condition, although the riparian buffer was documented as thin with mangled fencing on top of the gabions. A sloped stone revetment was observed in good structural and functional condition extending 60 feet from Station 12420 to Station 12360. Both of these revetments were most likely designed to stabilize the bank near Frost Valley Road.

A stacked rock revetment was observed protecting Frost Valley Road for the last 80 feet of the management unit beginning near Station 10380 and continuing into WBMU3. The revetment was documented in good structural and functional condition although deposition on the left bank appeared to be directing flow toward the revetment, which could be causing scour below the water level. It is recommended that this revetment be inspected for structural stability.

At Station 13900 a 115-foot stone berm was observed in the thick forested riparian buffer between a flood chute in the right floodplain and Frost Valley Road. The berm appeared to be be actively maintained as evidenced by recently placed stones. Downstream of the quarry rock at Station 12800 a 40-foot long stone berm was observed on the right bank. A stone berm was observed between the main channel and Frost Valley road extending 50 feet from Station 10700 to Station 10650. All three of these berms appeared to be designed to protect Frost Valley Road during high flow events.

Aquatic Habitat

Aquatic habitat is one aspect of the Neversink River ecosystem. While ecosystem health includes a broad array of conditions and functions, what constitutes "good habitat" is specific to individual species. When we refer to aquatic habitat, we often mean fish habitat, and specifically trout habitat, as the recreational trout fishery in the Catskills is one of its signature attractions for both residents and visitors. Good trout habitat, then, might be considered one aspect of "good human habitat" in the Neversink River valley.

Even characterizing trout habitat is not a simple matter. Habitat characteristics include the physical structure of the stream, water quality, food supply, competition from other species, and the flow regime. The particular kind of habitat needed varies not only from species to species, but between the different ages, or life stages, of a particular species, from eggs just spawned to juveniles to adults.

New York State Department of Environmental Conservation (DEC) classifies the surface waters in New York according to their designated uses in accordance with the Clean Water Act. The following list summarizes those classifications applicable to the Neversink River.

1. The classifications A, AA, A-S and AA-S indicate a best usage for a source of drinking water, swimming and other recreation, and fishing.
2. Classification B indicates a best usage for swimming and other recreation, and fishing.
3. Classification C indicates a best usage for fishing.
4. Classification D indicates a best usage of fishing, but these waters will not support fish propagation.

Waters with classifications AA, A, B and C may be designated as trout waters (T) or suitable for trout spawning (TS). These designations are important in regards to the standards of quality and purity established for all classifications. See the DEC Rules & Regulations and the Water Quality Standards and Classifications page on the NYSDEC web site for information about standards of quality and purity.

In general, trout habitat is of a high quality in the Neversink River. The flow regime above the reservoir is unregulated, the water quality is generally high (with a few exceptions, most notably low pH as a result of acid rain; see Section 3.1, *Water Quality*), the food chain is healthy, and the evidence is that competition between the three trout species is moderated by some *partitioning* of available habitat among the species.

The mainstem and major tributaries in WBMU4 have been classified as "C(T)" connoting best usage for fishing, and indicating the presence of trout. Trout spawning likely occurs in this management unit, but has not yet been documented in the DEC classification.

Channel and floodplain management can modify the physical structure of the stream in some locations, resulting in the filling of pools, the loss of stream side cover and the homogenization of structure and hydraulics. As physical structure is compromised, inter-species competition is increased. Fish habitat in this management unit appears to be relatively diverse.

It is recommended that a population and habitat study be conducted on the Neversink River, with particular attention paid to temperature, salinity, riffle/pool ratios and quality and in-stream and canopy cover.

Water Quality

The primary potential water quality concerns in the Neversink as a whole are the contaminants contributed by atmospheric deposition (nitrogen, sulfur, mercury), those coming from human uses (nutrients and pathogens from septic systems, chlorides (salt) and petroleum by-products from road runoff, and suspended sediment from bank and bed erosion. Little can be done by stream managers to mitigate atmospheric deposition of contaminants, but good management of streams and floodplains can effectively reduce the potential for water quality impairments from other sources.

Storm water runoff can have a considerable impact on water quality. When it rains, water falls on roadways and flows untreated directly into the Neversink River. The cumulative impact of oil, grease, sediment, salt, litter and other unseen pollutants found in road runoff can significantly degrade water quality. There are two piped outfalls that convey storm water runoff directly into the Neversink River in this management unit. It is recommended that the water quality impacts from the outfalls at Station 12360 and Station 10650 be investigated to better understand and possibly mitigate the water quality implications of these conveyances.

Sediment from stream bank and channel erosion pose a potential threat to water quality in the Neversink River. Clay and sediment inputs into a stream may increase *turbidity* and act as a carrier for other pollutants and pathogens. There is one bank erosion site in WBMU4 that is a potential minor source of fine sediment. None of the sites represent a significant source of turbidity.

Nutrient loading from failing septic systems is another potential source of water pollution. Leaking septic systems can contaminate water making it unhealthy for swimming or wading. Two structures are located in relatively close proximity to the stream channel in this management unit. These homeowners should inspect their septic systems annually to make sure they are functioning properly. Each household should be on a regular septic service schedule to prevent over-accumulation of solids in their system. Servicing frequency varies per household and is determined by the following factors: household size, tank size, and presence of a garbage disposal. Pumping the septic system out every three to five years is recommended for a three-bedroom house with a 1,000–gallon tank; smaller tanks should be pumped out more often.

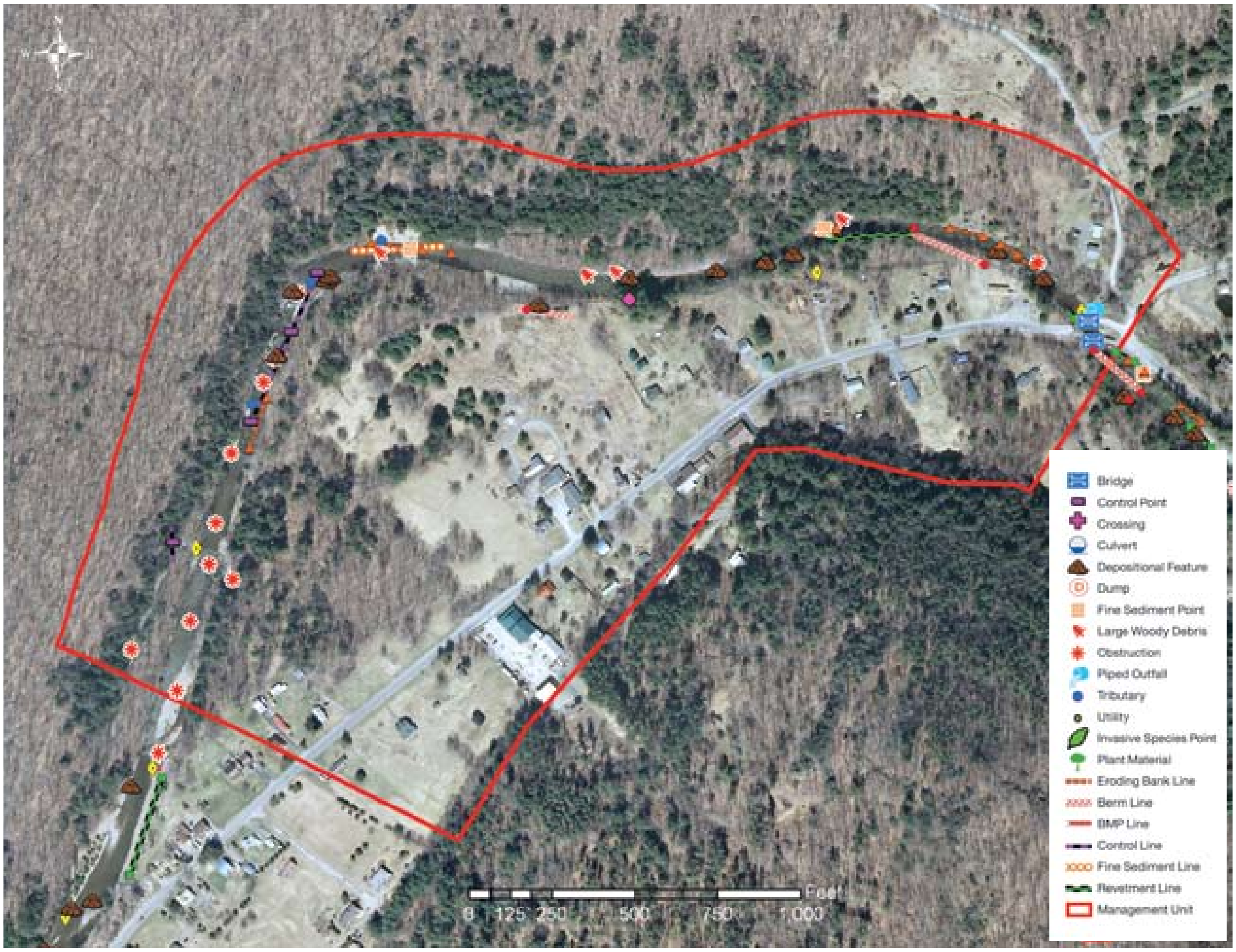
The New York City Watershed Memorandum of Agreement (MOA) allocated 13.6 million dollars for residential septic system repair and replacement in the West-of-Hudson Watershed through 2002, and the program was refunded in 2007. Systems eligible included those that are less than 1,000-gallon capacity serving one-or-two family residences, or home and business combinations, less than 200 feet from a watercourse. Permanent residents are eligible for 100% reimbursement of eligible costs; second homeowners are eligible for 60% reimbursement. For more information, call the Catskill Watershed Corporation at 845–586–1400, or see **http://www.cwconline.org/programs/septic/septic_article_2a.pdf**.

Neversink River East Branch

MANAGEMENT UNIT 3

STREAM FEATURE STATISTICS

- 8% of stream length is experiencing erosion
- 3.82% of stream length has been stabilized
- 39.78 acres of inadequate vegetation within the riparian buffer
- 50 ft. of the stream length is within 50 ft. of the road
- 8 structures are located within the 100-year floodplain boundary



Stream Feature Inventory 2010 (Figure 1)

EAST BRANCH MANAGEMENT UNIT 3

BETWEEN STATION 9200 AND STATION 5270

Management Unit Description

This management unit begins at the border between Ulster and Sullivan Counties, continuing approximately 3,951 ft. before the stream is crossed by a bridge on Denning Road. The drainage area ranges from 25.20 mi^2 at the top of the management unit to 26.80 mi^2 at the bottom of the unit. The valley slope is 1.02%. The average valley width is 1188.51 ft.

Summary of Recommendations
East Branch Management Unit 3

Intervention Level	Passive Restoration of the bank erosion site between Station 8860 and Station 8800 (BEMS ID # NEB3_8800). Passive Restoration of the bank erosion site between Station 8800 and Station 8740 (BEMS ID # NEB3_8700). Passive Restoration of the bank erosion site between Station 8680 and Station 8580 (BEMS ID# NEB3_8500). Passive Restoration of the bank erosion site between Station 8220 and Station 8195 (BEMS ID # NEB3_8200). Full Restoration of the bank erosion site between Station 6950 and 6790 (BEMS ID # NEB3_6800). Passive Restoration of the bank erosion site between Station 6200 and Station 6040 (BEMS ID# NEB3_6000).
Stream Morphology	Assess sediment deposition from the accumulation of large woody debris supplied by the watershed upstream. Conduct baseline survey of channel morphology.
Riparian Vegetation	Investigate enhancement of riparian corridor in left floodplain throughout management unit.
Infrastructure	Investigate flood threats to Denning Road.
Aquatic Habitat	Fish population and habitat survey.
Flood Related Threats	Assess threats to building structures in 100-year floodplain.
Water Quality	Assess ability of culvert to effectively convey storm water runoff from Wildcat Road.
Further Assessment	Long-term monitoring of erosion sites. Detailed survey of reach at BEMS NEB3_6800 to support restoration design.

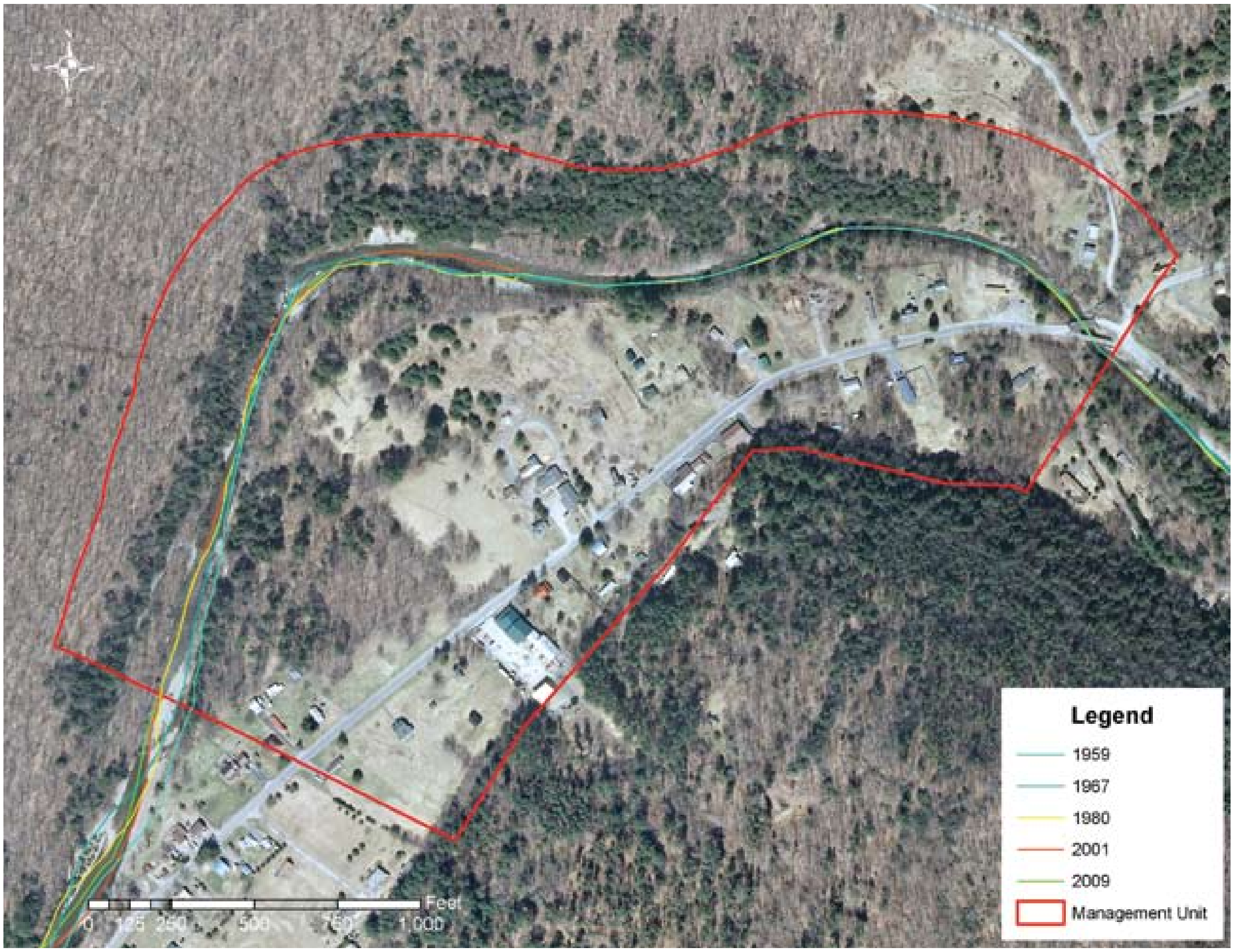
Historic Conditions

As the glaciers retreated about 12,000 years ago, they left their "tracks" in the Catskills. See Section 2.4 *Geology of Upper Neversink River,* for a description of these deposits. These deposits make up the soils in the high banks along the valley walls on the Neversink mainstem and its tributaries. These soils are eroded by moving water, and are then transported downstream by the River. During the periods when the forests of the Neversink watershed were heavily logged for bark, timber, firewood and to make pasture for livestock, the change in cover and the erosion created by timber skidding profoundly affected the Neversink hydrology and drainage patterns.

Excerpt from 1875 Beers Map (Figure 2)

The 1875 Beers Atlas of this area indicates that by that time, the stream had been harnessed for manufacturing, primarily saw mills, woodworking shops and tanneries *(Figure 2).* Raceways were built in the floodplains to divert water to ponds for use as needed. Floodplains were profoundly altered in the process, as these watercourses also became areas of preferential channelized flow when floodwaters inundated the floodplains. When woody debris jams blocked the primary channels, these raceways sometimes eroded out to become major secondary channels, or even took over the full flow to become a new primary watercourse.

During large runoff events, floodplains adjacent to the confluence of major tributaries receive large slugs of material eroded out of the steep streams draining the valley walls, overwhelming the Neversink's ability to transport it, creating an alluvial fan. Like changes in the floodplains made by humans, these episodes can result in catastrophic shifts in channel alignment. In the roughly one hundred and twenty centuries since the retreat of the glaciers, the position of Neversink River has moved back and forth across its floodplain numerous times in many locations. A comparison of historical channel alignments *(Figure 3, following page)* and in-stream observations made during a stream feature inventory in 2010 *(Figure 1, page 1)* indicate some lateral channel instability and 2 NYS Article 15 stream disturbance permits have been issued in this management unit, according to records available from the NYSDEC DART database (http://www.dec.ny.gov/cfmx/extapps/envapps/).



Historical channel alignments from five selected years (Figure 3)

Stream Channel and Floodplain Current Conditions

The following description of stream morphology references stationing in foldout Figure 4. "Left" and "right" references are oriented looking downstream, photos are also oriented looking downstream unless otherwise noted. Stationing references, however, proceed upstream, in feet, from an origin (Station 0) at the confluence with the Neversink West Branch. Italicized terms are defined in the glossary. This characterization is the result of surveys conducted in 2010.

This management unit begins just downstream of the two Denning Road bridge crossings. The stream flows close to the right valley wall for the entire management unit, restricting lateral channel movement to the right. The valley floor on the left side of the stream continues to widen throughout EBMU3, maintaining a well connected left floodplain. A significant amount of infrastructure development exists in this floodplain, often with a narrow vegetated riparian buffer. As a result, the buildings and roads in this area are at a very high risk of inundation during flood events and subsequent property damage.

An old cobble berm that began in EBMU4 continues into the first 60-feet of EBMU3, offering an attempt at flood mitigation for the infrastructure in the left floodplain. *(B265)* This berm is overgrown with vegetation and does not appear to have been maintained in recent years. Continuing downstream past the two bridges, the impact that these structures have on stream morphology becomes increasingly evident. It is likely that the bridge abutments are not spaced wide enough to accommodate large events, creating a bottle neck as flows are conveyed through. As a result, severe scour was documented around the abutments of the active bridge near Station 9100. This scour has created slow moving pools which continue for a short reach downstream of the structure. *(A326)* The slower velocities do not effectively transport sediment through the reach, resulting in a significant amount of aggradation under the bridge. The left bank is revetted with placed rip-rap beginning at the bridge abutment near Station 9060, continuing for approximately 50-feet until Station 9010. *(B276)*

Just downstream of the bridge along the right bank, a small tributary enters at Station 9080 from the direction of Taylor Road. The small perennial flow of this tributary is enhanced by a culvert that contributes road side drainage from Wildcat Road, making it a potential source for contaminants from road runoff. It is likely that the road drainage contributes chlorides (salt) and petroleum by-products from road runoff to the

Old cobble berm in left floodplain (B265)

Aggradation under bridge (A326)

Left bank reveted with rip rap at bridge abutment (B276)

Drainage pipe from Wildcat Road (A313)

Cobble side bar along left bank (B278)

Fallen tree causing obstruction to flow on right bank (A329)

Stabilizing slope failure on right bank (A334)

Neversink. *(A313)* This culvert is constructed from smooth steel which has rusted over time. There is no outfall or headwall protection present other than the stream cobbles which have deposited in the vicinity of the culvert.

EBMU3 could be largely characterized as a sediment storage reach, as several areas of aggradation were documented throughout the management unit. The first depositional area is a cobble side bar that begins along the left bank at Station 8900 and continues downstream before ending at Station 8740. *(B278)* Some grass and sedge species have established on this bar. Across from the bar, a fallen tree has deposited along the right bank and is causing an obstruction to high flows. *(A329)* Hydraulic erosion of the toe is causing the right bank to fail beginning at Station 8860, continuing for approximately 60-feet until Station 8800 (BEMS ID # NEB3_8800). Mature trees have begun to slide down this slope with their root wads still attached. In some cases these trees have been able to re-establish at a lower elevation on the slope. Although this bank does not appear to have reached an angle of repose, large cobbles have deposited along the toe of the slope, which along with the establishment of sedges has provided some stabilization to the eroding bank. With adequate toe stabilization it is possible that this site can continue to stabilize without treatment (passive restoration). However, it is recommended that it be monitored for future changes in condition. *(A334)*

The slope failure continues to be evident along the right bank for approximately 60-feet between Station 8800 and Station 8740, but appears to be at a more advanced stage of re-stabilization than the erosion site just upstream (BEMS ID # NEB3_8700). *(A337)* The toe of this slope is armored with large boulders and lush sedge clumps, and the bank appears to have reached an angle of repose. The healthy mature vegetation re-establishing itself on the slope suggests that this bank erosion site is steadily progressing towards stability (passive restoration). Recommendations for this site include monitoring for future changes in condition.

A larger re-vegetated slope failure begins at Station 8680 and continues for approximately 100-feet until Station 8580 (BEMS ID# NEB3_8500). *(A344)* Although exposed cobbles on this slope indicate a previous landslide, this bank has been naturally re-stabilized by the deposition of large boulders at the toe. A large percentage of the slope is now covered with mature vegetation, and all signs indicate that this bank will continue to stabilize without treatment (passive restoration).

In order to protect infrastructure, several attempts have been made to prevent the stream from connecting to its left floodplain during large events. A berm begins along the left bank behind the town hall at Station 8700 and continues until Station 8475. *(B288)* This berm mainly consists of cobbles, but also has large placed boulders interspersed. Near Station 8490 the berm transitions to a more

Large boulders contributing to bank stablilization (A337)

Re-vegetated slope failure (A344)

Berm along left bank (B288)

Boulder revetment along left bank (B293)

Slope failure due to upland drainage (A358)

Cobble sidebar on left side of channel (B297)

recently placed boulder revetment which continues downstream until Station 8210. *(B293)* This revetment has been washed out in some spots, but overall is in fair condition.

At Station 8220, water that is draining from upland sources through the bank is eroding and washing out finer soil particles (BEMS ID # NEB3_8200). The removal of these finer particles destabilized the bank, resulting in a failure of the hill slope which continues downstream for approximately 25-feet until Station 8195. *(A358)* Some silts and sands are exposed along this slope and could potentially be a source of fine sediment; however, they are not expected to be contributing to turbidity problems in the Neversink. A large percentage of the slope has re-vegetated naturally, suggesting that this bank has reached an angle of repose and will continue to stabilize without treatment (passive restoration). It is recommended that this site be monitored for future changes in condition.

Continuing downstream, the next 1000-feet of this management unit is characterized by a significant amount of sediment deposition. A cobble side bar begins along the left side of the channel at Station 8100, continuing downstream for approximately 100-feet until Station 8000. *(B297)* This depositional bar is free of debris or vegetation, indicating that it is frequently inundated during higher flows. Another side bar begins along the right side of the channel at Station 7850, spanning approximately 260-feet in length to Station 7590. *(A366)* Various species of herbaceous vegetation have established on this bar.

Large woody debris that has been deposited on the narrow right floodplain terrace illustrates the amount of power the stream has during flood events. At Station 7560 and Station 7460, large


Vegetated side bar on right side of channel (A366)


Large woody debris deposited on right floodplain (A371)

piles of tree trunks were documented significantly above the wetted channel width. *(A371)* Along the left bank, an access path has been mowed from the floodplain all the way down to the stream, removing all woody riparian vegetation at Station 7500. *(B301)* Removing significant amounts of vegetation from the riparian zone can reduce bank stability and lead to erosion. An intact riparian buffer including woody vegetation can strengthen the stream bank and slow erosive forces of higher flows during flood events, reducing the need for the installation of revetments and berms.


Access path along left bank (B301)

A berm begins along the left bank at Station 7400, continuing downstream for approximately 165-feet to Station 7235. *(B304)* This berm consists of large cobbles and is located where the narrowly forested portion of the riparian buffer transitions to open field. A construction site for a building structure was located in this field at the time that the inventory was conducted. This new development exists just outside of the delineated 100-year floodplain boundary, but is still at a very high risk of inundation and subsequent damage during flood events. A cobble bar begins along the left side of the stream in front of this berm


Berm along left bank (B304)


Cobble bar forming along left side of stream (B302)


Severe slope failure on right bank (A384)


Bedrock grade control (A408)

at Station 7300, continuing around the sharp bend for approximately 950-feet before ending at Station 6350. *(B302)*

As the channel approaches a hard left turn, there is a relatively severe slope failure that begins at Station 6950 and continues for approximately 160-feet until Station 6790 (BEMS ID # NEB3_6800). *(A384)* The glacial till that makes up this 70-foot high bank is exposed in most locations, indicating a source of fine sediment that can be entrained during high flows. The slope failure was most likely caused by a spring seepage that drains down through the bank, which continuously erodes the sediment particles that keep the slope intact. As the sediment particles become unstable, the bank fails under its own weight and large portions begin to slide down the slope. At the time of this inventory, several trees had either fallen to the base of the bank or were leaning with their root structures exposed. Due to the severe angle of this bank and the lack of scour protection at the toe, it is unlikely that this slope will stabilize without treatment. Remediation of this erosion site would likely have to be part of a full restoration of the channel in order to redirect the flow away from the bank.

The channel takes a sharp left turn against the left valley wall at Station 6650 and continues in a relatively straight reach for the remainder of the management unit. This straight reach is partially created by exposed bedrock in the stream bed and along the right bank. The bedrock provides both a grade and planform control that prevents the channel from migrating vertically or laterally to the right. This bedrock grade control continues downstream for approximately 490-feet before ending at Station 6160. *(A408)* A small perennial tributary enters from the right side at Station

6600. *(A401)* Small feeder streams such as this often play an integral role in ecosystem integrity, as they are a source of the cold and well oxygenated water that is necessary to support a diversity of aquatic life. Sediment is depositing on a center bar which begins at Station 6580 and continues downstream until Station 6500. At time of this inventory, flow was diverted to the left and right around this bar, allowing sedges to establish amongst the cobbles. *(A402)*

Large woody debris has accumulated with frequency in the next 600-foot stretch of the channel, resulting in obstructions to higher flows. Obstructions were documented along the left side of the stream at Station 6340 and Station 6250. *(B313)* These obstructions began as fallen trees, but are growing in size as they continue to gather woody debris as it is transported downstream. A series of woody debris obstructions begins along the right bank at Station 6020, continuing downstream until Station 5800. *(A413)* These obstructions have an effect on the ability of the stream to effectively transport sediment, resulting in sediment deposition throughout this reach.

Small perennial tributary entering on left (A401)

Sedges establishing on center bar (A402)

Obstructions along left bank (B313)

Series of woody debris along right bank (A413)

Erosion on left bank (B319)

Obstructions along left bank (A416)

The left bank begins to erode at Station 6200 and continues downstream for approximately 160-feet until Station 6040 (BEMS ID# NEB3_6000). *(B319)* This erosion site may be aggravated by the presence of large woody debris obstructions along the right side of the channel, which divert hydraulic pressure into the bank during high flows. The bank angle is not severe enough that it would indicate future failure, and large cobbles that have been exposed through the erosion process are now helping to armor the bank down to the toe. It appears that it is possible for this bank to stabilize without treatment (passive restoration). However, it is recommended that this site be monitored for changes in condition.

Continuing downstream, large woody debris obstructions continue to become evident as we approach the downstream end of EBMU3. Obstructions were documented along the left bank at Stations 5690 and 5500, and 5300. *(A416 and A418)* All of these obstructions are contributing to sediment deposition in this reach. The obstruction at Station 5300 is located on a well vegetated side bar that begins at Station 5320 and continues downstream into EBMU2.

Obstructions along left bank (A418)

Divergence of flow into side channel (B327)

Bedrock along right valley wall (B328)

Large obstructions in side channel (B332)

An obstruction along the right bank at Station 5700 has caused a divergence of flow into a side channel, significant during high flows. *(B327)* The side was mostly dry at the time of this inventory, but had received flow at some point this year as was evidenced by the lack of leaf debris on the channel substrate. This channel flows up against the right valley wall and continues to follow the course of this exposed bedrock before converging back with the main channel further downstream in EBMU2. *(B328)* Fallen trees are causing a large obstruction in the side channel at Station 5350. *(B332)*

It is recommended that this entire MU be included in a comprehensive Local Flood Hazard Mitigation Analysis to investigate hydraulics and sediment transport in the stream corridor, from Station 10500 on the East Branch, upstream of Sawmill Road through Station 14800 on the Mainstem, downstream of the Halls Mills covered bridge. The purpose of the analysis would be to develop a comprehensive solution for reducing flooding threats to this relatively dense population center of the Neversink Valley.

EBMU3 ends at Station 5270 at the border between Ulster and Sullivan Counties.

POST-FLOOD ADDENDUM

Neversink River East Branch

MANAGEMENT UNIT 3

Summary of Post-Flood Recommendations

Intervention Level	Assisted Restoration of the bank erosion site between Station 8900 and station 8560 (BEMS ID # NEB3_8800, BEMS ID # NEB3_8700, and BEMS ID# NEB3_8500). Passive Restoration of the bank erosion site between Station 8220 and Station 8195 (BEMS ID # NEB3_8200). Full Restoration of the bank erosion site between Station 7050 and 6790 (BEMS ID # NEB3_6800). Passive Restoration of the bank erosion site between Station 6200 and Station 6040 (BEMS ID# NEB3_6000). Full Restoration of split channel section impacted by emergency restoration efforts from Station 5700 to Station 4500 in EBMU2.
Stream Morphology	No change.
Riparian Vegetation	No change.
Infrastructure	No change.
Aquatic Habitat	No change.
Flood Related Threats	No change.
Water Quality	None.
Further Assessment	Include EBMU3 in comprehensive Local Flood Hazard Mitigation Analysis of Claryville MUs.

Stream Channel and Floodplain Current Conditions

The following description of stream morphology is the result of a survey conducted in December, 2011. “Left” and “right” references are oriented looking downstream, photos are also oriented looking downstream unless otherwise noted. Stationing references, however, proceed upstream, in feet, from an origin (Station 0) at the confluence with the Neversink West Branch. Italicized terms are defined in the glossary.

As the stream flows close to the right valley wall for this entire management unit, the valley floor on the left side of the stream continues to widen throughout EBMU3, maintaining a well-connected left floodplain.

POST-FLOOD ADDENDUM

A significant amount of infrastructure development exists in this floodplain, with a narrow vegetated riparian buffer in many locations. As a result, the buildings and roads in this area are at a very high risk of inundation during flood events and subsequent property damage. The right valley wall receives relatively high erosive forces during flood events in a number of reaches. This has resulted in several eroding bank segments on the right bank and excess sediment supply in this management unit.

Slope failure on the right bank across from cobble point bar. (IMGP1744)

A 440-foot long eroding bank segment with a maximum height of 55 feet from the stream bed was documented extending from Station 9000 to Station 8560 on the right bank across from a cobble point bar. This slope failure was previously documented as three individual eroding bank segments, BEMS ID # NEB3_8800, BEMS ID # NEB3_8700, and BEMS ID# NEB3_8500, which have connected due to hydraulic erosion during flood events since 2010.

Prior to recent flooding, large boulders and sedges had accumulated at the toe of this slope so it was anticipated that this site would remain stable. However, hydraulic erosion due to high near-bank velocities during recent flood events has extended this eroding bank segment and led to slumping from higher elevations on the slope. Therefore, *assisted restoration* is recommended for this site, including installation of a *bankfull stage* bench at the toe of the slope and use of bioengineering techniques to vegetate the exposed slope and reduce erosive forces on the bank during high flow events.

At Station 8220, water that is draining from upland sources through the bank is eroding and washing out finer soil particles (BEMS ID # NEB3_8200). During the initial stream survey in 2010 it was documented that a large percentage of the slope had re-vegetated naturally (See Picture A358 on page 8 for pre-flood condition). However, due to increased surface runoff from upland sources during recent heavy precipitation events and increased hydraulic erosion at the toe of the slope during the resulting flood events, this eroding slope has newly exposed sediments.

During the 2011 post-flood survey, small boulders were documented extending from the toe of the embankment, which may reduce near bank shear stress and hydraulic erosion at the toe. This rock may serve as a base for the accumulation of additional rock from higher on the slope, which may eventually reach a higher stage than the floodplain on the left bank, effectively hardening the toe of the bank. This natural toe protection could allow the bank to continue to stabilize without treatment (*passive restoration*). However, it is recommended that this site be monitored for future changes in condition.

Stabilizing slope failure on the right bank. (IMGP1751)

Slope failure with exposed glacial till on the right bank. (IMGP1756)

As the channel approaches a hard left turn, there is a relatively severe slope failure that begins at Station 7050 and continues for approximately 260-feet until Station 6790 (BEMS ID # NEB3_6800). The glacial till that makes up this 40-foot high bank is exposed throughout the reach, and represents a source of fine sediment that can be entrained during high flows. The slope failure was most likely initiated by a spring seepage draining through the bank exacerbated by fluvial erosion at the toe of the slope. As the sediment particles become unstable, the bank fails under its own weight and large portions begin to slide down the slope. At the time of the 2010 inventory, several trees had either fallen to the base of the bank or were leaning with their root structures exposed. By the 2011 inventory the trees were gone entirely from the bank. The channel appears to have been overwidened.

Due to the severe angle of this bank, lack of scour protection at the toe and unstable channel dimensions, it is unlikely that this slope will stabilize without treatment. Therefore, *full restoration* is recommended for this site in order to alleviate hydraulic pressure on the bank and establish stability. This restoration effort could include installation of a *bankfull stage* bench at the toe of the slope, an increased radius of curvature, and removal of mature trees at the top of the bank that could fall and obstruct flow in the main channel. In addition, both in-stream structures like rock vanes and use of bioengineering techniques to vegetate the exposed slope could help reduce erosive forces on the bank during high flow events, until the bench develops mature vegetation.

The left bank begins to erode at Station 6200 and continues downstream for approximately 160-feet until Station 6040 (BEMS ID# NEB3_6000). (See Picture B319 on page 12 for pre-flood condition) Although the location of woody debris jams shifted slightly since 2010, it is likely that this erosion site is still aggravated by the presence of large woody debris obstructions along the right side of the channel, which divert hydraulic pressure into the bank during high flows. As determined in 2010, the bank angle is not severe enough that it would indicate future failure, and large cobbles that have been exposed through the erosion process are now helping to armor the bank down to the toe. It appears that it is possible for this bank to stabilize without treatment (*passive restoration*). However, it is recommended that this site be monitored for changes in condition.

In 2010 an obstruction along the right bank at Station 5700 had caused a divergence of flow into a side channel in the right forested floodplain. (See picture B327 on Page 12 for pre-flood conditions.) The side was mostly dry at the time of the 2010 inventory. This channel flows up against the right valley wall and continues to follow the course of this exposed bedrock before converging back with the main channel further downstream in EBMU2.

Emergency efforts to realign the channel in this stream reach to protect infrastructure following the recent flood events included construction of a berm across the main channel at this location to divert the majority of the flow into this side channel (*IMPG1760*).

Berm in the main channel diverting flow into a previously dry side channel. (IMGP1760)

POST-FLOOD ADDENDUM

Side channel confined at upstream end by sidecast berms. (IMGP1768)

Appropriately sized main channel. Flow is diverted by a berm upstream. (IMGP1769)

This is perceived as a less threatening channel alignment; however, the side channel is undersized and cannot convey all of the flow during high flow events. As a result, sediment cannot be passed through the reach effectively, and is accumulating0 in the reach. This leads to channel shifting toward the left bank. Similar conditions occur just downstream opposite Claryville Post Office (*IMPG1768*).

Full restoration is recommended for this stream reach which extends to the convergence of the main channel and side channel near Station 4500 in EBMU2. The restoration should include removal of all berms in this stream reach to restore floodplain connectivity and re-establish an appropriate cross-sectional area for effective sediment transport. The majority of the flow should be returned to the appropriately sized left channel to prevent accumulation of bedload and channel shifting in the future. Flow deflection structures could be considered to prevent erosion of left bank.

As a part of the restoration designs for this management unit, it is recommended that this entire MU be included in a comprehensive Local Flood Hazard Mitigation Analysis to investigate hydraulics and sediment transport in the stream corridor, from Station 10500 through the Halls Mills covered bridge on the mainstem of the Neversink River, to develop options for reducing flooding threats to this relatively dense population center of the Neversink Valley.

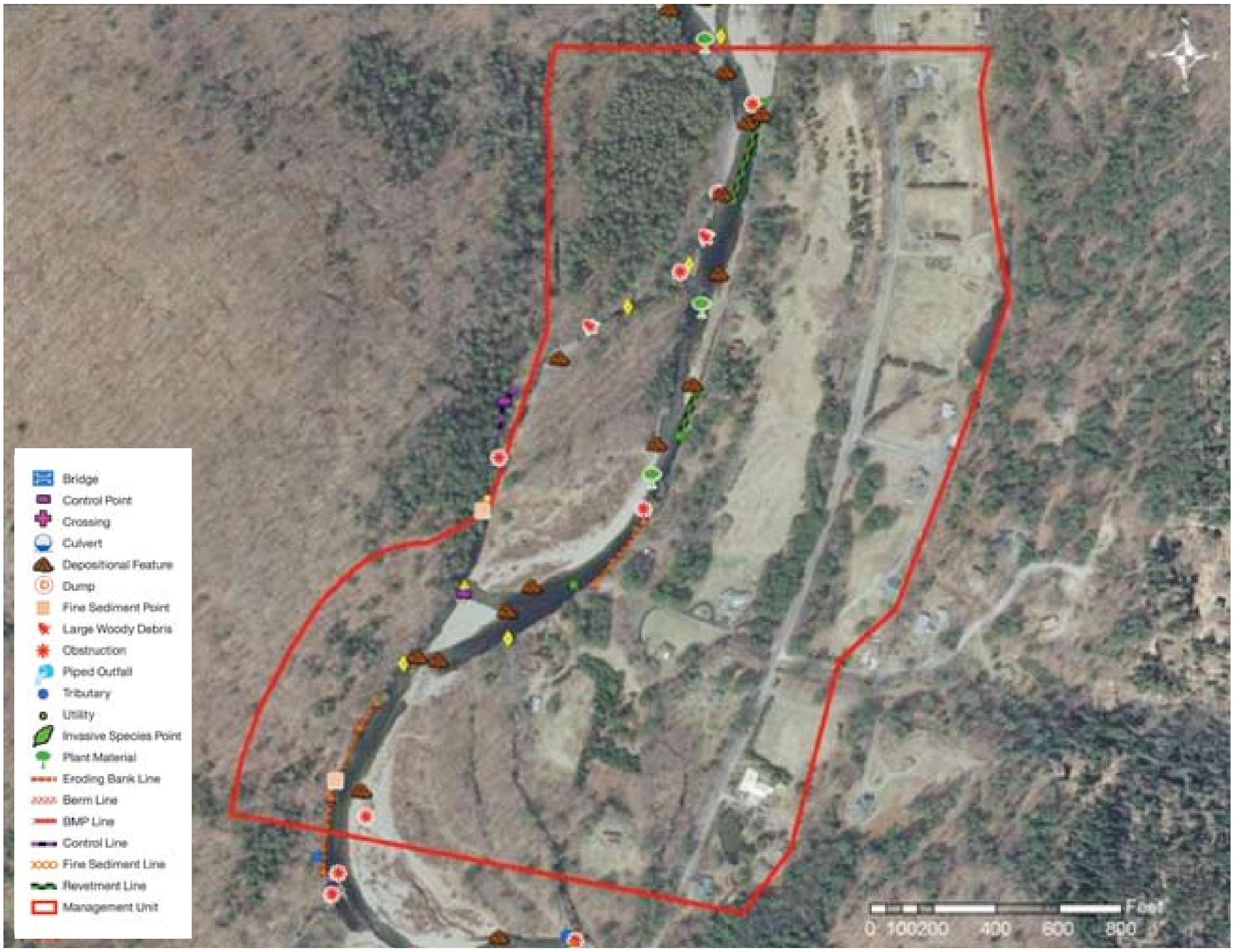
EBMU3 ends in the middle of this stream reach at Station 5270 at the border between Ulster and Sullivan Counties.

Neversink River Main Branch

MANAGEMENT UNIT 10

STREAM FEATURE STATISTICS

- 11 % of stream length is experiencing erosion
- 8.42 % of stream length has been stabilized
- 0.15 acres of inadequate vegetation within the 100 ft. buffer
- 0 ft. of stream is within 50 ft. of the road
- 4 structures located within the 100-year floodplain boundary



Stream Feature Inventory 2010 (Figure 1)

MAIN BRANCH MANAGEMENT UNIT 10

BETWEEN STATION 26790 AND STATION 29800

Management Unit Description

This management unit begins a the confluence of the east and west branches of the Neversink River and continues approximately 3,065.7 ft. downstream to an unnamed tributary confluence on the right bank. The drainage area ranges from 62.0 mi^2 at the top of the management unit to 63.20 mi^2 at the bottom of the unit. The valley slope is 0.68 %. The average valley width is 1439.03 ft.

Summary of Recommendations
Main Branch Management Unit 10

Intervention Level	Assisted restoration of the bank erosion site between Station 28280 and Station 28030. Passive restoration of the bank erosion between Station 27220 and Station 26680.
Stream Morphology	Protect and maintain sediment storage capacity and floodplain connectivity. Conduct baseline survey of channel morphology.
Riparian Vegetation	Improve riparian buffer from Station 28900 to Station 28020.
Infrastructure	None.
Aquatic Habitat	Fish population and habitat survey.
Flood Related Threats	Flood proofing as appropriate. http://www.fema.gov/library/viewRecord.do?id=1420
Water Quality	Maintain household septic systems.
Further Assessment	Long-term monitoring of erosion sites.

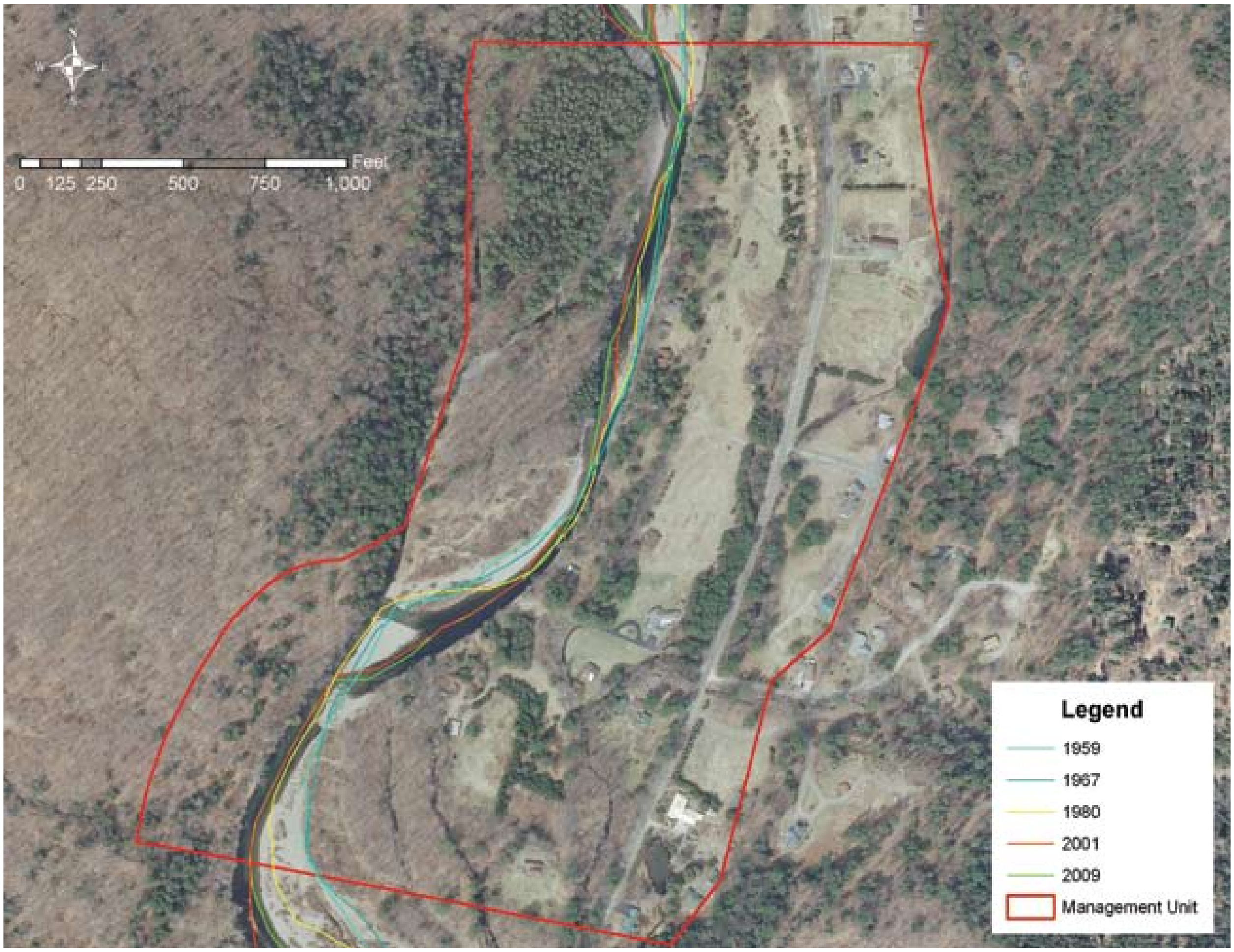
Historic Conditions

As the glaciers retreated about 12,000 years ago, they left their "tracks" in the Catskills. See Section 2.4 *Geology of Upper Neversink River,* for a description of these deposits. These deposits make up the soils in the high banks along the valley walls on the Neversink mainstem and its tributaries. These soils are eroded by moving water, and are then transported downstream by the River. During the periods when the forests of the Neversink watershed were heavily logged for bark, timber, firewood and to make pasture for livestock, the change in cover and the erosion created by timber skidding profoundly affected the Neversink hydrology and drainage patterns.

Excerpt from 1875 Beers Map (Figure 2)

The 1875 Beers Atlas of this area indicates that by that time, the stream had been harnessed for manufacturing, primarily saw mills, woodworking shops and tanneries *(Figure 2).* Raceways were built in the floodplains to divert water to ponds for use as needed. Floodplains were profoundly altered in the process, as these watercourses also became areas of preferential channelized flow when floodwaters inundated the floodplains. When woody debris jams blocked the primary channels, these raceways sometimes eroded out to become major secondary channels, or even took over the full flow to become a new primary watercourse.

During large runoff events, floodplains adjacent to the confluence of major tributaries receive large slugs of material eroded out of the steep streams draining the valley walls. overwhelmed the Neversink's ability to transport it, creating an alluvial fan. Like changes in the floodplains made by humans, these episodes can result in catastrophic shifts in channel alignment. In the roughly one hundred and twenty centuries since the retreat of the glaciers, the position of Neversink River has moved back and forth across its floodplain numerous times in many locations. A comparison of historical channel alignments *(Figure 3, following page)* and in-stream observations made during a stream feature inventory in 2010 *(Figure 1, page 1)* indicate significant lateral channel instability, and fourteen NYS Article 15 stream disturbance permits have been issued in this management unit, according to records available from the NYSDEC DART database (**http://www.dec.ny.gov/cfmx/extapps/envapps/**).



Historical channel alignments from five selected years (Figure 3)

Stream Channel and Floodplain Current Conditions

The following description of stream morphology references stationing in the foldout Figure 4. "Left" and "right" references are oriented looking downstream, photos are also oriented looking downstream unless otherwise noted. Stationing references, however, proceed upstream, in feet, from an origin (Station 0) at the confluence with the Neversink Reservoir. Italicized terms are defined in the glossary. This characterization is the result of surveys conducted in 2010.

The first 250 feet of this management unit is characterized by depositional features formed by the confluence of the East and West Branch. Backwatering associated with the joining of two flows reduces the flow rate at a confluence, leading to decreased sediment transport capacity. As a result, confluences typically exhibit bar formation, channel shifting, and a resetting of vegetation growth after each major flood event. Depositional bars on both the right and left banks from Station 28280 to Station 29550 are variously sorted with sand, gravel and cobble. The bars feature scattered grass, sedge and shrub growth. Within this reach the right bank is a low vegetated terrace below the *bankfull* elevation. Several woody debris piles scattered throughout this terrace indicate that it is regularly flooded. The left bank is at a slightly higher elevation, and is developed with residential structures close to the edge of the bank, including four structures at least partially within the FEMA-mapped 100-year floodplain. The bank along these structures is revetted with large dumped or stacked rip-rap at the upstream end from Station 28900 to Station 28020 and is eroding at the unprotected downstream end. *(B394, B400).*

Looking upstream, large stacked revetment on left bank (B394)

Erosion at downstream end of large revetment on left bank (B400)

At Station 29100 on the right bank there is a channel diversion where the floodplain terrace elevation drops. At the time of the stream feature inventory during the summer of 2010 the side channel was free of leaf debris indicating that the channel had received flow during winter and spring flood events. In addition, woody debris has accumulated associated with occasional flow into this side channel. This side channel flows through the floodplain on the right until it is confined by the right valley wall, where it follows a bedrock ledge for 45 ft.

At the divergence a cobble center bar has formed in the main channel from Station 29300 to Station 29100 *(B398)*. This *aggradation* is due to the loss of sediment transport capacity caused by the divergence of flows.

Looking downstream at large cobble center bar (B398)

Proceeding downstream, the main channel bends to the right along a long point bar, with 254 ft. of erosion along the left bank, from Station 28080 to Station 28020. *(B406)* until it rejoins the right channel thread at the valley wall. At Station 27700, the right channel thread reconverges with the main channel, with significant deposition of sand, gravel and cobble. *(A076, A080).*

Erosion on left bank (B406)

Recommendations for this reach of the Neversink River include assisted restoration of eroding and revetted bank as appropriate, and improvement of the *riparian* buffer. However, this reach is likely to require ongoing management due to the confluence at the upstream end and the divergence at the downstream end.

Downstream view of convergence (A076)

The relic millrace discussed in the history section above conveys significant flows during large flood events causing minor erosion in MBMU9. Further investigation of this channel in MBMU10 is recommended to determine how to best manage these impacts.

Downstream of the convergence the main channel begins a wide meander to the left. Upstream of this meander, a forested floodplain is formed on the left bank that features several flood chutes including two well-defined side channels. *(B411)* Across from the left bank floodplain on the

Looking upstream at convergence and cobble center bar (A080)

Side channels on left bank (B411)

Erosion and fine sediment on right bank (A84)

outside of the meander bend 449 feet of the bank is eroding exposing alluvial materials, from Station 27220 to Station 26680. This bank was identified as a fine sediment source. Sedge has established at the toe of the eroding bank indicating that the bank is beginning to stabilize. However, this is not preventing entrainment of fine sediments higher on the bank slope. *(A84)*
It is anticipated that this bank will revegetate and stabilize without treatment (passive restoration). However, it is recommended that this site be monitored for changes in condition.

It is recommended that this entire MU be included in a comprehensive Local Flood Hazard Mitigation Analysis to investigate hydraulics and sediment transport in the stream corridor, from Station 10500 on the East Branch, upstream of Sawmill Road through Station 14800 on the Mainstem, downstream of the Halls Mills covered bridge. The purpose of the analysis would be to develop a comprehensive solution for reducing flooding threats to this relatively dense population center of the Neversink Valley.

MBMU10 ends at Station 26800, where an unnamed tributary enters from the right.

POST-FLOOD ADDENDUM

Neversink River Main Branch

MANAGEMENT UNIT 10

Summary of Post-Flood Recommendations

Intervention Level	Full Restoration.
Stream Morphology	No change.
Riparian Vegetation	No change.
Infrastructure	No change.
Aquatic Habitat	No change.
Flood Related Threats	Inundation threat on Tannery flats due to channel aggradation.
Water Quality	None.
Further Assessment	Include MU10 in comprehensive Local Flood Hazard Mitigation Analysis of Claryville MUs.

Stream Channel and Floodplain Current Conditions

The following description of stream morphology is the result of a survey conducted in December, 2011. "Left" and "right" references are oriented looking downstream, photos are also oriented looking downstream unless otherwise noted. Stationing references, however, proceed upstream, in feet, from an origin (Station 0) at the confluence with the Neversink Reservoir. Italicized terms are defined in the glossary.

The first 250 feet of this management unit is characterized by an alluvial fan, formed by the confluence of the East and West Branch. Where two large tributaries come together, during high flow events, one or the other branch will predominate, depending on which valley receives more rainfall, causing the lower branch to backwater and deposit its bedload. Consistent with this typical confluence response to flood events over time, this section of this management unit exhibited bar formation, channel shifting, and a resetting of vegetation growth during the flooding that has occurred since 2010.

Within this reach the right bank is a low vegetated terrace. Several woody debris piles observed scattered throughout this terrace in 2010 indicate that it is regularly flooded. Woody debris has accumulated along the edge of this terrace, improving sediment transport through the reach by concentrating flow in the channel. Woody debris blockage of an overflow channel diversion through the right floodplain was removed to provide high flow relief and reduce flooding risk to the residences on the left floodplain.

The left bank is at a slightly higher elevation, and is developed with residential structures, many close to the edge of the bank, including four structures at least partially within the FEMA-mapped 100-year floodplain (new FEMA flood maps are currently in development and are expected to be available for community review in 2013). During the survey conducted in December, 2011, the bank along these structures was documented as revetted with large rip-rap at the upstream end from Station 28900 to Station 28020, and was eroding at the unprotected downstream end. In addition, a millrace originating upstream on the East Branch, a private pond and Bungalow Brook running adjacent to Denning Road offer a flowpath for overbank flows, and contribute to locational flooding in this section of the Neversink River during high flow events.

Proceeding downstream, the main channel bends to the right along a long point bar, with 254 ft. of erosion along the left bank, from Station 28280 to Station 28030.

At Station 27700 the right channel thread converges with the main channel, with significant deposition of sand, gravel and cobble. Downstream of the convergence the main channel begins a wide meander to the left. Upstream of this meander, a forested floodplain is formed on the left bank that features several flood chutes including two well-defined side channels that diverge from the main channel near Station 27700. These channels have become more severe during flood events

Large woody debris accumulation on left bank. (IMGP2303)

Erosion on the left bank near Station 28080. (IMGP2304) since 2010. In addition, a new flood chute that formed approximately 100 feet upstream of these diversions was the source of locational flooding and destruction of several structures during the flooding associated with Hurricane Irene.

Across from the left bank floodplain, on the outside of the meander bend, 449 feet of the right bank is eroding, exposing alluvial materials from Station 27220 to Station 26680. This bank was identified as a fine sediment source. Sedge that was documented at the toe of the eroding bank in 2010 was no longer present during the survey conducted in December, 2011. MBMU10 ends at Station 26800, where an unnamed tributary enters from the right.

Severely scoured flood chute in floodplain downstream of Station 27700. (IMGP2311)

Flood chute that caused severe damage to structures in the left flood plain near Station 27800. (IMGP2327)

POST-FLOOD ADDENDUM

Eroding bank segment on the right bank near Station 27100. (IMGP2329)

Recommendations for MBMU10 include full restoration of channel dimensions throughout the unit, capable of transporting the sediment supplied from the two branches, and improvement of the riparian buffer on the left bank to improve bank stability. However, as evidenced by the impacts of flooding since 2010, deposition in this reach is the result of sediment dynamics associated with the confluence at the upstream end and the divergence at the downstream end. Therefore as part of the restoration design, it is recommended that this entire MU be included in a comprehensive Local Flood Hazard Mitigation Analysis to investigate hydraulics and sediment transport in the stream corridor, from Station 10500 through the Halls Mills covered bridge downstream. The purpose of the analysis would be to develop a comprehensive solution for reducing flooding threats to this relatively dense population center of the Neversink Valley.

Neversink River Management Unit Recommendations

EAST BRANCH 1-6	EB1	EB2	EB3	EB4	EB5	EB6
INTERVENTION LEVEL						
Preservation	All	Remainder	Remainder	Remainder	Remainder	Remainder
Passive			BEMS	BEMS	BEMS	BEMS
Assisted				BEMS	Stn 14600 to Stn 15300, side channel	BEMS
Full		BEMS	BEMS	BEMS		BEMS
STREAM MORPHOLOGY						
Assess sediment deposition	X	X	X	X	X	X
Evaluate sediment transport dynamics	X	X	X	X	X	X
Establish single channel						
RIPARIAN VEGETATION						
Improve vegetation		Stn 5270 to Stn 3900 and Stn 1550 to Stn 1450	LB Stn 9000 to Stn 5300	Stn 13200 to Stn 10600	Stn 16600 to Stn 14800	
Install bioengineering		X		X		X
Monitor invasive species	Stn 380			Stn 10450		
Interplant revetment						
INFRASTRUCTURE						
Improve outfall protection for piped outfalls						
Bridge/culvert and channel improvements			Stn 9100			
Investigate control structures		X		X	X	
AQUATIC HABITAT						
Fisheries population & habitat study	X	X	X	X	X	X
FLOOD RELATED THREATS						
Evaluate integrity & impact of existing berms						
Restore sediment conveyance						
Assess road flooding	X	X	X	X	X	X
Assess threats to structures in 100-year floodplain	X	X	X	X	X	X
Floodproofing as appropriate					X	X
WATER QUALITY						
Evaluate potential for mitigation for water quality impacts						
Address fine sediment entrainment						BEMS
Long-term monitoring of erosion sites	X	X	X	X	X	X
Maintain household septic systems	X	X	X	X	X	X
Conduct Bank Erodibility Hazard Index Assessment						
FURTHER ASSESSMENT						
Conduct baseline survey of channel morphology	X	X	X	X	X	X
Hydraulics assessment						
Monitor debris jams			X	X	X	X

EAST BRANCH 7–12	**EB7**	**EB8**	**EB9**	**EB10**	**EB11**	**EB12**
INTERVENTION LEVEL						
Preservation	All	Remainder	Remainder	Remainder	Remainder	Remainder
Passive			BEMS	BEMS	BEMS	BEMS
Assisted		BEMS		BEMS		
Full				BEMS	BEMS	BEMS
STREAM MORPHOLOGY						
Assess sediment deposition	X	X	X			X
Evaluate sediment transport dynamics	X	X	X	X	X	X
Establish single channel						
RIPARIAN VEGETATION						
Improve vegetation			Stn 34860 and Stn 34360 to Stn 34135	LB Stn 40080 to Stn 39600 and RB Stn 36500 to Stn 36300	Stn 40900 to Stn 40730 and Stn 40800	Stn 42290 to Stn 43095 and Stn 42670 to Stn 42650
Install bioengineering				X	X	
Monitor invasive species						
Interplant revetment						
INFRASTRUCTURE						
Improve outfall protection for piped outfalls				X		
Bridge/culvert and channel improvements			Stn 30830			
Investigate control structures						
AQUATIC HABITAT						
Fisheries population & habitat study	X	X	X	X	X	X
FLOOD RELATED THREATS						
Evaluate integrity & impact of existing berms						
Restore sediment conveyance						
Assess road flooding	X	X	X	X	X	
Assess threats to structures in 100-year floodplain			X	X	X	X
Floodproofing as appropriate			X	X	X	X
WATER QUALITY						
Evaluate potential for mitigation for water quality impacts			Stn 30830			
Address fine sediment entrainment						
Long-term monitoring of erosion sites.		X	X	X	X	X
Maintain household septic systems		X	X	X	X	X
Conduct Bank Erodibility Hazard Index Assessment						
FURTHER ASSESSMENT						
Conduct baseline survey of channel morphology	X	X	X	X	X	X
Hydraulics assessment						
Monitor debris jams	X	X	X	X		

EAST BRANCH 13–16	EB13	EB14	EB15	EB16
INTERVENTION LEVEL				
Preservation	Remainder	Remainder	All	All
Passive	BEMS	BEMS		
Assisted	BEMS	BEMS		
Full	Stn 46200 to Stn 47200 (EB14)	Stn 46200 (EB13) to Stn 47200, and Stn 47700		
STREAM MORPHOLOGY				
Assess sediment deposition	X	X		
Evaluate sediment transport dynamics	X	X		
Establish single channel				
RIPARIAN VEGETATION				
Improve vegetation	RB Stn 46930 to Stn 46900			
Install bioengineering	X	X		
Monitor invasive species				
Interplant revetment				
INFRASTRUCTURE				
Improve outfall protection for piped outfalls				
Bridge/culvert and channel improvements				
Investigate control structures				
AQUATIC HABITAT				
Fisheries population & habitat study	X	X		
FLOOD RELATED THREATS				
Evaluate integrity & impact of existing berms				
Restore sediment conveyance				
Assess road flooding				
Assess threats to structures in 100-year floodplain				
Floodproofing as appropriate				
WATER QUALITY				
Evaluate potential for mitigation for water quality impacts				
Address fine sediment entrainment				
Long-term monitoring of erosion sites.	X	X		
Maintain household septic systems	X	X		
Conduct Bank Erodibility Hazard Index Assessment				
FURTHER ASSESSMENT				
Conduct baseline survey of channel morphology	X	X		
Hydraulics assessment				
Monitor debris jams				

WEST BRANCH 1–6	WB1	WB2	WB3	WB4	WB5	WB6
INTERVENTION LEVEL						
Preservation	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder
Passive		BEMS	BEMS		BEMS	
Assisted	BEMS	Stn 5700 to Stn 3200		BEMS	BEMS	
Full		BEMS				
STREAM MORPHOLOGY						
Evaluate sediment transport dynamics	X	X	X	X	X	X
Detailed geomorphic assessment		X				
RIPARIAN VEGETATION						
Improve vegetation	Stn 2200 to Stn 1400 and Stn 910 to Stn 770 LB	Stn 4830 to Stn 4110 and Stn 3480 to Stn 2110	Stn 10300 to Stn 10100 and Stn 8470 to Stn 8300	Stn 14700 to Stn 14250 and Stn 13550 to Stn 12910,	Stn 18810 to Stn 18810, Stn 17720 to Stn 17470, and Stn 16150 to Stn 15590	Stn 25000 to Stn 21330
Install bioengineering	X			X	X	
INFRASTRUCTURE						
Set back berms						
Upgrade revetment		Stn 3000 to Stn 1900	Stn 10300 RB	Stn 10380 RB		
Bridge/culvert and channel improvements						
Investigate control structures			X	X		
AQUATIC HABITAT						
Fisheries population & habitat study	X	X	X	X	X	X
Investigate relict habitat structures						
FLOOD RELATED THREATS						
Floodproofing as appropriate				X		
WATER QUALITY						
Evaluate potential for mitigation for water quality impacts		Stn 2200	Stn 8450 and Stn 8280	Stn 12360 and Stn 10650	Stn 17020	Stn 24020. Stn 22600, and Stn 21500
Address fine sediment entrainment						
Restore and monitor BEMS sites	X			X	X	
Long-term monitoring of erosion sites	X	X	X	X	X	
Maintain household septic systems				X		X
Assess Bank Erodibility Hazard Index	X			X	X	
FURTHER ASSESSMENT						
Baseline survey of channel morphology	X	X	X	X	X	X
Hydraulics assessment		X				
Monitor debris jams						

WEST BRANCH 7–12	**WB7**	**WB8**	**WB9**	**WB10**	**WB11**	**WB12**
INTERVENTION LEVEL						
Preservation	Remainder	Remainder	Remainder	Remainder	Remainder	Remainder
Passive		BEMS	BEMS	BEMS	BEMS	
Assisted		BEMS		BEMS		
Full		BEMS	Stn 33700 to Stn 33600			
STREAM MORPHOLOGY						
Evaluate sediment transport dynamics	X	X	X	X	X	X
Detailed geomorphic assessment		X	X			
RIPARIAN VEGETATION						
Improve vegetation	Stn 26500 to Stn 25000	Stn 32000 to Stn 31800, Stn 31600 to Stn 30800, and Stn 30500 to Stn 30100	Stn 34200 to Stn 32700 and Stn 32300 to Stn 32000	Stn 39700 to Stn 34300 RB	Stn 42900 to Stn 40100	
Install bioengineering						
INFRASTRUCTURE						
Set back berms						
Upgrade revetment	Stn 25330 to Stn 25000	Stn 31700 to Stn 30700 RB	Stn 33100	Stn 38125 and Stn 37100		
Bridge/culvert and channel improvements						
Investigate control structures	X		X	X	X	
AQUATIC HABITAT						
Fisheries population & habitat study	X	X	X	X	X	X
Investigate relict habitat structures	Stn 2513					
FLOOD RELATED THREATS						
Floodproofing as appropriate			X		X	
WATER QUALITY						
Evaluate potential for mitigation for water quality impacts	Stn 25900	X		X		
Address fine sediment entrainment						
Restore and monitor BEMS sites		X		X		
Long-term monitoring of erosion sites		X	X	X	X	
Maintain household septic systems			X	X		
Assess Bank Erodibility Hazard Index		X		X		
FURTHER ASSESSMENT						
Baseline survey of channel morphology	X	X	X	X	X	X
Hydraulics assessment		X	X			
Monitor debris jams						

WEST BRANCH 13–17	WB13	WB14	WB15	WB16	WB17
INTERVENTION LEVEL					
Preservation	Remainder	Remainder	All	Remainder	Remainder
Passive	BEMS			BEMS	Stn 27220 to Stn 26680
Assisted	BEMS	BEMS		BEMS	BEMS
Full					
STREAM MORPHOLOGY					
Evaluate sediment transport dynamics	X	X	X	X	X
Detailed geomorphic assessment					
RIPARIAN VEGETATION					
Improve vegetation	Stn 54200 to Stn 53650	Stn 54320 to Stn 54370	Stn 64100 to Stn 64300	Stn 64500 to Stn 64300	
Install bioengineering		BEMS			
INFRASTRUCTURE					
Set back berms					
Upgrade revetment					
Bridge/culvert and channel improvements				Stn 64600 and Stn 64300	
Investigate control structures					
AQUATIC HABITAT					
Fisheries population & habitat study	X	X	X	X	X
Investigate relict habitat structures					
FLOOD RELATED THREATS					
Floodproofing as appropriate	X				X
WATER QUALITY					
Evaluate potential for mitigation for water quality impacts		X	X	X	
Address fine sediment entrainment			Stn 62400		
Restore and monitor BEMS sites	X	X		X	X
Long-term monitoring of erosion sites	X	X		X	X
Maintain household septic systems	X	X			X
Assess Bank Erodibility Hazard Index	X	X		X	X
FURTHER ASSESSMENT					
Baseline survey of channel morphology	X	X	X	X	X
Hydraulics assessment					
Monitor debris jams					

MAIN BRANCH 1–5	MB1	MB2	MB3	MB4	MB5
INTERVENTION LEVEL					
Preservation	Remainder	Remainder	All	Remainder	Remainder
Passive	BEMS	BEMS		BEMS	BEMS
Assisted	BEMS				
Full					
STREAM MORPHOLOGY					
Evaluate sediment transport dynamics					
Detailed geomorphic assessment	BEMS				
RIPARIAN VEGETATION					
Improve vegetation	Stn 2900 to Stn 2700	Stn 3300			Stn 13500 to Stn 9770
Install bioengineering	X				
Woody vegetation plantings					
Interplant revetment					
INFRASTRUCTURE					
Assess abutment or pier scour					
Bridge/culvert and channel improvements					
Monitor changes in channel profile					
Investigate control structures		X	X	X	X
AQUATIC HABITAT					
Fisheries population & habitat study	X	X	X	X	X
Protect pool habitat					
FLOOD RELATED THREATS					
Assess road flooding					
Assess threats to structures in 100-year floodplain					
Floodproofing as appropriate		X			
WATER QUALITY					
Evaluate potential for mitigation for water quality impacts					
Address fine sediment entrainment					
Restore and monitor BEMS sites					
Long-term monitoring of erosion sites.	X	X		X	X
Maintain household septic systems					
Conduct Bank Erodibility Hazard Index Assessment		BEMS			
FURTHER ASSESSMENT					
Conduct baseline survey of channel morphology	X	X	X	X	X
Hydraulics assessment					
Long-term monitoring of in stream structures			X	X	
Monitor debris jams					

MAIN BRANCH 6-10	**MB6**	**MB7**	**MB8**	**MB9**	**MB10**
INTERVENTION LEVEL					
Preservation	Remainder	Remainder	Remainder	Remainder	Remainder
Passive	BEMS NMB6_16200 LB	BEMS NMB7_17900			
Assisted	BEMS NMB6_15400 RB	BEMS NMB7_17500	BEMS NMB8_20600		
Full			BEMS NMB8_18000	Stn 26790 to Stn 22090	Stn 29800 to Stn 26790
STREAM MORPHOLOGY					
Evaluate sediment transport dynamics			X	X	X
Detailed geomorphic assessment				Stn 25800 to Stn 25525	
RIPARIAN VEGETATION					
Improve vegetation		Stn 18300 to Stn 18000	Stn 20620 to Stn 20440	Stn 35500 to Stn 24200	Stn 28900 to Stn 28020 and Stn 28080 to Stn 28020
Install bioengineering	Stn 15400	Stn 18300 to Stn 17500			
Woody vegetation plantings	X	X	X	X	X
Interplant revetment		Stn 18300 to Stn 18000			
INFRASTRUCTURE					
Assess abutment or pier scour		X			
Bridge/culvert and channel improvements	X		X		
Monitor changes in channel profile	X				
Investigate control structures					
AQUATIC HABITAT					
Fisheries population & habitat study	X	X	X	X	X
Protect pool habitat		X			
FLOOD RELATED THREATS					
Assess road flooding				X	
Assess threats to structures in 100-year floodplain	X				
Floodproofing as appropriate			X		X
WATER QUALITY					
Evaluate potential for mitigation for water quality impacts			X		
Address fine sediment entrainment	X				
Restore and monitor BEMS sites	X				
Long-term monitoring of erosion sites.	X	X	X	X	X
Maintain household septic systems			X		X
Conduct Bank Erodibility Hazard Index Assessment					
FURTHER ASSESSMENT					
Conduct baseline survey of channel morphology	X	X	X	X	X
Hydraulics assessment			X		
Long-term monitoring of in stream structures					
Monitor debris jams				X	

Photo courtesy of Ed Ostapczuk

Water Quality Projects

The multi-faceted nature of Stream Management Planning requires coordinated effort among those interested in stream health and the most effective outcome. Sullivan County Soil & Water Conservation District is the local contracting agency with the mandate and technical experience to fulfill this coordination role: conducting stream assessments, designing and implementing stream best management practices and implementing the recommendations of the plan. Implementation projects often call for the involvement of multiple streamside landowners and residents, their town officials, county agencies and departments, and local community organizations. The Rondout Neversink Stream Management Program is operated as a field office of the District, working in close contact with these parties in the basins. Through neighborhood meetings and planning sessions, field surveys, documentation of stream management concerns and possible solutions, education and outreach activities, the Program operates on multiple tracks to establish a comprehensive partnership approach to watershed conservation in the community.

Conservation Partnerships In Action

The Rondout Neversink Stream Management Program, staffed with three full-time coordinators and seasonal interns, is based on the second floor of Neversink Town Hall. A Watershed Advisory Group formed in 2009 to lead the outreach and implementation of this plan, in addition to plans already created for the Upper Rondout and Chestnut Creeks. An Annual Action Plan identifies the priority tasks for the year. This chapter illustrates the types of projects geared to improving water quality and stream stewardship, both in the short and long terms—that the Stream Management Plan promotes in the Neversink watershed.

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opposite: *Stream bank erosion repaired in 2012 using vegetated soil lifts, a bioengineering practice. Catskill Streams Buffer Initiative, Town of Denning.*

West Branch Neversink Demonstration Project

This project met a 2007 requirement by the EPA of completing a stream restoration demonstration in the Neversink Watershed by February 2012 with full funding by NYC Department of Environmental Protection. Its major goals were to improve stream alignment through the bridge; protect water quality by increasing the buffer between the river and the road, and enhance aquatic habitat. During the project, collaborative partnerships were initiated with Wintoon Waters, LLC, owners of 5+ miles of stream which they maintains for fishing recreation; Sullivan County DPW which partnered for the repair of flood-damaged abutments; and Claryville Fire District, whose interest is to increase access to stream during emergencies.

Objectives:

- Stream channel realignment to achieve a more perpendicular approach to the bridge, improving sediment transport; repair of abutment damage from Tropical Storm Irene.
- Construction of a bankfull-stage rock-and-soil bench along the base of the rip-rapped embankment, vegetated with native plantings;
- Construction of root wad revetment underneath the floodplain bench to protect the base of the new channel stream bank using downed large woody debris located on site. Facing root wads upstream slows near-bank velocities and provides cover, shade and thermal refuge increasing trout habitat value.
- Trout habitat improvement structures: boulder clusters, lunker structures, rock runs and concave rock vanes, to provide overhanging cover, and flow diversion structures to maintain or improve scour pool habitat;
- Use of a "Stinger" tool for interplanting rip-rap with live willow stakes.

Vickers & Beechler Photography

Root wad installation is a bioengineering practice that creates a stable foundation for stream channel restoration.

Catskill Streams Buffer Iniative, Town of Denning

The Neversink River Stream Management Plan recommends exploring with landowners the benefits of protecting and restoring forested riparian buffers. A mature vegetation community along the bank and in the floodplain reduces threats of serious bank erosion while maintaining high quality aquatic habitat. The rooting structure of trees forms a dense mat, binding the soil together, while the multi-stemmed nature of most native shrubs creates friction in waters moving over the floodplain, further reducing the stream's energy and erosive power. In addition to restoring streamside buffers, Catckill Streams Buffer Initiative (CSBI) can assist landowners with invasive species identification and removal, and best management practice education and implementation.

During November 2012, CSBI repaired 504-feet of streambank on two adjacent properties which were eroding at a significant rate after years of maintaining a mowed lawn to the streambank edge. The bank was repaired using progressive bioengineering techniques, using coconut fiber blocks to form the structure of a series of soil lifts, which were interplanted with live willow cuttings. The top of the bank was planted with a variety of native trees and shrubs, reestablishing a buffer between the stream and lawn. Over the next few years, the plants' roots will develop, holding the bank in place against the powerful and erosive forces of water. The trees and shrubs will also provide a desirable habitat for mammals and songbirds, while the leaves will provide shade, cooling the stream water and creating a healthy habitat for fish and aquatic organisms.

For more information or an application visit **catskillstreams.org/CSBI**.

Flood Debris Removal

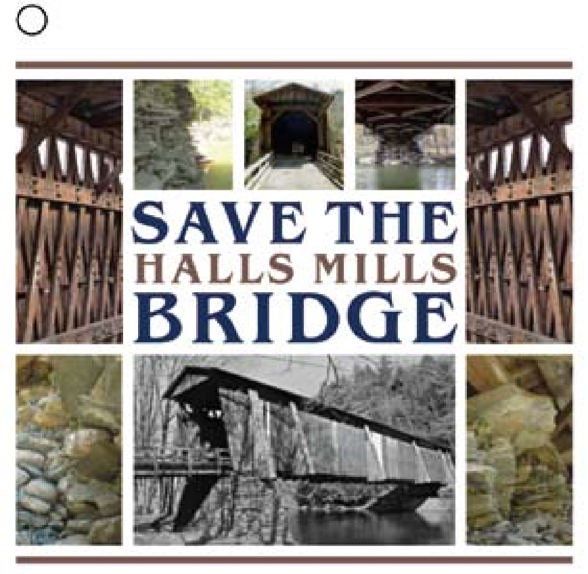
Through a grant from Catskill Watershed Corporation, Rondout Neversink Stream Program worked with over a dozen landowners on six sites to remove many tons of debris, including fuel tanks, construction, and large woody debris left in the Neversink River floodplain in the wake of Tropical Storm Irene. To address the potential spread of Japanese Knotweed and other invasive species, the program required that heavy equipment brought from other areas be power washed prior to mobilization. Pressure washers were employed of the same type used to prevent the spread of invasives in the NYC DEP reservoir boating program.

Flood debris removed from Jones Flats on the West Branch of the Neversink.

Education & Outreach Projects

SAVE THE HALLS MILLS BRIDGE

Summer of 2012 found Town of Neversink and the NY State Covered Bridge Society concerned for the future of the Halls Mills Covered Bridge. Rondout Neversink Stream Program partnered to sell the “River Bag” with proceeds earmarked for saving the bridge (repairs are currently underway; limited number of bags still available).



SCHOOL PARTNERSHIPS

Named by EPA and Sullivan County Soil & Water Conservation District as Conservationist of the Year, teacher Robert Hayes brought his conservation class students to numerous stream restoration sites to assist with installing plant material. Together with Cornell Cooperative Extension, Tri Valley students also run a stream table demonstration, which took a blue ribbon at New York State Fair and was featured at Little World’s Fair in Grahamsville 2012.

Education & Outreach Projects

NEVERSINK TRANSMISSIONS

Co-sponsored with the locally-based Wildcat Fellowship Program, Neversink Transmissions artists Ellie Irons and Dan Phiffer recorded stream-based oral histories in the community during the summer of 2011 and transmitted them from a driftwood "tower" based at Denning Town Hall. Hear the stories at **www.neversink.info**.

COMMUNITY FLOOD HISTORY

With record floods in August 2011 and September 2012, residents have begun to contribute data to a Flood Damage Database initiated by Rondout Neversink Stream Program. Over 40 landowners have shared facts about their properties in Claryville alone; this effort will expand in future.

EAST BRANCH NEVERSINK RIVER NORTHEAST OF DENNING, NY

1991–PRESENT

Date	Flood Discharge (cfs)
9/16/99	3,070
12/17/01	2,700
7/23/04	2,480
4/2/05	2,920
10/1/10	3,020
12/1/10	2,540
8/28/11	5,580
9/18/12	3,240

WEST BRANCH NEVERSINK RIVER AT CLARYVILLE, NY

1992–PRESENT

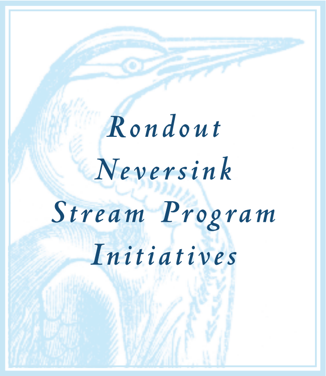
Date	Flood Discharge (cfs)
1/19/96	8,020
11/9/96	7,920
12/17/00	9,500
4/2/05	9,570
6/28/06	8,310
10/1/10	8,340
8/28/11	11,600
9/18/12	9,680

NEVERSINK RIVER NEAR CLARYVILLE, NY

1938–PRESENT

Date	Flood Discharge (cfs)
7/22/38	12,400
12/24/41	10,000
11/25/50	23,400
7/10/52	10,200
10/15/55	9,950
7/28/69	9,880
3/13/77	10,000
9/6/79	11,700
3/21/80	15,600
2/20/81	14,400
4/5/84	10,700
4/4/87	19,300
1/19/96	12,700
11/9/96	10,400
12/17/00	11,800
4/2/05	17,200
6/28/06	11,500
10/1/10	16,400
12/1/10	10,300
8/28/11	20,900
9/18/12	16,800

Priority Recommendations



Earlier sections of this Stream Management Plan (SMP) gave site-specific recommendations for management of the Neversink River stream system. Presented here are the top ten recommendations for more comprehensive, voluntary programs and tasks to enhance and improve stream management activities in the watershed. This list represents the results of input gathered through surveys conducted in November 2012 in the Towns of Denning and Neversink with the target audiences of the East, West and Main Stem Branches of the Neversink to address their stream management concerns at this point in time. All recommendations are voluntary (non-regulatory) and will evolve over time as projects are planned and completed, and further needs of the participating communities are identified. Through a funded, five-year contract with NYC DEP, Sullivan County Soil & Water Conservation District staff will guide this effort, together with its Watershed Advisory Group which meets 2-3 times a year and in sub-committees every other month.

Stream Stability Restoration

Recommended: Secure funding commitments for additional unfunded restoration projects on the Neversink River as discussed in individual management segments.

Notes: In this Plan, the Project Team identified a number of reaches which are strongly recommended for restoration. Additional restoration sites will be prioritized, ranked and continuing funding sought.

Debris Management

Recommended: That a protocol be developed for the inventory of floodplain debris and assistance to municipalities and communities in debris management.

Notes: Develop protocol to ensure responsible floodplain management, including annual clean-up efforts, prevention of illegal dumping, and flood event debris management. The Program Team may need to explore issues of landowner liability for managing large woody debris. Removal of large woody debris would focus on areas that pose a flood hazard to infrastructure and a threat to human welfare.

Selective Stream Gravel Removal

Recommended: That an independent stream scientist be funded to create a guidance document with recommendation on how, when and where to scientifically manage problematic gravel deposits within the Neversink watershed.

Notes: Numerous concerns have been expressed regarding current policies and regulations restricting gravel removal. It is the Stream Management Program's role to investigate these issues by advancing discussion with the appropriate regulatory agencies.

Post-Flood Technical Assistance

Recommended: To work cooperatively on improving immediate post-flood emergency intervention capabilities through demonstration and training with contractors and local municipalities in scientifically-based stream principles, procedures and methods.

Notes: In many areas post-flood work unravels stream systems more than any other non-flood work combined. Using Delaware County SWCD's contractor training workshop as a model, provide local contractors and highway superintendents with training on regional hydraulic relationship curves, natural stream restoration principles and techniques, and identifying best management post-flood intervention techniques.

Technical Assistance

Recommended: That long term access to technical assistance be provided to landowners and municipalities for assessment of their stream-related problems, development of effective management strategies and supervision stream project implementation.

Notes: It is recommended that the Sullivan and Ulster County Soil and Water Conservation Districts, NYCDEP and local municipalities evaluate how to insure long term availability of the high levels of technical resources currently available in the Neversink Watershed.

Flood Response Technical Resources

Recommended: That trained professionals be identified to provide onsite guidance for stream modifications immediately following flooding. Guidelines that integrate stream form and function should be developed for use during post flood response.

Notes: The existing approach to flood management of patching flood damage without stream process knowledge wastes limited funding, may leave localities more vulnerable to future floods and may create liability for already devastated communities. Guidelines for work on flood damaged with minimal stream disturbance would greatly reduce risk of further instability. Stream professionals can provide for rapid and coordinated expert review and guidance on a regional basis during planning, funding, permitting and construction phases of flood remediation.

Town Adoption of Management Plan & Principles

Recommended: That the Towns of Denning and Neversink review and adopt the Plan and its associated Stream Stewardship Principles.

Notes: Scientifically-based stream management practices are essential to the long-term health and stability of waterways flowing throughout the Rondout watershed. Following the principles of proper stream stewardship will ensure the preservation of stream health, aesthetics, recreational opportunities, water quality and aquatic habitat, and reduce or prevent costly restoration and repairs stemming from damages caused by unstable stream systems.

Flood Damage Database

Recommended: That the Towns of Denning and Neversink partner in the development of a flood damage reporting system to track types of flooding, their location and the costs associated with flood damage.

Notes: Initially, a database would collect overall records on past floods; then localized flooding occurrences and damages could be documented. Areas with repetitive damage can be prioritized for mitigation because this cumulative cost damage data provides justification for mitigation grant program funding. Training, funding and administrative support would ensure success.

Public Lands

Recommended: That governmental landowners in the Neversink watershed manage their lands using natural channel stability concepts, and serve as a model for other watershed landowners.

Notes: If NYSDEC, NYCDEP, municipalities and local institutions, conduct an evaluation of all riparian lands and identify protection, restoration and management needs, projects can be implemented to protect, restore and manage stream areas according to the recommendations set forth in this SMP.

Historic & Current Condition Analysis & Documentation

Recommended: That historical records for precipitation metrics be analyzed so current trends in precipitation amount, intensity, timing of snowmelt and other forces potentially affecting flood frequency and stream flow response can be shared with planners seeking to mitigate their effects.

Glossary

AGGRADATION The process by which streams are raised in elevation by the deposition of material eroded and transported from other areas. The opposite of degradation.

ALLUVIUM Loose unconsolidated gravel, sand and finer sediments deposited by flowing water.

AVULSION A rapid change in channel direction when a stream suddenly breaks through its banks typically bisects an overextended meander arc (oxbow cutoff).

BACKEDDY SCOUR Erosive action of water in streams by excavating and transporting bed and bank materials downstream caused by swirling water and reverse current created when water flows past an obstacle.

BACKWATER An area in or along a stream where water has been held back by an obstruction, constriction or dam. Condition in which the surface water movement is slowed by downstream flow impediments.

BANKFULL STAGE The elevation at which flooding occurs on a floodplain.

BASE FLOW The sustained low flow of a stream, usually resulting from groundwater inflow to the stream channel rather than surface water runoff.

BASIN, DRAINAGE an area in which the margins dip toward a common center or depression, and toward which surface and subsurface channels drain. The common depression may allow free drainage of water from the basin as in a stream, or may be the end point of drainage as in a lake or pond.

BED MATERIAL The composite mixture of substrate of which a streambed is composed.

BEDLOAD The amount and size of stream bed material or substrate that is mobilized by tractive and erosive forces measured or calculated at a specific discharge and are transported by jumping, rolling or sliding on the bed layer of the stream. Contrast to Suspended Load.

BIOENGINEERING The use of live vegetation, either alone or in combination with harder materials such as rock or (dead) wood, to stabilize soils associated with stream banks or hillslopes. Roots stabilize the soil, while stems, branches and foliage slow high velocity water, reducing erosion and encourage deposition of fine sediments.

BUFFER ZONE/BUFFER STRIP An area of permanent vegetation between waterways and adjoining land uses designed to intercept and filter out pollution before it reaches the surface water resources.

CHANNEL CROSS-SECTION The physical measurements (width and depth) across the channel and floodplain.

CHANNEL MIGRATION Lateral or longitudinal (down-valley) migration of the stream channel within the valley by the process of erosion and deposition.

CHANNELIZATION The modification of a natural river channel; may include deepening, widening, straightening, or altering of the slope, to accelerate conveyance or increase drainage of wet areas.

CONFLUENCE The meeting or junction of two or more streams, each with its own watershed.

CULVERT A closed conduit for the free passage of surface drainage water used to control water running along and under the road, and to provide a crossing point for water from road side drainage ditches to the stream, as well as for routing tributary streams under the road to join the mainstem.

DEGRADATION The process by which a stream reach or channel becomes deeper by eroding downward into its bed over time, also called "downcutting."

DEMONSTRATION STREAM RESTORATION PROJECT OR DEMONSTRATION PROJECT A stream stability restoration project that is designed and located to maximize opportunities for monitoring of project success, public and agency education about different stream restoration techniques, and interagency partnerships funding and cooperation.

DEPOSITION Accumulation of sediment on the channel bed or banks.

DISCHARGE OR STREAM FLOW The amount of water flowing in a stream, measured as a volume per unit time, usually cubic feet per second (cfs).

EDDY A circular current or a current of water running contrary to the main current, usually resulting from an obstruction.

ENTRENCHMENT Flood flows in an entrenched stream are contained within the stream banks or adjacent terraces. Flood flows in a stream that is not entrenched are spread out over a floodplain.

EPHEMERAL Referring to a stream that runs only in direct response to rain or snow events and whose channel is above the water table.

EROSION The wearing away of the land surface by detachment and movement of soil and rock fragments during a flood or storm or over a period of years through the action of water, wind, or other geological process.

FLOOD STAGE The gage height at which the stream begins to overflow its banks.

FLOODPLAIN The portion of a river valley, adjacent to river channel, which is covered with water when river overflows its banks at flood stage. The floodplain usually consists of sediment deposited b the stream, in addition to riparian vegetation. The floodplain acts to reduce the velocity of floodwaters, increase infiltration (water sinking into the ground rather than running straight to the stream—this reduces the height of the flood for downstream areas), reduce stream bank erosion and encourage deposition of sediment.

FLOODWAY The stream channel and those parts of the floodplain adjoining the channel that are required to carry and discharge the floodwaters or flood flow of the stream.

FLUVIAL 1. Of or pertaining to a river or rivers. 2. Existing, growing, or living in or about a stream. 3. Produced by the action of a stream or river, as in fluvial plain.

FLUVIAL GEOMORPHOLOGY The study of the formation of landforms by the action of flowing water.

HARDENING Any structural revetment that fixes in place an eroding stream bank, embankment or hillside by using hard materials, such as rock, sheet piling or concrete, that does not allow for revegetation or enhancement of aquatic habitat. Rip-rap and stacked rock walls are typically considered to be hardening measures, though some revegetation of these areas is possible.

HEADCUTTING The process by which the stream is actively eroding the streambed downward (degrading, incising, downcutting) to a new base level.

HEADWATER The upstream area in a stream system or area where streams originate.

HYDROLOGIC CYCLE The natural pathway water follows as it changes between liquid, soil, and gaseous states. The cyclic transfer of water vapor from the Earth's surface via evapotranspiration into the atmosphere, from the atmosphere via precipitation back to the earth, and through runoff into stream, rivers, lakes, and ultimately into the oceans.

IMPERVIOUS SURFACE Surfaces, such as roads, parking lots, and roofs, whose properties prevent the infiltration of water and increase the amount of stormwater runoff in a watershed.

IMPOUNDMENT A body of water, such as a pool, lake or reservoir, formed by confining a stream or other surface flow.

INSTABILITY An imbalance in the capacity of the stream to transport sediment and maintain its channel shape, pattern and profile.

INTERMITTENT STREAM A stream that only flows for part of the year and is marked on topographic maps with a line of blue dashes and dots.

INVASIVE PLANTS Species that aggressively compete with and replace native species in natural habitats.

LARGE WOODY DEBRIS Any woody material, such as from trees or shrubs, that washes into a stream channel or is deposited on a floodplain area. This debris provides important aquatic habitat functions, including nutrient sources and micro-habitats for aquatic insects and fish. Large woody debris is especially influential to stream morphology in small streams, though may be detrimental in the vicinity of structures and infrastructures.

LATERAL MIGRATION The movement of a channel across its floodplain by bank erosion. The outside banks of meanders move laterally across the valley floor and down the valley.

MACROINVERTEBRATES Stream-dwelling insects and crustaceans without a backbone that can be viewed without magnification. Examples include crayfish, leeches, water beetles and larva of dragonflies, caddisflies, and mayflies. Macroinvertebrates are an important food source for many species of fish.

MAINSTEM The common outlet or stream, into which all of the tributaries within a watershed feed.

MEANDER Bend or curve in a stream channel.

MONITORING The practice of taking similar measurements at the same site, or under the same conditions, to document changes over time.

MORPHOLOGY The form (dimension, pattern, and profile) and structure of the stream channel.

NATIVE VEGETATION Vegetation indigenous to an area and adapted to local conditions.

NON-POINT SOURCE Extensive or disperse source of pollution. Examples include agriculture, lawns, parking lots, roads, and septic systems.

NUTRIENT The term “nutrient” refers broadly to those chemical elements essential to life on earth, but more specifically to nitrogen and phosphorus in a water pollution context.

PEAK FLOW The highest discharge achieved during a storm event.

PERENNIAL STREAM A stream that normally contains flowing water at all times regardless of precipitation patterns.

POINT SOURCE Source of pollution from a single, well-defined outlet. Examples include wastewater treatment outfalls, combine sewer overflows, and industrial discharge pipes.

POOL Deep, flat, areas in the stream created by scour, with slow currents at low flow. Usually pools occur on the outside of a meander bend between two riffles or the bottom of a step. Pools generally contain fine-grain bed materials, such as sand and silt. Natural streams often consist of a succession of pools and riffles.

REACH A section of a stream with consistent or distinctive morphological characteristics.

REFERENCE REACH/SITE A stable portion of a stream that is used to model restoration on an unstable portion of stream. Stream morphology in the reference reach is documented in detail, and that morphology is used as a blueprint for design of a stream stability restoration project.

REVETMENT A facing stone, rootwads, cut trees, or other durable material used to protect a stream bank or hillside.

RIFFLE A reach of stream that is characterized by shallow, fast-moving water broken by the presence of rocks. Most invertebrates will be found in riffles.

RIPARIAN CORRIDOR/ZONE The area of land along stream channels, within the valley walls, where vegetation and other landuses directly influence stream processes, including flooding behavior, erosion, aquatic habitat condition, and certain water quality parameters.

RIPARIAN BUFFER An undisturbed, vegetated strip of land adjacent to a water course.

RIP-RAP Broken rock cobbles, or boulders placed on earth surfaces, such as a road embankment or the bank of a stream, for protection against the action of water; materials used for soil erosion.

RUNOFF The portion of rainfall or snowmelt that moves across the land surface into streams and lakes.

SCOUR Erosive action of water in streams by excavating and transporting bed and bank materials downstream.

SEDIMENT Material such as clay, sand, gravel, and cobble that is transported by water from the place of origin (stream banks or hillsides) to the place of destination (in the stream bed or on the floodplain).

SEDIMENTATION OR SILTATION The deposition of sediment.

SHEET FLOW Water, usually storm runoff, flowing in a thin layer over the ground surface; also one form of overland flow.

SIDE CHANNEL A secondary channel of the stream.

SINUOSITY The relative curviness of a stream channel. Quantified as the total stream length divided by valley length, or the ratio of valley slope to channel slope.

STABLE CHANNEL State in which a stream develops a stable dimension, pattern and profile such that, over time, channel features are maintained and the stream system neither aggrades nor degrades (Rosgen, 1996).

STREAM STABILITY RESTORATION DESIGN PROJECT An unstable portion of a stream that has been reconstructed, using morphology characteristics obtained from a stable reference reach in a similar valley setting, that returns the stream to a stable form (a shape that may allow the stream to transport its water and sediment load over time without dramatic changes in its overall shape).

SUMMER BASE-FLOW Stream discharge primarily from groundwater (not from surface runoff). Typically this is the lowest flow of the year, occurring in late summer, or following extended periods of drought.

SUSPENDED SEDIMENT OR SUSPENDED SEDIMENT LOAD The soil particles lifted into and transported within the streamflow for a considerable period of time at the velocity of the flow, free from contact with the stream bed. These materials contribute to turbidity.

THALWEG Literally means “valley view” and is the deepest point of a cross section of stream channel.

TRIBUTARY A stream that feeds into another stream; usually the tributary is smaller in size than the main stream (also called “mainstem”). The location of the joining of the two streams is the confluence.

TURBIDITY A measure of opacity of a substance; the degree to which light is scattered or absorbed by a fluid.

UNDERCUTTING The process by which the lower portion or “toe” of the stream bank is eaten away by erosion leaving a concave, overhanging section of stream bank. Often occurs on banks at the outside of stream bends.

VELOCITY In streams, the speed at which water is flowing, usually measured in feet per second.

WATER QUALITY A term used to describe the physical, chemical, and biological characteristics of water with respect to its suitability for a particular purpose.

WATERSHED Area that drains to a common outlet. For a stream, it is all the land that drains to it or its tributaries. Also called a basin, drainage basin, or catchment. A sub-basin or sub-watershed is a discriminate drainage basin within a larger watershed, typically defined for planning or modeling purposes. The size of a watershed is termed as its drainage area.

WETLAND An area that is saturated by surface water or ground water with vegetation adapted for life under those soil conditions, as in swamps, bogs, fens, and marshes.

WINTER BASE FLOW Stream discharge primarily from groundwater (not from surface runoff). Winter base flow is generally higher due to lower rates of evapotranspiration during vegetative dormancy.

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Painting by the late Bob Dice of Claryville, courtesy of the Dice family.

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