Upper Delaware River Tailwaters Watershed

A Non-Regulatory Guidance Document

Stream Corridor Management Plan

Volume 1

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Foreword

There are many people and organizations that deserve credit for the development of the Upper Delaware River Tailwaters Stream Corridor Management Plan (SCMP). Chief among them is the Upper Delaware River Tailwaters Coalition (UDRTC).

The UDRTC is comprised of elected officials from the towns and villages below the reservoirs and also includes the Upper Delaware River Business Coalition and members of regional and local non-profit conservation organizations. This important coalition, representing a diverse set of views, has made great strides since their inception in 2014 to advance community resiliency, conservation and economic initiatives in the Upper Delaware River. Their guidance, wisdom, and practical knowledge of the watershed was invaluable in the formulation of the SCMP and, moving forward, they will play a critical role in identifying and securing resources to implement the plan.

The SCMP also benefited from the guidance of a Project Advisory Committee (PAC) consisting of federal, state, regional, and local natural resource agencies and Community Advisory Groups (CAG) from each of the towns and villages in the project area. Delaware County agencies including the Department of Watershed Affairs and the Department of Planning provided critical project oversight and technical assistance. Thanks also to the technical assistance provided by Shepstone Management and by the project subcontractors Trout Unlimited, Woidt Engineering, and LandStudies Inc.

Finally, a heartfelt appreciation to the people of Delaware and Broome counties who care deeply about the sustainability of the local waterfront communities and the economic and environmental quality of this beautiful area. Through their involvement in the conception and development of the SCMP, they demonstrated a strong commitment to the future management and conservation of the water resources that play an enormous role in the quality of their lives and the identity of this region.

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List of Acronyms

BFE	Base Flood Elevation
BMP	Best Management Practices
CAG	Community Advisory Group
CCE	Cornell Cooperative Extension
CEMP	Comprehensive Emergency Management Plan
CEM	Comprehensive Emergency Management
CREP	Conservation Reserve Enhancement Program
CRISP	Catskill Region Invasive Species Partnership
CRS	Community Rating System
CWC	Catskill Watershed Corporation
DCAP	Delaware County Action Plan
DCDES	Delaware County Department of Emergency Services
DCDPW	Delaware County Department of Public Works
DCPD	Delaware County Planning Department
DCSWCD	Delaware County Soil and Water Conservation District
DCWSA	Delaware County Department of Watershed Affairs
DFIRMs	Digital Flood Insurance Rate Maps
DPW	Department of Public Works
EBDR	East Branch Delaware River
EOC	Emergency Operations Center
FAD	Filtration Avoidance Determination
FEMA	Federal Emergency Management Agency
FFMP	Flexible Flow Management Plan
FIRMs	Flood Insurance Rate Maps
FUDR	Friends of the Upper Delaware River
GIS	Geographic Information System
GPS	Global Positioning System
HMGP	Hazard Mitigation Grant Program
HMPs	Highway Management Plans
NFIP	National Flood Insurance Program
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
NYCDEP	New York City Department of Environmental Protection
NYCRR	New York Code of Rules and Regulations

NYSDEC	New York State Department of Environmental Conservation
NYSDOT	New York State Department of Transportation
NYSDOS	New York State Department of State
PAC	Project Advisory Committee
SCMP	Stream Corridor Management Plan
SEMO	State Emergency Management Office
SPDES	State Pollutant Discharge Elimination System
SWPPP	Stormwater Pollution Prevention Plan
SWCD	Soil and Water Conservation District
TU	Trout Unlimited
UDR	Upper Delaware River
UDRBC	Upper Delaware River Business Coalition
UDRTC	Upper Delaware River Tailwaters Coalition
USACOE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WBDR	West Branch Delaware River
WRI	Water Resources Institute

I. Executive Summary

This Stream Corridor Management Plan (SCMP) is the result of a highly collaborative effort among government agencies, non-profit organizations, and watershed stakeholders in the Upper Delaware River (UDR) Tailwaters. It provides a comprehensive analysis of the unique conditions and management needs of the waterways that make up the Tailwaters of the Pepacton and Cannonsville Reservoirs. The construction of the reservoir system resulted in the establishment of a world class wild trout fishery and cold water ecosystem. The UDR now offers extraordinary recreational opportunities and is rapidly emerging as an important economic anchor for the region. As such, the SCMP recognizes the integral role that the UDR Tailwaters play in the daily lives of watershed residents and stakeholders.

The SCMP is a **non-regulatory** resource management plan and is designed to be used by a wide range of watershed practitioners and the public to ensure that the watershed is managed through progressive approaches based on sound science.

The goal of protecting people, communities, local economies, water quality, and wildlife are the foundation for initiatives that provide for sustainable communities and environmental protection. It is understood that a healthy stream system not only benefits the sensitive UDR cold water ecosystem but also provides for community protection through flood mitigation and improved public infrastructure. Each of these factors supports the dynamic economic structure of the region.

An extensive public outreach effort was essential to the development of the SCMP. Residents and other stakeholders in the UDR Tailwater municipalities, including Colchester, Hancock, and Deposit, with small portions of other municipalities in Delaware County, and Sanford, in Broome County were invited to participate and provide information, guidance, and feedback on the plan as it was developed. More than two dozen public meetings were held throughout the project area to maximize opportunities to participate in the development of the SCMP.

Local stakeholders offered important information on the conditions of streams including characterizing significant changes in the hydrologic landscape over time, and historical to modern day impacts such as land use, development patterns, and flooding impacts. This helped paint a picture of an ever-changing watershed and was the basis for developing recommendations for future management activities that will address the needs of all watershed stakeholders.

This comprehensive public process shed a tremendous amount of light on the critical role water resources play in the daily lives of the people who live in the watershed and the communities that rely on healthy waterways for their safety, welfare, and economic livelihood.

The SCMP is a comprehensive document that lays out all of the critical steps and pieces of information needed to identify and develop local management practices, stream restoration projects and improve infrastructure in the focus area of the plan. This SCMP describes the physical characteristics of the landscape and geology of the UDR Tailwaters watershed and describes how both past and modern day land uses have changed watershed conditions. The plan discusses the demographics of the area and how natural resource based industries continue to play a vital role in the regional economy. It identifies broad watershed wide goals that represent the most pressing challenges in the UDR watershed.

The plan offers a step by step methodology to identify and prioritize “on the ground” projects that can help meet the watershed goals. The SCMP includes an Implementation Plan that articulates the next phase of this project which includes securing funding, generating more detailed watershed data, and identifying projects to be implemented. Finally, the plan includes a suite of recommendations that address funding needs, partnerships, stream restoration, and integrating the objectives of the plan into other watershed management activities both already underway and those that may be developed in the future.

II. Background

The need for a Stream Corridor Management Plan was identified by the Upper Delaware River Tailwaters Coalition (UDRTC). This coalition is comprised of local governments, businesses, and conservation non-profit organizations and was formed in 2014. The UDRTC quickly recognized the importance of developing a comprehensive plan that could inventory stream features, identify areas of concern throughout the stream system and provide a public process that would allow for a prioritization of objectives throughout the UDR Tailwaters. The UDRTC motivation developed out of concerns of changing flow management practices out of the New York City Reservoirs, climate change, devastating flood events, and an evolving local economy.

The UDRTC understands that rivers and streams cross political boundaries, so the strongest plan would be one developed in partnership with multiple governmental jurisdictions. Their motivation stemmed from an understanding of the importance of the areas waterways to public health, economic vitality, and environmental quality. The members of the UDRTC acknowledged the best way to attract much needed resources to one of the most rural areas in New York State was to develop an SCMP that provides a clear, voluntary and multi-jurisdictional management roadmap for the future.

In 2015, the Delaware County Department of Watershed Affairs received a grant from the New York State Department of State - Local Waterfront Revitalization Program for the purposes of developing a Stream Corridor Management Plan (SCMP). Additionally, The Community Foundation of South Central New York took notice and awarded an additional $25,000 to Watershed Affairs in support of the planning effort. In 2016, Watershed Affairs contracted with Friends of the Upper Delaware River and their sub-consultants, Northeast Trout Unlimited, Woidt Engineering, and Landstudies, Inc. to develop the plan. Additionally, Shepstone Management was hired to assess and review local land use tools and policies, provide public outreach and develop a project prioritization matrix.

To support the work of the consultants, Delaware County Planning developed a stream analysis tool based on the Vermont Protocol for Stream Assessment. This assessment tool was used by interns hired by the Planning Department to identify, assess, and evaluate stream features in the priority basins.

The development of the SCMP is a first of its kind comprehensive, non-regulatory, multi-jurisdictional plan to help guide the future management of the UDR Tailwaters below the NYC Delaware basin reservoirs. The SCMP is modeled after the highly successful East Branch Delaware River Stream Corridor Management Plan developed by the Delaware County Soil and Water Conservation District, the Delaware County Planning Department, and a host of other partners.

III. Vision Statement

The vision for the Upper Delaware River Stream Corridor Management Plan (SCMP) is to highlight non-regulatory opportunities to maintain, enhance, protect and restore stream systems, water quality, and habitat to promote a healthy and resilient Upper Delaware River ecosystem, ensure public safety, mitigate flooding, protect public infrastructure, enhance local economies, and increase recreation and tourism opportunities. The SCMP was developed with maximum public participation and involvement and is supported by watershed stakeholders including local government officials, businesses, landowners, recreational users, and civic organizations. The SCMP will be integrated and consistent with existing local programs associated with stream management activities and will promote economically sustainable and vibrant communities throughout the watershed.

IV. Planning Process

This document is Volume One of the SCMP and has been developed through public participation and analysis of GIS materials, scientific reports, and other regional plans. The planning process for resource management is an approach to problem solving that provides a systematic way of viewing conditions, concerns, opportunities and potential threats. The approach used is to define, categorize and ultimately develop short and long-term solutions, suggestions and overall management practices. The steps taken to complete Volume 1 of the UDR Tailwaters Stream Corridor Management Plan are:

1. **Form Project Advisory Committee (PAC) and Community Advisory Groups (CAGs)**

   A Project Advisory Committee (PAC) and three Community Advisory Groups (CAGs) were formed to provide guidance and leadership in the development of the Plan. The PAC was primarily designed to gather local stakeholders, interest groups, regional agencies and experts to discuss and define the parameters and content of the SCMP. The CAGs were designed to guide the process in each of the three primary communities by including local leaders, streamside landowners, business owners and local interest groups. Each CAG had a PAC representative to ensure the local comments and concerns were addressed. The series of meetings with the PAC and CAGs were to present sections of the document as it was being developed and to ask for input and concurrence with the data, findings, and identified goals and objectives. The PAC assisted with the development of a vision statement that clearly described the goals and objectives of the plan and articulated a community based vision for the future of waterway protection and restoration in the UDR Tailwaters. The local views presented in these meetings created the foundation for recommendations and ultimately the implementation strategy.

2. Develop Community Outreach Strategy

The development and implementation of a community outreach strategy (see Appendix 4) that ensured a maximum level of public participation and meaningful watershed stakeholder involvement included a multi-pronged approach. The UDRTC hosted a series of meetings with local stakeholders in each of the three primary communities, Colchester, Hancock and Deposit. The objective of the first series of meetings was to evaluate local laws and plans that impact land uses and economic priority areas within the watershed. These evaluations led to recommendations for changes that could be implemented to further protect people from flooding impacts, protection of the natural resources and provide for enhanced economic opportunities. The second set of meetings was used to identify changes and in the watershed region. This information was collected through a mapping exercise where stakeholders marked locations of historic flooding impacts, recreational uses and infrastructure improvements. Maps are in Appendix 1.

A series of public education meetings were held to provide a basic understanding to the public about the planning process, the function of streams and the economic importance of the UDR. Each set of meetings was designed to provide an informative presentation followed by questions, answers and public input. The topics covered were Stream Corridor Stewardship & Management Planning, Working with Natural Stream Systems, The Basics of Stream Dynamics: Past, Present, Future, Informed Flood Mitigation Planning and Resiliency, Tributary Protection in a Warming World: Helping Streams Adapt in the Upper Delaware River Basin, Overview of the Physical Characteristics and Demographics of our Watershed, and What’s a River Worth?

3. Generate Community Data

Community Data refers to data collected through input gathered at public meetings and other interactions with a wide variety of watershed stakeholders including landowners, local business operations, highway departments, code enforcement officers, elected officials, farmers, and recreational users of the resource. This data was collected by Shepstone Management, Friends of the Upper Delaware River, Trout Unlimited, Woidt Engineering and Consulting P.C., Delaware County Department of Watershed Affairs, Delaware County Planning Department, Delaware County Soil and Water Conservation District, and the Delaware County Departments of Watershed Affairs and Planning.

Additionally, the Delaware County Planning Department and the Delaware County Soil and Water Conservation District participated at local summer festivals in the summer of 2016 providing an opportunity for residents to learn about stream function. The Delaware County Soil and Water Conservation District set up their

Stream Table as an educational tool to demonstrate the impact of streams on infrastructure, surrounding land uses and agricultural practices. The educational opportunities provided an avenue for the public to learn about and participate in the planning process. (See Appendix 1)

4. Gather available Geographic Information Systems (GIS) Data

The initial steps to gathering information about the UDR watershed included the use of GIS and aerial photography. GIS Data describes qualities and features of the landscape. This data comes from a variety of sources such as universities, museums, Town and Village archives, and State and Federal Agencies.

The watershed was divided into smaller sub-basins where unique features and characteristics could be more easily identified. These smaller basins allow for specific recommendations, which will be developed in Volume Two, to improve a specific region of the watershed while also having an impact on the overall health of the watershed. It is easier to define watershed needs at this resolution and increases opportunities to garner funding and support for projects in the future.

In addition to developing sub-basins an evaluation of stream features, soil types, local geology, local geography, local land uses, land cover and infrastructure encroachments was conducted by the Delaware County Planning Department. This was a paper survey completed through the use of GIS mapping, aerial photography and limited field assessment. This inventory helped consultants define potential areas of concern and potential solutions that led to the development of several goals and objectives and provided the scientific foundation for the implementation strategies.

5. Assess Current Local Plans, Local Laws, and Regulations

Shepstone Management completed a thorough review of all existing plans, local laws and regulations in each of the communities in the study area. They highlighted the commonalities as well as made recommendations to address gaps in protection, contradictions among laws and plans and compliance with state and federal regulations. This established a baseline of local protections in the region that address impacts from flooding, impacts to streams and land use controls to provide for economic growth of local industries. (See Appendix 1)

6. Develop a Vision Statement

The Vision Statement was developed through the PAC to identify the overall goals and purpose of the project. It outlines the need, the tasks, and the overall objectives to be addressed in the plan.

7. **Develop Watershed Goals**

   Watershed goals were developed from the GIS Data and Community Data. These broad goals reflect the most important watershed impacts and needs in the project area. The goals support the vision statement and lay the foundation for specific recommendations. Objectives will be developed as part of Volume Two as they will call on additional data collected in the field – Stream Inventory Data. Goals and objectives are the concrete strategies that turn the mission and vision into measurable successes.

8. **Delineate Subbasins**

   The subbasins in the Upper Delaware River Tailwaters were delineated using a modified Vermont Agency of Natural Resources Watershed Assessment Methodology which resulted in the division of the Tailwaters into 26 subbasins. A subbasin is a defined catchment area within the overall watershed. As an example, Oquaga Creek is a subbasin within the larger UDR Tailwaters Watershed. Volume Two will provide a more detailed evaluation of the subbasins and the overall impacts to the whole watershed.

9. **Identify Recommendations**

   SCMP Volume One recommendations are supported by the overall findings of the plan and the goals. These recommendations were generated, in large part, at the community outreach meetings and reflect the knowledge, interests, and needs of diverse watershed stakeholders. (See Section X)

10. **Generate Implementation Plan**

   The Implementation Plan (found in Section IX), is designed to track the progress of the SCMP and identify future projects, project partners, and funding sources. These strategies will ensure publication of a SCMP that will serve as a multi-jurisdictional guidance document for the future management, restoration, and resiliency of the UDR Tailwaters.

   Volume Two is being developed to provide a more robust understanding of the stream miles as they currently exist in the basin. It will show where attention is needed for stream restoration projects as well as provide a baseline of data for tracking changes in the system. As individual basins are inventoried, objectives will be developed that will suggest specific ways to meet the watershed goals given the conditions in a specific subbasin. As a living system, subbasins will change with time, seasons and events. It is necessary to determine how these changes affect the watershed and the magnitude and speed at which these changes take place. Plans are evolving documents and are intended to be a snapshot in time.

The Volume 2 Methodology will contain four steps:

1. **Identify Locations for Additional Data Collection**

   Utilizing best professional judgement, Community Data, and GIS Data, identify areas where one or more impairments are contributing to a perceived problem in the watershed and prioritize the impairments based on the severity of their impacts utilizing a project prioritization matrix.

2. **Delineate Reaches and Collect Stream Inventory Data**

   A "reach" is defined as a unique, somewhat consistent section of stream. The beginning and end points of each reach have been selected based on breakpoints in the stream where physiographic conditions change. Examples of criteria that lead to a reach division include: stream size, valley width or confinement, valley slope and topography, land cover, meeting a tributary, and the presence of bridges.

   Stream Inventory Data (SI Data) is collected when field technicians walk the streams within a watershed. The intent of this data collection is to observe, map, measure and characterize the streams, their adjacent floodplains and proximal infrastructure. The data will be used to identify where work is needed and will contribute to defining a watershed's objectives.

3. **Analyze Data and Identify Projects**

   Community Data, GIS Data, and Stream Inventory Data will be used to develop a project list that supports the recommendations and Watershed Goals developed during the planning process. As projects are identified, project specific objectives are defined (i.e. stabilization of stream bank, reconnection of floodplain, improvement of fish habitat). The project's objectives can then be used to help prioritize projects for implementation.

4. **Prioritize Projects**

   The Project Prioritization Matrix can provide a systematic way to prioritize projects for implementation to ensure that the projects meet the watershed-wide goals and provide the most benefit to the community and the resource. Project prioritization using the matrix is completed by evaluating several metrics. Each project is given a numerical score that can be used to compare projects and develop a prioritized list for implementation. Metrics used in the prioritization process include the level of community and landowner support and the level of ecological and economical benefits of the project. Projects that address several watershed-wide goals will also be ranked higher.

SWOT ANALYSIS

A SWOT analysis is a strategic planning tool used to identify Strengths, Weaknesses, Opportunities, and Threats related to project planning. Strengths and weaknesses are internally-related while opportunities and threats are driven by outside influences and are more difficult to control.

- ***S****trengths*: characteristics of the project that give it an advantage
- ***W****eaknesses*: characteristics of the project that create disadvantage

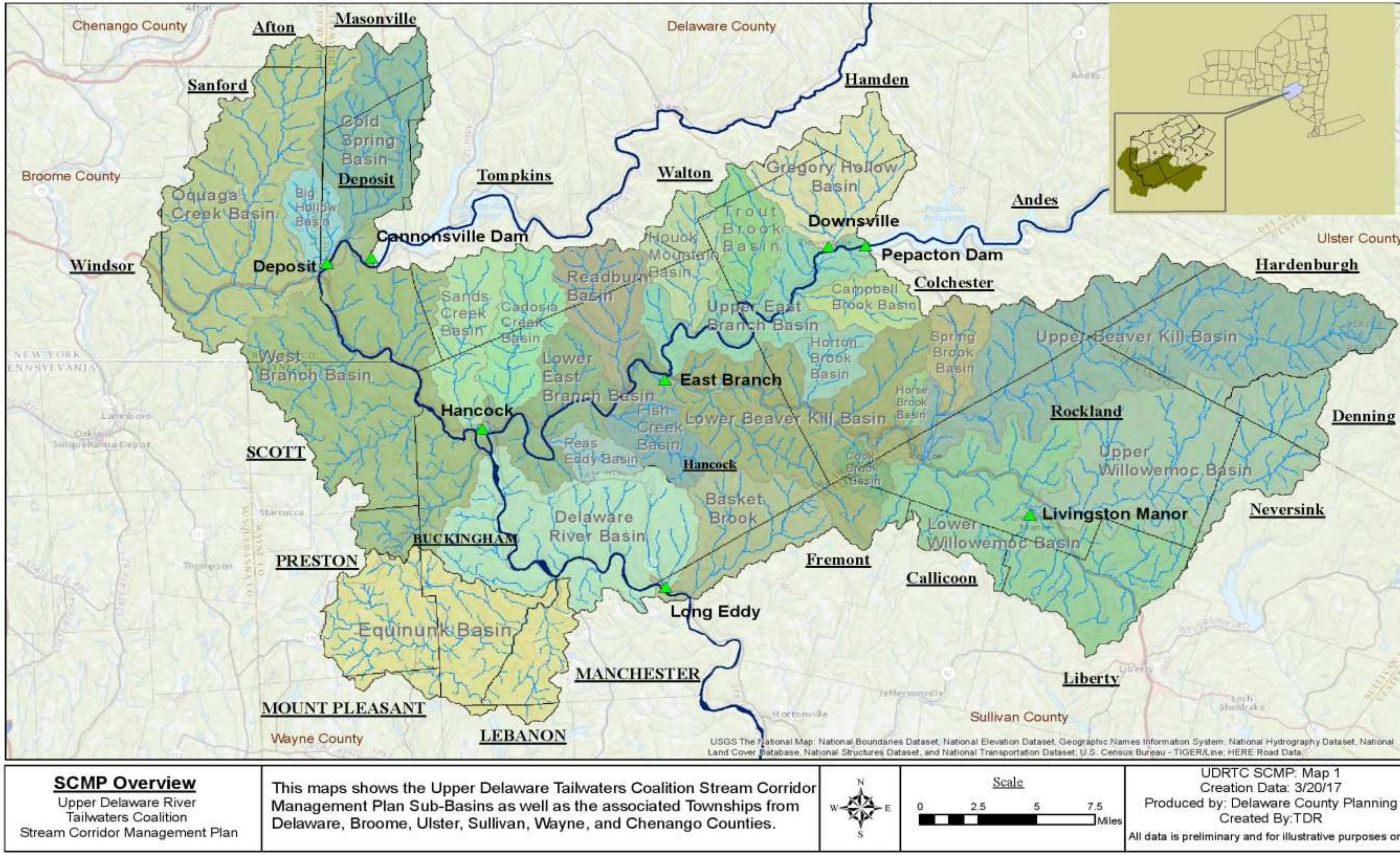
- ***O**pportunities*: elements that could be used to the advantage of the project
- ***T**hreats*: elements that could cause trouble for the project

Identification of SWOTs is important because they can inform later steps in planning to achieve the objectives. A basic SWOT analysis was conducted through the use of information gathered at local stakeholder meetings, PAC and CAC meetings along with data collected during field assessments.

V. Description of Project Location

The SCMP focuses on waterways in the UDR Tailwaters below the New York City (NYC) Delaware River basin reservoirs in Delaware County, NY and a small section of Broome County in the Oquaga Creek watershed. It primarily includes the Town and Village of Deposit, Town and Village of Hancock, Town of Colchester, and the Town of Sanford. It is recognized that the UDR Tailwaters watershed is much more expansive than the defined study area, traversing several other town and county lines as well as the state border into Northeast Pennsylvania. However, the larger watershed region will benefit from the findings in this document as the study is representative of the Tailwaters region.

Tailwater refers to waters located immediately downstream from a hydraulic structure, such as a dam, bridge or culvert. Tailwater fisheries are often defined as Tailrace fishing which occurs at the outflow of large dams, where the size of the reservoir creates a steep temperature gradient, with colder water stored at the bottom of the reservoir near the outlet.



Map 1: Project Area Map

VI. Watershed Overview

The assessment process used to develop a broad watershed overview of the UDR Tailwaters was developed by project leaders and a wide variety of watershed partners. These leaders collaborated to generate extensive localized information on existing stream management programs, public infrastructure, stream conditions, areas of vulnerability, flooding impacts, geologic characteristics, historic and modern land uses, water quality, and resource management recommendations and approaches.

This information was supplemented by the expertise of various members of the SCMP Project Advisory Committee (PAC) and the town and village based Citizen Advisory Groups (CAG). The Delaware County Planning Department provided Geographic Information System data and mapping in the Upper Delaware River Watershed that generated significant localized information on waterway characteristics and project needs.

1. Data Gaps

The UDR Tailwaters Watershed spans portions of both Pennsylvania (PA) and New York (NY). As a result, the watershed is managed by two state agencies, six counties and 24 townships. Data collection in the multi-jurisdictional watershed presents challenges in data availability and consistency. The Delaware County Planning Department attempted to gather the appropriate data from all management entities in the watershed for the watershed characterization portion of the management plan. In some cases, the requested data did not exist. For example, Pennsylvania does not have a data layer for dam resources that was available and consistent with the dam data layer for New York. Water quality classification also differs between the two states. For the purposes of the watershed characterization, the map legend provides detail on the data layer used when developing the map.

2. UDR Tailwaters Demographic/Economic Profile

An evaluation of the US Census data shows Delaware County is the fourth largest of 62 counties in New York State with an area of 1,442 square miles and the fifth most rural by population, estimated to be 46,480 residents in 2016. That makes for 33 people per square mile, far less than the 411 people per square mile in New York State and 88 people per square mile in the United States.

The U.S. Census Bureau reports that there are 31,158 housing units with only 18,817 occupied annually. The remaining 12,341 vacant housing units make up nearly 40% of the county housing stock and represent the large second-home and vacation home population that visits the region. Significantly, the amount of seasonal housing as a percentage of total housing stock is much higher in Delaware County, and still higher in the study area, than either Broome County or New York State (NYS) as a whole (see Table 1).

The median household income reported in 2016 was $46,055 with a mean income of $58,038. This is significantly lower than both the New York State and National median incomes reported as $60,741 and $55,322 respectively. It was also reported that 21,668 residents over the age of 16 were part of the local labor force with 19,876 listed as employed and 1,792 reported as unemployed. That makes an unemployment rate of 4.6%.

The largest employers are listed as educational services and health care/social assistance jobs with 27.3% of the workforce in these fields. Manufacturing and retail jobs follow with 13.5% and 10.6% respectively. Agriculture, forestry, mining, fishing and hunting make up 4% of jobs for the local workforce.

Table 1: Area Population and Housing Characteristics, 2009-2016

Area Population and Housing Characteristics, 2009-2016								
Characteristic	New York State	Broome County	Delaware County	Town of Colchester	Town of Deposit	Town of Hancock	Town of Sanford	Area Total
Population 2000	18,976,457	200,536	48,055	2,042	1,687	3,449	2,477	**9,655**
Population 2010	19,378,602	200,600	47,980	2,077	1,712	3,282	2,407	**9,478**
Population Estimate 2016	19,697,457	197,381	46,480	1,990	1,696	3,126	2,376	**9,188**
2010-2016 Change	**318,855**	**-3,219**	**-1,500**	**-87**	**-16**	**-156**	**-31**	**-290**
% Change	**1.6%**	**-1.6%**	**-3.1%**	**-4.2%**	**-0.9%**	**-4.8%**	**-1.3%**	**-3.1%**
Total Housing Units - 2000	7,679,307	88,817	28,952	1,587	1,048	2,512	15,454	**20,601**
Occupied	7,056,860	80,749	19,270	837	700	1,390	983	**3,910**
Vacant	622,447	8,068	9,682	750	348	1,122	562	**2,782**
Seasonal	235,043	1,272	7,700	635	271	965	455	**2,326**
% Seasonal	**3.1%**	**1.4%**	**26.6%**	**40.0%**	**25.9%**	**38.4%**	**2.9%**	**11.3%**
Total Housing Units - 2010	8,108,103	90,563	31,222	1,822	1,131	2,743	1,739	**7,435**
Occupied	7,317,755	82,167	19,898	900	709	1,350	970	**3,929**
Vacant	790,348	8,396	11,324	922	422	1,393	769	**3,506**
Seasonal	289,301	1,843	9,276	820	353	1,192	635	**3,000**
% Seasonal	**3.6%**	**2.0%**	**29.7%**	**45.0%**	**31.2%**	**43.5%**	**36.5%**	**40.3%**
Total Housing Units - 2016	8,191,568	89,919	31,158	1,831	1,111	2,751	1,802	**7,495**
Occupied	7,266,187	78,738	18,817	864	697	1,251	1,012	**3,824**
Vacant	925,381	11,181	12,341	967	414	1,500	790	**3,671**
Seasonal	330,297	1,969	10,217	918	388	1,326	652	**3,284**
% Seasonal	**4.0%**	**2.2%**	**32.8%**	**50.1%**	**34.9%**	**48.2%**	**36.2%**	**43.8%**

Historic census records show in 1800 there were 10,000 people in Delaware County. By 1860, there were 40,000 county residents and since then the population has only grown by about 6,000. According to the U.S. Census Bureau, the county population in 1990 was 47,225 and 47,523 in 2010. In 2016, the population had declined by more than 5% while New York State's population increased by nearly 2% and the overall national population increased by just under 5%.

This comparison to historical, state, and national data further supports local concerns regarding job loss and employment opportunities as well as the fact the aging population will require medical and social assistance while younger community members are forced to leave the region for employment opportunities. The emerging economic opportunities surrounding the recreational and tourism based jobs in the UDR tailwaters could provide needed options for the younger population desiring to stay in the region.

In Broome County, NY, the SCMP addresses the Oquaga Creek watershed which drains to the West Branch of the Upper Delaware River in the Village of Deposit below the Cannonsville Reservoir. This portion of Broome County is largely rural consisting of small agricultural operations and small service oriented businesses and is similar in demographic characteristics to Delaware County communities.

Economic activities in Delaware and Broome counties in the SCMP project area are in stark contrast to the rest of Delaware County with more natural resource based employers and an active agricultural community. There are fewer retail and manufacturing jobs, while education and health care services are the primary employers.

Table 2 below reflects the difference of employment opportunities in this region versus the rest of Delaware and Broome Counties as well as New York State.

Table 2: Study Area Population Employment by Industry, 2016

Study Area Population Employment by Industry, 2016								
Characteristic	New York State	Broome County	Delaware County	Town of Colchester	Town of Deposit	Town of Hancock	Town of Sanford	Area Total
Agriculture, forestry & mining	0.6%	0.8%	4.0%	1.7%	6.4%	7.2%	5.8%	**5.4%**
Construction	5.6%	5.4%	8.0%	7.6%	6.7%	5.4%	9.6%	**7.2%**
Manufacturing	6.3%	10.2%	13.5%	8.4%	12.3%	14.9%	10.4%	**11.8%**
Wholesale trade	2.5%	3.0%	1.8%	1.6%	5.1%	0.4%	1.7%	**1.7%**
Retail trade	10.7%	12.4%	10.6%	10.4%	10.3%	8.1%	6.3%	**8.6%**
Transp./distribution & utilities	5.1%	4.2%	3.7%	5.3%	8.3%	3.8%	5.7%	**5.4%**
Information	2.9%	1.6%	1.5%	2.1%	4.9%	0.9%	2.2%	**2.2%**
Finance, insurance & real estate	8.1%	4.3%	3.9%	4.7%	2.0%	2.5%	2.9%	**3.0%**
Professional, scientific & mgt.	11.6%	8.8%	6.9%	2.5%	8.0%	7.0%	13.4%	**7.5%**
Education, health care & social	27.4%	30.3%	27.3%	32.7%	21.9%	22.4%	25.6%	**25.6%**
Arts, entertainment & recreation	9.6%	9.4%	9.1%	6.6%	9.2%	18.6%	5.5%	**11.0%**
Other services	5.0%	5.3%	4.5%	6.0%	3.5%	5.1%	5.6%	**5.2%**
Public administration	4.6%	4.2%	5.1%	10.5%	1.5%	3.8%	5.3%	**5.4%**

Many of the manufacturing jobs in this region are directly related to the natural resource industries, offering jobs for many in processing resources for wood and stone products. This is evidenced by the primary employers of the region as shown below:

a. **Natural Resource Based Industry**: An abundance of unique raw materials support several different natural resource-based industries in the region including bluestone and other mining, logging, and wood products. The natural resource industries have long since been the largest economic driver of the region. The Village of Deposit got its name because logs were floated down the Delaware and "Deposited" to be made ready for transport to points further south at Deposit.

Hancock is famous for being the home of the Louisville Slugger baseball bat factory. The blanks for wooden bats were milled in Hancock and it employed a large number of people in the industry for many years. These traditional manufacturing jobs based around natural materials such as wood and stone continue with industries like New England Wood Pellets, Beaver Mountain Homes, Johnston and Rhodes Bluestone, and Schafer Enterprises.

b. **Agriculture:** Small farming operations, primarily dairy facilities, continue to exist in Delaware and Broome counties. Their long-term viability is threatened by the challenging economic conditions facing farmers in the region including low commodity prices, employment laws, available work force, and competition within the industry.

A shift in agricultural practices along with an abundance of low lying river flats has shown an emergence of crop farming, beef cattle operations and new crop ventures including hops, hemp and tree farming. These sustainable farming operations will continue to utilize vast acreage of growing fields to provide for the growing market in New York City, easily accessible to the Upper Delaware Region.

c. **Retail:** Dozens of small retail operations, often selling locally grown products dot the landscape of Delaware and Broome Counties and help supplement the income of local residents who often must rely on multiple entrepreneurial endeavors to provide for their families. The Village Main Streets help support these small businesses and provide for a quaint friendly space for visitors to the area.

d. **Tourism:** The census data supports local observations that tourism activities like fishing, boating, hiking, camping, and second home investments are emerging as an important element of the growing recreational economy of the region. A 2014 Economic Study of the value of the Upper Delaware River to local economies estimates a $400 million annual value to people and communities of this region.[1]

[1] Shepstone, T. (2014) Upper Delaware River Cold Water Fishing and Boating Economic Impact Study

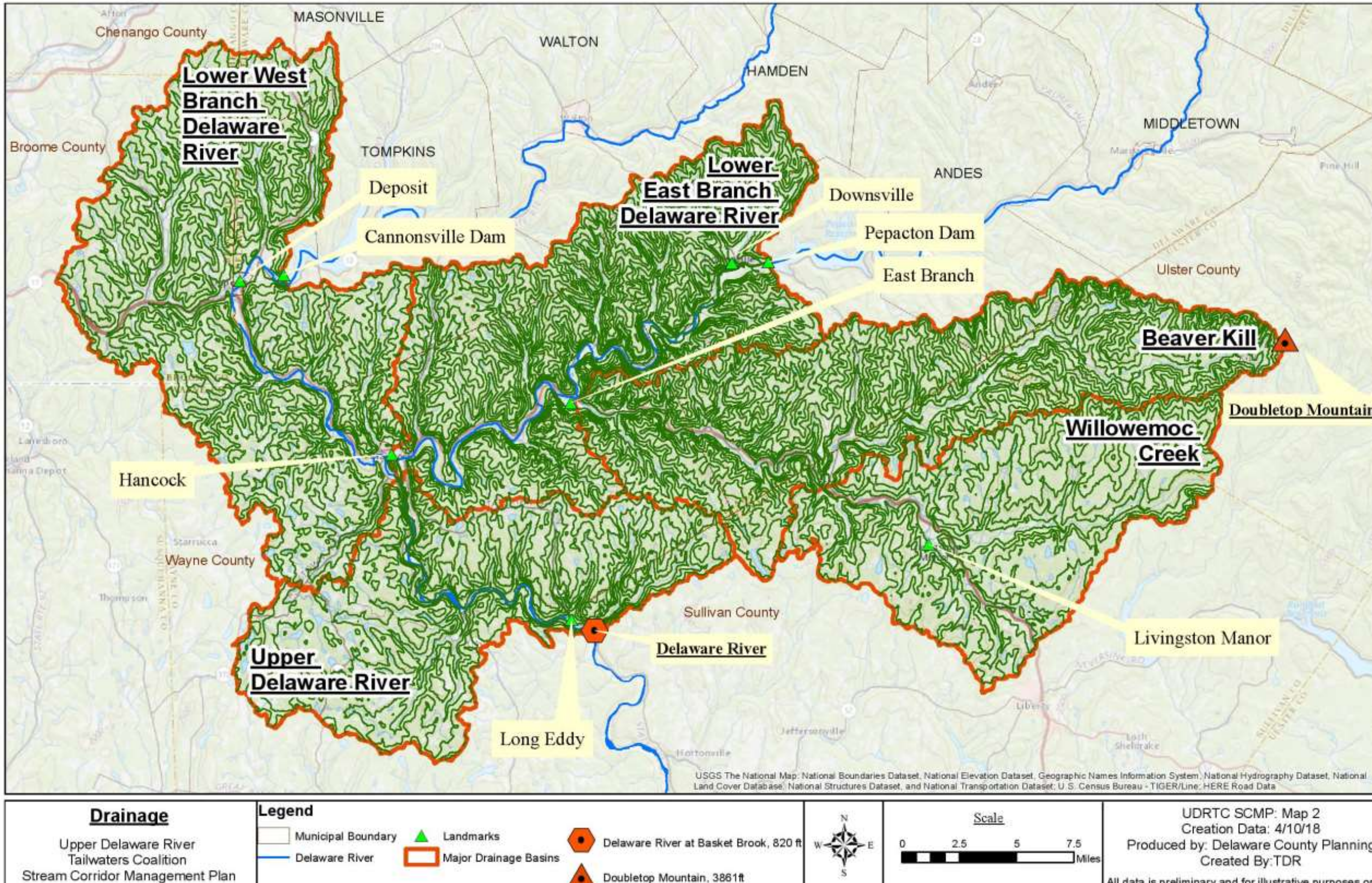
3. Physiography and Drainage

The Tailwaters is located in the northern portion of the Appalachian Plateau consisting of a glaciated ridge and valley system. For the purposes of this study the UDR Tailwaters Watershed is defined as the drainage area beginning below the Pepacton and Cannonsville Dams, going downstream as far as the confluence of Basket Brook, just south of Long Eddy in Sullivan County, NY. The Upper Delaware River Tailwaters Coalition (UDRTC) established the downstream limit of the study area at Long Eddy (See Map 2).

The Tailwaters watershed area is 816 square miles with roughly 85 percent (691 square miles) of the watershed lying within five counties in the State of New York (Delaware, Broome, Sullivan, Ulster, and Chenango Counties) with the remaining portion of the watershed located in Wayne County, PA as seen in Map 1 “SCMP Overview”. The watershed drains approximately 1,267 miles of stream; 1,032 miles or 81% in NY, and the rest in PA. The watershed boundary extends into portions of 24 townships and is composed of 26 sub-basins.

The highest point in the watershed is 3,861 ft. on Doubletop Mountain in Ulster County, NY, the Long Eddy location being the low point at 820 ft. This drainage area is unique because the reservoirs release notably cold water from the bottom of the reservoirs. The East Branch then converges with the warmer waters of the Beaverkill before merging with the West Branch in Hancock.

The sub-basins were delineated using a modified Vermont Agency of Natural Resources Watershed Assessment Methodology coupled with input from locally knowledgeable community members familiar with variations in the sub-basins. Due to the smaller size of sub-basins, it is likely that the physical and biological elements within the sub-basin are similar which allows for sub-basin specific assessments and recommendations. This also allows for smaller and more manageable implementation projects that can be focused on to mitigate potential problems, providing a basis for identification of funding sources.



Map 2: Drainage Area

4. Climate

The climate of this region is very similar to most of New York and is classified as Humid Continental. The UDR Tailwaters region generally experiences seasonable weather patterns characteristic of the northeastern United States. The average summer temperature, as recorded by the National Oceanic and Atmospheric Administration (NOAA) Climate Center is 66.3 degrees Fahrenheit with an average high temperature of 78.6 degrees Fahrenheit. Average winter temperature is 25.3 degrees Fahrenheit with an average maximum temperature of 34.9 degrees Fahrenheit. Table 3 reflects the 1981-2010 Climate Normals which are the National Climate Data Center's latest three-decade averages of climatological variables, including temperature and precipitation. Based on the average annual precipitation for this region at the Downsville Dam the 1971-2000 average was 43.89 inches of precipitation which has increased to 47.03 inches annually as per the 1981 to 2010 averages. This steady increase in the annual total precipitation is further exhibited in the data below (see Table 3).

Table 3: Climatological Variable Averages at Downsville Dam

DOWNSVILLE DAM, NY US – NCDCs 1981-2010 Averages				
Season	**Precip. (in.)**	**Min. Temp. (F)**	**Avg. Temp. (F)**	**Max. Temp. (F)**
Annual	47.03	35.1	46.3	57.5
Winter	8.88	15.8	25.3	34.9
Summer	13.62	54	66.3	78.6
Spring	12	32.6	44.1	55.7
Autumn	12.53	37.8	49.1	60.4

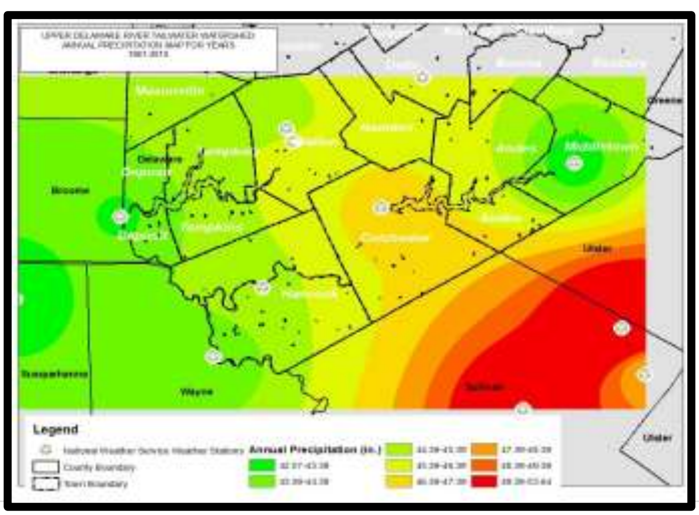
There is agreement among a growing number of climatological models that winter and summer temperatures will continue to trend upward. This shows that recent weather patterns of more sporadic rainfall will lead to more frequent short (one to three months) seasonal droughts broken by large intense rainfalls. This type of deviation coupled with the fact that the flows in the Delaware river are controlled through the dams will continue to have a profound impact on the streams and tributaries in the Tailwaters region. The controlled releases may not allow the river to react to the natural rain occurrences the same way the streams and tributaries do. This can cause degradation and instability in the streams, causing erosion and sedimentation to carry down to the Upper Delaware River.

There is a high level of certainty that these climate deviations will change the way our river valleys look. The continued accelerated sedimentation in the entire Upper Delaware River system could present multiple problems. The longer periods of drier weather may contribute to the rapid morphology of the streams lowering the water levels and exposing the stream bottoms more frequently and for longer periods of time. The result of this change could continue to create warmer water conditions and provide for the colonization of new plant species typically seen today in southern warmer climates.

5. Precipitation

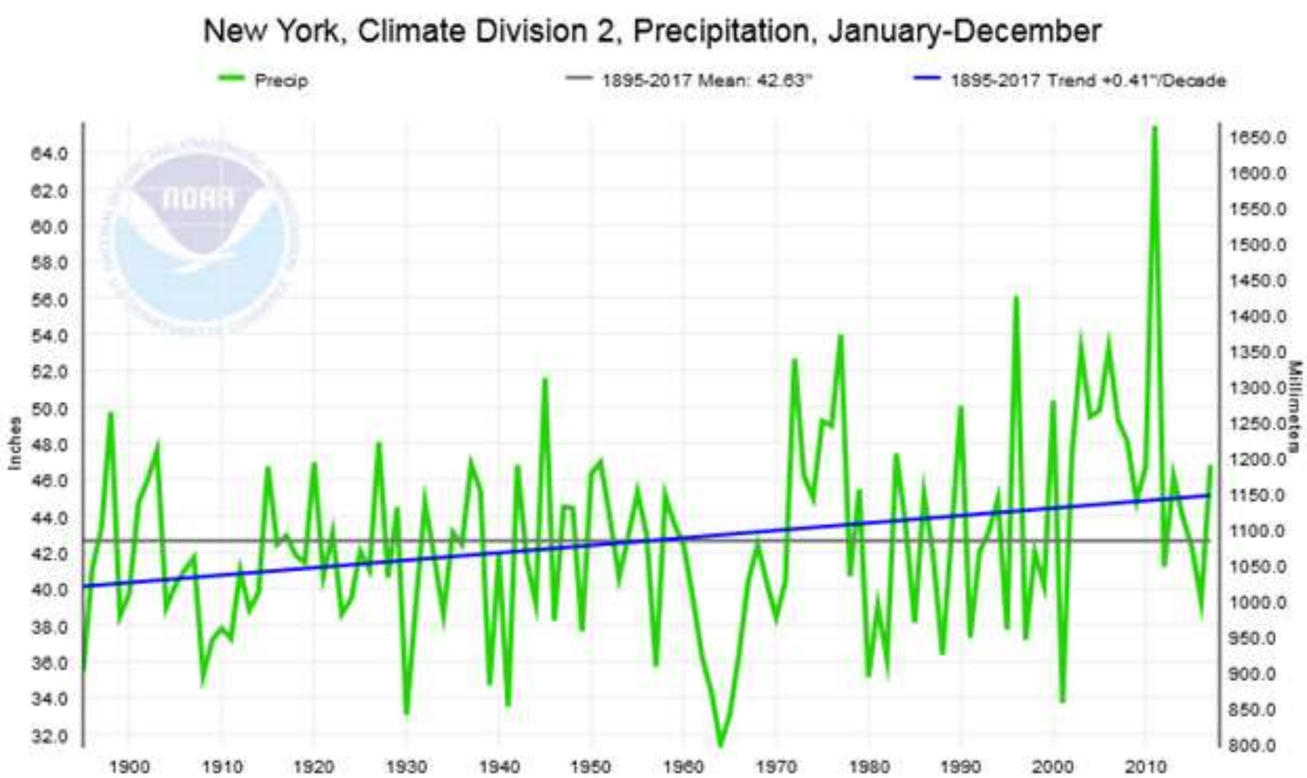
Precipitation is evenly distributed through the year with eastward-moving cold fronts bringing the area’s most frequent rain showers. Tropical storms will typically move north from the warmer southern coastline and are responsible for larger storms with more rain. Differences in latitude and topography all have an effect on the climate across the UDR Tailwaters. Figure 1, below, shows that the highest average annual rainfall (from 1981 to 2010) occurs on the southeastern part of the watershed. Moisture rich air moving in from the west runs into the Catskill Mountains, which act as a barrier. As the air moves up and over this mountain range, the air slows and cools forming raindrops leading to more rain falling over a shorter distance.

Figure 1: UDR Annual Precipitation Map for Years 1981-2010



The Tailwaters has an average of 39.5 inches of rainfall each year. This average is based on 106 years of rainfall data. The trend over the last century is an increase in the amount of rain since records were first being kept. For example, in the early 20th century, the average annual rainfall was between 36 inches and 38 inches compared to the early 21st century the average annual rainfall is between 42 inches and 43 inches (see Figure 2).

Figure 2: Annual Precipitation Trends in the UDR Tailwaters Region Between 1895-2017[2]



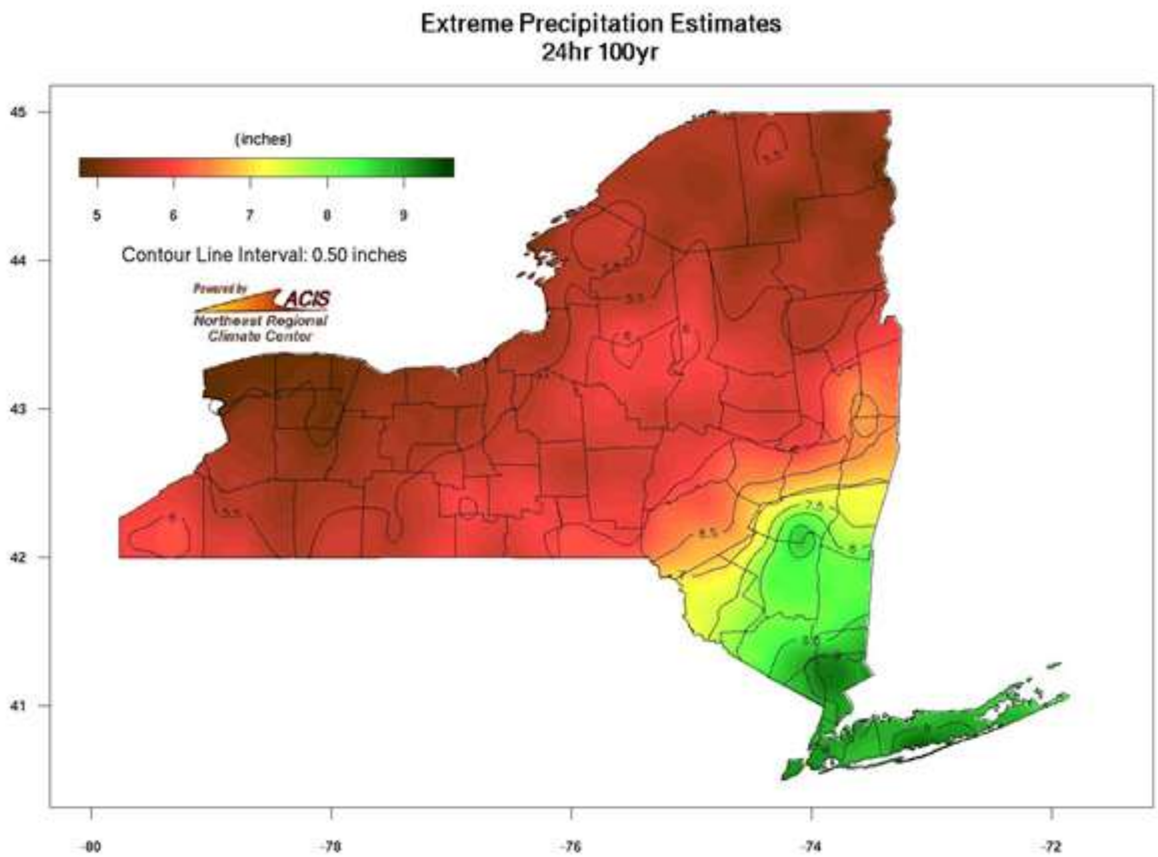
The types of rainstorms the UDR Tailwaters watershed experiences has also changed over the last several decades. The average number of rainstorms that produce two or more inches of rain has increased in the last two decades and it is anticipated that average annual rainfall amounts will increase by as much as 2.5" by the year 2060 (a

[2] National Oceanic and Atmospheric Administration (NOAA). (2017). *Climate at a Glance*. Available at: https://www.ncdc.noaa.gov/cag/regional/time-series [Accessed 23 Mar. 2018]

5% increase)[3] with higher percentages of the annual rainfall falling during intense storms between short seasonal droughts (see Figure 3). This trend of more frequent and intense rainfall events (greater than 2 inches) is predicted to continue.

A continuation of current trends could also lead to changes in streams and rivers whose physical shape is maintained by a balance between the amount of water flowing through them and the surrounding landscape. Many UDR Tailwaters streams and their watersheds, which have been disturbed by human activities (logging, dams, etc.) over the last 100 years, will experience notable damage during an intense rainfall event. The time required for a stream to find a new equilibrium is much longer, and the window between damaging rainfall events has shortened. The streambanks erode, sending trees and gravels downstream, reducing water quality and increasing flood debris risks.

Figure 3: Extreme Precipitation Estimates for a 24 hour 100 year Return Interval



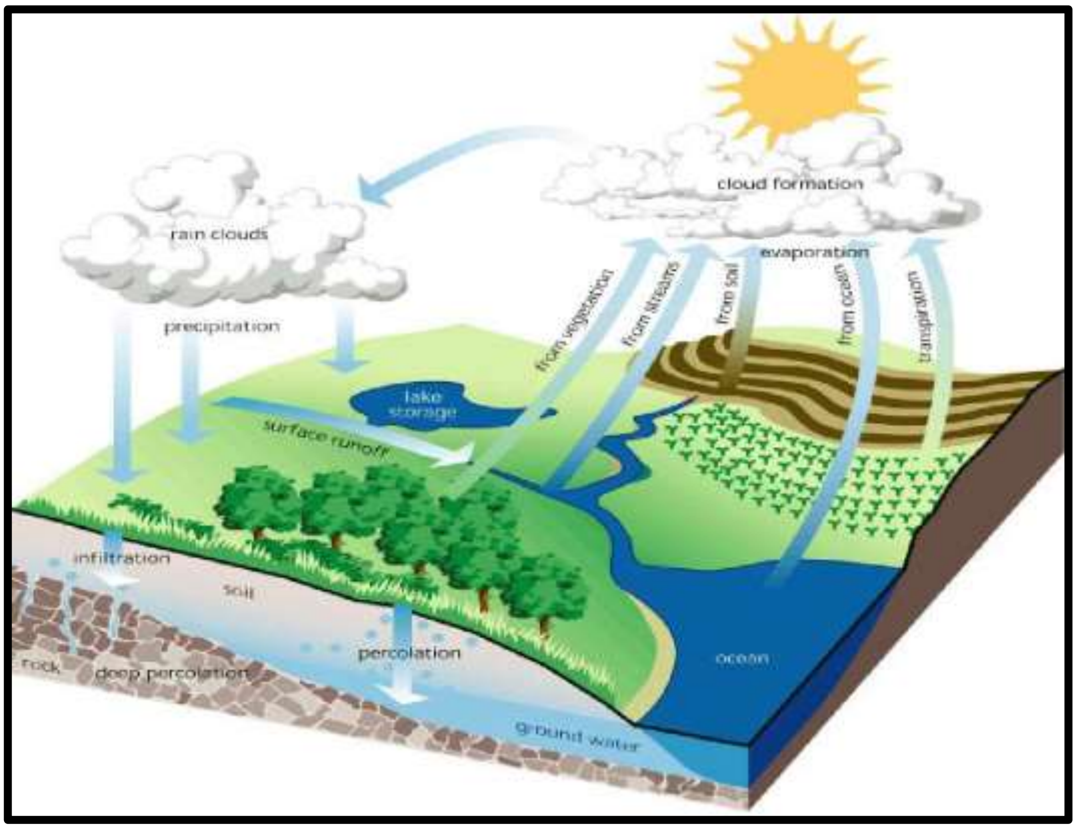
Storm Event; Data through 2012[4]

[3] Northeast Regional Climate Center, 2017, http://www.nrcc.cornell.edu/

6. Hydrology

Hydrology, in its most general description, is the study of the occurrence and movement of water on, over, and through the Earth's surface. The hydrologic cycle shown in Figure 4 shows the general factors of precipitation, infiltration, runoff and evapotranspiration that drive the movement of water in a watershed. The characteristics of watershed size, topography, regional climate, geology, soils, and vegetation specifically dictate the quantity and rate of water movement from the hillsides to the stream in the valley's lowest point. These characteristics, in turn, also control flood peaks, water quality, stream channel dimensions, and the stream's ability to transport sediment.

Figure 4: The Hydrologic Cycle (FISRWG, 1998)[5]



A factor that distinguishes the UDR Watershed hydrology from natural Catskill watersheds is the regulation of stream flow by the Cannonsville and Pepacton Dams. An agreement known as the Flexible Flow Management Program (FFMP) currently

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[4] Northeast Regional Climate Center (NRCC). (2012). Extreme Precipitation in New York & New England. *Extreme Precipitation Estimates.* Available at: http://precip.eas.cornell.edu/ [Accessed 23 Mar. 2018]
[5] Federal Interagency Stream Restoration Working Group. 1998. 2.A Hydrologic and Hydraulic Processes. *Stream Corridor Restoration* pp. 2-3.

regulates releases from these dams to meet New York City's water supply needs, protect tailwater fisheries, mitigate flooding, and repel the movement of salt water up the Delaware River (DRM, 2017)[6]. New York City's Operation Support Tool (OST) monitors water levels, and models future needs and inflows to determine daily tailwater releases from the dams. The result of this determination is a stream system driven more by human management than natural hydrological processes. As the rivers grow in distance from the dams, the influence of the tailwater releases give way to natural hydrological processes with growing input from natural watershed throughflow, groundwater discharge, and tributary inflow.

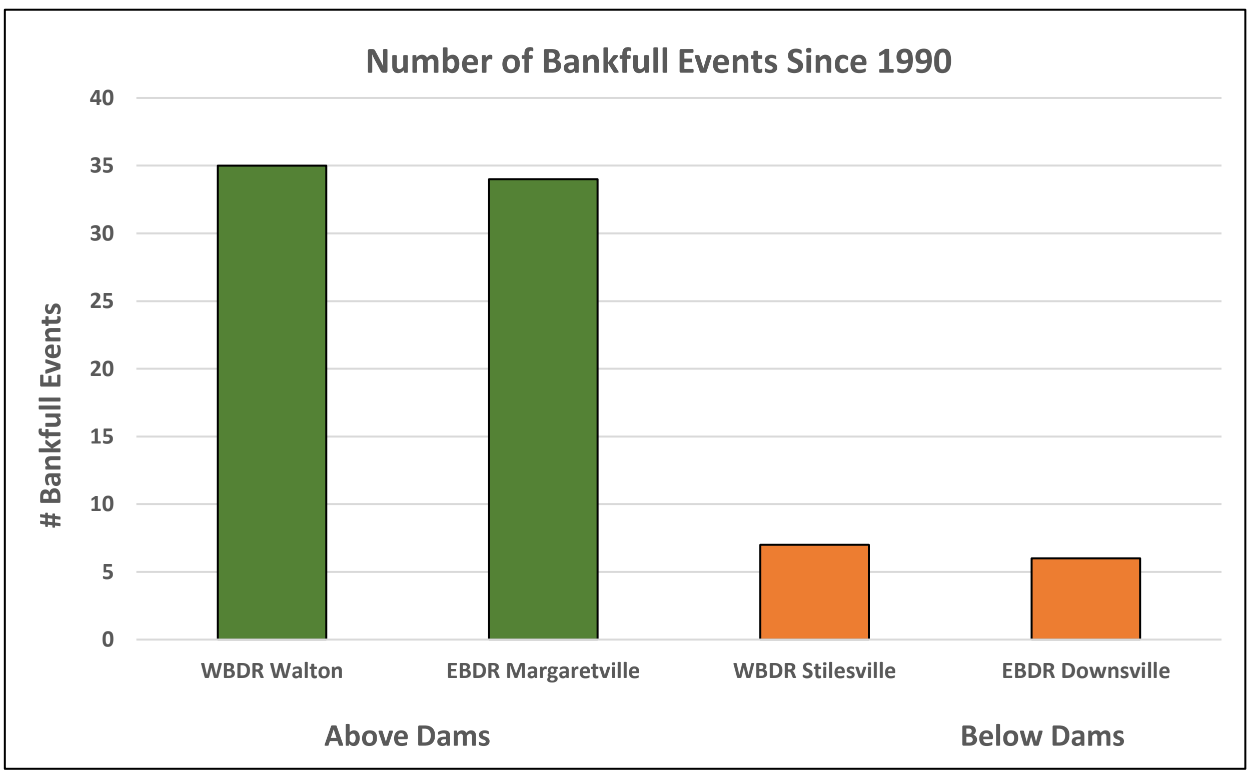
The concept of "bankfull" flow is essential to understanding the link between watershed hydrology, the dimensions of stream channels, and the ability of a stream to transport sediment. Bankfull flow can be defined as the flow responsible for shaping the dimensions of a stream channel due to the frequent recurrence of this flow and the ability of this flow to move sediment. This flow has enough stream power to move sediment and happens often enough that it is the flow responsible for moving the most sediment in a stream over time[7]. In most settings, where a stream is healthy and a floodplain is accessible, the bankfull flow corresponds to the stage and incipient elevation on the bank where flooding begins.[8] Regional regression relationships developed by the United States Geological Survey (USGS) make it possible to accurately predict bankfull flow based on location and watershed size.[9] Therefore, regional regression relationships also make it possible to determine what bankfull flow should be in an altered, dam regulated, system. Prior to dam regulation, bankfull flow at the outlet of the Cannonsville Reservoir was estimated to be 8620 cfs while bankfull flow at the outlet of the Pepacton Reservoir was estimated to be 9880 cfs.[10] At current time the outlet structures of the Cannonsville and Pepacton Reservoirs only allow for discharges of 1130 cfs and 270 cfs, respectively.[11] Therefore, bankfull flows only occur in each tailwater river when the dams overtop.

A situation arises below the dams in which the non-regulated tributaries experience bankfull and higher flows, transporting sediment to the East Branch, West Branch, and Main Stem of the Delaware River. The receiving rivers are, likely, not at bankfull flow

[6] Delaware River Master. 2017. *Delaware River Basin States and New York City Announce Ten-Year Reservoir Operating Plan Agreement*. https://water.usgs.gov/osw/odrm/
[7] Knighton, D. 1998, *Fluvial forms and processes: a new perspective,* Arnold, London; New York.
[8] Rosgen, D. 1996, *Applied River Morphology*, Second Edition
[9] Mulvihill, C.I., Baldigo, B.P., Miller, S.J., DeKoskie, D. & DuBois, J. 2009, *Bankfull Discharge and Channel Characteristics of Streams in New York State*, U.S. Geological Survey, Reston,Virginia.
[10] United States Geological Survey. 2018. USGS Streamstats. *The Streamstats Program.* https://water.usgs.gov/osw/streamstats/
[11] New York City Department of Environmental Protection. 2009. *City of New York West of Hudson Hydroelectric Project* (pp. 13-19, Issue brief No. 13287-000).

due to their regulation by a dam structure. If the stream power in the receiving river is not able to transport the sediment from the tributary, the result is a build-up of sediment at the confluence and in the receiving river channel. The likelihood of this phenomenon is evidenced in Figure 5 where one can see the discontinuity in the number of bankfull events at the USGS stream gauge above the dam versus the number of bankfull events at the USGS stream gauge below the dam in the East Branch Delaware River (EBDR) and West Branch Delaware River (WBDR). Gauges at Walton and Margaretville are upstream of the dams, while Stilesville and Downsville gauges are downstream of the dams. These stream gauges indicate that bankfull flows were experienced 35 times at the WBDR Walton gauge and 34 times at the EBDR Margaretville gauge. In comparison, the below-dam WBDR Stilesville gauge experienced 7 bankfull flows while the below-dam EBDR Downsville gauge experienced only 6 bankfull flow events during the same period of record. This amounts to a 5 fold reduction in bankfull events below the dam in the West Branch Delaware River and a 5.67 fold reduction in bankfull events below the dam in the East Branch Delaware River. The lack of bankfull flows below the dams are due to the retention and dissipation of the upstream flows by the reservoir.

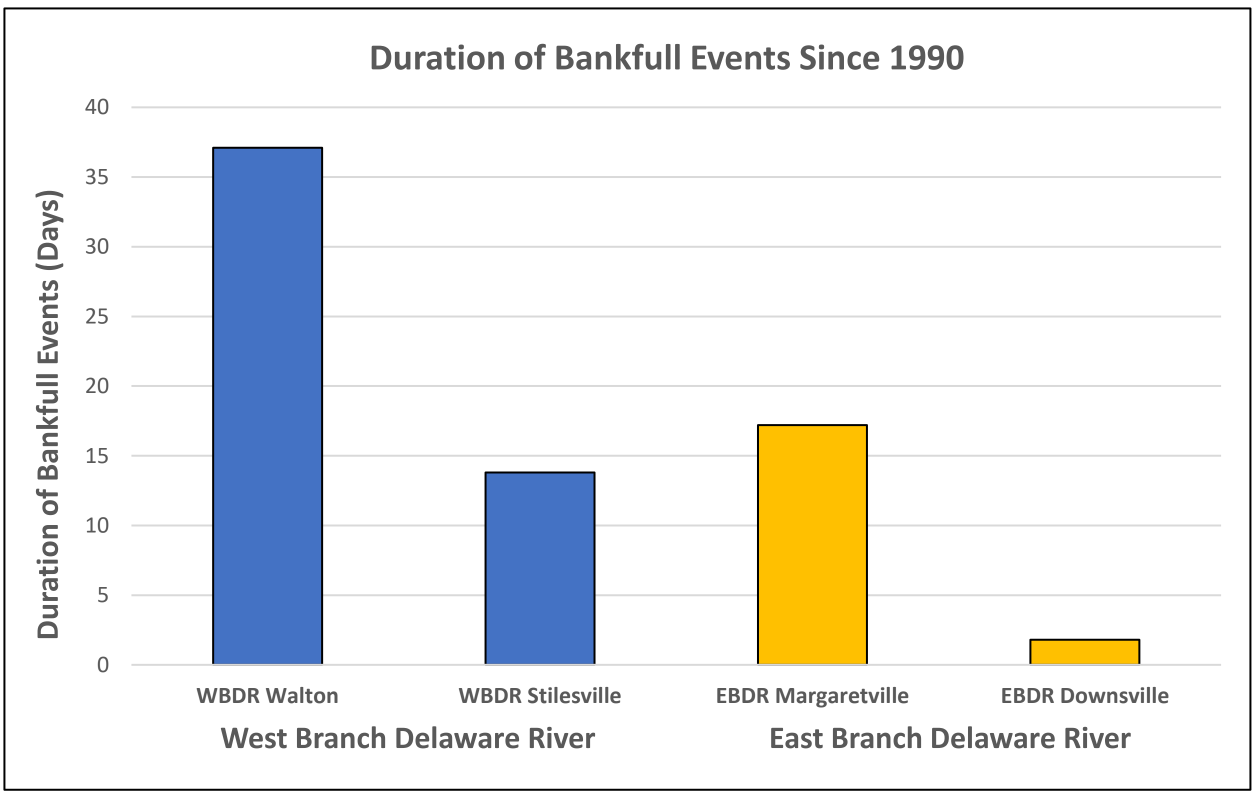
Figure 5: Comparison of the number of bankfull flows experienced at USGS gauges above (WBDR Walton an EBDR Margaretville) and below the dams (WBDR Stilesville and EBDR Downsville) in the East and West Branch Delaware Rivers.[12]



[12] United States Geological Survey. 2018. USGS WaterWatch. *Streamflow conditions.* http://waterwatch.usgs.gov

The duration of bankfull events is also important to consider in the estimation of a river's ability to transport sediment. The greater the duration of a bankfull event, the greater the amount of sediment transported. Figure 6 compares the duration of bankfull events at the WBDR Walton gauge (above dam) and WBDR gauge in Stilesville (below dam) and the duration of bankfull events at the EBDR Margaretville gauge (above dam) and EBDR gauge in Downsville (below dam). The duration of bankfull and greater flows above the dams at Walton and Margaretville are far greater than their counterparts below the dams at Stilesville and Downsville. The duration of bankfull and greater flows above the Cannonsville Dam is 2.69 times more than the duration experienced below the dam in the WBDR. The duration of bankfull and greater flows above the Pepacton Dam is 9.56 times more than the duration experienced below the dam in the EBDR. This, again, shows that the receiving rivers below the reservoirs are, likely, less capable of transporting sediment from their contributing, unregulated, tributaries.

Figure 6: Comparison of the duration of bankfull events at corresponding above dam (WBDR Walton an EBDR Margaretville) and below dam (WBDR Stilesville and EBDR Downsville) USGS gauges.[13]



[13] United States Geological Survey. 2018. USGS WaterWatch. *Streamflow conditions.* http://waterwatch.usgs.gov

In addition to the relation of flow to sediment transport, Figures 5 and 6 also show the benefit of regulated releases to communities below the dams. While sediment transport is hindered, the occurrence of floods is greatly reduced on the East and West Branch Delaware Rivers below the dams. As bankfull discharge is generally considered the incipient flow of flooding, any flow at or above this discharge indicates flooding. Thus, the number and duration of flood events are reduced 5 fold and 2.69 fold, respectively, below the dam in the West Branch and 5.67 fold and 9.56 fold, respectively, below the dam in the East Branch.

An informative measurement of stream and watershed hydrology is that of stream stage. The USGS has installed and currently maintains seven stream gauges in the Upper Delaware Tailwaters watershed (Table 4). Each stream gauge records the stage, or water height, of their stream/river at 15 minute intervals. Stage, along with measurements of channel dimension allow for the calculation of discharge in cubic feet per second. The collection of stream discharge data over time allows for the monitoring of stream flow trends and prediction of future flood severity. In fact, flow forecasts are currently offered by the National Weather Service's "Advanced Hydrologic Prediction Service" for gauges at Hale Eddy (01426500), Harvard (01417500), Fishs Eddy (01421000), and Cooks Falls (01420500). This information can be accessed at https://water.weather.gov/ahps/ .

Table 4: Stream gauges of the Upper Delaware River Tailwaters Watershed[14]

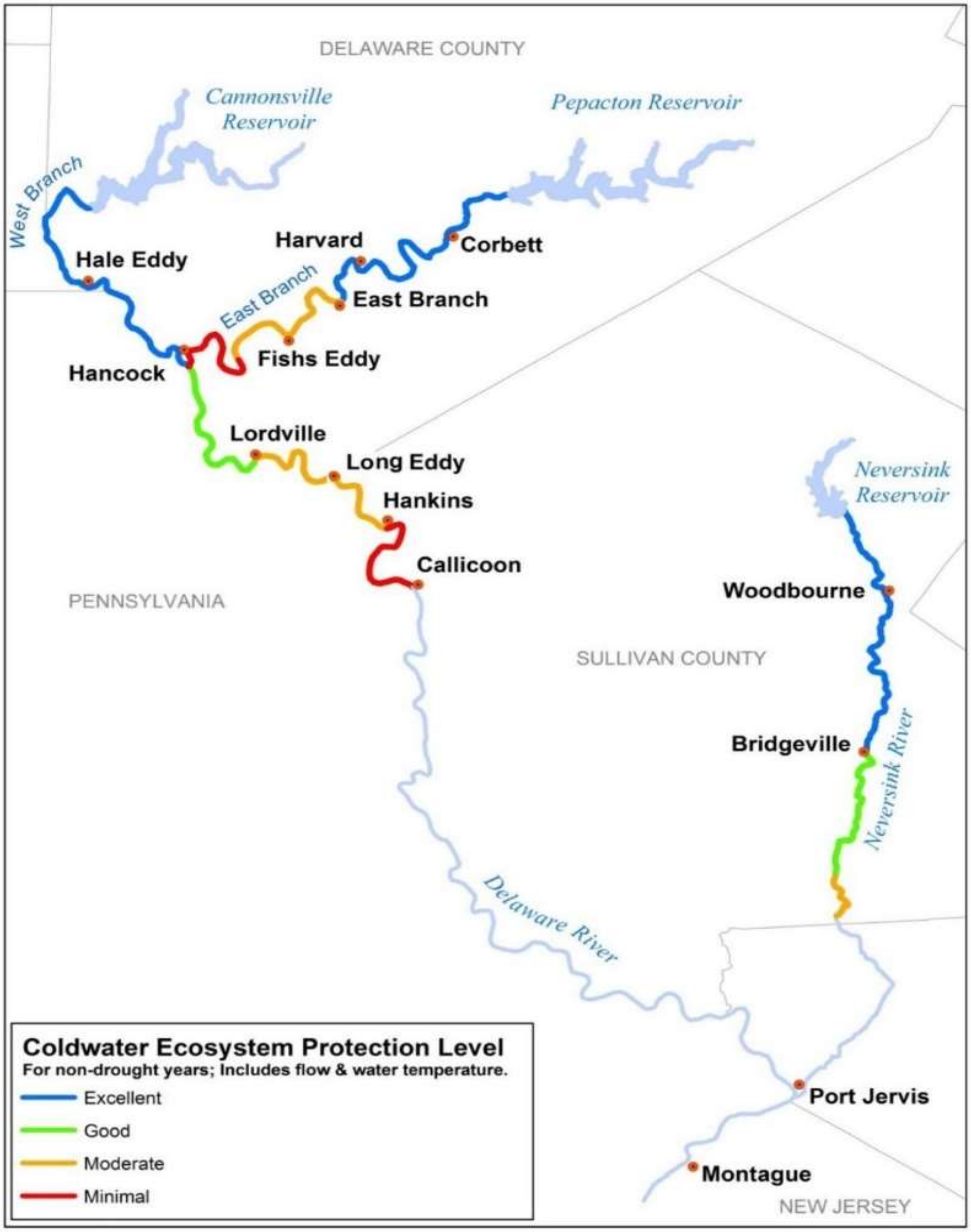
Station ID	Station Name	Drainage Area (mi^2)	Period of Record
01425000	West Branch Delaware River at Stilesville, NY	456	July 1952 to current year
01426500	West Branch Delaware River at Hale Eddy, NY	595	November 1912 to current year
01417000	East Branch Delaware River at Downsville, NY	372	July 1941 to current year
01417500	East Branch Delaware River at Harvard, NY	458	October 1934 to June 1967, November 1977 to current year
01421000	East Branch Delaware River at Fishs Eddy, NY	784	October 1912 to current year
01420500	Beaver Kill at Cooks Falls, NY	241	July 1913 to current year
01427207	Delaware River at Lordville, NY	1590	July 2006 to current year
01426000	Oquaga Creek at Deposit, NY	67.6	1941-1973, 1975-1976, 1979-2011, 2013-2014

7. Stream Temperatures in the UDR Tailwaters

The Tailwaters region of the Upper Delaware River has a distinction as a cold water fishery. This condition was created by the construction of the Pepacton dam in Downsville and the Cannonsville dam in Deposit for the purpose of expanding the New York City Water supply. The completion of these reservoirs in 1954 and 1964, respectively, changed not only the flow of water into the UDR tailwaters system below, but also the temperature of the water that flows into the system. The releases are made from the bottom of the reservoir, allowing the coldest waters to flow downstream. This dramatic temperature change altered the habitat for many native fish, bugs and plant species, making it more hospitable to those species that flourish in colder temperatures. The trout population was one of the biggest beneficiaries of this change, and now this very region is one of the most acclaimed fly fishing areas in the country. This region has varying levels of protections for the fishery based on the availability of cold water in the reservoirs, as illustrated in Figure 7.

[14] Stream gauges of the Upper Delaware River Tailwaters watershed ($USGS_2$, 2018).

Figure 7: **Coldwater Ecosystem Protection Level**[15]



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15 https://water.usgs.gov/osw/odrm/ffmp/FFMP_White_Paper_Version_Final_1_12_10.pdf, (as modified to add Long Eddy) page 12

The Upper Delaware, traditionally known for its recreational and scenic attractions, has seen an ever increasing number of visitors coming to the area to fish in this unique ecosystem. Anglers who visit the area appreciate the rare cold water fishery, as they are limited in the United States, and are willing to travel from all over the world for a chance to fish the Delaware waters. In addition, several native species of Bass, Shad, Walleye and Black Eel are commonly fished in and around the Delaware River.

Many of the visitors that come for weekend or week long vacations ultimately invest in the purchase of a second home in the area. This is supported by the census data which shows a 20% increase in seasonal homes in the region since the year 2000.

The regulation of water releases from the NYC Delaware River reservoirs may present a benefit for the mitigation of localized flooding and conservation of wild trout habitat and the cold water ecosystem. The consistent release of cold water from the bottom of the Cannonsville and Pepacton Reservoirs has created an ideal environment for wild trout, particularly in the upper reaches of the system near the dams. During the warmest and driest days of summer, water can be released that keeps these sections cold. Figures 8 and 9 show stream temperatures between 2007 and 2017 in the upper reaches of the East Branch Delaware River and West Branch Delaware River, respectively. One can see that these temperatures rarely exceed 70 degrees Fahrenheit which, combined with prolific insect populations, creates ideal conditions for the wild trout that inhabit the upper reaches of the cold water ecosystem. Many conservation organizations are working with the NYCDEP and the 1954 Supreme Court Decree Parties to expand healthy wild trout habitat in the lower sections of the tailwaters through cold water releases that are more consistent and timely.

Figure 8: Temperature of the West Branch Delaware River at Stilesville, NY between water years 2007 & 2017[16]

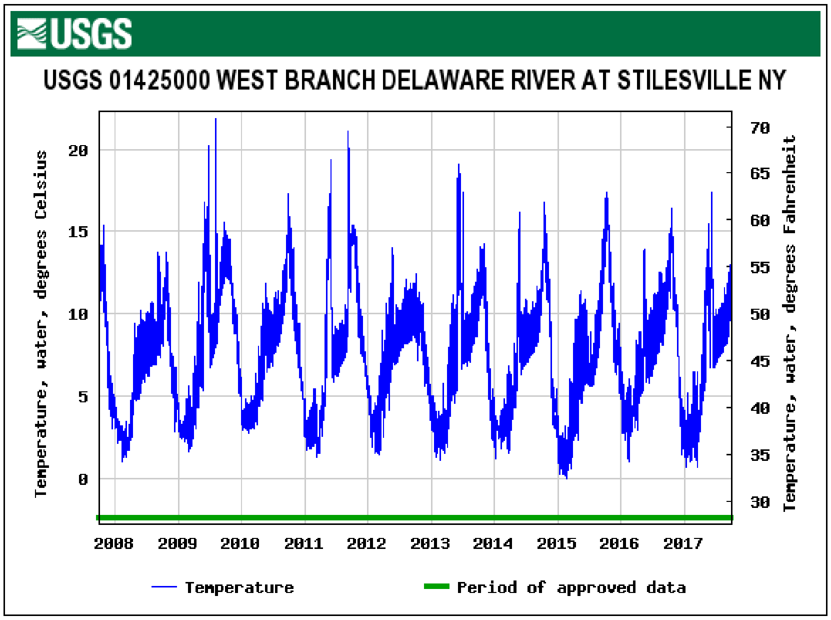
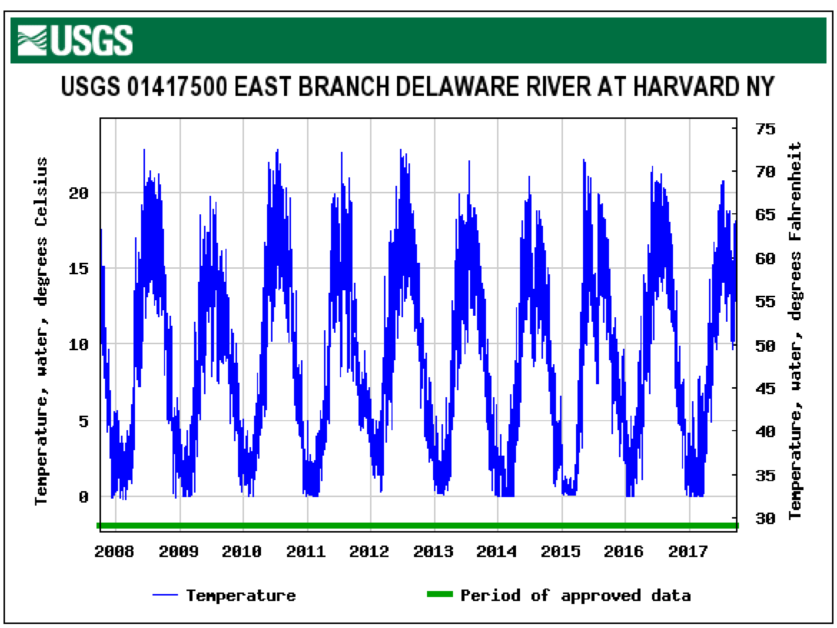


Figure 9: Temperature of the East Branch Delaware River at Harvard, NY between water years 2007 & 2017[17]



[16] United States Geological Survey. 2018. USGS WaterWatch. Streamflow conditions. http://waterwatch.usgs.gov

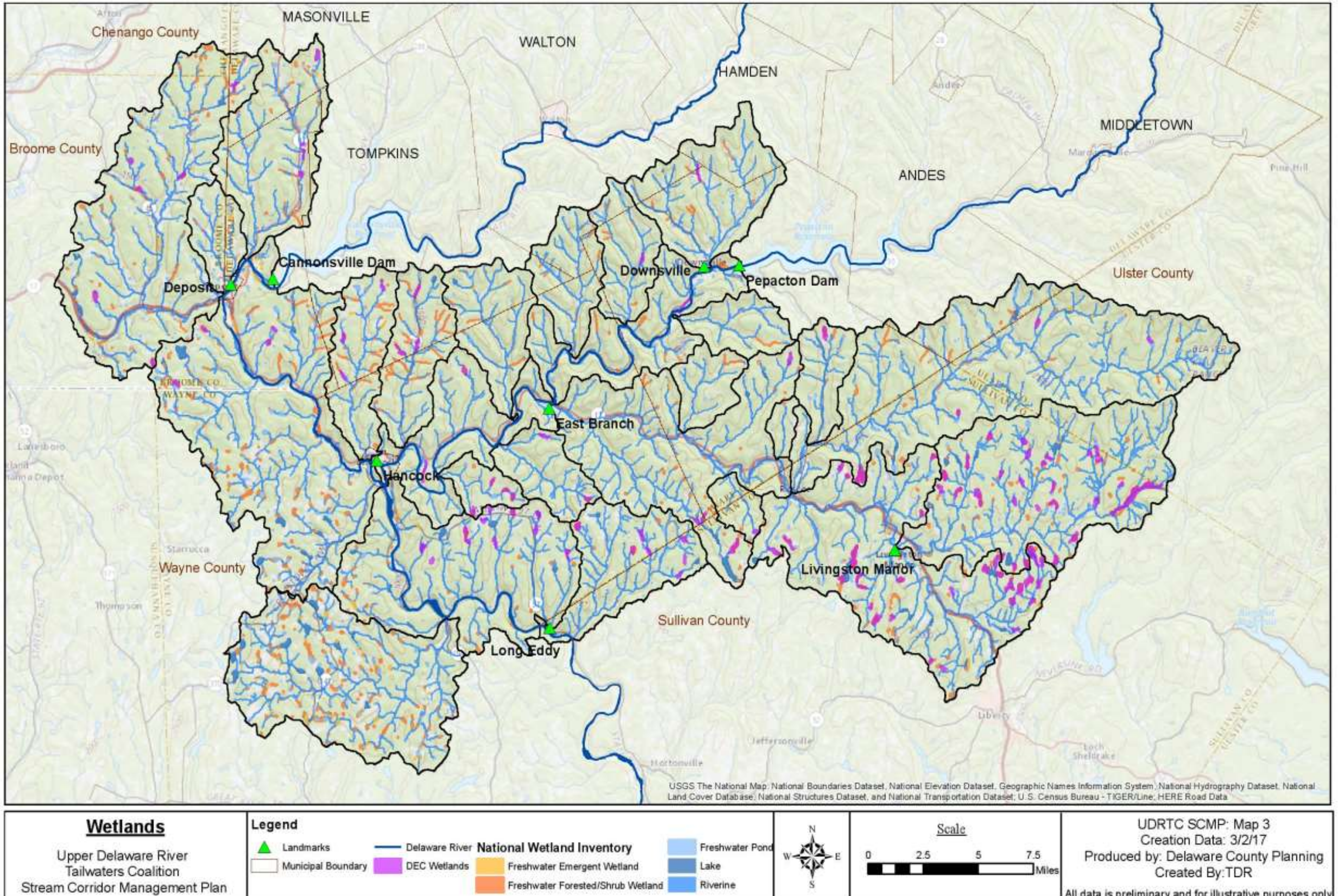
[17] United States Geological Survey. 2018. USGS WaterWatch. Streamflow conditions. http://waterwatch.usgs.gov

8. Wetlands

Wet portions of the landscape such as marshes, wet meadows, swamps (forested wetlands), bogs, and shallow margins surrounding ponds, lakes and seasonal floodplains are generally known as “wetlands”. Over the last few decades, society and the scientific community have increasingly recognized the functions of wetlands, their value to society and the various physical forms they take. Differences among wetlands arise from variation in vegetation, soils, hydrology and position in the landscape, all of which can make some wetlands more “valuable” than others. In their natural condition, wetlands provide flood control, erosion control, water quality protection, fish and wildlife habitats, opportunities for recreation, aesthetic appreciation as well as education.

The U.S. Fish and Wildlife Service (USFWS) has published their inventory of wetlands that includes the entire Tailwaters basin, including NY State and PA wetlands. Based largely on aerial photo interpretation, this information tends to be relatively accurate although precision is limited and field verification is scant. It is available as printed maps and also in digital format as spatial and tabular databases.

Map 3, “Wetlands”, below presents New York State Department of Environmental Conservation (NYSDEC) and USF&WS mapped wetlands where stream-wetland complexes can be seen as thin colored lines. Bogs or marshes appear as irregular shaped polygons in uplands.



Map 3: Wetlands within UDR Watershed as determined by National Wetland Inventory and NYSDEC

An analysis of wetland spatial information from the U.S. Fish & Wildlife Service produced the following noteworthy wetland characteristics in the Tailwaters watershed:

a) Compared with the headwaters of both the West and East branches of the UDR Delaware River, the Tailwaters contain a much greater proportion of wetlands. At nearly 16,000 acres, this equates to 3.1% of the watershed being wetlands (or 2.8 times that of the East branch, which has more wetlands than does the West Branch.).
b) With the exception of lakes with median size of 33 acres, most wetlands are relatively small, with median size ranging from 0.3 to 2.1 acres (similar to those of the East branch basin where median size ranged from 0.6 to 1.5 acres.)
c) Riverine wetlands are the most extensive type, followed by lakes and then palustrine forested swamps. It should be noted that forested wetlands are in many cases the most effective wetland type in reducing runoff, thus allowing more slow and steady releases to streams. These wetland types are often the most difficult to replace once they have been filled or cleared of trees, and the wildlife habitat they provide is likewise both valuable for wildlife and difficult to replace.

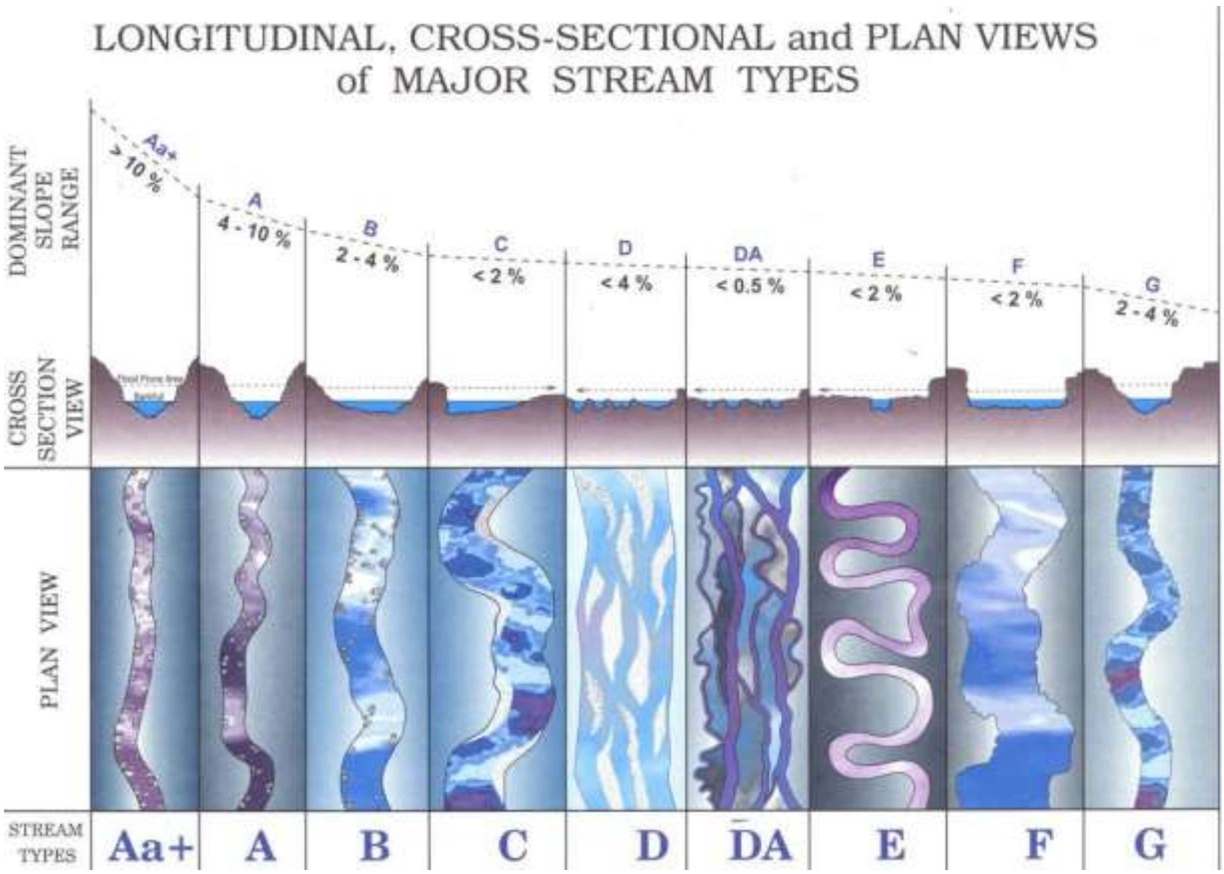
Wetlands can parallel a river (referred to as a riverine-wetland complex) or be a standalone feature such as a bog or marsh. Floodplain wetlands near streams have added benefits for flood mitigation: While all wetlands act as a sponge by absorbing water during wet times and releasing it during drier times, these wetlands often become fully inundated during high water events, temporarily trapping flood waters and sediment, thereby helping to reduce flood stage. A floodplain wetland near a first order stream (that is to say in the headwaters) provides more flood mitigation than an equally sized floodplain wetland located near a larger stream (2nd order, 3rd order etc.); this is because water detained in headwaters wetlands increases the time it takes for runoff to reach downstream segments, decreasing peak flows.

Both state and federal agencies provide legal protection of wetlands, with varying degrees of involvement and largely on a case-by-case basis. For example, in the 1970's New York was the first state in the country to offer protection to wetlands over 12.4 acres in size, all of which were (and still are) available for public viewing on a series of DEC maps that outline protected wet areas. The U.S. Army Corps of Engineers provides federal protection of even much smaller size in NY, PA, and the rest of the country. Pennsylvania offers protection through their Commonwealth's Dam Safety and Encroachments Act.

9. Stream Characteristics/Classification

Natural streams vary from steep to flat, wide to narrow, and relatively straight to a bending (or *sinuous*) flow pattern. The slope of a section of stream or "reach" largely depends on its position within a watershed. Streams are typically straighter and steeper in the headwaters where the valley is narrow and the slope is steep. As distance increases from the headwaters and the slopes begin to level in the lower, wider sections of the valley, the stream begins to meander back and forth. This is illustrated in Figure 10, below, where slope generally decreases from left to right and stream form is seen from both a cross-sectional and "aerial" view.

Figure 10: Longitudinal, Cross-Sectional and Plan Views of Major Stream Types



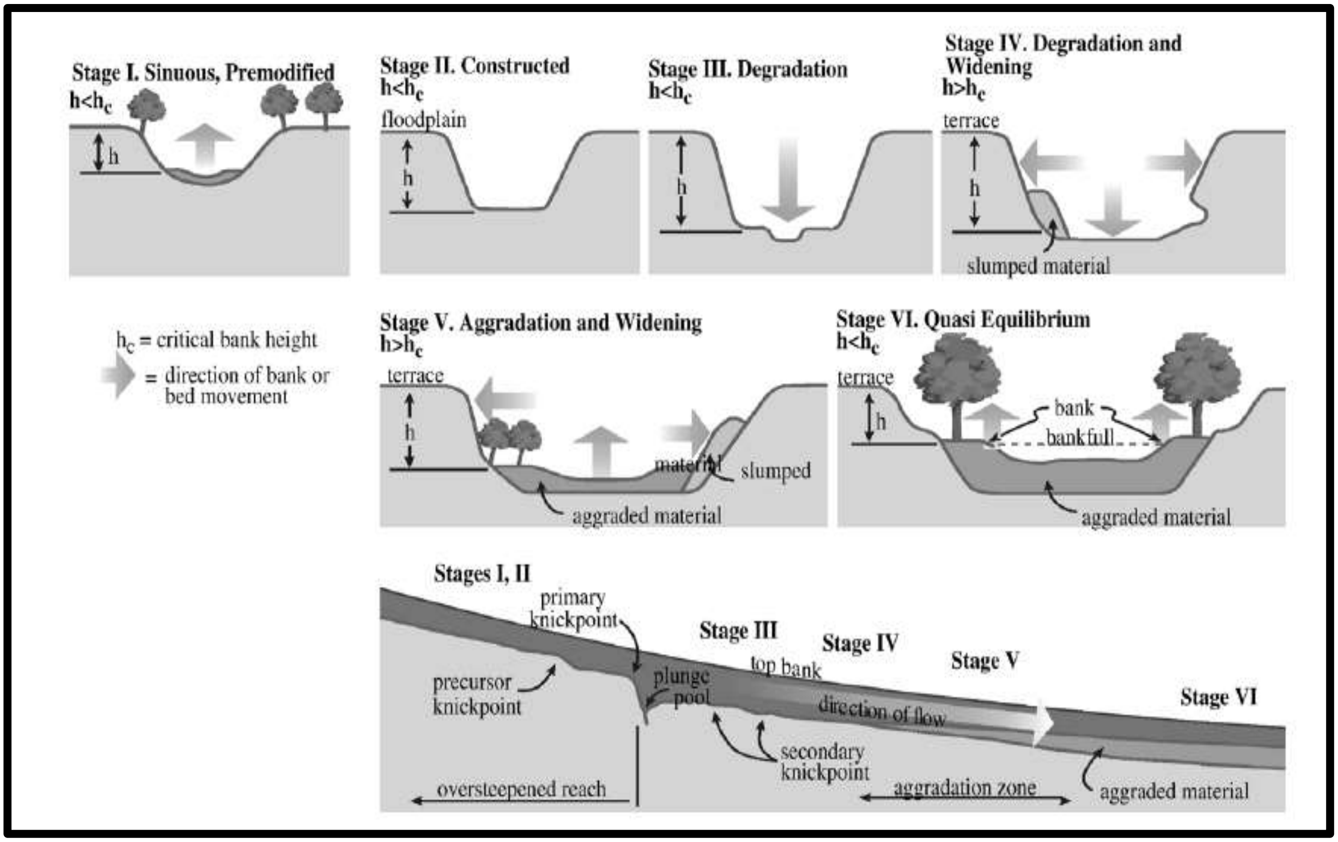
Streams and rivers in the UDR Tailwaters Watershed transport water from hillsides to larger bodies of water downstream, eventually flowing into the Atlantic Ocean. Streams also transport sediment such as sand and gravel as well as logs and other woody material. When in balance, a stream or a river will transport all three of these materials while maintaining its shape and location. This state of equilibrium is referred to as dynamic equilibrium or quasi-equilibrium. When human activities or catastrophic natural events (extremely large and rare floods, forest fire, or invasive species i.e. the Hemlock's Woolly Adelgid) modify the surrounding landscape or alter the stream itself, the balance between water, sediment, and woody material transport is shifted and the stream responds to this imbalance by changing its shape and/or location.

The "Channel Evolution Model" (Figure 11) presents an example of how a stream will respond if it is manipulated, for example, deepened or straightened, as seen in Stage II. This situation is a common occurrence after a large flooding event, where machinery is used to excavate material from the stream channel which deepens the stream. The stream will respond by deepening even more (Stage III) which then causes the streambanks to fail and slump (Stage IV). Stage IV is often marked with near vertical eroding banks with trees and root systems exposed and dangling high above the water surface. Stage V is marked with continued channel widening resulting from the erosion of stream banks, but also features locations where materials have settled out of the water, such as accumulations of sand and gravel at the channel edges, point bar in the middle of the channel, or spanning the channel are also characteristic of Stage V. A stream or river in Stages III through V is considered "unstable" or out of balance. Stage VI represents a quasi-equilibrium state where the stream's shape and location is in balance with the transport of water, sediment, and woody material.

The evolution of a stream channel following manipulation can take decades or centuries to complete. The time this cycle takes depends on natural and man-made interventions that may stall or break the evolution cycle.

An example of a natural intervention is if in Stage III, the channel deepens and hits bedrock before the channel depth causes enough streambank failure. The bedrock then halts the process where channel widening would begin (Stage IV). An example of a human intervention is the installation of large stones (often referred to as rip rap) on the streambank during Stage IV to protect a house or road that is threatened by the stream widening process. The rip rap slows down or even stops the natural evolution towards the quasi-equilibrium. Understanding the evolution of a stream channel and applying this understanding to the streams and rivers in the UDR tailwaters will help determine which management technique is appropriate to reduce the time that is needed to guide the stream into Stage VI, a quasi-equilibrium. Reducing the amount of time that is needed to reach a quasi-equilibrium will result in less eroding stream banks which will reduce losses of aquatic habitat and water quality pollution.

Figure 11: Channel Evolution Model[18]



10. Invasive Species

A significant contributing factor to changes in the landscape of the UDR Tailwaters is the presence of invasive plant and bug species that threaten the native plants and trees in the region.

Invasive plants represent a major threat to the watershed. They displace native plant communities, destroy wildlife habitat, degrade the wild and scenic beauty of the landscape, alter natural processes, and disrupt recreational activities. These changes can increase the rate of erosion along unstable stretches of stream. Many of these species are fast growing and can be easily transported through high water events, road ditching, and construction that involves earth movement. The presence of these plants along with the loss of native plants changes the local ecosystem and inhibits the growth of bug populations that are important to fish and wildlife habitat.

[18] Simon, A. and Hupp, C.R. (1986) Channel Evolution in Modified Tennessee Channels. Proceedings of the 4th Federal Interagency Sedimentation Conference, 2, 5.71-5.82.

According to the National Park Service there are twelve different invasive plant species that have been identified in the Upper Delaware region. They include Purple Loosestrife, Japanese Knotweed, Japanese Barberry, Multiflora Rose, Autumn Olive, Garlic Mustard, Water Chestnut, Bush Honeysuckle, Reed Canary Grass, Spotted Knapweed, and Japanese Hops. These invasive have crowded out the native plants and are taking over.

The invasive bugs that have been appearing throughout the region, including the emerald ash borer, are an ecological threat. The emerald ash borer is killing large stands of ash trees. The larvae of the adult beetles bore into the bark, girdling it, and causing tree death. These invasive species can cause such great changes in the local ecosystem that they can threaten or endanger plants, animals, and aquatic species.

The National Park Service has been partnering with many local and regional groups to address invasive species. The goal is to limit the further spread of those species already here and avoid the occurrence of new invasive species. Other parts of the Delaware River have begun to experience the introduction of invasive fish species such as the Blue Catfish and Northern Snakehead. Given the economic benefits of the local cold water fishery it is important to protect the ecosystem from these invasive fish types, protecting the native fish population, including the trout.

11. Water Quality

Water pollution and degradation is caused by both “point source” and “non-point source” impacts. Point source pollution refers to contaminants that enter waterways from a distinct and often readily identifiable source such as a wastewater discharge pipe from a sewage treatment plant or a factory. Non-point sources of pollution are the result of diffuse, overland runoff of materials such as sediments and nutrients from fields and impermeable surfaces. Waterways within the scope of the SCMP project are primarily impacted by non-point sources.

a) Sedimentation and Erosion

Sediment pollution is one of the primary water quality impacts in the project area. The primary sources of sediment pollution are stormwater runoff from intensive land based activities such as agriculture and development that creates impermeable surfaces including rooftops, roads, and structures. Delaware County is one of the wettest counties in New York State and receives significant rainfall that contributes to sediment movement and transport. A secondary source of sediment pollution comes from accelerated transport of gravel, cobble, and other sediment within the stream channel. This due to the often highly destabilized and erosive conditions of local waterways as a result of historic and modern day impacts.

b) Highways/Roads

Historically, communities in Delaware County developed near streams and rivers, as they served as a source of water for daily living and transportation. As roads in Delaware County were formed, they also followed the streams, connecting the dots from one community to another. Construction of the early road system was made easier in the valleys because the profile grades along streams were flatter than going over the mountains. The road system developed as a means to connect houses and farms that had been built up along the streams to larger markets for sale of products. As modes of transportation improved, the roads were improved; however, the alignment along the valleys and streams stayed the same. Therefore, it is not unusual to see a public road parallel and in close proximity to the streams and rivers in Delaware County.

In the early 1990's, it was still very typical to see Town and County highway departments cleaning miles of ditches along public roads with a grader and loader during summer months. The material from the ditches would be pulled into the roads with a grader and then loaded on trucks with a loader to be hauled away. The spoil areas were typically steep banks where the material would fall by gravity away from the dumping truck. This minimized the effort required to keep the material pushed off making room for more. Unfortunately, the steep slopes were typically directly adjacent to a stream. There were a number of major problems with this form of maintenance. First, when the material was pulled onto the road surface, it was nearly impossible to get completely cleaned from the road. It left a thin layer of mud formed on the road and subsequently washed off into the stream carrying with it contaminants and nutrients that are not good for water quality. In addition, the process left un-vegetated slopes along the road that were easily eroded during rainfall events also causing water quality impairments. And probably the most destructive aspect of this action was the spoil areas. Dumping unconsolidated or compacted material on steep slopes created many problems over time. Storm water, flowing from the roads over these spoil areas caused erosion but more importantly the uncompacted material soaked up the water causing tremendous increases in weight on the slope. This added weight caused the material to creep downhill. Over time as trees grew on the slopes they provided some temporary stabilization of the soil. However a combination of top heavy trees and saturated slopes would spell disaster. These slopes often fail catastrophically as they slide down into the stream adding tons of material to the streams bedload and creating a slope failure that is nearly impossible to stabilize.

Current day maintenance is done in a completely different way. Gradalls and excavators are used to clean the ditches and load the material directly into trucks. This minimizes the extent of the damage to the adjacent slopes and does not leave a lot of mud on the roads to have to clean up or have rain wash it away. Spoil areas are in upland areas and away from wetlands, steep slopes and streams so it does not have long term negative effects on the adjacent embankments or streams. In addition, the recently cleaned ditches are now hydro seeded to make sure that the disturbed slopes are stabilized as quickly as possible.

In addition, in an effort to reduce the frequency at which the ditches have to be cleaned, the County has moved from using aggregate in the winter for traction to using salt for deicing. The salt replaces tons of aggregate that used to be put on the roads during the winters and then swept into the ditches in the spring prior to line striping or surface treatment operations. Historically, it only took about four years between ditching cycles. Using the salt, the ditching frequency has been reduced to once every 12 to 15 years. And even then, it is more of spot ditching than full length ditching. In order to reduce the amount of salt applied on the roads, all of the trucks are outfitted with automatic hopper controllers that only apply the amount of salt required to clear the road. The controllers are calibrated to the speed of the truck so no matter who is driving or at what speed, just the minimum amount of material is applied to bare the road.

c) Structures/Bridges

The science behind planning for the interaction of streams and highways has changed considerably over the past 30 year period. At the time the interstate system was planned for and constructed, the technology used was to create open channel, steady state flow for the design of hydraulic structures. This technology had been modeled in the laboratory and was well understood. The resulting designs were based on moving water alone and did not take into account the movement of stream bedload. It resulted in uniform, typically straight trapezoidal channels to carry design storms. Designs did not contain any accommodation for the natural sinuosity in streams and typically did not account for different types of streams in different geologic materials or valley slopes. During the early 1900's, streams were relocated without any real consideration to accommodate larger meadows and straighter roads. Berms were also constructed along streams to accommodate higher storm flows without impacting the road or leaving debris on meadows. These features were built by locals with the national model being led by the Army Corps of Engineers in the construction of levees along large rivers including the Mississippi River. Historically, local engineers and highway superintendents did not have the technology for sizing waterway capacities for highway hydraulic structures. They used rules of thumb and common sense for sizing them.

Major changes in the science behind the management of streams occurred in Delaware County after the devastation caused by the January 19, 1996 flooding event. That event took a heavy toll on the infrastructure of Delaware County. Numerous bridges were washed out and destroyed and many roadways were completely washed away. The County leaders were quick to go to work and repair the infrastructure. Bridges were replaced and roads were reconstructed using whatever method was required to get it done. Streams that had been plugged with both woody and aggregate debris were cleaned out, made straight and widened to accommodate future storm events of a similar magnitude.

In addition to working on public infrastructure, the County also worked to help the private sector recover from the devastating flood. FEMA was quick to respond and help the County, local municipalities, residents and businesses that were affected by the event. However, there was no help for the local farmers to clean up their fields and to return the streams to the pre-event location because the property was not improved. The County Board of Supervisors took proactive steps and developed a program to address stream issues on agriculturally productive land. The program included a team of people from numerous agencies that would review applications before the work was done. The team included the NYS DEC and the ACOE. Contractors that did the work of returning the streams removed both woody and aggregate debris and uniformly shaped the channel. In accordance with generally accepted practices at the time, the channels were straight, trapezoidal channels with no low flow channels or bed features. Environmental groups were monitoring the work that was being performed by the County and heavily criticized the work. Newspapers from as far away as California had picked up the controversy between the County of Delaware and Trout Unlimited. As both sides dug in for a long argument of fish verses people, certain members of Trout Unlimited were taking time lapsed pictures of the County's response work. In addition, NYC DEP, concerned about the quality of their water in the reservoirs resulting from damage done during the event and subsequent recovery efforts, brought in a nationally renowned geomorphologist by the name of Dave Rosgen to review work and make a presentation on recovery efforts. The combination of the time lapsed pictures that TU had taken and Mr. Rosgen's theories made the DPW engineers start to take a critical look at the methods used for recovery. Completed projects were reviewed for performance. The County sent numerous engineers to Mr. Rosgen's training courses for additional education on a better, more sustainable way to design streams. DPW and others began to focus on the areas of the system that were not damaged to try to figure out why they succeeded when others had failed. At the same time, the USGS working with NYS DEC was developing an on line program for the interactive estimating of stormflows at any point in a watershed in NY using regression equations. These tools made designing highway crossings for future storm events much more efficient. Town highway Superintendents for the first time truly understood the impacts of undersized culverts and what the significant of large scour holes at the ends of their culverts meant.

As the new century approached, all had a better understanding of how more sustainable hydraulic crossings were not only a better use of taxpayer's money but were also better for wildlife habitat. The Delaware County Soil and Water Conservation District developed a "Post Flood Stream Intervention Program" that taught contractors and public officials how to better plan for and build more sustainable infrastructure. The sheer number of heavy rainfall events endured by Delaware County helped agencies within the county gain critical experience in a short period of time.

Although Delaware County and local municipalities had a better understanding of hydraulics and stream crossing there were still problems. One of the major impediments to the proper sizing of hydraulic structures after major flooding events was FEMA's rules for recovery. To control costs and avoid wasteful design, the Stafford Act had set the rules for flood recovery to replace in-kind the hydraulic structures damaged on a road. Mitigation in the form of larger culverts or designed culverts was only approved if they met certain cost benefit ratios. Because many municipalities did not have the records to prove repetitive damage from the numerous events at the same location, increasing hydraulic capacity was not easy unless the municipality had adopted codes and standards and had applied the standards during the normal course of operations. DPW's experience obtained post 1996 clearly proved the economy of designing the crossings for larger events. Therefore, in September of 2008, the County Board of Supervisors passed a resolution setting bridge design and construction standards to ensure all future structures are designed for future storm events. These standards address hydraulics, scour and natural stream design in an attempt to ensure more informed, sustainable designs in the future. The DPW's standard now for culvert replacement is a three sided box culvert with a natural bottom and floodplain drainage where required. It also includes the accommodation of bedload migration through the structures and scour control.

The DPW has also taken every opportunity that it can to relocate roads away from the stream or river. This can be hard to accomplish because the roads have to support the residences that have developed along the roads over time and right of way acquisition has become very difficult. However, the County was able to do a relocation project along the Beaverkill in the Town of Hancock at Elk Brook. At this location, the County relocated approximately 2,300 feet of County Route 17 away from the river and a failing slope. In addition, in 2007 on CR 7 in the Town of Colchester, a private road was relocated adjacent to the County road to accommodate a more natural stream alignment and hydraulic capacity of the crossing.

Current County design procedures for all replacement hydraulic structures now requires a review of the physical stream dimensions upstream and downstream of the replacement structure. They also include a review of the stream profile to make sure that any existing instability is accommodated for in the design. Grade control structures are also designed as required to ensure long term stability.

Town Highway Departments are now much more aware of the critical nature of stream crossings. They seek assistance from the Soil and Water Conservation District and the County in the design and construction of stream crossings. During post flood recovery times, the Towns and County work very closely with the SWCD to insure that stream geometry and stability is addressed in the recovery process.

d) Dams, Levees, Berms

Dams are a barrier constructed to hold back water and raise its level. The resulting reservoir could be used for commercial purposes (generation of electricity, mill wheels, etc.), flood mitigation, or for municipal purposes (water supply, fire-fighting, etc.). The most frequent function of the watershed's dams in the 21st century is to create pools of water for recreation. In the 19th and early 20th century, the most frequent function of the Tailwaters' dams were for industry. Conditions were created that powered grist mills and provided a reliable water supply to tanneries.

Dams retain a volume of water but also often retain the sand, gravels and cobbles by trapping them upstream of the dam. Historic dams built in the 18th through 20th centuries are often no longer tracked by the DEC because they are no longer classified as a dam, so they do not show up on DEC databases. Historic dams can have visual and ecological impacts for decades if not centuries after the dam is no longer functional and retaining. These impacts can be seen as eroding banks and large sediment bars which can impact water quality and aquatic habitat resources downstream. There are more than 7,000 dams in New York State with 205 regulated dams in Delaware County. Table 5 lists the regulated dams in Delaware County as identified by the NYS DEC metadata files within the UDC study area.

In addition to the many smaller dams in the UDR Tailwaters, New York City has two large water-supply reservoirs - Cannonsville and Pepacton - in the Delaware River basin. These reservoirs significantly impact stream flow in the East Branch, West Branch, and Main Stem of the Upper Delaware River.

Levees and berms are constructed man made features for flood mitigation used regularly in the earlier part of the 20th century. They became common practices and were widely used. However, it has been shown that they can often provide a false sense of security from flooding and can require a substantial amount of maintenance to remain effective. In addition, as unnatural features within the system they could have an adverse effect on the waterway and the natural flow of the channel. For those reasons they are rarely a preferred method of mitigation today.

Within the Tailwaters region there is an Army Corps of Engineers levee at East Branch. The levee was constructed in 1972 as a flood mitigation measure protecting the community of 60 or more homes and a major employer in the community, Johnston and Rhodes. Since that time flood mapping has changed and the levee has been determined to be insufficient to provide flood protection for the East Branch community. The loss of protection as a flood control instrument from the 100-year flood event puts the residents of East Branch in a potentially hazardous situation. Additionally, the fact that the levee cannot be considered as flood protection forces the property owners to comply with the local flood protection law which calls for residential properties to be elevated to a height of two feet above base flood elevation (BFE). The experience of the town has been that this is prohibitive given the low lying area is several feet below BFE, making it impossible for large improvement to properties to be made or for properties lost to disasters, including flooding, fire and wind storms to be able to rebuild. This has the potential to be a large loss of taxable properties if the levee is not elevated to accommodate the 100-year storm event.

Within the Village of Deposit there is a small Army Corp of Engineers project that was designed as a diversion channel and berm along Butler Brook. This was done to reduce flooding and protect the downtown district of the Village. This channel and berm were designed as flood protection however, they have created challenges to the community as they require regular maintenance to remain functional.

One of the many objectives of this plan is to evaluate the effectiveness of these practices and provide for solutions that are not as intrusive and replicate the natural environment as an alternative. It is understood the levees and berms that exist would be costly to replace and are functioning as a flood mitigation strategy and therefore continued maintenance and upkeep is recommended to provide for the greatest level of protection they can offer.

e) *NYC Water supply reservoirs*

The UDR Tailwaters are impacted by two of the largest reservoirs in the New York City water supply system. The West of Hudson Water Supply System is made up of six reservoirs, including the Pepacton and Cannonsville, located just above the Upper Delaware Region. The Cannonsville and Pepacton Reservoirs are the largest watershed areas in the New York City System, accounting for 826 sq. miles of land that is located within the protected watershed area. The two reservoirs combined hold a capacity of 236 billion gallons of water to serve the demands of New York City. This accounts for 43% of the 550 billion gallons of water supply capacity in the entire New York City water supply system.

Table 5: West of Hudson NYC Water Supply Reservoir Characteristics

WEST OF HUDSON NEW YORK CITY WATER SUPPLY RESERVOIRS			
Reservoir	**River System**	**Capacity**	**Watershed Area**
Catskill System			
Ashokan	Esopus Creek	122.9 Billion Gallons	255 Sq. Miles
Schoharie	Schoharie Creek	17.6 Billion Gallons	316 Sq. Miles
Delaware System			
Cannonsville	West Branch Delaware River	95.7 Billion Gallons	455 Sq. Miles
Neversink	Neversink River	34.9 Billion Gallons	92 Sq. Miles
Pepacton	East Branch Delaware River	140.2 Billion Gallons	371 Sq. Miles
Roundout	Roundout Creek	49.6 Billion Gallons	95 Sq. Miles

In addition to being two of the largest reservoirs in the system, the Pepacton and Cannonsville Reservoirs were the last to be constructed being completed in 1955 and 1964 respectively. As with all dams the impoundments at Downsville and Stilesville have interrupted the natural flow of the Delaware River impacting the river and stream systems in the Tailwaters area. Over the past 55 years the streams that feed into the Delaware River have begun to change to account for the artificial flows created by the dams and releases. The changes that are being exhibited include increased sedimentation at the mouth of the streams. As this has been a fairly short time period in the geologic history of the area it will require additional field survey, observations and data to determine what impacts are being created and how the streams will react over time.

TABLE X - DELAWARE COUNTY DAMS - UPPER DELAWARE TAILWATERS

River/Stream	Dam Name/Number	Hazard Level	Condition Rating	Nearest City	Year Built	River/Stream	Dam Name/Number	Hazard Level	Condition Rating	Nearest City	Year Built
East Masonville Creek	Masonville Dam	Low	NR	East Masonville	Unknown	Humphries Brook	Beaver Run Dam	Low	NR	Lordville	1976
Rood Creek	Silver Lake Improvement Dam	Low	NR	Silver Lake	1930	TR- East Branch Basket Creek	Deer Lake Dam	Low	NR	Acidalia	1940
Sherruck Brook	Scotty's Dam	High	No deficiencies Noted	Trout Creek	1949	TR - Abe Lord Creek	Edward Klimchock Dam	Moderate	NR	Long Eddy	1981
West Branch Delaware River	Cannonsville Dam	High	No deficiencies Noted	Deposit	1964	TR - Beaverkill	Bernadina Rieping Dam	Low	NR	Peakville	Unknown
TR- Beaverkill	Huggins Lake Dam	Low	NR	Beaverkill	1962	TR - East Branch Basket Creek	Lohr Dam	Low	NR	Acidalia	1998
TR- Trout Creek	Kahabka & Rutenber Pond Dam	Low	NR	East Masonville	1959	Orleans Swamp	Orleans Swamp Dam	Low	NR	Fishs Eddy	Unknown
TR - East Masonville Creek	Gifford, Kahabka & Rutenber Dam	Low	NR	East Masonville	1959	Orleans Swamp	Orleans Swamp Lower Dam	Low	NR	Fishs Eddy	Unknown
TR- Ivanhoe Brook	Everett Young Recreational Pond Dam	Low	NR	Masonville	1973	TR - Big Pond	Mountain Lake dam	Low	NR	Lew Beach	1930
Laurel Creek	Roods Creek Dam	No Hazard	NR	Deposit	Unknown	TR - Beaverkill	Paradise Lake Dam	Low	NR	Beaver Kill	1966
Pine Swamp Brook	Robert Nichol Dam	Low	NR	Hancock	1990	TR - Beaverkill	Knapp Dam	Low	NR	Beaver Kill	1915
None	Fred Debai Dam	Low	NR	Masonville	Unknown	TR - Beaverkill	Little Pond Dam	Low	NR	Beaver Kill	1916
TR- Sands Creek	John Carlson Dam	No Hazard	NR	None	Unknown	TR - Beaverkill	Big Pond Dam	No Hazard	NR	Lew Beach	1913
None	Howard Huntington Dam	Low	NR	Masonville	1990	Trib - Temper Kill	Geiger Dam	Low	NR	Downsville	2009
TR-Trout Creek	Western Delaware BOCES Dam	Low	NR	Trout Creek	Unknown	Trib - Russel Brook	Trout Pond Dam	Low	NR	Butternut Cove	Unknown
Little Faller Brook	Edwards Pond Dam	Low	NR	Horton	Unknown	Pease Eddy Brook	V C Peters Pond Dam	Low	NR	Pease Eddy	1916
TRB0 - Delaware River West Branch	Glenn Thompkins Lake Dam	Low	NR	None	1994	Linsley Hollow Brook	NY Wildlife Game Management Dam #11	Low	NR	Downsville	1936
TR - Whitcomb Hollow Brook	Shawe Pond Dam	Low	NR	Lew Beach	1966	East Trout Brook	Launt Pond Dam	Low	NR	Shinhopple	1938
TR - Mary Smith Brook	George Patterson Pond Dam	Low	NR	Lew Beach	1970	TR - Chase Brook	Raymond Glassman Lake Dam	Low	NR	None	1962
Hollow Brook	Kazam Pond Dam	Moderate	NR	None	1977	TR - Johnnie Brook	Arthur Rassmussen Pond Dam	Low	NR	None	1962
Campbell Brook	Upper Dam	Low	NR	Corbett	Unknown	TR - Trout Brook	C. Alvin Cosgrove Pond Dam	Low	NR	Shinhopple	1966
Campbell Brook	Lower Dam	Low	NR	Corbett	Unknown	Whitaker Brook	McCabe Hollow Pond Dam	Low	NR	Deposit	Unknown
East Branch Delaware River	Downsville Dam	High	No deficiencies Noted	Downsville	1954	Trib - Sands Creek	Hathaway Pond Dam	Low	NR	Kelsey	1800
Horse Brook	Lake Miriam Dam	Low	NR	Cooks Falls	1954	Trib - Trout Brook	Bear Spring Mountain Dam	Low	NR	Shinhopple	Unknown
TR - Spring Brook	B B Shepps Pond Dam	Low	NR	Rockland	1960	Wilson Hollow Brook	Round-Up Ranch #4 Dam	Low	NR	Downsville	2011
TR - Spring Brook	Colchester Delaware Club Pond Dam	Low	NR	Rockland	1961	Trib - Beaverkill	Morton Hill Dam #1	Low	NR	Roscoe	Unknown
Whirling Eddy Brook	Chiloway Lake Dam	Low	NR	Chiloway	1961	TR - East Brook	Rqm Dam #1	No Hazard	NR	Readburn	Unknown
TR - Hoolihan Brook	August Anderson Pond Dam	Low	NR	Long Eddy	1965	TR- East Brook	Rqm Dam #2	Low	NR	Readburn	1980

12. Geology

a) *Bedrock Geology* - The majority of the bedrock in the Tailwaters is of the relatively flat-lying, sedimentary type: sandstones, shales and conglomerate that formed during the upper Devonian time period, some 360 million years ago. Four geologic formations make up the Tailwaters: the Slide Mountain Formation, Upper and Lower Walton Formations and the Honesdale Formation. These rock units comprise most of the bedload in the streams, creeks and soils in the Tailwaters.

The above-mentioned rock formations appear similar to one another and have roughly similar physical and chemical characteristics, primarily composed of various forms of silica and other silicate minerals (i.e., without inclusions of limestone layers). They were originally the sediments eroded from an ancient mountain range to the east, formerly located around where the Berkshire Mountains of today are, deposited to great depths in a tidal/alluvial basin environment. In Pennsylvania's portion of the watershed all four bedrock types recognized in New York are simply considered the Catskill Formation, sandstone being the primary rock type.

This uniform and somewhat boring looking bedrock (which holds relatively few and poorly preserved plant fossils) is important to maintaining stable stream flows. Both bedding plane partings and deep perpendicular joints (i.e., horizontal and vertical cracks that form a grid like pattern) contribute significantly to the storage and slow release of groundwater to lower portions of the landscape. This helps maintain relatively even baseflow of cold water to streams, especially along the Beaverkill, even during drier spells. (for more information about this phenomenon, see Reynolds, 2000[19])

It should also be mentioned that the uniform sandstone layers produce some fine building materials. Local bluestone quarries are an important industry economically, which exists primarily due to the uniformity and great thickness of the local sandstone bedrock.

b) *Surficial Geology* - Surficial geology refers to the study of landforms and the unconsolidated sediments that lie beneath them. Most of the surficial geology in the Tailwaters region was produced by the Wisconsin glaciation. This glaciation climaxed approximately 21,750 years before present and was preceded by at

[19] Reynolds, R. 2000. Hydrogeology of the Beaver Kill Basin in Sullivan, Delaware, and Ulster Counties, New York. USGS Water Resources Investigations Report 00-4034

least two other major glaciations, the Illinoian and Kansan. The zenith of the Wisconsin glaciation erased most evidence of the previous glaciations and created almost all of the glacial features observed in the region[20]. Surficial deposits are important to the SCMP because often this medium regulates groundwater recharge to the bedrock and hence baseflow to the streams. Surficial geology is broken into three broad categories, differentiated by the way deposits were laid down: glacially-created, thin till over bedrock, or alluvial (transported by flowing water).

During the last glacial ice age, the entire watershed was under a sheet of ice known as the Laurentide Ice Sheet. In some areas the ice was over a mile thick; in other areas it was much less massive as the thickness reduced towards the glacier's thinner front edge. As seen in Figure 12 the study area is on the cusp of two general, yet major landscape zones[21]. Zone 1 has extensive end moraines, hummocky moraines, and ice thrust masses; Zone 2 has well developed (long) eskers and contemporaneous ice flow lineaments; Zone 3 has extensive ribbed moraines formed in association with drumlins and with eskers. The ice sheet was comprised of several lobes influenced by the underlying topography; this study area was under what is known as the Hudson-Champlain Lobe, which moved generally south-southwest[22]. The immense weight scraped the landscape clean of vegetation, broke off weak rock from mountain tops and ridges and began to shape the valleys in the UDR Tailwaters.

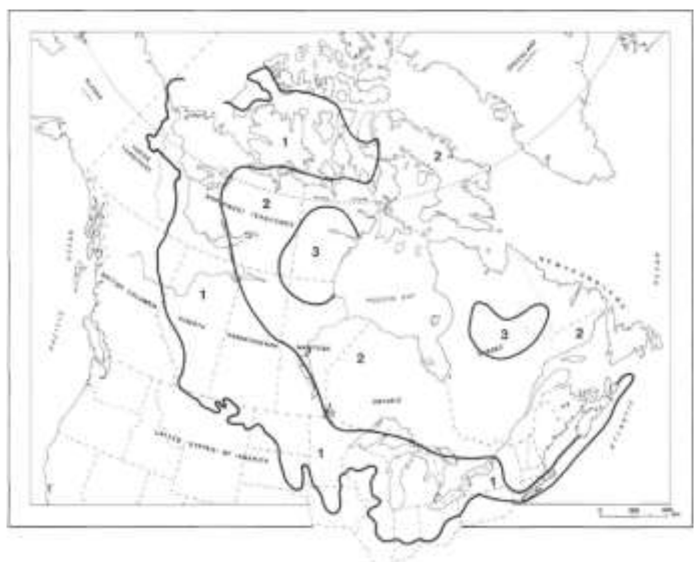
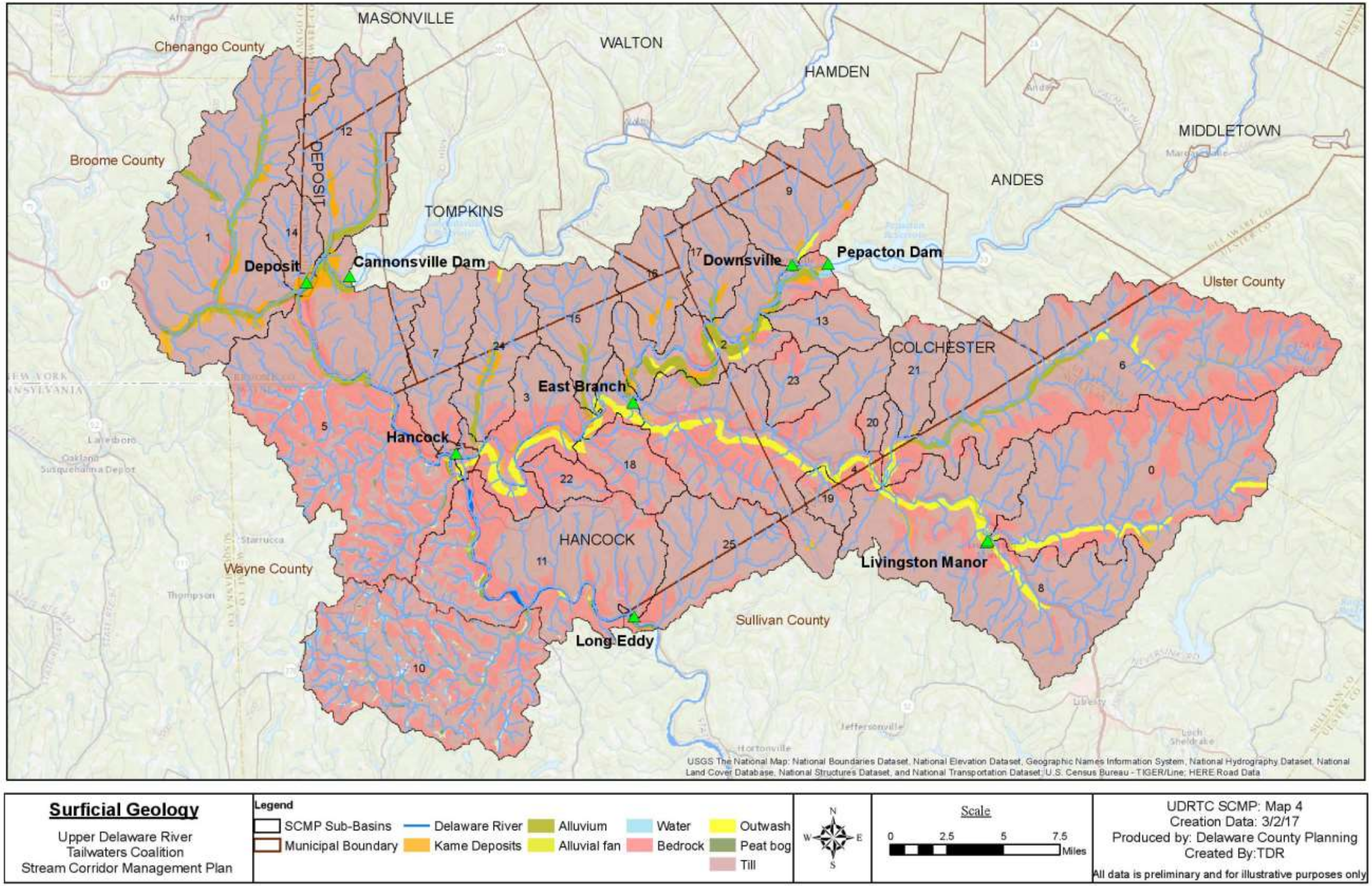


Figure 12: Laurentide Ice Sheet

[20] Titus, Robert. The Catskills in the Ice Age. Purple Mountain Press, 2003.
[21] Dyke, A S, and V K Prest. "Late Wisconsinan and Holocene Retreat of the Laurentide Ice Sheet." Géographie Physique Et Quaternaire, vol. 41, no. 2, 1987, pp. 237–263., doi:10.4095/122842.
[22] Ischsen, Y.W., et al., Geology of New York State: a simplified account. New York State Museum Educational Leaflet No. 28, New York State Museum, Albany, NY, 1991

Approximately 11,000 years ago the last ice age began to wane, the retreating glaciers left clay, sands, and larger stones behind. The heterogeneous mixture of material that has been carried by a glacier as it moves and is then left behind when the glacier melts or retreats is termed till. Large mounded deposits of this unconsolidated material (sometimes hundreds of feet thick) are termed moraines. Moraines can form in a variety of settings including along the side of a glacier (lateral moraines) and the toe of a glacier (end moraines). Many sand and gravel pits, important to the economy and sustainably of the region, are located on ancient moraines. As the glaciers retreated from the area, flowing water carried material out from underneath the glacier. These deposits are termed outwash. At times, the outwash flows were strong enough to cut through moraines carrying material downhill leading to the creation of the valley bottoms as we know them today.

As seen in Map 4, the surficial geology between New York and Pennsylvania appears quite different. The visible variation is likely caused by cartographic anomalies between two state agencies; the retreat of glaciers did produce more moraine type features to the south and, more esker type land forms northward.



Map 4: Surficial Geology of UDR Watershed

The generalized surficial geology presented in Map 4 indicates that 586 square miles (72% of the Tailwaters region) has been identified as till. As the depositional environment of glacial till varies widely, so do the physical characteristics of the deposits. Till is defined as being variably textured (boulders to silt), usually poorly sorted and sand-rich, deposited beneath glacier ice, with permeability varying highly with compaction, and thickness also being highly variable (1-50 meters). In the right environment, this material is quite densely compacted a few feet below the surface which results in high runoff and low water infiltration or low groundwater recharge in the uplands. In general, till is rich in a variety of minerals, given enough time and weathering it can become prime farmland.

Bedrock and associated surficial deposits make up 21% of the study area. These areas are identified as having bedrock within one meter of the surface. As seen in Map 4, these areas are generally mapped on the ridges of the Tailwaters region. However, outside of valley bottoms, it is quite common to have very thin soil profiles in this area.

Within this watershed, alluvium and outwash make up 3% and 2%, respectively. Alluvium is a relatively recent deposition, comprised of very permeable material ranging in size from fine sands to gravel. Alluvium can range in thickness from 1-10 meters and is generally confined to flood plains, however, at times can be found on terraces adjacent to valley bottoms (indicative of a previously elevated valley floor). Outwash is a permeable proglacial deposit comprised of stratified, well rounded, coarse to fine gravel with sand. These deposits generally range in thickness from 2-20 meters. In this region, outwash is shown occurring mainly from Livingston Manor to East Branch to the Village of Hancock and is a major source of cool baseflow for the region. It is interesting that this deposit is shown quite prevalent in this area and relatively absent in the rest of Delaware County.

13. Soils

Since the time the glaciers started retreating from the Tailwaters, approximately 11,000 years ago, physical, biological, and chemical weathering began creating the soils we see today. The variations observed in surficial geology are also reflected in the soils data and are attributed to the different characteristics of the glacial retreat as well as cartographic anomalies between politically separated agencies. Soil is a natural body comprised of solids (minerals and organic matter), liquid, and gases that occurs on the land surface and are characterized by one or both of the following: layers (or horizons) that are distinguishable from the initial material or the ability to support rooted plants in a natural environment[23].

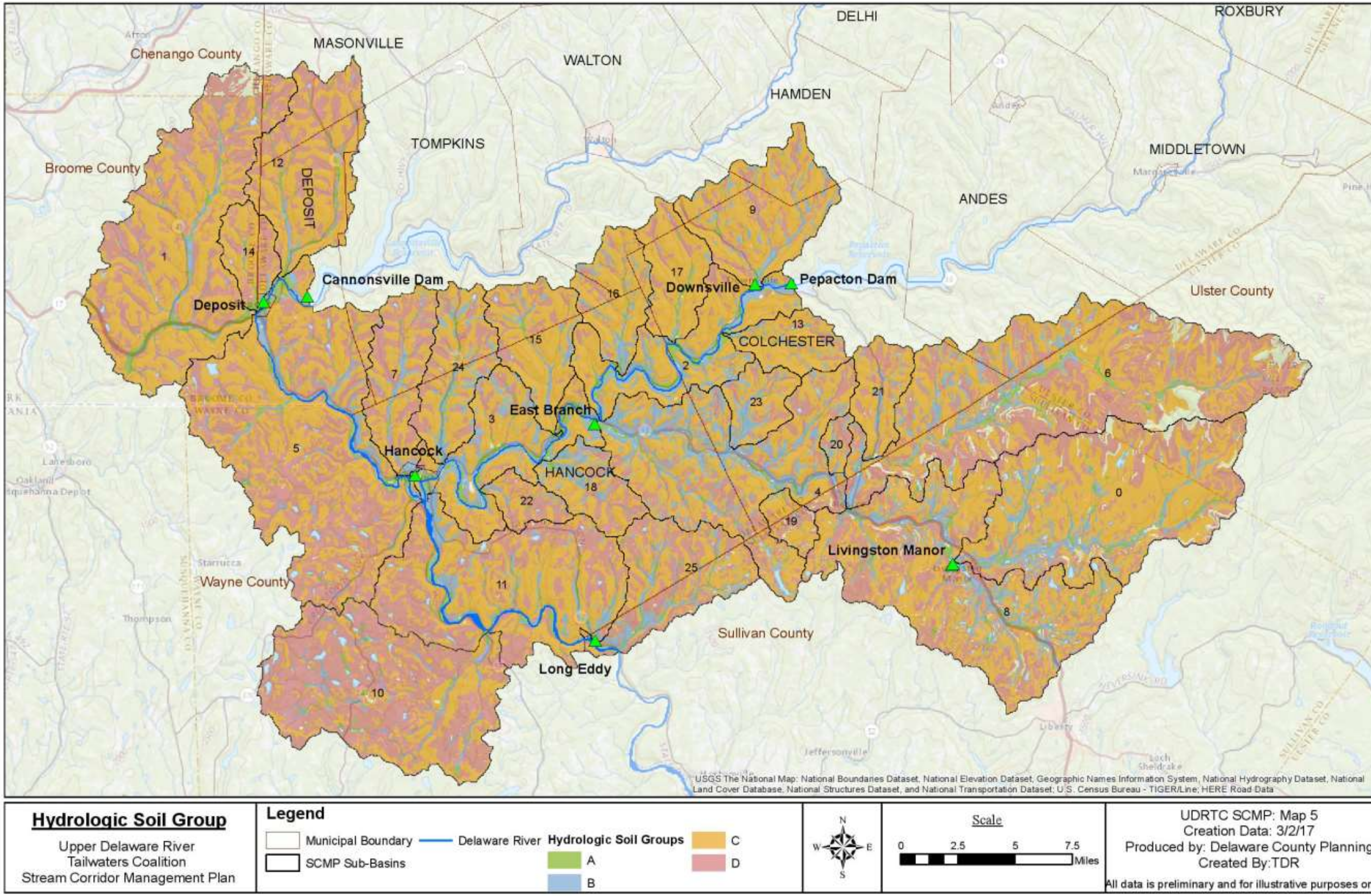
Soils provide important environmental functions that include food and fiber production, environmental services (nutrient cycling, air and water purification, waste decomposition), are a source of building materials, and regulate hydrologic and climatic processes by influencing surface runoff, infiltration and evapo-transpiration. In this study our focus is on soil hydrologic functions and the influence on stream flow.

Low permeability soils, such as soils with high clay content, will allow less water to move through them when compared to more permeable soils (such as soils with high sand content). Water that does not infiltrate into soils will runoff over the surface of the land until either absorbed, evaporated, or it enters a waterway directly. The runoff potential of soils is described by the soil's hydrologic soil group (HSG). Soils having a low runoff potential, such as a sand or silt loam, are classified in HSG "A" or "B" and higher runoff potential soils, such as a sandy clay loam or clay loam, are classified in HSG "C" or "D".

Map 5 shows a summary of the varying HSGs in the study area. For simplicity, it was assumed that all soils were classified in a drained condition. HSG "C" covers the majority of the area in the study area with 51% coverage followed by HSG "D" at 32%. The soils with less runoff potential, HSG "A" and "B", are located primarily in floodplains on valley bottoms or adjacent to small creeks and comprise just 13% of the UDRT.

Knowing that the area of low runoff potential soils (HSG "A" and "B") is relatively small within the Tailwaters, management recommendations will promote strategies to retain or increase infiltration and water retention, thus improving baseflow as well as water quality. When flood water spills out onto floodplains, water soaks into the soil and is cleaned and cooled. This is important as these soils help reduce flashiness of streams leading to a reduction in flooding and erosion. Reconnecting disconnected floodplains as well as green infrastructure practices will reduce flooding and benefit aquatic habitat as well as the related fishing and boating industries, which are a large component of the local economy.

[23] Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436



Map 5: Hydrologic Soil Groups of the UDR Watershed

14. Land Cover

Land cover is defined as the material that blankets the earth's surface. Land cover includes trees, grass, asphalt, water, bare soils and the like. Land cover is altered by land uses. The type of land cover attributes to how water flows and will effectively change how streams react to runoff and intense rain or snow events. Land cover also contributes to the transport of contaminants into the stream system. A region with a lot of impervious areas versus a region with buffered streams, wetlands and grassy areas will transport contaminants and water to the system faster without any absorption or filtering on the ground.

The following table and maps show a comparison of land cover in 1943 and 2016 in the Upper Delaware Tailwaters region. The table shows the majority of the region was forested, making up 76.5% of the overall land cover. That increased to 87.2% forest cover in 2016. The most notable shift in land cover was a change from 17.9% grassland in 1943 to only 0.1% in 2016. The major contributor to this change was the increase in crop lands to 9.7% in 2016 from the 4.3% in 1943. The urban land cover stayed nearly the same with only a slight increase.

> **The Upper Delaware Scenic and Recreational River**, added by the U.S. Congress in 1978 as the 19th component of the National Wild and Scenic River System, is exactly 73.4 miles long, extending from the confluence of the East and West Branches of the Delaware River above Hancock, NY downstream to Railroad Bridge No. 2 in Millrift, PA. This corridor is comprised of 55,575.5 acres of land. ***http://www,upperdelawarecouncil.org/about-us/history/***

This data supports the presence of both the current and historic natural resource based land uses. It also shows a stark contrast to other parts of the Catskill Region, where by the late 19th century, roughly 80% to 90% of the original forest was gone, leaving the steep hill slopes barren of mature vegetation that would retain rainfall and stabilized soils. With more rainfall hitting the ground and running off the hillsides, more water entered the small streams, draining these highlands and impacting the stream's stability. The streams eroded in response, becoming deeper, narrower and muddier resulting in the material that once lined the streams' bottom and sides to be swept downstream into bigger streams and eventually into the larger rivers in the basin.

The primarily forested landscape coupled with federal polices established to protect wild and scenic river corridors led to the federal designation of the Upper Delaware as a Scenic and Recreational River in November of 1978. This designation encouraged investment in public and private lands in the region to be used for environmentally friendly land uses and protected the river corridor for recreational and tourism based businesses. It also helped ensure the land cover of the region would continue to be forested, further supporting the predominant wood based businesses in the region.

15. Land Use

Land use is defined as the built environment and includes the management and modification of the natural environment. Land uses include the development of a built landscape such as downtown urban corridors as well as the working natural landscape for agricultural or natural resource industries. The land uses in the Upper Delaware Region can be described as primarily agrarian with small built landscapes that make up the more densely developed village and hamlet areas. Table 6, Map 6 and Map 7 illustrates the changes in land use types from 1943 to 2016.

First settled in late 18th century, the inhabitants of the UDR Tailwaters practiced subsistence farming settling along the edges of the waterways as a resource for food, water supply, energy, and transportation. By the late 19th century the regional economy had diversified with a focus on natural resource development and manufacturing. Businesses such as tanneries, mills, charcoal kilns and quarries sprung up throughout the watershed and locally produced manufactured goods could be more easily transported to larger markets due to nearby railroads[24]. The Upper Delaware River served as home to several acid factories that took advantage of the abundance of spoils from local sawmills.

Although acetate was produced in Delaware County as early as 1848, the wood chemical industry (known locally as “acid factories”) did not become a major industry until the 1870s. Using a process imported from Scotland these acid factories produced wood alcohol, creosote, wood ashes, acetate of lime, charcoal, wood tar and formaldehyde. The process required large amounts of hardwood and fresh water, making Delaware County an ideal location. From The History of Delaware County, 1797- 2007 by Tim Duerden, The UDR Tailwaters region was a prime location with acid factories located at Cadosia, Fernwood, Fishs Eddy, Hale Eddy, Harvard, Hazel, Horton, Readburn, Rock Rift, Shavertown, and Shinhopple.

> “Acid factories of the Northeast used only hardwoods, preferably birch, beech and maple. Acid factories commonly used scraps and treetops left over from a sawmill operation…” From The Wood Chemical Industry in the Delaware Valley by Frank Daniel Myers III

[24] Kudish, Michael. 2000. The Catskill Forest: A History. Purple Mountain Press, Ltd. Fleischmanns, NY.

Julius Corbett founded the acid factory in the town of Colchester during the first decade of the twentieth century and by 1912 the Corbett factory was one of the largest in the region (Duerden).

Using the Delaware River as a main transportation route, the UDR Tailwaters was dotted with sawmills and quarries that used the river to transport timber and stone to the growing urban market in Philadelphia. Timber would be harvested all winter and dragged to the river to be stored in the protected eddys along the shores. These businesses have been important throughout history and the tradition of timber harvesting, sawmills and bluestone mining continue today as a primary land use throughout the region.

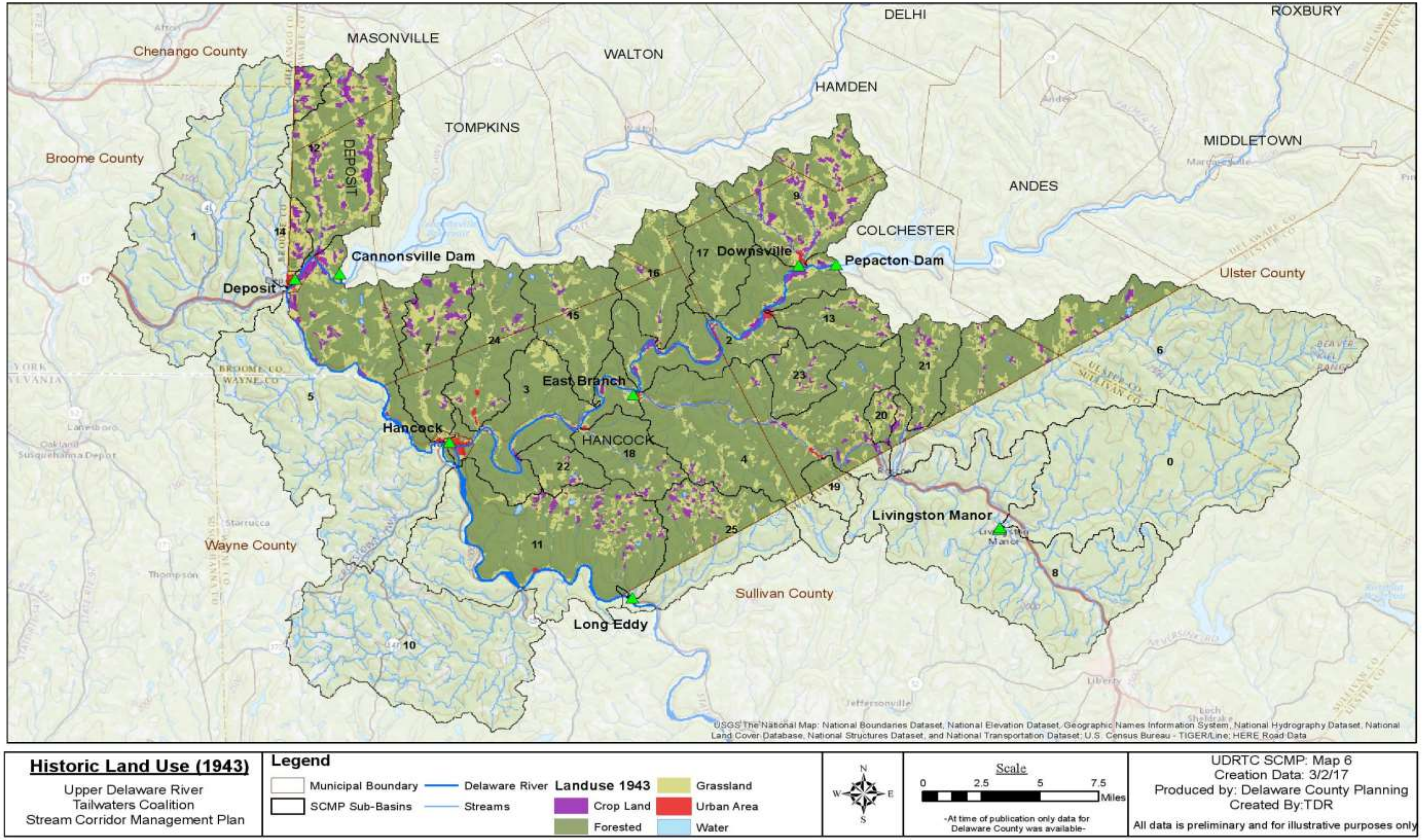
Due to the changing nature of the natural resource based businesses along with the introduction of new technology, the way the industry operated began to change in the mid-20th century. There was an increase in land conservation practices such as the introduction of reforestation policies and environmental accountability for development projects. These policy changes have made the timber and bluestone industries some of the most heavily regulated industries in the country. They are more accountable and encouraged to be good stewards of land. These changes account for an increase in forested land cover in the late 20th to early 21st century.

With little to no population growth, the region has seen land uses in the region become more tourist and recreation based. The 20th century brought tourism and recreational visitors to the region through the development of resorts and camps that cater to a summer population, taking advantage of the river and surrounding natural landscape. Tourism continues to grow each year as a dominant land use and has begun to shift to more vacant seasonal housing being constructed along the local waterbodies.

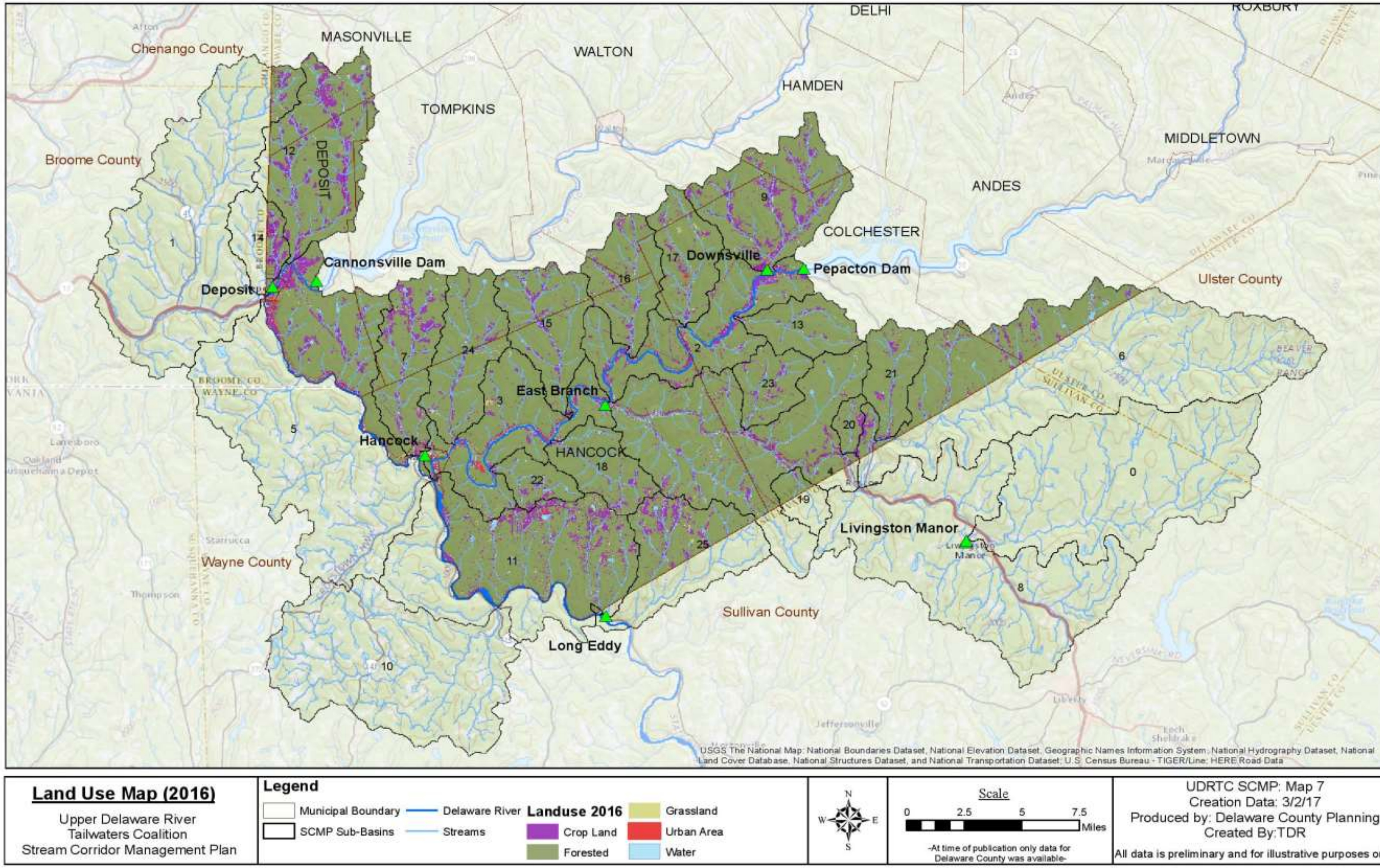
Land uses in the region have contributed to the narrowing and deepening of the streams due to a lack of buffer and an overuse of the floodplains for development. This has increased the threat of flooding and stream erosion making this the focus of many local communities in the region. Efforts to limit development in the floodplains, protect stream banks with buffer programs, and provide local laws and policies to protect these sensitive areas are among the many things local leaders are currently exploring.

Table 6: Land Use Types 1943 and 2016

Summary Table of 1943 and 2016 Land Use Types				
	1943		2016	
Land Use Type	Area (Square Miles)	Percentage of Watershed	Area (Square Miles	Percentage of Watershed
Forested	297.8	76.50%	339.5	87.20%
Grassland	69.8	17.90%	0.4	0.10%
Cropland	16.8	4.32%	37.8	9.70%
Water	3.92	1.01%	3.92	1.01%
Urban Area	1.1	0.28%	2.4	0.62%



Map 6: Historic Land Use (1943) within the UDR Watershed in Delaware County



Map 7: Delaware County Land Use within the UDR Watershed as of 2016

16. Flooding

The Delaware County All Hazards Mitigation Plan (AHMP) shows that flooding is the greatest threat from natural disasters throughout the County. Flooding is not only a major threat, it has proven to be costly to both the public and private entities in the county. The Towns of Colchester, Hancock and Deposit have not only experienced the large financial burden from flooding, but there have been six lives lost to flooding in the Tailwaters region in the past ten years. In 2004 flooding along Oquaga Creek in Deposit resulted in the loss of 2 lives and in 2007 a localized event in the Town of Colchester resulted in the loss of four lives. Maps 8 through 12 illustrate the flooding vulnerabilities of several municipalities within the SCMP project area.

Delaware County has the most federally declared disasters of any county in New York State with 33 declarations since 1950.

Since 1970, there have been 17 federally declared severe storm and flooding disasters and 4 undeclared events resulting in substantial financial impacts in Delaware County. In addition, there are annual events in the valleys that cause crop damage and damages to private properties. These are mostly unreported events that result in personal costs or flood/home owner insurance claims. Delaware County has the most federally declared disasters of any county in New York State with 33 declarations since 1950, with 23 of those declarations occurring since the year 2000. Severe storms, flooding and hurricanes account for 25 of the 33 declarations. These statistics, as reported by FEMA, are an indicator that climate change is causing more severe storms, resulting in flooding and increased costs to communities that have settled along the shores of streams and rivers.

An evaluation of the storm data shows the Tailwaters region has been most notably impacted by flood events associated with storms on August 28, 2011, June 19, 2007, June 28, 2006, April 2, 2005 and September 18, 2004.

The June 2006 flood event was the second most significant recorded flooding event in the Delaware River basin, however, it was the most costly. The flooding was wide-spread and resulted from extremely heavy rainfall during the June 24-28 period.

Village of Deposit - Photo Credit: George DeNys

According to the National Weather Service data 6-15 inches of rain fell in the watershed, causing streams to flash flood over roads, into homes, and across highways. New York State Route 17 was closed due to flooding and mudslides, while NYS Routes 268 and 30 were severely damaged closing them for weeks to traffic. Many local roads, bridges and homes were lost to heavy rains and swollen streams. This resulted in over $200 Million dollars in damages across Delaware County. At least 1,000 homes were either damaged or destroyed; hundreds of businesses were flooded; and over 500 people were evacuated. The Towns of Hancock and Deposit were most directly impacted, cutting them off from the rest of Delaware and Broome Counties for several days.

After the flood waters receded and roads began to reopen the recovery efforts began. The Towns were forced to make immediate decisions regarding their infrastructure and how they would proceed under emergency DEC permits for work in and around streams. This caused local controversy between conservation groups and the towns over the potential impacts to stream health and habitat protection. In many ways this was the beginning of the current efforts to provide for proactive stream management and local stream planning. As part of a long-term mitigation strategy, Delaware County sponsored a flood buyout to begin removing substantially damaged structures. In the Upper Delaware River Tailwaters region this resulted in the acquisition, demolition and natural site restoration of nine single family homes and one trailer park.

In the Town of Colchester, several large floods have been recorded on the East Branch Delaware River during the 60-year period since the Pepacton Reservoir was built in 1954. The four largest events over this period occurred in the last 15 years (September 18, 2004, April 3, 2005, June 28, 2006, and September 8, 2011).

The largest was on September 18, 2004 as a result of Tropical Storm Ivan. Remnants of Tropical Storm Ivan brought heavy rain to Delaware County. Between four and six inches of rain fell, causing flash floods. Most streams and creeks overflowed their banks. The East and West Branches of the Delaware River and the Beaverkill had major flooding. Seven people were rescued by State Police helicopter, 26 homes were destroyed, 60 homes suffered major damage, 60 homes had minor damage, 15 businesses were affected, and two campgrounds were destroyed. This was the worst flooding since Hurricane Diane in 1955. The County suffered approximately $14.5 M in damages.

Historically one of the most impactful floods in the Upper Delaware region occurred in October 1903. This event, known as the “Pumpkin Flood of 1903,” was caused by heavy rains from a hurricane which passed east of the Delaware River basin. The 1903 flood is the flood of record at Fishs Eddy on the East Branch Delaware River and at Hale Eddy on the West Branch Delaware River.

Emergency Flood Response

Flood response is a component of the Delaware County Comprehensive Emergency Management Program (CEMP). The CEMP consists of two volumes, Volume 1: The All Hazards Mitigation Plan (AHMP) and Volume 2: Delaware County Response and Recovery Plan.

On July 21, 2004, the first Delaware County Comprehensive Emergency Management Plan (CEMP) was adopted by the Delaware County Board of Supervisors. The plan was developed under authority Section 23 of the NYS Executive Law, allowing for counties to develop a plan to prevent, mitigate, respond, and recover from emergencies and disasters. The plan was developed in three phases: Risk Reduction (Mitigation), Response, and Recovery by a team of county departments:

1. Delaware County Emergency Services
2. Delaware County Public Health
3. Delaware County Planning Department
4. Delaware County Department of Public Works
5. Delaware County Sheriff's Office
6. Delaware County Public Safety Committee
7. Delaware County Social Services
8. New York State Office of Emergency Management

9. Delaware County Soil and Water Conservation District
10. New York State Police

In 2016 the CEMP was updated to combine all of the local planning efforts for emergency response, recovery, and remediation into one program to reduce duplication, eliminate contradictions and insure regular updates of all documents.

The development of the CEMP included an analysis of potential hazards that could affect the county and an assessment of the capabilities existing in the county to deal with potential problems. Authority to undertake this effort was provided by both Article 2-B of the State Executive Law and New York State Defense Emergency Act.

The Department of Emergency Services is designated to coordinate all emergency management activities for the county and assist with coordination of all local response efforts during an event. The Director of Emergency Services in conjunction with the Delaware County Chairman of the Board is responsible for opening and operating the Emergency Operations Center (EOC) and determining the level of response required based on the disaster. The EOC will remain open and operating until the Emergency Services Director has determined the response and recovery efforts are complete or within the ability of personnel to handle as part of the regular daily work load.

Once the immediate emergency response is over and recovery efforts are underway, the Delaware County Planning Director, who is the County's designated Hazard Mitigation Coordinator, becomes responsible for all county and local efforts to coordinate and prepare long term mitigation programs. This includes coordination with local officials, state and federal agencies and compliance with objectives of the adopted AHMP.

All Hazards Mitigation Plan

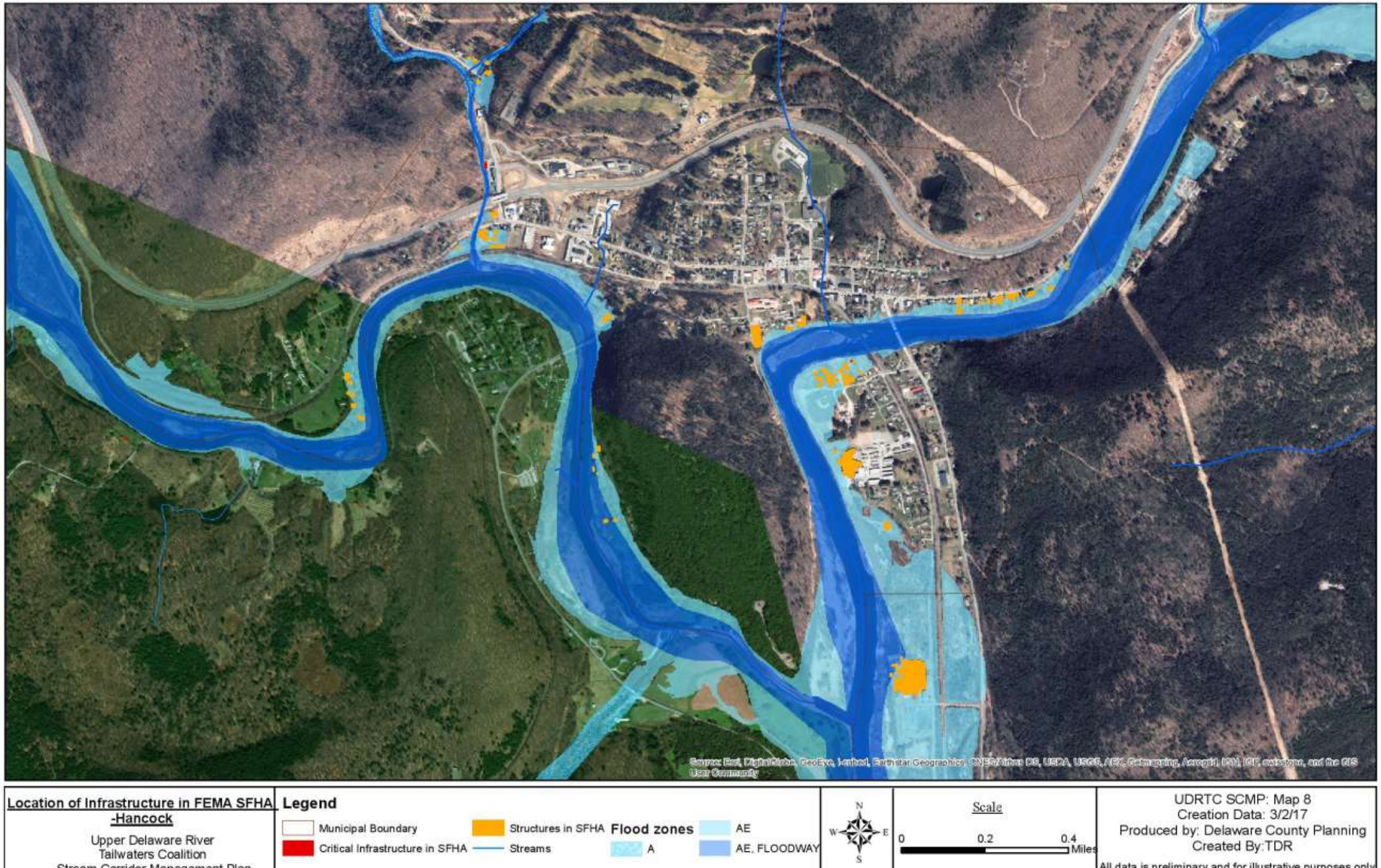
Hazard Mitigation is defined as any sustained action taken to reduce or eliminate the long term risk and effects that can result from specific hazards. The Federal Emergency Management Agency (FEMA) defines a *Hazard Mitigation Plan* as the documentation of a state or local government evaluation of natural hazards and the strategies to mitigate such hazards. The Disaster Mitigation Act of 2000 (DMA 2000), amended the 1990 Robert T. Stafford Disaster Relief and Emergency Assistance Act. Specifically, DMA 2000 requires that States, with support from local governmental agencies, develop hazard mitigation plans to prepare for and reduce the potential impacts of natural hazards. DMA 2000 is intended to facilitate cooperation between state and local authorities.

In February 2006 Delaware County, along with all 29 municipalities that make up the county, adopted the first Multi-Jurisdictional All Hazards Mitigation Plan (AHMP). The law requires an update of the plan be completed every five years and filed with FEMA. Without a current, adopted plan municipalities are not eligible for Pre-Disaster Mitigation (PDM) funding for projects through FEMA. This funding stream is one of the very few sources available to assist in funding projects that are intended to reduce or eliminate the threat of impacts from disasters. It is the intent of these programs to limit the need for future federal assistance associated with damages from disasters like flooding by removing the threat. The theory used by FEMA is that for every dollar spent (costs) on mitigation efforts there will be a dollar of savings (benefits) after the next disaster for that property.

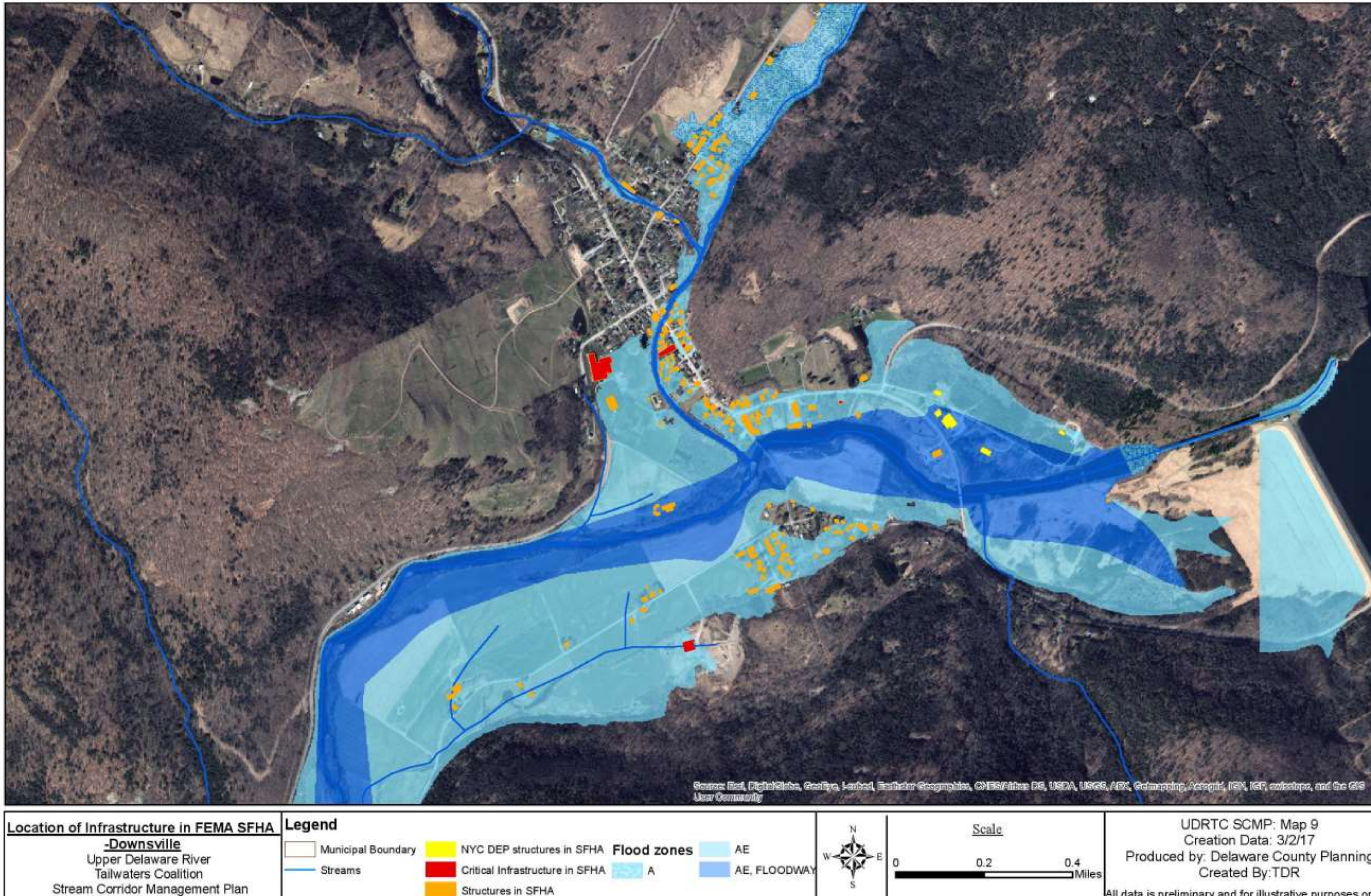
The plan was updated and re-adopted in 2013 and in 2016 it was incorporated into the Comprehensive Emergency Planning Program with the Comprehensive Emergency Management Plan (CEMP), Continuity of Operation Plans (COOP) and County Animal Response Team (CART) plans. The AHMP is currently being updated for re-adoption by the end of 2018.

Each municipality has an Annex in the AHMP that lists mitigation projects and their priority for completion. It is important to regularly update that list by removing completed projects and including new ones so that funding can be made available for mitigation strategies identified. Appendix 1 lists the overall objectives of the AHMP for the Towns of Colchester, Deposit and Hancock. Each community has identified projects that support improved hydraulic capacity of Town owned infrastructure, identifies specific stream stretches of concern, highlights the need to engage the public in the process of Hazard Mitigation and acknowledges the need to work with local, state and federal agencies to reach the goals identified. The AHMP is crucial to identifying, evaluating and prioritizing projects.

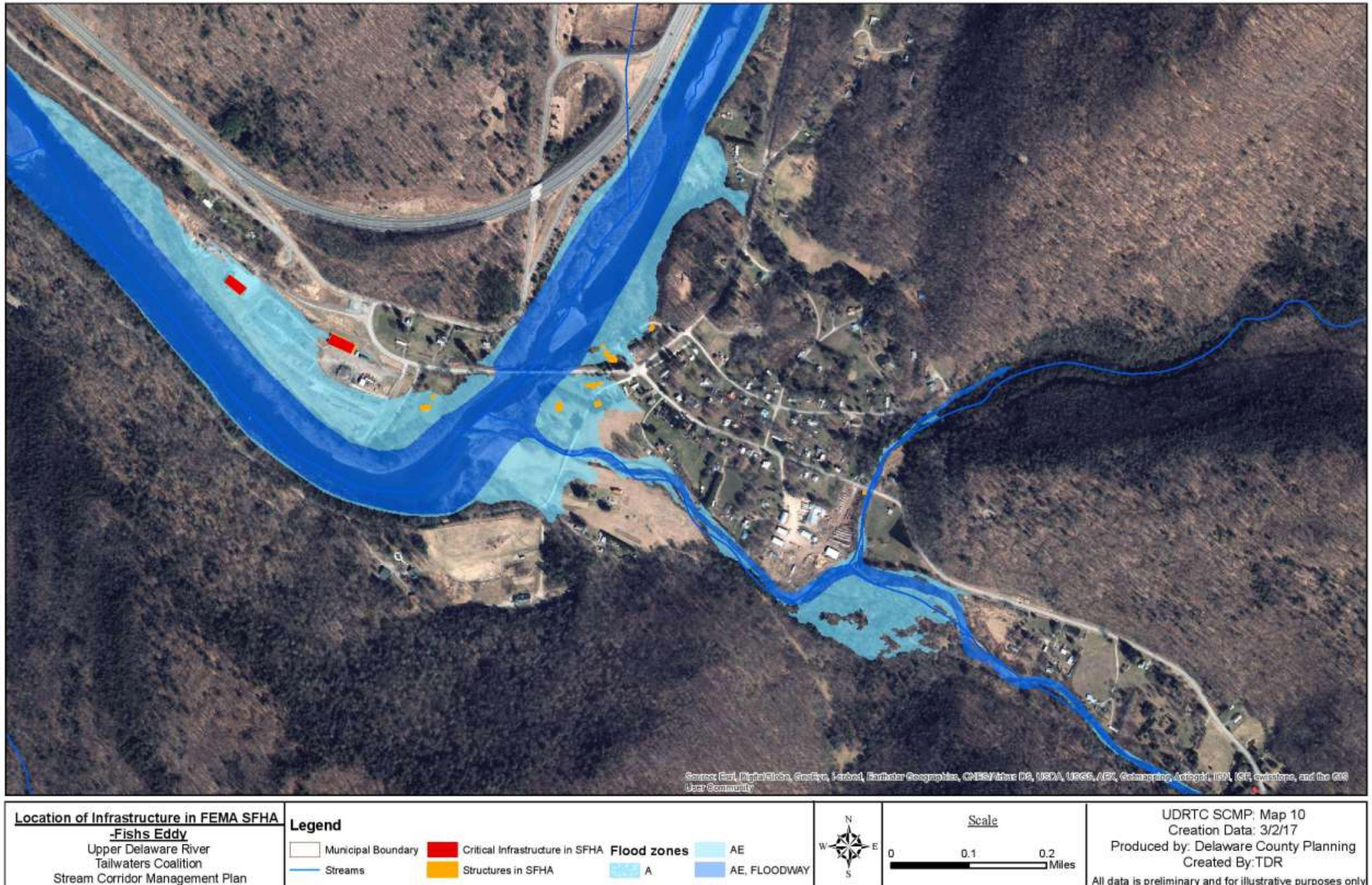
Town of Colchester AHMP Projects		Town of Deposit AHMP Projects		Town of Hancock AHMP Projects	
1	Resolve issues on Holliday Brook:	1	Address flooding issues along Columbia Lake Road:	1	Implement priority restoration projects identified in the Sands and Cadosia Creek Watershed Assessment prepared for Friends of the Upper Delaware and the Town of Hancock:
2	Resolve issues on Berry Brook:	2	Address stream/highway infrastructure issues at Silver Lake Road/Roods Creek crossing:	2	Develop a Gravel and Debris Management Plan:
3	County Route 17 Emergency Watershed Protection	3	Address stream/highway infrastructure issues at Hungry Hollow Road:	3	Upsize stream crossings on Houck Mountain Road
4	Upgrade all small drainage structures so the minimum size of driveway culverts is 18 inches and the minimum cross culvert size is 24 inches.	4	Replace retaining wall adjacent to County Route 19 along Butler Brook:	4	Upsize stream crossings at Peas Eddy
5	Retrofit structures located in hazard-prone areas to protect structures from future damage:	5	Address eroding streambank one-half mile from the intersection of County Route 20 and Secrest Road:	5	Retrofit structures located in hazard-prone areas to protect structures from future damage:
6	Acquire and demolish or relocate structures located in hazard-prone areas to protect structures from future damage:	6	Design and construct improvements to Airport Road to enhance traffic safety and emergency access	6	Acquire and demolish or relocate structures located in hazard-prone areas to protect structures from future damage:
7	Address dangerous trees threatening people and property through proactive vegetation management programs in conjunction with property owners and utility companies.	7	Retrofit structures located in hazard-prone areas to protect structures from future damage:	7	Address dangerous trees threatening people and property (particularly threatening roadways) through proactive tree-trimming (vegetation management) programs in conjunction with property owners and utility companies.
8	Use a watershed approach to address areas of excessive erosion, debris/gravel deposition and potential damage to infrastructure/property:	8	Acquire and demolish or relocate structures located in hazard-prone areas to protect structures from future damage:	8	Maintain compliance with and good-standing in the NFIP including:
9	Work with NYSDEC and land trusts to develop a method to manage debris removal from state-owned and other 'forever wild' lands	9	Study flooding issues along Airport Road downstream of the Oquaga Creek/West Branch Delaware River confluence	9	Have designated NFIP Floodplain Administrator (FPA) maintain Certified Floodplain Manager status through the ASFPM, and pursue relevant continuing education training such as FEMA Benefit-Cost Analysis.
10	Flood Risk Mapping and Analysis in the Delaware basins through the RiskMAP program	10	Maintain compliance with and good-standing in the NFIP including:	10	Participate in the Community Rating System (CRS) to further manage flood risk and reduce flood insurance premiums for NFIP policyholders:
11	Continue to deliberate adoption of East Branch Delaware River Stream Corridor Management Plan	11	Have designated NFIP Floodplain Administrator (FPA) maintain Certified Floodplain Manager status through the ASFPM	11	Archive elevation certificates
12	Maintain compliance with and good-standing in the NFIP including:	12	Archive elevation certificates	12	Training for municipal officials and staff:
13	Have designated NFIP Floodplain Administrator (FPA) maintain Certified Floodplain Manager status through the ASFPM, and pursue relevant continuing education training such as FEMA Benefit-Cost Analysis.	13	Training for municipal officials/staff and first responders:	13	Public education and outreach:
14	Participate in the Community Rating System (CRS) to further manage flood risk and reduce flood insurance premiums for NFIP policyholders:	14	Public education and outreach:	14	Continue to support the implementation, monitoring, maintenance, and updating of this Plan, as defined in Section 7.0.
15	Training for municipal officials/staff and first responders:	15	Continue to support the implementation, monitoring, maintenance, and updating of this Plan, as defined in Section 7.0.	15	Participate in local, county and/or state level projects and programs to develop improved structure and facility inventories and hazard datasets to support enhanced risk assessment efforts.
16	Public education and outreach:	16	Participate in local, county and/or state level projects and programs to develop improved structure and facility inventories and hazard datasets to support enhanced risk assessment efforts.	16	Develop Emergency Response procedure and evacuation routes for Frenchwoods Camp and family school.
17	Continue to support the implementation, monitoring, maintenance, and updating of this Plan, as defined in Section 7.0.	17	Explore the possibility of installing audible warning systems (sirens) for Cannonsville Dam emergencies	17	Provide back up communications during emergencies (phone, power)
18	Participate in local, county and/or state level projects and programs to develop improved structure and facility inventories and hazard datasets to support enhanced risk assessment efforts.	18	Enhance/ maintain mutual aid agreements with neighboring communities for continuity of operations.	18	Improve reverse 911 for cell service
19	Explore the possibility of installing audible warning systems (sirens) for Pepacton Dam emergencies. Warnings should be based on local knowledge of flood impacts as they correspond with flows of Pepacton Dam spillway.	19	Identify and develop agreements with entities that can provide support with FEMA/SOEM paperwork after disasters; qualified damage assessment personnel – Improve post-disaster capabilities – damage assessment; FEMA/SOEM paperwork compilation, submissions, record-keeping	19	Obtain back-up power (generators for shelter facilities including school, the Baptist church, and the medical facility.
20	Enhance and maintain mutual aid agreements with neighboring communities for continuity of operations.			20	Create/enhance/ maintain mutual aid agreements with neighboring communities for continuity of operations.
21	Periodically hold a meeting of people involved in disaster response in the municipality to review local emergency response procedures (as described in Municipal and Institutional Emergency Response Plans, Fire/EMS and Police procedures, Delaware County CEMP, etc.)			21	Identify and develop agreements with entities that can provide support with FEMA/SOEM paperwork after disasters; qualified damage assessment personnel – Improve post-disaster capabilities – damage assessment; FEMA/SOEM paperwork compilation, submissions, record-keeping
22	Identify and develop agreements with entities that can provide support with damage assessments and FEMA/SOEM paperwork after disasters				



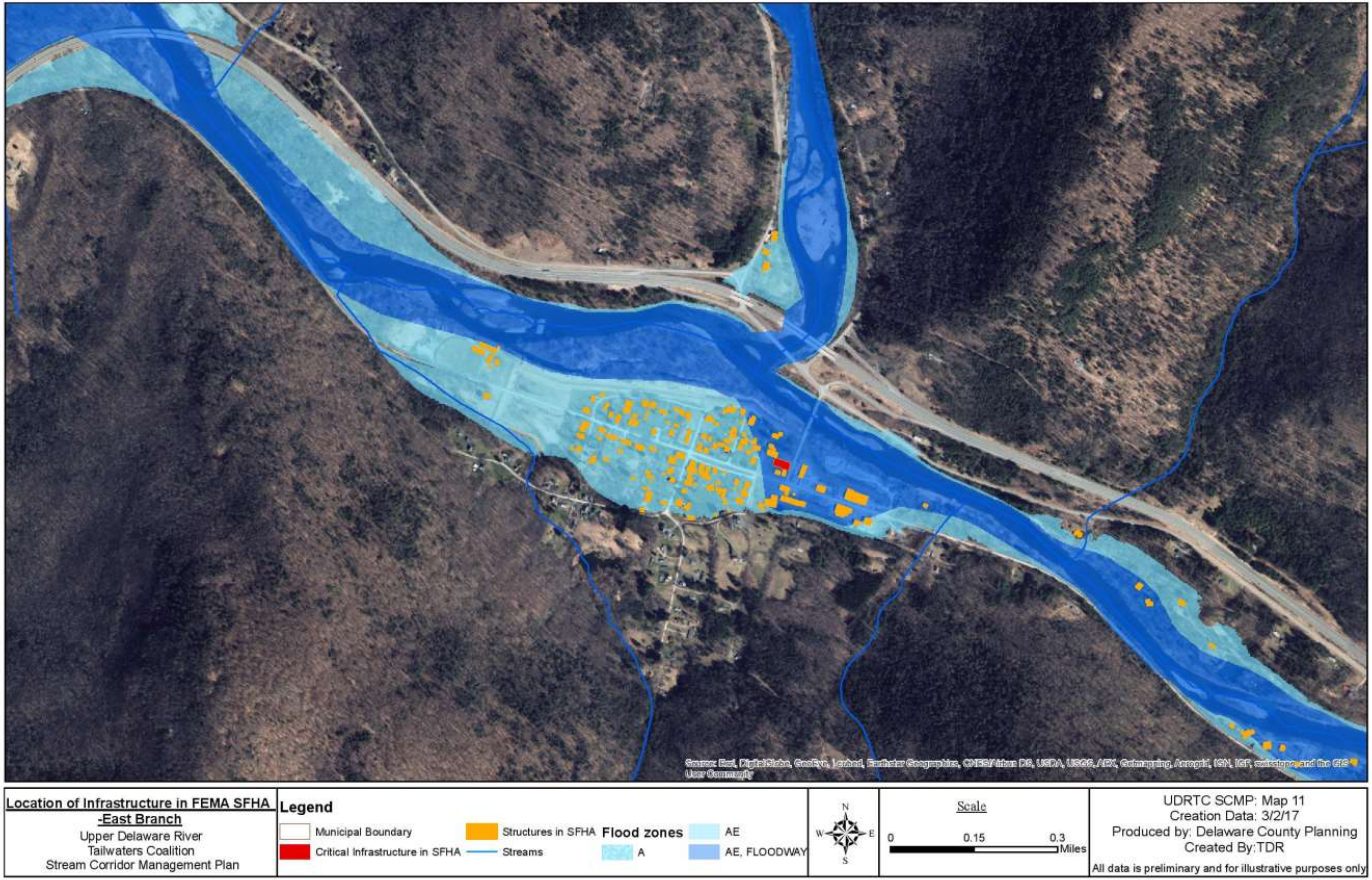
Map 8: Location of Infrastructure in FEMA SFHA – Hancock NY



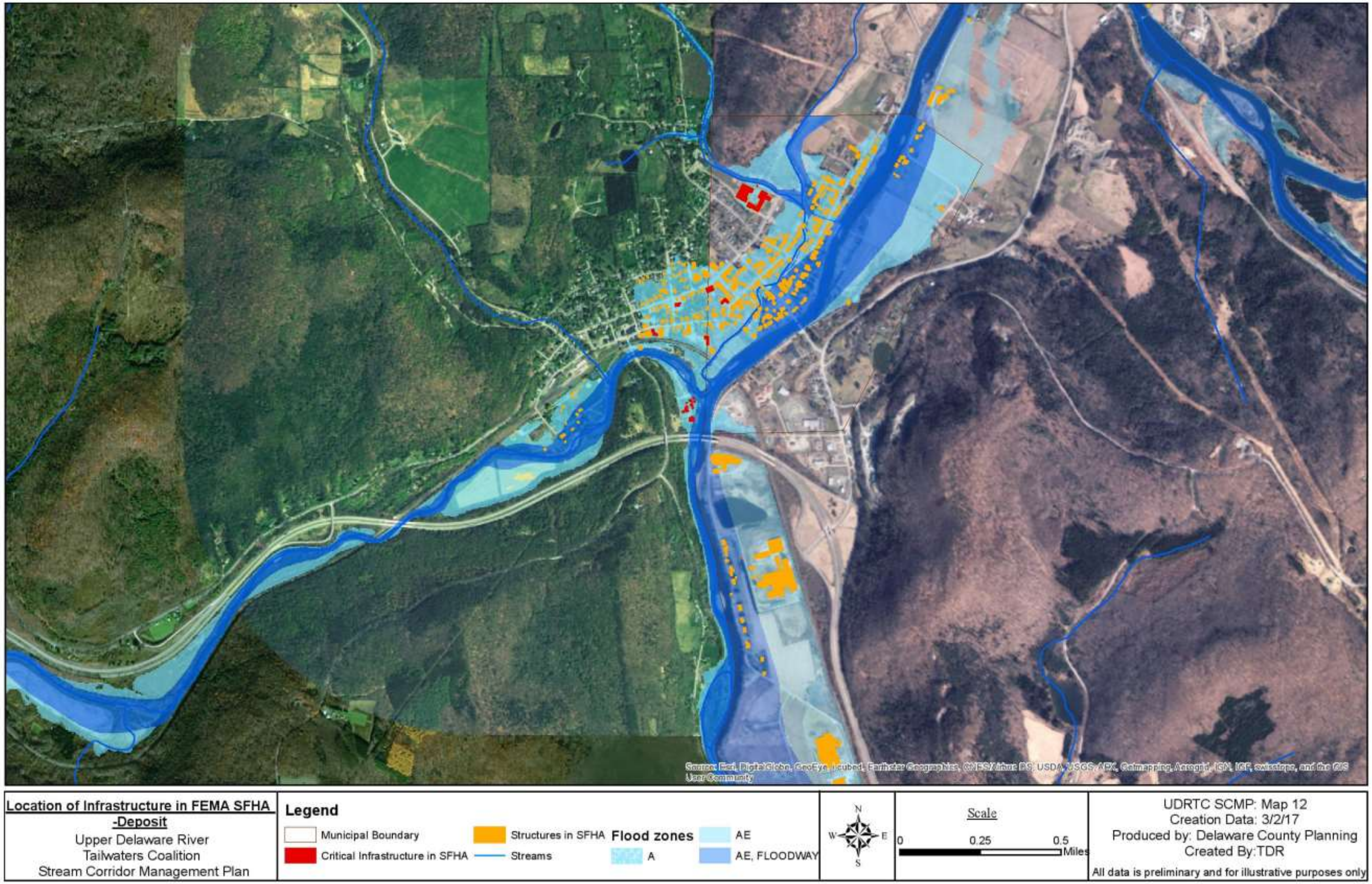
Map 9: Location of Infrastructure in FEMA SFHA - Downsville



Map 10: Location of Infrastructure in FEMA SFHA – Fishes Eddy



Map 11: Location of Infrastructure in FEMA SFHA – East Branch



Map 12: Location of Infrastructure in FEMA SFHA - Deposit

17. Flexible Flow Management Program (FFMP)

In 1954 the United States Supreme Court entered a decree in the case of New Jersey vs. New York, 347 U.S. 995 (1954) (Decree), to establish rights and obligations for New York City and New Jersey concerning water diversions out of the Delaware River Basin. The States of Delaware, New Jersey and New York along with the Commonwealth of Pennsylvania and New York City, were all named as parties to the Supreme Court decision and therefore became the Decree Parties. In 1961 the States of Delaware, New Jersey, New York and Pennsylvania along with the United States entered into the Delaware River Basin Compact. The Compact established the Delaware River Basin Commission (DRBC), which is comprised of representatives from each Compact partner. The DRBC was granted various authorities regarding water and associated management of the Delaware River Basin.

In 1954 the United States Supreme Court entered a decree in the case of New Jersey vs. New York, 347 U.S. 995 (1954) (Decree), to establish rights and obligations for New York City and New Jersey concerning water diversions out of the Delaware River Basin.

In 1982 the Decree Parties negotiated a Good Faith Agreement (GFA) for modification of diversions and releases out of the Cannonsville, Pepacton, and Neversink Reservoirs. The GFA specified allowances for modifications to accommodate drought-related diversions and releases as well as tailwater conservation releases.

In 2007 the Decree Parties agreed to a new reservoir management approach called the Flexible Flow Management Program (FFMP). The FFMP was intended to meet NYC water supply demands, protect fisheries habitat downstream of the New York City (NYC) Delaware Basin reservoirs, enhance localized flood mitigation, and repel the upstream movement of salt water in the Delaware Estuary.

The FFMP included a tailwaters habitat protection program with water release rates agreed upon in a joint fisheries white paper prepared by the New York State Department of Environmental Conservation and the Pennsylvania Fish and Boat Commission. The FFMP also included a discharge mitigation (dam spill reduction) program to prevent flooding below the dams. The FFMP is used in conjunction with a model known as the Operations Support Tool (OST) that determines diversions and release rates from the reservoirs based on reservoir capacity, anticipated water supply need, and estimated inflow to the reservoirs.

In 2017 the Decree Parties agreed to a new and revised 10-year FFMP. Three notable additions were included in the 2017 FFMP that will have an important impact on the UDR tailwaters. These include the adoption of two new programs to 1) eliminate erratic (aka “yo-yo”) water releases that can dramatically impact habitat conditions and 2) a “Thermal Protocol” to address dangerously warm water temperatures during summer months that threaten the viability of the world class wild trout fishery below the dams. The third addition was implementation of a 15 percent storage void in the three reservoirs from November 1st to February 1st to help reduce the threat of localized flooding below the dams from winter snow melt and spring rainfalls.

VII. Watershed Wide Goals

A series of public meetings were held in the UDR Tailwaters towns and villages. These meetings generated a significant amount of anecdotal and observational information from a wide variety of participants. The findings of the UDR SCMP’s community engagement activities and the computer based GIS analysis characterization of the UDR basin identified seven **Watershed-Wide Goals.**

Goals are general guidelines that explain what you want to achieve throughout the entire watershed. They are long-term and are considered a more generalized global representation of the overall vision for the UDR Tailwaters. There are ten goals for stream corridor management in the UDR Tailwaters.

Each goal listed here will be broken down into subbasin-specific objectives in Volume II. Objectives are measurable actions that can be achieved within a specified timeframe.

1. **Reduce Sedimentation and Erosion Hazards**
   Debris in stream channels and along the banks of streams has been proven to be one of the causes of catastrophic flooding, water quality degradations and a contributor to high erosion factors. Debris is anything that can become mobilized during high flows. Excessive erosion has led to an increase in sedimentation and debris recruitment. This results in the filling of channels or stream crossings increasing the likelihood of flooding, infrastructure damage, habitat degradation, and the diminishment of recreational opportunities. Through best management practices and stream restoration projects erosion hazards can be minimized in order to reduce the amount of material moving through the system. A healthy reach of stream will be able to mobilize the natural sediment load through the river system reducing the amount of gravel build up that has plagued much of the UDR area.

2. **Improve Water Quality**
   Chemical, physical, and biological characteristics of water, when out of balance, can negatively affect many aspects of our communities and those downstream. Water Quality is often a key phrase for regulators and politicians, however there is limited funding to address these concerns. Through scientific measures we can establish benchmarks and provide for goals that address water quality objectives. We know from other watersheds water quality can be improved by reducing turbidity, nutrients, and pathogens in the water. All other objectives provided for to improve stream health will help in this effort.

3. **Improve Economic Opportunities, Protect Existing Economic Assets**
   Promote resilient communities and support a vibrant, sustainable economy including recreation, tourism and resource-based industries. The abundance of natural resources including timber, stone, agricultural lands and recreational opportunities has been the heart of the local economy since the time of the original settlers. Each industry provides valuable job opportunities, income to other local businesses and provides for a strong local tax base. Preservation, protection and enhancement of each of these industries is essential to long term sustainability of the communities. A primary strength identified in the region is the support of local business leaders encouraging growth and providing for jobs, income and community identity. Preserving these resources is essential to the region's future.

4. **Reduce Threat to Public Infrastructure from Flood Inundation Hazards**
   The most costly impacts to the local tax payer is damage to public infrastructure during even small flood events. The public roadways along with the local sewer and water systems are the primary essential services provided by local governments. Damage to this infrastructure has far reaching impacts and costs. Without these public facilities local businesses are shut down, residents are stranded and life comes to a halt. It is essential to protect this infrastructure if a community is to remain sustainable. Through better engineering, a sound understanding of the hydraulics of the system and a robust plan to address the most critical impacts to public infrastructure we can reduce the threat and costs from future flood events.

5. **Reduce Threat to Public and Private Properties from Flood Inundation Hazards**
   Homes, businesses and agricultural operations within the mapped Special Flood Hazard Area (SFHA) are at risk of flood damage which negatively impacts living conditions, economic growth, and property values. These areas are recognized

by FEMA as having an increased risk from flood damage and are therefore more costly to develop and mitigate. Homes in these areas often require flood insurance as a security for a mortgauge making them difficult to sell, refinance and ultimately afford. This has implications on the property owner as well as the local tax base. It is important to remove critical public facilities as well as homes from these regions whenever possible and to mitigate impacts through acceptable flood prevention measures as defined by FEMA.

6. **Improve Stormwater Runoff Quantity and Quality**
   Stormwater can reduce water quality by transporting pollutants into streams, lakes, etc. Stormwater is defined as the water that runs off an area from a rain event. Stormwater can occur on impervious surfaces (parking lots, roofs) and non-impervious surfaces (agricultural fields). Pollutants can range from hydrocarbons (example, brake fluid) to nutrients (fertilizer). Through better highway management practices, land development practices and buffer initiatives stormwater runoff can be reduced and quality can be improved.

7. **Improve Fish Habitat**
   Cold water fisheries are an important economic driver in the UDR Tailwaters. Fish populations can be under duress for a variety of reasons including a lack of habitat and/or food sources, and fish passage barriers that disconnect habitat and lead to less genetic diversity. Warm water temperatures are detrimental to cold water fisheries. Turbidity caused by suspended sediment is an impediment to successful cold water fish populations. Insufficient riparian buffers are also a notable contributor to warm water temperatures. Through improvements to stream management, infrastructure repairs and continued cooperation with upstream partners and regulators the cold water fishery can be preserved and protected for future generations.

8. **Reconnect Disconnected Floodplains**
   Floodplains are a critical feature in stream health and flood hazard mitigation. Floodplains allow floodwaters to spill onto them, spreading flood volumes over a wider space. This increases flood storage, reduces downstream flood peak discharges and the damage they may cause. Floodplains can also store fine sediment and debris leading to improved water quality in streams after a flood. This storage capacity allows for better clean-up of debris as well as gravel and other sediments following a flood reducing impacts further downstream. Floodplains are often cut off from the stream by physical structures (roads, railroads, berms, etc.). Floodplain disconnection can also occur through an evolutionary stream process known as downcutting. Downcutting occurs when

the streambed elevation drops over time resulting in a deeper stream. A stream that has downcut and can no longer access its floodplains is considered incised. As stream reaches are assessed it is important to identify areas that can be used for floodplain connectivity or the development of flood benches to provide the important storage areas for flooding.

9. **Reduce Invasive Species Migration**
   Invasive plant and bug species have impacted the UDR Tailwaters causing native stream side plant species to be choked out and altering the make-up of vegetation that feeds the stream's eco-system. Additionally, invasive species often have shallow root systems that reduce the amount of protection from erosion that is created by the natural plant species that have traditionally grown in the region. The loss of tree species such as the native ash trees and some of the Elm lends itself to a smaller tree canopy, warming the waters and affecting the bug and fish habitat in the river system. Eradication of several species may not be feasible; however, a proactive approach to reduce the impacts of invasive species and slow the spread of these species is necessary for stream health.

10. **Improve Debris Management**
   Debris in stream channels and along the banks of steams has been proven to be one of the causes of catastrophic flooding, water quality impacts and a contributor to high erosion factors. Debris is anything that can become mobilized during a high water event in a stream channel causing problems during the course of its transport. Trees, loose brush, fuel tanks, hay bales and even household materials such as boards and tires contribute to the debris that gets stuck in culverts and bridges causing them to act as dams increasing flood waters behind them. These materials can also become projectiles moving swiftly through the water acting like bullets and leaving destruction of property in their wake. Management of debris can provide flood relief, and protect life and property.

VIII. Featured Subbasins

The Upper Delaware River Tailwaters Coalition identified three subbasins within the Tailwaters to feature in the SCMP. To maximize community engagement the featured subbasins are located near larger municipalities. The subbasins also represent a diversity of watershed characteristics to highlight the different challenges faced by the community. A thorough stream assessment was completed for the following subbasins (see Table 6).

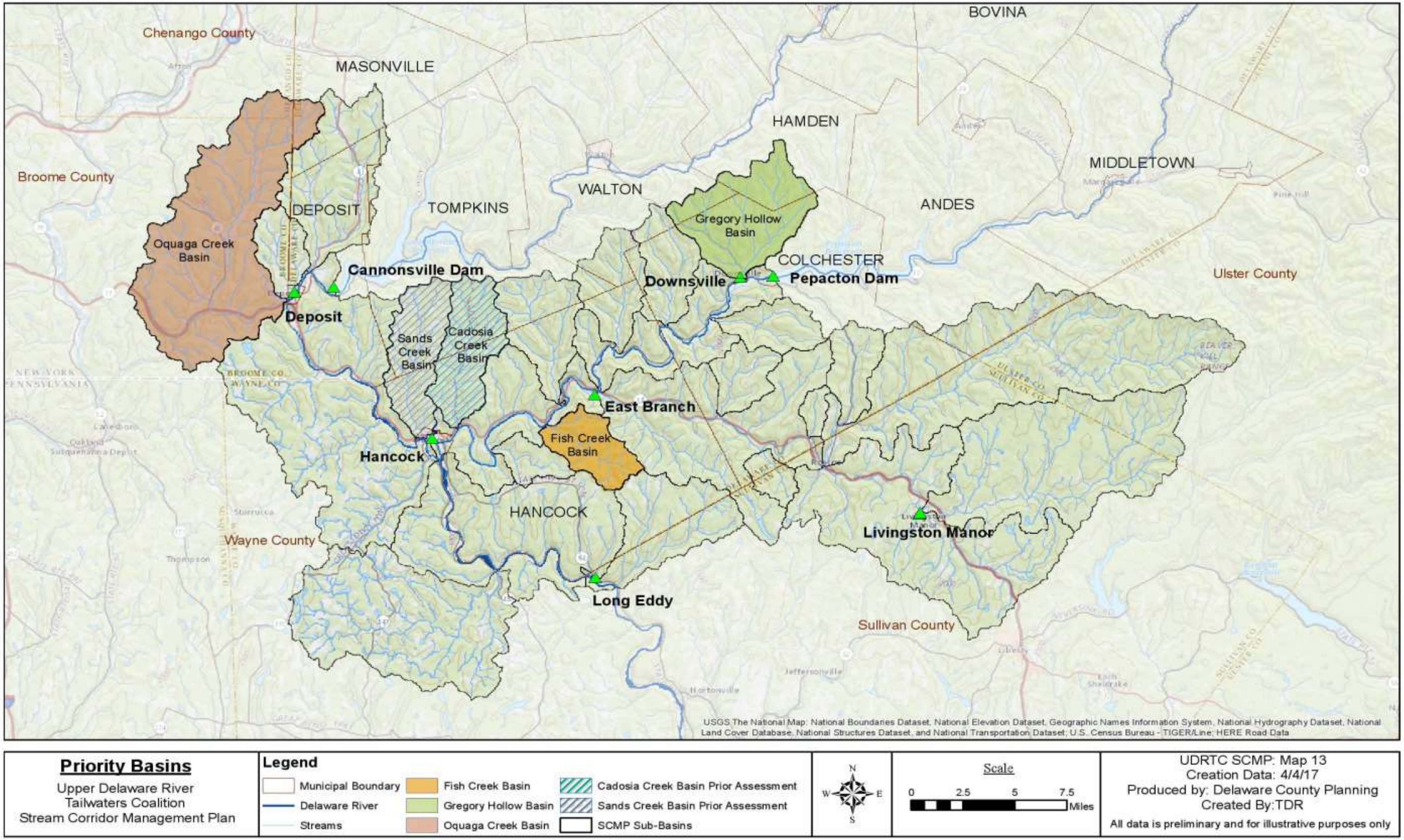
- Oquaga Creek, Towns of Deposit and Sanford
- Fish Creek, Town of Hancock
- Downs Brook (includes Wilson Hollow, Gregory Hollow and Telford Hollow), Town of Colchester

Stream inventories were completed in the featured watersheds during the summers of 2016 and 2017 to collect the data.

Additionally, extensive study of two subbasins in Hancock was completed by LandStudies in 2009 for Friends of the Upper Delaware River.

- Cadosia Creek, Town of Hancock
- Sands Creek, Town of Hancock

The map below shows the featured subbasins for the project area.



Map 13: SCMP Priority Basins

Oquaga Creek, Towns of Deposit and Sanford

Oquaga Creek flows from its headwaters in Sanford, Broome County, to where it joins the West Branch Delaware River in the Village of Deposit, Delaware County. The watershed drains 67.6 square miles of mixed secondary forest and agricultural lands. A thorough stream inventory of Oquaga Creek was completed during the summer of 2016 (see Table 6). Using the methodology presented in Chapter VIII, the inventory data will be analyzed in volume 2 to determine the watershed objectives which are relevant in Oquaga Creek.

All ten watershed-wide goals are applicable in the Oquaga Creek subbasin

Fish Creek, Town of Hancock

Fish Creek flows from its headwaters near Big Fork Mountain for just under 6 miles where it joins the East Branch Delaware River at Fishs Eddy. Located in the Town of Hancock of Delaware County, Fish Creek drains 11 square miles of mixed forest flowing adjacent to County Road 28 for a majority of its length due to its steep slopes and narrow valley bottom. The stream assessment of Fish Creek was completed during the summer of 2017 (Table 7).

Downs Brook (Wilson Hollow, Gregory Hollow and Telford Hollow), Town of Colchester

Downs Brook flows from its headwaters in Hamden, NY 9 miles along Gregory Hollow Road through the Hamlet of Downsville where it joins the East Branch Delaware River just downstream from the Pepacton Reservoir. Downs Brook drains from Tub Mills Falls, Wilson Hollow, Telford and Gregory Hollows.

Table 7: Stream Survey for featured Subbasins

Subbasin Statistics			
Featured Subbasin	**Oquaga Creek**	**Fish Creek**	**Downs Brook**
Drainage Area (miles^2)	67.49	11.21	27.1
Stream Length (feet)	103,468	29,945	92,884
Length of Eroding banks (feet)	4,939	3,634	2,549
% Eroding banks to total stream length	5%	12%	3%
Length of berm (feet)	950	none noted	220
% Berms to total stream length	1%	-	24%
Length of depositional feature (feet)	25,829	6,106	3,450
% depositional feature to total stream length	25%	20%	4%

IX. Implementation Plan

Volume 1 of the SCMP is primarily a planning process that provides watershed practitioners with important information about the UDR Tailwaters, a suite of management recommendations that serve as guideposts, an overarching set of broad water resource goals, and a methodology for identifying and prioritizing projects at the ground level to achieve those goals.

The second phase of the project will be laying the groundwork for implementation of the plan. This involves operationalizing the conceptual elements of Volume 1 in a “real world” sense.

1. **Identify Locations for Additional Data Collection**

   Utilizing best professional judgment and existing information and data including community input and GIS to identify areas where one or more impairments are contributing to a perceived problem in the watershed. Prioritize the impairments based on the severity of their impacts.

2. **Delineate Reaches and Collect Stream Inventory Data**

   A **reach** is defined as a unique, somewhat consistent section of stream. The beginning and end points of each reach have been selected based on breakpoints in the stream where physiographic conditions change. Examples of criteria that lead to a reach division include: stream size, valley width or confinement, valley slope and topography, land cover, meeting a tributary, and the presence of bridges. For example, Oquaga Creek is a watershed within the larger Tailwaters Watershed. Oquaga Creek has been further broken down into 19 reaches.

Stream Inventory Data (SI Data) is collected when field technicians walk the streams within a watershed. The intent of this data collection is to observe, map, measure and characterize the streams, their adjacent floodplains and proximal infrastructure. The data will be used to identify where in the watershed work can be completed contributing towards attaining a watershed's objective(s). The stream inventory was completed by interns working for the Delaware County Planning Department. The interns were trained and sent out to walk each of the three priority watersheds (Oquaga Creek, Downs Brook, and Fish Creek) as well as Campbell Brook, which will be included in Volume II, and documented the stream conditions through mapping and photographing.

3. Analyze Data and Identify Projects

Available data can be used to help develop projects that support the recommendation and Watershed Wide Goals developed during the planning process. As projects are identified, project specific objectives are defined (i.e. stabilization of stream bank, reconnection of floodplain, improvement of fish habitat). The projects objectives can then be used to help prioritize projects for implementation.

4. Prioritize Projects

The following Project Prioritization Matrix (Table 8) can provide a systematic way to prioritize projects for implementation to ensure that the projects meet the watershed-wide goals and provide the most benefit to the community and the resource. Project prioritization using the matrix is completed by evaluating several metrics. Each project is given a numerical score that can be used to compare projects and develop a prioritized list for implementation. Metrics used in the prioritization process include the level of community and landowner support and the cost effectiveness of the proposed work. Projects that address several watershed-wide goals will also be ranked higher.

Table 8: Project Prioritization Matrix

Project Prioritization Matrix			
Prioritization Metric	**Low (1 Point)**	**Moderate (3 Point)**	**High (5 Point)**
1. The project satisfies multiple watershed wide goals	The project contributes to the resolution of 1 watershed wide goal	The project contributes to the resolution of 2 watershed wide goals	The project contributes to the resolution of 2 or more watershed wide goals
2. Level of Public Support	Project application includes no evidence of public support	Project application includes one piece of evidence of public support	Project application includes more than one piece of evidence of public support
3. Ease of Acquiring Easements/Agreements	Two or more easements will be required	One easement will be required	Project will be completed on publicly owned land
4. Funding Availability	No identifiable funding source	One possible source of funding exists	More than one funding source exists
5. Level of Effort to Implement and Maintain	No obvious project sponsor or high maintenance costs	One project sponsor or moderate to high maintenance costs	More than one project partner or zero to low maintenance costs
6. Community Cohesion and Economic Development Protection	The project has no identifiable benefit to municipal capital.	The project has little to moderate benefit to municipal capital	The project has moderate to high benefit to municipal capital
7. Protection of Critical Infrastructure or Critical Transportation Corridor	The project does not protect or restore critical infrastructure or a critical transportation corridor	The project protects one piece of critical infrastructure or a minor critical transportation corridor	The project protects more than one piece of critical infrastructure or a major critical transportation corridor

5. Funding and Project Selection

The first and most important implementation step in putting the plan into action is to identify and secure funding that can support project leaders and invested watershed stakeholders. Fortunately, Phase 1 of the SCMP has already attracted the interest of several sources of funding at the national, state, and regional level. Examples include the National Fish and Wildlife Foundation (Washington, DC) and the Community Foundation for South Central NY (Binghamton, NY). Most of these sources of funding will come in the form of private foundation and government grants. One of the most important features of the SCMP is the support and engagement it engendered in its development from a wide variety of watershed stakeholders and the endorsement it has received from multiple governmental jurisdictions. It is truly a grassroots plan and with a strong foundation supported by five local governments and the UDR Tailwaters NGO community. These partnerships and the solid grassroots and community support for the plan should prove to be advantageous as project leaders seek funding for Phase 2 of the SCMP.

Another critical step in Phase 2 is to continue to generate deeper levels of data and other information about area waterways so that potential projects can be readily identified and prioritized. Additional community data can be collected from highway departments, building code enforcement officers, and community members in the future. Data can be collected regularly (annually, 5-years, etc.) or after an event. Community data can be collected as markups on maps but should be digitized to the ArcGIS shapefiles that were created as part of the Tailwaters SCMP development to allow for consistent data comparison.

As additional layers of watershed data are collected and organized, a larger list of potential projects will begin to emerge and more informed decisions can be made about their efficacy and value to the community. It is at this point that the methodologies and project identification steps outlined in Phase 1 can be ‘road tested” and refined.

As Volume 1 of the SCMP was under development, a number of waterway projects were identified that could serve as viable “demonstration projects” that will enhance Phase 2 of this project. These projects came to light for a number of reasons. Some received strong and unified public support that was clearly evident at the community outreach meetings while others were projects that are already in some stage of implementation (willing landowner, design complete, permitting secured, funding in place) with active sponsors. In Phase 2 of the SCMP, project leaders will prioritize these projects and actively seek support for their implementation. They include:

Sands Creek, Hancock, NY

The Sands Creek Restoration Project is located in the town of Hancock, NY. sponsored by Friends of the Upper Delaware River and Trout Unlimited located in the town of Hancock. Habitat improvements, primarily through the use of woody material and boulders, were installed in 2016 to enhance conditions for wild trout in approximately one mile of the stream known as “Site 5”.

Cadosia Creek, Hancock, NY

Lands Studies, Inc, a stream restoration firm based in Lititz, PA, has completed a conceptual design for the Cadosia Creek Restoration Project in the town of Hancock, NY. Friends of the Upper Delaware River and the town of Hancock are project sponsors. The project will address multiple purposes including enhancement of wild and native trout populations, sedimentation control and management, flood mitigation, and protection of infrastructure. The project requires funding and permits before construction can begin.

Oquaga Creek, Deposit, NY (Waste Water Treatment Plant)

The village of Deposit, NY operates a wastewater treatment plant at the mouth of Oquaga Creek where it drains to the West Branch of the Upper Delaware River. Numerous attempts have been made to stabilize the erosive banks that threaten the structural integrity of the plant. This project has been identified as high priority by the community for public safety, infrastructure needs, and water quality. A project design, funding, and permitting are all required for this site.

Gregory Hollow, Colchester, NY

The project will replace an existing culvert that conveys Tiffany Hollow Brook under Gregory Hollow Road. Gregory Hollow Road is a town road that lies within the Town of Colchester, Delaware County NY. The existing culvert is a barrier to aquatic organisms and is undersized. Tiffany Hollow Brook is conveyed through the culvert and has a water quality classification and standard of “C(ts)” meaning that it supports trout spawning. Tiffany Hollow Brook was last surveyed in 2010 during the Easter Brook Trout Joint Venture when young of the year, second year and older Brook Trout and Brown Trout were found.

Due to limited funding, the town currently cannot afford to properly replace this structure. The existing structure is a very old undersized boiler plate culvert with multiple cracks and a rusting out invert. Due to the poor condition of this culvert, there is a sink hole forming on the road surface. When this culvert is properly replaced and the barrier fixed, 3.696 miles of stream will be re-connected. This will be a great benefit to both Brook Trout and Brown Trout and the new larger culvert would convey a 100-year storm event.

The town has agreed to chip in $20,000 toward project match. In addition, they have agreed to satisfy eight bid items on the Opinion of Probably Construction Cost sheet totaling $26,850. The total match the town is able to provide is $46,850. The National Fish Passage Program will contribute $93,940 toward the completion this project.

Downs Brook, Downsville NY

Downsville has experienced many floods over the last several years. Following a past storm event, Downs Brook was dredged, straightened and large rock walls now line the stream bank, disconnecting the channel and its floodplain. In-stream habitat diversity and cover is lacking; the riparian vegetation is limited with little stream cover to protect and cool this important tributary. The project will include the excavation of a 20 ft wide floodplain bench for the entire 1,100 ft reach and the installation of 4-5 hardened riffles. In addition to the connecting the floodplain, 400-500 linear ft of large wood toe wood structure will be installed to provide deep water habitat and cover for fish. The entire site will be graded to extend the Town's Greenway and then the site will be planted with native trees and shrubs to help improve riparian habitat and help stabilize stream banks. This flood prone reach in the center of town is a great opportunity to demonstrate the importance of floodplain connectivity and habitat improvements while extending the Towns riverside recreation opportunities.

Oquaga Creek (Dewey Decker Property), Sanford NY

Oquaga Creek, a tributary to the West Branch Delaware River, flows through the Dewey Decker Farm in the town of Sanford NY. The stream banks are actively eroding, with erosion cutting into adjacent crop fields. Additionally, berms are present on the stream banks, preventing access to the stream's floodplain during flood events. Desirable trees and shrubs are sparse through this section of stream corridor.

The current combination of eroding stream bed and banks, lack of floodplain connection, loss of cropland and inadequate vegetation along both sides of the stream has resulted in the degradation of water quality and fish and wildlife habitat as well as negative economic impacts.

The proposal is to install stream stabilization practices to prevent future erosion and improve the riparian forest buffer along these problem areas. Stream and habitat restoration practices include rock riprap vanes, rock riprap at the toe of eroding banks and bioengineering. Berm removal will be necessary to reconnect the Oquaqa Creek to its floodplain. A diverse mix of native trees and shrubs will be planted adjacent to the streambanks to create a riparian forest buffer.

6. Monitoring and Tracking

The SCMP Volume establishes a foundation for the implementation of a systematic, comprehensive approach to watershed management, protection, and restoration of the UDR Tailwaters. It paints a picture of the watershed, creates methods on how to determine vulnerabilities and identify/prioritize waterway projects, establishes a set of demonstration projects, generates a suite of recommendations to guide the management activities of watershed practitioners, and lays out an implementation plan for the future.

Important monitoring and tracking activities to ensure the success of the SCMP should include:

1. The degree to which watershed practitioners incorporated the recommendations laid out in the SCMP
2. Continued evolution of a project prioritization inventory.
3. Progress on demonstration projects. Were they funded and permitted?
4. The success of the UDRTC and our partners to generate meaningful funding to implement additional projects.
5. Maintaining the ability to modify SCMP Volume 1 as new information is generated in subsequent phases

X. Stream Corridor Management Plan Recommendations

What follows is a series of waterway management recommendations for the UDR Tailwaters that are based on the public feedback received at the education and outreach meetings and from the advice of many project partners. All watershed practitioners and stakeholders are encouraged to use these recommendations to advance sound practices that effectively manage, protect, and restore area waterways.

1. The Role of the Stream Corridor Management Plan

1a. The approaches and recommendations outlined in the Stream Corridor Management Plan (SCMP) should be used by municipalities and other watershed practitioners as non-regulatory guidance for the future management and restoration of the waterways in the tailwaters.

The Stream Corridor Management Plan is a collaborative, multi-jurisdictional guidance document designed to assist tailwaters municipalities and agency personnel in future waterway management activities. It is not a regulatory document and does not carry any legal authority.

1b. The SCMP should be used by all communities within the watershed project area to ensure a comprehensive, holistic, and multi-jurisdictional approach to watershed protection in the Tailwaters.

Watersheds do not respect political boundaries and should be managed as whole systems with a collaborative approach that involves all watershed stakeholders including local government, state resource agencies, landowners, and Non-Governmental Agencies.

2. Securing Additional Funding and Resources

2a. Seek ongoing funding from federal, state, regional, and local sources to implement the recommendations in the SCMP.

The SCMP will be most effective when sufficient funding is secured to implement the management approaches and priority projects identified in the plan. A multi-jurisdictional community based plan such as this one should increase funding interest in plan implementation. All watershed stakeholders should be involved in identifying funding sources to implement the plan.

2b. Seek supplementary funding to complete a detailed analysis of the areas within the watershed but outside of the boundaries of the SCMP.

Portions of the Upper Delaware River watershed extend beyond the boundaries of the Stream Corridor Management Plan. These include areas in Broome, Sullivan, Ulster, and Delaware Counties in New York and Wayne County, in Pennsylvania. Every effort should be made by watershed stakeholders to secure additional funding to include those portions of the watershed in the SCMP

3. Expanding the Reach of the SCMP

3a. Work with municipal officials and other watershed stakeholders to expand the SCMP to include areas of the watershed outside the scope of this project.

While the SCMP has distinct boundaries and specified management activities within the project area it does not encompass the entire Upper Delaware River watershed below the NYC reservoirs. The goals and objectives of the SCMP are applicable to other municipalities outside the borders of the project area and every effort should be made to expand adoption and implementation of the plan in these areas.

3b. Use the methodology developed in the SCMP as a guide for further watershed analysis and project development.

The comprehensive approach in developing the SCMP, including expansive grassroots public engagement and buy-in to the plan, extensive "boots on the ground" field work, and a multi-jurisdictional approach to watershed planning establishes a baseline for watershed assessment and management approaches. Project leaders and other watershed stakeholders should continue to use this methodology to further refine, update, and expand this effort in the watershed.

3c. Promote the SCMP as a model document and methodology for other watershed planning efforts throughout the Delaware River watershed.

The methodology used to develop the SCMP is comprehensive and includes extensive public participation and science based approaches. This is not the structure of many watershed planning efforts in the larger Delaware River watershed which tend to be "top-down" and more difficult to implement on the ground. The SCMP should be promoted as a model and shared with other municipalities and water resource professionals throughout the Delaware River watershed.

3d. Utilize the SCMP to highlight Upper Delaware River watershed restoration and management needs in the U.S. Fish and Wildlife Service Delaware River Basin Restoration Project management plan.

The U.S. Congress enacted the Delaware River Basin Conservation Act in December of 2016. For the first time, the entire Delaware River watershed has a federally authorized, non-regulatory program with the potential to receive significant funding and technical resources to promote sound waterway management and restoration initiatives. The SCMP should be used as a baseline document to inform the U.S. Fish and Wildlife

Service as they identify resource needs and management approaches in the Upper Delaware River region in their larger basin wide plan.

4. Coordinating with Municipal Land Use Programs and Activities

4a. All municipalities in the project area should encourage the use of the SCMP to assist watershed planners and municipal officials in updating and integrating stream management principles into local land use programs such as municipal comprehensive plans, subdivision law, site plan review, floodplain development rules, stormwater management programs, and zoning laws where applicable.

The SCMP should be viewed as supplemental guidance with respect to all existing land use and waterway management programs at the municipal level. Local governments should make an effort, as appropriate, to incorporate the goals and objectives of the SCMP into all programs that govern waterway management activities.

4b. Encourage support for local natural resource based industries such as bluestone quarrying, timbering operations, and agricultural activities that engage in accepted environmental stewardship practices and contribute to the economic vitality and environmental quality of the region.

Longstanding natural resource based activities in the watershed are recognized in the SCMP as viable, important economic activities that add value to the region and play an important role in environmental stewardship. The goals and objectives of the SCMP should be applied to all land uses that intersect with water resources as a means of enhancing these activities and elevating their economic and ecological contribution to the region.

4c. Work closely with the managers of the Delaware County Action Plan (DCAP) for watershed protection and integrate the strategies and management approaches outlined in the Stream Corridor Management Plan into all relevant components of the DCAP.

The DCAP includes a proven and successful management approach to addressing watershed issues in Delaware County.

4d. Provide enhanced training opportunities for municipal officials, highway departments, resource agencies, and landowners on post-flood emergency intervention, management of highway stormwater programs, culvert/bridge maintenance, and floodplain development permitting following the model developed by the Delaware County Soil and Water

Conservation District and adopted by NYS Department of Environmental Conservation

One of the primary challenges to stream management in Delaware County is to ensure that resource managers and municipal officials receive the proper professional training to ensure the most modern methods are utilized when working in or near waterways. Every effort should be made to seek out training opportunities for town/village planners and other officials to build expertise and knowledge about the most effective methods to manage area waterways.

4e. Continue updating Highway Management Plans for all culverts/bridge crossings in the project area and encourage Highway Superintendents to maintain a database of all maintenance activities and ensure that these address engineering needs for hydraulic capacity and facilitating fish passage.

Highway managers are encouraged to maintain logs and databases of every activity they engage in associated with waterway management. This documentation serves as an important record of maintenance activities that should be regularly tracked in order to know what has happened at a particular site in the past and can inform future needs and actions.

4f. Develop uniform management approaches to ditch maintenance to ensure proper disposal of waste materials and proper channel configuration.

Ditches perform important drainage services in Delaware County for roadways and agricultural fields. Ditches should be viewed as part of the overall waterway system and best management practices should be applied at all times to enhance water quality and the ecological integrity of the watershed when ditch maintenance occurs while protecting public safety.

4g. Work in partnership with the National Park Service, Catskill Regional Invasive Species Partnership (CRISP) and other resource agencies to develop effective management approaches to control invasive species.

The introduction of invasive species such as Japanese Knotweed, Hogweed, and "Mile a Minute" vegetation can have significant adverse ecological impacts on area waterways. These foreign and pervasive plants crowd out other native species and accelerate soil erosion along streams and rivers. Existing programs to curb the spread of invasive plant species along waterways are implemented by the NPS and the CRISP *and the SCMP should be implemented in partnership with these agencies to maximize efforts to control these species.*

5. Improving the UDR Coldwater Ecosystem and Regional Economy

5a. The parties to the 1954 Supreme Court decision (The "Decree Parties") that governs the management of the New York City Delaware River basin reservoirs should ensure that the "2017 FFMP" supports consistent and sustainable water releases and maintain adequate water temperatures in the Upper Delaware River to maximize recreational opportunities and enhance local economies*.*

The management of the NYC Delaware basin reservoirs has enormous ecological and economic consequences for waterways in the Tailwaters. Cold water releases from the bottom of the dams dictate the health of the nationally recognized wild trout fishery and the recreational economy of the UDR region. The 5 Decree Parties (NY, NJ, PA, DE, and NYC) should adopt a long term reservoir management plan that ensures the health of the impacted reaches of the UDR ecosystem throughout the year.

5b. Encourage New York City's involvement and investment in watershed protection and restoration below the Pepacton and Cannonsville Reservoirs in alignment with the guidance and recommendations outlined in the SCMP.

Through the Flexible Flow Management Program (FFMP), the New York City Department of Environmental Protection (NYCDEP) does address some habitat and fisheries protection needs in the tailwaters below their Delaware system reservoirs. This is appropriate given the impacts the City's reservoirs and dams have on downstream ecological and economic conditions. Engagement by NYCDEP in the objectives the SCMP below their reservoirs should be encouraged as they increasingly recognize their role and responsibility below the reservoirs in Delaware and Broome counties.

5c. Initiate tributary restoration projects prioritized by the SCMP below the NYC Delaware River basin reservoirs that address ecological concerns such as erosion and accelerated sediment transport to ensure suitable aquatic habitat for fish, protect spawning conditions, and maintain high water quality.

Delaware and Broome County water resource managers, municipal officials, and conservation non-profit organizations should work together to encourage the involvement of NYC in water resource management below their water supply reservoirs. The impacts of the NYC reservoirs below the dams significantly impact flow conditions, *sediment transport, and water temperature and fishery conditions in the river below and NYC should be engaged as a responsible party to those outcomes.*

5d. Encourage waterway restoration projects that involve the creation of streamside buffers and the strategic placement of aquatic habitat improvements that protect water quality, mitigate the impacts of flooding, and protect wildlife without infringing on private property rights.

Stream buffers are proven approaches to improve the conditions of waterways for both economic and environmental considerations. The SCMP should promote the use of stream buffers as a conservation tool that are flexible, voluntary, and applied in site specific ways that fit local conditions.

SCMP should seek to optimize stream temperatures throughout the UDR watershed by promoting riparian revegetation activities, optimizing flow management, enhancing thermal refuge opportunities and tributary conservation and capitalizing on aquifer recharge opportunities.

6. Flood Mitigation and Erosion/Sedimentation Control

6a. Address excessive erosion and sedimentation problems in tributaries and encourage channel and bank stability and floodplain reconnection.

Implement management recommendations for restoration strategies and techniques that will address sediment and erosion problems. Highlight sensitive and critical areas that are highly erosive and cause excessive sedimentation to waterways in the project area. Identify opportunities to improve infrastructure, mitigate flood threats and identify sustainable flood response actions to protect communities and natural resources.

6b. Identify unmapped floodplain wetlands and look to conserve and enhance these wetlands.

A computer based assessment can be completed to identify areas not mapped by the USFWS or NYSDEC that could be areas for wetland protection, wetland enhancement or wetland creation. All of these activities would have benefits to stream health (water quality, flood protection, etc.).

6c. Locate historic dams and determine ecological impacts upstream and downstream and management needs.

Small dams dot the landscape of the Upper Delaware River watershed. These dams were used to power tanning mills and acid factories in late 1800's and early 1900's.

Many still remain in the tributaries of the river, often in a decayed state, and are the source of significant hydromodification impacts that can lead to excessive sedimentation and erosion.

6d. Evaluate the levee at East Branch developed by the Army Corps of Engineers as a flood mitigation levee

The East Branch Levee was constructed in 1972 by the Army Corps of Engineers as a flood mitigation measure. Changes in FEMA flood mapping and the standards that regulate the East Branch Levee as a flood control instrument have deemed the levee insufficient to be considered as protection from the 100-year or greater flood event, leaving the small community of East Branch in the Special Flood Hazard Area. This means the hamlet is susceptible to large or even catastrophic flooding without improvements to the levee to provide the additional needed protection.

7. Promote Regional Tourism Opportunities

7a. Update the 2014 Economic Study that quantifies the recreational and second home value of the Upper Delaware River cold water ecosystem.

The economic analysis of the recreational value of the Upper Delaware River in Delaware and Broome counties has proven to be an invaluable tool in promoting the importance of the river to people, communities, and the economic health of the region. This report should be a "living document" and efforts should be made to seek funding to update and refine the report in the coming years.

7b. Working with existing state/regional/local tourism promotion programs, create a branding and marketing campaign that promotes the high quality recreational experiences, such as fishing and boating, generated by the Upper Delaware River cold water ecosystem.

The Upper Delaware River region offers world class recreational opportunities such as fishing, boating, hiking, camping, biking and birdwatching. These activities fuel significant economic gains during the short recreational season. Many areas of New York State such as the Finger Lakes, Adirondacks, and Catskills have implemented branding a marketing campaign to showcase their natural resource attributes. A similar effort should be organized and funded for the Upper Delaware River region and marketed at a national level.

8. Selective Stream Gravel Management

The SCMP, NYCDEP, and the Delaware County Department of Watershed Affairs should work with the NYSDEC and U.S. Army Corps of Engineers to identify and fund an independent stream scientist or engineer to create a guidance document with recommendations on how, when and where to scientifically manage problematic gravel deposits within the Upper Delaware River system. Such a document might require a study. In this interim, the Delaware County SCMP Draft Stream Maintenance Protocol would be employed.

Throughout the development of this management Plan, several members of the public and local government leaders stated their belief that certain gravel deposits have had a harmful effect on streambank stability and flooding over the years. Numerous concerns have been expressed regarding current policies and regulations restricting gravel removal. The Stream Corridor Management Plan has the responsibility to investigate these issues and respond to these concerns by advancing discussion with the appropriate regulatory agencies.

The DCSWCD wishes to create an informed dialog among stakeholders about gravel and stream processes in the Upper Delaware River watershed. This dialog would share perceptions of and explore common goals between stream managers and the general public regarding sediment and woody debris mobilization, transport, and deposition. The goal would be to identify the information required to determine if and when an appropriate level of response should be exercised. The DCSWCD recognizes that in order to successfully advocate a specific plan of action regarding scientific gravel management, it must involve key regulatory agencies while developing a science-based understanding of local stream processes.

9. Coordinating with Regulatory Agencies

9a. Engage resource agencies such as the New York State Department of Environmental Conservation and the National Park Service on strategies and approaches recommended in the SCMP for all new or proposed regulatory and administrative actions that may impact communities and waterways within the project area.

State and federal regulatory authorities should be briefed on the management approaches outlined in the SCMP and be aware that the document was developed with *expansive public involvement. The goal is to engage and encourage partnerships with regulators so they support the goals of the SCMP. These agencies should view the document as supplementary guidance in any regulatory action that impacts waterways in the UDR tailwaters.*

9b. Regulatory agencies should use the SCMP as a reference document to assist in the evaluation of waterway projects such as stream stabilization efforts that require state and federal permits such as accumulated gravel deposits in waterways.

The SCMP includes specific and localized information and site-specific data on the UDR tailwaters. This is invaluable information for federal and state authorities who are responsible for permitting projects in area waterways. These agencies should consult the SCMP to assist them in their project evaluation and permitting activities.

9c. Work closely with relevant regulatory agencies to develop a protocol for inventorying floodplain/stream channel debris and accumulated gravel deposits and assist municipalities and communities with developing appropriate action plans to manage these impacts.

Local resource managers often have the best and most up to date information on waterway conditions and project needs in their towns and villages. This is especially true for floodplain conditions and debris build up in streams and rivers. Local resource managers should coordinate with other state and federal agencies on an accepted methodology for assessing these impacts and developing an action plan to manage these challenges.

10. Community Engagement/Enhancements

10a. Encourage the formation of local watershed associations who can use the SCMP as a blueprint for developing waterway protection and restoration plans*.*

Community based watershed organizations serve as the eyes and ears for their local waterways. They are most familiar with water quality issues and challenges such as public infrastructure because they live near their stream and have longstanding familiarity with challenges and conditions. Wherever possible, every major Delaware tailwaters tributary should have a watershed organization formed to address the site-specific needs of the stream at all times.

10b. Maximize the potential for enhanced water way related recreational activities such as greenways and streamside trail systems, parks, and boating and fishing opportunities in the Upper Delaware River watershed.

Communities throughout the country are now recognizing the economic and ecological value of promoting their waterways for recreational activities and tourist attractions. This is an approach that needs to be enhanced in the Upper Delaware River region. Municipal officials and watershed stakeholders should work together to create opportunities to enhance waterway conditions in a way that promotes outdoor activity, natural resource conservation, and water quality protection along their streams and rivers.

10c. Municipalities and other watershed stakeholders should procure additional weather monitoring equipment and the development of reporting methods that can be done in watershed sub-basins for the purposes of documenting weather and climate changes on local waterways.

Climate change is creating new challenges for waterway management as the intensity and frequency of storms increase. One of the first and most important actions that needs be employed is to gain a better understanding about how changes in weather patterns are impacting area waterways. Natural resource professionals and municipal officials should work together to institute weather tracking protocols that document impacts to streams and rivers as a means of developing innovative and modernized management approaches to mitigate these effects.

10d. Provide timely public updates and promote the procurement of advanced warning protocols in the watershed for flooding impacts and other reservoir management actions.

As the severity and frequency of weather patterns intensify, it is imperative that advanced warning protocols are put in place that provide area residents with timely information about potential impacts. These could include internet based systems that broadcast warnings with enough time to act, siren systems that are easily recognizable, and emergency based telephone systems. This is especially important for flooding concerns and reservoir management activities that may create public safety hazards and threaten loss of life.

10e. Encourage New York City to work closely with communities in the project area and implement the initiatives identified in their Emergency Response Plan.

NYC has developed an Emergency Response Plan for their reservoir system and they should be actively implementing all of the identified safety precautions and alert system called for in their plan.

11. Looking Towards the Future

11a. Municipalities should work together to develop a comprehensive list of prioritized stream projects in the targeted project area based on the ranking system and criteria developed in the SCMP.

Securing the necessary resources to implement waterway restoration and management projects is challenging and requires a systematic and well planned approach. Once potential stream projects are identified for a particular community, they need to be catalogued and scored through a criteria based ranking system that considers factors such as public safety, community need, aquatic habitat benefits, water quality, and flood mitigation. Through this kind of approach, funding sources can be more readily secured to address the most important projects first.

11b. Implement on-the-ground Waterway Projects

The most important measure of success is the ability to implement waterway projects that protect infrastructure and public health, mitigate flooding, and improve aquatic habitat.

The SCMP identifies priority projects where enhanced data gathering and other project preparatory work has already been completed. These projects should be implemented as rapidly as possible.

11c. Secure additional funding to supplement the data in the SCMP to provide a higher level of definition on area waterway conditions and specific protection and restoration management approaches.

Development and implementation of the SCMP should be viewed as iterative with ample opportunity to provide a higher level of definition as new information and technical resources become available to improve upon its initial findings. All watershed stakeholders should work together to secure additional funding to ensure that the SCMP increasingly adopts more precise analytical approaches that provide a more granular view of waterway conditions which will inform new and improved recommendations and management practices for area waterways.

11d. In cooperation with the SCMP Project Advisory Committee and the Community Advisory Councils, develop a process for periodically updating the SCMP.

The SCMP should be viewed as a "living document" that is constantly reviewed and updated as water resource needs change over time. Additional funding will be necessary to ensure that the SCMP remains a vital, relevant guidance document for watershed practitioners in the future.

XI. Appendices

a. Local Law and Planning Review, Shepstone Management
b. Community Input
c. Stream Project Implementation
d. Community Outreach Plan
e. Draft Stream Maintenance Protocol

Appendix 1:

Local Law and Planning Review

Town of Colchester Local Laws and Plans

Municipal Documents	Key Features	Observations
Fire Prevention and Building Code Enforcement Law	• Requires basic building permits and certificates of occupancy • Establishes administrative procedures and requirements for the application of the New York State Uniform Fire Prevention and Building Code in the Town of Colchester	• Establishes foundation for Flood Damage Prevention Law • Establishes potential foundation for site plan review by local law
Flood Damage Prevention Law	• Requires floodplain development permits subject to minimum standards established by the Federal Emergency Management Agency • Puts the Planning Board in charge of appeals and variances	• Town is permitted to establish more restrictive standards for purposes of stream corridor management • Development potential under law may be limited by NYC regulations • Puts Planning Board in a quasi-judicial role
Subdivision Law	• Establishes procedures for approval of land subdivisions • Establishes construction standards for certain improvements • Requires installation or bonding of improvements • Creates minor and major classes of subdivisions based on lots created • Establishes waiver procedure for boundary line adjustments • Requires subdivision approval for conservation easement creation • Creates a "Subdivision Inspector" to ensure improvements installed	• Doesn't address land development other than subdivisions • Doesn't establish or link to a minimum lot area standard • Has no provision for clustering or conservation subdivisions • Doesn't address multi-family development • "Subdivision Inspector" given authority that belongs to Town Board • Major subdivision classification should be based on the need or lack of need for improvements, rather than just lot numbers • Doesn't incorporate any particular stream protections • Boundary line adjustments should be exceptions, not waivers • Lacks significant stormwater and floodplain standard references
Town of Colchester Comprehensive Plan	• Includes detailed background studies on Town of Colchester • Includes goals and strategies to: > Protect steep slope areas through CEAs, TDR, special districts, incentives and a site plan review law > Require setbacks of septic systems from streams > Establish a site plan review law for stream protection, etc. > Work with Delaware County to implement DCAP > Employ SEQRA more effectively > Enhance the visual character and economy of Downsville > Strengthen the role of all hamlets through site plan review, etc. > Promote the bluestone and forestry industries > Economically promote Downsville and the Town of Colchester > Require site plan review for structures over 400 square feet > Improve the aesthetic character of the Town using a combination of site plan review and beautification/enhancement intiatives > Ensure emergency services are adquately supported > Improve the enforcement of local laws > Promote infrastructure development using new techniques > Improve recreational opportunties, particularly on NYC land > Promote historic preservation, resources and industries > Encourage senior, accessory apartment and affordable housing > Update road standards to reduce widths and impacts while ensuring safe levels of service are maintained and avoiding burdens on the Town budget > Open up NYC lands to timbering, quarrying and recreation > Promote a walter filtration system for the NYC water supply	• Plan largely based upon a site plan review law yet to be adopted • Several recommendations stretch the legal authority of the Town absent a site plan review law • Proposed road standards differ from Subdivision Law
Delaware County Hazard Mitigation Plan (Town of Colchester)	• Identifies hazard vulnerabilities in Town (mostly flood-related) • Documents losses (mostly storm and flood-related) • Identifies and ranks hazard risks • Assesses emergency management capabilities (including laws/plans) • Documents hazard mitigation activities and vulnerabilities • Proposes hazard mitigation initiatives including several structural items plus a watershed approach to address erosion, debris/gravel deposition, priortization of intervention to protect infrastructure and property and flood risk mapping and reduction • Analyzes and prioritizes hazard mitigation initiatives	• Includes numerous projects that should be part of Stream Corridor Management Plan implementation • Some planning measures suggested will require more in the way of site plan review to reduce future risks • Floodplain regulations are more permissive than risks identified in plan suggest are appropriate but may also simply recognize the reality there is significant property and improvements in otherwise developable floodplains

Village of Deposit Local Laws and Plans

Municipal Documents	Key Features	Observations
Flood Damage Prevention Law	• Requires floodplain development permits subject to minimum standards established by the Federal Emergency Management Agency	• Village is permitted to establish more restrictive standards for purposes of stream corridor management
Zoning Law	• Very basic zoning ordinance with few supplementary standards • Creates seven zoning districts four residential, two commercial and one industrial district • Includes special standards for car washes, gas stations, etc. • Establishes site plan review procedure • Provides for existing non-conforming uses	• Doesn't address cluster or multi-family issues in any detail • No particular storm water management provisions, outside of the NYC watershed area • No apparent integration with flood, driveway or road standards • Doesn't address many other land uses that could require attention • Doesn't address stream protection specifically
Subdivision Law	• Establishes procedures for approval of land subdivisions • Establishes construction standards for certain improvements • Requires installation or bonding of improvements • Creates minor and major classes of subdivisions • Establishes waiver procedure for boundary line adjustments • Includes erosion control requirements • Limits development of 15% slopes or greater • Includes environmental performance standards	• No flood plain regulation coordination involved • Some provisions regarding storm water management • Doesn't provide for financial performance with respect to maintenance of storm water or other improvements
Delaware County Hazard Mitigation Plan (Village of Deposit)	• Identifies hazard vulnerabilities (mostly flood and storm related) • Documents losses (mostly storm and flood-related) • Identifies and ranks hazard risks • Assesses emergency management capabilities (including laws/plans) • Documents hazard mitigation activities and vulnerabilities • Proposes hazard mitigation initiatives including storm water system upgrade protecting drinking water, flood-prone structure removal/retrofit, priortization of intervention to protect infrastructure and property and flood risk mapping and reduction • Analyzes and prioritizes hazard mitigation initiatives	• Includes numerous projects that should be part of Stream Corridor Management Plan implementation

Town of Deposit Local Laws and Plans

Municipal Documents	Key Features	Observations
Flood Damage Prevention Law	• Requires floodplain development permits subject to minimum standards established by the Federal Emergency Management Agency • Puts the Planning Board in charge of appeals and variances	• Town is permitted to establish more restrictive standards for purposes of stream corridor management • Puts Planning Board in a quasi-judicial role
Site Plan Review Law	• Requires site plan review for most new land developments except for one and two-family dwellings, agricultural uses and commercial structures additions of less than 25% • Establishes procedures and review criteria for applications • Establishes standards for: > Minimum lot area (1 acre) and stream setback (100 feet) > Traffic access management > Erosion control and storm water management > Vacation rentals > Stone processing facilities > Sewer and water > Flood hazard areas > Freshwater wetlands > Signage > Home occupations > Cellular towers > Lot development (1 acre lot area, 25% coverage, etc.) > Parking and loading standards > Lighting > Noise and odors > Landscaping > Protection of stream protection and other waterbodies > Wind turbines > Multi-family dwellings > Manufactured homes • Creates a Board of Appeals to handle variances • Grandfathers existing non-conforming uses	• Stream protection standards require review and approval of any watercourse alterations for water quality impacts, etc. • Storm water management provisions address the issue of facility maintenance, which many such regulations do not • Encourages avoidance of floodplain areas for new development
Subdivision Law	• Establishes procedures for approval of land subdivisions • Establishes construction standards for certain improvements • Requires installation or bonding of improvements • Creates minor and major classes of subdivisions • Establishes waiver procedure for boundary line adjustments • Includes detailed road standards • Defines conservation easements as subdivisions • Includes erosion control requirements • Restricts residential development in flood hazard areas • Limits development of 15% slopes or greater • Includes environmental performance standards • Includes soil testing requirements for purposes of sewage planning, setting minimum lot areas of up to 2 acres and a 100 feet water setback	• Doesn't effectively address clustering
Town of Deposit Comprehensive Plan	A well-prepared document including thorough background studies, goals and specfic recommendations, including, but not limited to: > Providing a public forum for informational and educational sessions pertaining to such issues as private septic maintenance, well system maintenance, wetlands, floodplain development, mining, etc. > Promote the town as a premier trout fishing location > Petition NYC-DEP and DRBC to secure better reservoir releases > Develop water quality standards and resource protection regulations through the development of Subdivision and Site Plan Review laws > Explore development of municipal water supply systems for Silver Lake, Crystal Lake, Columbia Lake, Roods Creek, Hale Eddy and Stilesville	• Site Plan Review and Subdivision Laws implement major recommendations
Delaware County Hazard Mitigation Plan (Town of Deposit)	• Identifies hazard vulnerabilities (mostly flood and storm related) • Documents losses (mostly storm and flood-related) • Identifies and ranks hazard risks • Assesses emergency management capabilities (including laws/plans) • Documents hazard mitigation activities and vulnerabilities • Proposes hazard mitigation initiatives including several structural items plus a watershed approach to address erosion, debris/gravel deposition, priortization of intervention to protect infrastructure and property and flood risk mapping and reduction • Analyzes and prioritizes hazard mitigation initiatives	• Includes numerous projects that should be part of Stream Corridor Management Plan implementation including infrastructure projects as well as buyouts and retrofits of flood-prone structures

Village of Hancock Local Laws and Plans

Municipal Documents	Key Features	Observations
Flood Damage Prevention Law	• Requires floodplain development permits subject to minimum standards established by the Federal Emergency Management Agency	• Village is permitted to establish more restrictive standards for purposes of stream corridor management
Zoning Law	• Very basic zoning ordinance with few supplementary standards • Creates six zoning districts (two residential, two commercial, one industrial and one floodplain overlay district) with lot standards typically basec upon avaiability of community sewer and water services • Includes special standards for campgrounds, manufactured home parks • Establishes site plan review procedure • Provides for existing non-conforming uses • References Flood Damage Prevention Law • Includes a required building setback of 100 feet from any water body in the case of waterfront lots along streams, lakes, ponds and rivers	• No linkage to the Upper Delaware Land & Water Use Guidelines • No particular storm water management provisions, although there is apparently a separate ordinance from 1983 addressing some aspects • No apparent integration with driveway or road standards • Doesn't address many other land uses that could require attention • Could address stream access in more detail • Doesn't address cluster, multi-family or subdivision issues in any detail
Comprehensive Plan	• A very basic Comprehensive Plan apparently adopted in 1984 • Lays the foundation for the Village Zoning Law • Mostly a demographic and opinion analysis	• Very out-of-date with little relationship to current Zoning Law • Doesn't address current infrastructure status or needs • Takes no particular account of flooding issues
Delaware County Hazard Mitigation Plan (Town of Hancock)	• Identifies hazard vulnerabilities (mostly flood and storm related) • Documents losses (mostly storm and flood-related) • Identifies and ranks hazard risks • Assesses emergency management capabilities (including laws/plans) • Documents hazard mitigation activities and vulnerabilities • Proposes hazard mitigation initiatives including storm water system upgrade protecting drinking water, flood-prone structure removal/retrofit, priortization of intervention to protect infrastructure and property and flood risk mapping and reduction • Analyzes and prioritizes hazard mitigation initiatives	• Includes numerous projects that should be part of Stream Corridor Management Plan implementation • Floodplain regulations are more permissive than risks identified in plan suggest are appropriate but may also simply recognize the reality there is significant property and improvements in otherwise developable floodplains

Town of Hancock Local Laws and Plans

Municipal Documents	Key Features	Observations
Flood Damage Prevention Law	• Requires floodplain development permits subject to minimum standards established by the Federal Emergency Management Agency • Puts the Planning Board in charge of appeals and variances	• Town is permitted to establish more restrictive standards for purposes of stream corridor management • Puts Planning Board in a quasi-judicial role
Site Plan Review Law	• Requires site plan review for most new land developments except for one and two-family dwellings, agricultural uses and commercial structures of less than 4,000 square feet • Establishes procedures and review criteria for applications • Establishes standards for: > Sight distances > Storm water management > Lot development (1 acre lot area, 25% coverage, etc.) > Parking and loading standards > Lighting of non-residential properties > Noise > Access > Lake and stream protection > Wind energy facilities > Multi-family dwellings and townhouses > Manufactured housing • Creates a Board of Appeals to handle variances • Grandfathers existing non-conforming uses	• Lake and stream protection standards designed to limit pressure on waterfronts and control intensity of use, complement Upper Delaware Land & Water Use Guidelines and restrict stream alterations • Storm water management provisions address the issue of facility maintenance, which many such regulations do not • Access standards require driveways to have a negative 2% grade within 50 feet of street centerline
Subdivision Law	• Establishes procedures for approval of land subdivisions • Establishes construction standards for certain improvements • Requires installation or bonding of improvements • Creates minor and major classes of subdivisions • Establishes waiver procedure for lot improvements • Includes detailed road standards • Includes a lake access provision • Includes storm water management provisions an erosion control performance standards	• Doesn't establish or link to a minimum lot area standard • Encourages clustering but sets no standards for it • Doesn't incorporate any particular stream protections • Should reference Hancock floodplain, road and site plan review laws although generic linkages to such standards are made
Delaware County Hazard Mitigation Plan (Town of Hancock)	• Identifies hazard vulnerabilities (mostly flood and storm related) • Documents losses (mostly storm and flood-related) • Identifies and ranks hazard risks • Assesses emergency management capabilities (including laws/plans) • Documents hazard mitigation activities and vulnerabilities • Proposes hazard mitigation initiatives including several structural items plus a watershed approach to address erosion, debris/gravel deposition, priortization of intervention to protect infrastructure and property and flood risk mapping and reduction • Analyzes and prioritizes hazard mitigation initiatives	• Includes numerous projects that should be part of Stream Corridor Management Plan implementation • Floodplain regulations are more permissive than risks identified in plan suggest are appropriate but may also simply recognize the reality there is significant property and improvements in otherwise developable floodplains

Town of Sanford Local Laws and Plans

Municipal Documents	Key Features	Observations
Land Use Management Law	• Blend of a zoning and site plan review law • Creates three residential, one agricultural, one commercial, one industrial, one other and one lake protection overlay districts • Establishes procedures and review criteria for applications • Establishes standards for: > Minimum lot area (1-2 acres) > Parking and loading > Signage > Gas stations > Cellular towers > Protection of lakes and other waterbodies > Cell towers > Sawmills > Adult uses • Creates a Board of Appeals to handle variances • Grandfathers existing non-conforming uses	• Stream protection standards include 35' setback and erosion performance criteria • Storm water management not addressed in any detail • No integration with floodplain regulations • No multi-family standards • No integration with road standards (Town has some, including road preservation law • No integration with mobile home regulations
Subdivision Law	• Establishes procedures for approval of land subdivisions • Establishes construction standards for certain improvements • Requires installation or bonding of improvements • Creates minor and major classes of subdivisions • Establishes waiver procedure for boundary line adjustments • Includes detailed road standards • Defines conservation easements as subdivisions • Includes erosion control requirements • Restricts residential development in flood hazard areas • Limits development of 15% slopes or greater • Includes environmental performance standards • Includes soil testing requirements for purposes of sewage planning, setting minimum lot areas of up to 2 acres and a 100 feet water setback	• Doesn't effectively address clustering
Town of Sanford Comprehensive Plan	A minimal document simply setting forth broad policy objectives and laying the most very basic framework for the Town's Land Use Management Law	• Goals and basic ecommendations are very practical and well-stated but lack back-up detail and justification • Document takes a balanced pro-growth pro-environment approach • More in the way of background studies and rationale is needed to support recommendations • Doesn't really address storm water, flooding and water quality issues that could use some attention
Broome County Hazard Mitigation Plan (Town of Sanford)	• Identifies hazard vulnerabilities (mostly flood and storm related) • Documents losses (mostly storm and flood-related) • Identifies and ranks hazard risks • Assesses emergency management capabilities (including laws/plans) • Documents hazard mitigation activities and vulnerabilities • Proposes hazard mitigation initiatives including several regulatory and study recommendations plus a watershed approach to address issues, priortization of intervention to protect infrastructure and property and flood risk mapping and reduction • Analyzes and prioritizes hazard mitigation initiatives	• Includes numerous projects that should be part of Stream Corridor Management Plan implementation including infrastructure projects as well as other non-structural recommendations

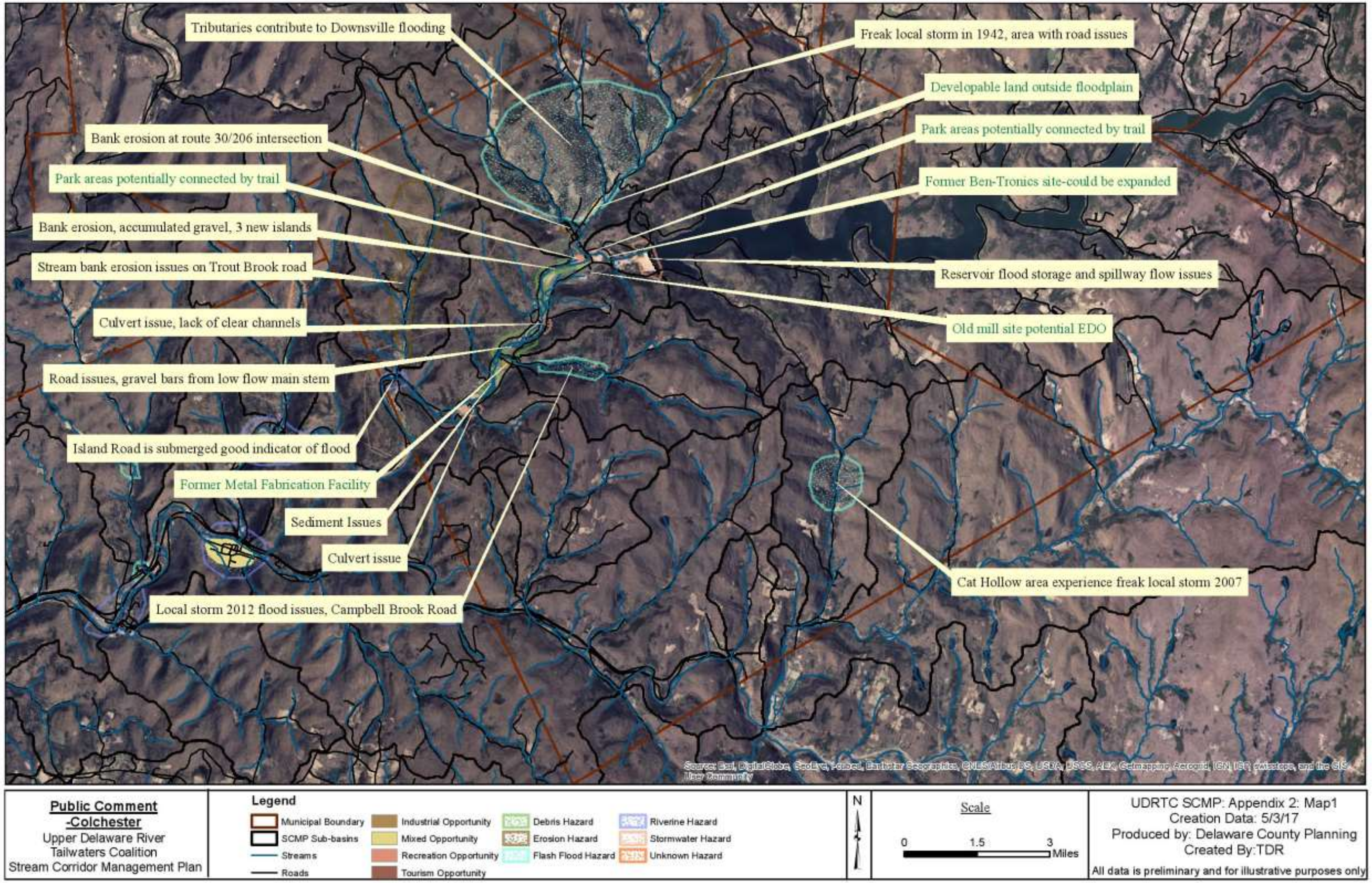
Town of Tompkins Local Laws and Plans

Municipal Documents	Key Features	Observations
Flood Damage Prevention Law	• Requires floodplain development permits subject to minimum standards established by the Federal Emergency Management Agency • Puts the Planning Board in charge of appeals and variances	• Town is permitted to establish more restrictive standards for purposes of stream corridor management • Puts Planning Board in a quasi-judicial role
Subdivision Law	• Establishes procedures for approval of land subdivisions • Establishes construction standards for certain improvements • Requires installation or bonding of improvements • Creates minor and major classes of subdivisions based on lots created • Provides for boundary line adjustments as subdivisions • Uses soils to establish a minimum lot area • Includes storm water management provisions • Includes floodplain regulation linkage	• Doesn't address land development other than subdivisions • Has no provision for clustering or conservation subdivisions • Doesn't address multi-family development • Major subdivision classification should be based on the need or lack of need for improvements, rather than just lot numbers
Town of Tompkins Comprehensive Plan	• Includes detailed background studies & NYC watershed section • Includes goals and strategies to: > Work with CWC to take advantage of infrastructure program > Examine the feasibility of initiating innovative mechanisms such as a decentralized management system of on-site septic systems > Work closely with the NYC DEP to ease restrictions on city land > Amend the local law to allow for cluster/conservation subdivision > Ensure road standards match the Delaware County's > Establish a site plan review law for structures over 400 sq. ft. > Consider including provisions in the site plan law to provide for: integration of open space and woodlands that remain on the site into adjacent natural areas or landscapes; protection of special site features such as important views by careful placement of structures; reduction of excess stormwater runoff by reduction of use of asphalt; reduced traffic impacts by requiring narrower lane width and use of shared access drives and parking; landscaping; lighting of the site done to reduce glare and light pollution, and other features needed to meet the goals of this plan > Establish rural siting guidelines > Set appropriate development densities to direct growth to the hamlet as much as possible; and establish design and siting standards to ensure all new development performs to the high expectations of the community	• Plan largely based upon a site plan review law yet to be adopted • Several recommendations stretch the legal authority of the Town absent a site plan review law • Some recommendations appear impractical for Tompkins
Delaware County Hazard Mitigation Plan (Town of Tompkins)	• Identifies hazard vulnerabilities (mostly flood and storm related) • Documents losses (mostly storm and flood-related) • Identifies and ranks hazard risks • Assesses emergency management capabilities (including laws/plans) • Documents hazard mitigation activities and vulnerabilities • Proposes hazard mitigation initiatives including several structural items plus a watershed approach to address erosion, debris/gravel deposition, priortization of intervention to protect infrastructure and property and flood risk mapping and reduction • Analyzes and prioritizes hazard mitigation initiatives	• Includes numerous projects that should be part of Stream Corridor Management Plan implementation • Some planning measures suggested will require more in the way of site plan review to reduce future risks • Floodplain regulations are more permissive than risks identified in plan suggest are appropriate but may also simply recognize the reality there is significant property and improvements in otherwise developable floodplains

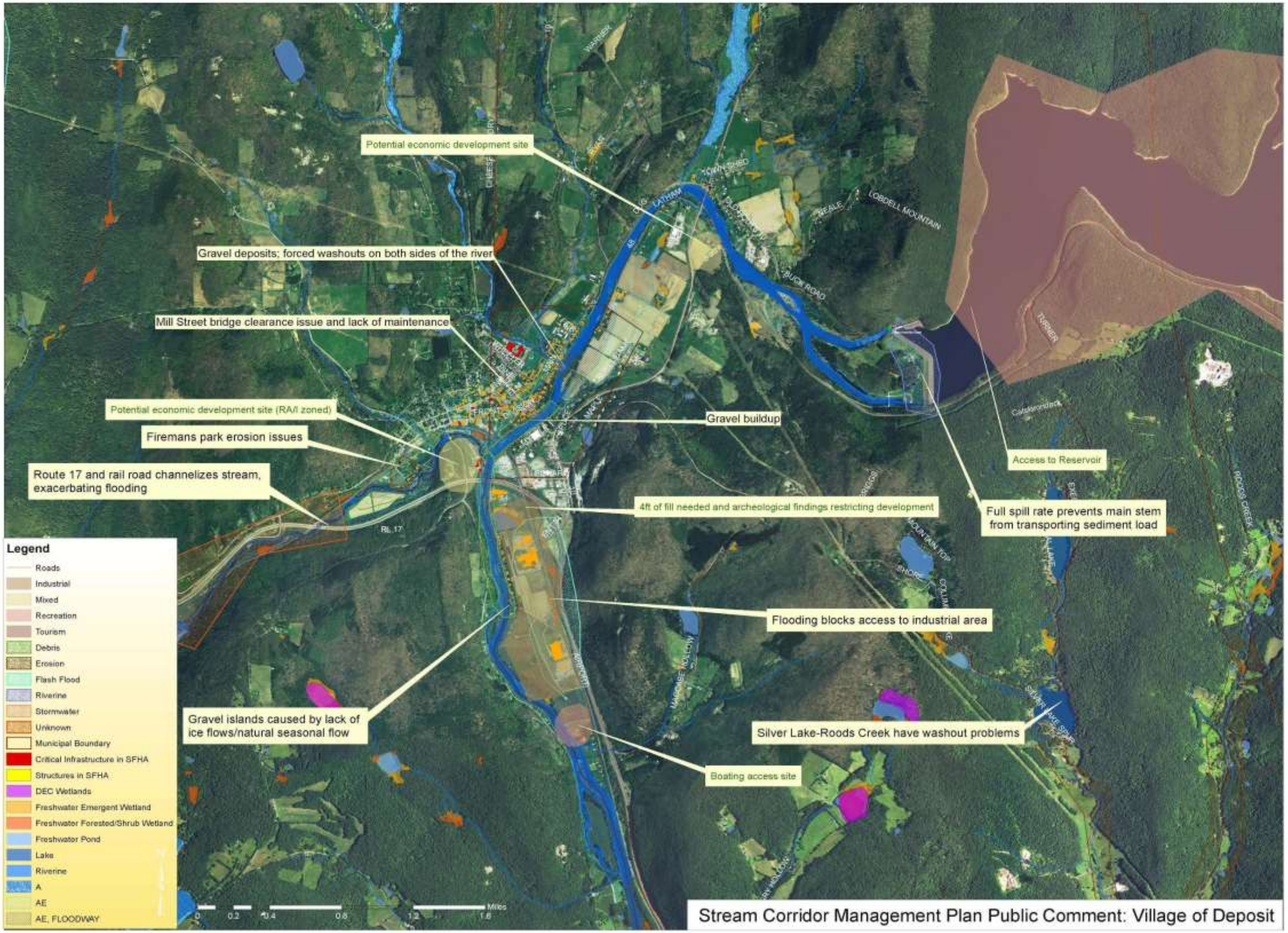
Appendix 2:

Community Input

Map 14: Village of Downsville Public Comments

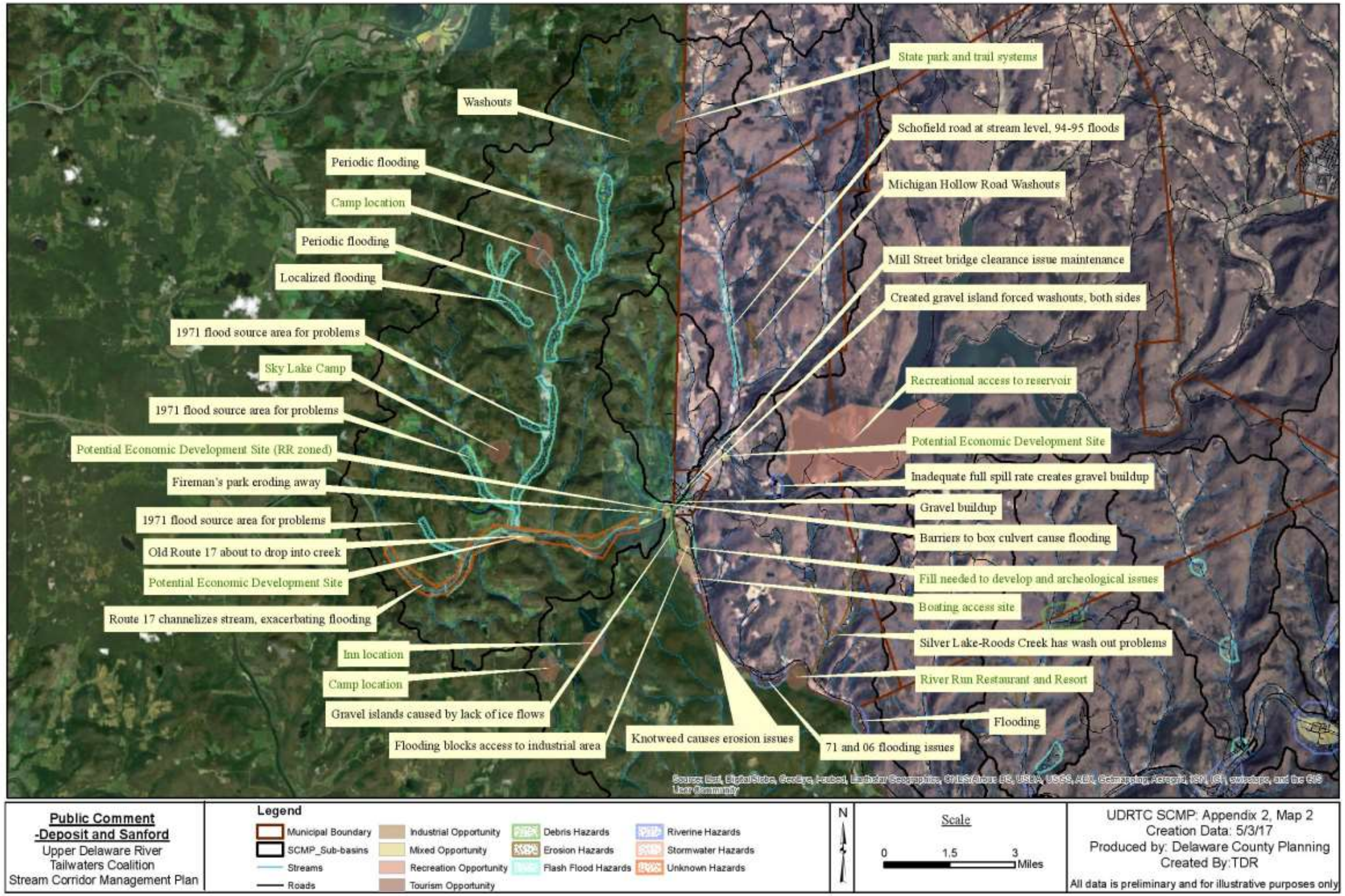


Map 15: Town of Colchester Public Comments

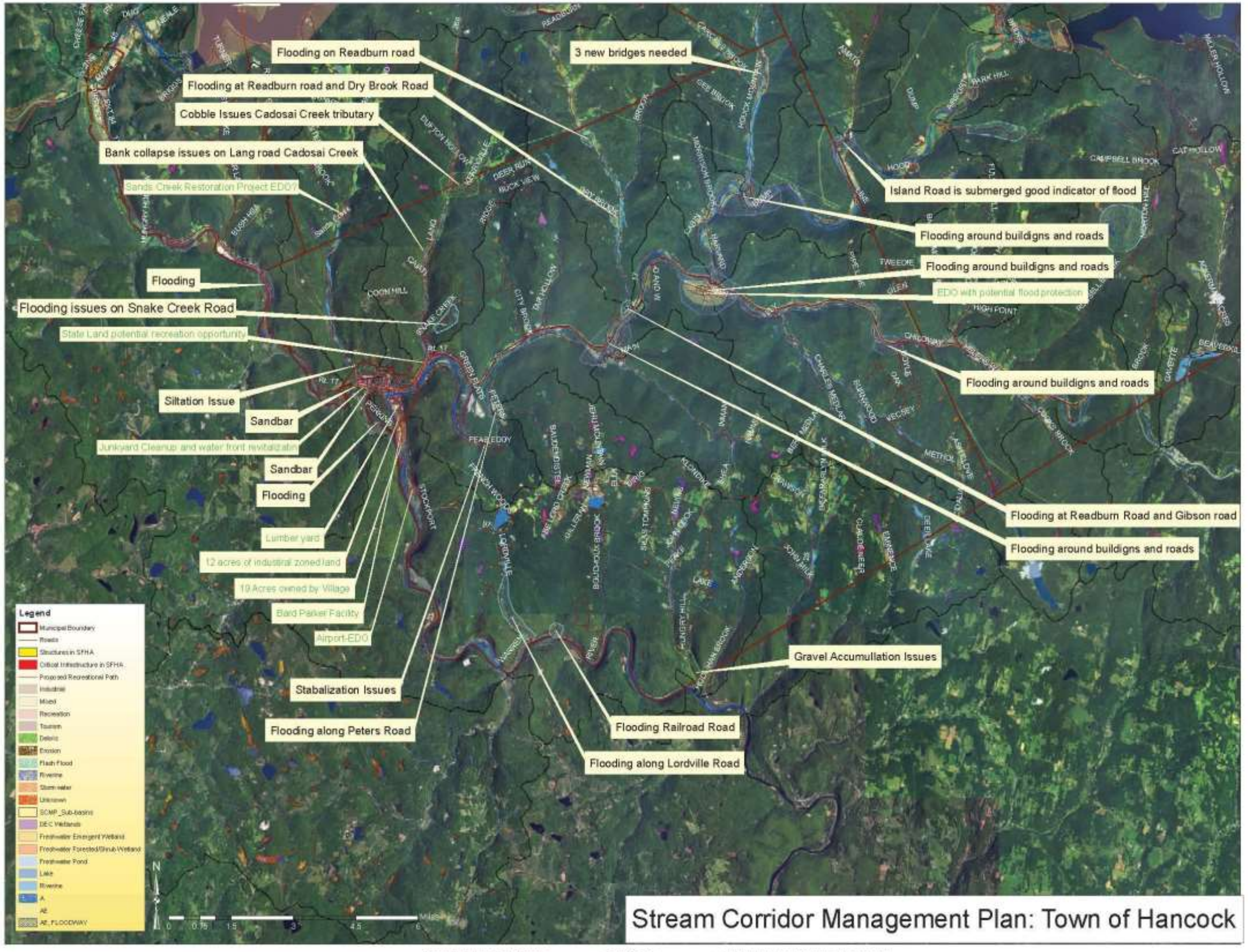


Produced By: Delaware County Planning Created By: TDR All data is preliminary and for observational purposes only

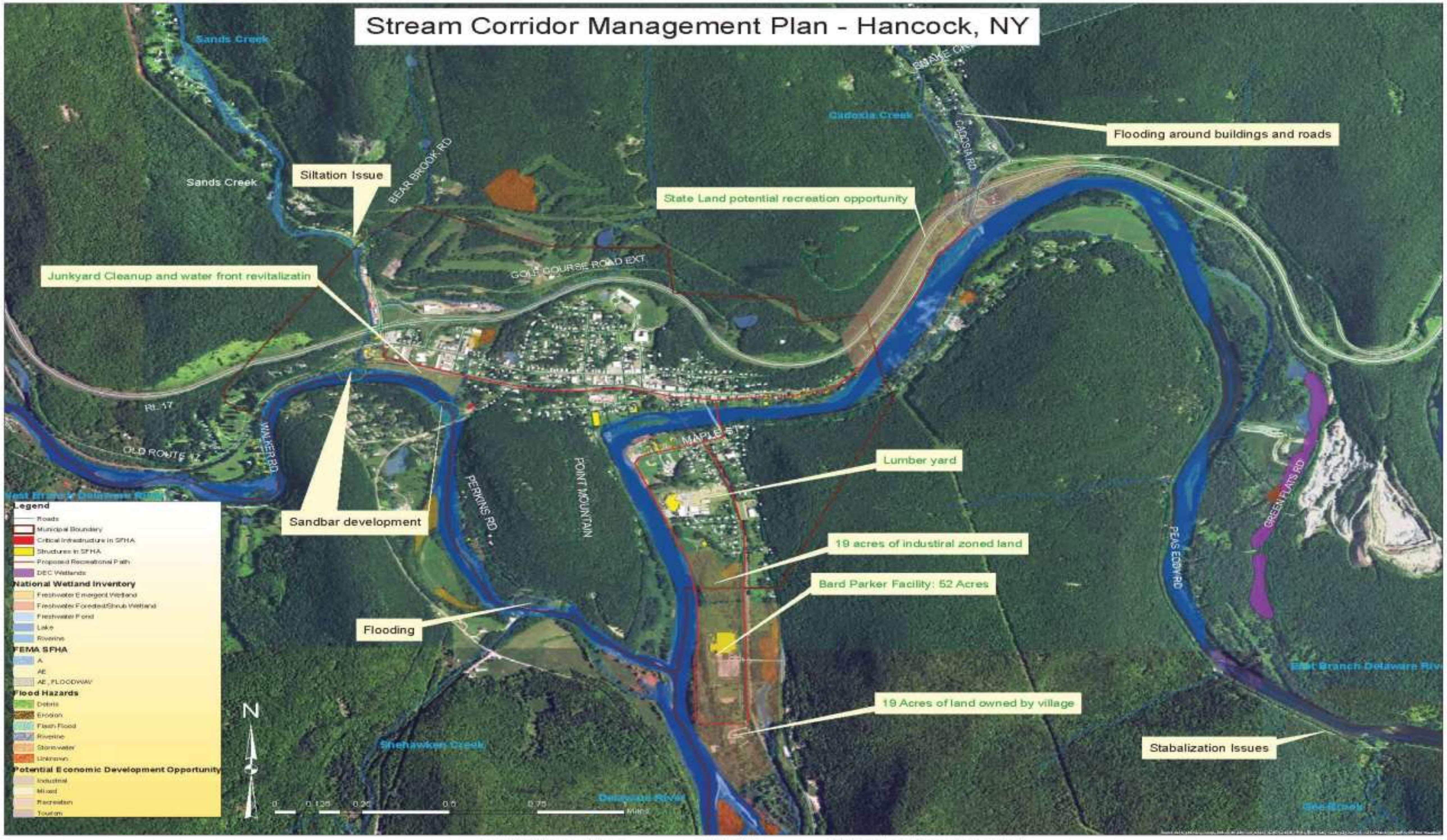
Map 16: Village of Deposit Public Comments



Map 17: Towns of Deposit and Sanford Public Comments



Map 18: Town of Hancock Public Comments



Map 19: Village of Hancock Public Comments

Appendix 3:

Stream Project Implementation

Project Identification

The first step in restoration planning is typically a feasibility study and conceptual design development for the restoration plan. For these studies and plans, one or more sites are considered for restoration/rehabilitation with a number of technical assessments often needed to determine potential feasibility of projects and their design and implementation constraints. These studies also help in assessing the spatial scale and complexity of a potential project.

Location

Consideration must be given to the project property limits (e.g., boundary survey and existing conditions map) and ownership (e.g., deed and title search). Are aerial photographs and topographic maps of the existing and/or past conditions available for the site? Are other sources available such as Environmental Assessments for the presence of contaminants or soils maps and geotechnical borings. As early as possible, potential constraints must be identified and input from regulatory and resource advisory agencies, project stakeholders and other interested parties on any significant issues associated with an anticipated project must be gathered. Public and stakeholder input, review and comment are critical to any informational meetings or any regulatory process hearing for restoration projects.

Regulations

Various federal, state, and local laws and regulations will apply to most river restoration projects. Evaluation of any regulatory constraints is essential early on, even though permit applications are not prepared and submitted until the later design phase. Permit processing sometimes requires significant time and cost. Environmental and land use constraints associated with projects may include:

- Federal, state, and/or locally-regulated wetlands;
- Federal Emergency Management Agency (FEMA) designated 100-year floodplain and floodway where earth fill and structures are limited;
- Threatened or endangered species subject to the federal Endangered Species Act and/or state regulations;
- Historical and/or archaeological resources or features (e.g., dams subject to the National Historic Preservation Act (NHPA) or state regulations promulgated by

the State Historic Preservation Office (SHPO) (or Tribal HPO on Native American lands);

- Contaminated sediments and hazardous waste (federal and/or state-regulated materials, e.g., asbestos tiles, sheeting, tires, lead paint, soils or sediments contaminated by lead, petroleum hydrocarbons) (See Adams et al.1992[25]; Shelton and Capel 1994)[26];
- Protected large "specimen" trees;
- Steep slopes regulated by municipal and/or county governments for disturbances;
- Other site features (e.g., buildings, utilities, walls, and bridges) that will potentially affect restoration work activities;
- Off-site constraints upstream of a project area that may affect success of the project, such as water withdrawals (e.g., uncertainty of water availability), bridges (e.g., footing scour potential), and utility lines (e.g., buried pipes that could be exposed with head cutting).

Design and Cost Estimating

Once all essential assessment work is completed, project partners then transition into the design phase. Preliminary and final project designs are developed based on conceptual plans prepared during the feasibility study. Design work often involves a team with members from a number of technical disciplines, including licensed civil, structural, and hydraulic engineers (professional engineers - PEs), registered landscape architects (RLAs), and experienced ecologists and river geomorphologists.

Once a project is permitted by all regulatory agencies and final plans are completed, a plan, specifications, and details package is developed to solicit the contracting industry to bid on the construction. As part of the bid package, the project engineer or manager must develop a cost estimate for each project phase and specific activity. Costs are projected by professional engineers and cost estimators applying in-depth work experience and using standardized unit material and labor costs along with regional/municipal multipliers and other information available to the industry, particularly costs available through construction manual *RS Means*.

[25] Adams, et al 1992, Ecotoxicology and Environmental Safety, Volume 24, Issue 3, December 1992, Pages 347-360
[26] Shelton, L. & Capel, P. 1994,Guidelines for collecting and processing samples of stream bed sediment for analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program, https://pubs.usgs.gov/of/1994/0458/report.pdf

Costs are often one of the primary factors determining whether a restoration project moves forward to implementation. A collaborative approach, combining efforts of multiple partners, is often required to secure adequate funds for costly restoration projects.

Construction

Restoration project construction is usually completed by private contractors. Community-based groups and other volunteers may be the principal workforce for smaller-scale projects. Regardless of the workforce size and composition, a project or site manager with in-depth work experience and communication skills is essential to complete a project in a timely and cost efficient manner.

River restoration and fish passage construction may include an array of equipment, laborers, and materials - whether pre-cast at an off-site location or poured in-place using forms. Excavators, backhoes, front-end loaders, cranes, or dump trucks may be needed to carry out on-site work and transport heavy loads to and from the site. Items such as temporary cofferdams, dewatering pumps, and siphon pipes are standard materials. Equipment and materials can be temporarily stored on or off-site staging areas nearby during the project period.

The project work zone should be delineated by the project manager and contractor before any on-site work begins. Construction activities in and near streams should always be conducted in such a manner as to avoid or minimize impacts to these stream and wetlands, and be in conformance with regulatory-approved project plans. Care must be taken to avoid disturbances to historic features that have been designated for protection, or if they are dismantled - such as an old dam - their internal structure should be documented by a qualified historian as it is removed.

The use of construction equipment mats and other best management practices applied in the forestry industry also help minimize damages to riparian vegetation and floodplain soils. The contractor should always employ best management practices for erosion and sediment control, noise (e.g., time of work periods) and dust control (e.g., site access road watering during extended dry periods), and other construction techniques that minimize disturbances of the site and to neighboring communities.

Appendix 4:

Community Outreach Plan

SCMP Community Outreach and Participation Plan

Stabilizing and Enhancing Local Economies in the Upper Delaware River and Tailwaters by Preserving the Unique Cold Water Fishery

New York State Department of State Delaware County Department of Watershed Affairs

The Development of a Stream Corridor Management Plan for Delaware County, NY below the NYC Delaware River Basin Reservoirs

Community Outreach Plan

Prepared by Friends of the Upper Delaware River

I. Goal Statement – SCMP Community Outreach and Participation Plan

Friends of the Upper Delaware River (FUDR) and project partners will develop and implement a comprehensive Community Outreach Plan to support the development of "Volume 1" of a Stream Corridor Management Plan ("SCMP") for waterways below the NYC Delaware River Basin Reservoirs in Delaware County, NY.

The Community Outreach Plan will identify key individuals, organizations, and entities involved in the project, identify a visioning process and the roles and responsibilities in coordinating the entire outreach process, logistics, and the proposed schedule of public meetings.

Goals of the SCMP Community Outreach Plan:

1) Ensure that a diverse set of community watershed stakeholders have a clear understanding of the goals, objectives, and value of the SCMP.
2) Provide an opportunity for watershed stakeholders to learn more about how streams function, the ecological services they provide, and how they intersect with the social, cultural, and economic conditions and needs in the Upper Delaware River watershed.
3) Create dynamic public forums where stakeholders can share their feedback and insight based on their personal, localized, and historic knowledge about area waterways.
4) Provide all members of the public and other stakeholders with an opportunity to participate in the development of all elements of the Stream Corridor Management Plan

II. Overview of the Development of "Volume One" of the Delaware County Stream Corridor Management Plan

The key components of Volume One of the Delaware County Stream Corridor Management Plan will include:

- Formation of a Project Advisory Committee and five Community Advisory Committees that will provide guidance and leadership in the development of the Stream Corridor Management Plan

- Development and implementation of a community outreach plan that ensures a maximum level of public participation and meaningful stakeholder involvement in all elements of the plan
- A comprehensive series of public meetings throughout the duration of the project that will provide a diverse set of watershed stakeholders with opportunities to participate in the development of the plan
- Development and refinement of a Project Vision Plan that will clearly describe the goals and objectives of the project and will articulate a community based vision for the future of waterway protection and restoration in the targeted project area.
- The plan will incorporate best management practices along with strategies for enhancements to local, county and state infrastructure to be included in existing plans and maintenance procedures.
- Provide a comprehensive assessment of local plans, local laws and regulations and how they support watershed enhancement and economic sustainability.
- Develop mitigation strategies to address flooding, storm water infrastructure and stream restoration for inclusion in the All Hazards Mitigation Plan.
- A delineation and assessment of waterways in the targeted project area that describes watershed conditions and assists in the identification and prioritization of protection and restoration projects.
- A set of management recommendations to guide collaborative efforts among Delaware County resource managers to protect and restore area waterways.
- An implementation strategy that will track the progress of the plan and will identify future restoration projects, project partners, and funding sources.
- Publication of a Stream Corridor Management Plan that will serve as a multi-jurisdictional guidance document for the future management, protection, and restoration of the Delaware County waterways below the NYC Delaware River Basin Reservoirs.

III. Key Individuals and Organizations

- **Friends of the Upper Delaware River (FUDR) –** FUDR will coordinate all elements of the SCMP project in consultation with other project partners and sub-contractors. FUDR has an office on Main Street in Hancock and is available during business hours for community members to stop in to ask questions and make comments on this plan and other UDRTC issues.

- **The Upper Delaware River Tailwaters Coalition (UDRTC) –** The UDRTC is comprised of municipal and non-profit leaders in the targeted project area. The UDRTC serves as the primary governing body of the project and will provide guidance and leadership to FUDR and other consultants throughout the duration of the project.

- **The SCMP Project Advisory Committee (PAC**) **–** The SCMP PAC is comprised of federal, state, regional, and local leaders with an expertise and stake in the management and protection of waterways in Delaware County, NY. The SCMP PAC will provide periodic input, guidance and technical input into the development of the SCMP. The PAC will review the plan throughout the development to enhance the sections with their various areas of expertise.

- **Five (5) SCMP Community Advisory Committees (CAC) –** The CAC's are comprised of local elected officials, agency personnel and other individuals associated with governance and management of local waterways in the towns of Deposit, Colchester, Hancock and Sanford and the villages of Deposit and Hancock. These committees will provide localized knowledge of waterway management needs and challenges that will assist in the development of the SCMP. They will also provide an overview of the community's relationship with the streams and river as it pertains to the local community, economy and historic management of the waterways.

- **Delaware County** The Delaware County Department of Watershed Affairs is the supervisor of the project with daily management responsibilities over the project the work of FUDR and project sub-contractors. Delaware County Planning will provide the technical analysis, mapping and field assessment data through the department's environmental planning and GIS professionals with the support of interns. Supporting Delaware County agencies including the Departments of Public Works, Emergency Services and Economic Development, along with the Delaware County Soil and Water Conservation District are providing significant in-kind and technical support over the entire management of the project and the development of the SCMP.

- **Project Subcontractors –** FUDR will hire and supervise three (3) project subcontractors to assist in the development of the SCMP: 1) Woidt Engineering, Ithaca, NY; 2) Trout Unlimited, Northeastern Office; and 3) Land Studies, Inc., Lititz, Pa. Each of these subcontractors have localized technical expertise and on-the-ground project experience in stream management, restoration, and protection. Each of the sub-contractors have received assignments for particular elements of the SCMP including the four rounds of public participation.

Coordination with Project Leaders

1) A minimum of five meetings will be scheduled with the Project Advisory Committee to provide project status updates and to receive feedback and guidance on all elements of the SCMP. In addition, FUDR and other project implementers will engage and consult with individual members of the SCMP PAC to seek guidance and technical expertise as needed.
2) FUDR and project implementers will work with Town Supervisors and Village Mayors in the project area in the formation and ongoing engagement with members of the local Community Advisory Committees

IV. SCMP Visioning Process

FUDR and Trout Unlimited, in consultation with the PAC and other project leaders, will develop a Project Vision Statement that encompasses the overall objectives of watershed management, flood relief and economic sustainability, and clearly describes what the communities hope to accomplish. The vision statement will set the tone of the plan and will be used throughout the planning process. An initial set of goals and objectives will be created to provide a realistic framework for achieving the vision as well as help focus limited resources. The New York State Department of State guidebook*: Watershed Plans; Protecting and Restoring Water Quality on Watershed Planning,* Chapter 3, will be utilized as a framework for developing the SCMP Project Vision Statement.

The first two rounds of public participation/outreach meetings (see below) will help inform the development of the vision statement. These meetings will generate important public feedback and localized knowledge of the watershed and will help formulate a future vision for what the public needs and expectations from this planning effort.

The draft Project Vision Statement will be completed on December 1, 2016 and sent to the Project Advisory Committee and other project implementers for review. The Project Advisory Committee will meet on December 15 to provide feedback and comment on the draft statement. The statement will be further revised as necessary after the second round of public meetings in the spring of 2017.

V. Public Participation/Outreach Meetings

There are four (4) rounds of public participation/outreach meetings built into the community outreach plan that will provide invaluable assistance in the development of the SCMP. An enormously important need is to ensure maximum public understanding, involvement, and buy-in into the SCMP planning process, the final product, and the future implementation of the plan.

In addition to the four rounds of public meetings in the NYS DOS SCMP project, additional funding secured and administered by the Delaware County Department of Watershed Affairs supported a series of meetings to help inform the SCMP. Tom Shepstone (Shepstone Management, Honesdale, NY) was hired to facilitate six (6) public meetings, two each in Colchester, Deposit, and Hancock to:

1) Inventory existing programs and regulations at the town and village level that address stream management, protection, and restoration. The purpose of gathering this material is to avoid duplication and ensure cohesiveness and consistency with existing public programs associated with waterway management in the project area.
2) Invite longtime residents of the area to relay information based on personal observation and memory and identify on maps specific local waterway conditions such as flooding impacts, highly erosive stream segments, floodplain impacts, and areas for potential economic development.

Fall 2016: 1st Round of Public Participation/Outreach Meetings

A series of 9 public watershed stakeholder meetings (3 topics) will be scheduled in the fall of 2016 and will be held in the NY towns/villages of Colchester, Deposit, and Hancock. The meetings will address and explore, in depth, identified priority issues that are most important to watershed stakeholders with regard to the future management, protection, and restoration of waterways in Delaware County.

Each meeting will include one or more speakers with an expertise in the selected topic.

The following topics will be addressed:

1) What is a Stream Corridor Management Plan and Why We Need One

This public meeting will address the importance of adopting a Stream Corridor Management Plan in Delaware County, NY, the public process necessary to ensure a comprehensive, meaningful and effective plan is developed, and the practical implementation of the plan is assured. The presentation will also highlight the historical impacts of severe weather patterns that have negatively impacted communities as a result of flooding and threats to public infrastructure to reinforce the need for a comprehensive plan.

Presenters:
Shelly Johnson-Bennett, Delaware County Planning Department
Wayne Reynolds, Delaware County Department of Public Works

2) **The Basics of Stream Dynamics**
This presentation will address basic information about how streams function, the ecological and economic services they provide, and both reactive and responsive management efforts that can protect waterways, people, and communities.

Presenters:

Graydon Dutcher, Delaware County Soil and Water Conservation District
Mark Guttshall, Land Studies, Inc**.**

3) **Flooding, Changing Weather Trends, and the Economic/Recreational Benefits of Stream Protection and Restoration**

This presentation will discuss how changing weather patterns have exacerbated flooding problems in the already flood prone area of Delaware County, how management practices can be implemented to mitigate the impacts of increasingly severe weather patterns, and the economic value of our waterways to communities and people highlighting the 2014 Upper Delaware River Economic Study.

Presenters:
George Fowler, Woidt Engineering
Stephanie Dalke, Pinchot Institute and Common Waters Partnership
Jeff Skelding, Friends of the Upper Delaware River
Tom Shepstone, Shepstone Management

April 2017: 2nd Round of Public Participation and Outreach Meetings

Three public meetings will be scheduled in April, 2017 in Deposit (includes Sanford and Broome County), Hancock (includes Tompkins) and Downsville (Colchester) during the waterbody characterization phase of the project to solicit public input in defining and characterizing the nonpoint source pollution issues in area waterways, address economic growth areas and flood mitigation strategies, refine the project vision, goals, and objectives, and to review and discuss water quality and watershed and stream corridor protection and restoration issues.

A CAC leader, Friends of the Upper Delaware River and Trout Unlimited will coordinate each of these meetings. An interactive mapping exercise that engages meeting participants will be used as a mechanism to gather information and identify specific locations in each community.

May, 2017: 3rd Round of Public Participation and Outreach Meetings

Three public meetings will be scheduled in Hancock, Deposit, and Colchester to allow for public review and comment on the Stream Corridor Management Plan draft recommendations and prioritization. A written summary of public input obtained at these meetings will be prepared and provided to Delaware County for review and comment. Public input will be incorporated into the final Stream Corridor Management Plan to the satisfaction of the County and the NYS Department of State.

A CAC leader, Friends of the Upper Delaware River staff, and Trout Unlimited will coordinate this series of meetings. Each participant will receive a copy of the draft recommendations (with a sidebar “notes” section) and will be asked to provide written comments, questions, and other forms of feedback during the meeting. Public comments will be collected at the end of each meeting and will be incorporated into the draft Stream Corridor Management Plan.

August 2017: 4th Round of Public Participation and Outreach Meetings

Three public meetings will be scheduled prior to the preparation of the final Stream Corridor Management Plan to allow for public review and comment on the draft document. A written summary of public input obtained at this meeting shall be prepared and provided to the County for review and comment. Public input shall be incorporated into the final Stream Corridor Management Plan.

A CAC leader, Friends of the Upper Delaware River staff, and Trout Unlimited will coordinate this series of meetings. Each participant will receive a copy of the draft recommendations (with a sidebar “notes” section) and will be asked to provide written comments, questions, and other forms of feedback during the meeting. Public comments will be collected at the end f each meeting and will incorporated into the draft Stream Corridor Management Plan.

<u>Public Participation Recruitment for Public Meetings</u>

It will be important to ensure substantial attendance at each of the public meetings in order to maximize the role of watershed stakeholders in the development and eventual implementation of the SCMP. The following recruitment actions will be undertaken with a goal of generating at least 50 participants at each meeting:

1. The placement of public meeting notices in the legal sections of local newspapers as required by the NYS Department of State two weeks prior to the meetings.
2. The placement of highly visible fliers announcing meeting time, location, and description posted in common community gathering areas throughout the targeted communities prior to the scheduled date.
3. Public meeting announcements utilizing the networks and contacts of our government, non-profit, and business partners.
4. Press releases issued to local media outlets including the Hancock Herald, The Reporter, Deposit Courier, the River Reporter, and the Watershed Post.
5. Extensive use of social media to promote the meetings and encourage public participation
6. Generation of traditional media coverage including radio programming and news stories in local media outlets throughout the targeted communities.

7. Meeting announcements utilizing the networks and contacts of regional coalition partners including the Common Waters Partnership, the Coalition for the Delaware River Watershed, and Trout Unlimited.

   All of the public meetings will be recorded and notes will be distributed to all meeting participants. The final summaries will also be submitted to DOS and DC for review and approval. The ideas and input from meeting participants will be used to guide the waterbody characterization phase of the project.

Glossary

NOTE: Italicized words within a definition are defined elsewhere within this glossary.

aggradation (aggrading) – A progressive build-up or raising of the channel bed and *floodplain* due to *sediment* deposition. The geologic process by which streambeds are raised in elevation and *floodplains* are formed. Aggradation indicates that stream *discharge* and/or *bedload* characteristics are changing.

aquatic habitat – Physical attributes of the stream channel and *riparian area* that are important to the health of all or some life stages of fish, aquatic insects and other stream organisms. Attributes include water quality (temperature, pH), *riparian* vegetation characteristics (shade, cover, density, species), stream bed *sediment* characteristics, and *pool*/*riffle* spacing**.**

bankfull depth – The depth from the elevation of water surface at the *bankfull discharge* to the deepest point in the channel.

bankfull discharge – The discharge (or flow) that occurs, on average, every 1.2 to 2.0 years. This discharge, from relatively frequent storms, is largely responsible for the shape of the stream channel within the *floodplain*.

bankfull width – The width of the water surface at the *bankfull discharge*.

base flood elevation – The height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum of 1929, the North American Vertical Datum of 1988, or other datum referenced in the Flood Insurance Study report, or average depth of the base flood, above the ground surface.

bedload – *Sediment* moving on or near the streambed and transported by jumping, rolling or sliding on the bed layer of a stream.

berm – A mound of earth or other materials, usually linear, constructed along streams, roads, *embankments* or other areas. Berms are often constructed to protect land from flooding or eroding, or to control water drainage (as along a road-side ditch). Some berms are constructed as a byproduct of a stream management practice whereby stream bed *sediment* is pushed out of the channel and mounded on (and along the length of) the stream bank - these berms may or may not be constructed for flood control purposes; some are simply piles of excess material. These berms often interfere with other stream processes such as *floodplain* function, and can exacerbate flood-related *erosion* or stream *instability*.

boulder – In the context of *stream assessment surveys*, a boulder is stream *sediment* that measures between 256 mm and 4096 mm (about 10 inches to 13.3 feet).

braided – A stream form in which the channel splits into 3 or more separate sub-channels, often crisscrossing to produce a "braided" pattern of connected channel with large or small islands between them. Islands formed between the channels can be either bare *gravel* or *cobble* materials, or contain mature forest vegetation.

channel-forming flow – see *bankfull discharge*

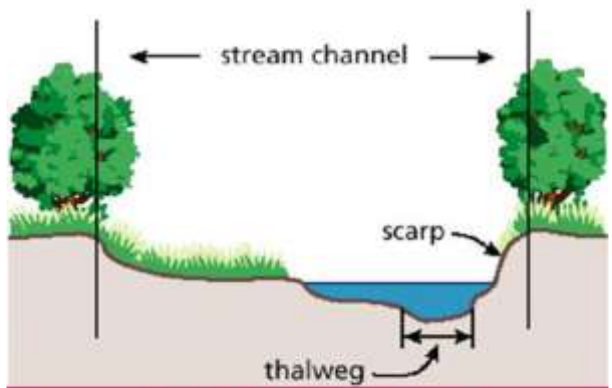
clay – Clay is the smallest *sediment* size present in a stream, measuring less than 0.0039mm in size. Clay can be identified by its smooth and slippery texture. Clay deposits can be seen in sections of the stream, and can produce *turbidity* in stream water when it is disturbed either during floods or by activity in the stream.

cobble – In the context of *stream assessment surveys*, cobble material is *sediment* that measures between 64 mm and 256 mm (about 2.5 inches to 10 inches).

cohesive - Soil types such as *clays* and *silts* that are held together owning to attraction between like molecules.

confluence – The location of the joining of two separate streams, each with its own *watershed*.

cross-section (see also monitoring cross-section) – In the context of *stream assessment surveys*, a *cross-section* is a location on a stream channel where stream *morphology* is measured perpendicular to the *stream flow* direction (as if taking a slice through the stream), including width, depth, height of banks and/or *terraces*, and area of flow.



Cross section of a stream channel

culvert – A closed conduit for the free passage of surface drainage water (Lo, 1992). Culverts are typically used by the Town and County 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 roads. Culverts are also used by landowners to route roadside drainage ditch water under their driveways to reduce or prevent *erosion*.

degradation (degrading) – The process by which a stream *reach* or channel becomes deeper by eroding downward into its bed over time, also called "downcutting", either by periodic episodes of bed scouring without filling, or by longer term transport of *sediment* out of a *reach* without replacement.

demonstration stream restoration project, (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 for funding and cooperation.

discharge (stream flow) – The amount of water flowing in a stream, measured as a volume per unit time, usually cubic feet per second (cfs).

embankment – A linear structure, usually of earth or *gravel*, constructed so as to extend above the natural ground surface (Lo, 1992). Similar to a *berm*, but usually associated with *road fill* areas, and extending up the hillside from the road, or from the stream up to the road surface.

emergent (wetlands) – A type of wetland dominated by erect, rooted, herbaceous, water-loving plants. Examples of emergent wetland plants include certain grasses, sedges, rushes and cattails. Such areas are also known as "marshes," or sometimes called "swamp pasture" by the farming community.

entrenched – In stream classification (see s*tream type*), entrenchment (or entrenchment ratio) is defined by stream *cross-sectional* shape in relation to its *floodplain* and valley shape, and has a specific numerical value that in part determines *stream type*. For example, if this number is less than 1.4, the stream is said to be highly entrenched, if between 1.4 and 2.2 it is mildly entrenched, and greater than 2.2 it is not entrenched. Entrenchment ratio is used with other stream shape data to determine *stream type*, and define baseline data for future *monitoring* (Rosgen, 1996).

equilibrium (see also Astable@) – The degree to which a stream has achieved a balance in transporting its water and *sediment* loads over time without *aggrading* (building up), *degrading* (cutting down), or migrating laterally (eroding its banks and changing course).

erosion B The wearing away, detachment, and movement of the land surface (*sediment*), by running water, wind, ice, or other geological agents, including such processes as gravitational creep or *slumping* (New York Guidelines for Urban Erosion and Sediment Control, 1972). In streams, erosion is a natural process, but can be accelerated by poor stream management practices.

evapotranspiration – the process of transferring moisture from the earth to the atmosphere by evaporation of water and transpiration from plants.
(http://dictionary.reference.com/browse/evapotranspiration**,Verified September 27, 2007)**

exotic plant – see *invasive plants*

floodplain B 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 by the stream, in addition to *riparian* vegetation (Rosgen, 1996). 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*. Vegetation on floodplains greatly improves their functions.

Geographic Information System (GIS) B Desktop software with a graphical user interface that allows loading and querying, analysis and presentation of spatial and tabular data that can be displayed as maps, tables and charts (ArcView GIS, 1996). The maps in the East Branch Delaware River Stream Corridor Management Plan were produced with GIS, and can be updated as new information becomes available.

Global Positioning System (GPS) B A satelliteBbased positioning system operated by the U.S. Department of Defense (DoD). When fully deployed, GPS will provide all-weather, worldwide, 24-hour position and time information (GPS Pathfinder Office: Getting Started Guide, 1999). The *stream assessment survey* done for the East Branch Delaware River Stream Corridor Management Plan included the use of a GPS unit to document the locations of all mapped stream features. This information was added to the *GIS* to produce the maps.

gravel – In the context of *stream assessment survey*, *gravel* is *sediment* that measures between 2 mm and 64 mm (about 0.08 inches to 2.5 inches).

head-cut – A marked change in stream bed slope, as in a Astep@ or waterfall, that is unprotected or of greater height than the stream can maintain. This location also referred to as a Aknick point@, moves upstream, eventually reaching an *equilibrium* slope.

imbricate - Having the edges of bed material overlapping in a regular arrangement like roof tiles or the scales of a fish. Rocks in a riverbed often end up leaning on each other, their tips pointing downstream in an imbricated pattern.

instability (see also Aunstable@) B An imbalance in a stream=s capacity to transport *sediment* and maintain its channel shape, pattern and profile.

incised – *Erosion* of the channel by the process of *degradation* to a lower base level than existed previously or is consistent with the current hydrology.

invasive plants – Non-native species that are able to compete with and replace native species in natural habitats, also referred to as Aexotic@ plants.

Japanese knotweed (see also invasive plants) – An *invasive plant*, not native to the Catskill region, that colonizes disturbed or wet areas, especially stream banks, road-side ditches and *floodplains*. This plant out-competes natives and other beneficial plants, and may contribute to *unstable* stream conditions.

left bank – The left stream bank as looking or navigating downstream. This is a standard used in *stream assessment surveys*.

matrix – The framework material within which other materials are lodged or included. For example, *cobbles* could be embedded in a matrix of *sand* and fine *gravel*.

meander – Refers both to a location on a stream channel that is curved (a "meander bend"), and to the process by which a stream curves as it passes through the landscape (a "meandering stream").

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

monitoring cross-section – For the purposes of the East Branch Delaware River Stream Corridor Management Plan, this is a location where metal rebar rods have been used to permanently locate an actively eroding stream bank. At this site, detailed data have been gathered to document the stream condition. The site is permanently marked to enable future measurements that, when compared to the existing condition, provide information about the stream's change. Measuring change over time is considered '*monitoring*,' and this information provides early warning to stream managers about important but perhaps visually imperceptible changes in the stream.

monumented – Refers to a location, usually a *cross-section*, that is marked with a permanent or semi-permanent marker, or "monument", to enable future *monitoring* at the same place.

morphology, stream morphology – The physical shape, or form, of a landscape or stream channel, that can be measured and used to analyze stream or landscape condition, type or behavior.

morphometry - The quantitative measurement of the form especially of living systems, such as watershed and its stream network.

nutrient – The term "nutrients" refers broadly to those chemical elements essential to life on earth, but more specifically to nitrogen and phosphorus in a water pollution context. In a water quality sense nutrients really deals with those elements that are necessary for plant growth, but are likely to be limiting – that is, where used up or absent, plant growth stops.

physiography – The physical features of the earth's surface, including landforms, currents of the atmosphere and climate, ocean and distribution of flora and fauna or the general "look" of the land.

planform – The general shape and layout of the river as viewed from above.

pool – A small section of stream characterized by having a flat or nearly flat water surface compared to the average *reach* slope (at low flow), and deep and often asymmetrical *cross-sectional* shape.

reach – A section of stream with consistent or distinctive *morphological* characteristics (New York Guidelines for Urban Erosion and Sediment Control, 1972).

reference reach, stable reference reach – 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 – Any structural measure undertaken to stabilize a road *embankment*, stream bank or hillside.

riffle – A small section of stream characterized by having a steep water surface slope compared to the average *reach* slope (at low flow), and a shallow and often uniform *cross-sectional* shape.

right bank – The right stream bank as looking or navigating downstream. This is a standard used in *stream assessment surveys*.

riparian (area, buffer, vegetation, zone) – The area of land along stream channels, within the valley walls, where vegetation and other land uses directly influence stream processes, including flooding behavior, *erosion*, *aquatic habitat* condition, and certain water quality parameters.

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* control (New York Guidelines for Urban Erosion and Sediment Control, 1972).

rotational failure (translational failure) – A geotechnical term referring to the shape and mechanism of a hillslope failure that results in a section of land surface that falls, or "fails", by rotating out of place along a curved plane surface (as opposed to sliding along a straight line or flat plane surface). This type of failure is common in the East Branch Delaware River valley, easily recognized by "back leaning" trees on displaced sections of the slope, separated by fault scarps (cracks in the ground surface perpendicular to the failure direction, also often curved) as these blocks of land rotate downward and outward.

runoff – The portion of precipitation (i.e., rainfall) that reaches the stream channel over the land surface.

sand – In the context of *stream assessment surveys*, sand material is *sediment* that measures between 0.063 mm and 2 mm (up to 0.08 inches).

sediment, stream bed 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 deposition (in the stream bed or on the *floodplain*) (Lo, 1992).

sediment discharge – The combination of *washload* plus *bedload* material.

silt – In the context of *stream assessment surveys*, silt material is *sediment* that measures between 0.0039 mm and 0.063 mm.

sinuosity – The ratio of channel length to direct down-valley distance. Also may be expressed as the ratio of down-valley slope to channel slope.

slump – The product or process of mass-wasting when a portion of hillslope slips or collapses downslope, with a backward rotation (also a rotational failure).

stable (see also equilibrium) – A stable stream is defined as maintaining the capacity to transport water and *sediment* loads over time without *aggrading* (building up), *degrading* (cutting down), or migrating laterally (eroding its banks and changing course). Stable streams resist flood damage and *erosion*, and provide beneficial *aquatic habitat* and good water quality for the particular setting.

stability – In stream channels, the relative condition of the stream on a continuum between *stable* (in *equilibrium* or balance) and *unstable* (out of *equilibrium* or balance). Stream stability assessment seeks to quantify the relative *stability* of stream *reaches*, and can be used to rank or prioritize sections of streams for management.

stacked rock wall – A *boulder revetment* used to line stream banks for stabilization. Stacked rock walls can be constructed on a steeper angle than *rip-rap*, so they take up less of the stream *cross-section*, provide a wider road surface, and provide less surface area for solar heating, allowing stream temperature to remain cooler relative to banks lined with *rip-rap*. These features can be augmented with bioengineering to enhance *aquatic habitat* and *stability* functions.

stage – In streams, stage refers to the level or height of the water surface, either at the current condition (i.e., current stage), or referring to another specific water level (i.e., flood stage).

stream assessment, stream assessment survey – The methods and summary information gathered in a stream *reach* or series of *reaches*, primarily focused on stream *morphology*.

stream flow (*discharge*) – The amount of water flowing in a stream, measured as a volume per unit time, usually cubic feet per second (cfs).

stream stability restoration (design, project) – An *unstable* portion of 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 (that is, to a shape that may allow the stream to transport its water and *sediment* load over time without dramatic changes in its overall shape).

stream type – As defined by Rosgen (1996), one of several categories defined in a stream classification system, based on a set of delineative criteria in which measurements of channel parameters are used to group similar *reaches*.

terrace – A level area in a stream valley, above the active *floodplain*, that was deposited by the stream but has been abandoned as the stream has cut downward into the landscape. These areas may be inundated (submerged) in higher floods, but are typically not at risk in more common floods.

thalweg – The line followed by the majority of the *stream flow* (New York Guidelines for Urban Erosion and Sediment Control, 1972). In *stream assessment*, this location is used as a reference location for surveys and other measurements, and is most often associated with the deepest point in the stream *cross-section* (i.e., the stream channel that would still have water flowing in it at even the lowest flow conditions).

toe – The bottom, or base, of a stream bank or *embankment*.

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. Streams with high turbidity are often referred to as being "turbid".

unstable (see also instability) – Describing a stream that is out of balance in its capacity to transport *sediment* and maintain its channel shape, pattern and profile over time.

washload – The finest-grained fraction of the total *sediment* load, consisting of particles whose settling *velocity* are so low that they are transported in suspension at approximately the same speed as the flow and only settle out when flow *velocity* are much reduced.

watershed – A unit of land on which all the water that falls (or emanates from springs) collects by gravity and runs off via a common outlet (stream) (Black, 1991).

waters of the United States

1. All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
2. All interstate waters including interstate wetlands
3. All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:

    - Which are or could be used by interstate or foreign travelers for recreational or other purposes; or
    - From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
    - Which are used or could be used for industrial purpose by industries in interstate commerce;

1. All impoundments of waters otherwise defined as waters of the United States under the definition;
2. Tributaries of waters identified in paragraphs (1)-(4) of this definition;
3. The territorial seas;
4. Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (1)-(6) of this section.

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.

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

Works Cited

- Shepstone, T. (2014) Upper Delaware River Cold Water Fishing and Boating Economic Impact Study
- National Oceanic and Atmospheric Administration (NOAA). (2017). *Climate at a Glance*. Available at: https://www.ncdc.noaa.gov/cag/regional/time-series [Accessed 23 Mar. 2018]
- Northeast Regional Climate Center, 2017, http://www.nrcc.cornell.edu/
- Northeast Regional Climate Center, http://www.nrcc.cornell.edu/
- Northeast Regional Climate Center (NRCC). (2012). Extreme Precipitation in New York & New England. *Extreme Precipitation Estimates.* Available at: http://precip.eas.cornell.edu/ [Accessed 23 Mar. 2018]
- Federal Interagency Stream Restoration Working Group. 1998. 2.A Hydrologic and Hydraulic Processes. Stream Corridor Restoration pp. 2-3.
- Delaware River Master. 2017. Delaware River Basin States and New York City Announce Ten-Year Reservoir Operating Plan Agreement. https://water.usgs.gov/osw/odrm/
- Knighton, D. 1998, Fluvial forms and processes: a new perspective, Arnold, London; New York
- Rosgen, David L. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology, 1996. Print.
- Mulvihill, C.I., Baldigo, B.P., Miller, S.J., DeKoskie, D. & DuBois, J. 2009, Bankfull Discharge and Channel Characteristics of Streams in New York State, U.S. Geological Survey, Reston, Virginia.
- United States Geological Survey. 2018. USGS Streamstats. The Streamstats Program. https://water.usgs.gov/osw/streamstats/
- United States Geological Survey. 2018. USGS WaterWatch. Streamflow conditions. http://waterwatch.usgs.gov
- https://water.usgs.gov/osw/odrm/ffmp/FFMP_White_Paper_Version_Final_1_12_10.pdf, page 12
- Simon, A. and Hupp, C.R. (1986) Channel Evolution in Modified Tennessee Channels. Proceedings of the 4th Federal Interagency Sedimentation Conference, 2, 5.71-5.82.
- Walter, R. & Merritts, D., 2008 Natural Streams and the Legacy of Water-Powered Mills, **Science** Vol 319, Issue 5861
- Reynolds, R. 2000. Hydrogeology of the Beaver Kill Basin in Sullivan, Delaware, and Ulster Counties, New York. USGS Water Resources Investigations Report 00-4034
- Titus, Robert. The Catskills in the Ice Age. Purple Mountain Press, 2003.
- Dyke, A S, and V K Prest. “Late Wisconsinan and Holocene Retreat of the Laurentide Ice Sheet.” Géographie Physique Et Quaternaire, vol. 41, no. 2, 1987, pp. 237–263., doi:10.4095/122842.
- Ischsen, Y.W., et al., Geology of New York State: a simplified account. New York State Museum Educational Leaflet No. 28, New York State Museum, Albany, NY, 1991
- Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service. U.S. Department of Agriculture Handbook 436
- Kudish, Michael. 2000. The Catskill Forest: A History. Purple Mountain Press, Ltd. Fleischmanns, NY.
- Adams, et al 1992, Ecotoxicology and Environmental Safety, Volume 24, Issue 3, December 1992, Pages 347-360
- Shelton, L. & Capel, P. 1994,Guidelines for collecting and processing samples of stream bed sediment for analysis of trace elements and organic contaminants for the National Water-Quality Assessment Program, https://pubs.usgs.gov/of/1994/0458/report.pdf