A Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the

Deerfield River Watershed

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Acronyms

ACRONYM	DEFINITION
319	319 Nonpoint Source Pollution Grant Program administered by MassDEP. Funding from EPA.
604b	604b Water Quality Management Grant Program administered by MassDEP. Funding from EPA.
APR	Agricultural Preservation Restriction Program administered by MDAR.
ARA	Active River Area
BMP	Best Management Practices
CFR	Coldwater Fish Resources
CR	Conservation Restriction
CRC	Connecticut River Conservancy
CSA	Comparative Subwatershed Analysis
DER	Department of Ecological Restoration (in MassDFG)
DLTA	District Local Technical Assistance grant program (Commonwealth of Massachusetts)
DRWA	Deerfield River Watershed Association
EEA	Massachusetts Executive Office of Energy & Environmental Affairs
EPA	United States Environmental Protection Agency
FCD	Franklin Conservation District
FEMA	Federal Emergency Management Agency
FLT	Franklin Land Trust
FRCOG	Franklin Regional Council of Governments
HUC	Hydrologic Unit Codes
LID	Low Impact Development
LI RCPP	Long Island Sound Regional Conservation Partnership Program
MAPPR	Mapping Priority Parcels for Resilience
MassDEP	Massachusetts Department of Environmental Protection
MassDFG	Massachusetts Department of Fish & Game
MassDOT	Massachusetts Department of Transportation
MassGIS	Massachusetts Geographic Information System
MEMA	Massachusetts Emergency Management Agency
MET	Massachusetts Environmental Trust grant program
MDAR	Massachusetts Department of Agricultural Resources
NAACC	North Atlantic Aquatic Connectivity Collaborative
NHESP	Natural Heritage and Endangered Species Program
NRCS	USDA Natural Resources Conservation Service
NRPZ	Natural Resource Protection Zoning
OSRD	Open Space Residential Development
PDM	Pre-Disaster Mitigation Grant Program funded by FEMA and administered by MEMA
TMDL	Total Maximum Daily Load (pollution “budget” for a river or pond)
TNC	The Nature Conservancy
UMass	University of Massachusetts
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
WTM	Watershed Treatment Model

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Introduction

Overview of the Deerfield River Watershed

The Deerfield River is a major tributary of the Connecticut River and is widely regarded as one of the coldest and cleanest rivers in Massachusetts. The watershed supports a wide variety of ecological, recreational, and commercial uses and there are many active stakeholders that have a vested interest in maintaining the high quality and resiliency of the watershed resources.

The Deerfield River Watershed straddles two states, Vermont and Massachusetts, and includes approximately 665 square miles of land that is primarily forested and undeveloped. From its headwaters in the Green Mountains of Vermont, the Deerfield River flows approximately 70 miles and drops roughly 2,000 feet in elevation before it joins the Connecticut River in Greenfield,

Massachusetts. The river enters Massachusetts between the towns of Monroe and Rowe in Franklin County and flows southeastward through the Berkshire Hills of Massachusetts in a narrow valley characterized by beautiful scenery, steep slopes, and rural village centers. As the river approaches its confluence with the Connecticut River, the river valley becomes wider and includes many agricultural fields in the Town of Deerfield and the urban area of the Town of Greenfield. Most of the Massachusetts portion of the watershed is located in Franklin County. A small percentage of the western and southwestern portions of the watershed are located in Berkshire and Hampshire Counties. There are ten HUC 12 subwatersheds and 14 towns in the Franklin County portion of the Deerfield River Watershed (Map 1).

Map 1: HUC 12 Subwatersheds and Towns within the Deerfield River Watershed

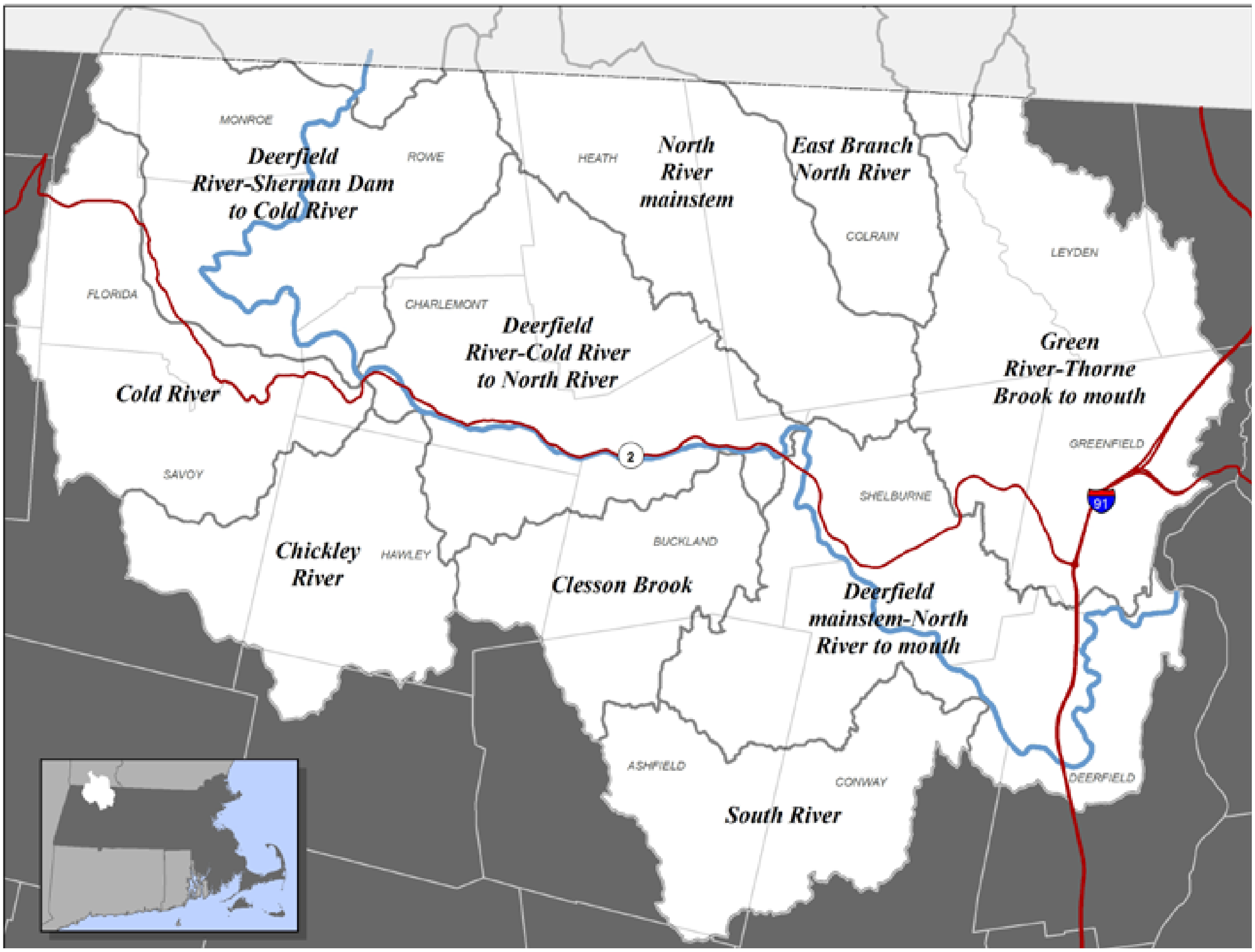


Figure 1: Holistic Watershed Planning Elements

The Need for a Comprehensive Watershed Plan

Protecting the current health of the Deerfield River Watershed, restoring impaired waterbodies and increasing the watershed's resiliency to climate change are priorities for stakeholders. The EPA's Healthy Watersheds Initiative recognizes that a holistic systems approach to protecting key watershed processes and habitats will maintain a healthy watershed. The Healthy Watersheds concept views watersheds as integrated systems that can be understood through the dynamics of essential ecological attributes, including:

Landscape Condition, Biotic Condition; Chemical/Physical Parameters; Natural Disturbance Regimes; and Hydrology/Geomorphology. Programs that protect and restore aquatic ecosystems are most effective when they integrate these dynamics and manage watersheds as systems.

Many of the issues identified in the Deerfield River Watershed must be addressed as part of a holistic watershed planning approach that recognizes that there are many types of impairments, even in a healthy watershed, and these impairments compromise the green infrastructure, climate change resiliency and overall health of the watershed and its resources (Figure 1). A holistic management approach also recognizes that the health and resiliency of the watershed directly affects the climate change resiliency of the municipal infrastructure, public safety and economic welfare of watershed residents. Maintaining the health and resiliency of the watershed's wetlands, floodplains, riparian corridors, forests and other vegetated open spaces will help to mitigate the impacts from severe storm events and flooding. These landscape-scale green infrastructure features also filter and recharge stormwater so groundwater and drinking water aquifers are replenished, which benefit watershed residents.

This plan integrates the 9 elements of a 319 Watershed-Based Plan, the tenets of EPA's Healthy Watersheds Initiative, and focuses on strategies and projects to protect and restore the watershed's Green Infrastructure as a cost-effective Climate Change adaptation strategy. This plan identifies mitigation, restoration, preservation and avoidance projects/strategies that address multiple problems and provide multiple benefits. The recommendations apply to various scales – the Deerfield River Watershed, its ten HUC 12 subwatersheds and the 14 watershed towns in Franklin County.

Plan Goals

As stakeholders work to implement the watershed management and land use recommendations, site-specific projects and additional watershed assessments described in this Watershed-Based Plan, the plan's primary goals will be realized. These goals include:

Goal #1 Protect, restore and enhance the health and climate change resiliency of the watershed's natural resources, including terrestrial and aquatic habitat, water quality and quantity, forests, floodplains, wetlands and open lands.

Goal #2 Protect, restore and manage the watershed's green infrastructure (floodplains, river corridors, headwater and high quality tributary streams, and forested upland areas) to provide flood resiliency to the watershed communities and their critical infrastructure.

Goal #3 Provide outreach and technical assistance to watershed communities to help residents understand the benefits of a holistic watershed management approach and to garner support for the implementation of plan recommendations.

Goal #4 Promote collaboration across municipal boundaries and engage a variety of stakeholder groups in plan implementation activities.

Plan Development Process

FRCOG developed the Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed (the Plan) with the assistance of key watershed stakeholders and the professional expertise of our consultants, Fuss & O'Neill and Field Geology Services. FRCOG reviewed and incorporated data and recommendations from previous studies conducted by FRCOG and others for the Deerfield River Watershed and several of its HUC 12 subwatersheds. FRCOG used our own Geographic Information System (GIS) database and data layers available from MassGIS to create watershed maps and facilitate the assessment and analysis completed by FRCOG. FRCOG developed two assessment methodologies specifically for this project to assess relative HUC 12 subwatershed health and the vulnerability of critical upland tributaries and watershed lands. Important data was also gathered during field assessments and used to develop conceptual designs for site-specific projects and watershed recommendations to protect watershed health, restore impaired water bodies and increase the watershed's resiliency to climate change.

The plan is consistent with EPA's guidance for watershed-based plans, which includes nine key elements that establish the structure of the plan. These nine elements include specific goals, objectives, and strategies to protect and restore water quality; methods to build and strengthen working partnerships; a dual focus on addressing existing problems and preventing new ones; a strategy for implementing the plan; and a feedback loop to evaluate progress and revise the plan as necessary. Following this approach will enable implementation projects under this plan to be considered for funding under Section 319 of the Clean Water Act (the MassDEP administers this grant program). Where possible, this document also identifies other possible sources of funding to help stakeholders with plan and project implementation.

Several technical assessments were completed by FRCOG, Fuss & O'Neill and Field Geology Services to inform plan development. These assessments are listed below and are included as appendices to the plan.

Baseline Watershed Assessment summarizes the existing data for the watershed's natural resources, land use and development patterns, vulnerabilities, needs and opportunities for additional assessment, and climate change resiliency. This document is an important reference for stakeholders working to implement plan recommendations.

Land Use Regulatory Review for the 14 watershed towns in Franklin County. FRCOG evaluated existing zoning, stormwater, wetlands and subdivision regulations with respect to watershed health, flood and stormwater management, and resiliency.

Four Comparative Subwatershed Analyses (CSA)

- The Watershed Health CSA was conducted using the EPA's model of a Watershed Health Index. The EPA Watershed Health Index assesses the condition of a watershed by examining the six essential ecological attributes fundamental to a healthy watershed, which are: Landscape condition; Habitat; Hydrology; Geomorphology; Water quality;

and Biological condition. FRCOG developed an assessment methodology that used multiple metrics to create sub-indices, which were then aggregated up into a single Watershed Health Index value for each HUC 12 subwatershed.

- Three CSAs were completed by the consultant, Fuss & O'Neill. The objective of these CSAs is to identify the HUC 12 subwatersheds with the greatest: 1) vulnerability to water quality degradation, 2) water quality restoration potential, and 3) flood risk vulnerability. Subwatersheds with higher aggregate vulnerability and restoration scores will be the focus of watershed management efforts, given limited financial resources. These subwatersheds should be targeted for field assessments and further development of restoration and protection strategies.

Pollutant Loading Model was used to estimate annual pollutant loads from the HUC 12 subwatersheds. Fuss & O'Neill used the Watershed Treatment Model (WTM), developed by the Center for Watershed Protection. The WTM is a screening-level model that can be used to estimate the loading of various pollutants to a waterbody based on land use and other activities within a watershed and how the implementation of restoration projects and best management practices can reduce pollutant loads. For this project, the results of the pollutant loading model were used to help prioritize/target subwatersheds and land uses for field work and other assessments.

Upland Tributary and Watershed Protection Assessment FRCOG used MassGIS data layers to assess the level of protection that exists for the Coldwater Fish Resources (CFRs) and surrounding upland areas that are tributaries to the HUC 12 mainstem rivers.

Stream and Watershed Geomorphic Assessments Field Geology Services conducted geomorphic assessments of specific stream and upland areas in the Deerfield River Watershed that were selected based on a review of the findings from the four CSAs and the Upland Tributary assessment conducted by FRCOG. The purpose of the geomorphic assessment is 1) to capture the range of conditions in the streams of the watershed, 2) to identify stressors and impairments, 3) to highlight stream reaches with degraded water quality, impaired habitat and geomorphic function, and increased fluvial erosion hazards and flood risk vulnerability, 4) to develop conceptual restoration designs to address stream channel instabilities, and 5) to identify priority areas for conservation.

Green Infrastructure Assessment evaluated the extent, condition and value of green infrastructure in the Deerfield River watershed. This analysis primarily used MassGIS data and U.S. Forest Service's iTree. Datalayers from BioMap2, a program of Massachusetts Natural Heritage and Endangered Species Program and The Nature Conservancy's Massachusetts Program, were also employed.

Watershed Health and Resiliency

Baseline Inventory of Watershed Conditions

A detailed inventory and assessment of the environmental conditions of the Deerfield River Watershed, including hydrology, watershed modifications, nonpoint source pollution, river corridors and floodplains, water quality, natural resources, climate change impacts, and green infrastructure is included as Appendix A. This document can serve as an important reference for watershed stakeholders. The inventory and assessment findings were used in the development of this plan to help identify the main environmental issues in the watershed and each of the ten HUC 12 subwatersheds, as well as some of the gaps in information that might be the focus of future data collection efforts.

Overview

The geology of the Deerfield River Watershed is characterized by a shallow depth to bedrock with glacial till being the dominant unconsolidated material. There are some sand and gravel deposits located within the river and stream valleys and along the eastern Deerfield Watershed lowlands. Floodplain alluvium deposits are found adjacent to rivers with the largest river area of these deposits associated with the low-lying areas along the river in the Town of Deerfield and the Connecticut River Valley.

Major roads running through the watershed include Interstate 91, State Highway Route 2, Route 10, Route 112, Route 116, and Route 8A. A major railroad also runs along the Deerfield River from the Town of Deerfield west to the Town of Florida. The eastern portion of the watershed (specifically Greenfield and Deerfield) is the most populated part of the watershed and has the greatest density of roads.

Table 1: Population of Communities within the Deerfield River Watershed (Franklin County, MA)

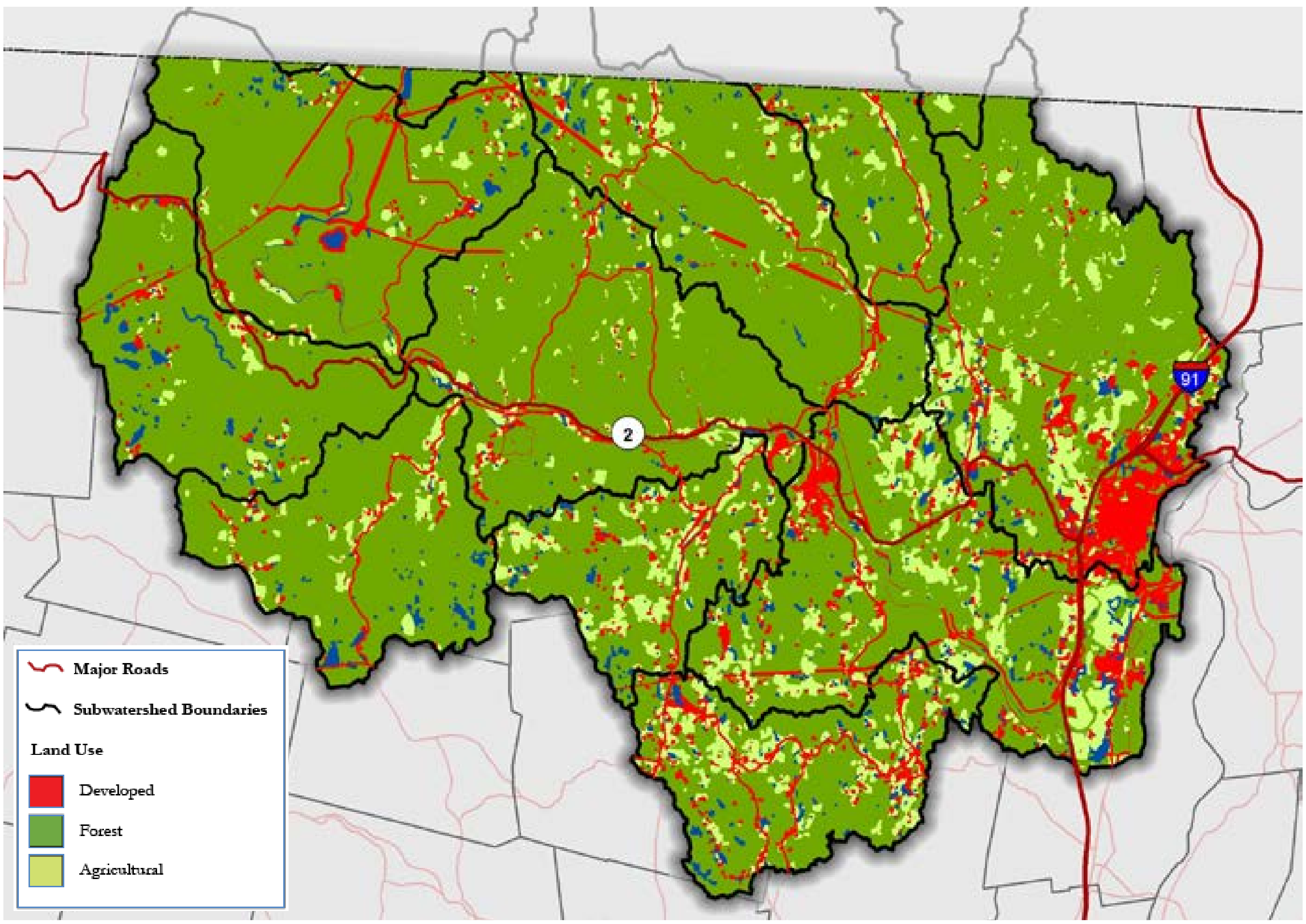
Community	Percent of Community in Watershed	Total Population
Buckland	100%	1,961
Charlemont	100%	1,218
Colrain	100%	1,680
Heath	100%	629
Monroe	100%	118
Rowe	100%	452
Shelburne	100%	1,979
Hawley	94%	435
Greenfield	85%	17,484
Leyden	76%	650
Ashfield	61%	1,749
Conway	60%	1,663
Deerfield	43%	5,097
Bernardston	12%	2,173
Total		37,288

Source: 2010-2014 American Community Survey 5-Year Estimates

The population in the Franklin County portion of the Deerfield River Watershed has been historically concentrated in the Greenfield/Deerfield and Shelburne Falls areas. There are fourteen municipalities in the Franklin County portion of the Deerfield Watershed with a total population of 37,288 (See Table 1). Almost half of this population is within the town of Greenfield, which is located in a HUC 12 subwatershed of the Green River. Projections show that the population of the Deerfield River Watershed will slightly decline over the next 30 years by approximately 2,500 people. This population loss is mostly due to an aging population that is not being replaced by younger residents. However, the anticipated arrival of broadband internet and passenger commuter rail to the region over the next decade may cause an increase in people relocating to the region in search of more affordable housing. These infrastructure changes have not been taken into account in the population projections and may cause an increase in future development pressures rather than a population loss.

The majority of the watershed is heavily forested with open farmland more common in the eastern portion. Development is concentrated in distinct areas of the watershed, particularly in the towns of Greenfield and Shelburne. Light industrial development is found in pockets along major rivers and commercial development is located mostly in village centers and along the Mohawk Trail (Route 2). Historic village centers include a mix of residential, municipal, and commercial uses. Residential subdivisions are uncommon in the watershed, and have occurred mostly in Greenfield, Deerfield, and Shelburne. Map 2 shows the type of land uses for each of the HUC 12 subwatersheds. Detailed land use information by subwatershed can be found in Appendix A.

Map 2: Land Use, Deerfield River Watershed, Franklin County, MA



Source: MassGIS

Since 1985, there have been significant changes in land use within the watershed. Specifically, large lot residential development has resulted in the loss of forest and farmland. Between 1985 and 1999, the 15 towns in the watershed experienced reductions in 1,750 acres of cropland (10%), 2,370 acres of pastureland (22%), and 2,070 acres of forest (1%), with a 58% increase in large-lot residential development (3,443 acres).[1] This development typically occurred via construction of single-family homes on lots along existing roadways, known as Approval Not Required (ANR) development. More recently, the region experienced a 2% loss in population between 2000 and 2010. Even so, the number of housing units increased in the region by 4%.[2] This is in part due to smaller household sizes, and may also point to second home construction in some communities. It is likely that land use in the watershed will follow a similar pattern in the foreseeable future.

Flood Resiliency and Watershed Health

Perhaps the single most important issue to many watershed stakeholders is flooding and how severe storm events impact watershed health and the residents who live in the watershed communities. Tropical Storm Irene, which devastated large sections of the watershed in 2011, is still a very recent memory. Tropical Storm Irene delivered between 3 and 10 inches of rain over western Massachusetts and resulted in a 15 foot rise in the Deerfield River in a matter of hours. Stream gages on the Deerfield River at Charlemont and West Deerfield recorded peak discharges of 54,000 and 89,800 cubic feet/second, respectively.[3] The gage on the North River recorded a peak discharge of 30,300 cubic feet when the average annual peak discharge for the past 75 years was

Farmland along the East Branch North River in Colrain was damaged by flooding from Tropical Storm Irene.

6,470 cubic feet/second.

This storm caused unprecedented damage to many locations in the watershed. Portions of Route 2 between Charlemont and Florida were closed for three months due to road washouts, and residents in the Town of Hawley were completely cut off for several days due to damages to Route 8A. The Interstate 91 bridge over the Deerfield was temporarily closed, and the Greenfield wastewater treatment plant was inundated and discharged untreated sewage into the river. More than $90 million of insurance damage claims were made in western Massachusetts, and as of 2013 more than $64 million in federal assistance

1 MassGIS Data - Land Use (1951-1999)

2 2000 and 2010 U.S. Census.

3 Lombard, P.J., and Bent, G.C., 2015, Flood-inundation maps for the Deerfield River, Franklin County, Massachusetts, from the confluence with the Cold River tributary to the Connecticut River: U.S. Geological Survey Scientific Investigations Report 2015–5104, 22 p., http://dx.doi.org/10.3133/sir20155104.

was made to individuals and public entities in Massachusetts as a result of Tropical Storm Irene.[4] The North River subwatershed in Vermont and Massachusetts was one of the hardest hit locations. This tributary suffered some of the worst damage from Tropical Storm Irene, including severe erosion of agricultural fields, streambanks, landslides, road washouts and damage to bridges. Severe bank erosion continues to threaten Colrain community wells and public wells for Shelburne and Buckland that are located in Colrain.

The force of Tropical Storm Irene's floodwaters washed away farm fields and deposited silt and debris in Deerfield and other towns.

Downstream near the mouth of the Deerfield River in the Town of Deerfield, soil from riparian buffers and farm fields was swept away, lowering the buffers by approximately 6 feet in some locations.[5] These damaged buffers render their adjacent farmlands, roads, houses and other infrastructure vulnerable to future floods.

To place this storm in context, UMass researchers have estimated that sediment discharged from the Deerfield River in one day exceeded at least 10 to 40 years' worth of normal sediment discharge and accounted for approximately 40 percent of the total sediment discharge from the Connecticut River resulting from Tropical Storm Irene.[6]

They also reported that Tropical Storm Irene caused the most severe erosion of any flood in the historic record, greater than that of events with more rainfall and higher peak discharges from the Deerfield River. They attribute this extreme erosion to the fact that at the time of the

4 Ibid, p.3.

5 Interview with Rita Thibodeau, NRCS District Conservationist, Franklin County, May 17, 2017, conducted by Deborah Shriver, Franklin Conservation District and Deborah Shriver Consulting.

6 Yellen, et al., 2014. Source, conveyance and fate of suspended sediments following Hurricane Irene. New England, USA. Geomorphology v. 226, p. 124-134.

Conditions on the North River, just below the confluence of the river's East and West Branches, prior to Tropical Storm Irene included a dam, canal and armored bank with Rte. 112 in river corridor.

After Tropical Storm Irene, the dam was largely washed away.

storm, soils were already saturated due to higher than normal rainfall. The researchers conclude that the potential for highly erosive storms is growing as wetter conditions increase due to climate change.[7]

Dethier, et al.[8] identified 274 landslides in the Deerfield River watershed (including the Vermont portion) associated with Irene. Roughly the same number of landslides occurred during Tropical Storm Irene as in the previous 30 years combined. Now, almost six years after the storm, for a given river flow the amounts of suspended sediments are approximately double the pre-Irene amounts.[9] These suspended sediments persist even in low flow conditions as streams continue to erode large glaciolacustrine deposits made up of a large volume of very fine sediments. Since revegetation of these sites may take between 5 and 30 years, this erosion and sedimentation will continue until the landslide scars are stabilized with vegetation.

In December 2011, the Franklin Conservation District convened Creating Resilient Communities, an ad hoc group of stakeholders that includes staff of Federal and State agencies, municipal officials, UMass researchers, the State Geologist, FRCOG and watershed organizations. The group has met regularly over the past six years to collaborate and secure funding for watershed assessment, planning and restoration of the watershed. In the months following Irene, Creating Resilient Communities members identified problem areas in the watershed (see Map A12 in the Appendices) and compiled a list of ongoing / planned projects which is periodically updated (see Appendix F).

7 Yellen, et al., 2016. Historically unprecedented erosion from Tropical Storm Irene due to high antecedent precipitation. Earth Surf. Process. Landforms, Wiley Online Library, DOI: 10.1002/esp.3896.

8 Dethier, Evan, F. Magilligan, C. Renshaw and K. Nislow, 2016. The role of chronic and episodic disturbances on channel-hillslope coupling: The persistence and legacy of extreme floods. Earth Surf. Process. Landforms 41, 1437-1447.

9 Interview with UMass researcher, Brian Yellen, May 16, 2017, conducted by Deborah Shriver, Franklin Conservation District and Deborah Shriver Consulting..

Land Use Regulatory Review

The comprehensive land use regulatory review completed for each of the 14 watershed towns is summarized below and included in Appendix D. Recommendations that were developed as a result of this review are included in Table 17. The recommendations were developed with a watershed scale as a backdrop. At a local level, the adoption of the recommendations will improve local conditions. If towns within a HUC 12 subwatershed adopt regulations and/or modify existing regulations to align with those of their neighboring towns in a subwatershed, then the scale of benefits and protections is enlarged. Over time, as towns improve their land use regulations across all 14 towns in the Deerfield River Watershed, the regulations will be more protective of the watershed's resources and enhance the resiliency of the watershed to climate change.

Background

Massachusetts is a home rule state, where essentially all land use decisions and regulations are handled at the town level. In the Deerfield River Watershed communities, volunteer Planning Boards, Zoning Boards of Appeal, Boards of Health, and Conservation Commissions review development projects and propose amendments to town bylaws and regulations. Few towns within the region have full or part time professional staff assisting these boards. Greenfield is the main exception. As the County's largest community, Greenfield maintains a professional planning staff that assist the Town's volunteer boards with reviewing projects and amending regulations. The Franklin Regional Council of Governments serves as the Regional Planning Agency for the Deerfield River Watershed towns, and provides targeted technical assistance to all towns in Franklin County for reviewing and drafting amendments to land use regulations. FRCOG can provide some consistency throughout the region in terms of recommending regulations that help protect water quality. Ultimately, however, these decisions are up to the local towns.

Toolkits to help municipalities incorporate Low Impact Development and other techniques into their local regulations include Incorporating Low Impact Development (LID) into Local Bylaws, *(excerpt shown above)created by the FRCOG.*

Land use regulations in one town can positively or negatively impact water quality and flooding in another town. For example, if development is allowed within the floodplain in one town, downstream communities may be impacted from more severe flooding, erosion, and sedimentation. On the other hand, if towns within a watershed regulate development within the floodplain in a consistent, scientifically-based manner, the benefits can extend well beyond the boundaries of each community and the watershed.

Table 2: Land Use Regulations within the Watershed and Date of Last Amendment

Town	Zoning Bylaws	Subdivision Regulations	Stormwater Bylaw / Policy	Local Wetlands Bylaw
Ashfield	9/29/2011	4/2007		
Bernardston	4/27/2016	6/28/1988		
Buckland	9/25/2014	5/26/1988		
Charlemont	12/17/2014	3/15/1979		
Colrain	5/6/2014	5/22/2003		
Conway	5/9/2016			
Deerfield	9/1/2015	9/15/2005	4/4/2010	
Greenfield	8/17/2016	5/29/1984	5/16/2012	5/21/2014
Hawley	4/9/2012	10/7/1987		
Heath	5/11/2013			7/23/1992
Leyden	5/17/2014	8/14/2014		
Monroe	7/2/1990	7/24/1974		
Rowe	11/2/2011	1979		
Shelburne	5/3/2016	3/16/2016		

How a community regulates land use has a direct impact on natural resources and community character over time. For instance, in the 1980s and 1990s, the population within the 15 towns in the watershed grew by 7%, yet large-lot residential development grew by 58%. Regulations that require large minimum lot sizes of 1 or 2 acres per housing unit result in greater land use change over time. Regulations that support or require clustering of homes on smaller lot sizes in rural areas, encourage redevelopment and new infill development within villages and downtowns (with water and sewer infrastructure that can support denser development), and utilize Low Impact Development site planning and stormwater management techniques, can meet the housing needs of the population with less impact on the environment. The Land Use Regulatory Review in the Appendix summarizes the extent to which watershed communities have implemented zoning and subdivision regulations that will protect water quality and natural resources.

Impacts from land use change and development have been severe for agricultural land in the watershed. Farmland located along existing roads is particularly vulnerable to development. It is easy and less expensive to develop as ANR lots – the land is already cleared, and is often relatively flat. Agricultural land in the watershed includes feed crops to support dairy and beef farms, pasture for grazing, fruit tree orchard plantings, and sugar maple stands that are tapped to produce maple syrup. Within the watershed, agricultural fields are most prevalent in the areas east of the North River in Colrain, and in Clesson Brook in Buckland.

The amount of agricultural land varies by town:

- Monroe, Hawley, and Rowe have 5% or less of their land in agriculture;
- Ashfield, Bernardston, Buckland, Colrain, Conway, Charlemont, and Heath have between 7% and 11% of their land in agriculture; and,
- Deerfield, Greenfield, Leyden, and Shelburne have between 12% and 20% of their land in agriculture.

In addition to contributing to the local food economy, the land that farmers steward can provide important ecological services, such as filtering water, reducing flooding, recharging aquifers, and providing year-round habitat for many species of fish and wildlife, and stopovers for migrating birds. According the 2015 MA Local Food Action Plan, "Farmers are important caretakers of our natural resources, and should be supported in and recognized for this stewardship role."[10] Although farms provide these many valuable ecosystem services, there are potential negative ecological impacts from farming practices. State and Federal programs exist that can help farmers implement practices to promote soil health, nutrient management, water quality and quantity, and other objectives. More assistance and outreach is needed, however, to educate farmers about these programs and to ensure practices are implemented and continued over the long-term.[11]

Forests are the most dominant land use in the watershed, and comprise between 65% (Green River) to 99% of the land use (Cold River) in each subwatershed. Forests provide many important benefits, such as clean water, carbon sequestration, wildlife habitat, scenic landscapes, recreational opportunities, and forest products. In 2014, Harvard Forest published *Changes to the Land: Four Scenarios for the Future of the Massachusetts Landscape,*[12] an evaluation of the consequences of four different trajectories for how land use could change in the state over the next 50 years, with a specific focus on the impacts to the region's forests. The scenarios reflect different amounts and intensities of land development, timber harvesting, farmland expansion, and forest conservation.

Key findings from the study show that treating forests as valuable living infrastructure provides benefits to people and nature. Under this scenario, accelerated land conservation targeted to areas of priority habitat would protect more than half a million acres of priority habitat by 2060. Widespread adoption of "improvement forestry" would maintain critical forest benefits while increasing local wood production. The majority of new development would be clustered and

10 MA Local Food Action Plan: http://mafoodsystem.org/plan/

11 Ibid.

12 http://harvardforest.fas.harvard.edu/changes-to-the-land

concentrated near existing cities and towns to minimize forest loss and reduce the impact of growth on water resources and forest habitat. Importantly, the study found that nearly the same amount of new development could occur under this scenario as would occur if recent trends continue, but with fewer negative impacts to forests, water quality, and wildlife habitat.

The report emphasizes how local land-use decisions can greatly influence the ability of the state's forests to offset greenhouse gas emissions and moderate the effects of climate change. The over-arching policy implications from the study are that there is much to gain by:

1. Recommitting to land conservation,
2. Redoubling land-use policy and smart-growth efforts through local and state zoning reform that supports transit-friendly, walkable communities where new growth uses land efficiently and limits impacts on natural resources, and
3. Promoting sustainable forestry in the Commonwealth.

Permanently Protected Land

Currently approximately 31% of the watershed (69,294 acres) is permanently protected from development. The amount of protected land varies between towns and subwatersheds. These lands are a combination of State-owned conservation lands, land owned by private non-profit conservation organizations such as land trusts, and privately-owned land where development rights have been restricted either through a Conservation Restriction (CR) or Agricultural Preservation Restriction (APR). Permanently protecting farm and forestland provides tremendous public benefits. The Trust for Public Land estimates that every $1 invested in land conservation in Massachusetts returns $4 in economic value, for stormwater management, water quality protection, carbon sequestration, air pollution removal, and soil retention. In addition to these benefits, protected lands support local economies through tourism and farm and forest product businesses.[13]

Methodology for Land Use Regulatory Review

Zoning

Zoning determines the uses, dimensions and sometimes design within different areas (districts) of a town. The purpose of zoning includes but is not limited to:

- To facilitate the adequate provision of transportation, water, water supply, drainage, sewerage, schools, parks, open space and other public requirements;
- To conserve the value of land and buildings, including the conservation of natural resources and the prevention of blight and pollution of the environment;
- To encourage the most appropriate use of land throughout the city or town, including consideration of the recommendations of the master plan.

13 *The Return on Investment in Parks and Open Space in Massachusetts*, Trust for Public Land, 2013. http://cloud.tpl.org/pubs/benefits-ma-roi-report.pdf

Amendments to a zoning bylaw or ordinance require a two-thirds vote of Town Meeting or Town Council. Most towns within the watershed have amended something within their zoning within the last 5-10 years. Towns typically amend zoning piecemeal over time; though sometimes a town will do a complete overhaul. Zoning applies to new development and redevelopment, depending on the nature of the project. Zoning bylaws outline what land uses (such as residential, commercial, or industrial) are allowed where, and what the land requirements are for building, including minimum lot size, minimum frontage (the portion of a lot that abuts a public road), and setbacks from lot lines for structures. The Building Inspector typically enforces the zoning bylaw in a community.

Table 3: Summary of Zoning Regulations that Address Water Quality Impacts in Watershed Communities

	Ashfield	Bernardston	Buckland	Charlemont	Colrain	Conway	Deerfield	Greenfield	Hawley	Heath	Leyden	Monroe	Rowe	Shelburne
Development in Floodplains	Not	Partially	Not	Not	Not	Not	Not	Partially	Not	Partially	Partially	Not	Not	Not
Stormwater Management	Partially	Partially	Partially	Partially	Partially	Partially	Fully	Partially	Not	Fully	Partially	Not	Not	Partially
Erosion / Sedimentation	Partially	Partially	Partially	Partially	Not	Not	Fully	Fully	Partially	Partially	Partially	Partially	Not	Not
Impervious Cover	Not	Partially	Fully	Fully	Fully	Not	Fully	Fully	Not	Partially	Fully	Not	Not	Not
Cluster / OSRD / NRPZ	Not	Not	Partially	Partially	Partially	Not	Partially	Partially	Partially	Partially	Fully	Partially	Not	Fully
Water Supply Protection	Not	Fully	Not	Not	Not	Not	Fully	Fully	Not	Fully	Fully	Not	Not	Not
Parking	Not	Fully	Fully	Not	Not	Not	Partially	Fully	Partially	Partially	Not	Not	Not	Partially
Common Driveways	Fully	Not	Not	Not	Not	Fully	Fully	Fully	Fully	Fully	Fully	Not	Not	Not
Site Plan Review	Not	Fully	Fully	Fully	Partially	Partially	Fully	Fully	Not	Fully	Fully	Not	Partially	Not
Vegetation / Trees	Partially	Partially	Partially	Partially	Partially	Partially	Partially	Partially	Not	Partially	Fully	Partially	Partially	Partially
Large-Scale PV	Partially	Partially	Fully	Not	Partially	Not	Partially	Fully	Not	Fully	Not	Not	Partially	Fully

Fully Addressed in Regulations
Partially Addressed in Regulations
Not Addressed / Minimally Addressed in Regulations

A review of zoning bylaws/ordinances within the Deerfield River Watershed towns was conducted to answer the following questions. A summary of the zoning review is illustrated in Table 3.

- Is development prohibited within the 100-year floodplain?
- What stormwater runoff / management standards are required?
- Is erosion and sediment control for construction activities and post construction conditions addressed?
- Is the amount of impervious surface on a lot minimized?
- Does the community allow, encourage, or mandate Open Space Residential Design subdivision that provides for clustered residential development with open space protection?
- Has a water supply protection district been established to protect groundwater resources?

- Does the community allow parking options that reduce overall impervious surface? Are trees and LID stormwater management required for larger parking lots?
- Are common driveways allowed to reduce overall impervious surface?
- Does a community have Site Plan Review, and does it address stormwater and encourage LID?
- Does the bylaw encourage or require preservation of existing vegetation and mature trees or the planting of new trees in development/ redevelopment activities?
- Does the community address stormwater impacts and land clearing for large-scale ground-mounted solar installations?

Subdivision Regulation

Subdivision regulations address road design, utilities, stormwater drainage, and other features of a new development when land is being divided into two or more parcels. The Subdivision Control Law (M.G.L. Ch. 41, Section 81K – 81GG) gives authority to a town's Planning Board to adopt and amend subdivision regulations after holding a public hearing. Despite the relative ease (compared to zoning) of amending subdivision regulations, most communities in the Deerfield River Watershed have not made changes to their regulations in many years. This is partly due to the lack of subdivision activity within much of the region. When new homes are built, they are usually sited along existing roads via the Approval Not Required process.

Table 4: Summary of Subdivision Regulations Addressing Water Quality Impacts in Watershed Communities

	Ashfield	Bernardston	Buckland	Charlemont	Colrain	Conway	Deerfield	Greenfield	Hawley	Heath	Leyden	Monroe	Rowe	Shelburne
Stormwater Management	Fully	Partially	Partially	Not	Partially	Not	Fully	Fully	Partially	Not	Partially	Not	Not	Fully
Erosion / Sedimentation	Fully	Partially	Partially	Not	Not	Not	Fully	Fully	Partially	Not	Partially	Not	Not	Fully
Vegetation / Nat. Features	Partially	Partially	Fully	Partially	Partially	Not	Partially	Partially	Fully	Not	Fully	Partially	Not	Partially
Street Trees	Fully	Not	Fully	Not	Fully	Not	Not	Not	Fully	Not	Fully	Not	Not	Partially
Road Design	Fully	Partially	Partially	Fully	Not	Not	Partially	Not	Partially	Not	Partially	Not	Not	Fully

Fully Addressed in Regulations; Partially Addressed in Regulations; Not Addressed / Minimally Addressed in Regulations

Unfortunately, once a development is proposed, it is too late to go back and amend the regulations. That is why it is useful for towns to review what is on the books, and start by making some changes to elements that might be outdated or that never fit the character of the town to begin with. For example:

- Are road widths excessively wide?
- Do regulations address stormwater runoff and erosion for the whole development, or just for roads?
- Are large pipes and detention ponds required, or are natural drainage and Low Impact Development (LID) encouraged?
- Is clearing of vegetation minimized, and the protection of natural features clearly identified?
- Are street trees required? Prohibited?

A review of subdivision regulations in the watershed towns sought to answer these questions. Table 4 provides a summary illustrating to what degree towns address these elements in their regulations.

Local Wetlands Bylaws

Wetlands help clean drinking water supplies, prevent flooding and storm damage, and support a variety of wildlife. Inland wetlands are areas where water is at or just below the surface of the ground. Although these wetlands can appear dry during some seasons, they contain enough water to support certain plants and soils. Inland wetlands include marshes, wet meadows, bogs, and swamps. Since Colonial times, almost one third of Massachusetts' wetlands have been destroyed. Concerned about the loss of wetlands, Massachusetts adopted the nation's first wetlands protection laws in the early 1960s. Today, wetlands are protected by state and federal laws. The Wetlands Protection Act (Massachusetts General Laws (MGL) Chapter 131, Section 40) protects wetlands and the public interests they serve by requiring a careful review of proposed work that may alter wetlands. The law protects not only wetlands, but other resource areas, such as land subject to flooding (100-year floodplains), the riverfront area (added by the Rivers Protection Act), and land under water bodies, waterways, salt ponds, fish runs, and the ocean. The law regulates many types of work in resource areas and buffer areas within 100 feet of a resource, including vegetation removal, regrading, and construction of houses, additions, decks, driveways, and commercial or industrial buildings.

A community's Conservation Commission administers the Wetlands Protection Act. Communities can adopt a local wetlands bylaw or ordinance in addition to the State law. These bylaws may expand upon the resource areas protected under State law, and may impose stricter standards for activities within resource areas. Two of the 14 communities within the watershed have adopted local wetlands regulations. The Town of Greenfield is the only watershed community that has a professional Conservation Agent to assist the Conservation Commission. See Appendix D for more details.

Stormwater Bylaws / Regulations

Stormwater management can be addressed in various ways within town regulations, as demonstrated by the review of zoning, subdivision, and wetland regulations in the Deerfield River Watershed communities, located in Appendix D. A more comprehensive way to address stormwater impacts from development activities is for a community to adopt a stand-alone stormwater bylaw and regulations. A stormwater bylaw establishes stormwater standards for new development and redevelopment, identifies the thresholds and types of activities needing a stormwater permit, and outlines the application process for obtaining a permit. Stormwater standards are based upon the MassDEP standards,[14] but may differ depending on the particular concerns of a community.

14 http://www.mass.gov/eea/agencies/massdep/water/regulations/stormwater-policies-guidance.html

Greenfield and Deerfield have each adopted stormwater bylaws and ordinances. Deerfield also has a best practices manual that provides guidance to developers for designing different types of stormwater Best Management Practices (BMPs), with an emphasis on LID techniques. This type of guidebook helps illustrate to developers what the community wants to see in terms of stormwater management, and can provide links to additional resources for design, construction, and maintenance.

Town of Deerfield's Efforts Toward Climate Resiliency

Since Deerfield lies near the bottom of the Deerfield River Watershed, it is subject to flood impacts from the entire watershed. The Town has undertaken a number of measures to improve resiliency to floods and other impacts of climate change since the October 2005 storm which caused $4.5 million in infrastructure damage. The Town also suffered damages from severe storms in 2007, 2009 and 2011. Measures include:

- ✓ The DPW and police departments mapped areas of inundation that occur at different storm intensities.
- ✓ The Town developed Deerfield Operation Neighborhood that identified parts of Deerfield that would be cut off and isolated during storm events, named coordinators and drilled for events. As a result of these preparations, the Town had no loss of life during Tropical Storm Irene.
- ✓ The Town identified culverts that were at risk for failure or fail regularly and other infrastructure such as roads and bridges that are potentially at risk.
- ✓ Stormwater runoff was identified as a concern, and in 2010 the Town adopted a Stormwater Bylaw and Regulations that, in line with the MassDEP stormwater regulations, require use of Low Impact Development (LID) approaches for stormwater management.
- ✓ In addition, the Planning Board adopted the "Deerfield Best Development Practices Guidebook", a set of voluntary stormwater guidelines to educate developers and homeowners about the Town's approaches to stormwater management.
- ✓ The Town supported conservation restrictions on agricultural floodplains using funds voted by the Town from the Community Preservation Act.
- ✓ Deerfield supported the maintenance of agricultural buffers with reduced assessment on agricultural land.
- ✓ The Town avoided riverbank armoring and channelization on a piecemeal basis and has used bioengineered solutions such as rock cross barbs and root wads to reduce the erosive force of the river, protect roads and the sewage treatment plant.

Watershed Health

As measured against the EPA's attributes of watershed health,[15] including landscape condition, habitat condition, hydrology, geomorphology, water quality, and biological condition, the Deerfield River Watershed score is high. Overall, the watershed is considered healthy. The FRCOG conducted a comparative analysis of the health of the Deerfield's HUC 12 subwatersheds using EPA's Watershed Health Index and found that most subwatersheds were healthy in comparison to each other with the exception being the HUC 12 that includes the most developed area of the Deerfield River Watershed, the Town of Greenfield (see Appendix B). Recently, the EPA released its 2017 Preliminary Healthy Watersheds Assessments for 48 states, including Massachusetts.[16] This analysis also shows the Deerfield River Watershed, and most of its HUC 12 subwatersheds, to be among the healthiest in the state.

The Deerfield River Watershed has extensive areas mapped as BioMap2 Core Habitat and Critical Natural Landscape.[17] The BioMap2 Forest Cores and Landscape Blocks are shown on Map 8, in the Green Infrastructure section. BioMap2 was developed to help guide conservation efforts to protect the state's biodiversity in the context of projected effects of climate change. Core Habitat are key areas that are critical for the long-term persistence of rare species and other species of conservation concern, as well as a wide diversity of natural communities and intact ecosystems across the Deerfield River Watershed. Critical Natural Landscape areas are large blocks of the natural landscape that are not developed or minimally impacted by development. These areas consist of contiguous forests, wetlands, rivers, lakes, and ponds. Of note is that pastures and power-line rights-of-way, which are common landscape features in the Deerfield River Watershed, are included in the BioMap2 critical natural landscapes because these areas are less intensively altered than most developed areas and also can provide habitat and connectivity for many species. Both the Core Habitat and Critical Natural Landscape areas are vital components of the green infrastructure of the Deerfield River Watershed. If these areas of green infrastructure are protected from development, they can provide habitat and maintain connectivity between life cycle habitats for native species, support intact ecological processes, and enhance climate change resilience for both the built and natural landscape.

From a watershed health and resiliency perspective, the Forest Cores and Landscape Blocks are particularly important not only to the preservation of biodiversity and the characteristics of a healthy watershed but also to the protection of the built environment and the natural resources, such as drinking water and working landscapes, that the residents of the watershed depend upon. Intact forest cores and large areas of intact predominantly natural landscape (forests, wetlands, rivers, lakes, and ponds) provide critical ecological functions, such as the filtration of drinking water, absorption of greenhouse gases and the absorption and retention of heavy rains thereby reducing flooding. Forests can also be working landscapes, providing economic opportunities for residents as well as opportunities for recreation.

15 https://www.epa.gov/hwp/integrated-assessment-healthy-watersheds#overview

16 https://www.epa.gov/hwp/download-2017-preliminary-healthy-watersheds-assessments

17 BioMap 2 Project developed by the Massachusetts Department of Fish & Game's Natural Heritage & Endangered Species Program (NHESP) and The Nature Conservancy's Massachusetts Program (2010). http://maps.massgis.state.ma.us/dfg/biomap2.htm

Comparative Subwatershed Analyses

While the entire Deerfield River Watershed can be characterized as healthy, there is a range of conditions within each of the HUC 12 subwatersheds. To examine the comparative health and vulnerability of the ten HUC 12 subwatersheds, four separate Comparative Subwatershed Analyses (CSA) were conducted – each with a different focus – with the goal of identifying the subwatersheds with the greatest:

1. Overall watershed health;
2. Vulnerability to water quality degradation;
3. Water quality restoration potential; and
4. Flood risk vulnerability.

In addition to these four CSAs, FRCOG completed an analysis for each subwatershed that examined the extent to which the upland tributaries are currently protected. These assessments were used as a screening-level tool to target in-field assessments and further develop restoration and protection strategies. Specifically, two types of field inventories were completed: geomorphic stream assessments and upland assessments. The results of both the comparative subwatershed analyses and the field assessments helped identify and prioritize watershed protection projects and guide the development of watershed planning recommendations with the goal of maintaining the health and improving the resiliency of the Deerfield River Watershed.

Approach

The first comparative subwatershed analysis (CSA) was conducted by the FRCOG Planning Staff and the other three analyses were conducted by the consultant, Fuss & O'Neill. The CSA approach involves analysis of available geospatial data to assign numerical ratings for a variety of indices and metrics that characterize the various conditions of each HUC 12 subwatershed. When the values of the metrics are combined, the resulting scores indicate a subwatershed's ranking for that CSA. The rankings compare the subwatersheds internally against each other and do not conduct any comparison outside the larger Deerfield River Watershed.

The Massachusetts portions of the ten HUC 12 subwatersheds that comprise the Deerfield River Watershed are included in these analyses. Two HUC 12 subwatersheds were excluded from the analysis since they are located either entirely (West Branch Deerfield River) or mostly (Deerfield River – East Branch to Sherman Dam and Green River – headwaters to Thorne Brook) in Vermont.

The methodologies used for all four of the CSAs are the same. Detailed explanations of the methodology and data sources can be found in Appendix B. Values for each individual metric were normalized so that the metrics could be combined to determine a composite score for each of the CSA indices. Normalization provides the ability to combine different metric values that may have different scales and units. Once the individual metrics were normalized, the normalized values were then combined to generate an overall index score for each subwatershed. Scores were directionally aligned so that higher metric scores correspond to higher health, water quality vulnerability, water quality restoration potential, and flood risk vulnerability. The index scores were then again normalized on a scale of 1 to 10 for reporting purposes.

Watershed Health Comparative Subwatershed Analysis

Methodology

FRCOG's Watershed Health CSA was conducted using the EPA's model of a Watershed Health Index.[18] The EPA Watershed Health Index assesses the condition of a watershed by examining the six essential ecological attributes fundamental to a healthy watershed, which are:

ESSENTIAL ECOLOGICAL ATTRIBUTES of a HEALTHY WATERSHED

1. Landscape condition
2. Habitat
3. Hydrology
4. Geomorphology
5. Water quality
6. Biological condition

Multiple metrics were selected for the Deerfield River Watershed to create the sub-indices, which were then aggregated up into a single Watershed Health Index value for each HUC 12 subwatershed. Due to data availability, rather than having a total of 6 ecological categories, the Habitat and Geomorphology categories were combined into one sub-index. Table 5 shows the 5 sub-indices and the individual metrics that were identified for each sub-index category. For detailed information on the methodology of this comparative analysis, see Appendix B.

Table 5: Sub-Index Categories and Individual Metrics for Watershed Health Assessment

	Watershed Health Index Sub-Indices				
	Landscape Condition	Hydrology	Habitat/ Geomorphology	Water Quality	Biological Condition
Metric	• Percent natural land cover • Percent natural stream corridor • Percent hubs	• Dam storage area	• Dam density • Percent Aquatic Core and Upland Buffer	• Percent Impervious Surface	• Percent Species of Conservation Concern

18 https://www.epa.gov/hwp/healthy-watersheds-developing-watershed-health-index

Table 6: Metrics for Watershed Health Assessment

Metric	How Metric is Measured	Rationale
Natural Land Cover	Percent of subwatershed that is not developed or in agriculture.	Higher amounts of natural land cover indicate more habitat, higher water quality, and higher resiliency.
Natural Stream Corridor	Percent of subwatershed's stream corridor (the Nature Conservancy's Active River Area is used here for the stream corridor) that is not developed or in agriculture.	Higher amounts of natural land cover indicate higher water quality and less vulnerability to flooding.
Hubs	Percent of subwatershed that is covered by a Hub (large, intact habitat nodes as mapped by The Nature Conservancy through the Berkshire Wildlife Linkage Project)	Higher percentage of acreage indicates greater potential for species diversity/resiliency and water quality.
Dam Storage	The ratio of the volume of water impounded by a dam and divided by annual flow volume at the dam outlet.	Higher ratios indicate greatly altered streamflow.
Dam Density	The number of dams per stream mile.	Higher dam density indicates stream habitat fragmentation.
Aquatic Core Habitat & Upland Buffer	Percent of acreage in subwatershed covered by BioMap2 defined Aquatic Core Habitat and Upland Buffer Critical Natural Landscape.	Higher percentages indicate more intact river corridors which are important for physical & ecological processes of the rivers.
Impervious Cover	Percent impervious cover in subwatershed.	Lower percentages correlate with higher water quality.
Species of Conservation Concern	Percent of acreage in subwatershed covered by BioMap2 defined Core Habitat for Species of Conservation Concern.	Higher percentages suggest areas that may be sensitive to development pressures.

Results of the Watershed Health CSA

The results of the Watershed Health CSA show that the western HUC 12 subwatersheds are comparatively healthier than the eastern ones, where the larger, more urban communities such as Greenfield are located. In addition, the Deerfield River mainstem subwatersheds are relatively less healthy than the tributary subwatersheds. Map 3 depicts the overall index values for each of the HUC 12 subwatersheds. The green watersheds are the healthiest.

Table 7 shows the subwatershed rankings for each of the 5 ecological categories. (The healthiest subwatersheds are ranked as 10 and the least healthy are ranked as 1.) These sub-index rankings are informative as to the specific strengths and weaknesses of the different HUC 12 subwatersheds. For example, while the Cold River subwatershed has a high overall Health Index Score, it actually scores low in the Habitat/Geomorphology category due to the high number of dams in its streams and small amount of Aquatic Core Habitat in the subwatershed. This indicates a potential vulnerability for the Cold River subwatershed, which should be prioritized with future projects.

Map 3: Results of Watershed Health Comparative Subwatershed Analysis

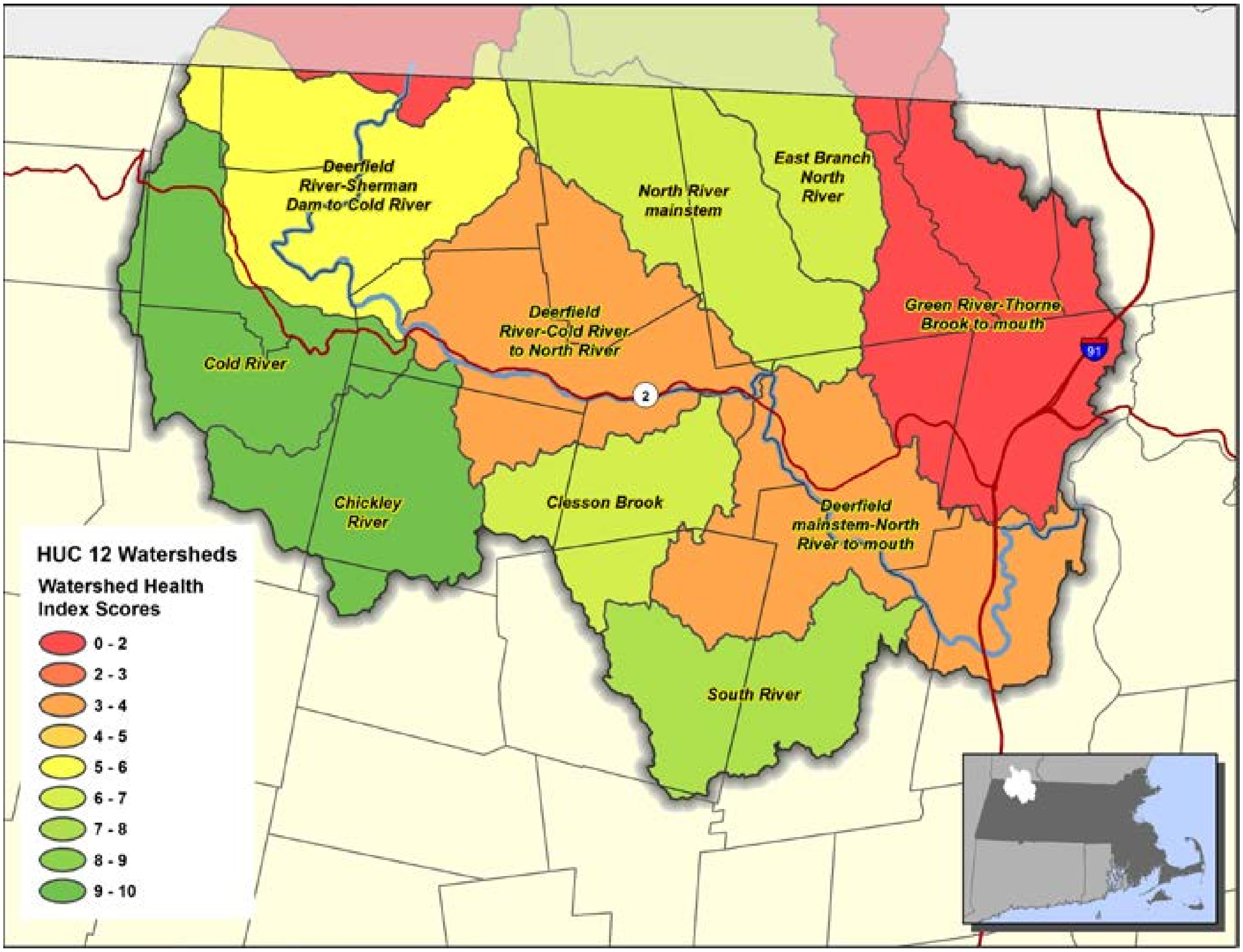


Table 7: Comparative Rankings of Subwatersheds by Ecological Category Sub-index

Subwatershed	Landscape Condition	Hydrology	Habitat/ Geomorphology	Water Quality	Biological Condition	Overall Health Index
Chickley River	9.68	9.96	10.00	9.99	1.63	9.85
Clesson Brook	3.89	10.00	4.83	9.47	2.64	6.64
Cold River	10.00	9.90	1.90	9.97	10.00	10.00
Deerfield Mainstem - North River to Mouth	1.21	5.61	4.04	5.62	2.89	3.14
Deerfield River - Cold River to North River	5.50	3.54	3.25	8.46	1.00	3.90
Deerfield River - Sherman Dam to Cold River	7.64	1.00	4.04	10.00	4.39	5.42
East Branch North River	3.79	9.97	5.61	8.58	1.43	6.19
Green River - Thorne Brook to Mouth	1.00	8.34	1.00	1.00	1.16	1.00
North River Mainstem	6.14	9.94	4.94	9.56	1.22	6.95
South River	4.54	9.92	5.61	9.46	2.66	7.10

Water Quality & Flood Risk Comparative Subwatershed Analyses

Methodology

As mentioned previously, three Comparative Subwatershed Analyses were completed by the consultant, Fuss & O'Neill. The objective of these Comparative Subwatershed Analyses is to identify the HUC 12 subwatersheds with the greatest: 1) vulnerability to water quality degradation, 2) water quality restoration potential, and 3) flood risk vulnerability.

COMPARATIVE SUBWATERSHED ANALYSES

1. Water quality vulnerability
2. Water quality restoration potential
3. Flood risk vulnerability

Subwatersheds determined to have higher aggregate vulnerability and restoration scores will be the focus of watershed management efforts, given limited financial resources. These subwatersheds should be targeted for field assessments and further development of restoration and protection strategies.

Table 8: CSA Metrics And Indices (Fuss & O'Neill)

	Index		
	Water Quality Vulnerability	**Water Quality Restoration Potential**	**Flood Risk Vulnerability**

Metric	• Impervious cover
	• Stream order
	• Developed land use
	• Agricultural land use
	• Unprotected or "developable" land
	• Stream corridor forest cover
	• Road stream crossing density
	• High quality waters
	• Potential pollution sources
		• Impervious cover
		• Public land
		• Unprotected or "developable" land
		• Stream density
		• Stream corridor forest cover
		• Road stream crossing density
		• Water quality impairments
			• Developed land in stream corridor
			• Agricultural land in stream corridor
			• Critical facilities in stream corridor
			• Density of "High and Significant Hazard" dams
			• Stream slope
			• Soil runoff potential
			• Road stream crossing vulnerability:
			  ○ Ecological disruption
			  ○ Emergency medical services disruption
			  ○ Specific Stream Power

Table 9: Water Quality Vulnerability

Metric	How Metric is Measured	Rationale
Impervious Cover	Percent impervious cover in subwatershed	Higher impervious cover suggests greater potential for water quality impacts
Stream Order	Percentage of first and second order streams in subwatershed	Higher percentage of lower order streams (i.e., as defined by Strahler Stream Order) suggests greater vulnerability of headwater streams, which play a critical role in protecting water quality
Developed Land Use	Percentage of developed land use in subwatershed	Higher percentage of developed land use (residential, commercial, industrial, institutional, municipal, etc.) indicates greater potential for water quality impacts and pollutant sources
Agricultural Land Use	Percentage of agricultural land use in subwatershed	Higher percentage of agricultural land use indicates greater potential for water quality impacts and pollutant sources
Unprotected or Developable Land	Percentage of developable land in subwatershed	Higher percentage of developable natural land indicates greater vulnerability to future development and associated water quality impacts
Stream Corridor Forest Cover	Percentage of stream corridor (Active River Area) in the subwatershed that is forested	Lower percentage of forest cover in stream corridor indicates greater vulnerability to water quality impacts due to development and lack of natural vegetation in riparian areas. Active River Area, as defined by The Nature Conservancy and calculated by FRCOG, used to represent the stream corridor.
Road Stream Crossing Density	Number of road stream crossings per square mile of subwatershed	Higher density of road stream crossings indicates greater potential for direct stormwater discharges from roadways
High Quality Waters	Percentage of watershed designated as Outstanding Resource Waters, surface water supply protection areas, MA DFW coldwater fisheries resources, or Zone I/II and Interim Wellhead Protection Areas	Higher amount of High Quality Waters indicates greater potential for impacts to sensitive surface and groundwater drinking water supplies and high quality fisheries habitat
Potential Pollution Sources	Number of potential pollution sources per subwatershed area (density of potential pollution sources) based on groundwater discharge permits, DEP major facilities, solid waste diversion and disposal, and DEP 21E sites, underground storage tanks, and nonpoint pollution sites identified from 2008 FRCOG Deerfield Nonpoint Source Pollution Assessment	Higher density of potential pollution sources (i.e., hotpsot land uses and activities) indicates greater potential for water quality impacts

Table 10: Water Quality Restoration Potential

Metric	How Metric is Measured	Rationale
Impervious Cover	Percent impervious cover in subwatershed	Higher restoration potential when impervious cover is low, suggesting range of possible sites for stormwater retrofits and stream restoration that can have a measurable impact on water quality
Public land	Percentage of public land in subwatershed	Higher amount of publicly-owned land in subwatershed indicates greater feasibility for implementation of retrofits and restoration projects
Unprotected or Developable Land	Percentage of developable land in subwatershed	Higher restoration potential when little future development is expected (i.e., percentage of developable land is low) - stable conditions increase feasibility of restoration management measures
Stream Density	Stream miles per square mile of subwatershed	Higher stream density suggests greater feasibility of stream corridor practices
Stream Corridor Forest Cover	Percentage of stream corridor (Active River Area) in the subwatershed that is forested	Lower percentage of forest cover in stream corridor suggests greater feasibility of riparian reforestation and stream restoration. Active River Area, as defined by The Nature Conservancy and calculated by FRCOG, used to represent the stream corridor.
Road Stream Crossing Density	Number of road stream crossings per square mile of subwatershed	Higher density of road stream crossings indicates greater potential for stream restoration and culvert modifications
Water Quality Impairments	Percentage of impaired streams and lakes/ponds in subwatershed	Higher percentage of water quality impairments indicates greater need and potential for water quality improvements

Table 11: Flood Risk Vulnerability[19]

Metric	How Metric is Measured	Rationale
Developed Land in Stream Corridor	Percentage of stream corridor (Active River Area) that consists of developed land use	Higher percentage of developed land use (residential, commercial, industrial, institutional, municipal, etc.) in stream corridor (i.e., areas subject to flooding) indicates greater risk of damages from flood inundation and fluvial erosion. Active River Area, as defined by The Nature Conservancy and calculated by FRCOG, used to represent areas subject to fluvial erosion hazards and inundation flooding.
Agricultural Land in Stream Corridor	Percentage of stream corridor (Active River Area) that consists of agricultural land use	Higher percentage of agricultural land use in stream corridor (i.e., areas subject to flooding) indicates greater risk of damages from flood inundation and fluvial erosion. Active River Area used to represent areas subject to fluvial erosion hazards and inundation flooding.
Critical Facilities in Stream Corridor	Number of critical facilities (police stations, hospitals, and school) in stream corridor (Active River Area)	Greater number of critical facilities in stream corridor indicates greater risk of impacts to critical public and emergency services in the event of flooding. Active River Area used to represent areas subject to fluvial erosion hazards and inundation flooding.
Density of "High and Significant Hazard" Dams	Number of high/significant hazard dams per stream mile in subwatershed	Failure of dams classified as "high" or "significant" hazard by the MA Office of Dam Safety will or may cause loss of life and damage to homes, industrial or commercial facilities, and public infrastructure and services.
Stream Slope	Average slope of mapped streams in subwatershed	Steeper streams are more susceptible to higher velocity and more erosive flood flows
Soil Runoff Potential	Percentage of subwatershed mapped as Hydrologic Soil Group C and D soils	Higher percentage of watershed having soils with greater runoff potential (i.e., C and D soils) indicates more potential for runoff generation and greater flood risk vulnerability
Ecological Disruption – Road Stream Crossings[1]	Average ecological disruption score of assessed road stream crossings in subwatershed	Higher average ecological disruption score indicates greater potential for ecological disruption resulting from limited passability of culverts and bridges to aquatic organism passage
Emergency Medical Services Disruption – Road Stream Crossings[1]	Average EMS disruption score of assessed road stream crossings in subwatershed	Higher average EMS disruption score indicates greater potential for disruption of emergency medical services resulting from single crossing failures
Specific Stream Power – Road Stream Crossings[1]	Average specific stream power (total stream power divided by bankfull width) of assessed road stream crossings in subwatershed	Higher average specific stream power indicates greater potential for damage to stream crossing structures, among other factors such as dominant particle size (bed resistance)

19 Full results of the MassDOT Deerfield Watershed Road Stream Crossing pilot study, including overall crossing prioritization scores, were unavailable for use in the analysis. Only scores/metrics that were made available by MassDOT for the last three categories in the table were used in the analysis.

Results of the Water Quality and Flood Risk CSAs

Table 12 provides a summary of the normalized scores for all three indices. As summarized in the table and shown in Map 4, the Green River, Deerfield Mainstem-North River to Mouth, South River, and North River Mainstem subwatersheds are rated highest for potential water quality degradation. Conversely, the Chickley River, South River, and Cold River have the highest potential for water quality restoration (Map 5), which is generally consistent with the results of the EPA's Recovery Potential Screening Tool, which identified impaired segments of the South River, Green River, and Chickley River.

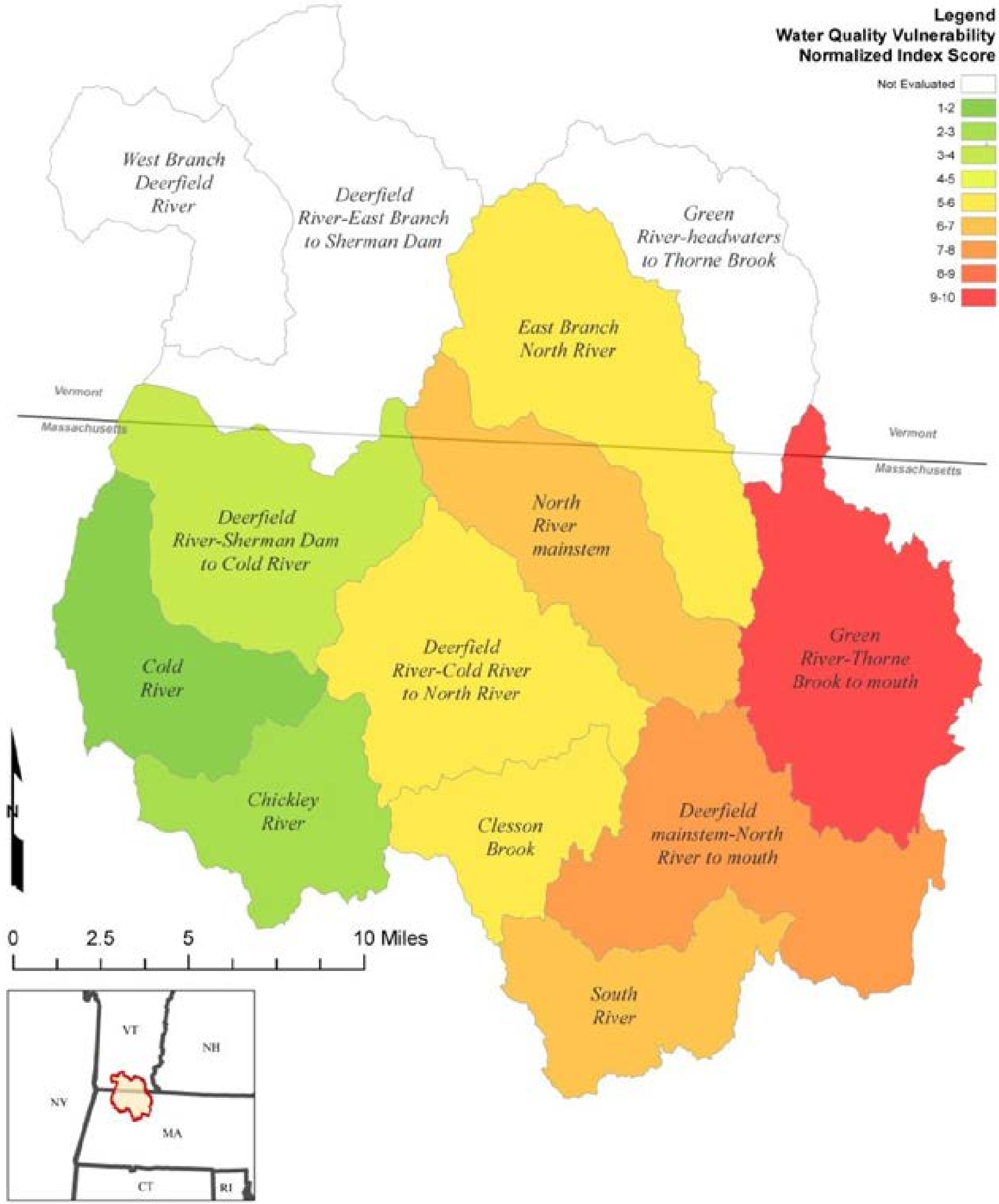
Table 12: CSA Scoring Summary

Subwatershed	Normalized Index Scores			
	Water Quality Vulnerability	Water Quality Restoration Potential	Total (Water Quality)	Flood Risk Vulnerability
Chickley River	2.35	10.00	12.35	1.00
Clesson Brook	6.00	4.97	10.97	3.97
Cold River	1.00	6.94	7.94	1.78
Deerfield Mainstem-North River to Mouth	7.86	5.96	13.82	6.39
Deerfield River-Cold River to North River	5.64	3.27	8.91	4.44
Deerfield River-Sherman Dam to Cold River	3.24	5.33	8.57	10.00
East Branch North River	5.58	1.00	6.58	4.73
Green River-Thorne Brook to Mouth	10.00	5.81	15.81	8.83
North River Mainstem	6.50	4.29	10.79	2.82
South River	6.91	7.51	14.42	4.08

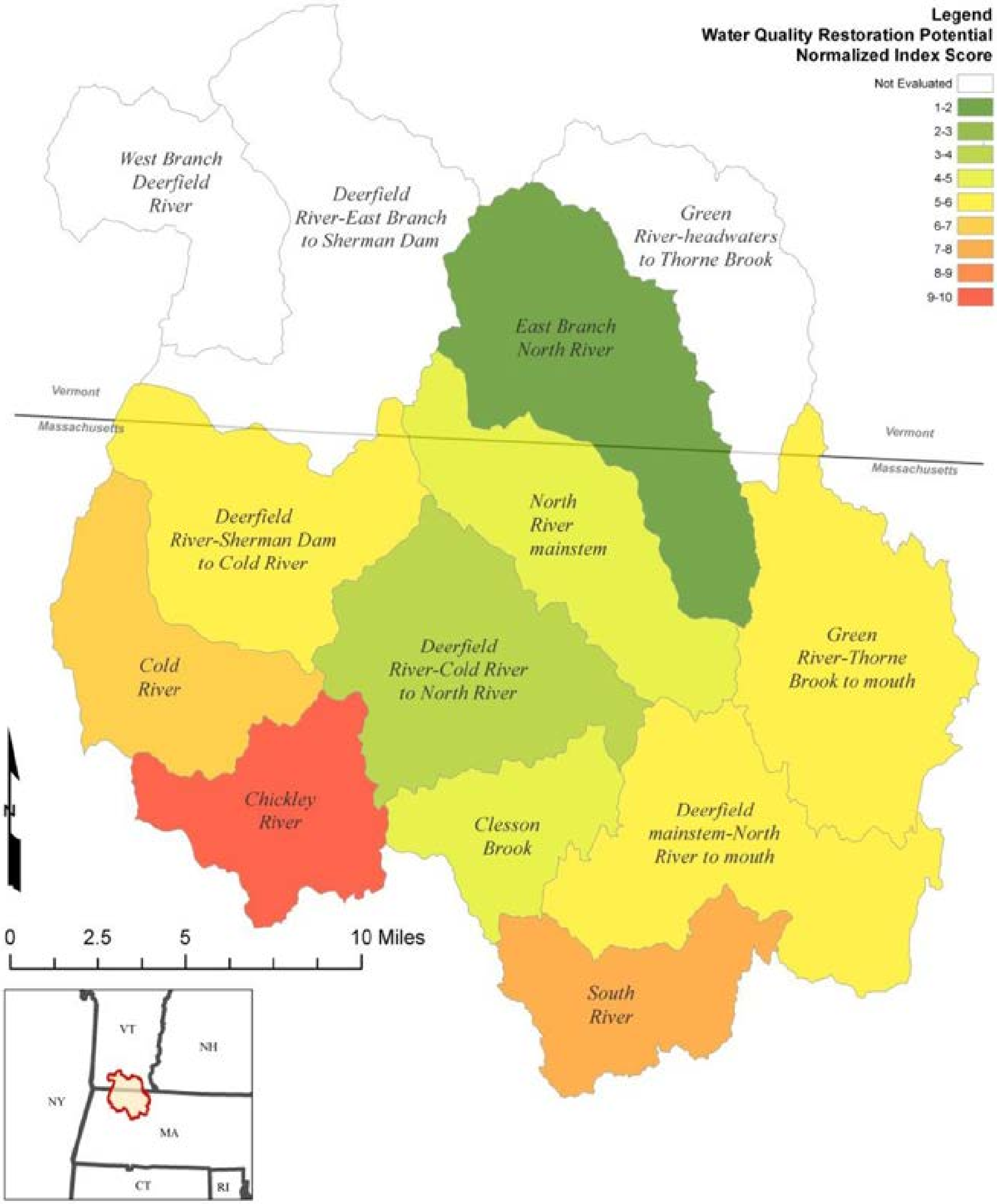
The normalized index scores for Water Quality Vulnerability and Water Quality Restoration Potential were added to consider a combined "water quality" score. The Green River, South River, Deerfield Mainstem-North River to Mouth, and Chickley River subwatersheds have the highest combined water quality scores and are highlighted in Table 12. These subwatersheds are logical targets for additional field assessments and development of water quality restoration strategies. In terms of flooding, the Deerfield River-Sherman Dam to Cold River, Green River, and Deerfield Mainstem-North River to Mouth subwatersheds have the greatest flood risk vulnerability (Map 6) and should be the focus of field assessments and watershed strategies to address flood-related hazards.

The metrics and indices presented in this analysis should also be considered collectively with FRCOG's Watershed Health Index and Upland Tributary Protection Index, which are intended to help prioritize subwatersheds and develop protection strategies consistent with EPA's Healthy Watershed Initiative.

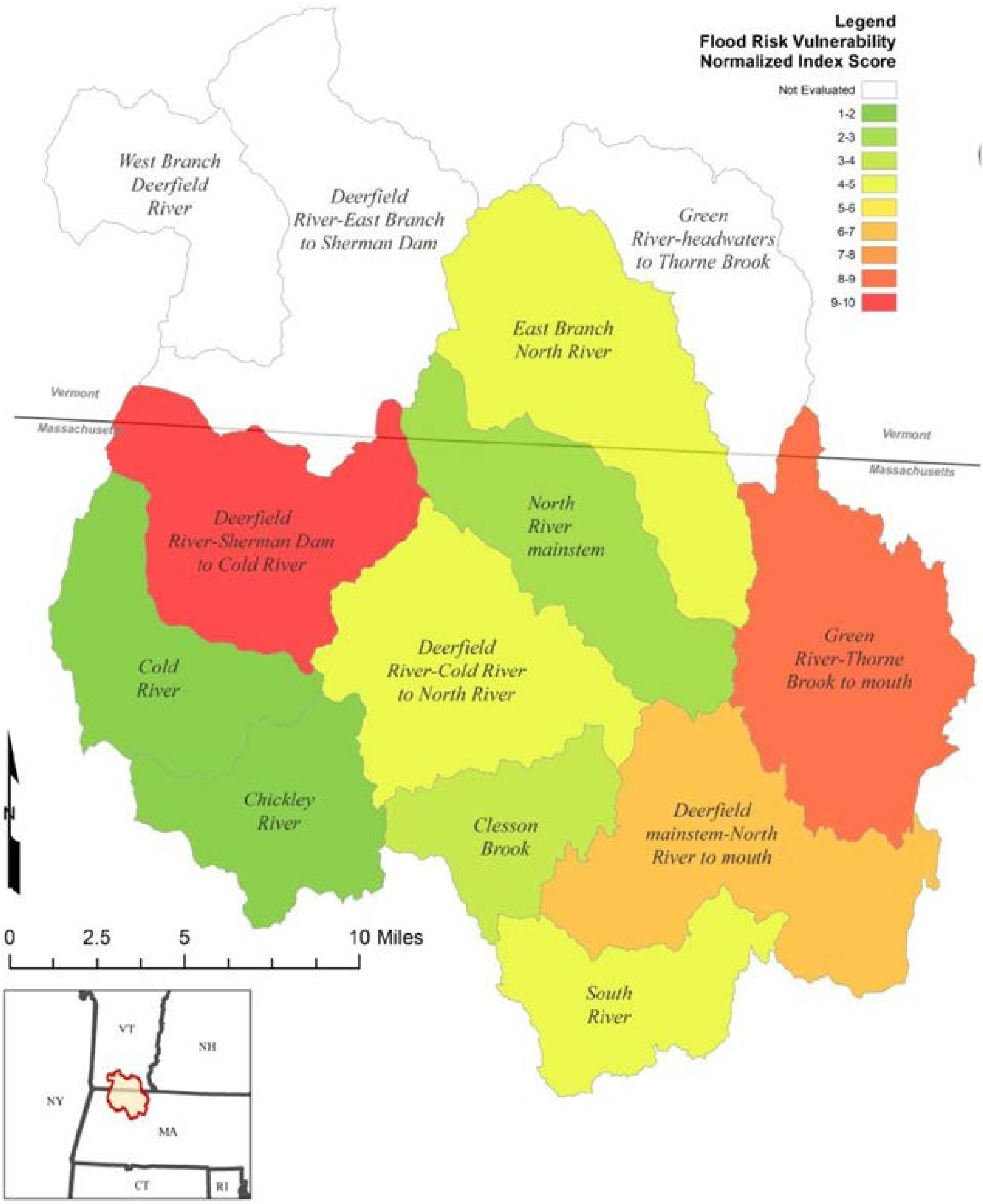
Map 4: Water Quality Vulnerability Normalized Index Score



Map 5: Water Quality Restoration Normalized Index Score



Map 6: Flood Risk Vulnerability Normalized Index Score



Upland Area Protection Assessment

This analysis examined the extent that the upland tributaries of each subwatershed are protected by permanently protected open space and the Massachusetts Natural Heritage and Endangered Species' (NHESP) Priority Habitat Areas. For the purpose of this analysis, the Upland Areas are defined as the Coldwater Fish Resources (CFRs) that flow into the mainstem rivers of each of the HUC 12 subwatersheds (note: this does not include the mainstem river of each HUC 12, just its tributaries). The goal of this analysis was to understand how much or how little of these sensitive areas are protected.

To conduct this analysis, a 200-foot buffer was created for the Coldwater Fish Resources. FRCOG then identified two levels of protection for the Upland Areas and overlaid these on top of the CFR buffered layer. These potential protections are:

1. Permanently protected land – these are parcels that are permanently protected from development through State, Town or private ownership or easements; and
2. NHESP Priority Habitat Areas – these are areas representing habitats of rare species and there are some regulatory controls over proposed development in these areas.

The analysis then examined how much of the 200-foot CFRs were covered by these two categories. The following table breaks down the amount of Upland Areas potentially covered by protections for each HUC 12 subwatershed. These results show that there are four subwatersheds that particularly stand out for having significantly less of their upland tributaries protected than the others. These vulnerable subwatersheds are: Clesson Brook, Deerfield River – Cold River to North River, East Branch North River, and Green River - Thorne Brook to mouth.

Table 13: Summary of Potential Protections for the Upland Areas of each Subwatershed

HUC 12 Subwatershed	Total Upland Acreage	Total Acreage Protected Open Space	Total Acreage NHESP Priority Habitat	Total Acreage Protected	% Total Acreage Protected
Chickley River	1218	622	129	**692**	**57%**
Clesson Brook	888	15	146	**153**	**17%**
Cold River	1143	677	266	**729**	**64%**
Deerfield mainstem - North River to mouth	1241	177	557	**701**	**56%**
Deerfield River - Cold River to North River	2270	213	137	**349**	**15%**
Deerfield River - Sherman Dam to Cold River	2337	1241	425	**1569**	**67%**
East Branch North River	548	71	36	**106**	**19%**
Green River - Thorne Brook to mouth	2439	258	411	**655**	**27%**
North River mainstem	2058	389	513	**829**	**40%**
South River	1047	156	393	**497**	**47%**

A third category of lands was also considered for the Upland Area analysis. They are the BioMap2 Aquatic Core Habitat and Upland Buffers. These areas have been identified by NHESP and The Nature Conservancy as areas with intact river corridors within which important physical and ecological processes of the river or stream occur. While these areas may not be protected by any regulations, they represent areas of high priority for protection in the Upland Areas. The results from this analysis show that the Clesson Brook, Cold River, and East Branch North River upland tributaries should be particularly prioritized for protection as they have very little of their BioMap2 Aquatic Core Habitat and Upland Buffer Critical Landscapes protected.

Table 14: Summary of BioMap2 Aquatic Core Habitat & Upland Buffer Acreage for Upland Areas of the Subwatersheds

HUC 12 Subwatershed	Total Upland Acreage	Total Core & Upland BioMap2 Acreage	% Core & Upland BioMap2 Acreage	Total Bio-Map2 Acreage Protected by OS + NHESP	% BioMap2 Acreage Protected by OS + NHESP
Chickley River	1218	**578**	**47%**	386	67%
Clesson Brook	888	**414**	**47%**	114	28%
Cold River	1143	**181**	**16%**	46	25%
Deerfield mainstem - North River to mouth	1241	**886**	**71%**	480	54%
Deerfield River - Cold River to North River	2270	**507**	**22%**	170	34%
Deerfield River - Sherman Dam to Cold River	2337	**636**	**27%**	354	56%
East Branch North River	548	**234**	**43%**	40	17%
Green River - Thorne Brook to mouth	2439	**716**	**29%**	268	37%
North River mainstem	2058	**1131**	**55%**	674	60%
South River	1047	**591**	**56%**	380	64%

Stream and Watershed Geomorphic Assessments

Field Geology Services conducted geomorphic assessments of specific stream and upland areas in four targeted HUC 12 subwatersheds that were selected based on a review of the findings from the three CSAs and the Upland Tributary assessment conducted by FRCOG. These HUC 12 subwatersheds were:

- Green River-Thorne Brook to mouth
- Deerfield Mainstem – North River to Mouth (Bear River, the largest tributary within the HUC12)
- Clesson Brook
- North River Mainstem

A technical memorandum that describes the geomorphic assessment methodology and results is included as Appendix B. Conceptual designs and cost estimates for the five priority projects identified as part of this assessment are included at the end of this section after Table 17.

GEOMORPHIC ASSESSMENT PURPOSE

1. To capture the range of conditions in the streams of the watershed
2. To identify stressors and impairments
3. To highlight stream reaches with degraded water quality, impaired habitat and geomorphic function, and increased fluvial erosion hazards and flood risk vulnerability
4. To develop conceptual restoration designs to address stream channel instabilities
5. To identify priority areas for conservation.

Results

The results of the geomorphic assessment of selected reaches within the Deerfield River watershed capture a wide range of conditions in the streams of the watershed. Despite the watershed's current conditions, which are a predominantly forested landscape with sparse, rural development, the legacy of historic land use and river channel manipulation is significant and widespread. The first step in the departure from pre-settlement conditions was land clearance, which can only be described as near-total deforestation for agriculture, pasture and fuel.[20] Deforestation accompanying colonization led to severe soil erosion and the delivery of sediment from the previously-forested uplands to the streams of the watershed. Much of this sediment was trapped behind mill dams which provided stream power and were the engine of the colonial economy. Using old census records, researchers estimated that there were more than 65,000 water-powered mills in the Northeastern United States by 1840.[21] On the South River mainstem, 30 dams have been mapped, or nearly one dam every half mile. While only 3 dams are still extant, fine-grained mill pond sediments remain in the former impoundments of many of the ruined dams.[22] These legacy sediments represent a source of suspended sediments for downstream reaches, contributing to water quality and habitat impairments.

Artificial channel straightening was a common practice on New England's streams in the 19th century. Evidence of historic channel straightening is seen throughout the Deerfield River watershed and has been mapped along 67 percent of the South River (Field, 2013) and 72 percent of the East Branch of the North River.[23] Straightened river reaches tend to be incised, with high width to depth ratios, increased flow velocities and degraded habitat conditions. These channels

20 Cronon, W., 1983, Changes in the land: Indians, colonists, and the ecology of New England: Hill and Wang, New York, NY, 241 p.

21 Walter, R.C., and Merritts, D.J., 2008, Natural streams and the legacy of water-powered mills: Science, v. 319, p. 299-304.

22 Field, J., 2013, Fluvial Geomorphic Assessment of the South River Watershed, MA: Unpublished report prepared for the Franklin Regional Council of Governments, Greenfield, MA, 108 p.

23 Field, J., 2015, Fluvial geomorphic assessment of the North River watershed, MA: Unpublished report prepared for Franklin Regional Council of Governments, Greenfield, MA, 111 p.

have the capacity to transport more sediment that often accumulates at sharp meander bends or valley or channel constrictions forming enlarged bars and leading to increased fluvial erosion hazards.

Historic land clearance and the legacy of channel modification are two of the main stressors still affecting the streams of the Deerfield River watershed today, although continued development, encroachments in the river corridor and climate change also contribute significantly to stress on the river system. Sediment is the largest impairment within the assessed streams of the Deerfield River watershed. The geomorphic assessment of Clesson Brook revealed severe sediment-loading issues in an unstable channel system following Tropical Storm Irene. A large mass failure (landslide in glacial deposits) immediately upstream of the Route 112 stream crossing threatens the bridge and contributes a significant volume of sediment to Clesson Brook. Sediment from Clesson Brook and other tributaries deposited in the Deerfield River contributes to the formation of large gravel bars and represents increased hazards to bridges, roads and other infrastructure. Clesson Brook is not the only stream in the watershed with sediment-loading problems. Green River also shows evidence of impairment due to its sediment load. Sediment accumulation upstream of constrictions and bedrock-controlled meander bends is representative of stream reaches where sediment storage and transport are not in equilibrium with channel form and morphologic function. Mass failures along Hinsdale Brook contribute a large volume of sediment to the Green River. Mass failures, because of the glacial origin of their sediments, which tend to be fine-grained and rich in clay, represent a very large source of suspended and bedload sediment in the streams in the watershed. Many mass failures were initiated or re-activated during Tropical Storm Irene, which destabilized these slopes. Further work is needed to map and quantify these impacts in the watershed, but the qualitative effects appear to be widespread and significant. Excess sediment, sourced in part from a large mass failure opposite the Barnhardt Manufacturing plant on the North River is accumulating around the center pier of the Route 112 bridge. The increased scour at the abutments threatens to undermine this bridge, which Mass DOT replaced in 2005.

Potential Management Strategies and Identification of Project Sites

Addressing the increased flood inundation and fluvial erosion hazard risks in the low gradient straightened reaches where accumulated sediment threatens infrastructure is often expensive and technically challenging. Bank erosion often requires engineering solutions (whether traditional or bio-engineered) for effective bank stabilization. Traditional bank stabilization techniques such as rock rip-rap, concrete retaining walls, or gabion baskets have limited benefits. These bank armoring techniques work by increasing the bank's resistance to erosive scour, but they increase the erosive forces acting on adjacent upstream and downstream river segments. Bank bio-engineering uses live plants and natural materials (wood) to stabilize the bank while enhancing instream and riparian habitat. A recent example of this approach is the 319-funded restoration projected completed in 2016 on the South River in Conway and the project on the upper section of the East Branch North River in Colrain that is currently in the permitting phase. Both of the sites were identified as priority river restoration projects in the 604b-funded Fluvial Geomorphic and Habitat Assessment projects completed by Field Geology Services for FRCOG.

Another way to address the increased hazards caused by the uneven distribution of sediment throughout the streams in the watershed is to increase sediment storage in the upper portions (upland areas) of the watershed. Wood addition projects have been implemented in streams all over New England to trap sediment, depress flood peaks, increase base flow and enhance habitat. One treatment technique known as "chop and drop" involves strategic cutting of trees from the riparian zone and placing the trees into and across the stream channel. This technique has had a great deal of success in forested reaches in New England, including the Green Mountain National Forest and the Northeast Kingdom in Vermont and Maine.[24] A chop-and-drop project on Griffith Brook in the Green Mountain National Forest trapped an estimated 31 to 46 cubic yards of sediment per year over the quarter mile length of the project.[25]

The 96-acre Crowningshield Conservation Area owned by the Franklin Land Trust contains one mile of frontage along both banks of the West Branch of the North River in the Town of Heath.[26] The conservation area is open to the public for passive recreation, including hiking, hunting, and fishing and represents an important new model for land conservation and stream management. The Franklin Land Trust has partnered with Trout Unlimited and local biologists to implement wood addition treatments on this managed parcel. Chop and drop along the nearby tributary, Sanders Brook, will be paired with engineered log jams and rootwad deflectors in an attempt to trap sediment and enhance instream aquatic habitat. Monitoring will consist of tracking and mapping the recruitment and movement of wood through the stream system and measuring its effects on pool depth, channel dimensions, substrate composition, temperature profiles, and invertebrate and fish populations. These studies have the potential to demonstrate the benefits of wood addition projects to trap sediment and enhance habitat.

The Crowningshield project is a model for conservation paired with geomorphically-compatible stream restoration and management. In this model, the land on both banks of the stream is conserved, making wood addition projects more feasible. Large wood added to a stream is part of a dynamic system, and as such is prone to movement. Therefore, the location of wood addition projects and the density of treatment must be carefully considered so as not to increase hazards for downstream reaches.

An appropriate reach for a Crowningshield-type conservation and stream restoration project was identified as part of this assessment. The site is on the upper Bear River in Ashfield. This

24 https://data.ecosystem-management.org/nepaweb/nepa_project_exp.php?project=31212
https://www.na.fs.fed.us/stewardship/newsltr/newsletter/10winter.pdf
http://www.tu.org/blog-posts/pbs-show-highlights-tus-stream-work-in-vermont

25 Field, J., 2008, Sediment storage associated with a wood addition project on Griffith Brook, VT: Unpublished report prepared for the Green Mountain National Forest, Rutland, VT, 29 p.

26 http://www.franklinlandtrust.org/map-app/crowningshield

area is undeveloped, heavily-forested, and surrounded by landowners amenable to the prospect of conservation. The conceptual design for this project includes pre- and post-implementation monitoring similar to that being carried out at the Crowningshield Conservation Area with the addition of water stage and turbidity monitoring. By monitoring turbidity, as an analogue to suspended sediment load, and setting up a stream gage, we can attempt to assess the influence of wood addition on suspended sediment load. Studies such as this are important as more wood addition projects are implemented to remove excess sediment and restore habitat.

The Crowningshield project, located in the Town of Heath, could serve as a model for conservation paired with geomorphically-compatible stream restoration and management.

With the help of the Franklin Land Trust, a prospective land conservation project has been identified on the lower Bear River. This area was identified after CSA results highlighted the Bear River, the largest tributary in the Lower Deerfield subwatershed, as a possible conservation target. In the proposed conservation project, several undeveloped and low density residential parcels adjacent to and/or in close proximity to the South River State Forest would be permanently protected. These lands, which include both banks of the lower two miles of the Bear River down to its confluence with the Deerfield River, contain a mix of pristine forested habitats including previously identified rare and endangered plant species. The steep, confined stream channel ranges from cobble riffle-pool, to boulder step-pool and bedrock cascade morphologies and represents a relatively natural reference condition with little evidence of past human manipulation. Conservation of these lands may qualify for a Land Partnership Grant. To qualify, lands must be a minimum of 500 contiguous acres, with fifty percent of land publicly accessible and must contain high value habitat. On the basis of the exemplary geomorphic condition, high quality of the coldwater fishery, presumed presence of rare and endangered plants, and proximity to State Forest lands, this project as envisioned should rank highly for this competitive grant.

The focus on land conservation as a stream management tool is an effective way to spend limited funds while achieving the maximum return in terms of attenuating sediment load, enhancing instream and riparian habitat, mitigating flood inundation and fluvial erosion risks, and building climate resiliency. The Crowningshield project, like the one proposed for the upper Bear River, is focused on protecting upland habitat while using wood additions to limit sediment transported out of the tributaries. The lower Bear River project would protect a natural "reference reach" channel and ecosystem. Both projects encourage public access as part of their core purpose.

Another type of conservation model is to identify and protect areas known as "attenuation assets". This is a model that has been developed in Vermont, in which lands are conserved for the purpose of allowing meander formation and storage of sediment.[27] These sites are typically fallow agricultural parcels that have sustained flood or erosion damage in the past, or are low-value parcels without the necessary frontage for development that are located along artificially straightened stream channels. The premise is that these riparian lands may be valuable to the community as flood storage attenuation assets. Given the propensity for meanders to re-form along straightened channels, by allowing a meander to form in one reach, over a fallow farm field or undevelopable parcel, the likelihood that a meander will form elsewhere and threaten homes or infrastructure is reduced. Following damaging flood events like Tropical Storm Irene, there are often lands impacted by flooding that could serve as attenuation assets and be protected in perpetuity by conservation restrictions or easements, or by purchasing the land outright. The geomorphic assessment identified parcels on the South River, West Branch North River, Green River and Clesson Brook that could be appropriate for this type of attenuation asset project if there are willing landowners and stakeholder support for the projects.

Potential Threats to Watershed Health

The Deerfield River, including its major tributaries and many small tributary streams, are some of the coldest and cleanest surface waters in Massachusetts. According to the Massachusetts Year 2014 Integrated List of Waters, the entire length of the Deerfield River has high water quality and is classified as a Category 2 Waters, attaining all four designated uses. Of the hundreds of stream miles in the watershed only 31 miles are listed as Impaired on the 2014 Integrated List of Waters.[28]

27 Kline, M., and Cahoon, B., 2010, Protecting River Corridors in Vermont: Journal of American Water Resources Association (JAWRA), p. 1-10.

28 http://www.mass.gov/eea/agencies/massdep/water/watersheds/integrated-list-of-waters.html

All of the rivers and streams identified in MassDEP's database for the watershed, except 18 miles of the Deerfield River from its confluence with the North River to the confluence with the Connecticut River, are designated as Coldwater Fish Resources (CFR), which means that reproducing coldwater fish use such waters to meet one or more of their life cycle requirements. CFRs are particularly sensitive habitats so changes in land and water use can reduce the ability of these waters to support trout and other kinds of coldwater fish.

Table 15: 2014 Integrated List of Waters: Impaired Segments

Name/Segment	Category 5 Requires TMDL	Cause of Impairment	Approximate Length of River Segment
Chickley River/MA33-11	✓	Fecal Coliform	11 miles
Davis Mine Brook/MA33-18	✓	pH, Low	3 miles
Green River/MA33-30	✓	Fecal Coliform	4 miles
South River/MA33-08	✓	Fecal Coliform; Physical substrate habitat alterations.	13 miles

However, there are numerous small headwater streams in the upland areas of the watershed[29] that likely meet the criteria to be designated as CFRs but have, to date, received only limited assessment or have not been assessed at all.[30] Until these streams are assessed and designated as CFRs, there are no regulatory protections in place to help maintain the high water quality of these important headwater streams.

While the Deerfield River watershed has pristine areas, some locations are at risk, and chemical standards alone do not adequately reveal the water quality. The Deerfield River Watershed has a fairly comprehensive biological and chemical data set because Mass Fish & Wildlife and the Deerfield River Watershed Association have completed studies of coldwater streams and fish species that are associated with them. However, this data set is 10 years old. FRCOG completed habitat and macroinvertebrate and fish community surveys as part of the Fluvial Geomorphic and Habitat assessments conducted for the South and East Branch North Rivers.[31]

Nonpoint Pollution

As shown in Table 15, nonpoint source pollution has degraded three of the Deerfield River's major tributaries. Stormwater runoff (Green River), failing septic systems (South River) and livestock accessing the river (Chickley) are likely sources of the fecal coliform. Davis Mine Brook is a tributary stream that flows into the Mill Brook, which enters the Deerfield River in the Town of Charlemont. Davis Mine Brook is listed as a Category 5 Waters and requires a TMDL for low pH. Approximately 3.5 miles of the brook, from its headwaters in the Town of Rowe to its confluence with the Mill Brook, is impaired by acid mine drainage. Between 1882 and 1911, Davis Mine was

29 http://deerfieldriver.org/maps/Reports/Deerfield_Headwaters_REPORT_7-9-12.pdf
30 http://deerfieldriver.org/maps/Reports/Deerfield_Headwaters_REPORT_7-9-12.pdf
31 http://frcog.org/wp-content/uploads/2017/06/North-River-Report_Final-FGS-compressed.pdf and http://frcog.org/wp-content/uploads/2017/06/South-River-Report_compiled_reduced.pdf

the largest working pyrite mine in the state of Massachusetts. Since the mine collapsed and was abandoned, very high concentrations of sulfate, iron, and trace metals from the exposed waste-rock piles have leached into surface runoff. These same contaminants have also entered groundwater via the collapsed mine shaft. Fish and other aquatic species are completely absent from the entire length of Davis Mine Brook.

With funding from a National Science Foundation Grant, researchers from UMass Amherst studied the conditions of Davis Mine Brook and the biogeochemistry of natural remediation of the contamination.[32] In other words, over time, the contamination caused by the acid mine drainage can be reduced by dilution of contaminated groundwater and surface water with clean water that flows into the system and the presence of natural bacteria in groundwater that "eat" the contaminants. The UMass researchers concluded their work in 2010. Without additional funding for research and remediation, there are no current plans to continue the monitoring or remove the mine tailings or prevent water from entering the collapsed mine shaft (source of the contamination). Other than noting the listing of Davis Mine Brook for a TMDL to address low pH, it is beyond the scope of this plan to address the very complex environmental conditions and remediation options for this tributary brook.

NONPOINT SOURCE POLLUTION:

1. Road runoff
2. Sand and gravel operations
3. Silviculture (forestry)
4. Storage tanks
5. Hazardous materials use/storage
6. Hazardous waste and Brownfields
7. Landfills and transfer stations
8. Illegal dumps sites, auto junkyards & discarded railroad ties
9. Road salt storage/application & snow dumping
10. Septic systems
11. Stormwater runoff
12. Agricultural runoff

Nonpoint source pollution poses a threat to other high quality waters in the watershed. A 604b-funded Nonpoint Source Pollution Assessment completed by the FRCOG in 2008 for the watershed identified numerous potential sources of nonpoint pollution and contained detailed recommendations for further assessment, public education/outreach and implementation projects to address these threats to water quality. To date, many of these recommendations have not been implemented, primarily because of the limited amount of funding available to do the work. The

32 Research paper: Environmental consequences of acid mine-drainage from Davis pyrite mine, Rowe, Massachusetts. Available from: https://www.researchgate.net/publication/286499612_Environmental_consequences_of_acid_mine-drainage_from_Davis_pyrite_mine_Rowe_Massachusetts . This and other research papers about Davis Mine Brook are available on-line.

2008 recommendations have been updated and carried forward into this watershed-based plan and appear in Table 17 as well as in the HUC 12 subwatershed plans. Stakeholder outreach conducted as part of this project provided updates and insights regarding current threats to watershed health (Appendix G).

A large landslide on the East Branch North River contributes sediment to the river. Note also the sparse riparian buffer on the opposite bank.

The 2008 report found that the high water quality of the Deerfield River and its tributaries is also threatened by sediment loading from hundreds of feet of eroding river banks. Recent assessment work by Dethier, et al. identified 274 landslides in the Deerfield River watershed (including the Vermont portion of the watershed).[33] Roughly the same number of landslides occurred during Tropical Storm Irene as in the previous 30 years combined. According to Dethier, et al., erosion and sedimentation downstream of landslides continue to have a persistent water quality impact at a site scale due to the presence of suspended sediments. These suspended sediments persist even in low flow conditions as streams continue to erode large glacio-lacustrine deposits made up of a large volume of very fine sediments. Since revegetation of these sites may take between 5 and 30 years, this erosion and sedimentation continues until the landslide scars are stabilized with vegetation.

Road Runoff and Sedimentation

There are 272 miles of dirt roads in the watershed[34] and sediment from spring re-grading of these roads and stormwater runoff is collecting in large quantities in the rivers and streams. The water quality of the upland headwater streams and sections of the larger tributaries are at high risk.

33 Dethier, Evan, F. Magilligan, C. Renshaw and K. Nislow, 2016. The role of chronic and episodic disturbances on channel-hillslope coupling: The persistence and legacy of extreme floods. Earth Surf. Process. Landforms 41, 1437-1447.
34 MassDOT

River Restoration Projects
Priorities for the implementation of restoration projects should follow those identified by NRCS staff and by the 604b-funded fluvial geomorphic and habitat assessments completed by FRCOG. The Colrain and Shelburne Fire District well sites in Colrain are high priorities for restoration since they affect public drinking water supplies. Other priority sites include locations in the South River, East Branch North River, North River, and other places where municipal infrastructure is at risk.

Floodplains and Riparian Areas
There are significant areas (in terms of acreage) in the watershed that have little or no riparian buffer. Stream shading is an important variable in terms of habitat condition and resiliency to the impacts of climate change. Lack of riparian vegetation, especially on actively farmed lands, can also contribute to water quality impairments (sedimentation, nitrogen, phosphorus). There are very few, if any, incentives for agricultural landowners to restore or establish riparian buffers due to the match requirements and potential tax burden associated with existing programs. The state of Vermont, through their river corridor easement program, requires a 75 foot riparian buffer strip be maintained. FRCOG has been awarded 319 funding to work with the Franklin Land Trust to develop a similar corridor easement tool for use in Massachusetts. Over the long-term, it is likely that less land will be taken out of production if a riparian buffer is established versus the amount of acreage lost to fluvial erosion.

Following Tropical Storm Irene, the NRCS conducted land surveys in areas of the lower Deerfield River Watershed in the Town of Deerfield. The results of these site visits indicated that soil loss from Irene had reduced riparian buffers by about 6 feet. From Stillwater Bridge downstream to the mouth of the Deerfield, Tropical Storm Irene produced "major devastation" to riparian areas and farmland soil loss. In many areas farmland was leveled and sediment from Irene pushed back into riparian buffer areas. Sediments covered shrubby growth and was heaped around trees, smothering their root systems, which over time is now killing the buffer trees.[35]

In the upper areas of the watershed in the Town of Charlemont and where Clesson Brook enters the valley, significant soil was lost from agricultural lands. Throughout the watershed, riparian buffers associated with agricultural land are severely damaged or non-existent. Most farmers received money from NRCS programs to repair their farmland. No funds were available for the restoration of riparian buffers. This scenario is true throughout the entire Massachusetts portion of the watershed. Farmers sought NRCS assistance only for restoring their farmland, not for buffers as they can make no money on buffer lands. While this is short-term thinking, it is part of the economic reality faced by farmers.[36]

35 Interview with Rita Thibodeau, District Conservationist, NRCS, May 17, 2017 conducted by Deborah Shriver, Franklin Conservation District and Deborah Shriver Consulting.
36 Ibid.

Dams and Road Crossings

Habitat fragmentation and compromised flood resilience are two problems associated with the high number of dams and road crossings in the Deerfield River Watershed. The MassGIS datalayer for dams is outdated. Recent field investigations indicate that the number of dams in the watershed, particularly low-head dams (3 to 4 feet in height), is seriously undercounted.[37] Additionally, even if a dam has been breached, often there are remnants of the dam structure in the floodplain, river corridor and/or river channel that impact habitat connectivity and flood resilience. This was a common condition found in the South River subwatershed (2013 Fluvial Geomorphic & Habitat Assessment Report) and likely to be found in many of the HUC 12 subwatersheds.

Numerous small dams in the Deerfield River Watershed no longer serve a purpose, are partly breached or are in poor condition. Ownership of some of these dams is not clear and can be an obstacle to removal. Several priority dam removal projects were identified by stakeholders:[38]

- At Foundry Brook near East Branch of the North River in Colrain is an old dam in poor condition. May be feasible for removal, but dam ownership is not clear.
- On the East Branch of the North River off Foundry Village Road is a remnant of a dam. Since it still has an approximately 3 foot drop, it impedes aquatic organism passage. This dam was a priority site noted in the FRCOG 604b-funded Fluvial Geomorphic and Habitat Assessment project for the East Branch North River. Yet again, dam ownership is not known. Since both of the above projects are near one another, removal might be done simultaneously. Both streams are coldwater segments.
- The Albert Davenport Dam in the Buckland-Shelburne area has been declared a "significant hazard" by the MA Office of Dam Safety. It sits on a tributary of the Deerfield River. If it ruptures, it could severely damage town roads and other infrastructure.

Although the dam on Foundry Brook is partially breached, it still acts as a fish barrier and hydraulic/flood barrier.

The main part of the dam on the East Branch North River is gone, but the sill is still a fish barrier and sediment trap. It's one of the few (if not last) barriers on the main stem of the East Branch all the way up through VT.

37 Interview with Erin Rodgers, PhD., Western New England Project Coordinator, Trout Unlimited, May 17, 2017 conducted by Kimberly Noake MacPhee, Franklin Regional Council of Governments.

38 Interview with Carrie Banks, MA Division of Ecological Restoration, Dept. Fish & Game, May 23, 2017 conducted by Deborah Shriver, Franklin Conservation District and Deborah Shriver Consulting. Interview with Erin Rodgers, PhD., Western New England Project Coordinator, Trout Unlimited, May 17, 2017 conducted by Kimberly Noake MacPhee, Franklin Regional Council of Governments.

Deerfield Watershed Road-Stream Crossings Pilot Study

The Massachusetts Department of Transportation (MassDOT), in collaboration with the University of Massachusetts, Amherst (UMass) and other project partners, is completing a detailed assessment of over 1,000 road-stream crossings in the Deerfield River watershed to evaluate the risks and vulnerabilities to ecological resources and transportation infrastructure in the watershed. The goal of the project is to develop a systems-based approach to improve the assessment, prioritization, planning, protection and maintenance of roads and road-stream crossings, and to provide a decision-making tool to be used during project planning and development phases. The project will develop risk-based and data-driven protocols for assessing the present and future extreme flood vulnerability of roadway crossing structures within the Deerfield River watershed.

The project will prioritize road-stream crossings for upgrade or replacement based upon various elements of risk and vulnerability. Each crossing structure is evaluated for the following factors:

- Structural risk of failure based upon rapid field assessments of structural condition
- Hydraulic risk of failure based upon the ability of a crossing to pass a critical flow including potential future flows under a climate change scenario
- Geomorphic risk of failure based on consideration of stream power and bed resistance, as well as channel characteristics such as channel width, structure alignment, and sediment continuity
- Disruption of emergency medical services resulting from single crossing failure in terms of disruption to emergency response trips and overall trip delay due to culvert or bridge failure
- Ecological disruption including disruption of continuity and habitat quality based upon the Critical Linkages methodology developed by the Landscape Ecology Lab at UMass Amherst as part of the Conservation Assessment and Prioritization System (CAPS) program (www.umasscaps.org).

An overall prioritization score will be developed for each crossing. When complete, the study will provide a prioritization and decision-making tool (i.e., GIS mapping and web-based decision support tool) that can be used by MassDOT and municipalities during project planning and development. This tool will facilitate a proactive approach to upgrading vulnerable structures, in place of the current event-driven reactive approach. A key recommendation for this watershed-based plan is to use the MassDOT study findings to guide planning and implementation activities associated with maintenance, repair, and upgrade of road stream crossings in the watershed to enhance flood resiliency and aquatic organism passage. The results of the MassDOT project should be available to watershed communities in late 2017. Some of the information and an interactive map that shows the locations of the road stream crossing are available now through the North Atlantic Aquatic Connectivity Collaborative (NAACC) on-line database.[39]

Trout Unlimited (TU) has a pilot culvert program in northern Vermont that could be expanded to include the Massachusetts portion of the Deerfield River Watershed if funding can be secured.

39 https://www.streamcontinuity.org/cdb2/naacc_search_crossing.cfm

TU members help develop grassroots support for culvert replacements and TU engineers provide technical assistance, initial engineering designs and help with grant applications to fund culvert upgrades.

Climate Change Resiliency and Green Infrastructure

As discussed in the Massachusetts Climate Change Adaptation Report (2011), the state is experiencing the effects of climate change in the form of hotter summers, rising sea levels, more frequent flooding and warmer waters. Flood resiliency is at the top of the list of climate change concerns for most watershed stakeholders, with the devastation caused by Tropical Storm Irene in 2011 still fresh in their minds.

Managing climate change impacts using a Green Infrastructure approach supports the health and resiliency of the watershed, supports biodiversity and provides many water quality benefits. Green Infrastructure (GI) is a cost-effective, resilient approach to minimize many climate change impacts, including riverine flooding and fluvial erosion, which are serious problems in the Deerfield River Watershed. GI projects and concepts can be applied on several scales, including: the watershed, subwatershed, town and site-specific scales. For example, at the scale of the Deerfield River Watershed (HUC-8) or its subwatersheds (HUC-12), GI is a network of conserved and working lands, floodplains and forests that provide resiliency services such as maintaining and enhancing the ability of river floodplains to slow and absorb floodwaters or protecting forests and other undeveloped areas so vegetation and trees can absorb and filter rainwater. GI also provides other benefits such as open space for recreation, clean drinking water and wildlife habitat. GI on a watershed scale results in cleaner stormwater runoff that provides recharge to rivers, streams, ponds, wetlands and aquifers. Flooding and fluvial erosion can also be reduced.

MAPPR: Mapping and Prioritizing Parcels for Resilience (MAPPR) Tool

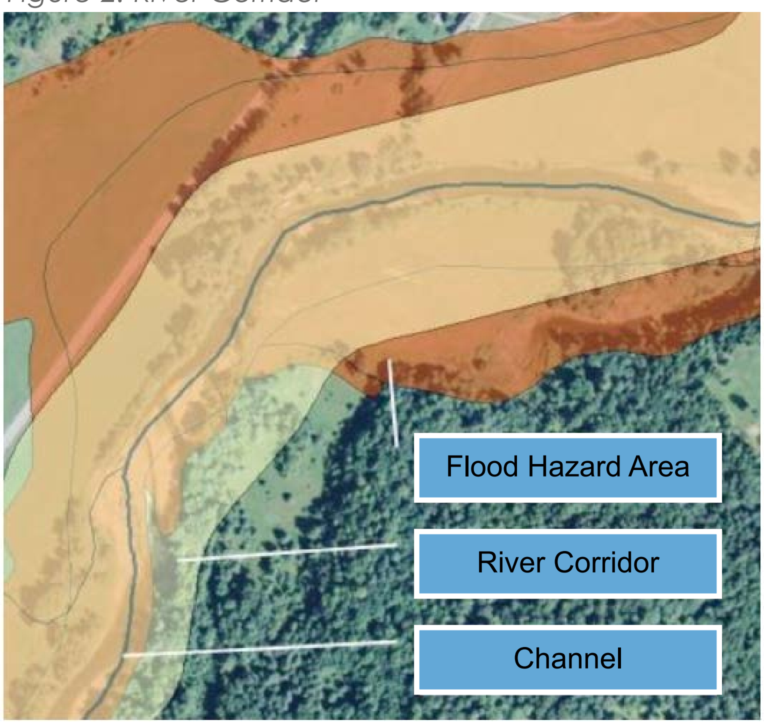
MassAudubon developed a free on-line tool that towns and stakeholders can use to identify critical green infrastructure parcels that should be protected. The Mapping and Prioritizing Parcels for Resilience (MAPPR) tool allows users to identify the parcels within an area of interest that are the highest priorities for protection based on habitat quality, climate change resilience, and other metrics such as parcel size and adjacency to existing protected parcels. http://www.massaudubon.org/our-conservation-work/advocacy/shaping-the-future-of-your-community/current-projects/mappr-project/mappr-tool

Stormwater runoff and flooding can be a source of pollution in the more developed areas of the Deerfield River Watershed, such as the Towns of Greenfield and Shelburne Falls, and the smaller village centers in the remaining watershed towns. The roofs, streets, and parking lots prevent rain from soaking into the ground. Typically, stormwater drains through gutters, storm sewers, and other engineered collection systems and is discharged (with minimal or no treatment) into nearby water bodies. The stormwater runoff carries trash, bacteria, heavy metals, and other pollutants from the urban landscape. Higher flows resulting from heavy rains also can cause erosion and flooding in urban areas and streams, damaging habitat, property, and infrastructure.

At the town and site-specific scale, managing stormwater runoff using GI provides many environmental, social, and economic benefits to the community, including minimizing the threat of flooding, protecting water quality, improving air quality and cooling urban environments. Green infrastructure uses vegetation, soils, and other elements and practices to restore some of the natural processes required to manage water and create healthier urban environments. In more urbanized settings, like the Town of Greenfield, GI also includes small scale features such as urban forests as well as grassed swales and riparian buffers that contribute to stormwater management, improve air quality and minimize heat island effects. At the town scale, GI can also be a patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the neighborhood or site scale, GI stormwater management systems like rain gardens and street trees mimic nature and soak up and store water.

The extent, condition and values of Green Infrastructure in the Deerfield River watershed were evaluated primarily with the use of MassGIS data (including BioMap2) and U.S. Forest Service's iTree. The Nature Conservancy's Active River Area (ARA) mapping and their Resilient and Connected Landscapes mapping were also reviewed. The complete Green Infrastructure Assessment is included in Appendix E and discussed in more detail in the Baseline Inventory (Appendix A).

Figure 2: River Corridor



This river corridor graphic was created by Flood Ready Vermont. http://floodready.vermont.gov/flood_protection/river_corridors_floodplains#what

Floodplains and River Corridors[40]

Floodplains and River Corridors are different but related areas along a river. Both floodplains and river corridors are critical to watershed resiliency and the protection of natural resources and the built environment. A *floodplain* is land that is covered by water when the river flows are high and overtop the river banks (a flood). The Federal Emergency Management Program (FEMA) has mapped the 100-year floodplain (Flood Hazard Area) in the watershed as part of the National Flood Insurance Program (NFIP). A *river corridor* is the land adjacent to a river that provides the physical space that the river needs to move and erode and deposit sediment (meander) over time in response to historic, current and future changes in land uses and development across the entire watershed, not just in the floodplain, as well as flood events. River corridors are mapped using the science of fluvial geomorphology and protocols such as those developed by Vermont.

40 Information for this section adapted from Flood Ready Vermont: http://floodready.vermont.gov/flood_protection/river_corridors_floodplains#what

River corridors and floodplains can overlap a great deal but the important thing to remember is that there are areas in the river corridor that will be eventually shaped (fluvial erosion and deposition) by the river over time (and not under water when the river floods) while the floodplain is under water during a large flood. Together, the river corridor and the floodplain comprise the area that a river needs to absorb the impacts from changes to the watershed lands and storm events. Avoiding new encroachments within river corridors and floodplains, which function as a "safety valve" for the river during a flood, is the least-cost method of mitigating flood damages.

Floodplains and river corridors play an important role in planning for climate change resiliency of both the built (infrastructure) and the natural environment (watershed resources). The high quality of the Deerfield River Watershed's natural resources, and the ecological and resiliency functions this green infrastructure provides, are primarily due to the large areas of undeveloped, forested land that dominate the higher elevations in the watershed. The smaller tributaries and headwater streams in these areas typically have narrow, undeveloped floodplains. Generally there are few, if any activities or development in the floodplains and river corridors in these areas other than forest management, road crossings or occasionally, agriculture.

Most of the development in the watershed has historically been and continues to occur within and adjacent to the 100-year floodplains of the major tributaries of the Deerfield River and along the river itself. Infrastructure, homes, and businesses located in these areas are affected by flooding and fluvial erosion. Development in the floodplain and river corridor cause an increase in impervious cover, reducing flood storage capacity and causing localized flooding and erosion damage from stormwater runoff. Changes to the river itself, such as straightening or relocating the channel, and installing berms and dams, even if these alterations occurred decades ago, still exacerbate flooding and fluvial erosion problems today. Water quality and habitat are also degraded by these modifications to the floodplain and river corridor. Undersized and failing road stream crossings (culverts and bridges) also contribute to flooding and fluvial erosion hazards in the floodplains and river corridors as well as in the upland tributary and headwater streams. In addition, these undersized/failing road stream crossing structures can be obstacles to fish and wildlife passage up and down a river, which can limit habitat availability for many species. The Massachusetts River & Stream Continuity Project maintains an on-line database and provides training for volunteers to conduct road stream crossing assessments, and developed the Massachusetts River and Stream Crossing Standards.[41]

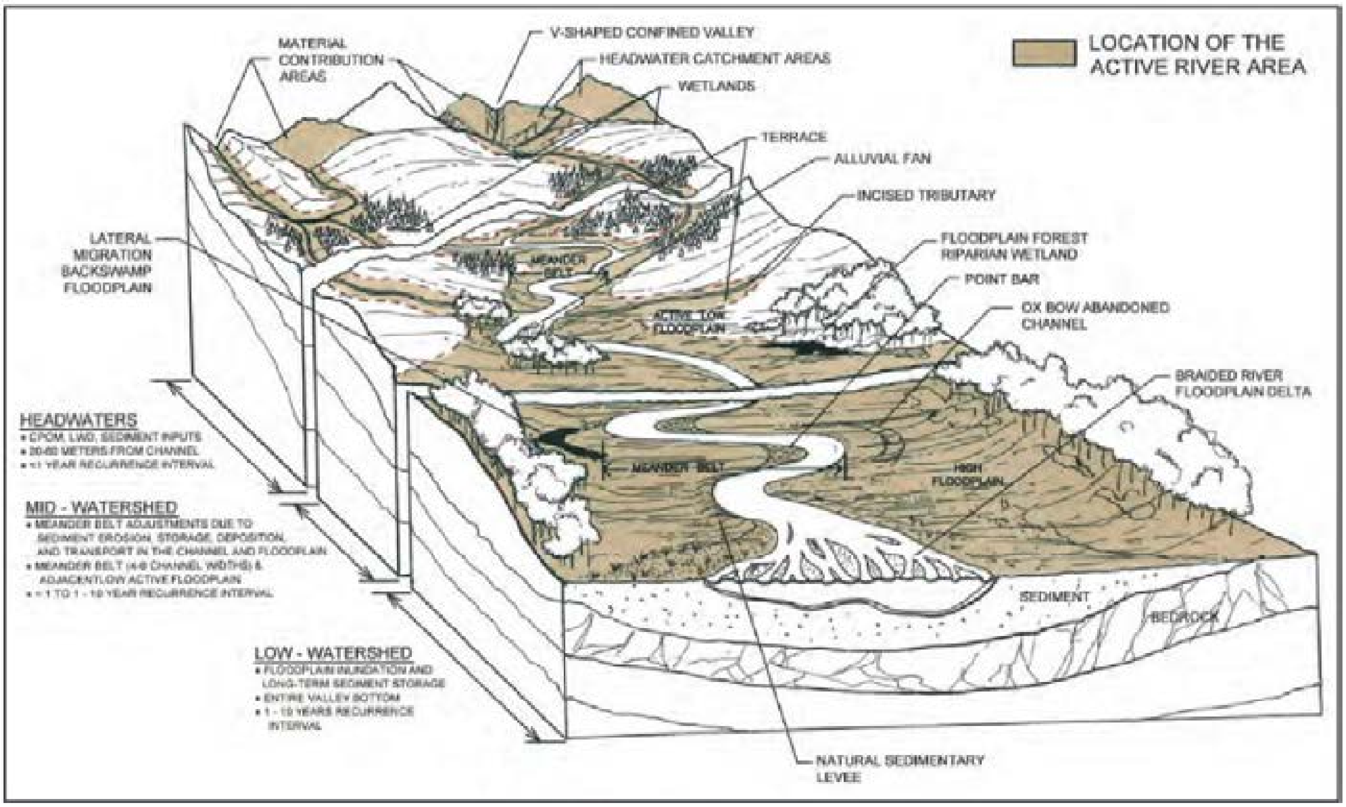
Active River Areas

The Nature Conservancy (TNC) developed a conservation framework for protecting rivers and streams called the Active River Area (ARA).[42] As noted by the US EPA Healthy Watersheds Program, the active river area framework provides a holistic vision of a river and represents the lands that contain both aquatic and riparian habitats and those that contain processes that interact

41 http://www.nae.usace.army.mil/Portals/74/docs/regulatory/StreamRiverContinuity/MA_RiverStreamCrossingStandards.pdf
42 https://www.floods.org/PDF/ASFPM_TNC_Active_River_%20Area.pdf

with and contribute to a stream or river channel over time.[43] The ARA framework was applied to the Connecticut River Watershed, which includes the watershed of the Deerfield River, a major tributary.

Figure 3: Dominant Processes and Disturbance Regimes of the Active River Area[44]



The active river area is an important tool for stakeholders and decision-makers because it presents a river as a dynamic system with a broad range of conditions that are typical of natural river systems. The active river area for the Deerfield River Watershed is spatially explicit and can be readily identified – narrow in some areas, wider in others – and captures the living, dynamic processes and places that define these systems. The active river area includes a number of distinct components that provide specificity to guide actions for protection, restoration and management (Figure 3).[45]

The ARA for the Deerfield River Watershed is shown on Map 7. From a green infrastructure and healthy watershed perspective, a naturally functioning and protected active river area provides a range of important benefits, including:

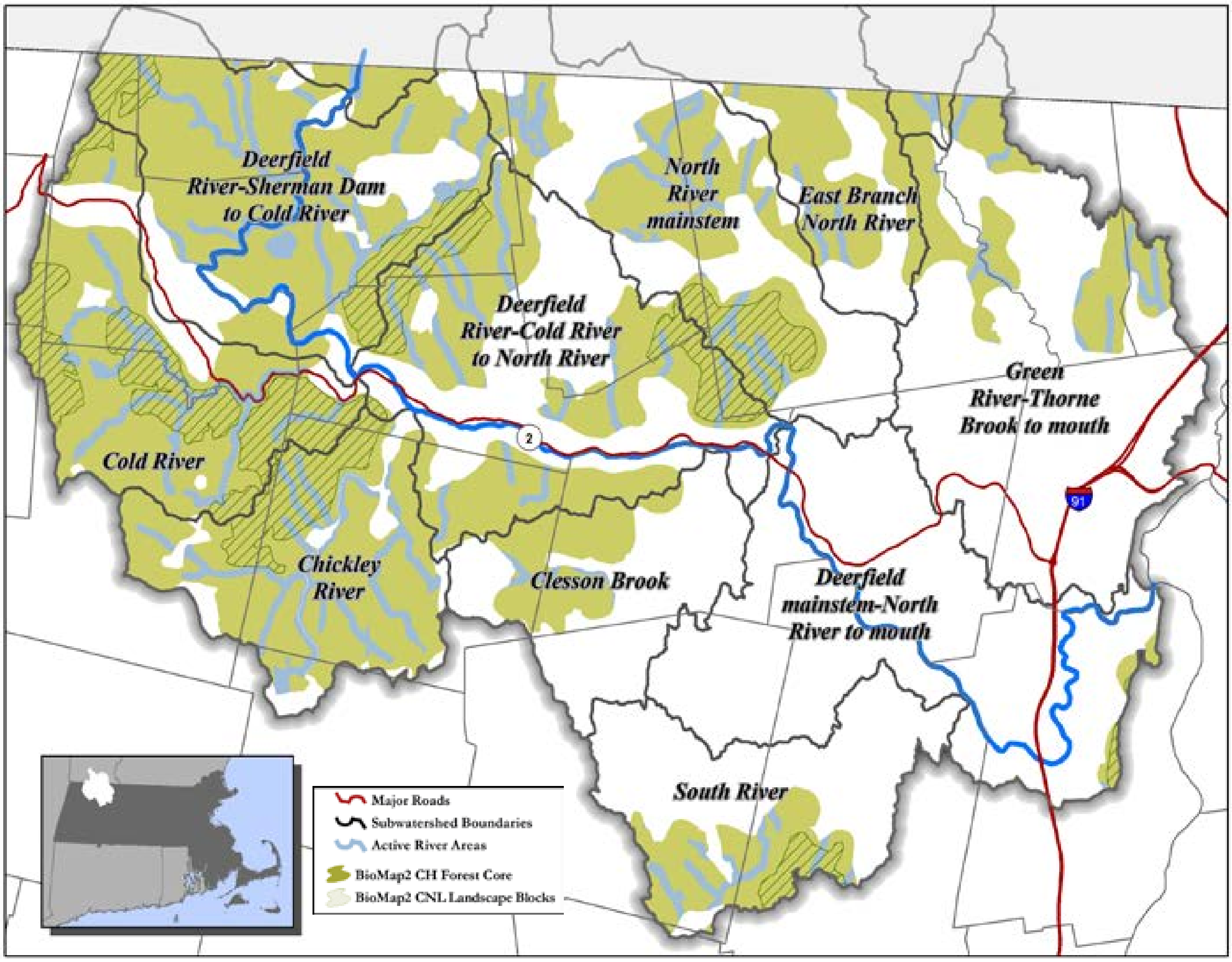
ACTIVE RIVER AREA BENEFITS

1. Improvement of aquatic and terrestrial habitat
2. Reduction in flood and erosion risks
3. Protection of areas with high quality water
4. Improvement of impaired waters quality

43 https://www.epa.gov/hwp/healthy-watersheds-projects-region-1
44 https://www.floods.org/PDF/ASFPM_TNC_Active_River_%20Area.pdf
45 https://www.floods.org/PDF/ASFPM_TNC_Active_River_%20Area.pdf

The ARAs cover a large portion of the watershed. Practically speaking, it may not be possible or even desirable to protect and manage this entire area. However, there are significant ARA areas that overlap with other landscape-scale areas, such as intact forests, agricultural lands, floodplains, and resilient landscapes that are mapped as part of the watershed's green infrastructure. These areas provide important services to a healthy and resilient watershed. Maps that include the ARA will assist stakeholders in efforts to prioritize areas for conservation and specific river corridor and land management activities to preserve the health and resiliency of the watershed.

Map 7: Active River Areas within BioMap2 Critical Natural Landscape Blocks

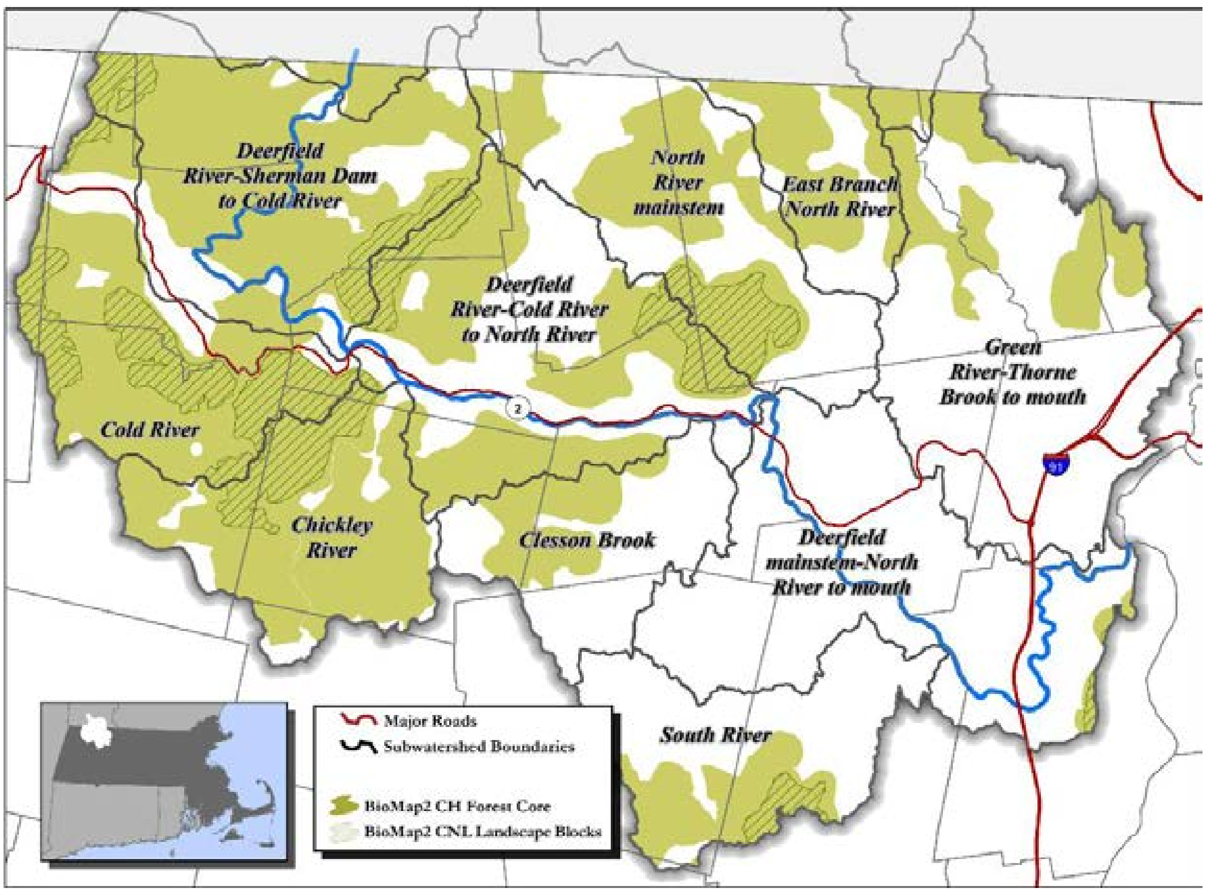


BioMap2

BioMap2, a program of Massachusetts Natural Heritage and Endangered Species Program and The Nature Conservancy's Massachusetts Program, is a conservation plan to protect the state's biodiversity. It is designed to guide strategic conservation in the State by focusing land protection and stewardship on the areas that are most critical for ensuring the long-term persistence of rare and other native species and their habitats, exemplary natural communities, and a diversity of ecosystems.[46]

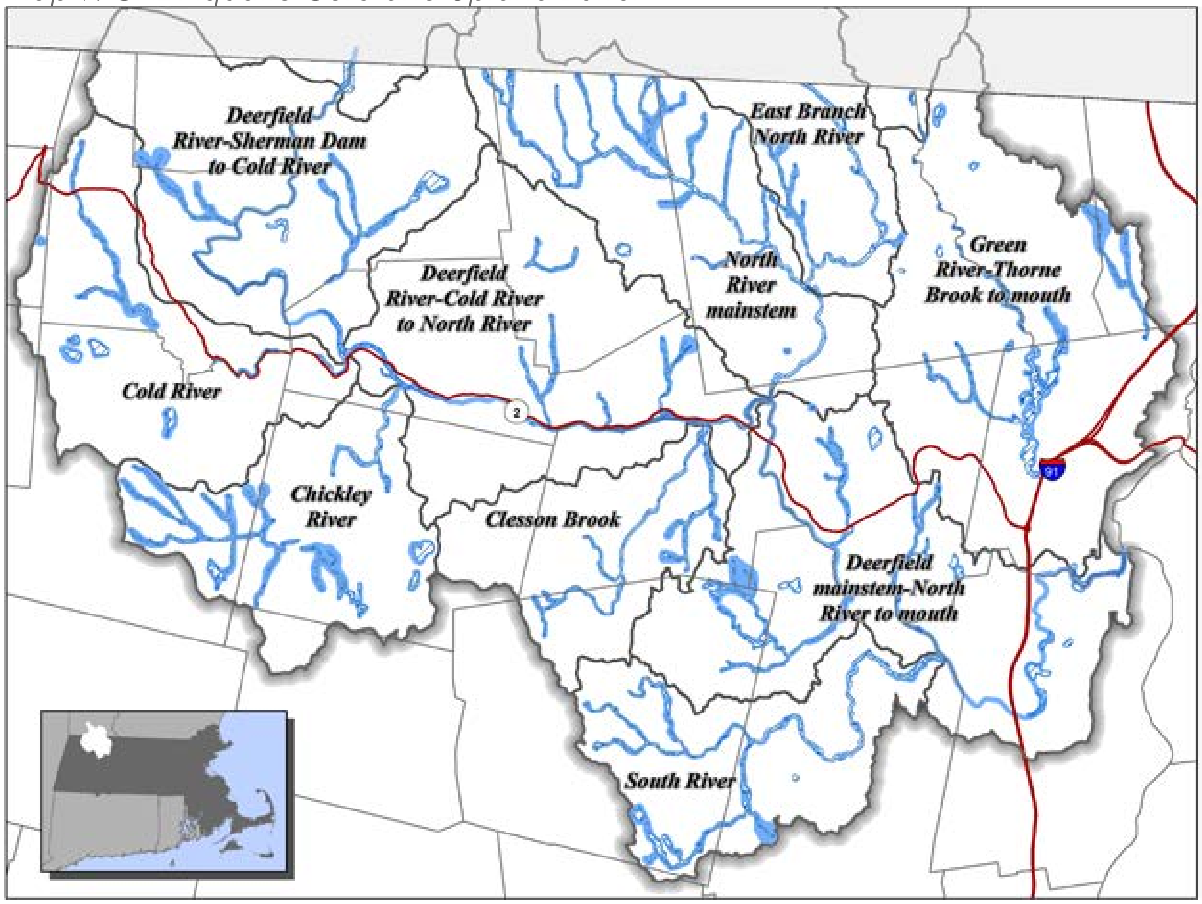
The data layers that comprise BioMap2 measure such landscape-scale properties as intact forest core and large natural landscape blocks that support intact ecological processes. As illustrated in Map 8, in the Deerfield River watershed there are three significant areas of intact BioMap2 Forest Core located in the central and western part of the watershed. Forest Core identifies the best examples of large, intact forests that are least impacted by roads and development. These areas of Forest Core in the watershed total about 19,244 acres, and provide important green infrastructure services for the watershed such as water filtration and flood storage. Within these forest cores, there are 17 headwaters of tributaries that feed the Deerfield River. Protection of Forest Core areas and the headwaters they contain is a high priority. Currently, of these 19,244 acres of Forest Core, about 60% is permanently protected.

Map 8: BioMap2 Core Habitat Forest Core and Critical Natural Landscape Blocks



46 http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/biomap2.html

Map 9: CNL Aquatic Core and Upland Buffer



BioMap2 Landscape Blocks are large areas of intact, predominately natural vegetation, consisting of contiguous forests, wetlands, rivers, lakes, and ponds. Pastures and power-line rights-of-way, which are less intensively altered than most developed areas, are also included since they provide habitat and connectivity for many species. These Landscape Blocks also provide green infrastructure services, such as buffering land around rivers and streams and ensuring the long term integrity of the lands and water they buffer. There are about 104,667 acres of Landscape Block land, located primarily in the northern and western areas of the watershed, although there are some areas in the southernmost part of the watershed. Of these 104,667 acres, nearly 40% are permanently protected.

The primary disturbances to the Forest Core in the watershed are roads, which travel through sections of Forest Core. Disturbances to the Landscape Blocks, in addition to roads, include dams, a junk yard and the former Yankee Rowe Nuclear Power Station.

BioMap2 Aquatic Core identifies intact river corridors within which important physical and ecological processes occur (Map 9). These areas are determined by buffering each river segment by 30 meters. All wetlands contained in whole or partially within these buffers are included as part of the Aquatic Core. There are approximately 7,200 acres of BioMap2 Aquatic Core in the watershed. Aquatic Upland Buffers are made up of protective areas around the Core Aquatic areas, including unfragmented habitats. These buffers help support the functionality of wetlands, streams and rivers, and the species that depend upon them. There are approximately 7,200 acres of BioMap2 Aquatic Core in the watershed, 21% of which is permanently protected. Of the approximately 11,610 acres of Aquatic Upland Buffer, 28% is permanently protected.

iTree Landscape[47]

While BioMap2 shows where and how much ecologically critical landscape exists in the watershed, iTree Landscape quantifies the value of forests. In terms of green infrastructure services, the forests in the watershed prevent about 171 million gallons of water from running off into streams and rivers per year, saving municipalities and residents over $1.5 million annually in stormwater mitigation and infrastructure costs. Forests in the watershed also intercept rainfall in the amount of over 20 million gallons per year. *Note: The iTree Landscape data includes the subwatershed portions located in Vermont, due to the lack of functionality of iTree to calculate only the Massachusetts area of the watershed.*

Table 16: iTree Landscape: Carbon Storage

Subwatershed	Annual carbon storage value in dollars
East Branch North River	$116,351,765
Deerfield River - Cold River to North River	$99,328,319
Deerfield River - Sherman Dam to Cold River	$98,135,750
Green River - Thorne Brook to mouth	$97,240,620
Deerfield mainstem - North River to mouth	$94,197,927
North River mainstem	$84,193,744
Cold River	$72,136,992
Chickley River	$63,352,069
South River	$55,082,838
Clesson Brook	$44,604,468
TOTAL	**$824,624,492**

iTree also quantifies the value forests provide in terms of carbon storage. This is important to watershed resilience because increased carbon storage can help lessen the severity of climate change, protecting habitat and water quality.

Forests in the Deerfield River watershed store carbon equal to approximately $824 million dollars annually. See Table 16. The subwatershed with the highest value carbon storage is the East Branch North River, which stores the equivalent of about $116 million a year in carbon (this includes the Vermont portion of the watershed).

Protecting forests for carbon storage is critically important for climate resilience. Providing incentives for forest owners - through carbon markets or other mechanisms - to protect their land for carbon storage is one strategy that can be used in the Deerfield River watershed to protect its green infrastructure.

47 https://landscape.itreetools.org/

Resilient and Connected Landscapes

Climate change is bringing more frequent and intense storm events, drought, and rising temperatures, all of which impact not only humans but the plants, animals and land upon which all species depend. The Nature Conservancy (TNC) recently completed a large, landscape-scale project to map climate-resilient sites, confirmed biodiversity locations and species movement areas (both zones and corridors) across Eastern North America.[48] The purpose of this project was to provide a conservation blueprint for ensuring that the land continues to support a diversity of wildlife and plants, and that the land continues to provide the raw materials for manufacturing and other types of economic development, food, and clean water that humans rely upon. The data for this project can be viewed with an interactive mapping program or downloaded.[49]

As the following map shows, the Deerfield River Watershed contains an abundance of these resilient and connected landscapes. Much of these two areas also contain confirmed species diversity, which means that these are known areas of rare species or unique natural communities.

Some of these areas, especially in the western part of the watershed where there are large blocks of State Forest land, are also already permanently protected conservation lands. The mapping identifies areas that, if appropriately managed or conserved, would sustain species diversity under a changing climate. The project also provides information that can be used to identify land that provides benefits to people, such as carbon storage and clean water supplies. For example, because much of the resilient land in the Deerfield River Watershed is intact forest, the amount of carbon storage provided is greater than 150 tons/hectare.[50]

Much of the resilient land in the watershed is mapped as having a high importance to surface drinking water supplies. This TNC mapping project also identified the intersection of shared priorities for protecting resilient lands between the TNC and the US Fish and Wildlife Service. In the entire Connecticut River Watershed, there are 1.5 million acres of unprotected lands that both the The Nature Conservancy and USFWS identify as being important for conservation. In Massachusetts, a significant amount of this land is in the Deerfield River Watershed. Some of this land is already permanently protected by conservation ownership (state forests, wildlife management areas, etc.) or conservation restrictions on privately owned land, but there are still areas of unprotected prioritized resilient and connected lands, which TNC has also mapped. See Maps 10-13.

48 http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/Pages/Maps.aspx

49 http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/Pages/Strategies.aspx

50 National Biomass and Carbon Dataset for th year 2000 (Kellnsdorfer 2012)

Resilient and Connected Lands

The resilient and connected lands represent all the characteristic environments of eastern North America while maximizing the permeability and flow that connects them.

By first identifying the natural flows and pathways that allow species populations to shift over time, and then identifying representative resilient sites situated within those pathways, the network was designed to sustain biological diversity while allowing nature to adapt and change. For more information on this analysis and results, please see : goo.gl/u4my53

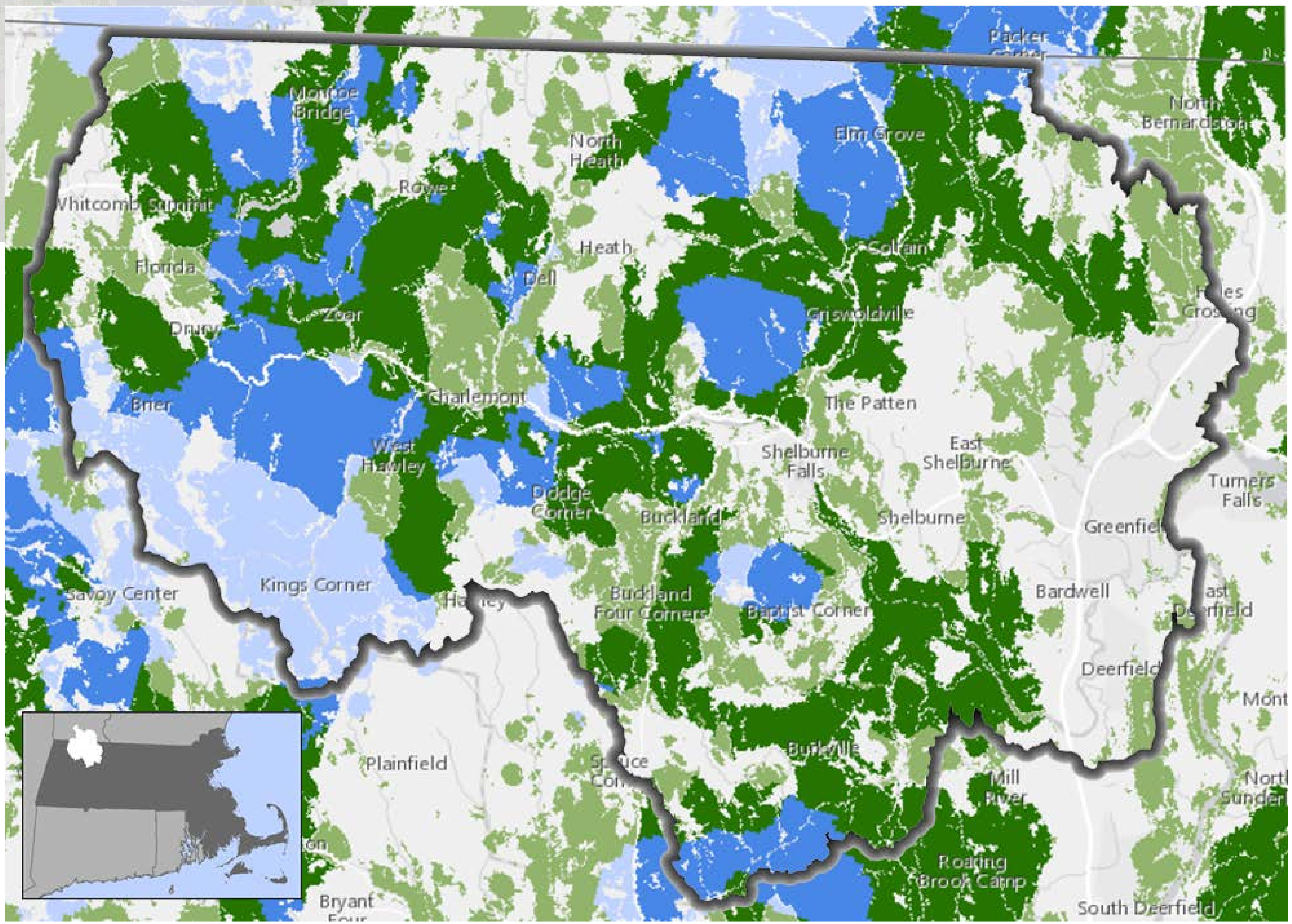
MAP LEGEND

With Confirmed Diversity

Resilient Area

Climate Flow Zone

Climate Corridor



Resilient Area: places buffered from climate change because they contain many connected micro-climates that create climate options for species.

Flow: the movement of species populations over time in response to climate. Flow tends to concentrate in the zones and corridors described below.

Climate Flow Zone: broad areas of high flow that is less concentrated than in the corridors. Typically intact forested regions.

Climate Corridor: narrow zone of highly concentrated flow, often riparian corridors or ridgelines.

Confirmed Diversity: known locations of rare species or unique communities based on ground inventory. Unconfirmed areas may contain the same species.

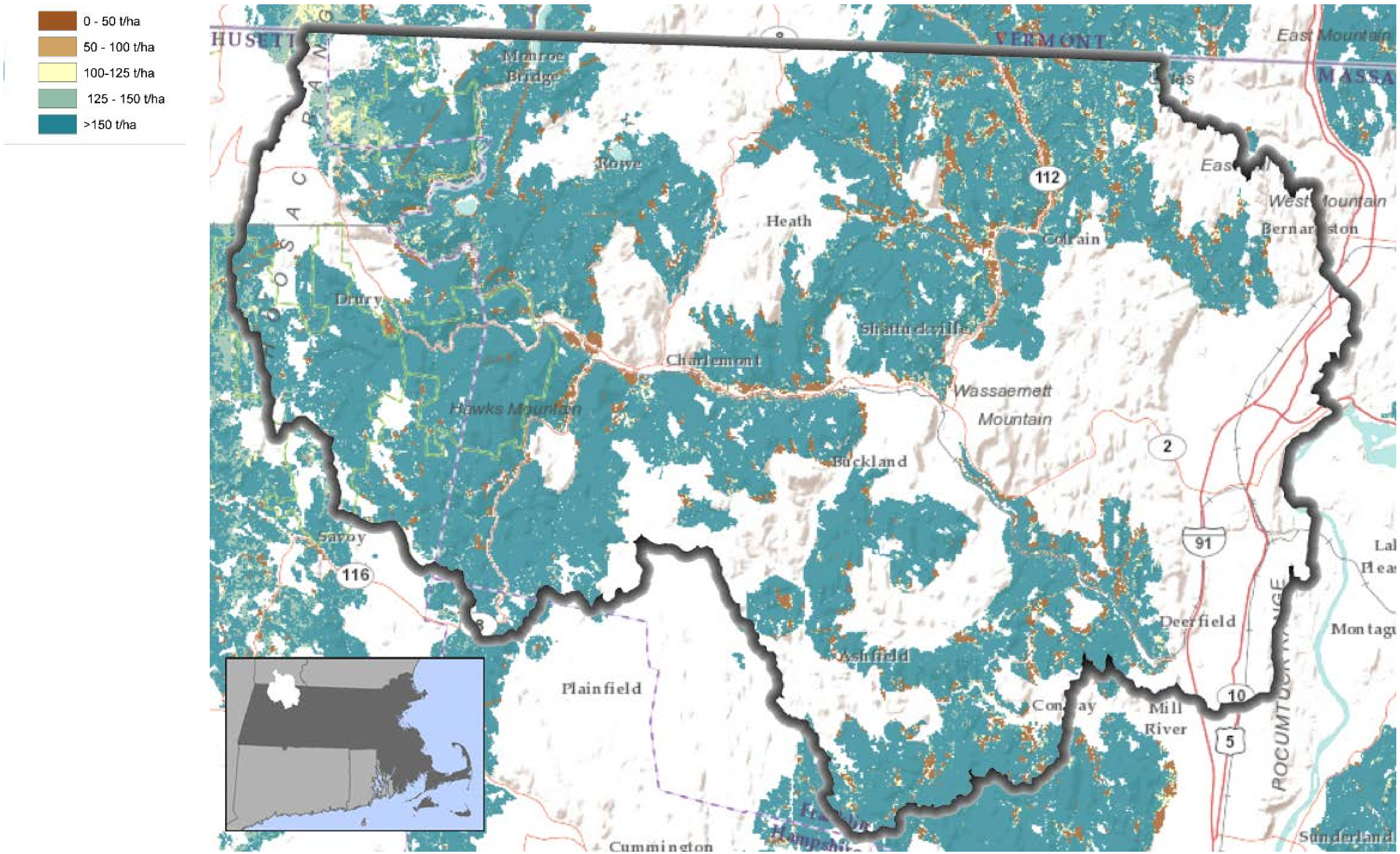
Source: The Nature Conservancy

Map 11: Increasing Carbon Storage (The Nature Conservancy)

Increasing Carbon Storage

Forests have a huge capacity to store carbon and the Eastern U.S. region has some of the highest forest biomass in the United States.

This map shows the estimated amount of above-ground carbon stored in each hectare of the priority resilience sites (in tons per hectare, for the US only; wetland and lake sediment carbon not shown).
The Resilient Prioritized Network stores 56% of the region's carbon although it only covers 22% of the area.



Source: The Nature Conservancy

Map 12: Shared Priorities with Partners (The Nature Conservancy)

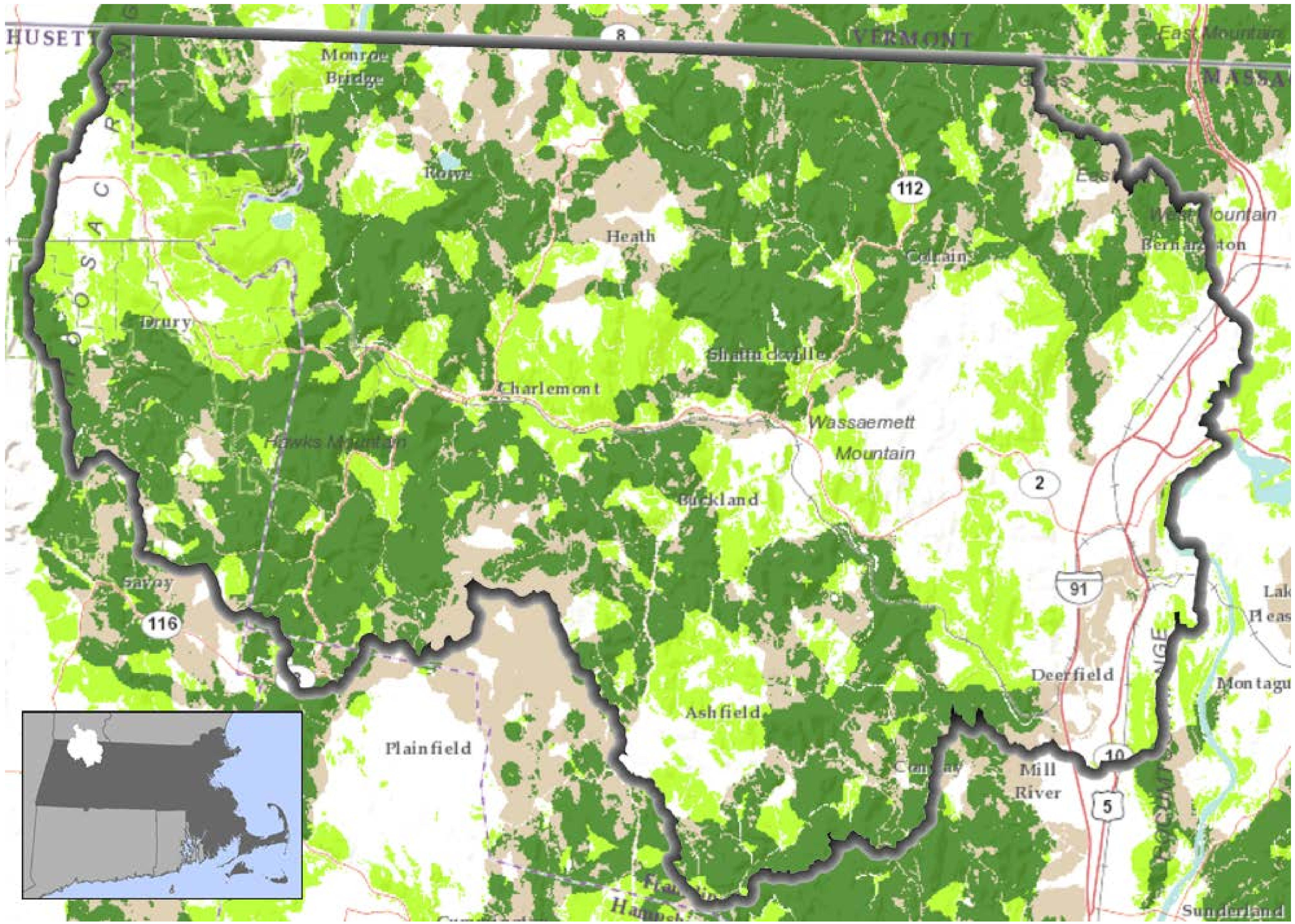
Identifying Shared Priorities with Partners

Working with partners on shared priorities can lend additional resources and higher probability of success to conservation projects. Here we examine the intersection of shared priorities with U.S. Fish and Wildlife Service (USFWS) partners.

This Map shows the overlap of partner USFWS Conservation Priorities and the TNC Prioritized Network.

In the Connecticut River watershed, there are 1.5 million acres of unsecured lands that both groups identify as being improtant for conservation.

- Partner and TNC Priority
- TNC Priority
- Partner Priority

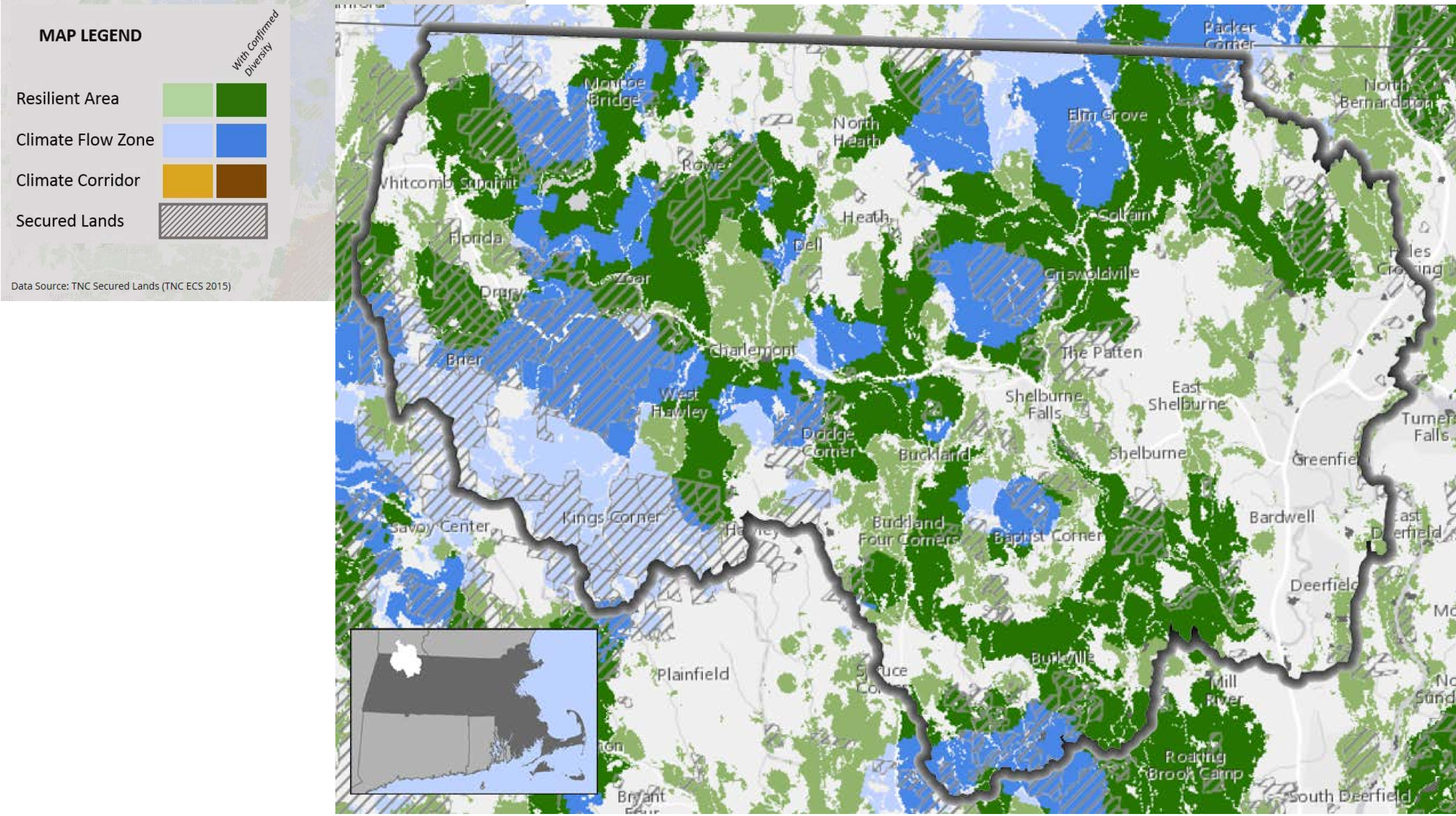


Source: The Nature Conservancy

Map 13: Expanding Land Protection (The Nature Conservancy)

Land and water permanently secured against conversion to development remains one of the most effective, long lasting, and essential tools for conserving the region's habitats and species. By focusing acquisition on land that is resilient and connected, we can provide a stage on which future diversity can adapt and thrive.

This maps shows protected lands in conservation ownership or conservation easement, along with unprotected prioritized resilient and connected lands.



Source: The Nature Conservancy

Plan Recommendations

FRCOG conducted general and targeted outreach to key watershed stakeholders to inform the development of the plan and its recommendations. General outreach included posts on FRCOG's website and Facebook page, a survey, a workshop targeted to local officials, project updates provided to the Creating Resilient Communities group and the MA Fluvial Geomorphology Task Force, and a presentation to the Franklin Regional Planning Board. Targeted outreach included interviews with representatives of key watershed stakeholder groups, including: Franklin Land Trust, Connecticut River Conservancy; USDA Natural Resources Conservation Service (NRCS); UMass-Amherst; Cole Ecological; Trout Unlimited; and MassDFG's Division of Ecological Restoration. The Franklin Conservation District assisted the FRCOG with the interviews of key stakeholders. The complete stakeholder outreach summary is included as Appendix G.

Work conducted as part of this watershed-based plan project revealed the strong connections between watershed health, impairments and the resiliency of the watershed to climate change. As we learned from the 604b-funded fluvial geomorphic and habitat assessments conducted for the South and North River HUC 12 subwatersheds, there are impairments in a healthy watershed that are not captured by the water quality testing and assessment methods used to develop the MassDEP's Integrated List of Waters. Examples of these impairments include: floodplain encroachments and disconnection, dams, unstable river systems with miles of eroding banks, compromised or non-existent riparian buffers, and undersized culverts and road crossings. There are many examples of these types of impairments in the Deerfield River Watershed that affect water quality, habitat, geomorphic function, climate change resiliency, and threaten prime agricultural lands, roads and other infrastructure.

The recommendations developed for this Watershed-Based Plan address the complex and interconnected nature of the impairments identified in the Deerfield River Watershed in an innovative and holistic manner. Examples include recommendations to:

- update and align land use regulations across the 14 watershed towns, with a focus on mapping and managing the river corridor;
- identify sediment storage, water quality protection and conservation opportunities in the upland areas of the HUC 12 watersheds; and
- conduct conservation/restoration projects that protect green infrastructure, improve flood resiliency and reduce sediment inputs to streams and rivers.

Due to the large size of the Deerfield River Watershed (HUC 8), additional assessment projects are included in the recommendations to help refine and develop implementation projects and watershed management strategies, primarily at the HUC 12 scale, which seems more manageable given funding constraints. The assessment recommendations are presented in Table 17 and throughout the ten HUC 12 subwatershed plans, beginning on page 107.

Table 17 includes watershed or landscape scale recommendations that can be implemented throughout the Deerfield River Watershed and can involve many or all of the HUC 12 subwatershed and watershed communities as well as a variety of stakeholders. These recommendations are intended to protect and restore watershed health and resiliency and engage and educate watershed residents. The many benefits of these measures can be cumulative as the number of towns and stakeholders involved in the implementation expands over time. There are three categories of watershed-scale recommendations: **1. Landscape Scale Assessment, Conservation, and Protection 2. Water Quality, and 3. River Corridors and Floodplains.** Table 17 also includes more targeted recommendations and site-specific projects that address issues identified in each of the ten HUC 12 subwatersheds. The implementation of these recommendations can have both short-term (mitigate a specific problem) and long-term benefits. Stakeholders should use Table 17 and the individual HUC 12 subwatershed plans to identify future assessment and implementation projects.

Timeframe for Implementation

The recommendations are further classified according to their implementation priority. As described below, the timeframes for implementation are described as short-term, medium-term, long-term, or ongoing. It is important to note that the implementation timeframe is fluid and depends, in large part, upon two things. First, the availability of grant funding, especially for landscape-scale conservation, assessment and river corridor mapping, and habitat/river restoration projects, will dictate the number and timeliness of project implementation. Second, since most of the watershed towns are run by volunteer boards (Select Boards, Planning Boards, Conservation Commissions, Agricultural Commissions, etc.), time available to work on land use regulation updates and education/outreach may be limited by other town priorities. The FRCOG is committed to assisting our watershed towns and stakeholders in their efforts to implement the recommendations in this plan. However, FRCOG relies on grant funding to support the work of our staff; therefore, the implementation priorities and timeframes may need to shift in order to accommodate grant cycles and availability.

- **Short-Term Recommendations** can be accomplished within the first one to two years of plan implementation. These actions can demonstrate immediate progress, which can energize stakeholders and encourage participation in plan implementation activities.
- **Medium-Term Recommendations** may build upon the work begun over the previous two years and include projects that take 3 to 5 years to plan, fund and implement.
- **Long-Term Recommendations** have an implementation timeframe of 5 to 10 years and beyond. These projects are primarily landscape-scale projects that involve land conservation and management, river restoration and river corridor management projects at both the HUC 12 subwatershed and Deerfield River Watershed scale.
- **Ongoing Activities** are generally ones that involve outreach and education activities, coordination among stakeholders, and review and update of the progress being made on implementing the plan recommendations.

KEY

IMPLEMENTATION PRIORITY

Low Priority	★
Medium Priority	★★
High Priority	★★★

PROPOSED TIMELINE

Short-Term (1-2 years)	S
Medium-Term (3-4 years)	M
Long-Term (5-10 years)	L
Ongoing	O

PROJECTED COST

less than $10,000	$
$10,000 to $50,000	$$
$50,000 to $100,000	$$$
greater than $100,000	$$$$

See acronyms table at the beginning of this report for agencies, lead entity and funding source abbreviations.

Table 17: Deerfield River Watershed Action Plan

Landscape Scale Assessment, Conservation and Protection	Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
	Implementation Priority																
Additional Green Infrastructure Assessment																	
Use recently available down-scaled climate change data (UMass) to update Green Infrastructure assessment and identify ecosystem services & vulnerabilities. Develop additional recommendations, as appropriate, that will enhance habitat, water quantity & quality, and flood resiliency in the Deerfield River Watershed.	★★★											FRCOG	S	Report, recommendations, updated GI assessment.	# of updates and recommendations	Community Compact Energy & Efficiency Grant, EEA, 319, Umass	$$
Use the results of this WBPlan, the updated GI assessment, & MassAudubon's MAPPR tool to identify and prioritize parcels for conservation or management.	★★											FLT, FRCOG, Towns	M	Prioritized list of parcels	# of parcels identified	Foundation grants	$
Secure funding and conduct fluvial geomorphic and habitat assessments for the remaining HUC 12 subwatersheds. Use methodology developed under FRCOG's previous 604-funded assessments for the South and North Rivers.	★★★											FRCOG	M	Reports, maps, recommendations, conceptual designs, cost estimates	# of assessments completed	604b, MET	$$$$
Forests																	
Develop an integrated forest protection, stewardship, and management plan that includes recommendations for public and privately owned forests that could be implemented at the landscape, HUC 12 and local scale. Use available information from the MA Clean Water Toolkit http://prj.geosyntec.com/npsmanual/sectionintroforestry.aspx and the 2013 Massachusetts Forestry Best Management Practices Manual and other available references.	★★★											FLT, FRCOG	M	Report, recommendations.	# of reports distributed	DCR, DEP	$$
Conduct outreach and education to forest landowners about protection and stewardship options, as well as transition planning for their land.	★★											FLT, FRCOG	M	Outreach materials	Number of meetings with landowners	DCR	$

Table 17: Deerfield River Watershed Action Plan (cont.)

	Implementation Priority																
Landscape Scale Assessment, Conservation and Protection	Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Encourage the use of resiliency mapping tools (TNC Active River Area; Resilient and Connected Landscapes; MAPPR) into forest management and stewardship plans. Conduct outreach/workshops for foresters and land trusts.	★★											FLT, FRCOG, DCR	M	Outreach materials	# of workshops	MassDEP, DCR	$
Provide assistance to landowners with accessing carbon markets and other ecosystem markets as applicable. Provide education and training for foresters and landowners on best practices in forest management for carbon sequestration and other ecosystem services.	★★											DCR, FLT, Umass	M	Outreach materials; workshops	# of landowners receiving technical assistance	DCR	$
Provide training and assistance to forestry businesses to upgrade equipment and promote low-impact logging techniques.	★★											DCR	M	Outreach materials; workshops	# of business receiving technical assistance	DCR	$
Conduct outreach and education to landowners about forest resiliency and how to assess their land for strengths and vulnerabilities.	★★											DCR, FLT, UMass	M	Outreach materials	# of landowners contacted	DCR, NRCS, MassDEP	$
Agricultural Land																	
Assist local farmers in their on-going efforts to continue sustainable and profitable farming operations, prevent loss of farmland to erosion, and avoid degradation of wetlands and surface and groundwater resources. Examples of projects that should be the focus of cooperative efforts to protect water quality include: a. Providing alternative sources of water for livestock, if necessary and erecting fencing to prevent direct access to surface water by livestock; b. Planting conservation buffers, particularly along riparian areas, to remove sediment, nutrients, pesticides and pathogens from stormwater runoff; c. Stabilizing eroding streambanks (farmland) in riparian areas using appropriate techniques such as bioengineering, planting riparian buffers, and other techniques described in the Clean Water Toolkit; d. Providing technical and financial assistance to farmers, as needed, for other site specific activities that may degrade water quality. For example, manure management.		★★★		★★★				★★★	★★★			FRCOG, NRCS, FCD, Local Agricultural Commissions	M	Outreach materials, meetings, site visits	# of BMPs implemented	NRCS, 319	$$$$

Table 17: Deerfield River Watershed Action Plan (cont.)

Landscape Scale Assessment, Conservation and Protection	Watershed Scale (Implementation Priority)	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
When available (2017?) review Stream Power mapping developed by the U Mass RiverSmart project that identifies locations of farmland most vulnerable to erosion. Conduct targeted outreach to farmers in the watershed to identify opportunities for improving flood resiliency and water quality via land conservation, easements and the implementation of BMPs identified in Umass' Farms, Floods & Fluvial Geomorphology project.	★★★											U Mass, FRCOG, Local Agricultural Commissions, Conservation Commissions	O	Outreach materials	# of meetings with farmers	U Mass	$$
Dams, Stream Crossings and Culverts																	
Use the MassDOT funded culvert assessment project to identify landscape scale (HUC 12) implementation priorities and leverage other planned infrastructure improvement projects, particularly transportation. Create a series of maps that show the priority locations for watershed towns.	★★★											FRCOG, MassDOT, Towns	M	Town maps	# of meetings with towns	319, MassDOT, Ch. 90, MET	$$
Implement high priority road-stream crossing upgrades or replacements to enhance flood resiliency and stream continuity	★★★											MassDOT, Towns, MassDFG, DER	L	Engineering Designs, constructed projects	# of crossing upgrades; # of crossing replacements	MassDOT, Towns, MassDFG, DER	$$$$
Conduct a comprehensive assessment of the dams in the watershed. Use the MassDFG Division of Ecological Restoration's (DER) new dam database (2017) to identify landscape scale (HUC 12) dam removal priorities and leverage other planned projects, develop recommendations to improve flood resiliency and ecological functions.	★★											DER, FRCOG, Towns	M	Prioritized list of dams for each HUC 12	# of stakeholder meetings	DER, foundations	$$

Table 17: Deerfield River Watershed Action Plan (cont.)

	Implementation Priority																
Landscape Scale Assessment, Conservation and Protection	Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Implement high priority dam removal projects to enhance flood resiliency and stream continuity. Consider those already identified by stakeholders: two in the East Branch North River subwatershed; Albert Davenport dam in Buckland-Shelburne area.	★★											DER, FRCOG, Towns	L	Engineering Designs, constructed projects	# of dams removed	DER, foundations	$$$$
MassDFG and watershed stakeholders should collaborate and secure funding to expand Trout Unlimited's (TU) pilot culvert program to the Deerfield River Watershed. In this program, TU members help develop grassroots support for culvert replacements and TU engineers provide technical assistance, initial engineering designs and help with grant applications to fund culvert upgrades.	★★★											TU, MassDFG DER, CRC, DRWA, FRCOG	M	Culvert technical assistance program	# of towns served; # of culvert upgrade designs	DER, foundations	$$$$
Land Use Regulations and Local Planning Initiatives																	
Develop a package of model land use regulations (floodplain bylaws, river corridor protection, zoning, subdivision, and stormwater) and updates to existing regulations to ensure consistency across the watershed towns. Create a regulatory review checklist for watershed communities. Provide technical assistance to towns to adapt models to local needs and update local regulations.	★★★											FRCOG, EEA, Towns	M	Model bylaw package	# of Towns that adopt model land use regulations	MassDEP, DLTA, MET	$$
Provide training to watershed towns on the use of MAPPR when updating maps and conservation/management priorities in local Open Space & Recreation Plans and Multi-Hazard Mitigation Plans.	★★											FRCOG, Towns	O	Training workshops	# of Towns that attend training workshops	MassAudubon, FLT	$
Develop a prototype watershed-scale Transfer of Development Rights (TDR) program for the Deerfield River Watershed to direct development to appropriate areas in the watershed while protecting green infrastructure and its ecological and resiliency functions.	★											FRCOG, EEA, Towns	M	Protoype watershed-scale TDR program		FLT, Foundation	$$

Table 17: Deerfield River Watershed Action Plan (cont.)

Landscape Scale Assessment, Conservation and Protection	Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
	Implementation Priority																
Wetlands																	
Develop model Wetlands Bylaw for watershed communities. Provide technical assistance to interested Conservation Commissions and towns to adopt the bylaw.	★★											FRCOG	M	Model bylaw package	# of Towns that adopt a Wetlands bylaw	DLTA, Mass Environmental Trust, 319	$
Develop a job description and long-term funding structure, and secure start-up funding, for a Wetlands Circuit Rider to provide technical assistance to watershed Conservation Commissions.	★★★											FRCOG	S	Wetlands Circuit Rider for the watershed towns		MassDEP, DLTA, MET	$$
Provide outreach and education to watershed Conservation Commissions about using the MassDEP Important Habitat Conservation Maps (CAPS) and MassDEP's Massachusetts Wildlife Habitat Protection Guidance for Inland Wetlands (June 2006) during project reviews.	★★											FRCOG, Wetland Circuit Rider	M	Use of CAPS maps by ConComs	# of Towns that attend training workshops	DLTA	$
Conduct an assessment of wetland resouces for the Deerfield River Watershed. Identify and map wetlands, level of protection and options for protection, if needed. Prioritize wetlands using metrics of flood resiliency, watershed health (water quality), and climate change resiliency.	★											U Mass, FRCOG, Local Conservation Commissions, volunteers	L	Report, maps, prioritized list		U Mass	$$
Cold Water Fisheries and Upland Watershed Tributary Areas																	
Expand upon the upland watershed assessments completed as part of this project. Complete additional desktop analysis and field inventories for the remaining HUC 12 watersheds. Identify priority projects using the metrics of flood resiliency, watershed health (water quality), and climate change resiliency.	★★★											FRCOG	M	Report, maps, recommendations		319	$$$
Conduct training sessions and outreach to local Conservation Commissions on their authority under the Wetlands Protection Act and Rivers Protection Act to protect riparian areas and Cold Water Fisheries. Use the 10 Ways Conservation Commissions and Others Can Help Protect Coldwater Streams and Their Inhabitants (fact sheet prepared by MassDFG.	★★											FRCOG, Conservation Commissions, FCD	M	Workshops, outreach materials	# of meetings and workshops	DLTA, 319	$

Table 17: Deerfield River Watershed Action Plan (cont.)

WATER QUALITY	Implementation Priority: Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Stormwater Management and Site Design																	
Conduct comprehensive Green Infrastructure Stormwater Management Assessments in the HUC 12 subwatershed to identify green infrastructure retrofit opportunities that improve or protect water quality and increase flood resiliency. The Scope of Work could include: 1) identify and field check feasible areas for green infrastructure retrofits; and 2) develop conceptual designs and cost estimates for high priority retrofit sites.					★★	★★			★★	★★★	★★	FRCOG, Towns	M	Reports, maps, conceptual designs, cost estimates	# of assessments completed # of Green Infrastructure projects installed.	604b, Mass Environmental Trust	$$$$
Prepare a series of fact sheets and/or handbook for watershed towns that describes a policy and process for incorporating green infrastructure into municipal drainage, infrastructure and transportation projects.	★★											FRCOG, Towns	S	Written materials	Number of towns receiving information; number of outreach meetings	319	$
Develop a stormwater management guidance document for incorporating GI into new development and redevelopment projects for the Deerfield River Watershed towns that can be used by Planning Boards and project proponents.					★★	★★			★★	★★★	★★	FRCOG, Towns	S	Written materials	Number of towns receiving information; number of outreach meetings	319	$
Update existing Open Space/Cluster provisions with language from the Mass Smart Growth/Smart Energy Toolkit models for Open Space Design/Natural Resource Protection Zoning. For towns without existing open space/cluster zoning, work to adapt model bylaw. (Also applicable to the Landscape Scale Assessment, Conservation and Protection under Land Use Regulations and Local Planning Initiatives.)	★★★											FRCOG, Towns	S	Written materials	Number of towns receiving information; number of towns adopting updated/new zoning bylaws	319	$
Creat a model stormwater bylaw taking a Low Impact Development approach for the watershed towns. Include provisions for rural town centers and more urbanized areas like Shelburne Falls and Greenfield. (Also applicable to the Landscape Scale Assessment, Conservation and Protection under Land Use Regulations and Local Planning Initiatives.)	★★★											FRCOG, Towns	S	Model bylaws	Number of towns that adopt the bylaw	DLTA, Towns	$
Create a guide to assist towns with updating subdivision regulations; include model language and road design options; work with interested towns to update regulations. (Also applicable to the Landscape Scale Assessment, Conservation and Protection under Land Use Regulations and Local Planning Initiatives.)	★★★											FRCOG, Towns	S	Model bylaws	Number of towns that adopt the bylaw	DLTA, Towns	$

Table 17: Deerfield River Watershed Action Plan (cont.)

WATER QUALITY	Implementation Priority: Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Update existing municipal land use regulations to encourage or require the use of GI for new development and redevelopment projects. Require the use of recent rainfall/climate data to ensure more resilient GI stormwater drainage systems.					★★	★★			★★	★★★	★★	FRCOG, Towns	S	Written materials	Number of towns receiving information; number of towns adopting updated/new zoning bylaws	319	$
Upgrade and improve existing river access points and parking areas. Use GI stormwater management techniques and stabilize eroding banks during access projects. These are recreational areas owned by MassDOT or Great River Hydro (Deerfield Hydro Projects).					★★★		★★★					MassDOT, Great River Hydro	M	Designs, constructed improvements	Number of GI features installed/eroded areas stabilized	MassDOT, Great River Hydro	$$
Water quality monitoring																	
Inventory and assess unnamed and other headwater streams not currently in MassDEP's database. Designate additional Coldwater Fish Resources based on water quality data.		★★★	★★★	★★	★★	★★★	★★	★	★★	★	★	DRWA/CRC, MassDFG, MassDEP	L	Water Quality data	# of streams assessed	604b, Mass Environmental Trust	$$$
Secure funding to continue monitoring the acid mine drainage from Davis Brook mine; monitor and assess effectiveness of natural bioremediation processes.							★★★					U Mass	O	water quality data	research use of data	National Science Foundation; other grants available to U Mass researchers	$$$$
Consider strategic monitoring (temperature, e.coli) of some HUC 12 subwatersheds/sites to bracket sources and monitor water quality. Involve trained volunteers.		★★						★★	★★	★★	★★	DRWA/CRC	O	Water quality data	Number of sampling locations; number of volunteers; data	Foundations; volunteers; donors	$$
Assess the current water quality of the 15 lakes and ponds in the Deerfield River watershed that are identified as Category 3 waters in the Massachusetts Integrated List of Waters. Category 3 waters are waterbodies for which the available water quality information is insufficient for MassDEP to assess designated uses. Prioritize those lakes and ponds that provide public water supply or have active recreational uses and potential for water quality impacts based on existing land use data and any other available information. Conduct in-lake ambient water quality monitoring and aquatic vegetation surveys of the priority lakes and ponds. Involve trained volunteers.		★★	★★			★★	★★		★★	★★	★★	DRWA, MassDEP, MADCR	O	Water quality data	Number of sampling locations; number of volunteers; data	604b; UMass research	$$

Table 17: Deerfield River Watershed Action Plan (cont.)

	Implementation Priority																
WATER QUALITY	Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Provide financial and technical support to existing volunteer monitoring programs, including the ones organized by the Deerfield River Watershed Association and the Connecticut River Conservancy.	★★											DRWA/CRC	O	Water quality data	Number of sampling locations; number of volunteers; data	Foundations; volunteers; donors	$$
Biological Monitoring																	
Conduct baseline habitat assessments as part of the fluvial geomorphic assessments recommended for the remaining HUC 12 subwatersheds. Use the methodology developed and piloted in the South River and East Branch North River subwatersheds (604b-funded projects). In tandem, develop a rotating schedule for reassessing and updating the data sets for the HUC 12 subwatersheds. Integrate with other data collection efforts (fish) undertaken by MassDFG.	★★											FRCOG, DRWA, CRC	L	Biological and habitat data	Number of HUC 12 subwatersheds assessed	604b	$$$
Landfills																	
Review the recommendations from the 2003 Fuss & O'Neill Landfill Assessment Project conducted for the Deerfield River Watershed and funded by MassDEP. Determine whether additional field assessments/updates of conditions noted in the 2003 is warranted. Secure funding and implement priority recommendations and projects.	★★											MassDEP, Towns, FRCOG	O	Removal of refuse from resource areas; monitoring data	Number of recommendations implemented	MassDEP	$$$$
Septic Systems																	
Establish a regional or multi-town Community Septic Management Program which could enable towns to implement a Community Inspection Plan or a Local Septic Management Plan. http://www.mass.gov/eea/agencies/massdep/water/wastewater/the-community-septic-management-program.html	★★											Towns, FRCOG	M	Septic System Inspection and Management Program	# of failing septic systems identified # of failing systems repaired	MassDEP, Towns, DLTA	$$$
Landslides																	
Assess, prioritize for containment/stabilization the landslides identified in the Dethier, et.al report to reduce erosion and sedimentation from these active landslides.	★★											U Mass	L	Reports, maps, conceptual designs, cost estimates	# of assessments completed	Foundation grants; 604b, Mass Environmental Trust	$$$$

Table 17: Deerfield River Watershed Action Plan (cont.)

WATER QUALITY	Implementation Priority: Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Road Runoff and Sedimentation																	
Develop a "Roads & Rivers" Training Program based on the VT Department of Transportation's successful program. Considering the River in the Design, Construction and Maintenance of Transportation Infrastructure in Vermont. http://dec.vermont.gov/sites/dec/files/wsm/rivers/docs/rv_Tier2_Overview.pdf	★★★											UMass, Byastate Roads, Creating Resilient Communities	S	Training program and outreach materials	# of participants in the training program	MassDOT, FCD, Umass	$$
Review the priority projects recommended in the 2008 Rural Roads Assessment Project for the Chickley River Watershed and update with information from the MassDOT culvert study. Implement water quality Best Management Practices (BMPs).		★★★										Town of Hawley	M	Water Quality & Stormwater management BMPs	# of completed projects	Town Ch. 90 funding; DER culvert program	$$$
Conduct assessments of conditions of the dirt roads in the HUC 12 subwatersheds. Identify priority sites for the implementation of low-tech BMPs, like swales, water bars, and bioretention. Investigate the use of best practices for maintenance of dirt roads (see the Unpaved Roads BMP Manual http://www.mass.gov/eea/docs/dep/water/resources/a-thru-m/dirtroad.pdf) and conduct outreach to town DPW staff.	★★★											FRCOG, Towns	L	Reports, maps, conceptual designs, cost estimates	# of assessments completed # of BMP projects identified and conceptual designs & cost estimates	604b, Mass Environmental Trust	$$$
Secure funding to conduct Rural Roads Assessment projects for the towns in the HUC 12 subwatersheds. Use Chickely River project as a template. Could also combine this task, which is an assessment of paved roads, with an assessment of dirt roads (described above).			★★	★★★	★★	★★	★★	★★★	★★★	★	★	FRCOG, Towns	L	Reports, maps, conceptual designs, cost estimates	completed # of BMP projects identified and conceptual designs & cost estimates	604b, Mass Environmental Trust	$$$$
Underground & Aboveground Storage Tanks																	
Inventory all registered and unregistered USTs and ASTs, reconcile inventory with tank registration records, and plot locations on watershed resource maps to identify vulnerabilities and priorities for removal or other remedial action.	★											Towns, FRCOG	L	Inventory of USTs and AGTs, maps, recommendations	# of towns participating	DLTA, Towns	$$
Develop model Underground Storage Tank bylaw and Board of Health regulations for watershed towns to address tanks currently exempt from the state laws (527 CMR 9.00). Work with towns to adopt bylaws.	★											Towns, FRCOG	L	Model bylaws	# of towns participating	DLTA, Towns	$

Table 17: Deerfield River Watershed Action Plan (cont.)

	Implementation Priority																
WATER QUALITY	Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Illegal Dumping and Junkyards																	
Assist local Boards of Health with completing an inventory of illegal dumping areas, discarded railroad tie sites, and junkyards in each of the project study area towns. Evaluate options for cleaning up these sites.	★											Towns, FRCOG	L	Inventory of sites	# of towns participating	DLTA, Towns	$
Hazardous Materials and Hazardous Waste																	
Compile a complete, up-to-date inventory of businesses that use and store hazardous materials and/or generate hazardous waste. This list should also include a description of any measures currently in place for preventing contamination of stormwater runoff and accidental spills and leaks.					★★	★★			★★	★★	★★		S	Inventory of businesses, maps, recommendations	# of towns participating; # of businesses participating	DLTA, Towns	$
Develop a model local Board of Health regulation and a Hazardous Materials bylaw to give watershed towns a mechanism for more local control and oversight of businesses that use and store hazardous materials.	★★												S	Model regulation and bylaw	# of towns participating; # of businesses participating	DLTA, Towns	$$
Public Education and Outreach																	
Conduct a series of workshops for local Planning Boards and Conservation Commissions to introduce them to and train them to use the on-line MA Clean Water Toolkit. The Toolkit has specific sections related to: Agriculture, Boating and Marinas, Erosion and Sediment Control, Forestry, Laws and Regulations, Onsite Wastewater, Natural Resource Extraction, Roads, Stream Corridor and Shoreline Protection and Urban Stormwater Runoff.	★★★											FRCOG, Towns	M	Training program and outreach materials	# of town board members participating	DLTA, Towns	$$
Develop outreach materials and organize workshops for 1) local officials and 2) watershed residents about the land use regulation/management strategies identified in the climate change survey that respondents indicated "not sure/need more information".	★★★											FRCOG	O	outreach materials, workshops	# of workshops; # workshop attendees	604b, 319, Mass Environmental Trust	$$
Develop a format, logo and consistent messaging strategy for outreach materials and watershed stewardship signage. Install stewardship signage. Organize groups of students and volunteers to identify and paint “drains to river” stencils around storm drains in towns, village centers and residential neighborhoods.	★★★											FRCOG, CRC, DRWA, towns, schools	O	outreach materials, signs, storm drain stencils	# of signs installed, # of storm drains stenciled	604b, 319, Mass Environmental Trust	$$

Table 17: Deerfield River Watershed Action Plan (cont.)

	Implementation Priority																
WATER QUALITY	Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Agricultural Runoff																	
Reduce water pollution from farming, especially through incentives and increased technical assistance including: 1. Expanding research to identify and fill gaps in the literature about the level of nonpoint source water pollution that agricultural activities can generate, and 2. Providing technical and financial support to farmers for irrigation and waste water testing, to assist in compliance with the U.S. Food and Drug Administration's Food Safety Modernization Act regulations and USDA's Good Agricultural Practice certification.	★★★											NRCS, UMass Extension	M	Updated or new fact sheets and infographics	# of farmers utilizing technical assistance	US FDA, NRCS, private foundations	$$$$

Table 17: Deerfield River Watershed Action Plan (cont.)

IMPLEMENTATION PRIORITY

RIVER CORRIDORS and FLOODPLAINS	Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Assess and Map Resource Areas																	
Incorporate TNC Active River Area mapping for the Deerfield River Watershed into town Open Space & Recreation Plans, and Multi-Hazard Mitigation Plans as a baseline for river corridor mapping.	★★★											FRCOG	M	Updated OSRPs and hazard mitigation plans	# of plans that incorporate ARA	FEMA/MEMA PDM grants, DLTA	$$
Develop cost-effective, science-based (fluvial geomorphology) river corridor mapping protocol for use in the Deerfield River Watershed.	★★★											FRCOG	S	Mapping protocol		319	$$
Map HUC 12 river corridors using protocol developed above. Identify priority restoration and conservation/protection projects in the mapped river corridors.		★★★	★★	★★★	★	★	★	★★★	★★★	★★		FRCOG	L	Mapped river corridors; priority projects; corridor management plans	# of HUC 12 river corridors mapped	319, FEMA/MEMA PDM grants, DLTA	$$$$
Conduct fluvial geomorphic assessments of the remaining stream segments in the watershed using the 604b-funded protocol developed by FRCOG.		★★★	★★	★★★	★	★	★			★★		FRCOG	L	Fluvial geomorphic & habitat assessments	# of stream segments assessed	604b	$$$$
Public Outreach and Education																	
Conduct outreach to watershed towns on river corridor management and protection options (river corridor easements; overlay districts; riparian buffers, etc.). Discuss using Active River Area maps with Conservation Commissions, Planning Boards until more detailed river corridor mapping can be completed.	★★★											FRCOG	O	Outreach materials	# of meetings; implementation of recommendations	319, FEMA/MEMA PDM grants, DLTA	$$
Protect and Restore Riparian Buffers																	
Conduct an assessment of riparian buffers at the HUC 12 scale. Identify priority riparian buffer restoration projects using the metrics of flood resiliency, watershed health (water quality), and climate change resiliency.		★★★	★	★★★	★★	★★	★	★★★	★★★	★★	★★	FRCOG, Conservation Commissions, DRWA, volunteers, landowners	M	Riparian buffer report, mapping, prioritized site list	# landowners participating in assessment	604b	$$
Prepare a brief riparian buffer fact sheet that includes information on BMPS and sources of funding. Distribute to riparian landowners.	★★★											FRCOG, Conservation Commissions, FLT	O	Outreach materials	# of landowners that receive information	DLTA, FLT	$

Table 17: Deerfield River Watershed Action Plan (cont.)

RIVER CORRIDORS and FLOODPLAINS	IMPLEMENTATION PRIORITY: Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
Develop and Implement River Corridor and Floodplain Protection Projects & Management Tools																	
Develop River Corridor Management Plans for HUC 12 river corridors mapped using new geomorphic-based protocols (see above recommendation) or TNC Active River Area.		★★★	★★	★★★	★	★	★	★★★	★★★	★★		FRCOG	L	corridor management plans	# of HUC 12 river corridor management plans	319, FEMA/MEMA PDM grants, DLTA	$$$$
Secure legal and Mass Agency review (EEA, DEP) to finalize the draft Model River Corridor Protection Overlay District developed by FRCOG.	★★★											FRCOG	S	final model overlay district bylaw		319	$
Develop River Corridor Easement for use in Massachusetts to protect healthy rivers and restore rivers with impaired geomorphic function.	★★★											FRCOG, FLT	S	final model river corridor easement		319	$$
Provide technical assistance to the Planning Boards in the Towns of Ashfield & Conway to adopt a River Corridor Protection Overlay District and the recently mapped River Corridor (based on VT ANR protocols).											★★★	FRCOG, towns	S	Bylaw for each town	# of towns that adopt the bylaw (2)	319	$$
Provide technical assistance to watershed towns to adopt a river corridor protection overlay district using site-specific corridor mapping (preferred - see recommendation, above) or Active River Area.		★★★	★★	★★★	★	★	★	★★★	★★★	★★		FRCOG, towns	L	Bylaw for each town	# of towns that participate; # of towns that adopt the bylaw	319, DLTA, Mass Environmental Trust	$$$

RIVER CORRIDORS and FLOODPLAINS	Watershed Scale	Chickley River	Cold River	Clesson Brook	Deerfield River Cold to North River	Deerfield mainstem North River to mouth	Deerfield mainstem Sherman Dam to Cold	East Branch North River	North River mainstem	Green River Thorne Brook to mouth	South River	Potential Lead Entity(s)	Proposed Timeline	Products	Evaluation Criterion	Funding Sources	Projected Costs
	IMPLEMENTATION PRIORITY																
Secure funding for land purchases or river corridor protection easements in the mapped river corridors and work with willing landowners to execute easements.	★★★											FLT, FRCOG	O		amount of funding secured; # of willing landowners	USDA, APR, Foundations, US Forest Service	$$$$
Provide technical assistance to watershed towns to amend their local floodplain regulations/bylaws to meet or exceed current National Flood Insurance Program (NFIP) requirements. FRCOG developed a model floodplain bylaw that is now several years old. This bylaw should be reviewed against current NFIP requirements and updated.	★★★											FRCOG, towns	L	Updated bylaw/regulations for each town.	# of towns that participate; # of towns that adopt the bylaw	DLTA, Mass Environmental Trust	$$$
Secure funding for and implement stream and floodplain restoration projects identified in the 604b-funded projects for the South and North River HUC 12 watersheds.								★★★			★★★	Connecticut River Conservancy, FRCOG, Trout Unlimited	O	Engineering design, project implementation	# of projects built	Long Island Regional Conservation Partnership Program, 319, Mass Environmental Trust, FLT, foundations	$$$$

Plan Implementation and Stakeholder Engagement

Plan Implementation Coordination and Support

There are several existing stakeholder groups that FRCOG will work with to implement the recommendations of the Deerfield River Watershed-Based Plan. FRCOG is either a member of or frequently collaborates with these groups, including the FRCOG's Franklin Regional Planning Board, Creating Resilient Communities, Franklin Land Trust, the Fluvial Geomorphology Task Force convened by UMass, Connecticut River Conservancy, and the Deerfield River Watershed Association.

The FRCOG will attend regular meetings of these groups to solicit feedback and report on the following:

- Development of annual work plans (i.e., specific "to-do" lists), including ways to leverage funding for plan projects with other work
- Report on accomplishments, roadblocks, lessons learned, and solicit feedback on plan updates and next steps.
- Periodically review and update the plan's action items in the plan (at least every 5 years).

FRCOG will collaborate with stakeholders to celebrate accomplishments, recognize participants, review lessons learned, and solicit feedback on plan updates and next steps at the scheduled annual meetings of the stakeholder groups.

FRCOG will publicize the plan and its recommendations via our website, FaceBook page and Twitter. We will provide press releases to the local newspaper and stakeholder groups. As part of our ongoing work with our towns, we will encourage and assist Deerfield River Watershed towns to incorporate recommendations and action items in local planning documents such as Open Space & Recreation Plans and Multi-Hazard Mitigation Plans. We will also encourage watershed towns to endorse the plan and post a link to the plan on the towns' websites.

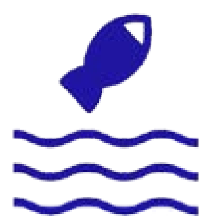
Public Education and Outreach

Raising awareness about the interconnectedness of healthy watershed resources (green infrastructure), climate change resiliency, quality of life, and local economies is critical to the success of many of the recommendations and projects in this plan. Rivers, forests, wildlife and the pollution or impairment of these resources is typically not constrained by town boundaries. Watershed residents, including those that work the forests and agricultural lands, and those who operate or own businesses in the watershed towns, have a critically important role to play in protecting the habitat, water quality and climate change resiliency of the watershed. The efforts of residents and watershed stakeholders can have a very positive impact at the local (town) level, the subwatershed level (among several towns) and across the entire Deerfield River Watershed. Helping stakeholders learn more about how their individual and collective actions can improve and protect watershed health is an important aspect of this plan. Providing outreach and education also helps bolster support for implementing plan recommendations. Specific education/outreach tasks are included in Table 17.

Watershed Education and Stewardship Signage

Every day, watershed residents engage in activities that can negatively impact water quality and the natural environment. Often, residents do not understand the connection between their activity and the environmental impact. Some examples of this behavior include the improper disposal of trash, pet waste, yard waste, and hazardous wastes; excessive use of fertilizers and pesticides on lawns and gardens; dumping oils and other materials in storm drains; and improper management of riparian areas. FRCOG developed a series of fact sheets related to many of these topics as part of Project 14-04/319 - Using Low Impact Development Techniques to Manage Stormwater Runoff in Greenfield. These materials can be adapted for the Deerfield River Watershed towns.

Another way to engage watershed residents and garner support for plan implementation is through signs and displays that have a uniform look, logo and a consistency in the messaging. Signage can help educate the public on the importance of preserving the watershed and its natural resources and how some common practices have an adverse and cumulative impact on these resources. Educational signage can take many forms and be placed in many locations such as kiosks in public areas and at public events, storm drain markers or stencils, anti-dumping signs, proper pet waste management signs, and roadside/stream side signage (examples include “adopt a stream/roadway” programs). There is some storm drain stenciling in the Town of Greenfield. Stormwater and pollution prevention signage is generally lacking in most other towns and areas of the watershed. The watershed towns, together with other local stakeholders and volunteers, could consider developing and installing stewardship signage and organizing groups of students and volunteers to identify and paint “drains to river” stencils around storm drains in towns, village centers and residential neighborhoods.



Conceptual Designs and Cost Estimates for Healthy Watershed Projects

Note that cost estimates for land conservation are complex, and those included in this document are provided for guidance and discussion purposes, along with the conceptual designs. The cost estimates should be updated with site-specific information as part of a final design and permitting process for the project. Continued outreach, local support and landowner buy-in are crucial to the actualization and success of these proposed projects. For background informaiton on these project designs, see the Geomorphic Assessment Technical memorandum in Appendix B: Watershed Assessments.

The conceptual designs and cost estimates were prepared by Field Geology Services: www.field-geology.com.

Field Geology Services
Fluvial Geomorphology

Lower Bear River Conservation Area

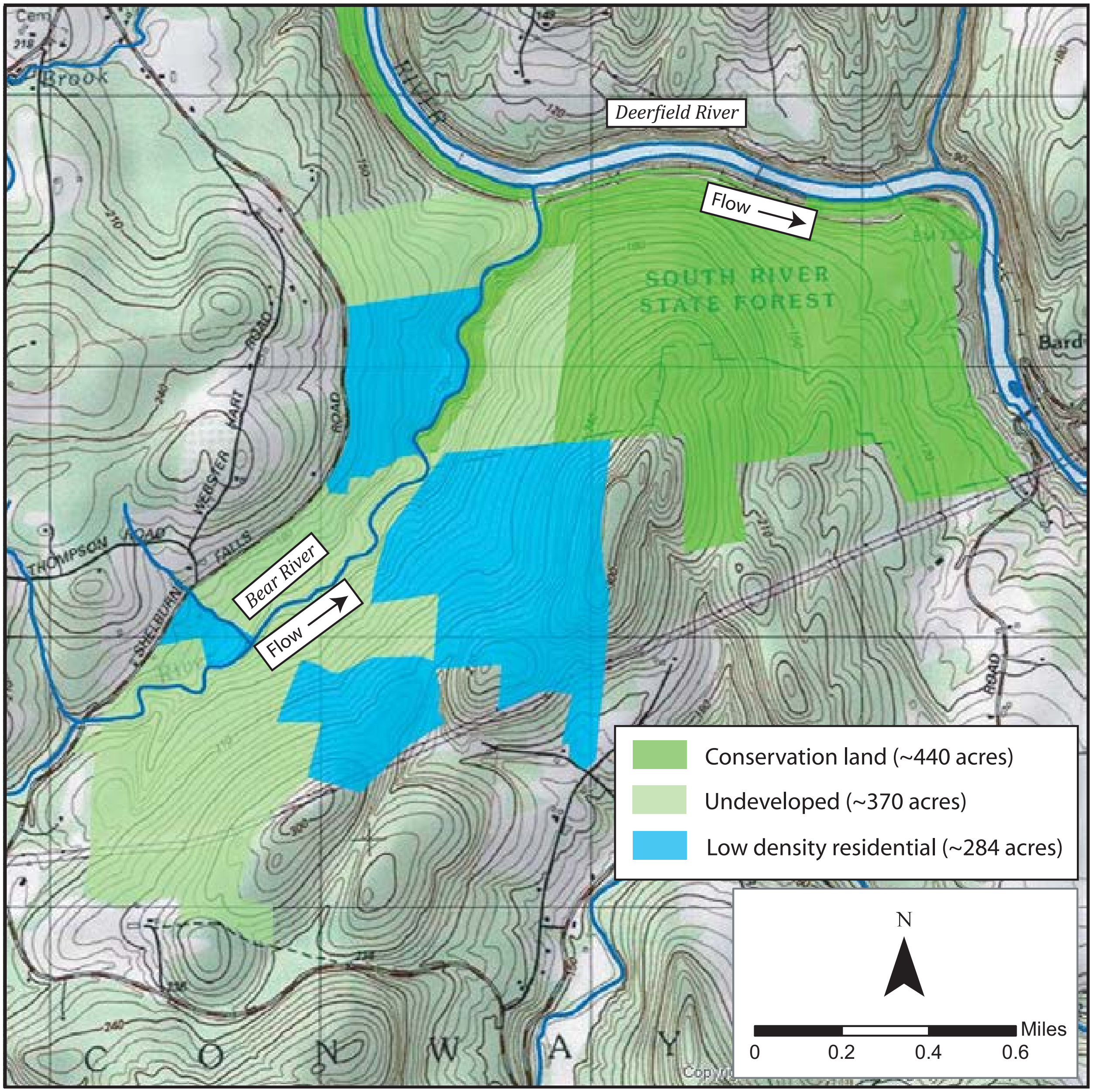
Project Benefits: Sediment Storage, Flood Attenuation, and Conservation of Green Infrastructure.

Project Description: Conservation of reference reach area on lower Bear River.

The permanent protection of 500-plus contiguous acres adjacent to the South River State Forest in Conway. These lands, which include both banks of the lower two miles of the Bear River down to its confluence with the Deerfield River, contain a mix of pristine forested habitats including previously identified rare and endangered plant species. The steep, confined stream channel ranges from cobble riffle-pool, to boulder step-pool and bedrock cascade morphologies and represents a relatively natural reference condition with little evidence of past human manipulation. As envisioned this project should rank highly for a competitive Land Partnership Grant. Land acquisition costs for this project, included in the following pages, are based on the assessed land values from the Town's tax assessment. From these values, the median value per acre for the undeveloped parcels was calculated ($1500 per acre). An additional $1000 per acre was added for residential parcels (based on a breakdown of increases in value in the data set).

Estimate of probable costs:

Treatment/Item	Unit	Quantity	Unit Cost ($)	Task Cost ($)
Land acquisition - undeveloped land	acre	370	$1,500.00	$555,000.00
Land acquisition - residential land	acre	284	$2,500.00	$710,000.00
Parking area construction includes grading, gravel lot, interpretive signs, etc	unit	1	$35,000.00	$35,000.00
Clear and establish walking trails	mile	2	$15,000.00	$30,000.00
Site upkeep and trail maintenance	year	5	$5,000.00	$25,000.00
TREATMENT SUBTOTAL				$1,355,000.00
20% Contingency				$271,000.00
Construction subtotal				**$1,626,000.00**
Surveying, permitting and legal costs				$100,000.00
Project total				$1,726,000.00



Lower Bear River Conservation Area - site map.

Lower Bear River Conservation Area. The a) bedrock cascade, b) boulder step-pool, and c) cobble riffle-pool stream morphologies of the lower Bear River represent a relatively natural reference condition with little evidence of past human manipulation.

a)

b)

Lower Bear River Conservation Area. a) Public access to the stream and surrounding land adjacent to South River State Forest is part of the proposed conservation; b) channel-spanning log jam maintaining deep pool and providing cover in this cold water fishery.

Upper Bear River Conservation and Geomorphic Restoration

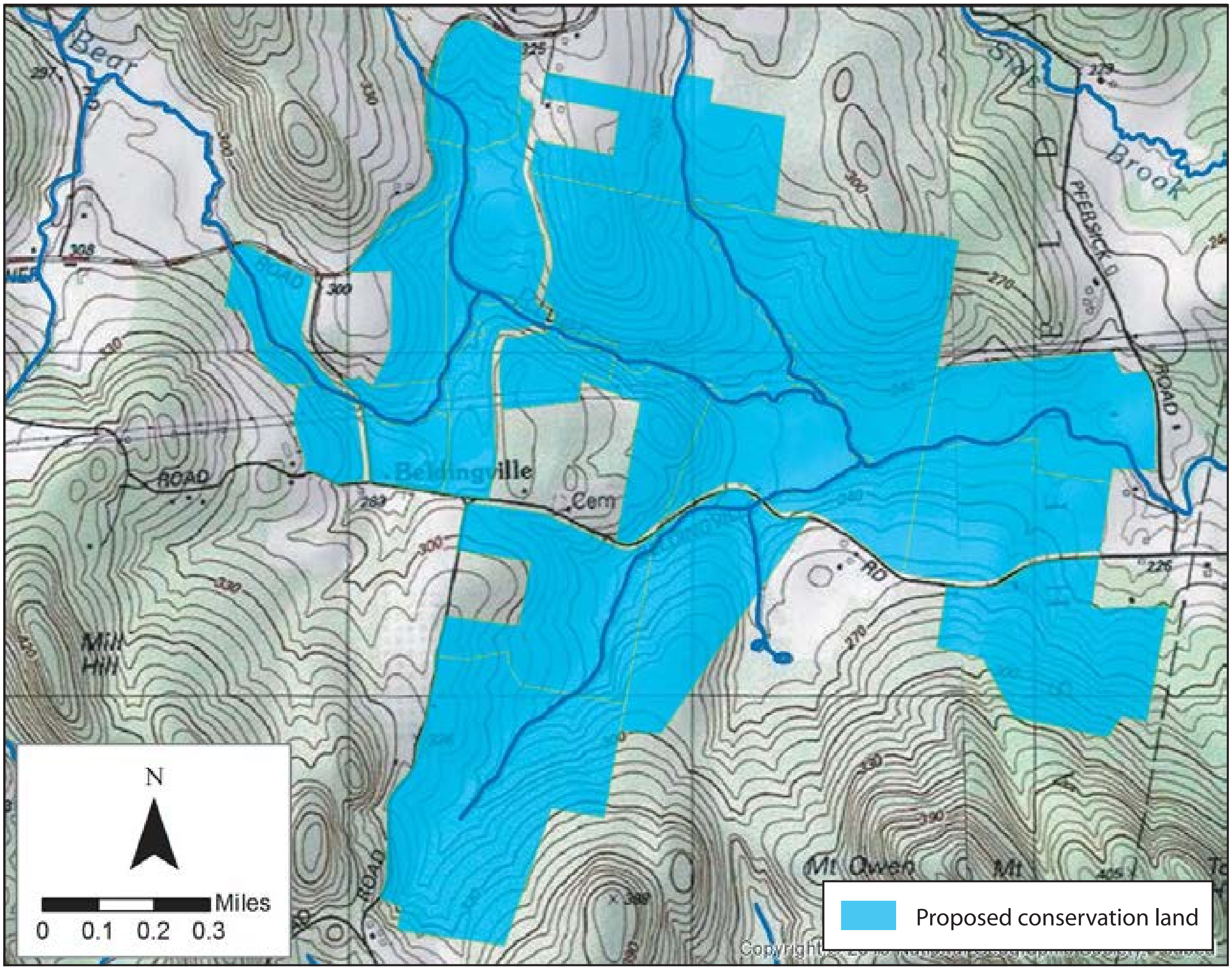
Project Benefits: Sediment Storage, Flood Attenuation, Habitat Enhancement and Conservation of Green Infrastructure.

Project Description: Conservation and geomorphic restoration (wood addition) on upper Bear River.

> Using the Franklin Land Trust's Crowningshield Conservation Area as a model for conservation paired with geomorphically-compatible stream restoration and management, this project seeks to protect a 200-foot wide river corridor through portions of the upper Bear River. As with the Crowningshield project, these predominantly forested parcels contain historically-altered stream channels in the upper portions of the watershed where wood addition projects have been shown to effectively trap sediment, depress flood peaks, increase base flow and enhance habitat. The proposed "chop and drop" treatment, where trees are strategically cut from the riparian zone and directionally-felled into and across the stream channel, has had a great deal of success in forested reaches throughout New England. The design calls for the addition of a minimum of 200 pieces of large wood per mile through chop and drop, although wood-loading density could be increased if desired. Additionally, marginal log jams and/or instream engineered log structures to be constructed with trees sourced from the river corridor will provide additional sediment storage and habitat benefits. Several of these structures could be built with the intention of recruiting any wood mobilized from the chop and drop reaches upstream. Monitoring, included as part of this project, will consist of tracking and mapping the recruitment and movement of wood through the stream system and measuring its effects on pool depth, channel dimensions, substrate composition, temperature profiles, and invertebrate and fish populations. Water stage and turbidity monitoring, an analogue for suspended sediment load, will attempt to assess the influence of wood addition on suspended sediment load. These studies have the potential to demonstrate the benefits of wood addition projects to trap sediment and enhance habitat.

Estimate of probable costs:

Treatment/Item	Unit	Quantity	Unit Cost ($)	Task Cost ($)
Corridor easement (200 feet wide)	acre	109	$1,500.00	$163,500.00
Chop and drop wood addition (200 pieces per mile)	mile	2	$15,000.00	$30,000.00
Marginal log jam / engineered log structures	EA	8	$2,500.00	$20,000.00
Machinery	day	3	$4,000.00	$12,000.00
Construction Oversight	day	3	$1,680.00	$5,040.00
Pre and Post-implementation monitoring: Monumented surveying and photo logs, fish and invertebrate surveys, water stage, turbidity, pebble counts, temperature profiles, tracking wood mobility	year	5	$7,500.00	$37,500.00
TREATMENT SUBTOTAL				$268,040.00
20% Contingency				$53,608.00
Construction subtotal				**$321,648.00**
Surveying, permitting and legal costs				$70,000.00
Project total				$391,648.00



Upper Bear River conservation and geomorphic restoration - site map.

a)

b)

Upper Bear River conservation and geomorphic restoration. a) Artificially straightened channels in the upper Bear River are appropriate targets for conservation and restoration through wood addition, where b) naturally recruited wood can be seen storing sediment.

a)

b)

Upper Bear River conservation and geomorphic restoration. The proposed design includes a) Chop and drop wood additions (photo from Griffith Brook, Green Mountain National Forest, VT) and b) marginal log jams (photo from Nash Stream, NH).

Conservation of Attenuation Assets and Encroachment Removal

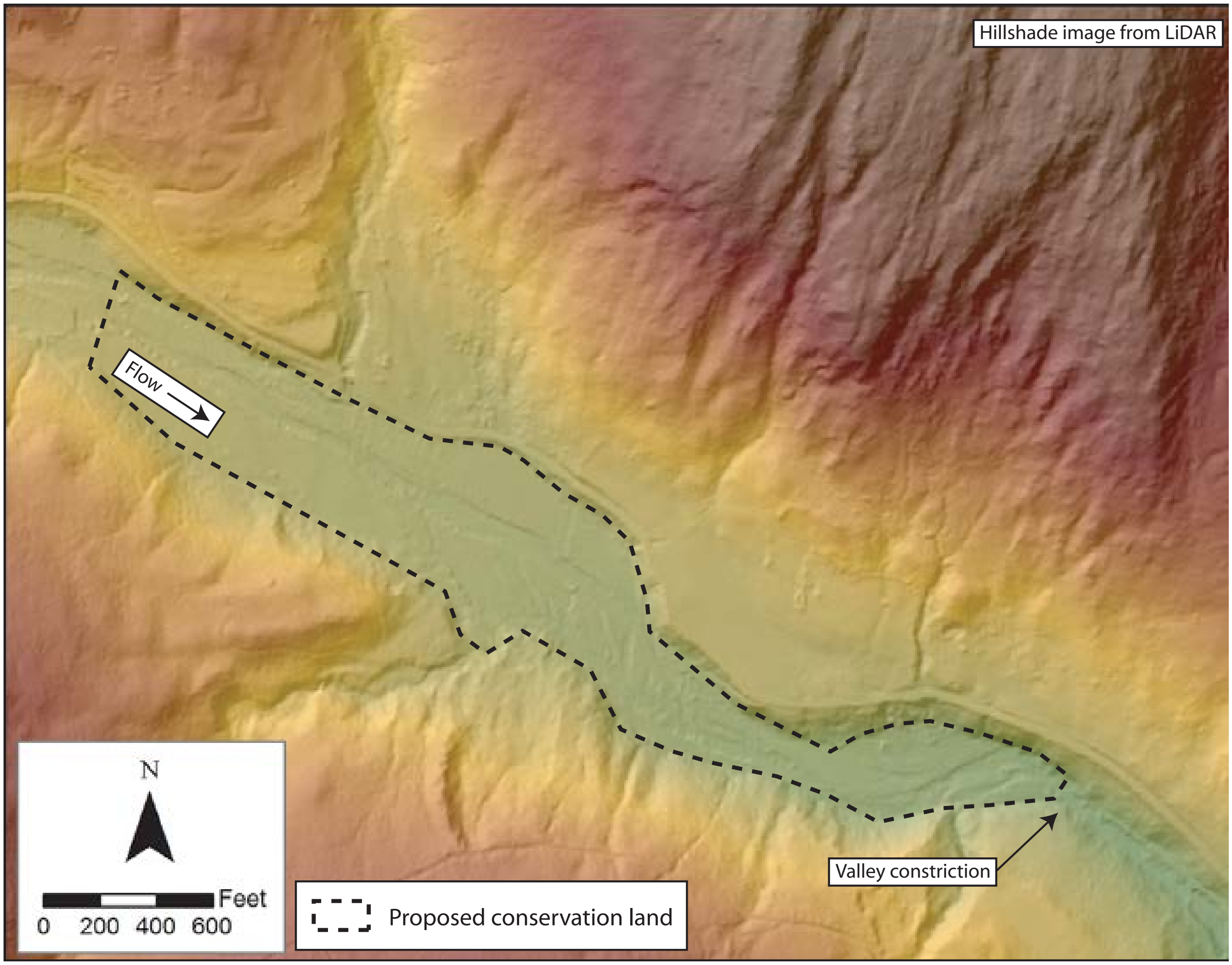
Project Benefits: Sediment Storage, Removal of Floodplain Encroachments (berms), Riparian Corridor Improvements, Floodplain Reconnection and Flood Water Attenuation, Habitat and Water Quality Enhancements, and Protection of Regionally Significant Infrastructure.

Project Description: Identification and enhancement/conservation of attenuation assets through berm removal, floodplain reconnection, corridor easements and corridor management strategies. Potential sites in three HUC 12 subwatersheds: North River Mainstem (West Branch North River); South River; and Green River.

The Geomorphic Assessment identified potential attenuation assets along North River Mainstem (West Branch North River), South River, and in the Green River Watershed. Along the West Branch North River many agricultural parcels sustained flood or erosion damage during Tropical Storm Irene. Several parcels have been identified for conservation in this dynamic alluvial fan setting in order to attenuate sediment load and build climate resiliency. Along South River, low-value parcels without the necessary frontage for development, have been identified along the artificially straightened stream channel. The South River is observed to be increasing its sinuosity by re-forming meanders in these reaches. The proposed conservation would encourage meanders to re-form and increase sediment storage on the floodplain and within the reach. Hinsdale Brook, a tributary to Green River, flows through a steep confined valley dominated by exposures of compacted glacial till and bedrock. The extensive mass failures along Hinsdale Brook contribute a large volume of sediment to the Green River as sediment is transported down the straightened channel. Above the confluence with Green River, continued development threatens to increase fluvial erosion hazards in this flood-prone corridor. Conservation of these parcels through acquisition or easements have significant potential benefits to downstream reaches in the form of sediment and flood water attenuation.

Estimate of probable costs (per site):

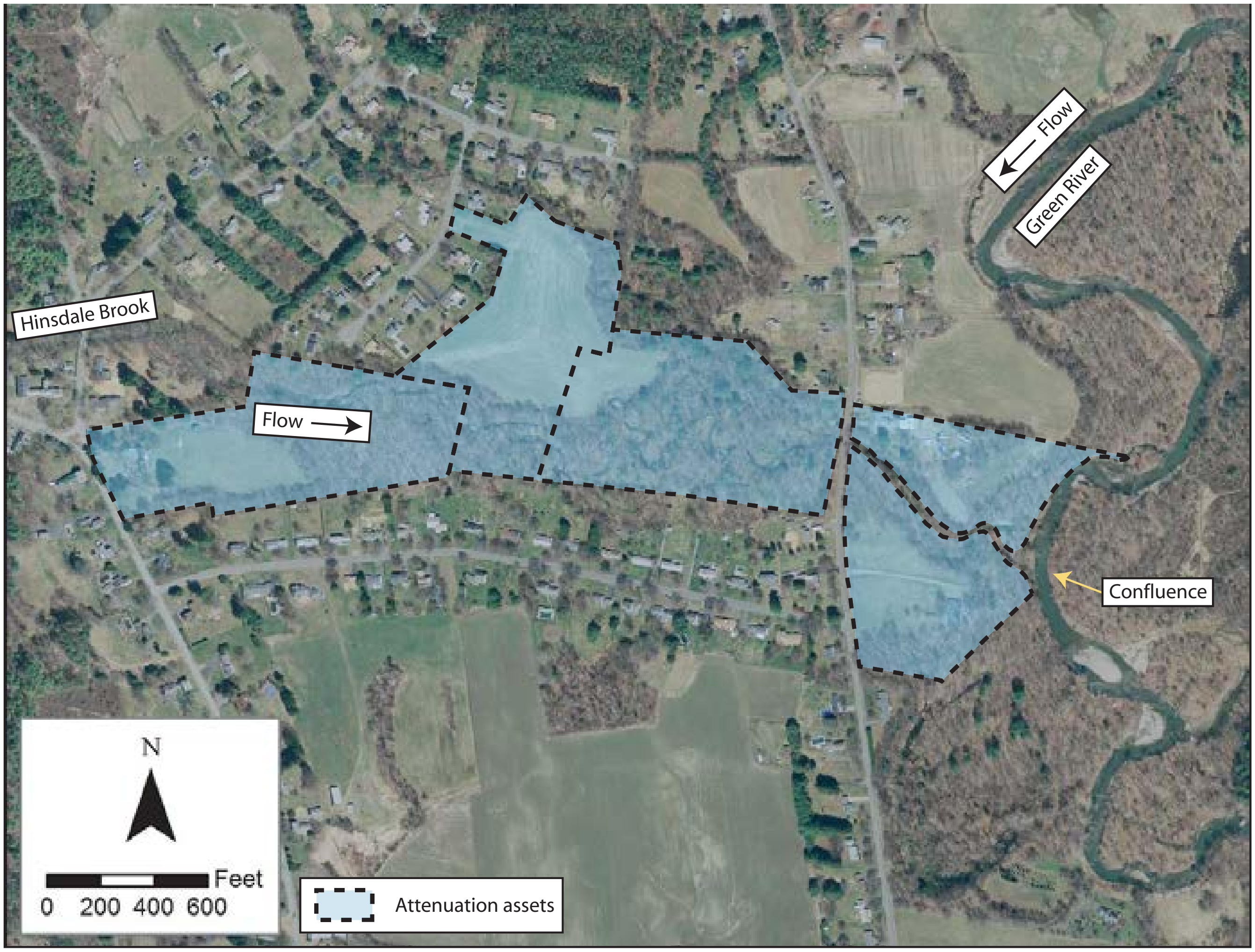
Treatment/Item	Unit	Quantity	Unit Cost ($)	Task Cost ($)
Land acquisition / corridor easement	acre	50	$1,500.00	$75,000.00
Berm removal	unit	1	$20,000.00	$20,000.00
Bank cutting / flow diversion	unit	1	$10,000.00	$10,000.00
Machinery	day	3	$4,000.00	$12,000.00
Construction Oversight	day	3	$1,680.00	$5,040.00
TREATMENT SUBTOTAL				$122,040.00
20% Contingency				$24,408.00
Construction subtotal				**$146,448.00**
Surveying, permitting and legal costs				$70,000.00
Project total				$216,448.00



Conservation of attenuation assets and encroachment removal - West Branch North River site map.

Conservation of attenuation assets and encroachment removal - West Branch North River. 2014 aerial photo showing flood-damaged riparian lands and extent of agricultural use prior to Tropical Storm Irene.

Conservation of attenuation assets and encroachment removal - South River. 2014 aerial photo showing identified attenuation asset along South River in Conway, MA. Significant bank erosion observed on agricultural parcel as meanders reform along straigntened channel.



Conservation of attenuation assets and encroachment removal - Green River Watershed. Identified attenuation assets along lower Hinsdale Brook upstream of Green River confluence in Greenfield, MA. Continued development along straightened channel threatens to increase fluvial erosion hazards in stream corridor.

Conservation of attenuation assets and encroachment removal - Example photos showing a) berm removal on West Branch North River, b) extent of floodplain lowering on South River, c) loading sediment for transport off site (South River), and d) topographic design survey of cross section of lowered floodplain (South River).

Lower Clesson Brook

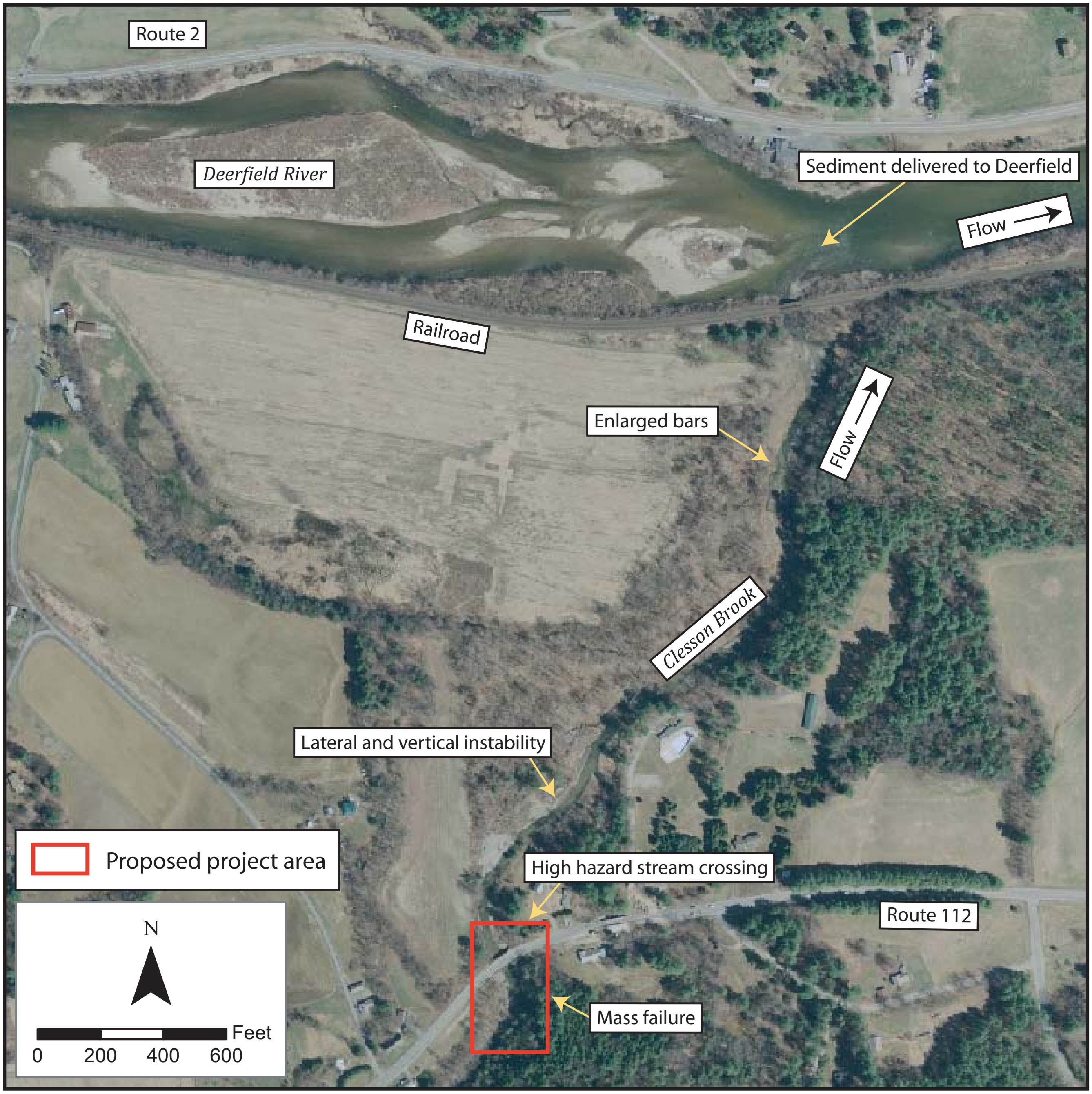
Project Benefits: Sediment Storage, Removal of Floodplain Encroachments (berms), Riparian Corridor Improvements, Floodplain Reconnection and Flood Water Attenuation, Habitat and Water Quality Enhancements, and Protection of Regionally Significant Infrastructure.

Project Description: Stabilization of mass failure on Clesson Brook to protect Rte. 112 bridge and limit sediment delivery to Clesson Brook delta, which has formed in the Deerfield River.

A 38-feet high mass failure (landslide in glacial deposits) immediately upstream of the Route 112 stream crossing threatens the bridge and contributes a significant volume of sediment to Clesson Brook. Sediment from Clesson Brook and other tributaries deposited in the Deerfield River contributes to the formation of large gravel bars and represents increased hazards to bridges, roads and other infrastructure. The proposed project includes the construction of a 150-foot long bankfull bench along the base of the eroding glacial bank. Five boulder deflectors will extend out from the front of the bench, which will also be lined with whole trees and woody material, increasing roughness and providing cover habitat. A similar technique was employed on South River in Conway in 2016. This design is intended to stabilize the glacial bank, which will be sloped, graded and seeded/planted with vegetation, thereby limiting sediment delivery to Clesson Brook and the Deerfield River.

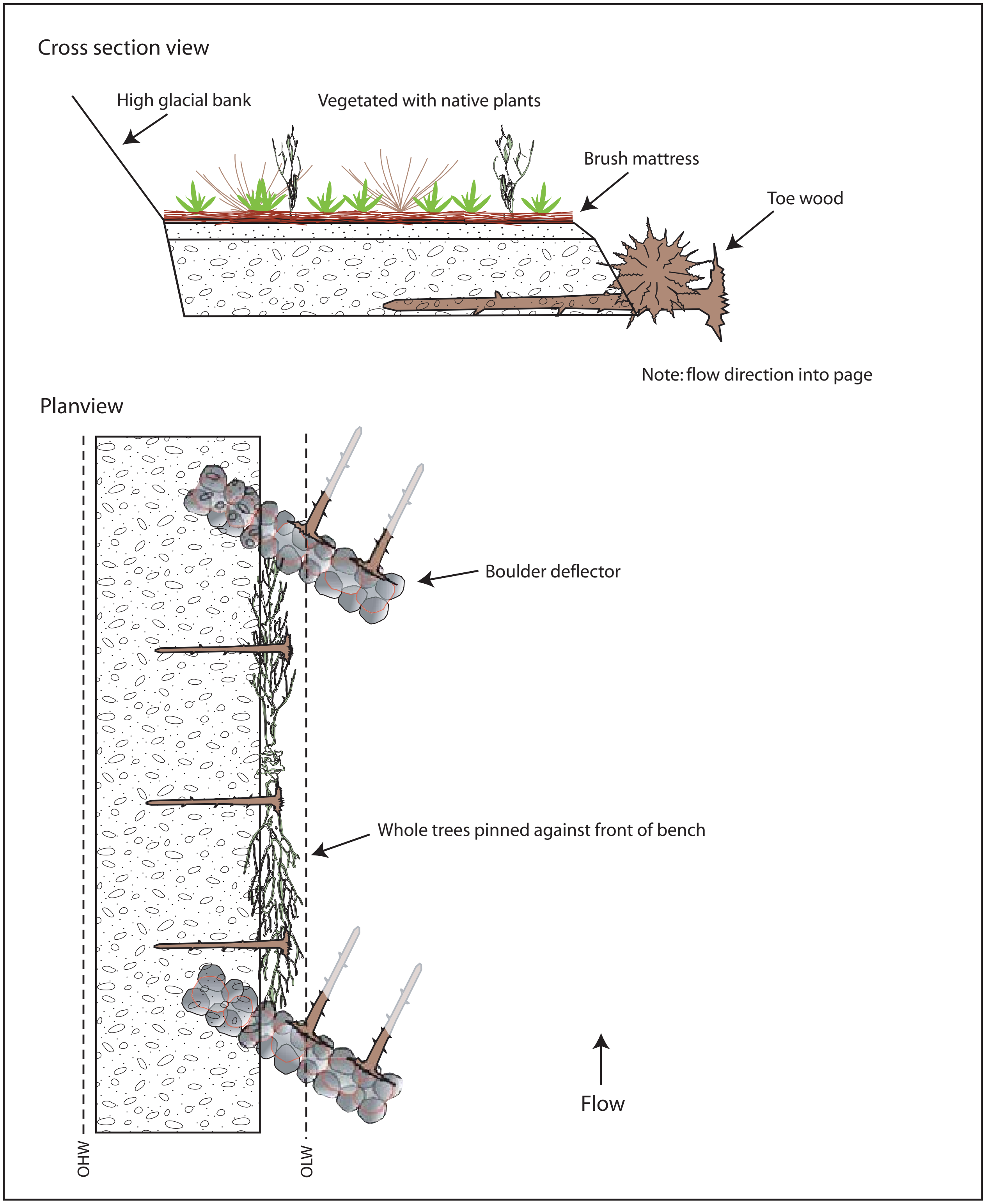
Estimate of probable costs:

Treatment/Item	Unit	Quantity	Unit Cost ($)	Task Cost ($)
Constructed bankfull bench	linear ft	150	$115.00	$17,250.00
Boulder deflectors	EA	5	$6,000.00	$30,000.00
Bank sloping / establish vegetation	unit	1	$12,000.00	$12,000.00
Machinery	day	5	$4,000.00	$20,000.00
Construction oversight	day	5	$1,680.00	$8,400.00
On-going sediment removal to maintain bridge	year	5	$10,000.00	$50,000.00
TREATMENT SUBTOTAL				$137,650.00
20% Contingency				$27,530.00
Construction subtotal				**$165,180.00**
Permitting costs				$70,000.00
Project total				$235,180.00



Lower Clesson Brook - area map.

Lower Clesson Brook - photo of mass failure just upstream of Route 112 crossing on lower Clesson Brook.



Lower Clesson Brook - constructed bankfull bench design typical.

North River Mainstem Sediment Management Project

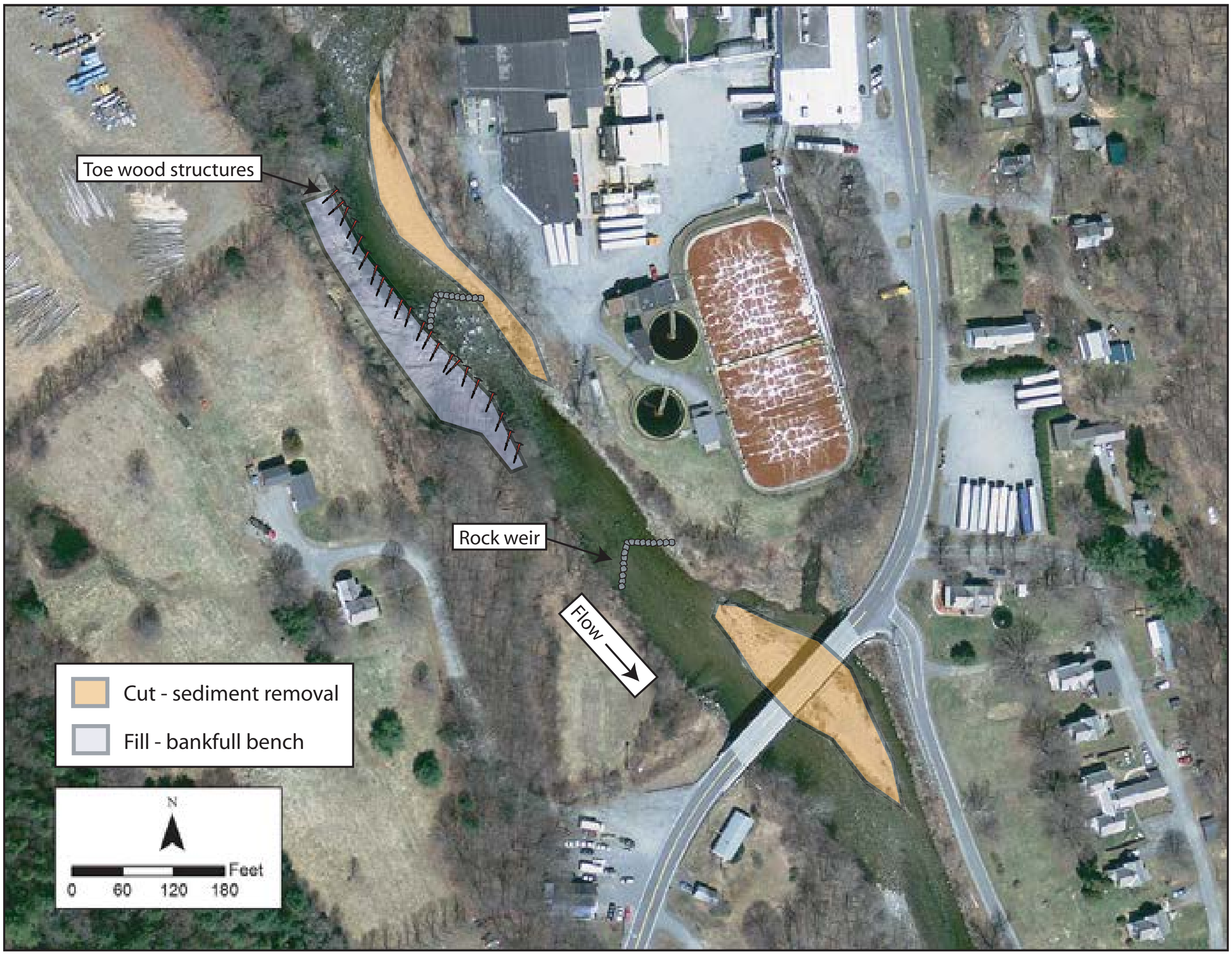
Project Benefits: Sediment Storage, Removal of Floodplain Encroachments (berms), Riparian Corridor Improvements, Floodplain Reconnection and Flood Water Attenuation, Habitat and Water Quality Enhancements, and Protection of Regionally Significant Infrastructure

Project Description: North River Mainstem sediment management project. Includes removal of excess sediment in and around the piers of the new Rte. 112 bridge and using the sediment to stabilize upstream mass failure adjacent to Barnhardt Manufacturing.

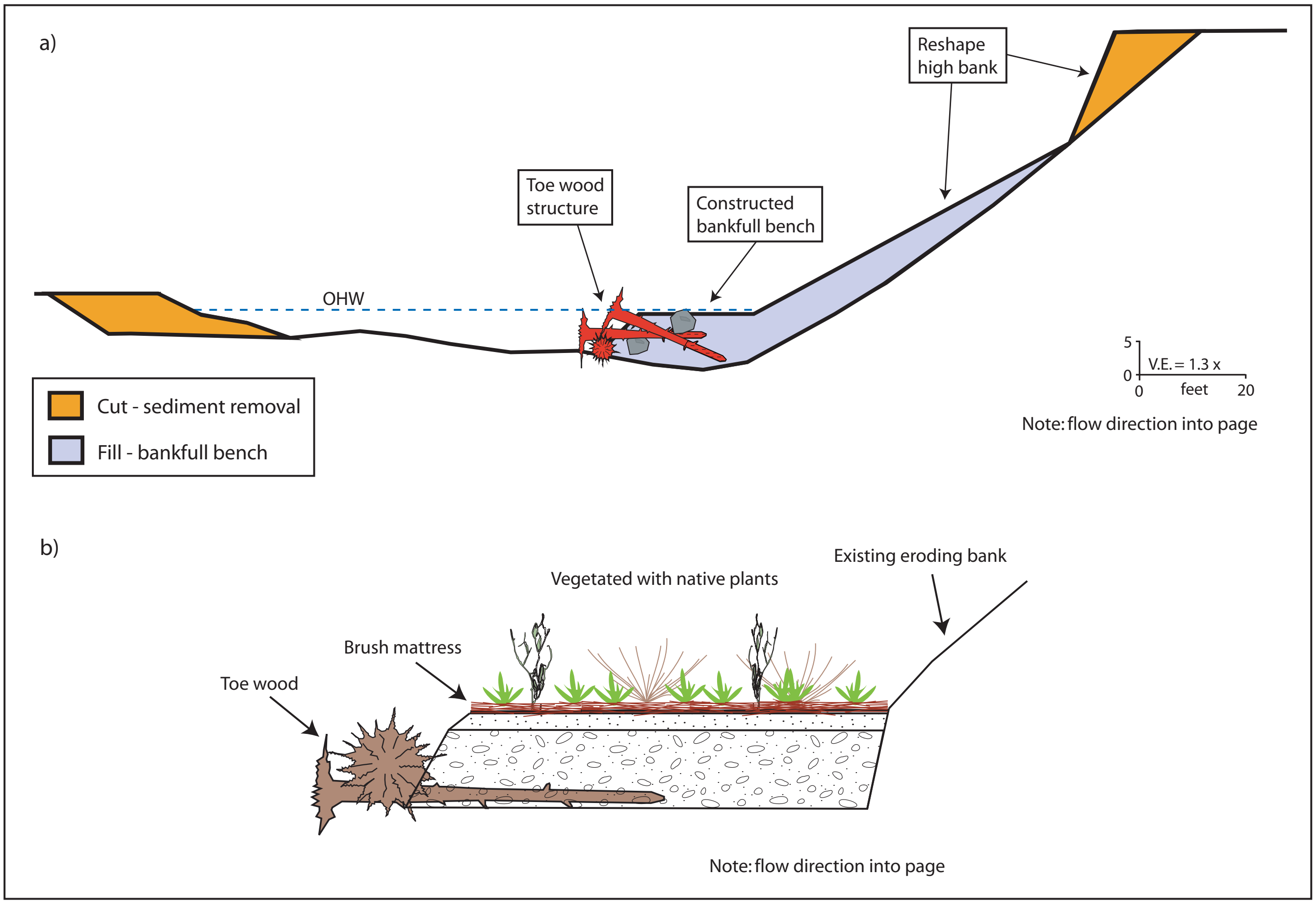
Excess sediment, sourced in part from a 50-foot high mass failure opposite the Barnhardt Manufacturing plant on the North River Mainstem is accumulating around the center pier of the Route 112 bridge. The increased scour at the abutments threatens to undermine this bridge, which Mass DOT replaced in 2005. The proposed design calls for removal of sediment from the area around the bridge's center pier and the establishment of a sediment management plan. As envisioned, this management plan would consist of an open permit or order with State, Federal and local officials allowing for sediment removal in and around the structure, under the supervision of a qualified fluvial geomorphologist, to maintain the safety and integrity of the stream crossing. No sediment would be removed from the stream channel during initial project implementation; rather this sediment would be used in the construction of a bankfull bench along the 450-foot long mass failure upstream. In a design similar to that proposed for the stabilization of the mass failure on lower Clesson Brook, a roughened and vegetated bankfull bench would be used to stabilize the high glacial bank by deflecting flow away from its base. Two channel-spanning porous rock weirs are included in the design to further deflect flow towards the center of the channel. These structures will improve the bridge's capacity by lining up the channel thalweg with the bridge openings and limiting gravel deposition around the center pier.

Estimate of probable costs:

Treatment/Item	Unit	Quantity	Unit Cost ($)	Task Cost ($)
Porous rock weirs	EA	2	$27,500.00	$55,000.00
Constructed bankfull bench	linear ft	450	$115.00	$51,750.00
Toe wood structures	EA	25	$3,750.00	$93,750.00
Machinery	day	10	$4,000.00	$40,000.00
Construction oversight	day	10	$1,680.00	$16,800.00
On-going sediment removal to maintain bridge	year	5	$10,000.00	$50,000.00
TREATMENT SUBTOTAL				$307,300.00
20% Contingency				$61,460.00
Construction subtotal				**$368,760.00**
Permitting costs				$70,000.00
Project total				$438,760.00



North River Mainstem Sediment Management Project - proposed planview.



North River Mainstem Sediment Management Project - constructed bankfull bench typical as a) surveyed channel cross section and b) close-up schematic.

a)

b)

North River Mainstem Sediment Management Project - Photos of a) 50-foot high mass failure opposite the Barnhardt Manufacturing plant on North River Mainstem and b) sediment accumulating around the center pier of the Route 112 bridge.