



A Framework for Resilience

Responding to
Climate Change
in the Deerfield
River Watershed

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River Watershed



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of Governments
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**Franklin Regional Council of Governments
Planning Program Staff**

Peggy Sloan, AICP

Director of Planning and Development

Kimberly Noake MacPhee, P.G., CFM

Land Use and Natural Resources Program Manager

Evan Abramson, M.S.E.D.

Land Use and Natural Resources Planner

Ryan Clary

Senior GIS Specialist

Megan Rhodes, AICP

Senior Transportation/Land Use Planner

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Tracy Rogers, *FRCOG Emergency Preparedness Program Manager*

Raine Brown, *FRCOG Western Region Homeland Security Program Manager*

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Table of Contents



Executive Summary	6
Introduction	9
Part 1: The Changing Climate	15
Changes in Precipitation	16
Rising Temperatures	20
Extreme Weather	22
Part 2: Impacts on Our Communities	25
Natural Resources & Habitat	30
Human Health & Welfare	36
Local Economy & Infrastructure	40
Part 3: Strengths & Vulnerabilities	47
Natural Resources & Habitat	47
Human Health & Welfare	53
Local Economy & Infrastructure	61
Part 4: Building Resilience	73
Natural Resources & Habitat	76
Human Health & Welfare	96
Local Economy & Infrastructure	101
Part 5: Next Steps	117
Appendix	124
References	144

Executive Summary: Power at the Watershed Scale

Towns working towards climate resiliency have a powerful tool available to them — the watershed. A watershed is an area of land where rainfall and snowmelt drain into a stream, lake, or river system. **Watersheds can be delineated at many different scales, ranging from the two-state regional landscape of the Deerfield River Watershed down to smaller drainage areas surrounding a culvert.** As the map on the opposite page shows, there are many subwatersheds within the Deerfield River Watershed that fit together like puzzle pieces to form larger watersheds.

Here in Franklin County, the Deerfield River Watershed includes land in all or part of 14 towns. There are 10 major subwatersheds associated with the large tributary rivers, like the South or Chickley Rivers, and many drainage areas within these subwatersheds. If we zoom in even closer, we would find hundreds of smaller watersheds associated with the small streams that drain the upland areas. There are even watersheds within the developed parts of each town, where drainage patterns are controlled by streets and buildings.

Because watershed boundaries do not follow town boundaries, **a watershed can provide a**

framework for understanding the interconnectedness of natural systems and the built environment as well as how climate stressors can affect different sectors simultaneously. For example, the natural resources of the Watershed, the people who live and work in the Watershed towns and the services provided by each town can all be impacted by a flood or drought. Watershed boundaries at different scales provide a useful decision-making framework. Past, current and future decisions about the way land and resources are used, and how towns that share a watershed work together to make their communities more resilient, can have positive impacts on those living down the road, down the hill, and perhaps most importantly, those living downstream.

Climate change functions as a stressor, exacerbating the risks and damages of natural hazards by amplifying their intensity, frequency and duration. Events like flooding, heat waves and storms become more powerful and more prevalent. In turn, existing vulnerabilities in the Watershed — such as development and infrastructure in the floodplain, or elderly members of the population living alone in remote locations — become even more at risk. Climate change can also



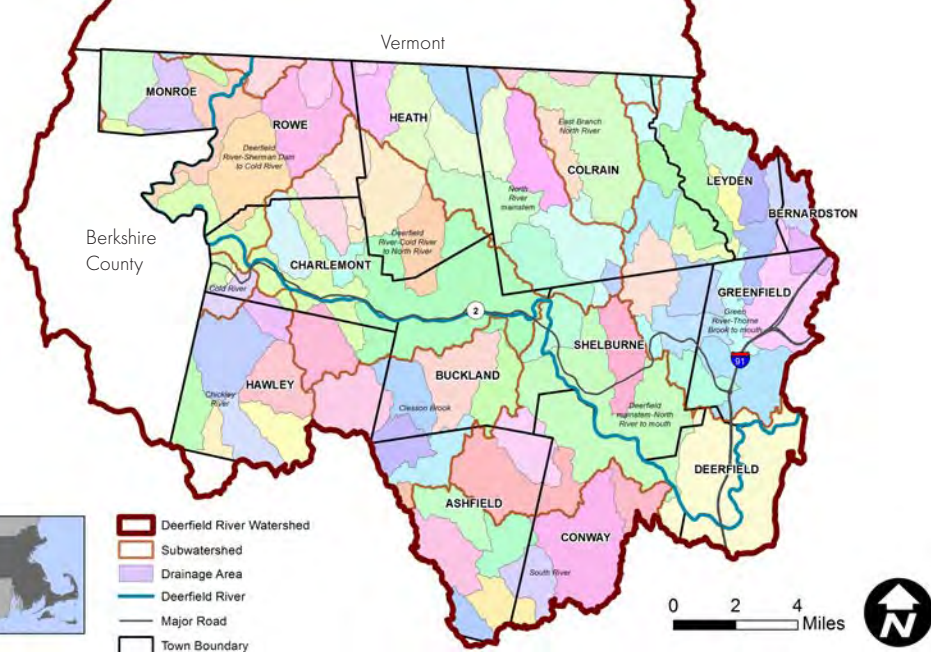
Franklin County Towns in the Deerfield River Watershed with Subwatersheds and Drainage Areas

place excessive pressures on the Watershed's strengths: acres of intact forest, social safety nets for the elderly, and regional services for emergency response can all become overwhelmed in the face of unprecedented weather or events.

This report provides the towns of the Deerfield River Watershed with information about how **Changes in Precipitation, Rising Temperatures and Extreme Weather will likely impact three important sectors: Natural Resources & Habitat, Human Health & Welfare, and Local Economy & Infrastructure.** These climate change stressors and sectors mirror the ones assessed in three climate change initiatives undertaken by the Commonwealth: the 2018 *Massachusetts Hazard Mitigation and Climate Change Adaptation Plan*, the Municipal Vulnerability Preparedness (MVP) Program, and the 2011 *Massachusetts Climate Change Adaptation Report*.

This plan can be used by local officials and Watershed residents to understand how climate change is affecting their lives, communities and landscape. It can also inform discussion about what measures can be implemented to build resiliency, so that towns are able to maintain functions, protect their residents and emerge stronger and better prepared for future events.

The reality of private land holdings and fourteen town boundaries in the Deerfield River Watershed makes watershed-scale approaches to climate resiliency challenging and complex. **By working in partnership with their watershed neighbors, towns can build a framework of actions that not only improve the climate resiliency of each town, but over time, create a more resilient Deerfield River Watershed.**



This plan describes the tools that are on hand to solve the most pressing of the issues confronting our communities today. Most importantly, the recommendations it proposes are:

- **Achievable** (within the power of towns and individuals to implement);
- **Address multiple climate stressors** (changes in precipitation, rising temperatures, extreme weather);
- **Benefit multiple sectors** (Natural Resources & Habitat, Human Health & Welfare, Local Economy & Infrastructure); and
- **Build resiliency at multiple scales** (property, town, and watershed).

Citizens and town officials don't have to look far to see how climate change can destroy vulnerable infrastructure, or overwhelm emergency response capacity and the safety nets in place for vulnerable populations. We need to look beyond our town borders, however, to find long-term, sustainable strategies for resiliency. Deerfield River Watershed towns know how to do this — many have already regionalized and share services with neighboring towns to support public safety and health, as well as other economic and government functions. **By taking the same cooperative approach, at a watershed scale, we can strengthen and improve the climate resiliency of each town and the Watershed as a whole.**

The Village of Shelburne Falls seen during Tropical Storm Irene in 2011 (top) and nearly one year later (bottom). Photographs © John Elder Robison all rights reserved.



Introduction: Survival in a Living World

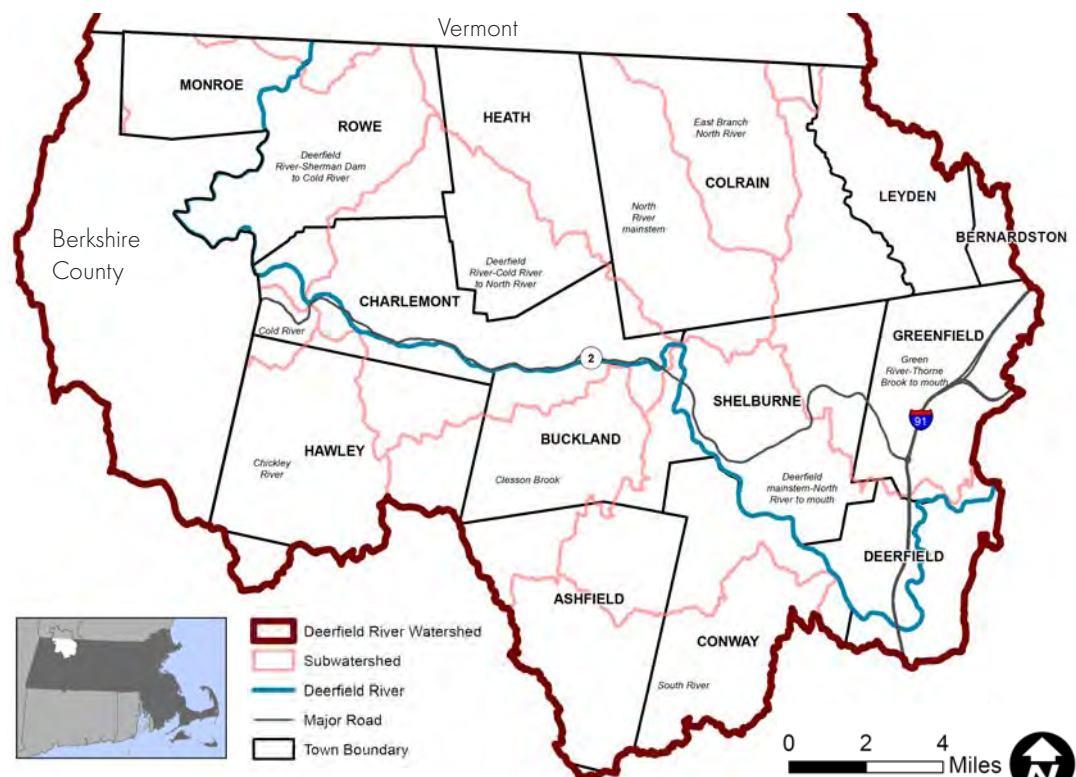
In recent years, extreme weather events have struck our region with alarming intensity and frequency. The courses of rivers and waterways have been altered; forests and homes have been toppled; roads and bridges crumpled. In the past thirteen years in Franklin County, Massachusetts alone, there have been twelve Presidential Disaster Declarations, including Tropical Storm Irene and the historic October snowstorm in 2011, Hurricane Sandy in 2012, and the February 2013 blizzard. A changing climate is undeniably at the center of these massive impacts to our lives and local communities. How we respond to and prepare for the effects of climate change will largely determine whether our towns are able to prosper in the 21st century. According to the 2011 *Massachusetts Climate Change Adaptation Report*, climate change is the greatest environmental challenge of this generation, with potentially profound effects on the economy, public health, water resources, infrastructure, energy demand, natural features, and recreation. The time to address climate change is now. Planning for and managing impacts of climate change before they occur are preferable to reactive decision-making after an impact takes place. This approach has the potential to reduce costs, minimize or prevent impacts to public health and safety, and minimize damage to crucial natural resources and built infrastructure.¹

The purpose of this report is to prepare the fourteen Franklin County towns in the Deerfield River Watershed for the current and projected future impacts of climate change, by building resilience on a local, town-wide scale, as well as on a regional, watershed-based scale.

Being resilient means having the ability to

recover after disturbances or significant, unpredictable changes in the environment, such as those caused by a fire, flood, blizzard, or injury.² Because so often what we do affects those living downstream, one of the objectives of this report is to help our fourteen towns understand not only how their actions and decisions impact their neighbors, but also how, **by working collaboratively across the Watershed, communities can pool resources, networks, and ideas to make their towns, subwatersheds and the Watershed as a whole more climate resilient.** Best practices will be explored, so that when towns are making land and natural resource use decisions, developing emergency response plans, or identifying vulnerable infrastructure, they can consider not only the needs of their own population, but also those of neighboring communities.

Franklin County Towns and Subwatersheds in the Deerfield River Watershed

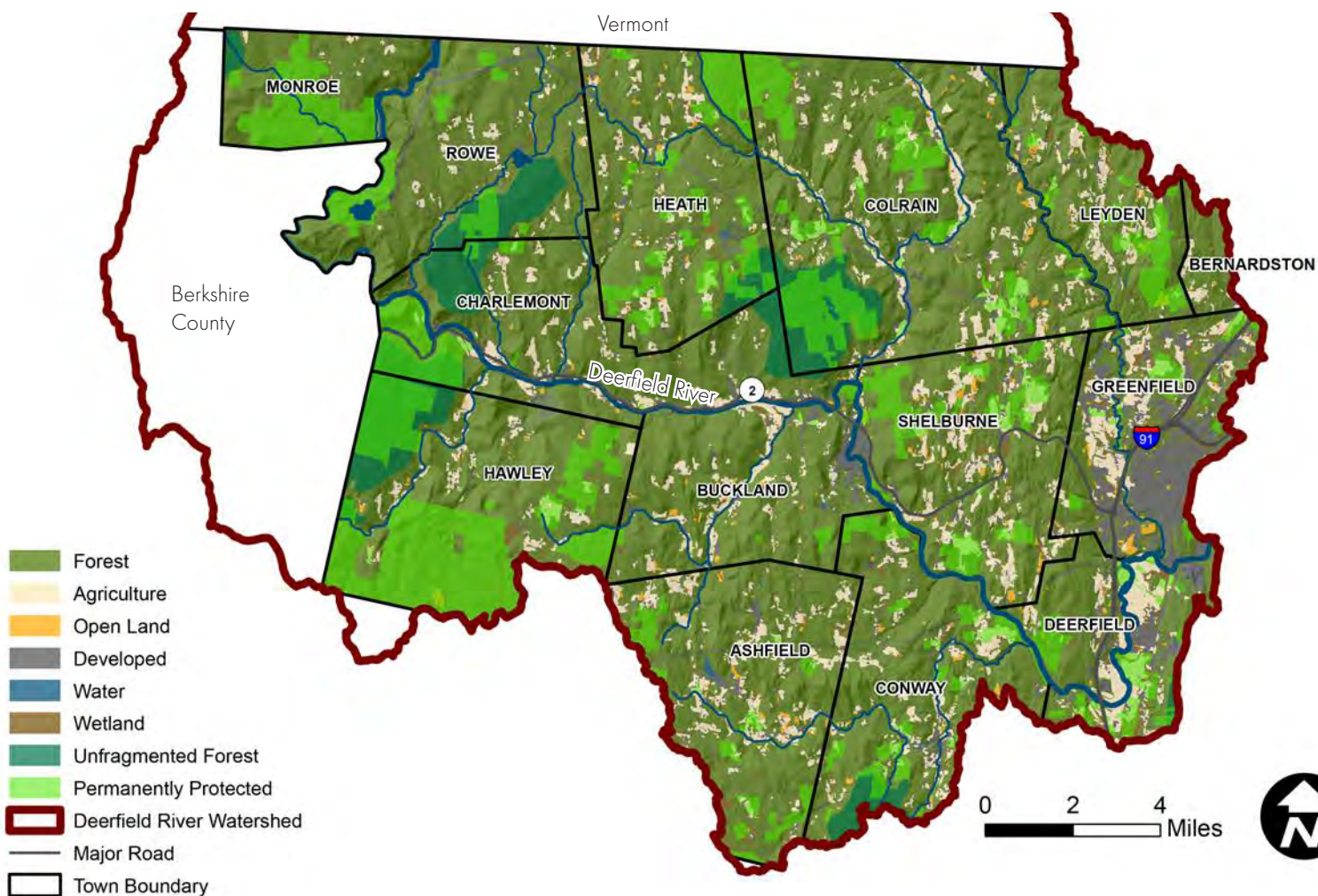


While our rural towns face challenges in responding to and preparing for climate change risks – in particular, physical isolation, limited economic diversity, and higher poverty rates, combined with an aging population – they also possess many strengths.³ Close-knit communities with strong citizen participation, intact forests, prime farmland, as well as a low percentage of impervious surfaces, all characterize the fourteen Franklin County towns that comprise the Deerfield River Watershed. Of their 242,094 combined acres, 76% of the land is forested, 8% is farmed, 5% is water, and 8% is developed. Twenty-nine percent of the Watershed is permanently protected from development. Only 3% of the Watershed is impervious. These large expanses of forest and an extensive natural resource base provide many resiliency benefits – such as reduced stormwater runoff and increased groundwater recharge – and are better equipped to absorb many of the impacts of climate change than developed areas. They also purify water and air, regulate air and water temperatures, and provide

wildlife habitat and food: all highly valuable assets in an era of unpredictable temperature and precipitation swings. That being said, our region is still vulnerable to the risks that a changing climate presents, and we must protect and manage our natural resources for multiple benefits.

Farmland in the Deerfield River Watershed is some of the best in the world, and the Franklin Regional Council of Governments (FRCOG), along with organizations such as Community Involved in Sustaining Agriculture (CISA), the Franklin County Community Development Corporation (FCCDC), the Franklin County Food Council (FC²), and the Northeast Organic Farming Association Massachusetts Chapter (NOFA/Mass) have done a lot of work in our communities to help bolster the development of a strong local food network. In addition to the scores of working farms, orchards, and food manufacturing and processing facilities present in the Watershed, many members of our local communities also grow their own food, hunt,

Land Use and Natural Resources in the Deerfield River Watershed



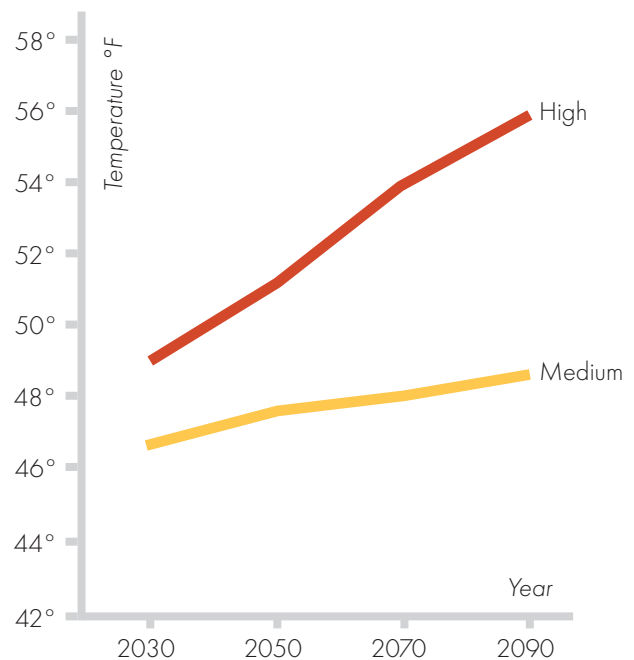


Greenfield Community Farm provides fresh vegetables to roughly three hundred residents of Franklin County as part of a Community Supported Agriculture (CSA) model. Over sixty percent of their CSA shares are held by low-income residents, making the farm the largest SNAP (Supplemental Nutrition Assistance Program) enrolled CSA in Massachusetts, and a model for food justice advocates across the nation. Photograph by Timothy Shivers.

and fish. As we will explore in the coming pages, such lifestyle decisions can strongly reinforce the resiliency of our towns and citizens.

Part 1 of this plan, **The Changing Climate**, presents the latest climate change projections for the Deerfield River Watershed. This information was developed by researchers from the Northeast Climate Science Center at the University of Massachusetts, Amherst. These highly valuable projections demonstrate how the climate is likely to transform in the Deerfield River Watershed over the course of the 21st Century, based on climate models used by the International Panel on Climate Change (IPCC) and two scenarios of future greenhouse gas emissions: ‘medium’ and ‘high.’ A ‘medium’ scenario assumes a peak in global greenhouse gas emissions around 2050, which then declines rapidly over the second half of the century due to carbon reduction efforts. A ‘high’ scenario assumes a “business as usual” continuation of the current emissions course. These scenarios represent different pathways that society may or may not follow to reduce emissions through climate change mitigation measures.

Annual Average Temperature Projections for the Deerfield River Watershed



Temperature ranges are based on medium and high emissions scenarios. See the resilient MA Climate Change Clearinghouse⁴ for more information.

The changing climate stressors that have already occurred in the Deerfield River Watershed, and will continue to do so in the future, are **Changes in Precipitation, Rising Temperatures** and **Extreme Weather**, which includes the increased frequency and magnitude and duration of events such as storms, droughts, rapid temperature swings, and loss of the shoulder seasons. These climate change stressors are the same ones discussed in the 2011 *Massachusetts Climate Change Adaptation Report*, the resilient MA Climate Change Clearinghouse⁵, as well as the 2018 *Massachusetts Integrated State Hazard Mitigation and Climate Adaptation Plan*.

In **Part 2**, the ways in which a changing climate has **Impacts on Our Communities** will be examined, by looking at three key sectors: **Natural Resources and Habitat, Human Health and Welfare**, and **Local Economy and Infrastructure**. Infrastructure is understood as being physical, such as roads and bridges, as well as social, such as volunteer fire departments and municipal governments. These three categories merge the sectors used in the 2011 *Massachusetts Climate Change Adaptation Report*, the new State Municipal Vulnerability Preparedness (MVP) program, as well as the recently published 2018 *Massachusetts State Hazard Mitigation and Climate Adaptation Plan*.⁶

In **Part 3**, we will determine the **Strengths and Vulnerabilities** of our towns, in each of the three key sectors. This information will be derived from the FRCOG's 2017 report *A Watershed-Based Plan to Maintain the Health and Improve the Resiliency of the Deerfield River Watershed*; the *Sustainable Franklin County* plan published by the FRCOG in 2013; a review of each town's Municipal Vulnerability Preparedness (MVP) and/or Hazard Mitigation Plans; analysis of results from a climate change survey which was distributed to residents and employees of the fourteen Watershed towns; stakeholder input gathered during meetings with the Franklin Regional Planning Board (FRPB); members of the Mohawk Area Public Health Coalition (MAPHCO) and the Cooperative Public Health Services Health District (CPHS); and spatial analysis of present-day land use, natural resource, and infrastructure patterns using GIS.

In **Part 4**, we will discuss what **Building Resilience** to the impacts of climate change can look like. This chapter presents concrete examples of how our

towns and citizens can collaborate across the Watershed in creating climate resilient communities; to incorporate Nature-Based Solutions into land, water, and built projects; as well as the importance of planning for the future on a town-wide scale, a subwatershed scale across town borders, and on a watershed-based scale across the region.

Finally, in **Part 5**, we will provide **Next Steps** that include a comprehensive list of resources and funding sources, as well as other information that residents and communities can use to **take action now**.



Natural Resources & Habitat



Human Health & Welfare



Local Economy & Infrastructure

It is our hope that this plan for climate change resilience in the Deerfield River Watershed will serve as a resource for local officials and residents to make sense of the impacts that climate change presents to their lives and livelihoods, and feel empowered with the tools and information they need to respond. As towns coordinate their work and implement projects at different scales, their efforts will build a framework for resilience across the Watershed.

One of the Coldest, Cleanest Rivers — But is it Resilient?

The Deerfield River Watershed covers an area of 665 square miles, and is home to one of the coldest and cleanest rivers in Massachusetts. It originates in the Green Mountains of southern Vermont, flowing approximately 70 miles and dropping roughly 2,000 feet before draining into the Connecticut River in Greenfield. The river enters Massachusetts between the Towns of Monroe and Rowe in Franklin County and flows southeastward through the Berkshire Hills in a narrow valley characterized by beautiful scenery, steep slopes and rural village centers. As the Deerfield approaches its confluence with the Connecticut, the river valley becomes wider and more developed, including the rich agricultural fields of the Town of Deerfield and the urban center of Greenfield. While most of the Massachusetts portion of the Watershed is in Franklin County, a small percentage lies within Berkshire County. There are ten subwatersheds and 14 towns in the Franklin County portion of the Watershed, which are the focus of this report.

Details on the Watershed:

It includes more than 149 streams, 21 lakes and ponds, and 20 municipalities, with a population of approximately 35,000 people.

The steep profile and high water quality of the Deerfield River attracts many sport-fisherman and whitewater enthusiasts.

Ten hydropower dams have been constructed on the River since 1911.

There are eight Federal Energy Regulatory Commission (FERC) licensed hydroelectric power plants in the Massachusetts portion of the Watershed.

While there is very little development in the Watershed, decades of natural and human-caused disturbances, such as land clearing and channel modification, have made streams and rivers highly unstable and prone to frequent flooding and erosion.

Climate change and continued development in the floodplain also contribute to significant stress on the river systems of the Watershed.

The Deerfield River Watershed of Vermont and Massachusetts



FRCOG is excited to report that we will be working with the Windham Regional Commission and the Green River Watershed Alliance in Vermont to identify and implement projects that will improve both watershed and community resilience, and restore impaired ecosystem and geomorphic functions. Franklin County's portion of the watershed is downstream from our Vermont neighbors, so this collaboration across state boundaries is a critical component of the framework for resilience that we are building.

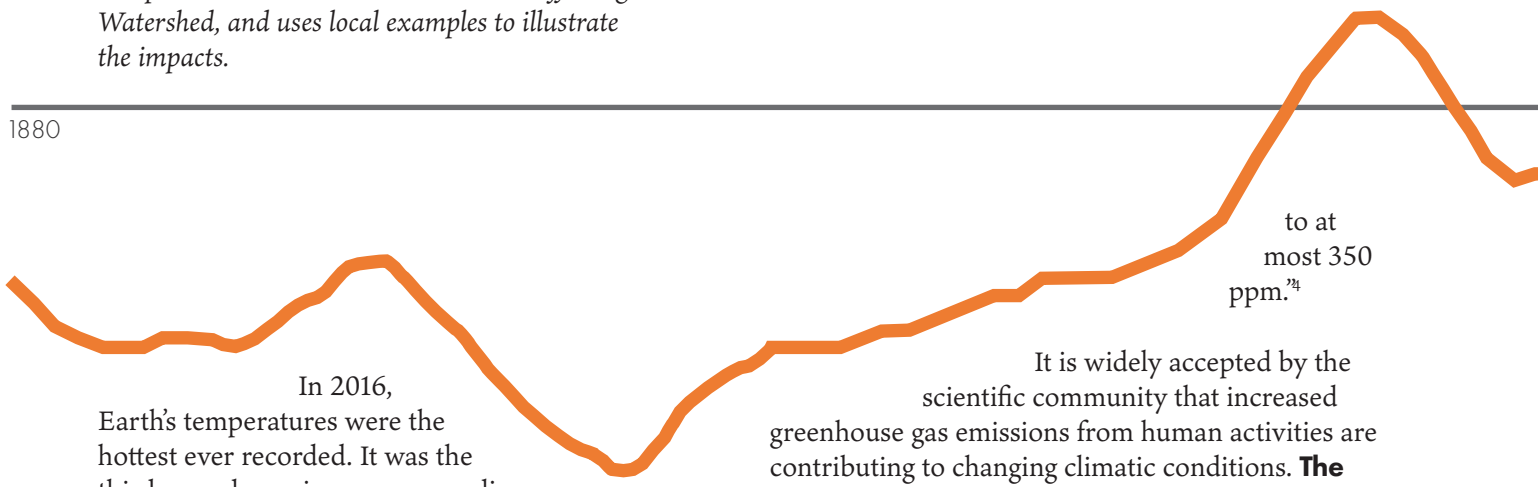
Impacts to the Watershed

The Deerfield River Watershed can expect significant climate change impacts to come:

- By mid-century, average temperatures will rise by 3 to 5 degrees Fahrenheit, with increases up to 4-11 degrees F under higher emissions scenarios
- More days of extreme heat: by century's end, we will have 14 to 80 days per year with temperatures above 90 degrees F, compared to 5-20 days today
- The occurrence of 100-year floods will increase to one every 2 to 3 years
- Massachusetts is expected to experience a 75% increase in drought
- Precipitation is also expected to increase, but likely in the form of winter rain

This section describes the three main climate change stressors — Changes in Precipitation, Rising Temperatures and Extreme Weather — affecting the Watershed, and uses local examples to illustrate the impacts.

1880



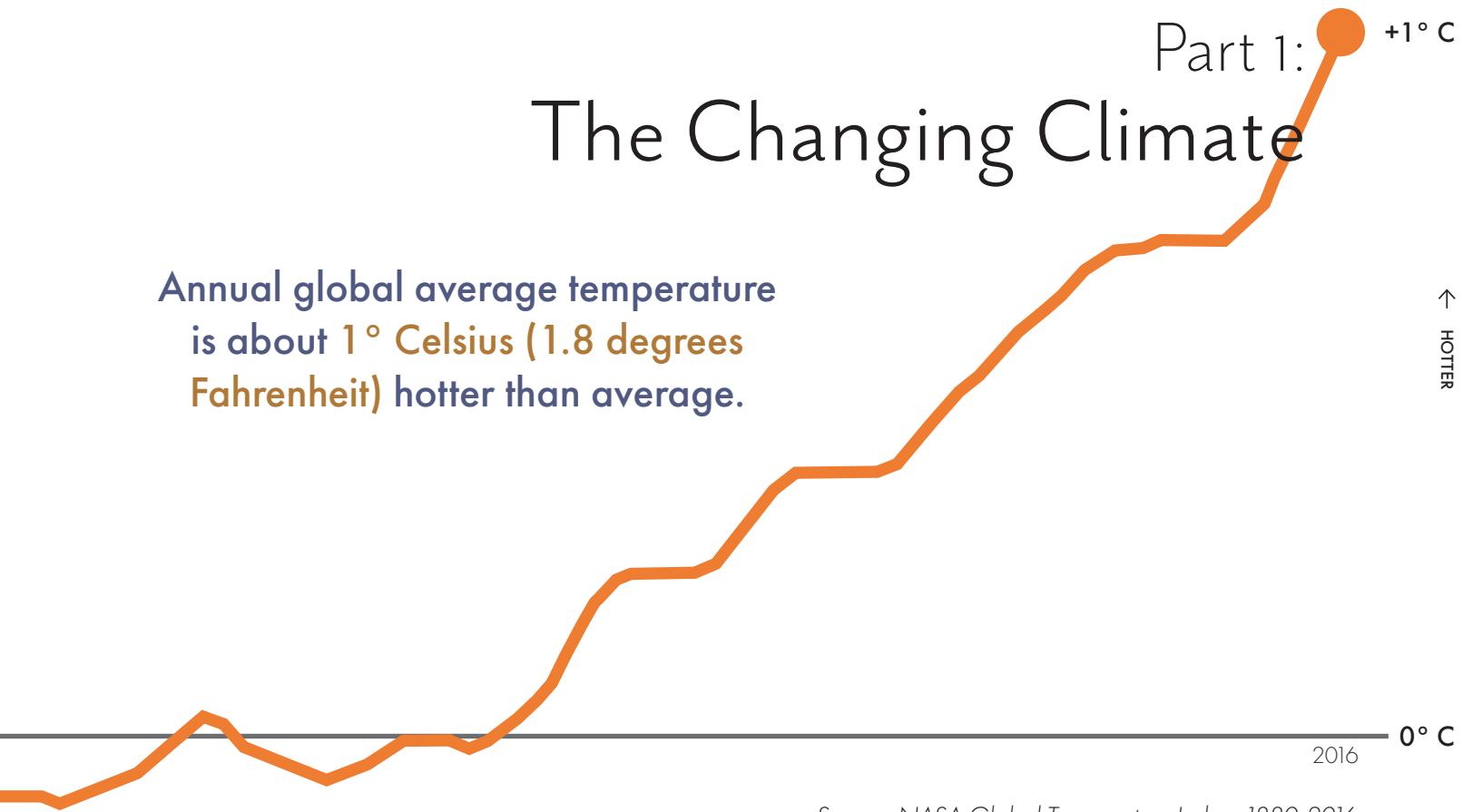
to at most 350 ppm.²⁴

In 2016, Earth's temperatures were the hottest ever recorded. It was the third record year in a row, according to the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA). Since 2001, seventeen of the eighteen warmest years in the 136-year record have occurred.¹ And while the planet's average surface temperature has risen about 2 degrees Fahrenheit since the late 19th Century, average annual temperatures in Massachusetts have increased almost 3° F in the past century.² Another record was broken in March of 2018, when global carbon dioxide concentrations surpassed 440 parts per million (ppm) for a month, the first time in recorded history.³ The last time CO₂ levels were that high, humans did not yet exist. According to former NASA climatologist Dr. James Hansen, "If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO₂ will need to be reduced ...

It is widely accepted by the scientific community that increased greenhouse gas emissions from human activities are contributing to changing climatic conditions. **The debate is not about whether climate change will occur, but the rate at and extent to which it will occur and the adjustments needed to address its impacts.** Much of the uncertainty results from the difficulty of projecting whether and how rapidly greenhouse gas emissions will be stabilized or reduced.⁵ Here in Western Massachusetts and across the Deerfield River Watershed, **the forms of climate change that we are seeing the most are Changes in Precipitation, Rising Temperatures, and an increase in the frequency and intensity of Extreme Weather and storm events.** These challenges increase the vulnerability of our region's residents, as well as our ecosystems, economy, and infrastructure.

Part 1: The Changing Climate

Annual global average temperature is about **1° Celsius (1.8 degrees Fahrenheit)** hotter than average.



Source: NASA Global Temperature Index, 1880-2016

Our Climate is Already Changing

Long-term observed warming trends in our region:

- The Northeast has been warming at a rate of nearly .5 degrees F per decade
- Winter temperatures are rising even faster, at 1.3 degrees per decade
- There are more frequent days with temperatures above 90 degrees
- Snowpacks are being reduced, with earlier spring snowmelts

An increase in extreme weather events is already occurring:

- The December 2008 ice storm downed trees and power lines across Western and Central Massachusetts, causing more than 100,000 people to lose power state-wide
- In August of 2011, Tropical Storm Irene dumped 10-15 inches of rain, causing extensive flood damages totaling nearly \$48 million in the Watershed alone
- In October that same year, a record early snowstorm of 24 inches left people without power for two weeks, and causing \$3 billion in damages across the Northeast
- A prolonged and extreme drought in 2016 devastated farmers across Massachusetts, causing the Commonwealth to open a Drought Emergency Loan Fund



Flooded farm field and barn on Mill Village Road in Deerfield. Image courtesy Paul Franz/The Recorder.

Flooding

On August 28, 2011, Tropical Storm Irene wreaked havoc across the Deerfield River Watershed. Throughout the region, unusually high August precipitation prior to the storm had already saturated the landscape, exacerbating Irene's destructive impacts. The Deerfield River rose 15 feet in a matter of hours, after an estimated 10 to 15 inches of rain had swollen the river.⁶ At the storm's peak, the river flows in the Deerfield were measured at 102,000 ft³ per second, smashing all previous historical records.⁷

It has also been reported that Tropical Storm Irene caused the most severe erosion of any flood in Massachusetts historical records. The storm resulted in 274 landslides across the Watershed, which is roughly the same number that had occurred in the previous 30 years combined, and formed a giant sediment plume entering the Long Island Sound that was visible from space days after the storm.^{8,9} Today, seven years after the storm, the amount of suspended

sediments in the Deerfield River is still double pre-Irene quantities.¹⁰



Image courtesy NASA Earth Observatory/U.S. Geological Survey Global Visualization Viewer.

“What do you do? You’re not going to get your topsoil back. You’d never expect to see land down to bedrock. It’s just heartbreaking. It’s a barren wasteland.”

—Rita Thibodeau, Franklin County District Conservationist, on farm damage from Tropical Storm Irene¹¹



Changes in Precipitation

The storm caused unprecedented damage to locations across 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 on Route 8A. The USDA Natural Resources Conservation Service (NRCS) recorded approximately 800 acres of crop loss or damage across the Watershed.



Irene's waters carried a portion of this road and bridge away on the North River in the Town of Colrain.

*Flooded farmland on the banks of the Deerfield River.
Image courtesy Town of Deerfield Multi-Hazard Mitigation Plan 2014 and the Town of Greenfield.*





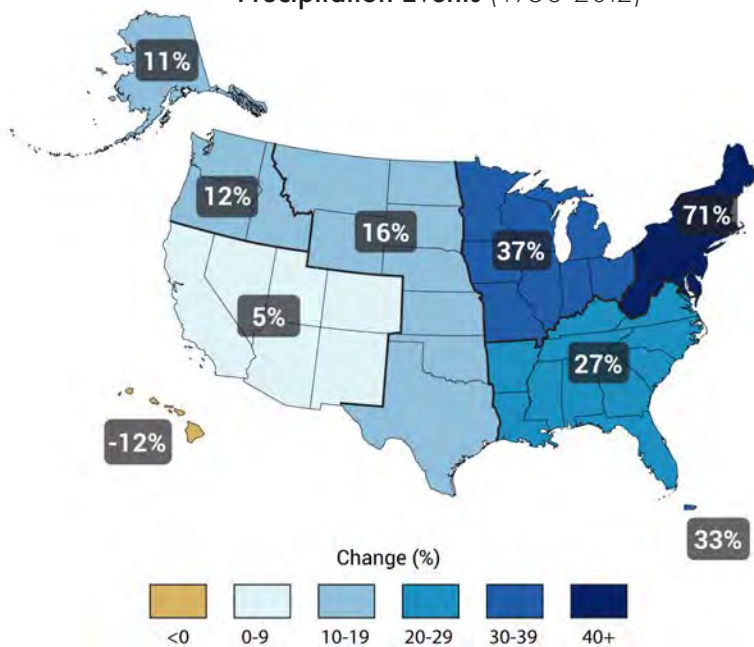
Flooded vegetable fields at Natural Roots Farm in Conway. Image courtesy David Fisher and Anna Maclay.

Heavy Rain

The Northeast has seen a greater increase in extreme precipitation than any other part of the country, experiencing a 71 percent increase in heavy precipitation events between 1958 and 2012. Massachusetts has seen a record-setting number of events occur over the past decade. In March of 2010 alone, three extreme rainstorms led to extensive flooding and \$2 billion in damages across the state and southern New England.¹² Climate change

projections show this trend of heavy rain and snowfall continuing to increase over the course of the century. In the Deerfield River Watershed, it is predicted that there will be an additional five days a year with over 1 inch of rainfall.

Observed Change in Heavy Precipitation Events (1958-2012)



There is a clear trend toward a greater amount of precipitation being concentrated in heavy rain events, particularly in the Northeast. Image courtesy U.S. Global Change Research Program, updated from Karl et al. 2009.



Jay Butynski walks along a row of drowned squash that will get harrowed into the ground at his farm in Greenfield. Paul Franz/The Recorder.

In August of 2018, the Town of Greenfield received nearly 9 inches of rain, at least three times more rain than in August 2017, according to Department of Public Works' records.¹³ According to U.S. Climate Data,¹⁴ Greenfield received over 17 inches of rain between June, July, and August 2018, much higher than the average for the period of 12.48 inches. It was also the sixth warmest summer on record since 1893, according to the National Weather Service.¹⁵

U.S. Drought Monitor
Massachusetts

September 13, 2016

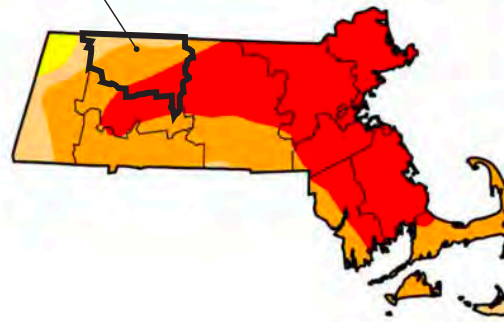
Intensity:



Drought

In the summer of 2016, Massachusetts was gripped with the worst drought conditions in recent memory. The prolonged period of warm, dry weather served as a stark reminder of how residents, communities, and industries depend upon the Commonwealth's fresh water resources. On September 21 of that year, the U.S. Department of Agriculture designated Franklin County, along with most other parts of the state, as primary natural disaster areas due to the ongoing drought and its affect on agriculture. A small projected decrease in average summer precipitation could combine with higher temperatures to increase the frequency of episodic droughts in the future.

Franklin County



Author: Eric Luebehusen, USDA

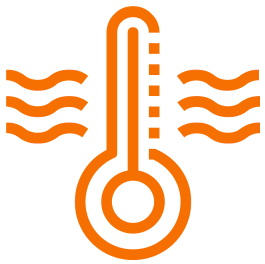
Droughts will create challenges for local water supplies by reducing surface water storage and the recharge of groundwater supplies, including private wells. Droughts can weaken tree root systems, making them more susceptible to toppling during high wind events. More frequent droughts can also exacerbate the impacts of flood events by damaging vegetation that could otherwise help mitigate flooding effects.¹⁶ Droughts also increase the risk of forest fires.



Left: Congressman Jim McGovern met with Tim Wilcox and Caroline Pam, owners of The Kitchen Garden farm in Sunderland, to discuss federal drought relief in 2016. Image courtesy Andy Castillo/The Recorder.

Below: During the 2016 drought, some farmers were compelled to water vegetables by hand. "Farmers have to invest a lot of labor into irrigating crops they normally don't have to," said Katie Campbell-Nelson of UMass Amherst's Center for Agriculture, Food and the Environment. Image courtesy Jesse Costa/WBUR.





Rising Temperatures

Heat Waves

On July 5, 2013, a 45 year-old Medford, Massachusetts postal worker died while working a second shift. As temperatures climbed into the mid-90s and combined with high humidity to feel like 100 degrees, he sent several messages to his wife about the excessive heat, reportedly texting shortly before collapsing, "I'm going to die out here today. It's so hot." He had worked for the U.S. Postal Service for 24 years.

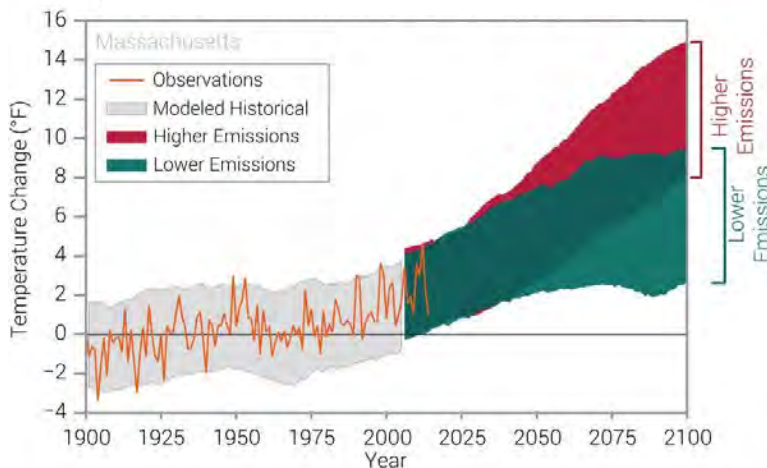


Image courtesy ehstoday.com

Since the beginning of the 20th century, temperatures in Massachusetts have increased almost 3 degrees F. In the Deerfield River Watershed, under a high emissions scenario, annual high temperatures are projected to increase by up to 11.49° F and annual low temperatures are projected to increase by up to 11.35° F.¹⁷

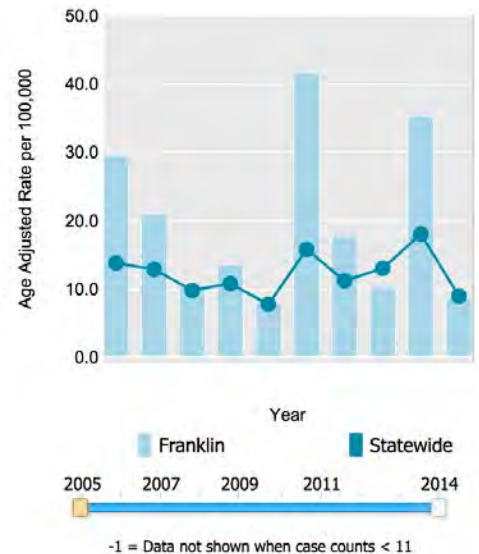
Extreme heat days are on the rise as well. By the end of the century, **days above 100° F are projected to increase to twelve or more each year in the Watershed.** Vulnerable populations, including seniors and children, are especially at risk.

Temperature Change in Massachusetts (1900-2100)



Observed and projected changes in near-surface air temperature for Massachusetts. Observed data are for 1900-2014. Projected changes are from global climate models for two possible futures: higher and lower emissions. Source: CICS-NC and NOAA NCEI.

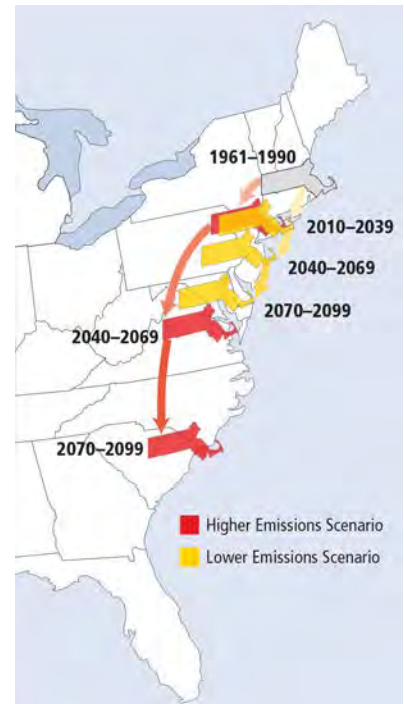
Heat Stress Emergency Room Visits in Franklin County



Emergency room visits due to heat stress were significantly higher in Franklin County than the state average between 2005 and 2014. Source: Massachusetts Environmental Public Health Tracking



Projected Summer Temperatures in Massachusetts by 2099



Right: By the end of this century, summer days in Massachusetts could feel like present-day South Carolina under a higher emissions pathway. Source: Union of Concerned Scientists (2006). Left: Japanese barberry image courtesy Plant Conservation Alliance's Alien Plant Working Group. Below: Red Fire Farm's Sarah Voiland holding Mile-a-minute vine. Image by Paul Franz/The Recorder.

Invasive Species

“We didn’t even know what the plant was at first,” said Sarah Voiland, co-owner of Red Fire Farm in Montague. “We were like, what is this weird weed we’ve never seen before?”¹⁸

Polygonum perfoliatum, or Mile-a-minute vine, can grow up to six inches a day and is covered in sticky, thorn-like hairs that make removal a painful task. Native to Asia, the vine smothers other vegetation, including the organic vegetables that Red Fire grows. Originally a problem in the mid-Atlantic states, the vine has moved north to Massachusetts in recent years due to warming temperatures. In our region, Mile-a-minute has been found on properties in Greenfield, Deerfield, Montague, Erving and Amherst.¹⁹

Warmer temperatures and extended heat waves could have very significant impacts on public health, as well as the health of plants, animals, and ecosystems. According to a team of New England researchers, Japanese barberry (*Berberis thunbergii*), a favored nesting site for ticks, will experience prolific population growth in our region under climate change.²⁰ Studies done by the University of Connecticut found that forests infested with barberry had twelve times more deer ticks than forests that were not.²¹



Rising temperatures will also affect important economic sectors such as agriculture and tourism, and infrastructure such as the electrical grid. According to downscaled data for the Watershed, the number of days in which cooling of homes and businesses is needed is expected to increase by 68-193% mid-century, and by 93-377% end of century.²²

Conversely, the Watershed is expected to experience a decrease in days with temperatures below freezing. **By the end of the century, there will only be 24-63 days a year with temperatures below freezing.** This will have an impact on the health of coldwater streams and fisheries, and sectors of the local economy such as the maple sugaring industry.



Conway tornado photos by Dave Roback/The Republican.

Tornadoes

On February 25, 2017, a tornado cut a five-mile swath through the Town of Conway in about five minutes. Wind gusts in most of the damaged area were between 80-110 mph. This was the first tornado on record to occur in Massachusetts in February. The storm knocked out power to most Conway homes and businesses, damaged barns, outbuildings, a recently restored church, and rendered six homes unsafe to occupy.

Winter Storms

During the Halloween Storm of 2011, heavy, wet snow was dumped across the region, with the Town of Shelburne receiving over 21 inches. More than 700,000 people in Western Massachusetts were left without power, and thousands of roads were closed due to dropped tree limbs and snow accumulation.

During “Snowtober” of 2011, heavy wet snow snapped trees and shut down roads across Franklin County.


Christina Hager ✓
 @HagerWBZ Follow

Upper right was bedroom where Conway, MA homeowner says her husband reads. If he'd been in there, he may not have survived
[#tornado](#) [#wbz](#)



9:25 AM - 27 Feb 2017

From Twitter account of journalist Christina Hager, reporting from Conway.





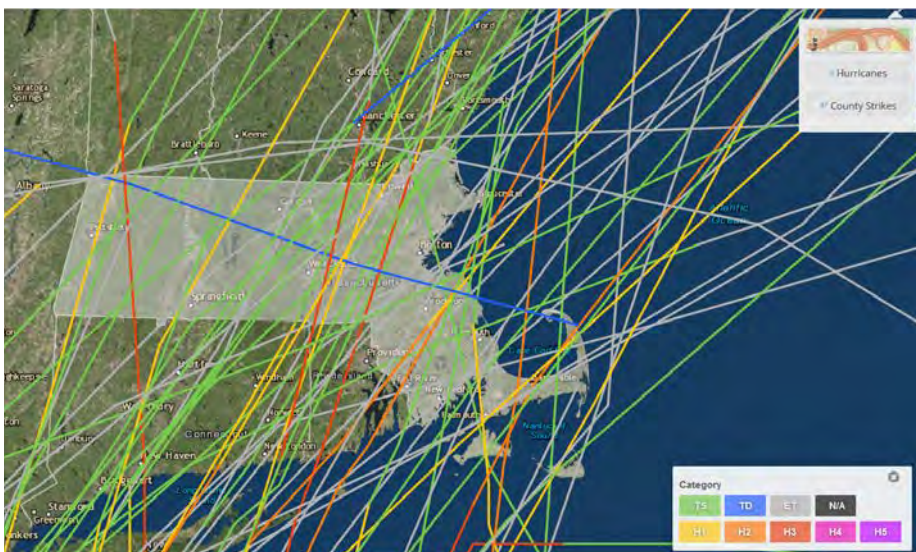
Hurricanes and Tropical Storms

We are already seeing that climate change is increasing the frequency of extreme weather events. According to NOAA's Historical Hurricane Tracks tool, 63 hurricanes or tropical storms have occurred within the Commonwealth of Massachusetts since 1858, or about one every two and a half years. With the anticipated increase in ocean temperatures, storm systems are expected to become larger and longer in duration. **Climate change may double the frequency of Category 4 and 5 storms by the end of the century, according to the 2011 MA Climate Change Adaptation Plan.** Flooding and high winds are the primary impacts of these events.



Extreme Weather

Historical Hurricane Tracks for Massachusetts (1858-2018)



Source: United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Ocean Service, Office for Coastal Management.





Part 2: Impacts on Our Communities



In October 2005, Tropical Storm Tammy caused severe damage across the Watershed. In Greenfield, Wedgewood Gardens mobile home park residents were forced to evacuate to higher ground due to flooding from the Green River. Photograph by Dave Molnar/The Republican.



On October 8, 2018, a new report issued by the IPCC stated that the planet will reach the crucial threshold of 1.5 degrees Celsius (2.7 degrees Fahrenheit) above pre-industrial levels by as early as 2030, precipitating the risk of extreme drought, wildfires, floods and food shortages.¹ While the true economic impact of climate change is hard to predict, it's safe to say that many key economic sectors – from agriculture to recreation to water and electrical utilities – will feel the long-term impacts.²

Here in Franklin County, we've already witnessed many of these impacts firsthand. The damages from Tropical Storm Irene in 2011 were particularly devastating. While initial estimates put the total cost of damages at \$26 million dollars county-wide, seven years after the storm, the real numbers are a lot larger. In the Town of Greenfield, damage to public infrastructure alone was nearly \$12.5 million, while in Deerfield total damages were estimated to be between \$13 and \$14 million. The USDA Natural Resources Conservation Service (NRCS) estimates that the overall damage in crop loss and land reclamation across the Watershed was \$5 million. In Charlemont, damages to public infrastructure cost nearly \$6.5 million; in Buckland, total Irene damages were over \$4 million; in Hawley, the storm cost

more than \$2.4 million; in Colrain, over \$2.2 million was spent in damage recovery; in Heath, \$927,000 was spent; in Conway, over \$500,000; while in Leyden, there were over \$22,000 in damages. This represents a total of almost \$48 million — nearly double the initial estimates.

Tropical Storm Irene caused nearly \$48 million in damages to just eight towns in the Watershed.

Damage from Irene (clockwise from top left): Conway Street in Buckland moments after Ann Brauer's yarn studio was washed away (photo by Paul Franz); flood waters swallow a building in Shelburne Falls (photo © John Elder Robison); River Road in Monroe was severed in two; Greenfield's wastewater treatment plant was inundated.



Climate change functions as a stressor, exacerbating existing natural hazards by amplifying their intensity and the frequency with which they occur. Phenomena like flooding, heat waves and storms become more powerful and more prevalent. In turn, existing vulnerabilities such as sick/dying trees, members of the population with respiratory problems, or failing culverts, become further challenged and stressed.

We can understand the impacts of climate change (**changes in precipitation, rising temperatures and extreme weather**) in the Deerfield River Watershed by examining how they affect three sectors:



Natural Resources & Habitat

(forests, rivers, streams, wetlands, drinking water supplies and wildlife)



Human Health & Welfare

(risks to public safety and health, including vulnerable populations such as the elderly, the infirm, and those with economic challenges)



Local Economy & Infrastructure

(physical infrastructure, such as roads, culverts and bridges, as well as social infrastructure, such as volunteer fire departments, highway departments, municipal governments and businesses)

Climate Change Impacts in the Deerfield River Watershed by Sector



CLIMATE CHANGE INTERACTION

NATURAL HAZARDS INFLUENCED

IMPACT: NATURAL RESOURCES & HABITAT



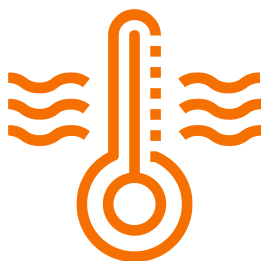
Changes in Precipitation

Flooding

Drought

Landslides

Flash Floods/Erosion/Soil Loss
 Stresses on Forest & Ecosystem Health
 Degradation of Stream Channels & Wetlands
 Lack of Groundwater Recharge
 Reduction in Stream & River Levels
 Reduction in Coldwater Fishery Habitat
 Changes in Extent & Duration of Snow Cover



Rising Temperatures

Heat Waves

Wildfires

Invasive Species

Shift in Seasons
 Mismatch of Key Food Sources & Wildlife
 Mismatch of Bloom Time & Pollinators
 Drying of Streams & Wetlands
 Eutrophication of Streams & Ponds
 Stresses on Forest & Ecosystem Health
 Loss of Ecological Diversity



Extreme Weather

Hurricanes/Tropical Storms

Winter Storms/Nor'easters

Tornadoes/Microbursts

Flash Floods/Erosion/Soil Loss
 Degradation of Intact Ecosystems
 Damage to Forests, Water Bodies & Wetlands
 Destruction of Habitat
 Loss of Carbon Storage



IMPACT: HUMAN HEALTH & WELFARE



IMPACT: LOCAL ECONOMY & INFRASTRUCTURE

Compromises to Drinking Water Supply
 Increase in Infectious & Vector-Borne Diseases
 Mold & Poor Indoor Air Quality
 Increased Risks for Elderly & Vulnerable
 Increased Potential for Loss of Life

Downtown/Village Flooding
 Drainage System Damage
 Crop Loss
 Increased Demand on Local Government
 & First Responders
 Disruption of Critical Services & Transportation
 Destruction of Property & Infrastructure
 Dam Damage/Failure

Heat Exposure
 Increase in Infectious & Vector-Borne Diseases
 Decline in Air Quality
 Associated Health Risks for Elderly & Vulnerable
 Increased Potential for Loss of Life

Energy Brownouts from Higher Demands
 Destruction of Property & Infrastructure
 Unpredictable Growing Season
 Crop Loss
 Increased Dependence on Irrigation
 Increased Demand on Local Government, Health
 Care Systems & First Responders

Isolation of Rural Populations & Inability to Meet
 Basic Needs
 Increased Risks for Elderly & Vulnerable
 Increased Potential for Loss of Life

Destruction of Property & Infrastructure
 Disruption of Critical Services & Transportation
 Increased Demand on Local Government
 & First Responders
 Crop Loss
 Business Interruption/Economic Disruption
 Dam Damage/Failure



Natural Resources & Habitat

are essential not only to the health and resiliency of the Watershed itself, but to its towns and citizens as well. Local industries such as agriculture, maple sugaring, recreational tourism, forestry, and even hydropower, are all dependent upon the health of local ecosystems, as well as the availability and abundance of natural resources. The well-being of our local population is similarly dependent upon things like clean drinking water and air, abundant food supplies, adequate shade cover and stormwater mitigation, all of which are supplied by the natural resources and habitat in the Watershed. As climate change stresses the natural environment, it will be less likely to provide the **ecosystem services** that humans rely upon, such as water and air purification, pollination and food production, soil formation, carbon storage and stormwater management. This highlights the importance of conservation measures and landscape management strategies to protect and strengthen our natural resources, including land protection, riparian buffers, and sustainable forestry practices, all with an eye toward making our communities more resilient to the projected impacts of climate change.

Wetlands like Bear Swamp in Ashfield provide essential ecosystem services, including water purification, wildlife habitat and climate change mitigation through the carbon sequestering capabilities of wetland soils and vegetation. Photograph by Evan Gregg.



What Are Ecosystem Services?

Ecosystem services are the contributions of the natural environment and ecosystems to the well-being of humans and other species. They support our survival and quality of life.

Ecosystem services can be categorized in four main types:

Provisioning services are the products obtained from ecosystems such as food, fresh water, wood, fiber and medicines

Regulating services are the benefits obtained from ecosystem processes such as climate regulation, natural hazard regulation, water and air purification, carbon sequestration, waste management, pollination or pest control

Habitat services highlight the importance of ecosystems to provide habitat for migratory species and to maintain the viability of gene-pools

Cultural services include non-material benefits that people obtain from ecosystems such as spiritual enrichment, intellectual development, recreation and aesthetic values



Natural Resources & Habitat: **Changes in Precipitation**

The ways in which natural resources and habitat are impacted by climate change is manifold. Changes in precipitation can cause flash flooding, leading to topsoil loss and erosion. This degrades the health of ecosystems and the ability of forests to clean and process runoff before it enters above ground water bodies, as well as drinking water supplies. Forests and shrublands also provide essential ecosystem services, such as rainwater absorption and buffers against storms and heavy wind. As rainfall patterns change, episodes of flooding may be followed by periods of drought, which can disturb the natural abilities of forests and vegetation to absorb rainwater adequately, potentially leading to erosion and landslides. Additionally, heavy rains and storms may kill or compromise the vigor of native trees, shrubs and vegetation, making forests, fields and wetlands more vulnerable to new and/or invasive plant and pest species.

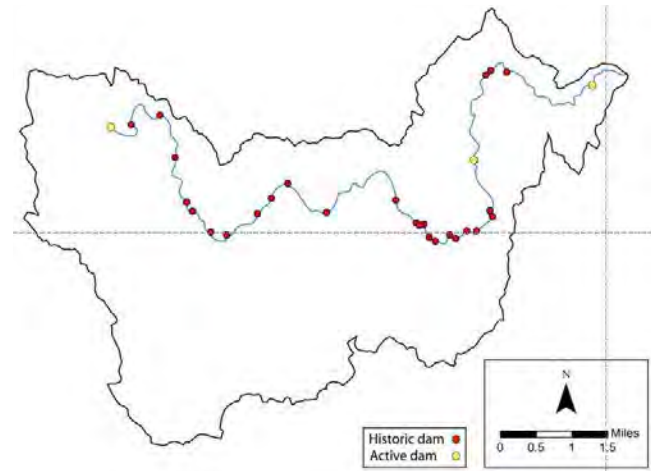
Waterbodies and wetlands provide vital habitats for plant and animal life in the Deerfield River Watershed. Increases in precipitation — in concert with rising temperatures — may cause water temperatures to rise and stream flows to be altered, which can have detrimental effects on fish and aquatic organisms, spiraling effects up the food chain to larger mammal and avian species — including humans. As aquatic habitats warm, coldwater fisheries will be especially affected. While some adult fish may be able to adapt to higher stream temperatures, their ability to reproduce may be reduced. Flooding can scour stream and river bottoms — as well as vernal pools — where fish and other aquatic species' eggs are deposited, potentially reducing their reproductive capabilities.



Eggs of aquatic species, such as these wood frogs and spotted salamander eggs, may be at risk from heavy rain events scouring river and vernal pool bottoms. Photograph by Steven Johnson.

As climate change influences temperature and precipitation patterns, it is predicted that drought conditions in the Northeast will become more prevalent.³

Map of active and historic dams in the South River watershed, which the towns of Conway and Ashfield share.



The Fourth National Climate Assessment published by the U.S. Global Change Research Program shows that annual precipitation in Massachusetts is projected to increase by as much as 7.3 inches by the end of this century. Because this additional precipitation will likely take the form of more intense periods of precipitation coupled with more frequent episodic drought, it is likely to result in more stormwater runoff and higher surface water levels. As storms occur more often and produce more precipitation, **areas that lie in floodplains will flood more frequently, and land that is not typically affected by flooding may become inundated.** Increases in extreme precipitation events will also increase the risk of flash flooding and damage to drainage systems not designed to accommodate the higher flows.⁴

Historic land clearing, dams and a legacy of channel modification are the main stressors still affecting the streams of the Watershed today, although continued development, encroachments in the river corridor and climate change also contribute significantly to stress on the river system.⁵



Heavy rainfall four days after Hurricane Florence made landfall in North Carolina caused flash flooding to swallow this car in Deerfield at the corner of Wapping and Depot Roads along Route 5 in a matter of minutes.

Climate change acts as a stressor, exacerbating weaknesses in our natural systems by amplifying the intensity and frequency with which environmental hazards may occur. In this example, channelized or otherwise artificially modified river systems, already prone to flooding, are further destabilized through the impact of heavy rainfall, resulting in potentially catastrophic flooding, land loss and destruction of habitat.



Changes in Precipitation



Unstable River Systems



Flooding and Land Loss



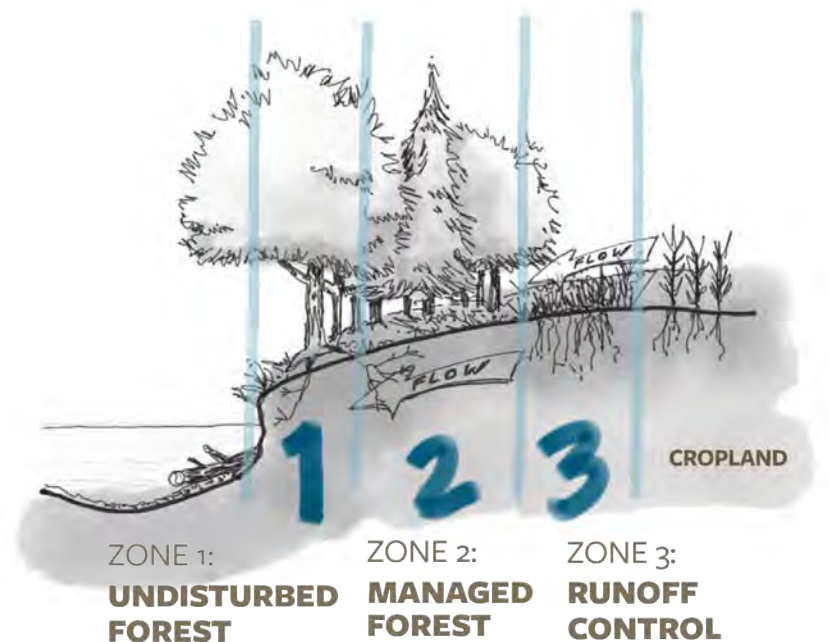
Natural Resources & Habitat: Rising Temperatures

Natural resources and habitat will be affected by rising temperatures. In the Watershed, several ecosystem types are particularly vulnerable. Riparian areas are lands that occur along watercourses and water bodies, such as floodplains and streambanks. They are different from surrounding lands because of the unique soil and vegetation characteristics they possess, which are strongly influenced by the presence of water. Lands next to water are fundamental to the well-being of many plants and animals, including humans. Birds and other wildlife congregate in riparian areas, often in abundance. At the same time, society values riparian areas for the production of food and fiber, access to transportation, opportunities for recreation, and natural scenic beauty.⁶

Riparian areas differ from uplands because of their high levels of soil moisture, frequent flooding, and unique assemblage of plant and animal communities.⁷ These areas are extremely valuable for ecological functioning — they are the protective, biodiverse buffers between human land use and aquatic ecosystems.⁸ Riparian ecosystems are particularly sensitive to rising temperatures, due in part to their dependence on water as well as their propensity for natural disturbance, and their composition will likely become fundamentally altered by climate change impacts over the course of the 21st century. This threatens to significantly degrade water quality as well as native plant and animal habitat in the Watershed, thereby reducing the mitigating effects on flood damage that riparian areas naturally provide.

Riparian Buffers on Farmland

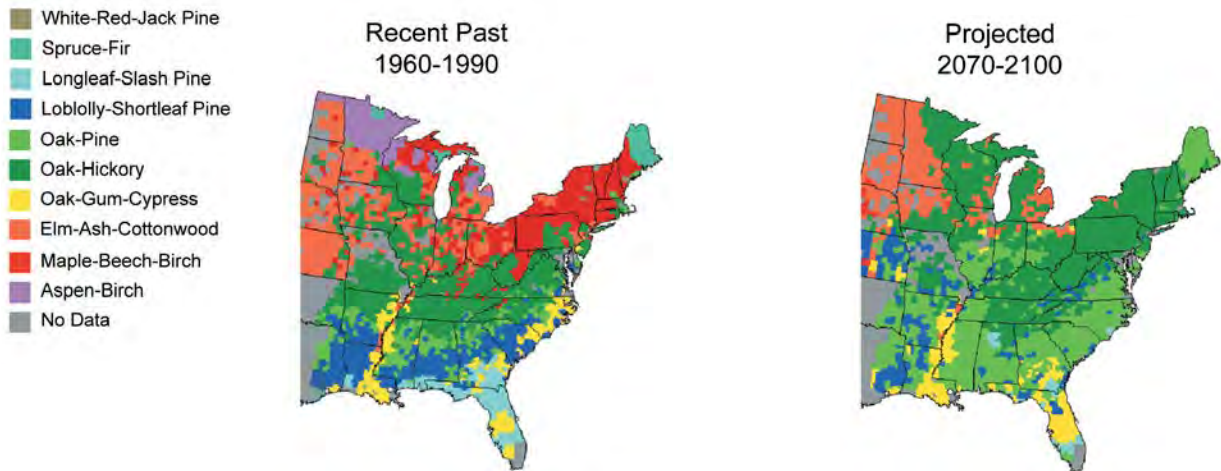
Farmland can provide important ecological services, including the establishment of riparian buffers and allowing floodplains to return to their natural formations. Various state and federal programs exist to help farmers implement practices to promote soil health, nutrient management, and ecological resilience in the ways their land interacts with river systems. See Part 5 for more information about these programs and funding streams. Illustration by David Grist, Ecological Resilience in Deerfield.



As temperatures rise, a shift to winter rains may lead to more seasonal runoff, flooding, and greater storm damage. Forest ecosystems will face further threats from earlier spring snow melt and more frequent high flow/low flow extremes (during spring runoff and summer droughts, for example).

Other local ecosystems that are expected to be particularly vulnerable to rising temperatures include spruce-fir forests, hemlock forests, northern hardwood forests, vernal pools, as well as street trees in town centers. Changes in tree species distribution have already been observed in Northeastern forests, according to NOAA. As seen in the diagram on the following page, the forest composition for Western Massachusetts is projected to change from predominantly maple-beech-birch and oak-hemlock-pine to oak-hickory over the course of the 21st century. This shift in tree species could have significant impacts on farmers, foresters and maple producers in the region.

Projected Forest Composition Change for the Eastern United States



The forest composition for Western Massachusetts is projected to change significantly over the course of the 21st century. Maps courtesy of Team, National Assessment Synthesis. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. Cambridge, UK and New York, NY, 2001.

Rising temperatures are also influencing plant and animal species migration. By revisiting records kept by Henry David Thoreau, scientists showed that plants of all kinds in Concord, Massachusetts, now flower about eighteen days earlier than they did in the 1850s. As plants and pollinators adjust to changing temperatures in different ways, mismatches may occur. Climate change is already being shown to disrupt the synchronization between flower bloom time and bee emergence.⁹ Without native pollinators, there can be devastating effects upon our local food system and natural ecosystems: 45% of the food crops in Massachusetts, and nearly 80% of the flowering plants on Earth, depend upon pollination.

The expansion of exotic pests, pathogens and plants as a result of rising temperatures will likely cause an overall loss of biodiversity, ecological function and resilience. Insects such as the hemlock woolly adelgid, emerald ash borer and southern pine beetle are poised to become more widespread as temperatures increase, threatening to devastate tree stands across the Northeast. Opportunistic plant species, such as Japanese knotweed and Oriental bittersweet, have already altered many of our riparian ecosystems, by outcompeting vegetation that wildlife depends upon for food.

The southern pine beetle has been expanding into the Northeast due to rising temperatures, posing significant economic and ecological risks, including shifts in forest structure and threats to native biodiversity. Photo by Erich Vallery, USFS.





Natural Resources & Habitat: **Extreme Weather**

Natural resources and habitat are impacted by hurricanes, tropical storms, tornadoes and microbursts primarily through flooding and wind damage. If the storm spreads pollutants, through floodwater for example, contamination can disrupt food and water supplies for species in that area — including humans. High winds may fell trees and vegetation, risking loss of human and animal life. On the other hand, fallen trees can also become habitat for fungi, plants and animals, providing nutrients for the regrowth of disrupted forests and ecosystems through their natural decomposition.

Downed patches of forest are more susceptible to opportunistic/invasive vegetation, such as Japanese barberry. Barberry also poses a risk to human health, as it's widely considered one of the main contributors to Lyme disease. Studies done by the University of Connecticut and the Connecticut Agricultural Experiment Station found that forests infested with Japanese barberry had 12 times more deer ticks than forests that were not: they observed 120 disease-infected ticks per acre in forests with barberry, compared with just 10 infected ticks per acre of forest without barberry.¹⁰ **Thanks to deer's**

distaste for its harsh chemicals and spiny branches, Japanese barberry thrives while other plants get shaded out or nibbled to the ground. Barberry also has foliage that's denser than most native species: as a result, the plants retain higher humidity levels — key to tick survival. The shrubs also provide nesting areas for white-footed mice and other rodents, primary carriers for Lyme disease.

Impacts to natural resources and habitat from severe snowstorms are relatively few, as our ecosystems are well adapted to winter conditions. Severe snowstorms that include heavy, wet snow or ice have the potential to cause tree trunks to snap under the weight of accumulation. In 2008, a severe winter storm that included significant icing caused widespread damage and loss of trees in the hill towns of the Watershed. The aftermath might include large gaps in forest cover, leaving them vulnerable to opportunistic species, as previously detailed. Additional wood loading from downed trees can also elevate the risk of forest fires, and contribute to problems with culvert blockages, leading to flooding.



A 2008 microburst downed large swathes of trees in the Town of Whately and left about 2,000 people in Berkshire, Franklin and Hampshire counties without power.



Pulling is an effective way to remove barberry, and avoid the negative health and environmental impacts that herbicides have. Photo courtesy Virginia Native Plant Society.

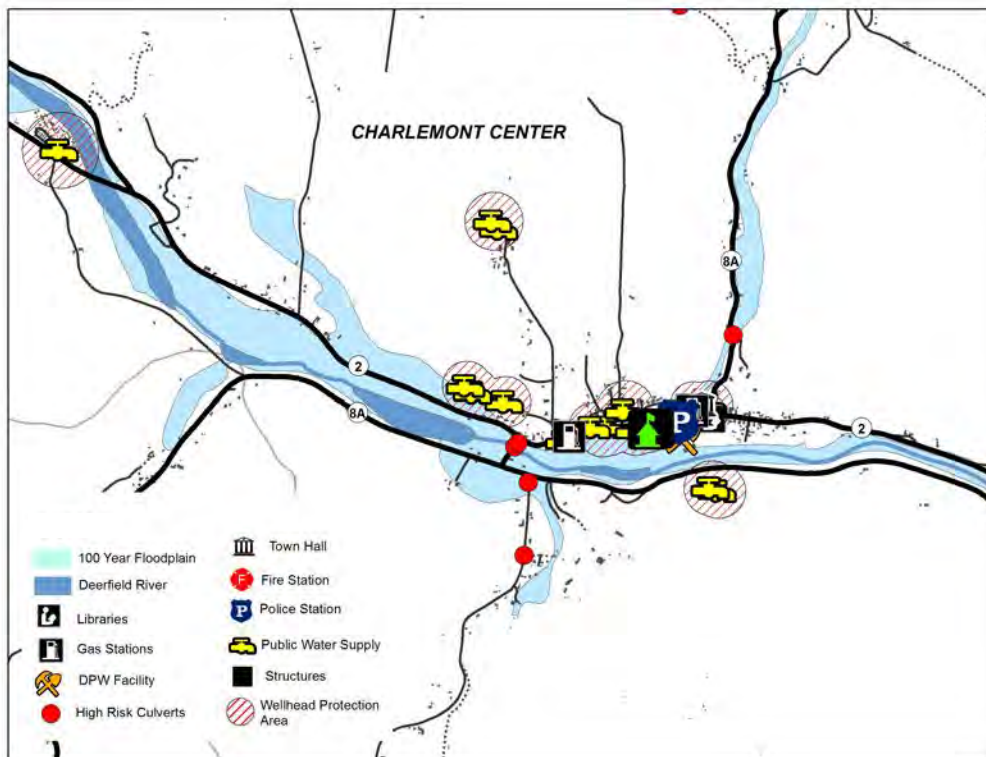


Human Health & Welfare

are also threatened by a changing climate. Increased flooding, episodes of drought, heat waves, invasive pests, storms and other extreme weather events all present a number of risks to human life and well-being. Water supplies in the rural communities of the Watershed, where nearly one-third of residents depend upon private wells, are particularly vulnerable to drought, and drinking water quality can also be compromised by flooding. Flooding also presents an immediate threat to individuals living or traveling within the 100-year floodplain. **As the Earth’s climate changes, extreme floods now described as “100-year” and “500-year” events are expected to become more frequent.** According to Michael Mann, a climate scientist at Pennsylvania State University, “What used to be, say, a 1,000 year event is now, say, a 30 year event, and will eventually become an event we see every few years if we continue on the course that we’re on.”¹¹

Climate change is causing 100-year floods to occur more frequently.

The estimated population of residents in the fourteen towns of the Deerfield River Watershed that are living in the 100-year floodplain is 641 people, approximately 2% of the total population of the towns. Of those 641 residents, many are high risk or “vulnerable” members of the population, such as seniors age 65 and older, and low-income household members who may not have access to a vehicle or back-up energy supply in the event of an emergency. Heat waves, hurricanes, storms and other extreme weather events can also pose a higher risk to more vulnerable Watershed residents. For example, 19% of Watershed residents are seniors; 14% have disabilities; 53% are obese; 17% have cardiovascular disease; and 14% live alone.



The village center of Charlemont exemplifies typical development patterns in the Watershed, where many key services and critical public infrastructure are located in or near the floodplain.



Human Health & Welfare: Changes in Precipitation

Flooding of rivers and streams threatens the lives and safety of Deerfield River Watershed residents, and floods are among the deadliest of all weather-related hazards in the United States.¹² According to MEMA, six inches of moving water can cause adults to fall, while one-to-two feet of water can sweep cars away.

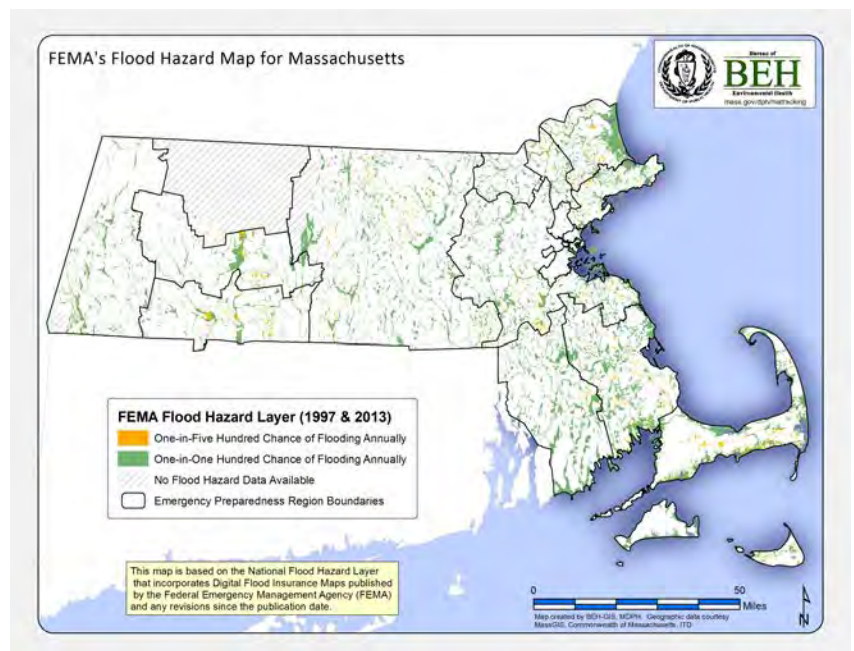
Flood water can often contain a wide range of infectious organisms, including intestinal bacteria, Hepatitis A, and agents of tetanus.¹³ Floodwaters may also carry agricultural, industrial and/or hazardous chemicals from under- or above-ground storage tanks that are compromised or carried away. Seeking shelter from storm events when advised is considered far safer than remaining in threatened areas, according to MEMA.

Flood events can also have significant impacts even after the initial event is over. Areas that have been flooded and that do not drain properly can become breeding grounds for mosquitos, which can transmit a number of diseases. The growth of mold, which can cause allergic reactions and exacerbate existing health problems such as asthma, can often be present in buildings for months after a flood.



An industrial storage tank floats down the Deerfield River in Shelburne Falls during Tropical Storm Irene. Photograph © John Elder Robison all rights reserved.

Mapped flood hazard areas are smaller than the areas impacted by flooding today: FEMA flood maps have not been updated for Franklin County since 1980.

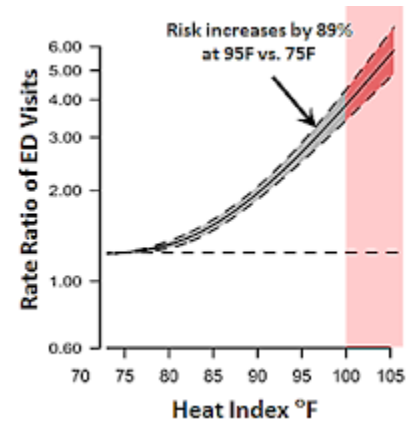




Human Health & Welfare: Rising Temperatures

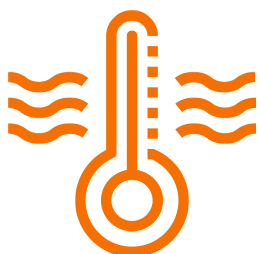
Rising temperatures are often associated with reduced air quality, because they cause higher levels of ground-level ozone and other pollutants. Individuals with pre-existing respiratory and cardiovascular conditions will be the most susceptible to reduced air quality, and vulnerable populations, such as seniors, children and the economically challenged who may not have access to adequate health care. Builders, landscapers, and others who work outdoors will be disproportionately impacted as well.

Deerfield River Watershed residents may be unprepared for heat hazards because historically, heat waves have been rare in the region, and many homes lack air conditioning. High temperatures can also contribute to deaths from heart attacks, strokes, and other forms of cardiovascular disease, and can increase visits to emergency rooms. Higher temperatures and shorter winters can also impact human health by providing favorable conditions for increases in vector-borne illnesses, such as Lyme disease.



Left: The OSHA-NIOSH Heat Safety Tool is a smartphone app that allows workers to calculate the “heat index” for their worksite, and displays a “risk level” for outdoor work. Users can get reminders about protective measures they can take to ensure workers are safeguarded from heat-related illness. Right: Relationship between heat index and hospital emergency department (ED) visits. As temperatures rise, so does the risk. Source: Massachusetts Environmental Public Health Tracking.

Those most at risk for the impacts of higher temperatures include the elderly, children, individuals with underlying physical and medical conditions, and those living in poverty. In the towns of the Watershed, there are nearly 3,500 households with incomes less than \$25,000/year, and nearly 7,000 residents age 65 and older. As heat-related illnesses increase, so too will demand for treatment. Local boards of health, first responders and public service agencies will be particularly impacted by these demands in their services.



Rising
Temperatures



Invasive
Pests



Increased
Risk of Disease

Climate change stresses the vulnerabilities of members of the population by amplifying the intensity and frequency with which risks to their health and well-being may occur. In this example, tick numbers expand as a result of rising temperatures, increasing the risk of Lyme disease and other co-infections in humans.



Heavy snow and winter storms, such as the 2008 ice storm, can cause widespread damage to trees and powerlines, and pose risks to human lives and health.



Human Health & Welfare: **Extreme Weather**

Severe winter storms impact human health primarily in the form of automobile accidents, overexertion, and exposure. The elderly, according to MEMA, are considered most susceptible, due to their increased frailty. Falls, overexertion, and hypothermia from attempts to clear snow and ice, or from losing heat due to power failures, all pose serious risks to the elderly. Exposure to extreme cold can also exacerbate pre-existing respiratory and cardiovascular conditions.

Immediate danger from extreme weather events such as hurricanes and tropical storms includes downed powerlines, sharp objects in the water, fast-moving debris or animals such as snakes that may be moving in or near water. Hurricanes and tropical storms can also harm mental health, causing widespread anxiety, depression and post-traumatic stress disorder (PTSD). Children, in particular, can be vulnerable to mental health issues in the wake of extreme flooding and displacement.



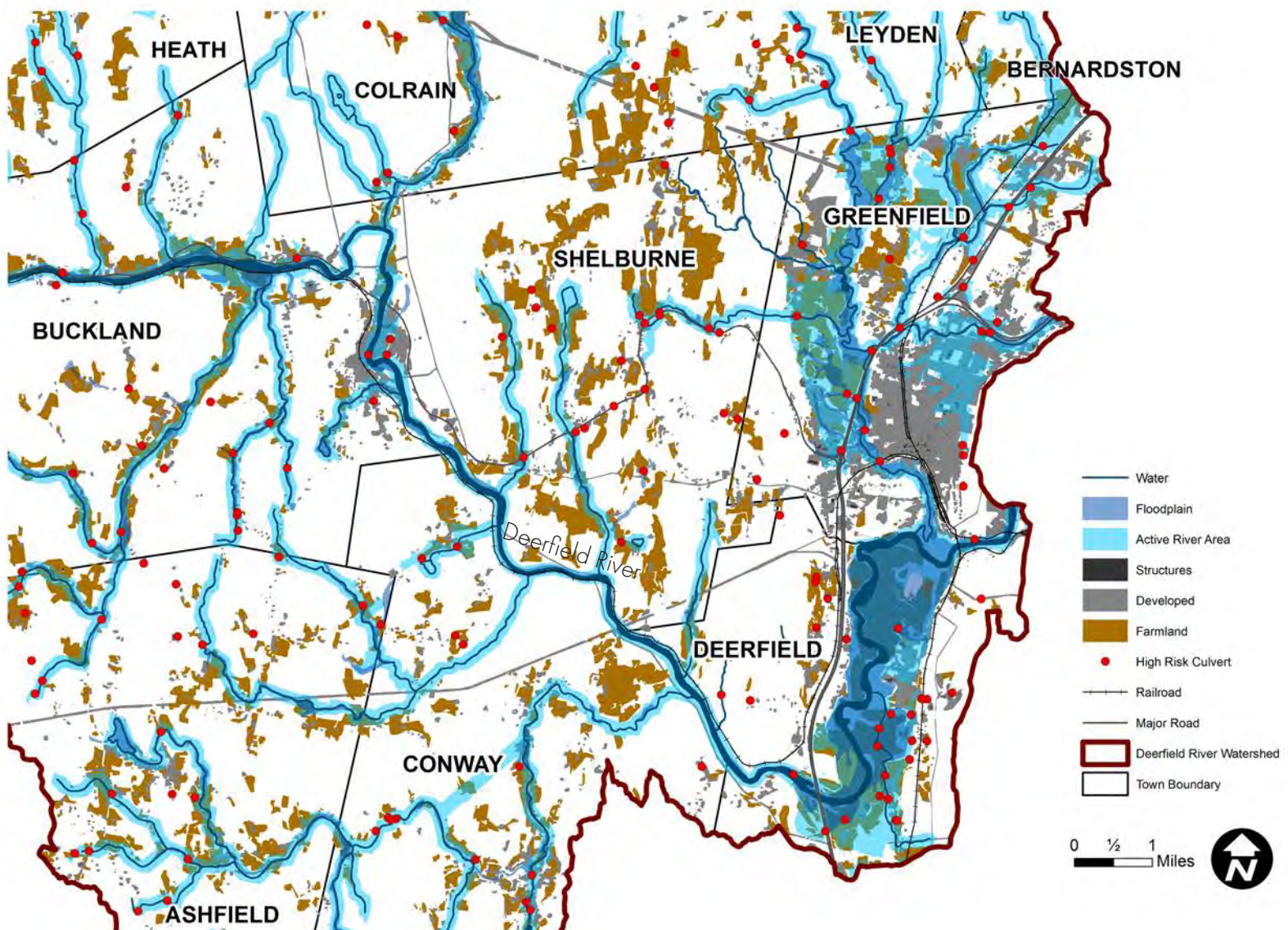
Nurse Lisa White (left) takes a blood pressure reading at the Deerfield clinic as part of the Cooperative Public Health Service (CPHS), a regional health department serving eleven towns in Franklin County, ten of which are in the Deerfield River Watershed. The Boards of Health of the towns of Buckland, Charlemont, Hawley, Heath, Leyden, Rowe, Shelburne, and Monroe share a regional Health Agent through the district. The same towns, plus Conway and Deerfield, share a public health nursing program as well.



Local Economy & Infrastructure

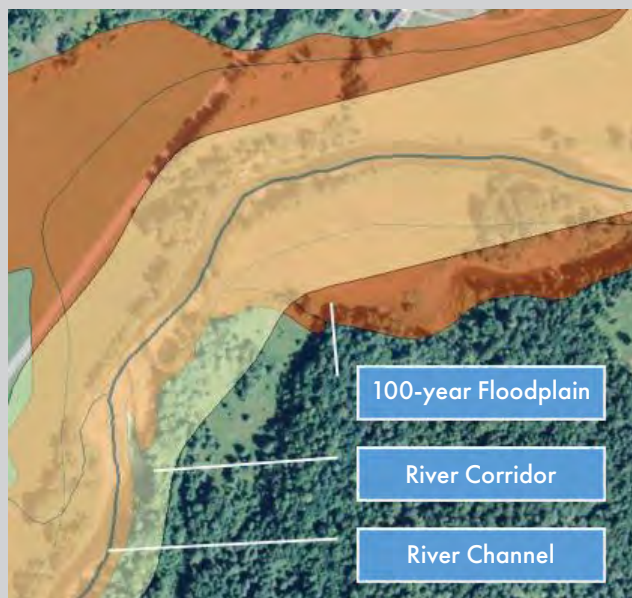
The local economy in the Deerfield River Watershed has already felt significant strains from the impacts of climate change. As mentioned earlier, **Tropical Storm Irene cost eight towns in the Watershed over \$48 million in damages.** According to data in the Multi-Hazard Mitigation Plans for the Watershed towns, there are **270 homes or dwelling units and 10,408 acres of land within the 100-year floodplain** of the towns in the Watershed. The assessed value of just the residential, industrial and commercial land within this flood zone is over \$113 million dollars, while **the total value of buildings in the floodplain for just half the towns in the Watershed is nearly \$1 billion dollars** (data is only available for seven towns). Of 933 stream crossings (culverts and bridges) assessed within the Watershed, over one-third (337) have a high risk of failure. The most recent bids for replacing a culvert in Franklin County range from \$400-800,000 dollars each (FRCOG). Additionally, there are 18,284 acres of agricultural land in the Watershed, of which 2,075 acres (over 11%) are within the “River Corridor/Flood Hazard Area” – an area that includes the 100-year floodplain, the mapped river corridor, and a 200-foot buffer along all streams.

Infrastructure and Farmland Vulnerable to Flooding in the Deerfield River Watershed (detail)



River Corridors and Floodplains

River Corridors and floodplains are different but related. The River Corridor is the area that provides the physical space that the river needs to express its energy and meander without causing it to dig down. A floodplain is the area where water flowing out over the river bank spreads out. River Corridors and floodplains overlap a great deal. However, there are areas in the River Corridor that will be eventually shaped by erosion — but are currently high and dry — and other areas in the floodplain that will be under water during a large flood even though the river channel may not need to access this area to maintain equilibrium. Together these areas describe the dynamic area affected by channel changes and/or by the extent of flood water.¹⁴



From more flood-prone river corridors, to rising temperatures and extreme weather, our region's shifting climate will require local government and industries to move quickly to adapt to change. Agriculture, forestry, recreation and tourism industries are all weather-dependent. Much planning has been based on historic weather patterns which climate change will disrupt. Adapting to these changes quickly will be key for all sectors of the local economy.¹⁵

The rivers of the Deerfield River Watershed attract numerous sport fishermen each year. But climate change is projected to impact the water quality of coldwater fisheries, threatening the long-term viability of this important sector of the local economy.



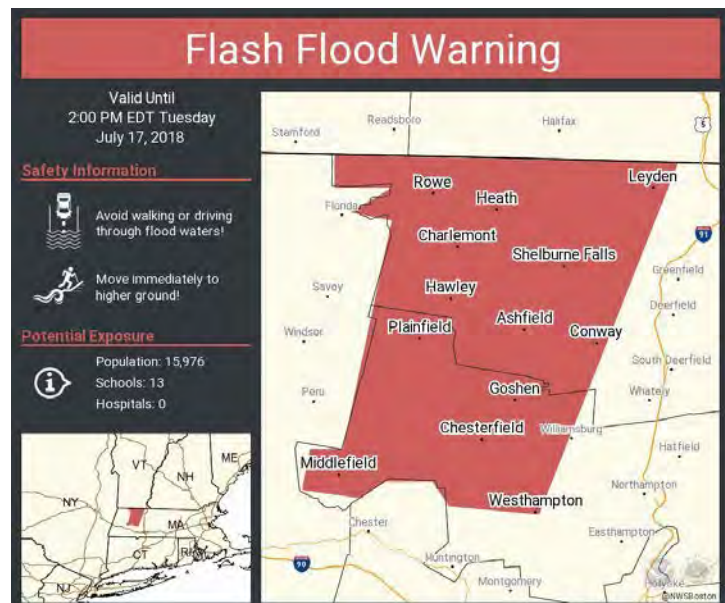
Avoiding new encroachments within river corridors, where meanders, bed forms, wooded banks, and floodplains function to dissipate flood energy and distribute flood deposits, is the least-cost method of mitigating flood damages.



Local Economy & Infrastructure: Changes in Precipitation

Although the extensive damages caused by Tropical Storms Tammy and Irene are well remembered, it is the more frequent flash flooding towns experience multiple times a year that routinely strains municipal budgets and impacts businesses. Changes in rain amount, intensity and frequency cause road closures and delays, as well as crop and soil losses for farmers. These heavy rain events have sometimes occurred during years of drought, so farmers have had to grapple with two precipitation extremes during the same growing season. During the historic 2016 drought, crop yields were down for most producers, and field crops like hay and corn suffered, affecting dairy farmers and others who raise animals. Topsoil was the driest in 20 years and the drought conditions across New England and New York were the driest since the 1960s.¹⁶

Yet earlier that same year, on February 25, 2016, a series of severe thunderstorms caused extensive flash flooding from the Green River in Greenfield, forcing multiple road closures.¹⁷ By mid-May the entire state was



Top of page: The Village of Shelburne Falls during Tropical Storm Irene © John Elder Robison all rights reserved. Above left: Drought on a corn farm in Old Deerfield by Paul Franz/The Recorder. Above right: Flash flood warning, July 2018 courtesy of the National Weather Service.



entering a period of severe drought that continued into mid-April 2017. Again in October of 2017, Watershed towns were experiencing abnormally dry conditions. Then on October 30, 2017, a storm dumped over 4 inches of rain in Hawley and Rowe and caused flooding in Greenfield. The Green River flowed over Nash's Mill Road and water was 1 ½ feet deep. When severe rainfall occurs during periods of drought, flooding is often more extreme, as dry ground is unable to absorb sudden large quantities of water.

Extreme and unpredictable rain also affects agritourism, a growing economy in our region. According to the 2011 *MA Climate Change Adaptation Report*, **the number one impact on most Massachusetts retail farm sales is weekend weather**, because poor weather reduces the volume of customers shopping at farms and farmers markets. Natural resource-based tourism providers will also see a shift in business, as heavy rain events in the winter reduce snow cover and hinder recreational activities dependent upon such conditions, including skiing and snowmobiling.

Heavy precipitation, coupled with milder winters, can reduce the number of days foresters are able to cut timber, as operating logging equipment typically requires frozen ground to minimize soil damage. Intense rainstorms also increase the costs of erosion control on logging sites, with profound ecological

impacts. Certain valuable tree species may no longer thrive in our area as heavy rainfall and higher temperatures change the species of our forests.

Businesses and local governments whose buildings and infrastructure are located near rivers, streams or within floodplains, will experience more flooding and damage to their facilities as a result of heavier precipitation and more extreme storm events. Public infrastructure maintenance upgrades will be necessary more often, as flooding undermines and/or destroys structures like culverts and bridges. Local governments and first responders may experience increased responsibilities related to disaster response, preparedness and planning.

Flooding can also interrupt utilities and cause the failure of wastewater treatment facilities. In the Town of Charlemont, **a small municipal wastewater treatment plant serving 450 users cost \$800,000 to repair** as a result of flooding damages sustained during Tropical Storm Irene.¹⁸

In instances where damages to infrastructure are overwhelming, access to food and supplies can be limited or cut off entirely. Increased intensity of precipitation also threatens dams. MassGIS lists 58 dams in the Watershed, most of which were designed to control floodwater volumes and velocities based on historic weather patterns and data.

Flooded farmland (above) and downed irrigation infrastructure (below) in Deerfield following Tropical Storm Irene. Courtesy of the Town of Greenfield (top) and the Recorder (below).





Local Economy & Infrastructure: **Rising Temperatures**

As summers become hotter, growing seasons for agricultural crops will likely lengthen. Downscaled data for the Watershed shows that the shoulder seasons of spring and fall are expected to see an increase in growing days. While there is some potential for benefit to certain crops, longer growing seasons and warmer winters will also be associated with increased weed and pest pressure, as these species emerge earlier and in greater numbers. Farmers will be challenged to respond quickly to these changes, and may opt to change some of the crops they grow, in order to maximize their farmland's productivity in the face of climate change.



Warming temperatures are also projected to increase drought risk, which endangers crops as well as livestock, and increases the risk of wildfire by the warming and drying out vegetation. Higher temperatures will also intensify farmers' dependence on irrigation, which may pose a risk to local groundwater supplies. Warmer winters can increase frost/freezing damage, such as when a prolonged warm period in late winter or early spring causes premature leaf-out or bloom in fruit and other perennial crops, followed by a refreeze. Fluctuating temperatures, such as extreme warm/cold shifts, can have devastating effects on food crops in general.

Maple sugaring, another significant agricultural economy in the Watershed, relies upon sustained springtime freeze and thaw cycles. Such cycles are expected to become less common, reducing the amount of maple syrup farmers and other producers are accustomed to generating.

Key infrastructure is also impacted by extreme heat. In the transportation sector, increased temperatures can accelerate the deterioration of asphalt roads, buckle railroad tracks and cause the thermal expansion of bridges, all resulting in a need for more frequent maintenance. Warmer temperatures and more frequent heat waves will likely result in increased energy consumption for cooling. These increased cooling needs may strain energy infrastructure, especially during periods of peak demand. Disruptions in service — including the potential for brownouts or blackouts — may be caused as a result.



Top of page: A 2016 Pan Am train derailment in Buckland. Most railroad infrastructure in the Watershed is aging and vulnerable to extreme temperature fluctuations that cause rail lines to expand and contract, which can cause derailments. Photo by Perry Fuller. Center: In late winter 2016, extreme cold froze the buds on peach trees, causing a complete loss of peaches in Western Massachusetts. Photo by Paul Franz. Bottom: Maple tapping at Williams Farm in Deerfield. Photo by Peter McDonald.



Local Economy & Infrastructure: **Extreme Weather**

In October of the same year as Tropical Storm Irene, the Halloween Snow Storm dumped heavy, wet snow across the region, with the Town of Shelburne receiving over 21 inches. More than 700,000 people in Western Massachusetts were left without power, and thousands of miles of roads were closed due to dropped tree limbs and snow accumulation. While rising temperatures associated with climate change mean that more precipitation is likely to fall as rain than as snow, **historical data shows that the frequency of extreme snowstorms in the U.S. doubled between the first half and the latter half of the 20th century.** This analysis also reveals that warming temperatures are exacerbating the severity of winter storms, because warming water in the Atlantic Ocean allows additional moisture to flow into the storm, fueling greater intensity storms.¹⁹ These severe snow storms will likely bring ice, sleet and freezing rain, as well as blinding wind-driven snow and extreme cold temperatures.

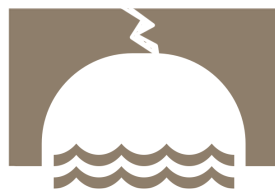


Nor'easter Riley approaching Massachusetts, March 2018. Source: NOAA.

Disruption to power transmission lines can also be caused by high winds. With hurricanes and tropical storms, buildings can be destroyed, or extensive damage can occur to roofs, windows and siding. Towns may be left dealing with large amounts of debris, including downed trees, power lines, and materials from damaged structures. Severe snow storms can also serve to immobilize a region, shutting down roads, disrupting emergency services and power supplies. Local governments may experience increased pressures and responsibilities related to disaster preparedness, sheltering of residents and debris clean up and storage.



Extreme
Weather



Aging
Infrastructure



Public Safety
Risk

The cost of snow and ice removal, and road repair from freeze/thaw processes can stress the resources of our small towns. Snow storms also impact local economies and government, with utility outages, road closures, loss of business function and/or income often resultant. For outdoor recreational businesses, customers may avoid visiting areas impacted by extreme weather, even if individual businesses are not affected. A region's economy can suffer if there is a perception that damage from extreme weather is worse than it actually is.

Despite the many risks that climate change poses to the land, waters and wildlife of the Deerfield River Watershed, its layers of infrastructure, and its citizens, it still remains a region well-suited to adaptation. With a strong foundation of healthy, diverse habitat and abundant natural resources, close-knit rural communities, and organized, proactive local governments who are at the forefront of community resilience building and hazard mitigation planning, the fourteen Franklin County towns in the Deerfield River Watershed are, as a whole, very lucky. Yet, there still remains work to be done.



Photograph of the Deerfield River by Matthew MacPherson.

Part 3: Strengths & Vulnerabilities



Natural Resources & Habitat

Descriptive Numbers

- Land in the Franklin County portion of the Deerfield River Watershed: 242,094 acres
- Permanently protected land: 69,294 acres
- Forested land: 183,104 acres
- Farmland: 18,284 acres
- Prime farmland soils: 29,092 acres
- Developed land: 18,499 acres
- Impervious surfaces: 6,992 acres
- Rivers, streams & wetlands: 11,321 acres
- Land in the river corridor (100-year floodplain, mapped river corridor and 200-foot buffer along streams): 23,653 acres
- Land in the river corridor that is permanently protected: 4,171 acres
- Land in the river corridor that is forested: 13,572 acres
- Land in the river corridor that is developed: 862 acres
- Land in the river corridor that is impervious: 656 acres
- Land in the river corridor that is farmed: 2,075 acres
- BioMap2 Critical Natural Landscape: 89,481 acres
- BioMap2 Forest Core: 18,000 acres
- BioMap2 Aquatic Core: 6,700 acres
- BioMap2 Aquatic Upland Buffer: 11,610 acres
- Threatened or Special Concern animals: 84 species
- Threatened or Special Concern plants: 73 species
- Endangered plants: 59 species
- Greatest source of aquifer recharge: uplands (70%)
- Public water supplies: 111
- Public water supplies with inadequate delineated protection areas: 80+
- High-quantity water users: 8
- Largest water user: Greenfield Water Department (2.12 million gallons daily)

BioMap2 is a collaboration between MassWildlife's Natural Heritage and Endangered Species Program (NHESP) and The Nature Conservancy. The project is a conservation plan to protect the state's biodiversity in the context of climate change by mapping significant natural communities, as well as threatened plant and animal species.

Strengths

Intact Forests and Habitat

With 76% of the Deerfield River Watershed under forest cover, 7% intact forest, and 29% of the land permanently protected, the region is poised to be highly resilient to many of the projected impacts of climate change. Research suggests that forest systems are best able to absorb and respond to disturbances and environmental changes if forest habitats are contiguous, because this connectivity supports biodiversity and plant and animal migration, essential parts of forest resilience.¹ Nearly half of the Watershed is BioMap2 **Critical Natural Landscape**, large areas of intact, predominantly natural vegetation, including contiguous forests, wetlands, rivers, lakes, and ponds. These unfragmented forest and wetland habitats not only support richness in plant and animal species — crucial in an era of unstable climate and exotic pests and pathogens — but they also sequester carbon, purify air and water, regulate air and water temperatures, and provide lumber, firewood, and a host of food-related products, including maple syrup, fish, and game. In addition, forests and wetlands provide recreational and tourism opportunities, and rural quality of life for residents. The areas of BioMap2 **Forest Core**, located in the central and western parts of the Watershed, identify the best examples of large, intact forests that are the least impacted by roads and development. These areas total 18,000 acres in the Watershed. Forest Core areas are important for ecosystem health and biodiversity, water filtration, and flood storage. About 40% of the BioMap2 Critical Natural Landscape and about 60% of the Forest Core are permanently protected in the Watershed.²

Fertile Farmland

As mentioned earlier, farmland in the Deerfield River Watershed is some of the best in the world. Land along the expansive Deerfield River floodplain, and in the flatter areas of the Watershed as a whole, is particularly excellent cropland. Upland areas also support a range of activities, including fruit and nut orchards, pasture lands, and apiaries. These native food sources are increasingly valuable assets of

climate resilience, as food prices rise along with transportation costs, and shifting environmental stressors oftentimes make it easier to meet nutritional needs locally. Compared to the primarily corn, soybean, and livestock economies of the Midwest, farms in Massachusetts are quite diverse, producing dairy products, vegetables, nursery crops, livestock, herbs, cut flowers, hay, garlic, trout, maple sugar, orchard fruits, eggs, honey, and wood.³ While approximately 18,300 acres of the Watershed are presently farmed, there are approximately 29,000 acres of mapped prime farmland soils. Prime farmland soils require less inputs to produce more food, which means that farming these lands may be more climate resilient as well as economically sustainable.

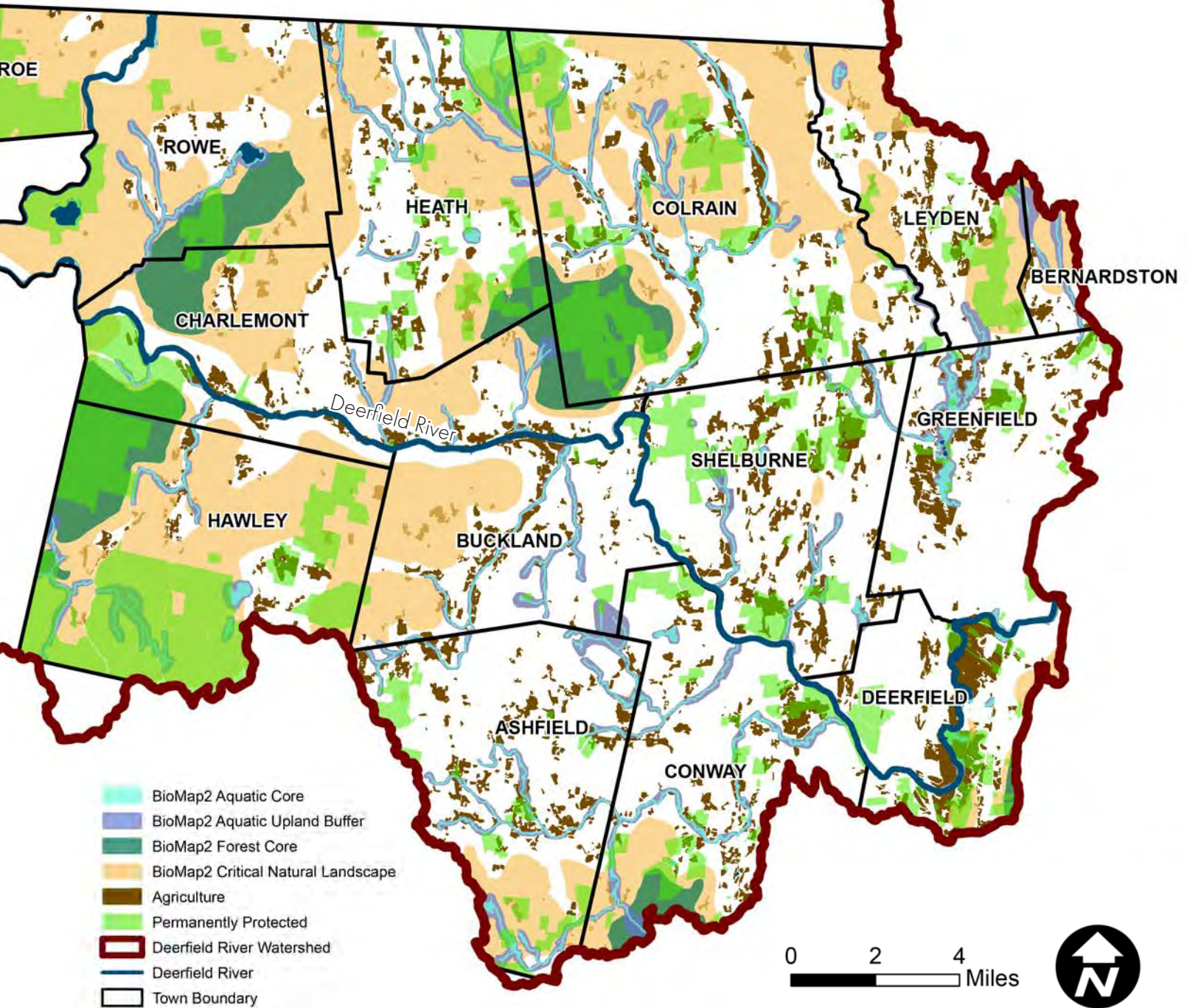
Abundant Water

Towns in the Watershed and their residents are fortunate to have predominantly clean, plentiful surface water — rivers, streams, wetlands and ponds — that crisscross their landscapes. These waterbodies provide local drinking water sources, irrigation, habitat for aquatic life and places for people to fish and recreate. There are also readily available underground aquifers that recharge public water supplies as well as private wells. The region typically receives enough precipitation throughout the year to recharge our rivers, streams and aquifers, to help provide drinking water, irrigate agricultural crops and to keep forest ecosystems robust.



BioMap2 and Permanently Protected Areas of the Deerfield River Watershed

Vermont



BioMap2 **Aquatic Core** identifies intact river corridors within which important physical and ecological processes occur. These areas are determined by buffering each river segment by 30 meters, and include all wetlands contained in whole or partially within these buffers. There are 7,200 acres of BioMap2 Aquatic Core in the Watershed, 21% of which are permanently protected. There are also 11,610 acres of BioMap2 **Aquatic Upland**

Buffers: these help to support the functionality of wetlands, streams and rivers, and the species that depend upon them. 28% of these upland buffers are permanently protected in the Watershed.

Vulnerabilities

Development in the Floodplain

Most development in the Watershed was historically within and adjacent to the 100-year floodplain of the Deerfield River and its major tributaries. The same is true for the mapped river corridors of the South, North and Green Rivers. Development adjacent to rivers inevitably creates an increase in impervious cover, as forest and natural ecosystems make way for roofs, lawns, driveways, roads and the like. This reduces flood storage capacity within the floodplain, causing localized flooding and erosion damage to infrastructure, homes and businesses. Changes to the river itself, such as straightening or relocating the channel, and/or installing berms and dams, continue to exacerbate flooding and erosion problems today, even if these alterations occurred decades ago. Water quality and habitat are also degraded by these modifications to the active river area. Undersized or failing road stream crossings also contribute to flooding and erosion hazards in the floodplains, as well as in upland tributary and headwater streams. Undersized/failing culverts and bridges can also become obstacles to fish and wildlife movement, thereby limiting habitat and food source availability for species up the food chain.⁴

Flooding and stormwater runoff can become a source of pollution in the more developed areas of the Watershed. Roofs, streets, and parking lots prevent rain from soaking into the ground, and as stormwater drains through gutters, storm sewers, and other engineered collection systems, it is discharged (oftentimes with minimal or no treatment) into nearby water bodies. This runoff often carries trash, chemicals, hydrocarbons, bacteria and other pollutants from the developed landscape. Higher flows resulting from heavy rains can also cause erosion and flooding in urban areas and village centers.⁵

Farming in the Floodplain

Farming is a way of life as well as a livelihood for many residents of the Deerfield River Watershed. **While farms thrive in the nutrient-rich soils of floodplains, their coexistence with rivers is seldom harmonious.** Not only are many agricultural fields vulnerable to damage from severe

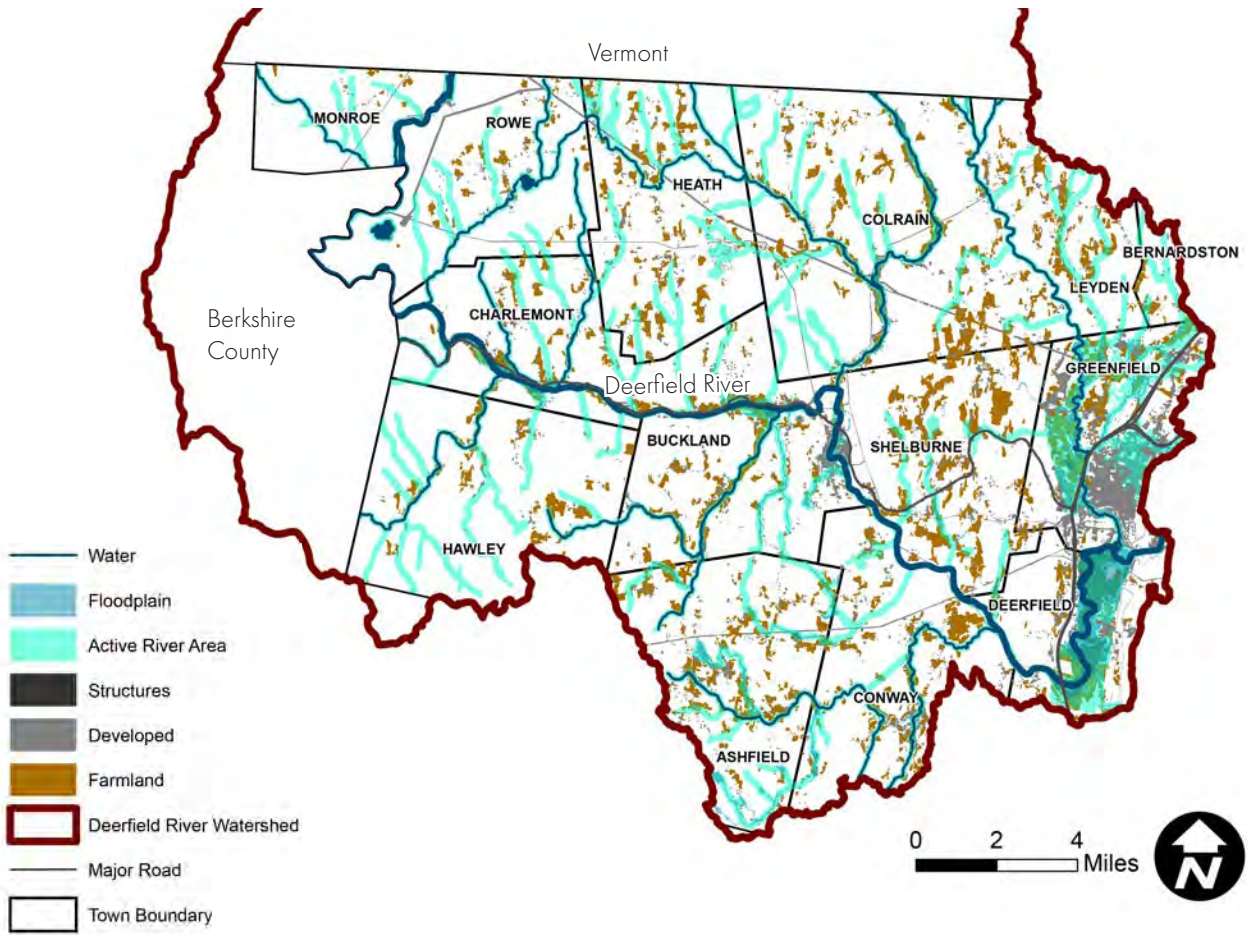
flooding — as witnessed during Tropical Storm Irene — but without adequate riparian buffers, they can also impair adjacent rivers via sedimentation from soil erosion and pollution from runoff. There are 2,075 acres of farmland in the river corridor of the Watershed, or 11% of farmland.

Rich, productive farmland helps sustain rural families and contributes greatly to our local economy, however climate change is likely to impact farmers and their land, as detailed in previous sections of this report. Thankfully, there are many innovative approaches to farming which have been shown to not only benefit riparian ecosystems, but also to be more resilient to climate change impacts such as drought, flooding and extreme weather. Among those approaches are forested riparian buffers, reduced and no-till agriculture, agroforestry, increased perennial crops, drainage and ditching systems and intercropping. More on emerging strategies will be discussed in **Part 4: Building Resilience**.

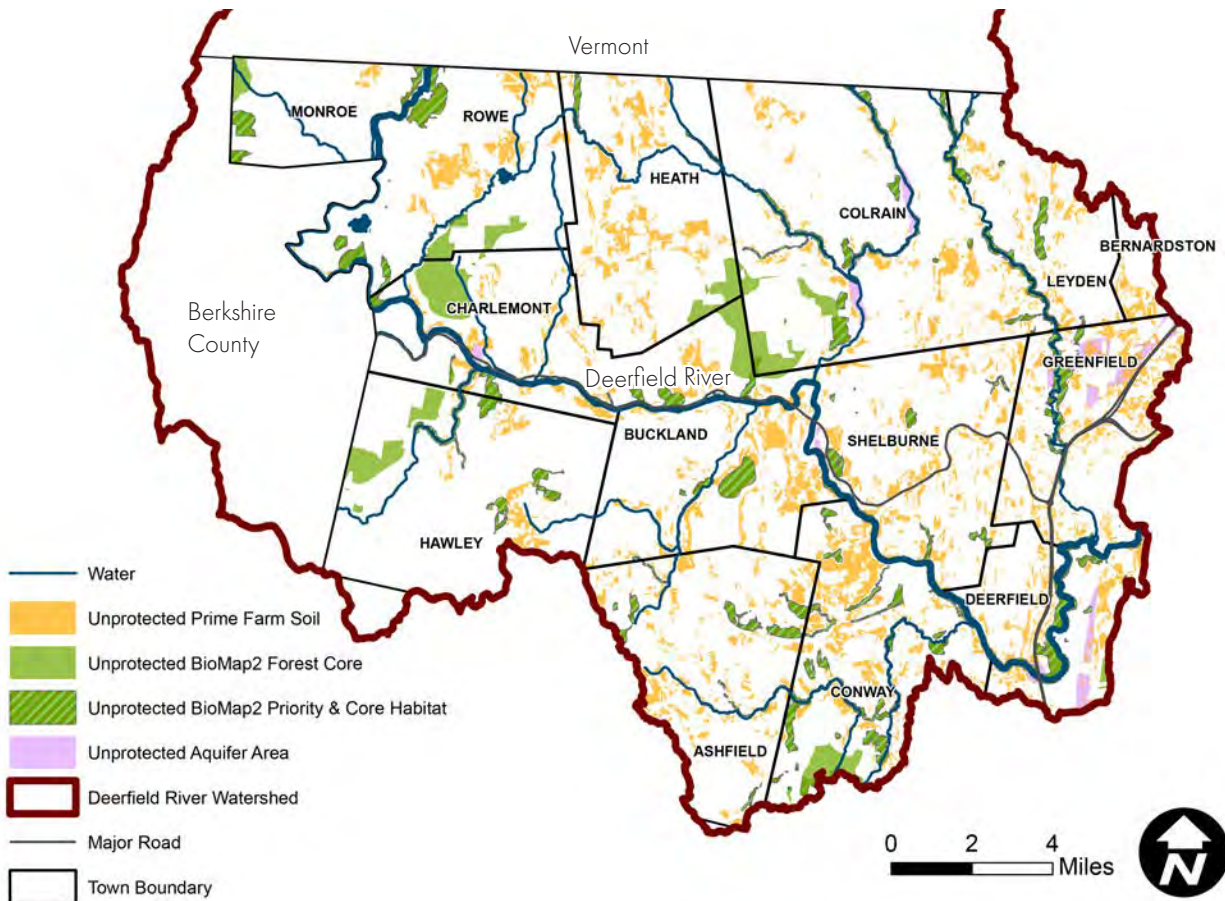
Forested Land and Habitat

While forests are one of the Watershed's greatest assets in the face of climate change, they are also vulnerable to its impacts. **Climate change, in conjunction with other stressors, will alter forest function and its ability to provide wildlife habitat, and could reduce the ability of forests to provide ecological services such as air and water cleansing.**⁶ With changing temperature and precipitation patterns, the predominantly maple-beech-birch and oak-hemlock-pine forests of the Watershed will slowly become dominated by oak and hickory. As cold-adapted trees like sugar maple struggle and eventually die out, managing and planning for disturbance from pests and pathogens will be increasingly necessary, as will concerted efforts at climate-resilient forestry. **The best way to guarantee resilience in forests is to maintain unfragmented blocks of acreage.**

Development and Farmland in Flood-Prone Areas



Opportunities for Protection of Key Landscape Features



Franklin County is one of the poorest in the Commonwealth, with a per capita income of \$33,010, which is 83% of the state average. The region has faced significant hardship as the manufacturing industry has departed in recent decades. But organizations like Just Roots are developing innovative strategies to feed families and build community: the Greenfield Community Farm that they run provides fresh vegetables to roughly 300 residents of Franklin County, 60% of whom are low-income. Their model is “Farm to Everyone’s Table.” Photograph by Timothy Shivers.





Human Health & Welfare

Descriptive Numbers

- Percentage of Deerfield River Watershed residents who are elderly: 19%
- Who have one or more disabilities: 14%
- Who live alone: 14%
- Who live alone and are elderly: 5%
- Who are elderly and have cardiovascular disease: 17%
- Percentage of Watershed residents over age 20 with diagnosed diabetes: 9%
- Percentage of children in the Watershed with asthma: 21%
- Percentage of Franklin County residents with limited access to healthcare: 17%
- Who are obese: 53%
- Increase in Lyme disease cases in Franklin County between 2005 and 2016: 163%
- Percentage of Watershed residents who are food insecure: 10.2%
- Percentage of children in the Watershed who are food insecure: 16.9%
- Percentage of Watershed residents who are food access challenged: 23%
- Who are living in poverty: 11%
- Who are without a vehicle: 7%
- Percentage of Watershed housing identified as sub-standard: 10%
- Homeless Residents in Berkshire, Hampshire and Franklin Counties combined: 490
- Percentage of Watershed residents with private wells: 28%
- On public water: 72%
- With private septic: 35%
- On public sewer: 65%



Photograph by Timothy Shivers.

Strengths

Many people in the Deerfield River Watershed share certain lifestyle choices that increase their resiliency in the face of climate change and its related impacts. These ways of life make residents more self-sufficient, at least in the short term. While it is difficult to measure how many people practice each of the following, as a whole, a significant number of residents in the Watershed:

Know Their Neighbors

Many residents come from families who have been in their small towns for generations, and know each other well. This may engender more tendencies to help each other out in times of emergency.

Support Their Community

Our rural towns are run by a small number of staff that depends upon citizen volunteers to help run boards and committees. Residents serve on Select Boards, Conservation Commissions, Boards of Health and other committees. Neighbors are also connected to the town and one another through civic and religious groups. In times of emergency, they may volunteer to help staff operations or shelters.

Grow Their Own Food

Many residents farm, garden or homestead, raise

livestock, and produce other food that they eat, supplementing that which they purchase at the store.

Heat with Wood

A significant number of residents (up to half in some towns) heat their homes, at least partially, with wood which they may cut on their own property or buy from a neighbor. In the event of a winter-time power outage, their wood stoves keep their houses warm and enable them to continue cooking. They may also provide heat and sustenance to neighbors or friends who are without power.

Hunt and Fish

Some residents also supplement their grocery purchases by hunting for deer or turkey, or by fishing.

Have Private Water

About 28% of Watershed residents have private wells, and do not depend upon a public water system. In the event of a compromise of the public water supply, these residents will have safe drinking water for themselves — and potentially for neighbors and friends.

Vulnerabilities

Pre-Existing Health and Economic Conditions

The challenges faced by individuals with health concerns and/or economic limitations will be exacerbated by climate change. People who are already frail and/or marginalized will fare the worst. Elderly people living alone, residents living in poverty and/or in substandard housing, people who experience hunger, and people without a vehicle are among those who are likely to be disproportionately impacted by climate change.

Residents Requiring Additional Assistance

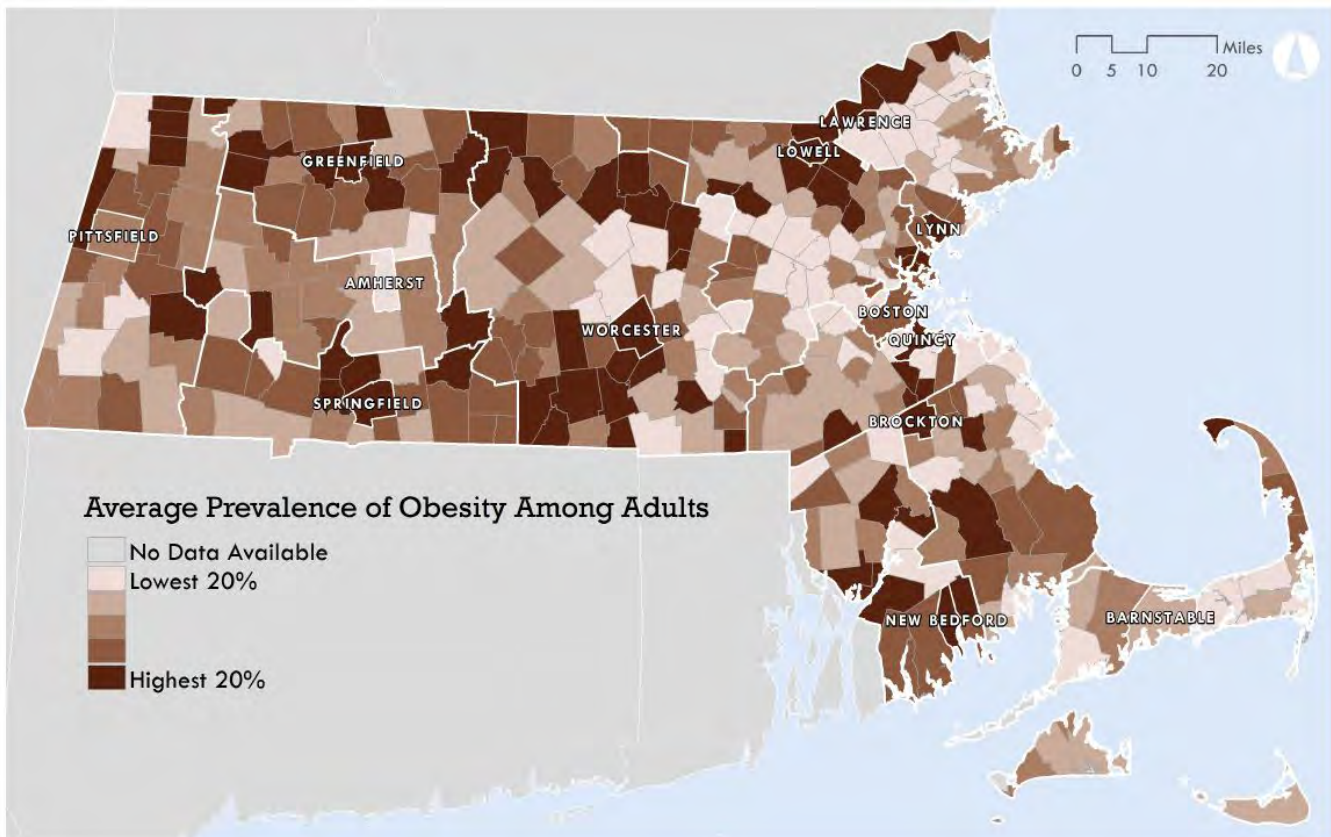
Some residents in the Watershed may require additional assistance to withstand climate change impacts such as flooding, storms and heat waves. Elderly residents are one such group. In general, elderly and infirm individuals are more vulnerable to high heat. The elderly are also more likely to suffer injury or death due to flooding and other extreme storm events, and may need assistance in order to evacuate their homes. Of the Watershed's **37,288**

residents, nearly 7,000 residents, or 19%, are over age 65. Residents with disabilities can have vulnerabilities similar to those of elderly residents. Approximately 14% of residents (about 5,000 people) in the Deerfield River Watershed have one or more disabilities.

People who live alone are also more apt to be vulnerable to extreme storms and other projected impacts. There are about 1,800 elderly people (and over 5,200 residents in all) who live alone in the Watershed. Should someone who lives alone suffer heat stroke or injury, there may be no one immediately aware of that person's situation. This emphasizes the importance of towns keeping Code Red/Reverse 911 lists up-to-date.

Residents with Health Issues

As temperatures rise, both indoor and outdoor air quality will decline, putting those with respiratory and/or cardiovascular conditions at higher risk.



Six out of fourteen towns in the Deerfield River Watershed have among the highest rates of obesity for adults in Massachusetts. Sources: Massachusetts Department of Public Health Prevention and Wellness Trust Fund Behavioral Risk Factor Surveillance System, 3-year average 2008-2010.

People with these pre-existing health conditions will also be particularly vulnerable to heat waves — and if they lack air conditioning, their conditions will be even further impacted. Those with problems breathing are also especially sensitive to molds, which may result from the flooding of homes and other structures. Children are also particularly at risk. Currently, 21% of children in the Watershed suffer from asthma, and according to the 2016 American Community Survey, 5.5% of children in Franklin County have some form of disability.

Incidence of vector-borne diseases — including Lyme disease, malaria, dengue fever, yellow fever, eastern equine encephalitis and West Nile Virus — may also rise due to climate change. According to MassDPH, Lyme disease and other tick-borne diseases are already on the increase, with 88 cases reported in Franklin County in 2016. Furthermore, the CDC estimates that just ten percent of Lyme disease cases are actually reported. In a 2017 survey of members of the Cooperative Public Health Services District (CPHS), who represent 10 out of fourteen towns in the Deerfield River Watershed, tick-borne disease was rated as the #1 climate change-related threat people were most worried about in their communities, surpassing flooding by over 15%. As changes in climate are predicted to favor the proliferation of ticks in our region, public health in general, and those with compromised immune systems in particular, will be impacted. In

many cases, Lyme disease can cause debilitating arthritis and other systemic effects on people, altering not only their health but also their ability to work and take care of themselves.

In addition to physical health, climate change may also affect the mental health and well-being of residents. Exposure to frequent storms and flooding, and being displaced from one's home, can cause stress and lead to depression and other mental health vulnerabilities. For those with pre-existing health conditions and those who are otherwise vulnerable, mental health may worsen during repeated exposures to climate change impacts.

Demand for healthcare is also likely to increase, as our population ages and existing health issues among residents are exacerbated. Unfortunately, there are already many who have limited access to healthcare in Franklin County. According to a 2016 Community Health Needs Assessment, seventeen percent of Franklin County residents live in a healthcare professional shortage area. The same assessment identified transportation as one of the top three barriers to health care for the region. While there are a number of transportation resources available for those eligible, it is oftentimes difficult for people to navigate the system and figure out what types of transportation may be available to them.

Neighbors Helping Neighbors

Shutesbury and New Salem's Med Ride programs offer free transportation to medical and dental appointments for eligible elderly residents. Drivers are volunteers who use their own vehicles and get mileage reimbursement from the state through the local Council on Aging. A regional Med Ride program for Franklin County residents needing to travel outside the county also exists through the Franklin Regional Transit Authority.



Photo by Kevin Gutting/Daily Hampshire Gazette.



Over **1 in 10** people
in Franklin County
are food insecure

Source: *Map the Meal Gap, Feeding America 2015. FRCOG/Mass in Motion.*

Residents with Income or Housing Challenges

Those living in poverty will also be at higher risk. They may live in poorly constructed housing which is less able to withstand the impacts of high winds, heavy snow or flooding. People in poverty may also lack technology that could inform them of impending extreme weather, and may lack the resources to move to higher ground should they be in the path of a flood. About 11% of the Watershed's population is living below the poverty level.

Substandard housing conditions can make people more vulnerable to climate change impacts. There are currently a total of 96 housing units (10%) in the Deerfield River Watershed that are substandard, according to the Census definition (overcrowded and/or lacking complete plumbing or kitchen facilities). However, since census data is self-reported, the number of homes with health and safety code violations due to structural defects, substandard plumbing or electrical systems, failing septic systems and other health hazards such as mold, may be higher.

People who are homeless are particularly vulnerable. Data on homelessness is not readily available at the town or county level in Massachusetts, since the shelter system is operated at the state level. In 2014, there were 490 homeless people in Berkshire, Hampshire and Franklin Counties combined. There are six family shelter spaces in Franklin County which have been consistently full for many years.

Residents with Food or Transportation Challenges

About seven percent of residents in the Deerfield River Watershed lack access to a vehicle. These individuals will have a greater challenge evacuating their homes in the event of a severe weather event. Additionally, the majority of the towns in the Watershed do not have public transit, making it even more difficult for people without a vehicle to respond to an emergency. Ashfield, Bernardston, Colrain,

Conway, Hawley, Heath, Leyden, Monroe and Rowe all lack fixed-route public transit.

People without a car or access to public transit can also have greater challenges reaching a grocery store, food pantry, or other place to obtain food. In Franklin County, over 10% of people are food insecure — defined as being without reliable access to a sufficient quantity of affordable, nutritious food. Nearly 17% of children are food insecure as well. These individuals may depend upon going to a food pantry on a particular day each week to obtain the groceries they are planning on eating that week. In the event of a storm or severe weather event, they may be unable to obtain the food they depend upon.

Food insecurity can also be measured in terms of a person's distance and/or travel time to a full-line grocery store. In the Deerfield River Watershed, there are several towns that meet this criteria, however, most have small mom-and-pop stores where residents can get basic food supplies to tide themselves over. Four towns do not even have such alternatives as gas stations or convenience stores: Hawley, Heath, Monroe and Rowe. People living in these towns may be disproportionately impacted should an extreme storm or other event cause road closures and prevent travel.

In a 2018 survey of over 1,300 Franklin County teens conducted by the FRCOG, nearly 25% expressed some level of food insecurity at home.



Facilities on the Deerfield Academy's campus were submerged in floodwaters for weeks following Tropical Storm Irene.

The impacts of climate change on local agricultural production may also negatively impact residents. If crops are more frequently damaged by flooding or a growing number of pests and disease, costs of food will likely increase. Some populations, such as elder adults and lower-income families, will be disproportionately impacted by food cost increases.

Water Quality and Sanitation

Private septic systems can be negatively impacted by flooding and seasonally high water tables. As the climate gets wetter in the Northeast, and traditional rainfall distribution patterns are disrupted, wetter soils may lead to anaerobic conditions in septic leach fields (septic failure) which in turn can cause poorer treatment of sewage effluent, and increased impacts to groundwater recharge. This can result in the surfacing of effluent, creating hazards to human health. In the Deerfield River Watershed, approximately 13,000 residents, or about 35%, utilize private septic systems.

Long periods of drought will result in lower dilution rates for sewage pollutants, and higher concentrations of nutrients and contaminants in local water tables being recharged in part by private septic system effluent. In areas that serve as recharge for aquifers, this reduced treatment and dilution could lower drinking water quality. If affected rivers and streams contribute to public water supplies, drinking water quality would also be decreased. Affected rivers and streams could also become unsafe for swimming and fishing.

Municipal wastewater treatment plants serve about 24,000 residents, or 64% of the Watershed's population. Most of these plants are located in the floodplain and vulnerable to flooding. In the Watershed, about 10,400 residents, or 28% of the

population, are served by private wells. Private wells can particularly be impacted by flooding. Well heads can be inundated with floodwaters or damaged by debris, and flooded upper layers of soil that are typically sealed off from contributing water to wells can develop hydrostatic pressures that result in compromised well seals and contamination of wells with soil, sewage bacteria and other components.

Similar to private wells, public water supplies are also affected by climate change. There are about 26,500 people, of 72% of the population of the Watershed, that are served by public water supplies. As described previously, both too much and too little precipitation will impact water tables, aquifer recharge areas and surface water supplies.







Local Economy & Infrastructure

Descriptive Numbers

- Miles of roads in the Franklin County portion of the Deerfield River Watershed: 963
- Miles of gravel or unpaved roads: 241 (25%)
- Miles of roads in the 100-year floodplain: 62 (6%)
- Number of stream crossings (culverts and bridges): 933
- Number of stream crossings with a high risk of failure: 337 (36%)
- Miles of rail lines transporting hazardous materials: 87 (all)
- Number of building structures: 21,156
- Number of building structures in the 100-year floodplain: 590 (3%)
- Miles of transmission lines: 108
- Hydroelectric facilities on the Deerfield River: 8
- Dams: 58
- Authorized wastewater discharge sites in the Watershed: 14
- Hazardous waste generators: 101
- Tier II toxic users storing hazardous substances in the Watershed: 63
- Known toxic releases: 8
- Number of brownfields sites: 27
- Acres of Zone II recharge areas for public water supplies: 1,339
- Acres of permanently protected Zone II recharge areas: 316 (23%)
- Towns without complete cellphone coverage: 10
- Towns without broadband internet service: 8
- Towns with Municipal Vulnerability Preparedness (MVP) designation: 6
- Towns with FEMA-approved Multi-Hazard Mitigation Plans: 14 (all towns)

New England's rivers have much less room to spread out, meander, move, lose volume, and dissipate energy than they used to, and there are more built structures in their way. Rivers regularly break through barriers and move parts of the landscape that we have treated as fixed. It is then that we face the worst damage.⁷ Photograph of Route 100 in the Vermont portion of the Watershed in the aftermath of Tropical Storm Irene by Lars Gange/Mansfield Heliflight.



Strengths

Regional Planning and Municipal Services

The Franklin Regional Council of Governments (FRCOG) supports all of the towns in Franklin County with regional planning and municipal services, including the fourteen towns of the Deerfield River Watershed. Planning areas include land use, natural resources protection, economic development, transportation, emergency and public health preparedness, as well as hazard mitigation. Presently, six out of fourteen towns in the Watershed have MVP designation (Deerfield, Ashfield, Conway, Charlemont, Colrain and Buckland) and all fourteen towns have FEMA-approved Multi-Hazard Mitigation Plans, both of which help to identify infrastructure and resources that are the most vulnerable to climate change impacts, as well as potential strategies for building resilience.

Emergency Preparedness Coordination

Over the last several years, significant weather-related emergencies have demonstrated the need for increased coordination, the sharing of scarce resources, and a regional approach to emergency management. Both Tropical Storm Irene and the historic October 2011 snowstorm revealed the number of challenges that can arise when large-scale disasters overwhelm the response capacity of local resources and staff. In response to this need, FRCOG and the Western Region Homeland Security

Advisory Council (WRHSAC) organized a Multi-Agency Coordination Center (MACC) that any town can request help from during an emergency. The MACC supports local emergency response efforts by providing a robust emergency operations center ready to support local Emergency Management Directors (EMDs). If a response calls for more resources than a single town has within its borders, volunteers working at the MACC will assist in obtaining resources from other Franklin County towns before forwarding that request up to MEMA to access state resources. Situational awareness gathering and dissemination by the MACC will help to establish a better operating picture for those communities in the midst of the disaster and for their neighboring communities.

Every town in Massachusetts is required under Federal SARA Title III law to have a local emergency planning committee to address procedures to deal with hazardous materials (“hazmat”) emergencies, meet right-to-know requirements, and encourage community awareness. In 2000, under the leadership and administrative support of the FRCOG, all 26 Franklin County towns opted into the Franklin County Regional Emergency Planning Committee (REPC) and elected an “all hazards” approach to emergency planning. This approach addresses planning for hazmat emergencies as well as other

natural, technological, and man-made events that call for a similar inter-town, inter-disciplinary response. The REPC developed and maintains a regional Hazardous Materials Emergency Plan (HMEP), which is a planning and guidance document that provides resources and recommendations for the development of individual community response plans. The Committee provides trainings and exercises to emergency responders and local community leaders throughout Franklin County to meet local and state training requirements. The Committee is recognized by the State Emergency Response Commission (SERC) as a fully-certified regional emergency planning committee.

The FRCOG serves as the fiduciary and sponsoring agency of the 94-town Western Massachusetts Health and Medical Coordinating Coalition (HMCC). The HMCC coordinates public health and healthcare system emergency preparedness, and provides regional coordination in times of disaster, in the four westernmost MA counties. As sponsoring organization, the FRCOG provides the HMCC with dedicated staffing for program management; project facilitation and oversight; meeting administration and support, and fiscal administration.

The WRHSAC has supported the purchasing and stockpiling of equipment such as shelter supplies and radios for Western Massachusetts. This equipment is stored at several locations in the Deerfield River Watershed. There is also a regional DART trailer available to provide equipment to support pets in shelters, which increases shelter use during times of emergency.

Local Network of Public Health Providers

The Mohawk Area Public Health Coalition (MAPHCO) is a regional collaboration of twenty-four Franklin County and two Hampshire County towns for public health emergency preparedness. MAPHCO helps local Emergency Management Directors, Boards of Health, and volunteers with planning, training, and drills for responding to public health emergencies, such as natural disasters and outbreaks of emerging infectious diseases. All of the Watershed towns are part of the coalition.

The Cooperative Public Health Service (CPHS) is a regional health department serving eleven towns in Franklin County, ten of which are in the Deerfield River Watershed. CHPS works to improve the public's health through environmental health inspections, code enforcement, education, wellness, and special programs. The Watershed towns of Buckland, Charlemont, Conway, Deerfield, Hawley, Heath, Leyden, Rowe, Shelburne, and Monroe participate in the program.



Photographs of emergency preparedness trainings (above and opposite) courtesy of the Western Region Homeland Security Advisory Council (WRHSAC).

Amateur Radio Club Keeps County Connected

When an ice storm hit the Northeast in 2008, it destroyed millions of dollars of property and threw residents of small Franklin County towns into difficult living situations. Albert Woodhull, an amateur radio enthusiast who lives in Leyden, remembers how his town of around 700 people was left without electricity, causing those with well systems to be without water too. Fortunately, the American Red Cross set up a space in the basement of Town Hall, providing essentials like food and water to those in need. In some cases, people also came to Town Hall for warmth, since the storm hit in December.



Franklin County Amateur Radio Club President Albert Woodhull (left) and another member run communications at the 40th annual Bridge of Flowers road race in Shelburne Falls. Photograph by Dan Little/The Recorder.

But there was one thing the Red Cross couldn't provide: communication. That's where Woodhull's Franklin County Amateur Radio Club came in. With the help of the club, residents and emergency service providers were able to communicate with outside agencies, keeping the world abreast of what was needed until the elements gave way to relief.

Damage was widespread once again when Tropical Storm Irene hit in 2011. Power was knocked out and flooding even washed out a portion of an Interstate 91 overpass. The Red Cross asked Woodhull and other ham radio operators to create a base for communications at Greenfield Middle School, where a shelter had been established. And while Greenfield was the largest Franklin County town that was impacted by the storm, the Amateur Radio Club helped smaller towns stay in touch with much-needed services as well.⁸



Images from High Risk Stream Crossings in Rowe, MA: A Resource for Assessing Risk and Improving Resiliency (FRCOG).

Sustainable Franklin County

A comprehensive analysis of Franklin County’s regional economy was undertaken in 2013 as part of the *Sustainable Franklin County* plan completed by the FRCOG. Like many areas in New England, most of Franklin County’s economic activity is concentrated in village centers or industrial and commercial areas. The scenario-planning workshops conducted as part of the project reaffirmed stakeholders’ desire to target economic development in locations that already have infrastructure and transit services. At the same time, efforts to retain and support agriculturally-based and home-based businesses were also encouraged.

Every town in the Watershed has its own community center, whether it consists of a small village or a thriving downtown. Two regional centers of economic activity in the Watershed were identified as *Priority Development Areas*: downtown Greenfield and the village center of Shelburne Falls. These areas include businesses, governmental institutions, housing, a local arts scene, and attract workers and customers from surrounding communities.

Mapping High Risk Stream Crossings

While over 1/3 of the road-stream crossings in the Watershed are categorized as having a high risk of failure, reports and maps which identify these crossings have only recently become available. The data comes from a pilot project by the Massachusetts Department of Transportation (MassDOT) and the University of Massachusetts, Amherst that assessed the vulnerability of these crossings to precipitation events. FRCOG staff compiled the information for each town in the Watershed, to help municipal officials and public works staff prioritize bridge and culvert upgrades. Reports can be downloaded at <https://frcog.org/publication/high-risk-stream-crossings-deerfield-river-Watershed/>

Greenfield’s Nine Sustainability Principles

The *Sustainable Greenfield Master Plan* (2014) identified the following principles to guide the town’s development and strengthen its resiliency to climate change:

1. **Multimodal Systems:** Create or promote the use of multimodal travel systems
2. **Health and Well-being:** Improve health and well-being of community members and visitors
3. **Energy Reduction:** Reduce fossil fuel-based energy consumption
4. **Equity:** Result in more equitable access to or distribution of resources
5. **Resilience:** Improve the resilience of the community, its infrastructure, and its services to impacts of climate change and/or other man-made or natural disasters
6. **Responsible Regionalism:** Enhance coordination on efforts with the surrounding region
7. **Economic Vitality:** Improve the economic vitality and resilience of the community
8. **Climate Change Mitigation:** Reduce the community’s contribution of climate-changing greenhouse gas emissions
9. **Natural Resource Protection:** Protect or restore natural resources

Flood Risk Table for Towns in the Deerfield River Watershed

TOWN	TOTAL POPULATION	ESTIMATED POPULATION IN FLOODPLAIN	DWELLING UNITS IN FLOODPLAIN	TOTAL LAND IN FLOODPLAIN (Acres)	DEVELOPED LAND IN FLOODPLAIN (Acres)
Buckland	1,796	116	45	691	Residential: 32.4 Industrial: 1.2 Commercial: 5.3 Public/Institutional: 1.2
Charlemont	1,173	75	33	815	Residential: 21.9 Industrial: 0 Commercial: 10.6 Public/Institutional: 2.8
Colrain	1,682	69	28	820	Residential: 33 Industrial: 8 Commercial: 1.8 Public/Institutional: 0.7
Heath	730	2	1	53	Residential: 1 Industrial: 0 Commercial: 0 Public/Institutional: 0
Monroe	95	2	1	75	Residential: 0 Industrial: 1.2 Commercial: 0 Public/Institutional: 0.4
Rowe	477	21	9	636	Residential: 4.4 Industrial: 4.3 Commercial: 0 Public/Institutional: No data
Shelburne	1,826	54	24	333	Residential: 8.1 Industrial: 0.3 Commercial: 3.4 Public/Institutional: 0.3
Hawley	426	37	16	217	Residential: 6.4 Industrial: 0 Commercial: 0.1 Public/Institutional: 0.5
Greenfield	17,477	83	38	1,449	Residential: 43 Industrial: 1.9 Commercial: 13.6 Public/Institutional: 4.8
Leyden	691	5	2	166	Residential: 3.5 Industrial: 0 Commercial: 0.1 Public/Institutional: 0.3
Ashfield	1,609	34	15	1,367	Residential: 11.3 Industrial: 1.7 Commercial: 3.7 Public/Institutional: 0
Conway	1,783	42	17	310	Residential: 11.4 Industrial: 0 Commercial: 0.6 Public/Institutional: 0.7
Deerfield	5,054	58	24	2,828	Residential: 41.3 Industrial: 0.2 Commercial: 4.9 Public/Institutional: 8.1
Bernardston	2,160	43	17	648	Residential: 16.4 Industrial: 1.5 Commercial: 4.8 Public/Institutional: 1.8

AVERAGE ASSESSED VALUE OF LAND IN FLOODPLAIN	TOTAL BUILDING VALUE IN FLOODPLAIN	HOUSEHOLDS WITH INCOME LESS THAN \$25,000/YEAR	SENIORS (AGE 65 AND OLDER)	PORTION OF TOWN IN DEERFIELD RIVER WATERSHED
Residential: \$9,095,470 Industrial: \$9,484,323 Commercial: \$422,945	\$25,964,680	193	393	100%
Residential: \$4,547,228 Industrial: \$0 Commercial: \$2,291,235	\$25,008,200	120	274	100%
Residential: \$7,118,360 Industrial: \$1,604,484 Commercial: \$796,811	No data	141	328	100%
Residential: \$224,529 Industrial: \$0 Commercial: \$0	\$224,529	67	146	100%
Residential: \$0 Industrial: \$112,000 Commercial: \$0	\$168,000	16	22	100%
Residential: \$1,048,744 Industrial: \$30,280,296 Commercial: \$0	No data	31	130	100%
Residential: \$2,508,269 Industrial: \$354,044 Commercial: \$1,231,472	\$29,828,200	212	443	100%
Residential: \$1,259,296 Industrial: \$0 Commercial: \$49,795	No data	36	107	94%
Residential: \$4,196,873 Industrial: \$141,138 Commercial: \$86,387	\$571,163,200	2,042	3,042	85%
Residential: \$751,562 Industrial: \$0 Commercial: \$1,520,269	No data	24	98	76%
Residential: \$3,632,306 Industrial: \$176,147 Commercial: \$818,589	No data	81	311	61%
Residential: \$10,236,705 Industrial: \$0 Commercial: \$389,247	No data	49	314	60%
Residential: \$13,861,541 Industrial: \$77,235 Commercial: \$91,442	\$301,793,280	273	817	43%
Residential: \$3,875,151 Industrial: \$123,587 Commercial: \$888,934	No data	154	510	12%

Sources: 2012-2016 American Community Survey (ACS) 5-Year Estimates; Multi-Hazard Mitigation Plans for the Towns of Buckland, Charlemont, Colrain, Heath, Monroe, Rowe, Shelburne, Hawley, Greenfield, Leyden, Ashfield, Conway, Deerfield, Bernardston (FRCOG); MassGis 2005 Land Use data.



Route 2 in Charlemont was closed for three months following Tropical Storm Irene.

Vulnerabilities

Critical Infrastructure Exposed to Flooding

As shown in the previous table, a significant amount of infrastructure, including commercial, industrial and public buildings, are in the 100-year floodplain. Major roads, railroad lines and transmission lines are vulnerable to extreme weather and precipitation. An aging housing stock across the Watershed includes permeable stone foundations and wooden construction, both of which are vulnerable to flooding and destruction from extreme weather.

Flooding causes road closures and building damages and sometimes these impacts are severe, like the three month Route 2 closure between Charlemont and Florida in 2011. Additionally, over $\frac{1}{3}$ of road-stream crossings have a high risk of flooding or damage during heavy precipitation events. There are also 63 Tier II toxic users storing hazardous and/or extremely hazardous substances in the Watershed, many of which are in the floodplain, posing risks to the health of area residents in the event of flooding.

Rural Area with a Weak Economy

Franklin County is the most rural area of the Commonwealth, with a population density of 98 people per square mile versus 867/sq. mi. for the state. Lower wages and incomes in comparison to the rest of the state are also common: eleven of the fourteen towns in the Watershed have median household incomes below the state average. Pockets of unemployment are common: declines in large-scale manufacturing, lack of important infrastructure

(such as broadband access) in some communities, and a declining and aging workforce are some of the issues that present challenges to revitalizing the region.

Lack of Economic Diversity

Over 30 businesses in Franklin County sustained product or infrastructure damage from Tropical Storm Irene, nearly all of which were in the Watershed. **Franklin County per capita impacts from Irene were \$319.68, compared to \$17.29 in neighboring Berkshire County, and \$3.83 statewide.** Per capita impacts were calculated by dividing FEMA Public Assistance cost estimates for TS Irene (per Preliminary Damage Assessments) by U.S. Census population figures. This may be a result of a combination of factors, including limited roads and transportation access; weather-dependent industries, such as outdoor recreational tourism, farming and food systems; and an overall lack of regional economic diversity. The four largest employers in the Watershed are all located near the Deerfield River, an area which was devastated after Irene. All of the above vulnerabilities will be exacerbated by the impacts of climate change.

Aging Transportation Infrastructure

Most of the 87 miles of railroad lines in the Deerfield River Watershed are vulnerable to extreme temperatures, which may cause rail lines to expand/contract, increasing risk of derailment. Stronger and more frequent rain events are causing failure of

culverts under rail lines, which also leads to derailments. While there is no publicly available data on the exact number of train accidents or derailments that occur, based on local observations shared during MVP workshops, they tend to happen at least once a year in the Watershed. In 2018, FRCOG staff conducted a study which demonstrated that on average 38% of the freight cars passing through Franklin County carry hazardous materials.

Of the 933 stream crossings (culverts and bridges) in the Watershed, over 1/3 have a high risk of failure. These aging culverts and bridges are either undersized for current precipitation patterns, or they are simply in need of replacement. **Public bids recently completed by the FRCOG found that culvert replacements cost between \$400,000 – \$800,000 dollars each.** Expensive upgrades such as these are beyond the ability of Watershed towns to fund. Unpaved roads, which amount to

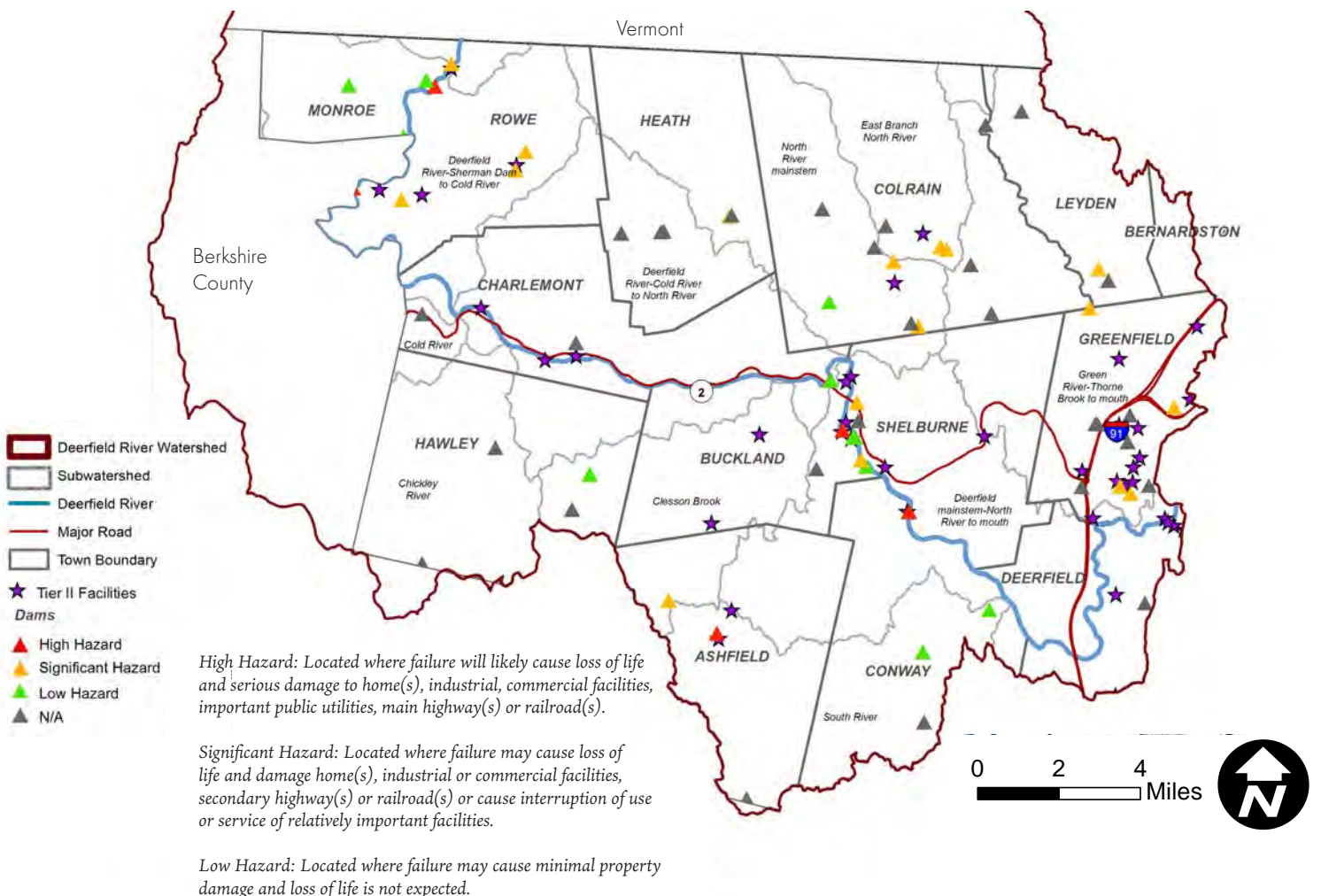
over 1/4 of all roads in the Watershed, are also vulnerable to damage from flash floods. Paving is not necessarily the answer, as the water still has to go somewhere.

Dams

The operation of the eight hydropower dams on the Deerfield River are not coordinated, and a lack of communication between dam operators, FERC, and local towns poses risks to human life during flooding. When dams are sold, new owners are oftentimes slow in obtaining emergency contact information from local towns, and getting an updated emergency plan out to communities downstream.

There are 58 state-regulated hazardous dams in the Watershed, many of which are aging and/or privately owned. Because dam owners are personally responsible for maintenance and upkeep, many of these dams may need repairs that owners struggle to

Hazardous Dams and Tier II Toxic Users in the Deerfield River Watershed



afford. This impacts climate resiliency in a number of ways, most notably by preventing rivers and streams from following their natural meanders, and the potential risk of breach or failure during severe storms. These dams also alter aquatic and riparian habitat, and prevent fish and amphibian migration, which is oftentimes necessary for spawning.

Development Patterns Threaten Forests and Farmland
The Approval Not Required (ANR) provision of the Subdivision Control Law, Chapter 41 of the Massachusetts General Law, allows land owners to develop land for residential use without Planning Board approval, as long as it meets frontage and access requirements. The consequences of this type of development include fragmentation of forests and farmland, increased municipal costs for road maintenance, infrastructure and services, and increased carbon emissions from longer drives to outlying areas. Large scale projects can fragment forests in the Watershed and often cover prime farmland. Traditional subdivision designs can also result in excessive land clearing and sprawling development. But towns do have options for managing the impacts of new development so climate resiliency is strengthened. These tools are discussed in Part 4 of this report.

Declining Populations and Lack of Staff
Throughout the rural communities of the Watershed, there exists a difficulty in staffing and

recruiting volunteer board members, committee members, as well as full or part-time town staff. Most towns in the Watershed do not have the capacity to hire full-time staff to provide essential government services, such as emergency management, elderly care, nurses, firefighters, and Emergency Medical Services (EMS). A regional

Challenges to Resilient Development

The majority of development in the Watershed has historically occurred along rivers, including in the 100-year floodplain and river corridor. Existing buildings and infrastructure may be at risk from more frequent flooding as a result of climate change. *Promoting climate-resilient infill and redevelopment and the reuse of Brownfields sites will be challenging due to the location of historic development.* Existing water and sewer infrastructure may not support infill and redevelopment because much of the public infrastructure in the Watershed was constructed over 100 years ago. Some town centers lack water or sewer infrastructure completely.

A typical large lot subdivision development in Massachusetts fragments what was once intact forest. Without appropriate subdivision and zoning regulations in place, development projects may reduce the resiliency of rural communities in the Watershed. Source: Mass Audubon.



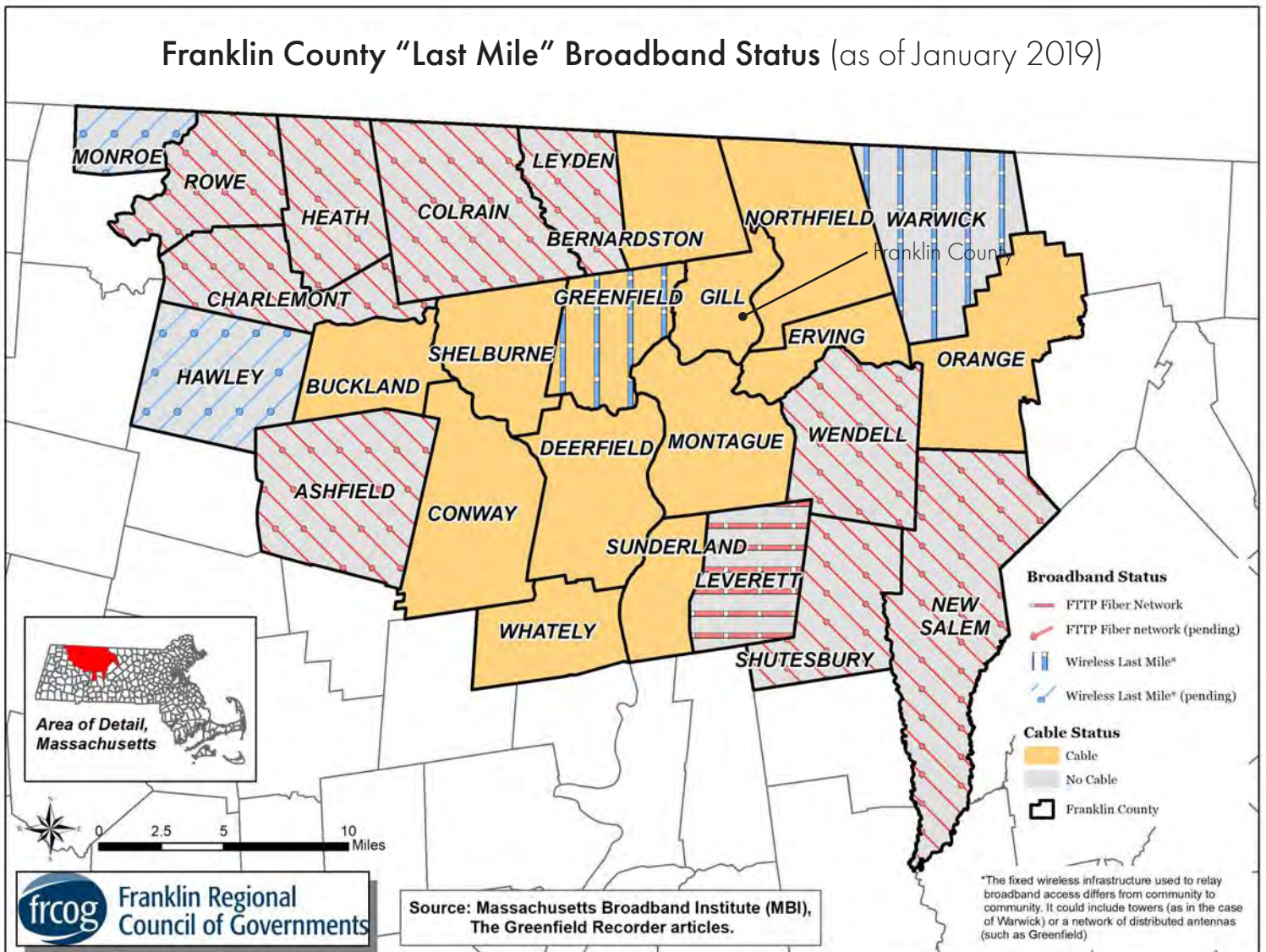
reliance on volunteers to provide such services means that there is variability in the skills and availability of some of the most important first responders and people to help with disaster recovery.

According to information provided by FRCOG Emergency Preparedness staff, the opioid crisis is straining the capacity of local and regional EMS. Many of the small Watershed towns rely on dedicated volunteer responders but the number of volunteers is dwindling. Regional and private EMS responders, such as MedCare and South County EMS, are at call capacity.

Declining enrollment in our rural schools, due in large part to an aging population, is causing the shutdown of some local schools, and can lead to much higher overall education costs per child caused by low student/staff ratio at schools, and the need for transportation to schools far away.

Lack of Communication Coverage

Many areas of the Watershed have gaps in cellphone service, which can be a serious liability during moments of emergency. The region is also disadvantaged by a current lack of last mile broadband access in many communities. However efforts are underway to expand access in all towns of the Watershed.



Natural resources, such as rivers, forests and aquifers, are systems that function at a broad landscape scale, disregarding the boundaries of ownership. The reality of private land holdings and fourteen town boundaries in the Deerfield River Watershed make watershed-scale approaches to climate resiliency challenging and complex.



Photograph of the Deerfield River by Massachusetts Office of Travel & Tourism

Part 4: Building Resilience

This section highlights concrete steps that towns and residents of the Deerfield River Watershed can take to become more climate-resilient and build resiliency across the Watershed. The recommendations in this plan were developed specifically to be implemented by local towns, including town staff and residents that serve on volunteer boards and committees. To be included, the recommendations had to be:

- **Achievable** (within the power of towns and individuals to implement)
- **Address multiple climate stressors**   
- **Benefit multiple sectors**   
- **Build resiliency at multiple scales** (property, town, subwatershed, watershed)

The recommendations also recognize the unique challenges faced by towns in the Watershed, including scarce funds; limited staff and volunteer board time; and the fact that the majority of the undeveloped land in the watershed is privately owned.

The single most powerful tool available to towns is their authority to regulate land use within their borders, and the broad powers of Local Boards of Health to protect town residents. In addition to the regulatory authority of Select Boards, Planning Boards, and Conservation Commissions, town staff — such as DPW Superintendents and EMDs — and volunteers who serve on OSRP Committees, Agricultural Commissions, Councils on Aging, and the like, all play key roles in creating climate resilient communities and a resilient watershed.

A regional approach to climate resiliency makes sense not only for individual towns but especially at the watershed scale.

Towns, landowners and watershed stakeholders can use this plan to find strategies that address their individual goals, and work together to strengthen municipal and watershed resilience over time. The Franklin Regional Council of Governments will use this plan, and others that we've recently completed for the Deerfield River Watershed, to continue advocating for a watershed-based approach to climate resiliency. **The first step is for FRCOG to convene a Resilient Deerfield River Watershed Coalition.** This group can begin the hard work of prioritizing recommendations from this report, and finding ways to work cooperatively across town boundaries to fund the implementation of projects that will build local and watershed-scale resiliency.

After towns join the Resilient Deerfield River Watershed Coalition (Resilient DRW), this coalition will help coordinate projects across the smaller subwatersheds. FRCOG will work with towns and stakeholders to identify funding, leverage planned projects to include climate resiliency components, conduct public education and outreach to build support from residents, and promote a watershed-based approach to climate resiliency.



A Framework for Resilience

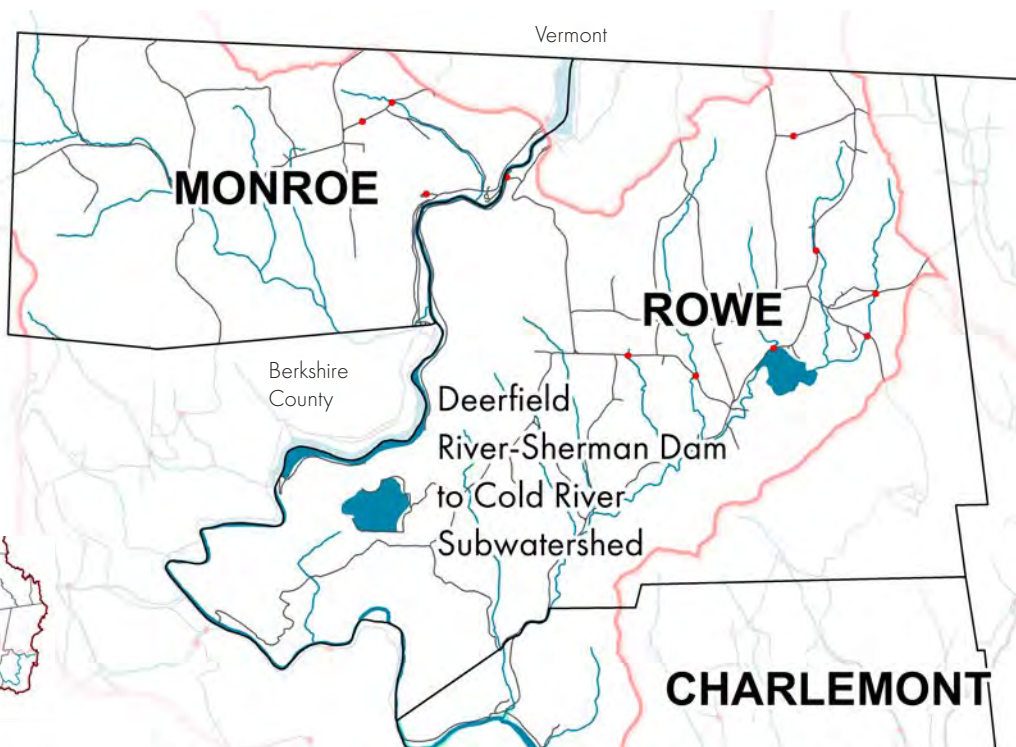
To build support for municipal and landscape-scale resiliency work, each town in the Deerfield River Watershed should first understand its position and relationship to the Watershed as a whole, as well as their relationship with neighboring towns with whom they share a subwatershed. Knowing where you are in the Watershed (upland, midland, lowland), the topographical features in your town (hills, rivers, valleys, floodplains) as well as present-day land use patterns (rural farmland, moderately developed village centers, densely developed urban centers) will help your town decide which resiliency recommendations to focus on, and will help inform discussions of the Resilient DRW Coalition.

- **Upland areas** are at the top of the Watershed. They are characterized by steep topography, tend to be sparsely developed, and are predominantly forested. The waterways running through these areas are secondary or primary tributaries of the Deerfield River.
- **Midland areas** are halfway down the Watershed. They are characterized by less steep topography and open valleys, are moderately developed, and partially forested. The waters running through these areas are primary tributaries of the Deerfield River, or the Deerfield itself.
- **Lowland areas** are at the bottom of the Watershed. They are characterized by flat, expansive river valleys and floodplains, are densely developed with a combination of residential, commercial and agricultural land use, and are the least forested portions of the Watershed. The Deerfield River runs through these lowland areas, spilling into the Connecticut River in Greenfield.

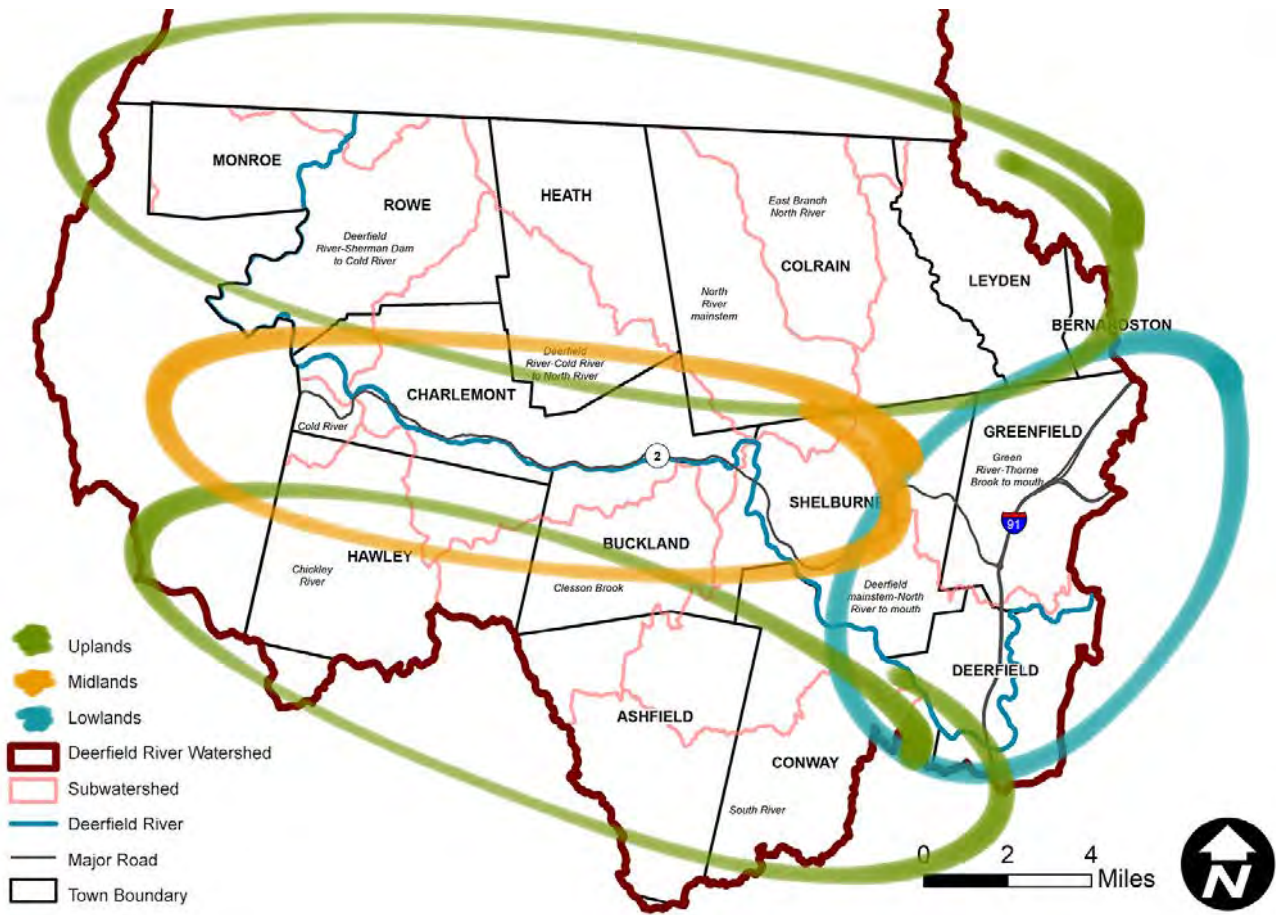
Three questions for every town to ask:

1. How many subwatersheds are in your town?
2. Do you know where your watershed boundaries are?
3. Who are your watershed neighbors?

Remaining subwatershed maps can be found in the Appendix.



Where Are You in the Watershed?



Nature-Based Solutions for Climate Resiliency

Nature-Based Solutions are actions that work with and enhance nature so as to help people adapt to socio-environmental challenges. They may include the conservation and restoration of natural systems, such as wetlands, forests, floodplains and rivers, to improve resiliency. NBS can be used across a watershed, a town, or on a particular site. NBS use natural systems, mimic natural processes, or work in tandem with engineering to address natural hazards like flooding, erosion and drought.

The 2018 *Massachusetts Hazard Mitigation and Climate Adaptation Plan* and the MVP program both place great emphasis on NBS, and multiple state and federal agencies fund projects that utilize NBS. For this plan, we are including Low Impact Development (LID) and Green Infrastructure (GI) under the blanket term of NBS.

Some examples of how NBS can mitigate climate stressors, protect watershed resources and residents:

- Restoring floodplains stores water, slows it down and reduces infrastructure damage downstream
- Managing stormwater with rain gardens and bioretention cells recharges drinking water supplies, reduces stormwater runoff, and reduces mosquito habitat and incidents of vector-borne illness by eliminating standing pools of water following heavy rain events
- Planting trees absorbs carbon dioxide and provides shade, lowering energy costs for village residents and improving air quality by reducing smog and particulate matter
- Vegetated riparian buffers absorb and filter pollutants before they reach water sources, as well as reduce erosion and water velocity during high flow events

Recommendations

*While the recommendations in this report are organized by the primary sector they benefit, all of the recommendations benefit at least two, if not all three sectors, and address multiple climate stressors. These recommendations are not prioritized for implementation, as this will be the work of the **Resilient DRW Coalition** to be formed by FRCOG.*



Natural Resources & Habitat

Manage Stormwater throughout the Watershed

More frequent and intense rain events and resulting flooding are arguably the primary impact of a changing climate, and the primary concerns of Watershed towns and stakeholders. More and more, Watershed towns are grappling with huge volumes of stormwater runoff that easily overwhelm undersized culverts, damage roads and key infrastructure. The loss or damage of road infrastructure can severely impact the deployment of emergency response services, compounding the severity of these rain events. Uncontrolled stormwater runoff causes rivers to flood and erode their banks (fluvial erosion), which damages farmland, critical infrastructure and homes. **Use a variety of Nature-Based Solutions at different scales — parcel, town, subwatershed and across the entire Deerfield River Watershed — to slow, spread and retain storm and flood waters.**

Build Resiliency through Future Development Projects

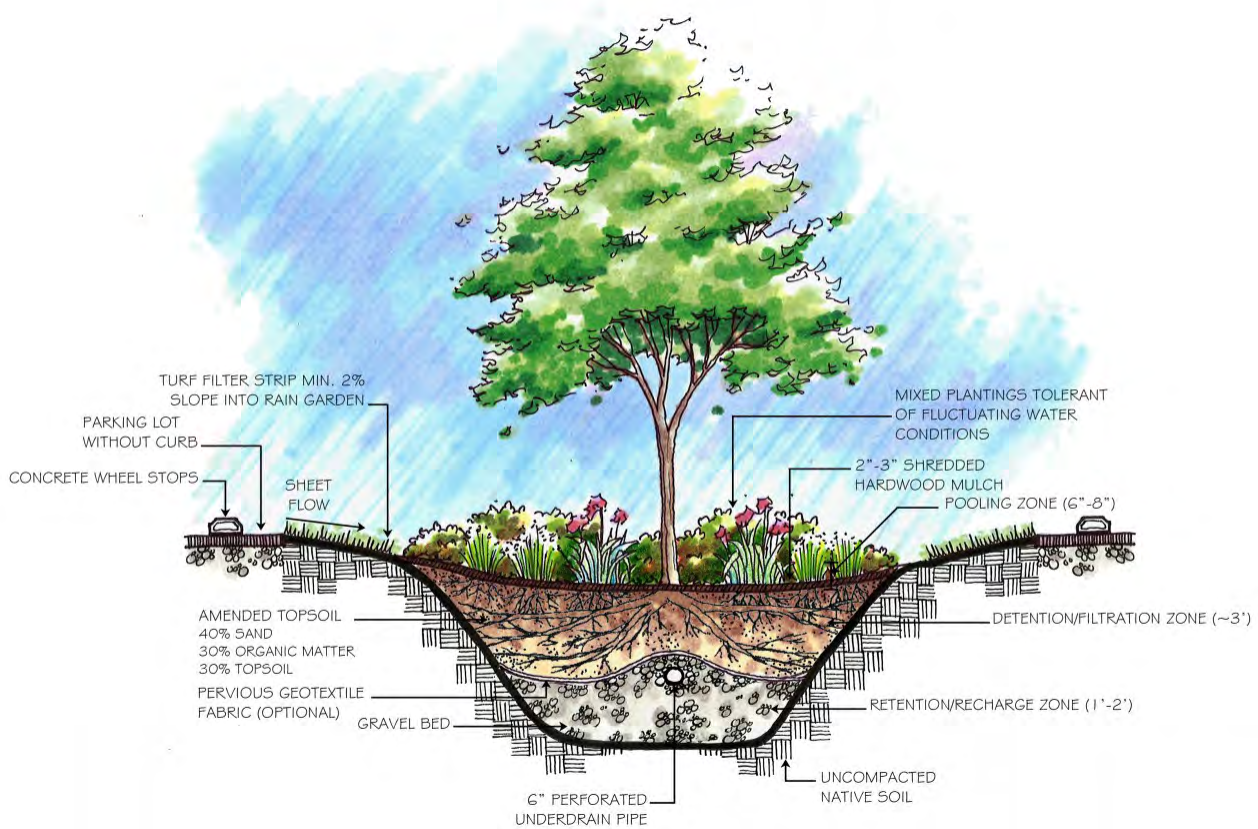
Identify opportunities to integrate Low Impact Development (LID) and other Nature-Based Solutions into new economic development and downtown/village center revitalization projects.

Look at redevelopment projects as opportunities to increase climate resiliency in town and village centers. This can be accomplished by planting more trees, managing stormwater with bioretention cells (another NBS), and by creating permeable parking



Vegetated swales, like these rain gardens on Olive Street in Greenfield, are one of many solutions to stormwater management discussed in the Town of Greenfield's Low Impact Development: A Developer's Guide.

lots and paving. For towns that are experiencing residential subdivision development, it is important to protect the resiliency functions of the landscape (wetlands, forests, open space) by using LID



Bioretention cells such as this parking lot rain garden provide multiple benefits to downtown areas, including beautification, shade cover for parked vehicles, and stormwater retention. Source: Clemson University.

principles and encouraging or requiring protected open space.

FRCOG worked with the Town of Greenfield to develop *Low Impact Development (LID): A Developer's Guide to Innovative Stormwater Management Techniques* and drafted recommended changes to the Town's Zoning Ordinance and Subdivision Regulations to encourage the use of LID. Greenfield is currently using these materials as it works on implementing its Sustainable Master Plan. Guidance documents like this can help potential developers understand a community's climate resiliency goals and comply with local regulations.

Use Green Infrastructure in Public Works Projects

Green infrastructure treats stormwater as a resource rather than a waste product, and can complement or replace traditional pipe and pond, or "gray" stormwater infrastructure, which utilizes extensive underground systems. In many communities, existing stormwater infrastructure is aging, expensive to maintain, and inadequate to handle the heavier rainfalls our region is experiencing due to climate

change. This leads to localized flooding and negative impacts to roads, bridges, property, and water quality. At the same time, many local roads and other public facilities are in need of upgrades. Integrating green infrastructure into public projects now and in the future can result in cost savings and provide a host of other public benefits.

FRCOG prepared a *Green Infrastructure (GI) Guide for Public Works Projects* that towns can use to identify appropriate GI techniques to incorporate into a variety of public works projects, including those funded by Community Development Block Grants (CDBG), Complete Streets, Chapter 90, and PARC grants. This resource also includes Green Infrastructure Case Studies, information on Green Street design guidelines and Best Management Practices for Unpaved Roads.

Manage Stormwater in Upland Watershed Areas

The many streams that drain the forested upland areas of the watershed, including state forests and privately-owned lands, are critically important from a flood resiliency standpoint. The channels of many



Detail of a map for the Town of Ashfield created by the FRCOG which identifies high risk stream crossings, maps their location and documents their condition.

of these streams were altered centuries ago as a result of widespread deforestation for agriculture and lumber. The many small mills that used to dot the landscape built dams on the streams to generate power. These streams are unstable and flashy during storm events, generating high volumes of runoff and transporting sediment to the lower, flatter reaches of the watershed.

NBS projects that reconnect these upland streams to forested floodplain areas and add more wood to streams and waterways will slow and spread stormwater, recharge aquifers and the baseflow of streams, and help protect downstream infrastructure (roads, culverts, etc.) from excessive amounts of stormwater runoff, sediment loading and flooding. These projects have been successful in providing flood resiliency and habitat enhancement in forested reaches throughout New England.

In the Deerfield River Watershed, wood addition projects could be used on small headwater streams in upland areas or combined with other NBS techniques on larger streams. These techniques should be combined with conservation of undeveloped upland areas using a River Corridor Easement (discussed later) or a Conservation Restriction on larger parcels of land. Of course the project designs would have to satisfy the permitting requirements of local Conservation Commissions and likely the State's Natural Heritage & Endangered Species Program. An example of this approach is the Franklin Land Trust's 95-acre Crowningshield

Conservation Area in Heath. This property includes one mile of frontage along both banks of the West Branch of the North River. The conservation area is open to the public for passive recreation, including hiking, hunting, and fishing. This project represents an important new model for land conservation and climate resilient watershed management. 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 Franklin Land Trust (FLT) partnered with Trout Unlimited (TU) and local biologists to install engineered log jams and other wood additions to reconnect the West Branch of the North River to its abandoned floodplain, and root wad deflectors to stabilize eroding river banks. In this project, 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.** Two potential Crowningshield-type conservation and stream restoration projects were identified in FRCOG's 2017 *Watershed-Based Plan for the Deerfield River Watershed* — one on the upper Bear River in Ashfield and one on the lower Bear River in Conway. Private

landowners interested in leveraging the co-benefits of flood resiliency and habitat enhancement with potential land conservation could work with FLT on these and other projects.

Many Watershed towns also have State Forests. Upland watershed tributaries in State Forests present a climate resiliency opportunity for stormwater management and the enhancement of coldwater fisheries. For example, FLT and TU completed a wood addition project on an unnamed tributary to Sanders Brook in the H.O. Cook State Forest, located in Heath. FLT and TU have a monitoring program for these sites to help assess habitat and resiliency benefits of the project.

Upland stormwater management will require creative approaches like the ones described and the participation of private citizens, who own most of the forested upland watershed acreage. Towns can inform stakeholders, identify funding sources and prioritize these innovative NBS resiliency strategies by including them in Multi-Hazard Mitigation Plans, MVP Plans and Open Space and Recreation Plans.

Use High Risk Stream Crossings Reports to Prioritize Culvert and Bridge Upgrades

As already mentioned, the FRCOG recently released

new reports and maps for all high risk stream crossings in the Deerfield River Watershed, which are available at <https://frcog.org/reports-maps-high-risk-stream-crossings-deerfield-river-watershed-now-available/>. Municipal officials and public works staff can use this information to prioritize bridge and culvert upgrades, which can be done as part of planned transportation projects, either funded by towns with Chapter 90 funding, or as part of larger MassDOT projects. Towns can also use this information to apply for funding under the state's Culvert Replacement Municipal Assistance Grant Program, which funds projects that improve climate resiliency and river health: <https://www.mass.gov/river-restoration-culvert-replacements>

To date, three Deerfield River Watershed towns have received funding from the Culvert Replacement Municipal Assistance Grants Program as follows:

Ashfield was one of two pilot communities for the launch of the grant program. A comprehensive site assessment and technical report was prepared for a culvert on an unnamed tributary to the Bear River, Baptist Corner Road in 2016. The design for the replacement used estimates of extreme rainfall from an interactive website tool for extreme precipitation analysis created by Cornell University: <http://precip.eas.cornell.edu/>

Buckland received \$91,000 in Fiscal Year 2018 to conduct field data collection, engineering, design and

The Franklin Land Trust is demonstrating climate-informed options for enhancing in-stream habitat on the Crowningshield property and West Branch of the North River. Project activities will connect this stream to its natural floodplain and increase habitat for aquatic organisms through "chop and drop" additions of large woody debris. Source: Northern Institute of Applied Climate Science.





The USGS Flood Inundation Mapper, an online tool for mapping floodplains, showing downtown Charlemont with the estimated flood conditions based on river flows as was measured in 2011 during Tropical Storm Irene. Source: USGS.

obtain permitting for a culvert replacement on Clark Brook. Replacing the culvert will provide passage for fish and wildlife and improve Buckland’s public safety by maintaining access for emergency and residential services to nearby homes.

Colrain also received \$90,000 in FY2018 to conduct field data collection, engineering, design and obtain permitting for a culvert replacement on an unnamed tributary to the North River. Replacing the existing undersized culvert will provide passage for fish and wildlife, and improve Colrain’s infrastructure by reducing the risk of culvert failure. For FY2019, Colrain received \$150,000 to construct a 12-foot open-bottom culvert on a tributary to the North River.

Restore, Manage and Protect Floodplains

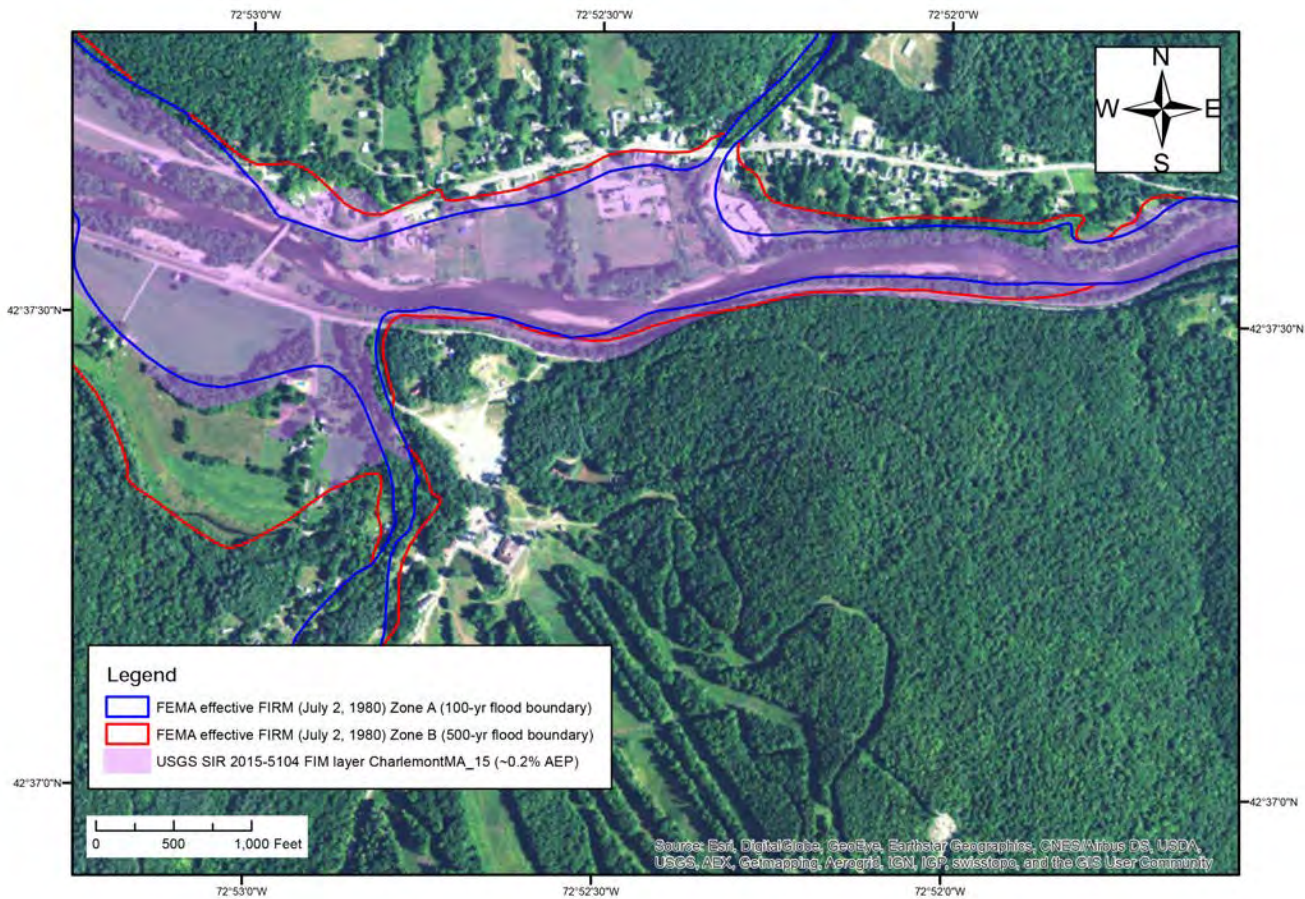
As mentioned earlier, FEMA Flood Insurance Rate Maps (FIRMS or “floodplain maps”) in Franklin County are several decades old, and may not represent an accurate picture of today’s floodplain. FEMA has recently begun a 7-10 year process to update these FIRM maps. The update will generate digital floodplain mapping, which is very useful, but

towns should incorporate other tools to use in their climate resiliency planning efforts. Two important points about these maps should be made:

1. The FEMA maps are used to help determine areas vulnerable to flooding and who is required to have flood insurance under the National Flood Insurance Program
2. The FEMA floodplain maps do not consider risks from fluvial erosion hazards (FEH), which are a substantial threat in the Deerfield River Watershed

Fluvial erosion hazards (FEH) are threats to public and private property, infrastructure and agricultural lands from catastrophic bank erosion that occurs as a result of flooding. **While inundation-related flood damages can be high, the most prevalent type of damages in the Deerfield River Watershed are due to fluvial erosion.** The most severe fluvial erosion events in recent years have resulted from heavy rain, such as during Tropical Storm Irene, which washed out roads across the watershed and destroyed several buildings.

The good news is that watershed towns have several tools currently available to them to evaluate flooding and fluvial erosion hazards within their communities



Map of downtown Charlemont with FEMA effective FIRM (last updated July 2, 1980) showing 100- and 500-year floodplain boundaries compared to USGS flood inundation mapping from 2015. Source: Charlemont 2017 Floodplain Action Plan.

and their watersheds. For example, a town could update its floodplain bylaws to regulate use of the 500-year floodplain where it has been delineated, which may be a more accurate representation of vulnerable areas.

A 500-year flood isn't necessarily something that happens once every five hundred years. Rather, a 500-year flood is an event that has a 1 in 500 chance of occurring in any given year, according to the National Weather Service. That means you can have multiple 500-year flood events happen back-to-back.¹

In Charlemont, the 500-year floodplain includes much of the land area flooded during Tropical Storm Irene, as depicted in the maps above. While the USGS flood-inundation maps do not replace the FEMA maps, towns can use the USGS information for planning purposes to estimate the potential extent of flooding. For example, towns can identify infrastructure that should be flood-proofed or relocated, and which redevelopment opportunities may be vulnerable to flooding so appropriate stormwater management and flood mitigation strategies can be used to protect the projects. Towns can also consider avoiding these areas for new

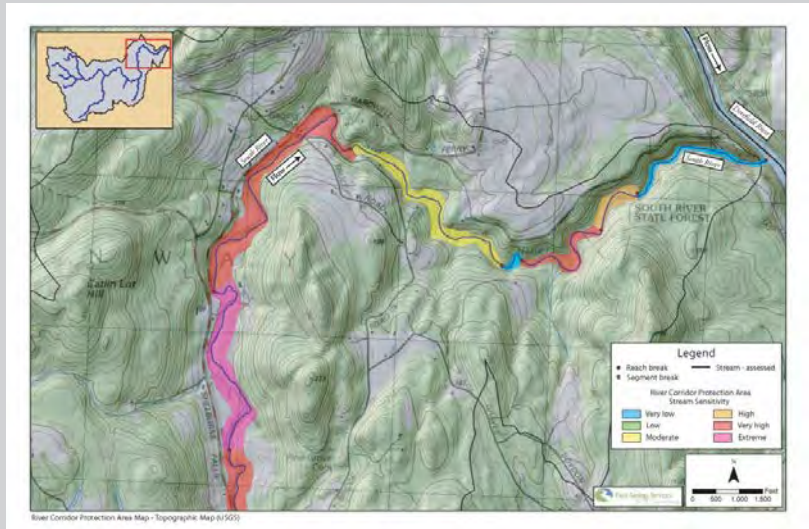
municipal or other types of development. The USGS Flood Inundation Mapper is available online for free.

Protect Abandoned Floodplains and Other Attenuation Assets

Using the USGS Flood Inundation Mapper, towns can identify “**attenuation assets,**” or **land that can serve as flood flow safety valves** and determine ways to protect and restore them. These lands could be permanently protected to allow the river to once again access its floodplain, and decrease the damaging effects of floodwaters. These sites are typically fallow agricultural parcels that have sustained flood or erosion damage in the past, or 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.** Given the propensity for meanders to reform along straightened channels, by allowing a meander to form in one reach, over a fallow farm field or undeveloped parcel, the likelihood that a meander will form elsewhere and threaten homes or infrastructure is reduced. Following events like

What Does a River Corridor Look Like?

A river corridor includes the river, its banks and the land close to the river that carries flood waters and accommodates the meander pattern or movement of the river. A River Corridor is not a traditional buffer or setback, like the 200-foot buffer regulated under the Rivers Protection Act. A River Corridor includes the active river channel, a protective buffer and the floodplain or riparian area that the river will access over time.



River Corridor Area for a Portion of the South River in Conway.

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. FRCOG's 2017 Deerfield Watershed-Based Plan 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.

form and function of rivers and the interaction between rivers and the landscape around them. According to the USGS, **“Understanding river channel responses to various human-caused and natural disturbances is important for effective management, conservation, and rehabilitation of rivers and streams to accommodate multiple, often conflicting, needs.”**

Implement Management Strategies for River Corridors and Active River Areas

Rivers and streams are natural systems in a constant state of change. Movement is normal for many rivers. Predicting where a river will move across the landscape, and where the river corridor boundaries are, is challenging but necessary to provide a higher level of climate resiliency and protect homes, businesses, farm fields, roads and other infrastructure near rivers. For towns to effectively manage and regulate the river corridor, the area should be mapped using methods grounded in science. Fluvial geomorphology is the study of the

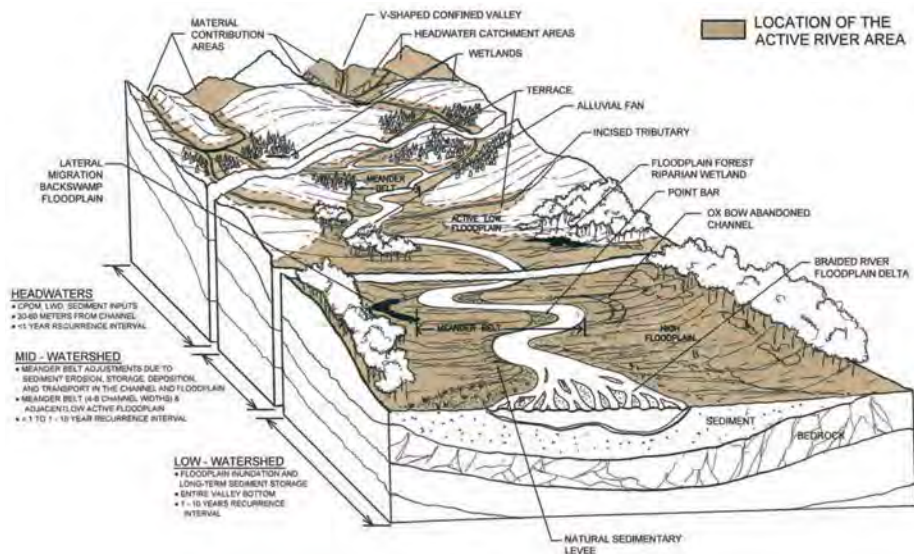


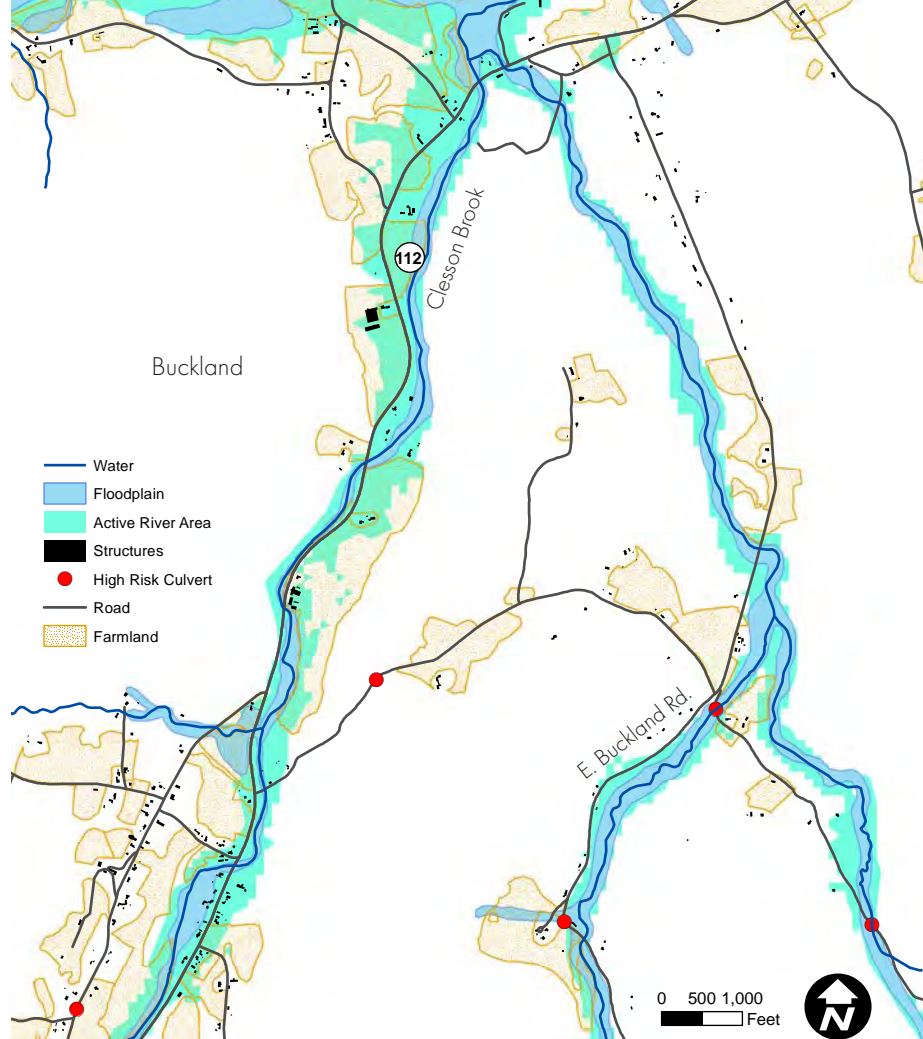
Diagram of the dominant processes and disturbance regimes of the Active River Area courtesy of The Nature Conservancy.

Farmland and Infrastructure in the Floodplain and Active River Area of the Clesson Brook Watershed in Buckland

Note: The jagged appearance of the Active River Area boundary is due to the regional scale of the data currently available.

Several watershed towns are well-positioned to move forward with a river corridor management approach for flood resiliency. With grants from FEMA/ MEMA and the MassDEP’s 319 and 604b programs, FRCOG has completed fluvial geomorphic assessments that identified over forty river restoration projects, mapped river corridors, identified fluvial erosion hazards, and developed river corridor management tools for the South River (Ashfield and Conway) and North River (Colrain and Heath) watersheds. Additional flood resiliency projects were identified in FRCOG’s 2017 Watershed-Based Plan. FRCOG’s current 319-funded project includes mapping the river corridor for the Green River, as well as preparing several different corridor management tools — River Corridor Easement, River Corridor Protection Overlay District and a hybrid Floodplain/ River Corridor Bylaw — that watershed towns can use to improve their flood resiliency. The towns of Greenfield, Leyden and Colrain in the Green River watershed will have a mapped river corridor in 2019.

Until additional grant funding is secured for more river corridor mapping in the Deerfield River Watershed, a mapping tool developed by The Nature Conservancy called the Active River Area (ARA) can be used by towns. The ARA mapping is most appropriate for regional and watershed-scale planning and analysis and project review processes. ARA mapping should not be used as a basis for a river corridor zoning overlay district because the methods used to develop ARA do not include the detailed field investigations used to develop river corridor maps. Several towns, like Buckland and Hawley, may want to consider using ARA mapping to inform planning efforts, such as updates to Multi-Hazard Mitigation Plans and OSRPs, and as part of the evaluation and decision-making process for municipal



infrastructure projects (culverts, roads, etc.). ARA river corridors are often larger than 100-year floodplain areas.

Increase Riparian Buffers throughout the Watershed

The value of riparian buffers for flood resiliency and resource protection cannot be overstated.

Throughout the Watershed, riparian buffers have

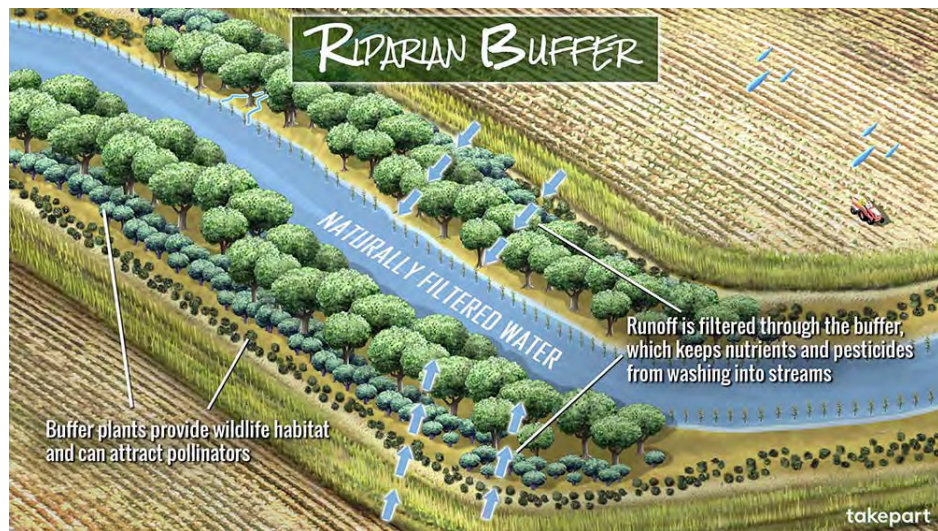
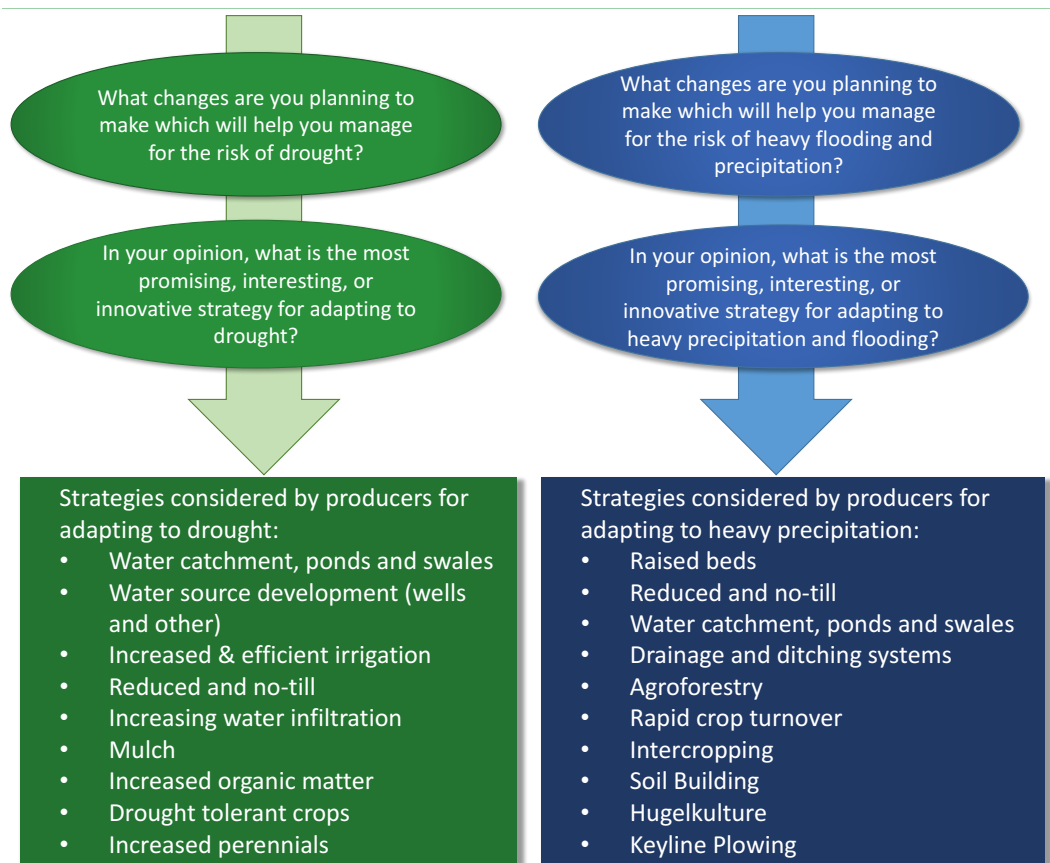


Illustration courtesy takepart.

Emerging Strategies Identified by Farmers for Adapting to Extreme Weather Risks

Thematic analysis of 190 farmers' responses to survey questions captures emerging knowledge about adaptation to the projected increased incidence of drought and heavy precipitation in Northern New England. Courtesy Alissa White, University of Vermont/Northeast SARE.



been compromised or are non-existent. Forested riparian buffers in particular can provide a high level of flood resiliency. In the Deerfield River Watershed, there are only 13,572 acres of forest land in the floodplain, river corridor and/or within 200 feet of rivers and streams. Most of the forested riparian buffer is in upland watershed areas. Opportunities exist along the Deerfield River and its major tributaries to plant forested buffers and buffers that complement existing agricultural activities.

Riparian buffer zones serve many purposes beyond protecting waterways from runoff. They can also be used for the production of tree crops and perennial food crops, and for improving soil quality. The Vermont Agency of Agriculture requires a ten-foot buffer of non-tilled land on all farms next to perennial streams, and where soil is in direct contact with a body of water, the buffer must be 25 feet. On farms with more than 200 mature animals, the buffer zone must be 25 feet everywhere, along both intermittent and perennial streams.

Town Agricultural Commissions can distribute information about the values of riparian buffers to encourage area farmers, as well as provide them with

potential sources of state and federal funding (see **Part 5: Next Steps**).

Because many farms are located in the floodplain and river corridor, they are on the front lines of climate-resiliency efforts.

Support Climate-Resilient Farming

In the Deerfield River Watershed, farming is woven into the fabric of every watershed town. Farming is a way of life, sometimes handed down through several generations. Like other economic sectors in the region, farming tends to be comprised of local,

privately-owned businesses, and as such, there is a bottom line that must be met. The challenge is to identify resiliency strategies that provide local and possibly watershed-scale benefits, and meet the landowners' economic needs as well as their vision for their land. Successful resiliency strategies will address this challenge and include economic incentives, when possible.

The Model River Corridor Easement under development by FRCOG and the FLT is a land conservation tool that will help maintain land in the river corridor in an undeveloped state (agricultural uses could continue) and allow river channel migration and floodplain access (a flood resiliency “safety valve”). Willing landowners would be compensated for the river corridor functions the easement protects. The River Corridor Easement will be a customizable tool that can be written to meet the needs of landowners and funding agencies, as well as climate resiliency goals.

As discussed previously, riparian buffers on agricultural land can provide climate resiliency benefits. The Town of Deerfield supports the maintenance of agricultural buffers by offering a


reduced tax assessment on agricultural land.

Owners of orchards, pasture and farms in upland areas may also own adjacent blocks of forested land. In this case, upland stormwater management projects that use a River Corridor Easement and “chop & drop” projects on small headwater streams may alleviate downstream flooding and stress on infrastructure. These same resiliency strategies, including the maintenance of healthy riparian buffers, could also reduce flood damages to upland farms and agricultural lands.

Federal and state agencies have an impressive online library of climate resiliency information and links to grant programs that fund resiliency projects for farmers, including reduced tillage and no till farming, and improved soil health through agroforestry and other perennial crop production, all of which combat climate change by sequestering more carbon and reducing soil losses. Watershed towns (and the region) are fortunate to have a local U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) office in Greenfield. In addition other resources include the Massachusetts Department of Agriculture (MDAR), the Franklin



Meryl LaTronica, Director of Farm Operations at Just Roots' Greenfield Community Farm, where sustainable farming practices are in place alongside food justice goals. Photograph by Timothy Shivers.



Challenges:

- Insufficient buffer between farm fields and the river
- Fields vulnerable to erosion
- Flooding from extreme precipitation threatens crops, topsoil loss and infrastructure, here and downstream

Opportunities:

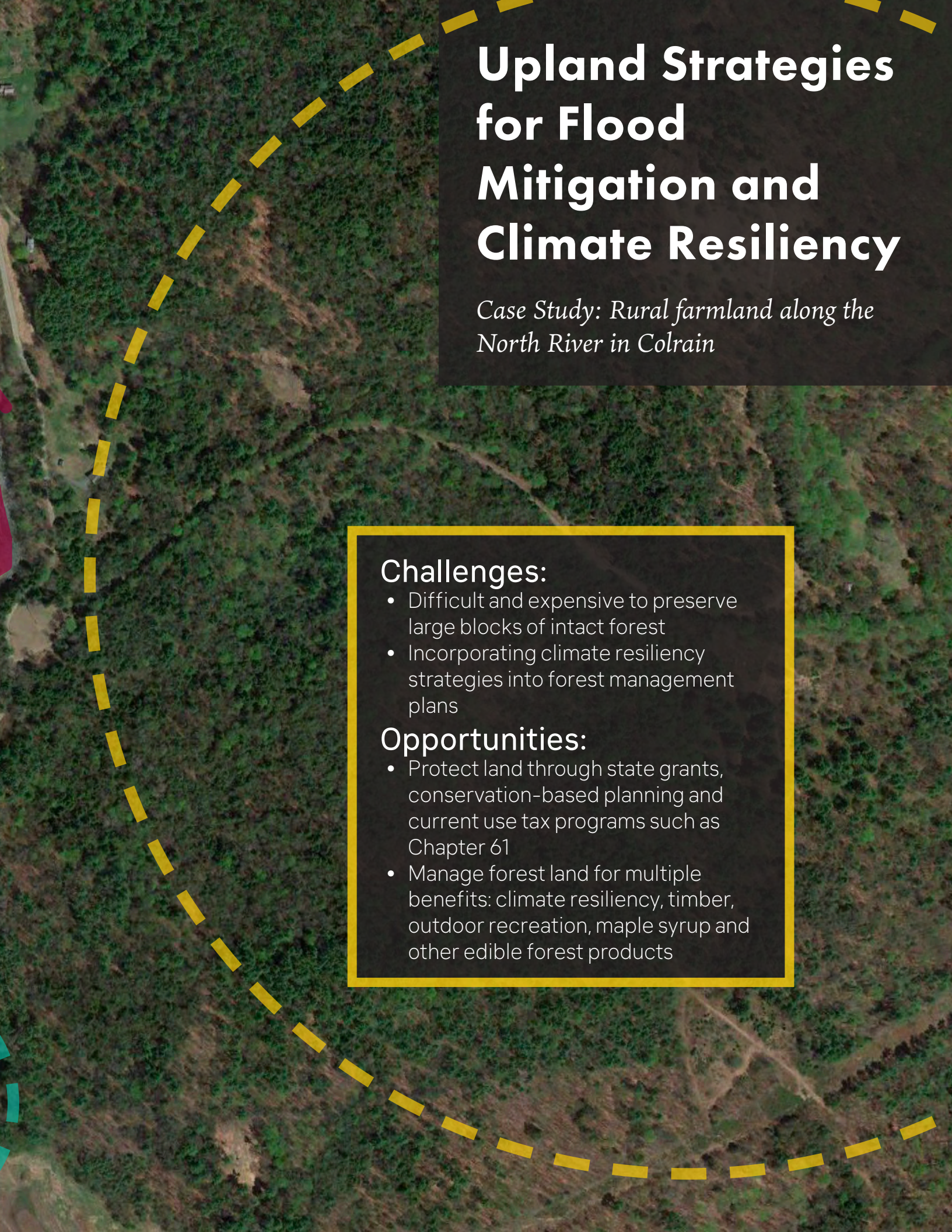
- 100-foot wide riparian buffers or filter strips
- Hedgerows, cover crops, no-till and other conservation management techniques to reduce runoff and drift
- Explore federal and state grants and incentives programs

Challenges:

- River not connected to its floodplain
- Lack of room for river to meander threatens roads and infrastructure
- River constrained by roads on either side; straightened and channelized under the bridge, a choke point
- Erosion of riverbank

Opportunities:

- Protect land along the river to provide space for flooding
- Provide incentives for floodplain restoration
- Bioengineered embankments and other nature-based solutions



Upland Strategies for Flood Mitigation and Climate Resiliency


*Case Study: Rural farmland along the
North River in Colrain*

Challenges:

- Difficult and expensive to preserve large blocks of intact forest
- Incorporating climate resiliency strategies into forest management plans

Opportunities:

- Protect land through state grants, conservation-based planning and current use tax programs such as Chapter 61
- Manage forest land for multiple benefits: climate resiliency, timber, outdoor recreation, maple syrup and other edible forest products



Challenges:

- Insufficient buffer between developed areas and the river
- Erosion along riverfront
- Flooding threatens roads and infrastructure

Opportunities:

- 100-foot wide riparian buffers or filter strips
- Nature-Based Solutions for bank stabilization and flood resiliency
- Protect land along the river to provide space for flooding “safety valves”
- Provide incentives for floodplain restoration

Challenges:

- Tributary runs off hills, often carrying sediment into river
- Lack of space for river to meander threatens roads and infrastructure, here and downstream

Opportunities:

- Increase culvert sizes
- Bioengineered embankments, chop and drop projects and other nature-based solutions for diverting flood waters and managing runoff
- Protect large blocks of forested land further up in the watershed

0 500ft.



Midland Strategies for Flood Mitigation and Climate Resiliency

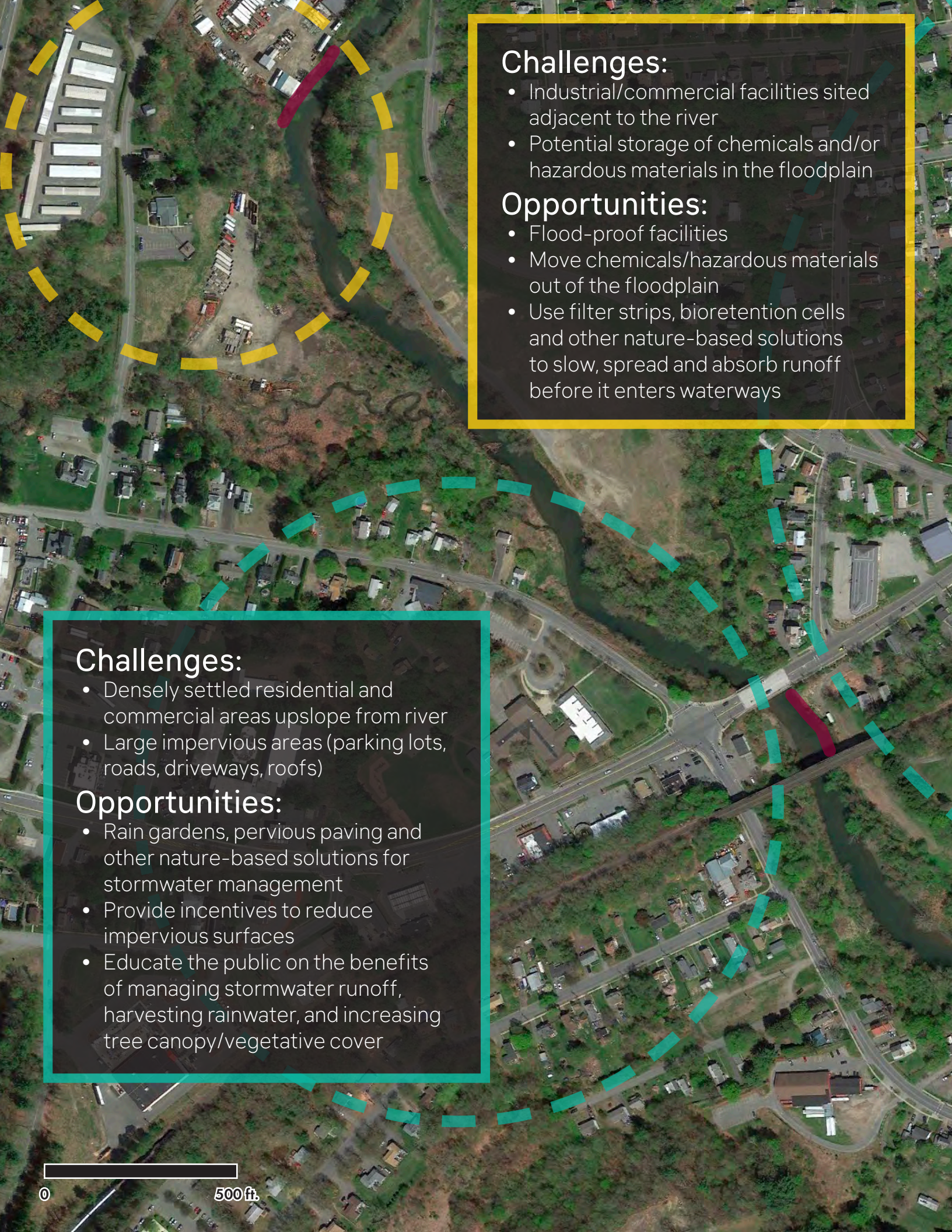
*Case Study: Moderately developed
village center along the Deerfield River in
Charlemont*

Challenges:

- Critical infrastructure sited adjacent to the river
- Potential storage of chemicals and/or hazardous materials in the floodplain

Opportunities:

- Flood-proof facilities
- Move chemicals/hazardous materials out of the floodplain
- Constructed wetlands and other nature-based solutions to temporarily store flood waters and redirect runoff

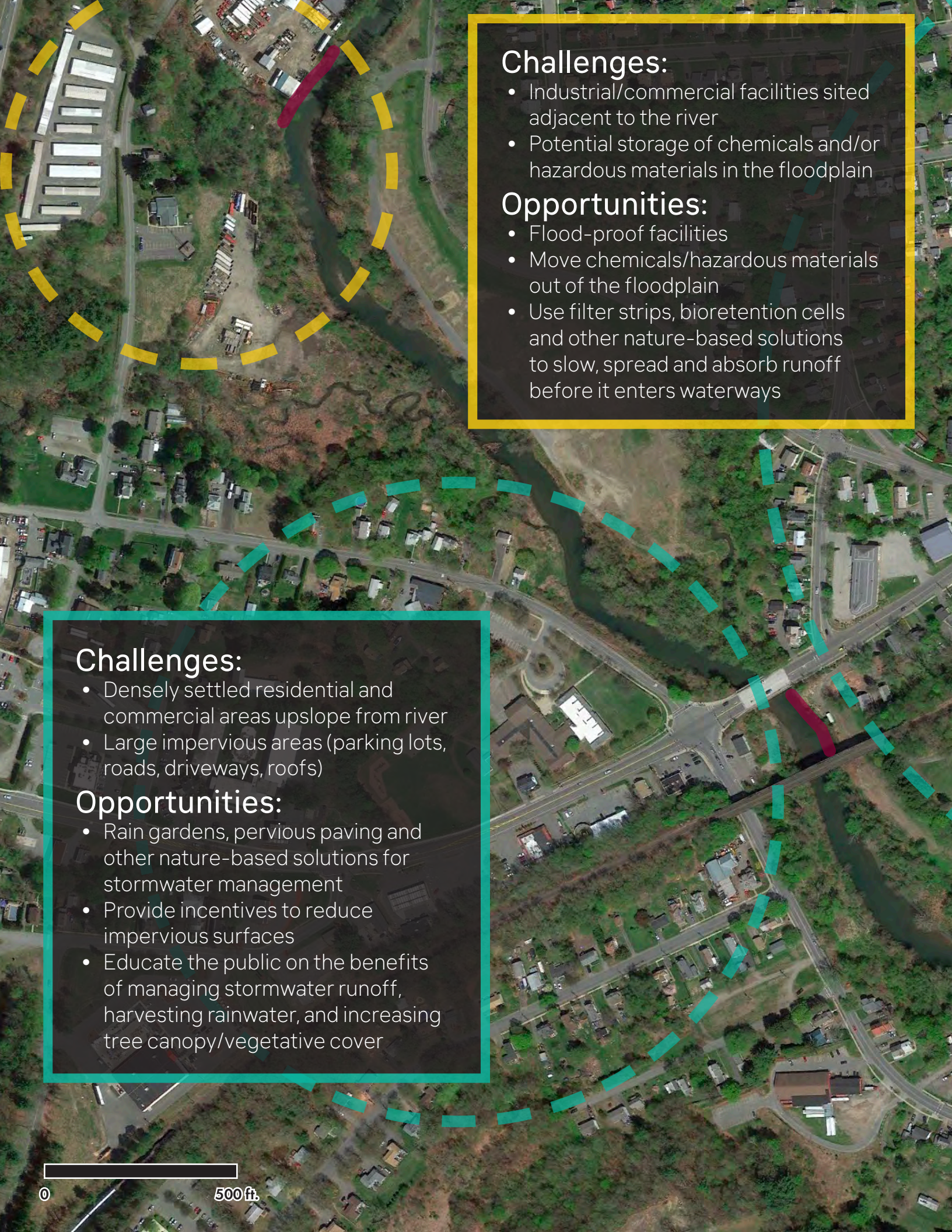


Challenges:

- Industrial/commercial facilities sited adjacent to the river
- Potential storage of chemicals and/or hazardous materials in the floodplain

Opportunities:

- Flood-proof facilities
- Move chemicals/hazardous materials out of the floodplain
- Use filter strips, bioretention cells and other nature-based solutions to slow, spread and absorb runoff before it enters waterways



Challenges:

- Densely settled residential and commercial areas upslope from river
- Large impervious areas (parking lots, roads, driveways, roofs)

Opportunities:

- Rain gardens, pervious paving and other nature-based solutions for stormwater management
- Provide incentives to reduce impervious surfaces
- Educate the public on the benefits of managing stormwater runoff, harvesting rainwater, and increasing tree canopy/vegetative cover

0 500 ft.



Lowland Strategies for Flood Mitigation and Climate Resiliency

*Case Study: Developed urban center along
the Green River in Greenfield*

Challenges:

- Insufficient buffer between roads, developed areas, and the river
- Runoff impairs water quality and habitat downstream
- Flooding threatens roads and infrastructure

Opportunities:

- 100-foot wide riparian buffers or filter strips
- Bioretention cells, green gutters and other nature-based solutions to manage runoff and stormwater
- Provide incentives for floodplain restoration



Japanese knotweed Polygonum cuspidatum photograph courtesy of Thomas Heutte, US Forest Service.

Conservation District (FCD), CISA and other groups whose staff are supporting, and will continue to support, Watershed farmers.

The ongoing challenge is to connect farmers with resources that address their needs as well as those of the larger watershed community. Town Agricultural Commissions can help bridge the gap between farmers and available resources by gathering information on the needs and vulnerabilities of farmers, researching available information and then presenting it at meetings or in outreach materials. Because farmers do not keep regular business hours, outreach efforts must be scheduled in advance. Farmers Markets or meetings of the Agricultural Commission might be good venues for outreach. In order for outreach to be successful, meetings with individual farmers or landowners may be required.

These initial steps towards resiliency are ones that town Agricultural Commissions can take to support their local farmers and owners of agricultural lands. FRCOG can provide technical assistance, using funding if available from the District Local Technical Assistance (DLTA) program, and work with local Agricultural Commissions to secure additional funding to support the implementation of these resiliency actions. Once these steps are complete, other climate resiliency projects can be developed that align and coordinate strategies to address landscape- and watershed-scale needs.

Solar Bylaws to Protect Forest Habitat

Nine Watershed communities have adopted bylaws to regulate the siting, construction, maintenance, and decommissioning of large-scale ground-mounted solar installations. These bylaws seek to minimize potential negative impacts of large installations while

also encouraging renewable energy by identifying areas in town where these systems would be most appropriate. In most towns, herbicides are prohibited for vegetation control, and stormwater management must be included as part of the ongoing operation and maintenance plan. Decommissioning requires re-vegetation of a site. Land clearing must be limited to what is necessary for the construction and maintenance of the system.

Shelburne and Heath specify land that should not be used for solar systems, such as prime farmland, permanently protected or Chapter 61 land, and NHESP priority habitat and BioMap 2 Core Habitat areas. Four towns limit the size of any single installation, ranging from 5 to 10 acres. To further reduce the impact of large-scale ground-mounted solar systems that result in clear-cutting of forests, towns could require a percentage of forest on the site be placed under temporary protection from development during the life of the installation. The Town of Shutesbury recently adopted a solar bylaw with the following requirement:

B. Mitigation for Loss of Carbon Sequestration and Forest Habitat

If forestland is proposed to be converted to a Ground-Mounted Solar Installation the plans shall designate thereon an area of unprotected (meaning not subject to c. 184, § 31-33 at time of application) land on the same lot and of a size equal to four times (4X) the total area of such installation. Such designated land shall remain in substantially its natural condition without alteration, including unauthorized (by SPGA) forestry/tree cutting, until such time as the installation is decommissioned. The special permit may be conditioned to effectuate and make enforceable this requirement.²

Invasive Species Management

In many instances, invasive plants are too widespread to be feasibly managed, except in selected situations where the impact is significant and the management costs acceptable. Despite our best efforts, invasive plant management may not be successful in all situations where it is attempted. So what can be done when faced with invasive plants

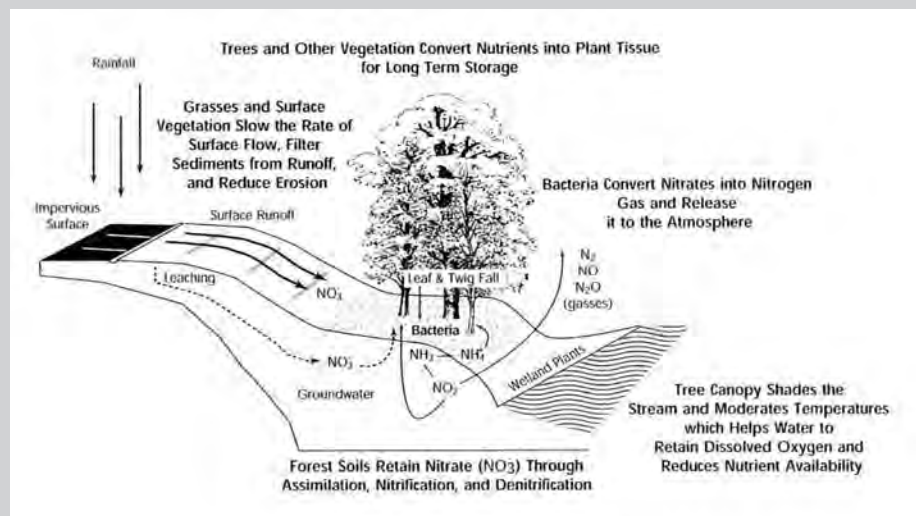
that cannot be adequately managed in valued conservation areas? Four general approaches may help:³

1. Provide native species with refugia from invasive species or otherwise mitigate their harmful effects (e.g. protecting isolated sites or deer exclosures).
2. Manage/restore ecosystem processes that favor natives (e.g. fire, hydrology).

Deerfield's Efforts Toward Climate Resiliency

The Town of Deerfield is located at the base of the Deerfield River Watershed, and is vulnerable to flooding impacts from the entire Watershed upstream. Following the devastating impacts of Tropical Storm Irene, the Town has undertaken a number of measures to improve its resiliency:

- The DPW and police mapped areas of inundation for different storm intensities
- The Town developed **Deerfield Operation Neighborhood** that identified parts of Deerfield that could be isolated during storm events, named coordinators and drilled
- The Town identified culverts, roads and bridges that are at risk of failure
- In 2010 the Town adopted a Stormwater Bylaw and Regulations that, in line with the MassDEP stormwater regulations, requires the 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
- 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 and protect roads and the sewage treatment plant



From Deerfield Best Development Practices Guidebook



Photograph courtesy of the Massachusetts Office of Travel & Tourism

3. Identify individuals/populations of native species with increased abilities to compete with or persist alongside the invasive species and use propagules in restoration efforts.
4. Change the conservation goal from restoration of a pre-existing community to the 'rehabilitation' of a portion of that community or even to a 'new' mixed community of native and non-native species with desirable ecosystem functions and properties possible.

There are not many effective ways to address the very widespread problem of invasive Japanese Knotweed in the Deerfield River Watershed that would show progress on a large scale. Within their borders, towns can work to prevent the colonization by knotweed of disturbed soils along road construction projects and at construction sites. The New Hampshire Department of Agriculture, Markets & Food recently released a new guidebook on preventing the spread of Japanese Knotweed at construction sites.⁴ The guidebook provides Best Management Practices for developers, site managers, contractors, utility companies, sand & gravel operations, highway/roadway maintenance crews, landscapers, and property owners.

Conservation Commissions and Planning Boards

can encourage or require riparian buffer preservation and rehabilitation (if invasives such as Japanese Knotweed are present) when permitting projects. Conservation Commissions and OSRP Committees could identify priority riparian areas for treatment and consider the recommendations of the Massachusetts Invasive Plant Advisory Group.

Improve Forest Resiliency

Most land in the Watershed is forested and privately owned. **Large blocks of intact forest in upland watershed areas and forested floodplains are both critically important to the health and resiliency of the watershed as well as local and regional economies.** Keeping forests healthy and climate resilient has economic benefits for landowners, as well as watershed-scale benefits of carbon sequestration, purifying air, recharging aquifers, and mitigating flooding by managing stormwater runoff. There are many resources available to landowners that are interested in making their forests more resilient to the pressures of development, invasive species and a changing forest composition due to climate change. Conservation Commissions and Boards of Assessors can provide information about these resources to private landowners who file Forest Cutting Plans for timber harvests or Forest Management Plans to be eligible

to enroll in the Forest Tax Program Chapter 61.

The MassWoods website <http://masswoods.net> has a lot of resources online, including: tools for conservation-based estate planning; current use state tax programs; best management practices for forestry; finding licensed foresters; as well as a step-by-step guide targeted for private landowners entitled *Increasing Forest Resiliency for an Uncertain Future*.

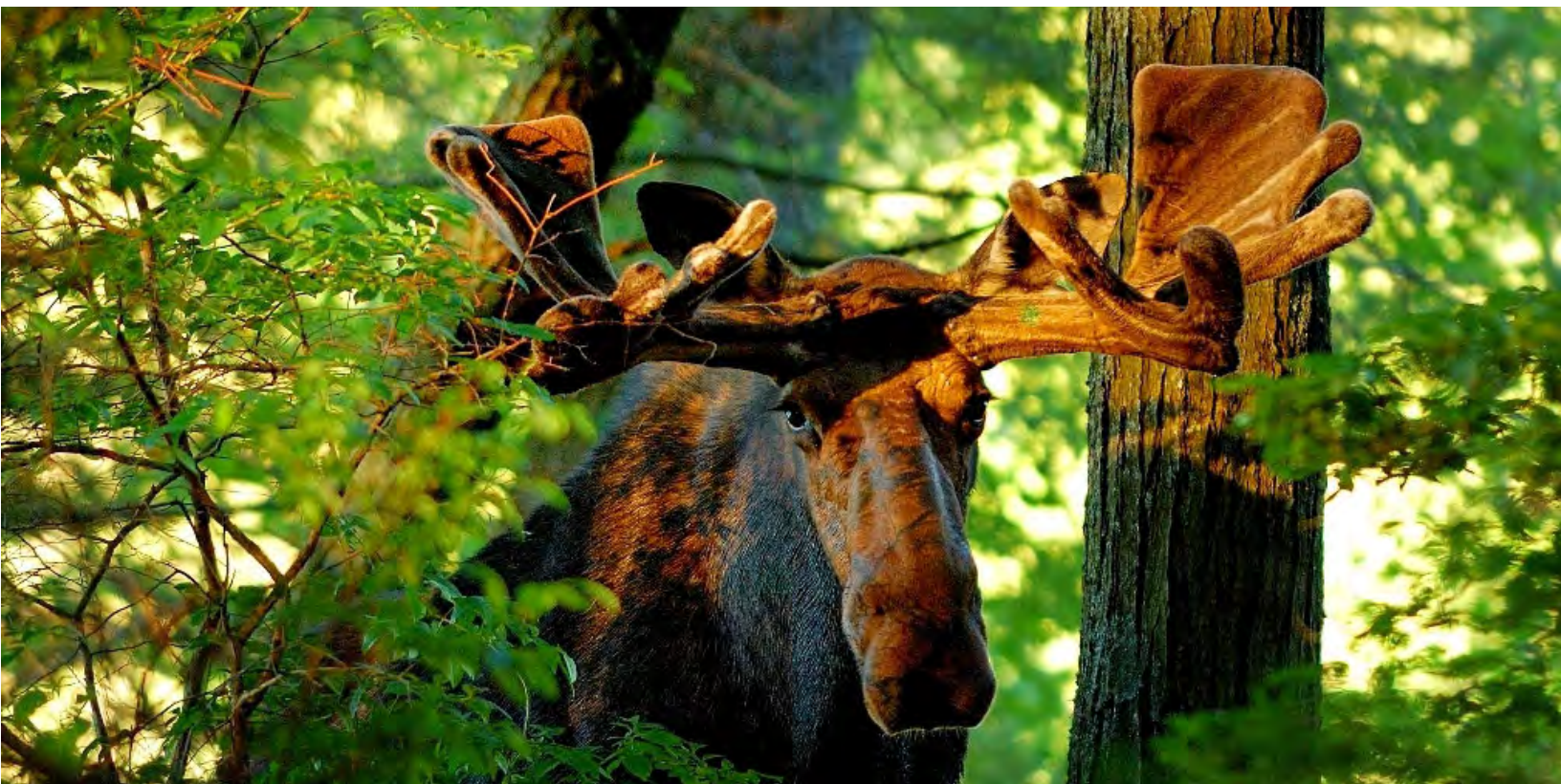
Another resource that will be available to private forest owners in 2019 is the “**Forests for the Fish**” toolkit under development by the Franklin Land Trust (FLT), Massachusetts Woodlands Institute (MWI), and Trout Unlimited (TU): <http://www.masswoodlands.org/projects/fisheries-management>

This toolkit can be used by private landowners who have forested land along coldwater streams and would like to work with a licensed forester and fisheries consultant to prepare a Forest Stewardship Plan that includes practices for enhancing habitat

and improving climate resiliency. **The toolkit will include information about invasive species control, management of forest cover in the riparian zone and catchment, identifying and managing cover around groundwater seeps and upwellings within the catchment, native planting of species for bank stabilization and the placement of in-channel structures such as large woody material including downed trees.** Such practices will maintain and improve conditions for fish and improve the flood resiliency of the Watershed in a time of changing climate conditions and increased stress on the landscape.

Towns can also develop Forest Stewardship Plans for Town Forests, forests owned by the Conservation Commission, or water supply land. If enrolled in the Forest Stewardship Program, towns can apply for funding to implement their forest stewardship practices available from the Community Forest Stewardship Implementation Grants for Municipalities program: <https://www.mass.gov/service-details/forest-stewardship-program>

Photograph of moose (*Alces alces*) in Massachusetts by Bill Byrne





Human Health & Welfare

Plan Ahead for Storms and Emergencies

Residents can help build resilient communities, reduce injuries and deaths, and minimize the economic impact of disasters and other types of emergencies if they take some time to develop a Family Emergency Plan and an Emergency Kit. This pre-disaster planning will help residents be prepared to shelter in place for the recommended 72 hours during an emergency or disaster event. Both FEMA and MEMA have many resources available to encourage individual and family preparedness. Towns can share these resources by adding links to FEMA and MEMA resources to town websites and by providing printed materials in public places, such as town halls and libraries: <https://www.mass.gov/be-prepared-for-emergencies> and <https://www.ready.gov/>.

Leverage Existing Services to Address Public Health Impacts

Continue to assess climate change-related public health vulnerabilities, and develop an Action Plan for your town, subwatershed or watershed.

Watershed towns are fortunate to have many local and regional organizations that advocate for and staff programs, as well as provide services for elderly residents and other vulnerable populations.

The challenge is to determine the most effective way to implement stakeholder

recommendations in order to address climate change stressors and vulnerable populations.

FRCOG proposes to convene the **Resilient DRW Coalition** in order to identify existing programs and services to leverage, research potential funding sources, and develop an implementation plan across



Image courtesy the Department of Homeland Security

the Watershed.

Potential members of **Resilient DRW** that could speak to public health needs across the Watershed include representatives from local Councils on Aging and Senior Center staff; MAPHCO; CPHS; LifePath Neighborhood groups; the FRCOG regional nurse; the Heath Town Nurse; the Rowe Town Nurse;

TRIAD officers; Meals on Wheels; VNA; Hospice of Franklin County; and HMCC, among others.

FRCOG has compiled a preliminary list of recommendations offered by Watershed stakeholders representing the public health sector. Most of the recommendations address the top two public health concerns that stakeholders agreed are exacerbated by a changing climate: the impacts of flooding and tick-borne diseases on vulnerable populations.

Flooding:

- Sheltering plans should include provisions for providing oxygen, accommodating service animals and pets, as well as residents that may need psychiatric medication or are being treated for opioid addiction
- Targeted outreach about personal preparedness, shelter in place, etc.
- Outreach to vulnerable populations in floodplains and mapped river corridors who are elderly, low income, disabled and have AFN (Access and Functional Needs)
- Need to identify who is not connected to reverse 911, chalkboard, etc.

Tick-borne Diseases:

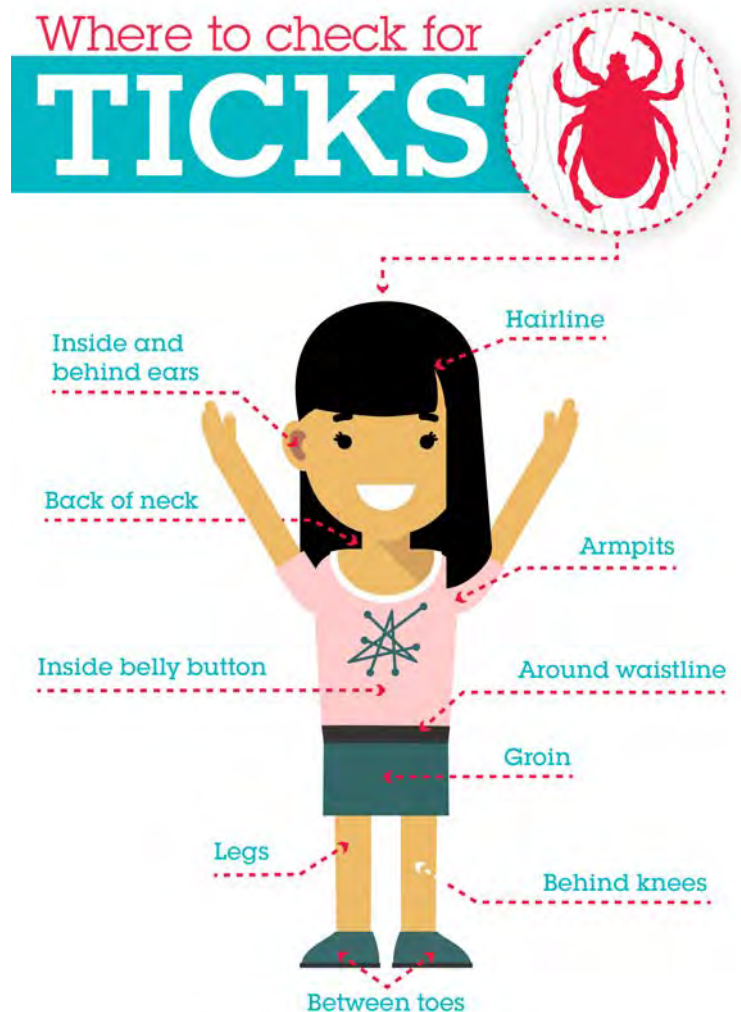
- Disseminate tick education/outreach materials through home health aides; caregivers; Visiting Nurse Association; Public Health Nurses; Meals on Wheels; LifePath; Vets District; and town transfer stations
- Provide outreach materials in different formats (audio, DMR/ARC)
- Support and participate in advocacy for vaccine and standardized testing protocol
- Increase transportation access to medical care, medicines, and insurance
- Increase education about use of eucalyptus oil, rose geranium oil, and other essential oils to repel ticks
- Increase educational signage
- Increase access to free permethrin and other

repellents, including Advantix and NexGuard for pets of low income populations; include outreach at agricultural fairs

- Educate children to perform self-checks for ticks: school outreach can help to change norms now

General:

- Towns with Emergency Dispensing Site planning groups that do not meet regularly could start doing so to build relationships
- Investigate the need for cooling centers and how to reach isolated elders and transport them to the cooling centers. The Town of Deerfield has



Sources: CDC, Massachusetts Department of Health and Human Services

Poster image courtesy WebMD, the CDC and the Massachusetts Department of Health and Human Services



Photograph of Hampshire County sheltering exercise courtesy of the Western Region Homeland Security Advisory Council (WRHSAC)

been opening a cooling center for a few years and could share lessons learned with other Watershed towns

Strengthen Safety Nets for Vulnerable Populations

Procedures for keeping contact information and lists of needs for vulnerable populations up-to-date could be improved. The Watershed towns have different systems for providing emergency information to their residents and keeping track of the needs of vulnerable populations, including Blackboard Connect, Triad and Reverse 911. The challenge is to ensure that vulnerable residents are enrolled and have the ability to receive the messages, particularly if phone lines are down and residents don't have cell service. **In the Town of Bernardston's digital newsletter, the fire chief has a column where he asks residents to directly email or call him with their family's list of needs.**

Towns without CodeRed/Reverse 911 capacity should add it, and make it very easy to get into the message system: for example, opting out, not opting in. To protect the elderly and those with access challenges, towns may consider a more formal FNSS (Functional Needs Support Services) registry type of system to build on the structures in place through public health nurses, TRIAD, and other

organizations.

Provide Support to Vulnerable Populations through Social Networks

It is clear from the findings of this report that Watershed residents are resilient, self-sufficient and look out for each other. Some specific recommendations that were offered by stakeholders in the public health field to strengthen these social networks include:

- Neighborhood generator cache to supply power for people with Access and Functional Needs (AFN)
- Volunteer community/neighborhood teams to help vulnerable populations before, during and after a storm event with needs such as plowing or shoveling driveways and walkways, delivering food, or helping with pets. **An existing example of this type of program are the services — chores, minor home repair and weekly trash pick-up — that volunteers (including youth age 14 and older) provide through the Rowe Council on Aging to eligible seniors.**
- Neighborhood "captains," especially for vulnerable populations

There are several other local examples to consider.

The recently formed **Buckland-Shelburne Village to Village Group** hopes to recruit volunteers to visit with seniors and help with such things as changing light bulbs or providing rides to medical appointments. These activities increase social connection, which can help during emergency events.

Because many Watershed towns contain spotty or non-existent cell phone service, and/or vulnerable populations that live in isolated, remote areas of town, it is also worth mentioning a program in the Town of Shutesbury that could be replicated in Watershed communities. **Shutesbury is piloting a neighborhood project that supplies a public safety radio to a designated person/ household in every neighborhood.** During an emergency or storm event, the designated person goes door to door to check on their neighbors. The Shutesbury EMD then has a limited number of people to communicate with regarding the needs of vulnerable populations and the safety of residents in each neighborhood.

Support Town Staff and Volunteer Participation in Regional Public Health Services

The three Watershed towns without public health nursing functions should consider participating in the Cooperative Public Health Service (CPHS) to strengthen local response to the current and projected increases in communicable and vector-borne diseases that are associated with a changing climate. CPHS is a regional health department staffed by FRCOG that supports local Boards of Health by providing environmental health inspections, code enforcement, education, wellness, and special programs. Another regional service is the Mohawk Area Public Health Coalition (MAPHCO), which helps local Emergency Management Directors, Boards of Health, and volunteers with shared regional equipment, planning, training, and drills for responding to public health emergencies, such as natural disasters and outbreaks of emerging

infectious diseases.

Continue to Advocate for More Funding to Expand the Capacity of Local and Regional EMS

A regional opioid crisis is currently straining the capacity of local and regional EMS providers. Add the stressor of climate change, and it is clear that more funding is needed to hire more first responders, purchase additional equipment, provide staff training, and support intermunicipal agreements and shared services for EMS between towns and private providers.

Climate-Resilient Septic Systems and Private Wells

Many residents, farms and businesses in the Watershed rely on private wells for their drinking water. The wastewater generated is often disposed of on-site through septic systems. Private wells can be contaminated by flooding or run dry during droughts. Septic systems can be damaged by uncontrolled stormwater runoff or by flooding and fluvial erosion if the system is located near a river or open water.

Protecting our water resources is one of the most important environmental health functions of a local Board of Health. Most Watershed BOHs use the FRCOG's Cooperative Public Health Service (CPHS) Regional Health Agent to review septic system plans and repairs to ensure public health and safety. Several CPHS member towns in the Watershed (Buckland, Charlemont, Hawley and Leyden) have adopted local septic regulations which require witnessing of Title 5 inspections and water testing. The remaining Boards of Health could consider adopting a similar regulation, if they don't already have one, or review their existing regulations and update them if necessary.

MassDEP regulates all public drinking water supplies, including individual wells that serve a business or a school. The local Board of Health

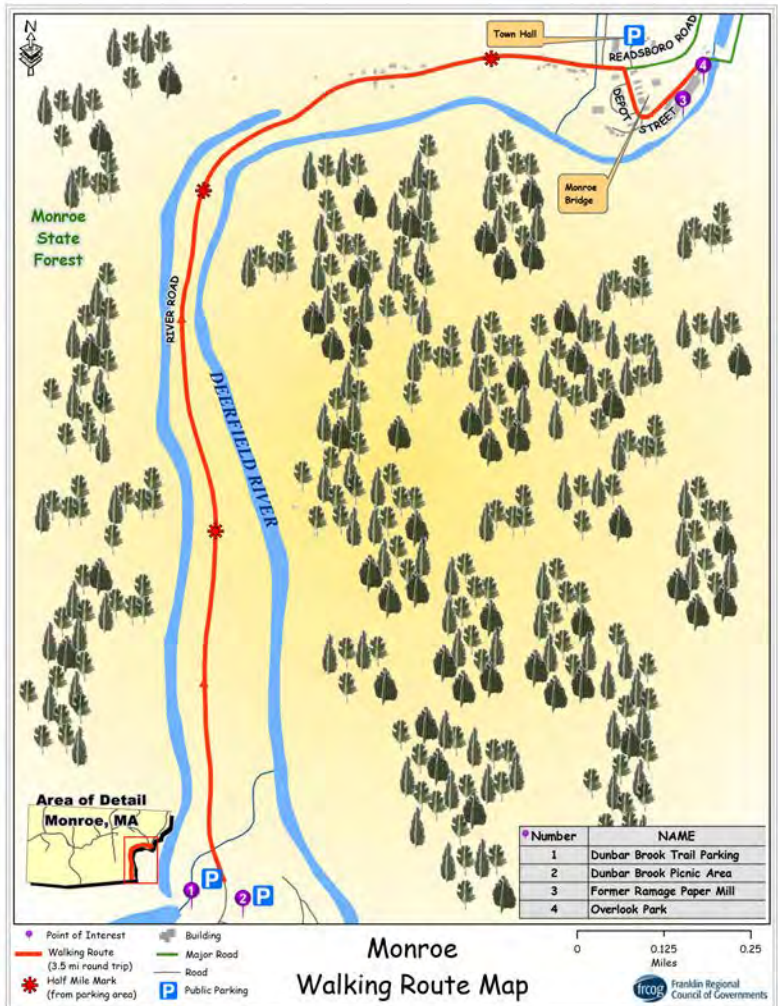
(BOH) is the gatekeeper to these public water suppliers, and responsible for regulating private wells in their towns. The local BOH has the power to adopt a Private Well Regulation that establishes criteria for private well siting, construction, and water quality and quantity. In July 2018, MassDEP issued their recently updated *Private Well Guidelines and Model Board of Health Regulations*, which can be found online.

Several Watershed towns that participate in the CPHS program (Buckland, Charlemont, Hawley and Leyden) have adopted private well regulations. These regulations include provisions for well construction and some water quality testing requirements to protect public health. These regulations should be reviewed against the new MassDEP model and updated, if necessary. Watershed towns without BOH private well regulations should consider adopting one and use the MassDEP model as a starting point. FRCOG can assist local Boards of Health with this task. Boards of Health can also partner with MAPHCO, CHPS and the Massachusetts Department of Public Health to secure funding to subsidize private well testing, particularly after a flood event.

Improve Access to Exercise and Healthy Foods

As mentioned earlier, several towns in the Watershed are among the highest ranking in the state for obesity. Getting around without a car can be challenging in rural areas, particularly given the steep terrain of many Watershed communities. Recently, the FRCOG published walking maps for every Franklin County town that highlight scenic walking routes ranging from one to four miles. These maps can be found at town halls and local libraries, and can also be downloaded from the FRCOG website. FRCOG has also published three bike maps for Franklin County, also available on the FRCOG site.

Municipal staff and board members have the power to adopt municipal policies to improve accessibility to healthy foods and physical activity, while community-based advocates such as Mass in Motion



Coordinators and community food advocates can inform and recommend policies. There are existing funding structures in place to improve such access, including those available to towns following Open Space and Recreation Plan updates, such as Mass DCS (Division of Conservation Services) grants.

Improving public education regarding SNAP (Supplemental Nutrition Assistance Program) benefits, as well as the WIC program (Women, Infants, and Children Food and Nutrition Service) can benefit residents who may not realize that they're eligible for such programs, such as nursing mothers.

Ordinances and bylaws are another way to improve healthy food access, including adopting right-to-farm bylaws. With the high quantity and quality of local farms and food producers in our region, it makes sense that towns should promote efforts to increase connectivity between local growers and food producers and consumers, including those on public assistance. Recently, the Pioneer Valley Planning Commission published the report *Municipal Strategies to Increase Food Access*, which is available for download online, and includes some of these strategies.



Local Economy & Infrastructure

Continuing Education of Town Staff and Volunteer Board Members

There are many training and professional development opportunities available to town staff and volunteer board members. By promoting these opportunities, towns reinforce the message that staff and volunteers can incorporate climate resiliency into their day-to-day work and their longer range planning projects. Towns can make local resiliency a priority by including modest training and workshop costs in their annual budgets for Planning Boards, Conservation Commissions, Agricultural Commissions, and by funding town staff to attend professional development workshops, such as those organized by BayState Roads for Highway Department staff. Many workshops are actually free, like the ones offered by DCR for Tree Wardens and Tree Committee members, the Citizen Planner Training Collaborative's workshops for Planning Board members, and FRCOG's Local Officials series. Funding a membership in the Massachusetts Association of Conservation Commissions (MACC) would provide Conservation Commission members access to important training opportunities, including the monthly webinar series Lunch and Learn.

Two examples follow of the climate resiliency benefits obtained by training volunteer board and commission members:

1. Conservation Commissions have a lot of authority under the Wetlands Protection Act and the Riverfront Act. They can condition projects to protect Coldwater Fisheries Resources (all of the rivers and streams in the Deerfield River Watershed are CFS), wildlife habitat, and riparian areas. Conservation Commissions can

own and manage land as well.

2. One of the responsibilities of town Planning Boards is to consider updates to existing land use regulations in order to address emerging development trends and the potential impacts on the community. There are many climate resiliency strategies for managing stormwater and development in floodplains and river corridors that Planning Boards can consider incorporating into town land use regulations.

FRCOG recognizes that volunteers and town officials have limited access to technical assistance. Training opportunities are very important to our towns, their staff and volunteers. However, with support from state programs, such as District Local Technical Assistance (DLTA), Community Compact, and EEA Planning Grants, towns have access to many services at the regional level.

Adopting the Community Preservation Act (CPA)

The CPA is a smart growth tool that helps communities preserve open space and historic sites, create affordable housing, and develop outdoor recreational facilities. CPA allows communities to create a local Community Preservation Fund that could be used by towns for projects that improve climate resiliency. For example, by preserving and rehabilitating open space that would allow a river to reconnect to its floodplain, or a rehabilitation project for an historic structure that includes storm proofing.

Only two towns in the Deerfield River Watershed have adopted the CPA and created a local Community Preservation Fund: Deerfield and Conway. Both towns have funded projects that have

Conceptual rendering by Field Geology Services of river bank restoration to allow natural flooding processes, from the Fluvial Geomorphic Assessment of the South River Watershed report published by the FRCOG in 2013 using CPA and Mass DEP 319 grant funding.

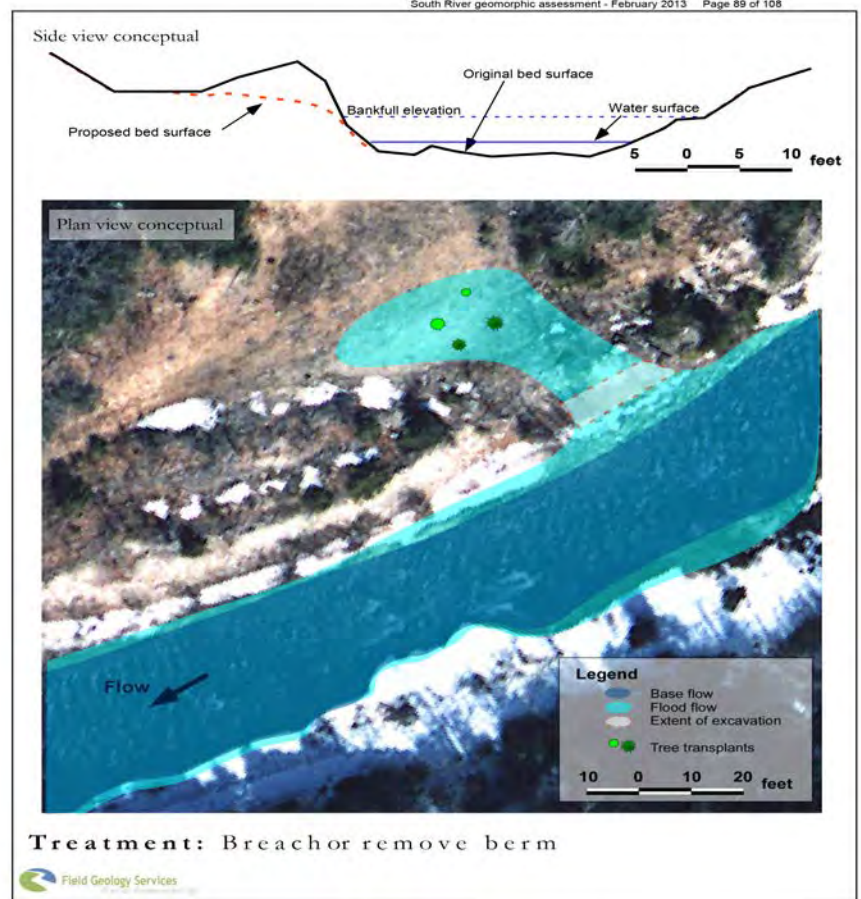
climate resiliency co-benefits. Deerfield used CPA funds as the required match for purchase of Agricultural Preservation Restrictions (APR) for approximately 100 acres of prime farmland and woodland in the floodplain of the Connecticut River. Conway used CPA funds as match for a MassDEP s.319 grant, which funded a bank stabilization, river habitat restoration and floodplain reconnection project in Conway Center.

Use Regional Programs to Strengthen the Resiliency of Emergency Preparedness Efforts

As previously described, climate change puts additional demands on local first responders and emergency preparedness infrastructure. The FRCOG hosts the Western Region Homeland Security Advisory Council (WRHSAC), which sponsors trainings for first responders and local officials, has equipment and supplies available to first responders and towns for use on a first-come, first-served basis during emergencies, and provides other resources on its website that are available to towns. One of the most useful things for towns to be aware of is the WRHSAC's Resource Guide and its companion Interactive Map: <http://wrhsac.org/news/interactive-resource-map/>. This online map provides quick information regarding WRHSAC's available equipment, including a brief description of the equipment, where it's located, and contact information for borrowing the equipment.

Recommendations from the Emergency Preparedness State of the County Workshop held December 6, 2018:

- The government should mandate that gas stations have generators, so when a disaster causes a long-term power outage, stations can still pump the gas they have. FRCOG is working on a white



paper about this issue to share with our legislative delegation.

- The FRCOG could help towns evaluate their emergency management readiness, including looking at their local plans and their local emergency operations center. FRCOG could help facilitate conversations to strengthen the connections between staff and volunteers within towns (e.g. Emergency Management Director, Board of Health, Fire, Police, Select Board).
- Identify regional points of dispensing of supplies to the public, such as bottled water.
- Request bids from contractors and emergency repair equipment companies on an annual basis, so towns have a current list when an emergency happens.
- Encourage EMDs to peer review their neighboring towns' plans. This would create familiarity with their neighbors' plans and an opportunity to see where they dovetail, or work against, their own plans.
- Vermont Yankee used to issue hazard warning radios to everyone within the evacuation zone. Explore feasibility of issuing radios to key neighborhood captains or every resident in the County, so they would be alerted during

emergencies.

Support and Fund the Professional Development of Emergency Management Directors (EMDs)

The FRCOG is working with Greenfield Community College (GCC) to offer a Professional Development program centered on emergency management principles for EMDs. The program should start in the Fall of 2019. While there will be a cost associated with the program, GCC hopes to be able to offer some scholarships.

Integrate Climate Resiliency into Town Planning and Construction Projects

When towns are considering new development projects, infrastructure improvements, and other economic development efforts, it's crucial to incorporate climate resiliency strategies at both the local and watershed scale. Some examples of ways that towns can integrate climate resiliency into their projects follow:

Multi-Hazard Mitigation Plans

All of the Watershed towns have FEMA-approved Multi-Hazard Mitigation Plans but several have expired or will expire soon. Over the next 18 months, ten of the Watershed towns will be working with FRCOG to update their Multi-Hazard Mitigation Plans. These projects can incorporate resiliency

strategies discussed in this document and other publications, including the Commonwealth's new 2018 Hazard Mitigation and Climate Adaptation Plan.

Open Space & Recreation Plans (OSRPs)

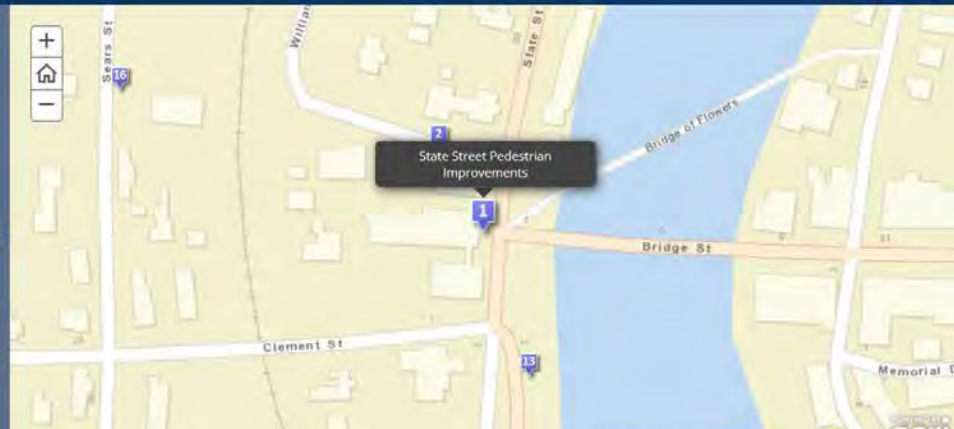
Only five of the 14 Watershed towns have approved OSRPs. These plans can be updated to include climate change data and climate resiliency action steps. The remaining towns have plans that expired recently or several years ago. **When a town undertakes an OSRP update, information about climate change and specific resiliency action steps should be included**, as the Town of Ashfield did in their 2018 OSRP. It makes sense to evaluate the climate resiliency benefits of land being considered for preservation or recreational use, because oftentimes there are co-benefits, particularly for land in the floodplain or river corridor, as well as upland, forested areas that can help with stormwater management. Having an approved OSRP makes a town eligible for several different state grant programs administered by the Division of Conservation Services, which can fund the acquisition of conservation and recreation land, as well as the development and renovation of parks.

Complete Streets and other transportation projects present opportunities to make road-stream crossings more climate resilient, use NBS to manage stormwater, reduce impervious surfaces and add more trees to developed landscapes. For example, towns can use the new reports and maps of high risk

Buckland: Complete Streets Prioritization Plan

Prepared by FRCOG

A Story Map



FRCOG developed an online Story Map for the Town of Buckland to document and prioritize locations for Complete Streets improvements.

stream crossings in the Deerfield River Watershed that are now available on FRCOG's website. The purpose of the maps and reports are to help municipal officials and public works staff prioritize bridge and culvert upgrades in their town. The reports also provide information on how to make road-stream upgrades more resilient to current and projected precipitation conditions, and lists potential funding sources for upgrading crossings.

Tools for Preparing for and Responding to Emergencies

The grant that funded the development of this resiliency plan also provided funding for the FRCOG to develop several tools that town Highway Superintendents, EMDs and other first responders can use when preparing for and responding to an

emergency or natural hazard. The tools are described below and will be given to the towns in electronic format:

1. A spreadsheet containing a list of equipment in the County that could be used during an emergency response, including fire apparatus and heavy highway equipment. This list will also be distributed to the Northwest MA Incident Management Team for use in the multi-agency coordination center (MACC). When a large event happens and towns need to borrow equipment to respond, the logistics personnel on the Team will put the requesting town in touch with another Franklin County town that has what they need. A copy will also be sent to Shelburne Control in case they get a request for equipment. A copy of just the equipment for a

Resilient Roads

Most culverts and many bridges in the Watershed are undersized, at a high risk of failure, or are contributing to the instability of rivers and streams. These conditions make the transportation infrastructure vulnerable to storm damage, and communities vulnerable to loss of emergency services and other forms of economic disruption. In addition to leveraging transportation projects to fund climate resilient upgrades and retrofits, towns can take these additional steps:

- Identify non-stream crossing road drainage infrastructure and assess vulnerability; prioritize for repair or replacement
- Incorporate climate resiliency into road maintenance projects eligible for reimbursement under MassDOT's Ch. 90 program
- Leverage non-transportation grant funding for drainage repairs and replacements from Community Development Block Grants and MVP Action Grants; additional grant programs are in the Appendix
- Participate in MassDOT's new **Roads & Rivers** training program for Highway Department and other municipal staff, which will include understanding of river processes, aquatic habitat, and how transportation infrastructure affects and is affected by river stability, as well as how to design, construct and maintain transportation infrastructure that accommodates river channel stability



Stormwater drainage improvements to Four Mile Brook Road in Northfield were funded by Ch. 90 and a grant from Mass DEP's 319 program.

respective town will go to the Highway Superintendent, EMD, Fire Chief, and Town Administrator in that town. The equipment is typed according to FEMA standards, including cost codes, which will make it easier for towns to file for FEMA reimbursement.

2. Each town will receive a customized copy of the Regional Debris Management Plan with their specific debris management site identified.
3. Preliminary calculations were run using a spreadsheet tool on the high risk culverts identified by FRCOG from the MassDOT database. The calculations could help town Highway staff determine whether an impending storm may result in the culvert being overwhelmed (e.g. if the storm will dump 4 inches of rain within a 24-hour period, culverts X, Y, and Z won't be able to handle it).
4. A similar tool was used to estimate flood risk of critical infrastructure buildings. The results of both tools will be sent to the towns and the MACC.

Become a Municipal Vulnerability Preparedness (MVP) Community

Six Deerfield River Watershed towns — Ashfield, Buckland, Charlemont, Colrain, Conway and Deerfield — are designated MVP communities.

Ashfield and Conway achieved MVP designation together, continuing an intermunicipal and intrawatershed partnership that has focused on the South River watershed. Common concerns and challenges were identified by both towns, as well as recommendations to benefit both towns and the South River watershed as a whole.

Not surprisingly, flooding was a top hazard identified by all six Watershed towns in their MVP plans. Damage to roads, bridges, culverts, businesses, homes and town buildings were listed as top concerns. Eroding river banks, lack of riparian buffers and damage to farm fields were top vulnerabilities. Several top recommendations to

improve local flood resilience present opportunities for the towns to collaborate and coordinate efforts to improve watershed resilience.

You Have the Power!

Towns can use zoning and other regulations to shape the future of their community and its resiliency to climate change. Town regulations are one of the most powerful tools available to towns. Watershed towns also have primary control over their natural resources, including wetlands and public water supply aquifers. If towns coordinate their land use regulations across a shared watershed, climate resiliency is strengthened.

Update Town Regulations and Work with Neighboring Towns to Build Resiliency at a Watershed Scale

In all the Watershed communities, volunteer Planning Boards, Zoning Boards of Appeal, Boards of Health, and Conservation Commissions review development projects. They can also propose amendments to town bylaws and regulations.

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 by 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 benefit the entire watershed.

	Ashfield	Barnardston	Buckland	Chathamont	Colrain	Conway	Deerfield	Greenfield	Hawley	Heath	Leyden	Momroe	Rowe	Shelburne
Development in Floodplains	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Stormwater Management	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Erosion / Sedimentation	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Impervious Cover	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Cluster / OSRD / NRPZ	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Water Supply Protection	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Parking	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Common Driveways	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Site Plan Review	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Vegetation / Trees	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Large-Scale PV	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally

	Ashfield	Barnardston	Buckland	Chathamont	Colrain	Conway	Deerfield	Greenfield	Hawley	Heath	Leyden	Momroe	Rowe	Shelburne
Stormwater Management	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Erosion / Sedimentation	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Vegetation / Nat. Features	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Street Trees	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally
Road Design	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally	Minimally

Fully Addressed in Regulations
 Partially Addressed in Regulations
 Minimally Addressed in Regulations

2016 summary of zoning and subdivision regulations that address water quality impacts in Watershed communities (FRCOG). Some towns may have updated their regulations since 2016.

Towns can update their Zoning and Subdivision Regulations to include requirements that mandate or encourage the use of Nature-Based Solutions to manage stormwater runoff and reduce impervious surfaces. **These updates should require the use of the most recent severe storm precipitation data** in order to size stormwater management systems, including culverts. Engineers should be required to use the NOAA Atlas 14 for Massachusetts, which includes detailed precipitation data for the Deerfield River Watershed based on monitoring stations in Heath, Ashfield, Greenfield and Colrain.

Another resource available to design engineers is an interactive website from Cornell that includes estimates of extreme rainfall for various durations (5 minutes to 10 days) and recurrence intervals (1 year to 500 years): <http://precip.eas.cornell.edu/>

Appendix D of the FRCOG’s 2017 *Deerfield River*

Watershed-Based Plan contains a comprehensive review and analysis of the land use regulations of all the Watershed towns to determine if they addressed climate resiliency. The results are shown above. The review criteria included the following questions:

- 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 projects such as ground-mounted solar installations?

What's Next?

- Planning Boards and FRCOG can assess how well the existing regulations of towns in each of the ten subwatersheds (see **Who Are Your Watershed Neighbors?** in the Appendix) align with each other and which regulations can be updated to meet town and watershed climate resiliency needs
- What opportunities exist to align other local regulations, such as Board of Health Regulations, General Bylaws, and Wetlands Bylaws?
- Where are opportunities to adopt new regulations that encourage Smart Growth and climate resiliency? Examples include: creating a River Corridor Protection Overlay District (described in the next section), Open Space Design (OSD)/Natural Resource Protection Zoning (NRPZ), Smart Parking, and an Aquifer Protection District

Encourage Climate-Resilient Infill and Redevelopment

Priority development areas of the Watershed (downtown Greenfield and Shelburne Falls) as well as all town centers could update their land use regulations to allow for mixed use development (residential, commercial, light industrial, retail); encourage rooftop and other low-impact siting of renewable energy; restore wetlands and the flood storage capacity of floodplains; and use NBS to manage stormwater. Ideally, infill and redevelopment should be prioritized in areas outside of the floodplain. If not, then projects should include creating compensatory flood storage and NBS for stormwater management.

Partner with Local Businesses to Increase Resiliency

The many private businesses in the Watershed are vulnerable to a changing climate as well, especially those located near rivers. There are also many small businesses that can suffer lasting economic damage from a single extreme weather event. Unlike larger businesses, they may lack access to capital, often operate from a single storefront, and are heavily dependent on the local community for business activity.

The economic impacts of climate change range from costs associated with direct damage, such as flooding or extended power outages, to indirect risks, such as changes in customer demand. There are steps that businesses can take to build climate resilience, however, including developing disaster recovery plans, adding on site power sources like rooftop solar, identifying backup supply and distribution chains, and communicating preparedness information to employees.

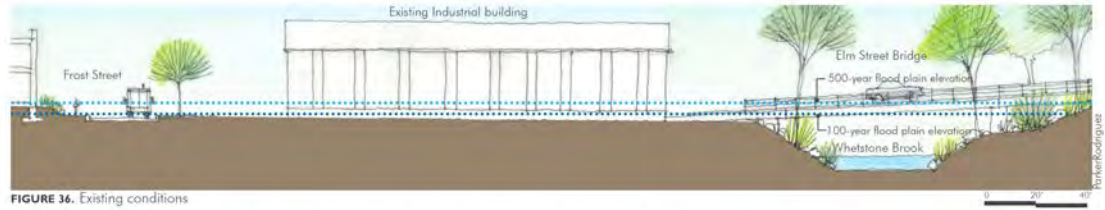


FIGURE 36. Existing conditions

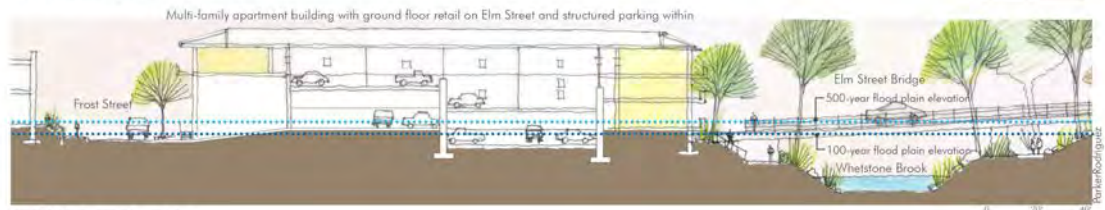


FIGURE 37. Proposed conditions

Major flooding of downtown Brattleboro, Vermont during Tropical Storm Irene led the town to embark on a series of initiatives to reduce the impacts of flooding. In 2016, the town received technical assistance from the EPA in order to identify design solutions for the lower Whetstone Brook that would reduce flood damage, manage stormwater runoff, envision infill development, and reconnect the brook to surrounding neighborhoods. Source: Design for Resilience in Brattleboro’s Lower Whetstone Brook Corridor (EPA Smart Growth)

Identify Climate Resilience Opportunities that Benefit Businesses, Towns, and Watershed

Examples include using NBS to manage stormwater, reducing impervious surfaces, and planting trees to reduce urban heat island effects. Complete Streets projects and economic development visioning projects for village centers and downtown areas are also opportunities to build climate resiliency into planning and construction projects. As previously mentioned, towns with updated land use regulations that encourage the use of these climate resiliency techniques for new development and redevelopment projects will help businesses avoid or minimize the impacts of climate change on their bottom line.

Local business associations can provide outreach and information on climate resiliency, including response, recovery and avoidance strategies as well as available state and federal grant programs and other financial incentives. Having town officials, such as the Emergency Management Director (EMD), actively involved in this outreach effort to businesses would also aid first responders during an event. In addition, the Shelburne Falls Area Business Association that serves nine of the 14 Watershed towns could assist with this outreach.

Regulate the Use and Storage of Hazardous Materials

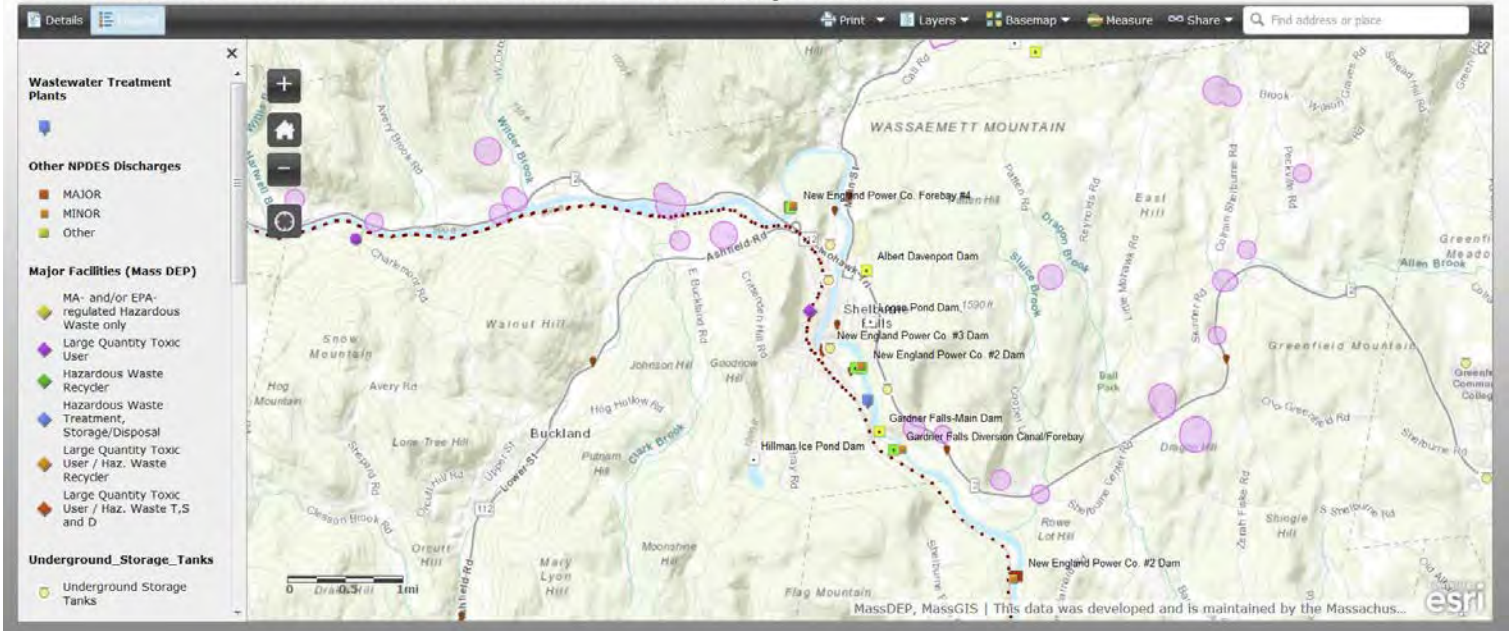
Because so many Watershed businesses are located

in or adjacent to the 100-year floodplain or mapped river corridor, **there is a risk of release of hazardous materials during a flood.** Towns have the authority to regulate businesses that use and store toxic and hazardous materials, and can accomplish this through their Zoning Bylaws, a General Bylaw or Board of Health regulation.

Use the resources of the Massachusetts Office of Technical Assistance (OTA), which offers many resources to reduce the exposure of workers, first responders, and communities to toxic and hazardous materials, in the event that critical infrastructure is damaged due to severe weather events or power outages. The OTA provides training and information to first responders, Boards of Health, and Local/Regional Emergency Planning Committees about preventing potential climate change related chemical accidents and improving community safety by incorporating toxics use reduction into local emergency preparedness and planning frameworks. OTA also has many resources available to towns, including a Chemical Safety & Climate Change Resiliency Curriculum and Training Materials, as well as an interactive mapping tool that towns can use to help them identify the locations of underground storage tanks, wastewater treatment plants, and facilities that generate hazardous waste or use toxic or hazardous materials.

OTA also provides free and confidential technical assistance to businesses and toxics users to help them reduce their use of hazardous and toxic chemicals, or conserve water, energy and other resources.

Massachusetts Toxics Users and Climate Vulnerability Factors



The Village of Shelburne Falls on the Massachusetts Toxics Users and Climate Vulnerability Factors interactive mapper operated by the OTA.

Protect Critical Infrastructure

Critical Infrastructure are the buildings, structures, facilities and systems that are critical to the health, safety and welfare of residents and to the operation of a community. Some of this infrastructure crosses town and watershed boundaries, such as roads and aquifers that supply drinking water. Some examples of Critical Infrastructure in the Watershed include:

- Public water supplies, sewer and stormwater management systems
- Town Halls, Fire, Police & EMS buildings
- Dams, energy and telecommunications systems
- Schools, railroads, transfer stations
- Hospitals

Given historic settlement patterns and the landscape of the Watershed, it is no surprise that most of the critical infrastructure is located adjacent to rivers, making it particularly vulnerable to extreme storms and changes in precipitation patterns, particularly flooding. For many towns, relocating critical infrastructure and facilities is not a feasible option. Even flood-proofing existing buildings may be cost prohibitive for our small rural towns, because grant programs that might help to fund retrofits, like FEMA mitigation grants, require a 25% local match. **Addressing the climate vulnerabilities of infrastructure may be the biggest challenge our towns face** and one that they will not only need funding for, but also the help of their watershed neighbors, FRCOG, state and Federal agencies.

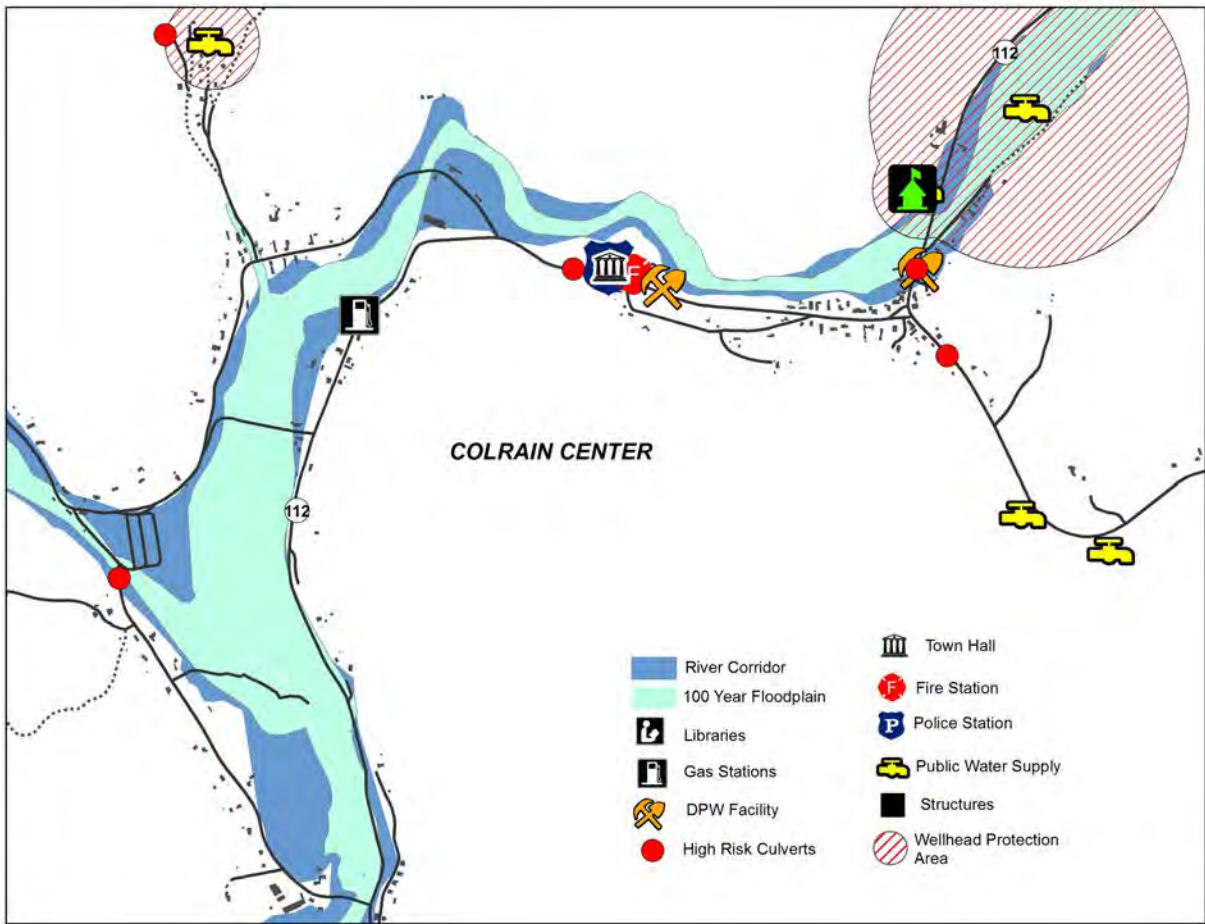
Many Watershed towns will be updating their Multi-Hazard Mitigation Plans over the next 18 months, so much of this work could be done as part of that effort. The steps to Resilient Infrastructure described on the following pages can also be done as part of the MVP Community Resilience Building project.

What steps can towns take to make their critical infrastructure climate resilient?

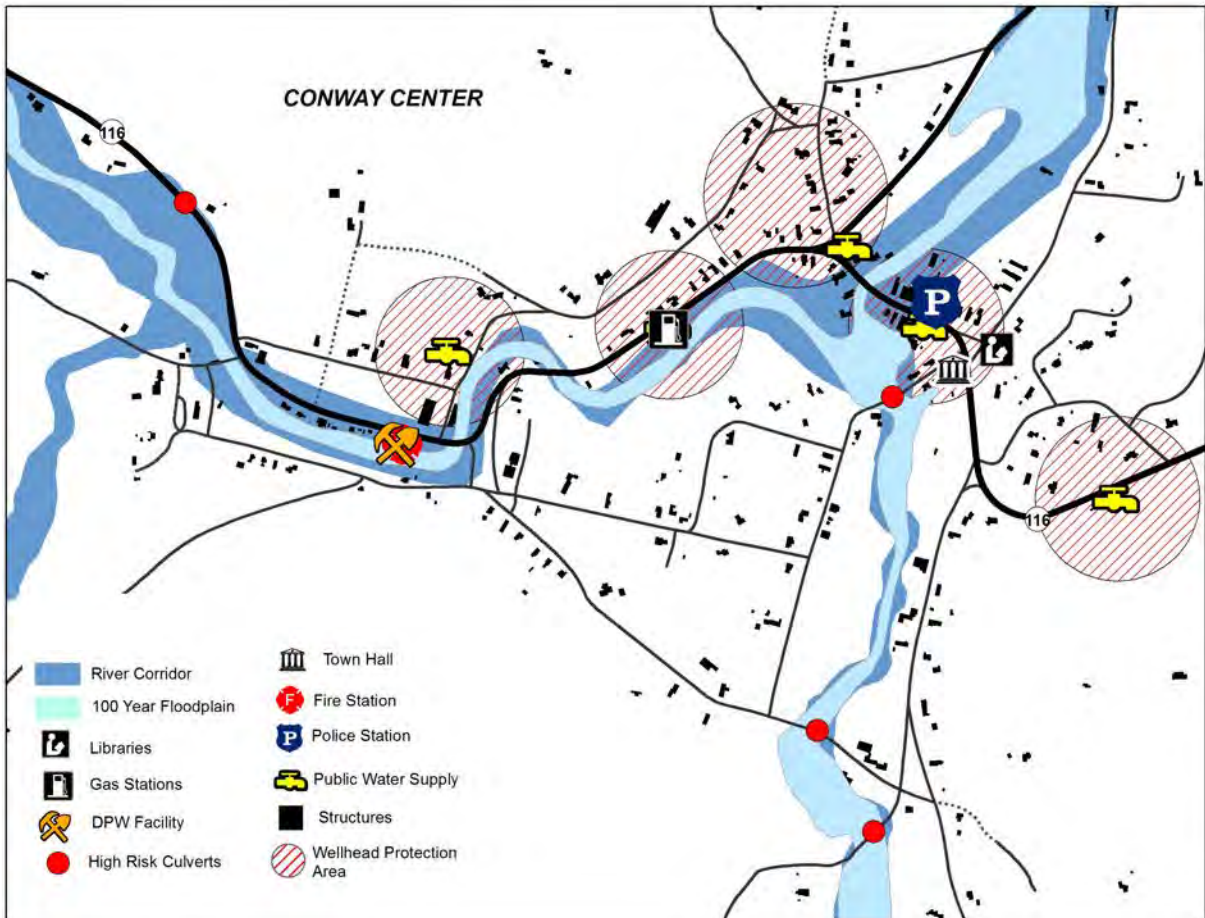
Identify and Assess Vulnerable Infrastructure

What and where is it? How or why is it vulnerable? Who owns it and therefore, who is responsible for it?

- Update the critical infrastructure maps in your town's Multi-Hazard Mitigation Plan. Identify critical infrastructure in the FEMA 100-year and 500-year floodplain (if it has been mapped). If your community has USGS inundation maps or River Corridor maps use those too. For other towns, use Active River Area (ARA) mapping.
- Understand the risks. Does the building flood because of stormwater runoff/drainage



Maps showing the river corridor and 100-year floodplain in the towns of Colrain and Conway, including critical infrastructure that is at risk from flooding and fluvial erosion due to changes in the location of the river channel as a consequence of climate change. The river corridor was mapped by the FRCOG using a protocol based on the science of fluvial geomorphology.



problems? Does it flood because river levels rise? Is it threatened by fluvial erosion? Are there other vulnerabilities that are exacerbated by climate change? Examples include: lack of capacity for water/sewer infrastructure; aging infrastructure; undersized culverts.

- Identify partners to work with to increase resiliency of non-municipal owned infrastructure (MassDOT, Eversource, National Grid, privately-owned businesses, etc.)

Prioritize Vulnerable Municipal Infrastructure and Identify Feasible Resiliency Options

Make a prioritized list of vulnerable infrastructure. Are failures/damages occurring frequently? What are the impacts? Loss of service, risks to public safety? What can be done to make the infrastructure more climate resilient?

The three Rs of Infrastructure Resiliency:

REDUCE

Reduce demands on public water supplies and municipal sewer systems. Encourage water conservation measures, such as rain barrels and roof rainwater catchment. Identify ways to reduce municipal demands on these systems and partner with private businesses to encourage their implementation of water conservation measures.

Reduce demands on the electrical grid. Identify areas prone to outages. Explore undergrounding of electric lines, mini grids and other innovative techniques to keep downtown and critical infrastructure up and running. Distribute information to residents about the wide range of programs available to all homeowners in Massachusetts to help them reduce their energy consumption. There are programs specifically designed to assist vulnerable populations with paying a portion of winter heating bills; emergency heating system repair and replacement services; and full-scale home energy conservation services. <https://www.mass.gov/energy-efficiency-for-your-home>

Maintain Green Communities Designation or consider becoming a Green Community, in

order to access grants for climate resilient energy projects that reduce municipal energy costs, strengthen the local economy, reduce greenhouse gas emissions and promote energy efficient building construction.

- Reduce flooding and fluvial erosion that threatens critical infrastructure
- Use NBS to manage stormwater runoff throughout the watershed: in developed areas, upstream areas and upland watershed areas
- Update zoning and other regulations to add stormwater management requirements for new and redevelopment projects, encouraging the use of NBS
- Protect open space, riparian buffers and floodplains to provide a “safety valve” during floods

RETROFIT

Identify feasible building retrofits that increase climate resiliency. Some examples to consider:

- Flood-proofing
- Heating/cooling system and energy retrofits for municipal buildings (Green Communities grants can help fund these)
- Adequate storage/containment/response provisions for municipal and private facilities that use or store hazardous materials (this is critically important for facilities vulnerable to flooding)
- Incorporate climate resiliency retrofits into planned capital and infrastructure projects and routine maintenance practices (some examples of this include using NBS in transportation projects, Complete Streets and urban tree plans)
- Plan for upgrades, replacements, and road maintenance practices that disperse and slow down stormwater runoff

RELOCATE

This is the most expensive and probably the least feasible of the climate resiliency options for small towns. However, remembering to consider climate

vulnerabilities when designing and locating new critical infrastructure, particularly municipal buildings like Fire Departments and Highway Garages, makes sense. Opportunities may arise for private structures to be removed from the floodplain or river corridor following a disaster event, as part of a redevelopment project, or if the structures have been abandoned or taken for back taxes.

Resilient Drinking Water Supplies and Wastewater Disposal Systems

According to the 2013 *Franklin County Regional Plan for Sustainable Development*, the preferred form of development is mixed use residential and commercial development in town centers, and infill and reuse of vacant or under utilized buildings and sites. This type of development can make a community more climate resilient by reducing fossil fuel use and greenhouse gas emissions and reducing development pressure on farmland and forests, which provide many climate resiliency services.

Many Watershed communities lack the ability to support this type of sustainable and climate resilient growth, however, because the water and sewer infrastructure is either aging or absent in town centers. Infrastructure that does exist is vulnerable to climate change impacts such as severe storms and flooding. The vulnerabilities of municipal water and sewer systems can have negative impacts on natural resources, public health, as well as town governments and the local economy, due to the serious constraints they impose on local economic development efforts, as well as the financial burdens they may create for towns. Conway has been talking about the need to sewer their village center for years. Colrain has explored expanding sewer service to residents and connecting to the

Barnhardt wastewater treatment plant. Deerfield has completed bank stabilization work to protect the Old Deerfield Wastewater Treatment Plant.

This is a critical issue that needs funding for additional feasibility studies and engineering analyses. Towns, with funding from the Commonwealth and assistance from FRCOG staff and other partners, could: follow up on the recommendations in existing studies; assess the need for climate resilient retrofits for existing systems; and if new wastewater treatment or municipal public water supply systems are constructed, make sure they are located and constructed to be resilient to climate change.

Moving Out of Flood's Way

In 2005, Tropical Storm Tammy dumped between 12 to 22 inches of rain across the region. In Greenfield, flooding on the Green River caused the evacuation of the Wedgewood Gardens Trailer Park. Thirty-five mobile homes were condemned as uninhabitable, leaving 75 residents homeless.



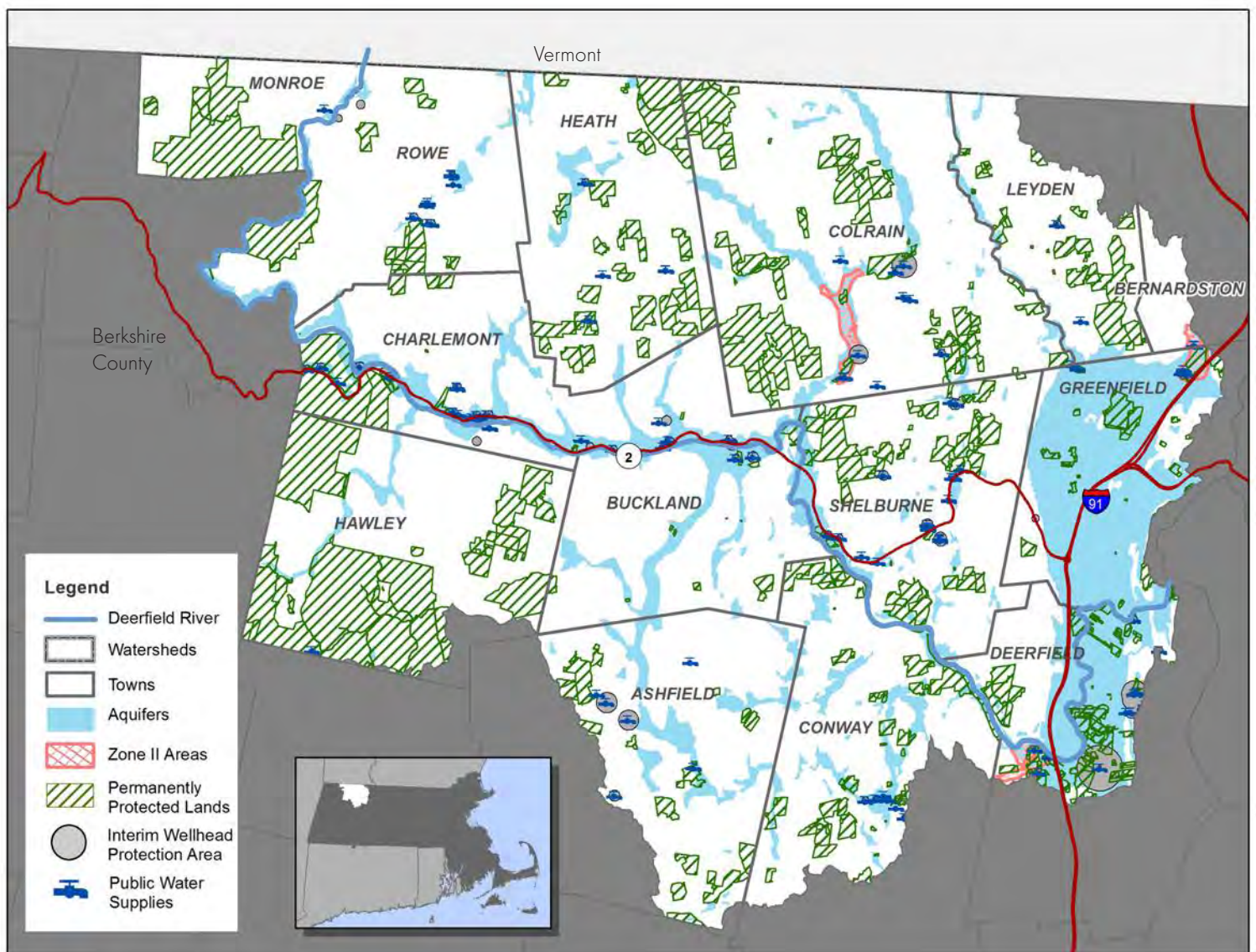
The former Wedgewood Gardens property is now part of the extension of the Riverside Greenway bike path. Photo by Paul Franz/The Recorder.

Two years later, the Town received a FEMA Flood Mitigation Assistance (FMA) grant and a state Urban Self-Help grant (now the PARC grant) to acquire the property and remove the trailer park pads and utilities. The land is now permanently protected open space and has been formally renamed Millers Meadow. This area was also a key parcel in the extension of Riverside Greenway and bike path.



Greenfield's wastewater treatment plant was severely inundated during Tropical Storm Irene. Plant staff worked to bring all facilities back online in top speed, and their work was recognized by an EPA Regional Wastewater Treatment Plant Excellence Award in 2011. While relocating the plant may not presently be feasible, it's certainly worth exploring funding options for improving its resiliency to future flooding.

Drinking Water Supplies in the Deerfield River Watershed with Level of Protection





This conceptual design by Field Geology Services for the Colrain Fire District site improves flood resiliency, restores habitat and protects critical infrastructure. The design proposes breaching of an instream berm, reactivation of side channels through the construction of log jams and the partial removal of an elevated road approach to an old bridge. This would reduce stream flow velocities through increased channel complexity and floodplain access; increase sediment storage over the length of the project reach; and improve aquatic habitat.

Steps to Resilient Public Water Supplies:

1. Review existing intermunicipal and private emergency water supply connection agreements and update, if necessary. Explore new opportunities for emergency water supply connections with your watershed neighbors
2. Make your public water supply more drought resilient by repairing leaks in the distribution system. Distribute information and encourage homeowners, businesses and agricultural operations to reduce water usage through conservation measures, and equipment retrofits or replacements
3. Use NBS to reduce impacts of flooding and fluvial erosion on municipal water supply wells and traditional wastewater treatment plants, which need to be located adjacent to rivers in order to function
4. Add flood-proofing retrofits to structures to increase climate resiliency

In Conclusion

As we've learned throughout this plan, the changing climate of our region is a stressor that impacts the natural resources, health and welfare of residents, and local economy and infrastructure of each town in the Deerfield River Watershed. Citizens and town officials don't have to look far to see how climate change can destroy or strain already vulnerable infrastructure, overwhelm emergency response capacity and the safety nets for vulnerable populations. We need to look beyond our town borders, however, to find long-term, sustainable resiliency strategies. Deerfield River Watershed towns know how to do this — many are already regionalized and share services with their neighbors to support public safety and health, as well as other economic and government functions, including the Franklin Regional Council of Governments. This same cooperative approach, at a watershed scale, can vastly strengthen the climate resiliency of each town and the watershed as a whole.

A watershed-based approach to climate resiliency makes sense for many reasons — not the least of which is that it makes economic sense. Rivers, forests and aquifers are systems that function at a broad, landscape scale. Transportation, energy and other infrastructure crosses municipal and watershed boundaries. Fixing a section of road that washes out during every large storm, without trying to manage or address the stormwater upstream, means that the road will likely continue to wash out. For so long, our response to storm damage, particularly flooding, has been to focus on repairing the damage at a particular site, without considering how that site fits into a larger drainage area. Towns in the Deerfield River Watershed are fortunate to have many tools within reach that they can use to help avoid or mitigate the impacts of climate change. As this work is accomplished at both local scale and watershed scale, it will build a framework for resilience that strengthens and reinforces over time.



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Part 5: Next Steps

The recommendations discussed in this section were selected because they're achievable, both in the short-term and over the course of several years. Towns in the Deerfield River Watershed have the local authority and control to determine how they will create more climate resilient communities and, over time, a more climate resilient watershed. Securing funding for this work will be a challenge, but our towns are not alone. FRCOG will continue to partner with communities to advocate for funding and apply for grants to implement the recommendations identified in this plan; help towns leverage planned projects to include climate resiliency components; conduct public education and outreach to build the support of watershed residents and stakeholders; and continue to promote a watershed-based approach to climate resiliency.

The implementation of this plan can best be accomplished with the formation of the Resilient DRW Coalition. Resilient DRW can work to set goals and a timeframe for implementation of the plan, as well as identify the projects and recommendations to achieve these goals incrementally, as funding, public support, and other considerations permit. How implementation of the plan is achieved could take many forms: for example, a town, or several towns that share a watershed, could volunteer to take the lead in implementing elements that a town has direct control over, such as zoning updates. This work could be implemented in the near term. Or it may be that several towns that share a watershed would work cooperatively on projects that require more time and funding to implement. Resilient DRW can help coordinate efforts, keep track of successes and problems, identify opportunities for leveraging other projects, and work with other stakeholders to secure project funding.

Opposite: MVP workshop in the Town of Erving in 2018. Below: South County EMS meeting in 2018.



Funding Sources

This list is meant to serve as a starting point for Resilient DRW, and includes mostly grant funding opportunities that are available to towns. There are many other sources of funding that a regionally focused watershed stakeholder, such as the FRCOG, the Connecticut River Conservancy, Trout Unlimited or the Franklin Land Trust, could access and then partner with a town or Resilient DRW to implement. Many of the grants could fund projects that address multiple climate stressors and provide benefits to one or more sectors. For organizational purposes, the grants that primarily focus on one sector, such as Infrastructure, are grouped together.

Climate Change Planning & Implementation

Massachusetts Executive Office of Energy & Environmental Affairs

The EEA's Office of Grants and Technical Assistance is a good resource to consult when scoping projects and looking for funding. This office can help towns and stakeholders seeking to fund projects that focus on developing responsible energy practices, conservation of natural resources and outdoor recreational programs. <https://www.mass.gov/orgs/eea-office-of-grants-and-technical-assistance>

EEA Planning Grant

The Executive Office of Energy and Environmental Affairs (EEA) provides funding to municipalities and Regional Planning Agencies to pursue Massachusetts Sustainable Development Principles that preserve natural resources, ensure sufficient and diverse housing, and prepare for climate change. Eligible requests include zoning for sustainable housing production, actions implementing the results of a climate vulnerability assessment or MVP program, or mitigation of climate change through zoning or other regulations that reduce energy use and greenhouse gas emissions.

<https://www.mass.gov/service-details/planning-assistance-grants>

Municipal Vulnerability Preparedness Program (MVP)

This program provides funding to municipalities to pay for technical assistance to complete assessments and planning using the Community Resilience Building workshop framework (CRB). Municipalities who complete this process are designated as a MVP Community and eligible for MVP Action grant funding to implement climate resiliency projects.

<https://www.mass.gov/municipal-vulnerability-preparedness-program>

FEMA Hazard Mitigation Assistance

FEMA provides three different grant programs for mitigation planning and projects that are designed to minimize loss and protect life and infrastructure from natural hazards such as flooding and extreme heat. Grant programs include Hazard Mitigation Grant Program (long-term planning and projects after federal declared emergency), Pre-Disaster Mitigation Program (hazard mitigation planning grant) and Flood Mitigation Assistance (planning and projects to reduce or eliminate risk of flood damage insured by NFIP). The Massachusetts Emergency Management Agency (MEMA) coordinates with FEMA and administers these grant programs.

<https://www.mass.gov/orgs/massachusetts-emergency-management-agency>

<https://www.fema.gov/>

Natural Resources & Habitat

Nonpoint Source Pollution (s.319) Grants and Water Quality Management Planning (604b) Grants

The US EPA provides states with funds to support a variety of activities to reduce nonpoint source pollution (s.319 grants), including technical and financial assistance, education and training, technology transfer, demonstration projects and monitoring to assess the success of projects. EPA has stated specifically that such grants can be used to reduce pollution from stormwater runoff and other sources, recognizing the importance of green infrastructure in managing stormwater. A 40% non-federal funding match is required. The 604b grants don't require a non-federal match and can be used for planning and conceptual design for projects that use green infrastructure for stormwater management.

<https://www.mass.gov/service-details/grants-financial-assistance-watersheds-water-quality#2>

Massachusetts Environmental Trust (MET) Grant

The MET grant provides funding to support programs, research, and other activities that promote the responsible stewardship of the Commonwealth's water resources. MET supports projects that: improve water quality or quantity, conserve aquatic habitat and species, reduce runoff pollution, mitigate the effects of climate change on water resources, promote human health as it relates to water resources, and/or other efforts consistent with the Trust's mission. Awards range from \$5,000 to \$100,000.

<http://www.mass.gov/eea/grants-and-tech-assistance/grants-and-loans/mass-enviro-trust/met-grants.html>

Division of Ecological Restoration (DER)

DER initiates projects that restore our rivers, streams, wetlands, and watersheds. DER partners with nonprofits, towns, individuals, and groups to implement projects. These projects improve habitat for wildlife and provide many benefits such as reduced flooding, improved water quality, and public safety. Programs include culvert and dam removal as well as coastal wetland, inland wetland, and river restoration. DER provides technical assistance, helps secure funding, and coordinates project management until completion.

<https://www.mass.gov/orgs/division-of-ecological-restoration>

Rivers, Trails, and Conservation Assistance Program

The National Park Service Rivers, Trails and Conservation Assistance Program (RTCA) assists community-led natural resource conservation and outdoor recreation initiatives. RTCA staff provides guidance to communities on: conserving waterways, preserving open space, and developing trails and greenways.

<https://www.nps.gov/orgs/rtca/apply.htm>

Forest Stewardship Plans for Town Forests

Towns can develop stewardship plans for town-owned forests, forests owned by Conservation Commissions, or water supply land enrolled in the Forest Stewardship Program, and apply for funding to implement their forest stewardship practices available from the Community Forest Stewardship Implementation Grants for Municipalities program.

<https://www.mass.gov/service-details/forest-stewardship-program>

Massachusetts Urban and Community Forestry

The Massachusetts Urban and Community Forestry Program assists communities and nonprofit groups in protecting, growing, and managing community trees and forest ecosystems, to improve the environment and enhance livability. The program includes grants, technical assistance, training and recognition awards, and provides guidance on urban forestry policy issues.

<http://www.mass.gov/eea/agencies/dcr/conservation/forestry-and-fire-control/urban-and-community->

[forestry.html](#)

Parkland Acquisitions and Renovations for Communities (PARC)

PARC assists cities and towns in acquiring and developing land for park and outdoor recreation purposes. Any city that has an authorized park or recreation commission is eligible to participate and use grant funds to acquire land, develop new parks or renovate existing outdoor public recreation facilities (which may include green infrastructure). Access by the general public is required. Municipalities must have a current Open Space and Recreation Plan to apply, and the land must be open to the general public. Awards range from \$50,000 to \$500,000 with reimbursement rates of up to 70% of project costs.

<http://www.mass.gov/eea/grants-and-tech-assistance/grants-and-loans/dcs/grant-programs/massachusetts-parkland-acquisitions-and.html>

Local Acquisitions for Natural Diversity (LAND)

LAND is a state grant program implemented by EEA's Division of Conservation Services. provides grants for the acquisition of land for passive parks or conservation areas in cities and towns – which can include green infrastructure. Grants are up to \$400,000 with reimbursement rates ranging from 52%-70% of the total project cost. Municipalities must have a current Open Space and Recreation Plan to apply, and the land must be open to the public.

<https://www.mass.gov/service-details/local-acquisitions-for-natural-diversity-land-grant-program>

Massachusetts Land and Water Conservation Grant Program

This program is administered by EEA and the Division of Conservation Services. The Federal Land & Water Conservation Fund provides up to 50% of the total project cost for the acquisition, development, and renovation of park, recreation and conservation areas. Municipalities must have a current Open Space and Recreation Plan to apply.

<https://www.mass.gov/service-details/massachusetts-land-and-water-conservation-fund-grant-program>

Sustainable Forest Management

The MassWoods webpage hosted by UMass, Amherst is a wealth of information on programs available to private landowners interested in permanently protecting, conserving and/or applying sustainable forestry practices to their land. Resources include information on the MassWildlife Habitat Management Grant Program, Chapter 61 Current Use Tax Programs, Forest Stewardship Program & Green Certification, Environmental Quality Incentives Program (EQIP), Wildlife Habitat Incentives Program (WHIP), and the Landowner Incentive Program (LIP).

<https://masswoodlands.org>

Forests for Fish

Another resource that will be available to private forest owners in 2019 is the Forests for the Fish toolkit under development by the Franklin Land Trust (FLT), Massachusetts Woodlands Institute (MWI), and Trout Unlimited (TU). This toolkit can be used by private landowners who have forested land along coldwater streams and would like to work with a licensed forester and fisheries consultant to prepare a Forest Stewardship Plan that includes practices for enhancing habitat and improving climate resiliency.

<http://www.masswoodlands.org/projects/fisheries-management>

Riparian and Wetland Buffers

There are many resources available to farmers and private landowners interested in creating vegetated buffers along rivers, streams and wetlands. The US Department of Agriculture (USDA) provides Conservation

Reserve program funds to the agricultural community. There are two types of programs: one that has a designated sign-up period and one that has continuous registration.

<https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/>

The USDA through the Natural Resources Conservation Service (NRCS) also offers funds through the Environmental Quality Incentives Program (EQIP), which provides financial and technical assistance to agricultural producers to plan and implement conservation practices on agricultural land and non-industrial private forestland.

<https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/>

Human Health & Welfare

Massachusetts Community Preservation Act (CPA)

Towns that have adopted the Community Preservation Act (CPA) receive an annual match from the state CPA Trust Fund. CPA provides funding for affordable housing, historic resources, and outdoor recreation/open space, and is flexible to help fund all types of creative improvements. Funds for open space and recreation, for example, can be used to acquire and restore land and water resources and to acquire and improve parks, playgrounds, ball fields, parks, greenways, farms and gardens that use nature-based solutions to help cities and towns become more resilient to climate change impacts.

<http://communitypreservation.org/>

HUD Loan Guarantee Program

The US Department of Housing and Urban Development's Section 108 Loan Guarantee Program allows future Community Development Block Grant allocations to be used to guarantee loans for neighborhood revitalization projects, including construction and installation of public facilities and infrastructure. Section 108-guaranteed projects can incorporate green infrastructure into their design and construction.

<https://portal.hud.gov/hudportal/HUD?src=/states/massachusetts>

EPA Smart Growth and Technical Assistance Program

The EPA administers a variety of technical assistance and planning grant programs to help communities improve the quality of the built environment, protect public health, and protect the environment.

<https://www.epa.gov/smartgrowth/smart-growth-technical-assistance-programs>

Infrastructure (Drinking Water & Wastewater)

Clean Water State Revolving Fund

This program is a federal-state partnership that provides communities a permanent, independent source of low-cost financing for a variety of water quality infrastructure projects: wastewater treatment, stormwater management, nonpoint source pollution control, and watershed management, including retrofit projects and certain types of "green" projects. Most loans are for a 20-year period and some are zero interest. Loans in Massachusetts are implemented by MassDEP.

<http://www.mass.gov/eea/agencies/massdep/water/grants/clean-water-state-revolving-fund.html>

Massachusetts DEP Drinking Water Supply Protection Grant (DWSP)

The DWSP grant program provides financial assistance to public water systems and municipal water departments for the purchase of land or interests in land for the following purposes: 1) protection of existing

DEP-approved public drinking water supplies; 2) protection of planned future public drinking water supplies; or 3) groundwater recharge. The program is a reimbursement grant with a maximum award of \$300,000 and 50% project cost reimbursement rate.

<https://www.mass.gov/service-details/drinking-water-supply-protection-grant-program>

Mass DEP Water Utility Resilience Program

This new program provides technical assistance, partnership opportunities, adaptation planning, asset management, vulnerability assessments and training to enhance the resilience of water and waste water utilities from hazards weather events related to climate change.

<https://www.mass.gov/guides/water-utility-resilience-program>

EPA Water Infrastructure and Resiliency Finance Center

This program administered by the EPA provides technical assistance, toolkits, and resources to help decision makers building wastewater infrastructure projects that protect human and environmental health.

<https://ofmpub.epa.gov/apex/wfc/f?p=165:1:::::>

Infrastructure (Transportation)

MassDOT Local Aid Programs

MassDOT has four Local Aid programs that towns can use to fund projects that make local road infrastructure more resilient to climate change: Ch.90, Municipal Small Bridge Program, Complete Streets and Safe Routes to School.

<https://www.mass.gov/topics/local-aid-programs>

Transportation Alternatives Program

The Transportation Alternatives Program provides funding for transportation “alternatives” that improve transportation networks by efficiently and cost-effectively mitigating street and alley flooding. Projects can include green infrastructure components of trails and sidewalks for non-motorized transportation, such as permeable pavements.

<http://www.massdot.state.ma.us/planning/Main/PlanningProcess/FundingConsiderations.aspx>

Infrastructure (Energy)

Green Communities Division (GCD)

The Massachusetts Department of Energy Resources’ Green Communities Division (GCD) provides grants, technical assistance, and local support from Regional Coordinators to help municipalities reduce energy use and costs by implementing clean energy projects in municipal buildings, facilities, and schools.

<https://www.mass.gov/orgs/green-communities-division>

Weatherization and Intergovernmental Program

The US Department of Energy’s Weatherization and Intergovernmental Program provides grants, technical assistance, and information tools to states, local governments and community action agencies for their energy programs. The funding can be used to encourage installation of green infrastructure, such as green roofs, as part of the weatherization process.

<https://energy.gov/eere/wipo/weatherization-and-intergovernmental-programs-office>

Massachusetts Clean Energy Center's (MassCEC) Community Microgrids Program

This program helps municipalities harness the innovative micro grid technology that lowers customer energy costs, reduces greenhouse gas (GHG) emissions, and provides increased energy resilience.

<http://www.masscec.com/community-microgrids-program>

MA Clean Energy Center (CEC) Government and Non-Profit Clean Energy Programs

MassCEC manages the Massachusetts Renewable Energy Trust Fund for the state and has diverse programs that promote clean energy, energy efficiency, and wastewater treatment plant innovation. Grant programs include solar energy, clean heating and cooling, hydro projects, organics to energy projects and many more.

<http://www.masscec.com/get-clean-energy/government-and-non-profit>

Learn More

Adaptation Resource Center: https://19january2017snapshot.epa.gov/arc-x_.html

BioMimicry: Nature's Unifying Patterns: <https://toolbox.biomimicry.org/core-concepts/natures-unifying-patterns/>

CAKE: Climate Adaptation Knowledge Exchange: <https://www.cakex.org/>

Climate Change Response Framework: <https://forestadaptation.org/new-england>

Climate Data Sources: <http://wise.web.unc.edu/teaching/data-sources/>

Colleges & Underserved Communities Partnership Program (CUPP): https://19january2017snapshot.epa.gov/communityhealth/collegeunderserved-community-partnership-program-cupp_.html

Connect the Connecticut: <http://connecttheconnecticut.org/data-tools/>

Massachusetts Climate Change Vulnerability Map: http://maps.massgis.state.ma.us/map_ol/cc_vuln.php

Massachusetts Environmental Public Health Tracking: https://matracking.ehs.state.ma.us/Climate-Change/climate_and_health_profile.html

Municipal Adaptation Planning: <https://climateactiontool.org>

Naturally Resilient Communities: <http://nrcsolutions.org/strategies/#solutions>

Resilience and Adaptation in New England (RAINE): https://19january2017snapshot.epa.gov/raine_.html

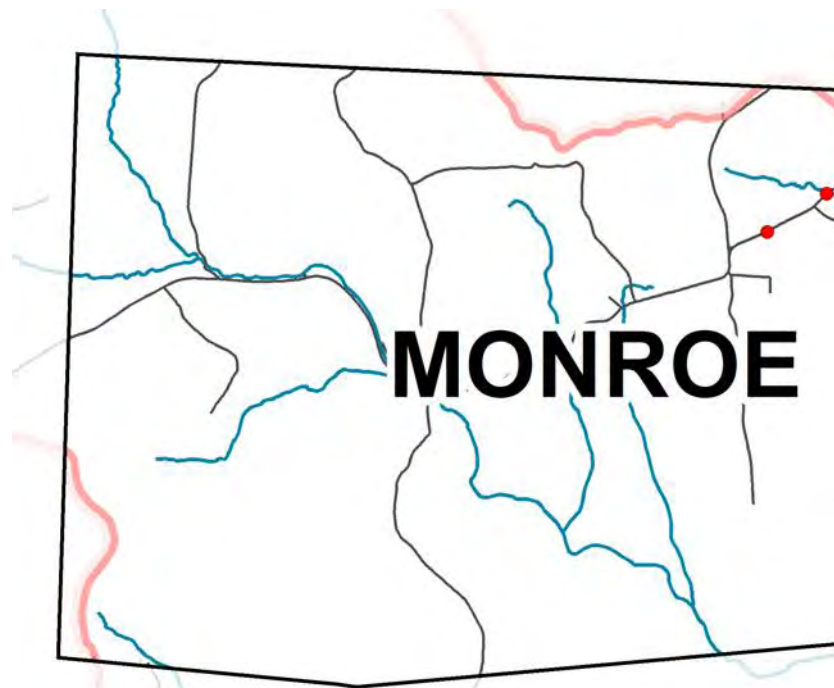
RiverSmart Communities: <https://extension.umass.edu/riversmart/resources/resources-farmers>

Smart Growth Technical Assistance Program: https://19january2017snapshot.epa.gov/smartgrowth_.html

Steps to Building Resilience: <https://toolkit.climate.gov/steps-to-resilience/explore-hazards>

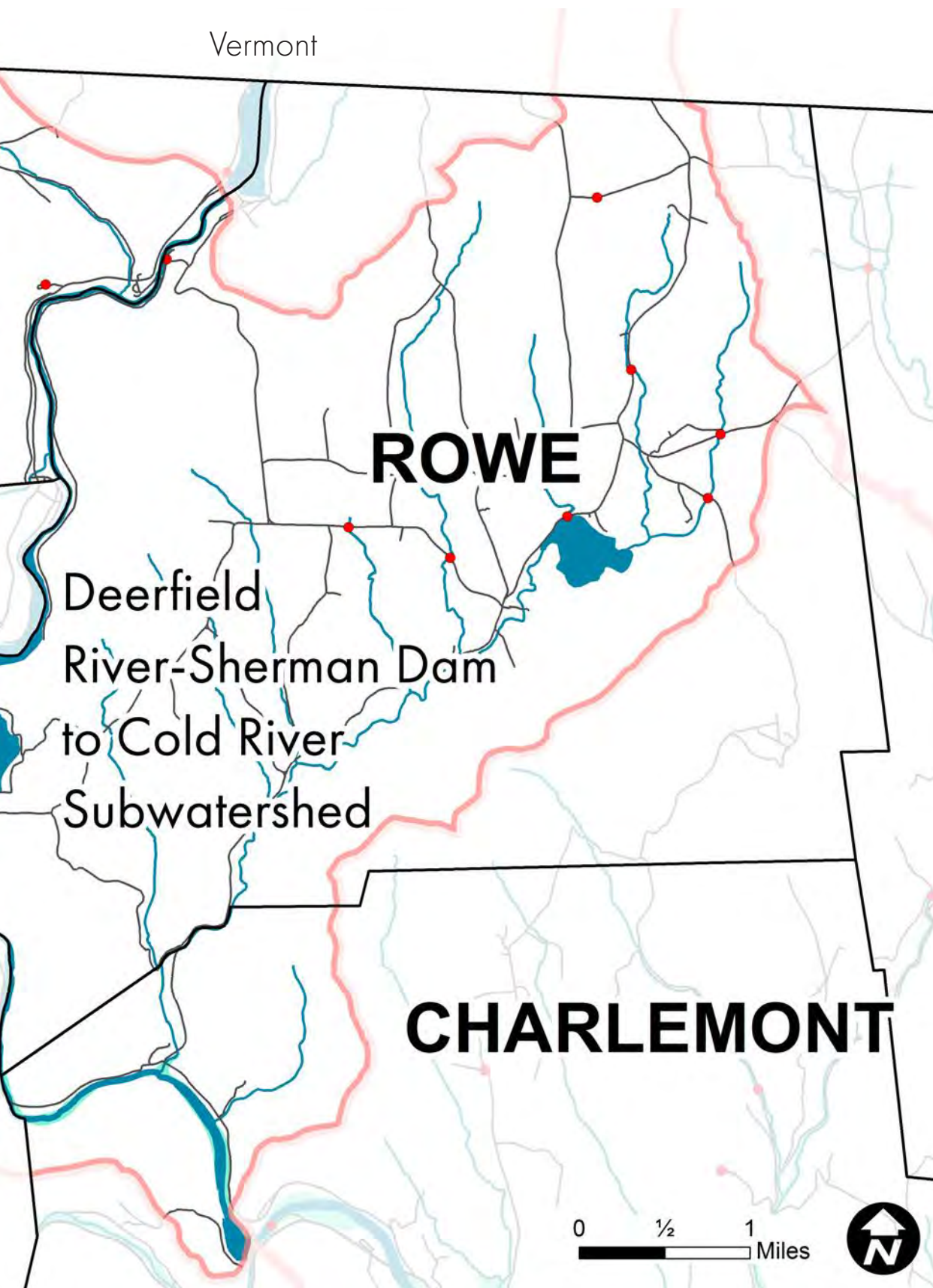
Appendix: Who Are Your Watershed Neighbors?

1. How many subwatersheds are in your town?
2. Do you know where your watershed boundaries are?
3. Which other towns share your subwatershed?



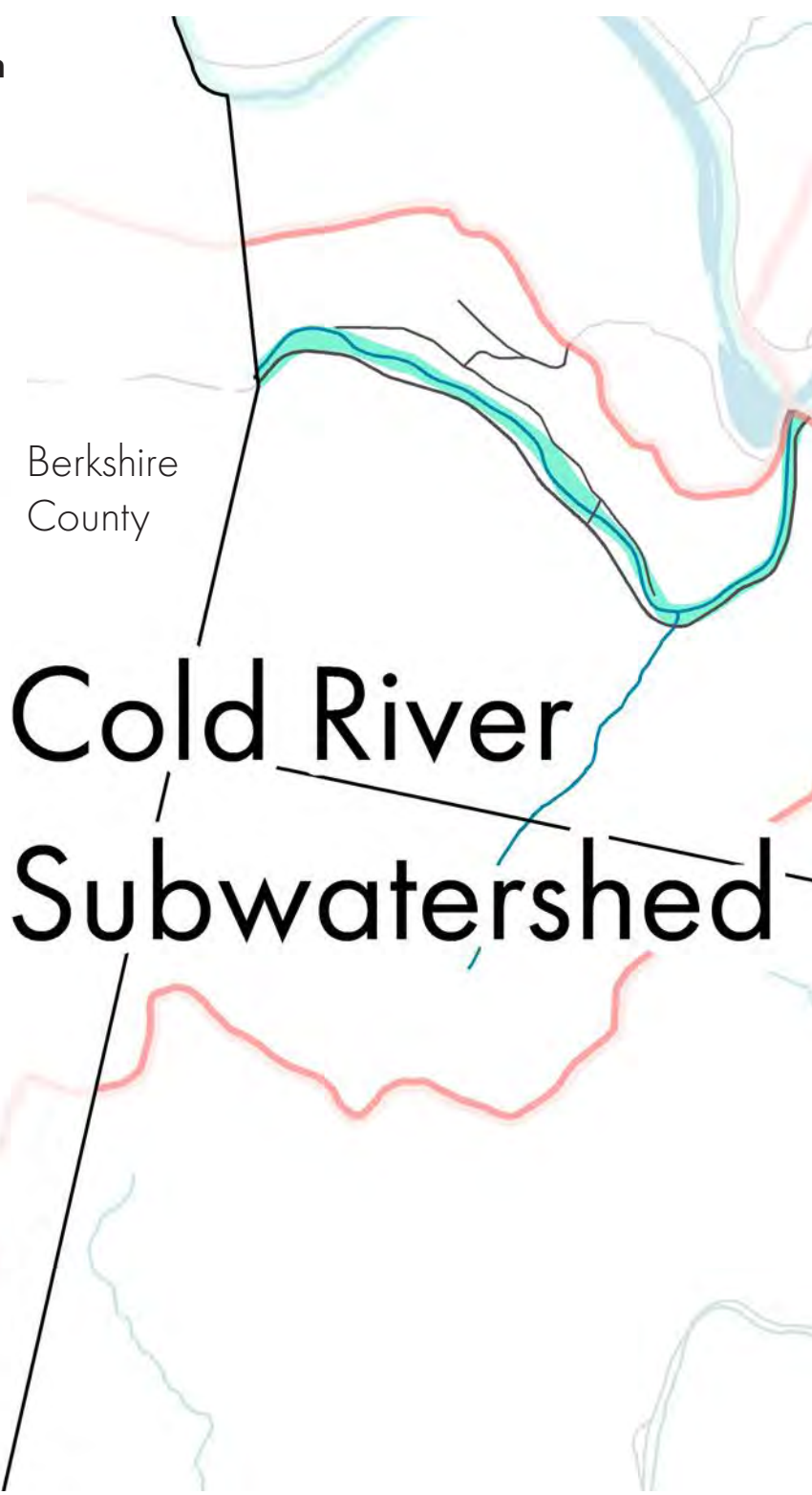
Berkshire
County



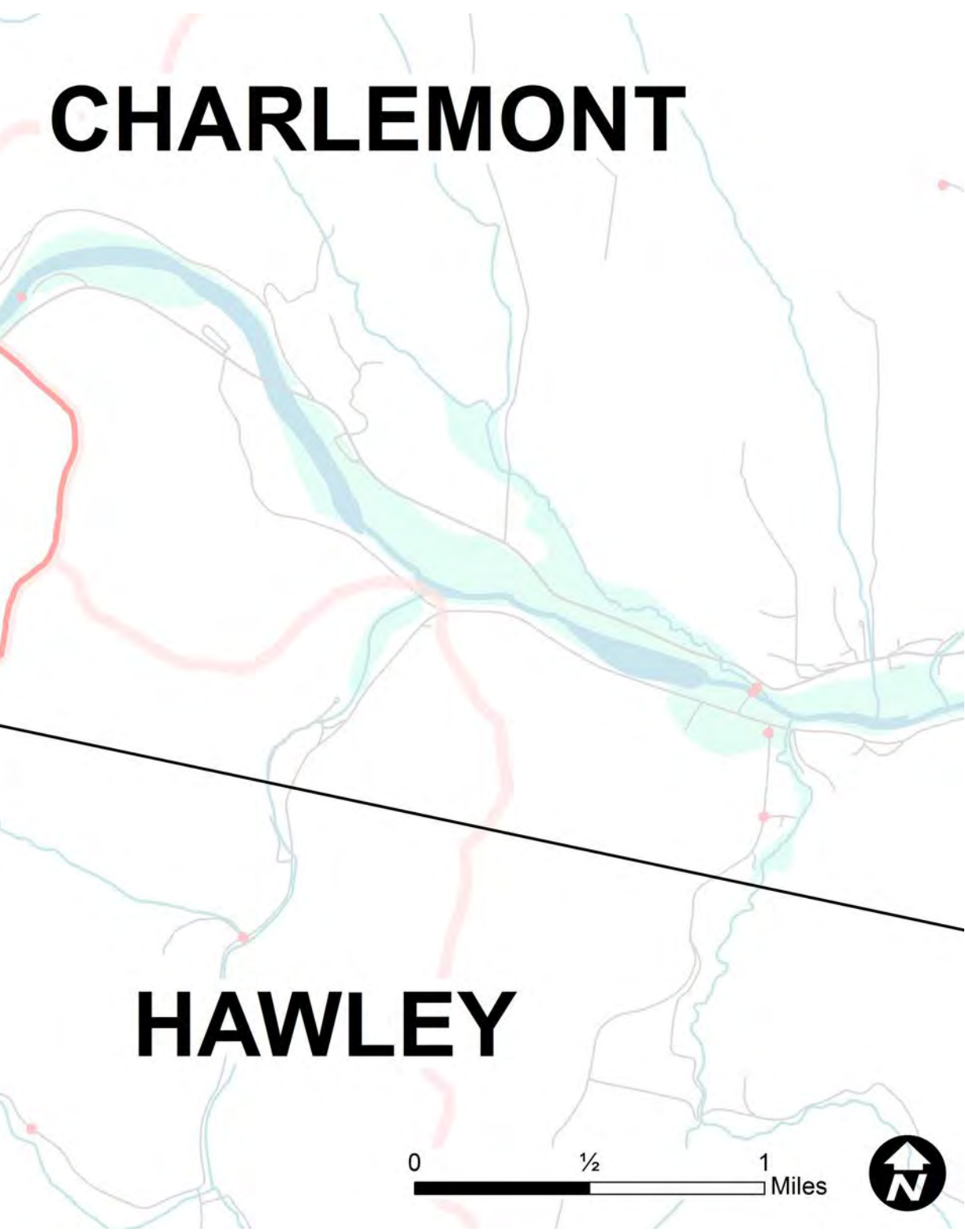


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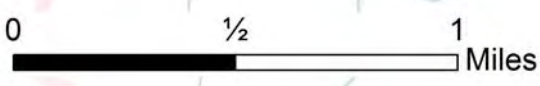
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CHARLEMONT

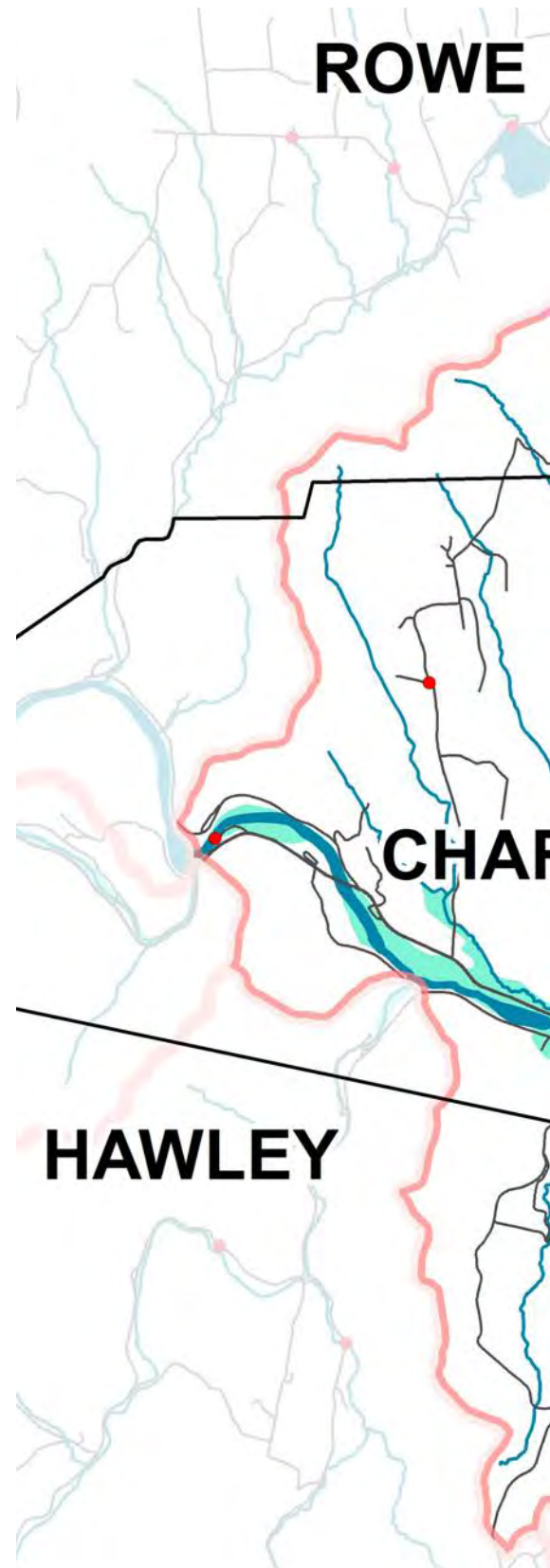


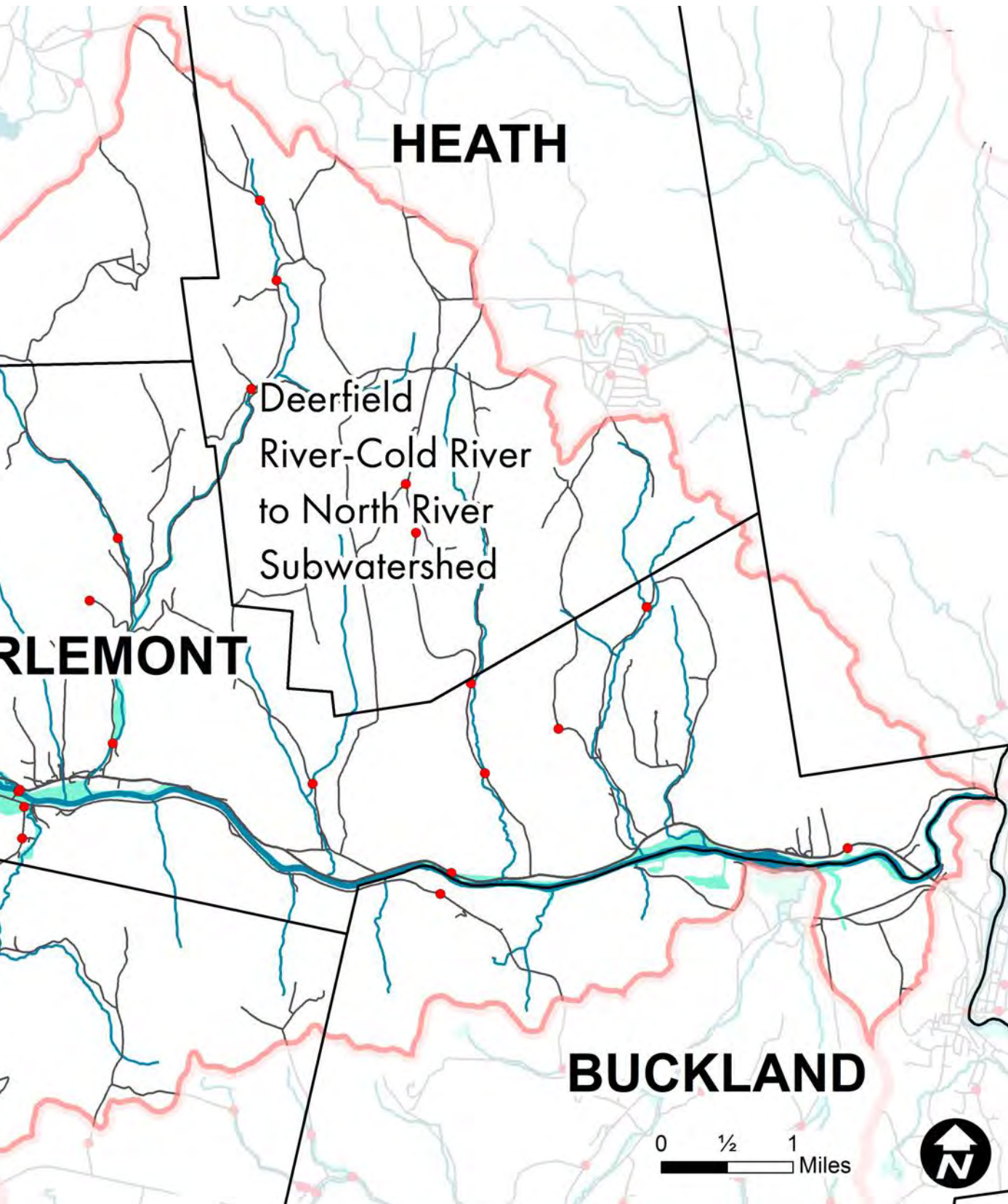
HAWLEY



Who Are Your Watershed Neighbors?

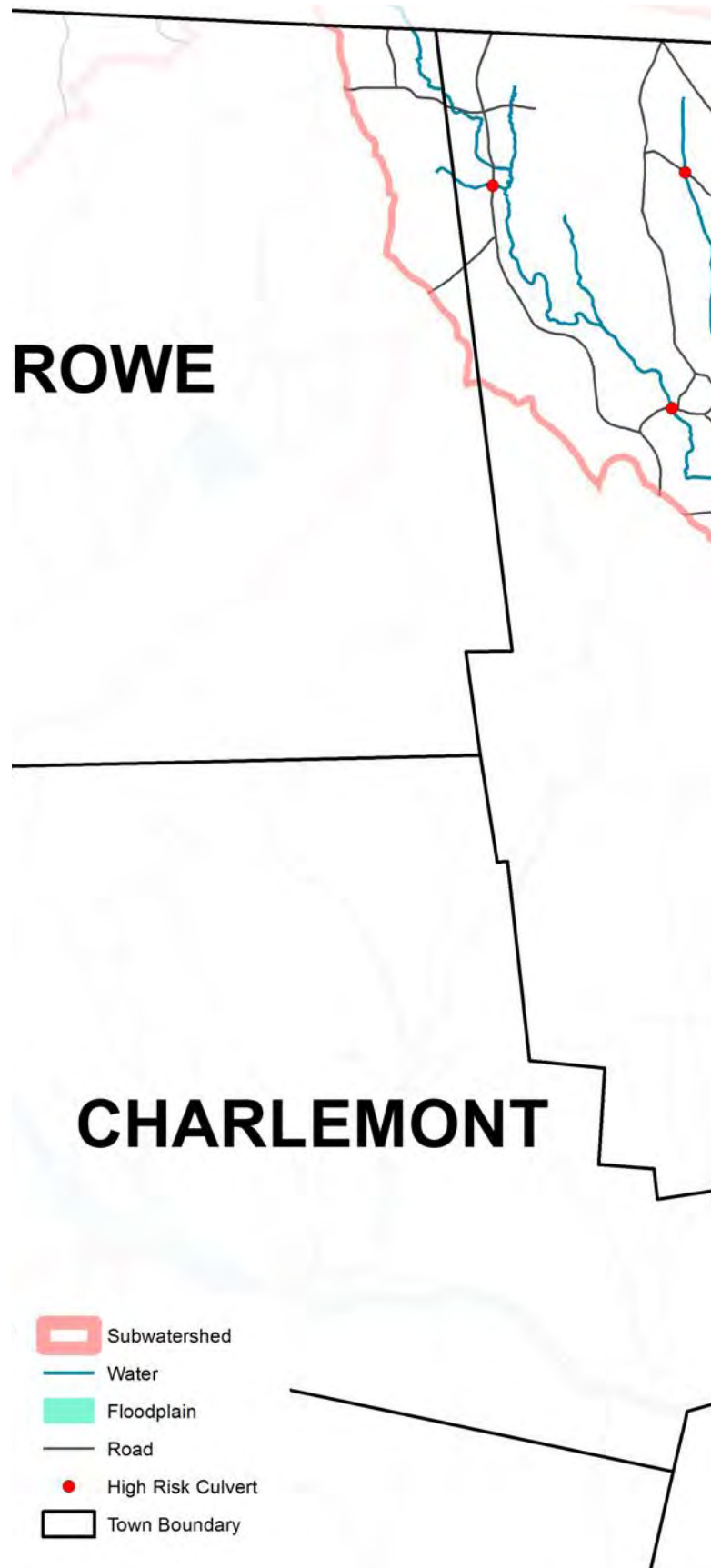
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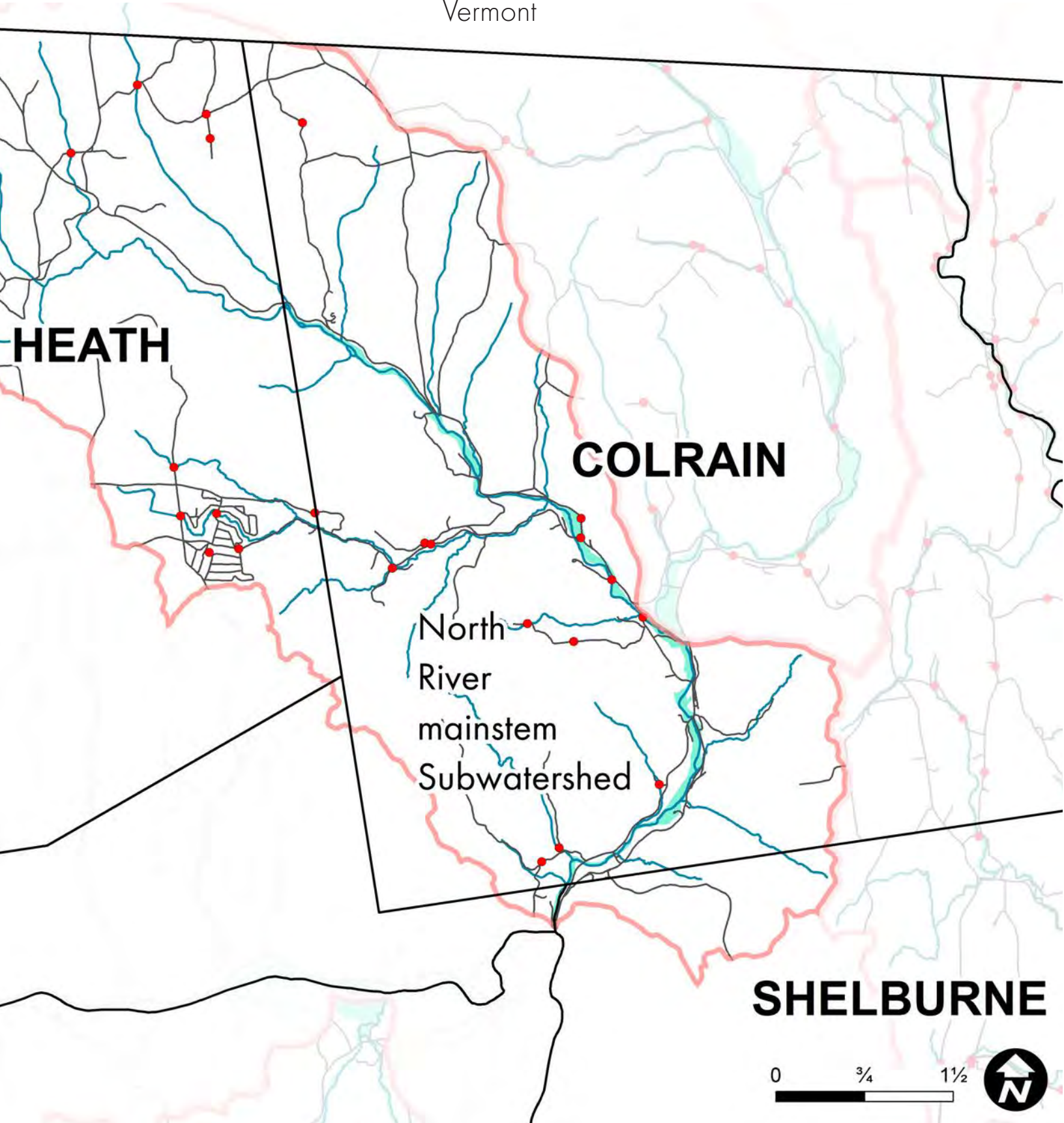


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Vermont



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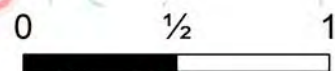
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Vermont

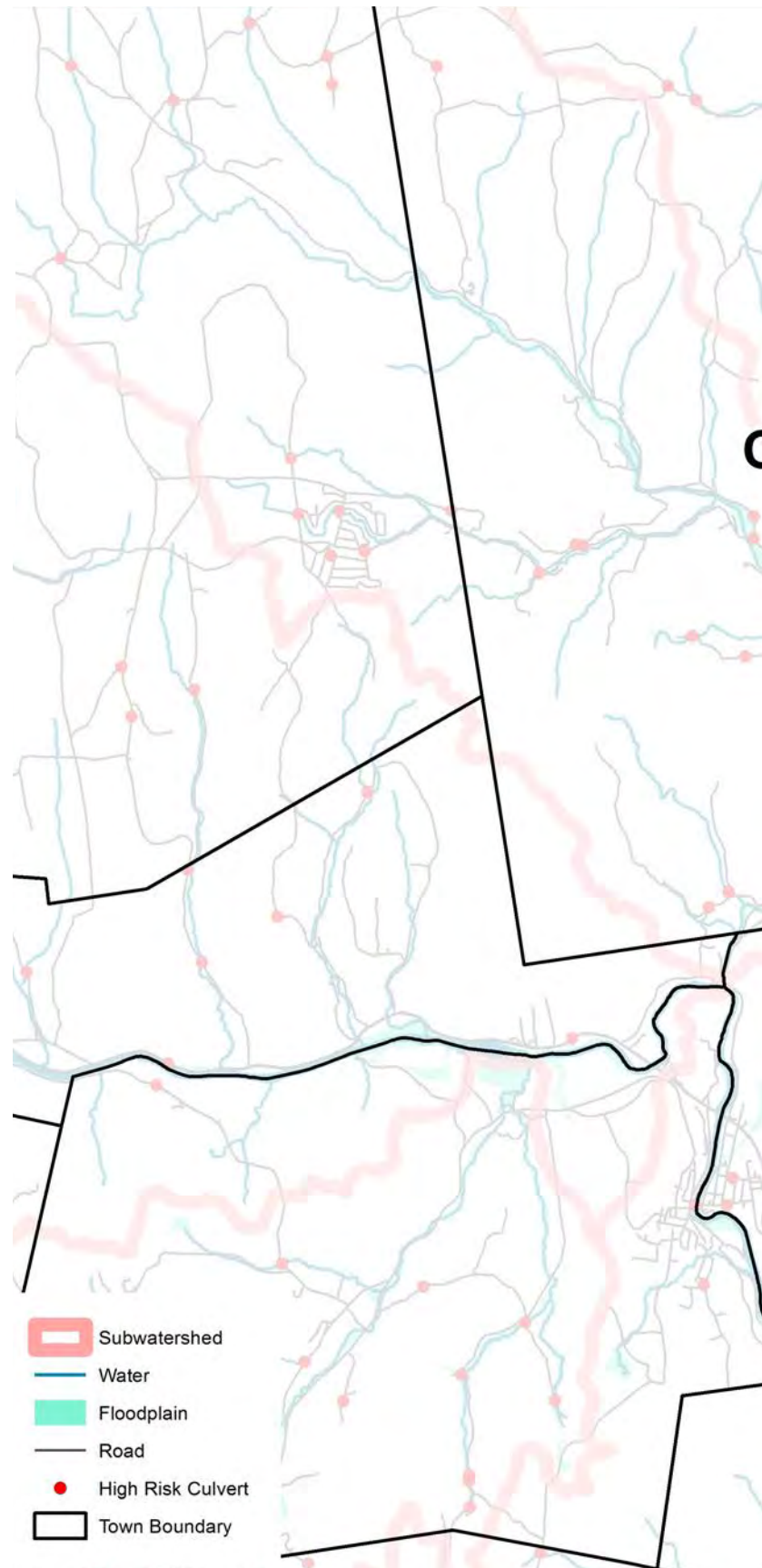
East Branch
North River
Subwatershed

COLRAIN

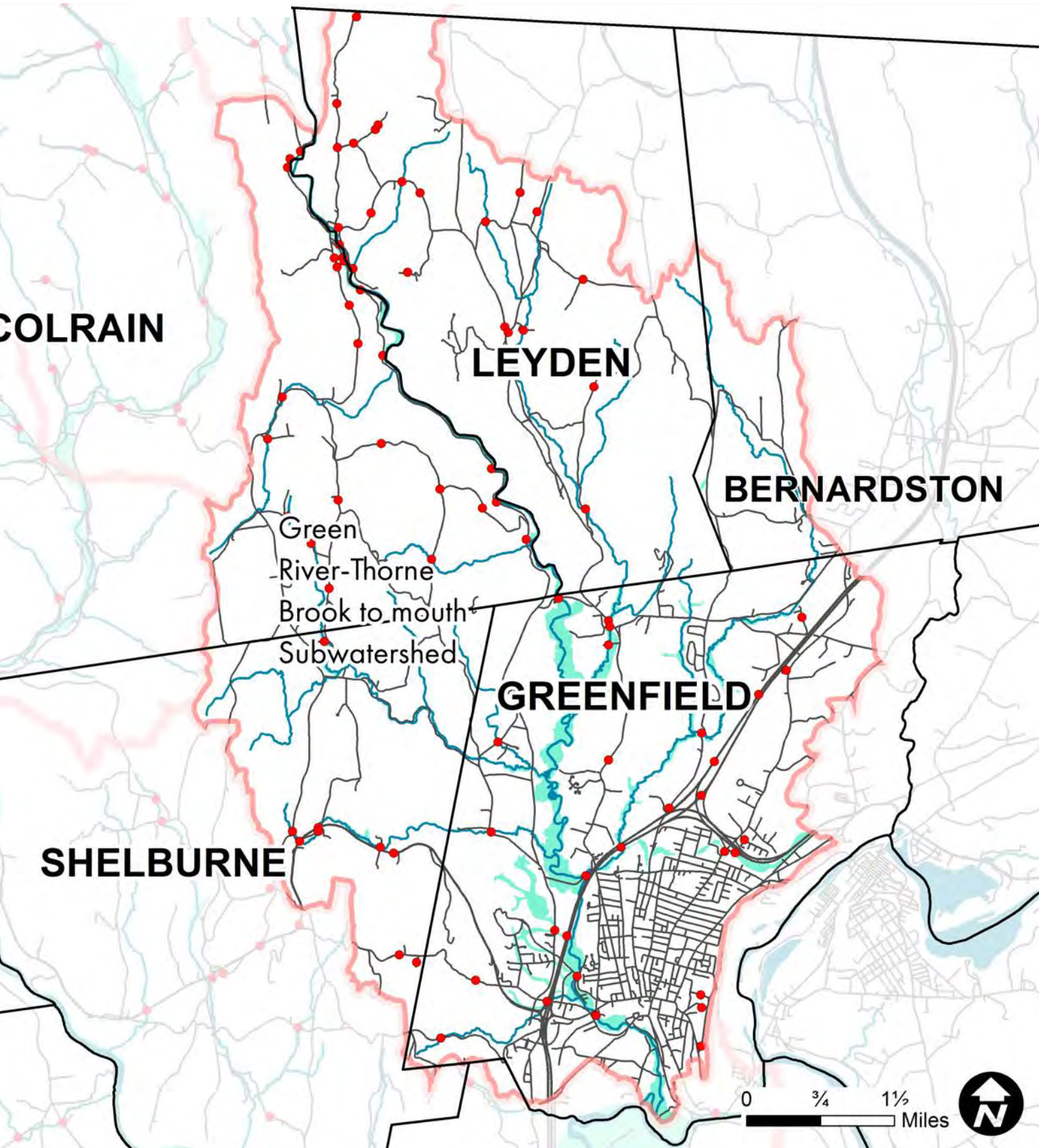


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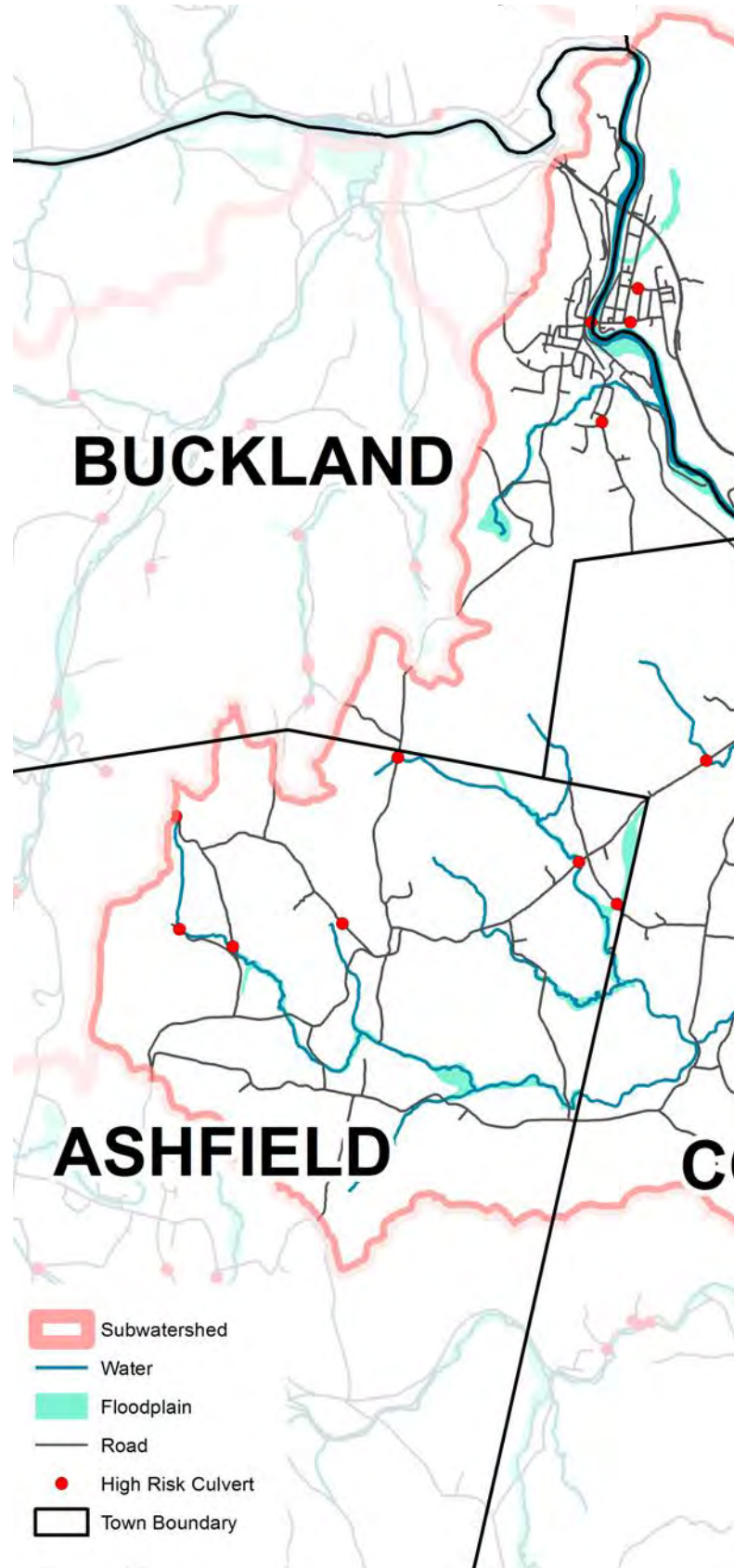


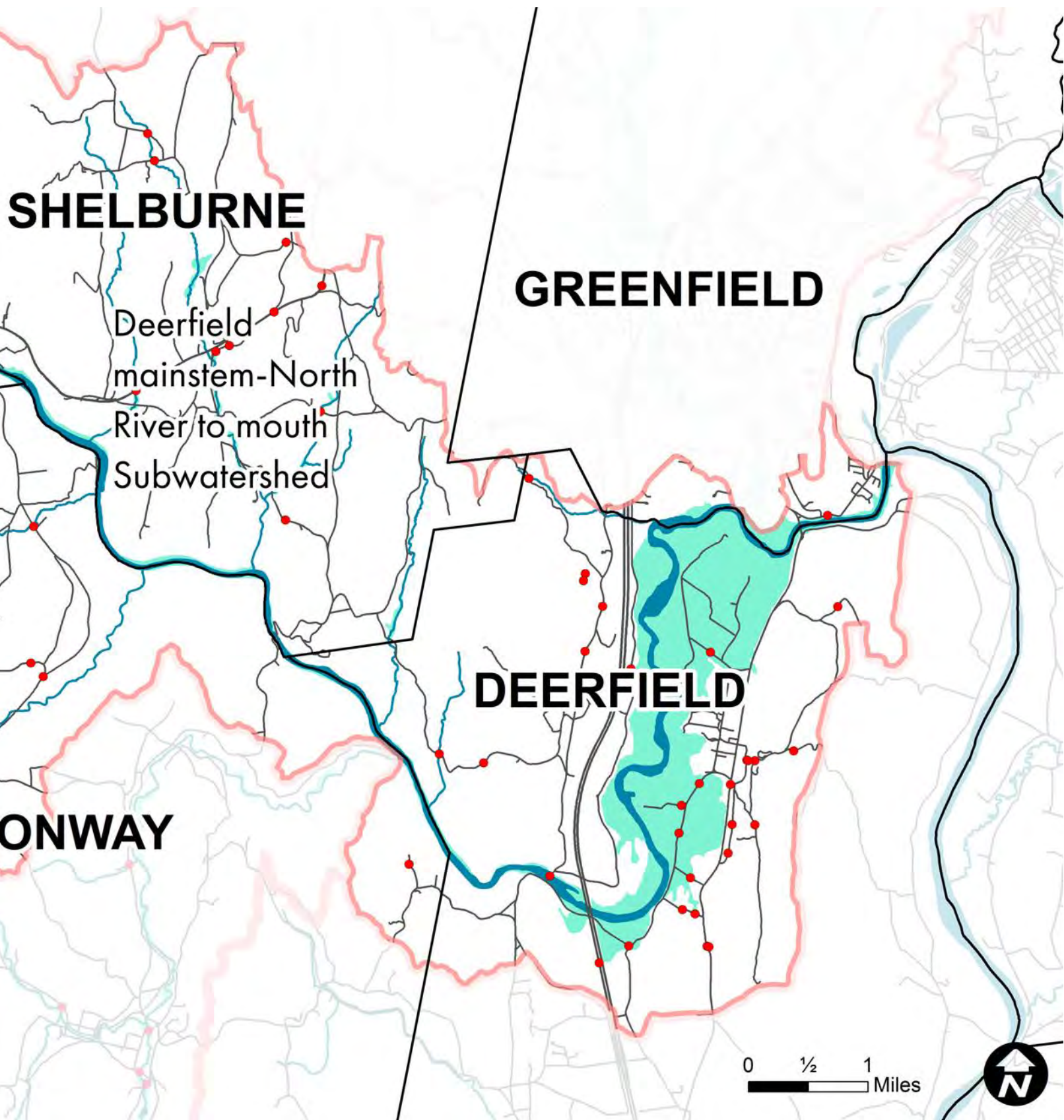
Vermont



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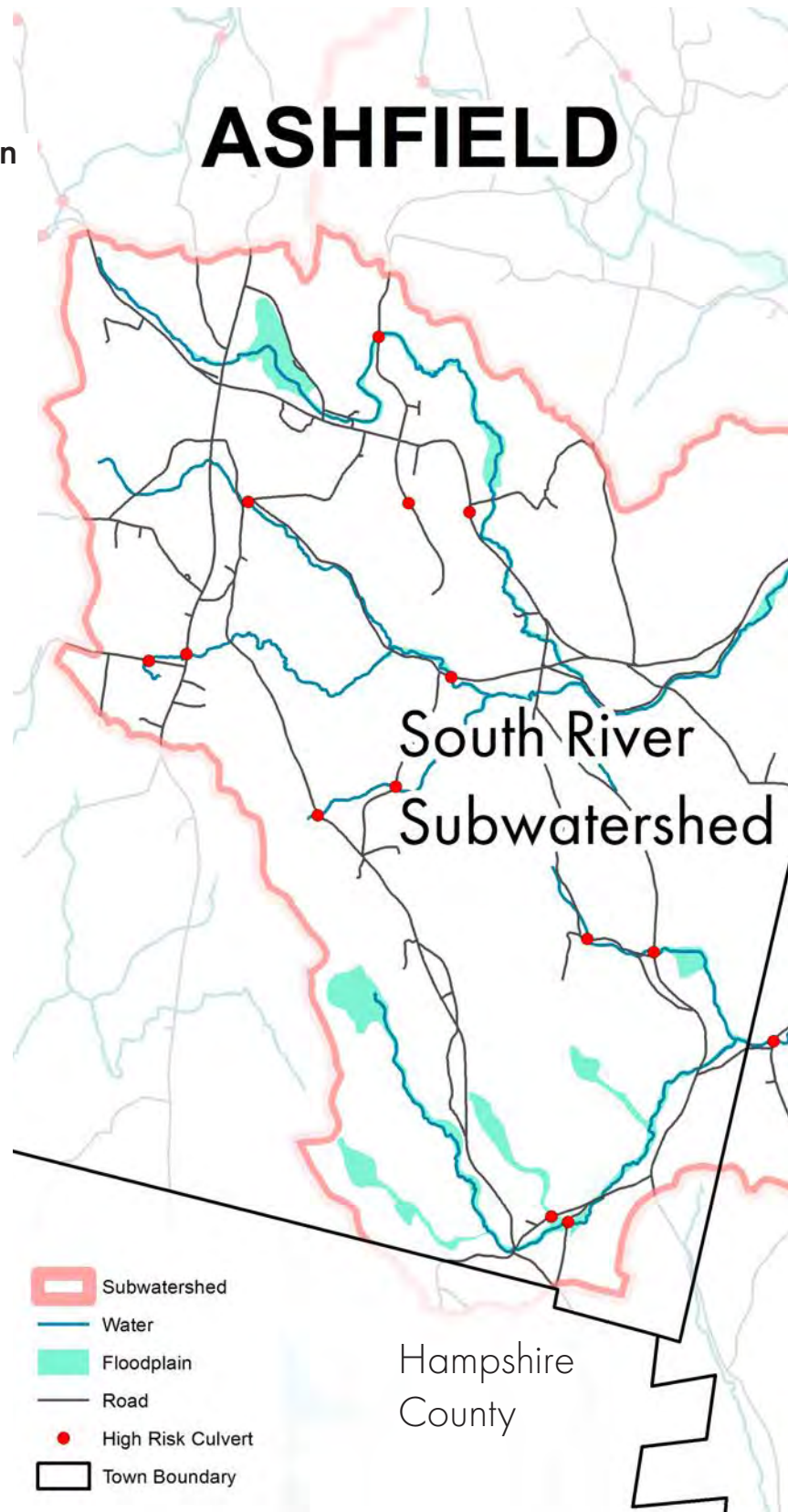
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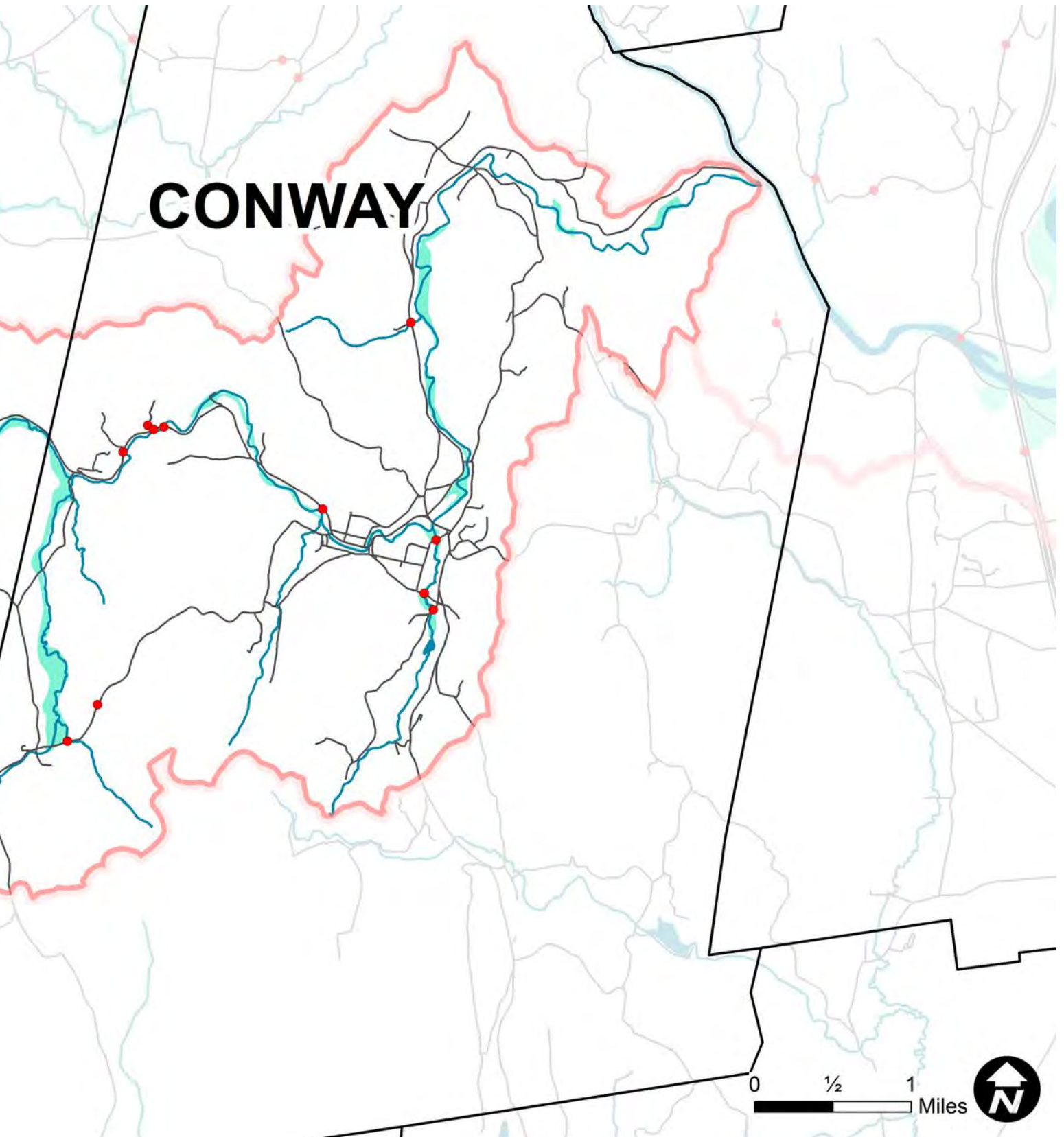




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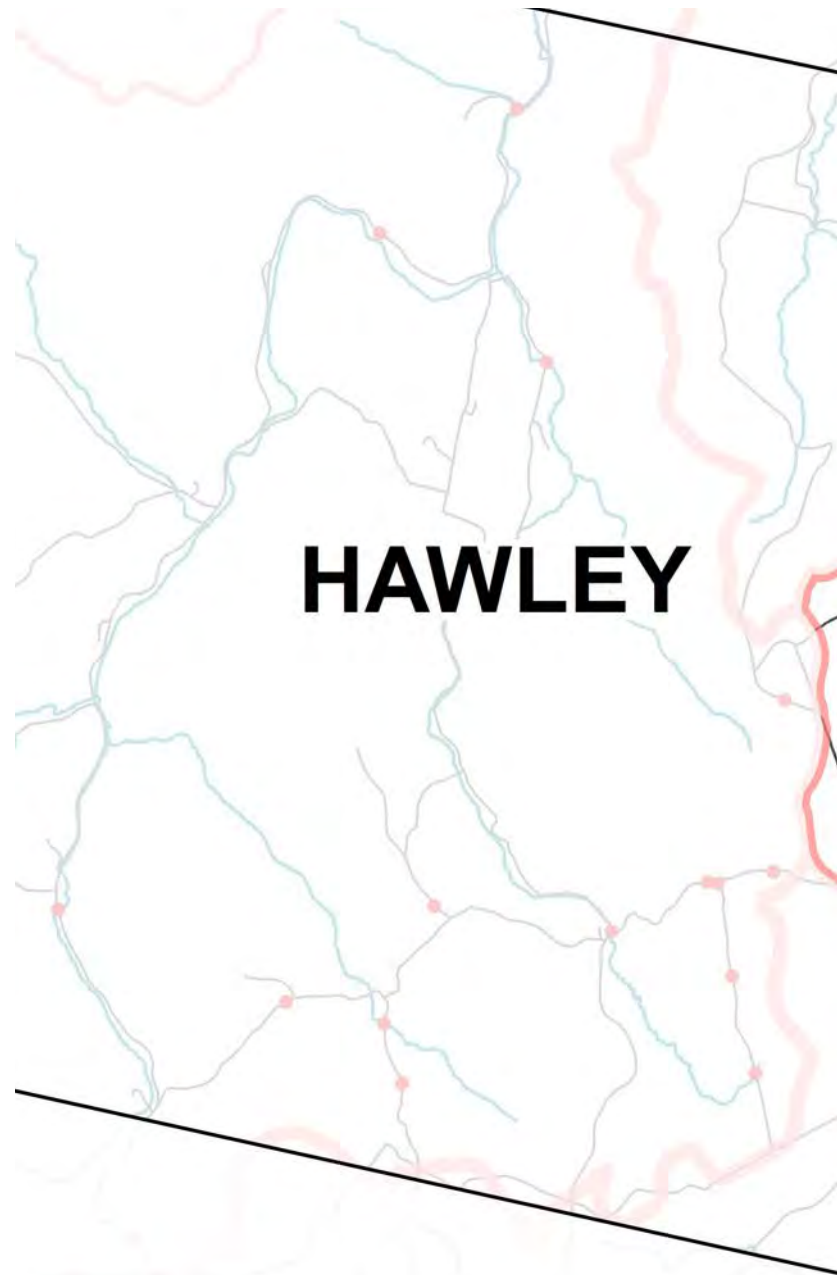
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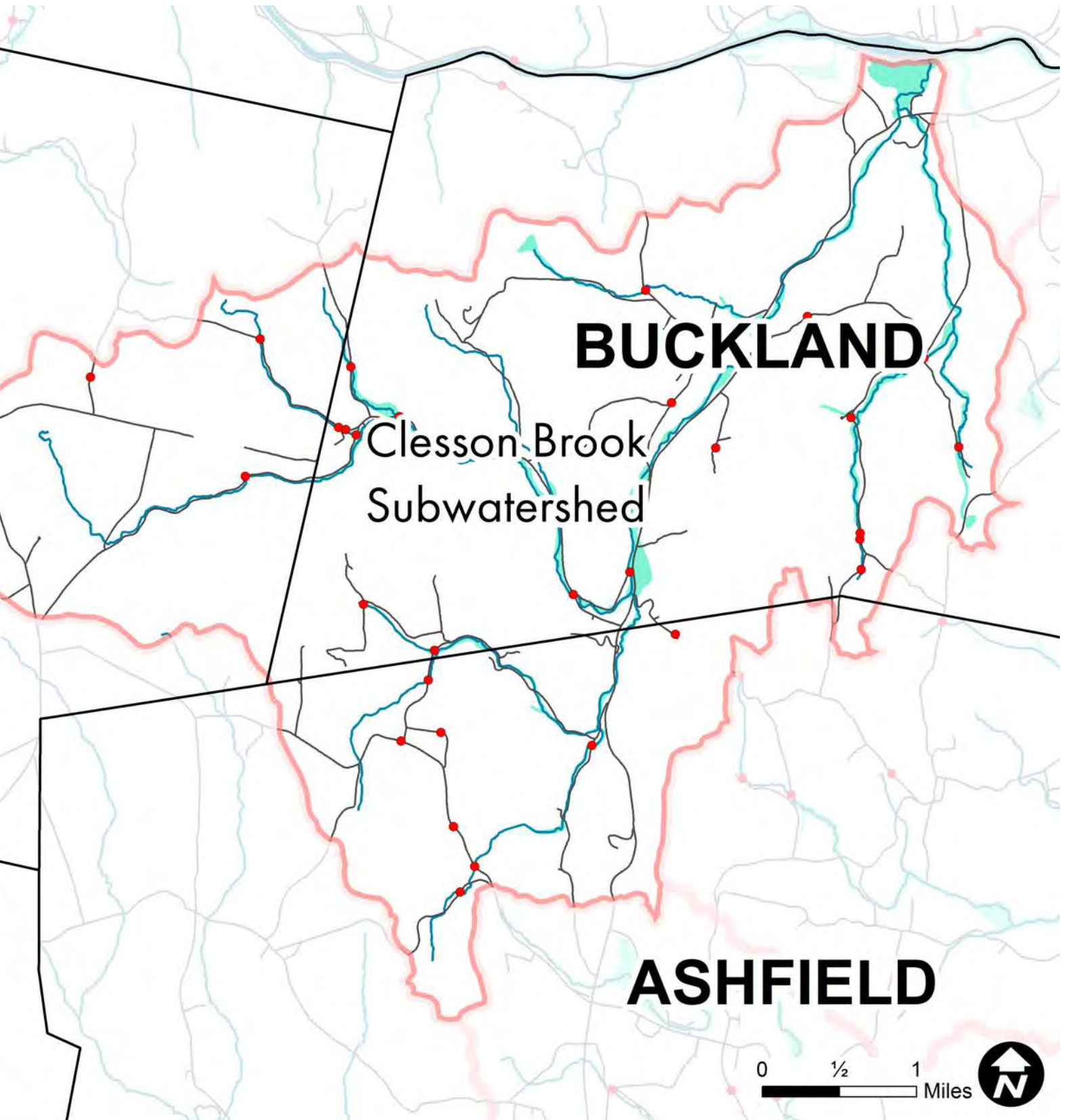
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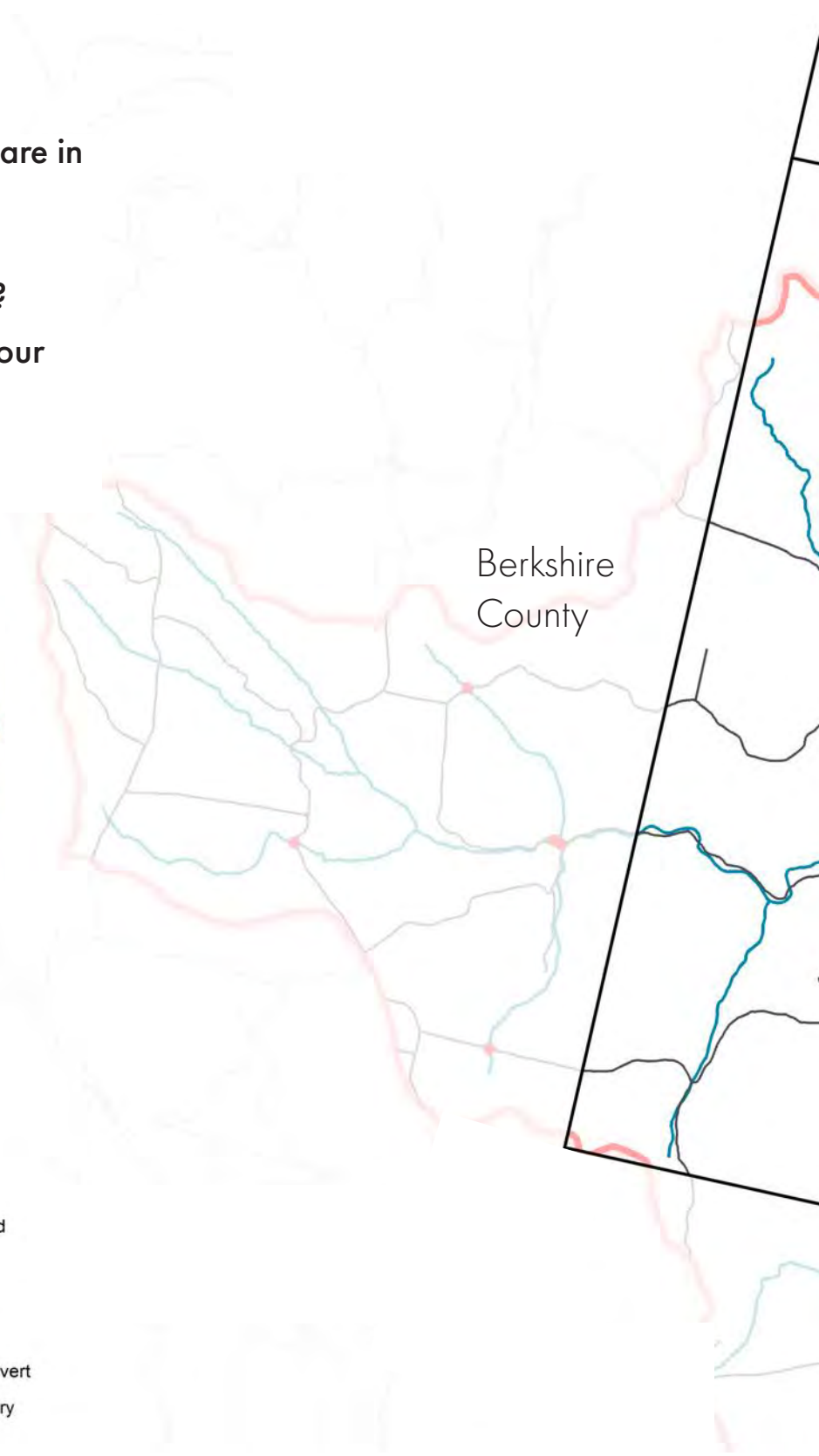
Hampshire
County





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CHARLEMONT

HAWLEY

Chickley
River
Subwatershed

Hampshire
County

0 1/2 1 Miles



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*"You are not Atlas carrying the world on
your shoulder. It is good to remember that
the planet is carrying you."*
Vandana Shiva





In Franklin County, Massachusetts, fourteen towns comprise the Deerfield River Watershed, whose varied topographies and terrains all find a common passageway to the sinuous, magnificent Deerfield River. Watersheds provide a level of organization for landscapes as well as communities, and a measure for understanding how natural hydrological patterns — such as flooding — are affected by development and land use decisions at the property, town and watershed scale.

This report provides the towns of the Deerfield River Watershed the relevant analysis to understand how climate change is affecting our lives and landscapes, as well as the tools that are on hand for solving some of the most pressing issues confronting our communities today. By following the recommendations outlined in this plan, and organizing efforts to improve resiliency at the individual, municipal and regional scale, the residents of the Deerfield River Watershed will not only survive, but thrive, in the 21st Century and beyond.