Water Resources

Connecticut River Management Plan

Riverwide Overview

CONNECTICUT RIVER JOINT COMMISSIONS INC

2008

CONTENTS

Adopted January 28, 2008
Produced with support from the New Hampshire Department of Environmental Services and the National Oceanographic and Atmospheric Administration.

Cover image: The Connecticut River, looking upstream from Lyme, New Hampshire and Thetford, Vermont

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Executive Summary

The Connecticut River, largest in New England, drains a third of New Hampshire and two-fifths of Vermont, uniting the two states for 271 miles of its 410 mile flow to Long Island Sound. This new Water Resources Riverwide Overview builds upon the 1997 *Connecticut River Corridor Management Plan*. It summarizes and builds upon the findings of our five local river advisory subcommittees, focusing upon topics of riverwide importance in the context of climate change and other broad influences upon the Connecticut River watershed.

This plan explores new and continuing challenges to water resources in the watershed, and encourages economic development that is compatible with the well-being of the river. It aims to stimulate stewardship and build partnerships across town lines, across the river, and across the array of interests of those who live and work on each side, aided by state and federal agencies with an interest in safeguarding the river's resources.

The most fertile soils, most valuable fish and wildlife habitat, and some of the most expensive real estate in the Connecticut River watershed are found along rivers and streams. Shoreland protection is unevenly applied; while New Hampshire has had limited statewide protection in place since 1994, Vermont remains the only state in New England that does not have a shoreland protection law. Development of all kinds, from industry and commerce seeking large expanses of flat, open land, to house lots marketed for their river views, competes increasingly with agriculture for room on riverfront lands, often on floodplains that offer natural flood storage. A town which permits building in its floodplain may be unwittingly creating a public nuisance by contributing to flooding of another across the river or downstream. Protecting floodplains from development would benefit public safety, agriculture, recreation, wildlife, and scenic values.

Riparian buffers are the river's best hedge against pollution, erosion, and flooding, and its best protection for wildlife. Landowners along rivers and streams should retain and enhance buffers of native vegetation. Towns should apply shoreland and buffer guidelines. The public should support the work of land trusts in protecting riparian lands in cooperation with interested landowners.

Riverbank erosion remains one of the most prevalent and misunderstood problems in the watershed. People cannot completely stop erosion - they can only speed it up or slow it down. Often, their attempts to treat localized erosion moves the problem elsewhere. The best solution is avoidance – choosing a river corridor protection strategy that gives the stream the room it needs to re-establish a healthy equilibrium. Activities in this sensitive area should be limited to agriculture, recreation, forestry, and wildlife conservation.

Stormwater runoff is the most common culprit in contamination of surface water. Anticipating impacts resulting from climate change, town planning boards and commissions should encourage new stormwater engineering practices such as "low impact development" designs, to reduce runoff and promote stormwater infiltration. New Hampshire towns should survey culverts and bridges to identify those that are undersized and poorly placed for fish passage.

While the federal Clean Water Act and local investments have brought the Connecticut River back from its days as an open sewer, some issues remain and new ones have arisen. Aging treatment plants require expensive maintenance while federal cost-sharing has disappeared. Today's facilities are not designed to remove pharmaceuticals and personal care products from the wastewater stream. Combined sewer overflows in St. Johnsbury and Lebanon mean dangerous pollution after storms and require costly remediation.

Groundwater, one of the region's hidden but most valuable resources, is closely linked both to public health and the health of surface water. Without a policy on groundwater withdrawal, and without adequate aquifer mapping, Vermont remains a target for commercial profit from a public resource. Further effort is needed to protect aquifers from contamination. States should ensure adequate water quality monitoring and continue to work with town conservation commissions and watershed groups to encourage and coordinate volunteer monitoring.

Water withdrawals for irrigation or industrial use can cumulatively affect the flow of streams. While a Protected Instream Flow for the Connecticut River is not imminent, it would be useful to have a means of identifying and controlling water withdrawals during extreme droughts.

There is room to expand river ecosystem and recreation benefits at existing dams and to carefully evaluate the public benefits of new hydro power proposals. There is currently no prescribed ramping rate for releases from Vernon, Bellows Falls, or Wilder Dams, and water levels can change abruptly above and below the dams when gates are opened. Ramping rates should be part of their future license, with provisions to allow a "black start" if energy conditions require it. The US. Army Corps of Engineers should institute a minimum flow at its flood control dam facilities and create or improve opportunities for fish passage.

The entire Connecticut River valley harbors rich agricultural soils of national significance that, if not developed, stand ready to provide healthy locally grown and distributed food. With transportation costs increasing and the possibility

of disruption of transportation networks, a sustainable local food supply is a matter of homeland security. Management practices to protect surface waters from pollution are still unevenly applied in the region, despite their clear benefits for the waters that drain farms and forests. Vermont has made great strides in assisting farmers with their efforts to protect water resources, including its Conservation Reserve Enhancement Program. New Hampshire's oversight of water quality impacts from farms is more limited, and Best Management Practices are not treated as requirements. There have been complaints from Vermont farmers witnessing poor practices across the river in New Hampshire, such as winter spreading of manure that was then washed downstream by spring high water.

Invasive plants are spreading rapidly in the region's rivers and streams, although the zebra mussel, despite the proximity of infested Lake Champlain, has not yet arrived. Eurasian milfoil now infests the river from Fairlee south, and a half-dozen other aquatic invasive species have also appeared in the river, especially near Massachusetts. Japanese knotweed, purple loosestrife, and exotic honeysuckle have aggressively colonized streambanks, and knotweed has formed pure stands along many streams. The invasive diatom Didymo or "rock snot" was discovered in the river in 2007.

Acid mine drainage continues to damage Vermont's Ompompanoosuc and Waits River watersheds. Three abandoned mines, all listed on the National Priorities List ("Superfund"), are pernicious sources of pollution that have severely affected aquatic life in these tributaries. The Vermont Congressional delegation should make copper mine remediation a priority**,** and seek adequate funding for EPA to permit capping and proper stabilization of the tailing piles.

The neurotoxin mercury gravely threatens public and environmental health and the region's tourism economy. Studies confirm that mercury is a dangerous presence in the tissues of Connecticut River fish, particularly from Canaan Dam to Moore Dam. More than 70 percent of the mercury impacting New England comes from pollution in upwind states. Vermont and New Hampshire will not be able to solve this problem without better federal regulations.

Climate change may affect river dynamics, water quality, aquatic habitat, erosion, and much more. Most scientists agree that climate change is already underway, and that the Northeast can expect higher temperatures and shifting seasons, reduced snow cover, and more extreme weather. More flooding could lead to greater erosion and increases in sediment, fertilizers, and other pollutants in stormwater runoff. The region has experienced some very severe storms in recent years, including a 500+ year event in the Cold River watershed that took four lives. Climate change effects in the watershed may also include droughts, especially if emissions are not soon controlled.

Studies in the Ashuelot River watershed suggest that current specifications for culvert sizing is inadequate to handle the higher frequency of greater intensity storms. The micro-watersheds of many culverts have less storage for runoff now than they did 30-40 years ago when these culverts may have been installed, because wetlands have been drained, land has been cleared, and more impervious surface has been added.

Protecting riparian buffers and the shallow soils of ridgelines, hillsides, and steep slopes from development can avoid contributing to sudden runoff that leads to flooding. Sustainable stormwater management in this new context is more important than ever, as is assuring open floodplains, effective riparian buffers, and property safe from sudden high water.

Introduction

The Connecticut River, the one that Native Americans called the Quinatuquet, is New England's largest and most powerful river, flowing 410 miles from its source in tiny Fourth Connecticut Lake near the Canadian border to its meeting with the sea at Long Island Sound. The Connecticut gathers the flow of thousands of streams spilling from the White and Green Mountains and the highlands running the length of both states.

In its first 271 miles, the Connecticut River forms New Hampshire's sinuous west coast and its border with Vermont. While royal decree gave the river to colonial New Hampshire in the eighteenth century, well over half of its 4.5 million acre upper watershed lies within Vermont. The watershed encompasses a full third (33 percent, 93 towns) of New Hampshire's land mass, and even more (41 percent, 114 towns) of Vermont. Fifty-three communities in these states claim the Connecticut River as a boundary. Long a migration corridor for commerce, waterfowl, and culture, the river remains a living thread that binds together the people of both these states in one valley.

Twenty four major tributaries and countless smaller ones drain a third of New Hampshire and two-fifths of Vermont, through the bed of a former glacial lake whose mark remains on the landscape to this day. Creating a plan for a river on this scale is a daunting challenge. This Water Resources plan for the Connecticut River is inevitably focused on its mainstem, but there is much of value in this plan for the tributaries.

Citizens of the Connecticut River Valley are well aware of the asset they now enjoy. The Connecticut commands respect when it releases its ice in the spring, when it floods after a storm, and when it turns turbines day after day to produce electricity for millions of people. Fertilizing its floodplain over thousands of years, the river's valley is home to some of the richest agricultural soils on the continent. Its waters, woods, and wetlands provide nationally recognized fish and wildlife habitat. It draws people to fish and canoe, and to explore the historic heritage of its nearby villages.

Water, the essence of life in nature, must be the essential target of protection. By most yardsticks, protecting the quality of the water also ultimately means protecting the economic value of the water and the health and security of those who depend upon it. This plan encourages continued economic development that is compatible with the well-being of the river. Stewardship of both the quality and the quantity of water flowing in the river is the responsibility of us all. Much has been learned and accomplished since CRJC first published the *Connecticut River Corridor Management Plan* in 1997. Many critical needs lie ahead.

This plan is not an attempt to dictate to citizens and towns what they can and cannot do on the banks of the Connecticut River. Instead, it aims to stimulate stewardship and build partnerships across town lines, across the river, and across the array of interests of those who live and work on each side, aided by state and federal agencies with an interest in safeguarding the river's resources.

The Connecticut River Management Plan ~ A New Water Resources Chapter

Seeking a local avenue for river decision-making, the Connecticut River Joint Commissions (CRJC) mobilized hundreds of valley residents and local officials to nominate the Connecticut River into the New Hampshire Rivers Management and Protection Program in 1991-2. Working with local citizen members of their five local river subcommittees, CRJC published the *Connecticut River Corridor Management Plan* in 1997.

At the request of the Connecticut River Joint Commissions, the New Hampshire Department of Environmental Services (NH DES) conducted a new assessment of water quality in the Connecticut River mainstem in 2004 with the support of the U.S. Environmental Protection Agency (EPA). CRJC's local river subcommittees began work on updating, revising, and expanding the 1997 Water Quality chapter, building upon the findings of this assessment in addition to new EPA studies of Connecticut River sediment quality and fish tissue toxins, geomorphic assessments sponsored by CRJC on the northern river, and erosion inventories conducted by the county conservation districts for the entire river in New Hampshire and Vermont. The subcommittees also explored new topics such as flow, flooding, drought, and groundwater, in an attempt to portray and address the full range of water resources in the region. The Commissions then examined their findings and selected topics of riverwide importance to explore and highlight in this Overview, in the context of climate change and other broad influences upon the Connecticut River watershed.

The Connecticut River Joint Commissions

Since 1989, when the Vermont Connecticut River Watershed Advisory Commission and the New Hampshire Connecticut River Valley Resource Commission first met together, we have been listening to people in the valley. From the many discussions that the Commissions have fostered across the river among communities and between local citizens and federal and state agencies, the Connecticut River Joint Commissions realize that aspirations for the river and its watershed are high and are widely shared.

The New Hampshire legislature created the Connecticut River Valley Resource Commission in 1987 to preserve and protect the resources of the valley, to guide growth and development here, and to cooperate with Vermont for the benefit of the valley. The Vermont legislature established the Connecticut River Watershed Advisory Commission in the following year. The two commissions banded together as the Connecticut River Joint Commissions (CRJC) in 1989, and also achieved the status of a non-profit organization. The legislatures assigned the commissions to work throughout the watershed in the two states, comprising approximately one third of the land area of New Hampshire and two-fifths of Vermont. The Connecticut River Joint Commissions are advisory and have no regulatory powers, preferring instead to advocate and ensure public involvement in decisions that affect the river and its valley. The CRJC's broad goal is to assure responsible economic development and economically sound environmental protection.

The thirty volunteer river commissioners, fifteen appointed by each state, are citizens who live and work in the valley and are committed to its future. The CRJC believe that the most effective action takes place when all the players come to the same table to achieve consensus. Members represent the interests of business, agriculture, forestry, conservation, hydro power, recreation, and regional planning agencies on both sides of the river. The Commissions hold joint meetings throughout the year, and are supported by four staff: the executive director, conservation director, communications director, and office manager. The Commissions are headquartered in Charlestown, New Hampshire.

1. SHORELAND PROTECTION

Issue: Statewide protection is uneven.

The most fertile soils, most valuable fish and wildlife habitat, and some of the most expensive real estate in the Connecticut River watershed are found along rivers and streams. Given the power of flooding waterways to destroy private property, sensible policy is required. What happens on the shore of a river has a profound influence on its water quality, riverbank stability, aquatic habitat value, recreational use, and scenic value.

New Hampshire enacted limited protection for lake, river, and coastal shores in 1994 through the Comprehensive Shoreland Protection Act, RSA 483-B, and in 2007 made improvements in the law based on findings of a legislative study committee representing diverse interests. The law applies to fourth order streams and larger, but leaves it to local communities to decide whether to protect the waters that flow into them. Since larger rivers are the sum of smaller ones that feed them, it makes sense that if shoreland protection extends to their tributaries, especially to headwater streams where the highest quality habitat may often be found, it will also benefit the larger rivers.

Vermont remains the only state in New England that does not have a shoreland protection law, although it permits towns to regulate land use activities near surface waters through a shoreland overlay. Indeed, more Vermont towns have enacted such protection than have their New Hampshire neighbors.

The land area covered by New Hampshire's law extends 250 feet from the ordinary high water mark, a distance less than the length of a football field and narrower than the width of the Connecticut River through most of its path between Vermont and New Hampshire. New Hampshire's law sets minimum standards for building setbacks, cutting of riparian buffers, building density and impervious surfaces, and use of fertilizer close to the water. It also prohibits establishment or expansion of salt storage yards, auto junk yards, solid waste, and hazardous waste facilities in this area.

> "Would you *really* advise your neighbor to build his building 51' from that river, the way it moves?"
>
> *Riverfront Landowner*
> *Orford*

New Hampshire's setback for buildings is only 50 feet from the water, a distance which may make sense on a relatively stable shoreline such as that of a rocky-bottomed lake, but which is of questionable value for a major river such as the Connecticut, which may claim 5-10 feet of territory each year where it is actively eroding.

The Silvio O. Conte National Fish and Wildlife Refuge, the only true watershed-wide refuge of the nation's 550 refuges, could be a significant player in water resource protection. Much of the important work in shoreland protection has been done, however, not by state or federal agencies but by local and regional conservation organizations. The Connecticut River valley is home to some of the most competent land trusts in the United States. The Upper Valley Land Trust, for example, has protected over 30 miles of river frontage in its region.

Opportunities & Recommendations: Provide shoreland protection to both shores.

Both sides of the Connecticut River deserve at least the minimum level of protection from the states, with an invitation to local communities to add their own. The *Connecticut River Corridor Management Plan* goes far beyond the Shoreland Protection Act in offering a diversity of tools for protecting the river, including regulatory and non-regulatory measures.

1. **The Vermont Legislature should adopt similar if not greater measures** than those in RSA 483-B to protect the shoreland of both the Connecticut River and its tributaries. Citizens should alert their legislators about the importance of shoreland protection and call upon the legislature to take action.

2. **The New Hampshire Legislature should consider adding shoreland protection for third order streams**, the smaller but still substantial tributaries that feed the larger streams already protected under the law. Citizens should alert their legislators about the importance of protecting these smaller streams and call upon the legislature to take action.

3. **NH Department of Environmental Services should educate town officials, real estate agents, developers, and landowners about the Comprehensive Shoreland Protection Act**, including the agency's responsibility for enforcement. DES should provide GIS layers and mapping of the protected shoreland for local zoning officers. All the tools currently exist to use recent aerial photography, snap a 250' offset from the centerline of all rivers of interest, and digitize existing vegetative buffers. This would be very low cost and could be given to each town, and could also be available on the GRANIT site for download. Towns that had digitized parcels could overlay that layer for the protected shoreland. Slope can be added relatively easily, as can floodplain elevations and varves, to be sure these aspects are considered as planning boards and commissions review proposals for

development. Vermont should provide similar services as soon as possible after the legislature enacts statewide shoreland protection.

4. **Town planning boards/commissions should adopt ordinances to ensure that structures, including roads, are set a safe distance back from the river** to reduce the risk of property loss in erodible areas. Vermont needs enabling legislation to allow this. Town planners should consult their regional planning commissions to help bring life to the river protection recommended in this Overview and their local subcommittee's plan, by incorporating meaningful standards for shoreland development in their town's master plan and zoning ordinance. Tailor these shoreland ordinances to reflect local shoreland conditions. CRJC believes that a setback of 50 feet for buildings and 75 feet for septic system leach fields (as set forth in New Hampshire law) is entirely inadequate in situations where the riverbank could become unstable, and urges communities to establish more conservative setbacks to prevent property loss and water contamination. Soil conditions and slope are important to consider because they will determine how septic leachate and runoff will move to the river.

5. **Town planning and conservation commissions and (in Vermont) development review boards should provide information** to every new riverfront landowner to explain the special challenges of owning and managing riverfront land, including the benefits of riparian buffers and the requirements of state shoreland protection laws. CRJC and state agencies should assist in preparing this information.

6. **Federal, state, regional, and local agencies and organizations should pursue conservation of key riverfront land** in cooperation with willing landowners**,** to protect water quality, flood storage, prime agricultural soils, wildlife habitat, and scenic views.

2. FLOOD STORAGE

Issue: Natural floodplain storage is being lost.

> "A flood is never a disaster until people get in the way."
> *Barry Cahoon,*
> *River Management Engineer*
> *VT Agency of Natural Resources*

The Connecticut River, the largest in New England, gathers the rain and snow falling on the 11,250 square miles of its watershed in New Hampshire, Vermont, Massachusetts, and Connecticut. Wetlands and floodplains are where the river naturally stores flood water and relieves the water's energy. The Connecticut River's broad floodplain, famous for its fine agricultural soils, has become key waterfront property now that the river is clean and attractive once again.

Development of all kinds, from industry and commerce seeking large expanses of flat, open land, to house lots marketed for their river views, competes increasingly with agriculture for room on riverfront lands. Yet few people remember those times when the worst possible combination of weather and river conditions produced catastrophic floods. In 1936, many riverfront towns were ten or twenty feet underwater. Flooding in Vermont on July 11, 2007 caused millions of dollars in damage. We do not know when such floods could come, but they could well come within our lifetimes, as they did on the Cold River in Alstead, New Hampshire, in October of 2005.

During the mid 1900s, the U.S. Army Corps of Engineers built seven flood control dams on tributaries of the Connecticut in an attempt to reduce hazard to downstream communities which had grown close to the river. Yet, these massive structures are able to control less than 15 percent of the 6266 square miles of the Connecticut River's watershed that drains through Vernon Dam near the Massachusetts line, and provide substantially less flood protection for the 250 miles above the West and Ashuelot Rivers where four of these seven dams sit.

The large investment of taxpayer dollars and the heavy fiscal and environmental cost of these dams eventually redirected attention to the idea of non-structural or natural flood storage, which meant keeping floodplains open and relatively undeveloped. The Corps' 1994 Connecticut River Basin Natural Valley Storage Reconnaissance Study identified two major flood storage areas in the upper basin. These are the reach from W. Stewartstown to Lancaster (12,000 acres of floodplain) and Woodsville to Bradford (4,000 acres). The study strongly advised discouraging development in these flood storage areas, although application of the Corp's standard cost/benefit formula led to the conclusion that federal purchase or easement acquisition would be economically unfeasible. Fortunately, the Upper Valley Land Trust has stepped in, working with willing farm landowners to protect much of the prime farmland in the lower reach, but 14 years after the Corps report, the rest remains vulnerable or is in the process of being developed.

The Federal Emergency Management Agency's (FEMA) Flood Insurance Program prohibits development in the floodway, but permits it in the 100-year floodplain if the developments are "flood proofed." This program does not consider environmental, social, aesthetic, or other relevant values. Most communities considered this to be adequate to protect their citizens from flood damage. Yet simply building a mound for a house site or calling for flood proof design does not solve the problem, it just moves it somewhere else. A town which permits building in its floodplain may be unwittingly creating a public nuisance by contributing to flooding of another town across the river or downstream. Only four of the 53 towns along the Connecticut River in New Hampshire and Vermont now specifically exclude construction in their floodplains.

Floodplain maps provided to the towns by FEMA show only calculated probabilities of flood frequency, rather than lines the river should not be expected to cross. Flood damage to structures built within the floodplain costs taxpayers billions of dollars in disaster relief nationwide. The maps are frequently inaccurate and do not reflect changes in hydrology due to development. Because the maps are based on inundation hazard, they also do not show areas that might be vulnerable to fluvial erosion hazards, which is a frequent form of flood damage in this region due to its topography and the ways rivers were managed in the past. Most maps were done in the 1970s, when many of the rivers depicted were well out of equilibrium condition. Floods have the greatest impact in terms of cost and loss of life on transportation infrastructure, principally due to catastrophic erosion affecting roads, road drainage systems, bridges, and culverts. Public exposure to floods is increasing because stream channels are enlarging as they are asked to carry more stormwater runoff from increasing development and as they respond to climate change.

> "You best not be building in those floodplains. Mother Nature doesn't like it. Now, money talks more than common sense."
>
> *Riverbend Subcommittee member and riverfront farmer from Guildhall*

The public may have a sense of false security that the large hydro dams on the Connecticut River mainstem will prevent damage from a major storm, yet at times during the preparation of both this plan and its 1997 predecessor, the river has carried enough water to cause significant flooding in spite of the best efforts of dam managers. Even when Moore Reservoir is lowered the full 40 feet allowed by its license, it can only capture one inch of rainfall in its 1600 square mile watershed without spilling it into the river below. Following heavy rains in October, 2005, flood water exceeded storage capacity at both Moore and Comerford Dams at Fifteen Mile Falls, and flooding occurred for miles below them.

Opportunities & Recommendations:
Protect floodplains from development & retain natural valley flood storage.

People cannot control flooding, but can manage it so that the water, when it inevitably arrives, can go where it can do little damage to human investments. FEMA regulations encourage adoption of higher standards than the FEMA minimums. Towns that adopt No Adverse Impact floodplain regulations may be rewarded by FEMA's community rating system. Since Hurricane Katrina, recognizing that it makes more sense and is less expensive to prevent disasters than to repeatedly repair damage after a disaster has struck, FEMA has provided funding to towns with a pre-disaster mitigation plan to address hazards such as floods before they happen.

Towns are often faced with difficult choices about where to permit development and where to prevent it. The first choice should be to avoid new development anywhere in the floodplain, as some towns have already voted to do. However, while adding to existing development in a heavily settled area of the floodplain, such as an historic village, still invites flood damage, it may be a better use of the land to continue to develop there than to allow new development in undeveloped agricultural floodplains. In the first setting, additional development can be flood-proofed with mitigation from new compensatory storage. In the latter setting, towns should strive to prohibit new floodplain development, both to prevent a public nuisance and to protect the integrity of this land use in addition to its vital flood storage function. Towns should carefully consider whether to continue to offer agricultural exemptions for such aspects of zoning, since structures such as greenhouses invite flood damage as readily as structures with other uses. To participate in flood insurance, towns should update their flood regulations to bring them into compliance with the minimum federal requirements.

New Hampshire has initiated a wetlands mitigation program to compensate for unavoidable losses of wetlands, and intends to use the funds to address wetland functions and values lost through land conversion. It can protect other wetlands within the same watershed as those that were lost. Towns can take advantage of this program if they are prepared with a natural resource inventory and knowledge of their valuable local wetlands needing protection. The Nature Conservancy has recently completed a GIS-based floodplain analysis of the Connecticut River Watershed. This analysis could be useful to regional and local planning agencies in selecting areas for floodplain restoration.

1. **Towns should not permit new building in the 100-year floodplain, or the special flood hazard area**, to protect their citizens and businesses from damage, to avoid adding to flooding of their downstream neighbors, and to reduce the public cost of disaster relief. Review preliminary Flood Insurance Rate Maps and meet with FEMA and the state to comment on the maps. Consider the flood implications of access roads to development sites in the floodplain, and ensure that they will not act as berms during high water. Vermont towns should avail themselves of the Municipal Education Grant Program to bring training to their communities as they consider adopting new river protections such as this.

2. **FEMA should create a system for evaluating the costs and benefits of avoiding floodplain development,** not just retrofitting development. Provide accurate floodplain maps for all river towns. Maps should include accurate river gradient drop as well as elevation for floodplain determination. Data sources could include the many USGS geodetic discs in the area, dam elevations, LIDAR type flights and the vertical GPS points collected.

3. **Public agencies, conservation organizations, and private landowners should work together to retain natural flood storage** in floodplains and wetlands. New Hampshire town conservation commissions should develop a list of candidate sites for protection through the state's wetlands mitigation program. The Nature Conservancy should make local planning boards and conservation commissions aware of its floodplain analysis.

4. **State emergency management offices should include local watershed groups in emergency planning** for river-related issues. Watershed groups should be at the table for river management and disaster planning long before a disaster occurs.

5. **Land conservation organizations and other appropriate agencies should purchase development rights from willing owners** of land in the natural valley flood storage area to help prevent flooding downstream. The U.S. Fish and Wildlife Service's Conte Refuge can also help accomplish flood storage protection by focusing on protecting riparian habitat.

6. **The U.S. Army Corps of Engineers should revisit its cost-benefit analysis of protecting natural valley storage** areas in the Connecticut River Valley. The 2007 authorization in the Water Resources Development Act provides an opportunity to pursue creative non-structural means of flood control. Include consideration of economic studies by the N.H. Lakes Association, costs of community services studies, and insurance pay-outs for flood damage.

3. RIPARIAN BUFFERS

Issue: Riparian buffers have been destroyed or rendered ineffective.

Riparian buffers are the river's best hedge against pollution, erosion, and flooding, and its best protection for wildlife habitat. These strips of native grass, shrubs, and especially trees along the banks of rivers and streams filter sediment and other contaminants from runoff and provide a transition zone between water and human land use. Riparian buffers capture pollutants from both water running off the land surface and, when thickly forested, from subsurface water moving toward the stream. They also provide biological services, protecting aquatic habitat by shading water and capturing pollutants, adding leaves and woody debris to the river ecosystem, and providing rich wildlife habitat and travel corridors. This essential "green infrastructure" is a real bargain compared to a multi-million dollar piece of built infrastructure.

Riparian buffers are a river's right-of-way.

Erosion inventories show that Connecticut River banks tend to exhibit more erosion when riparian buffers are absent. CRJC's 2004 geomorphic assessment of the northernmost 85 miles of the Connecticut River, conducted by Dr. John Field, found a lack of riparian buffer along a full 20 percent of the riverbank, and concluded that bank stability generally increases as buffer width increases, as long as a buffer is at least 25 feet wide. Dr. Field observed a 67 percent greater chance of finding erosion where there is no riparian buffer. (1) While a stream-side buffer can't promise to stop erosion – nothing can – it's the river's original stabilizer and provides other benefits, too.

A 100-foot buffer will generally remove 60 percent or more of pollutants, depending on local conditions. It will also provide food, cover and breeding habitat for many kinds of wildlife. For slopes gentler than 15 percent, most sediment settling occurs within a 35-foot-wide buffer of grass. Greater width is needed on steeper slopes, for shrubs and trees, or where sediment loads are particularly high. Because a century of channel straightening has forced many stream channels out of equilibrium and they are now becoming incised, cutting down through their beds, the river is below the root zone of many buffer plants, but the buffer can still create roughness that slows the water and captures sediment.

Vermont and New Hampshire have differing policies regarding riparian buffers, although river experts in both states agree that buffers are very important for protecting water quality and reducing erosion. Septic systems must be set back 75 feet from rivers and streams in both states. New Hampshire's Comprehensive Shoreland Protection Act requires that the area within 50 feet of a fourth order stream (and larger) must remain undisturbed, and also protects the natural woodland buffer within 150 feet of such waters.

Vermont has no statewide buffer protection, although the Agency of Natural Resources has adopted a Buffer Procedure (3 V.S.A. § 835) that may be used as guidance in conditioning Act 250 permits. This guidance can also be used by towns wanting to protect their local waters. Vermont requires a very minimal buffer of 10 feet on farms, and only between land used for growing annual crops (such as corn) and surface water. The state has appropriated funds for the Conservation Reserve Enhancement Program to assist farmers and other landowners who want to improve water quality by setting aside and even replanting riparian buffers. New Hampshire has no such requirement for farms, and no comparable state assistance, although it recommends use of buffers as a best management practice. Fortunately, silver maple floodplain forests, a well-documented and valuable plant community that provides an excellent riparian buffer, are returning in many places in the North Country, due to changes in farm practices.

While forestry is exempt from NH RSA 483-B, the Basal Area Law (RSA 227-J:9) requires that within 150feet of fourth order streams and great ponds, 50 percent of the pre-harvest basal area must be maintained, and that 50 percent of the pre-harvest basal area must be maintained within 50 feet of all perennial streams, rivers, and brooks. Vermont's Acceptable Management Practices for forestry specify that except for stream crossings, a protective strip shall be left along streams in which only light thinning or selection harvesting can occur.

Opportunities & Recommendations: Put nature's own water treatment systems to work.

Riparian buffers are a time-tested way of working *with* the land, not against it. The rewards of riparian buffers are many. *They provide economic services*: protecting citizens against property loss through flood damage and erosion; recharging aquifers and protecting the quality of public drinking water supplies; supporting the recreation and tourism industry; supporting sustainable yields of timber; and shielding farm fields from flood-borne debris. *They provide social services:* protecting clean surface water for public recreation; protecting prime agricultural soils from erosion; providing natural fences, visual screens, and noise control; providing outdoor laboratories for teaching and research; offering places for camping, nature study, birdwatching, hiking, hunting and fishing; improving air quality; recycling nutrients; trapping heavy metals and toxins; storing excess sediments; and trapping carbon dioxide. *They also provide biological services:* protecting aquatic habitat by shading water and capturing pollutants and providing rich wildlife habitat and travel corridors. Conservation easements are a useful tool for establishing and maintaining riparian buffers.

1. **Landowners should encourage riverfront forests where they remain.** Landowners along rivers and streams should retain and enhance buffers of native vegetation and remove invasive plants that try to gain a foothold there. Farmers will especially appreciate the capture of flood debris by large woody buffers during high water. Landowners can protect their privacy, enhance the appearance of their property, and protect water quality by leaving the natural buffer undisturbed. They should take advantage of state and federal cost-sharing programs and of the advice offered by county conservation districts and CRJC's printed guidance, *Riparian Buffers for the Connecticut River Watershed*.

2. **Towns should encourage riverfront buffers.** Stating the town's support of riparian buffers in the master plan is only window dressing if the zoning ordinance does not back it up. Apply shoreland and buffer guidelines on small streams as well as on larger rivers. Small streams are most vulnerable because they respond most dramatically to changes in adjacent land uses, tend to be located on the steepest sloping and erosion-prone lands, are subject to flash flooding, and often have the highest quality remaining habitat.

3. **State and local transportation departments should treat riparian buffers as natural allies in preventing pollution** by retaining buffers as a natural curb to road-related runoff**.** Encourage road agents to avoid mowing vegetation in riparian buffers where roads are close to streams. The often-too-small strip of grass, ferns, and other volunteer plants has a big job to do to keep trash, road pollutants, and sand out of the water. Include riparian buffer restoration, using native plants, as an integral part of road projects near rivers and streams. Too often, road project designs near waterways concern only the road surface itself, and ignore the biological portion of the project.

4. **The states of New Hampshire and Vermont and the U.S. Fish and Wildlife Service's Conte Refuge should invest in riparian habitat conservation and restoration** in cooperation with interested landowners.

5. **County conservation districts should work with riparian landowners,** including residential homeowners**,** to provide buffer plant material, planting plans, and buffer plant packages for various settings.

6. **The states should support buffer restoration through tax incentives and cost-sharing.** Vermont should continue to fund its Conservation Reserve Enhancement Program, and New Hampshire should consider creating a similar program to make buffer restoration more affordable for riparian landowners.

7. **Vermont should ensure that its current use program is not at odds with conservation goals** and allow riparian buffer protection on enrolled lands. Foresters designing management plans for property enrolled in the program should incorporate best forestry management practices to protect and enhance forested buffers.

8. **The public should support the work of land trusts and other conservation organizations in protecting riparian lands.** Encourage them to make aquatic and riparian habitat quality a priority in cooperation with interested landowners. An easement should include both the streambank and a buffer around it that includes the belt width of the river meander, or the lateral distance the stream is likely to migrate. This varies depending upon topography and the size of the stream, but usually averages six times the width of the channel. Encourage local conservation commissions to educate townspeople about the value of buffers and the ways in which personal choices can have lasting effects, both good and bad, on the region's water resources.

4. STREAMBANK EROSION

Issue: Riverbank erosion is one of the most prevalent and misunderstood problems on the Connecticut River and its tributaries.

While it is the nature of rivers and streams to move sediment through the landscape, human activities are having an increasing impact on river behavior. Rivers are constantly adjusting to many changes, from dam building or breaching to increases in stormwater runoff, deforestation, reforestation, road and railroad building, and even deglaciation. For example, a full third of the 85 miles from Murphy Dam in Pittsburg to Gilman Dam in Lunenburg was straightened in the late 1800s, probably for log drives. The river has been attempting ever since to restore a natural path by seeking a stable slope and depth to handle its sediment load. Erosion delivers not only sediment to a stream, thus increasing turbidity, but nutrients and other pollutants attached to the sediment.

> "Topsoil – it's New Hampshire's number one export."
>
> *Headwaters Subcommittee representative and selectman from Stewartstown*

Since publication of the 1997 *Connecticut River Corridor Management Plan*, research sponsored by CRJC and others has contributed greatly to our understanding of the reasons for erosion. Erosion inventories of the mainstem in both states have provided a snapshot in time of their condition. A new tool is fluvial geomorphology, a science that attempts to understand how river channels adjust their shape and planform through erosion and deposition to reach an equilibrium with natural conditions and human land use in the watershed. Since channels in equilibrium do not change their shape and planform over time, urging a stream toward equilibrium can greatly reduce erosion and deposition and minimize impacts on humans and aquatic habitat. Vermont's Agency of Natural Resources (VT ANR) estimates that up to 70 percent of the state's stream miles have been channelized and straightened over the years, to accommodate roads, the railroad, agriculture, and development, meaning that people will end up fighting those rivers at a cost of millions of dollars.

People cannot completely stop erosion - they can only speed it up or slow it down. Often, their attempts to treat localized erosion moves the problem elsewhere downstream. The best solution is avoidance – choosing a river corridor protection strategy that gives the stream the room it needs to re-establish healthy equilibrium conditions. Another important deterrent is allowing the banks to naturally fortify themselves with a protective buffer of vegetation, although not even a buffer will reduce bank erosion in an area where the river is out of equilibrium.

CRJC's geomorphic assessment of 85 miles of the river above Gilman Dam identified three causes of erosion and channel instability: human channelization and straightening; sediment inputs from tributary watersheds; and sediment inputs from high eroding banks of glacial outwash deposits (2). CRJC has provided maps of erosion and riverbank condition to the northernmost 16 towns along the river based on a geomorphic assessment. Farther downstream, erosion occurs where water levels fluctuate with the operation of dams, and where boat wakes strike soft riverbank soils. The Connecticut River can and does erode valuable agricultural soils and threatens roads and buildings. However, some ill-informed attempts to stop erosion can have unintended effects, and can actually start erosion somewhere else, on someone else's property. All projects on riverbanks require permits from the state.

Several areas of particularly severe erosion stand out on the mainstem. At the Northumberland Cemetery in New Hampshire, a steep, high bank is eroding into the river, threatening a number of burials at the top of the bank. Studies sponsored by CRJC indicate that bank instability at the cemetery is related to the breaching of the Wyoming Dam three miles downstream , the breaching of Nash Stream Bog Dam in the Upper Ammonoosuc watershed, and the resulting sand bar development on the Connecticut River at the confluence with the Upper Ammonoosuc River. The erosion situation is complex and as yet unresolved.

Such high sandy banks are often associated with eskers, reminders of glacial activity that are frequently close neighbors to rivers. Disturbance of these high sandy banks very close to the river, including sand and gravel removal, threatens to deliver large amounts of sediment to the river below that could smother aquatic habitat and even cause the river to shift its course.

Another significant problem area is a delta of gravel, silt, and clay deposited by Commissary Brook in Rockingham, Vermont six miles upstream from the Bellows Falls Dam. Fishermen and divers report that the Connecticut River is now only six inches deep in places where it was once 30 feet deep. The brook is sending a plume of turbidity into the river that violates the New Hampshire surface water quality standard, and in the five years since the turbidity was measured, this plume has moved hundreds of yards downstream. The sediment is coming from a small tributary to Commissary Brook, where clay extraction penetrated to the depth of shallow groundwater. Changes in hydrology caused from removing trees adjacent to the clay pit created the instability and failure of downstream embankments. A head cut is developing that could affect nearby homes. Officials believe that the plume will persist until the site is stabilized.

The presence of varved soils associated with glacial Lake Hitchcock appear to be a major contributing factor to the release of tons of sediment that have washed down the steep tributary into Commissary Brook and the Connecticut

River. VT ANR and the state's Act 250 Environmental Board both granted permit approval to the clay extraction in the early 1990s, and did not foresee the subsequent severe erosion and sedimentation that later occurred. The location of varves remains little known in much of the river valley, although mapping technology exists that could provide this valuable information to local planning boards and commissions. Soils maps can help predict the presence of varved soils.

A recently discovered erosional feature, not identified in earlier erosion inventories, is hidden riverbank undercuts. Observed in the Wilder impoundment, the extent of their presence is unknown. In these undercuts, cavities extend back some four to six feet. In such places, the root structures of the trees are currently holding up the bank, but they may eventually fall, bringing a large root ball with them. It is not currently known whether this kind of erosion occurs only on impoundments with fluctuating water levels or throughout the Connecticut River system.

People place their homes and businesses in danger if they build them too close to the river on erodible ground. The federal government spends millions of taxpayer dollars nationwide each year in disaster relief for damage to structures which may have been unwisely built within a river's eventual path. Vermont's River Management Program has developed a fluvial erosion hazard mapping method to better identify areas near streams that are highly prone to flood damages due to erosion. The maps can be used to delineate river corridors that should be protected from encroachments to preserve channel stability and avoid flood hazards.

"We have to stop chasing our rivers with riprap – it's not a sustainable policy."

Barry Cahoon
River Management Engineer, VT Agency of Natural Resources

Opportunities & Recommendations: People living, farming, and doing business near the river should understand how a river works.

It is the nature of rivers and streams to change course, especially to re-establish a lost equilibrium of flow within their watershed. Avoid setting up an erosion-prone situation in the first place.

1. **New Hampshire should consider offering fluvial erosion hazard mapping** similar to Vermont. Towns should work with regional planning commissions to identify their fluvial erosion hazard areas and develop pre-disaster mitigation plans.

2. **State agencies and local boards issuing permits for sand, gravel, or clay extraction close to the river should fully consider the potential for bank failure** in such excavations, require significant setbacks, and have a plan for mitigation and stabilization or restoration.

3. **Towns should contribute to controlling both erosion and property damage by discouraging development too close to the river** or within the floodplain, and adopt meaningful building setbacks. Activities in this sensitive area should be limited to agriculture, recreation, forestry, and wildlife conservation. Enforce developers' use of erosion and sedimentation control practices, and ensure that riverside activities do not impact riverbanks and riparian buffers**.**

4. **Towns should work with state geologists to map varves** in their towns, to be sure major construction does not take place on unsafe soils. These varve maps could also be a source of more accurate elevation data and include indication of the 100 year floodplain. Towns should consult existing soils maps and work with their county office of the USDA Natural Resources Conservation Service to identify where these unstable soil formations may occur within their boundaries.

5. **The U.S. Army Corps of Engineers should work with state environmental agencies to examine and address severe erosion sites** such as at Commissary Brook in Rockingham, Vermont and at the cemetery in Northumberland, New Hampshire.

6. **Riverbank restoration projects should include riparian buffer restoration** that is monitored for a number of years to ensure success, and include protection against rodent predation and a means of eliminating competing vegetation and invasive species, so that plantings can become established.

"A wise public must give the river room to be a river."

Sharon Francis, CRJC Executive Director

7. **Land conservation organizations and others acquiring conservation easements** on riverfront land should ensure, wherever possible, that the easement includes the belt-width of the river meander in that area, to accommodate future movement of the channel without harm to structures. Organizations that provide funds for easements should consider the same belt-width requirement for funding conservation, where adequate undeveloped space remains.

8. **The USDA county conservation districts should survey riverbanks for the presence of hidden riverbank undercuts**, with the assistance of local conservation commissions, and identify and test a means of restoring these cavities. These locations should be GPS located and attribute data added (tree species, depth and size), and the data base made public so that others may add to this documentation over time using proper methods and forms. It might also be of use to note any invasive or rare or endangered species encountered. Landowners should check their own property for these erosion features.

9. **The New Hampshire legislature must provide sufficient funds to allow the Department of Safety's Marine Patrol to adequately enforce existing boating laws** on the river. N.H. Marine Patrol should ensure a regular presence on the Connecticut River to help reduce boat wake-induced erosion. The N.H. Legislature should update the definition of personal watercraft to ensure that these wake-producing craft are limited to the widest areas of the river. Boaters should obey existing speed laws and watch their wakes to be sure that they do not strike the bank with erosive force.

10. **Landowners faced with an erosion problem should contact professionals** such as the Natural Resources Conservation Service for help in evaluating which solution, if any, is the best for the site, since each site is different and requires a practiced hand. Anyone contemplating work on a riverbank must obtain the proper permits before going ahead.

5. STORMWATER

Issue: Stormwater management is inadequate in the face of climate change.

Stormwater runoff is the most common culprit in contamination of surface water. Runoff from roofs, roads, driveways, and sidewalks carries automotive pollutants, sediment, pet waste, and litter down drains and into streams. Runoff from barnyards and feedlots brings mud and manure, while runoff from logging jobs brings silt and slash. With the specter of more frequent heavy storms as a symptom of climate change, the problem becomes even more urgent. If intercepted by a berm, buffer, bog, or other basin, the stormwater can drop its load and reduce velocity before reaching the stream. Water that can seep back into the soil won't reach the stream so fast, and the stream is less likely to flood or erode. The Wildlife Action Plans recently completed by New Hampshire and Vermont identified the impact of roads, pollution/sedimentation, and climate change as three of the top five threats to wildlife and wildlife habitat. All three are directly related to stormwater.

"Terrain drains!"

Upper Valley River Subcommittee member from Thetford

In the past, streets and sewers were designed simply to shed the water as quickly as possible, but today we realize the need to remove any hitchhiking contaminants before they reach a stream and to capture this water to recharge underground reservoirs. EPA, which regulates stormwater under the Clean Water Act, has phased in efforts to control this source of pollution. Beginning in 1992, permits have been required for manufacturing facilities, hazardous/solid waste processing, junkyards, sand and gravel mining, timber processing, power plants, vehicle maintenance, sewage treatment plants, and construction that disturbs more than five acres. More recently, permits have been required for construction sites from one to five acres and for town-owned activities such as sand pits, recycling centers, school bus maintenance, and treatment works.

New Hampshire does not issue its own stormwater permits, but reviews and certifies EPA's permits. The state does limit impervious surfaces within 250 feet of lakes, ponds, and fourth order and larger streams, and considers stormwater through its alteration of terrain permitting program. Otherwise, the state is involved only to provide technical assistance and public education. If DES receives a water quality related stormwater complaint, the state will go out to be sure there is a federal stormwater permit and a stormwater pollution prevention plan. Otherwise, controls on stormwater are through local regulation, if it exists.

In Vermont**,** the Department of Environmental Conservation Stormwater Program issues separate permits for runoff from impervious surfaces, construction sites and industrial facilities. VT ANR is delegated by EPA to issue these latter permits. Vermont has also provided funding to regional planning commissions to assist towns in identifying culverts and bridges that are undersized.

Culverts came under the microscope in 2005, when an oversized storm met an undersized culvert in the Cold River watershed, with devastating and deadly results in Alstead, New Hampshire. A report to the city of Keene that same year, from Michael Simpson of Antioch New England Graduate School, concluded that current engineering design specifications for culvert sizing in the nearby Ashuelot River watershed is inadequate to handle the higher frequency of more intense storms that can be expected with climate change. Geomorphic assessments are indicating that culverts should be sized to handle the bankfull flow of a waterway. Dams and under-size stream crossings (bridges and culverts) affect sediment transport, part of the reason why stream channels are incised and have lost floodplain access downstream.

Opportunities & Recommendations:

Recognize the polluting power of stormwater, and make stormwater an asset, not a liability.

Towns and developers have promising new tools for managing stormwater, collectively called "low impact design." Rather than channeling runoff into drainage ditches, LID calls for spreading runoff around in small vegetated catch areas and swales where it can slow down and soak into the ground to recharge groundwater rather than run off the land. At the University of New Hampshire's Stormwater Center, research has shown that bio-retention areas ("rain gardens," gravel wetlands, pre-treated subsurface units, and porous asphalt) all provide significantly better stormwater treatment than conventional ways of dealing with runoff. Fortunately, most of these techniques are cheaper than conventional ones.

Towns have both a public safety and an ecological opportunity in examining culverts. Studies of culverts in the watersheds of several major tributaries (the West, White, and Ashuelot Rivers) by volunteers organized by The Nature Conservancy, the White River Partnership, and others, have discovered situations where culverts are not only dangerously undersized but also disrupt aquatic habitat, creating impassable drops that fish and other aquatic life cannot overcome. These assessments can be used by states and towns to prioritize culverts for replacement by combining safety features with ecological benefits.

1. **Federal, state, and local agencies should adopt new stormwater engineering practices,** anticipating impacts resulting from climate change. NH DES should seek funding to support regional planning commissions in assisting New Hampshire towns to survey culverts and bridges to identify those that are undersized and poorly placed for fish passage, and seek funding for replacement where necessary. Simple mapping of each drainage area would serve as a useful reference as development occurs or is proposed.

2. **State agencies should inform local planning boards and commissions, developers and landowners about changes in the stormwater permitting process**.

3. **Town planning boards and commissions should plan for stormwater control** and look at ways to include "low impact development" ideas as they review projects, and at how to change existing development to reduce runoff and promote stormwater infiltration. Where possible, towns should discourage addition of impervious cover because of its effects on storm water runoff and harm to aquatic systems, and work with commercial and industrial developers to assist them in finding ways to retain all stormwater on site. Consider rewarding or crediting developers who provide vegetative buffers and maintain hydrologic connectivity of wetlands within projects.

4. **Developers, farmers, and forest workers should use best management practices** for stormwater, such as low impact development design techniques, redirecting barn roof runoff away from high cattle use areas, and smoothing and seeding skidder ruts after timber harvest so that these places do not become channels for erosion.

6. WASTEWATER DISCHARGES

Issue: Wastewater discharge problems remain.

The federal Clean Water Act and local public and private investments have largely brought the Connecticut River back from its days as an open sewer. A half century ago, the federal Public Health Service rated 219 of 269 miles of the upper Connecticut River as "Damaged. Unsuitable for recreational uses except boating, unsuitable for use in some industrial processes without treatment, and unsuitable for irrigation of crops consumed without cooking." Six miles were described as "unsuitable for most legitimate water uses. Suitable only for the transportation of sewage and industrial wastes, power development, and limited industrial uses."

> "I've been working on this river for 34 years, and I never thought in 1970 that I'd see how clean this water has gotten. I didn't see too much swimming in 1970; it depended on what color the water was running that day."
>
> *Ken Alton*
> *TransCanada Hydro Northeast*

Among the culprits were untreated wastewater discharges from pulp and paper mills, milk processing plants and other industries, and domestic sewage from 21,650 people in 17 municipalities on the mainstem alone. Twenty-four tributaries delivered their own pollution, bringing sewage and discharge from textile mills, machine tool factories, slaughterhouses, and more. (3)

Passage of the federal Clean Water Act and construction of multi-million dollar facilities to treat sewage and industrial wastewater utterly changed the river's character, allowing it to flush itself of most of these pollutants. Some issues remain, however, and new ones have arisen. Modern wastewater treatment facilities are not designed, for instance, to remove the complex organic molecules and sometimes tiny particles of pharmaceuticals and personal care products, and these drugs, artificial hormones, (whether consumed first or put directly in the wastewater stream) and perfumes pass virtually unaltered, or mixed to form new compounds, into the river with unknown results. Until 2007, the only guidelines that existed for disposal of pharmaceuticals was to flush them and send them to this fate, rather than recycle or landfill them.

Many years have passed since most communities built their wastewater treatment facilities. These plants are now serving larger populations and accepting wastewater from an increasing number of industries and leachate from landfills. Costs of maintaining, replacing, and upgrading these expensive public works projects have gone up, but assistance from the state and federal government has disappeared, other than revolving loans. An ongoing federal and state commitment is needed to help local communities with the costs of a new generation of upgrades, expansions, and replacements.

Phosphorus, a nutrient essential for plant growth and a common ingredient in soaps and detergents, also can move through most wastewater treatment systems to be discharged to the river, where it causes unsightly algal blooms and reduces habitat quality for aquatic life. While Vermont's phosphorus reduction efforts have been focused almost exclusively on Lake Champlain, an exception was made in the Connecticut River watershed. One of the most important achievements of the last decade was the investment by Vermont and the Town of Springfield in phosphorus removal at its wastewater treatment facility, and the massive mats of algae that formed in summer months at the mouth of the Black River, at one of the river's busiest boat ramps, are a thing of the past. However, phosphorus continues to travel through other treatment plants from households throughout the valley, especially in Keene's discharge to the Ashuelot River.

Nitrogen from the Connecticut River and its impact on Long Island Sound are also of concern, and are being evaluated by EPA and the states of Connecticut and New York. Should the New Hampshire and Vermont portion of the watershed be found to contribute substantial nitrogen loading that affects Long Island Sound, some nitrogen control may be needed in the future.

One wastewater discharge that could not have been imagined a century ago is the thermal discharge of cooling water from the Vermont Yankee nuclear power plant in Vernon, which began operating in 1973. The plant pumps heated water into the river's impoundment behind Vernon Dam, raising the water temperature while lowering its oxygen content and ability to assimilate other wastes in this heavily populated region. Distinctly warmer water is deleterious to the coldwater fish species that use the river for spawning and migration. The plant's owners have proposed to increase the temperature of this discharge and to relicense the plant. Despite the clear impact to the quality of Connecticut River waters, which are owned by New Hampshire, the State of Vermont chose to apply a $20 million mitigation payment to water quality improvements outside the watershed, on the Lake Champlain side of Vermont. During the summer of 2007, a malfunction and collapse of part of a cooling tower renewed concerns about the nuclear power plant's safety and its implications for the Connecticut River and nearby communities.

For four upper watershed communities, combined sewer overflows (CSO) are expensive leftovers of earlier efforts to manage stormwater. When municipal wastewater treatment systems were built, they were connected to collection systems for stormwater as well as for sewage. In some cases, the systems allow street runoff to overwhelm the wastewater treatment plant during a heavy storm, causing it to discharge untreated sewage to the river. Separating such an engineering tangle is a very expensive project. State aid grants and revolving loans are available but may not be sufficient. White River Junction

and Springfield, Vermont have eliminated nearly all of their CSOs (and may have done so by the time this goes to print), but St. Johnsbury (with 25 CSOs draining into the Passumpsic River system) and Lebanon (with five remaining CSOs discharging to the Connecticut) still face costly repairs. The states consider portions of the receiving rivers to be impaired as a result. The threat to human health is one we cannot afford to ignore, especially now that the river has once again become popular for swimming and boating.

Opportunities & Recommendations: Take steps toward the next generation of wastewater discharge cleanup. Vermont decided to tackle the phosphorus problem at the source, and passed legislation that prohibits phosphorus above trace quantities in most household cleansing products sold and used in the state. Legislation is pending that would also affect dishwashing soap. EPA has just announced new guidelines for disposal of unused medicines, although the public remains largely unaware of them.

1. **Federal and state agencies should focus on phosphorus**, and educate federal and state legislators about the cost of phosphorus pollution to the environment, and the cost to local communities of removing phosphorus from discharges. Congress should appropriate funds and provide legislative support to allow EPA to assist towns in adding capacity to remove phosphorus from wastewater. New Hampshire should follow Vermont's example on management of phosphorus entering wastewater, and limit the amount of phosphorus in cleaning products sold and used in the state.

2. **Federal and state agencies should** assist local communities with the high costs of upgrades, expansions, and replacements of aging wastewater treatment facilities.

3. **Federal and state agencies should work with local partners in guiding disposal of pharmaceuticals** and educate federal and state legislators about the need for action. Congress should appropriate funds to allow the U.S. Fish and Wildlife Service, EPA and the Food and Drug Administration to work with state agencies to develop better rules and well-distributed guidance for health care professionals and the public regarding the disposal of unused medicines, so that these pollutants do not end up in wastewater that can eventually reach the river. EPA should assist Hospitals for a Healthy Environment, a non-profit organization headquartered in the Upper Valley, in working with medical providers to encourage responsible disposal of pharmaceuticals. Hospital associations should encourage return of unused pharmaceuticals at consumer friendly locations.

4. **The states and affected communities should seek federal assistance through the Congressional delegations to remedy combined sewer overflows** on behalf of St. Johnsbury and Lebanon as quickly as possible.

5. **Federal and state agencies should cooperate to ensure the safety of Vermont Yankee** and limit the temperature of its discharge to New Hampshire waters. The Nuclear Regulatory Commission should reconsider its findings relative to Vermont Yankee and conduct a thorough safety inspection, inviting closely neighboring states to participate. Vermont should reconsider the propriety of applying mitigation funds outside the affected watershed, and should invite advice and comment from New Hampshire in recognition of New Hampshire's responsibilities for the Connecticut River and the shared responsibility of the two states for communities within the impact zone of Vermont Yankee.

7. GROUNDWATER

Issue: Groundwater supplies are not always well known or protected.

Groundwater, one of New England's hidden but most valuable resources, is closely linked both to public health and to the health of surface water. Groundwater feeds the river's flow, and the water beneath the river feeds groundwater. Pollution in groundwater can therefore pollute a nearby stream, and vice versa. A drop in underground water supplies could affect base streamflow, with domino effects on aquatic habitat and waste assimilation, let alone boating and recreation. The erratic precipitation patterns promised by models of climate change suggest that droughts could lower groundwater levels and affect the drinking water supply of the many thousands of rural residents who depend on shallow wells.

As severe and prolonged droughts threaten the Southeastern and Western United States, New England is learning not to take its abundant groundwater for granted. New Hampshire has made more progress than Vermont at this writing. DES has regulated new groundwater withdrawals for public community water systems since 1991, to ensure that these wells have a sustainable yield and are sited in appropriate places, and, since 1998, has regulated all groundwater withdrawals larger than 57,600 gallons/day. Stratified drift aquifers have been mapped for New Hampshire, and more detailed mapping is underway in some Connecticut River valley communities.

> "You protect the land, you protect the water."
>
> *Mascoma Watershed Conservation Council member*

Vermont's aquifers have not been mapped as comprehensively, although Source Protection Area maps are available for community water systems. A few towns along the river are studying and mapping aquifer recharge areas. Vermont requires that new public community water systems delineate the areas from which the groundwater is drawn, with potential sources of contamination identified. However, without a statewide policy on groundwater withdrawal, and without adequate aquifer mapping, Vermont remains a target for commercial water bottling companies looking for private profit from a resource that belongs to the public.

The list of threats to groundwater is long, and reaches back into time. Today's oil spill and snow dump join a litany of historical contaminants from unlined landfills, long-banned chemicals, junkyards, and old industrial sites, too often located on the banks of rivers. MtBE, a gasoline additive and suspected carcinogen now banned in the two states because of its ability to rapidly contaminate groundwater supplies, is an example of how groundwater can be threatened. Casual disposal of the many hazardous materials present in today's households can threaten both surface and groundwater when they are not removed from landfill leachate. A New Hampshire study in 2000 showed that only 11 percent of lands through which water flows to sources of public drinking water are protected by ownership or conservation easement, and 39 percent of community water systems do not even own the sanitary protective radius around their wells (75-400 feet). (3)

Opportunities & Recommendations: Evaluate and protect groundwater supplies.

Encourage consistently thorough mapping of groundwater resources, and ensure that groundwater extraction is well controlled by the states and protected from contamination. Investigate and restore brownfields and other contaminated sites to remove threats to groundwater and return these sites to active use.

1. **Vermont should complete mapping of its aquifers and create municipal and commercial groundwater withdrawal standards and a permanent permitting program** at least as stringent as New Hampshire's. Expand upon the groundwater mapping program begun in 2007 and provide aquifer mapping information to local planning commissions. Establish and amplify programs that offer grants to protect critical aquifer recharge areas.

2. **New Hampshire and Vermont should establish rules to protect key aquifers from contamination**. The states should not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, wastewater or septage lagoons, and outdoor salt storage or other de-icing chemical storage to be located on aquifers.

3. **Towns should evaluate water supplies for short and long term growth, and seek protection of water sources**. Avoid placing snow dumps and permitting other potentially contaminating activities on aquifers. Map the "cone of influence" for public wells, and develop regulations, such a ban on underground petroleum tanks, to apply in that cone of influence.

4. **Regional planning commissions should continue and increase their work on brownfields.** Seek federal funds to assist communities in evaluating and addressing brownfields sites, and encourage owners of potential brownfields properties to participate. Assist towns in providing more frequent and convenient opportunities for household hazardous waste collection, and put more effort into educating the public about the reasons.

8. RIVER/WATERSHED INVENTORY AND MANAGEMENT

Issue: Connecticut River tributaries remain unevenly understood and managed.

> "If you get in there and try to put the river where you think it ought to go, it may not necessarily agree with you."
>
> *Ben Copans, Vermont Agency of Natural Resources basin planner, speaking of the value of geomorphic assessments*

New Hampshire initiated river resource inventories in 1990 through the Rivers Management and Protection Act, relying on citizen volunteers within each river's watershed to nominate their river and then develop a corridor management plan. The Connecticut River entered this program in 1992. Vermont took a different approach in 2002, borrowing the useful concept of citizen participation and applying it to a state-directed inventory and planning process for entire basins.

Each has increased the knowledge and understanding of issues affecting individual rivers, and enhanced cooperation between volunteer and professional river watchers. However, New Hampshire's approach has left many important Connecticut River tributaries unstudied and unstewarded, waiting until energetic citizens decide to step forward. Only the Ammonoosuc, Cold, and Ashuelot Rivers are designated protected rivers in New Hampshire's Connecticut River watershed. Israel's River and the Mascoma and Sugar Rivers quickly come to mind as large multi-community tributaries with much to gain by inclusion in the state program. Seeking to avoid this problem, Vermont set a goal of completing basin plans for all 17 major watersheds in the state by 2006. It has missed its deadline, largely because a major question regarding water classification typing has not been resolved. Little is yet known about any Vermont tributaries north of the Passumpsic River, with the possible exception of the Nulhegan.

Among the first steps in gathering information about the state of a river is to monitor the quality of its water. Fortunately, both states have developed an ability to train and support citizen volunteers to make progress in this direction, and Vermont actively leads monitoring on those rivers for which basin planning is underway. However, most rivers in the watershed, including the Connecticut River itself, are not visited by volunteers bearing probes, test tubes, or monitoring apparatus. Volunteers are sometimes discouraged by the logistics of getting samples back to distant state labs for analysis, when local wastewater plants are capable of doing the tests.

NH DES and EPA responded to a call from CRJC in 2004 to undertake an intensive, one season effort to establish water quality information for the river. (5) In some cases these results raised more questions than they answered, especially in the North Country, where bacteria apparently contaminate 50 miles of waters popular for canoeing, kayaking, and swimming, including the designated "natural" segment of the river. A brief effort the following year in Colebrook found no problems, but further study is needed. DES does not have the staff to ensure a thorough follow-up effort, and an adequate corps of volunteers has not assembled to cover this gap.

In order to galvanize public action for river protection, the public needs ready access to information. Much remains to be done to improve public access to data such as from the 2000 sediment study, which examined sediment quality at many locations on 100 miles of the river from Fourth Lake to the mouth of the Ottauquechee River (6).

Opportunities & Recommendations: Support water quality monitoring and river management.

Citizens have many avenues for attracting the assistance of the states in monitoring and improving the rivers that are important to them. Citizen groups may apply to Vermont for funding for water quality testing. In New Hampshire, the Volunteer River Assessment Program offers training and other support for water quality work and nominating rivers. The National Park Service's Rivers and Trails Conservation Assistance Program offers technical assistance.

1. **States should ensure adequate and regular water quality monitoring** and continue to work with town conservation commissions and watershed groups such as the Connecticut River Watershed Council to encourage, expand, and coordinate volunteer water quality monitoring on the tributaries and on the mainstem. State agencies should make water quality monitoring data easily accessible to the public, including those who do not use computers, so the public understands the present condition of their waters. Assist local wastewater treatment plants with the cost of processing bacteria samples from river monitoring.

2. **EPA and state agencies should post sediment quality data** from their sediment study on the Web.

3. **Vermont should resolve questions associated with water classification typing to complete basin planning** as quickly as possible, including water quality monitoring of the Connecticut River tributaries in question. Approve basin plans for the West/Williams/Saxtons Rivers and the Waits/Wells/Ompompanoosuc/Stevens Rivers.

4. **New Hampshire citizens in tributary towns should consider nominating their rivers** into the state program.

9. INSTREAM FLOW

Issue: Incomplete information exists for future river management planning.

The threat of irregular precipitation linked with climate change, put together with New Hampshire's requirement to create instream flow rules for each river in the Rivers Program, points to a need to know where the water is coming from and where it goes, if it isn't headed for Massachusetts. Many sources of information can guide river managers, including streamflow gage data, reports from hydro power producers, and water withdrawal data. However, other than the dam reports required by federal regulators, other information about flow can be sparse or missing altogether.

Some gages, such as at North Stratford, Dalton, and Wells River, are critical for management of hydro dams, telling dam managers what flow to expect from upstream. Generally, the cost ($12,500/year/gage) of maintaining gages is shared by the U.S. Geological Survey with the states, and efforts to cut state budgets have threatened gage funding, especially in New Hampshire. While Vermont generally adds one to two gages a year, and has added ten gages between 2000 and 2005, New Hampshire has been losing stream gages since 1969, and in 2007 its stream gage network was at its lowest numbers since 1939. Fourteen stream gages were abandoned in 2004-2005 alone, including a number in the Connecticut River system. Fortunately, the New Hampshire Legislature approved new funding for gages in 2007, and at least four gages will be reinstated in the watershed.

> "People think the Connecticut River doesn't need any help because it flows all by itself."
>
> *Hank Swan, Connecticut River Commissioner*

Water withdrawals from the tributaries and mainstem, for irrigation, industrial use, or even to support fish hatcheries, can cumulatively affect the flow of the river. New Hampshire does not assess a fee for use of this water. That state has a registration program in place for withdrawals over 20,000 gallons/day, but there is no corresponding program and no record of how much water is withdrawn from the Vermont side of the river. While Vermont has an agency procedure for determining minimum instream flow and standards for water withdrawals that are applied in any permitting situation, including snow-making, the state does not have a withdrawal registration program. In a drought year, this information could be very valuable.

RSA 483 directs NH DES to establish flow rules for the Connecticut River and other rivers designated in the Rivers Management and Protection Program. Progress has been made on the Lamprey and Souhegan Rivers, and a Protected Instream Flow will soon be adopted for the Souhegan. At this time, there is no schedule for creating flow rules for the Connecticut River, whose flow is already fairly tightly controlled by federal operating licenses and sidebar agreements for the dams at Fifteen Mile Falls and at Wilder, Bellows Falls, and Vernon. While the relicensing of these last three dams in 2018 offers an opportunity to consider flow and possibly adjust minimum releases from these dams, it is unlikely that New Hampshire will ever have broad discretion to set flow rules that differ substantially from what is already inscribed in federal dam licenses for the Connecticut.

Opportunities:& Recommendations Lay the groundwork for an instream flow policy.

While a Protected Instream Flow for the Connecticut River is not imminent, it would be useful to articulate the valuable uses, characteristics, and resources of the river that are affected by instream flows, and to have a means of identifying and controlling water withdrawals during extreme droughts.

1. **Vermont should institute a water withdrawal registration system.**

2. **CRJC should identify Instream Protected Uses, Outstanding Characteristics and Resources** listed in RSA 483 – for the Connecticut River, based on consultations with organizations, agencies, and communities, as well as discussions in the local river subcommittees.

3. **USGS and the states should adopt and implement an effective system of stream flow gages.** New Hampshire should reinstate and place gages using a science-based approach to river management.

10. DAMS

Issues: There is room to expand river ecosystem and recreation benefits at existing dams and to carefully evaluate the public benefits of new hydropower proposals.

When the hydro dams on the Connecticut River were first built, the river was so degraded that energy production was one of the few values remaining to the river, other than waste assimilation. Since the Clean Water Act stimulated water quality improvements beginning in 1972, the river once again offers a rich resource for the public, who expect assurance that the river will be well managed by the private companies that hold licenses to use the public's resource to generate power. The Clean Water Act (section 401) gives the states review over dam operations, alterations, and the terms of dam licenses.

The 2001 license for Fifteen Mile Falls is a model of creative configuring of provisions that benefit the public and the river while assuring that this renewable power resource will continue to produce electricity. This license, devised in consultation with a wide range of stakeholders including CRJC, serves as an excellent example for TransCanada Hydro Northeast's three dams at Wilder, Bellows Falls, and Vernon, whose licenses expire in 2018.

There is no other river in New England that works as hard as the Connecticut.

Two issues at these dams are of particular interest. There is currently no prescribed ramping or "acceleration" rate for releases from these dams, and water levels can change abruptly above and below the dams when gates are opened. Sensitive habitat exists below Wilder Dam in particular, where an assemblage of rare, threatened, and federally endangered species inhabits the river. Just below Sumner Falls, considered the epicenter of the Connecticut River Rapids Macrosite for these species, is an active sand and gravel operation very close to the river on a steep, high bank. Erosion from the river's scouring action at the base of the bank has destabilized it, and, in combination with the mining activity at the top, threatens to add a heavy sediment load to a key piece of aquatic habitat. A hydrogeologist's report suggests that modifying the nature of the release from Wilder Dam could reduce this threat. Controlling the rate of release at the dams could also improve safety for recreationists below them and create more natural conditions for fish and other aquatic life. The ability of hydro dams to provide a "black start" during an energy blackout is one of the great assets of this kind of power generation, and a new license should provide for this action even as it calls for ramping rates under conventional conditions.

The U.S. Army Corps of Engineers identified water level fluctuations behind the dams as a key cause of riverbank erosion in the Vernon to Wilder segment of the river, as pressure imbalances on the bank face lead to piping when gates are opened. Slower ramping rates could help ease this condition. Other erosion conditions have appeared that may or may not have a relationship with dam operations, and should be investigated. These include hidden undercuts and cavities within forested banks in the Wilder impoundment.

The U.S. Army Corps of Engineers owns and operates seven flood control dams in the Connecticut River watershed, on the Ompompanoosuc, Ottauquechee, Black, West, and Ashuelot Rivers. These dams are operated according to protocols that reflect flood management needs but not habitat. Yet these rivers offer important aquatic habitat themselves, and operations of these dams affect habitat in the mainstem. Atlantic salmon have returned to spawn on the West River, and may eventually use the rest. The dams block fish passage and have no minimum required flow.

Pressures to make the most of alternative energy sources are redirecting attention to rivers and streams as renewable sources of power. Interest is growing in small hydroelectric development for this purpose, and agencies will probably see new applications in the watershed, either for retrofit of existing but unused dams, or for construction of new facilities, especially on smaller streams. While there are important benefits from local production of power, this raises questions of habitat and sediment transport disruption, altered flow, and future maintenance for projects that will likely operate on a small profit margin. Vermont is pursuing a way to help developers of small hydro projects to understand the natural resource issues involved as they begin planning their projects.

Of the approximately 1000 dams in the watershed, some have outlived their usefulness, and have become a liability to their owners and in some cases a hazard to those living downstream. An unusual situation is dams or other structures built, mostly in the 1960s, to control ice, which have had unwanted effects upon the rivers. Both states now have river restoration programs that assist in the assessment and removal of such structures.

Opportunities & Recommendations:
Continue and enhance good river stewardship by dam owners.

The Upper Connecticut River Mitigation and Enhancement Fund, established as part of the new license for the three dams at Fifteen Mile Falls, has provided very substantial permanent improvements in the watershed north of the White River confluence, from conservation of important natural flood storage areas to river-related research and habitat improvements. TransCanada Hydro Northeast, which acquired the Connecticut River dams from U.S. Gen New England, also plans to

conserve company-owned lands around Fifteen Mile Falls and also at an ecologically sensitive area at Sumner Falls in Hartland, Vermont. Much of this conservation work is complete. U.S. Gen set a fine example for other riverfront landowners by planting extensive riparian buffers on its land in Charlestown, New Hampshire.

Opportunities exist in many parts of the watershed for responsible, sustainable new development of power generation, carefully considered in light of river science so that non-hydro benefits are fully addressed. Such a hydro project should not create new barriers or interfere with ongoing watershed restoration, should maintain water quality, aquatic habitat, fisheries, and recreational values, and should also be economically sound. Should mitigation be necessary, it could include removal of other existing non-functional dams or dams that cannot be re-developed for hydro.

1. **The Federal Energy Regulatory Commission should include moderated ramping rates in the 2018 license** for Wilder, Bellows Falls, and Vernon Dams, with provisions to allow a "black start" if energy conditions require it. When laying out the terms for the new license, TransCanada (or its successor) and river stakeholders should consider extending the Upper Connecticut River Mitigation and Enhancement Fund to the entire Connecticut River watershed in Vermont and New Hampshire. Dam owners should thoroughly evaluate impacts of impoundment cycling on riverbank erosion as part of relicensing studies, and undertake mitigation as appropriate.

2. **TransCanada should complete its conservation plans** in the Fifteen Mile Falls and Connecticut Lakes regions and at Sumner Falls, and should consider conserving the rich agricultural lands it owns in the Bellows Falls pool.

3. **The US. Army Corps of Engineers should institute a minimum flow** at its flood control dam facilities and create or improve opportunities for fish passage. When dams are not being operated for flood control, the discharge from flood control dams should mimic run-of-river levels, or inflow=outflow, to protect aquatic life downstream. The Corps should institute larger water releases from the dams every few years to maintain a more natural channel shape in the rivers below them. It should take advantage of the expertise offered by The Nature Conservancy to "re-operate" these dams to alter flood control operations to allow for higher peak flows to restore riparian and floodplain habitats. The Corps should work in concert with NH DES to resolve issues of dam ownership; if a dam in Connecticut River tributary that is non-functional or in a state of serious disrepair is found to be owned by the Army Corps of Engineers, the Corps should act expeditiously with NH DES to effect removal of such a dam.

4. **The states should investigate issues surrounding development of micro hydro power generation** facilities, and develop policies and guidance for design that ensure that water quality, aquatic habitat, sediment transport, fisheries, recreation, and historic resources are not affected by new small hydro development. States should consider requiring off-site mitigation for projects that cannot be designed to avoid impacts and ensure that permittees set aside adequate funds to address facility maintenance and removal. Consulting potential stakeholders such as CRJC, the Connecticut River Watershed Council, and other appropriate watershed organizations would be helpful in identifying potential issues and concerns on this scale, as has already proved useful for relicensing of larger projects.

5. **Other riparian landowners should follow U.S. Gen's example of riparian buffer planting** on riverfront lands.

11. AGRICULTURE & FORESTRY

Issues: Agricultural land is inadequately protected from development. Best management practices are inconsistently applied and used.

The entire Connecticut River valley, from Pittsburg on down the river, harbors rich agricultural soils of national significance that, if not paved or otherwise developed, stand ready to provide healthy locally grown and distributed food. Yet, in all but two of the 26 New Hampshire river towns and 10 of the 27 Vermont towns, there is no local protection in place to restrain development of these valuable soils, and they are falling prey to badly-conceived development. In most towns, the only deterrent is the current use taxation program, which permits a reduced property tax on such land.

Much of the food sold in the Connecticut River valley is produced in the American west and beyond, requiring wasteful combustion of fossil fuel for transportation and unsustainable use of water for irrigation. Water supplies in the western states are increasingly undependable as the region is gripped by a long-term drought that could be exacerbated by climate change. Snowpack to feed western water supplies is diminishing, and Lake Mead, the largest reservoir in the United States, has fallen to 49 percent of its capacity, showing a foreboding bathtub ring. Food supplies that depend upon irrigation from such sources could be disrupted. A water-rich area such as New England should not be putting pressure on a water-poor area to grow food for its people. With transportation costs increasing with the price of gasoline, and the possibility of disruption of transportation networks, the ability to produce a sustainable local food supply looks more and more like a matter of homeland security.

Agriculture must have as firm a future in the Connecticut River Valley as it has a past.

Vermont has made great strides in assisting farmers with their efforts to protect water resources, especially through its Conservation Reserve Enhancement Program. CREP adds state dollars to the federal Conservation Reserve Program to make water quality-related improvements such as buffers, fencing, and alternative livestock water sources more affordable for cash-strapped farm operations. New Hampshire offers no such program, although the need and benefits are just as great.

Management practices to protect surface waters from pollution are still unevenly applied in the region, despite their clear benefits for the waters that drain farms and forests. Vermont's Acceptable Agricultural Practices, the base level of management required for all farms in the state, are designed to be easy to implement, low-cost solutions for addressing water resource concerns. They include a ban on spreading manure on frozen ground, a 10-foot vegetated buffer between annual crops and surface water, and provisions for managing livestock on pastures where access is given to surface water, among other practices, and they are enforced.

Vermont instituted farm permit programs for medium-sized farms in 2007 and updated its 1995 program for large farm operations. These protect water quality by providing a cost-effective alternative to a potentially burdensome federal permitting program. Farms with more than 700 dairy cows (or other livestock measures) must have a Large Farm Operation permit and adequate waste storage, and must land apply manure and other wastes according to a nutrient management plan. Odor, noise, traffic, insects, and other pests are also considered. The Medium Farm Operations Program applies to dairies with 200-699 mature animals (or other measures of livestock), and, under a single state general permit, prohibits discharges of wastes from a farm's production area to waters of the state and requires manure and other wastes to be land applied according to a nutrient management plan. Vermont offers financial assistance for crop practices and creating these plans, which ensure that fertilizer is captured by crops before it can enter streams. Vermont's Alternative Manure Management program helps bring income back to the farm or at least reduce the energy consumption from the grid by producing it with farm wastes.

New Hampshire's oversight of water quality impacts from farms is considerably more limited, although the state offers grants to farmers for creating nutrient management plans and for implementing nutrient Best Management Practices (BMPs) where there is a water quality benefit. While New Hampshire distributes a manual on BMPs for agriculture, they are not treated as requirements. State law requires the agriculture department to respond to complaints involving the mismanagement of manure, agricultural compost, and chemical fertilizer. There have been complaints from Vermont farmers witnessing poor practices across the river in New Hampshire, such as winter spreading of manure that was then washed downstream by spring high water.

Opportunities & Recommendations: Preserve the vitality of agriculture throughout the valley and ensure use of best practices to protect water resources.

Thriving local agriculture and productive agricultural soils are assets of national significance. Vital Communities, a non-profit organization headquartered in the Upper Valley, has piloted an immensely successful and innovative self-marketing program for promoting local agriculture that currently covers the region from Newbury/Haverhill to Vernon/Hinsdale.

Basic best management practices for agriculture should be consistently applied and employed by farm operations in the valley. Good forestry practices are equally important for protecting rivers and streams. *Acceptable Management*

Practices for Maintaining Water Quality on Logging Jobs in Vermont, *Best Management Practices for Erosion Control on Timber Harvesting Operations in New Hampshire,* and *Good Forestry in the Granite State* provide essential guidance.

The effect of timber harvesting on water quality is legendary. Now, forest landowners and foresters must recognize and respect the increased frequency of episodic weather events upon the forest, its soils, and timber management infrastructure. Forest roads, culverts, and bridges are at increased risk and should be constructed to accommodate excessive storm water drainage and minimize extreme snow melt damage. Additionally, the financial impact of insect, disease, wind and ice storms can be reduced if access to the forest is managed and maintained to facilitate possible salvage harvesting.

1. **The public should continue to support and encourage local agriculture**. Buy local and enjoy the festive and refreshing atmosphere at a local farmer's market. Chambers of commerce can assist by publicizing these events.

2. **Vermont should continue its Conservation Reserve Enhancement Program**, and New Hampshire should investigate ways to institute such a program.

3. **Both states should continue their current use taxation programs,** that reduce development pressures on valuable agricultural and forest land and allow them to remain available for production.

4. **Towns should consider adopting agricultural soil protection ordinances** to keep valuable soils available for farming and to keep development from interfering with flood storage.

5. **Vital Communities should continue to expand its Valley Food and Farm program** to encompass the entire northern Connecticut River Valley. State agriculture departments should support this successful and innovative program.

6. **New Hampshire should enforce best management practices**, including a ban on winter spreading of manure. States and county conservation districts should encourage farmers to use best management practices to control erosion and protect and enhance riparian buffers.

7. **Farmers should prepare a total nutrient management plan for their farm** if they have not already done so, with help from county conservation districts and the Cooperative Extension Service, to make best use of available nutrients, reduce potential for water quality impacts, and save money in purchasing fertilizer. Funding is available from both the federal and state levels to help with the cost.

8. **Forest landowners should follow guidelines** such as *Good Forestry in the Granite State* and minimize the water quality impacts of harvesting. Follow forest management plans created for land in current use. Take advantage of cost-share programs. Construct forest roads, culverts, and bridges to accommodate excessive storm water drainage and minimize extreme snow melt damage. Manage and maintain access to the forest to facilitate possible salvage harvesting of timber damaged by insect, disease, wind and ice storms.

12. INVASIVE AQUATIC SPECIES

Issue: Invasive plants are spreading rapidly in the region's rivers and streams.

The 1997 edition of the *Connecticut River Corridor Management Plan* warned about the threat of invasive exotic species, noting that Eurasian milfoil had been discovered two years before at Hoyt's Landing in Springfield, Vermont by one of CRJC's local river subcommittee members. The 1997 *Plan* focused largely on the zebra mussel. Fortunately, despite the proximity of Lake Champlain, which is now heavily infested with the mussel, the Connecticut River apparently remains free of them at this writing.

The river did not fare so well, however, with respect to invasive plants. Eurasian milfoil now infests the river from the outlet of Lake Morey in Fairlee to Hinsdale, appearing in sporadic populations above Hoyt's Landing, but more consistently in the river below. It has become particularly dense in Retreat Meadows at the mouth of the West River in Brattleboro. Inventories sponsored by CRJC and the county conservation districts have discovered that a half-dozen other submerged and floating aquatic invasive species have also since appeared in the river, especially in the reach closest to Massachusetts. Such plants reduce wildlife habitat value and interfere with recreation.

Perhaps the most visible biological shift has occurred within riparian buffers, where Japanese knotweed, purple loosestrife, and exotic honeysuckle have aggressively colonized streambanks. Within the last five years, Japanese knotweed has formed pure stands along many rivers and streams, notably the Black and Saxtons Rivers. Such stands are even present in the far north, along portions of the Connecticut River in Maidstone, Canaan, and West Stewartstown, and along Israel's River in Lancaster. While knotweed spreads energetically on its own, it is possible that this and other invaders are getting a lift from highway crews as they work on roads near infested riverbanks and are careless with the spoils. Ironically, Japanese knotweed was imported from Asia as a means of stabilizing streambanks, yet because it dies back each season and inhibits native plant growth structure, leaving riverbanks bare and vulnerable to erosion, it is poorly cut out for the job. While introduced *Galerucella* beetles are showing promise in helping to control purple loosestrife in the valley, no biological control for knotweed or honeysuckle has yet appeared.

> "Didymo is going to make purple loosestrife look minor. At least that's pretty."
>
> *Mt. Ascutney River Subcommittee representative from Plainfield*

Perhaps the most disturbing news relative to invasive aquatic species was the discovery in June, 2007 of the invasive diatom *Didymosphenia*, also known as Didymo or "rock snot." This organism, confirmed in the northernmost reaches of the Connecticut River mainstem and in the White River near Bethel, can form extensive colonies on the bottoms of rocky river beds, smothering aquatic life such as macroinvertebrates (aquatic insects). Its appearance is also very unattractive, making the water less appealing for recreation. Biologists believe that Didymo was introduced to this region on contaminated fishing gear, especially felt-soled waders, and that it could be spread by any other recreational equipment. There is currently no way to control or eliminate Didymo, and the agencies have concluded that the best approach is to attempt to prevent further spread by humans, especially to tributaries.

Opportunities & Recommendations: Pursue wide education on preventing dispersal of invasive species.

Good information and support are needed for the full range of those whose activities affect the dispersal of invasive plants.

1. **The US Fish and Wildlife Service's Conte Refuge should continue its coordinating work on invasive species in the watershed.**

2. **USDA should sponsor studies of potential bio-controls for Japanese knotweed and honeysuckle** similar to those for purple loosestrife, and inform the public about the results.

3. **Transportation agencies and road crews should make efforts not to transport fragments of invasive plants** during road construction projects, and consult agriculture departments about best practices for dealing with invasive species, including ways to sanitize spoils before disposal. New Hampshire's Roads Scholar Program and Vermont's Better Back Roads Program can offer special training for road crews on this issue.

4. **Vermont and New Hampshire conservation officers and wardens should educate about invasive species when issuing fishing and boating licenses, perhaps with** an attention-getting enclosure in the application or license. Replace signs at boat landings urging boat inspection and cleaning with more informative and effective signs. Maine's program and signage provide a good example.

5. **State environmental and fisheries agencies, TransCanada, sporting groups, and recreationists should continue to cooperate to better understand and address the Didymo infestation.** Publicize practical prevention measures that the public is likely to use. TransCanada, which sponsors the largest number of boat launches of any landowner on the Connecticut, should consider providing boat cleaning stations at its access sites, as should state agencies managing public access sites on the river. Local outfitters and guides should educate their customers about Didymo and other invasives. Fishermen and other recreationists must carefully clean their gear after visiting the Connecticut River and report sightings of invasive aquatic species to state agencies. Do not release unused bait into the water.

6. **Boaters or divers traveling from waters infested with zebra mussel and other invasives must wash** and dry all equipment before reuse, hose off the boat, diving gear or trailer, and drain and flush the engine cooling system and live wells of the boat, bait buckets and buoyancy control devices on diving equipment.

7. **Town conservation commissions should conduct an education and control campaign** against Japanese knotweed and other invasive species in their towns. Consult with the White River Partnership, New England Wildflower Society, Conte Refuge, and the Invasive Plant Atlas of New England for assistance and methods for dealing with invasive species.

13. COPPER MINES

Issue: Acid mine drainage continues to damage Vermont rivers in the Upper Valley.

Vermont's Ompompanoosuc and Waits River watersheds have a long history of copper mining that supported industrial growth for several centuries. The now-abandoned Elizabeth Mine, Pike Hill Mine and Ely Mine are now pernicious sources of pollution, sending acidic water drainage from both the mines and tailing piles that has severely affected aquatic life by increasing acidity, depleting oxygen, and releasing heavy metals. EPA included the Elizabeth Mine on the National Priorities List ("Superfund") in 2001, adding the Ely Mine in 2002 and the Pike Hill Copper Mine in 2004.

The Elizabeth Mine produced copperas (iron sulfate or green vitriol) from 1809 to 1882, and copper from 1832-1958. Between 1943 and 1958, approximately 90 million pounds of copper were produced at this mine, which employed up to 220 people from 16 surrounding towns. The Ely Mine employed 850 people near the peak of activity there in 1880.

The *Connecticut River Management Plan* raised concerns about acid mine drainage in 1997, when CRJC declared the Elizabeth Mine one of the top water pollution "hot spots" in the Connecticut River Watershed. Media coverage of that meeting captured the attention of Thetford residents who then organized the Elizabeth Mine Study Group. CRJC awarded grants to the Study Group through the Partnership Program in 1998, 1999, 2001 and 2002, to support efforts to organize a cooperative, community-based environmental remediation and historic documentation project at the mine. This work, and that of Vermont's Department of Environmental Conservation, led eventually to designation as a Superfund site.

A total of 16.1 miles of the Ompompanoosuc River and its tributaries, and 3.0 miles of Pike Hill Brook in the Waits River watershed have been placed on Vermont's impaired waters list because of their contamination by metals and acid from abandoned mine drainage. Copper emerged as a sediment pollutant in the two sediment studies conducted by EPA on the Upper Connecticut River, appearing at levels high enough to have ecological effects in the Waits River at Bradford and in both Ompompanoosuc River samples, in concentrations five to ten times higher than in most other samples. Copper also appeared in the sediments of the Connecticut River mainstem below the confluences of these tributaries.

After extensive planning with local governments and interested citizens, EPA began work in 2005, intending to stabilize, regrade, and cap the tailing piles, divert surface and groundwater around the piles, and treat runoff. In 2007, however, residents noted an increase in the orange coloration of sediments in the river. Because EPA was not given the funds to clean up the most difficult tailing pile, but only to stabilize it, some additional iron loading has occurred, and in combination with very low summer water levels, this has resulted in higher concentrations of iron in the river. The Ompompanoosuc River also contributes a noticeable sediment load to the Connecticut River after a heavy rain, and the plume of sediment can be seen running down the west side of the Connecticut mainstem for well over a mile, contrasting with clearer water delivered from upstream. This sediment has come from tailing piles and other exposed soils that are still not yet stabilized.

Opportunities & Recommendations:
Move forward with remediation and put the mines back into the history books.

Copper mining in the Vermont hills ravaged the landscape for 150 years, creating a leviathan of a contamination problem that is not likely to be solved easily, inexpensively, or quickly. The effects of the mines appear not only in the tributaries draining these mines, but also in the Connecticut River mainstem for miles downstream. While it is unlikely that all stakeholders will always agree how best to eliminate the problem, it is important to proceed. EPA estimates that if the project were adequately funded, the clean-up could be completed in three years. However, with the severe under-funding of the Superfund program, the project is apt to drag on for many years, resulting in inflated project costs, aggravation to the affected communities, and perpetuation of degraded rivers.

1. **The Vermont Congressional delegation should make copper mine remediation a priority,** and seek adequate funding for EPA to permit capping and proper stabilization using the cleanup plans at the Elizabeth Mine that have been accepted by both the State and the local community. Proceed with remediation at the Pike and Ely Mines.

14. MERCURY

Issue: The neurotoxin mercury gravely threatens public and environmental health and the region's tourism economy.

Results of the 2000 *Connecticut River Fish Tissue Contaminant Study: Ecological and Human Health Screening*, released in 2006, are cause for deep concern, but are no surprise to anyone who has followed the mercury contamination issue. In response to the 1997 *Connecticut River Corridor Management Plan.* EPA worked with the four Connecticut River states to conduct a comprehensive look at toxins in Connecticut River fish. This landmark study, which may be the first river-wide study of fish tissue in the nation, represents significant cooperation among the four states, each of which contributed substantial funding and staff. (7)

> "The magic starts to leave the North Woods when you can't eat the fish. Where is the federal leadership? That's the problem."
>
> *Hank Swan, Connecticut River Commissioner*

Results confirm that mercury is a dangerous presence in the tissues of Connecticut River fish, particularly in the reach from Canaan Dam to Moore Dam. Total mercury concentrations in all three species of fish studied were significantly higher upstream than downstream, although the design of the study did not permit results to be tied to specific geographic locations on the river. As part of the 401 certification of Fifteen Mile Falls, the operators will carry out fish tissue mercury testing at five-year intervals.

Mercury levels prompted the states to issue fish consumption guidelines, including much stricter cautions for the Fifteen Mile Falls region of the Upper Connecticut River. Other recent studies have associated water level manipulations in reservoirs and reservoir creation with increases in fish mercury concentrations, and identified the Fifteen Mile Falls region and similarly managed parts of the upper Androscoggin and Kennebec River watersheds as mercury hot spots.

Reacting responsibly to the issue, New Hampshire and Vermont joined a larger regional mercury reduction effort in 1998, setting an aggressive goal of reducing mercury emissions by 75 percent by 2010. In 2007, the New England states and New York jointly submitted to EPA a cleanup plan, called the "Northeast Regional Mercury Total Maximum Daily Load," (TMDL) which calls on EPA to require other states to take similar steps to reduce mercury emissions. New Hampshire, along with several other states, has brought suit against EPA to enforce their requirements regarding mercury.

New Hampshire has already reduced emissions from waste-to-energy plants and medical waste incinerators by 95 percent, has banned certain mercury-containing products, passed a comprehensive law to control emissions from the state's coal-fired power plants, and banned disposal of mercury-containing materials in landfills. Since 1998, overall mercury emissions in New Hampshire have been reduced by more than 60 percent. While Vermont has not had the mercury-emitting industries of its sister state, it too has passed legislation to control the sale and disposal of mercury-added products and set up a Mercury Education and Reduction Campaign.

Mercury is not just an environmental issue – it is an economic issue for those on the receiving end of the emissions that deliver this heavy metal. In a 2007 study of the economic impact of the potential decline in New Hampshire water quality, more than two-thirds (69%)of respondents to a survey indicated that they would decrease the number of visits they make to a river, stream, lake, or pond if they perceived a change in water clarity and purity. For the purpose of this study, "water clarity and purity" include mercury, milfoil or other invasives, and algae. Perceived declines in water clarity and purity would result in about $51 million of lost sales, $18 million in lost income and more than 800 lost jobs statewide. (8)

Opportunities & Recommendations:

Address mercury poisoning of the environment – and the tourism economy – on a national scale.

More than 70 percent of the mercury impacting New England comes from pollution in upwind states. Downwind states such as Vermont and New Hampshire will not be able to solve this problem without better federal regulations.

1. **EPA should approve the TMDL for mercury** offered by the New England states.

2. **State authorities should continue to legislate reductions in mercury contamination**. New Hampshire should follow Vermont's example in regulating outdoor furnaces, which could be sources of mercury. States should enforce their ban on barrel burning of trash.

3. **EPA and the states of Vermont and New Hampshire should plan to cooperate on a follow-up study of mercury** and other fish tissue toxins in the next decade, to track progress in achieving mercury reductions. CRJC should participate in design of future studies. The next effort should include a focus on coldwater species in the northernmost reach of the river.

15. CLIMATE CHANGE

Issue: Climate change may affect river dynamics, water quality, aquatic habitat, erosion, and much more.

Most scientists agree that climate change is already underway, and that the Northeast can expect higher temperatures and shifting seasons, reduced snow cover, and more extreme weather. (9) During the 20th century, the average temperature in Hanover, NH, increased 2°F (10), while in Vermont, the average temperature in Burlington increased 0.4°F (11). Climate change has potential for wide-spread economic effects, ranging from collapse of the states' current reliance upon snow-dependent tourism such as skiing and snowmobiling to loss of the iconic maple sugar industry, but there are implications for the river system as well.

Effects of climate change are predicted to include more precipitation in short, intense bursts (more than 2 inches of rain in a day), which could lead to more flooding. Measurable increases in the number of heavy rain storms have already occurred across the Northeast in recent decades, including two micro-bursts in Westmoreland, NH in 2003 affecting Mill Brook; severe storms in Canaan, VT affecting Leach and Bolter Creeks and in Hanover, NH in 2004; floods on Indian Stream and the Sugar River in 2005; and two severe storms in the Mohawk River watershed in 2006. All of these storms resulted in heavy erosion and turbidity in the Connecticut River, in some instances causing a shift of the huge mainstem's current in response to sediment deposited there by a relatively tiny tributary.

None of these storms, however, matched the unraveling of the Cold River in 2005, when a 500+ year storm brought 11 inches of rain in 24 hours, reaching a total of 17 inches during the ensuing week. Flooding caused over $4 million in damage in New Hampshire and seven deaths, four of them in the Cold River watershed. At the same time, flood water exceeded storage capacity at the large hydro dams at Fifteen Mile Falls, and flooding occurred below them.

> "The rain that fell on October 8 and 9 completely rewrote our river."
>
> *Deb Hinman, Cold River Local Advisory Committee*

More flooding could lead to greater erosion and increases in sediment, fertilizers, and other pollutants in stormwater runoff. The Soil and Water Conservation Society predicts that a relatively small increase in rain intensity of ten percent will result in a 24 percent average increase in soil erosion (12).

Climate change effects in the watershed may also include droughts, especially if emissions are not soon controlled. Such droughts could lower groundwater levels and affect the drinking water supply of rural residents who depend on shallow wells. Farmers finding reduced soil moisture in their fields due to drought and increased evaporation may turn toward irrigation to satisfy their crops' water needs at a time when river flow is already down, setting up a possible conflict with flows needed to support fisheries. During the drought of 2002, the hydro power company supplied water from Lake Francis and the Connecticut Lakes to Comerford Reservoir to meet a new minimum flow requirement, dropping water levels upstream in the Lakes and stranding docks and boats.

A warmer climate could lead to earlier spring snowmelt and result in higher streamflows in winter and spring and lower streamflows in summer and fall. Warmer water temperatures also reduce dissolved oxygen, adversely affecting fish habitat, and lower summer streamflows could reduce the ability of rivers to assimilate waste. This is a subject of special concern in some parts of the Valley where multiple wastewater treatment plants discharge into the Connecticut River mainstem within a short distance, or into impounded reaches such as at Vernon that are also warmed by a thermal discharge from the Vermont Yankee nuclear power plant.

Solutions for reducing greenhouse gas emissions often refocus attention on alternative energy sources such as hydro power. However, studies show that reservoirs behind hydro dams contribute methane, a potent greenhouse gas, through anaerobic decay of organic matter, and can remove some of the carbon sink provided by vegetation by removing trees and flooding the area. (13) While use of the dams avoids the effects of conventional fossil fuel-burning plants, these effects should be taken into account.

> "Climate change is reshuffling the deck and changing all the rules."
>
> *Barry Cahoon, River Management Engineer, VT Agency of Natural Resources*

A 2005 study by Michael Simpson at Antioch New England Graduate School in Keene (14) projects a 30% increase in the occurrence of 25-year storms. This study concluded that current engineering design specifications for culvert sizing is inadequate to handle the higher frequency of storms of greater intensity that can be expected with climate change. The micro-watersheds of many culverts have less storage for runoff now than they did 30-40 years ago when these culverts may have been installed, because wetlands have been drained, land has been cleared, and more impervious surface has been added.

Engineering guidelines for culvert sizing, created in 1960, have not been updated to reflect increasingly heavy storms, or even to compensate for increased imperviousness. The Antioch study found that steep slopes are closely associated with flashy runoff in headwater streams, because soils are thin and cannot absorb much runoff. In the Black

Brook micro-watershed in the Ashuelot River basin, the study predicted a 104 percent increase in runoff over baseline conditions, in a two year storm over 24 hours when steeply sloped areas were built out according to current zoning. Removing steep slopes from the build out analysis reduced runoff nearly to the baseline level. The Antioch study also found that by instituting riparian buffers of at least 75 feet in width, runoff increase under a build-out scenario was limited to seven percent.

Opportunities & Recommendations: Think globally, act locally.

There never was a more appropriate context for this old saw. Actions taken in the Connecticut River watershed can join those across the country and elsewhere in the world to mitigate the effects of climate change both here and abroad. The states are developing a climate change policy, and need the support and encouragement of citizens. Policymakers have begun to recognize the role of the states' forests in storing carbon and mitigating climate change. Recently, a researcher at the University of Vermont suggested that increasing that carbon storage could have a value of some $1 billion. (15)

Sustainable stormwater management in this new context is more important than ever, as is assuring open floodplains, effective riparian buffers, and property safe from sudden high water. Protecting riparian buffers and the shallow soils of ridgelines, hillsides, and steep slopes from development can avoid contributing to sudden runoff that leads to flooding. Low Impact Development measures for stormwater capture, such as porous pavement, can also be a key to reducing runoff. Identifying undersized culverts in a hazard mitigation plan can help a town qualify for funding for their replacement.

1. **States should articulate a clear policy with regard to climate change, and provide guidance** to towns and citizens regarding actions they can take to maximize energy efficiency, cope with the impacts of climate change, and reduce their carbon footprint.

2. **State transportation agencies should** revise design guidelines for culverts and stream crossings to reflect new storm frequencies and runoff volumes.

3. **Public agencies and private landowners should work together to retain existing natural flood storage**, such as in wetlands and floodplains. Promote riparian buffers to shade and help control water temperatures and protect riverbanks against erosion. Promote effective, dispersed stormwater management to help control stormwater runoff.

4. **Towns should evaluate whether culverts and bridges are sized properly** in order to carry the water that might come their way during larger storms. Towns should adopt ordinances prohibiting filling and building in the 100-year floodplain and on flowage rights of way. Discourage development on steep slopes in order to minimize the burden on culverts and bridges to carry runoff during heavy storms. Require riparian buffers of at least 75 feet along all rivers and streams to promote stormwater absorption and help guard against erosion. Require developers to use Low Impact Development measures for capturing stormwater and reducing runoff. Weigh the costs and benefits of identifying and replacing inadequately sized culverts, and go to a phased, risk-based program of culvert upgrades to reduce exposure to damaging floods.

Footnotes

Riparian Buffers

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Streambank Erosion

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Appendices

Acknowledgments

We have been fortunate to be able to call upon the expertise of state agencies, regional planning commissions, and local watershed group leaders to advise in the preparation of this plan. We would like to express our gratitude to those who lent their time to this effort:

- Steve Couture, Rivers Coordinator, *NH Department of Environmental Services Rivers Coordinator*
- Rick Hopkins, *Vermont Department of Environmental Conservation, Water Quality Planning Division*
- Laura Weit, *NH DES Watershed planner*
- Ben Copans*, VT DEC Basin planner*
- Marie Caduto*, VT DEC Basin planner*
- John Field, *Field Geology Services*
- North Country Council, NH
- Northeastern Vermont Development Association, VT
- Upper Valley Lake Sunapee Regional Planning Commission, NH
- Two Rivers Ottauquechee Regional Commission, VT
- Southern Windsor County Regional Planning Commission, VT
- Southwest Region Planning Commission, NH
- Windham Regional Commission, VT

Technical assistance - Mapping and other technical assistance were provided by

- Upper Valley Lake Sunapee Regional Planning Commission through a grant from USGen New England.
- New Hampshire Department of Environmental Services
- US Geological Survey

Funding to support the work of the Connecticut River Joint Commissions in preparing this plan came from:

- NH Department of Environmental Services
- National Oceanographic and Atmospheric Administration
- USGen New England
- Upper Connecticut River Mitigation & Enhancement Fund

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Those commissioners indicated in bold are members of CRJC's Water Resources Committee.

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Glossary

- Basin - watershed, the land area drained by a body of water.
- Black start -the process of restoring a power station to operation after a wide-area power outage has occurred.
- GIS - geographic information system, a system for capturing, storing, analyzing and managing data and associated attributes which are spatially referenced to the Earth. GIS is a tool that allows users to create interactive queries, analyze the spatial information and create maps.
- Head-cut erosion - a fluvial process of erosion that lengthens a stream, a valley or a gully at its head and also enlarges its drainage basin. The stream erodes away at the rock and soil at its headwaters in the opposite direction that it flows. Once a stream has begun to cut back, the erosion is sped up by the steep gradient the water is flowing down. As water erodes a path from its headwaters to its mouth at a standing body of water, it tries to cut an ever-shallower path. This leads to increased erosion at the steepest parts, which is head-cut or headward erosion.
- LIDAR - Light Detection and Ranging, an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target, usually with laser pulses. LIDAR technology can be used to discern subtle landscape features, such as the shadows of old river flood chutes.
- Meander belt width - the breadth of the landscape through which a river or stream channel may migrate over time. The larger the belt width, the more erosion hazard posed by the stream. Averages six times the width of the channel.
- River ramping rate - the change in water release rate at a dam.
- Soil piping - a particular form of soil erosion that occurs below the soil surface. It is associated with water level fluctuations behind dams as well as sink hole formation. Water pressure imbalance at the riverbank face can cause water to leave the soil at the bank face, carrying soil particles with it. Eventually, such weeping of soil and water can cause bank slumping.
- Stream order - a means of roughly describing the size of a stream based on a hierarchy of its tributaries. Streams range from the smallest at the headwaters (a first order stream) to the most powerful (the Amazon River is a "12.")When two first-order perennial streams (streams that flow all year round) come together, they form a second-order stream. When two second-order streams come together, they form a third-order stream, and so on. Streams of lower order joining a higher order stream do not change the order of the higher stream. Thus, if a first-order stream joins a second-order stream, it remains a second-order stream.
- Varve - an annual layer of sediment. Varves form in marine and lake depositional environments from seasonal variation. The classic varve is a light / dark colored couplet of layers deposited in a glacial lake. The light layer is usually silt and fine sand deposited when meltwater deposits a sediment load into the lake water. During winter months, when meltwater and associated suspended sediment input is reduced, and often when the lake surface freezes and stills the water, fine clay-size sediment is deposited forming a dark colored layer. Varves are common in the Connecticut River Valley in areas that were once submerged under glacial Lake Hitchcock and other glacial lakes. They are important because the layers behave differently with water; the clay layers can slip against the sand/silt layers or convey water laterally.

List of Acronyms

AAP	Accepted Agricultural Practice
AMP	Acceptable Management Practice
ANR	(Vermont) Agency of Natural Resources
BMP	Best Management Practice
CRJC	Connecticut River Joint Commissions
CREP	Conservation Reserve Enhancement Program
CRWC	Connecticut River Watershed Council
DES	(New Hampshire) Department of Environmental Services
EPA	(United States) Environmental Protection Agency
FEMA	Federal Energy Regulatory Commission
GIS	Geographic Information System
LID	Low Impact Development (a stormwater management system)
NOAA	National Oceanographic and Atmospheric Administration
TMDL	Total Maximum Daily Load