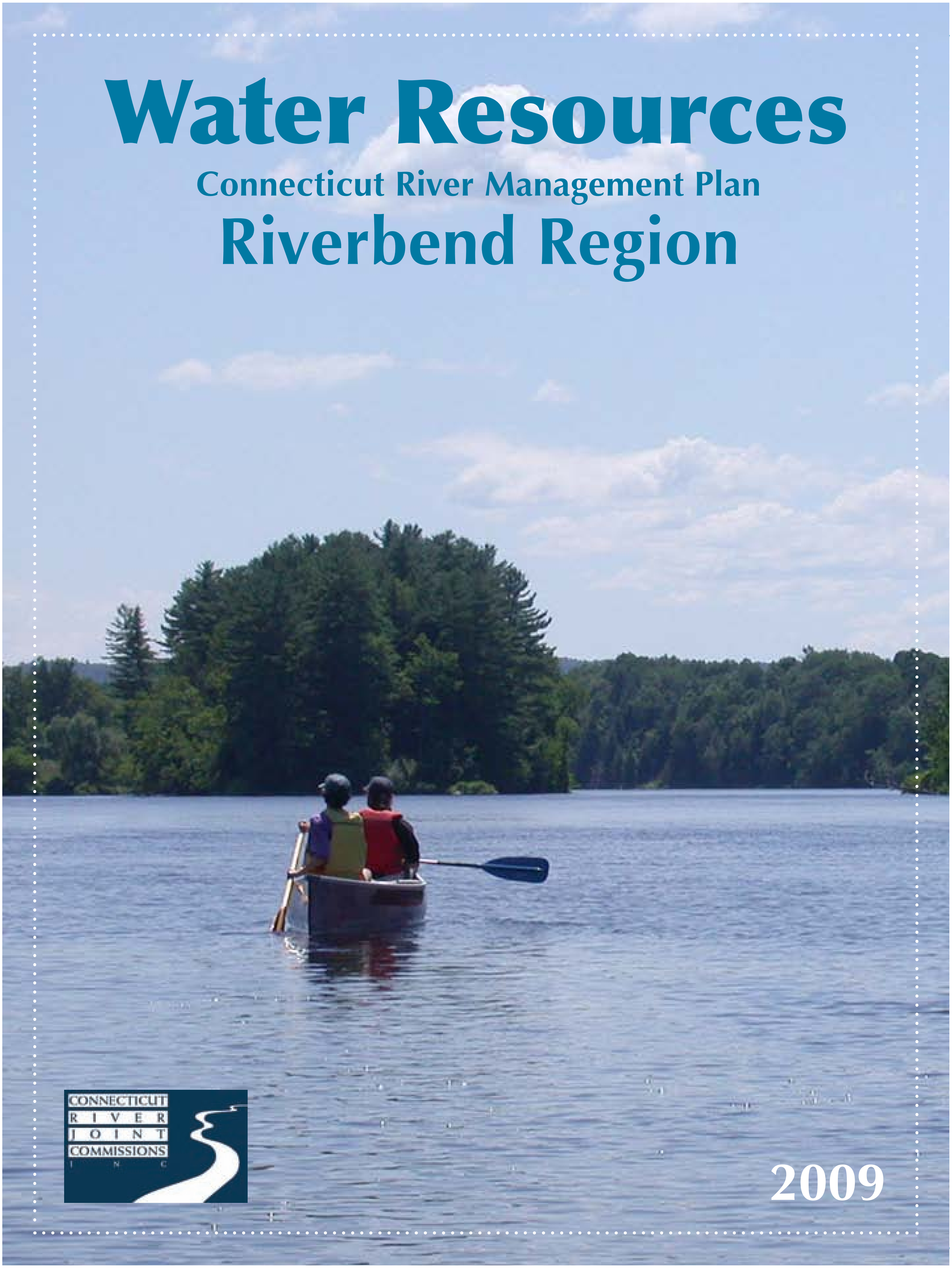
Water Resources

Connecticut River Management Plan

Riverbend Region



CONNECTICUT RIVER JOINT COMMISSIONS INC

2009

Water Resources

Riverbend Subcommittee of the Connecticut River Joint Commissions

Adopted November 29, 2007, Updated July, 2009

Produced with support from the New Hampshire Department of Environmental Services, the National Oceanic and Atmospheric Administration, US Gen New England, the Davis Foundation, and the Vermont Conservation License Plate Program.

Drafted by the Riverbend Subcommittee with the assistance of Adair D. Mulligan.

This report is also available at www.crjc.org/waterresources.htm

Connecticut River Joint Commissions

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Cover image: The Connecticut River, looking downstream from Monroe, N.H. and Barnet, Vt.

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Key Recommendations

- **Ensure adequate and regular water quality monitoring.** States should ensure adequate and regular water quality monitoring; continue to work with town conservation commissions and watershed groups to encourage, expand, and coordinate volunteer water quality monitoring.

- **Address mercury contamination.** State and federal authorities should continue to legislate reductions in mercury contamination of the region. EPA should work with the states every 10 years to conduct a more detailed, comprehensive long-range study of sediment and fish contamination to better understand the distribution and types of contaminants, and their trends.

- **Retain natural valley flood storage.** Land conservation organizations and the U.S. Army Corps of Engineers should purchase development rights from willing owners of land in the natural valley flood storage area to help prevent flooding downstream.

- **Continue communication between TransCanada and Fifteen Mile Falls region towns and the public.** The N.H. Department of Environmental Services (NH DES) and the Vermont Department of Environmental Conservation (VT DEC) should cooperate with TransCanada to educate local officials and citizens about how the river and project lands and amenities are managed in the region, the terms of the Fifteen Mile Falls Settlement Agreement, and how drought affects river management. Communication among TransCanada, area towns, landowners, and the public has been useful and should continue. Town emergency management plans should call for better coordination with dam managers.

- **Evaluate and protect groundwater supplies.** Town planning boards and commissions should evaluate water supplies for short- and long-term growth. Towns should not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, snow dumps, wastewater or septage lagoons, and outdoor salt storage or other de-icing chemical storage to be located on aquifers.

- **Prohibit development in the floodplain.** Town zoning ordinances should prohibit development in the 100-year floodplain. The Federal Emergency Management Agency (FEMA) should ensure that floodplain maps are accurate. Towns should consider adopting agricultural soil protection ordinances to keep valuable soils available for farming and to keep development from interfering with flood storage.

- **Ensure that culverts are properly sized and allow fish passage.** Town highway departments, working with conservation commissions, should ensure that culverts are properly sized and placed for fish passage when replacing them during road work. New Hampshire towns should ask for help from regional planning commissions to survey culverts to identify those that are undersized and block fish passage; seek grants for replacing them.

- **Plan for stormwater control.** 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. These include keeping riparian buffers to filter the runoff and other innovative, yet cost-free natural treatments.

- **Require best/acceptable management practices for agriculture and forestry.** Agencies should enforce best/acceptable management practices, including a ban on winter spreading of manure, and look more closely at the effect of nutrient enrichment on river life, including fish. States and county conservation districts should encourage farmers to use best management practices to control erosion and protect and enhance riparian buffers.

- **Establish or retain riparian buffers.** Landowners should establish or retain riparian buffers on their waterfront property to help filter out sediment and nutrients washing off the land, to allow trees and vegetation to help stabilize the banks and keep waters cooler, and to provide privacy. County conservation districts should be sure landowners know about sources of assistance and where they can find nurseries for buffer plant material.

I. Preface

A. A Citizen-based Plan for the Connecticut River

The Riverbend Subcommittee tours Comerford Dam.

The Riverbend region's plan is a blueprint for stewardship of the Connecticut River – for communities, landowners, businesses, and agencies on both shores. Gathering together to create this plan for the Riverbend segment of the river were representatives from the New Hampshire towns of Lancaster, Dalton, Littleton, Monroe, Bath, and Haverhill, and the Vermont towns of Guildhall, Lunenburg, Concord, Waterford, and Newbury.

The strength of the Riverbend Subcommittee's planning process lies in the diversity of its membership. These citizens, as directed by RSA 483, represent local business, local government, agriculture, recreation, conservation, and riverfront landowners. Therefore, the group is truly reflective of the region, representing many perspectives from both sides of the river. All of the recommendations of the Riverbend Subcommittee's plan represent the consensus of this diverse group of citizens. Subcommittee members are appointed by the selectmen of their riverfront towns from both states. The members, past and present, are listed in Appendix A.

"A lot of the authenticity of the River Commissions comes from this participation at the grassroots level."

Cleve Kapala, CRJC President

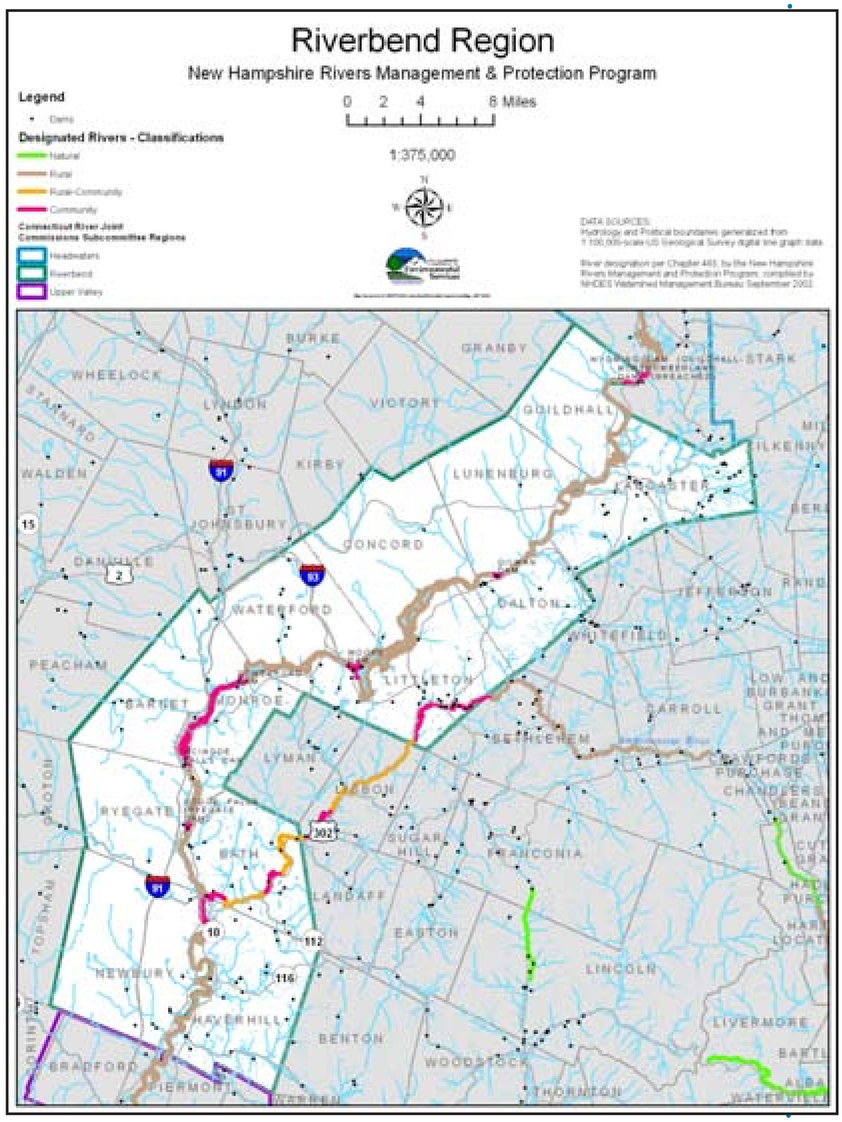
B. Origin of the Connecticut River Management Plan

The Connecticut River Joint Commissions (CRJC) mobilized hundreds of valley residents and local officials to join them in nominating the Connecticut River into the New Hampshire Rivers Management and Protection Program in 1991-2. The New Hampshire Legislature subsequently designated the river for state protection under RSA 483, which authorized CRJC to develop a river corridor management plan. CRJC sought support from the Vermont Legislature as well, so citizens from both states could engage in planning for their shared river. With backing from both legislatures, CRJC then contacted select boards or city councils from the 53 New Hampshire and Vermont riverfront communities and asked them to nominate representatives to serve on five bi-state local river subcommittees. This partnership between local town representatives and the state commissions for the Connecticut River enabled CRJC to publish the first edition of the *Connecticut River Corridor Management Plan* in 1997, after five years of work by the Commissions and the five bi-state local river subcommittees. Since this planning process began in 1993, nearly 200 citizens have thus participated in the subcommittees' work.

Following its publication, communities on both sides of the Connecticut River examined its findings and used them as a basis for enacting new or enhanced protection for the river. State and federal agencies also pursued its recommendations, embarking on studies of sediment and water quality and fish tissue toxins. The *Connecticut River Corridor Management Plan* was cited as a basis for designation of the Connecticut River as an American Heritage River by the White House in 1998. A summary of progress on the plan's recommendations appears in Appendix B.

C. A New Water Resources Plan

At the request of CRJC, a new assessment of water quality in the Connecticut River mainstem was conducted in 2004 by the New Hampshire Department of Environmental Services with the support of the U.S. Environmental Protection Agency (EPA). Following announcement of the results in January, 2005, CRJC asked the local river subcommittees to begin work on updating, revising, and expanding the 1997 Water Quality chapter, exploring new topics such as flow, flooding, drought, groundwater, and other areas, in an attempt to portray and address the full range of water resources in the region. Because tributaries are responsible in large part for the river's condition, the subcommittees included an examination of tributary issues. Several members conducted windshield assessments of smaller tributaries within their towns, previously unstudied.



D. Plan Process

The Riverbend Subcommittee met at the Littleton Community House from January, 2005 until November, 2007 to develop the new water resources chapter of the Connecticut River Management Plan for this section of the river. CRJC's conservation director transcribed the subcommittee's discussions to construct drafts of the plan, which the members revised and approved. Ryegate, Vt. did not appoint a representative and did not participate.

A first draft of the plan was circulated for public comment in May, 2007. After considering comments from the agencies, general public, and CRJC's Water Resources Committee, the Subcommittee adopted a final version in November, 2007.

E. Scope of the Plan

The Subcommittee has concentrated its planning upon the towns that border 70 miles of the Connecticut River in this segment. While the recommendations of this plan are directed toward this area, the Riverbend Subcommittee believes that their consideration beyond the riverfront towns could benefit the river, its tributaries, and the region as a whole. Recommendations are presented within each topic area, and are summarized in Appendix C, arranged by responsible party. Some are aimed beyond town boundaries, to guide state and federal agencies. The Subcommittee recognizes that proper care of the river is a big job and important public duty. Help from beyond the watershed is sometimes appropriate and needed from those agencies which share responsibility for the river.

F. Local Adoption of Recommendations

N.H. RSA 483, the Rivers Management and Protection Act, encourages communities on protected rivers such as the Connecticut to adopt a locally-conceived means of conserving the river and its shoreline. The Legislature sought also that "the scenic beauty and recreational potential of [the Connecticut River] shall be restored and maintained, that riparian interests shall be respected" without preempting the land zoning authority already granted to the towns. The mechanism for adoption of this plan in both states is the conventional local planning process. Planning boards and commissions can review recommendations in the water resources chapter and integrate them into the local master plan, and select appropriate recommendations to bring to townspeople for adoption as specific additions to their zoning ordinances. The Subcommittee has also made many recommendations that are non-regulatory in nature, inviting landowners and others to put them into action.

G. The Connecticut River Joint Commissions

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, 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 in 1989, and are headquartered in Charlestown, N.H. The 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. CRJC's broad goal is to assure responsible economic development and economically sound environmental protection. The 30 volunteer river commissioners, 15 appointed by each state, represent the interests of business, agriculture, forestry, conservation, hydro power, recreation, and regional planning agencies on both sides of the river.

H. Acknowledgments

The strength of this plan lies largely within its creation by a cross-section of local citizenry. From time to time, however, the local subcommittee called upon the expertise of state agencies, regional planning commissions, and local watershed group leaders to educate them about issues of particular concern. We would like to express our gratitude to those who lent their time to share information with the Riverbend Subcommittee:

- Ben Copans, *Vermont Agency of Natural Resources*
- Bob Ball, *Israel's River Volunteer Advisory Group*
- Ray Lobdell, *Lobdell Associates*
- Ginny DiFrancesco, *UNH Cooperative Extension Service*
- Steve Couture, Rivers Coordinator, *NH Department of Environmental Services*
- Ken Alton, *TransCanada Hydro Northeast*
- John Severance, Nat Tripp, and Robert Christie, *Connecticut River Commissioners*

We are particularly grateful to the Littleton Community House for providing meeting space.

Technical assistance - Mapping and other technical assistance were provided by the Upper Valley Lake Sunapee Regional Planning Commission through a grant from USGen New England.

Funding to support the work of the Riverbend Subcommittee came from:

NH Department of Environmental Services
National Oceanic and Atmospheric Administration
USGen New England
Davis Foundation
Vermont Conservation License Plate Program

A list of acronyms appears in Appendix K.

II. Introduction

The Connecticut River assumes many different personalities in its flow through the Riverbend Region, traveling 70 miles from the northern boundaries of Lancaster, N.H. and Guildhall, Vt. to the southern boundaries of Haverhill, N.H. and Newbury, Vt. Meandering through fertile farmlands and among deep forests, it moves within its floodplain as it has throughout the ages, delivering soil and taking it away again.

Moore Dam, northernmost of the three hydro dams in the Fifteen Mile Falls project.

From Guildhall to Lunenburg, the river flows freely until just above Gilman Dam. The river's dramatic drop at Fifteen Mile Falls, once a spectacular series of cascades and waterfalls that deterred even Rogers' Rangers centuries ago and posed a mortal threat for hardy river log drivers, has been exchanged for the magnificent expanse of Moore and Comerford reservoirs and hydro power production. Operations at these, the largest hydro dams in New England, influence the flow of the river from this region through the rest of its path between Vermont and New Hampshire.

After a short stretch of rapids below Gilman Dam, the river enters the succession of three impoundments at Fifteen Mile Falls. At Moore Reservoir, the first, New Hampshire's longest river becomes its largest undeveloped lake. Below, the river's flow remains strongly influenced by activity at Fifteen Mile Falls, but runs without impoundment except for a minor pool at Dodge Falls. The river meets two major tributaries at "The Narrows" between Bath and Ryegate, a dramatic gorge of deep holes, huge eddies, and spectacular rock formations. At the downstream end of the Riverbend segment, the river slows as it reaches the Wilder impoundment.

The upper Connecticut River region is known for its abundant ground and surface water supply. Recreational uses include fishing, boating, and swimming. Hydroelectric power generation is the prime commercial use, in addition to cooling water for a wood-chip fired power plant in Ryegate and for process water at the paper mill in Gilman, Vt. (at this writing, the paper mill is closed).

The river flows past the larger towns of Lancaster, Littleton, Woodsville, and Wells River. St. Johnsbury sits nearby on a major tributary. Minor clusters of residential, commercial, and, rarely, industrial development surround smaller town centers. Riparian buffers, or filter strips of natural shoreland vegetation, remain in many locations to help hold the banks and to catch pollutants in runoff before they can reach the river.

III. River Quality

A. Clean Water Has Clear Economic Value

Good water quality is important not just for appearance and aquatic habitat, but also for the economy of the Riverbend region. Today the river is once again generally safe for canoeing, kayaking, boating, swimming, wildlife habitat, and productive fisheries. Its water quality is also important aesthetically to residential use and tourism. The Connecticut River Byway, an economic development initiative that has built strong momentum in the last five years, is centered on the river's appeal for recreation. River water is once again suitable for industrial water supplies. Public and private wells are located near the river with the potential to draw upon associated groundwater.

A 2007 study in New Hampshire found that about $379 million in total sales is generated by those who are fishing, boating or swimming in New Hampshire fresh waters, or about 26 percent of all summer spending in the state.[1] Fishing, boating and swimming have about the same economic impact as snowmobiling, downhill skiing, cross-country skiing, and ice-fishing combined.

Interviews with users of nine public boat ramps in the White Mountains Region, including at Dodge Hill and Pine Island boat launches on Moore Reservoir in Littleton, found that 72 percent of anglers, boaters and swimmers say they would decrease their intended visits to the White Mountains if water clarity and purity diminished. For the purpose of this study, "water clarity and purity" include milfoil or other invasives, mercury, and algae. Of those who would decrease their intended visits, 26 percent would leave the state and 14 percent would leave the region. Approximately 35 percent would go to some unspecified location in New Hampshire, and 26 percent would remain in the region. Those recreational users who would leave the state because of declining water clarity and purity would create a loss of 18 percent – or about 483,000 visitor days. The Riverbend Subcommittee suggests that the economic impact of mercury pollution should be considered for mitigation.

The river offers good, clean fun that brings dollars into the region, such as for fishing derbies.

The study found that overall, surface water recreation in the 14 towns in New Hampshire's White Mountains tourism region generates over 1,000 jobs, over $24 million in personal income and over $67 million in business sales, totaling about 18 percent of the recreational revenue generated by anglers, boaters and swimmers in New Hampshire. A perceived decline in water clarity and purity in the White Mountains region would lead to a loss of almost 200 jobs, a loss of about $4 million in personal income and approximately $12 million in lost business sales.

There is no similar information available for Vermont, but it's clear that Vermonters also benefit from clean water here for recreation, industry, and irrigation.

The recreational opportunities offered by the Connecticut River which depend upon its water quality represent a $26-31 million dollar business in the river towns of Haverhill to Pittsburg, on the New Hampshire side alone, according to a study prepared for the Riverbend Subcommittee in 1996.[2] Swimming, canoeing, kayaking, motor boating, and fisheries directly depend upon high quality water, while the quality of life for local residents and the region's appeal to visitors depend indirectly on a clean river. When surveyed in 1996, local water-dependent businesses were strongly interested in maintaining or improving water quality, with the assistance of local governments.

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1. *The Economic Impact of Potential Decline in New Hampshire Water Quality: The Link Between Visitor Perceptions, Usage and Spending.* Prepared for the New Hampshire Lakes, Rivers, Streams and Ponds Partnership by Anne Nordstrom, May 2007.
2. National Wildlife Federation and North Country Council, *Rivers, Recreation, and the Regional Economy: A Report on the Economic Importance of Water-Based Recreation on the Upper Connecticut River*, 1996.

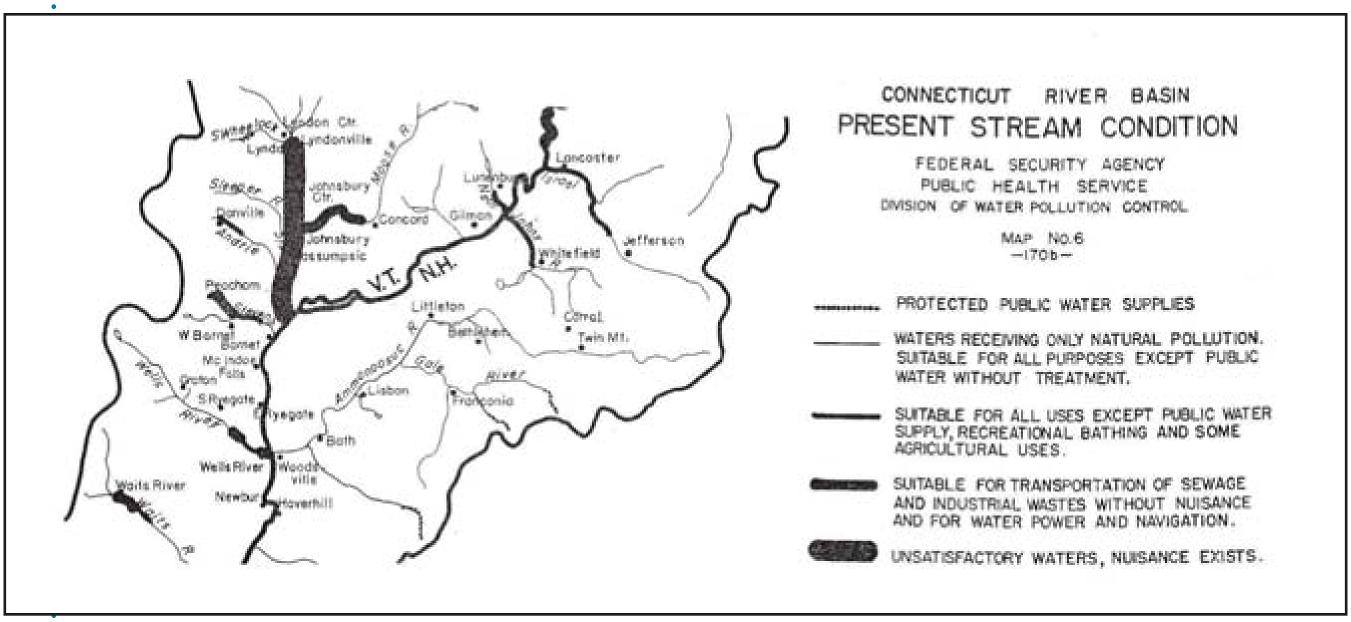
The Riverbend Subcommittee recognizes that the real price of clean water and a healthy river is too often realized only when it is too late and thousands of dollars must be invested, such as for clean-up of contaminated drinking water or re-building after flood damage. The Subcommittee suggests that adopting wise ways of guiding growth and development, and using best management practices, are cost-effective means to prevent expensive troubles.

B. Connecticut River Water Quality

Many conditions must come together to sustain water quality: water for safe swimming and other water contact uses must be free from bacterial contamination and toxics. To flush pollutants and add oxygen, there must be adequate flow through impoundments and in free-flowing sections. Nonpoint pollution, including nutrients from failing septic systems and sediment, must be controlled. Sewage and storm water must be treated separately. Domestic on-site systems must be inspected to ensure they will treat sewage adequately. Wetlands near the river and throughout the region must be healthy and undisturbed so that they can reduce flooding and trap pollution. Riverside vegetation, or riparian buffers, must remain along the river to trap pollutants and help stabilize riverbanks. Industrial discharges and landfill leachates must not send toxins and heavy metals to groundwater, streams, lakes, or ponds.

1. River Management Planning

New Hampshire - Vermont and New Hampshire approach river planning differently. New Hampshire relies upon local citizens to design a river management plan after the river is designated into the state's Rivers Management and Protection Program, a process that begins and ends with citizens. The legislature designated the Connecticut River in 1992 with the support of local residents and CRJC. Designation allows riverfront towns to have a



Water quality in the Riverbend region in 1951.

voice in decisions made about their river. New Hampshire does not conduct its own river management planning.

As part of this designation, the state required CRJC to act as the local advisory committee for the river and to develop a Connecticut River Corridor Management Plan with the help of five local river subcommittees set up under state law. CRJC published the six-volume first edition of the plan in 1997. The present document is a revised and updated version of the water quality chapter of that plan.

A similar process has begun for the Ammonoosuc River, after the New Hampshire Legislature designated this major tributary into the Rivers Program in 2007. Citizens of the Ammonoosuc River watershed nominated the river for this designation in 2006, with strong support from watershed towns, CRJC, and NH DES.

Vermont - Vermont embarked upon watershed planning in 2002, under a mandate from the legislature that originally gave VT DEC until 2006 to complete basin plans for the state's 17 watersheds, although this will now not be complete until after 2011. Under the guidance of state basin planners, citizen committees are developing basin plans in a process modeled partly on the grassroots approach used by CRJC. At the same time, the state agency is moving ahead with watershed assessment and restoration projects, such as studies of river dynamics.

Watershed planning is nearly complete in Vermont's Basin 14 (Wells and Stevens Rivers). Because of staff and budget cuts in Vermont government, basin planning will not begin in the Passumpsic River basin (Basin 15) for several years. Following the Passumpsic, attention will turn to Basin 16, which includes the smaller tributaries that flow directly to the Connecticut River in the Riverbend region. For the next few years, the Riverbend Subcommittee's Water Resources Plan must serve as the primary management plan for these Vermont tributaries.

2. Water Quality has Improved Dramatically in the Last 50 Years

The quality of waters in the Connecticut River watershed has improved vastly since 1951, when the federal Public Health Service listed the many thousands of homes discharging raw sewage and the hundreds of industries releasing untreated wastes into the river and its tributaries.[1] The Passumpsic River, which was then deemed so polluted it was unsuitable even for power production, was one of the most polluted rivers anywhere in the four-state watershed. The report also stated that the Connecticut River mainstem from Lancaster to Woodsville was suitable for "all uses except recreational bathing, some agricultural uses, and public water supply."

"In the summertime, when it got hot and the river got down, it literally stunk."

Guildhall farmer, describing the Connecticut in the 1950s.

1. Federal Security Agency, Public Health Service, *Connecticut River Drainage Basin: A Cooperative State-Federal Report on Water Pollution,* 1951.

A mere half century ago, the river carried untreated domestic sewage from 16,400 people in the greater Riverbend region of New Hampshire and 9,600 in nearby Vermont. Untreated wastewater from ten dairy processing plants, three paper mills, a tannery, a gravel washing operation, metal working shop, sawmill, and slaughterhouse flowed into the Connecticut River and its local tributaries, contributing to the burden brought by the Connecticut from several paper mills upstream. The 13 resort hotels and inns in the basin were a particular source of pollution in the 1950s, sending untreated sewage in the summer from a daily average of 3,870 people into the Israel's and Ammonoosuc Rivers and other tributaries here and farther north.

While the quality of the Riverbend stretch had deteriorated less than in downstream reaches, it too has improved with the passage of the Clean Water Act and investment in wastewater treatment plants, modern septic systems and leach fields, manure storage facilities, and use of best management practices. Today it is not only possible but enjoyable to swim in the river, where several decades ago, one might have had to look the water over carefully before plunging in. The presence of such rare species as the bald eagle and the dwarf wedge mussel is an indication of the good quality riverine habitat and water quality found in this stretch of the river.

3. Water Quality Management by the States

New Hampshire water quality standards apply to the Connecticut River. Water classifications set by the states give the management goals for a stretch of river. Water quality standards are used to protect the state's surface waters, and each state defines water quality in its own way, based on its statutes and administrative rules. For example, the two states have different limits for bacteria when determining whether water is safe for swimming. Vermont has the strictest standard for *E. coli* in the nation, although the Department of Environmental Conservation does not have the resources to enforce these standards consistently. Class B waters must not

New Hampshire Water Quality Standards

Tracking water quality is the responsibility of the Watershed Management Bureau of NH DES. Standards in New Hampshire consist of three parts: designated uses, including swimming, fishing, boating, and aquatic habitat; numerical or narrative criteria to protect the designated uses; and an anti-degradation policy, which maintains existing high quality water that exceeds the criteria. New Hampshire measures physical and chemical aspects of water, and also has a relatively new biological monitoring program for assessing aquatic life.

Class A waters - *Escherichia coli* are not to exceed a geometric mean of 47 *E. coli*/100 ml (based on at least 3 samples obtained over a 60-day period) or more than 153 *E. coli*/100 ml in any one sample. There shall be no discharge of any sewage or wastes into these waters.

Class B waters - *Escherichia coli* are not to exceed a geometric mean of 126 *E. coli*/100 ml (based on at least 3 samples obtained over a 60-day period) or more than 406 *E. coli*/100 ml in any one sample, shall have no objectionable physical characteristics, and shall contain a dissolved oxygen content of at least 75 percent of saturation.

exceed 77 *E. coli* organisms per 100 milliliters of water, while New Hampshire tolerates 126 per 100 ml. State water quality standards may be compared at www.neiwpcc.org/PDF_Docs/i_wqs_matrix04.pdf.

New Hampshire - Today, New Hampshire has two classifications: A and B, and has designated the entire Connecticut River as Class B, although back in 1951, only 44 miles of the 275 in the state qualified as Class B.

Vermont - Vermont considers most of the Connecticut River to be Class B, with the exception of 3.74 miles in Waste Management Zones, which are designated mixing zones where the river receives direct discharges of wastes which, prior to treatment, contained organisms pathogenic to humans. Permits are issued by the states for these discharges. In the Riverbend Region, there are three such zones, including 1.2 miles around the Gilman mill discharge, 0.34 miles around the Ryegate mill discharge, and 2.22 miles around the Woodsville wastewater discharge.

Vermont Water Quality Standards

The Water Quality Division of the Department of Environmental Conservation, in the Vermont Agency of Natural Resources, manages water quality information for this state. Standards in Vermont include designated uses, including swimming, fishing, boating, aquatic biota, wildlife and habitat, and aesthetics, numerical or narrative criteria to protect the designated uses including flow, and policies for flow, anti-degradation, and basin planning, among others. Vermont's water quality monitoring program emphasizes biomonitoring (an ambient monitoring program started in 1982) and also measures physical and chemical aspects of water bodies.

Class A waters - *Escherichia coli* are not to exceed a geometric mean based on at least 3 samples obtained over a 30 day period of 18 organisms/100 ml, no single sample above 33 organisms/100 ml. None attributable to the discharge of wastes.

Class B waters - *E. coli* are not to exceed 77 organisms/ 100ml. Vermont's water quality standards also include criteria for turbidity, dissolved oxygen and temperature based on whether the waters are designated for cold or warmwater fish habitat, and for aquatic biota, wildlife and aquatic habitat. Standards for phosphorus exist for the Lake Champlain basin, but not for the Connecticut River watershed. Nitrate standards exist for all waters, based on flow.

Vermont's Water Resources Board will eventually designate all Class B waters as either Water Management Type 1, 2, or 3, in order to more explicitly recognize their attainable uses and the existing level of water quality protection. Until waters are designated as a specific type, the criteria based on such designations do not apply. Vermont's Water Management Typing process has been before the Water Resources Panel for a long time and at this writing has not been resolved.

Total Maximum Daily Load (TMDL) - The EPA requires each state's water quality agency to identify those water bodies that are not meeting their water quality standards, and calculate the maximum amount of a pollutant that each can receive and still meet the state's water quality standards. The agency also develops a means to reduce these pollutants. TMDLs can be calculated for correcting water pollution from specific discharges or throughout a watershed and balance how much the pollutant needs to be reduced based on location. The draft 2008 state water quality assessments (Clean Water Act Section 303d List of Impaired Surface Waters) are the most recent available as this study was prepared.

Vermont TMDL list: Vermont has identified several areas in the Riverbend Region for which TMDLs will be required: the lower Sleeper's River in St. Johnsbury and a five mile section of the Passumpsic River for bacteria resulting from combined sewer overflows. Ticklenaked Pond in the Wells River watershed is plagued with high phosphorus levels, and a TMDL is required to deal with this problem. EPA approved a plan for reducing mercury in Moore and Comerford Reservoirs on December 20, 2007.

Vermont also publishes a list of priority surface waters that are outside the scope of Clean Water Act Section 303(d) including impaired surface waters for which no TMDL determination is required, surface waters in need of further assessment, those with completed TMDLs approved by EPA, and waters altered by exotic species, flow regulation, and channel alteration. In the Riverbend Region, in addition to mercury concerns in the Connecticut River, these include the effects of urban runoff on the Passumpsic River, instability on the Stevens River from Route 5 to I 91, nickel and oil in Sleepers River sediments that may be related to the old Fairbanks-Morse foundry site, and possible pollution of the Wells River by leachate entering from the Newbury landfill. More information about water quality in Vermont may be found at www.vtwaterquality.org/planning.htm.

New Hampshire TMDL list: In addition to Moore and Comerford reservoirs, where mercury exceeds water quality standards, New Hampshire has identified a number of threatened or impaired water bodies needing TMDLs that drain into the Connecticut River in this region. Aluminum, a naturally occurring metal in the region's soils, can move into the water when soil water becomes sufficiently acid. Acid rain may be contributing to this problem.

Streams in the region that have reduced aquatic habitat quality due to low pH include:

- Lancaster: parts of the Israel's River and Bunnell, Otter, Caleb, Bone, and Indian Brooks
- Dalton: 3.87 miles of the John's River, Cushman Brook, and unnamed brook flowing into Forest Lake
- Bath: 7.88 miles of the Wild Ammonoosuc River
- Haverhill: 8.5 miles of Clark Brook

Those streams that violate limits for *E. coli* include:

- Lancaster: Otter, Caleb, and Bone Brooks
- Littleton: 3.32 miles of the Ammonoosuc River
- Haverhill: 10.1 miles of Oliverian Brook and 8.5 miles of Clark Brook

On the Connecticut River mainstem, 5.72 miles of the river in Lancaster are above limits for *E. coli*, and there are sporadic problems with pH and aluminum in the Dalton, Littleton, and

Monroe sections of the mainstem. More information about water quality in New Hampshire may be found at http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm.

4. Water Quality Monitoring Activities

Surface waters are sampled to see whether they meet each state's water quality standards, but not on a regular basis, although the federal Clean Water Act requires the states to report surface water quality conditions and problems to EPA every two years.

"We cannot rely too heavily on volunteerism. Local, state, and federal levels must step up and take a greater responsibility for monitoring and enforcement."

Rick Walling, Riverbend Subcommittee Co-chair

Chemical/Physical monitoring - Both states are now welcoming the help of citizen volunteers in gathering data about their local waters. In 1998, NH DES started the New Hampshire Volunteer River Assessment Program (VRAP), providing training, water quality monitoring equipment, and technical support. VRAP data are available on-line at http://des.nh.gov/organization/divisions/water/wmb/vrap/index.htm. VRAP supports over a dozen volunteer groups throughout the state who conduct water quality monitoring, including recently organized citizen groups on the Ammonoosuc and Israel's Rivers. No baseline information about either river existed until these groups began water quality monitoring with equipment bought with CRJC Partnership grants. The Ammonoosuc group has used this equipment on the Wild Ammonoosuc River and also provided monitoring equipment to Woodsville Power and Light, which is collecting data daily and sharing the equipment with volunteers in Wells River. Witnessing the usefulness of the Israel's River monitoring efforts, Lancaster has requested the volunteer group's assistance in monitoring other streams within the town. The town of Dalton embarked on a water quality monitoring program for the John's River and nearby Connecticut River in 2007.

Otherwise, there is currently no regular, on-going water quality monitoring program on the Connecticut River or its New Hampshire tributaries in the Riverbend region.

Vermont has helped organize a volunteer citizen monitoring program on parts of the Stevens River as part of state-led basin planning. The Newbury Conservation Commission has sponsored a limited monitoring program on the Wells River near the landfill and in Boltonville to learn more about water quality threats.

Biological monitoring - The species and variety of aquatic life surviving in a stream give a good picture of the quality of the water and sediments in which they live. Biologists visit streams to collect fish and aquatic insects as well as basic physical and chemical water quality data and assess habitat.

Vermont has used a biological monitoring approach since 1982. Biomonitoring began on the Wells River in 1999, and is ongoing in coordination with Blue Mountain School. New Hampshire started biomonitoring in 1997, and has looked at many locations on Riverbend region tributaries, including a new focus on the Israel's River.

5. Water Quality in the Connecticut River Today

In 2004, NH DES, assisted by EPA, responded to CRJC's request to assess the entire river mainstem in New Hampshire in preparation for the update of this plan. (1, Appendix D) In the Riverbend region, samples were taken at

- Guildhall-Northumberland Bridge
- Route 2 Bridge, Lancaster
- Mt. Orne Covered Bridge, Lancaster
- RR Bridge at John's River, Dalton
- Gilman Road Bridge, Dalton
- Old Waterford Boat Launch
- Route 18 Bridge, Littleton
- Comerford Reservoir
- Comerford Dam Tailrace, Monroe
- McIndoe Falls-Monroe Bridge
- McIndoe Falls Tailrace, Monroe
- Dodge Falls Dam, Bath
- Route 135 canoe access, Bath

"We want to thank the groups from up north for sending us clean water."
Gordon Schofield, Wantastiquet Subcommittee Chair, Hinsdale

Results from this one season's testing indicated that the river's quality fully supports swimming and other forms of recreation, except in the area near and above the Guildhall/Northumberland Bridge, where bacteria were found in one sample to be above the state standard. Low pH and high aluminum in the half mile below Gilman Bridge and low pH in the mile below Comerford Dam rendered the river's aquatic habitat quality poor. These pH problems were also reported in the 1997 edition of this plan. Results of this brief study on aquatic habitat quality in Moore and Comerford reservoirs were inconclusive.

The 1994 Connecticut River Water Quality Assessment identified the following problems in the Riverbend segment: organic enrichment, sedimentation, and fluctuating flows. Three of the major tributaries entering the Riverbend segment, the Passumpsic, Ammonoosuc, and Wells Rivers, are adding nutrients to the mainstem waters. The organics and nutrients entering the river from these tributaries and from upstream point sources (paper mills) and non-point sources (including farms) combined with the longer time these pollutants spend in the impoundments may be over-enriching the waters, as shown by the type of river bottom life found in water quality studies.

As noted above, there is no regular water quality monitoring of the Connecticut River mainstem. Monitoring activities here and on the tributaries are challenged by the need to bring bacteria samples to state laboratories in a short time frame. However, there are labs at

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1. *2004 Connecticut River Water Quality Assessment, Preliminary Assessment Status,* NH DES.

local wastewater treatment plants that could provide processing as long as the states covered the cost. There is a fully equipped laboratory at the White Mountain School in Bethlehem and formerly at the Woodsville High School in New Hampshire. The lab offers help for volunteer monitoring efforts, although not all types of tests are done at each lab.

Recommendations for Water Quality Monitoring

- NH DES and VT DEC should ensure adequate and regular state funded water quality monitoring; continue to encourage and expand volunteer water quality monitoring and coordinate these activities to avoid isolated efforts.

- Local conservation commissions should encourage water quality monitoring programs in their towns, using state protocols.

- States should investigate ways to compensate local wastewater treatment plants and appropriate laboratories for processing water quality samples.

- NH DES and the University of New Hampshire should explore ways to reduce overlap in their water quality monitoring programs by sharing data and presenting it in one database.

- States should ensure that water quality data are easily accessible to the public.

- Watershed groups such as the Connecticut River Watershed Council should help set up local volunteer water quality monitoring programs where they do not exist.

- Water quality agencies should follow up on water quality violations.

- New Hampshire and Vermont should explore ways to reduce the differences between their water quality standards.

C. Connecticut River Sediment Quality

Sediment monitoring typically looks for heavy metals and organic pollutants such as automotive fluids, pesticides, and PCBs. Recent studies of river sediments help describe what may be present in the silts and sands of the river bottom. In response to the 1997 Connecticut River Corridor Management Plan, EPA conducted two studies of sediments in the Riverbend region. Results indicate that road runoff has probably had an effect upon the river as heavy metals and polyaromatic hydrocarbons (PAHs) associated with automobiles appear in the sediments. Results are summarized here and presented in Appendix E.

1. 1998 Sediment Study

In 1998, EPA conducted a limited sediment study of ten sites on the New Hampshire/Vermont portion of the river.[1] Two of the sites were located in the Riverbend region: just above the

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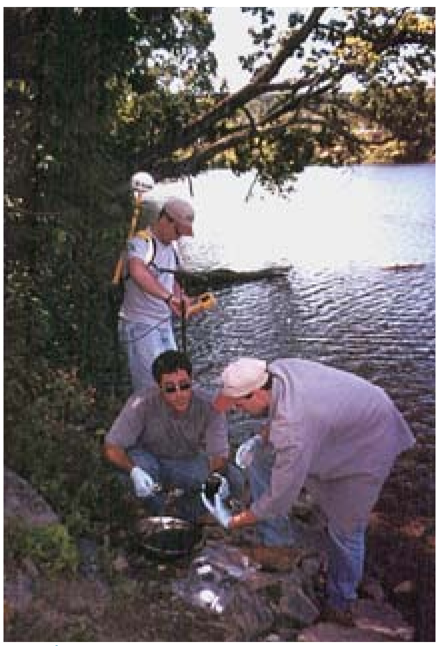
1. *Upper Connecticut River Sediment/Water Quality Analysis*. U.S. Environmental Protection Agency, Region 1, October, 1999.

breached Wyoming Dam in Guildhall, and downstream from the Ammonoosuc River in Haverhill. At Guildhall, EPA found very low concentrations of the breakdown products of DDT, a pesticide that is now banned and has not been used for years, but persists in the environment. This site also had the lowest level of PAHs of any of the ten sites in the study. Nickel was present here in levels which might be expected to affect aquatic life. At Woodsville, chrysene was the only contaminant found by the 1998 study in a concentration that could affect aquatic life. This pollutant is commonly found in river sediments where runoff from roads and parking lots enter the river.

2. 2000 Sediment Study

"Screening level"-

Level at which effects on aquatic life might be expected, such as reproduction problems.



Sampling of river sediments, including here at the Bedell Bridge site in Haverhill, showed the effects of long-time agricultural use in the region, among other things.

Two years later, EPA returned for a more detailed study, and took 100 samples of sediment at 93 sites on 200 miles of the river.[1] In the Riverbend region, the study looked at 27 sites on the mainstem, including six in Moore Reservoir and two in Comerford Reservoir. The study also sampled at two sites each on the Israel's, Passumpsic, and Wells Rivers, and one each inside the mouths of the John's and Ammonoosuc Rivers and Oliverian Brook. Samples were analyzed for 244 different kinds of volatile organic compounds, pesticides, PCBs, metals, and other pollutants. Results are presented in Appendix E.

At the majority of these 36 sites, no contaminants were found above "screening levels," the levels at which one would expect a risk to aquatic life, although traces of many appeared. Two sampling sites in the Riverbend region had relatively high sediment contamination, however, based on the numbers of contaminants that appeared in higher concentrations: the Connecticut River in Woodsville just below the mouth of the Ammonoosuc River, and the Wells River just above the dam near Adams Paper Company.

Metals and other elements - Several heavy metals exceeded screening levels in the Riverbend region:

- arsenic (2 sites)
- cadmium (1 site)
- lead (1 site)
- mercury (2 sites)
- nickel (6 sites)
- chromium (1 site)
- copper (1 site)
- zinc (1 site)

Pesticides - A large variety of pesticides showed up in Riverbend region sediments in the 2000 study, although in very low concentrations that do not present much risk to aquatic life.

1. *Upper Connecticut River Valley Project, New Hampshire and Vermont*. U.S. Environmental Protection Agency, Region 1 by Roy F. Weston, Inc., 2001.

Among them are endrin ketone a few miles below the Grafton County Farm, c-Permithren just above Woodsville, and 2,4′-DDD, thallium, and 2,4′methoxychlor in the Dodge Falls impoundment. The site near the breached Wyoming Dam in Guildhall showed the pesticide endrin in very low concentrations, but the highest found anywhere in the study.

Various parts of Moore Reservoir returned differing results. In very low concentrations, but at the highest levels found anywhere in the study, were carbon disulfide, four different types of PCBs, and three different kinds of dioxins and furans. Near Littleton, also in very low concentrations, but at the highest levels anywhere, were eight kinds of dioxins and furans. DDT is banned in the U.S., although other countries may still permit its use.

“We used to use motor oil to keep the dust down on our roads. We didn’t know better.”

Riverbend region riverfront farmer

PAHs - Polyaromatic hydrocarbons showed up in stream sediments in several places, such as the phenanthrene, pyrene, benzo(a)pyrene, benzo(a)anthracene, fluoranthene, and chrysene found near the mouth of the John’s River, and 10 of these contaminants were found in levels high enough to affect aquatic life. These chemicals can get into streams when roads closely follow waterways, from leaks and drips from automobiles, snowmobiles, or other vehicles, and from leaking underground storage tanks. Pyrene and benzo(a) anthracene both exceeded the screening levels at 13 mainstem sites and seven tributary sites; benzo(a)pyrene at 12 mainstem sites and seven tributary sites; phenanthrene at 10 mainstem sites and seven tributary sites; fluoranthene in seven mainstem sites and five tributary sites; anthracene at three sites, fluorene at two, and naphthalene at one site.

Hazardous waste - While many of the contaminants found in Riverbend Region sediments are traces of times when such environmental poisons as DDT were used legally, others are the result of inappropriate use and disposal of household items that can be dangerous in a river system, or of spills that have moved into groundwater.

North Country Council organizes hazardous waste collections for its member towns, although the nearest collection locations (Littleton and Lincoln) are often over an hour’s drive for area residents. In Vermont, these collections rotate among the towns, and are held every month during the summer, so it is possible to find a convenient drop-off point for hazardous waste. Paints, cleaners, pesticides, and mercury-containing items such as fluorescent lights and thermometers are examples of items that should go to a hazardous waste collection so that they don’t end up entering groundwater and then rivers and streams. However, many area residents do not understand how items collected at such an event are handled, whether it is truly worth the effort to separate this trash, and what the costs of recycling are.

D. Connecticut River Fish Tissue

In 2000, EPA worked with the four Connecticut River states to conduct a comprehensive look at toxins in Connecticut River fish.[1] 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. The concept for the study comes directly from the public, raised in the 1997 *Connecticut River Corridor Management Plan*.

Fish Consumption Guidelines:
Women of reproductive age and children under seven should eat no fish from Moore or Comerford Reservoirs, while others can eat up to two meals per month of fish from these waters. For fish taken from McIndoe Falls Reservoir, the State advises women of reproductive age and children under seven eat no more than one meal per month, except for yellow perch, which can be consumed twice per month. Other people should eat no more than six meals of yellow perch per month and three meals of all other fish. The NH Fish & Game Department's Web site has current information at www.wildlife.state.nh.us.

Methods - Biologists sampled white sucker, yellow perch, and smallmouth bass from eight sections of the Connecticut River, choosing fish species that represent different levels of the food chain and are widely found in the 410-mile long river. Smallmouth bass, yellow perch and white suckers were collected during 2000 from the mainstem of the Connecticut River and composite samples were analyzed for total mercury, coplanar (dioxin-like) PCBs and organochlorine pesticides, including DDT and its breakdown products. Riverbend Region fish were sampled as part of Reach 6 (Wilder Dam to Moore Dam) and Reach 7 (Moore Dam to Canaan Dam). Fish collected throughout each reach were run together through a blender before the composite samples were tested; therefore, fish from Moore Reservoir were combined with fish from the free-flowing part of the river upstream, making it difficult to draw conclusions about conditions in various parts of the river.

PCBs - Risk from PCBs was generally lower in upstream areas than in downstream areas, although this varied by fish species and was different for the humans, mammals, birds or fish that eat them. PCB levels do not appear to threaten fish-eating mammals or recreational fishermen in Reach 7, although this threat increases downstream in Reach 6.

Pesticides - DDT breakdown products present a threat to subsistence fishermen and fish-eating birds such as kingfishers in the Riverbend region, but not to fish-eating mammals.

Dioxins and furans - Fish in the Riverbend Region were tested for these contaminants only in Reach 7, where they were found to pose a threat to subsistence fishermen, but not to other fish consumers.

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1. *Connecticut River Fish Tissue Contaminant Study: Ecological and Human Health Screening, 2000*. Prepared for the Connecticut River Fish Tissue Working Group by Greg Hellyer, Ecosystem Assessment Unity, USEPA - New England Regional Laboratory, N. Chelmsford, MA, May 2006.

Mercury - The study found that total mercury concentrations in all three species of fish were significantly higher upstream than downstream, and particularly in Reach 7.

New Hampshire has set fish consumption guidelines for the Connecticut River and others in the state. On Moore, Comerford, and McIndoe Falls Reservoirs, the state has issued stricter guidelines due to the presence of mercury in the sediments of these fluctuating impoundments, which moves up through the food chain in its more dangerous methylated form. 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 of the Upper Connecticut River and similarly managed parts of the upper Androscoggin and Kennebec River watersheds as mercury hot spots.[1] TransCanada is developing a plan for long-term monitoring of mercury in fish tissue at Moore and Comerford as required by the 2002 license for these dams.

"Mercury contamination can no longer be viewed as a possible problem, but now enters the realm of defined reality. Real dangers to human and animal welfare exist."

Riverfront landowner, Bath

The Subcommittee is particularly concerned about contamination of fish tissue by toxins and heavy metals, including mercury delivered not only from outside the region by prevailing winds, but also introduced into the river and its sediments over the years through discarded appliances and vehicles. Mercury and dioxins are also added to the atmosphere locally by burning of trash. Backyard burning of household trash is no longer permitted, partly for this reason. Fish should be reliably safe for human consumption.

Recommendations for Sediment and Fish Contamination

- Landowners should use riparian buffers to capture pollutants before they can reach rivers and streams.

- Homeowners should reduce or eliminate use of pesticides.

- Farmers using pesticides should observe setbacks from streams.

- State and federal authorities should continue to legislate reductions in mercury contamination of the region.

A father and daughter fish the Connecticut River below Dodge Falls Dam.

1 "Biological Mercury Hotspots in the Northeastern United States and Southeastern Canada," David C. Evers et al., *Bioscience*, Vol. 57, No. 1, January 2007.

- Citizens should avoid using household items containing mercury or recycle them so the toxin does not end up in a landfill or trash incinerator where it could escape into the environment.

- North Country Council and the Vermont Waste Management Division should educate homeowners on the many benefits of household hazardous waste collection, and encourage homeowners to car-pool for convenience in using these collections.

- Homeowners should avoid backyard burning of household trash, which is illegal in both states. States and local fire departments and fire wardens should enforce the ban on backyard burning.

- Anglers should practice “catch and release” to avoid exposure to mercury-laden fish.

- EPA should work with the states to conduct a more detailed, comprehensive long-range study of sediment and fish contamination every 10 years to better understand the distribution and types of contaminants, and their trends. Develop a standard method of conducting this type of study.

E. Invasive Aquatic Species

Exotic aquatic plants and animals began to affect water bodies in New Hampshire and Vermont in the mid-1960s, and arrived in the Connecticut River in the mid-1990s, when Eurasian milfoil was discovered in Springfield, Vermont. The most recent unwanted arrival is the invasive alga Didymo, discovered in 2007 near the Old Wyoming Dam in Guildhall, Vermont, and upstream. A list of aquatic invasive species in the region appears in Appendix F.

Native plants have evolved together over thousands of years with beetles and other insects that specialized to feed on them. Exotic plants and animals, growing without such natural controls, can encroach into the habitats of native plants, disrupting the food chain and stunting fish growth. Exotic aquatic plants can interfere with boating and swimming and reduce the value of waterfront properties. Exotic animals can overcome native ones, and in the case of the zebra mussel, harm industry, recreational use, and fisheries.

Once an invasive plant or animal is established in a water body, continuous management is the only way to control it. Therefore, it is important to prevent infestations and to identify new infestations early. State biologists conduct field investigations each summer, but the efforts of volunteers in monitoring for new infestations are critical. Both states offer grants to local groups and towns for the control and treatment of exotic aquatic weeds, and have set up training programs for volunteer “weed watchers.”

Sources of invasive aquatics - Invasive species could reach the Riverbend Region in many ways. Plants such as milfoil can come in on the propellers and trailers of boats that have been in infested waters. Zebra mussel larvae can lurk in bait buckets, live wells, or engine cooling systems. Aquatic invasives could come from aquariums dumped into surface waters or from flooding of landscaped “water gardens” planted with exotic plants. Road crews can spread soil and fill contaminated with the seeds or root fragments of plants such as Japanese knotweed. Didymo apparently arrived in the Connecticut River on the soles of fishing waders belonging to a fisherman who had recently traveled to New Zealand, where Didymo is a severe problem.

Didymo - *Didymosphenia geminata* (Didymo, also called rock snot), is an invasive freshwater diatom (microscopic algae). It can form extensive colonies on the bottoms of rocky river beds, smothering aquatic life such as macroinvertebrates (aquatic insects). Didymo's stalks attach to rocks and river vegetation, and it can form masses 10-12 inches thick on the river bottom, trailing for lengths of 2-3 feet in the current. Its appearance is very unattractive, making the water less appealing for recreation. Didymo is generally a northern circumpolar species of river systems with cobble or rock bottoms, although biologists are noticing a shift to include streams in warmer climates and with more nutrients. While it may not pose a threat to sandy or silty portions of the Connecticut River in the Riverbend Region, it could affect tributary streams.

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, including bait buckets, neoprene diving gear, water shoes, canoes, kayaks, and life jackets. There is currently no way to control or eliminate Didymo. The alga can remain viable for several weeks if kept moist. The agencies have concluded that the best approach is to attempt to prevent further spread by humans, especially to tributaries.

Other Invasive Aquatic Plants - Among invasive wetland plants, purple loosestrife is still relatively uncommon in the Riverbend region, but is increasing, as is Japanese knotweed, which is rapidly taking over riparian areas such as along the Israel's River, especially where disturbed by nearby road work. The 2006 Connecticut River Aquatic Invasive Plants Outreach & Survey Project, funded by the Connecticut River Joint Commissions' Partnership Program, surveyed for invasive plants at 21 mainstem sites in New Hampshire and Vermont from Hinsdale to Pittsburg, and found few invasive plants in the five areas surveyed in the Riverbend portion. A subsequent study in 2007 was funded by the Wellborn Ecology Fund. Findings include:

- Israel's River/CT River confluence & portion of the CT River; Route 2 bridge boat launch - Japanese knotweed

- Moore Reservoir, Waterford, Vt.; Public boat launch, Riverside Cemetery Rd.- no invasive species seen

- Moore Reservoir, Littleton, N.H.; Public boat launch, Hilltop Rd. - no invasive species seen

- Moore Reservoir, Pine Island, Littleton, N.H. Public boat launch, Route 135/18 - purple loosestrife

- Comerford Reservoir, Barnet, Vt.; Public boat launch at Comerford Dam - purple loosestrife

- Connecticut River from Horse Meadows to Howard Island - purple loosestrife, Japanese knotweed, true forget-me-not, yellow flag iris

- Connecticut River near Haverhill Bridge, Newbury, Vt. - purple loosestrife, Japanese knotweed, true forget-me-not

- Connecticut River near Bedell Bridge, Haverhill, N.H. - purple loosestrife, Japanese knotweed, true forget-me-not

Moore and Comerford Reservoirs are perhaps the most vulnerable water bodies in the Riverbend Region for milfoil and other such invasive aquatic plants, since they receive many boaters visiting from infested water bodies, especially for fishing derbies. However, there is no boat/trailer check program in place at either reservoir to ensure that these boats are not delivering hitch-hiking weeds from other waters.

Invasive aquatic animals - The zebra mussel has not yet invaded the Connecticut River, which is considered one of the few New Hampshire water bodies susceptible to this invader because of the chemistry of the water. The zebra mussel is fast becoming a scourge in Lake Champlain. The status of other invasive aquatic animals in the Riverbend Region is currently unknown. Elsewhere in the watershed, exotic animals such as rusty crayfish are increasing after being released by fishermen using them as bait.

Recommendations for Invasive Aquatic Species

- State environmental and fisheries agencies should continue to cooperate to better understand and address the Didymo infestation.

- Fishermen and other recreational users 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.

- The New Hampshire Lakes Association should set up a Lake Host program, with the assistance of TransCanada and NH DES, to check for invasive species at Moore and Comerford Reservoir boat launches.

- Local outfitters and guides should educate their customers about Didymo and other invasives, and encourage them to clean their gear.

- Boaters or divers traveling from waters infested with zebra mussel 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 the buoyancy control device from diving equipment.

- Aquarium owners should not dump aquarium plants or animals into any water body, but dispose of them by freezing or drying before putting them in the trash.

- Transportation agencies and road crews should be made aware of the possibility of spreading invasive species through ground disturbance and disposal of spoil.

- Town conservation commissions should initiate programs to eliminate invasive plants before these plants become widely established, especially along roads near waterways.

IV. River Flow

Dams influence much of the Connecticut River's flow in the Riverbend region and downstream. Here, the river's flow is controlled by McIndoe Falls Dam.

A river is much more than just the runoff of rainfall. Rivers also draw their waters from underground springs, seepage from wetlands, and melting snow. The flow changes naturally during the year as the ground freezes and thaws, as trees leaf out and draw moisture from the soil, and as warm winds evaporate surface water.

Humans can affect the flow in a river by withdrawing water for irrigation or industrial use, building dams, clearing forests, filling wetlands, covering soil with hard surfaces like pavement and roofs, and by drilling wells to pump out groundwater that otherwise might reach the stream. Some of these actions, like withdrawals, simply reduce the amount of water flowing in the river. Others, such as clearing and development, send runoff to the river more quickly and erosively, rather than slowly filtered and steadily. Dams can influence river flow by holding back water and allowing only a portion to flow, and by creating an impoundment where water can evaporate more readily before it has a chance to flow downstream.

All rivers rise and fall through the year, and respond to changes in weather and watershed. A healthy river has enough water flow to keep fish and other aquatic life alive year-round. Humans depend upon the river to dilute and flush pollutants. A healthy river also floods, but humans can affect the severity and amount of damage by where they build and how they alter water's natural path to the river. Local regulations regarding protection of wetlands and shorelands are summarized in Appendix G.

A. Streamflow Gaging Stations

Gaging stations measure flow, and are useful in helping to forecast flooding, set floodplain levels and regulations, and understand historical flooding trends in river systems. Gages cited in water use permits, such as at Fifteen Mile Falls, help define operations of hydro generating plants that affect flow and improve coordination between mainstem dams and tributary flood control dams. Scientists use gage information to understand how controlling river flow has affected vegetation and wildlife in and near the river. Good river management requires good knowledge of current river conditions, now possible due to satellite communication and computer technology.

There are two gaging stations on the Connecticut River mainstem in the Riverbend Region, at Dalton and at Wells River. Links to gage data are available at www.crjc.org/riverflow.htm.

Table 1a. Active Gages in the Riverbend Region

Location	River	Gage number	Drainage area (sq.mi.)	Measurements available (real time)	Years of Record	Funding source
Dalton N.H.	Connecticut River	01131500	1,514	flow, gage height Operations at Fifteen Mile Falls dams are based primarily upon readings at this gage.	since 1928	USGS and NH DES
Wells River, Vt.	Connecticut River	01138500	2,644 (Combined flow of Connecticut, Wells, and Ammonoosuc Rivers)	flow, gage height	since 1941	USGS and NH DES
Bethlehem Junction N.H.	Ammonoosuc River	01137500	87	flow, gage height, precipitation, air temperature	since 1940	National Streamflow Information Program
Lisbon, NH	Ammonoosuc River	01137940	288	flow, gage height, air and water temperature	Since 2009	USGS and NH DES
Wells River, Vt.	Wells River	01139000	98	flow, gage height	since 1941	USGS and VT DEC and other state agencies
Victory, Vt.	Moose River	01134500	75	flow, gage height	since 1947	USGS
St. Johnsbury, Vt.	Sleepers River	01135300	42	flow, gage height	since 1988	USGS
N. Danville, Vt.	Pope Brook (Passumpsic)	01135150	3	flow, gage height	since 1990	USGS
East Haven, Vt.	East Branch (Passumpsic)	01133000	53.8	flow, gage height	since 1939	USGS
Passumpsic, Vt.	Passumpsic River	01135500	436	flow, gage height (this gage is essential for managing McIndoe Falls Dam at extreme high water)	since 1929	USGS and VT DEC and other state agencies

Funding for gage upkeep is shared by U.S. Geological Survey (USGS) with other agencies, and averages $12,500/year/gage. There have been threats to this funding in recent years as a result of efforts to cut state budgets, and gages have been eliminated.

Table 1b. Discontinued Gages in the Riverbend Region

River	Drainage area (sq.mi.)	Gage number	Years of Record
Ammonoosuc River	395	01138000	1935-1980
Connecticut River	2,825	01139500	1918-1950

New gages - New Hampshire's Rivers Management Advisory Committee has recommended new gages, particularly in the watersheds of designated rivers such as the Connecticut and the Ammonoosuc. Since more extreme weather patterns seem to be emerging, and water is an increasingly valued commodity, it is important that gages remain funded so that the data will continue to be available. USGS has worked with NH DES to install a new gage on the Ammonoosuc River below Lisbon Dam. Also being considered were a site on the Ammonoosuc River at Bath (where a gage was discontinued in 1980), the John's River, and the

Israel's River. Gaging on these high elevation and flashy (highly fluctuating flow) streams could offer protection to areas under development pressure, including Bethlehem and Woodsville. Other than Bath, none of the towns in the Ammonoosuc watershed has zoning preventing development in floodplains.

Recommendations for Gages

- USGS and states should cooperate to ensure that existing gages are maintained for public safety.
- USGS and states should cooperate to provide or restore gages on tributaries as proposed.

B. Flow & Flooding

The Connecticut River in this region typically flows heavily with spring ice-out and snowmelt, and also following heavy rains in the river's upper watershed, but the strongest influence on the river year-round is from the dams at Fifteen Mile Falls. Several tributaries, especially the Ammonoosuc, can also greatly affect the river below their confluences. At times, peak flows on the Ammonoosuc can be similar to those on the Connecticut, since it is a large, steep watershed. Heavy rainstorms can result in very high water: 6-7 inches of rain in the Headwaters region in October, 2005 brought the Connecticut River up in Guildhall higher than has been seen in the last half century.

Water from the Connecticut Lakes is the lower river's insurance in August and September, when rainfall is typically less than at other times of the year. The 2002 license for Fifteen Mile Falls set a new minimum flow from Comerford Dam. During the drought of 2002, the hydro power company supplied water from Lake Francis and the Connecticut Lakes to Comerford Reservoir to meet this requirement, with the result that water levels dropped noticeably upstream in the Lakes, prompting a legislative inquiry. Since the amount of rainfall the basin receives cannot be controlled, it is difficult to balance recreational, fisheries, and agricultural interests and power production in management of the dams in times of drought.

1. Instream Flow

Instream flow refers to how much water is flowing in a river or stream – how often, how long, when, and how fast it changes. Instream flow is affected by rainfall, snowmelt, drought, and also by damming, diversion, withdrawals, and development. This can in turn affect water quality, erosion, water temperature, recreation, nearby water supplies, and especially habitat. As a river designated into New Hampshire's Rivers Management and Protection Program, the Connecticut River is to be governed by instream flow rules to ensure that there is adequate flow for "public uses including but not limited to navigation, recreation, fishing, storage, conservation, maintenance and enhancement of aquatic and fish life, fish and wildlife habitat, wildlife, the protection of water quality and public health, pollution abatement, aesthetic beauty, and hydroelectric energy production."

Instream flow has become a topic of increasing concern since the region sustained pronounced droughts in the late 1990s that resulted in sharply reduced water levels.

Minimum flow standards, which are required by N.H. RSA 483, have yet to be developed by the state. NH DES has recently established a Protected Instream Flow for the Souhegan River and will be developing its Water Management Plan over the next few years. At this time, there are no plans to attempt to create flow rules for the Connecticut River.

Vermont considers instream flow when issuing dam permits and water quality certificates, snow-making withdrawals, stream alteration permits, and Act 250 projects. The purpose is to "assure the passage of adequate water to maintain fisheries interests, aesthetic qualities, recreational and potable water supply uses appropriate to the water body in question." The state focuses on minimum flows adequate for fisheries-related interests, and uses the "7Q10" level, which means a drought flow equal to the lowest mean flow for seven consecutive days, adjusted to nullify any effects of artificial flow regulation, that has a 10 percent chance of occurring in any given year.

Role of wetlands in determining river flow - Wetlands, even small ones high in a tributary watershed, together play a big role in absorbing rainfall and releasing it slowly, keeping flooding down. State law protects only Class 1 and Class 2 wetlands, which appear on National Wetlands Inventory Maps, and are considered significant in functions such as surface and groundwater quality maintenance, stormwater abatement, and wildlife habitat. Vermont wetlands rules restrict activities in these wetlands and in a buffer around them, but do not protect Class 3 wetlands, those determined by the Water Resources Board to not provide functions at a significant level, although the great majority of these wetlands do help protect the quality of surface and groundwater. Towns have the ability to prevent loss of this flood control "device," although only Bath and Haverhill have done so.

2. Flood Control

Natural valley flood storage - In 1994, the U.S. Army Corps of Engineers completed a reconnaissance of natural valley flood water storage within the Connecticut River watershed.[1] The Connecticut River Valley Flood Control Commission requested the study to evaluate the potential impacts if these floodplains were to be developed. Five of the Corps of Engineers' 16 flood control reservoirs had filled to capacity in 1987, pointing to the need for other ways to manage flooding.

Two of the four major flood storage areas identified on the mainstem in the four-state watershed are in the Riverbend region: 12,000 acres of floodplain in Dalton, Lancaster, Lunenburg, and Guildhall, up to West Stewartstown, N.H. and Canaan Vt., and 4,000 acres of floodplain in Haverhill, Newbury, Bradford, and Piermont.

The study concluded that development of these natural valley storage areas will indeed increase downstream flood stages and damages, and went on to calculate the cost of purchasing flowage easements on 11,000 acres of this land and the savings in future increases in flood damages. At the time, the Army Corps estimated it would cost $20 million to purchase easements in all four areas to keep these floodplains open and able to hold

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1. *Connecticut River Basin Natural Valley Storage Reconnaissance Study, Connecticut, Massachusetts, New Hampshire and Vermont, 1994.* U.S. Army Corps of Engineers,

flood waters, but would save only $181,400-$383,800 in flood damage in Vermont, New Hampshire, Massachusetts, and Connecticut. The Corps concluded it could not justify spending federal dollars to protect these floodplains, but recommended that

> *"development in the four identified mainstem reaches should be discouraged as it increases stage and flow on the river. In addition to storage of flood flows, natural valley storage areas have other values that warrant protection. Easements would have a positive impact on natural resources by curtailing or minimizing further loss of natural habitat. This would help preserve existing plant and animal communities, and maintain regional biodiversity. Preventing development would also maintain the significant benefits often provided by natural valley storage areas."*

In 2003 and again in 2004, CRJC asked the Corps of Engineers to revisit this study to see whether the cost-benefit calculations should be revised, as development threats grow in the region and as the value of flood-prone real estate grows in downstream communities. The economic value of these resources for recreation should also be considered.

Since the 1994 study, many acres of land in the Haverhill - Newbury floodplains have been conserved, primarily by farmers working with the Upper Valley Land Trust, in addition to lands conserved by the state of New Hampshire at Bedell Bridge State Park and the Grafton County Farm. The value of this conservation work was apparent during the flooding of October, 2005. However, many acres in this region and most of the Dalton-Lancaster-Guildhall floodplain remain completely unprotected from development that could increase flooding downstream. Lunenburg's floodplains are not as vulnerable, since the town does not participate in the National Flood Insurance Program, and so it is more difficult to get loans for construction in the floodplain.

Flood control dams - There are no flood control dams in this region of the Connecticut River watershed, such as have been built by the U.S. Army Corps of Engineers on more southern tributaries.

"It is a great river and has big problems when it has them."

Vermont stream scientist

Role of mainstem dams in flood control - The dams on the mainstem of the Connecticut River were built for hydro power generation, not for flood control, although when possible, they are operated to help ease flooding in the Connecticut River. The federal license for the dams at Fifteen Mile Falls requires that the reservoirs be lowered at times of high flow. However, it is a mistake to assume that even the largest hydro dams are able to control flooding at all times. 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 passing water through the generators. Following heavy rains in October, 2005, flood water exceeded storage capacity at both Moore and Comerford Dams, and flooding occurred below them.

There may be communication difficulties that are contributing to mainstem flooding. In October, 2005, 6-7 inches of rain fell in the Indian Stream watershed in the Headwaters region. Shortly afterward, a forecast for further heavy rain forced a large water release from

Murphy Dam at Lake Francis, causing water levels to rise very suddenly downstream, all the way to Guildhall and Lancaster. Area farmers suffered financial losses when equipment was stranded in lower fields. The mill at Gilman reportedly did not open its dam to relieve flooding in Lancaster until a Lancaster official called the NH DES Dam Bureau. Better coordination is needed between the managers of various privately owned dams, such as TransCanada (owners of dams at Fifteen Mile Falls and the Connecticut Lakes), Dalton Hydro (Gilman Dam), and the Dam Bureau at NH DES. An effective and reliable warning system is urgently needed above Fifteen Mile Falls, particularly to allow farmers to move equipment and livestock to higher ground. Farmers should move hay and equipment out of fields subject to such flooding as soon as they are done working, so they will not be caught off guard. The dams at Fifteen Mile Falls are equipped with sirens and other warning devices to alert those immediately downstream of water releases.


Ice jam on the Ammonoosuc River.

Role of ice in flooding - Ice jams can block the water's flow, sending it in a new path, causing a back-up of meltwater, or causing sudden release and flooding as the jam breaks. Ice plays an important part in flooding on the Ammonoosuc River. Abrasion by ice is a very significant cause of bank erosion in this region.

River dredging for flood control - Years ago, some rivers were dredged in the belief that this would create more storage room for flood water, and was actually encouraged by USDA and other resource management professionals at a time when sediment transport in streams and other stream mechanics were poorly understood. Contrary to expert advice and public opinion, extensive gravel mining contributed directly to the destabilization of river channels and increased bank erosion and flood-related property damage as the streams began to readjust to their natural shape. The states no longer permit gravel dredging in rivers except under very limited circumstances. A better way to prevent flood damage is to restore a stable stream form and protect the stream corridor from incompatible development.

3. Climate Change, Extreme Storms, and Water Resources

The Riverbend region has begun to experience some sudden, severe rainstorms, although none as devastating as the storm that affected the Cold River watershed in October, 2005. Such storms have been described as symptoms of climate change, and can have very damaging effects on smaller streams in particular.

According to the most recent research, climate change is already underway, and the Northeast can expect higher temperatures and shifting seasons, reduced snow cover, and more extreme weather.[1] How large these changes will be depends on emissions choices we make now and in the near future, both here in the Riverbend Region, in the Northeast, and globally. The economic effects of climate change in the Riverbend region may include not only costs of

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1. *Climate Change in the U.S. Northeast*. A report of the Northeast Climate Impacts Assessment, Union of Concerned Scientists, Cambridge, MA, 2006.

flood damage repair but loss of revenue-raising recreation industries such as snowmobiling and skiing, loss of the region's famous maple sugar industry, and losses for the wood products industry associated with forest type shifts.

Stream flow - During the summer, the flow of many rivers and streams is typically down, creating low water levels and putting stress on fish and other aquatic life. Fall rains usually bring the streams back up, and conditions improve. With higher emissions, however, projections show that stressful low water levels could occur nearly a month earlier in the summer and persist almost a month longer into the fall. With lower emissions, the low-flow period is also expected to expand, by roughly two additional weeks in fall.[1]

Because evaporation is likely to increase with warmer temperatures, and over a longer growing season, it could result in lower river flow and lake levels, especially in summer. Warmer water temperatures also reduce dissolved oxygen, adversely affecting fish habitat, and lower summer streamflows could reduce the ability of rivers to assimilate waste. Less flow in summer streams would mean less dilution of pollutants and poorer water quality.

Temperature - The build-up of heat-trapping gases — primarily carbon dioxide, methane, and nitrous oxide – is already affecting the earth's climate, as human activities alter the chemical composition of the atmosphere.[2] During the 20th century, the average temperature in Hanover, N.H., increased 2°F,[3] while in Vermont, the average temperature in Burlington increased 0.4°F.[4]

With continued high emissions, scientists predict dramatic warming in the Northeastern U.S. of 7 to 12°F by the end of the century, while lower emissions would cause roughly half this warming. Summers in New Hampshire and Vermont could feel like the current summer climate of North Carolina if emissions continue at their present rate. If we limit emissions, the North Country climate will still change, but feel more like the climate of Maryland.[1]

Precipitation - Climate change would do more than add a few degrees to today's average temperatures. Some places would be drier, others wetter. More important, more precipitation may come in short, intense bursts (more than two 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, and both average and extreme precipitation are expected to continue to increase. Similar increases are expected on both the lower- and higher-emissions pathways.[1] More flooding could lead to greater erosion and increases in sediment, fertilizers, and other pollutants in runoff.

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1. *Climate Change in the U.S. Northeast*. op cit.
2. *Climate Change 2007: the Physical Science Basis; Summary for Policy Makers. Intergovernmental Panel on Climate Change*, Paris, February 2007.
3. *Climate Change and New Hampshire*. US Environmental Protection Agency, Office of Policy (EPA fact sheet 230-F-97-008cc), September 1997.
4. *Climate Change and Vermont*. US Environmental Protection Agency Office of Policy (EPA fact sheet 236-F-98-007aa), September 1998.

Droughts - On a higher-emissions pathway, a short seasonal drought can be expected every year in most of New England by the end of this century, while the frequency of longer droughts could triple. On a lower-emissions pathway, the risk of drought is projected to be only slightly greater than today.[1] Such droughts could lower groundwater levels and affect the drinking water supply of some smaller towns and rural residents who depend on shallow aquifers and wells. Farmers finding reduced soil moisture in their fields due to drought and increased evaporation may turn more toward irrigation to satisfy their crops' water needs, at a time when river flow is already down, setting up a possible conflict between flows needed to support fisheries.

Snow pack - The number of days of snow cover on the ground is predicted to decline. With higher emissions, not even the Riverbend region may retain snow cover for at least 30 days during the winter by the end of this century.[1] By contrast, lower emissions would result in a 25 percent reduction in snow-covered days. Therefore, while some winter warming and reduced snowfall appears inevitable, the most extreme change is not.

Winter snow accumulation and spring melt strongly affect river flow. Precipitation that falls in early winter as rain rather than snow can run off frozen ground, rather than staying to melt in the spring. A warmer climate could also lead to earlier spring snowmelt, and result in higher streamflows in winter and spring and lower streamflows in summer and fall.

State action - Both New Hampshire and Vermont have adopted state climate change action plans:

New Hampshire Climate Change Action Plan
http://des.nh.gov/organization/divisions/air/tsb/tps/climate/index.htm

Vermont Comprehensive Energy Plan and Vermont Greenhouse Gas Action Plan, 1998
http://publicservice.vermont.gov/pub/state-plans-compenergy.html

Recommendations for Flow and Flood Control

- TransCanada, town emergency management officials, and the NH DES Dam Bureau should cooperate to create a warning system for riverfront towns and landowners to warn of coming high water or dam failure, and coordinate with managers of other dams in the area.

- Farmers should move hay and equipment out of fields subject to flooding as soon as they are done working.

- Towns should survey smaller wetlands so they know where they are, and consider adding protection for them in towns that do not have such protection in place. Landowners should avoid filling wetlands.

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1. *Climate Change in the U.S. Northeast.* A report of the Northeast Climate Impacts Assessment, Union of Concerned Scientists, Cambridge, MA, 2006.

• New Hampshire towns should ask regional planning commissions for help with a survey of culverts and bridges, to identify those that may be under sized. Develop a simple method to calculate this in chart or graph form. Landowners should check culverts on their land often to be sure they are not blocked.


Pumpkins afloat in October, 2005. The Upper Valley Land Trust has conserved many acres of agricultural floodplain here in Newbury and Haverhill, protecting agricultural soils while also preserving their ability to help protect those downstream against flooding. Photo credit: Valley News

• Land conservation organizations, NRCS, and the U.S. Army Corps of Engineers should purchase development rights from willing owners of land in the natural valley flood storage area to help prevent flooding downstream.

• Towns should consider enacting a floodplain ordinance similar to Bath's.

• TransCanada should communicate with the states and the US Fish and Wildlife Service under extreme weather conditions, in order to operate its dams to manage the river in an environmentally sensitive manner. Compromises must be made, and guidance from these agencies will help achieve the best result.

• Town emergency management plans should call for better coordination with dam managers. Towns should participate in testing of the Connecticut River Emergency Action Plan in 2008.

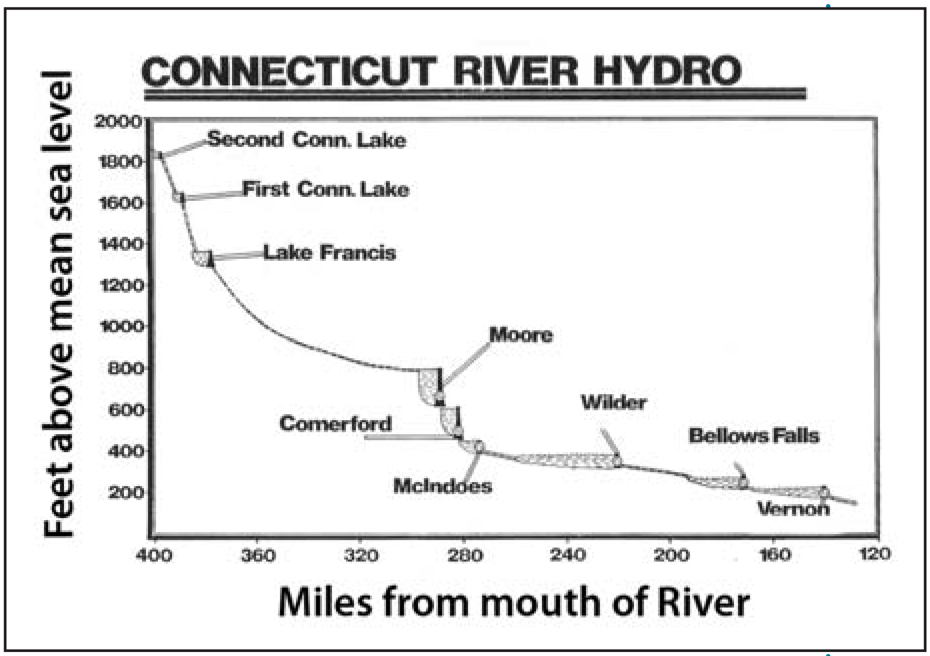
• Vermont should establish a way of registering water withdrawals and share the information with New Hampshire. If water is withdrawn from non-impounded parts of the river, New Hampshire water withdrawal registration rules should apply.

• Water quality agencies should educate riverfront landowners about registering their water withdrawals.

• Citizens and states should support federal initiatives to curb emissions of gases that cause climate change.

V. Working River - Hydro Power Dams

The Connecticut River is more heavily developed for hydropower generation in the Riverbend region than anywhere else on its four-state path. Five dams power riverside industry or send electricity throughout the region, including the two largest hydro dams in New England. A sixth dam is now breached. The river now flows freely for 85 miles from Murphy Dam at Lake Francis in Pittsburg before encountering the Gilman Dam in Lunenburg, Vt. and Dalton, N.H., a run-of-river dam owned by Dalton Hydro and leased by Dirigo Paper Company, and then enters a 30-mile run that is almost entirely managed for peaking hydro generation, before once again passing through a run-of-river dam between Monroe, N.H. and Ryegate, Vt.



Location of Moore, Comerford, and McIndoe Falls Dams on the upper river, showing the change in elevation at 15 Mile Falls. From New England Power Company.

Just below Gilman Dam, the river enters the stretch still known as Fifteen Mile Falls, a series of cascades legendary among river drivers that was transformed in the mid-20th century by construction of two massive dams. Moore Dam (between Waterford, Vt. and Littleton, N.H.) changed the face of this steep and rocky part of the river to a vast, 11-mile-long, lake known as Moore Reservoir. Cemeteries and entire villages were moved before the valley was inundated for the project. The flooded stone walls and farmhouse foundations of the villages of Waterford and Pattenville can still be seen on the lake bottom. Upon leaving the tailrace at Moore, the water soon enters the impoundment behind Comerford Dam (between Barnet, Vt. and Monroe, N.H.), and then flows once again as a river for a short distance to the much smaller impoundment behind McIndoe Falls Dam (also in these towns) three miles downstream. Just below this dam, which serves to dampen the fluctuations from the two larger dams above, the river enters the four-mile-long, stable impoundment behind the Dodge Falls Dam between Ryegate, Vt., and Bath, N.H. The river below Dodge Falls is free flowing once again until it reaches the Wilder impoundment at Newbury/Haverhill.

Because the state line follows the original west bank of the river before construction of the dams, nearly half of Moore, Comerford, and McIndoe Falls Reservoirs are considered Vermont waters.

In addition to mainstem dams, there are nine hydro power producing dams on New Hampshire tributaries in this region, including one on Garland Brook in Lancaster, one on Pettyboro Brook in Bath, and two on the Ammonoosuc River, in Bath and Haverhill.

A. Fifteen Mile Falls

The three dams at Fifteen Mile Falls were purchased in 2005 by TransCanada Hydro Northeast from USGen New England. All three dams are daily peaking generation plants, storing and releasing water during periods of the day, and are controlled remotely through connections to Wilder Dam in Wilder, Vt. The timing and amount of this release depend mostly upon flow conditions in the river and upon market price for electricity, but also include a new and higher minimum flow.

1. 2002 License

The federal operating license for Fifteen Mile Falls was renewed in 2002 and expires in 2042. To prepare for re-licensing, then-owner New England Power Company selected an Integrated Licensing Process, inviting federal and state agencies and other interested organizations to participate in shaping the terms of the new license. These terms were negotiated over a period of five years with a diverse group of stakeholders including state and federal agencies, Trout Unlimited, and the Connecticut River Watershed Council, with CRJC, North Country Council, and Northeastern Vermont Development Association representing the interests of the affected towns in the negotiations. Recommendations of the Riverbend Subcommittee were included in these discussions, and many were adopted into the new license. Communication among TransCanada, area towns, landowners, and the public about the management of the dams, associated lands, and recreation amenities, begun during relicensing of the dams, has been useful and should continue.

The new license continued the company's ability to operate the dams as peaking hydro power generation plants, but made several changes to improve habitat quality in this reach of the river. Operations were altered at McIndoe Falls Dam to restore some of the upstream end of the impoundment to a riverine condition. The new license requires a minimum discharge from Comerford Dam, to provide more reliable flow to sustain fish in the many miles of river below the dam. The company agreed to place 6500 acres of lands surrounding Moore Reservoir under the protection of conservation easements. Planning for this protection is underway but, seven years later, not all the land has been conserved. The re-licensing process also resulted in an agreement for management of water storage and lands at the Connecticut Lakes.

The company also established the Upper Connecticut River Mitigation and Enhancement Fund, providing a source of funds for projects aimed at improving conditions in the river from the confluence of the White River north to the headwaters. The fund is administered by the New Hampshire Community Foundation's Upper Valley office, and is expected to provide approximately $12 million over a 15-year period for river restoration, wetland protection, restoration and enhancement, and shoreland protection. The fund also provided substantial grants to the towns in which the dams are located.

2. Peaking Hydro Power Dams

Table 2a. Fifteen Mile Falls - Riverbend Region

	Moore Dam	Comerford Dam	McIndoe Falls Dam
Owner	TransCanada Hydro Northeast	TransCanada Hydro Northeast	TransCanada Hydro Northeast
Date constructed	1957	1930	1931
Location	Littleton N.H. - Waterford Vt.	Barnet Vt. - Monroe N.H.	Barnet Vt. - Monroe N.H.
Dam type	concrete and earthen	concrete	concrete and earthen
Dam dimensions	178 feet high, 2920 feet long (Largest dam in New England)	170 feet high, 2253 feet long (Second largest dam in New England)	30 feet high, 730 feet long
Operating limits	769 - 809 feet above mean sea level (msl)	610 - 650 feet above msl	447.5 - 451 feet above msl
Normal operating range	804 - 806 feet above msl	646 - 648 feet above msl	447.5 - 451 feet above msl
Required minimum flow per hour	320 cubic feet per second (cfs) or inflow if less; special bass spawning flows May 21 - June 30 (keep reservoir at or above 802', no drawdown more than 2' from max elev)	818 cfs June 1-Sept 30; 1145 cfs Oct 1-March 31; 1635 cfs April 1-May 31; special bass spawning flows May 21 - June 30 (keep reservoir at or above 645', no drawdown more than 2' from max elev)	1105 cfs June 1-Sept 30 2210 cfs Oct 1-March 31 4420 cfs April 1-May 31
Spill capacity	18,000 cfs/hour	18,000 cfs/hour	24,900 cfs
Fish passage	none	none	downstream only, gate following
Impoundment	3500 acres, 11 miles long	1,093 acres, 8 miles	543 acres, often less since operating levels are three feet lower due to new license
Bypass	none	none	none
Generating capacity	192 megawatts	164 megawatts	13 megawatts
Watershed drainage area	1600 square miles	1,635 square miles	2,210 square miles
Hazard to Life Code	high hazard potential; inspected every 2 years	high hazard potential; inspected every 2 years	low hazard potential; inspected every 6 years

Moore Dam - Management of this dam throughout the year follows a series of general steps. In early February, drawdown of the reservoir starts in preparation for spring runoff, and reaches the 778-foot elevation by early March. By the end of March, or when spring runoff actually begins, the reservoir will be down in the range of the 770-foot elevation, or nearly 40 feet below the maximum elevation. While Moore can store a large amount of water, it cannot capture all of the spring runoff from upstream, so the company continues to maintain a low reservoir as long as possible, and will start to store water when the river's inflow reaches 13,000 cubic feet per second (cfs) or if flooding begins downstream. In the summer, and during other times of low flow, water stored at Moore Reservoir helps maintain flows downstream to Wilder, Bellows Falls, and Vernon Dams and in the river between them. In early September, Moore Reservoir is lowered to the 800-foot elevation to make room for fall rains. Water released from Lake Francis in Pittsburg reaches Moore Dam in approximately 44 hours.

Comerford Dam - This dam was the largest of its kind when it was built, later surpassed only by its neighbor, Moore Dam. During summer months, the company maintains a minimum elevation of 646 feet above mean sea level for recreational use, which also leaves storage capacity to capture rain. Discharge from Comerford is limited by the amount of storage room in McIndoe Falls Reservoir. The winter drawdown is kept short due to Comerford's smaller storage capacity, and begins in mid to late February. By mid March, the elevation is at 630-635 feet. During the beginning of spring runoff, Comerford Reservoir is filled back to 645 feet. Water released from Moore reaches Comerford Dam in one hour.

The 2002 license included a new minimum flow from Comerford Dam. During a prolonged drought in 2002, the hydropower company responded to extreme weather conditions, and, with the approval of state and federal agencies, reduced the minimum flow from Comerford Dam to the level set by the previous license in order to avoid drawing too heavily on water levels in the Connecticut Lakes, although effects in the Lakes still included waters that retreated far beyond docks and other water-dependent structures.

McIndoe Falls Dam - While McIndoe Falls Dam also produces electricity, its primary purpose is to dampen the swings in river flow coming from Comerford and Moore. Water released from Comerford reaches McIndoe Falls Dam in one hour. Water released here takes eight hours to flow to Wilder Dam. The new license for Fifteen Mile Falls included a reduced elevation for the impoundment at McIndoe Falls Dam that returned some three miles of the Connecticut River to a free-flowing riverine condition and other formerly flooded areas are now emergent wetlands, although these areas may sometimes be inundated at very high water.

Emergency Management Plans - Towns that may be affected by dam failures should have emergency management plans in place. Bath's current flood maps related to dam failure are inaccurate and are presently being updated. The most recent Connecticut River Emergency Action Plan was tested in 2008, providing an opportunity for towns to participate.

B. Other Mainstem Dams

Three other dams straddle the Connecticut River in the Riverbend Region. The uppermost, the breached Wyoming Dam, occupies the site of a waterfall and the oldest dam site on the northern river. Gilman Dam and Dodge Falls Dam continue to supply power for industry and are operated as run-of-river dams.

1. Breached Wyoming Dam

The oldest dam site on the northern Connecticut River is between Guildhall and Northumberland at the northern end of the Riverbend region. A dam has been located here since the 1700s with the latest rebuilt in 1936. In 1916, local newspapers reported that "the huge paper machine of the Hall & Richter Paper Co. is now making its full day's work and business is humming at Northumberland Falls. The company is making a large shipment of newspaper..."[1]

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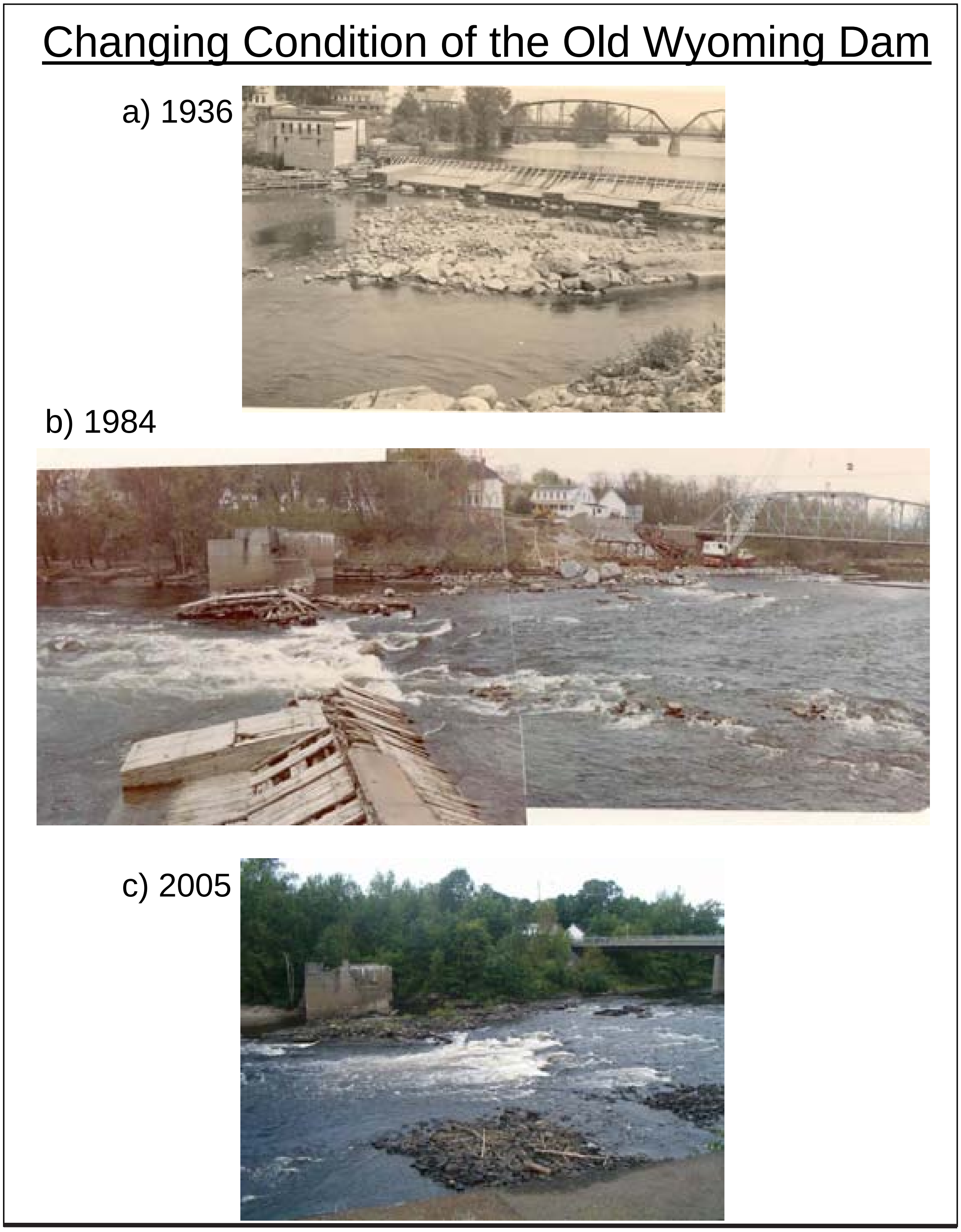
1. cited in Coös County Democrat, June 21, 2006.

In the mid-1980s the river overcame the dam and only the abutments at the margins of the channel remain above water level today. Here, the river races over the remains of the dam's concrete and timber crib.



The river reclaims the site of the Wyoming Dam. Source: Field Geology Services.

Attempts were made to rebuild the dam despite objections from Vermont. As the New Hampshire Legislature considered the nomination of the Connecticut River into the Rivers Management and Protection Program in 1992, NH DES proposed changing the designation of this part of the river from “community” (which would have permitted reconstruction of the dam) to “rural-community” (which would not permit reconstruction), although this change was not eventually adopted by the legislature. Reasons cited by the department were adverse impact on fisheries and concern that the James River Paper Company, just upstream in Groveton, would have to upgrade its water pollution controls if it had to discharge into a reservoir rather than into a free flowing river. Oxygen returned to the river here is critical to the river’s ability to assimilate treated wastes.

EPA’s 1998 study of sediment in this area found low concentrations of DDT breakdown products, once used locally on Colorado potato beetles, but concluded that there is no significant environmental concern as sediments captured above the breached dam are washed downstream as the dam continues to degrade.[1]

In 2005, CRJC sponsored a study of the breached dam by fluvial geomorphologist John Field.[2] Surveys and hydraulic modeling show that the breaching of the dam has resulted in a minimum 3.0 foot drop in water level and a doubling of the water surface slope since the dam was breached. The related increases in stream velocity are probably a primary cause for the extensive erosion and bank slumping along the 40 foot high banks in the 3.3 mile reach between the dam site and the Upper Ammonoosuc River confluence. The study concluded that the breaching of the dam is an important cause of erosion at the Northumberland Cemetery near this confluence. Although the dam is over three miles downstream of the cemetery, the extremely low gradient of the river through this reach allowed water impounded behind the dam to back up several miles upstream. The hydraulic modeling did not extend above the backwater influence of the dam, so the total length of river impacted by the breaching of the dam is not known.

2. Gilman Dam

Until recently, Dirigo Paper Company leased and operated the paper manufacturing part of the facility at the dam owned by Dalton Hydro LLC. During the summer months, the crest gate is lowered to spill a 210 cfs minimum flow when the river flow drops below 1,000 cfs, to protect water quality and improve the potential dissolved oxygen deficit that may exist below the dam. The generators are operated to maintain the impoundment at an elevation of 833.3 feet at all times. During spring runoff, the crest gate is fully open and bladders deflated to pass the maximum amount of water through and over the dam to alleviate upstream flooding. The dam was built to handle flows of 55,000 cfs. Water released from Lake Francis in Pittsburg reaches the Gilman Dam in approximately 24 hours.

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1. Peter Nolan, EPA, pers. comm. 2/24/2000.
2. *Bank Stabilization Implementation and Assessment of the Connecticut River near Colebrook and Groveton, New Hampshire: Final Report.* Prepared for Connecticut River Joint Commissions by Field Geology Services, Farmington, Maine, January 2006.

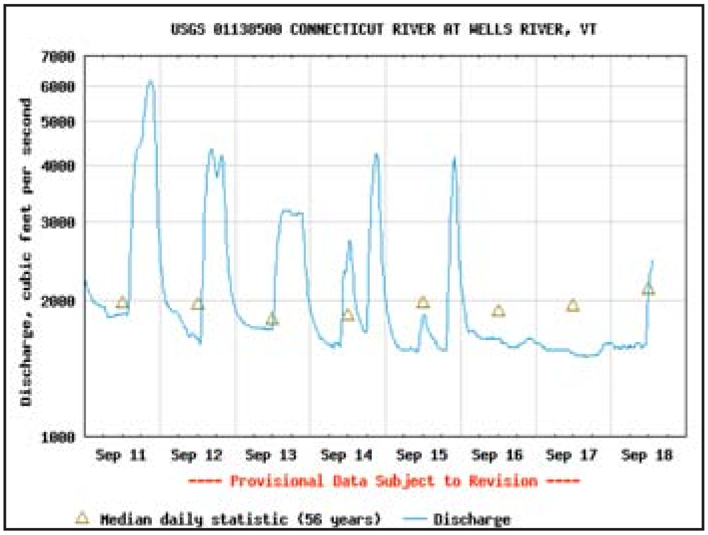
Gilman Dam is preparing to replace the existing hydro intake trash racks and downstream fish passage (as requested by the U.S. Fish & Wildlife Service), install a new trash rack truck dock and new powerhouse foundation, and build extensions to the existing tailrace retaining walls. Concrete debris remains in the river channel from the dam's original construction.

3. Dodge Falls Dam

This dam, located between Ryegate and Bath, is exempt from FERC licensing requirements. It is owned and operated by Essex Hydro. The dam was used until 1966 to supply waterpower to drive pulp grinders at the CPM Paper Mill in Vermont. The river provides process water. In the late 1980s, a reinforced concrete powerhouse with an integral intake was constructed on the New Hampshire side of the dam. A 60-foot section of the dam was removed and a 75-foot side spillway was constructed along the right side of the forebay to compensate for the loss in spillway capacity. A 60-foot tailrace was excavated in rock to carry flows back to the main channel. A requirement for upstream fish passage will be triggered by the number of Altantic salmon reaching this dam.

Table 2b. Run of River Hydro Electric Dams - Riverbend Region

	Gilman Dam	Dodge Falls Dam
Owner	Dalton Hydro, LLC	Essex Hydro
Date constructed	originally built ~1900, washed out in 1927 flood; 1927 timber crib/rock filled structure was rebuilt in 1996	updated in 1986
Location	Gilman, Vt. - Dalton N.H. River mile 299	Ryegate, VT - Bath NH River mile 269
Dam type	concrete	grouted, rock-filled timber crib with a timber crest and wood-plank facing.
Dam dimensions	38 feet high, 319 feet long	15 feet high, 485 feet long
Operating limits	run of river	run of river
Required minimum flow	210 cfs spill over crestgate when river flow is less than 1000 cfs from June 1- Oct 15	no requirements
Spill capacity	~24,000 cfs at 835 foot elevation	
Fish passage	none	none
Impoundment	2.9 miles, 130 acres	4 miles
Generating capacity	4850 kilowatts	5000 kilowatts
Watershed drainage area	1514 sq mi	2215 sq mi
Hazard to Life Code	low hazard potential	low hazard potential; FERC responsible for safety



USGS stream gage data show fluctuating water levels in the Connecticut River from operations at the Fifteen Mile Falls hydro projectups tream.

C. Effects of Dams

1. Black Start

Unlike power plants using non-renewable energy sources, hydro dams can provide a "cold" or "black" start to the electrical grid, as the Connecticut River hydro dams did during the widespread blackout of the Northeast in 1965. A small generator provides enough power to open the gates, allowing water flowing through them to produce power first to re-start other power plants throughout New England, and then to provide power for consumers.

2. Influence of Fifteen Mile Falls

The three dams of the Fifteen Mile Falls project benefit the river and the region in several ways. They provide energy without using fossil fuels, and are important contributors to the tax base of the towns in which they are located. By inundating tributary mouths and other low-lying areas, the dams have created backwaters and wetland areas that provide habitat especially for waterfowl, warm water fish, and other wildlife. The flatwater pools provide deep water for power boating and other forms of recreation not possible on the river until the dams were built, although paddlers now must portage around the dams. The dams also provide a way to influence water levels during times of flooding, ice breakup, and drought.

The dams also change conditions for aquatic habitat and species. Dams which impound water alter the natural character of the river and change the pattern of flow, so that the river behaves more like a lake. Water temperatures in the impoundment increase as a result of the greater surface exposure to sunlight, leading to reduced dissolved oxygen and reducing habitat quality for trout and other coldwater fish. Warm-water species such as walleye, perch, and bass now inhabit the warmer water of the impoundments, using the shallows of tributary setbacks for spawning. Because water flow is slow in the impoundments, nutrients and contaminants may accumulate as they are not as quickly flushed, and some sediment and toxic substances may settle out in the quieter water. Floodplains no longer function as before, because the dam can alter patterns of flooding and sediment deposition.

3. Water Level Fluctuations

While there are many causes of riverbank erosion, an important one is water level fluctuations from operations at the dams. Rapidly changing water levels can cause pressure imbalances at the water-saturated bank face, causing water to leak out of the bank, carrying small particles of soil with it. This is called soil piping, and it can lead to bank collapse. In Dalton, for instance, observers have noted cavities in the riverbank that reach back five to six feet, undercutting even heavily forested banks. Since these cavities remove physical support for the trees above, they could result in bank failure. The cause of these cavities is deserves investigation.

TransCanada operates within the terms of its federal license for Fifteen Mile Falls, raising and lowering the water level within limits. However, its 2002 license does not include a "ramping rate" to provide for gradual changes in water level through limits on how quickly the impoundments can be raised or lowered. The permit allows the dams to release water quickly in case a black start is required. Warning signs and sirens below the dams alert boaters and fishermen that the water may rise very suddenly. The significant water level fluctuations at Moore and Comerford appear to result in changes to mercury in river sediments, allowing bacteria in the sediments to convert it to its more toxic form, methylmercury.[1]

D. New Dams

The New Hampshire Rivers Management and Protection Act permits new dams only in a designated "community" segment, if construction of a dam is consistent with protecting the resources for which the segment was designated, and only if the dam is run-of-the-river, has no significant diversions, and impoundment height is constant and not above the maximum historic level for the site. In river segments designated natural, rural, or rural-community, the Act allows repair of a dam which was in place when the river was designated in 1992, at the same place and with the same impoundment level, but only within six years of the failure.

The law appears to provide one location where a new dam may be built on the Connecticut River in the Riverbend region: the confluence of the Ammonoosuc River in Woodsville to a point 1.9 miles downstream. Only a low flow, low head dam would be possible in this setting, but it would impound a highly scenic and historic site and the only free-flowing part of the river between Dodge Falls and Wilder Dams. The six designated "community" segments in the Riverbend region are located at:

- Former Wyoming Dam (from one mile above to one mile below the dam)
- Gilman Dam (0.3 miles above to 0.3 miles below the dam)
- Moore Dam (0.4 miles above to 0.6 miles below the dam)
- Comerford Dam (0.3 miles above the dam to 0.2 miles below McIndoe Falls Dam)
- Dodge Falls Dam (0.3 miles above to 0.2 miles below the dam)
- The 1.9 mile segment in Woodsville and Wells River from the Ammonoosuc River to the

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1. *The Connecticut River Fish Tissue Contaminant Study*. U.S. Environmental Protection Agency Region I, 2000. (released 2006).

point where Routes 135 and Route 10 meet in Haverhill.

Plans for rebuilding the Wyoming Dam were abandoned in 1992 over concern that creating an impoundment could result in violations of state water quality standards for dissolved oxygen, since there has been a discharge from the Groveton paper mill several miles upstream.

Recommendations for Dams

- Water quality agencies should cooperate with TransCanada to educate local citizens about how the Connecticut River is managed in the region, the terms of the Fifteen Mile Falls Settlement Agreement, and how drought affects river management.

- TransCanada should communicate with the states and the U.S. Fish and Wildlife Service under extreme weather conditions, in order to operate its dams to manage the river in an environmentally sensitive manner. Compromises must be made, and guidance from these agencies will help achieve the best result.

- Citizens and local citizen groups should encourage continued communication between TransCanada and its successors, with local communities and landowners.

- Town emergency management plans should call for better coordination with dam managers.

- TransCanada should update and correct Emergency Action Plans for Moore and Comerford Dams as planned.

- States should discourage dam construction on the Connecticut River in Woodsville.

- County conservation districts and conservation commissions should survey the riverbank for the presence of eroding cavities.

VI. Using the Water

A. Water Withdrawals

Water withdrawals could influence the instream flow of the river, even here in the Riverbend region where the river has gained substantial size. Its status as a designated river in New Hampshire's Rivers Management and Protection Program shields the Connecticut River from actions that would divert its water outside of New Hampshire's portion of the watershed. The public expects that the water will continue to be there, despite growth in the region and the possibility that demand for water for industry, irrigation, waste disposal, and household use will rise.

New Hampshire water withdrawals - New Hampshire requires registration of water withdrawals over a certain size, but does not require a permit unless there is a physical disturbance to the river. There is no charge for using the public's water. This registration program helps identify potential future problems of well interference, declining water tables and/or diminished streamflows, but does not actually limit withdrawals or provide a means of avoiding these problems.

There are 16 registered water withdrawals on this segment, including seven water suppliers and nine hydro power producers. While the dams do not actually withdraw water from the river, their use of river water is recorded as a withdrawal. A list of registered water withdrawals appears in Appendix H.

Vermont water withdrawals - Vermont requires permits for water withdrawals from in-state waters, limiting them to the "7Q10" level. This level is the lowest mean flow for seven consecutive days, disregarding artificial flow regulation, that has a 10 percent chance of occurring in any given year. However, the state has no system for tracking withdrawals from the Vermont side of the Connecticut River. The amount of water that would otherwise have flowed in the Connecticut River from Vermont is unknown. Gray's in Newbury and Peaslee's in Guildhall are the Vermont farms in this region withdrawing directly out of the Connecticut River for irrigation.

Recommendations for Water Withdrawals

- Vermont should establish a way of registering water withdrawals and share the information with NH. If water is withdrawn from non-impounded parts of the river, NH water withdrawal registration rules should apply.

- Water quality agencies should educate riverfront landowners in New Hampshire about registering their water withdrawals.

NH policy on surface water withdrawals

New Hampshire requires registration of water withdrawals with the NH Geological Survey of DES that exceed 20,000 gallons per day averaged over any 7-day period from a single location or exceed a total of 600,000 gallons during any 30-day period. Once registered, monthly water use must be reported on a regular basis as long as the source is being used. No permit is required unless the withdrawal involves a physical disturbance to the bed or banks of the river. Examples of those affected uses include: water supply for domestic, commercial, industrial or institutional use, dilution of treated or untreated municipal or industrial discharges, including industrial process water, contact and non-contact cooling water, water for agricultural irrigation and snow making, and water used for power generation.

VT policy on surface water withdrawals

The proper management of water resources now and for the future requires careful consideration of the interruption of the natural flow regime and the fluctuation of water levels resulting from the construction of new, and the operation of existing, dams, diversions, and other control structures. These rules provide a means for determining conditions which preserve, to the extent practicable, the natural flow regime of waters. Act 250 and Stream Alteration permits may be needed, as well as a permit from the U.S. Army Corps of Engineers and a Section 401 Water Quality Certification. For most types of water withdrawals, the Agency has adopted a procedure for determining the minimum streamflow necessary to meet Vermont Water Quality Standards.

B. Groundwater and Drinking Water Supplies

While no individual actually owns groundwater, clean drinking water may be our most valuable and under-appreciated commodity. In the Connecticut River watershed, stratified drift aquifers, where large stores of groundwater are available, are closely related to the river and its tributaries. Surface water and groundwater are closely linked. 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.

1. Identifying and Regulating Groundwater Supplies

Stratified drift aquifers have now been mapped for New Hampshire. The New Hampshire State Geologist is now pursuing even more detailed mapping in towns along the Connecticut River south of this region, to give a more precise idea of where water supplies are located. This mapping also identifies glacial lake deposits, or varves, which can be unstable for development.

"Groundwater is literally the life blood of the area."

Bath planning board member

Vermont's aquifers have not been mapped as comprehensively as New Hampshire's, although the state is now moving in this direction. An older set of "Groundwater Favorability maps" covering most of Vermont show rough aquifer delineations based on surficial geology. Source Protection Area maps are available for Vermont community water systems.

Groundwater regulation by the states - In New Hampshire, 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. The legislature's intent is to prevent harm to existing water users and nearby ponds, streams, and rivers from large withdrawals at a new well, such as for a bottling plant.

Vermont requires that new public community water systems have delineated 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 until very recently remained a target for commercial water bottling companies looking for private profit from a resource that belongs to the public.

2. Threats to Groundwater

Groundwater, which many people pump into their homes for drinking, can be contaminated by a long list of pollutants which are difficult if not impossible to remove. Septic systems located within the floodplain and inadequate or failed septic systems are a problem, because they can send disease-carrying pathogens, and whatever else homeowners put down the drain, to groundwater which may also reach the river. Leaking underground fuel storage tanks, chemical spills, pesticide and fertilizer application areas, leaking sewer lines, junkyards, auto service centers, dry cleaners, industrial sites, sludge piles and lagoons, landfills, metal-working shops, improperly built manure storage, and even cemeteries can contaminate groundwater. Both states have set up permitting programs to eliminate groundwater contamination by the improper disposal of waste.

Malfunctioning or inadequate septic systems and leaking underground storage tanks can result in surface or groundwater flow of effluent into waterways. The failure of septic systems in the years to come can be expected. The potential for pollution from existing systems during flood periods is also a real threat. If more development is allowed to occur in the floodplain, the probability increases that both of these problems will threaten the river.

MtBE - The gasoline additive MtBE (methyl tertiary butyl ether), which was introduced after lead was removed from gas in the 1980s and was intended to increase the octane rating and reduce air pollution from burning gasoline, proved to be a worrisome problem for groundwater. MtBE is considered a possible carcinogen. It degrades very slowly, is colorless, and is highly soluble in water. Leaking underground fuel storage tanks have allowed this contaminant to pollute groundwater in southeastern New Hampshire. In the Riverbend region, it has appeared in Barnet.

Salt - Salt contamination is a growing concern. Salt above a certain level in groundwater makes the water unhealthy for drinking, since it can lead to high blood pressure and other diseases. Salt dissolves easily in water, and can reach groundwater through road salting, road salt storage areas, and places where snow is dumped, since there is often road salt mixed with the snow. For more on this issue, see Roads and Railroads.

3. Protecting Drinking Water Supplies

Recent studies demonstrate that conserving land to protect drinking water quality makes good economic sense. A study of 27 surface water supplies in watersheds with 10 to 60 percent forest cover found that the more forest cover in a watershed, the lower the treatment costs. For every 10 percent increase in forest cover, treatment and chemical costs decreased approximately 20 percent.[1]

While clean drinking water is essential, few communities have taken steps to protect it. A 2000 New Hampshire study 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 or plume area around their wells (75-400 feet).[2] Local regulations regarding groundwater protection are summarized in Appendix G.

New Hampshire's Source Water Protection Program offers grants to help communities conserve land around their public water supplies to protect the quality of the water that

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1. *Protecting the Source: Land Conservation and the Future of America's Drinking Water.* Trust for Public Land and the American Water Works Association, 2004.
2. Research funded by NH DES and performed by the Society for Protection of NH Forests.

reaches the wells. Vermont currently offers low interest loans from the Drinking Water State Revolving Fund for public water supply protection, but not a specific grant program. However, each state's conservation license plate program offers grants that can be used to protect water supplies.

In the Riverbend subcommittee region, only Bath and Newbury regulate the use of land over underground water supplies, and have identified public well supply areas. Barnet requires an on-site sewage disposal buffer around water supplies.

Drinking water contamination has a high cost, both in terms of human health and the money that must be spent to clean up the contamination and provide a safe source of water. Many communities and businesses are struggling with such problems in other parts of both states and farther south along the river. The Riverbend Subcommittee believes it is more cost-effective to protect sources of drinking water than wait and address contamination happens when it happens.

Recharging groundwater - The quantity of groundwater is as important as the quality. If groundwater supplies drop, there is less water to feed both wells and streams. Prolonged drought is one of the few causes of reduced groundwater levels that people cannot control. Changing the surface of the soil, such as through paving, development, or diversion through storm drains, prevents rain and melting snow from soaking into the soil to restore or "recharge" groundwater. By building many small vegetated areas, such as "rain gardens" to capture water that might otherwise have run off, and keeping impervious surfaces and development on steep slopes to a minimum, careful developers can invite water to soak in and recharge groundwater as it might have naturally.

Most water is used locally, and eventually goes back into the groundwater or river. However, sometimes the groundwater is withdrawn and not replaced in the same watershed. Imagine water pumped from an aquifer in Barnet to be sold as bottled water in Burlington. The water will not return.

Recommendations for Groundwater

- New Hampshire should continue to develop and improve aquifer maps.

- Vermont should identify and map groundwater supplies.

- States and towns should train and encourage developers to provide vegetative buffers and maintain connections between wetlands within development projects.

- Vermont should enact a system for regulating large groundwater withdrawals.

- Towns should confirm with the state if their identified water supply information is correct.

- Town planning boards and commissions should consider surficial geology mapping for more specific groundwater supply information and evaluate water supplies for short and long term growth.

- Towns should identify old dump sites to look for those close to ground and surface water supplies.

- Towns should ensure adequate setbacks and lower density for clearing, building, and septic systems.

- Towns should consider wellhead protection; take advantage of source water protection grant and loan programs.

- Towns should not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, snow dumps, wastewater or septage lagoons, and outdoor salt storage or other de-icing chemical storage to be located on aquifers.

The Connecticut River slips beneath the Mt. Orne Covered Bridge between Lunenburg, Vt. and Lancaster, N.H.

- Town conservation commissions should educate people to handle automotive fluids, pesticides, and other chemicals properly so they don't contaminate their own wells, and to keep their septic systems in good operating condition.

- Towns should ask developers to keep natural drainage patterns and use swales and depressions ("rain gardens") to reduce runoff and recharge groundwater.

VII. Land Use & Water Resources

A. Point Source Pollution

Thanks to the Clean Water Act and considerable federal, state, and local investments, riverfront industries and communities no longer pipe untreated poisons and pathogens to the river. The federal government once bore 80 percent of the burden of building wastewater treatment plants and the state contributed 10 percent. The government's participation has evaporated in the years since, leaving towns responsible for the heavy cost of upgrading their plants to meet new needs.

1. Wastewater Discharges

Careful management of wastewater discharges is important for public safety and for the health of the streams that receive these discharges. Many of the area's wastewater treatment plants were built 30-40 years ago, when substantial federal assistance was available. The cost of wastewater treatment plant maintenance and improvements, including separation of combined sewer overflows, is very high for small towns, and except for briefly available federal stimulus funds, there is no longer federal money to help with this cost.

Overflows - From time to time, untreated sewage reaches the Connecticut River. For example, on August 20-21, 2006, the Lunenburg Fire District #2 Pump Station accidentally discharged an estimated 37,000 gallons of untreated sewage to the Connecticut River. The public should be notified when such incidents occur.

Pharmaceutical and personal care product pollutants - Many substances, some harmful and some not, can pass through wastewater treatment systems and are not removed before the water is discharged into rivers and streams or when septic system leachate passes into groundwater. Scientists have only been able to detect these chemicals in streams since about 2000, and little is known about their effect upon groundwater. In 2002, 80 percent of streams sampled (139 rivers in 30 states) by the U.S. Geological Survey showed evidence of drugs, hormones, steroids, and personal care products such as soaps and perfumes.[1] While no studies have been done in the Connecticut River watershed to see whether this is a problem, disturbing evidence of the effects of these chemicals has been found in deformed fish in other rivers, including the Potomac and Shenandoah.

Painkillers, antibiotics, contraceptives and other hormones, chemotherapy drugs, and other medicines can pass through the body and through a wastewater treatment plant. Antibiotics flushed down the toilet can harm the beneficial bacteria that break down waste in septic systems and wastewater treatment plants. Hormones, fragrances, other substances have been detected in all urbanized and farm-intensive watersheds in the U.S. Cosmetics, cleaners, insect repellant, and even nicotine and caffeine have been detected in some studies of waterways. Wastewater treatment plants are not required to upgrade to remove these chemicals. Most tend to be largely removed or broken down but remain in sludge, where they usually do not mix with water but could become a problem if biosolids erode into streams or if pH changes. Biosolids aged more than 15 days are safer than fresher sludge.

Recent studies indicate that half of antibiotics produced are given to farm animals, which metabolize only 10-30 percent. The antibiotic level in manure slurry is thousands of times higher than municipal wastewater, landfill leachate, or sludge. Research suggests that soils rich in clay and iron oxides will be good at holding antibiotics in land-applied manure, although adding lime or phosphorus to cropland could prompt release into waters.

For years, patients have been told to discard unused or expired medications by flushing them down the toilet, where they go directly into the wastewater stream. Federal rules for disposal of controlled medications have not changed since the 1970s, and require the presence of a law enforcement officer. The conventional method of disposal in many hospitals, hospices,

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1. Kolpin, D. W.; et al. *Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams, 1999–2000: A National Reconnaissance*. Environ. Sci. Technol. 2002, 36, 1202–1211.

and nursing homes is to flush unused narcotics and other medications after the death of a patient, even when they are enclosed in sterile packaging and could be reclaimed for use by other patients.

A better way to dispose of these materials is urgently needed. In February, 2007, EPA advised that individuals wishing to dispose of medicines could add a small amount of water to solid drugs and flour, kitty litter, or sawdust to liquid medicines before capping, double sealing, and placing in the trash. To protect its surface waters and drinking water supplies, Maine began to experiment with collections of unused drugs in 2005, and in 2006, began allowing residents to mail unused drugs to the state. However, more direction is needed. For more information, see http://des.nh.gov/organization/divisions/water/dwgb/dwspp/pharmaceuticals.htm.

Table 3: Wastewater Treatment Plants in the Riverbend Region

Wastewater Treatment Plant	age	condition of discharge	comments
Lancaster WWTF (to Otter Brook)	1972, upgrades 1985, 1991	generally good	working on infiltration/inflow issues, buying a new chlorine pump, minor operations and maintenance issues
Lancaster Grange WWTF (to CT R.)	1970s, upgrade 1994	pH violations, occasional oxygen and total suspended solids violations.	Completed infiltration/inflow work to bring facility back to below capacity operation; considering groundwater discharge.
Whitefield WWTF (to John's River)	1984, upgrade 1997	improved after lagoon cleaning	close to capacity - need upgrade prior to more growth; recently cleaned lagoons
Bethlehem WWTF (to Ammonoosuc R.)	1984, upgrade 1994	generally good	plenty of capacity if infiltration/inflow issues addressed
Littleton WWTF (to Ammonoosuc R.)	1963, upgrades 1989, 2001	generally good	collection system problems; combined sewers, illicit connections
Lisbon WWTF (to Ammonoosuc R.)	1977, upgrade 1994	generally good	
Woodsville WWTF (to CT R.)	1980	generally good	owned and operated by Woodsville Fire District, a village district in Haverhill. Running 2 plants, at 80% capacity; exploring new technology options for replacing a plant.
Lunenburg	1978		overflow in 2006
Lyndon	1976		
Ryegate	1995		
St. Johnsbury	1990		has 25 combined sewer overflows in the system, very costly to fix

2. Combined Sewer Overflows

Combined sewer overflows (CSOs) can allow runoff from a heavy storm to mix with untreated sewage, sending it into the river. River contamination is therefore more likely during and immediately after heavy rainfall. CSOs affecting the Riverbend region of the Connecticut River are discharged to the Passumpsic and Sleeper's Rivers in St. Johnsbury. There are approximately 25 CSO discharges within the St. Johnsbury collection system, the largest such problem remaining in the Upper Connecticut River Watershed. Vermont issued an amended order to St. Johnsbury in 2006 which mandated a schedule to complete construction to reduce or eliminate some of these discharges, conduct an effectiveness study to assess the work done to date, and determine the most cost effective way to eliminate the remaining overflow discharges.

Eliminating CSOs is an expensive burden on small communities. However, CSOs render the water unsafe for swimming and diminish its value for recreation. The Subcommittee is concerned at the delay in addressing combined sewer overflows at St. Johnsbury.

Many of the Riverbend Region towns' underground collection systems are composed of old vitreous clay pipes, and may be cracked and leaking. While NH DES has not yet identified CSOs in the New Hampshire towns of the Riverbend region, it is possible that they exist, particularly in Lancaster and Littleton. Required flow charts for wastewater treatment plants clearly display evidence (increased flow spikes) of this occurrence during and after storm events.

3. Other Direct Discharges

A number of industries also discharge wastewater to the river and its tributaries in this region. In addition to wastewater discharges from Lancaster, Gilman, Littleton, and Woodsville, there are several industrial waste water treatment facilities permitted to discharge directly to the mainstem, including a discharge of heated water from the Ryegate chip plant and a discharge from Dalton Hydro at Gilman. The 1997 edition of this plan reported turbidity in discharges from paper company operations in Gilman and Ryegate. Straight pipe discharges and failed septic systems in the Passumpsic River watershed, reported in the 1997 Plan, have since been cleaned up.

The ability of the river in the Riverbend region to assimilate additional treated wastes depends upon the specific location of the discharge. The segment is partly a series of slow moving impoundments, with limited ability for re-aeration, and already receives organic and nutrient enrichment from point and non-point sources, although it also receives the waters of several large tributaries which substantially increase the volume of the river as it passes through the Riverbend Region, diluting the discharge. New Hampshire's water quality standards state that "waste assimilation and transport shall not be considered to be beneficial uses." For a number of years, oxygen-demanding wastes discharged from the paper mill at Groveton resulted in a sag in oxygen levels in the river downtream, although this problem was not observed when the river's water quality was monitored in 2004.

Recommendations for Wastewater Discharges

- Towns should pursue careful and prompt maintenance of all wastewater treatment facilities which discharge into waters which reach the Connecticut River. Plan ahead for updating and replacing aging facilities.

- VT DEC and EPA should assist in eliminating combined sewer overflows in St. Johnsbury.

- NH DES should check for CSOs in New Hampshire towns in the Riverbend region.

- Towns should encourage use of low-phosphorus detergents to reduce phosphorus entering wastewater treatment plants.

- Towns and regional planning commissions should educate people to wrap and discard their unused and out-dated medicines in regular household trash rather than flushing.

- The U.S. Fish & Wildlife Service and EPA should devise and publicize new ways of safely disposing of old medications, including narcotics.

B. Non Point Source Pollution

These sources of pollution are sometimes difficult to identify because they do not come from an easily observed point, but can include home landscapes, road runoff, storm drains, farms, logging sites, failed or inadequate septic systems, and eroding riverbanks. Tributaries can also deliver such pollution to the mainstem.

1. Landfills, Junkyards, & Transfer Stations

In years gone by, people simply dumped their refuse in a stream gully, off a bridge, or over a riverbank, thinking that it would be gone by spring. The Connecticut River and its tributaries are still home to these old informal dumps. Most public dumps have been identified and capped, but most older landfills are not lined, and their contents can still seep into groundwater. Informal dumps remain untreated on several tributaries. Modern landfills are built with liners and internal collection systems that gather the liquid leachate so it can be sent to the nearest wastewater treatment plant. The leachate, however, still reflects the materials in the landfill, which can include heavy metals, poisons, pesticides, and all kinds of hazardous materials that were dumped there, such as products containing mercury, rather than collected for safer disposal.

On the New Hampshire side, new solid waste facilities (including transfer stations) are not permitted within the 500-year floodplain of the Connecticut River and must be set back at least 100 feet beyond this level and screened from the river with a vegetative or other natural barrier to minimize visual impact. An existing solid waste facility located within 250 feet of the normal high water mark may continue to operate under an existing permit, provided it does not cause degradation to an area in excess of that area under permit. A resource recovery operation can occur at such a landfill. Vermont's regulations require a 300-foot setback from surface waters.

The major regional landfill on the New Hampshire side of the Riverbend region is located on an aquifer near the Ammonoosuc River in Bethlehem. The Ammonoosuc River Advisory Committee has started water quality monitoring in the river above and below the landfill. In Vermont, the Boltonville landfill, which has been capped but is unlined, may be leaching into the Wells River.

Recycling - Communities are working to reduce the tonnage of solid waste they bring to landfills, by recycling, although rates vary greatly. Bath takes its recyclables to Littleton, which has a state-of-the-art recycling facility, and Haverhill has an agreement with Newbury to accept recycled materials. Other towns have their own programs that require or encourage recycling and some have implemented "pay as you throw" programs that successfully encourage residents to recycle.

Household Hazardous Waste - In Vermont, household hazardous waste collections are held several times a year and rotate through the communities, providing a fairly good opportunity for people to dispose of this kind of waste responsibly. In New Hampshire, however, collections vary greatly. Monroe has four collections a year, and Lisbon one. Residents of other communities often must travel a great distance, such as to Plymouth, to bring their waste to a collection site. More frequent and convenient collections would help keep hazardous materials out of landfills and eliminate the temptation to burn them or toss them on roadsides or streambanks. Some citizens are skeptical that such collections are worth the cost and effort, and whether the materials are actually handled differently than they would be at a landfill.

Table 4. Municipal Solid Waste and Recycling - reported by NH towns in 2007 (source: NH DES)

Town	Combined municipal solid waste (tons)	Commercial/ Industrial Waste (tons)	Construction/ Demolition Waste (tons)	Compost (tons)	Recycling (tons)	Recycling rate
Lancaster	497	0	496	80	717	62%
Dalton	140	0	34	0	53	27%
Littleton	643	0	260	75	1,471	71%
Monroe	not available	not available	not available	not available	not available	not available
Bath	not available	not available	not available	not available	private hauler	not available
Haverhill	200	not available	not available	not available	0	0

Littering - Many towns in the area hold an annual "Green Up" Day in spring, encouraging residents to help pick up and recycle the winter's accumulation of roadside trash. From time to time, people still illegally dump tires and other refuse in the Connecticut River and other waterways. Roadside dumping is also still a problem. The amount of litter in the river has declined due to the Connecticut River Watershed Council's annual source to sea cleanup in which area people have participated for several years. A volunteer group on the Israel's River has energized local citizens for a series of highly successful cleanups on this beautiful tributary.

Construction and demolition debris - A strong source of concern is disposal of debris from construction and demolition sites. This material may include woodwork painted with lead paint, wiring and other construction materials that contain heavy metals, insulation, and others that, if incinerated, could deliver dangerous pollutants to the air. However, the many costs of disposal are also considerable. Handling of these materials should be regulated and performed by a competent, licensed contractor.

Recommendations for Landfills, Junkyards, and Transfer Stations

- New Hampshire should assist the North Country Council in holding more frequent and more convenient household hazardous waste collections.

- Towns should strongly encourage citizens to make use of regular household hazardous waste collections and should organize car pooling or "waste pooling" to distant collection sites.

• States should ensure that construction and demolition debris is handled by competent contractors.

• Towns should hold annual "Green Up Days."

• Towns should not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, wastewater or septage lagoons to be located on aquifers.

Prime agricultural soils for sale - in Lunenburg and elsewhere.

2. Shoreline & Floodplain Development

Riverfront land has growing appeal for riverfront homes, especially since lakefront and oceanfront land has now largely been developed, and memories of the river as a "nuisance" or a health hazard have begun to fade. Flat floodplains attract the attention of large commercial developers in a region that is known more for its steep and difficult terrain. Development in such sensitive areas, however, carries much risk.

New Hampshire Shoreland Protection - Since 1992 the New Hampshire side of the Connecticut River has been covered by the Comprehensive Shoreland Protection Act (RSA 483B) within 250 feet of the ordinary high water mark. This law also applies to the Israel's, John's, and Ammonoosuc Rivers and several others in the region. The rivers under the protection of this law are listed in Appendix I. Its goal is to protect the river for the public, and avoid "uncoordinated, unplanned and piecemeal development along the state's shorelines, which could result in significant negative impacts on the public waters." The law also protects property owners by preventing investments dangerously close to the river. Towns must not issue permits for projects that violate state law.

"We used to call them foam castles."

Haverhill teacher, speaking of pollution in the river during her childhood.

This law calls for buildings to be set back at least 50 feet from the river. Bath, which has more river frontage than roads, has established even stronger protection for its riverfront that is better suited to such a large and powerful river All new riverfront lots are subject to subdivision approval by NH DES. Minimum lot size is determined by soil type in places dependent on septic systems, and must have at least 150 feet of shoreland frontage. No fertilizer, except limestone, shall be used within 25 feet of the reference line. Twenty-five feet beyond the reference line, low phosphate, slow release nitrogen fertilizer may be used on lawns or areas with grass. No other chemicals, pesticides or fertilizers of any kind shall be

applied within 50 feet.
In 2007, New Hampshire enacted new, easier to understand riparian buffer protection. In the Waterfront Buffer (within 50 feet of the reference line), no natural ground cover shall be removed except as necessary for a six foot wide path to the water. Limited pruning may be done to improve a view, and a minimum amount of tree cover must be maintained. Stumps and root systems within 50 feet of the river cannot be removed because they keep riverbank soil in place. Owners of lots legally developed before July 1, 2008 may maintain but not enlarge cleared areas, including existing lawns and beaches, within the waterfront buffer.

Between 50 and 150 feet from the reference line, in the Natural Woodland Buffer, at least 50 percent of the area outside of impervious surfaces shall remain undisturbed. Owners of lots legally developed before July 1, 2008 that do not comply are encouraged to, but shall not be required to, increase the percentage of area maintained in an undisturbed state. The updated law also limits impervious surfaces within 250 feet of the river to 20 percent of the lot, with some exceptions based on buffer and stormwater management. Property owners and developers are encouraged to seek creative solutions that utilize low impact development techniques. If impervious surface limitations are increased to 30 percent within the protected shoreland, a DES-approved stormwater management plan is required.

Until recently, the state has been largely unable to monitor or enforce this law, and violations have occurred. The Subcommittee is concerned about this lack of enforcement, and about development of lands along the river which could threaten water quality through changes in storm water movement, erosion during construction, and new septic systems. Homeowners may apply too much fertilizer or pesticide, or underestimate the importance of riparian buffers in protecting their property against erosion and capturing sediment and other pollutants washing off the land. Fortunately, the New Hampshire Legislature voted to provide DES with the ability to set up a permitting program and increase enforcement of the provisions of the law. This permit does not apply to timber harvesting that is not part of shoreland development, which is covered by a separate regulation.

The law applies only to fourth order streams, and leaves protection of smaller streams up to the towns. The subcommittee believes that there should be more protection for smaller streams.

Vermont Shoreland Protection - Vermont is the only state in the Northeast without a statewide shoreland protection law. Vermont's Agency of Natural Resources has issued riparian buffer guidance for Act 250-regulated projects. The guidance recommends 100 feet from lakes and ponds, and depending on the situation, either 50 or 100 feet from rivers and streams. This is only guidance, however, and does not protect rivers or streams in the case of smaller projects. However, Guildhall, Barnet, and Newbury have their own shoreland protection for the Connecticut River and other streams which is comparable to or more protective than the New Hampshire law.

Building in floodplains - All of the towns along the Connecticut River in the Riverbend region, except for Bath and Lunenburg, currently permit building in the 100-year floodplain, the land that has a 1 percent chance of flooding every year, or 100 percent chance of flooding in any 100-year span. Because building in floodplains takes over valuable farmland, transfers flooding problems downstream, drives up insurance prices, and costs taxpayers money when flooding occurs, Bath and a number of other Connecticut River towns do not allow construction here. Local regulations regarding shoreland and floodplain protection are summarized in Appendix G.

The National Flood Insurance Program, administered by the Federal Emergency Management Agency, requires special construction standards for buildings that are built in floodplains, but they still permit buildings to be built on this dangerous land, and a building (or the mound on which it is placed) is allowed to take up space that flood waters would otherwise have occupied. While this might reduce the amount of flood damage to the individual property itself, it does nothing to prevent pollution from flooded septic systems or to stop increased flooding downstream. One building may not make much difference, but the effects of allowing many buildings to take up space in a floodplain can be a different story. Floodplain development is a dangerous and ill-advised use of space that the river has occupied in the past and is likely to use again in the future. Agricultural buildings are exempt from permit requirements in Vermont, even though they take up floodplain space as any other building would. Because Lunenburg does not participate in the National Flood Insurance Program, it is more difficult to get loans for construction in the floodplain.

"You best not be building in those floodplains. Mother Nature doesn't like it. Now, money talks more than common sense."

Guildhall riverfront farmer

Floodplain development became a topic of immediate concern in the Riverbend region in the mid 1990s, as the flat Ammonoosuc River floodplain just below downtown Littleton came under the eye of big box store developers. Some members of the Riverbend Subcommittee could recall seeing that same area many feet deep in flood water, covered with large blocks of river ice. Concern expressed by the Riverbend Subcommittee, CRJC, and others prompted Littleton to enact a 100-foot building setback from the river.

Development went ahead, however, prompting a reaction from the downstream communities of Lisbon, Bath, and Haverhill, some of which withdraw drinking water from the river. Shortly after construction of the first large store and parking lot, downstream residents reported concerns about increased river velocity. Undersized culverts increase the speed of parking lot runoff, and can create new erosion along the riverbank. While river geomorphology studies have been included in the design of more recent developments in this area, they have not removed the threat of flooding or pollution from parking lot runoff. The loss of flood storage and increase in erosion are major concerns. Wetlands and drainage swales created as part of a floodplain construction project need maintenance such as dredging and cleaning, but there may not be an adequate safeguard in place to be sure that this actually occurs many years down the road.

Floodplain maps - It is essential for landowners, town officials, and banks issuing mortgages and loans to have correct information on floodplain locations. Unfortunately, floodplain mapping is often grossly inaccurate, and also does not take into account the significant role that ice jams play in flooding, especially on the Ammonoosuc River. The 1997 edition of this plan recommended that FEMA provide more accurate floodplain maps (Flood Insurance Rate Maps) to the towns. This request was answered by FEMA for the southernmost 16 towns in New Hampshire and Vermont in 2001, based on a new study of the river from its headwaters down to the Massachusetts border. This left the 37 river towns upstream with outdated and inaccurate floodplain maps. Newer maps have been issued using aerial photographs that show buildings, roads, and other landmarks, but the floodplain information has not been updated.

"You can spend a little now and preserve your floodplains or pay through the nose later."

Littleton Conservation Commission member

Natural valley flood storage - In 1994 the U.S. Army Corps of Engineers identified the broad floodplain in Lancaster, Lunenburg, Haverhill, and Newbury in 1994 as the key to some of the most important natural flood control on the entire 410-mile long river. However, the Army Corps decided that it was not worth the cost to purchase conservation easements on this land, even though it knew that development in this region would greatly affect future flood damage downstream. Property values have since risen sharply, and the answer might be different today. It is much more cost-effective to protect the "green infrastructure" offered by these floodplains now rather than let them get developed and spend taxpayer dollars on disaster relief.

These floodplains also hold some of New England's most valuable agricultural soils, still useful for growing crops to feed the valley's own population. Towns with agricultural land protection ordinances have a greater ability to keep floodplains open and to keep valuable soils undeveloped and available for agriculture. Fortunately, the Upper Valley Land Trust has worked successfully with the owners of much of the rich floodplain farmland in Haverhill and Newbury, and together they have protected many acres from development, keeping these soils open both for farm production and for flood storage. Other landowners in Lancaster have voluntarily conserved their floodplain grasslands through the federal Natural Resources Conservation Service (NRCS).

Varves - Thousands of years ago, much of the lower lying areas of the Riverbend region was under the waters of glacial Lakes Hitchcock and Coös. The lake bed deposits they left behind, called varves, could pose problems for anything built upon them. Varves have layers with differing physical properties that can create unstable drainage and cause water to move laterally. Knowledge of varves is important for land use planning, because varves behave differently from other kinds of soils. If a town planning board knows where the varves are and can ask applicants to deal with the challenges posed by varves, then the board can then better decide whether a proposed project is safe. Siting landfills, bridges, buildings, and other structures on varved deposits is risky at best.

Flowage rights - In 2005, TransCanada acquired flowage rights on many acres of riverfront land in the Riverbend region associated with the Fifteen Mile Falls project. New England Power originally purchased these rights from riverfront landowners in the mid-20th century.

NEP purchased permanent easements that included the right to inundate portions of riverfront properties in anticipation of impounding the river behind the dams. In some cases, these flowage rights extend only to a specified elevation on the property, and in other cases, apply to the entire property. These flowage rights run with the land and are recorded in the county registry of deeds. Other dams in the Riverbend region do not have associated flowage rights.

Recommendations for Shoreland and Floodplain Development

- Town zoning ordinances should prohibit development in the 100-year floodplain 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.

- FEMA should ensure that area towns have accurate, up to date floodplain maps.

- Towns should encourage developers and landowners to establish and/or maintain buffers of native vegetation along rivers and streams for pollution control and riverbank stability.

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

- Towns should identify the extent of sewage disposal problems, especially among seasonal homes converted to year-round use; inspect sewage systems before they are completed; educate home buyers and real estate agents.

- Land conservation organizations, NRCS, and others should encourage purchase of development rights from willing landowners in the floodplain, especially in the natural valley flood storage area, to keep the land free from development and open for farm production and flood storage.

- State agencies should require maintenance for permit-required wetlands and flood storage areas, perhaps by requiring the developer to post a bond for this purpose.

- Towns could encourage oxbow wetlands to develop naturally by giving tax breaks for this land.

- NH DES should enforce the Shoreland Protection Act and provide GIS data and maps of the protected shoreland to communities.

- Town conservation commissions in NH should educate town officials and landowners about the Shoreland Protection Act.

- Towns on NH side should not issue permits for projects that violate the state shoreland protection law, and should set up a checklist for permitting to be sure that all appropriate parties have been alerted and that all applicable laws are observed.

- New Hampshire legislature should apply shoreland protection to smaller tributaries not currently covered by the Shoreland Protection Act.

- Vermont should adopt measures to protect the shoreland of the Connecticut River and its third and fourth order tributaries.

- Town conservation commissions or planning boards should work with state geologists to map varves in their towns, to be sure major construction does not take place on unsafe soils. (50/50 match from USGS).

- Riverfront property owners can find out whether the power company owns flowage rights on their land.

3. Roads and Railroads

The construction, repair, and maintenance of roads, which in this area often run very close to the river and its tributaries, can result in loss of the riparian buffer and cause sediment to be washed into waterways. Sediment studies tend to show more pollutants in the river where the roads are close to the banks. Sand and salt from roadways and bridges can affect fish habitat. Better riparian buffers might help hold streambanks in place and help capture escaping road-related pollutants. Both states have training workshops for road crews in how to manage roads to avoid polluting streams: Vermont's Better Back Roads Program, and New Hampshire's Roads Scholar Program.

Railroads - An active rail line runs on the Vermont side of the river. There is concern about whether the railroad manages brush near the river with herbicides rather than cutting. Spraying of herbicides in power and railroad line rights-of-way near waterways may be a threat to water quality. Plans for herbicide use go through an agency council in Vermont and include a requirement for public notification through newspapers.

Road salt - Winter road salt threatens water quality in the many streams followed too closely by roads. Careful storage of salt and salted sand is essential to keep this environmental poison from reaching waterways. Improper salt storage and loading procedures can easily lead to trouble, since salt dissolves so easily in water.

A recent study of three rivers, including one at Hubbard Brook in rural northern New Hampshire just east of the Riverbend region, found that salt concentrations have been increasing for the past 30 years.[1] Research shows that sodium and chlorine, the elements that make up salt, are increasing and staying at elevated levels even when salt is not in use on the roads. In spring, summer and fall the levels of chloride concentrations at study sites were 10 to 100 times higher in the waters near salt use areas than in more isolated waters, and in the winter, concentrations were up to 1,000 times higher in the exposed waters. The study suggested that salt from a half century of use on winter roads is accumulating in soils, groundwater and rivers themselves.

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1 "Increased salinization of fresh water in the northeastern United States", Kaushal, Sujay S., et al, *Proceedings of the National Academy of Sciences of the United States of America*, September, 2005.

Salt storage - New Hampshire does not permit establishment or expansion of salt storage yards within 250 feet of the Connecticut or any other river covered by its Shoreland Protection Act. An uncovered sand/salt pile located very close to Cushman Brook in Dalton, a smaller stream not covered by the law, is managed by NH Department of Transportation and may be allowing salt to reach this tributary of the Connecticut River. Vermont has no similar protection for its waters, beyond requiring that the Agency of Transportation (VTrans) store salt under cover and on an impervious material, so it does not leach into the ground. Vermont has guidelines that recommend that towns avoid storing salt on floodplains, over aquifer recharge areas, or where salt could run off into streams or wetlands, but these are not enforceable. The Vermont Local Roads Program assists town highway departments on the full range of road issues, including storage building designs. VTrans must report weekly to the Agency of Natural Resources about the amount of de-icing material applied during the winter. VTrans is now offering grants to Vermont towns which require only a 20 percent match, for projects like moving sand and salt storage.

"A well-set culvert equals fish portage."

Guildhall riverfront farmer

Culverts - A sudden heavy storm can cause problems with blocked culverts and send sediment into a stream. Under-sized or poorly located road culverts are a public safety problem. An under-sized culvert or bridge can become blocked with debris and cause a stream to cut through a road.

Town road agents deserve the respect of all for their long hours of work to keep roads passable and safe, but they often do not have the engineering experience to gage proper culvert sizing. Many culverts may be too small, keeping both water and sediment from moving through. Regional planning commissions can help towns identify some undersized and failing structures that could become public safety and flooding hazards during a heavy storm. While logs and other woody debris in streams create healthy fish habitat, culverts need to be kept clear to allow water to move through. Historic drylaid stone culverts should receive special attention.

Too often, culverts have been installed without consideration for the fish they might convey and the aquatic habitat they might interrupt, and may present a barrier to fish passage that is as effective as any dam. When culverts are replaced, they should be designed with a natural bottom or set at a low enough elevation that fish may easily pass through them. Such a situation long existed at Rix Brook in Dalton, where this trout stream passed through a damaged and undersized culvert under Route 135. The town worked with NH DOT to raise enough funds to replace the culvert with a better crossing, greatly improving habitat and safety for motorists. NH Fish and Game Department and NH DES worked together to offer stream crossing guidelines to properly size culverts for fish passage.

Because culvert and bridge size is so important for public safety, they should be checked in all towns. Vermont has a program to do this in cooperation with the U.S. Geological Survey and the regional planning commissions, but there is no similar program in New Hampshire. Funding is available for culvert replacement from several sources, especially for hanging culverts that create obstacles for fish passage. The USDA Natural Resources Conservation

Service's Wildlife Habitat Improvement Program and Environmental Quality Incentives Program are among these sources. New Hampshire's Aquatic Resource Mitigation Fund, established in 2006, is another.

Snow dumping - The sand and salt used to keep roads clear in winter can easily end up in a stream or river. Snow removed from streets and parking lots and dumped near the river contains pollutants such as oils, fuels, salt, sand, broken glass, trash, and other chemicals. Long-time snow dumping sites may also show signs of lead accumulation in the soil from the days of leaded gasoline. In one valley town, high concentrations of lead were found in a small area where the town had piled snow for years, and the contaminated soil must be cleaned up. Other towns may have the same problem. There are no recent reports of Riverbend region towns dumping snow directly into waterways.

Roads close to rivers - Building roads close to rivers adds to the salt contamination problem and is dangerous, both because black ice is more likely in damp areas and because some streams can erode the base of the road, such as occurred on Route 2 in Lunenburg. when moisture freezes on the road. However, many roads in the region follow earlier travel ways of settlers, who themselves followed paths of Native Americans, who often followed waterways. An example is Route 2 in Lunenburg, a major east-west highway, where riverbank erosion closed one lane of the road in the mid 1990s. The road was rebuilt at considerable expense both to the state and to the river. Construction of the interstate highways (I-91 and I-93) created some areas of major wetlands and altered stormwater drainage.

Recommendations for Roads and Railroads

- Railroads, transportation agencies, and utilities should review their herbicide spraying program for rights of way near waterways, and consider alternatives; consult landowners about herbicide spraying, and provide an incentive for them to perform cutting as an alternative to spraying.

- Regional planning commissions can help towns and state highway agencies anticipate downstream effects in the planning for future transportation projects.

- Towns and state highway agencies should make an effort to retain riparian buffers between roads and rivers; when planning road widening near rivers, they should add width on the side away from the water, and not just take the buffer because it's the easy way out.

- State agencies and towns should include riparian buffer restoration in road projects near streams and rivers.

- States and towns should pursue alternatives to salt for de-icing, such as using larger sand particles, and follow best management practices for road maintenance and winter care.

- NH DOT should move and cover the sand/salt pile near Cushman Brook in Dalton.

- Towns should avoid constructing new roads near rivers and streams.

Stormwater usually drains directly to rivers and streams, as here in Bath near The Narrows, carrying with it whatever rain washes off the pavement.

- Town highway departments, working with conservation commissions, should ensure that culverts are properly sized and placed for fish passage when replacing them during road work; use a natural bottom where possible and appropriate. Increased minimum design standards may be necessary based on recent research in New Hampshire.

- New Hampshire towns should ask for help from regional planning commissions to survey culverts and bridges to identify those that are undersized; also note if they block fish passage and seek grants for replacing them where necessary.

- Towns should support a policy of low salt use on roads.

- State and town road crews and the railroad should avoid cutting and mowing the riparian buffer near streams.

- Local and state highway crews should use best management practices in treating winter roads.

- Towns should follow snow disposal best management practices. Snow should be stored on flat, pervious surfaces, such as grass, and at least 25 -100 feet from the edge of a stream or river, with a silt fence between the snow and the stream. There are larger setbacks for snow disposal near public wells. Once snow melts, debris should be quickly cleared from the site and brought to the landfill.

- Towns should test the areas where they have piled snow for many years, to see if lead has accumulated in the soil.

- Towns and landowners should keep culverts clear of woody debris.

4. Storm Water Runoff

Rain falling on a forested hillside is absorbed and runs off very differently than rain that falls on a recently cleared hillside, a residential backyard, or a paved parking lot. Each place sheds water differently – with thickly vegetated and forested areas less likely to allow fast runoff that causes erosion, and picking up pollutants such as motor oil or pesticides and sending hem into streams, lakes, or rivers. Stormwater runoff may be the most common but least understood means of water pollution. As a result, EPA and the states are phasing in stronger stormwater controls.

Impervious surfaces - Increased growth with its demands for impervious surfaces (roofs, roads, driveways, parking areas) causes tremendous increases in runoff and pollution. The pollutants in runoff are directly related to how much impervious surface is in its watershed. Studies in Vermont show that when more than 10 percent of a stream's watershed is impervious (pavement, rooftops, compacted soil), the stream and its fish suffer from water quality problems.[1] Roads and parking lots can account for as much as 70 percent of the total impervious surface in developed places. Towns should view commercial parking lots and down towns as hot spots for petroleum hydrocarbons, metals, nutrients, or solids, and especially for salt and warming of water. Elevated salt and temperature typical of parking lot runoff can be lethal to aquatic life.

"If you control your runoff at every single dwelling then you don't have a problem with all that water running into your stream."

Public Works Director, Colebrook

High pollutant loading comes from high traffic areas, such as parking areas with frequent visitors (grocery stores, shopping centers, restaurants, drive-through services) and on-street parking on downtown streets. Runoff contaminated by bacteria from pet waste could cause a swimming hazard during and just after storms, as now exists in downstream reaches of the river. The town of Lancaster has installed pet waste collection stations at its riverside park, out of concern that pet droppings could be contaminating the Israel's River. Littleton has similarly provided pet waste collection stations along Mill Street to protect the Ammonoosuc River.

Land clearing - The total runoff volume for a one-acre parking lot is about 16 times that produced by an undeveloped meadow. Heavy clearing, whether for forestry or for development, can change stormwater runoff, how a tributary flows, and ultimately the Connecticut River itself. Soil types, especially their ability to hold water, have an effect on runoff when they are not frozen. Towns should be aware that such clearing can affect the roads and culverts they are responsible for maintaining. Studies in the Ashuelot River watershed indicate that when steep slopes (25 percent and steeper) are developed, the resulting runoff during a heavy storm can cause flashy stream flow that can contribute to flooding downstream.

Low impact development - There are a number of common sense ways to keep runoff from causing trouble downhill. Developers can mimic natural runoff by slowing it down and soaking it up when a property is developed, with "low impact development" techniques. Rather than channeling runoff into larger drainage ditches, low impact design calls for spreading runoff around and detaining it in many small vegetated catch areas and swales where it can soak into the ground and recharge groundwater rather than run off the land. Low impact design also recommends narrower and/or shared driveways, porous paving materials, and smaller parking lots. Also advised are directing runoff to places with porous

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1. Pease, James, "Urban Nonpoint Pollution Source Assessment of the Greater Burlington Urban Stormwater Characterization Project." Vermont Department of Environmental Conservation, 1997, in *Champlain Initiative, The Case for a Healthy Community: The History of Sprawl in Chittenden County*. March 1999.

soils, building on soils that are less porous, reducing slopes on cleared areas, keeping as many trees as possible or planting more, and avoiding construction close to streams. The water that eventually arrives at the stream tends to be cleaner. And, more rainwater or snowmelt percolates through the ground, keeping water levels up in wells and in waterways.

Recommendations for Stormwater Runoff

- Towns should protect the river and its tributaries from storm water runoff by keeping riparian buffers to filter the runoff and other innovative, yet low-cost or cost-free natural treatments.

- Town planning boards and commissions should require sedimentation and erosion controls during and after construction. Require additional treatment to remove oil, solids, and metal for new discharges and redevelopment projects to surface waters and dry wells.

- Towns should ensure that culverts are sized in anticipation of runoff from future cleared slopes. Ask regional planning commissions for advice in how to avoid runoff problems related to large scale clearing. Consider discouraging roads and development on steep slopes to control stormwater runoff.

- Towns should 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. Require that all new development include provisions for infiltration of stormwater runoff on the site. Towns with capital improvement plans should include stormwater runoff and culvert upgrading expenses in projecting impact fees and site plan review.

- Town planning boards and commissions should discourage black-topping of driveways and parking areas, and should encourage ledge pack, gravel, pervious pavement, and other pervious surfaces as alternatives. Discourage development of steep slopes to minimize fast runoff.

- Trail managers should ensure that trails have water bars to keep stormwater from eroding compacted soils.

- Pet owners should pick up after their dogs, especially when walking them near rivers.

5. Home Landscapes

Second-home building has added in recent years to residential development in the Riverbend region. Homeowners living near rivers and streams have a responsibility to be sure they are good caretakers of those waters.

Many people building on a waterfront parcel are tempted to cut down the vegetation along the stream in order to get a water view. They likely do not realize that they are removing the protective barrier that keeps runoff from their lawns and gardens from reaching the water, and keeps the riverbank from eroding. Unlike farmers, who are professionally trained and certified to apply fertilizers and pesticides in the proper amount and at the proper time, homeowners have no such training and are likely to use much more herbicides and fertilizers such as Round-Up and Miracle-Gro, for instance, than is necessary or advisable. Runoff from driveways, roofs, and lawns can wash these pollutants into streams. State law in New Hampshire prohibits use of fertilizer within 25 feet of the high water mark of the Connecticut River and other fourth order streams. Sometimes it's what a homeowner doesn't do that can cause trouble, such as neglecting to maintain a septic system, so that it fails and pollutes a nearby stream. One of the biggest impacts to water quality is new home construction. The states should encourage the development of BMPs for construction sites and driveways, and educate developers and local planning boards and commissions about the value of using them.

Recommendations for Home Landscapes

- Homeowners should not use fertilizer near rivers or streams.

- Homeowners living near waterways should retain buffers of native woody vegetation along the banks, and consider planting some of the many ornamental native plants listed in CRJC's riparian buffer guidance. Such plants require less water and are better adapted to riverbanks, and offer food and cover for wildlife.

- States should offer an information packet to owners of shoreland to educate them about the best ways to manage their property.

"It's a very good concept not to utilize riverfront land all the way to the river's edge."
Riverfront farmer

- States should develop best management practices for residential construction sites and driveways, and educate developers and local planning boards and commissions about the value of using them.

6. Farms and Rivers

Prime agricultural soils distinguish much of the remaining floodplain in the Riverbend region. Farmland along both sides of the river, especially in Guildhall, Lunenburg, Lancaster, Monroe, Barnet, Bath, Newbury, and Haverhill signals a valued way of life in the river valley, and provides beautiful views. Working farms on these productive soils are a better use of Riverbend region floodplains and shorelands than residential or commercial development. Most farmers working near the river understand how to manage manure and other fertilizers well so that they serve the farm and are not lost to the river, where they could cause algal growth downstream. However, at least one farmer on the New Hampshire side still spreads manure on the snow.

Sources of unwanted nutrients are sometimes difficult to identify. While farmers are generally well informed about how to handle fertilizers and pesticides, unwise use of these and other toxic materials can lead to unintended pollution of streams. Runoff from barnyards, manure piles, and cropland can enter water bodies and contain phosphorus and other nutrients, pathogens and/or toxic substances. This is particularly true if there are no vegetative buffers. Cultivation of fields up to the edge of stream banks can cause erosion and runoff of nutrients and sediments. Vermont requires 10-foot riparian buffers on farmland. Animals allowed access to streams contribute manure to the water and can increase bank erosion by trampling the banks and crushing vegetation. State oversight and regulations regarding sludge spreading are important for protecting the river and the future use of valley soils.

Dairying, which for well over a century has been the primary form of farming in the Riverbend region, has recently diversified to include organic dairy farming. Under this system, which offers many water quality benefits, more cows are fed on pasture and farms maintain fewer cows in total. Corn is not grown on the same piece of land continuously by organic farms because this cannot be done without spraying. Nutrients for crop growth are provided in the form of animal and green manure, rather than by chemically-produced fertilizers that dissolve more quickly in water and are more likely to be carried into surface waters by runoff. Some organic farming practices may be adaptable to non-organic farming by those who want to minimize detrimental effects on water quality.

The Riverbend Region is home to many fine farms, such as this dairy farm in Guildhall.

Cost-sharing programs: NRCS offers several cost-sharing programs to assist with riparian buffers, fencing, and other farm projects that improve water quality. Incentive programs are needed to help farmers keep soil covered throughout the year to reduce erosion. For its Conservation Reserve Enhancement Program, Vermont has voted in extra dollars to make the Conservation Reserve Program more helpful to farmers for water quality improvements, such as planting riparian buffers, and funds are available in the Connecticut River valley. Unfortunately, similar assistance is not available from New Hampshire.

Recommendations for Farming

- U.S. Department of Agriculture should provide cost-sharing for conservation practices, including construction of manure storage pits to help farmers eliminate winter spreading of manure within the floodplain to protect water quality; encourage area farmers to participate in the Environmental Quality Incentives Program, Wildlife Habitat Improvement Program, and Vermont's Conservation Reserve Enhancement Program.

- Vermont should continue funding its Conservation Reserve Enhancement Program, and New Hampshire should establish a similar program.

- Farmers should consider practicing no/low till; keep soil covered throughout the year to reduce erosion; rotate corn frequently with other crops, particularly on flood-prone land.

- New Hampshire should stipulate that manure may not be spread between December 15 and April 15, and not rely solely upon voluntary compliance with best management practices. Establish a minimum riparian buffer on farmland, as has Vermont.

- Water quality agencies should enforce best/acceptable management practices and look more closely at the effect of nutrient enrichment and water level changes on river life forms, including fish.

- Water quality agencies should enforce regulations respecting biosolid disposal, including setbacks from rivers.

- Farmers should use filter strips more consistently on agricultural lands to keep sediment and nutrients from washing into surface waters; seek assistance for fencing to keep livestock out of waterways.

- Citizens should support local agriculture.

7. Forests and Rivers

A forest is well known as the best guardian of the quality of water for drinking and for trout. Thus, forest managers in the watershed are in a sense managing the water quality of the Connecticut River and its tributaries. Forest landowners can use forested riparian buffers to control flooding and erosion, trap pollutants, shelter coldwater fisheries, and provide an attractive streambank and recreational opportunities.

In New Hampshire, those planning to make a timber cut can cut up to 10,000 board feet, or 20 cords for personal use, without the need to file an "Intent to Cut" form with the town. This translates to two fully loaded logging trucks. In Vermont, a landowner must submit an Intent to Cut Notification to the Vt. Department of Forests, Parks and Recreation only if he or she plans to conduct a heavy cut of 40 acres or more.

Should such cutting take place within a riparian buffer or on a steep slope, it could affect nearby waters. Flash flooding and siltation can result from increased surface runoff when large areas of forest cover are removed. Siltation can result in impacts to fisheries, water quality, and aesthetics, and pose problems at downstream industrial water intake pipes. Forestry rules restrict cutting along streams.

Recommendations for Forests

- Landowners, loggers, and foresters should follow best/acceptable management practices for timber harvesting, and minimize the water quality and visual impacts of clear-cutting and other timber harvesting operations, particularly near surface water. Skidder ruts should be smoothed and seeded as soon as possible once a timber harvest is done.

8. Airborne Pollutants

The Connecticut River and its tributaries are not secure from contaminants that arrive on the wind. Both New Hampshire and Vermont have issued fish consumption advisories for the Connecticut and other rivers, based on mercury levels. EPA's 2000 study of Connecticut River fish tissue toxins found that mercury concentrations were significantly higher in the Riverbend reach of the river than downstream.[1] Older fish tend to have higher levels of mercury and other contaminants, such as PCBs and dioxins. Much of this mercury originates from Midwest power plant and urbanized eastern seaboard emissions.

The states are doing a good job at addressing this problem. In 2007 the New England Interstate Water Pollution Control Commission worked with New Hampshire, Vermont, and the other New England states and New York to form a draft mercury reduction plan using the federal Clean Water Act to establish the maximum levels of mercury that local lakes and rivers can absorb (TMDL, "total maximum daily load"). The federal government has not set national standards.

EPA banned the use and manufacture of PCBs in the U.S. in 1977, and there are no known current sources of PCBs in the river, so contaminants in the fish result from historical contamination in the watershed. Dioxins are produced by humans as byproducts of chlorine bleaching in pulp and paper mills, as contaminants in certain chlorinated organic chemicals, and through incineration and combustion, such as by illegal burning of trash in backyard barrels or in private outdoor furnaces. Dioxins are also produced in nature.[1] Once in the river, all of these contaminants bio-accumulate in the food chain. Fortunately, backyard barrel trash burning, now outlawed in both states, is much less common than it was in past years.

Recommendations for Airborne Pollutants

- State and federal legislators should continue to advance legislation to curb the introduction of acid rain producing pollutants, and of airborne mercury.

- Citizens should support the efforts of the New England states to force EPA to enforce its own rules on pollutants and to decrease airborne pollution entering the region from the Midwest.

- EPA should abandon a cap and trade system that would allow polluting power plants to continue to operate without emissions reduction.

- The federal government should tighten vehicle emission standards for trucks and sport utility vehicles.

- Citizens should obey the ban on burning of trash in backyard barrels or in outdoor furnaces.

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1. *The Connecticut River Fish Tissue Contaminant Study*. U.S. Environmental Protection Agency Region I, 2000.

9. Brownfields and Other Hazardous Waste Sites

"Brownfields" is a term for land that cannot be easily redeveloped or reused due to the potential or perceived presence of hazardous substances or other pollutants. Historical industrial and commercial sites along the Connecticut River and its major tributaries are likely to have such properties where contamination may prevent the property from contributing once again to the tax rolls and economic vitality of the community. An excellent example is the former rail station in Woodsville, now a public park where people may enjoy the fine scenery at the confluence of the Connecticut and Ammonoosuc Rivers.

Regional planning commissions can assist property owners and prospective buyers with environmental site assessments of brownfield properties, and in finding grants and loans for cleanup of contaminated sites. There are 37 hazardous waste sites nearby St. Johnsbury, a community with a long and proud industrial history. Most of the sites involve leaking underground storage tanks. Seeking out cleanup opportunities can return these places, which are often in centrally located, valuable locations, to active use where they can contribute once again to the community's vibrancy and also to local tax rolls.

Recommendations for Brownfields

- States should keep this information updated, clearly identify priorities for remediation, and pursue cleanup.

- EPA should provide funds to support cleanup to get these properties back on the market.

VIII. Riverbank Erosion

Bank erosion and loss of river bottom land is a significant problem, particularly in Haverhill and Newbury. Eroded sediments are accumulating in the reservoirs and to a slight extent in the six miles of free-flowing river below Dodge Falls Dam. On the New Hampshire side alone, there is bank erosion on half of the 49 miles from Moore Reservoir to Haverhill. This represents a cost to landowners in loss of property.

Erosion may create habitat for bank swallows and some other wildlife, but it also adds sediment to the river that can smother fish spawning areas and add nutrients that contribute to growth of algae. While bank erosion is a naturally occurring process on rivers, caused primarily by shear stress of water forced against the bank, and abrasion by ice, and wind-driven waves, it can be made worse by human actions, including water level fluctuations at the dams, boat wakes, and removal of the riverside vegetation that naturally holds the bank together.

Vermont's River Management Program provides technical help to conduct geomorphic assessments of streams and their watersheds. Understanding the natural tendencies of a stream, its current condition, and what changes may be anticipated in the future is invaluable

Riverbank erosion is a concern, such as on this Guildhall farm field.

to making sound protection, management, and restoration decisions.

County conservation districts have performed a valuable public service in conducting inventories of riverbank erosion on the Connecticut River. CRJC followed this up in 2004 and 2005 with a detailed survey of the upper 85 miles of the river, extending down into the Riverbend region as far as Gilman Dam between Lunenburg and Dalton.

A. County Erosion Inventories

A 1995 inventory of erosion sites by the Coös and Essex County Conservation Districts found 34 sites of active erosion in the five northernmost towns included in this segment.[1] A similar inventory of Grafton County riverbanks was conducted in 1992, and in the Caledonia County towns of Waterford to Ryegate and also Newbury in 2000.[2,3] An erosion inventory is a snapshot in time, and can become out-dated as bank conditions change due to natural or human-made flow conditions, but useful conclusions can be drawn.

"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."
Vermont basin planner

All three studies showed that most of the moderate and severe erosion sites occurred on agricultural land, and areas with no vegetative buffer at all tended to have a higher rate of erosion, especially in combination with lack of vegetation due to livestock grazing. Steep, high banks are most prone to erosion. The most common erosive force is the river current. Concave banks, where the current is forced against the shoreline, are especially vulnerable to erosion. Fluctuations in the river level due to power production in dammed sections averaged less than one foot daily, and where shorelines are exposed and banks are undercut due to water level fluctuations, erosion occurs. Seasonal flooding is an evident erosive force. Boat wakes, ice action and freeze/thaw cycles also contribute to erosion. Various methods of erosion control have been employed, from stone riprap, tires, old car bodies, and "biotechnology," and some have produced stable banks in this segment.

According to the Caledonia County Conservation District, "Much of this portion of the river is impounded and much of the erosion that we documented was due to wave action from the wakes of boats or slumping caused by fluctuating water levels. This means that when we consider remediation or prevention we cannot think in terms of a normal free-flowing river, even though some characteristics of a natural system are also present."
Researchers noted that the high percentage of erosion on farmland is related to the fact that farming is concentrated where the best soils and flattest fields are, along the meandering floodplain south of Wells River. "While the lack of forest on these banks certainly affects the

1. *Connecticut River Erosion Inventory of Coös County NH and Essex County VT*. Coös County Conservation District and Essex County Natural Resources Conservation District, 1995.
2. *Connecticut River Erosion Inventory.* Grafton County Conservation District, 1992.
3. *Connecticut River Erosion Inventory, Waterford to Hartford, VT.* Caledonia County Natural Resources Conservation District, 2000.

rate of erosion, the river has always eroded its banks and cut new channels through these floodplains no matter what the land use," the Caledonia report concluded. Seven percent of the forested land had severe erosion, as did four percent of developed land, although the researchers concluded that this figure was low because more of the developed land was also riprapped. Railroad beds, usually with riprap, ran along 24 percent of the riverbank.

B. Geomorphic Assessments

In 2004, the CRJC sponsored an intensive assessment of the 85 miles of the Connecticut River from Murphy Dam to Gilman by John Field, a fluvial geomorphologist, to look further into the causes of erosion in this region that might relate to natural patterns of river movement.[1] CRJC and Dr. Field provided erosion maps to Lancaster, Dalton, Guildhall, and Lunenburg, as well as Headwaters region towns upstream, showing the results of the study.

Field's research revealed that one third of the river had been straightened by humans before 1925, probably to remove obstructions for log drives, and that the river was likely adjusting to this major change. The New Hampshire General Court gave permission in 1863 and 1867 to the Upper Connecticut River and Lake Improvement Company to remove rocks and other obstructions, and to enlarge the channel of the river from First Connecticut Lake to Fifteen Mile Falls. In 1864, the first log drive went through the region. The long, straight stretches of river created by this work are not natural, and the river is now reshaping the resulting sharp corners back into smoother, more natural curves. Straightening the channel has also caused the river to cut down three to four feet within its bed. The river is now trying to widen and slow as it recovers from these dramatic changes. For this reason, it is dangerous to build levees and berms close to the river, because they will not stand up to the river forces at work. A better approach would be to ensure that human development is kept far enough from the river to allow it to continue readjusting without threatening homes or businesses.

Tributaries are also changing the mainstem of the Connecticut. Sediment dropped in the mainstem from tributaries such as the Upper Ammonoosuc River has shifted the current to erode the opposite bank in Vermont. In this watershed, failure of the Nash Stream Dam decades ago has deposited a large load of cobbles and gravel in this major tributary. Heavy land clearing in a tributary watershed may cause too much sediment to enter these tributaries. Sand spread on roads close to streams may also contribute to the problem. Dredging the sand and gravel bars that appear at the tributaries' mouths is not a solution because the tributaries will continue to make these deposits. A better solution is to prevent excess sediment from entering the tributaries in the first place.

High eroding banks of glacial outwash, such as at the Groveton Cemetery opposite Guildhall, also lead to deposits of bars that deflect the river current onto nearby riverbanks. The 2004 study also showed that stone riprap is not foolproof on the upper Connecticut River, and that

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1. *Fluvial Geomorphology Assessment of the Northern Connecticut River, Vermont and New Hampshire*. Field Geology Services. Prepared for the Connecticut River Joint Commissions, October 2004.
2. *Bank Stabilization Implementation and Assessment of the Connecticut River near Colebrook and Groveton, New Hampshire*. Field Geology Services. Prepared for the Connecticut River Joint Commissions, January 2006.

in some places, the river has eroded behind the stone as it attempts to widen and slow down in recovery from straightening. Stone armoring can also move the river's energy and erosive power somewhere else.

Dr. Field continued in 2005 to investigate the role of dams in causing erosion in this part of the river, and assessed three miles of the Connecticut River from the mouth of the Upper Ammonoosuc River to the breached Wyoming Dam. He concluded that the breaching of the dam resulted in a drop in the riverbed here, which has likely led to increased erosion at the Groveton Cemetery.

Fluvial Erosion hazard mapping - Vermont's River Management Program has developed a fluvial erosion hazard mapping method to better define high-hazard streams and places that could be threatened by erosion-induced flooding even though they are not technically within a floodplain. The maps can be used to delineate river corridors that should be protected from encroachments to preserve channel stability and avoid flood hazards. In 2009, New Hampshire followed Vermont's example, enacting legislation to allow communities to adopt fluvial erosion hazard ordinances to help protect their citizens from this special danger in hilly country.

C. Riparian Buffers

Keeping natural vegetation along streams and rivers is probably the simplest, least expensive, and most effective way to slow erosion and capture nutrients and sediments washing off the land and keep these waters from becoming too warm for healthy aquatic life. These strips of grass, shrubs, and/or trees along the banks of rivers and streams filter polluted runoff, capture sediment and nutrients, and provide a transition zone between water and human land use. Vegetated buffers are relatively inexpensive and have the added advantage of providing habitat for both land based and aquatic animal species and privacy for landowners. Shading streams with vegetation helps to create the best light and temperature conditions for certain species, such as trout.

"Buffers may be the natural result of neglect, benign or otherwise."

Riverfront landowner, Bath

The three conservation district studies and the 2004 geomorphic assessment all concluded that human activity appears to be affecting erosion rates in some reaches where riparian vegetation has been removed from the bank. They also showed that landowners need to be more aware of the potential erosion problems that removing riparian buffers could cause.

In 2004, Dr. Field found a lack of riparian buffer along a full 20 percent of the riverbank, and observed a 67 percent greater chance of finding erosion where there is no riparian buffer. He concluded that a forested buffer at least 25 feet wide is associated with greater bank stability and that bank stability generally increases as buffer width increases.

Local regulations regarding riparian buffer protection are summarized in Appendix G.

D. Sedimentation

Erosion sends sediment into streams, where it covers fish habitat and can back up behind dams and reduce water storage or even threaten the dam itself. Sediment can come from many sources, including improperly constructed skid roads and wakes from power boats. Major clear-cutting on steep slopes near surface waters can cause erosion that sends sediment into streams, threatens fisheries, and accelerates the build up of sediment behind dams. Extensive clear-cutting also changes the water retention ability of the watershed, and leads to increased runoff. These can pose a number of problems downstream, including increased flooding, riverbank erosion, and problems at industrial water intakes.

Recommendations for Erosion and Riparian Buffers

- Landowners, foresters, and loggers should follow best/acceptable management practices for timber harvesting, and minimize the water quality and visual impacts of clear-cutting and other timber harvesting operations, particularly near the river and its tributaries.

- Landowners should learn about stewardship, erosion, and the value of riparian buffers. Establish or retain riparian buffers on their waterfront property to help filter out sediment and nutrients washing off the land, to allow trees and vegetation to help stabilize the banks and keep waters cooler, and to provide privacy.

- Fish and game/wildlife agencies should enforce existing boating laws and discourage increased heavy-wake boating because of its potential to increase bank erosion, and plan boating access to avoid increasing erosion on sensitive shorelines.

- Water quality agencies should encourage use of vegetative stabilization if bank stabilization is deemed appropriate on eroding banks. Enforce the present permitting process and guidelines for gravel removal, dredge, and fill activities. Educate landowners and the public on stewardship, erosion, and the value of forested riparian buffers.

- Farmers should use filter strips more consistently on farmland to keep sediment and nutrients from washing into the river. Vermont farmers should look into the possibility of adding buffers with help from the Conservation Reserve Enhancement Program.

- Vermont Department of Forests, Parks and Recreation should permit riparian buffer protection on lands enrolled in the current use taxation program.

- States and county conservation districts should encourage farmers to understand and use best management practices to control erosion and protect and enhance riparian buffers. County conservation districts should be sure landowners have information about sources of assistance and where they can find nurseries for buffer plant material.

IX. Current Protection for the River

A. State Tools for Protecting Riverfront Lands and Water Quality

1. New Hampshire

New Hampshire's Comprehensive Shoreland Protection Act (RSA 483-B) sets minimum shoreland protection standards for shore lands along the state's great ponds, fourth-order rivers, artificial impoundments and coastal waters. These standards are designed to minimize shoreland disturbance in order to protect the public waters, while still accommodating reasonable levels of development in the protected shoreland. Although the act sets minimum standards, section 483-B:8 gives municipalities the authority to adopt land use control ordinances which are more stringent. The Legislature updated the Act in 2007 and 2009.

"People think the Connecticut River doesn't need any help because it flows all by itself."

Hank Swan, River Commissioner, Lyme

2. Vermont

Vermont is the only state in the Northeast without statewide protection for shore lands. Section 1422 of Title 10 of the Vermont Statutes gives towns the authority to regulate shore lands to prevent and control water pollution; preserve and protect wetlands and other terrestrial and aquatic wildlife habitat; conserve the scenic beauty of shore lands; minimize shoreland erosion; reserve public access to public waters; and achieve other municipal, regional or state shoreland conservation and development objectives. Other state regulations set standards for management of agricultural land, silvicultural practices, and sediment and erosion control. In-stream water quality continues to be directly regulated at the state level, including withdrawals and discharges from and into surface waters.

B. Local Tools for Protecting Riverfront Lands and Water Quality

Besides the state statutes, many tools are available to communities and individuals to protect water quality; some are of a regulatory nature, some are non-regulatory. Local tools can include adopting a master plan or town plan and/or water resources management plan with strong recommendations for protecting water quality, scenic views, agricultural soils, riparian buffers, prime wetlands, floodplains, open space, and wildlife habitat. These recommendations can then be carried through to regulatory documents such as zoning, subdivision and site plan review.

1. Local Regulatory Measures

Floodplain Ordinances - Floodplain ordinances can prohibit construction in the floodplain. Floodplains provide flood storage, wildlife habitat and essentially act as buffers to protect water quality. Construction, development, or filling in of floodplains removes flood storage and displaces floodwater to locations further downstream. There is the added benefit of protecting buildings from flood damage which costs taxpayers millions of dollars each year. Vermont towns should update their floodplain ordinances, incorporating them into town zoning bylaws where possible.

Shoreland Overlays - A community can also adopt a shoreland protection ordinance or a buffer overlay to the zoning ordinance in which protection measures for surface waters can be more closely defined than for the rest of the town. In both states the requirements of the shoreland ordinance supersede that of the underlying zoning ordinance.

Fluvial Erosion Hazard Area Zone or Overlay District - A community can help account for river erosion hazards and help to maintain the stability of a stream system by establishing an overlay district based on fluvial erosion hazard mapping. There are several ways that towns can implement fluvial erosion hazard overlay zones. Education of property owners is a less intensive way to implement these zones, and incorporating the zones into town zoning bylaws is ideal.

Others - Towns may also adopt measures to limit the amount of impervious surface created by new development to reduce the transportation of sediments and nutrients, require sediment and erosion control measures during and after construction, and minimize development on valuable agricultural soils.

Model Ordinances - North Country Council, the planning commission for the Riverbend region in New Hampshire, developed a model ordinance for riparian buffers in 2002. In 1993, the Upper Valley Lake Sunapee Regional Planning Commission prepared a River Protection Overlay District Model Zoning Amendment as part of the Grafton County Nonpoint Pollution Project, which can be used as a model for riverfront communities. The Southern Windsor Regional Planning Commission in Vermont has developed "Suggested Criteria for Protection of Surface Water Quality." All of these could be used to develop a local shoreland protection ordinance.

2. Local Non-regulatory Methods

Vegetated Buffers - The use of riparian buffers can be either regulatory or voluntary, and is one of the best and most commonly used methods of protecting surface water. This strip of natural or planted vegetation along the riverbank can intercept harmful nutrients, toxic chemicals and sediments before they enter the surface waters, and help control bank erosion in many settings.

Conservation Purchase or Easements - Towns or conservation groups can use these tools to provide a buffer on land adjacent to surface waters and wetlands, to protect water quality and to provide public access without creating new regulations. Prime agricultural soils, water supply recharge areas, floodplains, sites for rare and endangered species, and historic and archaeological sites can be protected in the same manner.

At Dodge Falls, land conservation by a willing landowner working with a land trust and the NH Land and Community Heritage Investment Program protected riverfront land for public recreation, habitat, and water quality.

Incentives - Current use tax assessment programs in both states encourage landowners to keep their land undeveloped. A variety of incentive programs offered by the USDA Natural Resources Conservation Service encourage landowners, especially farmers and forest landowners, to implement best management practices that benefit water resources, such as buffer planting, fencing of livestock, roof drainage improvements, and much more.

Education programs - Education programs through schools and non-profit education and land use organizations can increase the awareness of the general public regarding private property rights and ways to control non-point pollution on private land. Programs should emphasize the locations and use of existing public access and asking permission before stepping on private property.

X. Tributaries

Many small brooks and large rivers enter the Connecticut River in the Riverbend region, draining portions of Vermont's Northeast Kingdom and New Hampshire's North Country. Most of them have not been assessed, although citizens have begun active water quality monitoring programs on a few tributaries. Riverbend region tributaries are described in Appendix J.

The Connecticut River is fed by several major tributaries draining the western slopes of the White Mountains, including the Israel's, John's, and Ammonoosuc Rivers. In 2007, the New Hampshire Legislature accepted citizens' nomination of the Ammonoosuc River and designated it into the state's Rivers Management and Protection Program. The headwaters of the river were added to this designation in 2009.

In 2001, Vermont embarked upon an ambitious project to create basin plans for all of its waterways, working with local citizens and communities. Citizens are becoming constructively involved, particularly in the watersheds of the Wells and Stevens Rivers in Vermont's Basin 14, where a citizen basin planning group is at work that includes some New Hampshire members. The Passumpsic River watershed, gathering the flow of the Sleeper's and Moose Rivers, is designated as Basin 15. In 1951, this river had the dubious distinction of being one of the most polluted rivers in the entire four-state watershed. Basin 16 includes Essex and other Caledonia County tributaries. Watershed planning has not yet started for either of these basins.

XI. Conclusion

The Riverbend Region of the Connecticut River is, in many ways, the powerhouse of New England, where the region's largest river meets its largest dams to capture its renewable energy. It is also the home of productive farms and forests, and a long tradition of working the land as well as the river. While both remain powerfully beautiful, neither has escaped the effects of human activity, according to clues buried in sediments, in the bodies of fish, and and in the increasing development that is encroaching onto river shores and floodplains.

Leadership in ensuring a healthy future for the river must come from private landowners and decisions at town meeting. The Riverbend Subcommittee looks for all to participate in safeguarding this, the life blood of the North Country and Northeast Kingdom.

Remains of stonewalls, Moore Dam.

Appendix A. Subcommittee Members

These Riverbend Subcommittee members participated in development of this updated water resources chapter of the *Connecticut River Management Plan*:

Philip Blanchard, *Monroe, NH*
Pauline Corzilius, *Haverhill, NH*
Michael Crosby, *Dalton, NH*
Nancy Crosby, *Dalton, NH*
Keith Darby, *Haverhill, NH*
Jan Edick, *Littleton, NH*
Dennis Goodwin, *Waterford, VT*
Bill Graves, *Barnet, VT*
Donald Hallee, *Lunenburg, VT*
Scott Labun, *Newbury, VT*
Richard Martin,* *Guildhall, VT*
Andy Mosedale, *Barnet, VT*
Deborah Noble, *Concord, VT*
Vic St. Cyr, *Dalton, NH*
Traci Wagner, *Lancaster, NH*
Rick Walling,* *Bath, NH*
Ron Wert, *Lancaster, NH*

** elected officers of the subcommittee*

The following Riverbend Subcommittee members participated in development of the 1997 *Connecticut River Corridor Management Plan* which formed the basis for the current plan.

William Allin, *Lancaster, NH*
Moriah Bessenger, *Lancaster, NH*
Philip Blanchard, *Monroe, NH*
David Blanchette, *Lunenburg, VT*
Ken Cantin, *Lunenburg, VT*
Jon Carpenter, *Barnet, VT*
Laurie Carr, *Lancaster, NH*
Pauline Corzilius, *Haverhill, NH*
Vern Dingman, *Haverhill, NH*
Chester Eaton, *Lunenburg, VT*
Keith Eddy, *Waterford, VT*
Bill Elder, *Ryegate, VT*
Hugh Elder, *Ryegate, VT*
Janine Elliott, *Lancaster, NH*
Scott Forbes, *Lancaster, NH*
Roger Gingue, *Lancaster, NH*
Dennis Goodwin, *Waterford, VT*
Craig Hervey, *Newbury, VT*
Harry Lackie, *Bath, NH*
Lantagne, Mary Anne, *Barnet, VT*
Dale Lewis, *Haverhill, NH*
Richard Martin, *Guildhall, VT*
Charles Metz, *Newbury, VT*
Donald Mooney, *Dalton, NH*
Nancy Mooney, *Dalton, NH*
Peter Poulsen, *Littleton, NH*
Leighton Pratt, *Lancaster, NH*
Carl Schaller, *Littleton, NH*
Albert Sponheimer, *Ryegate, VT*
Peter Stanton, *Monroe, NH*
Dean Sweeney, *Dalton, NH*
Judy Tumosa, *Bath, NH*
Rodney Zwick, *Barnet, VT*

Appendix B. Progress Since 1997

Since publication of the first *Connecticut River Corridor Management Plan i*n 1997, much progress has been made. Water quality monitoring programs have begun on the Israel's, Ammonoosuc, Wells, and Stevens Rivers. The Ammonoosuc River Local Advisory Committee has formed to involve citizens in learning more about their river, beginning with nomination and designation into the New Hampshire Rivers Management and Protection Program. An energetic volunteer watershed group has assembled on the Israel's River. Water quality is improving as St. Johnsbury works to eliminate combined sewer overflows. Both states have greatly improved public access to water quality information in the last several years, through their Web sites. The most current data for the Connecticut River are posted at http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm.

New Hampshire has applied an improved Comprehensive Shoreland Protection Act to its side of the Connecticut River, and some towns have enacted even stronger water quality protection for their shorelines, most notably Bath. Littleton enacted a 100-foot building setback from the Ammonoosuc River. New Hampshire has enacted a grant program to provide assistance to farmers for nutrient management. Vermont has assembled citizen basin planning groups that have completed basin plans for the Wells and Stevens Rivers. The state has also funded the Conservation Reserve Enhancement Program to help Vermont farmers with water quality-related improvements. The Upper Valley Land Trust has protected many more acres of agricultural floodplain in Newbury and Haverhill, keeping this essential "green infrastructure" open and functioning for flood control and farming while protecting valued valley views.

Following five years of work and cooperation by New England Power Company, state and federal agencies, and non-profit organizations, the Federal Energy Regulatory Commission issued a new operating license for the three hydro dams at Fifteen Mile Falls, in a process that greatly expanding knowledge of the area's history, water quality, and fisheries, prompted conservation of the thousands of forested acres that protect the view and the river's quality at Moore Reservoir, and established a mitigation and enhancement fund that has benefited the river and its tributaries in many ways. In 2009, FERC accepted the Riverband Subcommittee's *Connecticut River Water Resources Plan* and *Connecticut River Recreation Plan* as comprehensive plans for this part of the river.

The Connecticut River has been the focus of energetic assessment of its waters, sediments, and fish in recent years, in response to the 1997 *Connecticut River Corridor Management Plan*. In preparation for the update of this plan, the New Hampshire Department of Environmental Services, with support from the Environmental Protection Agency, conducted an assessment of the entire 275 miles of the river during the summer of 2004. The extensive study provided greatly improved information over what had previously existed. Two studies of sediment quality by EPA and a study of toxins in fish tissue by EPA and all four states brought new information that will be useful in many ways. In 2009, CRJC sponsored a geomorphic assessment of the entire Ammonoosuc River, a major tributary that joins the Connecticut in the Riverbend Region.

Appendix C. Summary of Recommendations Arranged by Responsible Party

Federal	
Congress	• Legislate reductions in mercury contamination of the region. • Tighten vehicle emission standards for trucks and sport utility vehicles.
USGS	• Cooperate with states to ensure that existing gages are maintained for public safety and to provide or restore gages on tributaries as proposed.
US Army Corps of Engineers	• Purchase development rights from willing owners of land in the natural valley flood storage area to help prevent flooding downstream.
FEMA	• Ensure that area towns have accurate, up to date floodplain maps.
EPA	• Work with the states to conduct a more detailed, comprehensive long-range study of sediment and fish contamination every 10 years to better understand the distribution and types of contaminants, and their trends. Develop a standard method for this type of study. • Assist in eliminating combined sewer overflows in St. Johnsbury. • Devise and publicize new ways of safely disposing of old medications, including narcotics. • Abandon the cap and trade system that would allow polluting power plants to continue to operate without emissions reduction. • Provide funds to support cleanup to get brownfields properties back on the market.
US Fish & Wildlife Service	• Devise and publicize new ways of safely disposing of old medications, including narcotics.
NRCS & county conservation districts	• Purchase development rights from willing owners of land in the natural valley flood storage area to help prevent flooding downstream, to keep the land free from development and open for farm production and flood storage. • Survey the riverbank for the presence of eroding cavities. • Provide cost-sharing for conservation practices, including construction of manure storage pits to help farmers eliminate winter spreading of manure within the floodplain to protect water quality; encourage area farmers to participate in the Environmental Quality Incentives Program, Wildlife Habitat Improvement Program, and Vermont's Conservation Reserve Enhancement Program. • Be sure landowners have information about sources of assistance and where they can find nurseries for buffer plant material. • Encourage farmers to understand and use best management practices to control erosion and protect and enhance riparian buffers.
States	
NH Legislature	• Continue to legislate reductions in mercury contamination of the region. • Apply shoreland protection to smaller tributaries not currently covered by RSA 483B. • Establish a program similar to Vermont's Conservation Reserve Enhancement Program.
VT Legislature	• Continue to legislate reductions in mercury contamination of the region. • Continue to fund the Conservation Reserve Enhancement Program. • Enact a system for registering surface water withdrawals. • Adopt measures to protect the shoreland of the Connecticut River and its third and fourth order tributaries.

Appendix C. Continued

environmental agencies (NH DES & VT DEC)	• Ensure adequate and regular water quality monitoring; continue to encourage and expand volunteer water quality monitoring and coordinate these activities to avoid isolated efforts. Investigate ways to compensate local wastewater treatment plants and appropriate laboratories for processing water quality samples. Ensure that water quality data are easily accessible to the public. • Follow up on water quality violations. • Explore ways to reduce the two states' differences in water quality standards. • Enforce the ban on backyard burning of trash. • Cooperate with USGS to ensure that existing gages are maintained for public safety and to provide or restore gages on tributaries as proposed. • Cooperate with TransCanada and town emergency management officials to create a warning system for riverfront towns and landowners to warn of coming high water or dam failure, and coordinate with managers of other dams in the area. • Support federal initiatives to curb emissions of gases that cause climate change. • Cooperate with TransCanada to educate local citizens about how the Connecticut River is managed in the region, the terms of the Fifteen Mile Falls Settlement Agreement, and how drought affects river management • Discourage any new dam construction on the Connecticut River in Woodsville. • Ensure that construction and demolition debris is handled by competent contractors. • Do not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, wastewater or septage lagoons to be located on aquifers. • Require maintenance for permit-required wetlands and stormwater storage areas, perhaps by requiring the developer to post a bond for this purpose. • Include riparian buffer restoration in road projects near streams and rivers. • Offer an information packet to owners of shoreland to educate them about the best ways to manage their property. • Develop best management practices for residential construction sites and driveways, and educate developers and local planning boards and commissions about the value of using them • Enforce best/acceptable management practices and look more closely at the effect of nutrient enrichment and water level changes on river life forms, including fish. • Enforce regulations respecting biosolid disposal, including setbacks from rivers. • Keep brownfields and hazardous waste site information updated and pursue cleanup. • Encourage use of vegetative stabilization if bank stabilization is deemed appropriate on eroding banks. • Enforce present permitting process and guidelines for gravel removal, dredge, and fill activities. • Educate landowners and the public on stewardship, erosion, and the value of forested riparian buffers. • Train developers to provide vegetative buffers and maintain connections between wetlands within development projects. • Continue to cooperate to better understand and address the Didymo infestation.
NH Department of Environmental Services	• Work with the University of New Hampshire to explore ways to reduce overlap in their water quality monitoring programs by sharing data and presenting it in one database. • Educate riverfront landowners about registering their water withdrawals. • Continue to develop and improve aquifer maps. • Check New Hampshire towns for possible presence of CSOs. • Assist North Country Council in holding more frequent and more convenient household hazardous waste collections. • Enforce the Shoreland Protection Act and provide towns with GIS data and maps of protected shorelands. • Work with the New Hampshire Lakes Association and TransCanada to set up a Lake Host program to check for invasive species at Moore and Comerford Reservoir boat launches. • Develop guidelines and standards for development of impervious surfaces.
Vermont Department of Environmental Conservation	• Establish a way of registering water withdrawals and share the information with NH. If water is withdrawn from non-impounded parts of the river, New Hampshire water withdrawal registration rules should apply. • Identify and map groundwater supplies. • Assist in eliminating combined sewer overflows in St. Johnsbury.
transportation agencies	• Review the herbicide spraying program for rights of way near waterways, and consider alternatives; consult landowners about herbicide spraying, and provide an incentive for them to perform cutting as an alternative to spraying. • Make an effort to retain riparian buffers between roads and rivers; when planning road widening near rivers, add width on the side away from the water. Include riparian buffer restoration in road projects near streams and rivers. Avoid cutting and mowing the riparian buffer near streams. • Pursue alternatives to salt for de-icing, such as using larger sand particles, and follow best management practices for road maintenance and winter care. • Take care to avoid spreading invasive species through ground disturbance and disposal of spoil.
Fish & wildlife agencies	• Discourage increased heavy-wake boating because of its potential to increase bank erosion, and plan boating access to avoid increasing erosion on sensitive shorelines.

Appendix C. Continued

VT Dept. of Forests, Parks, Recreation	• Permit riparian buffer protection on lands enrolled in the current use taxation program.
NH Dept. of Agriculture	• Stipulate that manure may not be spread between December 15 and April 15, and not rely solely upon voluntary compliance with best management practices.
NH Dept. of Safety	• Enforce boating laws to help protect shorelines against erosion.
Towns	
Town management	• Cooperate with TransCanada and NH DES Dam Bureau to create a warning system for riverfront towns and landowners to warn of coming high water or dam failure at Murphy Dam upstream, and coordinate with managers of other dams in the area. Emergency management plans should call for better coordination with dam managers. • Participate in testing of the Connecticut River Emergency Action Plan. • Pursue careful and prompt maintenance of all wastewater treatment facilities which discharge into waters which reach the Connecticut River. Plan ahead for updating and replacing aging facilities. • Encourage oxbow wetlands to develop naturally by giving tax breaks for this land. • Avoid constructing new roads near rivers and streams. • Support a policy of low salt use on roads. • Test the areas where snow has been piled for many years, to see if lead has accumulated in the soil.
Planning boards & commissions	• Prohibit development in the 100-year floodplain, as has Bath, 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. • Encourage developers to establish and/or maintain buffers of native vegetation along rivers and streams for pollution control and riverbank stability. • Consider adopting agricultural soil protection ordinances to keep valuable soils available for farming and to keep development from interfering with flood storage. • Consider surficial geology mapping for more specific groundwater supply information and evaluate water supplies for short and long term growth. Work with state geologists to map varves, to be sure major construction does not take place on unsafe soils.(50/50 match USGS) • Ensure adequate setbacks and lower density for clearing, building, and septic systems. • Consider wellhead protection; take advantage of source water protection grant and loan programs. • Ask for help from regional planning commissions to survey culverts and bridges to identify those that are undersized; also note if they block fish passage and seek grants for replacing them where necessary. • Confirm with the state if their identified water supply information is correct. • Consider discouraging roads and development on steep slopes to control stormwater runoff. • 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. Require that all new development include provisions for infiltration of stormwater runoff on the site. • Encourage developers to provide vegetative buffers and maintain connections between wetlands within development projects. • Include stormwater runoff and culvert upgrading expenses in projecting impact fees and site plan review. • Require sedimentation and erosion controls during and after construction.
Planning boards & commissions	• Do not permit landfills, hazardous waste disposal facilities, auto salvage yards, junkyards, snow dumps, wastewater or septage lagoons, and outdoor salt storage or other de-icing chemical storage to be located on aquifers. • Ask developers to keep natural drainage patterns and use swales and depressions ("rain gardens") to reduce runoff and recharge groundwater. • Identify the extent of sewage disposal problems, especially among seasonal homes converted to year-round use; inspect sewage systems before they are completed; educate home buyers and real estate agents. • In NH, do not issue permits for projects that violate the state shoreland protection law, and should set up a checklist for permitting to be sure that all appropriate parties have been alerted and that all applicable laws are observed. • Require additional treatment to remove oil, solids, and metal for new discharges and redevelopment projects to surface waters and dry wells. • Ask regional planning commissions for advice in how to avoid runoff problems related to large scale clearing. Discourage development of steep slopes to minimize flashy flow. • Discourage black-topping of driveways and parking areas, and encourage ledge pack, pervious pavement, and other pervious surfaces as an alternative.

Appendix C. Continued

Conservation Commissions	• encourage water quality monitoring programs in their towns, using state protocols. • survey smaller wetlands so they know where they are, and consider adding protection for them in towns that do not have such protection in place. • identify old dump sites to look for those close to ground and surface water supplies. • educate people to handle automotive fluids, pesticides, and other chemicals properly so they don't contaminate their own wells, and to keep their septic systems in good operating condition. • encourage use of low-phosphorus detergents to reduce phosphorus entering wastewater treatment plants. • educate people to wrap and discard their unused and out-dated medicines in regular household trash rather than flushing. • strongly encourage citizens to make use of regular household hazardous waste collections and should organize car pooling or "waste pooling" to distant collection sites. • hold an annual "Green Up" Day. • encourage landowners to establish and/or maintain buffers of native vegetation along rivers and streams for pollution control and riverbank stability. • educate NH town officials and landowners about the Shoreland Protection Act. • working with road crews, ensure that culverts are properly sized and placed for fish passage when replacing them during road work; use a natural bottom where possible and appropriate. • survey the riverbank for the presence of eroding cavities. • initiate programs to eliminate invasive plants before they become widely established, especially along roads near waterways.
Fire Departments	• Enforce ban on backyard burning of trash.
Road crews	• Make an effort to retain riparian buffers between roads and rivers; when planning road widening near rivers, add width on the side away from the water. Include riparian buffer restoration in road projects near streams and rivers. Avoid cutting and mowing the riparian buffer near streams. • Pursue alternatives to salt for de-icing, such as using larger sand particles, and follow best management practices for road maintenance and winter care. • Working with conservation commissions, ensure that culverts are properly sized and placed for fish passage when replacing them during road work; use a natural bottom where possible and appropriate. Increased minimum design standards may be necessary based on recent research in New Hampshire. • Follow snow disposal best management practices. Snow should be stored on flat, pervious surfaces, such as grass, and at least 25-100 feet from the edge of a stream or river, with a silt fence between the snow and the stream. There are larger setbacks for snow disposal near public wells. Once snow melts, debris should be quickly cleared from the site and brought to the landfill. • Keep culverts clear of woody debris. Ensure that culverts are sized in anticipation of runoff from future cleared slopes. • Take care to avoid spreading invasive species through ground disturbance and disposal of spoil.
Regional Organizations	
Regional Planning Commissions	• Educate homeowners on the many benefits of household hazardous waste collection, and encourage homeowners to car-pool for convenience in using these collections. • Educate people to wrap and discard their unused and out-dated medicines in regular household trash rather than flushing. • Help towns and state highway agencies anticipate downstream effects in planning for future transportation projects and assist with surveys and evaluation of bridge and culvert adequacy. Develop a simple method to calculate this in chart or graph form.
Land conservation organizations	• Purchase development rights from willing owners of land, especially in the natural valley flood storage area, to help prevent flooding downstream, to keep the land free from development and open for farm production.
regional waste districts	• Educate homeowners on the many benefits of household hazardous waste collection, and encourage homeowners to car-pool for convenience in using these collections.
Utilities	
Trans Canada	• Cooperate with town emergency management officials and NH DES Dam Bureau to create a warning system for riverfront towns and landowners to warn of coming high water or dam failure, and coordinate with managers of other dams in the area. • Communicate with the states and the US Fish and Wildlife Service under extreme weather conditions, in order to operate its dams to manage the river in an environmentally sensitive manner. • Cooperate with the New Hampshire Lakes Association to set up a Lake Host program to check for invasive species at Moore and Comerford Reservoir boat launches. • Update and correct Emergency Action Plans for Moore and Comerford Dams as planned.
Railroads	• Review the herbicide spraying program for rights of way near waterways, and consider alternatives; consult landowners about herbicide spraying, and provide an incentive for them to perform cutting as an alternative to spraying. • Avoid cutting and mowing the riparian buffer near streams.

Appendix C. Continued

Utility companies	• Review the herbicide spraying program for rights of way near waterways, and consider alternatives; consult landowners about herbicide spraying, and provide an incentive for them to perform cutting as an alternative to spraying.
Volunteer Groups	
Watershed groups	• Groups such as the Connecticut River Watershed Council should help set up volunteer water quality monitoring • Encourage continued communication between TransCanada and its successors, with local communities and landowners. • New Hampshire Lakes Association should set up a Lake Host program, with the assistance of TransCanada and NH DES, to check for invasive species at Moore and Comerford Reservoir boat launches.
Recreation groups	• Anglers should practice "catch and release" to avoid exposure to mercury-laden fish. • Ensure that trails have water bars to keep stormwater from eroding compacted soils. • Local outfitters and guides should educate their customers about Didymo and other invasives, and to clean their gear. • Boaters or divers traveling from waters infested with zebra mussel 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 the buoyancy control device from diving equipment. 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.
Land Owners	
Farmers	• Use setbacks from streams for pesticide use. • Move hay and equipment out of fields subject to flooding as soon as they are done working. • Consider practicing no/low till; keep soil covered throughout the year to reduce erosion; rotate corn frequently with other crops, particularly on flood-prone land. • Use filter strips more consistently on agricultural lands to keep sediment and nutrients from washing into surface waters; seek assistance for fencing to keep livestock out of waterways. • In VT, look into the possibility of adding buffers with help from the Conservation Reserve Enhancement Program.
Forest landowners	• Follow best/acceptable management practices for timber harvesting, and minimize the water quality and visual impacts of clear-cutting and other timber harvesting operations, particularly near surface water. Skidder ruts should be smoothed and seeded as soon as possible once a timber harvest is done.
Waterfront landowners	• Learn about stewardship, erosion, and the value of riparian buffers. Retain buffers of native woody vegetation along the banks, and consider planting some of the many ornamental native plants listed in CRJC's riparian buffer guidance. Such plants require less water and are better adapted to riverbanks, and offer food and cover for wildlife. Allow trees and vegetation to help stabilize the banks and keep waters cooler, and to provide privacy. • Avoid using fertilizer near rivers or streams.
All landowners	• Avoid using household items containing mercury and recycle them so the toxin does not end up in a landfill or trash incinerator where it could escape into the environment. • Reduce or eliminate use of pesticides. • Avoid backyard burning of household trash, which is illegal in both states. • Avoid filling wetlands. • Check culverts on their land often to be sure they are not blocked. • Support federal initiatives to curb emissions of gases that cause climate change. • Keep culverts clear of woody debris. • Pick up after their pets when walking their dogs near rivers. • Support local agriculture. • Support the efforts of the New England states to force EPA to enforce its own rules on pollutants and to decrease airborne pollution entering the region from the Midwest. • Obey the ban on burning of trash in backyard barrels or in outdoor furnaces. • Avoid dumping aquarium plants or animals into any waterbody. Dispose of them by freezing or drying before putting them in the trash.

Appendix D. Connecticut River Mainstem Water Quality

Results of 2004 water quality assessment by the New Hampshire Department of Environmental Services, with support from CRJC and US EPA Region I.

Connecticut River Mainstem Segment	Sampling Location	Towns	Miles	Assessment - 2004
Wyoming Dam to Israel's River	Route 2 Bridge, Lancaster	Guildhall Northumb Lancaster	9.31 miles	safe for swimming, fishing, boating insufficient info on health of aquatic life
Israel's River to John's River	Mt. Orne Covered Bridge, Lancaster	Lancaster Guildhall Dalton Lunenburg	5.72 miles	insufficient information on safety of swimming, fishing, boating, or health of aquatic life
Impoundment of Gilman Dam	Railroad bridge at John's River, Dalton	Dalton Lunenburg	3800 acres	insufficient information on safety of swimming, fishing, boating, or health of aquatic life; 40' high dam
Gilman Dam to Cushman Brook	Gilman Road Bridge, Dalton	Dalton Lunenburg	.58 miles	unhealthy for aquatic life due to pH, source unknown safe for swimming, fishing, boating
Moore Reservoir	Old Waterford Road Bridge	Dalton Lunenburg Littleton Concord Waterford	3490 acres	safe for swimming, fishing, boating insufficient info on health of aquatic life
Moore Dam to Comerford Reservoir	Route 18 Bridge, Littleton	Littleton Waterford	1.06 miles	not assessed
Comerford Reservoir	Comerford Reservoir	Littleton Waterford Monroe Barnet	1093 acres	safety for swimming, fishing, boating - not assessed insufficient info on health of aquatic life
Comerford Dam to McIndoe Falls Reservoir	Comerford Dam tailrace, Monroe	Monroe Barnet	.92 miles	not assessed
McIndoe Falls Reservoir	McIndoe Falls - Monroe Bridge	Monroe Barnet	545 acres	safe for swimming, boating, fishing insufficient info on health of aquatic life; 25' high dam
McIndoe Falls tailrace	McIndoe Falls Dam tailrace, Monroe	Monroe Barnet	10 acres	safety for swimming, fishing, boating,- not assessed insufficient info on health of aquatic life
Dodge Falls impoundment	Dodge Falls Dam, Monroe	Bath Ryegate	280 acres	not assessed. 28' high dam
Dodge Falls Dam to Ammonoosuc River	Route 135 canoe access, Bath	Bath Ryegate	4.36 miles	not assessed
Ammonoosuc River to Eastman Brook	Newbury Road Bridge, Haverhill	Haverhill Newbury Piermont Bradford	18.84 miles	safe for swimming, boating, fishing insufficient info on health of aquatic life

Swimming, fishing, and boating - determined by measurements of bacteria *(E. coli)*
Aquatic habitat - determined by measurements of dissolved oxygen, pH, specific conductance, and temperature
Fish consumption advisories: Information is available on the Web at:
www.wildlife.state.nh.us/Fishing/fish_consumption.htm.

Appendix E. Connecticut River Sediment Quality

Data from:

1) 2000 Upper Connecticut River Valley Sediment Study, US EPA, Region 1.
Study of 100 sites on 200 miles of the mainstem and inside mouths of tributaries, Pittsburg NH to Hartland VT

2) 1998 Upper Connecticut River Sediment/Water Quality Analysis, US EPA, Region 1. Study of 10 locations from Stewartstown to Hinsdale NH.

Sampling Location	Town	Site	Contaminants that Exceeded Screening Level	Source
Above Wyoming Dam	Guildhall	UCTR03	Found in very low concentrations: breakdown products of pesticide DDT. Nickel exceeded the level at which some ecological effects could be expected.	1998 EPA study
Wyoming Dam	Guildhall	SD023L	No pollutants found above screening levels. Found in very low concentrations, but the highest found anywhere, was the pesticide endrin.	2000 EPA study
at Neal Brook, 1.7 m. below Wyoming Dam	Guildhall	SD023L	No pollutants found above screening levels.	
3.4 miles below Neal Brook	Guildhall	SD025L	No pollutants found above screening levels. Found in very low concentrations, but at the highest levels found in the 200-mile study, was 4-methylphenol	
Kwik Stop, Lancaster Bridge above Israel's River	Lancaster	SD026L	no pollutants found above screening levels.	
below Lunenburg WWTF	Lunenburg	SD029L	Pyrene, benzo(a)pyrene	
1.2 mile below Mt. Orne bridge	Lancaster	SD030E & 100E	4,4′ DDE, phenanthrene, pyrene, benzo(a)pyrene, benzo(a) anthracene. Also found in very low concentrations, but at the highest levels found in the 200-mile study, was toluene.	
Confluence of John's River and Connecticut River	Dalton	SD031L	Phenanthrene, pyrene, benzo(a)pyrene, benzo(a)anthracene, fluoranthene, chrysene	
Gilman Dam	Lunenburg	SD033L	Phenanthrene, pyrene, benzo(a)pyrene, benzo(a)anthracene	
Moore Reservoir	Concord Littleton	SD034L	No pollutants found above screening levels.	
Moore Reservoir	Concord Littleton	SD036E	Pyrene, benzo(a)pyrene. Also found in very low concentrations, but at the highest levels found in the 200-mile study was carbon disulfide, four different types of PCBs, and three different kinds of dioxins and furans.	
Moore Reservoir	Concord Littleton	SD038E	Pyrene, nickel. Also found in very low concentrations, but at the highest levels found in the 200-mile study, were 8 kinds of dioxins and furans	

Appendix E. Continued

Sampling Location	Town	Site	Contaminants that Exceeded Screening Level	Source
Comerford Reservoir	Littleton Waterford	SD040L	Arsenic, nickel. The highest level of cadmium was found here.	2000 EPA study
Comerford Reservoir	Littleton Waterford	S D041L	Arsenic, chromium, copper, lead, zinc, nickel, low level mercury. The highest levels of aluminum, barium, cobalt, iron, magnesium, potassium, sodium, and vanadium found in the 200-mile study were found here.	
Below Passumpsic River	Monroe	SD043L	No pollutants found above screening levels.	
Above the Stevens River	Monroe	SD045L	Benzo(a)anthracene. Also in very low concentrations, but at the highest levels found in the 200-mile study, was the pesticide endosulfan sulfate.	
Below the McIndoe Falls Dam	Monroe	SD046E	Phenanthrene, fluoranthene, pyrene, benzo(a)pyrene, chrysene, benzo(a)anthracene. Also in very low concentrations, but at the highest levels anywhere, was trichlorofluoromethane, the pesticide hexachlorobenzene, and five PCBs.	
Below the Dodge Falls Dam	Bath	SD047L	Phenanthrene, anthracene, fluoranthene, pyrene, benzo (a) pyrene, benzo(a)anthracene. Also in very low concentrations, but at the highest levels found in the 200-mile study, were pesticides 2,4′-DDD and 2,4′methoxychlor, and thallium.	
Above the Ammonoosuc River	Woodsville (Haverhill)	SD048L	Fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)pyrene, benzo(a)anthracene, chrysene, indeno (1,2,3-cd)pyrene, nickel. Also in very low concentrations, but at the highest levels anywhere in the study, was the pesticide c-Permithren.	
Below the Ammonoosuc River	Woodsville (Haverhill)	SD050L	Phenanthrene, pyrene, benzo(a)pyrene, benzo(a)anthracene	
Below the Ammonoosuc River	Woodsville (Haverhill)	UCTR04	Chrysene appeared at level at which some ecological effects could be expected.	1998 EPA study
Grafton County Farm	Woodsville (Haverhill)	SD053L	No pollutants found above screening levels.	2000 EPA study
Oxbow, 3.2 miles south of Grafton County Farm	Newbury	SD054E	Phenanthrene, fluoranthene, pyrene, benzo(a)pyrene, chrysene, benzo(a)anthracene. Also in very low concentrations, but at the highest levels found in the 200-mile study, were the pesticide endrin ketone and two PCBs.	
Newbury	Newbury	SD055L	Phenanthrene, fluoranthene, pyrene, benzo(a)pyrene, chrysene, benzo(a)anthracene	
Above Oliverian Brook confluence	Newbury	SD056L	Phenanthrene, fluoranthene, pyrene, benzo(a)pyrene, chrysene, benzo(a)anthracene	
Bedell Bridge, below Oliverian Brook confluence	Haverhill	SD058L	Benzo(a)anthracene	

Appendix F. Invasive Aquatic Species

Invasive Aquatic Species*		New Hampshire		Vermont		Present in CT River mainstem	Present in Riverbend Region?
		present	prohibited	present	prohibited		
Floating Plants	European Naiad - *Najas minor*	X	X	X		X	
	Water Chestnut - *Trapa natans*	X	X	X			
	Yellow Floating Heart - *Nymphoides peltata*		X	X			
Submerged Plants	Rock Snot - *Didymosphenia geminata*	X		X		X	
	Variable Milfoil *Myriophyllum heterophyllum*	X	X				
	Fanwort - *Cabomba caroliniana*	X	X		X		
	Eurasian Water-Milfoil - *Myriophyllum spicatum*	X	X	X		X	
	Brazilian Elodea - *Egeria densa*	X	X		X		
	Curly-leaf Pondweed - *Potamogeton crispus*	X	X	X		X	
	Parrot Feather - *Myriophyllum aquaticum*		X				
	Hydrilla - *Hydrilla verticillata*		X		X		
	European Frogbit - *Hydrocharis morsus-ranae*		X	X	X		
	Indian Water Star - *Hygrophila polysperma*				X		
	Giant Salvinia - *Salvinia auriculata*				X		
	Giant Salvinia - *Salvinia herzogii*				X		
	Giant Salvinia - *Salvinia molesta*				X		
	Giant Salvinia - *Salvinia biloba*				X		
	Great Water Cress - *Rorippa amphibia*			X			

Appendix F. Continued

Invasive Aquatic Species*		New Hampshire present	New Hampshire prohibited	Vermont present	Vermont prohibited	Present in CT River mainstem	Present in Riverbend Region?
Emergent Plants	Purple Loosestrife - *Lythrum salicaria*	X	X	X		X	X
	Common Reed - *Phragmites australis*	X	X	X		X	
	Flowering Rush - *Butomus umbellatus*		X	X			
	Japanese Knotweed - *Fallopia japonica*	X		X		X	X
	Yellow Flag Iris - *Iris pseudoacorus*	X		X		X	X
	True forget-me-not - *Myosotis scorpioides*	X		X		X	X
Animals	Zebra Mussel - *Dreissena polymorpha*			X			
	Faucet Snail - *Bithynia tentaculata*			X			
	Chinese mystery snail - *Cipangopaludina chinensis*			X			
	Common Carp - *Cyprinus carpio*			X			
	Gizzard Shad - *Dorosoma cepedianum*			X			
	White Perch - *Morone americana*			X			
	Rusty Crayfish - *Orconectes rusticus*		X	X			
	European Rudd - *Scardinius erythrophthalmus*		X	X			
	Walking Catfish - *Clarias batrachus*		X				
	Grass carp - *Ctenopharyngodon idella*		X				
	Round goby - *Neogobius monachus*		X				

*Please note: this list is the result of informal observations by CRJC staff and more formal observations taken during a 2006 Connecticut River Aquatic Invasive Plants Outreach & Survey Project, funded by the Connecticut River Joint Commissions' Partnership Program. This survey took place at 21 mainstem sites in New Hampshire and Vermont, from Hinsdale to Pittsburg. Because the entire region was not surveyed intensively, and because invasive species may have established colonies since these observations were made, it is likely that this list is not complete.

Appendix G. Local Shoreland and Water Quality Protection

New Hampshire Towns

Municipal Tools	Lancaster	Dalton	Littleton	Monroe	Bath	Haverhill
1. Master Plan is in effect	Yes (2001)	Yes (1989)	Yes (2004)	Yes (1989)	Yes (2007)	Yes (1999)
2. River is mentioned in master plan	Yes	Yes	Yes	Yes	Yes	Yes
3. Scenic/historic resources mention in master plan/ zoning	Yes	Yes	Yes	Yes	Yes	Yes
4. Zoning is in effect	Yes (2005)	No	Yes	Yes (1979)	Yes (1989)	Partial
5. Subdivision Regulations are in effect	Yes (1993)	Yes (2002)	Yes (1993)	Yes (1987)	Yes (2004)	Yes (2002)
6. Site Plan Review is in effect	Yes (2002)	No	Voluntary	No	No	No
7. Excavation Regulations are in effect	No	No	No	No	Yes	No
8. Shoreland Protection Regulations	No	No	No	No	Yes	No
a. Building setback required from waterways? (50′ setback on CT River - state law)	No	No	No	No	Yes	No
b. Development prohibited in flood hazard area? (100 year floodplain)	N/A	No	No	No	Yes	No
c. Riparian buffer protected?	No	No	No	No	No	No
d. Overlay district for rivers & streams?	No	No	Yes *	No	No	No
e. Minimum frontage required for shore lots? (150′ min. on CT. River if no sewer-state law)	No	No	No	No	Yes - 150′	No
f. Local regulation of docks in effect?	No	No	No	No	No	No
9. Wetlands Regulations	No	No	No	No	Yes	Yes
a. Uses regulated in wetlands?	No	No	No	No	Yes	Yes
b. Uses regulated in buffer around wetlands?	No	No	No	No	No	Yes - 75′
10. Groundwater Protection Regulations	Yes	No	Yes	Yes	Yes	Yes
a. Uses regulated over aquifers?	No	No	No	No	Yes	Yes
b. Well-head protection area defined?	No	No	No	No	Yes	No
c. On-site sewage disposal buffer for water supplies?	No	No	No	No	Yes - 200′	No
11. Agricultural Soils Protection Regulations	No	No	No	No	No	No

Municipal Tools	Lancaster	Dalton	Littleton	Monroe	Bath	Haverhill
12. Steep Slopes Regulations	No	No	No	No	Yes - 25%	No
13. Town has a conservation commission	Yes	Yes	Yes	Yes	Yes	Yes

Source: North Country Council, June, 2005
**Littleton overlay district for rivers and streams:* Conservation of water, plants, & wildlife; Emergency procedures necessary for safety or protection of property (erosion or safety threat); Usual & necessary maintenance; Recreation & nature trails; Overhead or underground utility crossings; Wetland mitigation measures; Storm water drainage practices.

Vermont Towns (see notes below)

Town Tools	Guildhall	Lunenburg	Concord	Waterford	Barnet	Ryegate	Newbury
1. Town Plan is in effect (most recent)	Yes (2005)	Expired 1996	Expired 1997	Rewriting	Rewriting	Yes (2001)	Yes
2. River mentioned in master plan	Yes	No	Yes	Yes	Yes	Yes	Yes
3. Scenic or historic resources mentioned in master plan and/or zoning	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Zoning is in effect	Yes	No	Yes	Yes	Yes	No	Yes
5. Subdivision Regulations in effect	Yes	No	No	No	Yes	No	Yes
6. Site Plan Review in effect	Yes	No	Yes	Yes	Yes	No	Yes
7. Excavation Regulations in effect	Yes	No	No	Yes	Yes	No	Yes
8. Shoreland Protection Regulations	Yes	No	Yes - Shadow Lake & Miles Pond only	No	Yes	No	Yes - 250′ from rivers/ streams, 500′ from ponds
a. Building setback required from waterways? (No state protection)	Yes - 75′	No	Yes	No	Yes	No	Yes - 100-250′ for ponds
b. Development prohibited in flood hazard area? (100 year floodplain)	No	Yes	No	No	No	No	Yes
c. Riparian buffer protected?	No	No	No	No	No	No	Yes
d. Overlay district for rivers & streams?	No	No	No	No	No	No	No
e. Minimum frontage for shore lots?	No	No	Yes - 35′	No	Yes	No	Yes - if w/in 250′ requires 50′ frontage
f. Local regulation of docks?	No	No	No	No	Yes	No	No

Appendix G. Continued

Tools	Guildhall	Lunenburg	Concord	Waterford	Barnet	Ryegate	Newbury
9. Wetlands Regulations	No	No	No	No	No	No	No
a. Uses regulated in wetlands?	No	No	No	No	No	No	No
b. Activities regulated in a buffer zone around wetlands?	No	No	No	No	No	No	No
10. Ground water Protection Regulations	No	No	No	No	Yes	No	Yes
a. Uses regulated over aquifers ?	No	No	No	No	No	No	Yes
b. Well-head protection area defined?	No	No	No	No	No	No	Yes
c. On-site sewage disposal buffer around water supplies?	No	No	No	No	Yes	No	Yes - 500’
11. Agricultural Soils Protection Regulations	Ag District –min 25 acres	No	Rural Lands District --min. 25 acres	Rural Resid’l Dist. min. 2 acres	Ag District -- min. 3 acres	No	No
12. Steep Slopes Regulations	No	No	No	No grading over 2:1	Fences to excavations	No	Yes - not over 25%
13. Conservation commission	No	No	No	No	No	No	Yes

Sources:
Northeastern Vermont Development Association, June 2005 (all towns except Newbury)
Research by Deborah Noble, April, 2005 (Newbury)

Notes:
*Vermont town plans expire after five years. Date given is date of last update.
Guildhall: Historic resources in town plan: “…These buildings surround another traditional landmark of Vermont’s towns, the Common. This scene at Guildhall is a classic one, which should be preserved.” Guildhall Village is an Historic/Design Review District. Scenic resources in town plan: Scenic roads and vistas should be preserved so that tourists continue to come to Guildhall and add to the regional tourist economy. Three rural lands districts. Alternative energy and forestry conservation lands along LaMott Road. Alternative energy zone.

Lunenburg: Zoning, as well as some protection to Neal’s Pond were recommended in the plan.

Waterford: Plan recommends tax incentives to owners who protect wetlands, as well as inclusion in a “Rural Lands/Forestry” District.

Barnet: Plan calls for the creation of a conservation commission.

Ryegate: No zoning, however, the town plan makes specific recommendation for water and soil protection. A stated goal is to maintain or improve water quality to a level that approaches the quality of 200 years ago.

Appendix H. Water Withdrawals - New Hampshire

Type	Name	Facility	Town	Source	Source Type
water supplier	Lancaster Water Works	Lancaster Water Works	Lancaster	Garland Brook	surface water
hydroelectric power	Garland Mill Hydro	Garland Sawmill	Lancaster	Garland Brook	surface water
hydroelectric power	Dalton Hydro Co	Gilman Hydro Plant	Dalton	Connecticut River	surface water
water supplier	Littleton Water & Light Dpt	Water Works	Littleton	Gale River, well	surface water
hydroelectric power	Transcanada	Moore Station	Monroe	Connecticut River	surface water
hydroelectric power	Transcanada	Comerford Station	Monroe	Connecticut River	surface water
hydroelectric power	Transcanada	McIndoe Falls Station	Monroe	Connecticut River	surface water
water supplier	Monroe Water Works	Monroe Water Works	Monroe	wells	groundwater
hydroelectric power	Dodge Falls Association	Dodge Falls Hydro	Bath	Connecticut River	surface water
hydroelectric power	Ellyson Co Inc/RJ McHugh	Pettyboro Brook Hydro	Bath	Pettyboro Brook	surface water
hydroelectric power	Bath Electric Power Co	Bath Electric Power Co	Bath	Ammonoosuc River	surface water
water supplier	Precinct of Haverhill Cnr	Water Works	Haverhill	wells	groundwater
water supplier	Mountains Lake District	Water Works	Haverhill	wells	groundwater
water supplier	Woodsville Water & Light	Water Department	Haverhill	Ammonoosuc River	surface water
hydroelectric power	Chi Operations Inc	Woodsville Hydro Project	Haverhill	Ammonoosuc River	surface water
water supplier	Woodsville Water Light	N Haverhill Water Works	Haverhill	Lime Kiln Springs	groundwater

Appendix I. New Hampshire Comprehensive Shoreland Protection Act-NH RSA 483-B

The New Hampshire shore of the Connecticut River, from the river's source at Fourth Connecticut Lake, is covered by this law. The law also applies to lakes and ponds of 10 acres or more, and to other rivers and streams in New Hampshire's Riverbend Region that are fourth order and larger:

City/ Town	River/ Stream	Stream Order	Upstream limit of section covered by law (beginning of fourth order or designated segment)
Lancaster	Connecticut River	6	(all)
	Israel's River	5	Juncture of South Branch Israel River in Jefferson
	Garland Brook	4	Juncture of Bunnell Brook
	Otter Brook	4	Juncture of Caleb Brook and Burnside Brook
Dalton	Connecticut River	6	(all)
	John's River	5	Juncture of Carroll Stream in Whitefield
Littleton	Connecticut River	6	(all)
	Ammonoosuc River	4	(all)
Monroe	Connecticut River	6	(all)
Bath	Connecticut River	6	(all)
	Ammonoosuc River	5	(all)
	Wild Ammonoosuc River	4	Juncture of unnamed 3rd order stream in Easton
Haverhill	Connecticut River	6	(all)
	Ammonoosuc River	5	(all)
	Oliverian Brook	4	Junction of North Branch Oliverian Brook

New Hampshire's shoreland law was originally enacted in 1991, setting minimum standards for the subdivision, use, and development of shorelands of the state's larger water bodies. In 2005 the Legislature established a commission to study the effectiveness of the act. The Commission was comprised of 24 members representing a variety of stakeholders including the General Court, the conservation community, the regulatory community, natural resource scientists, agricultural interests, business and economic interests, and members of the general public. Its final report contained 17 recommendations for changes to the law, 16 of which were enacted and became effective April 1, 2008. The changes include impervious surface allowances, ways of measuring riparian buffer vegetation that are easier for landowners to understand and use, a provision for a waterfront buffer in which vegetation removal is restricted, shoreland protection along rivers designated under RSA 483 (Designated Rivers), and the establishment of a permit requirement for many construction, excavation or filling activities within the 250 foot protected shoreland area.

For more information about the NH Shoreland Program, contact NH DES at 603-271-3503 or http://des.nh.gov/organization/divisions/water/wetlands/cspa/index.htm.

Appendix I. Continued

RSA 483-B
Comprehensive Shoreland Protection Act (CSPA)
A Summary of the Standards

Effective July 1, 2008, **A STATE SHORELAND PERMIT is required for many construction, excavation or filling activities within the Protected Shoreland.** Forest management not associated with shoreland development or land conversion and conducted in compliance with RSA 227-J:9 or under the direction of a water supplier for the purpose of managing a water supply watershed, and agriculture conducted in accordance with best management practices as required by RSA 483-B, III is exempted from the provisions of the CSPA. Projects that receive a permit under RSA 482-A, e.g., beaches, do not require a shoreland permit. A complete list of activities that do not require a shoreland permit can be found in the Shoreland Administrative Rules, Env-Wq 1406.

250 feet from Reference Line—THE PROTECTED SHORELAND:

Impervious Surface Area Allowance. Twenty percent of the area within the protected shoreland may be impervious surface. This may be increased up to 30 percent if there are 50 points of tree coverage in each 50 foot x 50 foot grid segment in the waterfront buffer (WB), and a storm water management plan is submitted and approved by DES.

Other Restrictions:

- No establishment/expansion of salt storage yards, auto junk yards, solid waste and hazardous waste facilities.
- All new lots, including those in excess of 5 acres are subject to subdivision approval by DES.
- Setback requirements for all new septic systems are determined by soil characteristics.
  - 75 feet for rivers and areas where the there is no restrictive layer within 18 inches and where the soil down gradient is not porous sand and gravel (perc>2 min.).
  - 100 feet for soils with a restrictive layer within 18 inches of the natural soil surface.
  - 125 feet where the soil down gradient of the leachfield is porous sand and gravel (perc rate equal to or faster than 2min/in.).
- Minimum lot size in areas dependent on septic systems determined by soil type.
- Alteration of Terrain Permit standards reduced from 100,000 square feet to 50,000 square feet.
- For *new* lots with on-site septic, the number of dwelling units per lot shall not exceed 1 unit per 150 feet of shoreland frontage.

150 feet from Reference Line—NATURAL WOODLAND BUFFER (NWB) RESTRICTIONS:

- For lots that contain ½ acre or more within the NWB, between 50 feet and 150 feet of the reference line, the vegetation within at least 50 percent of the area, exclusive of impervious surfaces, shall be maintained in an unaltered state.
- For lots that contain less than ½ acre within the NWB, between 50 feet and 150 feet of the reference line, the vegetation within at least 25 percent of the area shall be maintained in an unaltered state.

50 feet from Reference Line—WATERFRONT BUFFER and PRIMARY BUILDING SETBACK:

- Effective April 1, 2008, all primary structures must be set back at least 50 feet from the reference line. Towns may maintain or enact their own setback only if it is greater than 50 feet.
- Within 50 feet, a waterfront buffer must be maintained. Within the waterfront buffer, tree coverage is managed with a 50-foot x 50-foot grid and points system. Tree coverage must total 50 points in each grid. Trees and saplings may be cut as long as the sum of the scores for the remaining trees and saplings in the grid segment is at least 50 points.
- No natural ground cover shall be removed except for a footpath to the water that does not exceed 6 feet in width and does not concentrate stormwater or contribute to erosion.
- Natural ground cover, including the duff layer, shall remain intact. No cutting or removal of vegetation below 3 feet in height (excluding lawns) except for the allowable footpath. Stumps, roots, and rocks must remain intact in and on the ground.
- Pesticide or herbicide applications must be by a licensed applicator only.
- Low phosphorus, slow release nitrogen fertilizer may be used for the area that is beyond 25 feet from the reference line. No fertilizer, except limestone, shall be used between the reference line and 25 feet.

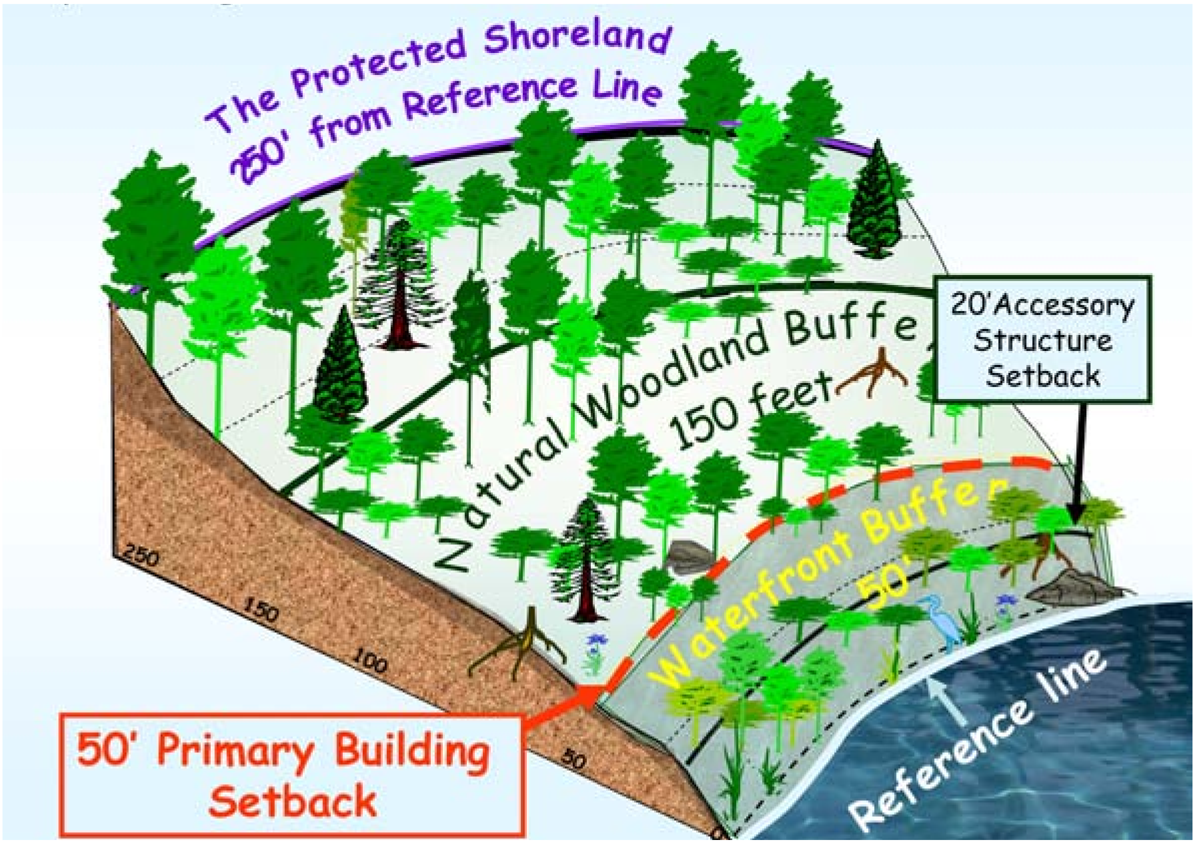
REFERENCE LINE: For ***coastal waters*** it is the highest observable tide line; for ***rivers*** it is the ordinary high water mark; for ***natural fresh waterbodies*** it is the natural mean high water level; and for ***artificially impounded fresh waterbodies*** it is the elevation at the spillway crest or, if there are flowage rights, the elevation of the flowage rights.

NON-CONFORMING STRUCTURES Are structures that, either individually or when viewed in combination with other structures on the property, do not conform to the provisions of the CSPA, including but not limited to the impervious surface limits of RSA 483-B:9V(g). They may be repaired, renovated, or replaced in kind using modern technologies, provided the result is a functionally equivalent use. Such repair or replacement may alter the interior design or existing foundation, but shall result in no expansion of the existing footprint except as authorized by the department pursuant to paragraph II of RSA 483-B.

A SITE ASSESSMENT is required prior to executing a purchase and sale agreement for any "developed waterfront property" using a septic disposal system and which is contiguous to or within 200 feet of a great pond (a public water of more than 10 acres) as defined in RSA 4:40-a and upon which stands a structure suitable for either seasonal or year-round human occupancy.

For more information, please visit the DES Shoreland Website at www.des.nh.gov/cspa

Appendix I. Continued



The protected shoreland in New Hampshire. Source: NH DES.

Appendix J. Tributaries to the Connecticut River

New Hampshire

Tributary	State Assessment*	Sediment Quality** contaminants found above level at which ecological effects might be expected	Local Observations
Town where tributary enters Connecticut River: LANCASTER			
Israel's River	Largely supports swimming and other recreation. Some low pH readings that could reflect natural conditions. 6.63 miles in Jefferson and 2.03 miles in Lancaster do not support recreation due to *E. coli* bacteria.	SD027l (lower river near WWTF and CT R.)- no pollutants found above screening levels. SD028L (upper, near Lancaster Ctr)- phenanthrene, pyrene, benzo (a)anthracene, chrysene, benzo(a)pyrene found above screening levels.	Once known as Siwooganook. Israel River Volunteer Advisory Group began WQ monitoring in 2006 with all three towns in the watershed (Lancaster, Jefferson, Whitefield) at 8 stations. Results met state standards. Group has gained confidence of towns, is now sampling in nearby streams. Geomorphic assessment underway for Stagg Hollow Brook in Jefferson. US Army Corps of Engineers ice control structures.
Bunnell Brook	7.85 miles aquatic life impaired, low pH		
Otter Brook	2.34 miles aquatic life impaired by low pH; swimming impaired by *E. coli*		
Caleb Brook	swimming impaired by *E. coli*		
Indian Brook	3.32 miles aquatic life impaired by low pH		
Bone Brook	swimming impaired by *E. coli*		
Town where tributary enters Connecticut River: DALTON			
John's River	upper river not assessed; lowest 3.9 miles aquatic habitat impaired due to low pH; insufficient information on safety of swimming	SD 032L (French Rd. bridge) -phenanthrene, pyrene, fluoranthene, benzo(a) anthracene, chrysene, benzo(a) pyrene, low level mercury	
Rix Brook	not assessed	not assessed	High quality brook trout stream, upper watershed largely forested; runs through damaged and undersized culvert under Route 135, large scour hole below culvert. Efforts to replace culvert with natural bottom design and appropriate size.
Cushman Brook	4.44 miles impairments to aquatic life based on fish bioassessments		
unnamed brook to Forest Lake	0.65 miles aquatic habitat impaired- low pH		

Appendix J. Continued

Tributary	State Assessment*	Sediment Quality** contaminants found above level at which ecological effects might be expected	Local Observations
Town where tributary enters Connecticut River: LITTLETON			
Carpenter Brook	not assessed	not assessed	
Cow Brook	not assessed	not assessed	
Mullikin Brook	not assessed	not assessed	
Town where tributary enters Connecticut River: MONROE			
Roaring Brook	not assessed	not assessed	
Hunt Mtn. Brook	not assessed	not assessed	
Town where tributary enters Connecticut River: BATH			
Chamberlain Brook	not assessed	not assessed	
Caribu Brook	not assessed	not assessed	
unnamed brook, enters above The Narrows	not assessed	not assessed	Second order stream, length 1.1 miles. Corridor partly forested, partly in agriculture; some road runoff, dispersed development, intensive cropping, lack of buffer, perched culverts, cemetery. Discarded appliances and other trash was observed between Route 135 and CT R in 2006; new landowner cleaning it up in 2007. No evident WQ problems.
Town where tributary enters Connecticut River: HAVERHILL			
Ammonoosuc River *Designated into NH Rivers Management and Protection Program, 2007 + 2009*	Had not been assessed until 2005, when volunteer river assessment monitoring began at 14 sites. 2006 - all stations met WQ standards for dissolved oxygen, turbidity; and specific conductance; all but 2 for pH. Average water temperature varied from 15.5 °C. to 20.2 °C. 3.32 miles in Littleton impaired by *E. coli.* Aquatic habitat impaired due to low pH in 16.88 miles in Carroll, 10.61 miles in Bethlehem, 1.23 miles in Landaff Wild Ammonoosuc River (tributary) impaired for 7.88 miles by low pH.	SD049L (Woodsville)-phenanthrene, pyrene, fluoranthene, benzo(a) anthracene, chrysene, benzo(a) pyrene. Also found in very low concentrations, but at the highest levels found anywhere in the study, was the pesticide Dacthal.	50 miles long, approx. 400 sq mi watershed. Increasing development on the floodplain in Littleton prompted concern from the downstream communities of Lisbon, Bath, and Haverhill. Used for drinking water supply. Steep scenic watershed; peak flows can be similar to those on the Connecticut. Most erosion seems to be caused by ice. Important coldwater fishery. Half of corridor is aquifer. Nearly all meets/exceeds Class B standards for WQ. One of NH's best whitewater rivers. Threatened by development boom. 5 functioning dams, 9 breached. Wild Ammonoosuc River, a tributary: Zinc could pose a problem for water supply or irrigation. Monitoring by a home school group at 5 sites, including macroinvertebrates, found excellent water quality. Gold dredging is still going on.

Appendix J. Continued

Tributary	State Assessment*	Sediment Quality** contaminants found above level at which ecological effects might be expected	Local Observations
Oliverian Brook	10 miles unsafe for swimming due to bacteria from unknown sources, Morris Brook	SD057L (1/4 mi. up from CT R.)-phenanthrene, pyrene, fluoranthene, benzo(a) anthracene, chrysene, benzo(a) pyrene, indeno (1,2,3-cd) pyrene	Complaint from neighbors about aerial manure spraying led to some water quality monitoring that showed that *E.coli*, conductivity, and phosphorus went up when spraying occurred. The group hoped to get the landowner to change practices and to do more monitoring, but did not get the funding for it. Becket School, a large landowner in this watershed, may set up a water quality monitoring program.
Clark Brook	8.5 miles unsafe for swimming due to bacteria from unknown sources and impaired by low pH and aluminum		County Conservation District won Moose Plate Grant in 2007 that resulted in project to prevent feedlot contamination at Brian Stone Farm in N. Haverhill from entering tributary of Clark Brook

*2008 draft 303(d) List of Impaired Surface Waters
**2000 Upper Connecticut River Valley Sediment Study, US EPA, Region 1. Study of 100 sites on mainstem and inside mouths of tributaries, Pittsburg NH to Hartland VT.

***For more information on the condition of NH water bodies, see NH DES Water Division - Surface Water Quality Assessments and "report cards" for each water body at http://www2.des.nh.gov/SWQA/SWQAList.aspx.

Appendix J. Continued

Vermont

Tributary (watershed area)	State Assessment*	Sediment Quality**	Local Opinion
Town where tributary enters Connecticut River: Guildhall			
Neal Brook	not assessed	not assessed	
Towns where tributary enters Connecticut River: Lunenburg, Concord, Waterford			
	not assessed	not assessed	
Town where tributary enters Connecticut River: Barnet			
Passumpsic River	TMDL list: *E. coli* contamination from St. Johnsbury CSOs contaminates this river from Pierce Mills Dam to 5 miles below Passumpsic Dam; also Lower Sleepers River. St. Johnsbury is working to fix CSOs Basin planning will begin in 2008. Straight pipe discharges and failed septic systems in E. St. Johnsbury have been cleaned up. Further assessment needed of effects of urban runoff. On the Sleepers River, further assessment is needed of elevated nickel and oil levels in sediment possibly associated with the Fairbanks-Morse foundry site.	SD042L (lower river)-no pollutants found above screening levels. Found in very low concentrations, but at the highest levels anywhere in the study, was the pesticide Pentachloroanisole. SD044L (upper river)- phenanthrene, pyrene, benzo(a) anthracene, benzo(a)pyrene, nickel	Direct discharge of gray water to the Moose River, a Passumpsic trib, in Concord village. The Passumpsic Valley Land Trust is conserving land
Stevens River	Watershed is 68% forested, 17% agricultural. 1999- No reported water quality problems, although aquatic habitat in lowest mile is affected by fluctuations from McIndoe Falls dam. Major concerns are flooding, erosion, and nonpoint source pollution from landfills, septic systems, and poor logging. Roads are contributing to sediment runoff. A bridge and culvert survey is being done. Further assessment needed of instability between Route 5 and I91.	not assessed	Baseline info was collected and results met VT standards, although they went up with rainfall.
Town where tributary enters Connecticut River: Newbury			
Wells River	Watershed is 81% forested. 1999- From Groton to Wells River, 10 miles threats due to siltation, iron, some nutrients, other metals and organics from a large gravel pit, unlined landfill, loss of vegetation in areas where yards and pasture encroach on riparian zone, bridge and road runoff and maintenance. US Geological Survey 1993 sediment study in the town of Wells River found chromium, lead, nickel, and zinc at levels which might lead to biological effects. 2005 Wells River watershed council: runoff from winter salting and sanding, stormwater runoff, river straightening and floodplain filling for road construction, and undersized bridges and culverts..Road wash out contributing sediment. Major concerns are flooding, erosion, and nonpoint source pollution from landfills, septic systems, and poor logging. Monitoring is needed. Ticklenaked Pond in the watershed is on TMDL list for high phosphorus.	SD051L (Wells R. behind info ctr)- naphthalene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a) anthracene, chrysene, benzo(a) pyrene, indeno (1,2,3-cd)pyrene SD052L (above dam at Adams Paper Co.)- phenanthrene, fluoranthene, pyrene, benzo(a) anthracene, chrysene, benzo(a) pyrene. Also found in very low concentrations, but at the highest levels found anywhere in the study, was the pesticide Lindane and the element beryllium.	

*2008 VT draft 303(d) List of Impaired Surface Waters and 2008 draft VT List of Priority Surface Waters Outside the Scope of Clean Water Act Section 303(d).

**2000 Upper Connecticut River Valley Sediment Study, US EPA, Region 1. Study of 100 sites on main-stem and inside mouths of tributaries, Pittsburg, N.H. to Hartland, Vt.

Appendix K. List of Acronyms

BMP = best management practices
CFS = cubic feet per second
CREP = Conservation Reserve Enhancement Program (Vermont)
CRJC = Connecticut River Joint Commissions
CRWC = Connecticut River Watershed Council
CSO = combined sewer overflow
EPA = United States Environmental Protection Agency
FEMA = Federal Emergency Management Administration
FERC = Federal Energy Regulatory Commission
NH DES = New Hampshire Department of Environmental Services
NPDES = National Pollutant Discharge Elimination System
NRCS = Natural Resources Conservation Service of USDA
PAH = polyaromatic hydrocarbon
PCB = polychlorinated biphenyl
TMDL = total maximum daily load
USDA = United States Department of Agriculture
USGS = United States Geological Survey
UST= underground storage tank
UVLT = Upper Valley Land Trust
VRAP = Volunteer River Assessment Program
VT DEC = Vermont Department of Environmental Conservation of ANR
VT ANR = Vermont Agency of Natural Resources
WWTF = wastewater treatment facility

Appendix L: New Hampshire Rivers Classifications

ENVIRONMENTAL Fact Sheet

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

29 Hazen Drive, Concord, New Hampshire 03301 • (603) 271-3503 • www.des.nh.gov

R&L-14 2009

River Classifications and State Regulated Protection Measures As They Apply To Each Classification

	RIVER CLASSIFICATIONS			
	Natural	**Rural**	**Rural-Community**	**Community**
Activities Allowed				
Dams & Encroachments				
Construction of New Dams	No	No	No	Yes
Reconstruction of Breached Dams	No	Yes (within six years)	Yes (within six years)	Yes
Channel Alterations	No (excluding repair)	Yes (with conditions)	Yes (with conditions)	Yes (with conditions)
Water Quality/ Water Quantity				
Water Quality	Class A or B	Class B	Class B	Class B
Interbasin Transfers	No	No	No	No
Protected Instream Flow	Yes	Yes	Yes	Yes
Waste Disposal				
New Landfills	No (within 250 ft.)	No (within 250 ft.)	No (within 250 ft.)	No (within 250 ft.)
New Hazardous Waste Facilities	No (within 250 ft.)	No (within 250 ft.)	No (within 250 ft.)	No (within 250 ft.)
Other New Solid Waste Facilities	No (within 250 ft.)	No (within 250 ft.)	No (within 250 ft.)	No (within 250 ft.)
New Septic Systems	No (within 75 ft.)	No (within 75 ft.)	No (within 75 ft.)	No (within 75 ft.)
New Auto Junk Yards	No (within 250 ft.)	No (within 250 ft.)	No (within 250 ft.)	No (within 250 ft.)
Fertilizer				
Limestone	Yes	Yes	Yes	Yes
Sludge and Septage	No (within 250 ft.) Conditions apply	No (within 250 ft.) Conditions apply	No (within 250 ft.) Conditions apply	No (within 250 ft.) Conditions apply
Low Phosphorus, Slow Release Nitrogen	No (within 25 ft.)	No (within 25 ft.)	No (within 25 ft.)	No (within 25 ft.)

Appendix L. Continued

All Other Fertilizers	No (within 25 ft.)	No (within 25 ft.)	No (within 25 ft.)	No (within 25 ft.)
Pesticides and Herbicides				
All pesticides and herbicides	Yes (with conditions)	Yes (with conditions)	Yes (with conditions)	Yes (with conditions)
Recreation Use				
Motorized Watercraft	No	Yes (within 150 ft. of shoreline, only "headway" speed)	Yes (within 150 ft. of shoreline, only "headway" speed)	Yes (within 150 ft. of shoreline, only "headway" speed)
New Building				
Primary Structure	No (within 50 ft.)	No (within 50 ft.)	No (within 50 ft.)	No (within 50 ft.)
Multiple Dwellings	Yes (with conditions)	Yes (with conditions)	Yes (with conditions)	Yes (with conditions)
Impervious Surface Cover	Yes (with conditions)	Yes (with conditions)	Yes (with conditions)	Yes (with conditions)
Subdivision	Yes (with approval)	Yes (with approval)	Yes (with approval)	Yes (with approval)l
Buffer Removal				
Natural Ground Cover	No (within 50 ft., except for 6 ft. path)	No (within 50 ft., except for 6 ft. path)	No (within 50 ft., except for 6 ft. path)	No (within 50 ft., except for 6 ft. path)
Stumps, Roots and Rocks	No (within 50 ft.)	No (within 50 ft.)	No (within 50 ft.)	No (within 50 ft.)

For further information about the N.H. Rivers Management and Protection Program visit the DES website at www.des.nh.gov/organization/divisions/water/wmb/rivers/index.htm or contact Steve Couture, Rivers Coordinator, 29 Hazen Drive, PO Box 95, Concord, NH 03302-0095; (603) 271-8801; steven.couture@des.nh.gov.

Appendix M. Water Resources Maps: Riverbend Region

Data Sources:
NH base map features, including roads and railways, from 1:24,000 Digital Line Graph (DLG) data supplied by Complex Systems Research Center, UNH (CSRC). VT base map features from 1:5,000 orthophotos distributed by VT Center for Geographic Information (VCGI). VT roads from Enhanced 911 Board, distributed by VCGI. VT railway from USGS 1:100,000 DLG data, distributed by VCGI, 1987.

NH watershed boundaries by US Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) and NH Department of Environmental Services (NHDES), 1:24,000 scale, distributed by CSRC, 1983. VT watershed boundaries by USDA NRCS, 1:24,000 scale, from USGS DLG's and Digital Raster Graphics (DRG), distributed by VCGI.

Wetlands data provided by the US Fish & Wildlife Service, National Wetlands Inventory (NWI). NH wetlands distributed by CSRC, 1:24,000 scale. VT wetlands distributed by VCGI, 1:80,000 scale.

Aquifers mapped by US Geological Survey (USGS) in cooperation with NHDES, 1:24,000 scale, distributed by CSRC, 2000. For detailed information, see Geohydrology and Water Quality of Stratified-Drift Aquifers in the Middle Connecticut River Basin, West-Central NH, USGS Water-Resources Investigations Report 94-4181 or Geohydrology and Water Quality of Stratified-Drift Aquifers in the Upper Connecticut and Androscoggin River Basins, northern New Hampshire: USGS Water-Resources Investigations Report 96-4318. No digitized aquifers available in the state of VT.

NH public drinking water supply sources from NHDES, 1:24,000 scale, distributed by NHDES, 1997. VT public drinking water sources by Halliburton NUS Corporation, funded by US Environmental Protection Agency (EPA), distributed by Vermont Agency of Natural Resources (VTANR), 1994.

Sediment locations from Weston Solutions, Inc., 2000, distributed by US Environmental Protection Agency--New England, funded in cooperation with NHDES and VTANR. See Upper Connecticut River Valley Sediment Study from Weston Solutions, Inc. for detailed information on sediment samples. This study sampled river sediments in 100 locations along the mainstem and inside the mouths of tributaries between Fourth Connecticut Lake in Pittsburg, NH and the confluence of the Ottauquechee River in Hartland, VT. Sediments were analyzed for the presence of 159 possible contaminants. "High risk priority" means that the concentration of the pollutant(s) found in the sediment suggests a strong likelihood of impacts to aquatic life. "Moderate risk priority" means that the concentration of the pollutant(s) found in the sediment suggests a moderate likelihood of impacts to aquatic life.

Potential water quality threats in NH distributed by NHDES include the following:
- Underground Storage Tank Facilities, 2004.
- Automobile Salvage Yards, 1991.
- Point/Non-point Potential Pollution Sources**
- Groundwater Hazard Inventory, 2003 **

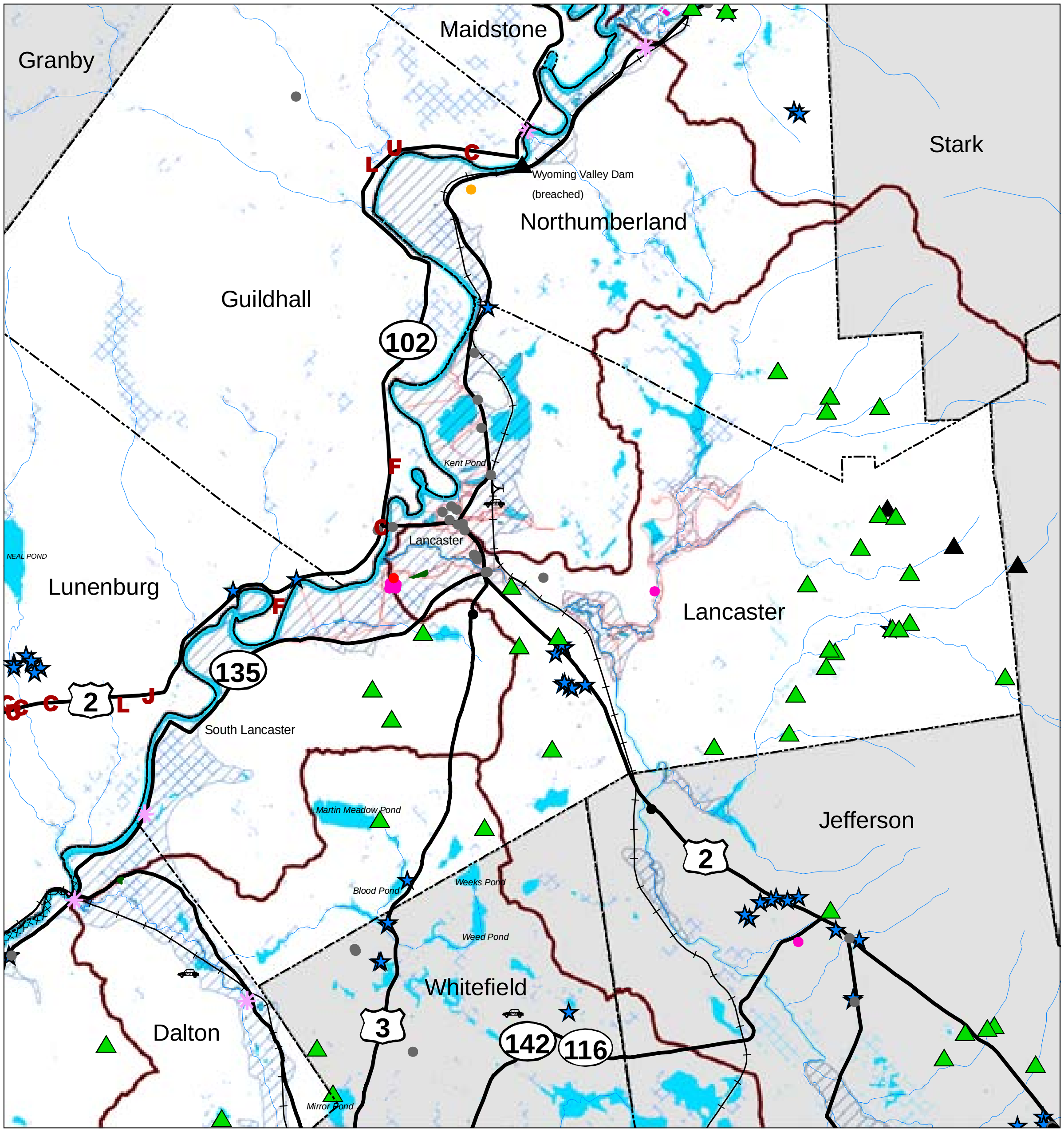
**Refer to written report for more detailed information on each potential water quality threat categories.

Potential Water Quality Threats in VT from VTANR distributed by VCGI include Underground Storage Tank Facilities and the Pollution Source Inventory of 1980.

Partial floodplain coverage in Lancaster, NH, digitized by Cartographic Associates, Inc. based on Federal Emergency Management Agency flood insurance rate maps.

The impoundment zone, or upstream extent of impoundments, generated by MicroData, 1994, based on source data provided by Connecticut River Joint Commissions.

Maps created by Upper Valley Lake Sunapee Regional Planning Commission, by R. Ruppel, GIS Analyst.



Water Resources - Lancaster, NH

Riverbend Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Stratified-Drift Aquifers
Impoundment Zone

100-Year Floodplain (Lancaster only)
Public Water Supply

Sediment Locations
High Risk Priority
Moderate Risk Priority

Dams
Low Hazard Potential
Significant Hazard Potential
High Hazard Potential
Hazard Potential Not Assigned

N W E S

Water Quality Threats

VT Pollution Source Inventory of 1980
- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

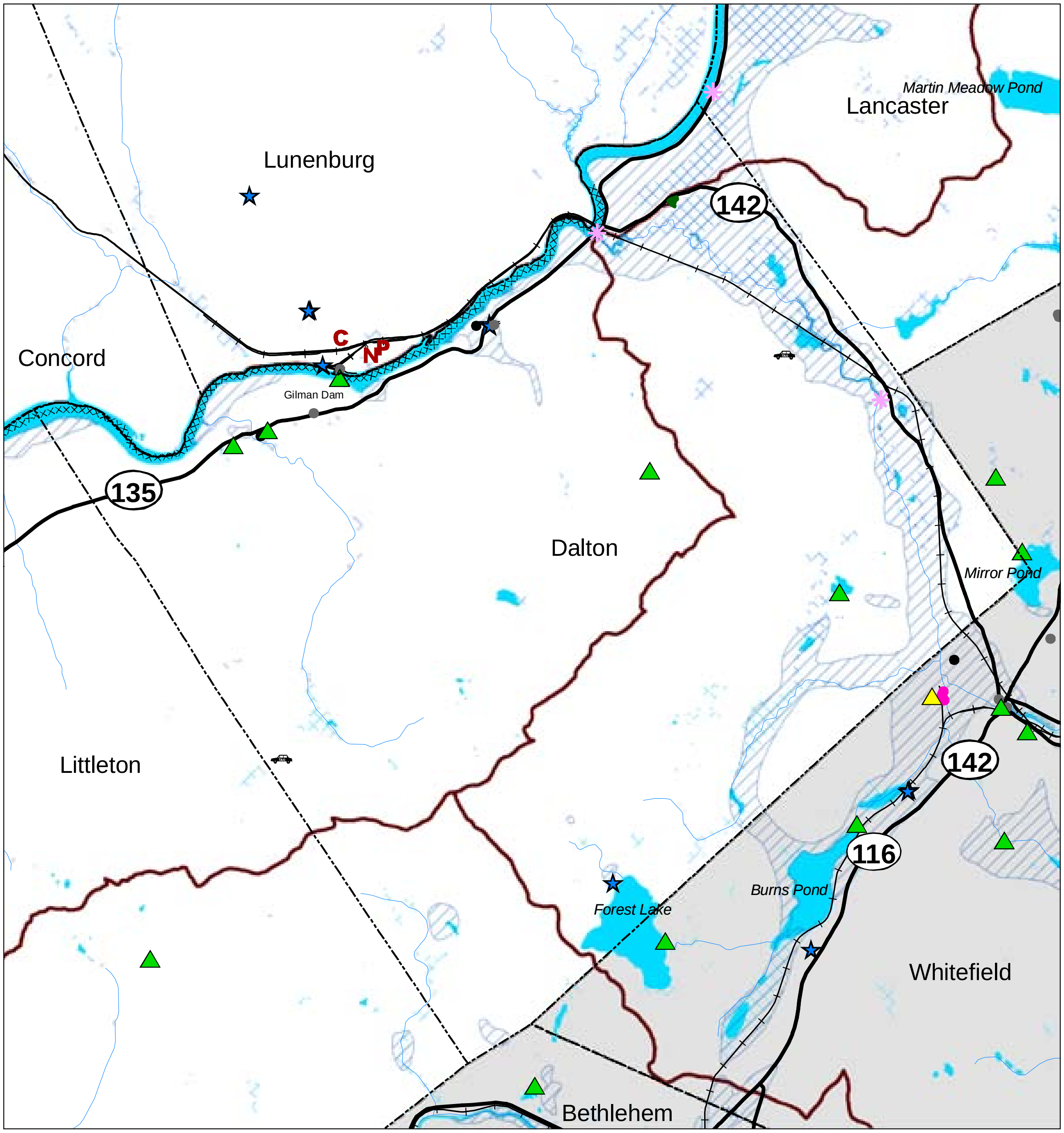
NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:115,000

Map created by
Upper Valley Lake Sunapee Regional Planning Commission for the Connecticut River Joint Commissions, December 2007.

Funding provided by CRJC and US Gen New England.



Water Resources - Dalton, NH

Riverbend Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Stratified-Drift Aquifers
Impoundment Zone

Public Water Supply
Sediment Locations
High Risk Priority
Moderate Risk Priority

Dams
Low Hazard Potential
Significant Hazard Potential
High Hazard Potential
Hazard Potential Not Assigned

N W E S

Water Quality Threats

VT Pollution Source Inventory of 1980
- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

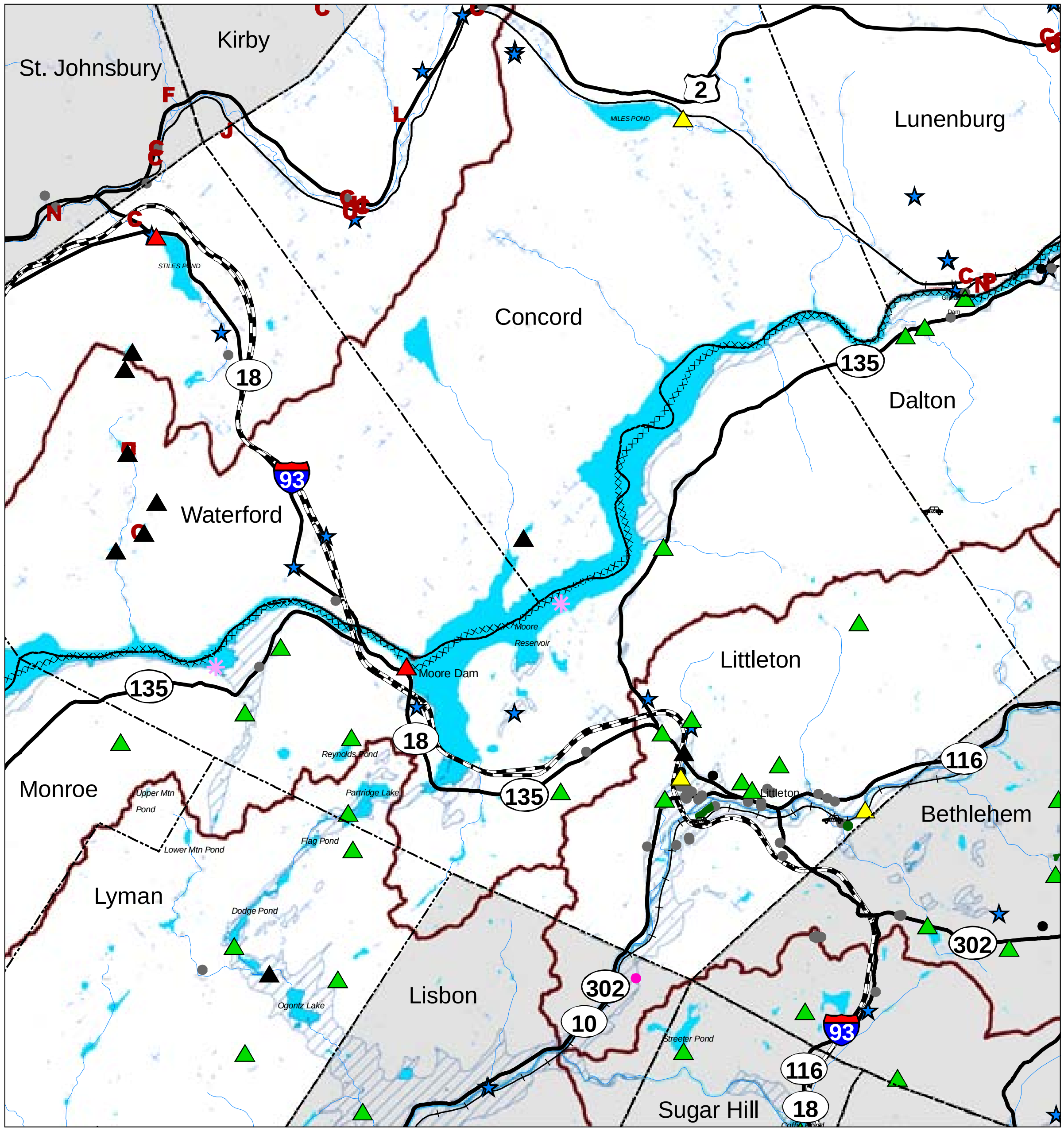
NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

0.75 0 0.75 1.5 Miles

1:70,000

Map created by
Upper Valley Lake Sunapee Regional Planning Commission
for the Connecticut River Joint Commissions, December 2007.

Funding provided by CRJC and US Gen New England.



Water Resources - Littleton, NH

Riverbend Subcommittee

- Political Boundary
- Watershed Boundaries
- Interstate
- State or Local Highway
- Railway

- Major Water Bodies
- Wetlands
- Stratified-Drift Aquifers
- XXXXX Impoundment Zone

- Public Water Supply

Sediment Locations
- High Risk Priority
- Moderate Risk Priority

Dams
- Low Hazard Potential
- Significant Hazard Potential
- High Hazard Potential
- Hazard Potential Not Assigned

N E S W

Water Quality Threats

VT Pollution Source Inventory of 1980
- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

- Underground Storage Tank Facilities

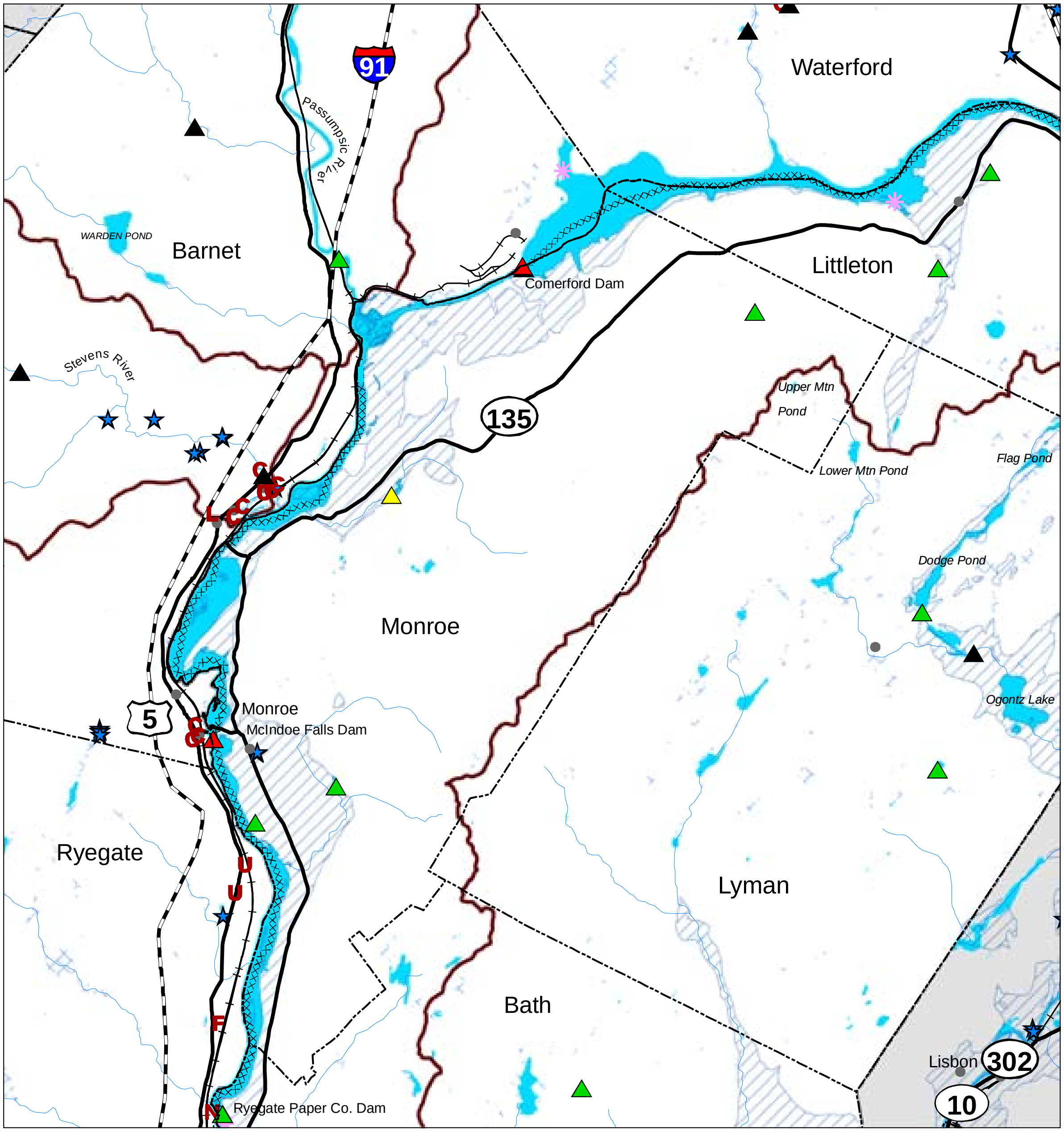
NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:125,000

Map created by
Upper Valley Lake Sunapee Regional Planning Commission for the Connecticut River Joint Commissions, December 2007.

Funding provided by CRJC and US Gen New England.



Water Resources - Monroe, NH

Riverbend Subcommittee

- Political Boundary
- Watershed Boundaries
- Interstate
- State or Local Highway
- Railway
- Major Water Bodies
- Wetlands
- Stratified-Drift Aquifers
- XXXXX Impoundment Zone

Public Water Supply

Sediment Locations
- High Risk Priority
- Moderate Risk Priority

Dams
- Low Hazard Potential
- Significant Hazard Potential
- High Hazard Potential
- Hazard Potential Not Assigned

N W E S

Water Quality Threats

VT Pollution Source Inventory of 1980
- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

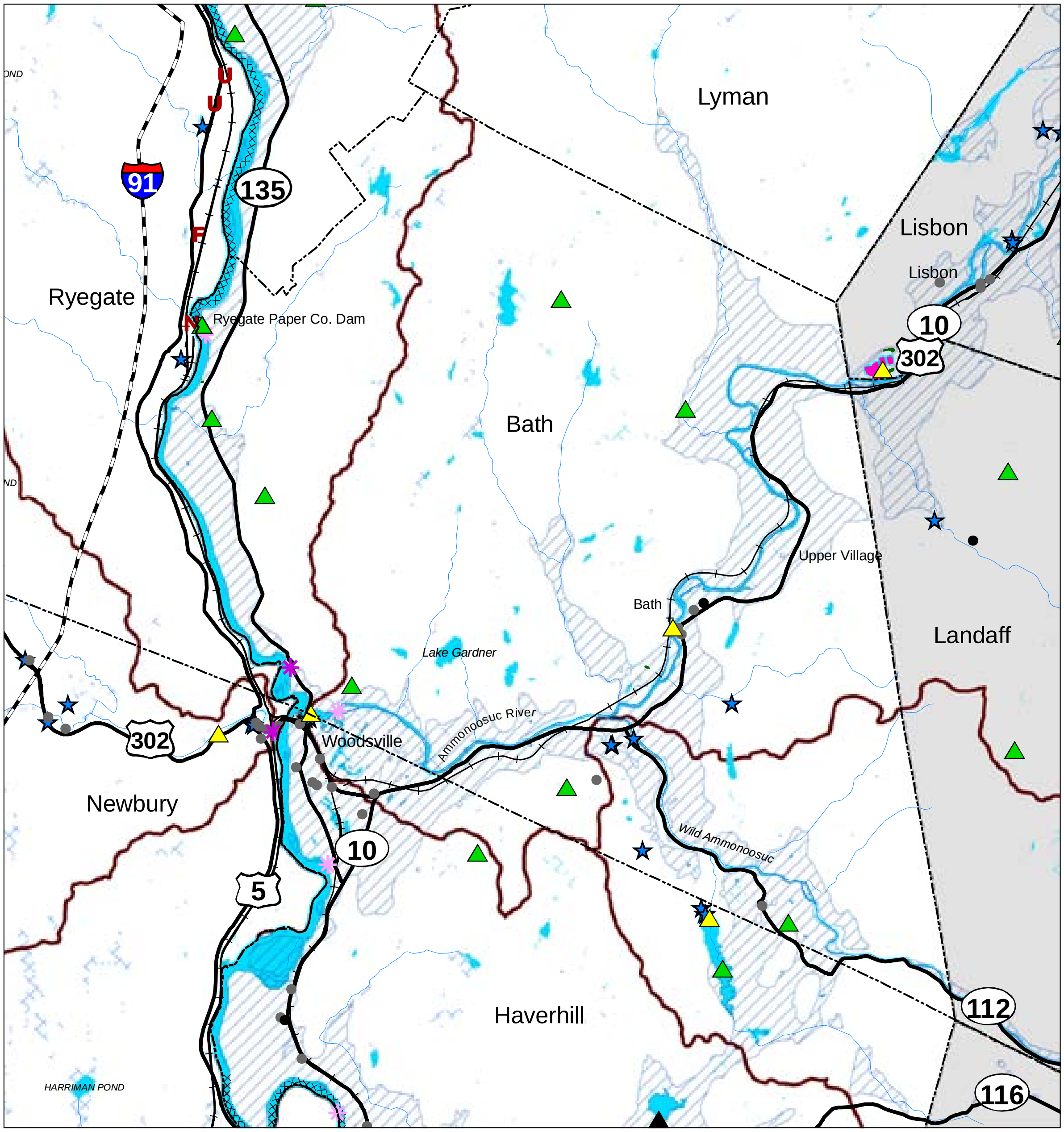
NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:85,000

Map created by
Upper Valley Lake Sunapee Regional Planning Commission
for the Connecticut River Joint Commissions, December 2007.

Funding provided by CRJC and US Gen New England.



Water Resources - Bath, NH

Riverbend Subcommittee

- Political Boundary
- Watershed Boundaries
- Interstate
- State or Local Highway
- Railway
- Major Water Bodies
- Wetlands
- Stratified-Drift Aquifers
- xxxxx Impoundment Zone
- Public Water Supply

Sediment Locations
- High Risk Priority
- Moderate Risk Priority

Dams
- Low Hazard Potential
- Significant Hazard Potential
- High Hazard Potential
- Hazard Potential Not Assigned

N W E S

Water Quality Threats

VT Pollution Source Inventory of 1980
- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

- Underground Storage Tank Facilities

NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:85,000

Map created by
Upper Valley Lake Sunapee Regional Planning Commission for the Connecticut River Joint Commissions, December 2007.

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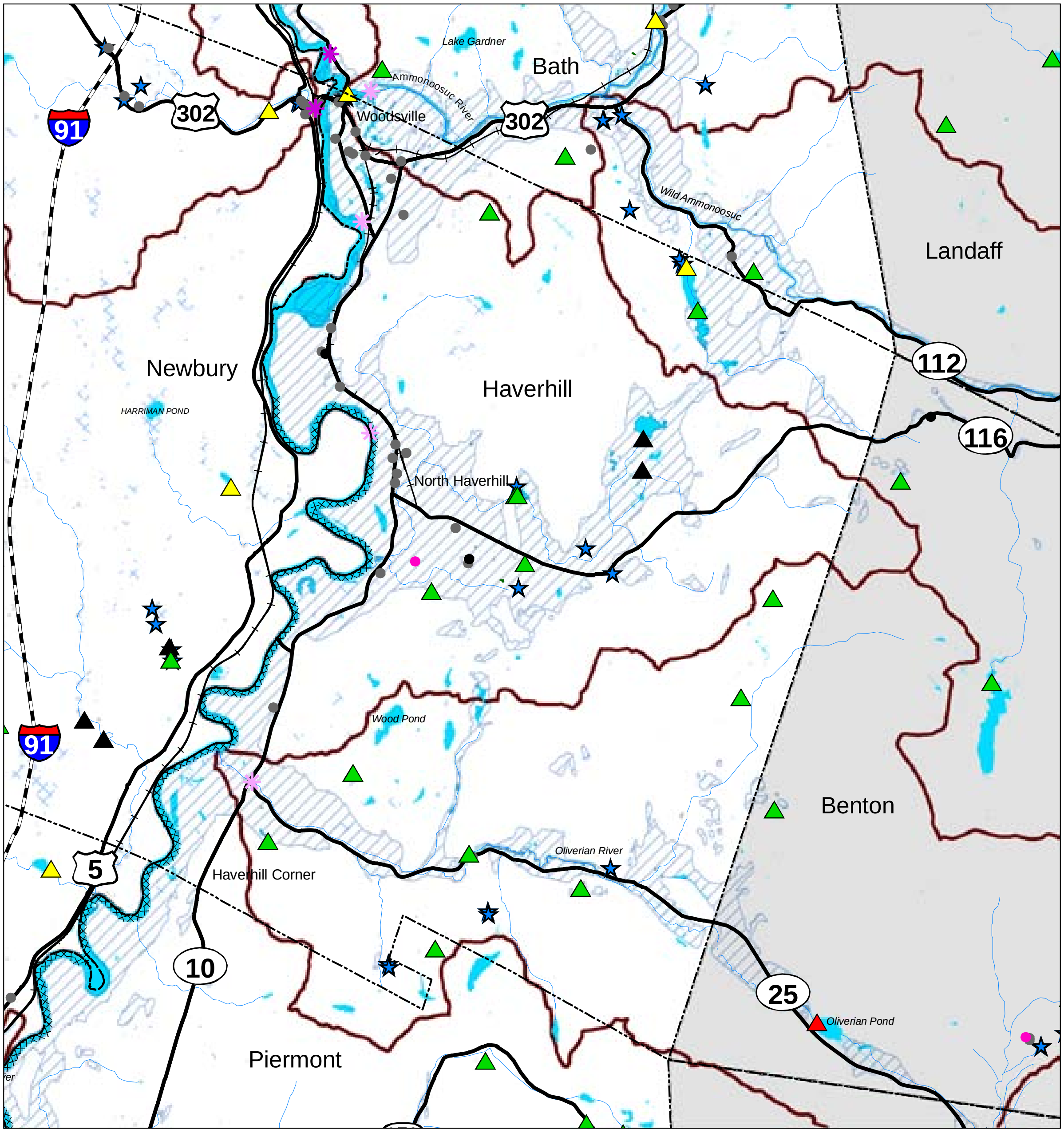

Water Resources - Haverhill, NH

Riverbend Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Stratified-Drift Aquifers
Impoundment Zone

Public Water Supply

Sediment Locations
High Risk Priority
Moderate Risk Priority

Dams
Low Hazard Potential
Significant Hazard Potential
High Hazard Potential
Hazard Potential Not Assigned

N S E W

Water Quality Threats

VT Pollution Source Inventory of 1980
C Petrochemicals
F Agricultural Wastes
J Junk Yard/Salvage Yard
K Liquid Waste to Land Surface/Subsurface
L Landfilll/Dump
N Lagoon-Industrial
P Lagoon-Municipal
U Salt/Salted Sand

Underground Storage Tank Facilities

NH Water Quality Threat Inventories
Snow Dump/Salt Storage
Automobile Salvage Yard
Lagoon
Landfill/Dump
Large Septic System
Land Application

1 0 1 2 Miles

1:100,000

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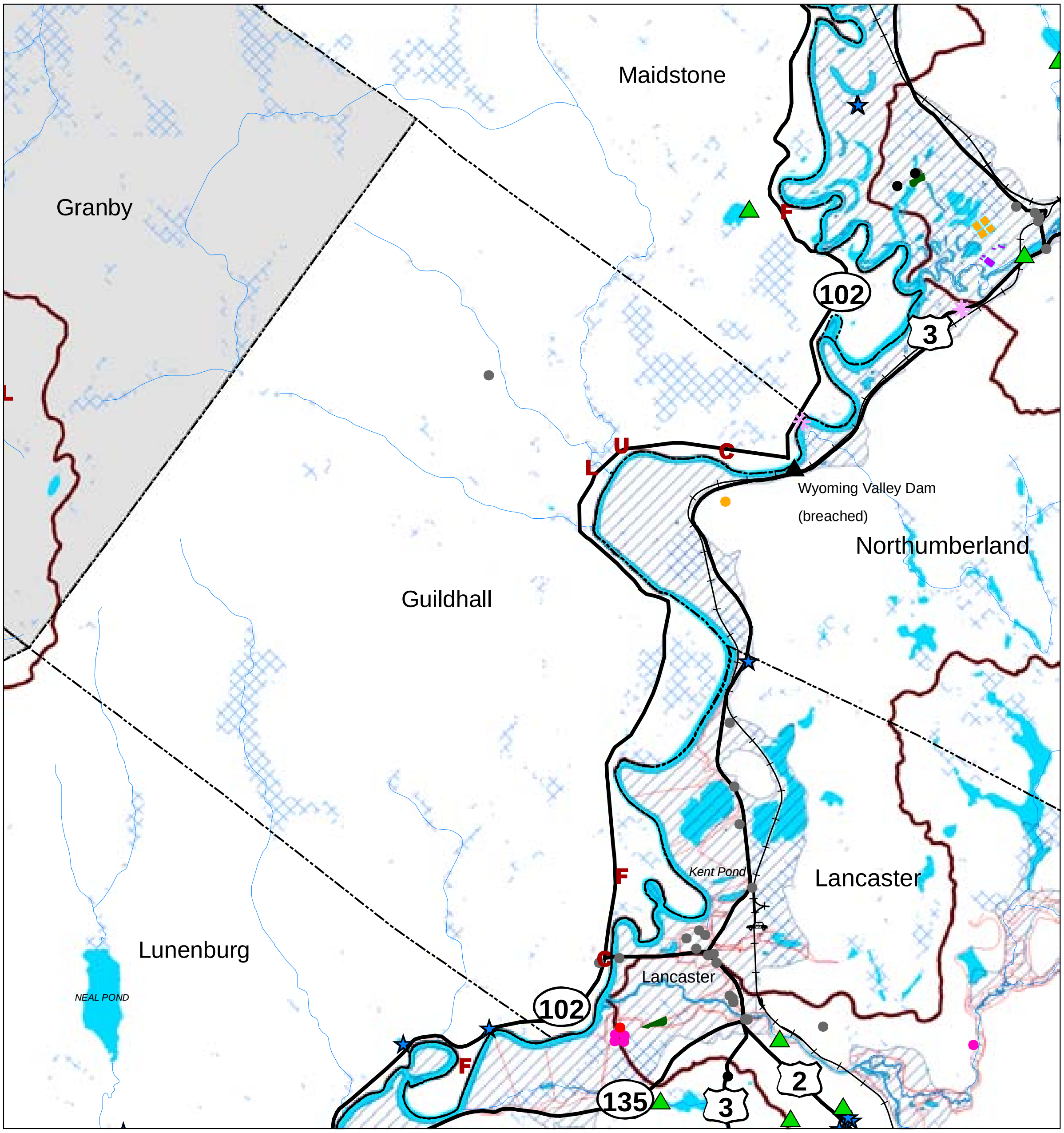

Water Resources - Guildhall, VT

Riverbend Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Stratified-Drift Aquifers
Impoundment Zone

100-Year Floodplain (Lancaster only)
Public Water Supply

Sediment Locations
High Risk Priority
Moderate Risk Priority

Dams
Low Hazard Potential
Significant Hazard Potential
High Hazard Potential
Hazard Potential Not Assigned

N
W E
S

Water Quality Threats

VT Pollution Source Inventory of 1980
- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:85,000

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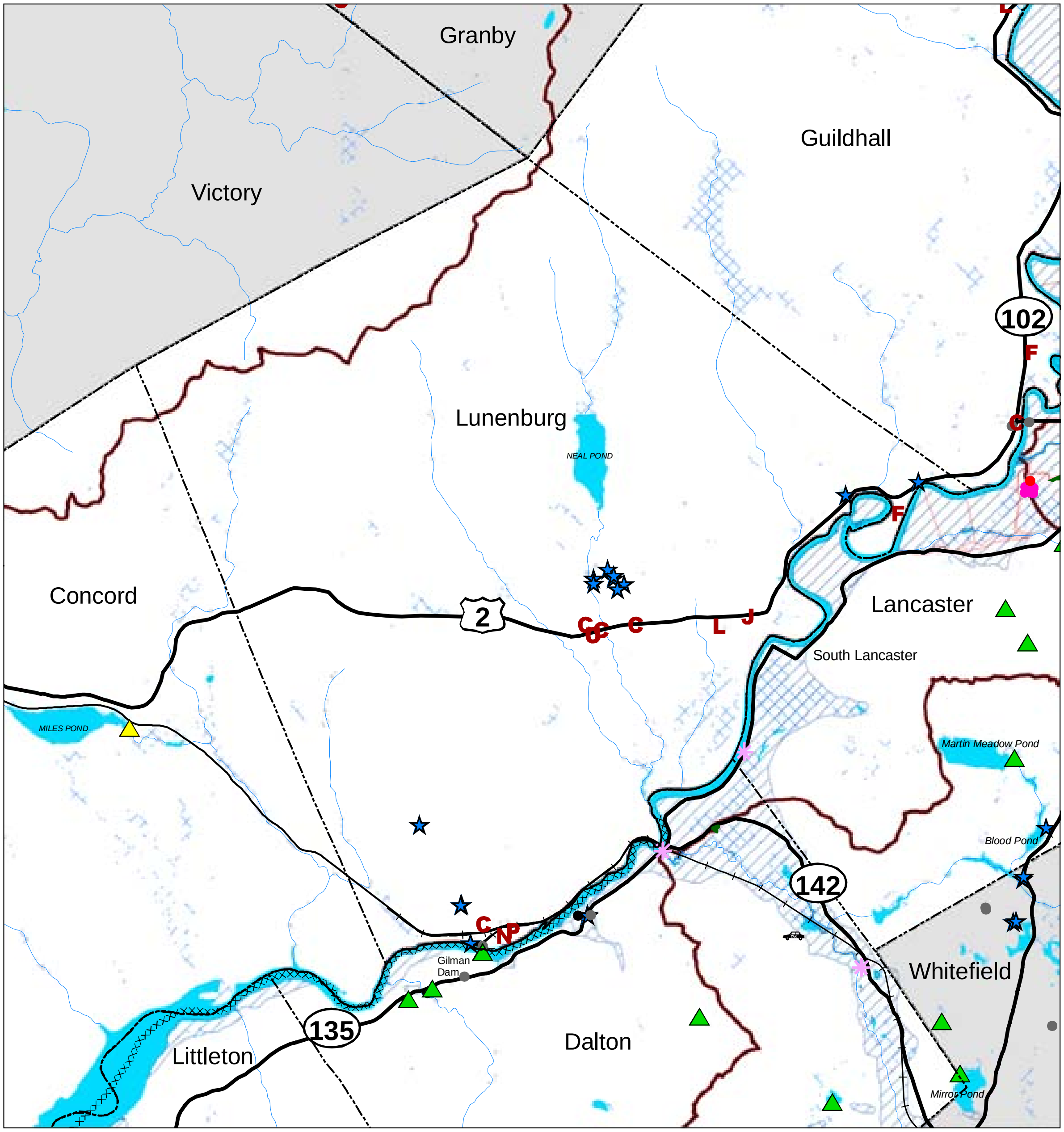

Water Resources - Lunenburg, VT

Riverbend Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Stratified-Drift Aquifers
Impoundment Zone

100-Year Floodplain (Lancaster only)
Public Water Supply

Sediment Locations
High Risk Priority
Moderate Risk Priority

Dams
Low Hazard Potential
Significant Hazard Potential
High Hazard Potential
Hazard Potential Not Assigned

N
W E
S

Water Quality Threats

VT Pollution Source Inventory of 1980
- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:100,000

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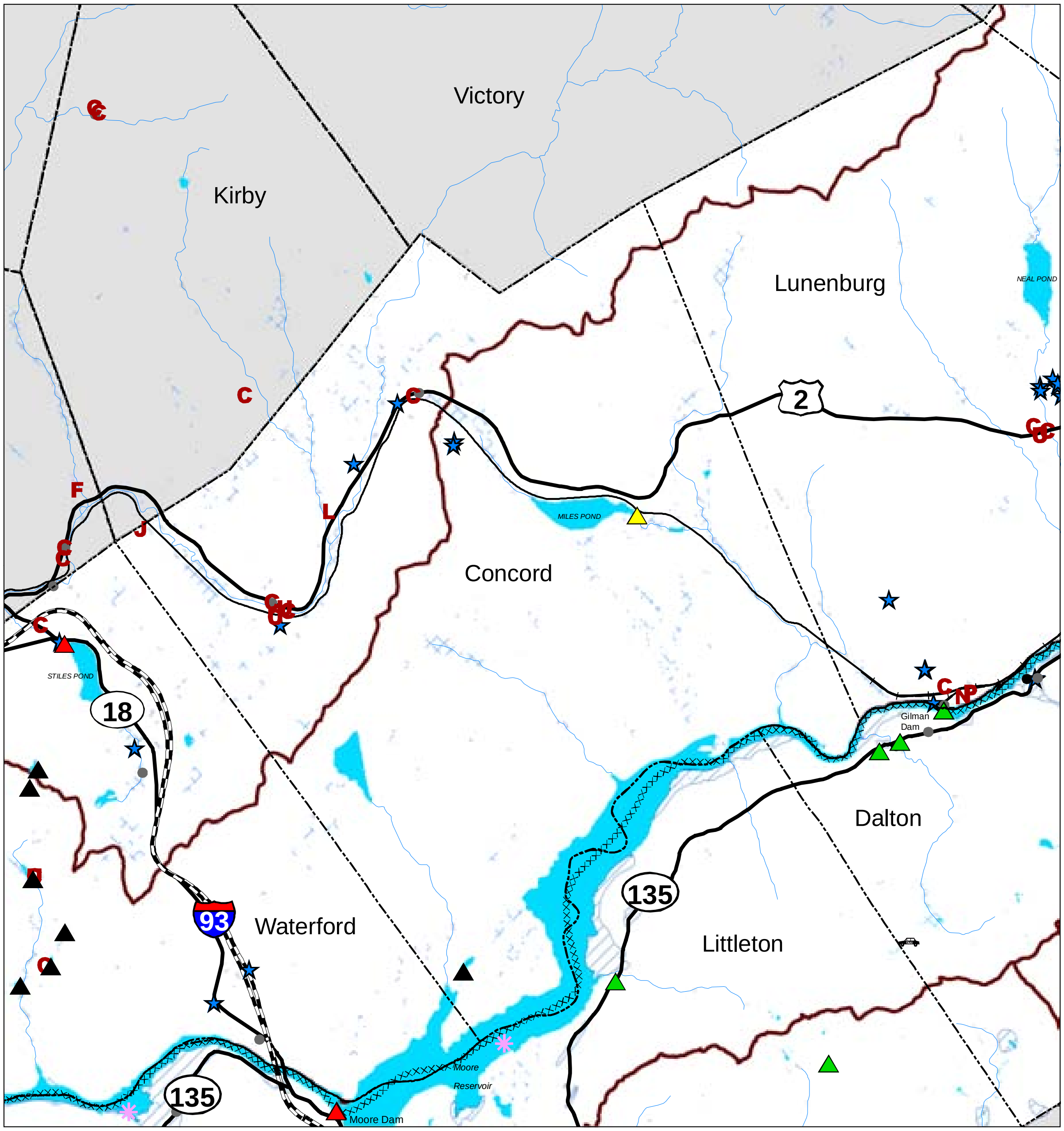

Water Resources - Concord, VT

Riverbend Subcommittee

- Political Boundary
- Watershed Boundaries
- Interstate
- State or Local Highway
- Railway
- Major Water Bodies
- Wetlands
- Stratified-Drift Aquifers
- Impoundment Zone
- Public Water Supply

Sediment Locations

- High Risk Priority
- Moderate Risk Priority

Dams

- Low Hazard Potential
- Significant Hazard Potential
- High Hazard Potential
- Hazard Potential Not Assigned

N E S W

Water Quality Threats

VT Pollution Source Inventory of 1980

- **C** Petrochemicals
- **F** Agricultural Wastes
- **J** Junk Yard/Salvage Yard
- **K** Liquid Waste to Land Surface/Subsurface
- **L** Landfilll/Dump
- **N** Lagoon-Industrial
- **P** Lagoon-Municipal
- **U** Salt/Salted Sand

- Underground Storage Tank Facilities

NH Water Quality Threat Inventories

- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:115,000

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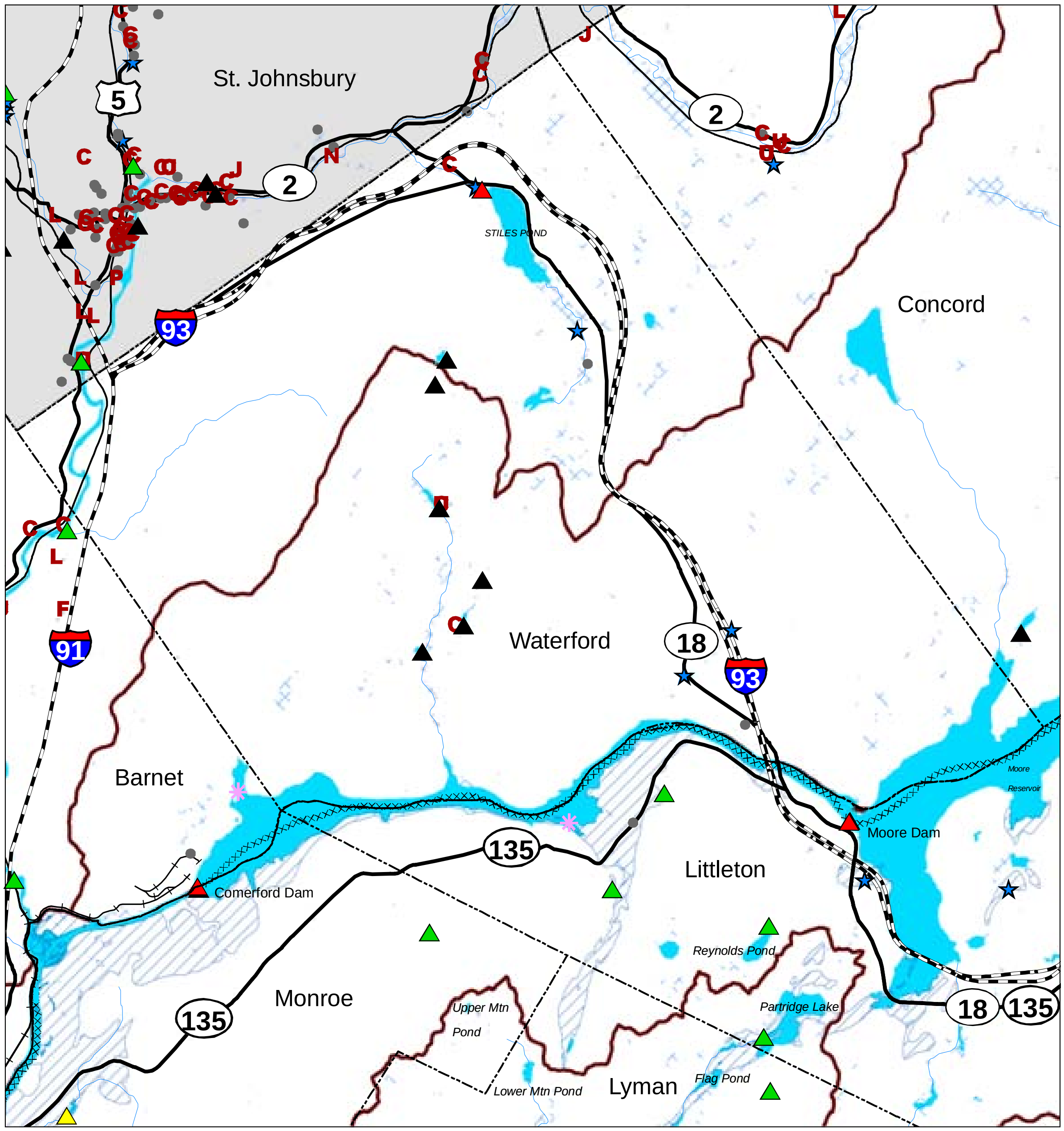

Water Resources - Waterford, VT

Riverbend Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Stratified-Drift Aquifers
XXXXX Impoundment Zone

Public Water Supply

Sediment Locations
High Risk Priority
Moderate Risk Priority

Dams
Low Hazard Potential
Significant Hazard Potential
High Hazard Potential
Hazard Potential Not Assigned

N W E S

Water Quality Threats

VT Pollution Source Inventory of 1980
- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:85,000

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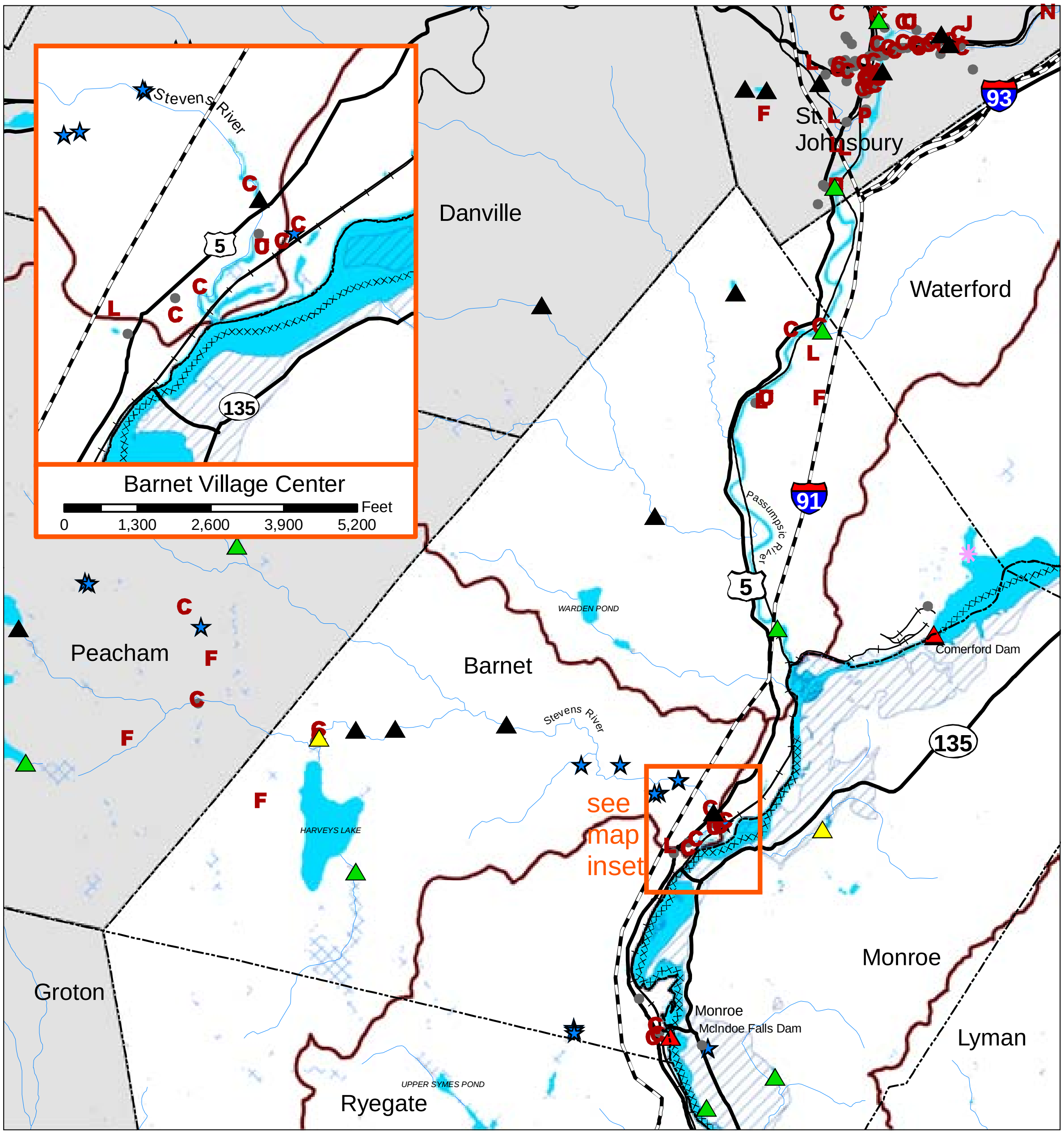

Water Resources - Barnet, VT

Riverbend Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Stratified-Drift Aquifers
Impoundment Zone

Public Water Supply

Sediment Locations
High Risk Priority
Moderate Risk Priority

Dams
Low Hazard Potential
Significant Hazard Potential
High Hazard Potential
Hazard Potential Not Assigned

N
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Water Quality Threats

VT Pollution Source Inventory of 1980
- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:100,000

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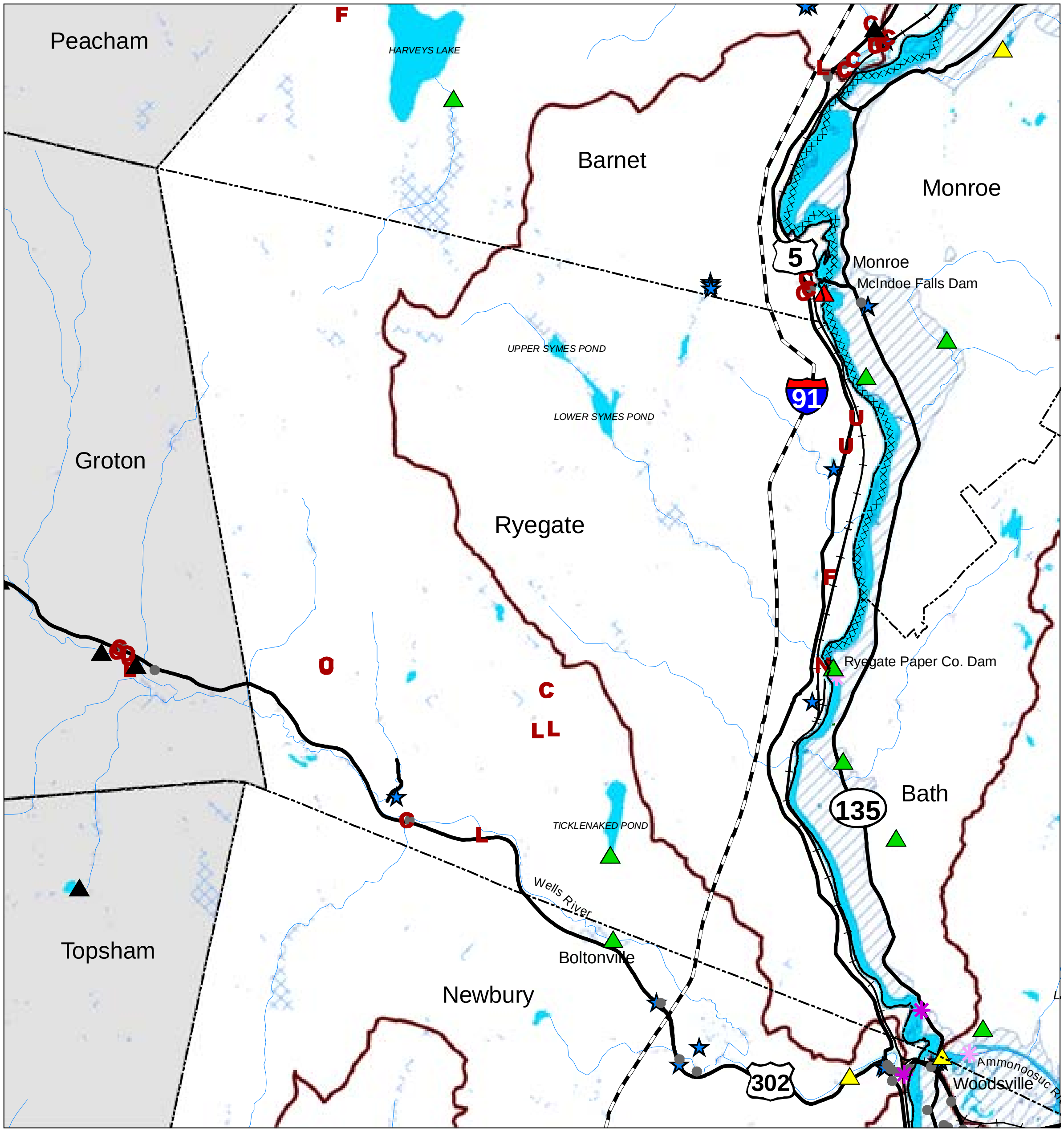

Water Resources - Ryegate, VT

Riverbend Subcommittee

- Political Boundary
- Watershed Boundaries
- Interstate
- State or Local Highway
- Railway
- Major Water Bodies
- Wetlands
- Stratified-Drift Aquifers
- Impoundment Zone
- Public Water Supply

Sediment Locations

- High Risk Priority
- Moderate Risk Priority

Dams

- Low Hazard Potential
- Significant Hazard Potential
- High Hazard Potential
- Hazard Potential Not Assigned

N W E S

Water Quality Threats

VT Pollution Source Inventory of 1980

- C Petrochemicals
- F Agricultural Wastes
- J Junk Yard/Salvage Yard
- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- N Lagoon-Industrial
- P Lagoon-Municipal
- U Salt/Salted Sand

- Underground Storage Tank Facilities

NH Water Quality Threat Inventories

- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:85,000

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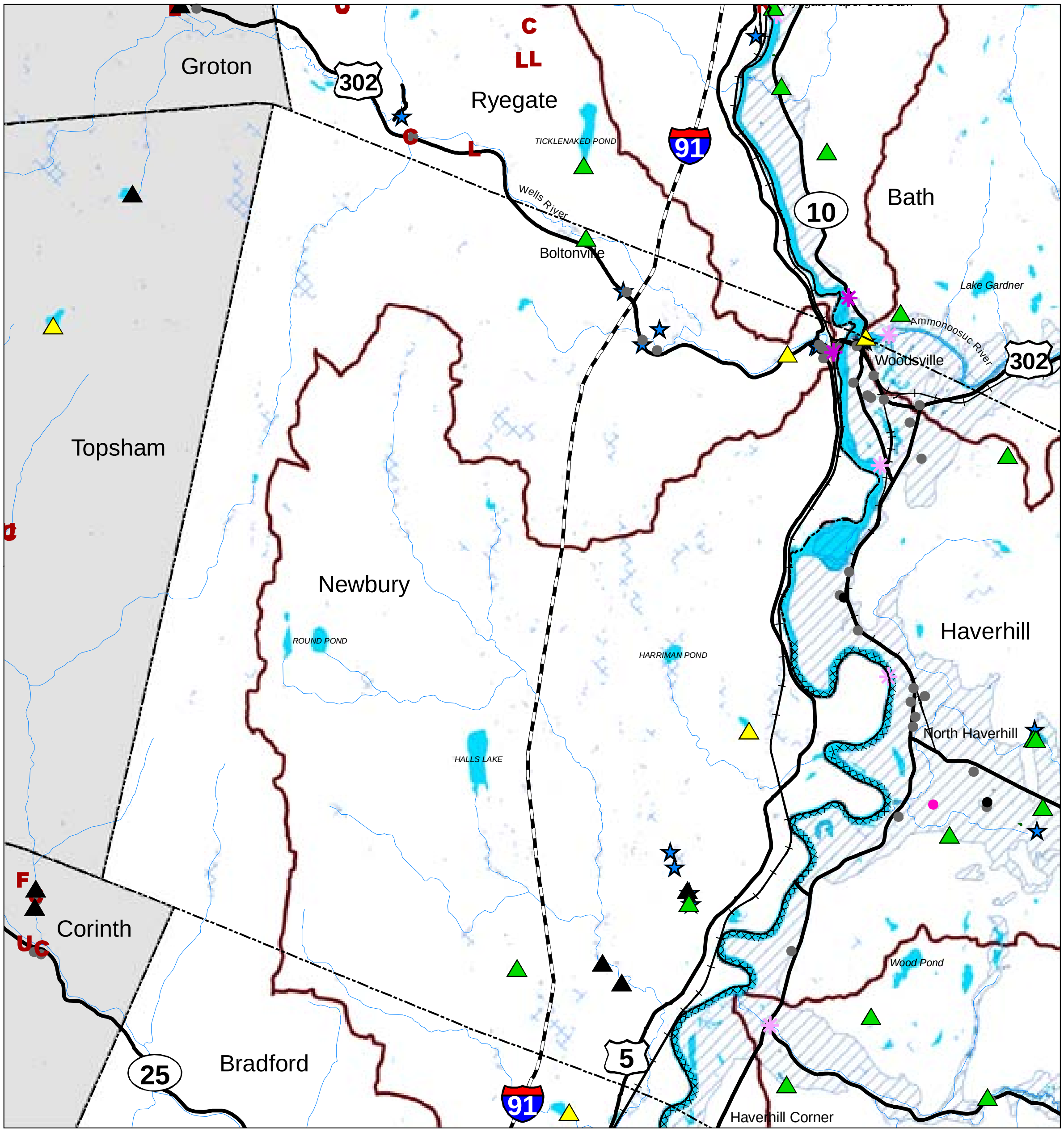

Water Resources - Newbury, VT

Riverbend Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Stratified-Drift Aquifers
Impoundment Zone

Public Water Supply

Sediment Locations
High Risk Priority
Moderate Risk Priority

Dams
Low Hazard Potential
Significant Hazard Potential
High Hazard Potential
Hazard Potential Not Assigned

N
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Water Quality Threats

VT Pollution Source Inventory of 1980
- **C** Petrochemicals
- **F** Agricultural Wastes
- **J** Junk Yard/Salvage Yard
- **K** Liquid Waste to Land Surface/Subsurface
- **L** Landfilll/Dump
- **N** Lagoon-Industrial
- **P** Lagoon-Municipal
- **U** Salt/Salted Sand

Underground Storage Tank Facilities

NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump
- Large Septic System
- Land Application

1 0 1 2 Miles

1:100,000

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