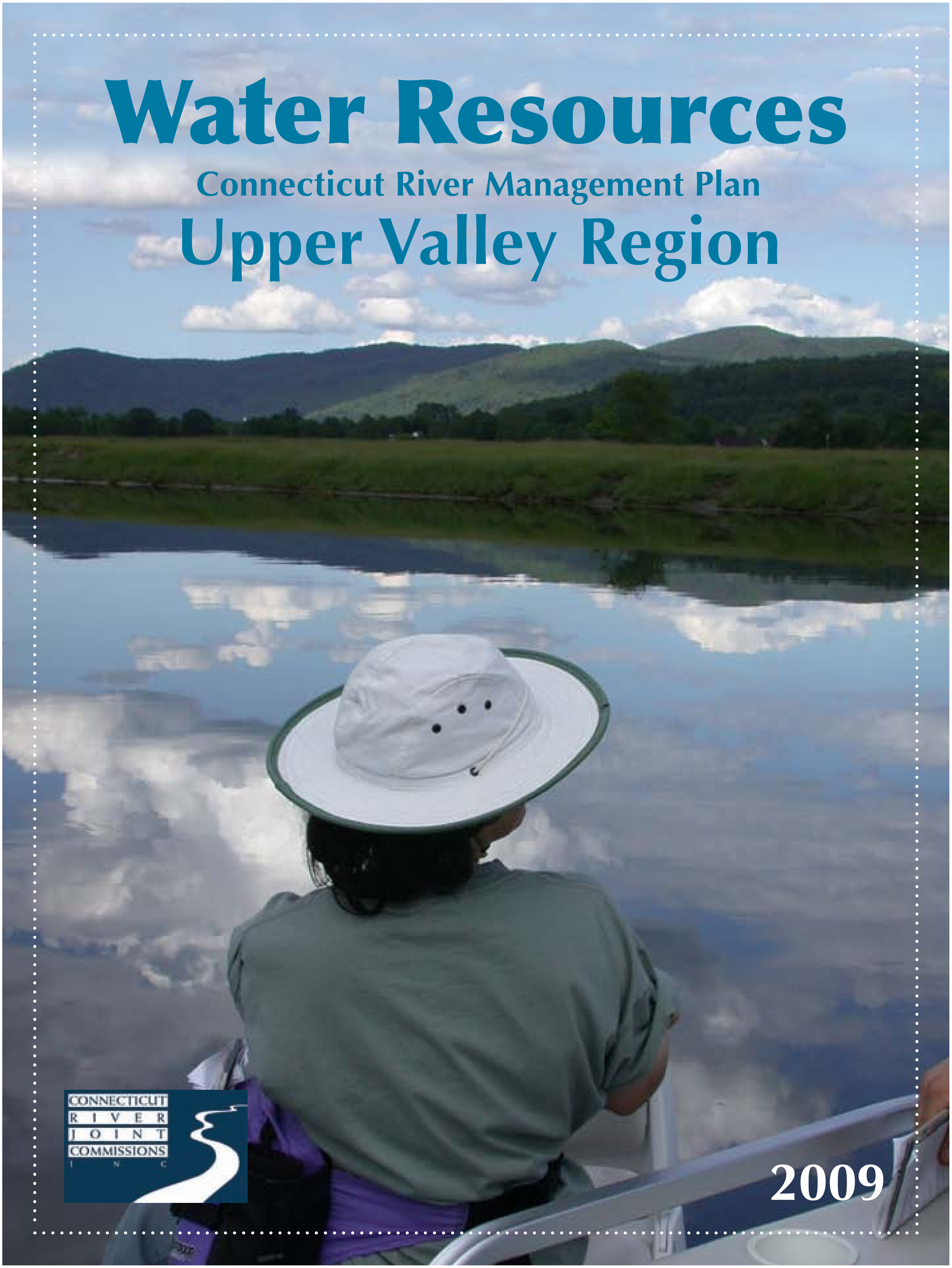
Water Resources

Connecticut River Management Plan

Upper Valley Region



CONNECTICUT RIVER JOINT COMMISSIONS INC

2009

Water Resources

Upper Valley River Subcommittee of the Connecticut River Joint Commissions

Adopted November 19, 2007, Updated July, 2009

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Drafted by the Upper Valley River 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: An Upper Valley River Subcommittee member reflects on the Connecticut River as it flows between Orford and Fairlee.

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Key Recommendations

- **Improve shoreland protection in New Hampshire.** The New Hampshire Department of Environmental Services (NH DES) should educate town officials, real estate agents, developers, and landowners about the Comprehensive Shoreland Protection Act, including responsibility for enforcement. The New Hampshire legislature should consider shoreland protection for tributaries not currently covered by the Act.

- **Provide shoreland protection in Vermont.** Vermont should consider adopting measures to protect the shoreland of both the Connecticut River and its tributaries.

- **Provide local shoreland and floodplain protection**. Towns should adopt ordinances prohibiting filling and building in the 100-year floodplain and ensure that buildings are set a safe distance back from the river even when outside of the floodplain. They should encourage developers and landowners to establish and/or maintain buffers of native vegetation along rivers and streams for privacy, pollution control, and habitat.

- **Retain natural flood storage**. Public agencies and private landowners should work together to retain current natural flood storage, such as in wetlands and floodplains, which is effective and valuable.

- **Identify and protect groundwater supplies.** Vermont should identify and map groundwater supplies in cooperation with the towns. Towns should understand their capacity for providing drinking water, evaluate water supplies for short and long term growth, and establish a baseline for use.

- **Minimize contamination from wastewater discharges.** Upper Valley towns should study their capacity for providing wastewater treatment and the river's ability to assimilate it in this region. The US Fish & Wildlife Service, the federal Environmental Protection Agency (EPA) and the states should work together to establish updated rules for disposal or return of unused medicines.

- **Improve stormwater management.** Developers should include infiltration methods such as networks of many small swales to capture runoff for groundwater recharge. Towns should encourage low impact development design and consider how to retrofit existing development to reduce runoff and promote stormwater infiltration.

- **Examine culverts to ensure proper drainage and aquatic habitat connectivity.** New Hampshire should consider working with the regional planning commissions to conduct a bridge and culvert survey program similar to Vermont's to identify culverts that are undersized or block fish passage and seek grants for replacing them where necessary. Towns should ensure that culverts are properly engineered and installed when replacing them during road work.

- **Address erosion and promote riparian buffers.** The US Department of Agriculture county conservation districts should survey the Upper Valley reach of the river for the presence of hidden riverbank undercuts, and identify and test a means of restoring these cavities. The federal government should conduct a study of the effects of dam-related water level fluctuations on bank erosion as well as upon fish habitat and populations of endangered species. The USDA Natural Resources Conservation Service should continue research into appropriate methods of bank stabilization including the funding of test areas, expand education of riparian landowners concerning methods of stabilization, expand programs that offer professional and financial assistance to riparian landowners for appropriate methods of bank stabilization, and investigate ways to simplify the permitting process.

- **Address fish tissue contaminants.** Congress and the states should take immediate priority action to reduce mercury contamination of the region.

I. Preface

A. Citizen-based Plan for the Connecticut River

Members of the Upper Valley River Subcommittee tour Wilder Dam.

The Upper Valley 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 Upper Valley segment of the river were representatives from the towns of Piermont, Orford, Lyme, Hanover, and Lebanon, in New Hampshire and Bradford, Fairlee, Thetford, Norwich, and Hartford in Vermont.

The strength of the Upper Valley River 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. All of the recommendations of the Upper Valley River Subcommittee's plan represent the consensus of this diverse group of citizens. Subcommittee members are listed in Appendix A.

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.

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

Cleve Kapala, CRJC President

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 the Connecticut River Joint Commissions, a new assessment of water quality in the Connecticut River mainstem was conducted in 2004 by NH DES with the support of the 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 Upper Valley River Subcommittee met at the Thetford Bicentennial Building 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.

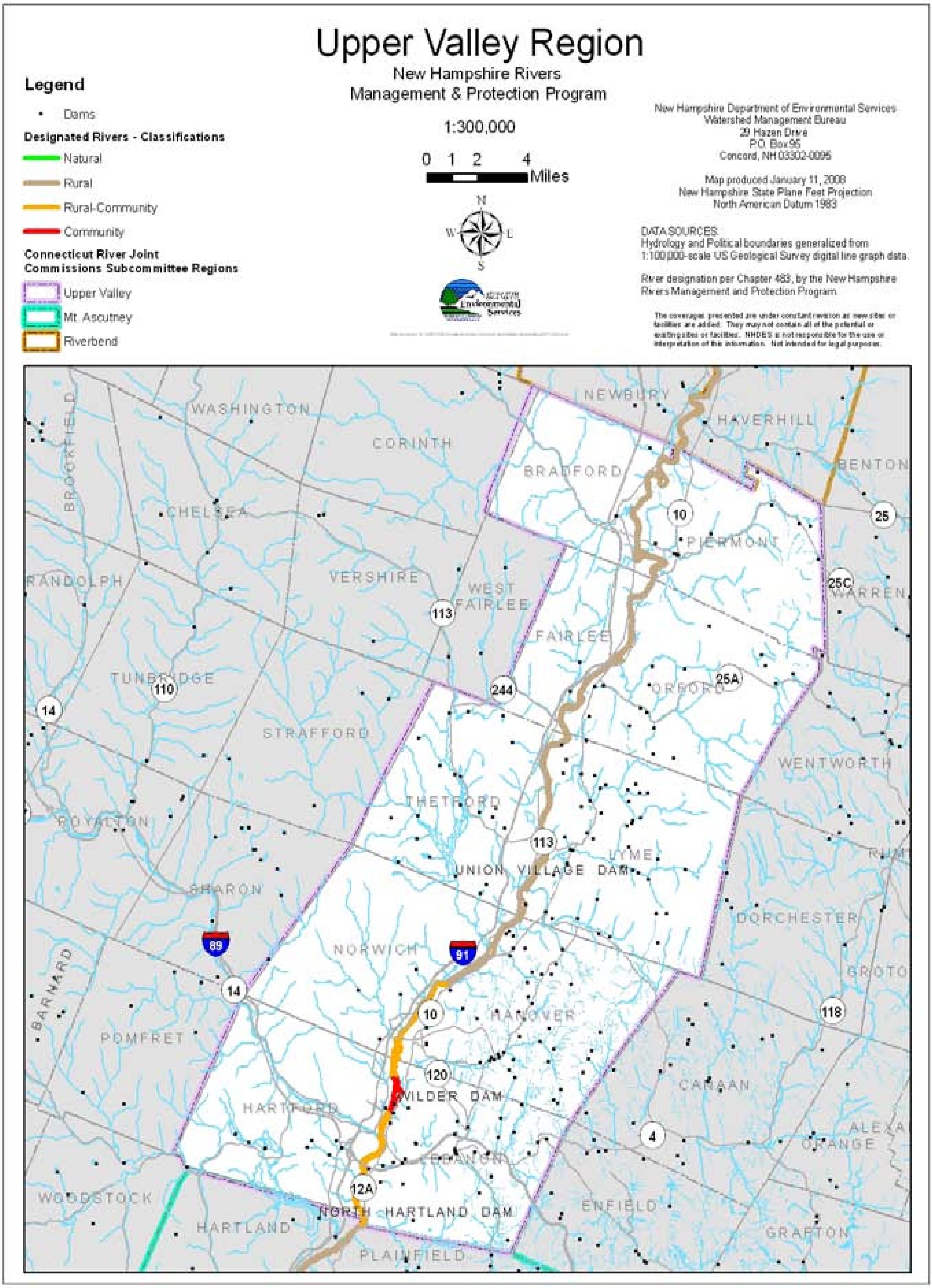
A first draft of the plan was circulated for public comment in May, 2007. After considering comments from the agencies, general public, and CRJC's Water Resources Committee, the Subcommittee adopted a final version in November, 2007.

E. Scope of the Plan

The Subcommittee has concentrated its planning upon the 39 miles of the Connecticut River in this segment. While the recommendations are directed toward this area, the Upper Valley 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 such a big job and important public duty that help from beyond the watershed is sometimes appropriate and needed from those agencies which share responsibility for the river.

F. Local Adoption of Recommendations

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


Upper Valley Region
New Hampshire Rivers
Management & Protection Program
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S
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Legend
Dams
Designated Rivers - Classifications
Natural
Rural
Rural-Community
Community
Connecticut River Joint Commissions Subcommittee Regions
Upper Valley
Mt. Ascutney
Riverbend
New Hampshire Department of Environmental Services
Watershed Management Bureau
29 Hazen Drive
P.O. Box 95
Concord, NH 03302-0095
Map produced January 11, 2008
New Hampshire State Plane Feet Projection
North American Datum 1983
DATA SOURCES:
Hydrology and Political boundaries generalized from 1:100,000-scale US Geological Survey digital line graph data.
River designation per Chapter 483, by the New Hampshire Rivers Management and Protection Program.
The coverages presented are under constant revision as new sites or facilities are added. They may not contain all of the potential or existing sites or facilities. NHDES is not responsible for the use or interpretation of this information. Not intended for legal purposes.
Environmental Services
NEWBURY
HAVERHILL
WASHINGTON
CORINTH
BROOKFIELD
BRADFORD
BENTON
CHELSEA
PIERMONT
RANDOLPH
VERSHIRE
WEST FAIRLEE
WARREN
FAIRLEE
TUNBRIDGE
ORFORD
STRAFFORD
WENTWORTH
THETFORD
ROYALTON
LYME
UNION VILLAGE DAM
SHARON
DORCHESTER
NORWICH
BARNARD
HANOVER
POMFRET
CANAAN
WILDER DAM
HARTFORD
ORANGE
LEBANON
WOODSTOCK
ENFIELD
NORTH HARTLAND DAM
HARTLAND
GRAFTON
PLAINFIELD
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25
25C
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25A
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14
113
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91
14
10
118
120
4
12A

has also made many recommendations which 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 Upper Valley River Subcommittee:

- Sally Mansur, Two Rivers-Ottauquechee Regional Commission
- Ken Alton, TransCanada Hydro Northeast
- Ben Copans, Vermont Agency of Natural Resources
- Annie Bourdon, White River Partnership
- Kurt Gotthardt, Mascoma Watershed Conservation Council
- Steve Couture, Rivers Coordinator, NH Department of Environmental Services
- John Lawe, Connecticut River Commissioner

We are particularly grateful to the Thetford Library and Bicentennial Building for providing meeting space.

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Funding to support the work of the Upper Valley River Subcommittee came from:

NH Department of Environmental Services
National Oceanic and Atmospheric Administration
USGen New England
Davis Foundation

A list of acronyms appears in Appendix K.

II. Introduction

A clean Connecticut River supports a vibrant aquatic ecosystem, safe recreation, and an aesthetically beautiful waterway – the key to a quality of life that pleases valley residents and appeals to business leaders considering a move to the region. River communities, supported by their states and the federal government and the Clean Water Act, have spent years of effort and millions of dollars investing in water quality improvements that have largely returned "the country's best-landscaped sewer" to the clear and refreshing river that it was centuries ago. The region has a strong industrial history, including log drives, copper mining, and production of paper, textiles, and hydro power, in a rich agricultural setting. The river is now becoming known as a destination for those who enjoy the kinds of recreation that depend upon clean water and a beautiful and healthy environment.

The historic Samuel Morey Bridge links Orford and Fairlee.

A. The Upper Valley Segment of the Connecticut River

The Upper Valley River Subcommittee's segment covers 39 miles of the Connecticut River as it runs from the northern boundaries of Bradford, Vt. and Piermont, N.H. to the southern boundaries of Hartford, Vt. and Lebanon, N.H.. Where it is impounded above Wilder Dam, the Connecticut River functions ecologically more as a lake than a river. Riverbanks are affected by water level fluctuations at the dam and by boat wakes, as well as by natural processes including wind-driven waves, ice movement, and flooding. Below the dam, the Connecticut River functions more like a free-flowing river, although its flow varies in volume and velocity due to peaking operations at the dam.

While major federal and local investments in wastewater treatment systems have helped the river recover from years of abuse, it is still threatened by contaminated runoff during heavy storms, by erosion, and by the increasing pace of development along its banks, particularly on vulnerable floodplains.

III. River Quality

A. Economic Value of Clear Water

Good water quality is an important economic as well as aesthetic and ecological resource for the Upper Valley. Today the river is once again safe for canoeing, kayaking, boating, wildlife habitat, and fisheries, and holds strong appeal for recreation and tourism. River water is also suitable for agricultural and industrial water supplies, and a number of 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. Fishing, boating and swimming have about the same economic impact as snowmobiling, downhill skiing, cross-country skiing, and ice-fishing combined.[1] Interviews with users of 11 public boat ramps in the Dartmouth-Sunapee Region, including at Fullington Landing in Hanover, found that 85 percent of anglers, boaters and swimmers say they would decrease their intended visits to the Dartmouth-Sunapee Region if water clarity and purity diminished. For the purpose of this study, "water clarity and purity" include milfoil or other invasive plants, mercury, and algae. Of those who would decrease their intended visits, 23 percent would leave the state and 26 percent would leave the region. Approximately 9 percent would go to some unspecified location in New Hampshire, and 42 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 12 percent…a loss of about 35,000 visitor days.

The river offers good, clean fun that brings dollars into the region.

The study found that overall, surface water recreation in the 33 towns in New Hampshire's Dartmouth-Sunapee tourism region generates over 100 jobs. These jobs equate to over $2.6 million in personal income and almost $7.5 million in business sales, totaling about 3.5 percent of the recreational revenue generated by anglers, boaters and swimmers in the state of New Hampshire. A perceived decline in water clarity and purity in the Dartmouth-Sunapee region would lead to a loss of loss of almost $1 million in business sales. While similar figures not available for Vermont, it is clear that Vermont residents and visitors are also enjoying these waters.

The nationally recognized Connecticut River Byway, an economic development initiative that is building strong momentum, is centered on the river's appeal as a recreation asset. The last several years have seen a number of new tourism businesses that depend upon a healthy river, including fishing guide services, river outfitters, and a scenic excursion train that runs along the river. Vermont towns, particularly White River Junction, are turning to their riverfronts once again.

B. Connecticut River Water Quality

1. River Management Planning

New Hampshire and Vermont 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 with citizens. The

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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.

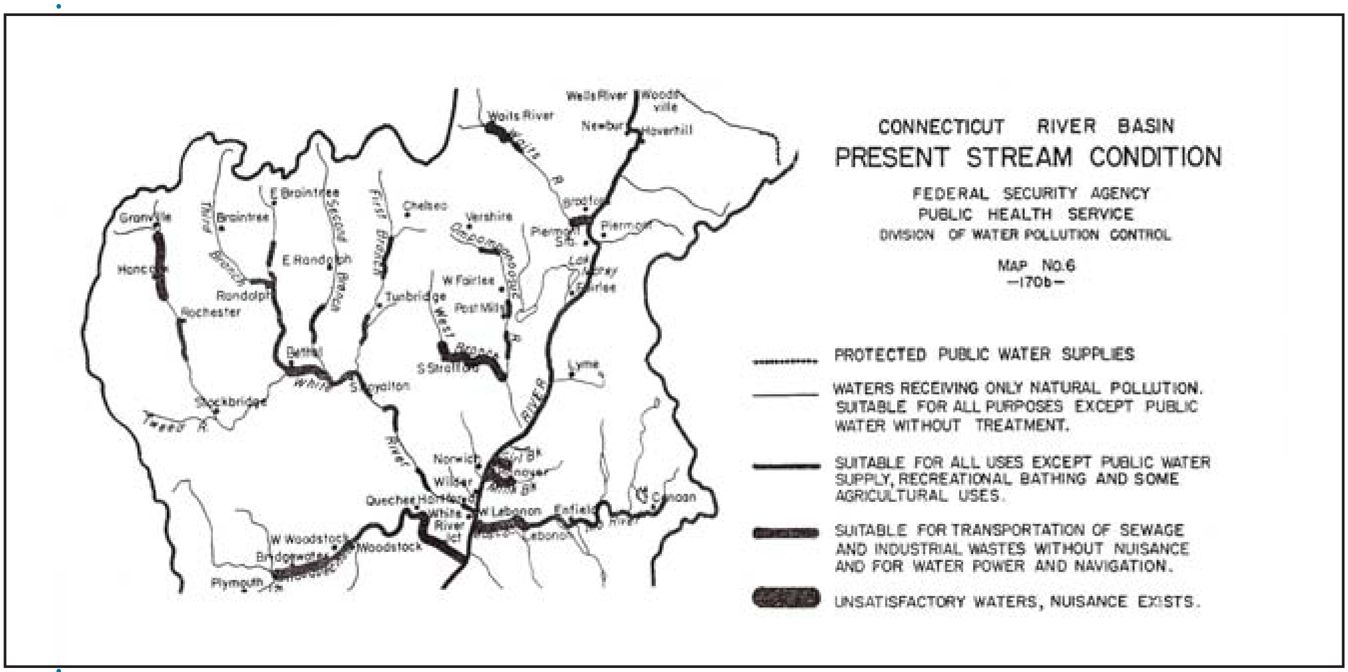
legislature designated the Connecticut River in 1992 with the support of local residents and the Connecticut River Joint Commissions. Designation allows riverfront towns to have a voice in decisions made about their river. The state does not conduct its own river management planning.

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. This document is a revised and updated version of the water quality chapter of that plan.

Vermont embarked upon watershed planning in 2002, under a mandate from the legislature that gave the Department of Environmental Conservation 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 the Connecticut River Joint Commissions. At the same time, the state agency is moving ahead with watershed assessment and restoration projects, such as studies of river dynamics. This basin planning began with the White River (completed in 2002) and was completed in Basin 14 (Waits and Ompompanoosuc Rivers) in 2008.

2. Water Quality has Improved in the Last 50 Years

In 1951, the federal Public Health Service rated 219 miles of the Connecticut River between New Hampshire and Vermont as Class C ("Damaged"), and six miles as Class D, with several tributaries registering as Class E.[1] Thankfully, such waters, and such river classifications, are a thing of the past. A mere half century ago, the river carried untreated domestic sewage from 11,000 people in the Upper Valley region of New Hampshire and 6,200 in nearby Vermont. Untreated wastewater from textile mills, tanneries, sawmills, and dairy operations on the



Water quality in the Upper Valley in 1951.

Mascoma, White, Ompompanoosuc, and Connecticut Rivers added to the burden brought by the Connecticut from its many upstream miles.

The lower Mascoma River, (from downtown Lebanon to the Connecticut), lower Girl and Mink Brooks in Hanover, 10 miles of the West Branch of the Ompompanoosuc River in Strafford and Thetford, and the last mile of the Waits River in Bradford were described in 1951 as "suitable for transportation of sewage and industrial wastes without nuisance, and for water power and navigation." The rest of the Upper Valley's waterways, including the Connecticut River mainstem and most of the White River, were considered "suitable for all uses except public water supply, recreational bathing, and some agricultural uses."

3. Water Quality Management by the States

New Hampshire water quality standards apply to the Connecticut River, which is included in the state's geographical boundaries. 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. An interesting difference appears between the two states' water quality standards, such as their concepts for bacterial contamination. 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 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 Water Quality Standards

Tracking water quality is the responsibility of the Watershed Management Bureau of the New Hampshire Department of Environmental Services (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.

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

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

Vermont - Vermont considers most of the Connecticut River to be Class B, with the exception of Waste Management Zones. Waste Management Zones are a specific reach of Class B waters designated by a permit to accept the discharge of properly treated wastes that prior to treatment contained organisms pathogenic to human beings. Throughout the receiving waters, water quality criteria must be achieved, but increased health risks exist in a waste management zone due to the authorized discharge.

In the Upper Valley region, there is a 0.49 mile designated waste management zone around the Hanover wastewater discharge, and a one mile zone around the Lebanon and White River Junction discharges.

Total Maximum Daily Load (TMDL) - The EPA requires each state's water quality agency to identify those water bodies that fail to meet 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 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.

TMDLs in Vermont - In the Upper Valley region, a total of 11.3 miles of the Ompompanoosuc River and its tributaries, and 3.0 miles of Pike Hill Brook in the Waits River watershed, have been placed on Vermont's TMDL list because of their contamination by metals and acid from abandoned mine drainage. The state expects to issue a TMDL, or a formula for reducing this pollution, by 2011 for most of these. In addition, several sections are contaminated by *E. coli* from unknown sources, especially near the Union Village beach and near West Fairlee village. Farm and barnyard runoff and milk-house effluent have contaminated a tributary to Pike Hill Brook.

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. Of concern is the Waits River below the south branch confluence, where sediment and warm temperatures from erosion, habitat alteration, and land runoff threaten the river. In the White River watershed, concerns vary from agricultural runoff to unknown sources of bacteria, loss of riparian vegetation, acid precipitation, erosion, and elevated levels of chromium and nickel in sediments. For more information see www.vtwaterquality.org/planning.htm.

TMDLs in New Hampshire - New Hampshire's TMDL list includes:

- Hardy Hill Brook in the Mascoma River watershed, where 3.0 miles of the brook exceed *E. coli,* lead, and aluminum limits.

- Blodgett Brook, where 3.1 miles also exceed *E. coli* limits.
- Mascoma River, where a total of 3.65 miles of the mainstem in Lebanon and nine miles in Hanover exceed water quality standards for *E. coli*, and in the Hanover section, also for aluminum, dissolved oxygen, and pH.
- Great Brook, where 2.1 miles are contaminated with *E. coli*.
- Several tributaries and ponds, including Lake Tarleton and 0.64 miles of Eastman Brook in Piermont, Lyme's Post Pond, Reservoir Pond, a 0.88 mile tributary flowing into it from Mud Pond, and Cummins Pond in Dorchester show pH levels below water quality standards.

For more information see *http://des.nh.gov/organization/divisions/water/wmb/swqa/index.htm*.

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.

4. Water Quality Monitoring Activities

The federal Clean Water Act requires the states to report surface water quality conditions and problems to the Environmental Protection Agency every two years. However, the states are not able to sample these conditions on a regular basis to see if they meet water quality standards.

Monitoring efforts are presently insufficient to determine whether water quality in some areas of river popular with recreational users is actually good enough to support that recreation. When *Along the Northern Connecticut River: An Inventory of Significant In-stream Features* was compiled for the Connecticut River Joint Commissions in 1994, nine governmental and eight volunteer water quality monitoring stations were on the mainstem, and on the tributaries were 12 governmental and nine volunteer stations. However, the frequency of state water quality monitoring is now greatly diminished due to staffing and budget restraints at NH DES. Now, there are no ongoing monitoring stations, and occasional federal funds for specific studies. The Connecticut Riverwatch Network, the volunteer group that once had a successful program in this segment, is no longer monitoring due to lack of funds.


A volunteer samples the Connecticut River for bacteria at the Wilder Picnic Area.

In 2008-2009, working under a Targeted Watershed Initiative grant from EPA,CRJC led a two-year effort to monitor the effects of combined sewer overflow. This monitoring, conducted by volunteers from Hartford, Lebanon, Hartland, and Cornish in the Lebanon/Hartford to Cornish/Weathersfield section of the Connecticut River, found only three bacteria violations out of over 170 samples during two of the rainiest seasons on record.

Despite the growth in the region's population and its dependence upon the river, there is no regular, on-going river water quality monitoring program on the Connecticut River. This would be a suitable activity for conservation commissions.

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 Volunteer River Assessment Program (VRAP), providing training, water quality monitoring equipment, and technical support. VRAP followed in the footsteps of DES's very successful Volunteer Lakes Assessment Program. Volunteer monitoring is taking place on Jacobs Brook in Orford and at a few swimming areas in the region, but not on other New Hampshire tributaries in the area. VRAP data are available online at http://des.nh.gov/organization/divisions/water/wmb/vrap/index.htm.

In Vermont, water quality monitoring rotates through the various basins on a seven year schedule. A volunteer monitoring program has taken place on Blood Brook, although it is a challenge to find volunteers dedicated enough to drive the samples to the state lab in the short time frame required. Funding for the lab was cut by the state of Vermont in 2009. Monitoring has occurred in conjunction with the basin plan developed for the Waits and Ompompanoosuc Rivers. The Vermont Agency of Natural Resources (ANR) sponsored monitoring in 2006 on the east branch of the Ompompanoosuc and below the Post Mills landfill and Ely Mine. The White River Partnership coordinates water quality monitoring on 20 sites in that watershed, including recreation areas and below wastewater treatment plants, and processes samples at the partnership's office.

Biological monitoring - The particular species and the 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 macro invertebrates (aquatic insects, the basis of the food chain), as well as basic physical and chemical water quality data and evaluate habitat. Volunteers also participate in biomonitoring.

Vermont has used this approach since 1982. New Hampshire started biomonitoring in 1997, and has looked at several locations in the Upper Valley region, including Eastman Brook in Piermont, Grant and Hewes Brooks in Lyme, and several sites on the Mascoma River in Dorchester and Canaan.

5. Water Quality in the Connecticut River Today

In preparation for the update of this plan, NH DES, assisted by EPA, responded to a request of the Connecticut River Joint Commissions to assess the entire river mainstem in New Hampshire in 2004.[1] This effort is detailed in Appendix D. Sampling during this one year project indicated that for 32 miles from Bradford/Piermont downstream to the mouth of the White River in Hartford, the river fully supports swimming, other recreation, and aquatic habitat. Samples were taken at

- Samuel Morey Bridge (Route 25A) in Orford
- Ledyard Bridge in Hanover
- Route 4 Bridge and railroad bridge in West Lebanon
- Interstate 89 bridge in West Lebanon

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

However, because combined sewer overflows (CSOs) existed until 2008 in Hartford and still exist in Lebanon, New Hampshire continues to classify the Connecticut River from its confluence with the White River to Blow Me Down Brook in Cornish as not supporting swimming. Because the water quality problem results when storm water overwhelms the capacity of wastewater treatment facilities, which occurs only during heavy storms, it is likely that the river is safe for swimming on most days in this area.

The part of the river considered threatened by bacteria from CSOs receives wastewater from the three plants serving Hanover, Lebanon, and White River Junction. Bacteria can also reach rivers through poorly functioning septic systems and through runoff, such as drainage from a livestock pasture or stormwater washing over a city street where dog owners do not pick up after their pets.

Best management practices (referred to as BMPs in New Hampshire, and called Acceptable Management Practices in Vermont) are land treatment or operational techniques which reduce or prevent pollution. They cover such activities as the operation of septic systems, erosion at road construction sites, road salting and snow dumping, site excavation and development,

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1. *2004 Connecticut River Water Quality Assessment, Preliminary Assessment Status*. NH Department of Environmental Services.

and agriculture, golf courses and lawns. By following BMPs, landowners can help reduce these problems.

Recommendations for Water Quality Monitoring

- States should provide adequate funding to ensure adequate and regular water quality monitoring; identify monitoring gaps and ensure coverage; continue to encourage volunteer monitoring activities on tributaries.

- Local conservation commissions should consider setting up water quality monitoring programs in their towns and share results. New Hampshire conservation commissions should consider participating in the VRAP program.

- NH DES should conduct biomonitoring in areas of intensive development, such as riverside development in West Lebanon, to assess ecological effects of pollution.

- State fish and wildlife conservation officers should notify their sister water quality agencies when water quality problems are observed.

- States should communicate results of water quality monitoring more readily to the public, especially conservation commissions.

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 Upper Valley. Results for mainstem sampling appear in Appendix E, and for the tributaries, in Appendix J.

Results show 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. The Upper Valley segment of the Connecticut River also shows striking signs of copper contamination from abandoned mines. Such sediment contaminants threaten aquatic life, including the federally endangered dwarf wedgemussel. Dwarf wedgemussels occur in an 18-mile reach of the river between Haverhill and Orford known to biologists as the Middle Macrosite, considered one of the three most important river reaches remaining for this federally endangered species (along with the Connecticut River's Northern and Southern Macrosites).[1]

1998 Sediment study: In 1998, EPA studied sediments at 10 sites on the New Hampshire/ Vermont portion of the river.[2] Two of the sites were located in the Upper Valley, in Norwich below the confluence of the Ompompanoosuc River, and in Lebanon below the confluences of the White and Mascoma Rivers. The site below the Ompompanoosuc River had the highest copper and zinc levels of any of the 10 sites in that study. EPA concluded that the sharply elevated copper in the Connecticut River mainstem in Norwich reflects drainage from the abandoned Elizabeth Copper Mine in Thetford and Strafford. Drainage from the mine flows into the West Branch of the Ompompanoosuc River in South Strafford, Vt. The Lebanon site, eight miles downstream, also had elevated copper and zinc, and the highest concentration of lead of the 10 sites. Chromium, copper, and nickel at both sites were all above the level that warrants suspicion that these heavy metals could have ecological effects upon aquatic life. Copper levels in the mainstem were above the "severe effects" level.

Air pollution, runoff from parking lots, leaking storage tanks, and outboard motor exhaust are all potential sources of PAHs in the Connecticut River. Concentrations of PAHs were found at each of the sampling sites, but at levels not expected to have detrimental effect on aquatic life. An exception was below the confluences of the White and Mascoma Rivers in Lebanon, where chrysene, a common contaminant in parking lot runoff, was found in the sediments in levels high enough to have an effect upon aquatic life.

2000 Sediment study: 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.[3] The EPA analyzed samples for 244 different kinds of volatile organic compounds, pesticides, PCBs, metals, and other pollutants. In the Upper Valley, the study looked at a total of 31 sites, 17 on the mainstem, and two each on the Waits, Ompompanoosuc, White, and Mascoma Rivers, and one each on Eastman, Jacobs, Clay, Grant, Hewes, and Mink Brooks. Tributaries sampled twice were sampled upstream of their mouths where they were not influenced by the Connecticut River, and again above densely settled areas. Results are summarized here and presented in Appendix E.

Metals and other elements - Metals exceeding screening levels in Upper Valley sediments include

- arsenic (4 sites)
- cadmium (1 mainstem site)
- chromium (2 tributary sites)
- copper (3 tributary sites)
- lead (3 sites)
- mercury (3 sites)
- nickel (6 sites), and
- zinc (2 sites)

Copper again emerged as a sediment pollutant from the Vermont copper mines, appearing at levels above the screening level in the Waits River at Bradford and in both Ompompanoosuc River samples, in concentrations five to ten times higher than in most other samples. Copper

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1. Ethan Nedeau, *Characterizing the Range and Habitat of Dwarf Wedgemussels in the "Middle Macrosite" of the Upper Connecticut River*. Report prepared for the US Fish and Wildlife Service and New Hampshire Fish and Game Department, 2006.
2. *Upper Connecticut River Sediment/Water Quality Analysis*. U.S. Environmental Protection Agency, Region 1, October 1999.
3. *Upper Connecticut River Valley Project*, New Hampshire and Vermont. U.S. Environmental Protection Agency, Region 1 by Roy F. Weston, Inc., 2001.

appeared in mainstem sediments below these tributary mouths, but in the 2000 study, not above the screening levels. The abandoned mines in the Ompompanoosuc and Waits River watersheds have been the subject of concern for many years and are discussed further in this plan under Acid Mine Drainage on page 64.

Arsenic appeared at levels above the screening level at four sites: confluence of Clay Brook in Lyme, the lower Ompompanoosuc River and in the mainstem below, and just above the Wilder Dam in Hartford. Mercury exceeded screening levels at three sites: on the Waits River below the town of Bradford, on the Mascoma River above downtown Lebanon, and on the Connecticut River just above Wilder Dam.

"Screening level" = level at which effects on aquatic life might be expected, such as reproductive impairment or other signs of poor health.

Pesticides - Pesticides showed up at only three places in the Upper Valley region sediments in concentrations above screening levels: 4,4'DDE just below the East Thetford/Lyme Bridge and at Dartmouth's Ledyard Boathouse swimming area, where 4,4'DDT was also found above screening levels. This swimming area is just downstream from the Hanover golf course. Also present at this site in very low concentrations, but the highest found in the study, are nine other pesticides: 2,4' DDE, 2,4' DDT, heptachlor epoxide, endosulfan I, alpha-chlordane, gamma-chlordane, toxaphene, c-nonachlor, and t-nonachlor. Many of these pesticides are no longer used, but traces can linger for years in the sediments.

PAHs - Polyaromatic hydrocarbons, or petroleum compounds such as phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(a)pyrene, naphthalene, fluorene, benzo(g,h,l) perylene, and indeno (1,2,3-cd)pyrene, showed up in river sediments in many places, with 102 instances of exceeding the screening levels. These chemicals can get into streams when roads closely follow waterways, from leaks and drips from automobiles, snowmobiles, motor boats, or other vehicles, and from leaking underground storage tanks. Chrysene exceeded the screening level at 13 sites throughout the region, from Piermont to White River Junction. Chrysene in sediments above Wilder Dam was present at 32 times the level found in most samples.

Wilder site - The longest list of pollutants (37) found anywhere on the 200-mile sediment study came from this site (#SD-082E), at what is now the northern end of the Wilder Dam Recreation Area in Hartford. A number of contaminants were present in concentrations well above levels where ecological effects can be expected: naphthalene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(a)pyrene, indeno(1,2,3-cd) pyrene, benzo(g,h,l)perylene, arsenic, lead, nickel, low level mercury. Also present in very low concentrations, but the highest found in the study, was one type of PCB.

This site has a long history of industrial use. Papermaking was an industry at Olcott Falls, beginning with a mill on the New Hampshire side in 1865 followed by the Olcott Falls Paper Company on the Vermont side in 1883, and later International Paper from 1889-1927. In 1950, the site was partially inundated by the construction of Wilder Dam.

While there is known risk to aquatic life from the sediments at this site, the human health risk is unknown. A brownfields assessment by Two Rivers-Ottauquechee Regional Commission could help answer important questions about the use of this property, especially since the Town of Hartford and TransCanada have considered cooperating on development of a riverside public recreation facility here.

Recommendations for Sediment Quality

- TransCanada should request the help of Two Rivers-Ottauquechee Planning Commission for a Phase I brownfields assessment of its property near the former paper mill site in Wilder, as part of the redevelopment of the area, and pursue a Phase II assessment (drilling, sampling, and monitoring) if approved by EPA. The landowner could apply for cleanup funds with the assistance of the RPC.

- Landowners and town road crews should use best management practices (BMPs) for handling and disposing of toxic substances.

- NH DES should evaluate whether sediments at the Wilder site pose any human health risks to swimmers, since a river recreation facility is under consideration for this site.

- States should investigate new methods to capture pollutants, encourage research into new technology, and share the information with towns.

- States should continue and expand education of landowners, developers, and land use boards on the value of maintaining riparian buffers.

- Landowners and town road crews should restore and retain riparian buffers to capture road pollutants.

- Towns should avoid incineration of construction and demolition debris, which can put heavy metals and dioxins into the air.

- Landowners should not burn household trash, which is illegal in both states.

D. Connecticut River Fish Tissue Toxins

In 2000, the EPA worked with the four Connecticut River states to conduct a comprehensive fish tissue toxin study, whose results were released in 2006. 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, as raised in the 1997 *Connecticut River Corridor Management Plan*.

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.

Upper Valley Region fish were sampled as part of Reach 5 (Wilder Dam to Vernon Dam) and Reach 6 (Wilder Dam to Moore Dam). The study found that total mercury concentrations in all three species of fish were significantly higher upstream than downstream, and are a threat in this region to subsistence fishers and also to mammals and birds that eat the fish. 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. DDT breakdown products pose a risk to subsistence fishers and to fish-eating birds such as kingfishers, but not to recreational fishermen or to fish-eating mammals such as otter.

Recommendations for Fish Contamination

- Congress and the states should take immediate action to reduce mercury contamination of the region and follow up on recommendations for further research given in the Connecticut River Fish Tissue Contaminant Study.

- States should identify and eliminate sources of PCB contamination.

- Towns should avoid incineration of construction and demolition debris.

Fish Consumption Guidelines:
(do not apply to stocked fish): Pregnant and nursing women, and women who may get pregnant can safely eat one 8-ounce meal per month of freshwater fish. Children under age 7 can safely eat one 4-ounce meal per month of freshwater fish. All other adults and children age 7 and older can safely eat four 8- ounce meals per month of freshwater fish. When eating bass, pickerel, white perch or yellow perch, limit consumption to fish 12 inches or less in length while following the above guidelines. Stocked trout contains relatively low levels of mercury. For rainbow and brown trout, women of childbearing age and children can safely eat one meal per week, others can eat 6 meals per week. Brook trout could be either stocked or from a reproducing population, therefore they should be consumed at the rate of the general statewide advisory. Sensitive populations should not consume any fish from Mascoma Lake; others may consume two meals per month.

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

E. Invasive Aquatic Species

Exotic aquatic plants and animals have been a growing problem in New Hampshire and Vermont since the mid-1960s, and are now regarded as the number two threat to biodiversity after habitat loss. Increasing numbers of species, each with increasing populations, now infest many dozens of water bodies in each state, and, since the mid-1990s, have begun to infest the Connecticut River. The most recent unwanted arrival is the invasive alga *Didymosphenia geminata,* also called "rock snot." Didymo was discovered in the watershed here in 2007, far upstream in Bloomfield, Vt. In the Upper Valley it has been found in the White River in Bethel, Vt. A list of invasive aquatic species appears in Appendix F.

Invasive aquatic species pose serious problems for water resources primarily by altering aquatic habitat, and also by interfering with water-based recreation, industry, and other economic activities. Native plants have evolved over millennia with animals such as beetles and other insects that have become specialized to feed on them. Exotic plants and animals, growing without such natural controls, can rapidly spread into the habitats of native plants, disrupting the food chain and stunting fish growth. Exotic aquatics can interfere with boating and swimming and reduce the value of waterfront properties. Upland non-native plants such as Japanese knotweed and honeysuckle have become increasingly common in riparian buffers in the Upper Valley.

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. Volunteers can greatly assist the efforts of state biologists. Both states offer grants to local lake associations and towns for the control of exotic aquatics and training programs for volunteer "weed watchers."

Sources of invasive aquatics - Exotic invasive plants and animals reach the Upper Valley in many ways. Plants such as Eurasian milfoil can come in on the propellers and trailers of boats that have been in infested waters, or spread through drainage from such waters. Zebra mussel larvae can survive several days in bait buckets, live wells, or engine cooling systems. Aquatic invasive plants and animals, such as goldfish, could come from aquariums dumped into surface waters or from flooding of landscaped "water gardens" planted with exotic plants. Road crews can inadvertently spread soil and fill contaminated with the seeds or the excavated fragments of plants such as Japanese knotweed. Mowing at the wrong time, after a plant such as purple loosestrife has gone to seed, can spread the seeds. Many weed seeds arrive on mulch hay used for erosion control. Didymo apparently arrived in the Connecticut River watershed on the felt soles of waders belonging to a fisherman who had recently traveled to New Zealand, which had already become infested.

Didymo - Didymo is an invasive freshwater diatom (microscopic algae). It can form extensive colonies on the bottoms of rocky river beds, smothering aquatic life including macroinvertebrates. Its appearance is very unattractive, making the water unappealing for recreation.

Didymo is generally a northern circumpolar species of river systems with cobble or rock bottoms, although biologists are noticing a shift to 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 Upper Valley region, it could move through them into tributaries.

Biologists believe that Didymo could continue to be spread by any recreational equipment, including bait buckets, diving gear (neoprene), 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. State natural resource agencies have concluded that the best approach is to attempt to prevent further spread by humans, especially to tributaries.

Eurasian Milfoil *(Myriophyllum spicatum)* - The northernmost infestation of milfoil on the Connecticut River is currently in Fairlee, at the outlet of the drainage from infested Lake Morey. It is currently unknown whether the milfoil infestation at Clay Brook in Lyme, N.H. has occurred as a result of milfoil reaching the Connecticut River through this drainage, although this is suspected. There is no boat/trailer check program in place anywhere on the river in the Upper Valley to ensure that boats are not delivering hitch-hiking weeds from other waters. Fortunately, a courtesy boat check program has now been instituted on Lake Morey.

State researchers evaluate milfoil growth just above Wilder Dam.

Other Invasive Plants - The 2006 Connecticut River Aquatic Invasive Plants Outreach & Survey Project, funded by CRJC's Partnership Program, surveyed for invasive plants at 21 mainstem sites in New Hampshire and Vermont, from Hinsdale to Pittsburg, and found a number of invasive plants in the areas surveyed in the Upper Valley portion of the Connecticut River. A subsequent study in 2007 was funded by the Wellborn Ecology Fund.

Purple loosestrife *(Lythrum salicaria)* has become noticeably more common in the last 10 years in the Upper Valley region, as has Japanese knotweed *(Polygonatum cuspidatum)*. Both afflict the White and Mascoma River banks. Releases of *Galerucella* beetles to control purple loosestrife have occurred in a number of areas, sponsored by the Purple Loosestrife Coalition, a former project of the Hanover Garden Club. While some success has been reported with this bio-control, it has been found that water level fluctuations in the Wilder impoundment affect winter beetle survival in soils close to the river.

Invasive aquatic animals - The zebra mussel has not yet invaded the Connecticut River, which is considered one of the few New Hampshire water bodies possibly susceptible to this invader because of the more neutral chemistry of its water. The zebra mussel has become a scourge in Lake Champlain, covering intake pipes, boat hulls, docks, and beaches. Studies funded by CRJC in 2005 indicate that the exotic rusty crayfish, an aggressive competitor of native crayfish, is increasing in the White River watershed after fishermen using them as bait released them into the water. The status of other invasive aquatic animals in the Upper Valley Region is currently unknown.

Invasive Plants in the Upper Valley Region

Site	Town	Invasive Species Found
CT River/Halls Brook confluence and mainstem	Bradford, VT & Piermont, NH	Purple Loosestrife
Waits River/CT River confluence & small portion of CT River, VT side	Bradford, VT	Purple Loosestrife
Jacob's Brook/CT River confluence	Orford, NH	Purple Loosestrife
CT River on NH side near town boat landing	Orford, NH	Purple Loosestrife Yellow Flag Iris
CT River backwater cove, Lake Morey outlet brook/CT River confluence	Fairlee, VT & Orford, NH	Eurasian Milfoil Purple Loosestrife Yellow Flag Iris
Lower Clay Brook above and below Edgell Covered Bridge, upstream of CT River confluence	Lyme, NH	Eurasian Milfoil Purple Loosestrife
Clay Brook/CT River confluence & portions of the CT River, NH & VT sides	Lyme & Orford, NH and Fairlee, VT	Eurasian Milfoil Purple Loosestrife Phragmites True Forget-Me-Not Yellow Flag Iris
CT River above and below N. Thetford boat launch	Thetford, VT	Eurasian Milfoil Purple Loosestrife Japanese knotweed
Lower Grant and Hewes Brooks and CT River between their confluences	Lyme, NH	Purple Loosestrife Japanese knotweed True Forget-Me-Not
Ompompanoosuc River/CT River confluence & small portion of CT River, VT side	Norwich, VT	Eurasian Milfoil Purple Loosestrife Phragmites
Lower Mink Brook and nearby CT River	Hanover, NH	Eurasian Milfoil Purple Loosestrife
Wilder Dam Boat Launch and areas immediately above Wilder Dam	Hartford, VT	Eurasian Milfoil Purple Loosestrife Japanese knotweed Phragmites Honeysuckle
Lower Mascoma River & nearby CT River	Lebanon, NH & Hartford, VT	Purple Loosestrife Japanese knotweed

2007 Connecticut River (in VT & NH) Aquatic Invasive Plants Outreach & Survey Project, Final Report.

Recommendations for Invasive Aquatic Species

- State environmental and fisheries agencies should continue to cooperate with watershed groups and conservation commissions to understand and address the Didymo infestation. Provide clearer depictions on posters at boat launches. Use fishing license applications to educate the public.

- Fishermen and other recreational users must be educated to 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.

- Local outfitters and guides, outdoor stores where bait is sold, and local recreation programs should educate their customers and participants about Didymo and other invasives, and urge them to clean their gear.

- Pet shops should educate their customers not to release aquarium animals or plants.

- 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.

- Local road crews and highway departments should work with state agriculture departments and natural resource agencies to educate the public and landowners, rethink the timing of roadside mowing, and take care when disposing of spoils from mowing and excavation.

- Town conservation commissions should educate the public and town recreation departments about invasive species.

- NH Lakes Association should extend its courtesy boat inspection program.

IV. River Flow

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 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 and steadily. Dams influence river flow by holding back water and allowing only a portion to flow, and by creating an impoundment where water can evaporate 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 aquatic life alive year-round. Humans depend upon adequate flow in 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 water level and flow rates, and are needed to forecast flooding, set floodplain levels and regulations, and look at historical flooding trends in river systems. River managers, state and local officials, recreational users, and landowners use gage information to monitor flow conditions on the river and its tributaries, and take appropriate action. Gages are also cited in water use permits, help define operations of hydro generating plants that affect flow, and help 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.

Effective river management requires good knowledge of current river conditions, now further enhanced by satellite communication and computer technology. There is one gaging station on the Connecticut River mainstem in the Upper Valley region, at West Lebanon, and another 50 miles upstream in Wells River. There are six gages on tributaries that enter the river in this area. Real time gage data are available at www.crjc.org/riverflow.htm, linked to the U.S. Geological Survey (USGS) Web site.

Funding for gage upkeep is shared by USGS with other agencies, and in 2004, averaged $12,500/year/gage for gage calibration, equipment maintenance, data analysis, and data management, according to NH DES. There have been threats to this funding in recent years, primarily as a result of efforts to cut state budgets, and gages have been eliminated in other parts of the river basin. New Hampshire's Rivers Management Advisory Committee has recommended addition of some gages, particularly in the watersheds of designated rivers such as the Connecticut, and in 2007 New Hampshire appropriated new funding for this purpose. Since more extreme weather patterns seem to be emerging, and water is an increasingly valued commodity, it is important to be sure gages remain funded so that the data will continue to be available.

NH DES has proposed a new gage on Eastman Brook in Piermont upstream of the new wastewater treatment system, to help ensure its good performance. DES also may restore a discontinued gage on Mink Brook in Hanover. While there are two gages on the Mascoma River, they do not register the contribution of four major brooks draining intensively developed and populated parts of Lebanon that have flooded the downtown and nearby areas. There is also no gage to monitor the contribution of the Waits River to the flow of the mainstem.

Recommendations for Gages

- States and USGS should maintain existing gages for public safety.

- NH DES and USGS should cooperate to add gages on Eastman and Mink Brooks, and should consider adding a gage on the lower Mascoma River near its confluence with the Connecticut.

- VT ANR and USGS should consider adding a gage on the lower Waits River.

Table 1a. Active Gages in the Upper Valley Region

Location		River	Gage number	Drainage (sq.mi.)	Measurements available (real time)	Years of record	Funding source
Connecticut River mainstem	Wells River, Vt.	Connecticut River	01138500	2,644	discharge (flow), gage height	since 1949	USGS and NH DES
	West Lebanon, N.H.	Connecticut River at the RR bridge	01144500	4,092	discharge, gage height	since 1911	National Streamflow Information Program.
Waits River watershed	East Orange VT	East Orange Branch, Waits R.	01139800	9	discharge, gage height, precipitation	since 1958	USGS
Ompompanoosuc River watershed	Union Village, Vt.	Ompompanoosuc River	01141500	130	discharge, gage height, precipitation, air temperature	since 1940	USGS and US Army Corps of Engineers
White River watershed	Randolph, Vt.	Ayer's Brook	01142500	30	discharge, gage height, precipitation	since 1939	USGS and VT DEC and other state agencies
	West Hartford, Vt.	White River	01144000	690	discharge, gage height	since 1915	USGS and VT DEC and other state agencies
Mascoma River watershed	West Canaan, N.H.	Mascoma River	01145000	80	discharge, gage height	since 1939	NH DES
	Lebanon, N.H.	Mascoma River at outlet of Mascoma Lake	01150500	153	discharge, gage height	since 1923	NH DES

Table 1b. Discontinued Gages in the Upper Valley Region

Location		River	Gage number	Drainage Area (sq.mi.)	Measurements available (real time)	Years of record
Connecticut River mainstem	Orford, N.H.	Connecticut River	01140500	N/A	historical stream flow information only	1900-1921
Mink Brook near Etna	Hanover, N.H.	Mink Brook	01141800	4.6	historical stream flow information only	1962-1998

B. Flow & Flooding

Except in very high water conditions, operations at Wilder Dam almost completely control instream flow of the Connecticut River in most of the Upper Valley region. The large watershed of the free-flowing White River, which enters the Connecticut just below Wilder Dam, adds natural variation to the closely managed mainstem flow.

The Connecticut River in this region typically experiences large flows with spring ice-out and snowmelt, and also after heavy rains at other times of year in the river's watershed upstream.

Storms that affect tributary watersheds do not always have an equal effect on the mainstem. For instance, during one storm in the White River watershed in June, 1998, the White River carried nearly 35,000 cubic feet of water per second (cfs), while the Connecticut River mainstem, usually the much larger river, flowed at only 22,000 cfs. This effect echoes the 1927 flood, when the White River was flowing at 120,000 cfs and the Connecticut at 30,000 cfs.

The 2002 license for the hydro dams at Fifteen Mile Falls, 30 miles upstream from the Upper Valley segment, includes a new higher minimum discharge from Comerford Dam which may result in higher flows above
Wilder Dam at some times of the year than might otherwise occur. This higher flow is not likely to affect river levels below Wilder Dam, however.

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. 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." (RSA 483:9-c).

"Terrain drains!"

Thetford resident, speaking of flooding

Instream flow is affected by rainfall, snowmelt, drought, and also by damming, diversion, withdrawals, and development. This in turn affects water quality, erosion, temperature, recreation, nearby water supplies, and especially habitat. 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 the New Hampshire Rivers Management and Protection Act, have yet to be developed by the state. Instream flow rules for the Souhegan and Lamprey Rivers elsewhere in the state have been drafted through a pilot process that will eventually be used on other rivers. A Protected Instream Flow has been adopted for the Souhegan River. At this time, there are no plans to attempt to create flow rules for the Connecticut River.

Floodwaters doom the Lyme-North Thetford Bridge in March, 1936.

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. Establishing jurisdiction over water is complicated and deserves more attention from the states as water becomes in greater demand.

2. Flooding and Flood Control

Natural valley flood storage - In 1994, the U.S. Army Corps of Engineers identified the river valley in Haverhill, Newbury, Bradford, and Piermont as one of the four most important natural valley flood control areas on the entire 410-mile long river.[1] Here, the river can spread out on 4,000 acres of floodplain and farmland and dissipate its energy. Additional development of the "green infrastructure" in this region will transfer flooding downstream, greatly increasing flood damage in the Upper Valley and beyond. See the shoreline and floodplain development section on p. 48.

Role of ice in flooding - Ice jams can block the water's flow, sending it in a new path, causing it to back up, or causing sudden release and flooding as the jam breaks. Abrasion by ice can also be a significant cause of bank erosion. In the Upper Valley region, ice generally melts in place and does not pass through Wilder Dam. Depending upon winter conditions, the White River, which joins the Connecticut below Wilder Dam, will deliver rubble ice to the mainstem's sheet ice. The thickness and strength of this ice depend upon winter conditions in the White River watershed. Once this ice enters the mainstem, it breaks up sheet ice there and grounds itself in several prominent locations before jamming and backing up water in the river. One common site for ice jamming is at a large ledge on the Vermont side just below the Interstate 89 bridge. Ice jams there endanger the shopping plazas built in the floodplain at West Lebanon by deflecting the current toward the riverbank. Dam operators attempt to manage river flow to control ice jamming at this site to the extent it is possible, keeping ice moving by releasing enough water from Wilder Dam to lift it off the ledge when the water is available.

Role of development in flooding - The growing pace of development in the Upper Valley is likely to have an increasing effect upon river flow as forests and other rainfall-absorbing land cover become roads, parking lots, roofs and lawns. Residents note that smaller tributaries in the more heavily developed areas of the Upper Valley tend to rise and fall more quickly than in less developed areas. The effects of large-scale landscape clearing upon river flow were driven home in the early 1900s when the denuding of the White Mountains far upstream of the mills in Manchester, N.H., led to flooding and then a flow in the Merrimack River that was so diminished that it harmed river-dependent industry. Large-scale landscape changes have cumulative effects downstream. For example, long-time local residents have observed that drainage from Interstate 91 has caused flooding in Fairlee and Bradford that did not occur before the highway was built. The old thinking was to move water off developed surfaces and drain it quickly away. Newer approaches to stormwater management are to adapt development to the site and create stormwater infiltration on the site. Redevelopment, such as has happened in the commercial district of West Lebanon, offers a chance to improve stormwater treatment.

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

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 this practice 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.

Role of mainstem hydro power 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. However, it is a mistake to assume that even the largest hydro dams are able to control flooding at all times. Even when Moore Reservoir is lowered the full 40 feet allowed by its license, it can only capture one inch of rainfall in its 1,600 square mile watershed without passing water downstream. Following heavy rains in October, 2005, flood water exceeded storage capacity at both Moore and Comerford Dams upriver at Fifteen Mile Falls, and flooding occurred below them in the Upper Valley segment.

Flood control dams - Flooding in the river in Norwich and Hanover and below is now reduced to a minor extent by the Union Village Dam on the Ompompanoosuc River, in Thetford, Vt. This dam controls only 130 of the nearly 4000 square miles of the Connecticut River watershed that lies above. The Army Corps of Engineers constructed this dam, along with others on more southern tributaries, in response to catastrophic flooding that affected the region in 1936, 1938, and again in the 1950s.

In recent years, partly as a result of the 1997 *Connecticut River Corridor Management Plan,* the Army Corps has communicated information about its water releases and dam operations at Union Village Dam more effectively to managers of mainstem dams. However, homeowners living in the floodplain near the mouth of the Ompompanoosuc River still experience occasional flooding if releases from Union Village Dam are made to a flooding Connecticut River.

The Army Corps, working with The Nature Conservancy, has begun to look at structural changes to these dams to determine the best way to provide fish passage and to better regulate flow and temperature to lessen their effects on downstream waters.

3. Extreme Storms

The Upper Valley region has recently experienced some sudden, severe rainstorms, although, as of this writing, none as strong as the tragic 500-year storm that affected the Cold River watershed in Alstead, N.H. in 2005. A strong and very localized microburst in 2004 washed out roads and caused much damage in Hanover, but did not affect neighboring towns. Such storms can have very damaging effects on small streams.

Culverts and bridges must be sized properly in order to carry the water that might come their way. In Vermont towns, regional planning commissions are assisting with surveys of their bridges and culverts, to identify those that may be too small and could be a public safety hazard in times of high water. (for more, see section on roads and railroads). Many culvert watersheds have less storage for runoff now than they did 30-40 years ago when these culverts may have been installed. This is because wetlands have been drained, land has been cleared, and more impervious surface has been added.

Table 2. Union Village Flood Control Dam	
Owner	U.S. Army Corps of Engineers
Date constructed	1950, cost $4 million
Location	Ompompanoosuc River, Thetford VT
Operating limits	managed for flood control; dam top elevation 584.0 feet above mean sea level. Spillway crest 564.0 feet
Dam size	1,100 feet long, 170 feet high
Dam type	earthen
Impoundment	38,400 acre-feet, 12.3 billion gallons in a 740 acre lake
Watershed area	130 square miles
Fish passage	none
Property size	1272 acres, managed for flood control, public recreation, forestry, and wildlife

4. Climate Change and Water Resources

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

Vermont stream scientist

Extreme storms such as those described above are cited as symptoms of climate change by many scientists, and can have important implications for the flow and quality of rivers and streams. 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 Upper Valley, in the Northeast, and globally.

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 Northeast 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 Upper Valley's climate will still change, but feel more like the climate of Maryland by 2099.[1]

Precipitation - Climate change will do more than add a few degrees to today's average temperatures. Some places may become drier, others wetter. In addition, more precipitation may come in short, intense bursts (more than 2 inches of rain in a day), which could lead to more flooding. Measurable increases in the number of heavy rain storms have already occurred across the Northeast in recent decades, 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 stormwater runoff. A 2005 study by Michael Simpson at Antioch New England Graduate School in Keene concluded that current engineering design specifications for culvert sizing is inadequate to handle the higher frequency of storms of greater intensity that can be expected with climate change.

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 with flows needed to support fisheries.

Snow pack - The number of days of snow cover is predicted to fall. With higher emissions, by the end of this century the Upper Valley region will no longer retain snow cover for at least 30 days.[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 could be avoided.

Stream flow - 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.

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]

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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, Mass., 2006.
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*. U.S. Environmental Protection Agency Office of Policy EPA fact sheet 236-F-98-007aa), September 1998.

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, a subject of concern in the Upper Valley – where three wastewater treatment plants discharge into the Connecticut River mainstem within the space of five miles. Less flow in summer streams could mean less dilution of pollutants and poorer water quality.

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

Lyme's Grant Brook during a 2002 drought.

Recommendations for Flow and Flood Control

- Public agencies and private landowners should work together to retain current natural flood storage, such as in wetlands and floodplains, which is effective and valuable.

- TransCanada should alert riverfront towns if a problematic ice jam is anticipated.

- Towns should evaluate whether culverts and bridges are sized properly in order to carry the water that might come their way during larger storms. Regional planning commissions can help towns with culvert and bridge surveys to identify those that may be too small or damaged, ineffective, or plugged.

- States should develop an instream flow policy for rivers and streams that contribute to the flow of the Connecticut River.

- The U.S. Army Corps of Engineers should coordinate flood control dam operations with mainstem dams to avoid local flooding where possible when flood waters need to be released from Union Village Dam.

- Managers of other tributary dams where flow can be managed, such as at Mascoma Lake, should coordinate operations with mainstem dams during spring runoff.

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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, Mass., 2006.

- The Army Corps should maintain the discharge from Union Village Dam at periods of low flow at run-of-river levels, or inflow=outflow, to protect aquatic life downstream. The Corps should institute larger water releases from the Union Village Dam every few years to maintain a more natural channel shape in the Ompompanoosuc River. The Corps should enable fish passage changes at the dam.

- Towns should adopt ordinances prohibiting filling and building in the 100-year floodplain and on flowage rights of way. Consider establishing a building setback that reflects local soil conditions and the historic record of soil loss into the river, and ensure that buildings are set a safe distance back from the river even when outside of the floodplain.

- Federal, state, and local governments should identify mechanisms for decreasing carbon dioxide emissions.

V. Working River - Hydro Power Dams

A. Wilder Dam

Wilder Dam, the major hydro power dam influencing the Upper Valley segment of the Connecticut River mainstem, is located at Hartford, Vt. and Lebanon, N.H.

1. History of the Dam Site

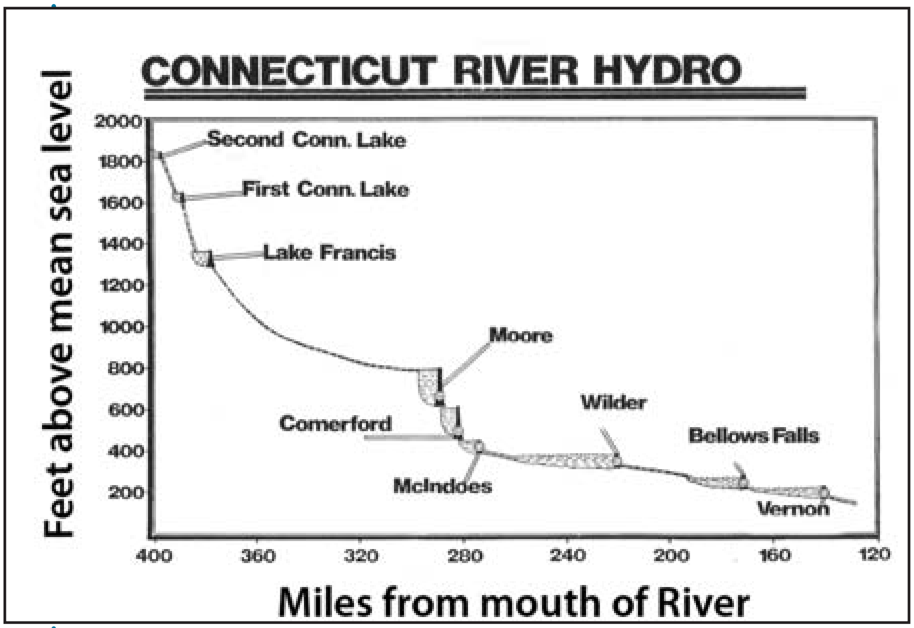
Wilder Dam occupies the former site of Olcott Falls, a pair of natural falls which were over 650 feet long and 40 feet high. In 1810 a canal with locks was built on the New Hampshire side to allow canal boats and rafts to pass around the falls. The first dam across the Connecticut here was an 808-foot cribwork dam at the upper falls, built in 1882. A new concrete dam followed just downstream in 1927. Wilder Dam, built in 1950 three quarters of a mile below the cribwork dam, flooded both of the original dam sites. TransCanada Hydro Northeast purchased Wilder Dam in 2005 from USGen New England. Its current federal operating license expires in 2018 along with those of Bellows Falls and Vernon Dams.

2. Wilder Dam Operations

A "daily peaking" generation plant, Wilder Dam raises and lowers water in the Wilder impoundment as it stores and releases water during the day. The timing and amount of this release depends upon flow conditions in the river and upon market price for electricity.

Since 2000, Wilder Dam has been the control center for hydro power operations throughout the Connecticut River mainstem, including the dams at Fifteen Mile Falls, Bellows Falls, and

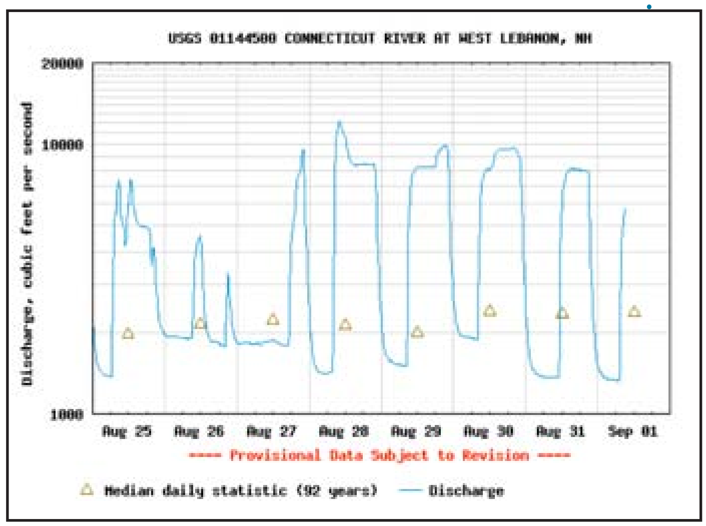
Vernon. The exception is the dams at the Connecticut Lakes. The company has also trained its staff to manage the river's flow from stations at the other dams should it be necessary. While the dam's federal license conditions allow water behind the dam to fluctuate by as much as five feet, the water usually rises and falls within a narrower range. During the summer, the company operates Wilder Dam within narrower limits to benefit recreational use. It takes approximately eight hours for water to travel from McIndoe Falls Dam in Barnet Vt./Monroe, N.H. to Wilder Dam, a distance of 60 miles, and another eight hours to travel to the head of the Bellows Falls impoundment in Weathersfield, Vt./Claremont, N.H.



Wilder Dam's location on the upper river. New England Power Co.

Material removed from the trash racks behind Wilder Dam can include docks, logs, trash, and other debris. It is recycled when possible, and natural organic material such as branches and other woody debris is returned to the river, where it is an important component of aquatic habitat.

Wilder Dam impoundment - Wilder Dam impounds the river for some 45 miles to Newbury and Haverhill. Because Wilder impounds such a long section, the power company releases water at the dam when high flows are expected from upstream. Public safety is a prime concern, and the company uses loudspeaker announcements when gates are opened, plus flashing lights and signs.



Fluctuations in discharge at Wilder Dam create water level fluctuations in the river, measured at the West Lebanon gage just below the dam, August 2006.

The phenomenon known as "pond tilt" allows water levels to be very low near the dam, yet quite high some miles upstream. This occurs because it takes time for water arriving at the upstream end of the impoundment to reach the area of the dam.

Dam design - Wilder Dam was designed to handle flows of 162,000 cubic feet per second, the magnitude of flow during the Flood of 1927. Since the dam's construction in 1950, the largest recorded flow was only 55,000 cfs. Wilder Dam includes three turbines, one on the Vermont side of the river, and two on the New Hampshire side; they are the original units that were installed in 1950. The company uses vegetable oils for hydraulic lubricants in its machinery. The 1978 license issued by the Federal Energy Regulatory Commission (FERC) required up and downstream fish passage at this dam, Bellows Falls, and Vernon, and it was installed at a total cost of $40 million.

Black start - Unlike power plants using non-renewable energy sources, hydro dams can provide a "cold" or "black" start to the electrical grid, as Wilder Dam and others on the Connecticut River did during the historic 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 for consumers.

Table 3. Wilder Dam

Owner	TransCanada Hydro Northeast
Date constructed	1950
Location	Wilder (Hartford) VT/Lebanon NH, river mile 217
Dam type	concrete
Operating limits	380 feet to 385 feet above mean sea level
Normal operating range	382.0 and 384.5 feet above msl
Required minimum flow	675 cubic feet per second (cfs) or inflow, year round
Spill capacity	101,400 cfs
Fish passage	upstream and downstream
Impoundment	approximately 46 miles; storage of 13,350 acre feet
Generating capacity	42 megawatts (Two 19.5 MW turbines and one 3 MW turbine)
watershed drainage area	3,375 square miles
Bypass	none
Time of flow to next impoundment	8 hours to Bellows Falls

Influence of Wilder Dam: The construction of Wilder Dam resulted in several benefits to the river and its corridor. It provides energy without using fossil fuels, and contributes to the tax base of the towns in which it is located. By inundating tributary mouths and other low-lying areas, the dam created ecologically rich backwaters and wetland areas such as Wilder Wildlife Management Area in Lyme, the Ompompanoosuc flats in Norwich, and Reed's Marsh in Orford, which provide habitat especially for waterfowl, warm water fish, and other wildlife. The flatwater pool behind the dam provides deeper water for power boating and other forms of recreation, which was not possible on the river until the dam was built, although the dam itself forces paddlers to portage their craft. Local people recall that it was possible to wade across the river from Bradford to Piermont before the dam was built. The dam also provides a way to influence flooding, ice breakup, and flows in time of drought.

When an impoundment is created by a dam, however, it alters the natural character of the river and changes the pattern of flow, so that the river behaves more like a lake. Water temperatures 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. Fish populations shift to warmwater species, and walleye, perch, and bass now inhabit the warmer water of the

Wilder impoundment, using the shallows of tributary setbacks for spawning. 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. Because the dam can alter patterns of flooding and sediment deposition, some floodplains no longer function as before, although they are still essential.

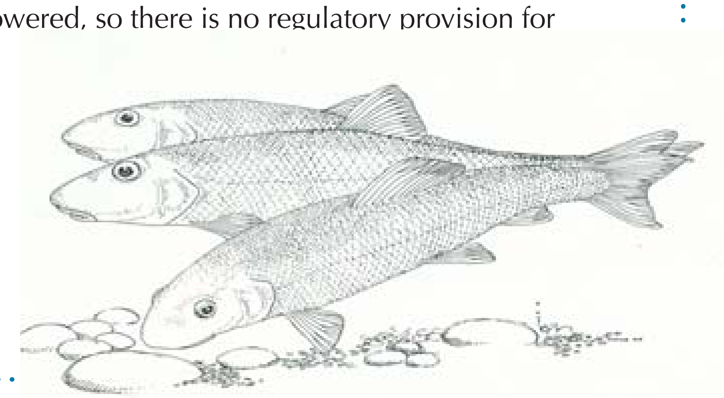
Wilder Dam creates a 45-mile-long impoundment.

3. Water Level Fluctuations and Erosion

Regularly fluctuating water levels are a particular concern in the Wilder impoundment. While there are many causes of riverbank erosion, the second most important in this region, as determined by the Army Corps of Engineers, is water level fluctuations from operations at Wilder Dam. The primary cause is natural scour. Rapidly changing water levels can cause pressure imbalances at the water-saturated bank face, causing water to seep out of the bank, carrying small particles of soil with it. This is called soil piping, and it can contribute to bank collapse. Water level changes also magnify the area of riverbank face that is exposed to erosive wave action.

An Upper Valley River Subcommittee member has recently discovered a disturbing feature of some parts of the Hanover riverbank in the Wilder impoundment, where even heavily forested banks have been undercut, forming cavities that reach back five to six feet. Since these cavities remove physical and nutritive support for the trees above, they could result in bank failure. The cause of these cavities, thought to be primarily wave action, deserves investigation, particularly because of the high economic and aesthetic value of the riverfront in this region.

Riverfront landowners and other observers have reported that in recent years, and particularly since TransCanada acquired the Connecticut River dams, the level of the Wilder impoundment seems to show more pronounced variation than in years past, with higher high water levels and lower lows, and more rapid draw downs. This creates concern for riverbank stability and sedimentation. The company is required to operate within the terms of the dam's federal license, raising and lowering the water level within set limits, but subtle shifts in management of this dam seem to be exploring the full range of allowable limits, rather than the more moderate regime of prior years. For this dam, the license also does not spell out a "ramping rate," or how quickly the impoundment can be raised or lowered, so there is no regulatory provision for gradual changes.



B. Other Dams

Tributary dams - There are 38 active dams on the tributaries in this segment, ranging from farm pond berms to abandoned water supply reservoir dams and a major flood control project at Union Village Dam. The impoundments vary in size from 0.13 acres to 1,155 acres, and include public water supply reservoirs, conservation ponds, swimming holes, and fishing ponds. Four of the privately owned dams produce hydro power. The 21 breached dams on tributaries in our region relate stories of our history.

Lebanon has repaired the dam on Boston Lot Lake under orders from the state. Repairing the dam, long overdue for maintenance, is intended to prevent damage to Route 10 and discharge of sediment and other debris to the river.

New Dams - No new dams may be built on the Connecticut River in the Upper Valley region, according to the New Hampshire Rivers Management and Protection Act. 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 one designated "community" segment in the Upper Valley embraces Wilder Dam. In this selected area, the Rivers Act permits hydroelectric production, flood control, and dam replacement and repair.

Recommendations for Dams

- FERC should institute a ramping rate at Wilder Dam in the next FERC license, to reduce soil piping in the riverbanks of the impoundment and to minimize negative effects on aquatic and riparian habitat; include a provision for emergency gate operation, such as in the context of a black start when the dam is needed to provide immediate power in case of a blackout. Assess possible effects of sediment build-up behind Wilder Dam and the extent to which it has affected flood storage capacity. Require the company to maintain discharge at run of river levels at periods of low flow in the next FERC license, to protect aquatic life downstream.

- County conservation districts and others should investigate causes of riverbank cavities and methods to restore them.

- Dam owners/managers should coordinate flood control dam operations and those of other operable tributary dams with mainstem dams to avoid local flooding where possible, especially when flood waters need to be released from Union Village Dam. Strongly consider removing dams that no longer serve a purpose and cost more to fix than the benefits they offer or are a threat to areas downstream.
- Towns should monitor dams within their borders for safety and environmental reasons. Educate the public about local flood hazards and emergency procedures.

- Local citizen groups should participate in the relicensing process for Wilder Dam.

VI. Using the Water

A. Water Withdrawals

Water withdrawals from the Connecticut River could influence its instream flow, even here in the Upper Valley 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, changing weather patterns, and the distinct possibility that demand for water for industry, irrigation, waste disposal, and household use may rise.

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.

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 12 registered water withdrawals in the Upper Valley segment on the New Hampshire side, only one of which is from the mainstem. They serve for hydroelectric power production (5), water supplies (2), industry (1), mining (2), irrigation (1), snow making (1). A list of registered water withdrawals appears in Appendix H.

Vermont water withdrawals - The state of Vermont requires permits for water withdrawals from in-state waters, limiting them to 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. 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.

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.

Recommendations for Water Withdrawals

- Vermont should explore establishing a program to register water users.
- New Hampshire should evaluate whether requests for withdrawals have increased in order to decide whether the 20,000 gallon/day threshold for registering water users should be lowered.
- States and towns should work with large water users to examine their present water use and identify areas for conservation.

B. Groundwater and Drinking Water Supplies

Clean and historically abundant drinking water may be our region's most valuable but under-appreciated commodity. In the Connecticut River watershed, stratified drift aquifers, where large stores of groundwater are available, are closely associated with the river and its tributaries. No individual actually owns groundwater. 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 & Regulating Groundwater Supplies

It is especially important to know where aquifers occur before development is proposed. Stratified drift aquifers have now been mapped for the state of New Hampshire. More detailed surficial geologic maps can be used to identify groundwater resources and recharge areas, as well as glacial lake deposits, or varves (see the Shoreland section on pp. 51), which can be unstable for development. Vermont's aquifers have not been mapped as comprehensively as New Hampshire's, although the state is now moving in this direction. Older "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.

Both state geological survey offices offer geological mapping support to towns on a 50/50 cost share basis. In New Hampshire, surficial geologic maps have recently been completed for the Hanover and Enfield USGS quadrangles, and survey work on the Lyme and Smarts Mountain quads is underway at this writing.

Lebanon public water supply - The city of Lebanon relies on surface water from the Mascoma River to supply its 13,000 residents and 25,000-40,000 workers and commuters with drinking water. In 2004, the city processed nearly 700 million gallons for consumption, averaging 1.91 million gallons each day. NH DES prepared a source assessment report in 2002 that examined the safety of the water supply. The report identified areas where the city's water supply is susceptible to contamination. With the help of the Upper Valley Lake Sunapee Regional Planning Commission, the city has mapped the Mascoma River watershed and inventoried and inspected potential contamination sources.

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. Since 1998, New Hampshire has regulated all groundwater withdrawals larger than 57,600 gallons/day, a threshold that is based on the regulations for community water supply wells, and is lower than most other eastern states. 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. Attempts by a large commercial water bottling company to tap groundwater in southeastern New Hampshire has put communities statewide on alert about the vulnerabilities of their public water supplies.

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, until the recent passage of legislation, Vermont was 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, poorly maintained, or failed septic systems can send disease-carrying pathogens, and whatever homeowners put down the drain, to groundwater which may also reach the river. Leaking underground fuel storage tanks, chemical spills, pesticide 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.

While USGS has established and maintains two groundwater monitoring gages in the Merrimack River basin, none are deployed in the Connecticut River basin.

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 on pp. 53.

Groundwater contamination in Upper Valley region towns - Most groundwater contamination is from leaking underground storage tanks and several former dry cleaning establishments. The urgency of cleaning up these sites is affected by whether or not there is an alternative water supply for the area. Many sites have been cleaned up. While much information about specific sites is now available to the public on the states' Web sites, posted information on the Vermont side is often out of date and incomplete.

MtBE - MtBE (methyl tertiary butyl ether) was introduced after lead was removed from gasoline in the 1980s, intended to increase the octane rating and reduce air pollution. It has become a problem for groundwater. Considered a possible carcinogen, MtBE 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. On the Vermont side of the Upper Valley, it has appeared in Bradford, Hartford, and Hartland.

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]

Norwich identifies its public well supply area.

While clean drinking water is essential, few communities have taken steps to protect it. A New Hampshire study in 2000 showed that only 11 percent of lands through which water flows to sources of public drinking water are protected by ownership or conservation easement, and 39 percent of community water systems do not even own the sanitary protective radius or plume around their wells (75-400').[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 reaches the

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 the Protection of N.H. Forests.

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 Upper Valley subcommittee region, only Lyme, Bradford, Thetford, and Norwich have groundwater protection regulations, regulate the use of land above underground water supplies, and have identified a public well supply area. Fairlee and Lebanon have taken steps in this direction.

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. Demand for groundwater is much more intense now that one no longer needs to haul it by hand, but can simply turn on the spigot. Increases in population and industrial demand have also put pressure on groundwater supplies. Suburban habits such as washing cars and irrigating large lawns have replaced watering livestock and irrigating fields. Studies in New England demonstrate that the average total daily water use is approximately 70 gallons per person.[1] Many people are now unaware of where their water comes from. Lebanon, for example, is seeing increasing demands on the city water supply, especially by hotels. Concern about pressure on the Mascoma River watershed from this demand may be reason enough to nominate the Mascoma River into the N.H. Rivers Management and Protection Program, so that it eventually will have instream flow protection.

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 run off, and keeping impervious surfaces and development of steep slopes to a minimum, careful developers can encourage water to soak in and recharge groundwater as it might have naturally.

Most water is used locally, and 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 Thetford to be sold as bottled water in Burlington. The water will not return.

Recommendations for Groundwater

- Working with towns, Vermont should identify and map groundwater supplies.

- Towns should understand their capacity for providing drinking water and establish a baseline for use. Take advantage of surficial geology mapping assistance available from state geological survey offices. Confirm with the state whether their identified water supply information is correct. Identify old dump sites to look for those close to ground and surface water supplies. Evaluate water supplies for short and long term growth. Ensure adequate setbacks and lower

1. Brandon Kernon, NH DES Source Water Protection Program, pers. comm. 9/11/06.

density for clearing, building, and septic systems over recharge areas. Consider wellhead protection; take advantage of community source water protection grant and loan programs.

- Towns in the Mascoma River watershed should nominate the Mascoma River for designation into the N.H. Rivers Management and Protection Program.

- State agencies and towns should not allow landfills, salvage yards, and junkyards to be located above aquifers.

- Towns should sponsor more regular household hazardous waste collections.

- Town planning boards should encourage developers to use Low Impact Development techniques: keep natural drainage patterns and use swales and depressions ("rain gardens") to reduce runoff, and work with developers to follow through on recomendations of the 2002 Upper Valley stormwater conference.

- States should assist towns and landowners in prioritizing and clean up contaminated groundwater sites and monitor for possible MtBE contamination. Educate people to handle automotive fluids, pesticides, medicines, and other chemicals properly so they don't contaminate their own wells, and educate them about less hazardous alternatives. Educate people to keep their septic systems functioning properly with regular maintenance. Educate people about the source of their water, including carrying water bottles filled from one's own tap for drinking, rather than purchasing bottled water taken from someone else's aquifer.

- Vermont should update its posting of hazardous sites on the web.

VII. Land Use & Water Resources

A. Point Source Pollution: Wastewater Discharges

Thanks to the 1972 federal Clean Water Act and considerable federal, state, and local investments, riverfront industry and communities no longer pipe untreated toxins and pathogens to the river. New forms of economic development are now possible based on a cleaner, healthier river: recreation and tourism. Initially, the federal government bore 80 percent of the burden of building wastewater treatment plants and the state contributed 10 percent. The government's participation has nearly evaporated in the years since, leaving towns responsible for the heavy cost of upgrading their plants to meet new needs.

In fact, the Upper Valley segment of the Connecticut River still carries treated waste that, especially in times of low flow through the impoundment behind Wilder Dam, can test the river's capacity to assimilate it. These point discharges come from several sources. The development capacity of the Upper Valley region may well be at least partially limited by the capacity of the Connecticut River to deal with the wastewater such development creates. At the same time, the appeal of the cleaner river is partly responsible for the appeal of the region to new residents and businesses.

1. Direct Discharges

This segment of the river receives treated wastewater discharges from three municipal plants in a fairly short distance (Hanover, Hartford, and Lebanon), and water quality is noticeably poorer during times of low flow. Municipal wastewater discharges into the rivers and tributaries of this segment include Hanover (Connecticut River), Hartford (Connecticut and White), Lebanon (Connecticut and Mascoma), Piermont (Eastman Brook), and Bradford (Waits).

There are two industrial or institutional discharges: the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory to the Connecticut River, and Timken Aerospace, to the Mascoma River. Other businesses and institutions, such as Dartmouth Hitchcock Medical Center, Hanover Country Club, and part of Timkin, discharge to wastewater treatment facilities.

There have been rare releases of untreated sewerage from the wastewater treatment plants in

Table 4. Wastewater Treatment Facilities discharging to the Connecticut River mainstem

Wastewater Treatment Plant	age	Comments
Bradford, Vt.	1978, upgrades 2006	added new aeration and clarifiers, replaced pumps
Piermont, N.H.	1985, upgrade 2006	Removed discharge from Eastman Brook and now discharging to groundwater.
Hanover, N.H.	1960s, upgrade 2003-5, 2008	Has had *E.coli* violations, which have been fixed. Moved the discharge pipe from lower Mink Brook into the middle of the Connecticut River in 2005. Discharge pipe is held down by concrete saddles.
Lebanon, N.H.	1978	Under EPA order to complete remediation of CSOs (see below) by 2012; winner of EPA's 2001 national first-place award for operations & maintenance, due to the plant's energy-efficiency and its work with industrial sewer users to prevent the disposal of materials that could harm the treatment plant."
Hartford/WRJ, Vt.	early 1970s, 1989 upgrade	once had 6 CSOs, have been eliminated, and effectiveness of this work is being evaluated. Town voted in 2009 to add capacity and collection improvements.

Hanover and also to the White River from a treatment plant in Bethel, Vermont. An accidental release of chlorine from a wastewater treatment plant in the White River watershed led to a significant fish kill.

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. Eliminating CSOs, which is required by the federal government, is an expensive burden on small communities. However, CSOs can render the water unsafe for swimming and diminish its value for recreation.

Pathogens from combined sewer overflows in Lebanon and until recently from Hartford sometimes affect the quality of the river for nearly 13 miles, from White River Junction/Lebanon

south to the confluence of Blow-Me-Down Brook in Cornish and Windsor. This section includes the popular paddling waters from Blood (True's) Brook down to Sumner Falls. Water quality monitoring of the river here by volunteers organized by CRJC in the very wet summers of 2008 and 2009 has indicated bacteria violations on only one day in 2008 and one in 2009.
The most significant CSO problem in the region is in Lebanon, where the combined sewerage system dates from the 1930s. At times of heavy flow, combined sewer overflows have been observed shooting mixed sewerage and stormwater four feet into the air in a Lebanon parking lot close to the Mascoma River. In 2000, EPA ordered the City to correct the situation by 2012, and much progress has been made by eliminating two of the seven or eight overflows, but significant and costly work remains. The US Army Corps of Engineers initially provided $5.75 million in funding, but withdrew this assistance, and the city must now rely on borrowed money, sewer and water user fees, and property taxes. For this reason, the city requested an extension in the time line to complete the separation. In 2009 some funding from the American Reinvestment and Recovery Act was made available to Lebanon for this purpose. The last of Hartford's six CSOs appears to have been eliminated in 2008, with the effectiveness of the work still being evaluated.

3. 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. 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. Anti-biotic resistant DNA (genes) are also showing up in surface waters.

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. Dartmouth Hitchcock Medical Center could potentially contribute a significant load of such drugs to the Hanover wastewater treatment plant, in addition to patients using and discarding medicines all over the region. Hormones, fragrances, other substances have been detected in all urbanized and farm-intensive watersheds in the United States. Cosmetics, cleaners, insect repellant, and even nicotine and caffeine have been detected in some studies of waterways.[1] 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.

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.

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, 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 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.

4. Waste Assimilation in the Upper Valley Segment

Within a stretch of only a few miles, the segment receives treated wastewater discharged by Hanover, Hartford, and Lebanon. During times of low flow, the river has less ability to dilute this discharge, with noticeable results. This may have implications for limits to further development in the more densely populated areas of the Upper Valley, and means that the quality of existing discharges must be the best attainable.

The ability of the Connecticut River in this segment to assimilate additional treated wastes is hampered in several ways.[1] The Upper Valley segment has the disadvantage of a relatively flat river gradient, which affects the re-aeration capacity of the river. The impoundment above Wilder Dam acts as a lake without the mixing process found in running water. Such areas are apt to encourage the growth of algae when nutrients are present and oxygen levels are low because of the effects of temperature and water density layering which further reduce the river's waste assimilation capacity. The mainstem in this segment does, however, have the advantage of increased volumes due to the entry of major tributaries, although the Mascoma River is classified as impaired and is presently contributing its own load of pollutants to the Connecticut. Tumbling over the ledges at Sumner Falls, a few miles downstream in Plainfield and Hartland, Vermont, also mixes in oxygen, helping the river to better assimilate the wastewater it receives from Lebanon, Hartford, and Hanover.

Reducing the amount of water entering wastewater treatment plants, by conserving water and

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1. *Connecticut River Water Quality Assessment*. NH Dept. of Environmental Services and VT Dept. of Environmental Conservation, 1994.

re-using gray water where possible, will reduce the amount of water requiring treatment that is ultimately discharged to the river. Both states have recently passed legislation banning the use of phosphorous in dishwashing and laundry detergents, which will lead directly to a decrease in the amount of phosphorus reaching waterways.

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. Encourage tertiary treatment.

- Towns should reduce phosphorus entering from wastewater treatment facilities - encourage use of low-phosphorus detergents.

- States should educate the public and local governments about the benefits of reclaiming gray water and water conservation. Explore ways to reuse or reduce wastewater and new technology to avoid new discharges to the river or to groundwater. Explore alternatives to adding conventional wastewater treatment plants.

- Towns should understand the limited capacity of Wilder impoundment to assimilate further waste when planning future development.

- States and the federal government should provide financial assistance to Lebanon to complete the elimination of CSOs.

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

- US Fish & Wildlife Service, EPA and the states should work together to establish updated rules for disposal or return of unused medicines and work with medical providers for more responsible disposal of medicines. Provide funding for education about disposal of pharmaceuticals and personal care products.

- Regional planning commissions should evaluate the area's wastewater treatment system capacity.

B. Non Point Source Pollution

These sources of pollution sometimes go undetected and therefore unresolved because they do not come from an easily observed point, but can include residential uses, 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.

Most of these older landfills, such as the Post Mills landfill, are not lined, and their contents can still seep into groundwater and may pose a threat to drinking water supplies. Informal dumps remain untreated on several tributaries. To protect ground and surface waters, 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. Despite this safety feature, it remains unwise to site landfills on top of aquifers, or on top of unstable soils such as varves. The leachate still reflects the materials in the landfill, which can include heavy metals, poisons, 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 that boundary 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, including harvesting of methane gas for fuel or mining for copper or other materials.

The old town dump in Fairlee was one of dozens of riverbank dumps at a time when the Connecticut River was known as New England's best landscaped sewer.

Major landfill work has recently occurred close to the Connecticut River in Lebanon, where the city's older landfill has been capped and a new area opened. At the same time, a recycling facility has been moved and improved. In May, 2007, NH DES inspected the landfill and discovered that leachate was breaking out in 11 areas and reaching the Connecticut River. DES also cited litter built up around fences and in drainage swales. The city repaired the problems and no concerns were found later that year.

Old Fairlee Town Dump - A large riverside dump in Fairlee was investigated by EPA in 1999. This public dump closed in 1974, but debris had fallen down the steep bank and entered the river. Several drums containing volatile and semi-volatile organic compounds were removed from the river, and nearby sediment was analyzed. Results indicated that the river sediment is contaminated only by one compound at an extremely low level: bis(2-ethylhexyl)phthalate, a common semi-volatile compound. EPA concluded that the river sediment at the toe of the old Fairlee Town Dump does not appear to present a problem and will not be removed.

Recycling and hazardous waste - Communities are working to reduce the tonnage of solid waste they bring to landfills, by recycling, although rates vary greatly. Options for recycling vary widely among towns, and few towns offer recycling for a wide range of plastics or for conventional batteries. As more households begin to use long-life, low-wattage light bulbs that contain mercury, there is a need for good public information on how to properly dispose of these bulbs, which are accepted for recycling by some area hardware stores. The Greater Upper Valley Solid Waste District sponsors hazardous waste collections for area towns twice a year, but the Subcommittee suggests more frequent collections are needed.

Lyme adopted a pay-as-you-throw system in 2006, and its recycling rate jumped from 13 percent to 54 percent while its expenses for solid waste disposal dropped from $109,000 to $24,000. The program proved a strong motivator to recycle, so less material was thrown away at the town's expense and the town made more money from recycled materials.

Table 5. Municipal Solid Waste and Recycling - reported by NH towns in 2007 (source: DES)

Town	Combined municipal solid waste (tons)	Construction/ Demolition Waste (tons)	Compost (tons)	Recycling (tons)	Recycling rate
Piermont	126	0	4	112	48%
Orford	506	73	0	100	n/a
Lyme	273	53	0	289	51%
Hanover	To Lebanon	3,978	0	861	11%
Lebanon	24,554	17,903	23	1,896	10%

Littering - Many towns in the area hold an annual "Green Up" Day in spring, encouraging residents to help pick up the winter's accumulation of roadside trash. From time to time, people still illegally dump tires in the Connecticut River. 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. In the past, the Rotary Clubs in the Lebanon area have sponsored very successful cleanups of the Mascoma River.

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 that can then reach water and aquatic life. As growth and development pressure increases in the region, towns need to deal with the increased volume of this debris. Landfills are filling too quickly with this material, which should not be incinerated. New Hampshire outlawed its incineration in 2007. Regional planning for this waste disposal is needed.

Recommendations for Landfills, Junkyards, and Transfer Stations

- Area solid waste districts should assist towns in holding more frequent household hazardous waste collections and sites. Assist towns in exploring options to create greater recycling markets, especially for plastics, and encourage more recycling by towns of more materials. Explore incentives for greatly reducing solid waste, including construction materials.

- Towns should strongly encourage citizens to make use of regular household hazardous waste collections, including organizing car pooling or "waste pooling." Encourage mercury product recycling, especially of new low wattage long-life light bulbs and electronics, and encourage paint swaps and educate the public on how to dispose of paint, since paint is expensive to treat.

- Commercial and industrial businesses should recycle as much material as possible.

- State environmental agencies should develop best practices for resource recovery activities at landfills.

- Towns should hold an annual "Green Up" Day.

- States and towns should not permit landfills to be located on top of aquifers.

Shoreline development threatens much of the Upper Valley's riverfront.

2. Shoreline & Floodplain Development

"I'm picky about protecting first order streams because if they get polluted it pollutes everything else. It's also easier to clean up a smaller stream."
Norwich resident

People are strongly attracted to riverfront land. Those with no memory of the
river as a "nuisance" or a health hazard have made the value of shorefront property rise sharply, and riverfront homes are appearing at an increasing rate in the Upper Valley, although new riverfront owners are not always entirely aware of the hazards and regulations associated with living next to the largest river in New England.

Development is the greatest threat to the river segment designated by the N.H. Rivers Management and Protection Act (RSA 483:7) as "rural," the 28.76 miles from the Piermont/Haverhill town line to Camp Brook (Storrs Pond Brook) in Hanover. The increased demand for level, easily developed soils and picturesque house sites in this special, rural place can suburbanize the river corridor, threatening water quality, blocking wildlife travel corridors, and eliminating wildlife habitat. Water quality impacts can occur 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. Such development also changes the overall visual quality of the riverfront and, by fragmenting or removing what are often prime agricultural soils from potential production, threatens agriculture as a viable enterprise in the area.

New Hampshire Comprehensive Shoreland Protection Act - The New Hampshire side of the Connecticut River is covered by the Comprehensive Shoreland Protection Act (RSA 483-B) within 250 feet of the ordinary high water mark. As of 2008, this law also applies to seven other fourth-order and larger streams in the Upper Valley River Subcommittee region. Provisions of this law and the rivers it covers in the region are described in more detail in Appendix I.

The goal of this state law 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 financial investments in structures dangerously close to the river.

This law calls for buildings to be set back at least 50 feet from the "reference line" at the edge of the water. For natural fresh waterbodies, this is the natural mean high water line. For artifically impounded waterbodies, it is the elevation at the dam's spillway crest or the allowable high water line. All new riverfront lots are subject to subdivision approval by 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, even under the eye of local zoning administrators. The Subcommittee is concerned about this lack of enforcement and about confusion among local administrators about responsibility for jurisdiction. The Subcommittee also believes that realtors should be well aware of the provisions of the law so that they can inform potential buyers of shorefront property.

Three of the five New Hampshire towns of the Upper Valley Subcommittee region have established protection for their river frontage that is more suited to such a large and powerful river. Lyme requires a 200-foot building setback from the Connecticut River and 100 feet for other surface waters. Hanover and Piermont require a 75-foot setback.

The law also applies only to fourth order streams, and leaves protection of smaller streams up to the towns. The subcommittee believes that it is wise to provide more protection for smaller streams, because a healthy riparian buffer can have an even more beneficial effect on aquatic habitat and water quality in a small stream, and the cumulative effect of healthy smaller streams also benefits the rivers into which they flow, and ultimately, the Connecticut.

Vermont Shoreland Protection - Vermont is the only state in the Northeast that does not have 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, Bradford, Fairlee, Norwich, and Hartford have adopted their own shoreland protection for the Connecticut River and other streams which is comparable to or more effective than the New Hampshire law.

The Subcommittee believes that the state should ensure that buildings are set a safe distance back from the river even when outside of the floodplain, to protect water quality and to reduce the risk of property loss in erosion-prone areas. In the absence of state action, towns should pursue every opportunity to protect their waters and the property of their citizens by establishing a building setback that reflects local soil conditions, slope, and the historic record of soil loss into the river, and protecting riparian buffers.

Flowage rights - In 2005, TransCanada acquired flowage rights on many acres of riverfront land in the Upper Valley region associated with the Wilder Dam. These rights were originally purchased from riverfront landowners in the early to mid-20th century. The company's predecessors purchased permanent easements that included the right to inundate portions of riverfront properties in anticipation of impounding the river behind Wilder Dam. 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. Title searches sometimes do not go back more than 50 years, and may not pick up an earlier easement. Landowners wishing more information can search their property's records at the county registry or contact the company.

"Floodplains are called floodplains for a reason. If we keep building in floodplains, we use up the sponge."

Fairlee riverfront farmer

Building in floodplains - Because building in floodplains takes over valuable farmland, transfers flooding problems downstream, and costs taxpayers money when flooding occurs, several towns have passed ordinances banning construction here. Piermont, Lyme, and Hanover no longer permit building in the 100-year floodplain. Local regulations regarding shoreland and floodplain protection are summarized in Appendix G. However, the other Upper Valley towns along the Connecticut River do continue to permit construction in the floodplain if buildings are built according to certain restrictions. Unfortunately, this policy has led to heavy big box store development in Lebanon. Here, trash from the parking lots and loading docks is increasing in the river, particularly after construction in 2005, and untreated stormwater from older commercial development can affect the quality of its water.

The National Flood Insurance Program, administered by the Federal Emergency Management

Agency (FEMA), requires special construction standards for buildings that are built in floodplains, but they still permit buildings to be built on this vulnerable land, and a building is allowed to take up space that flood waters would otherwise have occupied. Filling in floodplains invites flooding elsewhere. Simply building a mound to raise a building above the 100-year floodplain may reduce the chance of flood damage to that particular building, but it does nothing to prevent pollution and eliminates flood storage space, forcing floodwater somewhere else. 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. Mobile homes in floodplains are particularly threatened during high water, and the region has had experience evacuating flooded mobile homes. Prohibiting filling and building in the 100-year floodplain and on flowage rights of way will protect citizens and businesses from damage, avoid adding to flooding downstream, and reduce the public cost of disaster relief.

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

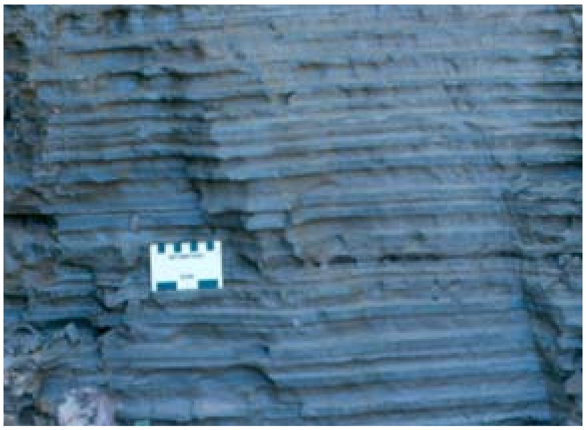
Riverfront town Conservation Commission member

Some people believe that the large hydro power dams upstream at Fifteen Mile Falls will protect buildings in their floodplains against flooding. Two weeks of rain in October, 2005 proved that this is not the case, as these impoundments quickly filled and could not prevent flooding downstream in Piermont and Bradford.

Although the U.S. Army Corps of Engineers identified 4,000 acres of floodplain from Woodsville south into Bradford and Piermont as one of the four most important natural valley flood control areas on the entire river, the Corps decided against purchasing conservation easements on this land, even though development in this region would greatly affect future flood damage downstream. Fortunately, the Upper Valley Land Trust has worked successfully with the owners of much of this rich floodplain farmland, and has protected many hundreds of acres from development, but more needs to be done.

Conservation saved this fertile Lyme floodplain's agricultural future.

Floodplain maps - It is essential for landowners, town officials, and banks issuing mortgages and loans to have correct information on floodplain locations. Unfortunately, these maps are often grossly inaccurate. 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 effort stopped at the Plainfield-Lebanon and Hartland-Hartford lines, leaving most of the Upper Valley, the focus of strong development pressure, 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.



Varves are alternating clay/silt layers that once formed the lakebed of glacial Lake Hitchcock. They have distinct drainage properties that make them challenging for development.

Varves - Thousands of years ago, some of the river valley was a lake bed, with soil deposits that can cause problems for anything built upon them. Glacial Lake Hitchcock left behind layers of ancient lake-bottom sediments that in some places sort themselves into varves, layers that have differing physical properties that can slip and collapse. The glacial lake covered much of the lower lying areas of the Upper Valley.

Knowledge of varves is important for land use planning, because they 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 decide on whether a proposed project is safe. Good mapping of varves and other surficial geological features such as aquifers can give a land use board the information it needs to make good decisions. Siting landfills, bridges, large buildings, and other important structures on varved deposits is risky. Varves may have been the underlying cause of the sudden and repeated appearance of a large subsurface gully in a riverside field in Lyme, after construction of a nearby pond created changes in subsurface drainage.

As of this writing, the N.H. Geological Survey worked with Hanover on a 50/50 cost-share basis to map varves and other features in the Hanover and Enfield topographic map quadrangles, and is working with the Town of Lyme to map the Lyme and Smarts Mountain quads. Similar efforts are possible on the Vermont side.

Recommendations for Shoreland and Floodplain Development

- NH DES should educate town officials and landowners about the Comprehensive Shoreland Protection Act, including responsibility for enforcement, and should continue to offer training sessions on the Shoreland Protection Act for realtors that would count toward continuing education requirement. The New Hampshire legislature should consider developing shoreland protection measures for tributaries not currently covered by the Act. New Hampshire towns should not issue permits for projects that violate state shoreland protection law.

- Vermont should consider adopting measures to protect the shoreland of both the Connecticut River and its tributaries.

- Towns should adopt ordinances prohibiting filling and building in the 100-year floodplain and on flowage rights of way. Consider establishing a building setback that reflects local soil conditions, slope, and the historic record of soil loss into the river, and ensure that buildings are set a safe distance back from the river even when outside of the floodplain. Make use of state GIS data, perhaps with assistance of the regional planning commission. Include recommendations in their master plans concerning water quality and shoreline protection measures and implement them by adopting regulations supporting those measures.

- Town conservation commissions or planning boards should work with state geologists to map varves in their towns, to be sure major construction takes these soil features into account. Cost-sharing grants are available with USGS funds. Encourage developers and landowners to establish and/or maintain buffers of native vegetation along rivers and streams for privacy and pollution control. Require sedimentation and erosion controls before, during and after construction, and not permit septic systems close to water bodies. Seek geologic mapping of varves and aquifers in partnership with the state geological survey.
- FEMA should apply hydrologic studies of the entire river completed in 2003 to update flood insurance rate maps for Lebanon, Hartford, and other Upper Valley towns upstream.

3. Roads and Railroads

In our region, the river and its tributaries were the first highways, and as settlement proceeded, trails and roads naturally followed them. Today, the construction, repair, and maintenance of roads can result in loss of the riparian buffer and cause sediment to be washed into these waters. Sand from roadways and bridges can affect habitat quality of the riverbed. A sudden heavy storm can cause problems with blocked culverts and send sediment from such a blockage into a stream. Winter road salt threatens water quality in the many streams followed too closely by roads. Sediment studies tend to show more pollutants in the river where the roads are close. Conserving and restoring riparian buffers would help hold streambanks in place and help capture road-related pollutants escaping into the stream.

"A well-set culvert equals fish portage."
Two Rivers-Ottauquechee Regional Commission planner

For nearly a decade, Lebanon, just upstream from one of the most biologically interesting areas of the Connecticut River, has considered building a road on the edge of the riverbank to relieve traffic problems at its heavily developed commercial district in West Lebanon. Observers note that the river already receives parking lot runoff into the river and blowing trash from the entire commercial area in West Lebanon. The Subcommittee strongly advises against adding more pollutants from a roadway so close to the river.

Culverts and bridges - Culverts and bridges can have a critical role in preventing flooding and property damage, and also in ensuring good fish passage along the streams they traverse. An under-sized, damaged, or poorly designed, located, or maintained culvert or bridge can block with debris in a sudden storm and cause a stream to cut through a road. A similar problem in Alstead, N.H., contributed to a major flood disaster on the Cold River in October, 2005. The increasing frequency of extreme storms such as the one that affected the Cold River valley is further reason to ensure that culverts and bridges are up to the job.

Town road agents deserve the respect of all for their long hours of work to keep roads passable and safe, but they may not have the engineering experience to gage proper culvert sizing. Many culverts may be too small, keeping both water and sediment from moving through. While logs and other woody debris create healthy fish habitat, culverts need to be kept clear to allow water to move through.

Two Rivers-Ottauquechee Regional Commission has completed a bridge and culvert survey for the towns in the Ompompanoosuc River and Blood Brook watersheds, and helped towns identify some undersized and failing structures that could become public safety and flooding hazards during a heavy storm. However, no such inventories have been done in New Hampshire towns in the region. 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. Vermont state engineers may be able to assist with sizing decisions. It is important to look upstream when making such decisions, and to include what flow and stormwater runoff might come from upstream from future development if it is planned.


A hanging culvert at the Dartmouth Skiway obstructs fish passage.

Some culverts in flowing streams have been installed in such a way that they obstruct fish movement, preventing fish and other aquatic life from using habitat on the other side. 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, will be another.

Road salt - Salt and salted sand used for road de-icing can pollute ground and surface waters. Salt in drinking water can threaten public health. Salt in surface waters is toxic to fish and other aquatic life. 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 Experimental Forest just east of the Connecticut River watershed, 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.

Salt is a contamination problem for both surface and groundwater, brought into sharp focus in the Upper Valley by troubles resulting from construction by the railroad of a salt storage shed on the Fairlee/Thetford line. Shortly after the salt shed went into operation, a nearby residential well was contaminated. A federal court has declared the railroad's operations to be outside the jurisdiction of state and local authorities which might have prevented this pollution.

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

While the need to minimize the amount of salt reaching streams and groundwater is obvious, adopting a low-salt policy for town road maintenance is a complicated question. States and towns have differing policies, which can be seen in the different treatment of Route 5 in Vermont and Route 10 in New Hampshire.

New Hampshire installed a new de-icing system in the decking of the southbound lane of the Interstate 89 bridge over the Connecticut River in 2006. Weather sensors monitor the surface temperature of the bridge deck. When icing conditions are present or anticipated, the system automatically discharges a spray of an anti-icing liquid (potassium acetate) from nozzles installed in the bridge pavement. Electronic equipment controls and records weather conditions and system discharges, and provides automatic notification to the New Hampshire Department of Transportation. Potassium acetate contains no chlorides and biodegrades in low temperatures to potassium, water and carbon dioxide. The chemical is stored in a 6,100-gallon plastic tank that has a subsurface concrete sump/foundation to provide 100 percent secondary containment. The pump and control systems include fail-safe routines to prevent excessive use of de-icer. Studies cited by NH DOT concluded that potassium acetate does not penetrate groundwater aquifers and does not affect water chemistry.

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. 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 only guidelines. 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.

Snow dumping - The sand and salt used to treat roads in winter can easily end up in a stream or river. End of winter cleanup on area bridges, including the Ledyard Bridge, often includes washing which can force sand and other solids to enter the river below. 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 that have fallen onto those areas from vehicles. Towns have not always followed state guidelines on snow dumping and storage.

The railroad follows the VT shore in the Upper Valley and affects the river's movement within its floodplain.

Long-time snow dumping sites may also show signs of lead accumulation in the soil from the days of leaded gasoline. In Windsor, Vt., 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 be unknowingly suffering a similar problem.

Railroad - The railroad follows the Connecticut River on the Vermont side throughout the Upper Valley region, and its presence, especially its riprapped rail bed, dominates the riverbank for many miles. On the New Hampshire side, there has been rail activity as far north as West Lebanon. In many places, the railroad company has removed the riparian buffer growing between the tracks and the river, removing a source of protection for the bank and for water quality.

Recommendations for Roads and Railroads

- States and towns should focus on smart growth to help avoid the need for new roads near rivers and streams; when they are necessary, design them to include adequate riparian buffers.

- Towns should ensure that culverts are properly engineered when replacing them during road work.

- New Hampshire should consider working with the regional planning commissions to conduct a bridge and culvert survey program similar to Vermont's. NH towns should ask for help from regional planning commissions and NH DOT 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 salt reduction on roads as well as prioritize efforts to identify and introduce use of less toxic salt substitutes.

- Railroads should abandon their policy of eliminating the riparian buffer where the tracks pass along the river's edge, and avoid using herbicides near water. Seek a native species for vegetative cover that grows thickly and only a few feet high, that can be controlled with mowing every 5-10 years. Employ best management practices in siting structures such as salt sheds in order to protect water quality.

- The railroad should expand testing of groundwater near the Ely salt shed, particularly in swales below the shed.

- State transportation agencies should develop incentives for towns to use road sediment catchment systems.

- Towns should follow snow disposal best management practices. Snow should be stored on flat, pervious surfaces, such as grass, and at least 100 feet from the edge of a stream or river, with a silt barrier 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. Sweep bridges first in spring to capture solids that remain from winter sanding, before washing. Towns should test the areas where they have piled snow for many years, to see if lead has accumulated in the soil.

- State and town road crews should keep culverts clear of woody debris.

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

- Towns and the railroad should locate all salt storage at least 250 feet from rivers.

4. Stormwater Runoff

Stormwater runoff may be the simplest but least understood means of water pollution, and possibly the easiest source of pollution to control. As a result, EPA and the states are phasing in stronger stormwater controls.

> **"The river is flushing itself with parking lot runoff!"**
> *Norwich planning commission member*

What happens to rain falling on a forest is considerably different than what happens on a recently cleared hillside, the family yard, or a paved parking lot. Each surface sheds water differently – faster or slower, with more or less chance to gather speed, cause erosion, and pick up pollutants. Roofs, roads, closely cropped lawns and compacted soils all contribute to non-point source pollution in the Upper Valley. The runoff may contain fertilizers, herbicides, and pesticides from the home landscape, and petroleum products, salt, and trash from parking lots and roadways.

Impervious surfaces - Rising demands for impervious surfaces (roofs, roads, driveways, parking areas) cause tremendous increases in runoff and in sources of pollution. The quantity of pollutants in runoff in an urban area is directly related to the imperviousness found in its watershed. Cleared, compacted, or paved land sends water downhill faster than when it is captured by thick vegetation and transpired by trees.

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 urban areas. Towns should view commercial parking lots and down towns as hot spots for petroleum compounds, 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. Monitoring in the winter of 2004-2005 at UNH's Stormwater Center showed that chloride was above the chronic level 95 percent of the time and above the acute level 33 percent of the time, as defined by EPA.

High pollutant loading comes from high traffic areas, such as parking areas with a frequent

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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.

turnover of visitors (grocery stores, shopping malls, restaurants, drive-through services, etc.) and on-street parking areas of municipal streets in commercial areas. Average Annual Daily Traffic Counts are being increasingly used as a practical tool for planning and prioritizing efforts for managing runoff quality in highly urbanized areas.

"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

Land clearing - The total runoff volume for a one-acre parking lot is about 16 times that produced by the same sized undeveloped meadow. Heavy clearing, whether for forestry or for development, can change stormwater runoff, how a tributary flows, and ultimately the Connecticut River itself and even property in another state. Towns may become concerned how such clearing can affect the roads and culverts they are responsible for maintaining.

Animal waste - The typically urban problem of what to do with pet waste has arrived in some towns in the Upper Valley. Stormwater is washing pet waste into the river and contributing to bacteria levels found here. Some towns, such as at Hartford's new dog park near the White River, have installed pet waste stations with bags. Resident geese are a spotty problem, but can be discouraged from using a waterfront area if their sight line to the water is cut off by a riparian buffer. (See the farming section on page 60 for more on livestock waste.) A public education program on animal waste is a good place to start.

Stormwater from West Wheelock St. in Hanover is detained and cleaned here, not delivered directly to the river.

Low impact development - This approach to reducing and treating stormwater runoff has captured attention in the Upper Valley, where the Upper Valley Lake Sunapee Regional Planning Commission, the League of Women Voters of the Upper Valley, and CRJC sponsored "Keeping Stormwater Where It Falls," a two-day conference in 2003.

There are a number of common sense ways to keep runoff from causing trouble downhill. Most of them are lower in cost as well as lower in environmental impact than conventional stormwater treatment devices such as retaining ponds. Developers can mimic natural runoff when a property is developed by using "low impact development" techniques to slow it down and soak it up. 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, terraces, and swales where it can soak into the ground and recharge groundwater rather than run off the land. Low impact design also recommends narrower or shared driveways, porous paving materials, smaller parking lots, smaller road setbacks, directing runoff to places with porous soils, building on soils that are less porous, flattening 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 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 requiring suitable filtration of the runoff and minimizing impervious surfaces adjacent to water bodies.

- Federal, state, and local road designers should minimize road runoff directly into waterways.

- Towns should discourage roads and development on steep slopes to control stormwater runoff.
- Towns should work with states to improve prevention of runoff problems related to large scale clearing for development.

- Developers should include infiltration methods such as many small swales and runoff basins to capture runoff for groundwater recharge.

- Towns should include "low impact development" ideas as they review projects, and at how to change existing development to reduce runoff and promote stormwater infiltration. Require additional treatment to remove oil, metals, and other pollutants for new discharges to surface waters and dry wells, and ensure that these treatment systems are maintained over time.

- Towns can educate pet owners to pick up pet waste by providing information when dogs are registered.

5. Home Landscapes

Residential development pressure is significant in the Upper Valley, and much of the riverfront, especially in Norwich, Hanover, and Lyme, features homes built to take advantage of river views. A number of them have lawns extending to the river's edge. Except in downtown Hanover, West Lebanon, and Hartford, this development is out of range of municipal wastewater collection systems, and the homes rely upon on-site septic disposal. Development has more recently encroached on prime agricultural soils after farm landowners retired or could no longer afford to keep the land in production, and sold it for subdivision and development.

This shift from farmland to residential use often means a change for the river. Where farmers are well trained and licensed to apply fertilizers and pesticides, homeowners are not. Uncontrolled and often uninformed use of fertilizers, pesticides, and other toxic materials by homeowners can lead to unintended addition of these pollutants to streams. The N.H. Comprehensive Shoreland Protection Act does not permit use of fertilizer (other than lime) within 25 feet of the Connecticut and other fourth order rivers, and between 25 and 250 feet from the river, only low-phosphate fertilizer may be used. While these rules apply to fourth order rivers on the New Hampshire side, care with fertilizers around homes located on tributaries large and small is also wise.

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1. *Cost of Community Services Fact Sheet*, American Farmland Trust, August, 2006.

Home septic systems must be regularly maintained to prevent contaminating surface waters. Homeowners seeking a clear view of the river may be tempted to cut trees and other vegetation growing naturally in the riparian buffer that protects their shoreland and provides habitat for wildlife.

Cost of Community Services studies can help a town understand the relative costs for public service (police, fire protection, education, etc) for various kinds of land use, and better evaluate the cost to the town when farmland or other undeveloped land is converted to house lots. Studies compiled by the American Farmland Trust in 24 states show that tax and other revenues collected from farm, ranch and forest landowners more than covered the public service costs these lands incur.[1] A study in Lyme showed similar results. These studies show that on average, residential development generates significant tax revenue but requires costly public services that typically are subsidized by taxes on commercial and industrial land uses. Farm and forest lands are important commercial land uses that help balance community budgets. Conservation of these lands can allow them to continue in production without the cost to the community of added public services.

Recommendations for Home Landscapes

- Waterfront landowners should learn about the proper use and disposal of fertilizers, pesticides, and toxic materials; refrain from using fertilizer within 250′ of rivers, and consider alternatives to chemical fertilizers, herbicides, and pesticides. Consult CRJC's *Homeowner's Guide to Nonpoint Source Pollution in the Connecticut River Valley* (1994).

- Towns should educate landowners to establish, maintain and enhance the native riparian buffer vegetation on their property. Consider a cost of community services study to investigate how conservation easements can help keep town service and school costs down if the land is not developed into house lots or into second homes which could later become year-round residences.

- Landowners should know the location of and regularly maintain their on-site septic systems.

6. Farms and Cultivated Landscapes

Prime agricultural soils, some of the highest quality soils in the nation, distinguish much of the floodplain in the Upper Valley region. Although much fine farmland is now either developed or submerged under the impoundment behind Wilder Dam, farmland along both sides of the river, especially in Thetford, Fairlee, Bradford, Piermont, Orford, and Lyme, is the emblem of a treasured way of life in the river valley. This valuable land provides beautiful views and healthy, locally grown foods. This flat, usually well-drained, ledge-free land, a rare commodity in this hilly region, is also the most vulnerable to development. The Upper Valley River Subcommittee believes that food production is a good use of riverfront land, and that it is well worth the cost and effort to conserve this land to prevent its conversion to development.

Many 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. Upper Valley dairy farms now have nutrient management plans in place to make best use of available nutrients, reduce potential for water quality impacts, and save the farm money by reducing the cost of fertilizer purchases. The general public, however, is largely unaware of the training, licensing, and planning that farmers employ to ensure that their operations avoid pollution.

> **"It's a very good concept not to utilize riverfront land all the way to the edge."**
> *Upper Valley riverfront farmer*

Agriculture is diversifying in the Upper Valley, and a region once known for its dairy farms now also features vegetable and fruit farms, horticultural operations, and a number of horse farms, both large and small. Among the horse owners are many relatively recent arrivals in the Upper Valley, who may have little or no experience in keeping livestock, especially in preventing water quality problems associated with manure storage and pasture management.

Runoff from barnyards, manure piles, cropland, and other areas exposed to pesticides and fertilizers may enter water bodies. Runoff from such places can contain phosphorus and other nutrients, pathogens and/or toxic substances. This is particularly true if there are no vegetative buffers. Cultivation of fields and use of pastures up to the edge of stream banks can cause erosion and runoff of nutrients and sediments. Animals allowed access to streams contribute manure to the water and can increase bank erosion by trampling the banks and crushing vegetation. Funding is available to help provide alternative water sources, fencing, and water crossings.

Vermont's rules on Accepted Agricultural Practices require management of barnyards and manure storage to prevent the discharge of manure or other wastes; buffers to neighbors' wells and prohibitions on manure stacking on land subject to overflow from adjacent waters; a prohibition on manure application between December 15 and April 1; and buffers of perennial vegetation 10 feet from the top of the streambank on cropland and 25 feet from the top of the bank at points of runoff. New Hampshire's Best Management Practices call for similar measures, but function more as guidance rather than rules.

Cost Sharing Programs - The USDA Natural Resources Conservation Service (NRCS) offers several federal cost-sharing and incentive programs to assist with riparian buffers, fencing, and other farm projects that improve water quality: the Environmental Quality Incentive Program (EQIP), the Wildlife Habitat Incentive Program (WHIP), and others. Information is available from the county conservation district offices of NRCS. The U.S. Fish and Wildlife Service's Partners for Wildlife Program has been helpful on some Upper Valley farms. Vermont authorized extra dollars to make the Conservation Reserve Program more helpful to farmers for water quality improvements, and funds are available in the Connecticut River valley for the Conservation Reserve Enhancement Program (CREP). Unfortunately, similar assistance is not available from New Hampshire.

Septage spreading - A few farms in the area are certified by federal and state regulators for land application of domestic septage. Responsible management by a local landowner can make the difference between an operation that successfully disposes of waste in a beneficial way and a water quality disaster.

Recommendations for Farming

- Farmers who do not yet have a nutrient management plan should work with conservation districts and Cooperative Extension Service to prepare one; employ best management practices. Farmers should not cultivate or pasture to the edge of the river or streambank; Vermont farmers should take advantage of the CREP program to cover the costs of reserving a riparian buffer area. Eliminate non-point sources of bacterial contamination, such as from livestock that have access to the river and its tributaries.
- Towns should investigate how conservation easements can promote agriculture and protect water quality.

- Vermont should continue to fund its CREP program.

- Cooperative Extension Service should educate hobby horse owners about ways to manage their land and animals to protect water quality. Educate the general public about the many water quality protection measures used by and/or required of farmers, including regulations surrounding septage spreading.

7. Forests and Rivers

A forest is well known as the best guardian of the quality of water for drinking and for aquatic habitat. Those who manage forests also indirectly manage 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 attractive streambanks and recreational opportunities. As with farming, the general public has many misconceptions about proper forest management.

Those planning to make a timber cut in New Hampshire 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. Filing an "Intent to Cut" does not require the town to oversee or monitor the cutting, and the logging that takes place may or may not have an effect on water quality. 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.

Headwater streams are particularly vulnerable to poorly managed logging or land clearing for development. 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. New Hampshire forestry rules restrict cutting along streams. Much good information is available on responsible forestry, such as Vermont's Acceptable Management Practices for forestry and "Good Forestry in the Granite State: Recommended Voluntary Forest Management Practices for New Hampshire."[1]

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1. Published by the New Hampshire Division of Forests & Lands (DRED) and the Society for the Protection of New Hampshire Forests, 1997.

Recommendations for Forests

- Landowners should avoid logging on steep slopes near the river, and in the riparian buffer.

- County foresters should educate landowners, conservation commissions, and consulting foresters about the value of riparian buffers.

- Forest landowners should consider conserving their forestlands.

- Towns should promote responsible stewardship of forestlands.

8. Airborne Pollutants

The Connecticut River and its tributaries are not secure from contaminants that arrive on the wind. Acid precipitation continues to threaten the watershed of the Connecticut River. Both New Hampshire and Vermont have issued fish consumption advisories for the Connecticut and other rivers, based on mercury levels.

EPA and the four Connecticut River states cooperated in 2000 on a study of fish tissue toxins in Connecticut River fish, described above.[1] Total mercury concentrations in all fish studied were significantly higher in upstream areas than in downstream. Mercury poses a risk to recreational and subsistence fishers and to fish-eating wildlife. Much of this mercury originates from Midwest power plants, urbanized eastern seaboard emissions, and local sources. Once in the river, mercury bio-accumulates to high levels in the food chain. Older fish tend to have higher levels of mercury and other contaminants, such as PCBs and dioxins.

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 ("total maximum daily load"=TMDL). The federal government has not set national standards.

Dioxins are produced in nature and also by humans. Sources include combustion processes such as at waste incinerators and illegal burning of trash in backyard barrels. Recently enacted state controls have successfully reduced emissions on New Hampshire incinerators by 90 percent.

While the emissions that cause acid rain have decreased, acid precipitation continues to affect the Connecticut River watershed, particularly at higher elevations in the North Country and Northeast Kingdom. A significant portion of the uppermost Connecticut River and its tributaries suffer from pH below New Hampshire water quality standards. Research at Hubbard Brook Experimental Forest indicates that sulfuric and nitric acids have acidified soils, lakes and streams, stressing or killing terrestrial and aquatic biota.[2] Acid deposition has also caused

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1. *The Connecticut River Fish Tissue Contaminant Study*, U.S. Environmental Protection Agency Region I, 2000. (released 2006).
2. "Acidic Deposition in the Northeastern U.S.," Hubbard Brook Ecosystem Study, BioScience, Vol.51, No.3, 2001.

significant leaching of calcium from the soil, preventing immediate recovery as acid rain-related emissions decrease, and increasing the concentration of toxic forms of aluminum in soil waters, lakes and streams.

Recommendations for Airborne Pollutants

- Congress and the states should devote high priority attention to immediate action to reduce sources of mercury contamination.

- Citizens should obey the ban on barrel burning of trash.

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

9. Brownfields

Drainage from abandoned copper mines in the Ompompanoosuc and Waits River watersheds has polluted Upper Valley tributaries for centuries.

"Brownfields" is a term coined by EPA for land that cannot be easily redeveloped or reused due to the potential or perceived presence of hazardous substances or other pollutants. Historical industrial or commercial sites along the Connecticut River are likely to have such properties where contamination by hazardous substances or petroleum products may prevent the property from contributing once again to the tax rolls and economic vitality of the community.

The Westboro Rail Yard in West Lebanon is such a site, with recreation, tourism, and economic development potential that has been waiting for federal funds to assist the city in cleaning up contamination left over from this once-busy transportation hub. EPA awarded the city a $200,000 grant in 2008 for this purpose. Others under investigation are the former Tip Top Tire site in Wilder and three other sites in Hartford.

The regional planning commissions can assist property owners and prospective purchasers of brownfields with environmental site assessments of brownfield properties, and in finding grants and loans for cleanup of contaminated sites. Two Rivers-Ottauquechee Regional Commission has won four grants from EPA since 2003 to inventory brownfields sites and conduct environmental assessments in the area. The Upper Valley Lake Sunapee Regional Planning Commission does not as yet have funds to assist communities on the New Hampshire side.

10. Acid Mine Drainage

Vermont's Upper Valley region has a long and rich history of mining that supported industrial growth for several centuries. These mines, located in the Ompompanoosuc and Waits River watersheds, include the now abandoned Elizabeth Mine, Pike Hill Mine and Ely Mine. Their legacies are many, but unfortunately include severe effects upon water quality from acidic water draining out of above-ground or under-ground mines and tailing piles, long after they have been abandoned. Mine drainage affects stream and river ecosystems by increasing acidity, depleting oxygen, and releasing heavy metals. The Elizabeth Mine was added to EPA's National Priorities List ("Superfund List") in 2001. The smaller, but similarly polluting Ely Mine was added to the list in 2002 and the Pike Hill Copper Mine in Corinth in 2004.

Elizabeth Mine - Located in Thetford and Strafford, Vermont, the Elizabeth Mine has a 150-year history of ore extraction and processing. The mine, visited by President James Monroe in 1817, is eligible for the National Register of Historic Places. Sulfide ore was mined and processed here to produce copperas (iron sulfate or green vitriol) from 1809 to 1882, and for copper from 1832-1958. Between 1943 and 1958, approximately 90 million pounds of copper were produced at this mine, which employed up to 220 people from 16 surrounding towns.[1] By contrast, at the peak of activity at the Ely Mine in 1880, about 850 people were employed, many of whom lived on site.

Concerns about acid drainage from the Elizabeth Mine were brought to the attention of CRJC in 1994 shortly after work began on the first edition of the *Connecticut River Management Plan*, and emerged in the first edition of the Upper Valley Region's plan and CRJC's River-wide Overview. These findings were publicized at a CRJC meeting in 1996 in conjunction with the New England Interstate Water Pollution Control Commission, when CRJC declared the Elizabeth Mine one of the top water pollution "hot spots" in the Connecticut River watershed. Media coverage of that meeting captured the attention of some Thetford residents, who then organized the Elizabeth Mine Study Group (now the Elizabeth Mine Community Advisory Group). CRJC awarded grants to the study group through its Partnership Program in 1998, 1999, 2001 and 2002, to support the group's efforts to organize a cooperative, community-based environmental remediation and historic documentation project at the mine.

This work, and that of Vermont's Department of Environmental Conservation, led eventually to designation of the Elizabeth Mine as a Superfund site. A battery of studies began, including sampling of mine tailings, surface water, sediment, fish tissues, ground water, and drinking water, collected and analyzed for metals. The results indicated the presence of metals that exceeded background levels. The entire length of Copperas Brook and several miles of the West Branch of the Ompompanoosuc River fail to meet Vermont Water Quality Standards based on both numerical and biological criteria.

After extensive planning with local town governments and interested citizens, EPA began work in 2005 to stabilize, regrade, and cap the tailing piles, divert surface and groundwater around the piles, and treat runoff. The tailing dam has been stabilized. Attention is now turning to areas identified as potential threats to human health or the environment, including lead contaminated soil and toxic sediments in Copperas Brook and the Ompompanoosuc River.

In 2007, residents noted an increase in the orange coloration of sediments in the river, due to an increase in iron coming from the mine drainage. The Ompompanoosuc River still contributes a noticeable sediment load to the Connecticut River after a heavy rain, and the plume of sediment can be seen running down the west side of the Connecticut mainstem for well over a mile,

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1. "Green Mountain Copper: The Story of Vermont's Red Metal" by Collamer Abbott c. 1973. (Originally published as a series in the White River Valley Herald of Randolph.)

contrasting with clearer water delivered from upstream. This sediment may be coming from tailing piles and other exposed soils that are still not yet stabilized.

Recommendations for Brownfields and Acid Mine Drainage

- Upper Valley Lake Sunapee Regional Planning Commission should seek a grant to conduct a brownfields inventory of its member towns, and prioritize cleanup.

- Vermont municipalities and developers of potential brownfields sites should contact Two Rivers-Ottauquechee Regional Commission for help with environmental site assessments.

- Lebanon should continue seeking funds to clean up the Westboro Rail Yard.

- The EPA should continue with cleanup at the Elizabeth Mine and other mines, and address the problems of iron deposition and sediment.

VIII. Riverbank Erosion

Riverbank erosion is a significant cause of concern for landowners on this segment of the Connecticut River. Erosion is a natural process caused primarily by shear stress of water forced against the bank, abrasion by ice, and also wind-driven waves. It is made worse by human actions in the Upper Valley region through water level fluctuations due to operations at Wilder Dam, boat wakes, and removal of the riverside vegetation that naturally holds the bank together. Area landowners report that they have lost as much as 5-10 feet of their land along the river in a year to erosion.

Bank erosion causes non-point source pollution, threatens habitat of all aquatic and riparian life, results in the loss of acres of valuable agricultural soils, trees, and vegetation, and diminishes the scenic quality of the river corridor. Damage to the river is caused not only by actions taking place on the mainstem, but also in every tributary. The results can be seen at the mouth of every stream entering the mainstem, where sediment deposits are evident, particularly at the mouth of the Ompompanoosuc River.

Erosion sends sediment into streams, where it covers preferred gravel-bottomed fish habitat and can back up behind dams and reduce water storage or even threaten the dam itself. Vermont's River Management Program provides technical assistance 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 to making sound protection, management, and restoration decisions.

Conservation Districts in the area have performed a valuable public service in conducting inventories of riverbank erosion on the Connecticut River; for the New Hampshire side in 1992 and the Vermont side in 2000. However, an erosion inventory is a snapshot in time, and can become out of date as bank conditions change.

Although there does not appear to be a simple solution to the problem, the members of the Subcommittee believe that bank erosion is a great threat to water quality, aquatic and riparian habitats, water-based recreation, and riverfront property in the corridor. As the population grows and the use of the river increases, this problem will certainly intensify, and bears continued attention and study.

A. U.S. Army Corps of Engineers Study

Causes of erosion are many and complex on the Connecticut River, as on most large rivers. Erosive forces can act alone or together, making it difficult to pinpoint exact causes. The New England Division of the U.S. Army Corps of Engineers conducted a study of riverbank erosion on the Connecticut River in 1979 between Wilder Dam (NH and VT) and Turners Falls Dams (Massachusetts).[1] The study concluded that the primary cause of erosion is shear stress of high-velocity flows, especially on banks composed of granular, non-cohesive material. The sandy to silty soils in this part of the river valley are non-cohesive and therefore are very susceptible to erosion.

The Corps of Engineers also identified other causes of erosion as pool fluctuations behind dams, boat wakes, gravity, seepage, natural flow variations, wind-driven waves, ice, flood variations, and freeze-thaw effects on the banks, in that order of importance. The study suggested that even though natural causes of erosion could not be controlled, man-made ones could be, and that steps to limit pool fluctuations and the amount of wake-generating boat traffic, together with further vegetative stream bank stabilization measures, could be beneficial.

B. Erosion Inventories

New Hampshire: A Connecticut River Erosion Inventory by the Grafton County Conservation District in 1992 found that 25 of the 40 miles of riverbank in this segment in New Hampshire were experiencing slight, moderate, or severe erosion.[2] The results of the study support the conclusion that when lands adjacent to a river are intensively used, and very little if any buffer of perennial vegetation exists between the river and the land use, riverbank soils are more easily eroded. The study observed the greatest amounts of moderate to severe erosion in Orford and Piermont. According to the study, "The most common erosive force was wave action in the slower sections, which comprise 85 percent of the bank length. Observed fluctuations in the river level due to power generation at Wilder Dam averaged two feet, and the exposed shoreline and undercut banks are causing soil to fall into the water. Concave banks, where the current is forced against the shoreline, were especially vulnerable to erosion. Seasonal flooding was evident, as well as erosion caused by periodic releases of water below the dam. Ice action and freeze/thaw cycles also contribute to erosion, but these processes were not observable during the time of the field work." More recent observations by Subcommittee members raise concern about undercutting of banks in the Wilder impoundment, including banks that are heavily forested.

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1. *Report on Connecticut River Streambank Erosion Study: Massachusetts, New Hampshire, and Vermont.* U.S. Army Corps of Engineers, New England Division, Waltham, Mass.,1979.
2. *Connecticut River Erosion Inventory.* Grafton County Conservation District, 1992.

Vermont: The Caledonia County Natural Resources Conservation District conducted a somewhat more detailed survey of the Vermont riverbanks in the Upper Valley segment in 2000.[1] The study concluded that "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."

"I used to have a hundred-foot grass buffer which isn't any more because New Hampshire has encroached on Vermont."

Vermont riverfront farmer

This study looked at riverbanks throughout the Upper Valley and as far north as Waterford, Vt. This study found that 89 percent of severe erosion is on the 48 percent of streambank that is agricultural land. 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 rate of erosion, the river has always eroded its banks and cut new channels through these floodplains no matter what the land use." 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.

Boat wakes are a significant cause of riverbank erosion in the Upper Valley's Wilder impoundment. Here, wakes strike farmland known for its prime agricultural soils.

Hidden undercuts - A number of riverbanks listed as "forested and stable" on the Grafton County erosion survey of 1992 are actually riddled with hidden undercuts and six foot deep holes. In such places, the root structures of the trees are currently holding up the bank, but they may eventually fall, bringing a large root ball with them. It is not currently known whether this kind of erosion occurs only on impoundments with fluctuating water levels or throughout the Connecticut River system.

Possible effects of Wilder Dam - Among the causes of bank erosion in the Upper Valley noted by the Caledonia County Conservation District, particularly in the Wilder impoundment, is water level fluctuation. "When the water is maintained at high levels for a significant period, the soil becomes saturated and unstable," the study states. "When the levels then drop suddenly it causes the banks to slump." Pressure imbalance at the bank face occurs when pressure builds up behind the bank face because the groundwater table is higher than the surface of the river. Seepage occurs, forcing soil particles to loosen. This pressure imbalance may take place when there is a rapid drawdown of the water level at Wilder Dam.

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1. *Connecticut River Erosion Inventory, Waterford to Hartford, Vt.* Caledonia County Natural Resources Conservation District, 2000.

The Subcommittee is concerned about a policy that originated with New England Power Company in 1974 to maintain a higher pool level during summer weekends. Although the origins of the policy are unclear, a representative of the company informed the Subcommittee that this policy calls for a minimum level of 382.5 feet at the dam for the benefit of recreational boaters on weekends during the summer months. The Subcommittee believes this policy may result in exposure to boat wakes of softer, more vulnerable upper portions of riverbanks as well as a large and fast drop in the water level on Mondays, both of which can contribute significantly to bank erosion. The rate of pool level change, or "ramping rate," can affect soil stability, since sudden drawdowns can result in soil piping and collapse when water leaves the bank face.

"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

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. This mapping is underway in both the Blood Brook and Ompompanoosuc watersheds in Vermont.

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

Buffers filter out sediment and debris from surface runoff; trap pollutants that could otherwise wash into surface waters and groundwater; stabilize streambanks and reduce erosion; and absorb surface water runoff and slow water velocity. Vegetated buffers are inexpensive, easy to install or encourage, and have the added advantage of providing habitat for both land-based and aquatic animal species. Shading streams with vegetation improves temperature and oxygen conditions for the survival of coldwater species including trout. Naturally vegetated buffers promote biological productivity and diversity. In 2000, CRJC published a series of 10 fact sheets on riparian buffers, written for various landowner and decision-maker interests.[1]

Tree revetments are installed on the eroding riverbank at Birch Meadow Farm in Fairlee, 2002.

The conservation districts concluded that human activity appears to be affecting erosion rates in some reaches where riparian vegetation has been removed from the bank, and that landowners need to be

1. *Riparian Buffers for the Connecticut River Watershed*. Connecticut River Joint Commissions, Charlestown, N.H. September, 2000.

more aware of the potential erosion problems that removing riparian buffers could cause. The erosion inventory noted that several farm parcels on both sides of the river lacked riparian buffers and that crops were planted less than 10 feet from the top of the riverbank.

The Vermont erosion inventory measured riverbank vegetation, and found that buffers were significantly narrower, if they existed at all, in the Upper Valley region towns than in the towns studied from Wells River north. The Caledonia County Conservation District concluded that buffers of 50 feet or more in width do appear to slow the rate of erosion. Local regulations regarding riparian buffer protection are summarized in Appendix G.

"The river needs a vegetation cop."

Fairlee citizen, speaking of people cutting down riparian buffers

Riverbank Restoration Project at Birch Meadow Farm - In 2002, a group of federal and state agencies, CRJC, and the Vermont Youth Conservation Corps helped the owner of Birch Meadow Farm in Fairlee to install an innovative demonstration project to restore a severely eroding riverbank. The goal was to safeguard prime agricultural soils, improve water quality, contribute to wildlife habitat, and protect archeological resources. A 1,200-foot long section of riverbank had been scoured, and an average of two feet of land a year had gone downstream. Boat wakes from powerboats contribute to bank instability and the site is influenced by water level fluctuations at Wilder Dam.

The design included a large tree revetment of 20-40-foot conifers cabled into the bank with duckbill anchors. Hundreds of willow stakes and dogwood cuttings were planted among their branches to root and hold the bank, further trapping sediment. A riparian buffer of 600 plants was installed to give better anchor to the soil and provide wildlife habitat. The experimental buffer was designed to provide a cash crop of berry- and nut-bearing trees and shrubs that could benefit the farm economically.

The objective was to evaluate the effectiveness of tree revetments as a "soft engineering" approach to streambank stabilization on a large river. Tree revetments have been successful on smaller streams, but the Birch Meadow project was the trial on a river as large as the Connecticut. A secondary goal was to utilize local forest resources and make area contractors aware of conservation practice to reduce erosion along rivers. An extra benefit is the nursery of willows developed at the farm, which provides a source of stabilizing plant material for Birch Meadow Farm and others.

As of 2006, the experimental revetment had survived ice-out over four years, and all trees remain in place, although the revetment is being undercut. As wave action disturbs the trees and cables, silt comes out around the cables, and is not being captured by the tree branches because of wave action and water level fluctuations.

The buffer is also a limited success, since the well-drained soils of this part of the farm made establishment difficult in spite of regular irrigation. Plum trees survived better than expected. Blueberry shrubs did not survive well, perhaps because the soils had previously been amended to raise their pH beyond the acidic conditions preferred by blueberries. The U.S. Fish and Wildlife Service grant that funded the buffer set conditions that the grass between the woody buffer plantings could not be mowed, which may have led to failure of some tree plantings when they were overcome by competing grasses and attacked by voles which found cover in the tall grass. Sumac has established itself in the area, however. This demonstration project should be revisited to learn from its result.

Recommendations for Erosion and Riparian Buffers

- The federal government should conduct a study of the effects of dam-related water level fluctuations on bank erosion as well as upon fish habitat and populations of endangered species. The study should be conducted on-site, at multiple locations, and result in action recommendations.

- The Federal Energy Regulatory Commission should encourage a dialogue between the owner of Wilder Dam and independent engineers to ascertain what steps could be taken at Wilder Dam to reduce its effects on the banks of the river, downstream as well as upstream.

- The Natural Resources Conservation Service should continue research into appropriate methods of bank stabilization including the funding of test areas; expand education of riparian landowners concerning methods of stabilization such as conducting targeted workshops in municipalities along the river; expand programs that offer professional and financial assistance to riparian landowners for appropriate methods of bank stabilization; investigate ways to simplify the permitting process.

- States should establish a comprehensive program of education for boaters concerning the impact of boat wakes, and should provide sufficient funding to enable increased enforcement of existing regulations concerning boat wakes.

- Towns should enforce buffer laws and should encourage landowners to create and maintain riparian buffers. For the first five years, new plantings should be protected from competition from more aggressive or taller plants. This may be accomplished by mowing between the new buffer plantings, encircling them with heavy mulch, or using protective rings that also protect them from predation by mice and beaver.

- Towns should encourage landowners to create or maintain riparian buffers to provide pollution filtration.

- New Hampshire should pursue fluvial hazard erosion mapping similar to Vermont

- The USDA county conservation districts and others should survey the Upper Valley reach of the river for the presence of hidden riverbank undercuts, and identify and test a means of restoring these cavities.

- NRCS and the US Fish & Wildlife Service should revisit Birch Meadow Farm and other such projects to help the landowner evaluate the project's success, consider replanting unsuccessful parts of the buffer, and consider lessons learned in establishing buffers.
- CRJC should continue to disseminate its guidance on riparian buffers.

- NRCS should sponsor a fluvial geomorphic assessment of the Connecticut River throughout the Upper Valley.

IX. Current Protection for the River

A. State Tools for Protecting Riverfront Lands & Water Quality

1. New Hampshire

The Comprehensive Shoreland Protection Act (RSA 483-B, Appendix I) sets minimum shoreland protection standards for shore lands along New Hampshire'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 2007and 2009.

2. Vermont

Vermont is the only state in the Northeast that still has no 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 Vermont 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.

Vermont may designate certain waters as Outstanding Resource Waters under 10 V.S.A. 1424a because of their water quality values, requiring that their existing quality shall, at a minimum, be protected and maintained. Three miles of the Ompompanoosuc River have been designated.

B. Local Tools for Protecting Riverfront Lands & Water Quality

In addition to 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 a Water Resources Management Plan with strong recommendations for protecting water quality, riparian buffers, scenic views, agricultural soils, prime wetlands, floodplains, open space, and wildlife habitat. These recommendations can then be put into action by regulatory tools such as zoning, subdivision, and site plan review requirements.

1. Regulatory Measures

Regulatory measures for controlling non-point pollution can include requiring vegetated buffers along shorelands to prevent contaminants from entering surface water; separation of storm water and wastewater in municipalities with combined sewer overflows; reducing the amount of impervious surface created by new development to reduce the transportation of sediments and nutrients, and the use of sediment and erosion control measures during and after construction.

> **"Here's this incredible resource, and by thousands of cuts, a lot of it has been undermined or lost. We have to do these things NOW."**
>
> *Orford riverfront land owner*

Floodplain Ordinances - Floodplain Ordinances can prohibit building in the floodplain. Construction, development, or filling in floodplains removes flood storage and shifts flood water to places downstream. Such floodplain ordinances have the added benefit of protecting taxpayers from the potential burden of paying for disaster relief on structures unwisely built in the river's way and would tend to maintain existing riparian buffers. 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 its Zoning Ordinance, providing more stringent protection measures for surface waters than for the rest of the town. In both New Hampshire and Vermont, the requirements of the shoreland ordinance supersede that of the underlying zoning ordinance. Municipalities along the Connecticut River have the opportunity to examine their sections of the river and, where it is appropriate, recommend stronger controls than those set forth in the Comprehensive Shoreland Protection Act.

Recommendations should take into account the designation of the segment. For example, while the majority of the Upper Valley segment of the Connecticut River is designated by the N.H. Rivers Management and Protection Act as "rural," the "rural-community" and "community" sections of the segment have included commercial/industrial centers for almost 200 years. Regulations for these sections need to protect or improve water quality without placing unnecessary burdens and restrictions upon commerce and industry.

Fluvial Erosion Hazard Area Zone or Overlay District - Communities 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.

2. 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 control bank erosion.

Conservation Purchase or Easements - Towns and 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.

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.

"You protect the land, you protect the water."

Mascoma Watershed Conservation Council member

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 nonpoint pollution on private land. Programs should emphasize the locations and use of existing public access and asking permission before stepping onto private property.

Recommendations

- NH DES should work on education about the Comprehensive Shoreland Protection Act.

- Communities should communicate with landowners around ponds and rivers covered by the Comprehensive Shoreland Protection Act.

- NH should provide adequate Shoreland Protection staffing for compliance.

- Mascoma Watershed Conservation Council should consider nominating the Mascoma River into the N.H. Rivers Management and Protection Program.

- Vermont should adopt statewide shoreland protection.

X. Tributaries

Many small brooks and large rivers enter the Connecticut River in the Upper Valley, draining central portions of Vermont and New Hampshire. These tributaries are described in Appendix J. Many of them, especially in New Hampshire, have not been fully assessed. The Mascoma River, the largest tributary on the New Hampshire side of the Upper Valley region, begins on the slopes of Smarts and Cardigan Mountains and drains relatively densely developed industrial and residential areas. Data suggest that these tributaries are contributing to the water quality threats and impairments reported for the Upper Valley segment of the mainstem.

Vermont's largest free-flowing river, the White River, meets the Connecticut below Wilder Dam, and at times has carried more water than the Connecticut itself. River managers attend closely to ice-out on the White River, in an attempt to protect the heavily developed commercial district in West Lebanon's floodplain. Smaller but still significant are the Ompompanoosuc and Waits Rivers, well known both for their coldwater fisheries and also for the copper they deliver to the mainstem, a relic of the copper mines in their watersheds.

In 2001, Vermont embarked upon an ambitious project to create basin plans for all of its waterways by the year 2006, working with local citizens and communities. A basin plan for the White River (Basin 9) was the first completed. Basin plans for the Ompompanoosuc and Waits Rivers (Basin 14), initiated in 2003, are now complete. A 2002 study included smaller tributaries in this region.

Other than recent interest in the Mascoma River, there are as yet no similar planning efforts underway for New Hampshire tributaries in the Upper Valley, where the state has little information about any of them. Several Upper Valley River Subcommittee members volunteered to conduct a windshield survey during the summer of 2006. Using maps prepared by NH DES for this purpose, members used a simple field recording sheet to assess the condition of small tributaries in their towns. Summaries of their reports are included in Appendix J.

XI. Conclusion

The Upper Valley Region of the Connecticut River, still the home of productive fields and forests encircling a lively human community, is well aware of its past, present, and future. Upper Valley citizens and communities have become more aware than ever of the value of their way of life and the nature of threats to their waters. Whether it is a new patch of knotweed, a new house in a fertile floodplain, or a new gully on a riverbank, there is evidence that Upper Valley people are increasingly ready to respond.

Leadership in ensuring a healthy future for the river must come from private landowners and decisions by town meeting and city council. The Subcommittee looks for all to participate in safeguarding the Connecticut River, life blood of the Upper Valley.

Appendix A. Subcommittee Members

The following Local River Subcommittee members participated in development of this updated water resources chapter of the *Connecticut River Management Plan*:

Susan Almy, *Lebanon, NH*
Lynn Bohi,* *Hartford, VT*
Caryl Collier, *Hanover, NH*
Nicole Cormen, *Lebanon, NH*
Mary Daly, *Fairlee, VT*
Charles Grant, *Piermont, NH*
Billie Jo Johnstone, *Lebanon, NH*
Nancy Jones, *Bradford, VT*
David Kotz, *Lyme, NH*
Jeff Mathias, *Norwich, VT*
Linda Matteson, *Thetford, VT*
David Minsk,* *Hanover, NH*
Joan Monroe, *Lebanon, NH*
Carl Schmidt, *Orford, NH*
Cyrus Severance, *Thetford, VT*
Steve Stocking, *Fairlee, VT*
Freda Swan, *Lyme, NH*
Marc White, *Orford, NH*
Linda Wilson, *Hartford, VT*

** elected officers of the subcommittee*

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

Suellen Balestra, *Lebanon, NH*
Lynn Bohi, *Hartford, VT*
Joan Brewer, *Lebanon, NH*
David Cole, *Lyme, NH*
Michael Collins, *Bradford, VT*
Tim Cook, *Lyme, NH*
Hal Covert, *Piermont, NH*
Jean Dyke, *Orford, NH*
Bill Flynn, *Norwich, VT*
Morgan Goodrich, *Norwich, VT*
Karen Henry, *Lyme, NH*
Earl Hodgdon, *Hartford, VT*
David Jescavage, *Lebanon, NH*
Ken Kinder, *Hartford, VT*
Bob MacNeil, *Lebanon, NH*
Melissa Malloy, *Thetford, VT*
Chuck Manns, *Lebanon, NH*
Miranda Martin, *Thetford, VT*
Jean McIntyre, *Lyme, NH*
Phil Odence, *Hanover, NH*
Arlene Palmer, *Thetford, VT*
Nancy Prosser, *Hanover, NH*
Ellen Putnam, *Piermont, NH*
Freemont Ritchie, *Piermont, NH*
Carl Schmidt, *Orford, NH*
Sue Sliwinski, *Hanover, NH*
Donald Stocking, *Fairlee, VT*
Freda Swan, *Lyme, NH*
Pat Tullar, *Orford, NH*
Walker Weed, *Hanover, NH*
Albert Young, *Piermont, NH*

Appendix B. Progress Since 1997

Since initial publication of the *Connecticut River Corridor Management Plan* in 1997, much progress has been made. New Hampshire has applied the protections of the Comprehensive Shoreland Protection Act to its side of the Connecticut River watershed and strengthened its provisions. In some towns, local governments have enacted even stronger water quality protection for their shorelines, most notably Piermont and Hartford.

River communities are working to eliminate combined sewer overflows and upgrade their wastewater treatment plants, holding the promise of improving water quality in the Hanover / White River Junction /Lebanon region. Voters are also investing more funds in land conservation to discourage polluting uses, and many landowners are improving pollution control on their property by enhancing riparian buffers and reducing use of fertilizers and pesticides near waterways. The Upper Valley Land Trust has protected many more acres of agricultural floodplain, keeping this essential "green infrastructure" open and functioning for flood control while protecting valued valley views. The Mascoma Watershed Conservation Council has protected significant wetlands and wildlife habitat at Bear Pond in the headwaters of this major tributary, as well as downstream along the Mascoma River, and an effort is underway to nominate the river into the New Hampshire Rivers Management and Protection Program.

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, NH DES, with support from the EPA, conducted an assessment of the entire 275 miles of the river in New Hampshire during the summer of 2004. The extensive study provided greatly improved information over what had previously existed. Two studies of sediment quality by EPA brought new information that will be useful in many ways, and conducted a study of toxins in fish tissue in conjunction with the four Connecticut River states. EPA also responded to strong concern about the effect of acid mine drainage at the Elizabeth Mine, declaring it and other nearby mines a Superfund site and working with local communities to address the extreme water quality problems posed by the mine.

Both states have greatly improved public access to water quality information in the last several years through their web sites. Vermont's regional planning commissions have made significant contributions by conducting bridge and culvert surveys for their communities. Communications have improved between the U.S. Army Corps of Engineers and the hydro power company managing mainstem dams regarding flows in the major tributaries, allowing better management of Connecticut River flows.

Perhaps even more encouraging is the energetic volunteerism of watershed groups on a number of the tributaries, including the White River Partnership. Basin planning on the Vermont tributaries of the Ompompanoosuc and Waits Rivers has focused new volunteer energy on these waterways, which in turn benefits the Connecticut River.

Appendix C. Summary of Recommendations Arranged by Responsible Party

Federal	
Congress	• Take immediate priority action to reduce mercury contamination of the region. • Continue to advance legislation to curb the introduction of acid-rain producing pollutants and of airborne mercury.
USGS	• Maintain existing gages for public safety. Cooperate to add gages on Eastman and Mink Brooks, and consider adding a gage on the lower Mascoma River near its confluence with the Connecticut and on the lower Waits River.
US Army Corps of Engineers	• Work with public and private entities to retain current natural flood storage, such as in wetlands and floodplains. • Coordinate flood control dam operations with mainstem dams to avoid local flooding where possible when flood waters need to be released from Union Village Dam. • Maintain the discharge from Union Village Dam at periods of low flow at run of river levels, or inflow=outflow, to protect aquatic life downstream. Institute larger water releases from the Union Village Dam every few years to maintain a more natural channel shape in the Ompompanoosuc River. The Corps should enable fish passage changes at the dam. • Provide financial assistance to Lebanon to complete the elimination of CSOs. • Conduct a study of the effects of dam-related water level fluctuations on bank erosion as well as upon fish habitat and populations of endangered species. The study should be conducted on-site, at multiple locations, and result in action recommendations.
FERC	• Institute a ramping rate at Wilder Dam in the next FERC license, to reduce soil piping in the riverbanks of the impoundment and to minimize negative effects on aquatic and riparian habitat; include a provision for emergency gate operation, such as in the context of a "black start" when the dam is needed to provide immediate power in case of a blackout. Assess possible effects of sediment build-up behind Wilder Dam and the extent to which it has affected flood storage capacity. Require the company to maintain discharge at run of river levels at periods of low flow in the next FERC license, to protect aquatic life downstream. • Encourage a dialogue between the owner of Wilder Dam and independent engineers to ascertain what steps could be taken at Wilder Dam to reduce its effects on the banks of the river, downstream as well as upstream.
EPA	• Identify mechanisms for decreasing carbon dioxide emissions. • Work with the states to establish updated rules for disposal or return of unused medicines. Work with medical providers for more responsible disposal of medicines. Provide funding for education about disposal of pharmaceuticals and personal care products. • Continue with cleanup at the Elizabeth Mine and other mines in the watershed.
Cooperative Extension Service	• Educate hobby horse owners about ways to manage their land and animals to protect water quality. • Educate the general public about the many water quality protection measures used by and/or required of farmers, including regulations surrounding septage spreading. • Educate landowners, conservation commissions, and consulting foresters about the value of riparian buffers.
US Fish & Wildlife Service	• Work with the states to establish updated rules for disposal or return of unused medicines.
NRCS & county conservation districts	• Work with public and private entities to retain current natural flood storage, such as in wetlands and floodplains. • Survey the Upper Valley reach of the river for the presence of hidden riverbank undercuts, and identify and test a means of restoring these cavities. • Revisit Birch Meadow Farm and other such projects to help the landowner evaluate the project's success, consider replanting unsuccessful parts of the buffer, and consider lessons learned in establishing buffers. • Sponsor a fluvial geomorphic assessment of the Connecticut River throughout the Upper Valley. • Continue research into appropriate methods of bank stabilization including the funding of test areas; expand education of riparian landowners concerning methods of stabilization such as conducting targeted workshops in municipalities along the river; expand programs that offer professional and financial assistance to riparian landowners for appropriate methods of bank stabilization; investigate ways to simplify the permitting process.
FEMA	• Apply hydrologic studies of the entire river completed in 2003 to update flood insurance rate maps for Lebanon, Hartford, and other Upper Valley towns upstream.

Appendix C. Continued

States	
VT Legislature	• Adopt statewide shoreland protection. • Continue to fund the Conservation Reserve Enhancement Program. • Continue to advance legislation to curb the introduction of acid-rain producing pollutants and of airborne mercury.
NH Legislature	• Consider developing shoreland protection measures for tributaries not currently covered by the Shoreland Protection Act. • Continue to advance legislation to curb the introduction of acid-rain producing pollutants and of airborne mercury.
Transportation agencies	• Restore and retain riparian buffers to capture road pollutants. Minimize road runoff directly into waterways. • Develop incentives for towns to use road sediment catchment systems. • Keep culverts clear of woody debris. • Work with state agriculture departments and natural resource agencies to educate the public and landowners about invasive species, rethink the timing of roadside mowing, and take care when disposing of spoils from mowing and excavation.
Fish & wildlife agencies	• Conservation officers should notify water quality agencies when water quality problems are observed. • Continue to cooperate with watershed groups and conservation commissions to understand and address the Didymo infestation. Provide better color photographs on posters at boat launches. Use fishing license applications to educate the public.
NH Dept. of Safety	• Establish a comprehensive program of education for boaters concerning the impact of boat wakes; provide sufficient funding to enable increased enforcement of existing regulations concerning boat wakes.
Environmental agencies (NH DES & VT DEC)	• Provide funding to ensure adequate and regular water quality monitoring; identify monitoring gaps and ensure coverage; continue to encourage volunteer water quality monitoring activities on tributaries. • Communicate results of water quality monitoring more readily to the public, especially to conservation commissions. • Investigate new methods to capture pollutants and encourage research into new technology; share the information with towns. • Continue and expand education of landowners, developers, and land use boards on the value of maintaining riparian buffers. • Take immediate priority action to reduce mercury contamination of the region. • Identify and eliminate sources of PCB contamination. • Identify mechanisms for decreasing carbon dioxide emissions. • Work with public and private entities to retain current natural flood storage, such as in wetlands and floodplains. • Develop an instream flow policy for rivers and streams that contribute to the flow of the Connecticut River. • Work with large water users to examine their present water use and identify areas for conservation. • Do not allow landfills, salvage yards, and junkyards to be located above aquifers or on varves. • Assist towns and landowners in prioritizing and clean up contaminated groundwater sites and monitor for possible MtBE contamination. Educate people to handle automotive fluids, pesticides, medicines, and other chemicals properly so they don't contaminate their own wells, and educate them about less hazardous alternatives. Educate people to keep their septic systems functioning properly with regular maintenance. Educate people about the source of their water, including carrying water bottles filled from their own tap for drinking, rather than purchasing bottled water. • Educate the public and local governments about the benefits of reclaiming gray water and water conservation. Explore ways to reuse or reduce wastewater and new technology to avoid new discharges to the river or to groundwater. Explore alternatives to adding conventional wastewater treatment plants. • Work with EPA to establish updated rules for disposal or return of unused medicines. • Develop best practices for resource recovery activities at landfills. • Work with towns to improve prevention of runoff problems related to large scale clearing for development. • Continue to cooperate with watershed groups and conservation commissions to understand and address the Didymo infestation. Provide more informative color photographs on posters at boat launches.
NH DES	• Conduct biomonitoring in areas of intensive development, such as riverside development in West Lebanon, to search for ecological effects of pollution. • Provide financial assistance to Lebanon to complete the elimination of CSOs. • Evaluate whether sediments at the Wilder Picnic Area sediment sampling site pose any human health risks to swimmers. • Maintain existing gages for public safety. Cooperate to add gages on Eastman and Mink Brooks, and consider adding a gage on the lower Mascoma River near its confluence with the Connecticut. • Evaluate whether requests for withdrawals have increased in order to decide whether the 20,000 gallon threshold for registering water users should be reduced. • Educate town officials and landowners about the Comprehensive Shoreland Protection Act, including responsibility for enforcement, and continue to offer training sessions on the Shoreland Protection Act for realtors that would count toward continuing education requirement. Provide adequate Shoreline Protection staffing for compliance. • Consider working with the regional planning commissions on a bridge and culvert survey program similar to Vermont's. • Pursue fluvial hazard erosion mapping similar to Vermont's.
Vermont DEC	• Consider adding a gage on the lower Waits River. • Explore establishing a program to register water users. • Identify and map groundwater supplies working with the towns. • Update posting of hazardous sites on the Web.

Appendix C. Continued

Towns	
Town management	• Avoid incineration of construction and demolition debris, which can put heavy metals and dioxins into the air. • Identify mechanisms for decreasing carbon dioxide emissions. • Monitor local dams for safety and environmental reasons. Educate the public about local flood hazards and emergency procedures. • Sponsor more regular household hazardous waste collections. • Pursue careful and prompt maintenance of all wastewater treatment facilities which discharge into waters which reach the Connecticut River. Encourage tertiary treatment. Reduce phosphorus entering from wastewater treatment facilities - encourage use of phosphorus-free detergents. • In NH, ask for help from regional planning commissions and NH DOT 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. • Lebanon should continue seeking funds to clean up the Westboro Rail Yard.
Planning boards & commissions	• Adopt ordinances prohibiting filling and building in the 100-year floodplain and on flowage rights of way. Consider establishing a building setback that reflects local soil conditions and the historic record of soil loss into the river, and ensure that buildings are set a safe distance back from the river even when outside of the floodplain. Include recommendations in master plans concerning water quality and shoreline protection measures and implement them by adopting regulations supporting those measures. Encourage developers and landowners to establish and/or maintain buffers of native vegetation along rivers and streams for privacy and pollution control. • Encourage developers to keep natural drainage patterns and use swales and depressions ("rain gardens") to reduce runoff, and work with developers to follow through on the 2002 Upper Valley stormwater conference. Include "low impact development" ideas during review of projects, and consider how to change existing development to reduce runoff and promote stormwater infiltration. Require additional treatment to remove oil, metals, and other pollutants for new discharges to surface waters and dry wells and ensure that these treatment systems are maintained over time. • Require sedimentation and erosion controls before, during ,and after construction, and do not permit septic systems close to water bodies.
Planning boards & commissions	• Ask regional planning commissions for help with a culvert and bridge survey to identify those that may be too small or damaged, ineffective, or plugged. • Understand the town's capacity for providing drinking water and establish a baseline for use. Take advantage of surficial geology mapping assistance available from state geological survey offices. Confirm with the state whether identified water supply information is correct. Identify old dump sites to look for those close to ground and surface water supplies. Evaluate water supplies for short and long term growth. Ensure adequate setbacks and lower density for clearing, building, and septic systems over recharge areas. Consider wellhead protection; take advantage of community source water protection grant and loan programs. Work with large water users to examine their present water use and identify areas for conservation. • Understand the limited capacity of the Wilder impoundment to assimilate further waste when planning future development. • Do not allow salvage yards or junkyards to be located above aquifers. • Do not permit landfills to be located on aquifers or varves. • In NH, do not issue permits for projects that violate the state shoreland protection law. • Work with state geologists to map varves in town to be sure major construction takes these soil features into account. • Focus on smart growth to help avoid the need for new roads near rivers and streams; when they are necessary, design them to include adequate riparian buffers. • Protect the river and its tributaries from storm water runoff by requiring suitable filtration of the runoff and minimizing impervious surfaces adjacent to water bodies. Discourage roads and development on steep slopes to control stormwater runoff. Work with states to improve prevention of runoff problems related to large scale clearing for development. • Consider a cost of community services study to investigate how conservation easements can help keep town service and school costs down if the land is not developed into house lots or into second homes which could later become year-round residences.
Conservation Commissions	• Consider setting up water quality monitoring programs in their towns and share results. • Work with public and private entities to retain current natural flood storage, such as in wetlands and floodplains. • In the Mascoma River watershed, nominate the Mascoma River into the NH Rivers Management and Protection Program. • Educate people to handle automotive fluids, pesticides, medicines, and other chemicals properly so they don't contaminate their own wells, and inform them about less hazardous alternatives. Educate people to keep their septic systems functioning properly with regular maintenance. Educate people about the source of their water, including carrying water bottles filled from their own tap for drinking, rather than purchasing bottled water taken from somebody else's aquifer. • 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, including organizing car pooling or "waste pooling." Encourage mercury product recycling, especially of new low wattage long-life light bulbs and electronics, and encourage paint swaps and educate the public on how to dispose of paint, since paint is expensive to treat. • Hold an annual "Green Up" Day. • Educate pet owners to pick up pet waste by providing information when dogs are registered. • Investigate how conservation easements can promote agriculture and protect water quality. • Educate landowners to establish, maintain and enhance the native riparian buffer vegetation on their property. • Promote responsible stewardship of forest lands. • Communicate with landowners around ponds and rivers covered by the N.H. Comprehensive Shoreland Protection Act. • Educate the public and town recreation departments about invasive aquatic species.

Appendix C. Continued

Road crews	• Use best management practices for handling and disposing of toxic substances. • Restore and retain riparian buffers to capture road pollutants. • Be sure that culverts and bridges are sized properly in order to carry the water that might come their way during larger storms. Keep culverts clear of woody debris. • Support a policy of salt reduction on roads and prioritize efforts to identify and introduce use of less toxic salt substitutes. Locate all salt storage at least 250 feet from rivers. • Follow snow disposal best management practices. Snow should be stored on flat, pervious surfaces, such as grass, and at least 100 feet from the edge of a stream or river, with a silt barrier 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. Sweep bridges first in spring to capture solids that remain from winter sanding, before washing. Towns should test the areas where they have piled snow for many years, to see if lead has accumulated in the soil. • Minimize road runoff directly into waterways. • Rethink the timing of roadside mowing, and take care when disposing of spoils from mowing and excavation.
Regional Organizations	
Regional Planning Commissions	• Evaluate the area's wastewater treatment system capacity. Understand the limited capacity of the Wilder impoundment to assimilate further waste when planning future development. • In NH, 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. • Upper Valley Lake Sunapee Regional Planning Commission should seek a grant to conduct a brownfields inventory of its member towns and prioritize cleanup.
Upper Valley Land Trust	• Work with public and private entities to retain current natural flood storage, such as in wetlands and floodplains. • Help towns and landowners understand how conservation easements can promote agriculture and protect water quality.
Solid waste districts	• Assist towns in holding more frequent household hazardous waste collections and sites. • Assist towns in exploring options to create greater recycling markets, especially for plastics, and encourage more recycling of more materials. Explore incentives for greatly reducing solid waste, including construction materials.
Utilities	
Trans Canada	• Request the help of Two Rivers/Ottauquechee Planning Commission for a Phase I brownfields assessment of company property near the former paper mill site in Wilder, as part of the redevelopment of the area, and pursue a Phase II assessment (drilling, sampling, and monitoring) if approved by EPA. • Alert towns if a problematic ice jam is anticipated.
Railroad	• Abandon the policy of eliminating the riparian buffer where the tracks pass along the river's edge, and avoid using herbicides near water. Seek a native species for vegetative cover that grows thickly and only a few feet high, that can be controlled with mowing every 5-10 years. Employ best management practices in siting structures such as salt sheds in order to protect water quality. • Expand testing of groundwater near the Ely salt shed, particularly in swales below the shed. • Locate all salt storage at least 250 feet from rivers.
Business	
	• Recycle as much material as possible. • Local outfitters and guides and outdoor stores where bait is sold should educate their customers and participants about Didymo and other invasives, and urge them to clean their gear. Pet shops should educate their customers not to release aquarium animals or plants.
Volunteer Groups	
Watershed groups	• Participate in the relicensing process for Wilder Dam. • Mascoma River Watershed Council should help nominate the Mascoma River into the NH Rivers Management and Protection Program.
Recreation groups	• Local recreation programs should educate their participants about Didymo and other invasives, and urge them to clean their gear. • Fishermen should not release unused bait into the water. • 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.

Appendix C. Continued

Landowners	
Dam owners	• Managers of tributary dams where flow can be managed, such as at Mascoma Lake, should coordinate operations with mainstem dams during spring runoff. • Consider removing dams that no longer serve a purpose and cost more to fix than the benefits they offer or are a threat to areas downstream.
Developers	• Minimize road runoff directly into waterways. • Include infiltration methods such as many small swales and runoff basins to capture runoff for groundwater recharge.
Farmers	• Those who do not yet have a nutrient management plan should work with conservation districts and Cooperative Extension Service to prepare one; employ best management practices. Farmers should not cultivate or pasture to the edge of the river or streambank; Vermont farmers should take advantage of the CREP program to cover the costs of reserving a riparian buffer area. Eliminate non-point sources of bacterial contamination, such as from livestock which have access to the river and its tributaries.
Forest landowners	• Avoid logging on steep slopes near the river and in the riparian buffer. • Consider conserving forest lands.
Waterfront landowners	• Work with public and private entities to retain current natural flood storage, such as in wetlands and floodplains. • Learn about the proper use and disposal of fertilizers, pesticides, and toxic materials; refrain from using fertilizer within 250′ of rivers, and consider alternatives to chemical fertilizers, herbicides, and pesticides. Consult CRJC's *Homeowner's Guide to Nonpoint Source Pollution in the Connecticut River Valley* (1994).
All landowners	• Use best management practices for handling and disposing of toxic substances. • Avoid burning of household trash, which is illegal in both states. • Know the location of and regularly maintain on-site septic systems. • Aquarium owners should not release aquarium plants and animals into the water but 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
Confluence with Ammonoosuc River to confluence with Roaring Brook, Piermont	Haverhill-Newbury Bridge	Newbury Haverhill Bradford Piermont	19 miles	Safe for swimming, boating, fishing Meets state standards for supporting aquatic life Fish consumption unsafe -mercury
Confluence with Roaring Brook to confluence with Clay Brook, Lyme	Samuel Morey Bridge	Bradford Piermont Fairlee Orford Thetford Lyme	12 miles	Safe for swimming, boating, fishing Meets state standards for supporting aquatic life Fish consumption unsafe -mercury
Wilder impoundment Confluence with Clay Brook to Wilder Dam	Ledyard Bridge	Thetford Norwich Hanover Hartford Lebanon Lyme	19 miles 1760 acres	Safe for swimming, boating, fishing Meets state standards for supporting aquatic life Fish consumption unsafe -mercury
Wilder Dam to confluence with White River	Route 4 Bridge	Hartford Lebanon	1.5 miles	Safe for swimming, boating, fishing Meets state standards for supporting aquatic life Fish consumption unsafe -mercury
Confluence with White River to confluence with Mascoma River, Lebanon	Railroad Bridge W. Lebanon	Hartford Lebanon	1.3 miles	Unsafe for swimming due to combined sewer overflows in Lebanon and Hartford Safe for boating, fishing Meets state standards for supporting aquatic life Fish consumption unsafe -mercury
Confluence with Mascoma River to confluence with Blow Me Down Brook, Cornish	Sumner Falls Hartland	Hartford Lebanon Hartland Plainfield Windsor Cornish	12.5 miles	Unsafe for swimming due to combined sewer overflows in Lebanon and Hartford Safe for boating, fishing Meets state standards for supporting aquatic life Fish consumption unsafe -mercury

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 mainstem and inside mouths of tributaries, Pittsburg, N.H. to Hartland Vt.
2) 1998 Upper Connecticut River Sediment/Water Quality Analysis, US EPA, Region 1. Study of 10 locations on the mainstem from Stewartstown to Hinsdale NH.

Sampling location	Town	Site	Contaminants that exceeded screening level	Source
CT River above confluence of Waits R.	Bradford	SD059L	benzo(a)pyrene	2000 EPA study
CT River above Rt. 25 bridge	Piermont	SD-062L	benzo(a)pyrene, phenanthrene, pyrene, benzo(a) anthracene, chrysene	
CT River below Route 25 bridge	Piermont	SD-063L	benzo(a)pyrene, phenanthrene, pyrene, benzo(a) anthracene, chrysene also present in very low concentrations, but the highest found in the study, was the pesticide beta-BHC	
CT River at Fairlee	Fairlee	SD-065L	no pollutants above screening levels	
CT River at Orford boat landing	Orford	SD-067L	no pollutants above screening levels	
CT River below outlet of Lake Morey at Birch Meadow Farm	Fairlee	SD-068L	no pollutants above screening levels	
CT River at confluence of Clay Brook	Lyme	SD-069L	pyrene, benzo(a)pyrene, benzo(a)anthracene, arsenic at highest level of all Upper Valley samples	
CT River below Clay Brook	Lyme	SD-070E	benzo(a)pyrene, benzo(a)anthracene, nickel	
CT River above confluence of Grant Brook	Lyme	SD-071L	pyrene, benzo(a)pyrene, benzo(a)anthracene, chrysene, phenanthrene 4,4’ DDE	
CT River above confluence of Ompompanoosuc R.	Norwich	SD-074L	pyrene,benzo(a)anthracene	
Inside mouth of Ompompanoosuc River	Norwich	UCTR05	highest concentration of copper and zinc in 1998 study. Copper exceeded the level at which severe ecological effects could be expected, and nickel at level at which some ecological effects could be expected.	1998 EPA study
CT River below confluence of Ompompanoosuc R.	Norwich	SD-077L	arsenic, above biological effects level	2000 EPA study
CT River opposite CRREL	Norwich	SD-078L	benzo(a)pyrene, benzo(a)anthracene	
CT River at Ledyard boathouse	Hanover	SD-079E	pyrene, benzo(a)pyrene, benzo(a)anthracene, chrysene, phenanthrene, fluoranthene, cadmium, 4,4’ DDE, 4,4’ DDT; also present in very low concentrations, but the highest found in the study, are nine other pesticides: 2,4’ DDE, 2,4’ DDT, heptachlor epoxide, endosulfan I, alpha-chlordane, gamma-chlordane, toxaphene, c-nonachlor, and t-nonachlor.	
CT River above confluence of Mink Brook, collected at Montshire Museum	Norwich	SD-080L	nickel	

Appendix E. Continued

CT River below Mink Brook, at Wilder Picnic Area	Hartford	SD-082E	longest list of pollutants (37) found in study, a number in concentrations well above levels where ecological effects are expected - naphthalene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, benzo(g,h,l)perylene, arsenic, lead, nickel, low level mercury. Also present in very low concentrations, but the highest found in the study, was one type of PCB.	2000 EPA study
CT River above confluence of White River	Hartford	SD-083L	no pollutants above screening levels	
CT River below confluence of White River	Hartford	SD-086L	phenanthrene, fluoranthene, pyrene, chrysene, benzo(a) anthracene, benzo(a)pyrene	
CT River below confluence of White River, above Mascoma River, under I-89 bridge	Hartford	SD 088L	phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(a)pyrene, nickel	
CT River below confluence of White River	Lebanon	UCTR06	elevated concentration of copper and zinc; copper and nickel exceeded the level at which some ecological effects could be expected. Highest concentration of lead found in study.	1998 EPA study

Appendix F. Invasive Aquatic Species

Invasive Aquatic Species*		New Hampshire		Vermont		Present in CT River mainstem	Present in Upper Valley?
		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	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

Emergent Plants	Purple Loosestrife *Lythrum salicaria*	X	X	X		X	X
	Common Reed *Phragmites australis*	X	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			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

Town Tools	Piermont	Orford	Lyme	Hanover	Lebanon
1. Master Plan is in effect (most recent update)	Yes (1991)	Yes (2001)	Yes (1985)	Yes (2003)	Yes (2002)
2. River is mentioned in master plan	Yes	Yes	Yes	Yes	Yes
3. Scenic or historic resources mentioned in master plan/ zoning	Yes	Yes	Yes	Yes	Yes
4. Zoning is in effect	Yes	No	Yes	Yes	Yes
5. Subdivision Regulations are in effect	Yes	Yes	Yes	Yes	Yes
6. Site Plan Review is in effect	No	No	Yes	Yes	Yes
7. Excavation Regulations are in effect	Yes	Yes	Yes	Yes	No
8. Shoreland Protection Regulations	Yes	No	Yes	No	No
a. Building setback required from waterways? *(50′ setback on CT River - state law)*	Yes - 75′	No	Yes - 200′ from CT River, 100′ others	Yes - 75′	No
b. Development prohibited in flood hazard area? *(100 year floodplain)*	Yes	No	Yes	Yes	No
c. Riparian buffer protected? *(150′ buffer on CT River where such buffer exists-state law)*	Yes - 75′	No	Yes - 200′ from CT River, 100′ others	Yes	No
d. Overlay district for rivers & streams?	Yes	No	Yes	No	No
e. Minimum frontage required for shore lots? *(150′ min. on CT. River if no sewer-state law)*	No	No	Yes 200′ or 300′	No	No
f. Local regulation of docks in effect?	No	No	No	No	No
9. Wetlands Regulations	Yes	No	Yes	Yes	Yes
a. Uses regulated in wetlands?	No	No	Yes	Yes	Yes
b. Uses regulated in buffer around wetlands?	No	No	Yes - 100′	Yes - 75′	USTs : 200′
10. Groundwater Protection Regulations	No	No	No	No	No
a. Uses regulated over aquifers ?	No	No	Yes	No	No
b. Well-head protection area defined?	No	No	Yes	No	Yes
c. On-site sewage disposal buffer for water supplies?	No	No	Yes - 400′	No	Yes - 75′
11. Agricultural Soils Protection Regulations	No	No	Yes	No	No
12. Steep Slopes Regulations	Yes	No	Yes - 20% max	No	Yes-25% max
13. Town has a conservation commission	Yes	Yes	Yes	Yes	Yes

Source: Upper Valley Lake Sunapee Regional Planning Commission, October 27, 2005

Appendix G. Continued

Vermont Towns

Town Tools	Bradford	Fairlee	Thetford	Norwich	Hartford
1. Town Plan is in effect (most recent)	Yes (2005)	Yes (2001)	Yes (2007)	Yes (2001)	Yes (2003)
2. River mentioned in master plan	Yes	Yes	Yes	Yes	Yes
3. Scenic or historic resources mentioned in master plan and/or zoning	Yes - historic overlay district	Yes	Yes	Yes	Yes - design control, scenic townscape preservation
4. Zoning is in effect	Yes	Yes	Yes	Yes	Yes
5. Subdivision Regulations in effect	No	Yes	Yes	Yes	Yes
6. Site Plan Review in effect	No	No	No	Yes	Yes
7. Excavation Regulations in effect	Yes	Yes	Yes	No	Yes
8. Shoreland Protection Regulations	Yes	Yes - w/ in 500′ of Conn R., lakes	No	Yes	Yes
a. Building setback required from waterways? (No state requirement)	Yes -50′ from Conn. & Waits Rs., 35′ others	Yes - 75′ ; 35′ accessory	Yes	Yes - 60′; 30′ accessory, only CT, Ompomp. Rivers	Yes - 100′
b. Development prohibited in flood hazard area? (100 year floodplain)	No	No	Yes	No	No
c. Riparian buffer protected?	Yes, but no buffer depth specified	Yes	No	Yes, but no buffer depth specified	Yes - 100′ from CT, White,Ottauquechee Rivers; 30′ others
d. Overlay district for rivers & streams?	No	Yes	No	No	Yes
e. Minimum frontage for shore lots?	Yes - if w/in 250′ is 50′	No	No	No	Yes
f. Local regulation of docks?	No	No	No	No	Yes
9. Wetlands Regulations	No	Yes	No	Yes	No
a. Uses regulated in wetlands?	No	Yes	No	Yes	No
b. Activities regulated in a buffer zone around wetlands?	No	No	No	Yes - 50′	No
10. Groundwater Protection Regulations	Yes	Yes	No	Yes	No
a. Uses regulated over aquifers ?	Yes	No	No	Yes - for public supply only	No
b. Well-head protection area defined?	Yes	Yes	Yes	Yes - 1000′ from public supply	No
c. On-site sewage disposal buffer around water supplies?	Yes - 500′	No	No	Yes - 100′	No
11. Agricultural Soils Protection Regs	No	No	No	Yes	No
12. Steep Slopes Regulations	Yes - not over 25%	Yes - not over 25%	No	Yes - not over 25%	No
13. Conservation commission	Yes	No	Yes	Yes	Yes

Sources:
Bradford, Fairlee, Hartford: Research by Deborah Noble Associates, April 2005; Bradford update: Ben Copans, VT ANR;
Hartford: Town of Hartford, April 2007
Thetford: Research by Stuart Blood, March, 2006; town plan revision.
Norwich: Research by Jeff Mathias, March 2005

Appendix H. Water Withdrawals - New Hampshire

Type	Name	Facility	Town	Source
Hydroelectric Power	Evans Evans & Evans Inc	Eastman Brook Hydro	Piermont	Eastman Brook
Hydroelectric Power	Evans Evans & Evans Inc	Celley Mill	Piermont	Eastman Brook
Hydroelectric Power	Drabick Mark	Brackett Brook Hydro	Orford	Brackett Brook
Snow Making	Dartmouth College Trustees	Dartmouth Skiway	Lyme	Grant Brook
Industrial	US Army Corps of Engineers	Cold Regions Research & Eng Lab	Hanover	Connecticut River esker (well)
Irrigation	Hanover Country Club	Hanover Country Club golf course	Hanover	Connecticut River
Water Supplier	Hanover Water Works Co	Water Works	Hanover	Camp & Mink Brook
Water supplier	Lebanon City	Water Works	Lebanon	Mascoma River
Mining	Pike Industries Inc	Lebanon Crushed Stone	Lebanon	Settlement Ponds
Mining	Twin State Sand & Gravel	Twin State Sand & Gravel	Lebanon	Mascoma River
Hydroelectric Power	Mascoma Hydro Corporation	Glen Mascoma Hydroelectric Project	Lebanon	Mascoma River
Hydroelectric Power	Rivermill Hydroelectric Inc	Rivermill Hydro	Lebanon	Mascoma River

Appendix I. Rivers Covered by the N.H. Comprehensive Shoreland Protection Act

RSA 483-B also applies to lakes and ponds of 10 acres or more, and to other rivers and streams in New Hampshire's Upper Valley Region that are fourth order and larger:

City/ Town	River/ Stream	Stream Order	Beginning of Fourth Order or Higher Segment
Piermont	Connecticut River	6 & 7	(all)
Orford	Connecticut River	7	(all)
Lyme	Connecticut River	7	(all)
Hanover	Connecticut River	7	(all)
	Goose Pond Brook	4	Juncture of Marshall and Pressey Brooks
	Mink Brook	4	Juncture of unnamed 3rd order stream
Lebanon	Connecticut River	7	(all)
	Mascoma River	5	Outflow of Mascoma Lake
	Bloods (True's) Brook	4	Juncture of Newton Brook in Plainfield
	Great Brook	4	Juncture of unnamed 3rd order stream

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 N.H. 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.

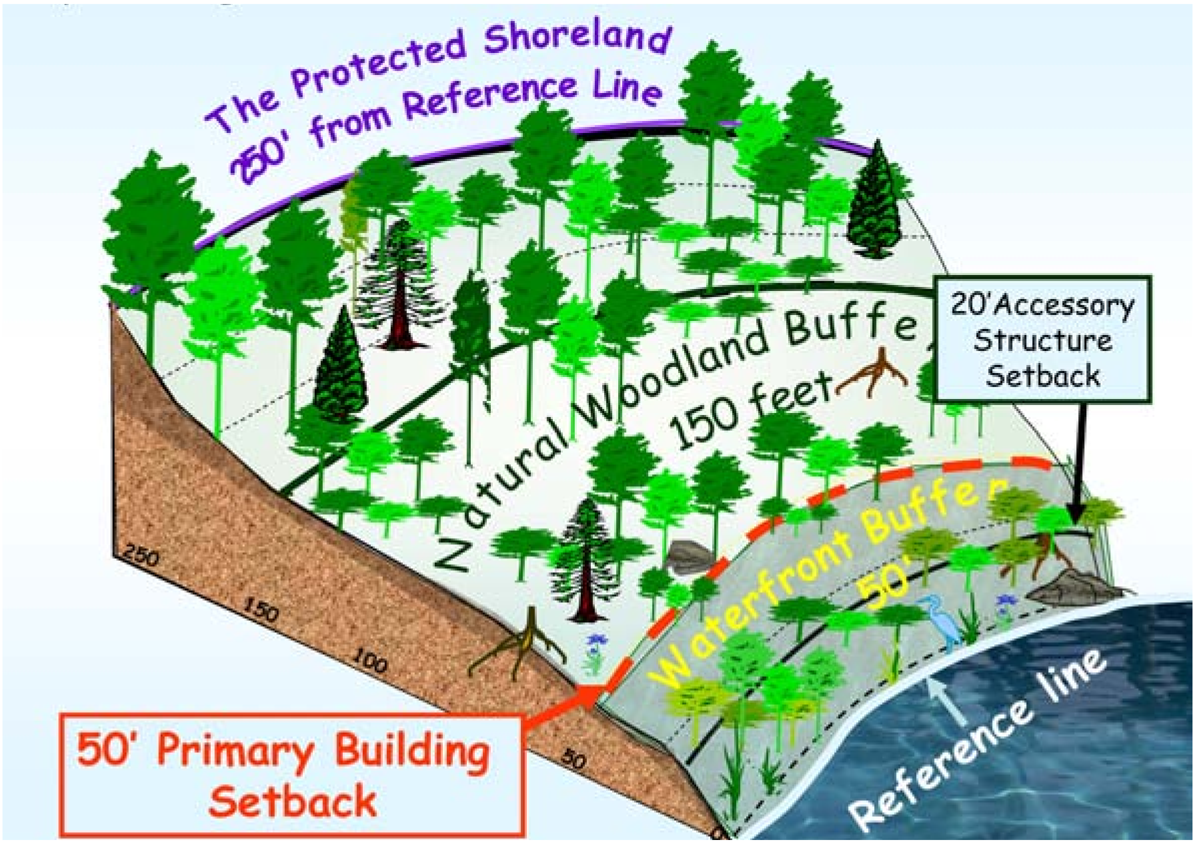
REFERENCE LINE: For ***coastal waters*** it is the highest observable tide line; for ***rivers*** it is the ordinary high water mark; for ***natural fresh waterbodies*** it is the natural mean high water level; and for ***artificially impounded fresh waterbodies*** it is the elevation at the spillway 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



Source: NH DES

Appendix J. Tributaries to the Connecticut River

New Hampshire

Tributary	State Assessment 2008 draft Section 303(d) List of Impaired Surface Waters	Sediment Quality 2000 Upper Connecticut River Valley Sediment Study, US EPA, Region 1	Local Observations
Town where tributary enters Connecticut River: Piermont			
Bean Brook	town beach - pollutants from public bathing area *(E. coli)*	not assessed	
Eastman Brook	0.64 miles aquatic habitat impaired by low pH	SD064L - benzo(a)pyrene, phenanthrene, pyrene, benzo(a)anthracene, chrysene	Passes through village of Piermont; ledges, waterfalls. Heavy agricultural use in lower corridor. Upper corridor forested, dispersed residential development.
unnamed brooks	not assessed	not assessed	
Town where tributary enters Connecticut River: Orford			
unnamed brook	not assessed	not assessed	First order stream near Grimes Hill Road, 1.1 miles long, watershed 2 sq.mi. Corridor largely forested on south side and hayfield and pasture on north side. Grazing animals have significant access to stream; buffer partially absent. Large auto junkyard near source of stream. Bottom type is cobbles/gravel with some silt, waterfalls, erosion. Beaver dam 25 yards in from confluence with CT River. Turbidity and algae in area of beaver dam. No trash observed.
unnamed brook	not assessed	not assessed	Second order stream 2 miles north of Fairlee bridge, less than 1/4 mile long. Steep upper corridor heavily forested, 2 homes with septic systems and lawns close to brook on lower end. Algae near CT River confluence. No trash observed.
Reeds Marsh Brook	not assessed	not assessed	First order stream, 2.25 miles long, passes by Reeds Marsh before confluence with CT River. Upper corridor steep, heavily forested; then runs along Route 25A for ½ mile. Lower corridor passes close to homes with lawns and farm ponds near brook, and then through heavily cropped pasture with little buffer. Grazing access to stream. No trash or obvious water quality problems.
Jacob's Brook	not assessed	SD-066L - lower Jacob's Brook - phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene	Third order stream. Ledges, waterfalls, cascades. Upper watershed heavily forested, logging. Dispersed development of homes; town landfill; gravel road and Route 25A run very close to brook for a mile. A number of older homes with unknown septic facilities located close to banks. Volunteer WQ monitoring by conservation comm.

Appendix J. Continued

Tributary	State Assessment 2008 draft Section 303(d) List of Impaired Surface Waters	Sediment Quality 2000 Upper Connecticut River Valley Sediment Study, US EPA, Region 1	Local Observations
Town where tributary enters Connecticut River: Lyme			
Clay Brook	not assessed (Post Pond sampled annually by Lyme Conservation Commission; town swimming beach; on state list of acid ponds)	not assessed	Third order stream, starts as Trout Brook on heavily forested mountainside. Passes through much conservation land. Dispersed development; large beaver dam and forested wetland. Slightly rerouted at town recreation fields. Trout Brook empties into Post Pond; floodplain filled, artificial beach. Wildlife sanctuary, active beaver dams. Old dump on banks, pasture, glacial clays on bank, bottom type silty/clay after leaving Post Pond. Milfoil at mouth.
Grant Brook	6.4 miles aquatic impairment documented by fish bio-assessments	SD-072L - lower Grant Brook - *no pollutants above screening levels*	Third order stream, heavily forested upper corridor, AT conserved land. Snow-making withdrawal for Dartmouth Skiway; receives sediment from skiway parking lot. Local road closely follows for much of its length; significant residential development, but buffer largely intact. Several large waterfalls. Parts of corridor protected; beaver activity. Trail along much of stream. Enters CT River near Wilder Wildlife Mgt area. No evident water quality problems. Bottom type cobbles, boulders, gravel, ledge. Atlantic salmon fry released; subject of Dartmouth studies. Flow tends to be consistent. Coldwater fishery.
Hewes Brook	9.38 miles aquatic impairment documented by fish bio-assessments	SD-073L - lower Hewes Brook - *no pollutants above screening levels*	Third order stream, forested upper corridor, then open old fields. Large constructed wetland nearby, some protected land. Dispersed homes, high value wetlands. School uses for teaching. Snowmobile trail close to brook. Enters steep hemlock ravine with ledges, cascades, old town dump on banks, before reaching CT River and public canoe launch area. Bottom type varies from ledge to sand and silt. No evident water quality problems, some trash.
Stream from Mud Pond to Reservoir Pond	0.88 miles aquatic habitat impaired by low pH		
Town where tributary enters Connecticut River: Hanover			
Slade Brook	not assessed	not assessed	Upper forested corridor largely protected; slides and cascades; new residential development near confluence with CT River; riparian land management plan in place through Hanover Conservation Council.
Coleman Brook	not assessed	not assessed	
Girl Brook	not assessed	not assessed	Passes through golf course, stream banks degraded. Bottom type sand/silt. Subject of geomorphic assessment.
Camp Brook	not assessed	not assessed	Drains Storrs Pond, forested watershed, heavy recreational use
Mink Brook	safe for swimming, boating, fishing for 8.1 miles, although the lowest .14 mi. has not been assessed	SD081L - lower Mink Brook - phenanthrene, fluoranthene, pyrene, benzo(a) anthracene,benzo(a) pyrene, chrysene, indeno(1,2,3-cd)pyrene, nickel	Fourth order stream from Etna. Upper watershed largely forested, dispersed residential development. Homes and roads close to bank in Etna village. Passes through town conservation area. Phragmites, buckthorn, other invasives. Wastewater discharge from Hanover plant removed from Mink Brook in 2005.

Appendix J. Continued

Tributary	State Assessment 2008 draft Section 303(d) List of Impaired Surface Waters	Sediment Quality 2000 Upper Connecticut River Valley Sediment Study, US EPA, Region 1	Local Observations
Town where tributary enters Connecticut River: Lebanon			
Boston Lot Lake outlet	not assessed	not assessed	Boston Lot Lake dam repaired in 2006. Forested watershed, foot trails, recreational use. Drops steeply to CT River. Outlet flows under heavily traveled Route 10 just before entering Connecticut River at Wilder Dam.
Mascoma River	Public water supply for City of Lebanon. Portions are unsafe for swimming due to CSOs & other unknown sources *(E. coli)*; safe for fishing & boating; variable info on health of aquatic life. 3.02 miles of Hardy Hill Brook exceed *E. coli,* lead, and aluminum limits, and 3.1 miles of Blodgett Brook exceed *E. coli* limits. 3.65 miles of the Mascoma mainstem in Lebanon and 9 miles in Hanover exceed water quality standards for *E. coli*, and for aluminum, dissolved oxygen, and pH.	SD-087L - lower Mascoma R. - pyrene, chromium SD-089L - upper Mascoma R.- naphthalene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a) anthracene, chrysene, benzo(a)pyrene, indeno(1,2,3-cd) pyrene, chromium, lead, zinc, low level mercury. Highest level of chromium found in the study.	Mascoma Lake has been sampled extensively through the New Hampshire Department of Environmental Services Volunteer Lake Assessment Program (VLAP) for many years. Heavy residential/industrial/commercial/ urban development along shores, with diminished buffer along roadways. River source at Cummins Pond, in large parcel of protected forest land. Passes through old industrial sites that were powered by the river. Mascoma Watershed Conservation Council includes membership from 7 watershed towns, has completed a major land protection project at Bear Pond. Completed natural resource inventory in 2003.
Great Brook	Lower 2.1 miles are contaminated with *E. coli*. Several tributaries and ponds show low pH levels.	not assessed	Considered Lebanon's cleanest brook. Mostly forested watershed, some residential and agricultural development but vegetated buffer remains substantially intact for most of its length. However, road along brook is carrying increasing traffic. NH Fish & Game stocks lower portion annually.
True's (Blood) Brook	not assessed	not assessed	Heavily used swimming hole at ledges; conservation area. (see observations of upper part of True's Brook in Mt. Ascutney Region chapter)

Appendix J. Continued

Vermont

Tributary	State Assessment*	Sediment Quality 2000 Upper Connecticut River Valley Sediment Study, US EPA, Region 1	Local Observations
Town where tributary enters Connecticut River: Bradford			
Waits River	Basin planning underway. Watershed 144 square miles. 8 percent in agriculture. Pike Hill Brook (from mouth to 3 miles upstream) is impaired due to metals from former mining operations. A tributary to the Tabor Branch is impaired for 0.1 mile by "undefined" pollutants including agricultural runoff and milk house effluent. Need evaluation of impairment: between West Topsham and the confluence of the South Branch and below the confluence of the South Branch to the Connecticut River, for channel widening, erosion, and runoff. Geomorphic assessments underway.	SD060L - lower Waits R.- pyrene, phenanthrene, benzo(a)anthracene, fluoranthene, chrysene, copper, lead, zinc, nickel, low level mercury. Highest levels of copper, lead, zinc, and mercury found in the study. Also present in low concentrations but in the highest levels found in the study were cyanide and tin. SD-061L - upper Waits R. - pyrene, phenanthrene, benzo	(local volunteers are participating in state basin planning process as Waits River Watershed Council)
Town where tributary enters Connecticut River: Fairlee			
outlet of Lake Morey	unknown. Part of Basin 16, basin plan not yet prepared.	not assessed	infested with milfoil delivered from Lake Morey, has introduced milfoil to Clay Brook and Connecticut River.
Town where tributary enters Connecticut River: Thetford			
Ompompa-noosuc River	Basin planning underway. Watershed 136 square miles. 5 percent in agriculture. Major issues include a lack of riparian buffers and nonpoint source pollution from erosion and road runoff. Phase 1 geomorphic assessment work has been done on Copperas Brook, Lords Brook, West Branch and the lower Ompompanoosuc River, adjacent to old mining operations. Ely Brook (2.2 miles) and 1.5 miles of Ompompanoosuc River below Ely Mine listed as impaired by metals from acid mine drainage, as are W. Branch Ompompanoosuc (3.8 miles), 1 mile of Copperas Brook, and 2.8 miles of Lords Brook Brimstone Corners to below West Fairlee Village and from Sawnee Bean Brook to the beach area at the Union Village Dam: listed as impaired for elevated *E. coli* from unknown sources. Local Watershed Council conducted a stream monitoring program during Summer 2006, found elevated *E. coli* in densely populated residential areas with on-site septic systems.	SD-075L - lower Ompompanoosuc R. - pyrene, benzo(a) anthracene, benzo(a) pyrene, arsenic, copper SD-076L - upper Ompompanoosuc R. - phenanthrene, pyrene, copper 1999 EPA sediment study - mouth of the Ompompanoosuc had highest copper and zinc levels of 10 sites on the CT River.	(local volunteers are participating in state basin planning process as Ompompanoosuc River Watershed Council)

Appendix J. Continued

Tributary	State Assessment*	Sediment Quality 2000 Upper Connecticut River Valley Sediment Study, US EPA, Region 1	Local Observations
Town where tributary enters Connecticut River: Norwich			
Blood Brook	water quality monitoring by Norwich Conservation Commission. Part of Basin 16, basin plan not yet prepared.	not assessed	conservation commission is monitoring water quality
Town where tributary enters Connecticut River: Hartford			
Dothan Brook	unknown. Part of Basin 16, basin plan not yet prepared.	not assessed	
White River	Basin 9. Basin plan complete. Largest CT River tributary in either state, and longest free flowing river in Vermont. Watershed 710 square miles Overall water quality in the White River Basin is exceptionally good. Phase 1 geomorphic assessment has been completed on the entire river and Phase 2 on most of the watershed. 20 restoration projects have been done, now mostly using bioengineering and using these assessment data. Many of the streams in the watershed were channelized for roads and for agricultural use. Water quality monitoring is taking place on 20 sites, including recreation areas and below wastewater treatment plants. *E. coli* and turbidity problems from ag runoff. Streambank destabilization and loss of riparian buffers are the main causes of sedimentation, thermal modification, and turbidity. Numerous land uses contribute nutrients and pathogens. White River Partnership volunteers have conducted weekly water quality monitoring during the summer at 24 sites since 2001. 7 sites are chronically above the EPA standard for *E. coli*, and 12 are above the stricter Vermont standard.	SD-084L - lower White R. - no pollutants above screening levels SD-085L - upper White R. - no pollutants above screening levels	Active watershed organization, the White River Partnership. Community-based river corridor planning focused on erosion at Ayer's Brook.

*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).

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
NH DES = New Hampshire Department of Environmental Services
NPDES = National Pollutant Discharge Elimination System
NRCS = Natural Resources Conservation Service of USDA
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. Water Resources Maps

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; Geohydrology and Water Quality of Stratified-Drift Aquifers in the Lower Connecticut River Basin, Southwestern NH, USGS Water-Resources Investigations Report 92-4013; 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. Hartford, VT stratified drift aquifers digitized by Upper Valley Lake Sunapee Regional Planning Commission (UVLSRPC), 2002 based on Ground Water Resources of the White River Junction Area, VT by A.L. Hodges, Jr., D. Butterfield, J.W. Ashley, 1976. No other 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 **

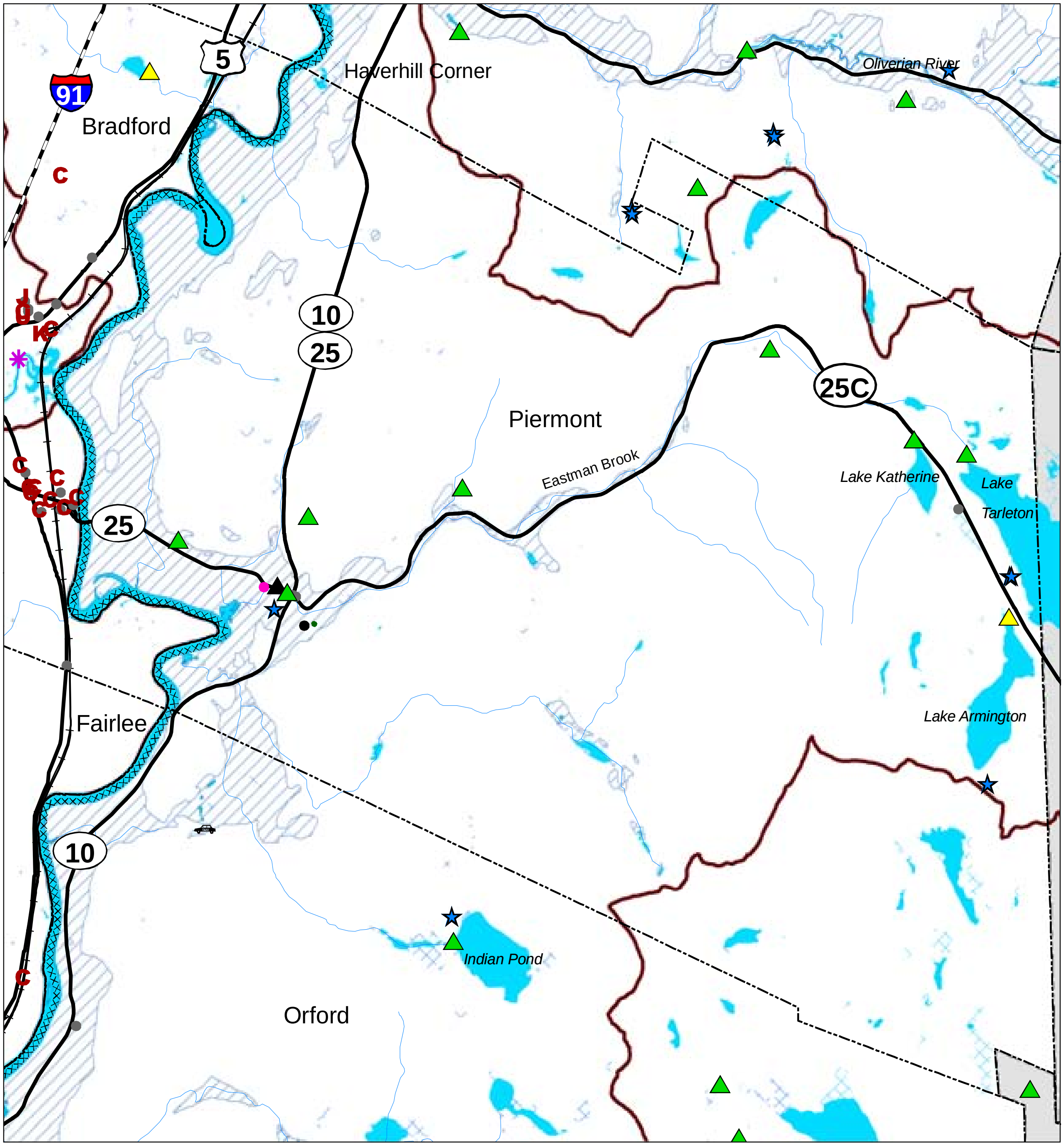
**Refer to written report for more detailed information on each potential water quality threat categories.

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

Lebanon and Hanover, NH floodplains digitized by UVLSRPC based on Federal Emergency Management Agency flood insurance rate maps. Lyme, NH floodplains from Cartographic Associates.

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 - Piermont, NH

Upper Valley Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Aquifers
Stratified-Drift Aquifers
Glacial Lake Bottom Deposits

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
XXXXX Impoundment Zone

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
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

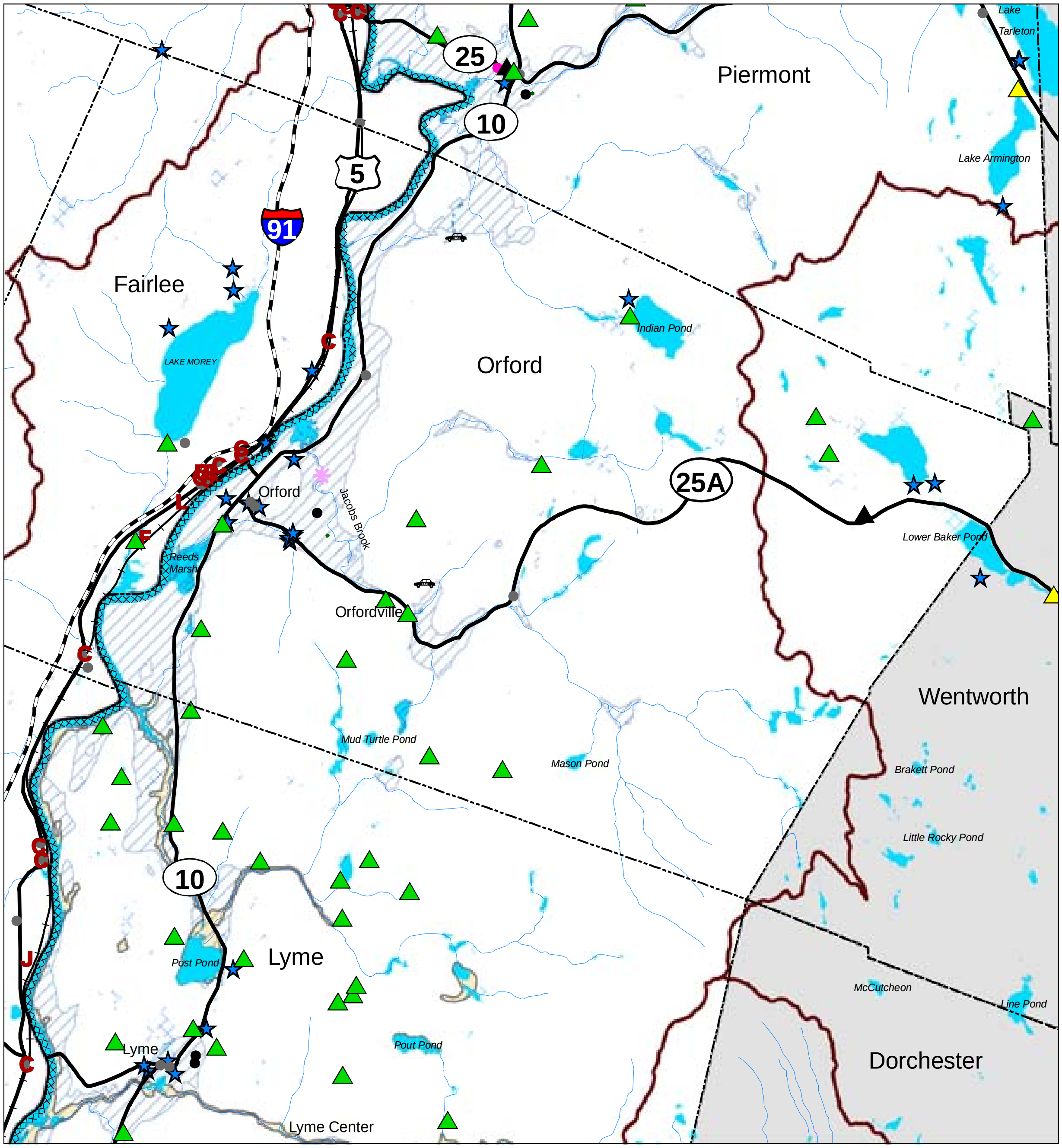
NH Water Quality Threat Inventories
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump

0.5 0 0.5 1 Miles

1:70,000

Map created by
Upper Valley Lake Sunapee Regional Planning Commission
for the Connecticut River Joint Commissions, January 2008.

Funding provided by CRJC and US Gen New England.



Water Resources - Orford, NH

Upper Valley Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Aquifers
Stratified-Drift Aquifers
Glacial Lake Bottom Deposits

100-Year Floodplain (Lyme 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
XXXXX Impoundment Zone

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
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

NH Water Quality Threat Inventories

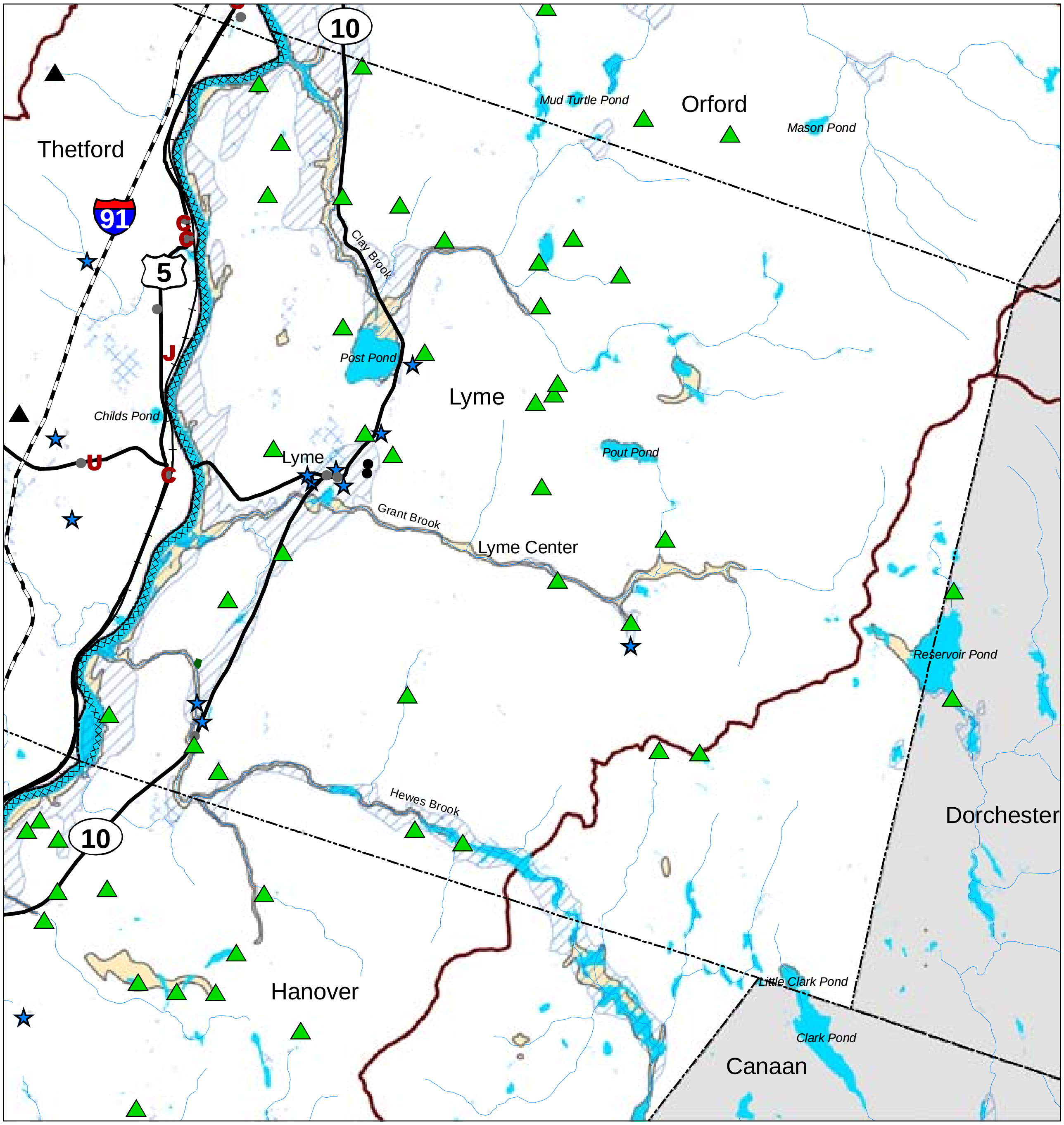
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump

0.7 0 0.7 1.4 Miles

1:100,000

Map created by
Upper Valley Lake Sunapee Regional Planning Commission
for the Connecticut River Joint Commissions, January 2008.

Funding provided by CRJC and US Gen New England.



Water Resources - Lyme, NH

Upper Valley Subcommittee

- Political Boundary
- Watershed Boundaries
- Interstate
- State or Local Highway
- Railway
- Major Water Bodies
- Wetlands

Aquifers

- Stratified-Drift Aquifers
- Glacial Lake Bottom Deposits
- 100-Year Floodplain (Lyme/Hanover 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
- XXXXX Impoundment Zone

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
- 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

0.7 0 0.7 1.4 Miles

1:85,000

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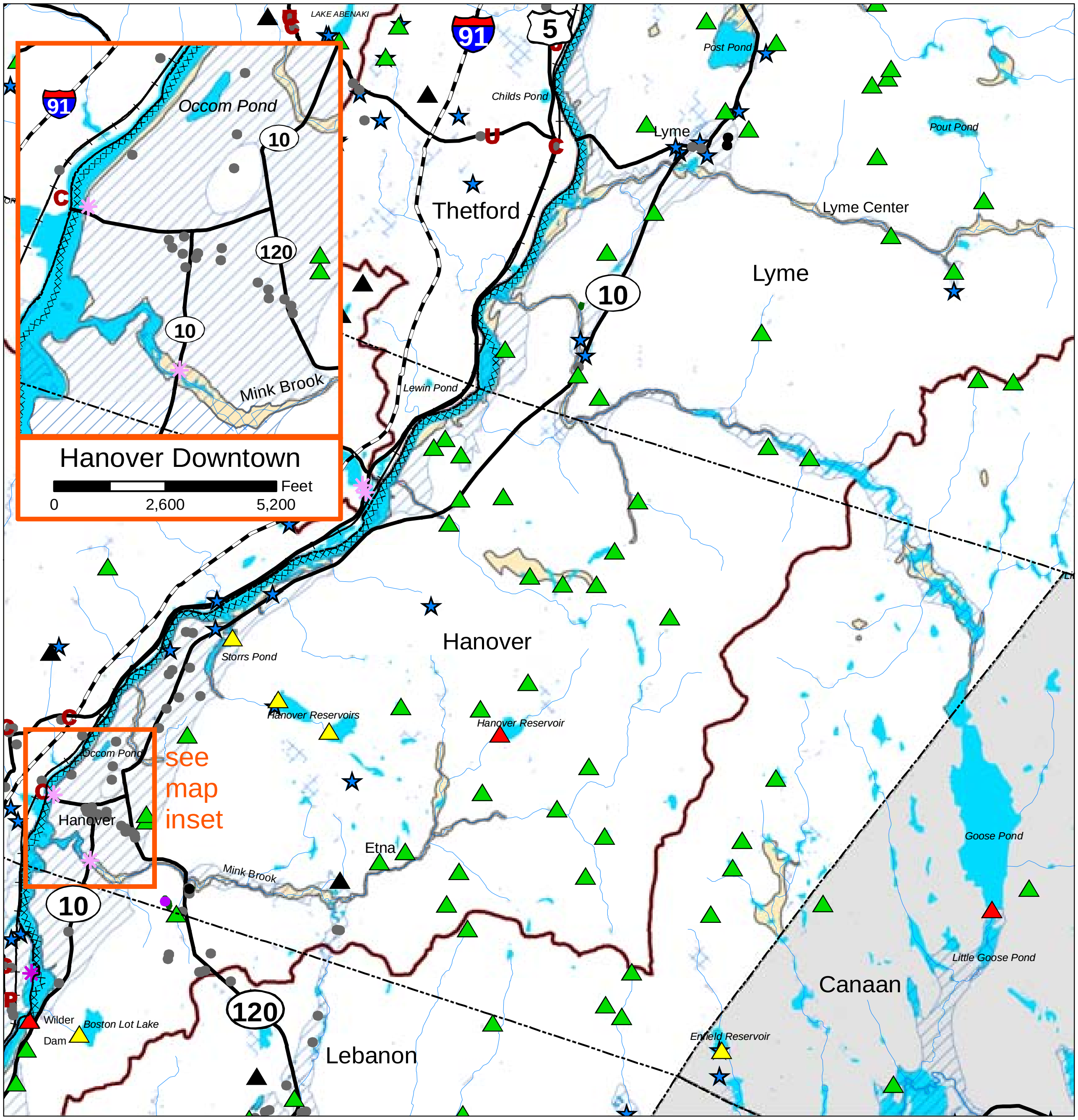
Funding provided by CRJC and US Gen New England



Water Resources - Hanover, NH

Upper Valley Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Aquifers
Stratified-Drift Aquifers
Glacial Lake Bottom Deposits

100-Year Floodplain (NH towns 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
XXXXX Impoundment Zone

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
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

0.75 0 0.75 1.5 Miles

1:100,000

Map created by
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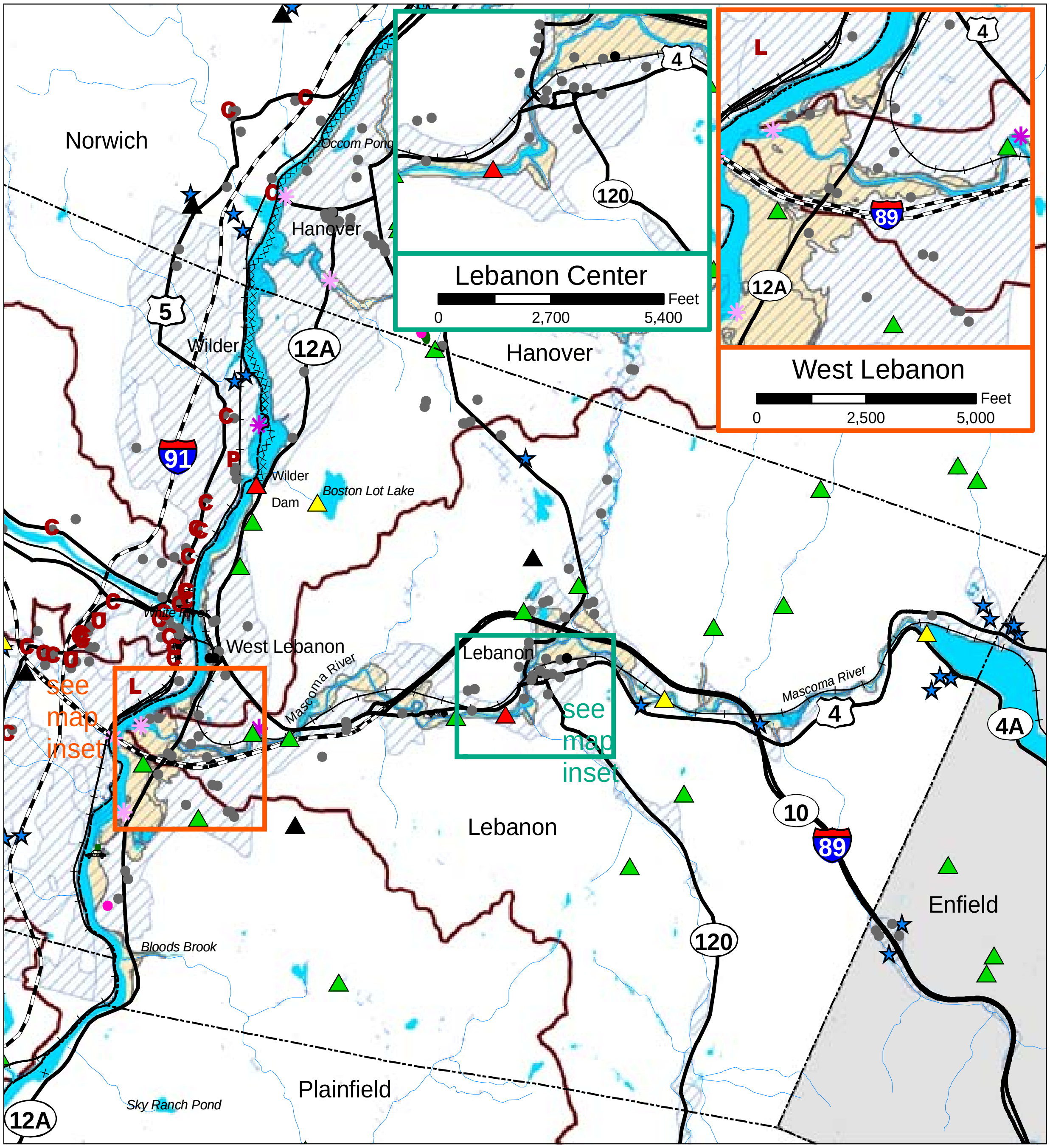

Water Resources - Lebanon, NH

Upper Valley Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Aquifers
Stratified-Drift Aquifers
Glacial Lake Bottom Deposits

100-Year Floodplain (NH towns 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
XXXXX Impoundment Zone

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
- 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

0.7 0 0.7 1.4 Miles

1:80,000

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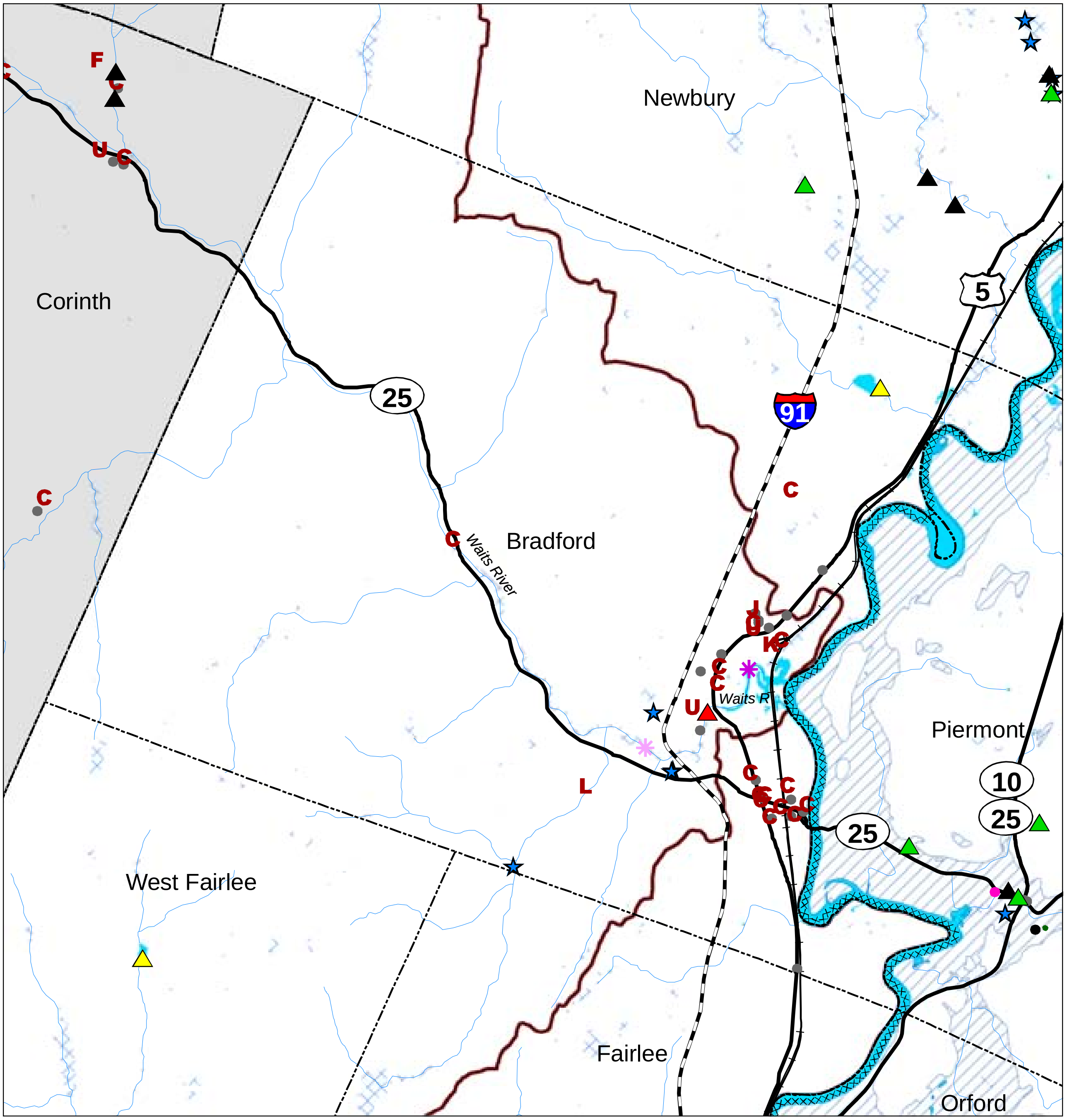

Water Resources - Bradford, VT

Upper Valley Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Aquifers
Stratified-Drift Aquifers
Glacial Lake Bottom Deposits

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
XXXXX Impoundment Zone

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
- **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

0.5 0 0.5 1 Miles

1:70,000

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Upper Valley Lake Sunapee Regional Planning Commission
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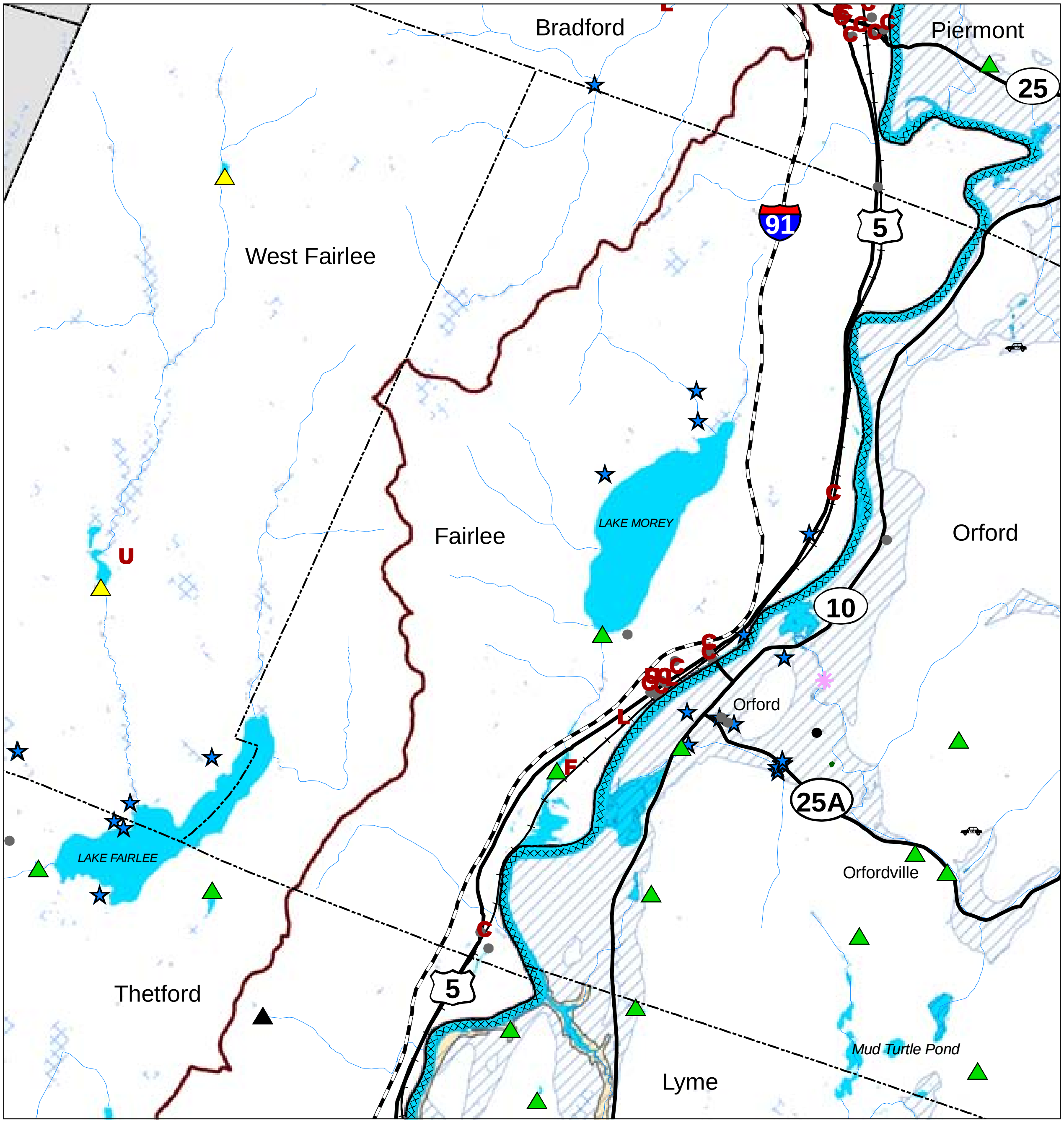

Water Resources - Fairlee, VT

Upper Valley Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Aquifers
Stratified-Drift Aquifers
Glacial Lake Bottom Deposits

100-Year Floodplain (Lyme 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
XXXXX Impoundment Zone

N W E S

Water Quality Threats

VT Pollution Source Inventory of 1980

- C Petrochemicals
- F Agricultural Wastes
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- L Landfilll/Dump
- 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

0.5 0 0.5 1 Miles

1:70,000

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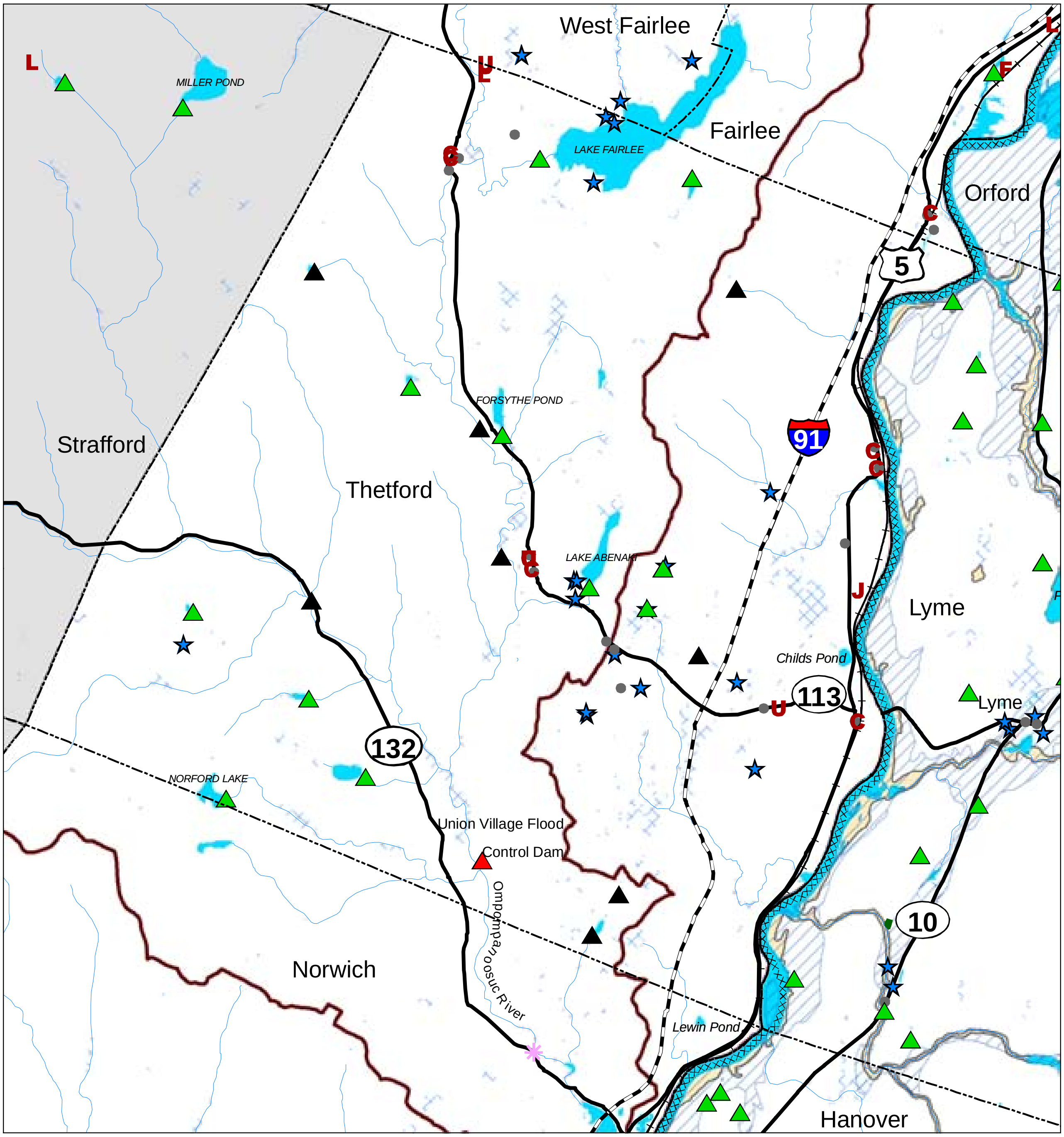

Water Resources - Thetford, VT

Upper Valley Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands
Aquifers
Stratified-Drift Aquifers
Glacial Lake Bottom Deposits

100-Year Floodplain (Lyme/Hanover 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
Impoundment Zone

N W E S

Water Quality Threats

VT Pollution Source Inventory of 1980

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- K Liquid Waste to Land Surface/Subsurface
- L Landfilll/Dump
- P Lagoon-Municipal
- U Salt/Salted Sand

Underground Storage Tank Facilities

NH Water Quality Threat Inventories

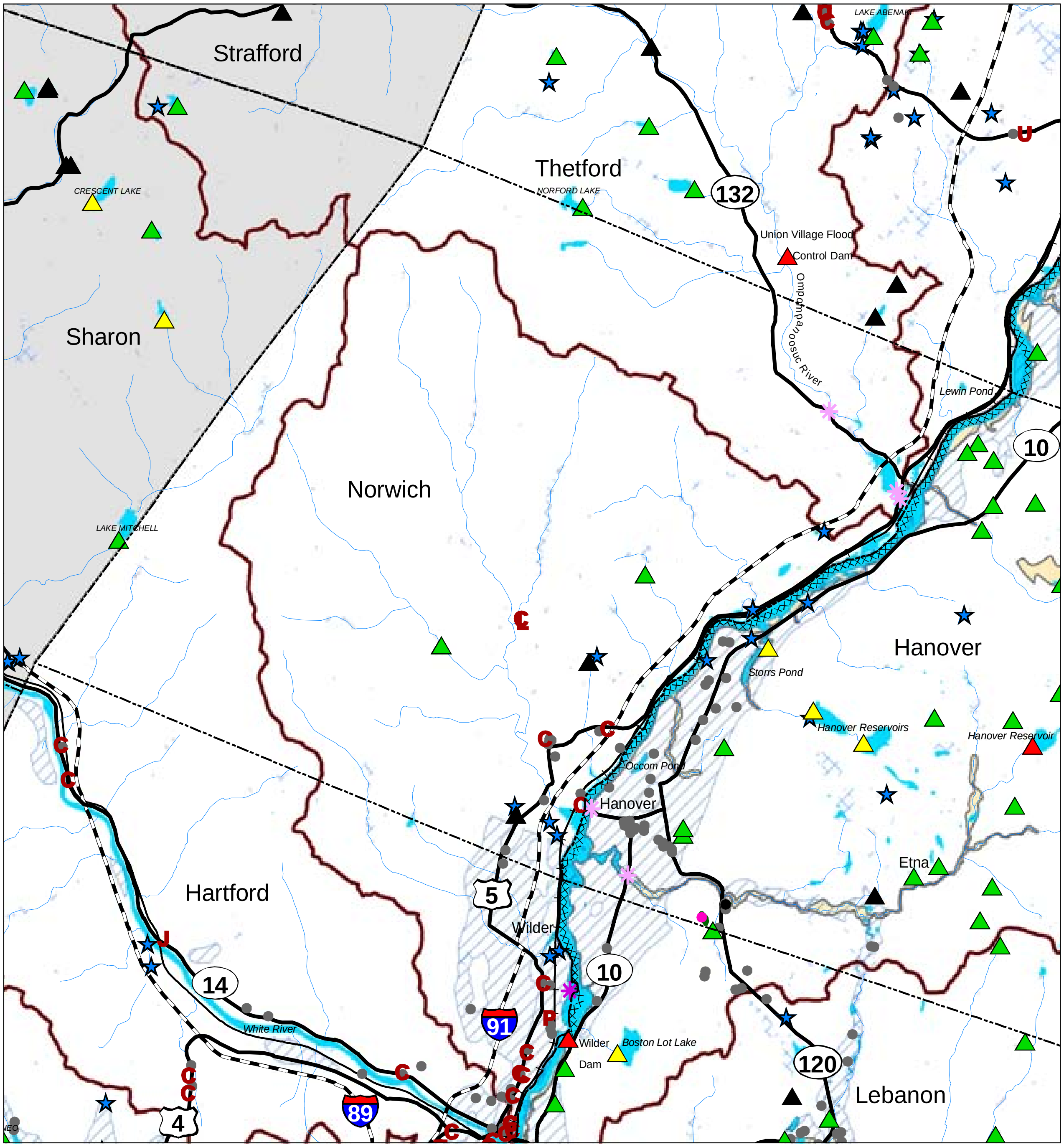
- Snow Dump/Salt Storage
- Automobile Salvage Yard
- Lagoon
- Landfill/Dump

0.75 0 0.75 1.5 Miles

1:80,000

Map created by
Upper Valley Lake Sunapee Regional Planning Commission for the Connecticut River Joint Commissions, January 2008.

Funding provided by CRJC and US Gen New England.



Water Resources - Norwich, VT

Upper Valley Subcommittee

Political Boundary
Watershed Boundaries
Interstate
State or Local Highway
Railway

Major Water Bodies
Wetlands

Aquifers
Stratified-Drift Aquifers
Glacial Lake Bottom Deposits

100-Year Floodplain (NH towns 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
XXXXX Impoundment Zone

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
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

1 0 1 2 Miles

1:100,000

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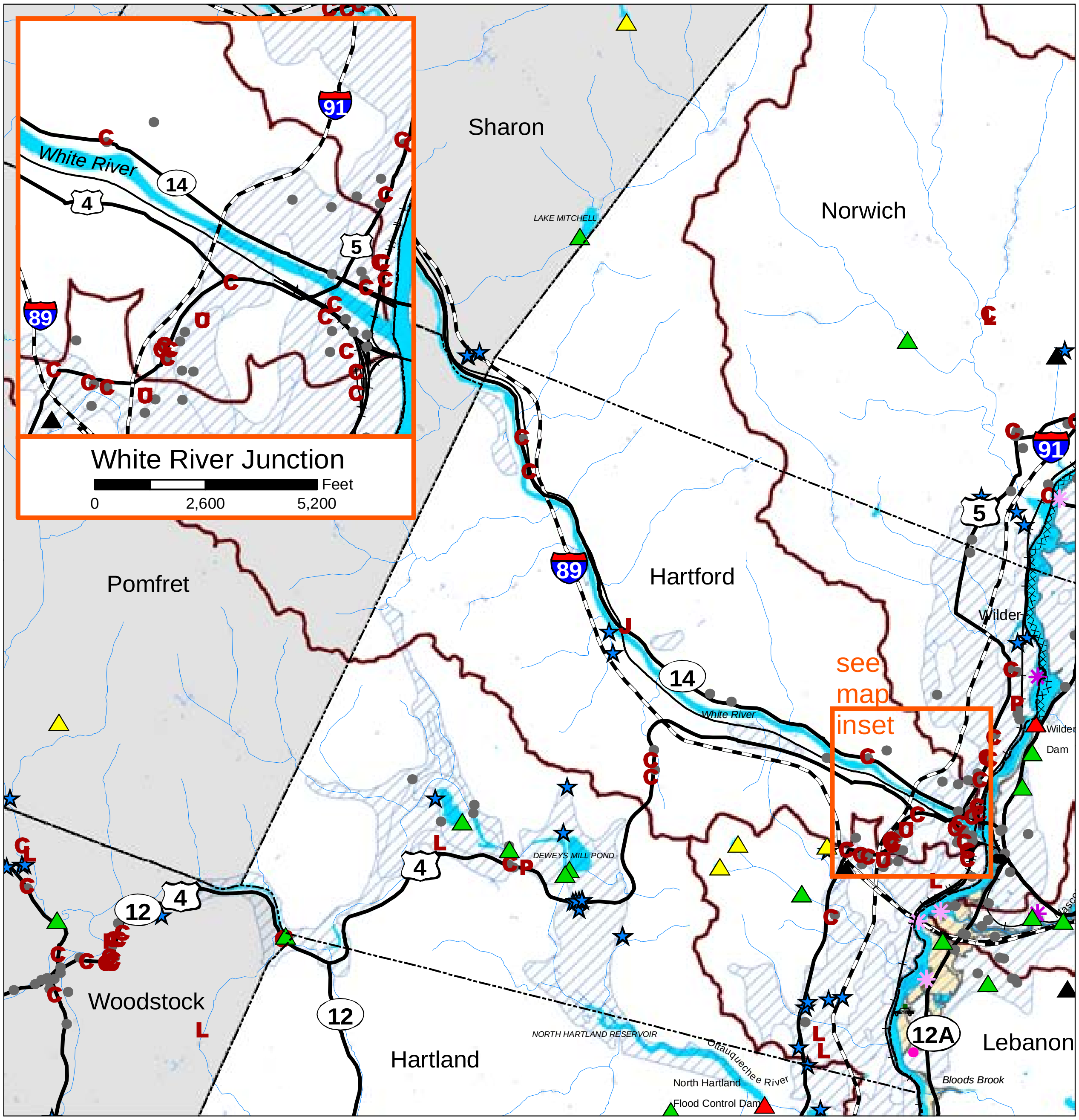

Water Resources - Hartford, VT

Upper Valley Subcommittee

- Political Boundary
- Watershed Boundaries
- Interstate
- State or Local Highway
- Railway
- Major Water Bodies
- Wetlands

Aquifers
- Stratified-Drift Aquifers
- Glacial Lake Bottom Deposits

- 100-Year Floodplain (NH towns 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
- XXXXX Impoundment Zone

N E S W

Water Quality Threats

VT Pollution Source Inventory of 1980
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- 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

0.75 0 0.75 1.5 Miles

1:100,000

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Funding provided by CRJC and US Gen New England.

Notes

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